KAISER HILL COMPANY

ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

FINAL DESIGN ANALYSIS AND DESIGN CALCULATIONS (APPENDICIES A-G)

Project No. 57378.6040
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ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

FINAL
DESIGN ANALYSIS

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LIST OF ACRONYMS AND ABBREVIATIONS

CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
cfs	cubic feet per second
CQAE	Construction Quality Assurance Engineer
CSI	Construction Specifications Institute
DM	Design Manager
Earth Tech	Earth Tech, Inc.
ECR	Engineering Change Request
EPA	Environmental Protection Agency
g	gravity
gpm	gallons per minute
H:V	horizontal:vertical
IA	Industrial Area
IM/IRA	Interim Measure/Interim Remedial Action
K-H	Kaiser-Hill
NAG	North American Green
NRCS	National Resource Conservation Service
OLF	Original Landfill
QA/QC	quality assurance/quality control
RAR	Regulatory Agency Representative
RCRA	Resource Conservation and Recovery Act
RFA	Rocky Flats Alluvium
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI	Request for Information
RM	Responsible Manager
RUSLE	Revised Universal Soil Loss Equation
WEQ	Wind Erosion Equation

PREFACE

This design was developed based on the Statement of Work for the Accelerated Action Design for the Original Landfill (OLF), Subcontract No. KH-020525, and includes the following five submittals:

- The Design Analysis, which includes a narrative description of the soil cover design (Regulatory Review Design Analysis, April 2005);
- The Design Analysis Appendices, which includes supporting technical calculations (Regulatory Review Design Calculation Appendices, March 2005);
- The Design Drawings, which include drawings to support construction (Regulatory Review Design Drawings, March 2005)
- The construction specifications, which are consistent with the Construction Specification Institute (CSI) specifications template (Regulatory Review Specifications, March 2005); and
- The Construction Quality Assurance (QA)/Quality Control (QC) Plan (Regulatory Review Construction Quality Assurance/Quality Control Plan, March 2005).

The design submittals are organized into design documents and construction documents. The design documents include the Design Analysis and supporting calculations found in the Design Analysis appendices. Construction documents include the set of Design Drawings, the Specifications, and the Construction QA/QC Plan. The drawings contain information related to existing conditions, site regrading, final design grades, buttress design grades, surface water management, and supporting details. The Specifications and Construction QA/QC Plan contain detailed instructions on cover construction and construction quality.

1.0 INTRODUCTION

1.1 DESIGN OBJECTIVES

The OLF Accelerated Action Design discussed in this design analysis was prepared to meet the objectives outlined in the Interim Measure/Interim Remedial Action (IM/IRA) for the OLF (Kaiser-Hill [K-H] 2005). Based on the IM/IRA, an accelerated action consistent with the municipal and military landfill presumptive remedy of source containment after hot spot removal (completed in July 2004) was determined appropriate for the OLF.

The presumptive remedy design was developed to meet the following objectives:

- Design a stable landfill cover to prevent direct contact with landfill soil or debris and
- Design a landfill cover that adequately controls erosion caused by stormwater run-on and runoff with minimal disturbance to natural habitat.

These design objectives were met using a soil cover with the following components:

- A regraded 18 percent surface and buttress at the toe of the landfill to meet stability requirements. Groundwater will be directed away from the buttress using a drain rock layer below the buttress.
- A 2-foot soil cover above the regraded surface to prevent direct contact with landfill soil or debris.
- Cover diversion berms and side channels with both temporary and permanent erosion control materials, including sufficient vegetation to control erosion.

1.2 DESIGN CRITERIA

The OLF will be closed consistent with the Resource Conservation and Recovery Act (RCRA) and Colorado Hazardous Waste Act closure performance standard for interim status units (6 Code of Colorado Regulations [CCR] 1007-3, Section 265.111). The design criteria for the OLF are functional requirements used as the basis for the design. The design criteria presented in the design include both minimum requirements that were formulated by compiling pertinent regulations, the Rocky Flats Cleanup Agreement (RFCA), industry standards, and engineering judgment to ensure proper design of the cover (K-H 2005).

The following criteria were used to design the soil cover to meet the objectives:

- Develop final soil cover top slopes of 18 percent and buttress top slopes of 2.75 to 5 percent with 3 horizontal to 1 vertical (3H:1V) sideslopes.
- Determine slope limitations and buttress requirements to maintain stability of the cover with factor of safety of 1.5 for static conditions and 1.0 for seismic conditions using a seismic coefficient of 0.06 gravity (g). Alternatively for seismic, the deformation from a seismically induced permanent displacement must be 12-inches or less.
- Accommodate anticipated settlement and subsidence of the landfill and cover.
- Minimize surface soil erosion to a maximum of 2 tons per acre per year (Environmental Protection Agency [EPA] 1991).
- Determine surface water drainage patterns and the physical characteristics of the landfill and surrounding area to promote efficient surface water runoff and collection associated with a 100-year storm event with additional capacity to handle the 1,000-year, 24-hour event.

This proposed design meets criteria for the remedial action listed on Table 6-1 of the IM/IRA.

1.2.1 Main Assumptions

Assumptions are necessary to complete the design objectives and criteria. The lateral extent of wastes, one of the fundamental pieces of information necessary to develop plans for the OLF Accelerated Action, was previously supplied by Kaiser-Hill as identified on the design drawings.

Other assumptions used during the design include the following:

- The variability, depth, areal extent, and engineering properties of on-site soils, overburden soils, and underlying geologic units have been sufficiently characterized during previous site investigations.
- Existing design drawings of above- and/or belowground structures on-site represent as-built conditions.

1.3 ORGANIZATION OF DESIGN ANALYSIS

The Design Analysis is organized into five sections: this introduction (Section 1.0), the general site setting (Section 2.0), a summary of the design activities (Section 3.0), a summary of the construction documents (Section 4.0), and references (Section 5.0).

2.0 GENERAL SITE SETTING

The Rocky Flats Environmental Technology Site (RFETS) is located on a 6,240-acre site in Sections 1 through 4 and 9 through 15 of Township 2 South, Range 70 West, 6th Principal Meridian, approximately 16 miles northwest of Denver, Colorado, in northern Jefferson County.

2.1 SITE DESCRIPTION

The OLF covers approximately 20 acres and is located south of the RFETS Industrial Area (IA) pediment on a south-facing hill slope north of Woman Creek (K-H 2005). The OLF was used to dispose of solid sanitary and construction debris wastes generated at the Rocky Flats Plant from 1952 to 1968 (Rockwell 1988). The landfill was not designed or operated as an engineered landfill. Aerial photographs indicate that the landfill was operated as an area fill (EG&G 1994). Waste was merely dumped in the area vertically below and just south of the southern edge of the alluvial pediment on which the RFETS IA is located. The waste disposal area lies north of Woman Creek. The waste was generally spread over the south-facing hillside, filling in the area below the pediment edge. No liner or other collection barrier was installed between the waste and the existing surfaces. Further data on the OLF and its physical status are available in the OLF IM/IRA.

2.2 PREVIOUS REPORTS

A number of previous reports have been prepared for the site for the purpose of evaluating physical characteristics, potential contamination, and remedial actions/designs. Previous reports reviewed for this design include:

- Accelerated Action Design for the Original Landfill Geotechnical Investigation Phase 3 Stability Analysis Technical Support Memorandum (Earth Tech 2004);
- RFETS Geotechnical Investigation for Operable Unit No. 5 (Metcalf and Eddy 1995); and
- Final IM/IRA for the OLF (K-H Company 2005).

3.0 SUMMARY OF DESIGN ACTIVITIES

The Accelerated Action Design includes soil cover and buttress grade development as well as supporting calculations. A summary of the grade development and calculations used to develop the OLF soil cover is included in the following sections.

3.1 LANDFILL REGRADE, FINAL GRADE, AND BUTTRESS CONTOUR DEVELOPMENT

To support the proposed soil cover, the surface of the landfill will be regraded and sufficiently compacted. To accomplish this, soil and potential waste material will be relocated within the limit of waste and regraded to 18 percent as specified by the design, leaving exposed waste at the surface. To ensure the elimination of this exposure to waste, the design regrade surface will initially be graded to 1 foot below design regrade surface. One foot of Rocky Flats Alluvium (RFA) will then be imported and placed over the surface in order to reach the design regrade elevations. This will be followed by placement of a 2-foot soil cover.

The buttress design includes the excavation of unconsolidated fine-grained materials within the buttress footprint at the toe of the existing OLF slope. The excavation depth will be at the discretion of the site engineer or geologist. Once the unconsolidated fine-grained material is reached, biaxial geogrid will be placed on the surface, eliminating potentially unsuitable areas or soft spots. Drain rock will then be placed over the geogrid. In areas where the buttress footprint is above the existing toe of the OLF, the surface will be grubbed before placing 1 foot of drain rock. The drain rock will then be covered with a geotextile filter fabric, after which buttress material will be added to meet the design grades of 2.75 to 5 percent on top and 3H:1V for sideslopes.

3.2 STABILITY OF PROPOSED COVER

PCSTABL5M software was used to analyze slope stability of the proposed soil cover for the OLF under both static and dynamic (seismic) conditions. Possible slope failure may be caused by translational forces through weak soil layers and rotational failures within surfaces passing through the cover system and underlying wastes.

The stability of the proposed soil cover with buttress is controlled by the following:

- Properties of the foundation soils;
- Strength characteristics and weight of the in-place waste;
- Inclination of the proposed slopes;
- Saturated waste levels in the landfill; and
- Ability of the cover to drain freely.

The objective of the slope stability analysis is to assess the stability of long-term conditions (post-closure conditions) and to study the effect of seismic loading on the anticipated slopes. PCSTABL5M models were conducted for four sections of the soil cover and buttress based on cross-sections developed by Metcalf & Eddy in the RFETS Geotechnical Investigation report for OU5 (Metcalf & Eddy 1995). In addition, the stability of the buttress itself was determined along these cross-sections.

The stability analyses were completed under static and seismic (pseudostatic) loading conditions. For static conditions, a 1.5 factor of safety was used. For seismic loading conditions, a pseudostatic acceleration coefficient of 0.06g was used as determined in the Geotechnical Investigation Phase 3 Stability Analysis Technical Support Memorandum of the Accelerated Action Design for the Original Landfill ([Phase 3 Report] Earth Tech 2004). This is equal to one-half of the peak bedrock acceleration as determined as part of the study of both the probabilistic and deterministic site-specific seismic shaking hazard by Risk Engineering (Risk Engineering 1995). If this factor of safety was calculated below 1.0, then a deformation analysis was conducted to verify that the design met the criteria of permanent seismically induced displacements of less than 12 inches.

Results of the stability analysis are found in Appendix A and summarized in Table 3-1. These slope stability calculations indicate that the cover system and the underlying materials will meet the required factors of safety for both static and pseudostatic conditions.

3.3 SETTLEMENT OF PROPOSED COVER

Settlement of the cover at the OLF may occur as a result of consolidation of underlying material and settlement of the cover material themselves. Settlement may result in the following:

- Increased permeability of final cover soils because of cracking and depressions;
- Slope instability because of modified side slopes; or
- Surface water drainage disruption or ponding because of changes in design slopes.

The settlement analysis was based primarily on section B-B′ of the Metcalf & Eddy report. Settlement of weathered claystone, valley fill alluvium, colluvium/slide material, waste, buttress material, regrade material, and cover soil was considered on four points along Metcalf & Eddy cross-section B-B′. In addition, settlement was calculated at points along Metcalf & Eddy cross-sections A-A′ and C-C′ to determine lateral settlement. The Sowers Method was used for the calculation of geotechnical data from the Phase 3 Report, and Centennial Pit Fine and RFA data.

Once settlement at the specific points was calculated, differential settlement situations were evaluated to determine whether excessive slopes or ponding would be problematic should this extreme differential settlement occur. Results found in Appendix B and summarized in Table 3-2 indicate that slopes could increase to 20.6 percent along cross-section B-B′ or 26 percent if a "pothole" type settlement situation exists. For both situations, this slope increase would not result in excessive erosion using the Revised Universal Soil Loss Equation (RUSLE) discussed in Section 3.4. Ponding as a result of decreased slopes is not expected using the calculations because of the relatively steep 18-percent design grades on the cover. However, because settlement and differential settlement could occur, monitoring is integral to the post-closure period.

3.4 RAINFALL SOIL EROSION AND WIND EROSION LOSS

Calculations were performed to evaluate the potential for rainfall and wind erosion at the OLF and to determine if additional erosion control measures are required. The evaluation of potential rainfall erosion of the OLF soil cover was based on the following design criteria:

- The OLF consists of an 18-percent slope and a maximum drainage distance of 150 feet using diversion berms.
- Buttress top slopes are 2.75 to 5 percent and sideslopes are 3H:1V with a maximum flow distance of 30 feet using diversion berms.
- As guidance only, the design erosion rate shall not exceed 2.0 tons per acre per year (tons/acre/year) as stated in Section 2.2.5.3 of the Technical Guidance for RCRA/CERCLA Final Covers (EPA 2002).

3.4.1 Rainfall Soil Erosion Loss

Soil erosion at the OLF will occur when soil particles are displaced and carried away by storm water. The rate at which this erosion occurs depends on the properties of the cover soil, the slope of the land, rainfall intensity and duration, and the volume and characteristics of the water flow.

The soil erosion rate due to rainfall was calculated using the RUSLE. The RUSLE predicts the average soil losses in runoff from a given site based on specific physical and management erosion variables. The U.S. Department of Agriculture has developed a program that computes rainfall soil erosion using data for different sections of the country. These data are contained in databases that have been incorporated into the program.

Rain erosion for several cover conditions was calculated and results are found in Appendix C. The results show that when the RFA reaches a mature state, rain erosion is 1.3 tons/acre/year on the soil cover slope regardless of whether vegetation is established. If the cover is bare before the RFA reaches a mature state (which is similar to the conditions immediately after construction), the rain erosion rate is 7.5 tons/acre/year or above the maximum allowable. Bare conditions are unlikely since the cover will be seeded, mulched, and covered with temporary erosion control mats, resulting in a rain erosion rate of 0.53 ton/acre/year. Rain erosion on the buttress sideslope was determined at 0.72 ton/acre/year with erosion control mat and 1.5 tons/acre/year with established vegetation.

3.4.2 Wind Erosion Loss

The erosion rate due to wind was calculated using the Wind Erosion Equation (WEQ). The WEQ predicts the long-term average soil losses due to wind from a given site based on specific physical and management erosion variables.

Wind erosion for several cover conditions was calculated and results are found in Appendix C. The results show that when the RFA reaches a mature state, wind erosion is 0 ton/acre/year on the soil cover regardless of whether vegetation is established. If the slopes are bare before the RFA reaches a mature state, the wind erosion is excessive. Bare conditions are unlikely since the cover slope will be seeded, mulched, and covered with erosion mat, resulting in a wind erosion rate of 0.60 ton/acre/year. The same erosion rate of 0.60 ton/acre/year applies when vegetation becomes established. The buttress sideslope will be covered with temporary erosion control mat which result in a wind erosion rate of 0.40 ton/acre/year. With established vegetation, the wind erosion is also 0.40 ton/acre/year.

3.4.3 Rainfall and Wind Erosion Summary

The calculations show that erosion control material is needed on both the cover slope and buttress sideslope to limit erosion. Once vegetation has established and RFA reaches a mature state, total erosion is below the guidance criteria. Table 3-3 provides a summary of rainfall erosion, wind erosion, and total erosion for the OLF.

3.5 SURFACE WATER MANAGEMENT

The design approach to the OLF storm water control addresses the following criteria:

- Use surface water control structures to adequately convey the runon to and runoff from the OLF based on a 100-year, 24-hour storm event with freeboard capacity to handle a 1,000-year, 24-hour storm event.
- Reduce sediment transport following construction while the landfill area is disturbed. Once vegetation is established, conditions will be similar to surrounding areas.
- Minimize the loss of habitiat by eliminating structures such as riprap channels or riprap check dams.

SEDCAD4 software was used to model the 100-year and 1,000-year storm run-on and runoff surface water flows. The software is based on the National Resource Conservation Service (NRCS) approach for rainfall distribution and on the NRCS curve number/unit hydrograph approach to predict peak flows. The NRCS storm-type distributors are considered very conservative, leading to higher peak flows than any actual measured storm.

Surface water management features required at the OLF to achieve the design criteria are discussed in Appendix D and include the following:

- Seven cover diversion berms with temporary check dams to capture overland flow, reduce sediment load, and route it to side channels. Diversion berms will be lined with erosion control mat until vegetation is established, sufficiently limiting channel erosion.
- Three buttress sideslope diversion berms with temporary check dams to capture overland flow, reduce sediment load, and route surface water off of the buttress. Diversion berms will be lined with erosion control mat until vegetation is established.
- A permanent erosion control/vegetation-lined channel on the west to convey stormwater to below the buttress fill.
- A permanent erosion control/vegetation-lined channel on the east to convey stormwater to below the buttress fill.

Temporary and permanent erosion protection for the side channels and diversion berms was determined using the North American Green (NAG) Erosion Control Materials Design Software, Version 4.2. NAG software calculates flow depth, velocity, and hydraulic radius using the continuity equation (Q=VA) and Manning's Equation (or a modified Chezy's Equation). Once these are known, the shear stress on the lining material is calculated.

3.6 GROUNDWATER CONTROL

3.6.1 Groundwater Model

The 1995 Metcalf & Eddy report concluded that, based on examination of 62 shallow groundwater monitoring wells and geotechnical borings, most groundwater in the study area appears to be perched atop bedrock within the deeper portions of colluvium and fill overlying bedrock. The source of most groundwater was interpreted to be within the lower portion of the

Rocky Flats Alluvium, penetrating the colluvium and/or fill surficial deposits. Based on the previous groundwater level measurements, the shallow groundwater appeared to concentrate in the lower portion of the surficial deposits and flow downslope near parallel to the ground and bedrock surfaces, as shown on Metcalf & Eddy geologic cross sections.

More recently, in support of the current project efforts, a comprehensive hydrogeologic model has been developed for K-H Company by Integrated Hydro Systems, LLC, based on the groundwater monitoring wells and geotechnical borings throughout the RFETS area. The results of this hydrogeologic model are the subject of a separate technical support memorandum. Input from the model in assigning groundwater levels used in the landfill slope stability analysis, for the geologic cross sections analyzed, is included in Appendix A.

In general, groundwater was found to approximately follow the shape of the top of the weathered claystone bedrock profile and to be located within the lower portion of colluvium and fill surficial deposits. For the stability analysis, the groundwater was modeled for a typical year using the regraded surface and the buttress with sub-drain. For a wet season climate condition, modeled groundwater was observed to rise. The modeled groundwater elevations used in the slope stability evaluation were those for a mean annual wet-year groundwater level, and a maximum annual wet-year groundwater level. Groundwater depths for these conditions can be found in the cross-sections included in Appendix A.

Simulated annual discharge rates for the sub-drain were less than 1 gallon per minute (gpm) as determined by Integrated Hydro Systems (2004). This value was then used to size the buttress sub-drain drainage rock discussed in the following section.

3.6.2 Buttress Sub-Drain

A buttress sub-drain was designed as part of the buttress to direct groundwater flow below the buttress to the stream alluvium of Woman Creek. This will minimize buttress saturation, which would compromise the stability of the landfill.

The buttress sub-drain was designed to meet the following criteria:

- Pass a maximum discharge of 1 gpm based on the discharge rate presented in the Integrated Flow and VOC Fate and Transport modeling (Integrated Hydro Systems 2004); and,
- Minimize sedimentation of the buttress drainage system from native and buttress materials.

To determine the drainage rock size, Darcy's law was used, which shows that a well-sorted sub-angular rock with diameters from 1½ inches down to ¾ inches has the capability of transmitting 112 gpm or above the 1 gpm criteria. To minimize sedimentation of the buttress drainage system, the drainage rock will be overlaid with a geotextile filter fabric. Results of the buttress sub-drain design are found in Appendix E.

3.7 EVALUATION OF 100-YEAR EVENT FROM WOMAN CREEK ON THE TOE OF THE BUTTRESS

The toe of the buttress will be constructed within the flood plain of Woman Creek and will act as the channel sideslope during certain storm events. Therefore, the 100-year storm is evaluated to determine the height of the flow on the buttress and if the proposed cover material on the buttress sideslope is sufficient to minimize erosion.

The velocities of the Woman Creek flow at the given 480 cubic feet per second (cfs) were determined with three methodologies: (1) the continuity equation (Q=VA), (2) Chezy's Equation, and (3) the NAG model (which uses a modified Chezy's Equation). Four cross-sections within the buttress and Woman Creek were evaluated, which resulted in varying channel widths and sideslopes. The highest flow depth up the buttress was calculated at 2.02 feet and the greatest velocity was 4.06 feet per second. The model showed that vegetation is sufficient to protect the buttress, although permanent erosion mat will be placed to reinforce the vegetation. Results are found in Appendix F.

3.8 GEOTECHNICAL AND BOREHOLE/TEST PIT LOG DATA

Appendix G presents both geotechnical data and borehole/test pit logs used to develop the OLF soil cover and buttress. Currently, a pit fine material from local borrow areas is proposed for use

as the buttress. Pit fines are created from the portion of material in the quarry that passes the 0.5-inch sieve. Both local borrow sources, Centennial and LaFarge, have stockpiles of this material. The appendices include data from the Centennial Pit fines, including sieve analyses, Atterberg limits, standard Proctor data, consolidation data, and strength data. RFA is proposed for use as regrade and soil cover material. Centennial RFA sieve and Atterberg data are also included. Borehole and test pit logs are included for those locations within the footprint of the buttress. These were used to determine the potential depth of the excavation preceding buttress placement.

4.0 CONSTRUCTION DOCUMENTS

4.1 DESIGN DRAWINGS

The information presented in this design analysis report is reflected in the Design Drawings that form an integral part of the design for the OLF Accelerated Action. These drawings document existing conditions, final conditions, and construction details. The drawings include:

Drawing	Description
51788-X001	RFETS OLF Cover Sheet
51788-001	Vicinity Map and Drawing Index
51788-002	Existing Conditions
51788-003	Buttress Footing Excavation
51788-004	Buttress Construction Grades
51788-005	Cut/Fill Isopach of 1-Foot Lowered Regrade Surface
51788-006	Design Top of Regrade Surface Final Contours
51788-007	Design Top of Final Cover Contours
51788-008	Design Channels
51788-009	Surface Water Management Plan
51788-010	Landfill Wide Cross Sections
51788-011	Landfill Cover Details Buttress Construction
51788-012A	Landfill Cover Details Surface Water Controls
51788-012B	Landfill Cover Details Surface Water Controls
51781-013	Buttress Cross Sections
51788-014	Final Cover Perimeter Tie In Details
51788-015a	Typical Channel Cross Section for Construction – West Channel
51788-015b	Typical Channel Cross Section for Construction – East Channel

4.2 SPECIFICATIONS FOR CONSTRUCTION

This section provides an index of the Specification sections used from the 16 CSI Divisions. Divisions used for the design and construction of the cover for the OLF at RFETS are as follows:

- Division 1 – General Requirements (9 Sections)
- Division 2 – Site Construction (10 Sections)

Divisions 3 through 16 were not used.

These specifications follow recommended procedures and philosophy of the CSI, as adopted by Earth Tech. The specifications are provided under separate cover.

4.3 CONSTRUCTION QUALITY

A construction QA/QC plan has been prepared under separate cover to ensure the following:

- All RFETS project activities are performed in a manner consistent with the intent of all approved Design Drawings and Specifications.
- All performance criteria are achieved.
- The specified quality of work is maintained.

These objectives will be accomplished with QC and QA personnel on-site during construction. QC is the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that the process, item, or standard meets the established requirements. QA is the system that provides oversight and evaluation of the QC process and overall quality goals to ensure that QC is working effectively and that the project goals are being met.

5.0 CHANGE MANAGEMENT

Change is an inevitable part of projects; therefore, change management is an essential part of the process. Changes during construction enhance value to the overall project. Planning for change by developing appropriate guidelines and processes is crucial to the successful execution of the project.

5.1 TYPES OF CHANGES

Changes encountered during a project generally arise from within the project team, from the owner, or from external sources (e.g., regulatory agencies). Changes arising from the project team may include the following:

- Continuous improvement of the design during construction to improve performance, constructibility, reliability, operability, or aesthetics;
- Deviation from quality standards;
- Owner-initiated changes to the design;
- Changes in availability of materials, labor, equipment, or other resources; and
- Changes due to field conditions.

5.2 THE CHANGE MANAGEMENT PROCESS

The process of managing change is as follows:

1. Identify the issue.
2. Evaluate options.
3. Recommend corrective measures.
4. Document the issue and corrective measure.
5. Get approval as appropriate.

5.3 SPECIFIC CHANGE MANAGEMENT PROCESS FOR OLF

Three types of change management will be used at the OLF depending on the issues and selected corrective measures. The goal of the project is to resolve all design issues withing 24 hours so that there are no delays in the schedule.

5.3.1 Engineering Change Request (ECR)

ECRs will be used to document design changes. The following process will be used for ECRs:

1. Potential changes may be identified by anyone: field staff, regulators, QA/QC staff, safety, engineering, or management. The RM will be immediately notified of a potential change.

2. The RM or designee will notify CDPHE by telephone or e-mail that a potential issue has been identified, and the project team will evaluate options. (CDPHE is welcome to participate.).

3. The ECR should clearly describe the proposed change and reason(s) that the change is being requested. For specification changes, the design change should provide the specific modified language along with the location of the change within the specifications. For a drawing change, a modified or marked up portion of the drawing should be provided along with the description and reasons for the change.

4. The project team will present proposed design/construction modifications (if necessary) to the CQAE and the DM for concurrence.

5. The project team will present the proposed option as an ECR to the RM for approval.

6. The ECR will be assigned a number and entered into the ECR log.

7. The RM or designee will forward the ECR by e-mailor fax, followed up by phone call, to the designated person at CDPHE for approval. The designated person at CDPHE must be available at all times to resolve the issues in a timely manner.

8. The CDPHE representative must respond within 12 hours and have the issue resolved within 24 hours.

9. Exceptions may be necessary for especially complex issues that may require the involvement of many people.

10. For time critical changes, a "conditional release" could be granted pending approval. A conditional release implies that the project is proceeding with the design change at risk.

5.3.2 Request for Information (RFI)

The RFI process will be used for clarification of and/or additional information about the design.

The following steps will take place during the RFI process:

1. The issue is identified.

2. The project team identifies the issue as "clarification" or "information only."

3. After approval by the RM, the issue is documented and e-mailed or faxed to the appropriate person or agency to address.

4. The RFI is assigned a number and entered into the RFI log.

5. The RFI shall be addressed within 12 hours.

6. Approval signatures will not be required.

5.3.3 Field Changes

Minor changes to the alignment of the the surface water control structures, the limits of the regrade, and limits of the cover soil due to unexpected field conditions may be documented by the field change process. These changes will not impact surface water drainage or the minimum of 2 feet of cover over the waste. Examples may be extending the cover soil for improved drainage, additional grading to improve drainage near the limits of the grading, minor changes to diversion ditch alignment, etc. This process is described as follows:

1. Unexpected conditions are identified that negatively affect the alignment or limts.

2. The alignment change will have concurrance from the CQAE and documented in the foreman's field log book.

3. Field changes will be approved by the RM or designee.

4. Final documentaion of minor alignment changes will be captured in the red-line drawings and "As-Built" drawings.

5.4 PROJECT TEAM RESPONSIBILITIES FOR MANAGING CHANGE

The project team responsibilities include the following:

- A construction Superintendant shall be on-site during all design construction activities.
- The Site Quality Assurance Manager shall be on-site during all design construction activities.
- The RM (or designee) shall be **available** during all design construction activities.
- The DM shall be available during all design construction activities.
- A design engineer shall be on-site during all design construction activities or as directed by the RM.
- A project safety representative shall be on-site during all design construction activities.

- The CDPHE and Department of Energy project representatives should be on-site as much as possible to address and authorize ECRs.

Each of the above must authorize a competent person to perform the above duties when not available. Being **available** means immediate contact by phone and can be on-site within approximately one hour.

5.5 CHANGE MANAGEMENT SCHEDULE

Due to the aggressive scheule of this project, all changes will attempt to be completed and authorized within 24 hours or less. This schedule will require timely response to each change from the entire project team, RM, DM and CDPHE representative (and supporting agencies as necessary). Authorization may be accomplished by e-mail or fax.

6.0 REFERENCES

Earth Tech Inc. 2004. Accelerated Action Design for the Original Landfill Geotechnical Investigation Phase 3 Stability Analysis Technical Support Memorandum. November.

EG&G. 1994. Technical Memorandum No. 15, Addendum to Final Phase I RFI/RI Work Plan, Amended Field Sampling Plan, Volume 2, Woman Creek Priority Drainage, Rocky Flats Plant. May.

Environmental Protection Agency (EPA). 1991. Design and Construction of RCRA/CERCLA Final Covers (Seminar Publication), U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC., EPA/625/4-91/025. May.

EPA. 2002. Technical Guidance for RCRA/CERCLA Final Covers. U.S. EPA Office of Solid Waste and Energy Response. April.

Integrated Hydro System. 2004. Integrated Flow and VOC fate and transport modeling for the Original Landfill at the Rocky Flats Environmental Technology Site. December.

Kaiser-Hill Company, L.L.C. 2005. Final Interim Measure/Interim Remedial Action for the Original Landfill (Including IHSS Group SW-2; IHSS 115, Original Landfill and IHSS 196, Filter Backwash Pond). March.

Metcalf & Eddy. 1995. Rocky Flats Environments Technology Site Geotechnical Investigation Report for OU5. September.

Risk Engineering. 1995. Seismic Hazard Analysis for Rocky Flats Plant. September.

Rockwell. 1988. Remedial Investigation and Feasibility Study Plans for Low Priority Sites, Volume I – Site Descriptions, Groupings and Prioritization. June.

TABLES

TABLE 3-1
SUMMARY OF SLOPE STABILITY CALCULATIONS
RFETS ORIGINAL LANDFILL

Cross Section A-A′ Stability

Groundwater Condition	Geometric Condition	Analysis Type[1]	Minimum Safety Factor		Yield Acceleration[3]	Maximum Seismic Displacement
			Static	Pseudostatic 0.06g[2]		
100-Year Wet Year	Overall 18% Regrade with Buttress	Circular Search	1.7	**0.9**	0.04	5-inches
		Sliding Block Search	1.6	**0.9**	0.03	6-inches
	Local Toe/Buttress Area	Circular Search	1.5	1.0	0.05	4-inches

Cross Section B-B′ Stability

Groundwater Condition	Geometric Condition	Analysis Type	Minimum Safety Factor		Yield Acceleration[3]	Maximum Seismic Displacement
			Static	Pseudostatic 0.06g[2]		
100-Year Wet Year	Overall 18% Regrade with Buttress	Circular Search	1.9	1.1	0.08	1-inch
		Sliding Block Search	1.9	1.0	0.06	3-inches
	Local Toe/Buttress Area	Circular Search	1.8	1.2	0.09	<1-inches

Cross Section C-C′ Stability

Groundwater Condition	Geometric Condition	Analysis Type	Minimum Safety Factor		Yield Acceleration[3]	Maximum Seismic Displacement
			Static	Pseudostatic 0.06g[2]		
100-Year Wet Year	Overall 18% Regrade with Buttress	Circular Search	1.9	1.1	0.08	1-inch
		Sliding Block Search	2.0	1.1	0.08	1-inch
	Local Toe/Buttress Area	Circular Search	1.7	1.1	0.10	<1-inches

TABLE 3-1
SUMMARY OF SLOPE STABILITY CALCULATIONS
RFETS ORIGINAL LANDFILL

Cross Section D-D′ Stability

Groundwater Condition	Geometric Condition	Analysis Type	Minimum Safety Factor		Yield Acceleration[3]	Maximum Seismic Displacement
			Static	Pseudostatic 0.06g[2]		
100-Year Wet Year	Overall 18% Regrade with Buttress	Circular Search	1.8	1.0	0.05	4-inches
		Sliding Block Search	1.8	1.0	0.05	4-inches
	Local Toe/Buttress Area	Circular Search	1.5	1.0	0.05	4-inches

Notes: Bold results indicate a safety factor below design criteria safety factors. However, deformation analyses showed deformation within design criteria. See Appendix F and Figure F10 of the Phase 3 report for deformation analysis procedure.

[1] Circular search results based on Bishop's Modified Method of Analysis. Sliding block search based on Janbu's Modified Method of Analysis, with results based on more rigorous and more accurate Spencer's Method of Analysis performed on the critical surface identified from the search.

[2] Seismic coefficient for pseudostatic analysis.

[3] Seismic coefficient that produces safety factor of 1.0 in pseudostatic analysis.

TABLE 3-2
SUMMARY OF SETTLEMENT CALCULATIONS
RFETS ORIGINAL LANDFILL

Point Location	Total Calculated Settlement (feet)	Distance Between Points (feet)	Design Final Grade Elevations at Point Locations (feet)	Design Slope Between Point Locations	Revised Top of Landfill Slope @ 30 Years (feet)	Revised Slope Between Point Locations
Point A	2.86		6025		6022.14	
		85		18%		17.3%
Point B	2.54		6010		6007.46	
		155		13%		12.2%
Point C	1.45		5990		5988.55	
		130		14%		14.3%
Point D	1.99		5972		5970.01	
Point A	2.86		6025		6022.14	
		310		5%		4.4%
Point E	1.34		6010		6008.66	
Point A	2.86		6025		6022.14	
		370		9.5%		9.1%
Point F	1.42		5990		5988.58	

TABLE 3-3
SUMMARY OF SOIL EROSION CALCULATIONS
RFETS ORIGINAL LANDFILL

Condition	Cover Slope RFA (tons/acre/year)	Cover Slope Mature RFA (tons/acre/year)	Buttress Sideslope (tons/acre/year)
Bare Disturbed soil immediately after construction with no erosion control	Rain: 7.50 Wind: 21.6 Total: 29.1	Rain: 1.30 Wind: 0.00 Total: 1.30	Rain: 18.0 Wind: 11.8 Total: 29.8
Seed/Mulch Disturbed soil immediately after construction with seed and mulch	Rain: 3.60 Wind: 0.60 Total: 4.20	NA	Rain: 3.80 Wind: 0.40 Total: 4.20
Temporary Erosion Control Disturbed soil immediately after construction with seed, mulch and temporary erosion mat	Rain: 0.53 Wind: 0.60 Total: 1.13	NA	Rain: 0.72 Wind: 0.40 Total: 1.12
Established Vegetation	Rain: 1.90 Wind: 0.60 Total: 2.50	Rain: 0.34 Wind: 0.00 Total: 0.34	Rain: 1.50 Wind: 0.40 Total: 1.90

Note: NA Not applicable

APPENDIX A

LANDFILL ENGINEERING – FINAL DESIGN
SLOPE STABILITY ANALYSIS

APPENDIX A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL

LANDFILL ENGINEERING – FINAL DESIGN
SLOPE STABILITY ANALYSIS

MAY 11, 2005

Prepared by:

Earth Tech, Inc.
5575 DTC Parkway, Suite 200
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(303) 694-6660

This calculation was performed by Earth Tech, Inc. Although each sheet composing this calculation may or may not be initialed, it has nonetheless been reviewed and checked.

Prepared By: SK Date: 4/14/05

Checked By: RT Date: 4/14/05

Approved By: RT Date: 4/14/05

LIST OF TABLES

Table A-1	Design Criteria
Table A-2	Cross-Section A-A′ Stability
Table A-3	Cross-Section B-B′ Stability
Table A-4	Cross-Section C-C′ Stability
Table A-5	Cross-Section D-D′ Stability

LIST OF ATTACHMENTS

Attachment 1	Results
Attachment 2	Stability Criteria
	Section for Analysis
	Engineering Material Properties
	Groundwater Levels
Attachment 3	Computer Program Input Data – PCSTABL5M
Attachment 4	Input/Output File Setup/Management
Attachment 5	Computer Runs – Overall Stability
Attachment 6	Computer Runs – Toe/Buttress Stability
Attachment 7	Regulatory Agency Requested Model

1.0 INTRODUCTION

The purpose of this calculation is to determine the stability of the Original Landfill located on the Rocky Flats Environmental and Technology Site (RFETS). The slope stability is determined using of PCSTABL5M computer software.

2.0 LANDFILL DESCRIPTION AND LOCATION

The Original Landfill site is located south of RFETS Buildings 440 and 460, along the north hillside of a ravine in the Woman Creek drainage area, extending from an approximate elevation of 6,040 feet at the top to an elevation of 5,950 feet at its base. Waste operations began in the early 1950s and continued through 1968. The Original Landfill site footprint has a maximum length along the east-west direction of approximately 1,700 feet and approximately 500 feet in the north-south direction, with an approximate area on the order of 20 acres. Existing slope gradients range from approximately flatter than 6 to 1 (horizontal to vertical) to 2 to 1, with a total slope height from the top of the hillside to the Woman Creek drainage of about 90 feet.

As part of the accelerated action at the Original Landfill, the existing slopes will be regraded to an overall 18 percent slope with a 2-foot soil cover and drainage improvements. In addition, a buttress and buttress toe drain (also considered a blanket drain) will be installed at the base of the landfill for stability enhancements.

3.0 REFERENCES

Slope stability evaluation of the proposed cover was completed using the guidelines provided in the following documents:

1. PCSTABL5M Design Software. Purdue University.
2. Accelerated Action Design for the Original Landfill Geotechnical Investigation, Phase 3 - Stability Analysis Technical Support Memorandum, Earth Tech, 2004.
3. RFETS, Geotechnical Investigation for Operable Unit No. 5, Metcalf and Eddy, September 1995.
4. Factors of Safety: "Technical Guidance for RCRA/CERCLA Final Covers," Chapter 6, Geotechnical Analysis and Design, Draft. US EPA, April 2002 (Attachment 1, Page 6-21) and Reference 1.

4.0 STABILITY CRITERIA

The stability analysis will meet the following design criteria developed in the Accelerated Action Design for the Original Landfill Geotechnical Investigation Phase 3 Stability Analysis Technical Support Memorandum (Phase 3 report) (Earth Tech 2004). Static stability is based on Technical Guidance for RCRA/CERCLA Final Cover (US EPA 2002) There are no specific guidelines regarding seismic stability, therefore the criteria were developed considering the project site setting, geologic conditions, standard of practice, and various regulatory requirements. The design criteria are as follows:

Table A-1 Design Criteria

Stability	Minimum Safety Factor
Static	1.5
Seismic	1.0 for a seismic coefficient of 0.06g or Deformation analysis with a seismically induced permanent displacement of 12 inches or less

5.0 PCSTABL MODELS

The PCSTABL model runs were conducted for four cross-sections originally defined in the RFETS Geotechnical Investigation for Operable Unit No. 5 (Metcalf and Eddy 1995). The Metcalf and Eddy cross-sections (A-A′, B-B′, C-C′, and D-D′) were modified to include the proposed grading plan and the buttress. The PCSTABL models require development of a section for analysis as well as input of the engineering properties of the material within the sections. Additional input data including boundaries, piezometric surface data, and failure type are also required. The following sections summarize this input. Additional information is found in Attachment 2.

Section for Analysis

Sections for analysis were similar to those analyzed in the Phase 3 report with the addition of Metcalf and Eddy cross-section A-A′. Minor changes were made to cross-sections A-A′, B-B′, C-C′, and D-D′ to reflect the latest grading plan and buttress configurations and to reflect updated groundwater levels and drainage beneath the buttress.

Engineering Material Properties

Engineering material properties used in the modeling are identical to those used in the Phase 3 report and from the Centennial Pit Fine data included in Appendix G and summarized in Attachment 2. See Figures 2 through 6 of the Phase 3 report for material properties.

Groundwater Levels

Groundwater levels used for the stability modeling are based on the updated groundwater modeling of the OLF by Integrated Hydro Systems (see Attachment 2). From this modeling, the 100-year wet year (maximum annual groundwater level – wet year climate) was transposed to the four stability cross-sections for analysis.

Computer Program Input Data

Additional input data are found in Attachment 3 and include boundaries of the section for analysis, soil properties, piezometric surface data, and failure type. Actual input/output file names are found in Attachment 4, and computer runs are found in Attachments 5 and 6.

6.0 RESULTS

Attachment 1 and the following tables summarize the output of the PCSTABL model runs. Maximum seismic displacements were calculated using a simplified deformation analysis as described in the Phase 3 report.

Table A-2 Cross Section A-A′ Stability

Groundwater Condition	Geometric Condition	Analysis Type[1]	Minimum Safety Factor		Yield Acceleration[3]	Maximum Seismic Displacement
			Static	Pseudostatic 0.06g[2]		
100-Year Wet Year	Overall 18% Regrade with Buttress	Circular Search	1.7	**0.9**	0.04	5 inches
		Sliding Block Search	1.6	**0.9**	0.03	6 inches
	Local Toe/ Buttress Area	Circular Search	1.5	1.0	0.05	4 inches

Table A-3 Cross Section B-B′ Stability

Groundwater Condition	Geometric Condition	Analysis Type[1]	Minimum Safety Factor		Yield Acceleration[3]	Maximum Seismic Displacement
			Static	Pseudostatic 0.06g[2]		
100-Year Wet Year	Overall 18% Regrade with Buttress	Circular Search	1.9	1.1	0.08	1 inch
		Sliding Block Search	1.9	1.0	0.06	3 inches
	Local Toe/ Buttress Area	Circular Search	1.8	1.2	0.09	<1 inch

Table A-4 Cross Section C-C′ Stability

Groundwater Condition	Geometric Condition	Analysis Type[1]	Minimum Safety Factor		Yield Acceleration[3]	Maximum Seismic Displacement
			Static	Pseudostatic 0.06g[2]		
100-Year Wet Year	Overall 18% Regrade with Buttress	Circular Search	1.9	1.1	0.08	1 inch
		Sliding Block Search	2.0	1.1	0.08	1 inch
	Local Toe/ Buttress Area	Circular Search	1.7	1.1	0.10	<1 inch

Table A-5 Cross Section D-D′ Stability

Groundwater Condition	Geometric Condition	Analysis Type[1]	Minimum Safety Factor		Yield Acceleration[3]	Maximum Seismic Displacement
			Static	Pseudostatic 0.06g[2]		
100-Year Wet Year	Overall 18% Regrade with Buttress	Circular Search	1.8	1.0	0.05	4 inches
		Sliding Block Search	1.8	1.0	0.05	4 inches
	Local Toe/ Buttress Area	Circular Search	1.5	1.0	0.05	4 inches

Notes: Bold results indicate a safety factor below design criteria safety factors. However, deformation analyses showed deformation within design criteria. See Appendix F and Figure F10 of the Phase 3 report for deformation analysis procedure.

[1] Circular search results based on Bishop's Modified Method of Analysis. Sliding block search based on Janbu's Modified Method of Analysis, with results based on more rigorous and more accurate Spencer's Method of Analysis performed on the critical surface identified from the search.

[2] Seismic coefficient for pseudostatic analysis.

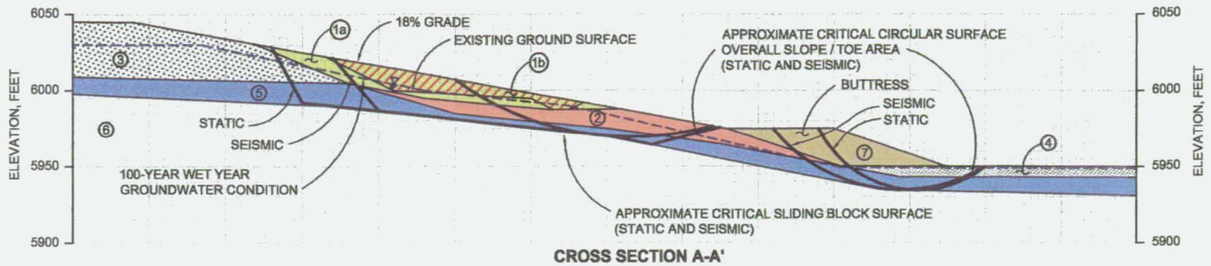
[3] Seismic coefficient that produces safety factor of 1.0 in pseudostatic analysis.

The slope stability of the Original Landfill meets the design criteria for both the static and pseudostatic conditions even with the following conservative aspects:

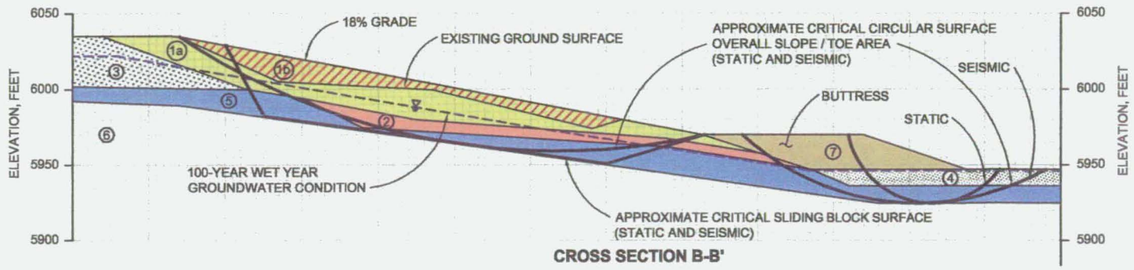
- Strength parameters used for the critical materials controlling stability results are conservative lower bound values of all test data within the anticipated stress range.
- Neglecting cohesion in the somewhat overconsolidated clay type colluvium and weathered bedrock materials, as established in material parameter selection, particularly for the undrained strength used for short-term seismic loading, is conservative to the stability analysis results.
- The highest groundwater condition analyzed in combination with seismic loading is quite conservative as the likelihood of both these conditions occurring simultaneously is low.

APPENDIX A

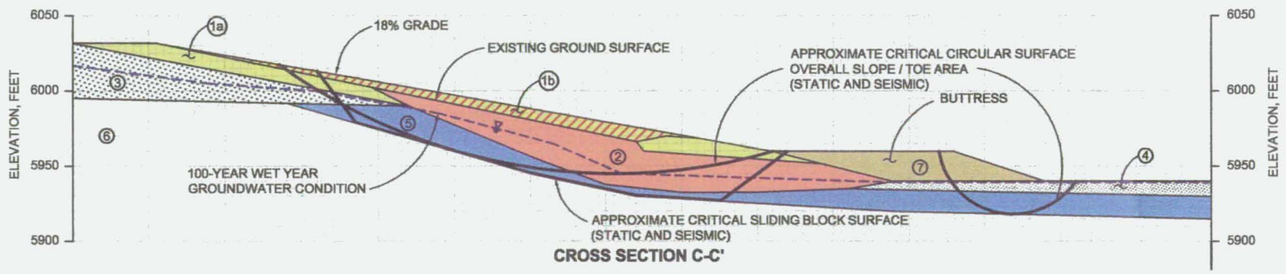
ATTACHMENT 1
RESULTS



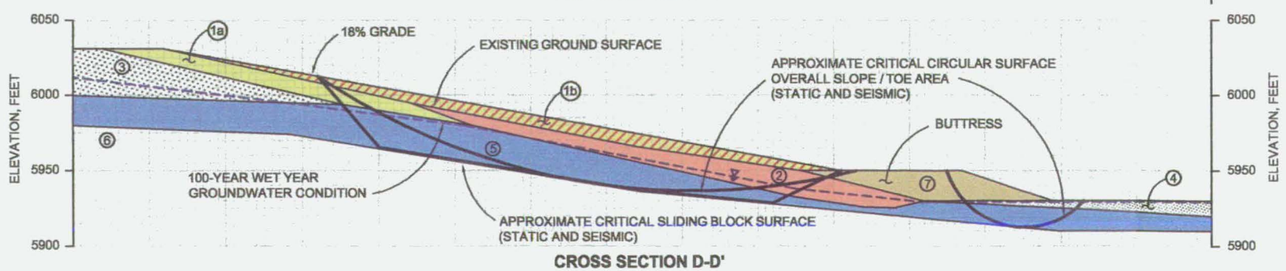
CROSS SECTION A-A'



CROSS SECTION B-B'



CROSS SECTION C-C'



CROSS SECTION D-D'

STABILITY ANALYSIS SOIL PARAMETERS

KEY	MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT		SHEAR STRENGTH			
					STATIC		SEISMIC	
			MOIST (pcf)	SATURATED (pcf)	COHESION (psf)	FRICTION ANGLE (degrees)	COHESION (psf)	FRICTION ANGLE (degrees)
	1a	WASTE	120	125	50	30	50	30
	1b	WASTE / FILL / COVER	120	125	50	30	50	30
	2	COLLUVIUM / SLIDE	120	125	0	20	0	15
	3	ROCKY FLATS ALLUVIUM	120	125	0	37	200	30
	4	STREAM ALLUVIUM	125	130	0	33	0	33
	5	WEATHERED CLAYSTONE	120	125	0	20	0	15
	6	UNWEATHERED CLAYSTONE	125	130	600	30	600	30
	7	ENGINEERED FILL	130	135	50	33	50	33

1995 METCALF & EDDY REPORT GEOLOGIC SECTIONS A-A', B-B', C-C', AND D-D'

0 25 50
SCALE IN FEET

GROUNDWATER CONDITION	GEOMETRIC CONDITION	ANALYSIS[1] TYPE	MINIMUM SAFETY FACTOR		YIELD[3] ACCELERATION	MAXIMUM[4] SEISMIC DISPLACEMENT
			STATIC	0.06 g[2]		
100-YEAR WET YEAR	OVERALL 18% REGRADE WITH BUTTRESS	CIRCULAR SEARCH	1.7	0.9	0.04	5"
		SLIDING BLOCK SEARCH	1.6	0.9	0.03	6"
	LOCAL TOE/BUTTRESS AREA	CIRCULAR SEARCH	1.5	1.0	0.05	4"
100-YEAR WET YEAR	OVERALL 18% REGRADE WITH BUTTRESS	CIRCULAR SEARCH	1.9	1.1	0.08	1"
		SLIDING BLOCK SEARCH	1.9	1.0	0.06	3"
	LOCAL TOE/BUTTRESS AREA	CIRCULAR SEARCH	1.8	1.2	0.09	<1"
100-YEAR WET YEAR	OVERALL 18% REGRADE WITH BUTTRESS	CIRCULAR SEARCH	1.9	1.1	0.08	1"
		SLIDING BLOCK SEARCH	2.0	1.1	0.08	1"
	LOCAL TOE/BUTTRESS AREA	CIRCULAR SEARCH	1.7	1.1	0.10	<1"
100-YEAR WET YEAR	OVERALL 18% REGRADE WITH BUTTRESS	CIRCULAR SEARCH	1.8	1.0	0.05	4"
		SLIDING BLOCK SEARCH	1.8	1.0	0.05	4"
	LOCAL TOE/BUTTRESS AREA	CIRCULAR SEARCH	1.5	1.0	0.05	4"

[1] CIRCULAR SEARCH RESULTS BASED ON BISHOP'S MODIFIED METHOD OF ANALYSIS. SLIDING BLOCK SEARCH BASED ON JANBU'S MODIFIED METHOD OF ANALYSIS, WITH RESULTS BASED ON MORE RIGOROUS SPENCER'S METHOD OF ANALYSIS PERFORMED ON THE CRITICAL SURFACE IDENTIFIED FROM THE SEARCH.

[2] SEISMIC COEFFICIENT FOR PSEUDOSTATIC ANALYSIS.

[3] SEISMIC COEFFICIENT THAT PRODUCES SAFETY FACTOR OF 1.0 IN PSEUDOSTATIC ANALYSIS.

[4] ESTIMATED MAXIMUM SEISMICALLY INDUCED PERMANENT DISPLACEMENT USING SIMPLIFIED DEFORMATION ANALYSIS.

EARTH TECH

ORIGINAL LANDFILL STABILITY ANALYSIS RESULTS CHECK FOR GRADING PLAN DESIGN REFINEMENT

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

APRIL 2005 57378

L:\work\57378\cad\Task 6040\Stability Results.dwg - 18 Apr 2005

APPENDIX A

ATTACHMENT 2
STABILITY CRITERIA
SECTION FOR ANALYSIS
ENGINEERING MATERIAL PROPERTIES
GROUNDWATER LEVELS

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET PAGE ____ OF ____

PROJECT NO. 57378.6030

CLIENT Kaiser Hill SUBJECT Stability Prepared By SAR DATE 3/3/05

PROJECT Rocky Flats OU Linear Fill Grading Plan ~~Reviewed~~ UPDATED By SAR DATE 4/14/05

Design Refinement Approved By ____ DATE ____

(2) STABILITY CRITERIA

NO CHANGE FROM 11/04 PHASE 3 STABILITY REPORT

(3) SECTION FOR ANALYSIS

- MINOR CHANGES TO SECTIONS B/C/D FROM 11/04 PHASE 3 STABILITY REPORT, TO REFLECT GRADING PLAN & BUTTRESS CONFIGURATION REFINEMENTS, & TO REFLECT UPDATED GROUNDWATER LEVELS FROM MODELING TO REFLECT GRADING PLAN REFINEMENTS & DRAINAGE BLANKET BENEATH BUTTRESS*
- ADDED GEOLOGIC SECTION A-A' ADDED FOR ANALYSIS, INCORPORATING THE ABOVE REFINEMENTS
- SEE (1) FOR SECTIONS

* NOTE: UPDATED ANALYSIS INCLUDES LATEST GROUNDWATER MODEL LEVELS TRANSMITTED BY ROCHA ON 3/15/05 - SLIGHT LOWERING OF GROUNDWATER IN CENTRAL PORTION OF CROSS SECTIONS

(4) ENGINEERING MATERIAL PROPERTIES

NO CHANGE FROM 11/04 PHASE 3 STABILITY REPORT**

** NOTE: ASSIGNED STRENGTH FOR BUTTRESS ENGINEERED FILL REDUCED TO BE IN LINE WITH TEST DATA ON ROCKY FLATS ALLUVIUM PIT FINES INDICATED BY DESIGN FOR USE - SEE ATTACHED

(5) GROUNDWATER LEVELS

- BASED ON UPDATED GROUNDWATER MODELING BY INTEGRATED HYDRO SYSTEMS, AS INDICATED IN (3)
- SEE ATTACHMENT 2 FOR MODEL GENERATED GROUNDWATER LEVELS ON SECTIONS A/B/C/D
- 100-YEAR WET YEAR (MAXIMUM ANNUAL GROUNDWATER LEVEL - WET YEAR CLIMATE) GROUNDWATER LEVEL TRANSPOSED TO STABILITY CROSS SECTIONS FOR ANALYSIS - SEE (1)

TABLE 1
ROCKY FLATS/FIELD and LAB TESTING/CO
SUMMARY OF SOIL DATA

ICU TRIAXIAL TEST DATA
C' φ'
PSF DEGREES

Sample Type	Sample Number	Sample Depth (ft)	U.S.C.S. Soil Classi-fication	Delivered Moisture (%)	Atterberg Limits			Grain Size Distribution			Specific Gravity	Moist/Den Relationship Standard Proctor		~~Additional Tests~~ ~~Comments~~ (See Notes)	
					LL	PL	PI	% Finer 3/4"	% Finer #4	% Finer #200		PCF (Dry)	Moist (%)		
Bulk	PF-1	1-2	SC	16.1	39	19	20	100	84	30	--	120.6*	10.7*	0	34.0
Bulk	PF-2	1-2	SC	10.3	43	19	24	100	85	29	--	119.9*	11.7*	137	30.7
Bulk	PF-3	1-2	SC	18.1	43	18	25	100	81	30	--	121.0*	10.9*	111	29.8
Bulk	PF-4	1-2	SC	17.4	35	16	19	100	89	30	--	122.9*	10.6*	185	22.2
Bulk	PF-5	1-2	SC	12.8	37	19	18	100	86	29	--	121.9*	10.8*	0	40.8
Bulk	PF5-Dup	1-2	SC	11.4	40	19	21	100	87	28	--	122.3*	11.1*		
Bulk	PF-6	1-2	SC	11.5	45	20	25	100	82	30	--	120.3*	12.5*	0	41.9
Bulk	PF-7	1-2	SC	13.5	35	18	17	100	87	24	--	125.1*	10.3*	166	31.1
Bulk	PF-8	1-2	SC	14.9	41	19	22	100	82	28	--	117.9*	11.9*	196	22.9
Bulk	PF-9	1-2	SC	13.8	38	18	20	100	87	25	--	125.1*	10.4*	72	37.0
Bulk	PF-10	1-2	SC	14.8	43	18	25	100	83	28	--	122.1*	11.0*	146	34.1
Spec	Foundation	NA	NA	NA	NA	NA	NA	100	81.3	20.5		NA	NA		
Spec	Cushion	NA	NA	NA	NA	NA	NA	100	81.3	20.5		NA	NA		

NOTES:
LL = LIQUID LIMIT
PL = PLASTIC LIMIT
PI = PLASTIC INDEX
SL = SHRINKAGE LIMIT

T = TRIAXIAL TEST
U = UNCONFINED COMPRESSION TEST
C = CONSOLIDATION TEST
DS = DIRECT SHEAR TEST
PERM = PERMEABILITY

* ASTM D4718

ROCKY FLATS ALLUVIUM PIT FORCES FOR BUTTRESS ENGINEERED FILL
SAK 4/14/05

(4) (CONTINUED)

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET

PAGE ____ OF ____

PROJECT NO. 57378.6040

CLIENT Kaiser Hill

SUBJECT Stability

Prepared By [illegible] DATE 4/14/05

PROJECT Rocky Flats OLF

Check for Grading Plan Design Refinements

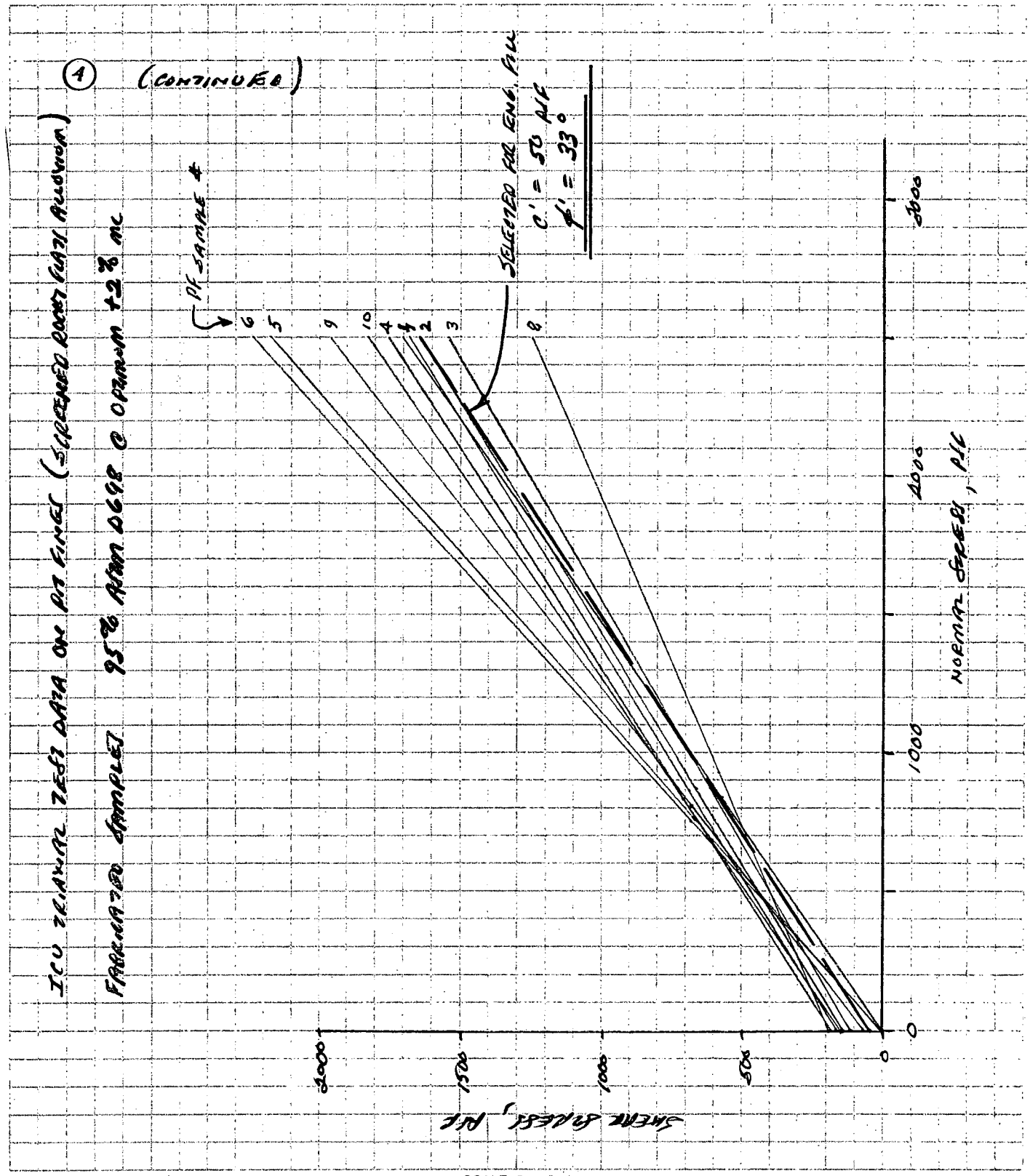
Reviewed By ____ DATE ____

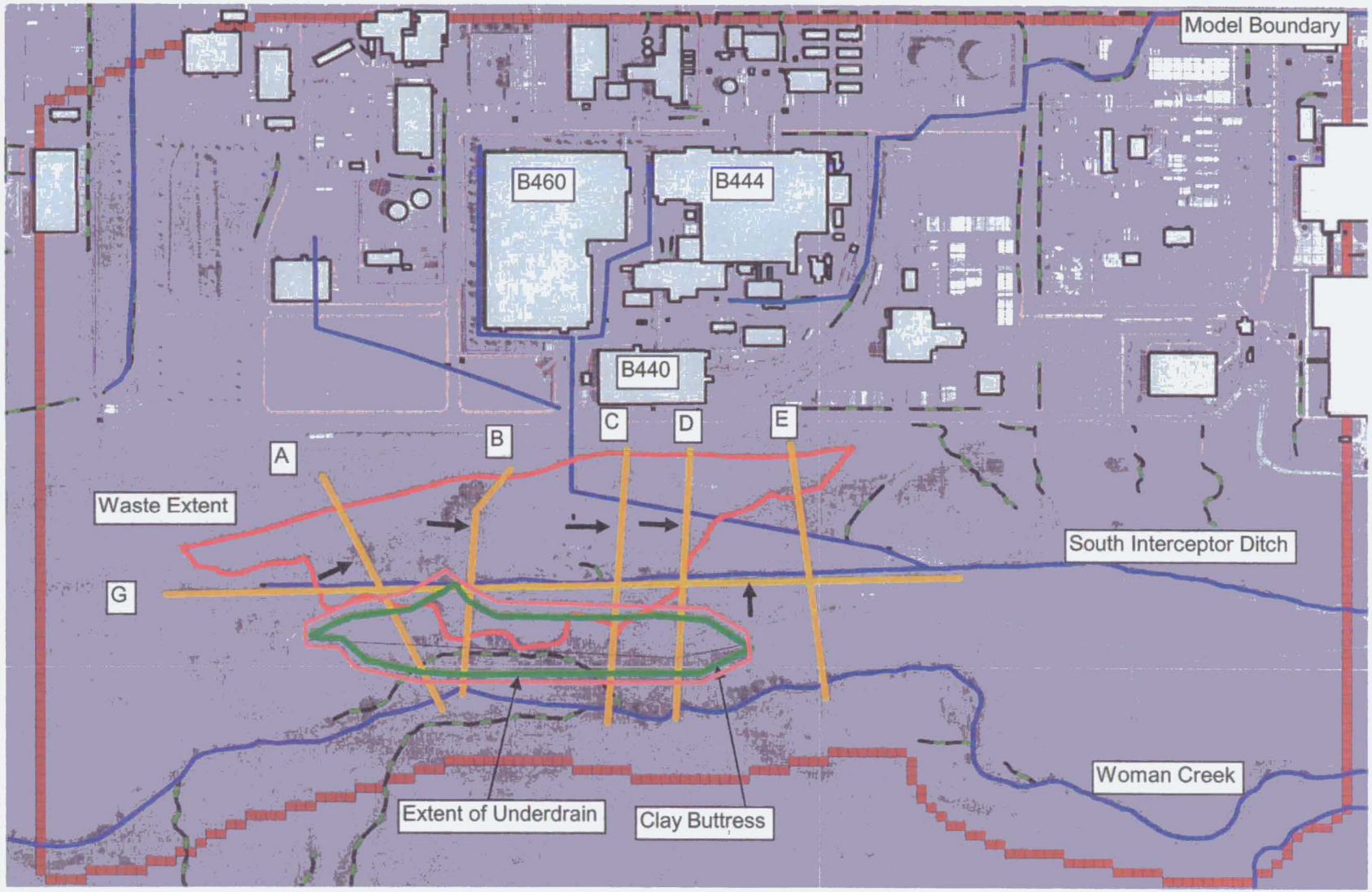
Approved By ____ DATE ____

(4) (Continued)

ICU Triaxial Tests Data on Pit Finer (Screened Rocky Flats Alluvium)

Fabricated Samples 95% ASTM D698 @ Optimum ±2% mc





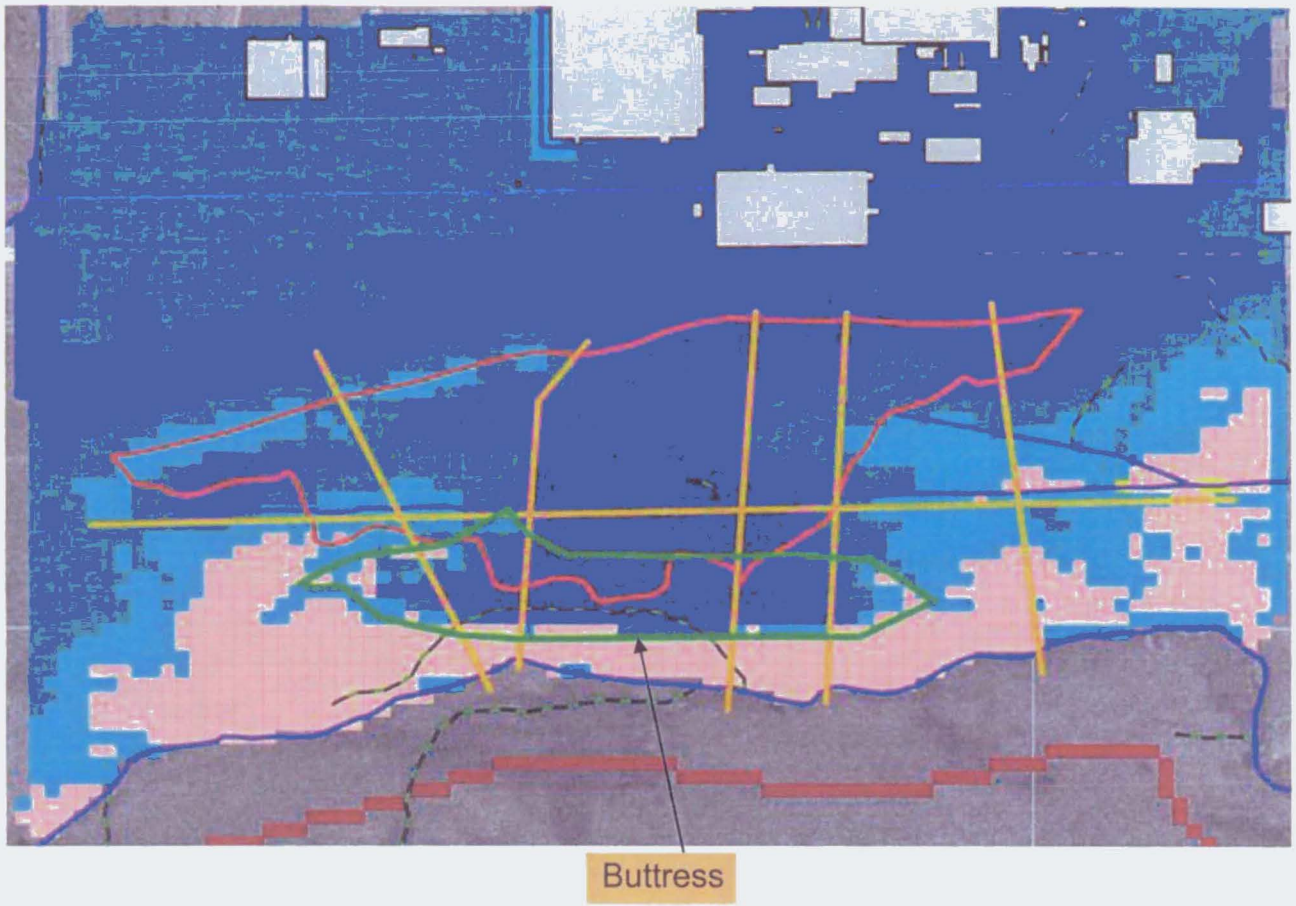
NOTE:

A Vertical Profile Location - Initially defined in Metcalf & Eddy Report (9/1995)

Profile View Direction

Integrated Hydro Systems, LLC

Figure 1
OLF study area, waste extent, current surface topography, and vertical profile locations.



Simulated average annual groundwater depths (feet).

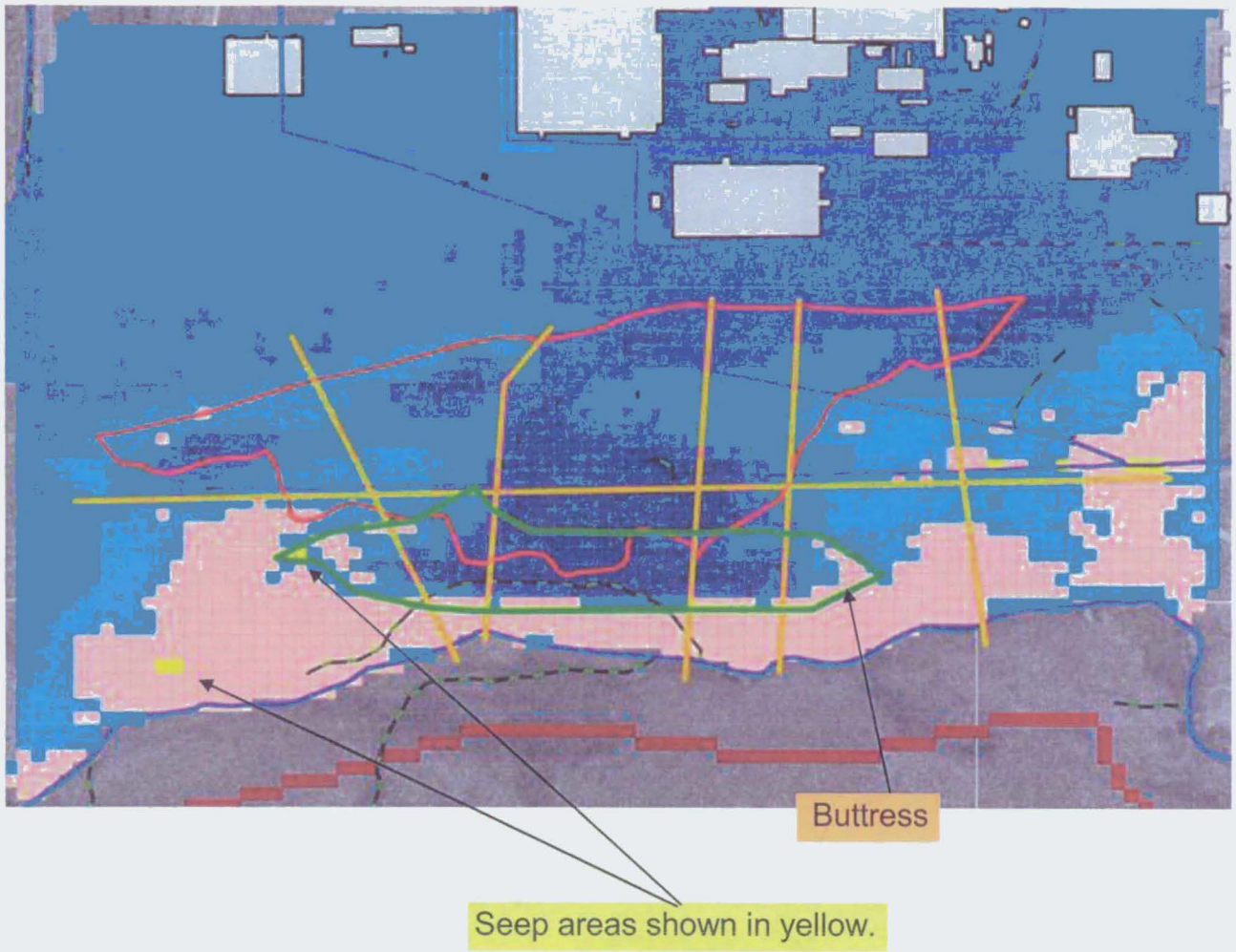
- -10 - 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 45

Note:
1) Negative numbers (yellow) indicate groundwater levels are above ground surface. These areas represent seeps or baseflow.

2) Average annual levels are calculated from simulated levels calculated every 6 hours over WY2000 (October 1999 to 2000).

Integrated Hydro Systems, LLC

Figure 2
Revised Regrade, Clay Buttress and Gravel Drain
Average Annual Groundwater Depths (ft) - Wet-Year Climate



Simulated minimum annual groundwater depths (feet).

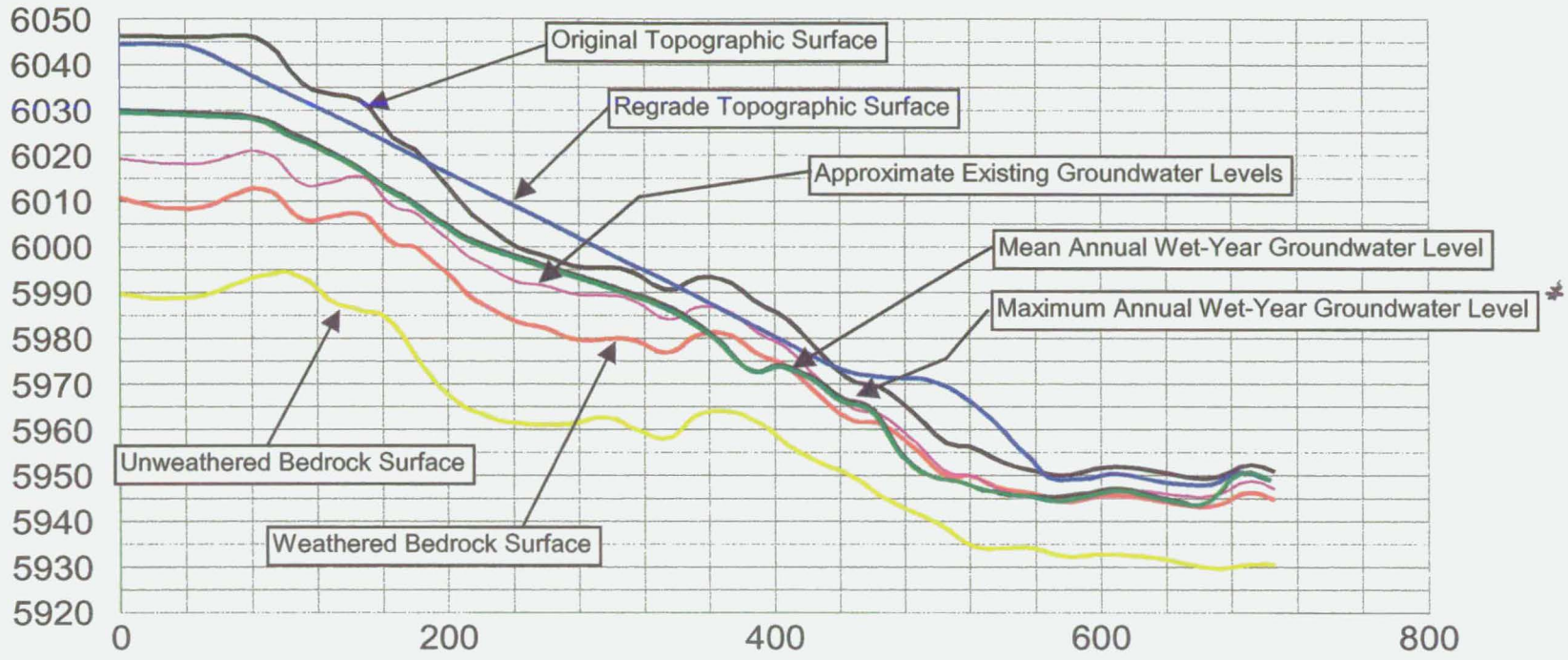
- -10 - 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 45

Note:
1) Negative numbers (yellow) indicate groundwater levels are above ground surface. These areas represent seeps or baseflow.

2) Average annual levels are calculated from simulated levels calculated every 6 hours over WY2000 (October 1999 to 2000).

Integrated Hydro Systems, LLC

Figure 3
Revised Regrade, Clay Buttress and Gravel Drain
Minimum Annual Groundwater Depths (ft) - Wet-Year Climate

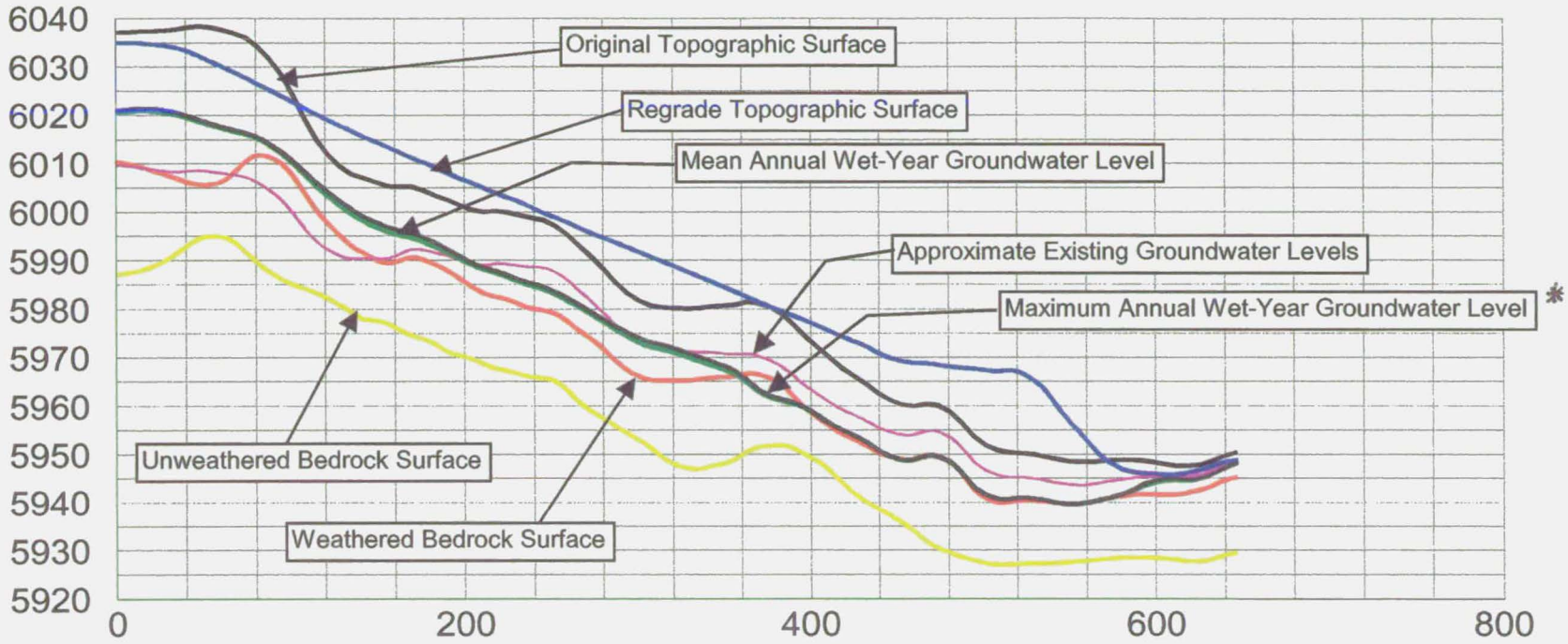


NOTES:
1) Horizontal and Vertical Units are feet
2) Vertical exaggeration is 3x
3) Wet Year water levels based on 100-year climate sequence (see OLF groundwater tech report for details).

* USED IN STABILITY ANALYSIS (100-YEAR WET YEAR LEVEL)

Integrated Hydro Systems, LLC

Vertical Profile A
Geologic Surfaces and Groundwater Levels

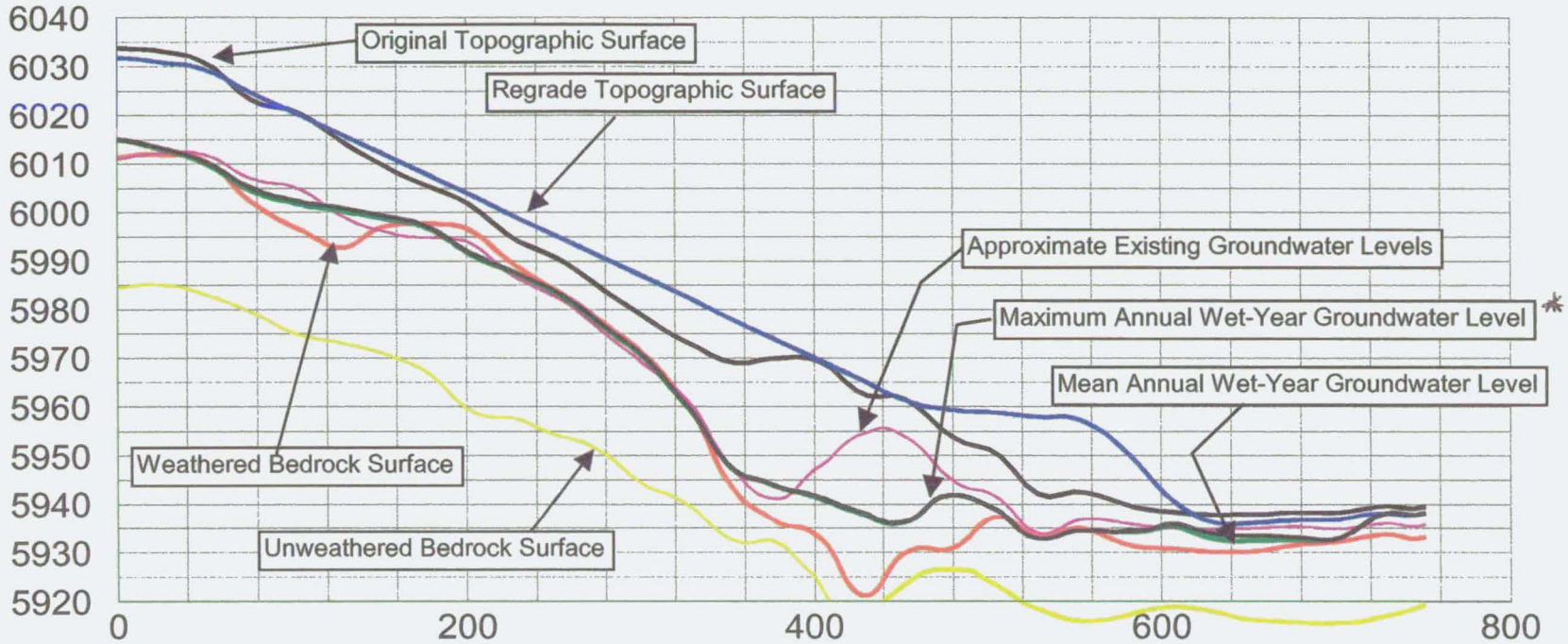


NOTES:
1) Horizontal and Vertical Units are feet
2) Vertical exaggeration is 3x
3) Wet Year water levels based on 100-year climate sequence (see OLF groundwater tech report for details).

* USED IN STABILITY ANALYSIS (100-YEAR WET YEAR LEVEL)

Integrated Hydro Systems, LLC

Vertical Profile B
Geologic Surfaces and Groundwater Levels

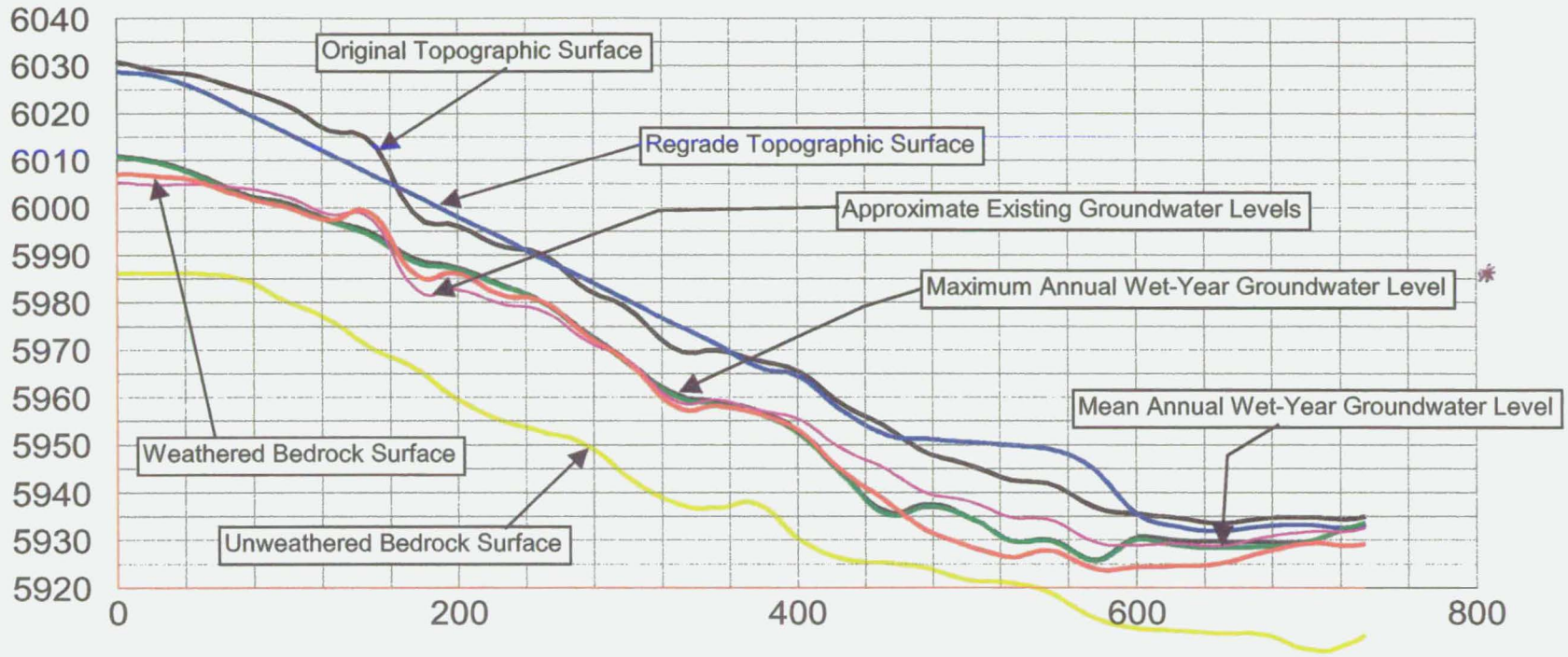


NOTES:
1) Horizontal and Vertical Units are feet
2) Vertical exaggeration is 3x
3) Wet Year water levels based on 100-year climate sequence (see OLF groundwater tech report for details).

* USED IN STABILITY ANALYSIS (100-YEAR WET YEAR LEVEL)

Integrated Hydro Systems, LLC

Vertical Profile C
Geologic Surfaces and Groundwater Levels



NOTES:
1) Horizontal and Vertical Units are feet
2) Vertical exaggeration is 3x
3) Wet Year water levels based on 100-year climate sequence (see OLF groundwater tech report for details).

* USED IN STABILITY ANALYSIS (100-YEAR WET YEAR LEVEL)

Integrated Hydro Systems, LLC

Vertical Profile D
Geologic Surfaces and Groundwater Levels

APPENDIX A

ATTACHMENT 3
COMPUTER PROGRAM INPUT DATA – PCSTABL5M

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET

PROJECT NO. 57378.6030

CLIENT Kaiser Hill | SUBJECT Stability | Prepared By [illegible] DATE 3/2/05

PROJECT Rocky Flats OU | Check for Grading Plan Design Refinement | UPDATED ~~Reviewed~~ By [illegible] DATE 11/14/05

Approved By _____ DATE _____

(6) COMPUTER PROGRAM INPUT DATA - ACTIVE SEM

M&E SECTIONS B/C/D (PREVIOUSLY ANALYZED)

MINOR ADJUSTMENTS MADE TO BUTTRESS GEOMETRY RELATIVE TO REFINED GRADING PLAN & MINOR ADJUSTMENTS MADE TO HIGH GROUNDWATER LEVELS RELATIVE TO GROUNDWATER MODELING UPDATE UTILIZING REFINED GRADING PLAN & BUTTRESS FOOTPRINT WITH UNDERDRAIN BLANKET

M&E SECTION A-A' (NEW ANALYSIS)

* REVISED TO 175 FOR 3:1 BUTTRESS SLOPE IN TOE/BUTTRESS CHECK

BOUNDARY	LEFT X	LEFT Y	RIGHT X	RIGHT Y	SOIL
1	0	150	187.5*	150	4
2			250	175	7
3			320	175	7
4			392.9	188	2
5			630	230.6	1
6			710	245	3
7			800	245	3
8	322.9	188	435	188	2
9			520	195	2
10			570	205	2
11			630	230.6	3
12	187.5*	150	245	150	4
13			320	175	2
14	0	143	205	143	5
15			245	150	5
16			325	165	5
17			400	175	5
18			500	185	5
19			570	205	5
20			800	210	5
21	0	130	220	135	6
22			580	190	6
23			800	200	6

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET

PROJECT NO. 57378.6030

CLIENT Kaiser Aluc | SUBJECT Stability | Prepared By SMC | DATE 3/3/05

PROJECT Rocky Flats OLF | CHECK FOR GRADING PLAN | UPDATED ~~Reviewed~~ By SMC | DATE 4/14/05

DESIGN REFINEMENT | Approved By ____ | DATE ____

(6) (CONTINUED)

SOIL

SAME PARAMETERS AS USED IN PHASE 3 ANALYSIS (BASED ON RESULTS FIGURE)

PIEZOMETRIC SURFACE

POINT	X	Y
1	0	150
2	145	150
3	425 ~~445~~	190
4	520	200
5	665	230
6	800	230

CIRCULAR SEARCH

DEEP FOUNDATION AIRLINE

- INITIATE 10 POINTS
  X = 100 - 400
- TERMINATE X = 500 - 700
- MINIMUM ELEVATION FOR SEARCH 140
- LINE SEGMENTS FOR CIRCULAR SEARCH → 22

SLIDING BLOCK SEARCH

- BOXES DEFINING CENTRAL BLOCK BASE

BOX	LEFT X	LEFT Y	RIGHT X	RIGHT Y	HEIGHT
1	150	129.4	400	167.5	10
2	500	182.8	620	201.2	10

- 1000 TRIAL SURFACES
- LINE SEGMENTS FOR ACTIVE / PASSIVE PORTION → 23

APPENDIX A

ATTACHMENT 4
INPUT/OUTPUT FILE SETUP/MANAGEMENT

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET

PROJECT NO. 57378.6030

CLIENT KAISER MILL | SUBJECT STABILITY | Prepared By SMK | DATE 3/3/05

PROJECT ROCKY FLATS OLF | CHECK FOR GRADING PLAN DESIGN REFINEMENT | UPDATED ~~Reviewed~~ By SMK | DATE 4/14/05

Approved By _____ | DATE _____

(7) INPUT / OUTPUT FILE SET-UP / MANAGEMENT

COMMON CONDITIONS ANALYZED: - BUTTRESS
- HIGH GROUNDWATER (100-YR WET YR)

CONDITION		FILE NAME+	
MIE SECTION A / CIRCULAR SEARCH / STATIC		ABHCSR	REFINED ANALYSIS
	0.06g	06R	
0.04	0.05g *	05R	4
SLIDING BLOCK / STATIC		SSR	
	0.06g	06R	x
	0.03g *	03R	
MIE SECTION B / CIRCULAR SEARCH / STATIC		BBHCSR	
	0.06g	06R	
0.08	0.07g *	07R	8
SLIDING BLOCK / STATIC		SSR	
	0.06g	06R	x
	0.05g *	05R	
MIE SECTION C / CIRCULAR SEARCH / STATIC		CBHCSR	
	0.06g	06R	
0.08	g *	0 R	8
SLIDING BLOCK / STATIC		SSR	
	0.06g	06R	x
0.08	g *	0 R	8
MIE SECTION D / CIRCULAR SEARCH / STATIC		DBHCSR	
	0.06g	06R	
	0.05g *	05R	
SLIDING BLOCK / STATIC		SSR	
	0.06g	06R	x
	0.05g *	05R	

* YIELD ACCELERATION ASSOCIATED WITH PSEUDOSTATIC FACTOR OF SAFETY 1.0
x 'S' ADDED TO FILE NAME FOR SPENCER ANALYSIS RUN
+ 'R' CHANGED TO 'T' FOR TOE / BUTTRESS LOCAL STABILITY CHECK

APPENDIX A

ATTACHMENT 5
COMPUTER RUNS – OVERALL STABILITY

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET

PAGE ____ OF ____

PROJECT NO. 57378.6030

CLIENT Kaiser Hill

SUBJECT Stability

Prepared By [illegible] DATE 3/5/05

PROJECT Rocky Flats OU

CHECK FOR GRADING PLAN DESIGN REFINEMENT

UPDATED ~~Reviewed~~ By [illegible] DATE 4/14/05

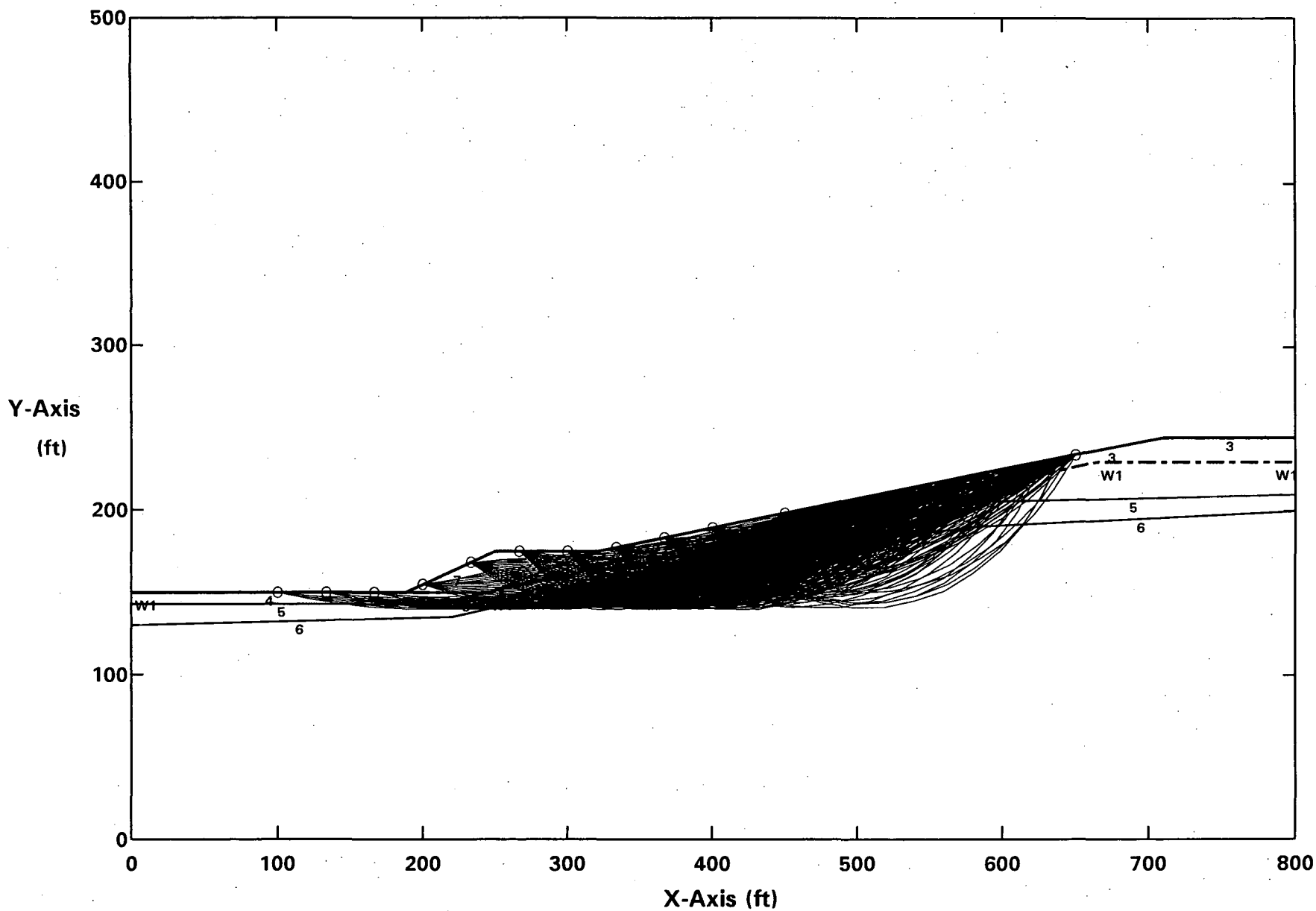
Approved By ____ DATE ____

STABILITY COMPUTER RUNS - OVERALL STABILITY

- SECTION A - STATIC - CIRCULAR
  - SLIDING BLOCK
  - SEISMIC - CIRCULAR (0.06g & 0.03g)
  - SLIDING BLOCK (0.06g & 0.03g)
- SECTION B - STATIC - CIRCULAR
  - SLIDING BLOCK
  - SEISMIC - CIRCULAR (0.06g & 0.07g)
  - SLIDING BLOCK (0.06g & 0.05g)
- SECTION C - STATIC - CIRCULAR
  - SLIDING BLOCK
  - SEISMIC - CIRCULAR (0.06g) & 0.08g
  - SLIDING BLOCK (0.06g) & 0.08g
- SECTION D - STATIC - CIRCULAR
  - SLIDING BLOCK
  - SEISMIC - CIRCULAR (0.06g & 0.05g)
  - SLIDING BLOCK (0.06g & 0.05g)

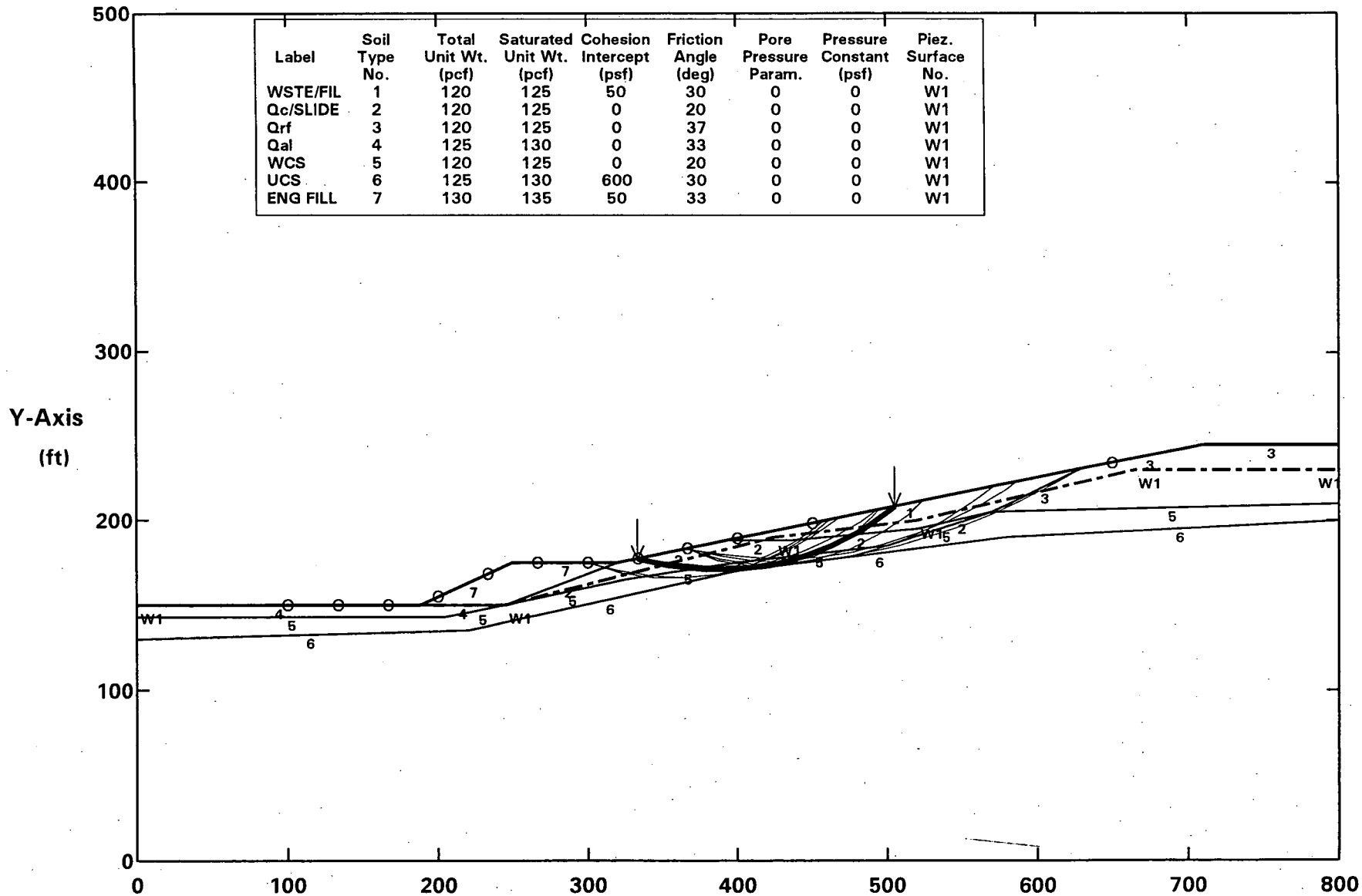
SCALE: 5 sq./inch

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:ABHCSR.PLT By: STAN KLINE 04-13-05 9:41pm



Factors Of Safety Calculated By The Modified Bishop Method

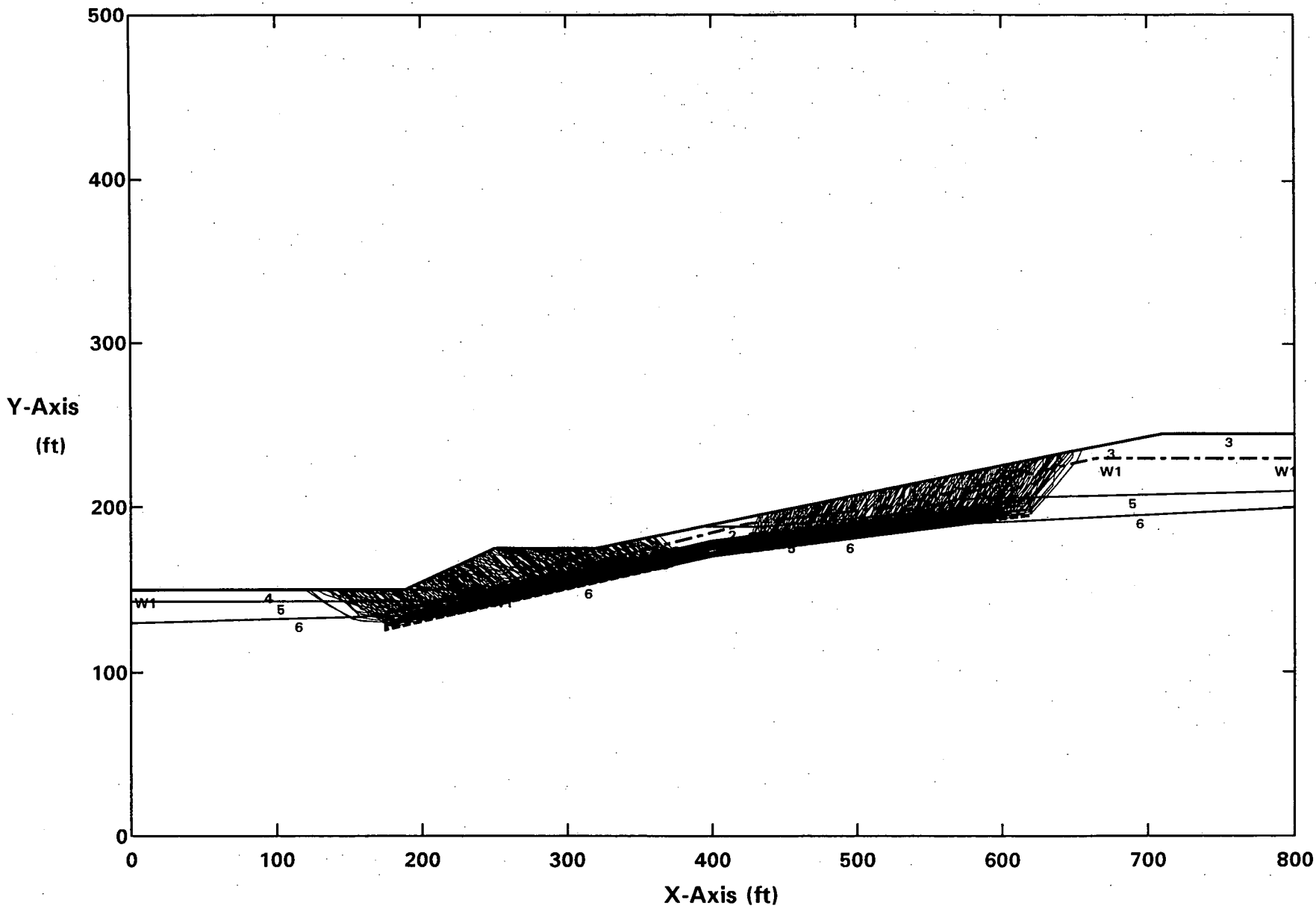
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:ABHCSR.PLT By: STAN KLINE 04-13-05 9:41pm



Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1

PCSTABL5M/SI FSmin = 1.66 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

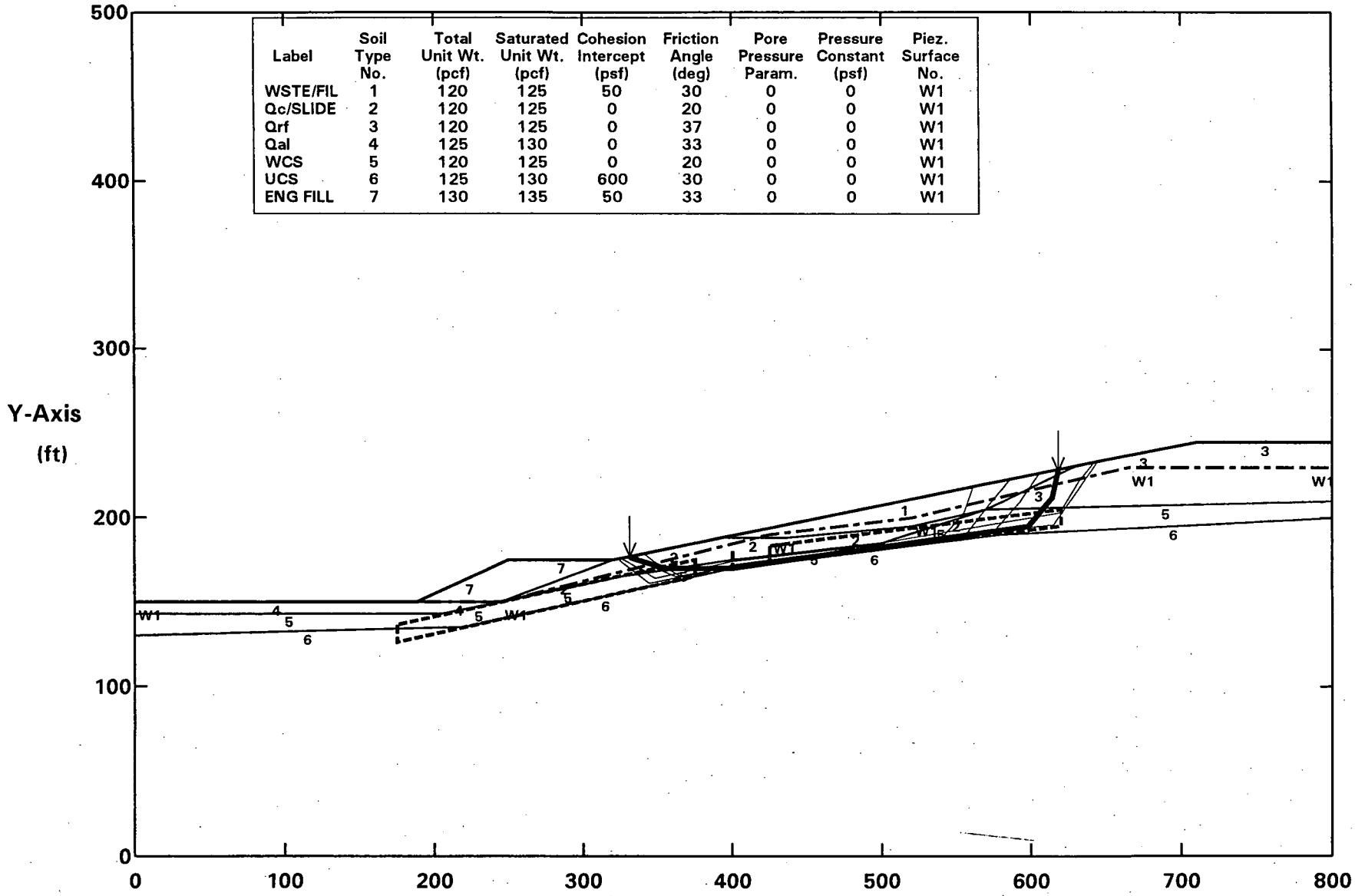
ROCKY FLATS OLF - M&E A 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:ABHSSR.PLT By: STAN KLINE 04-13-05 9:43pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E A 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Ten Most Critical. C:ABHSSR.PLT By: STAN KLINE 04-13-05 9:43pm

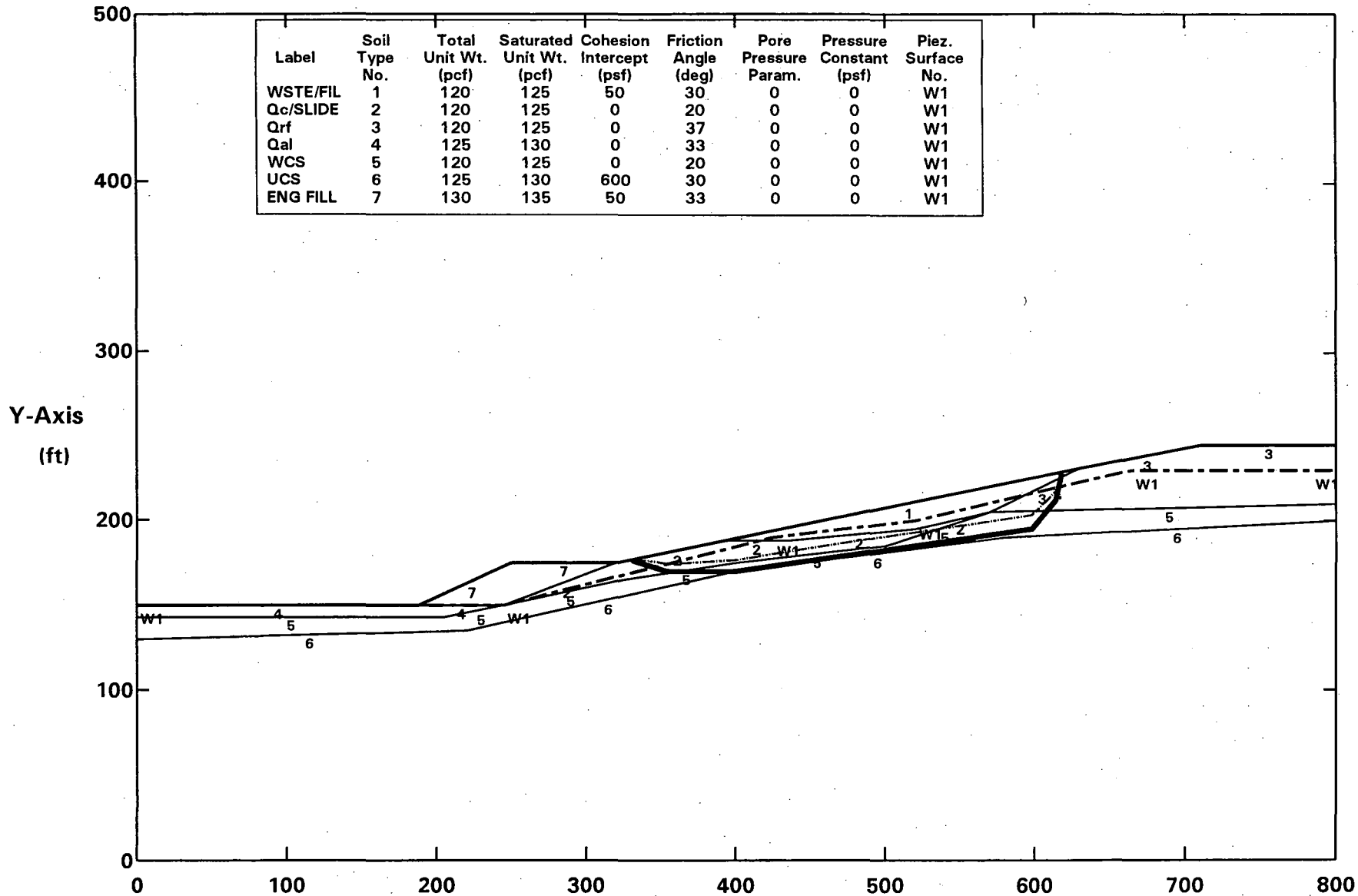
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin=1.56 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

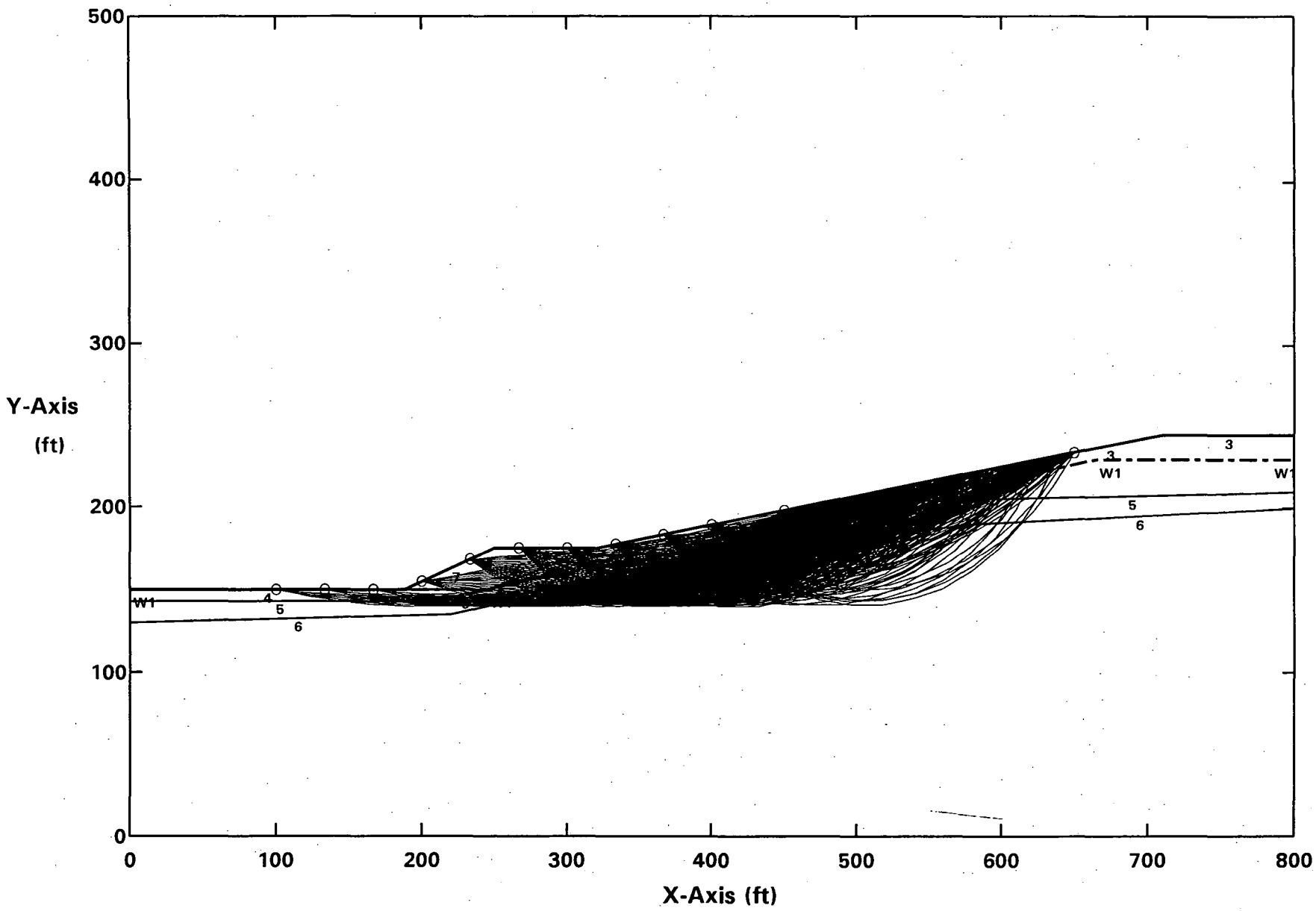
ROCKY FLATS OLF - M&E A 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-ABHSSR.OUT. C:ABHSSRS.PLT By: STAN KLINE 04-13-05 9:45pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



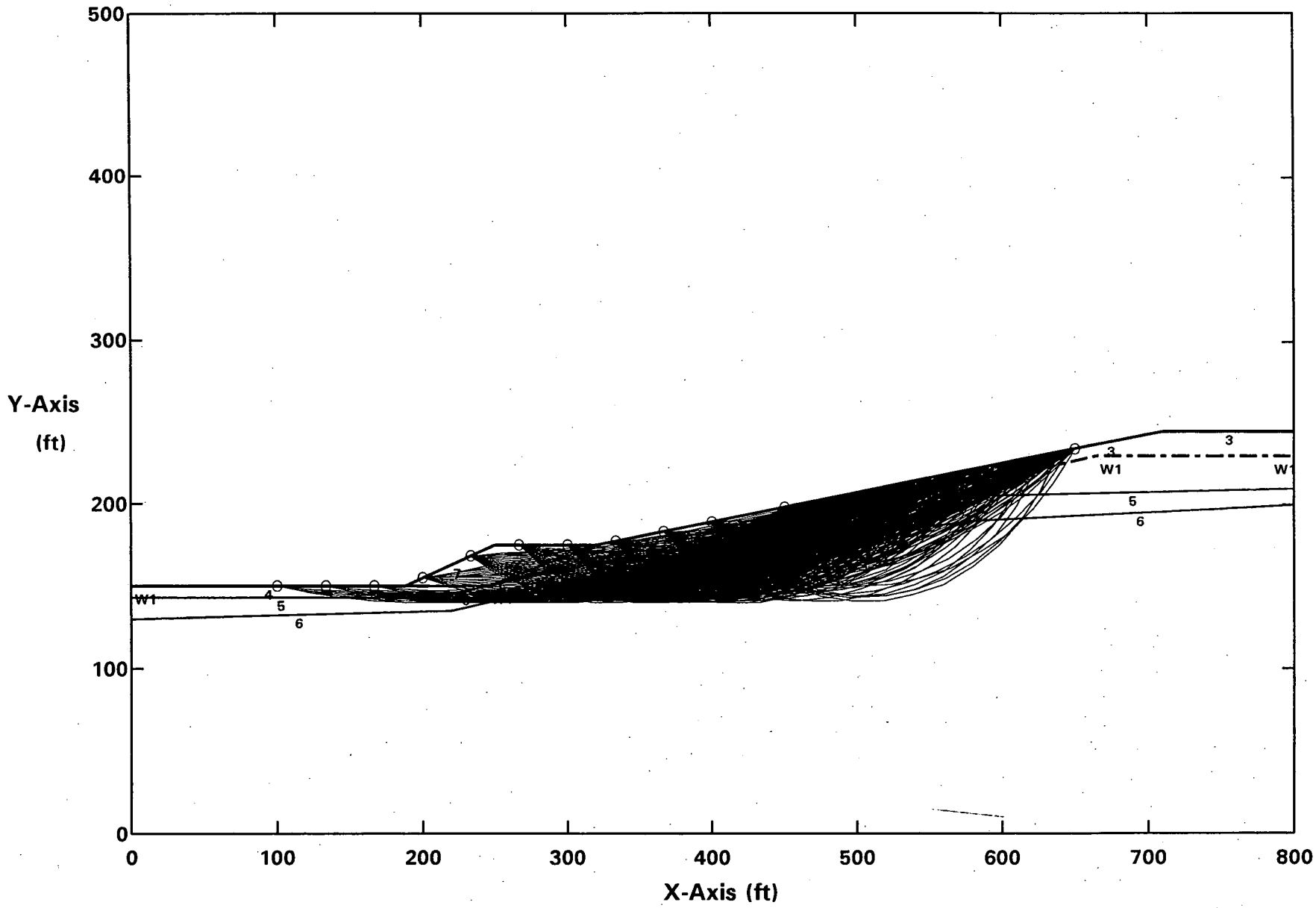
PCSTABL5M/SI FS=1.63 Theta=8.72 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:ABHC06R.PLT By: STAN KLINE 04-13-05 9:49pm



Factors Of Safety Calculated By The Modified Bishop Method

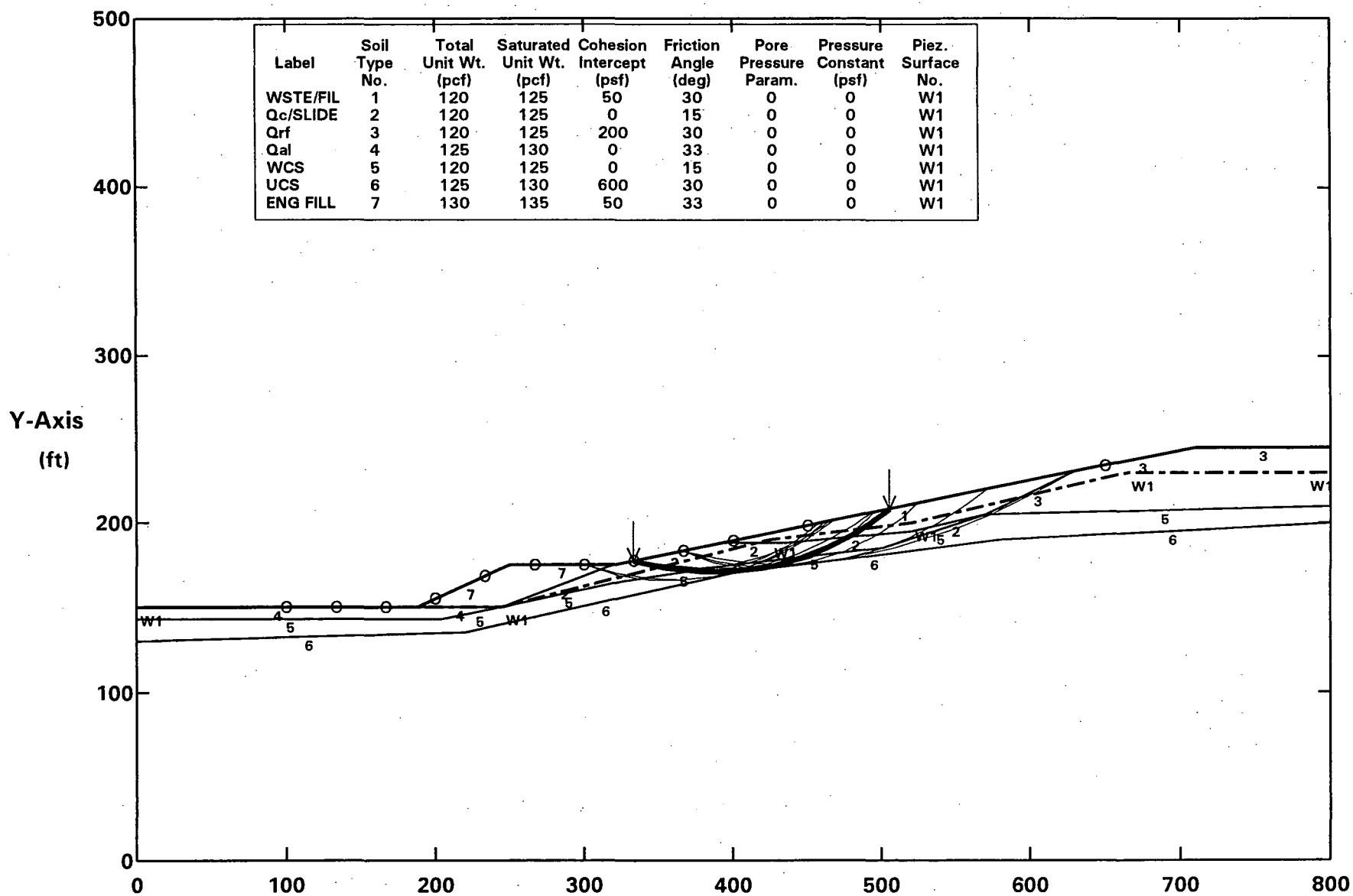
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.04g
All surfaces evaluated. C:ABHC04R.PLT By: STAN KLINE 04-13-05 9:59pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.04g
Ten Most Critical. C:ABHC04R.PLT By: STAN KLINE 04-13-05 9:59pm

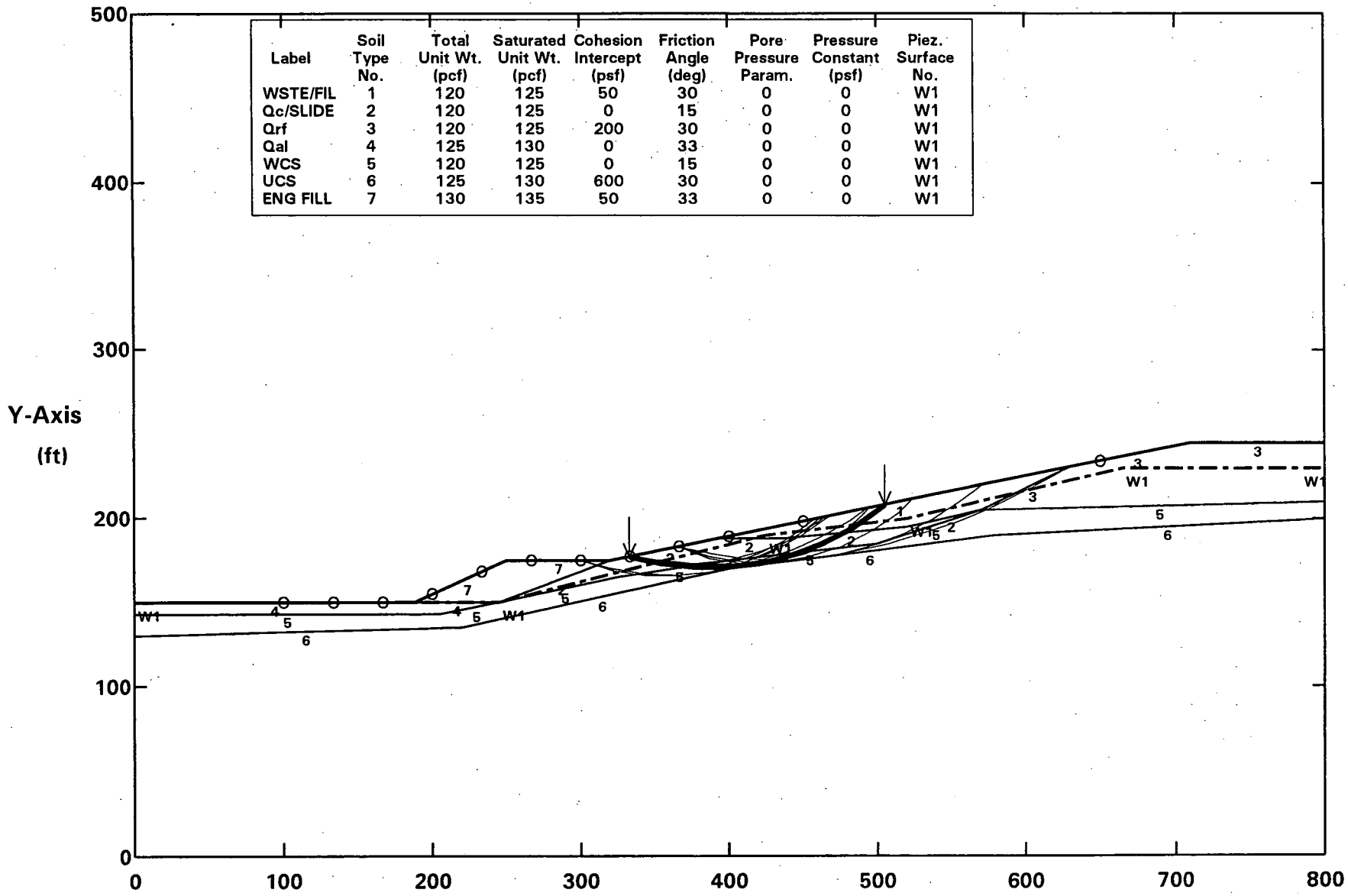
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.03 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:ABHC06R.PLT By: STAN KLINE 04-13-05 9:49pm

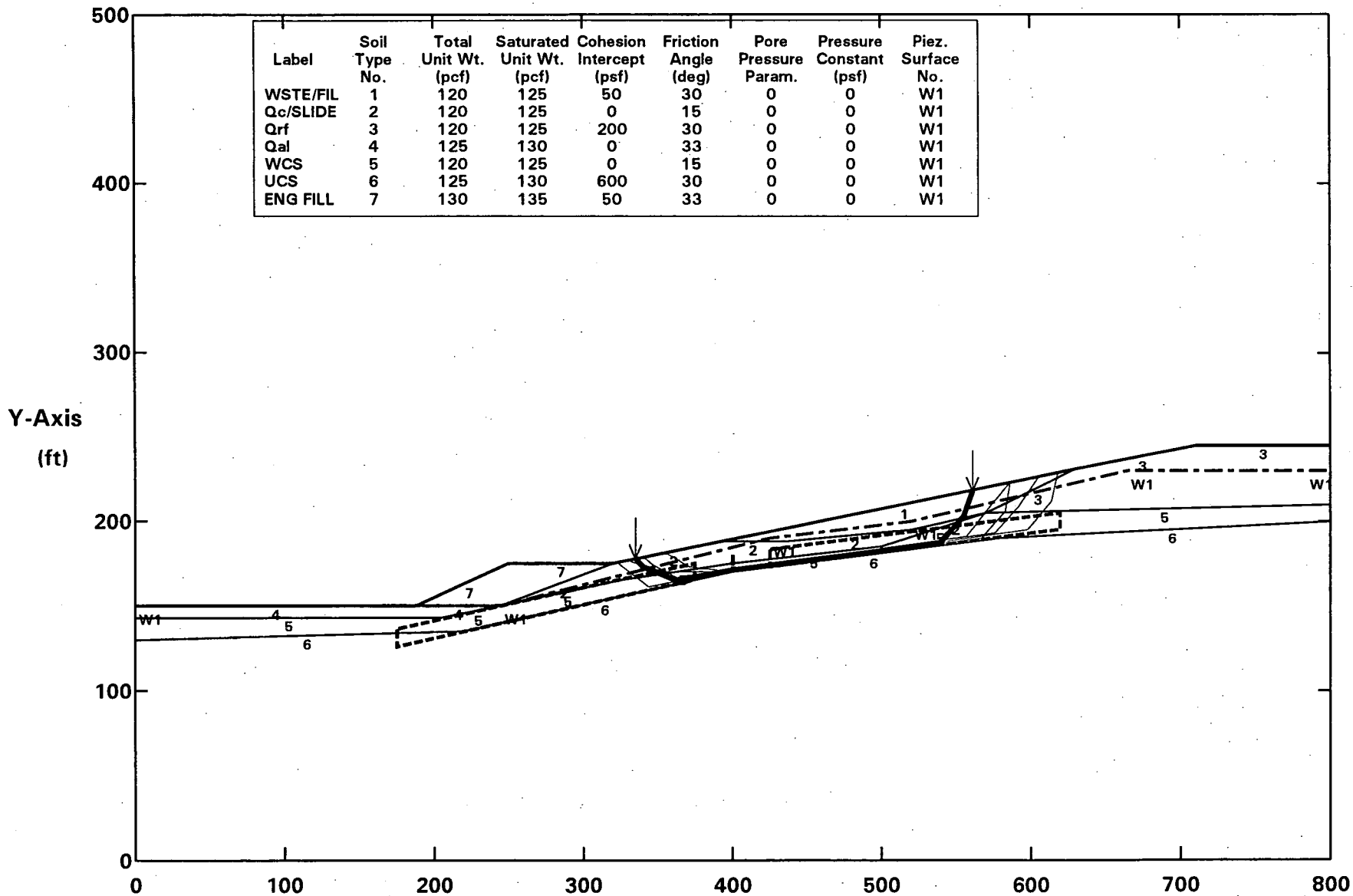
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.94 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Ten Most Critical. C:ABHS06R.PLT By: STAN KLINE 04-13-05 10:01pm

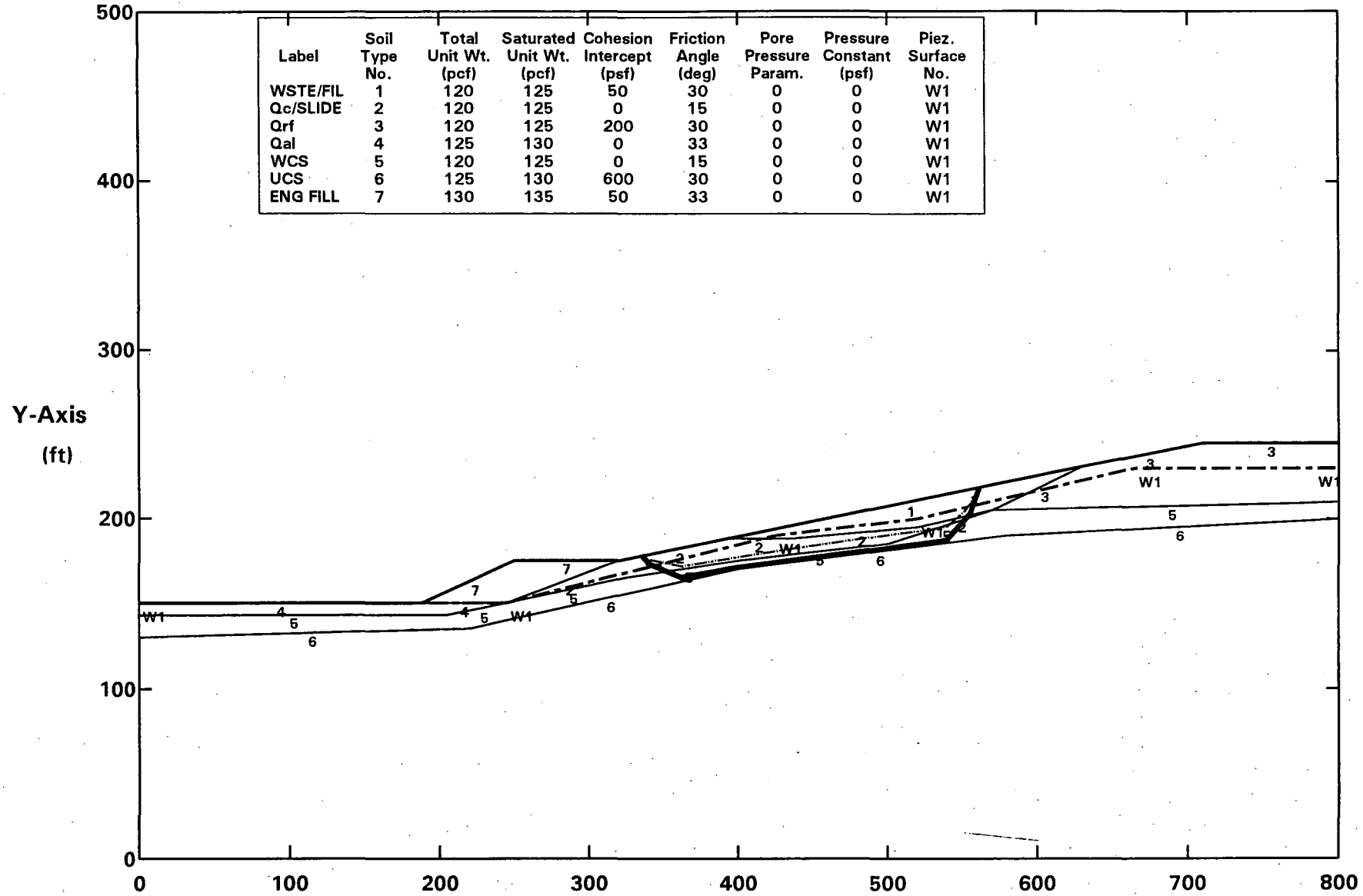
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.86 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

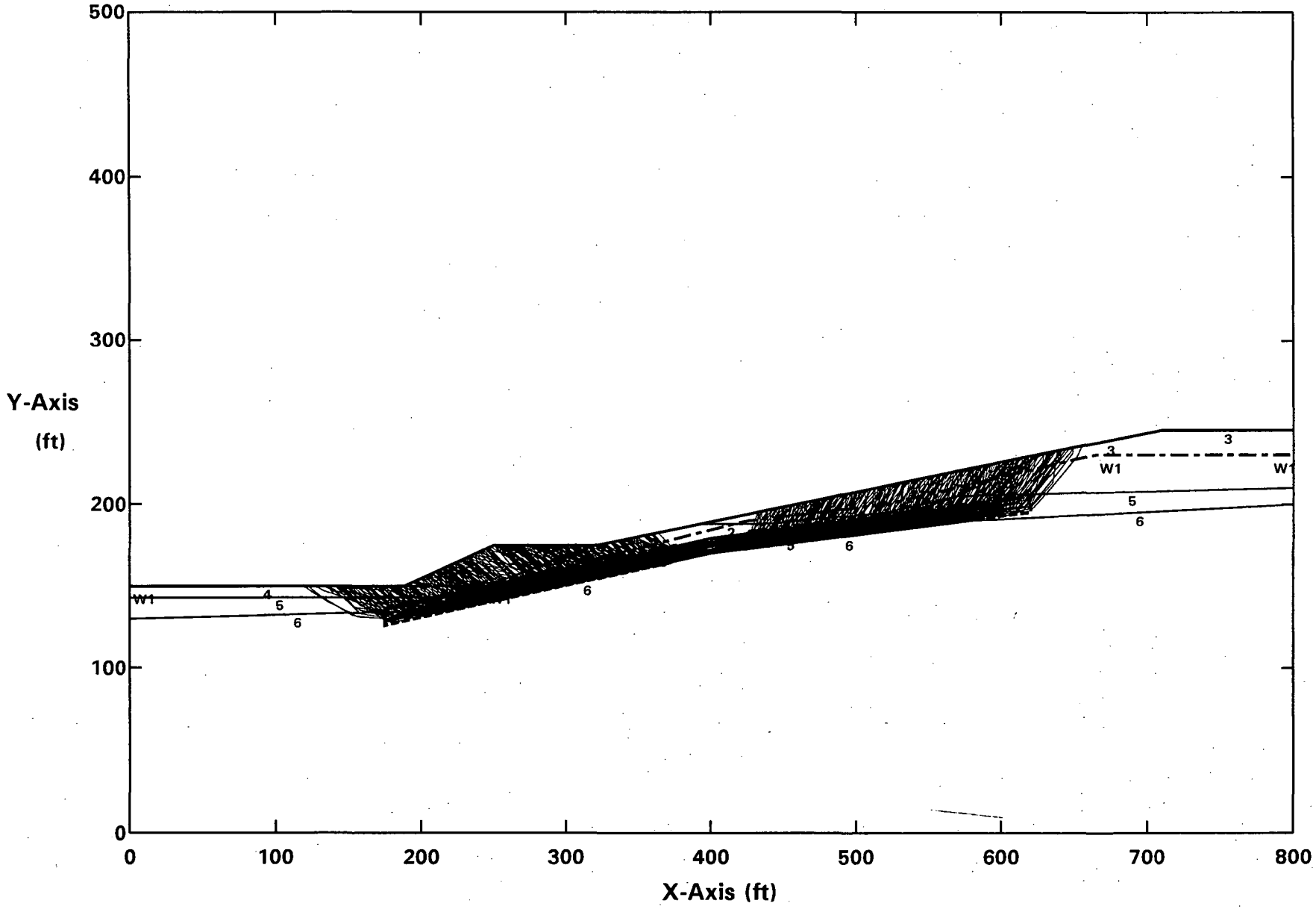
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-ABHS06R.OUT. C:ABHS06RS.PLT By: STAN KLINE 04-13-05 10:05pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS = 0.89 Theta = 8.02 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

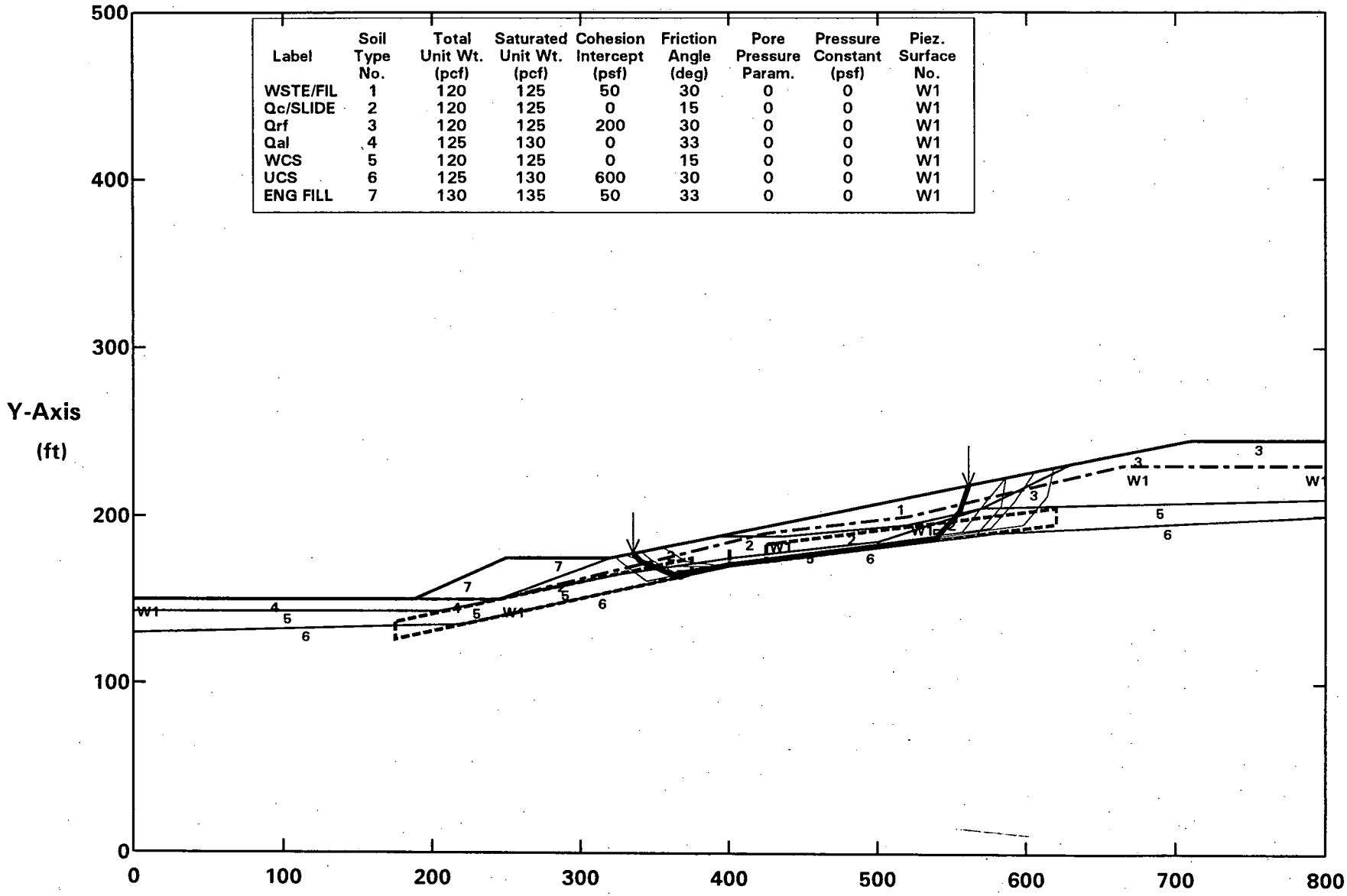
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:ABHS06R.PLT By: STAN KLINE 04-13-05 10:01pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.03g
Ten Most Critical. C:ABHS03R.PLT By: STAN KLINE 04-13-05 10:07pm

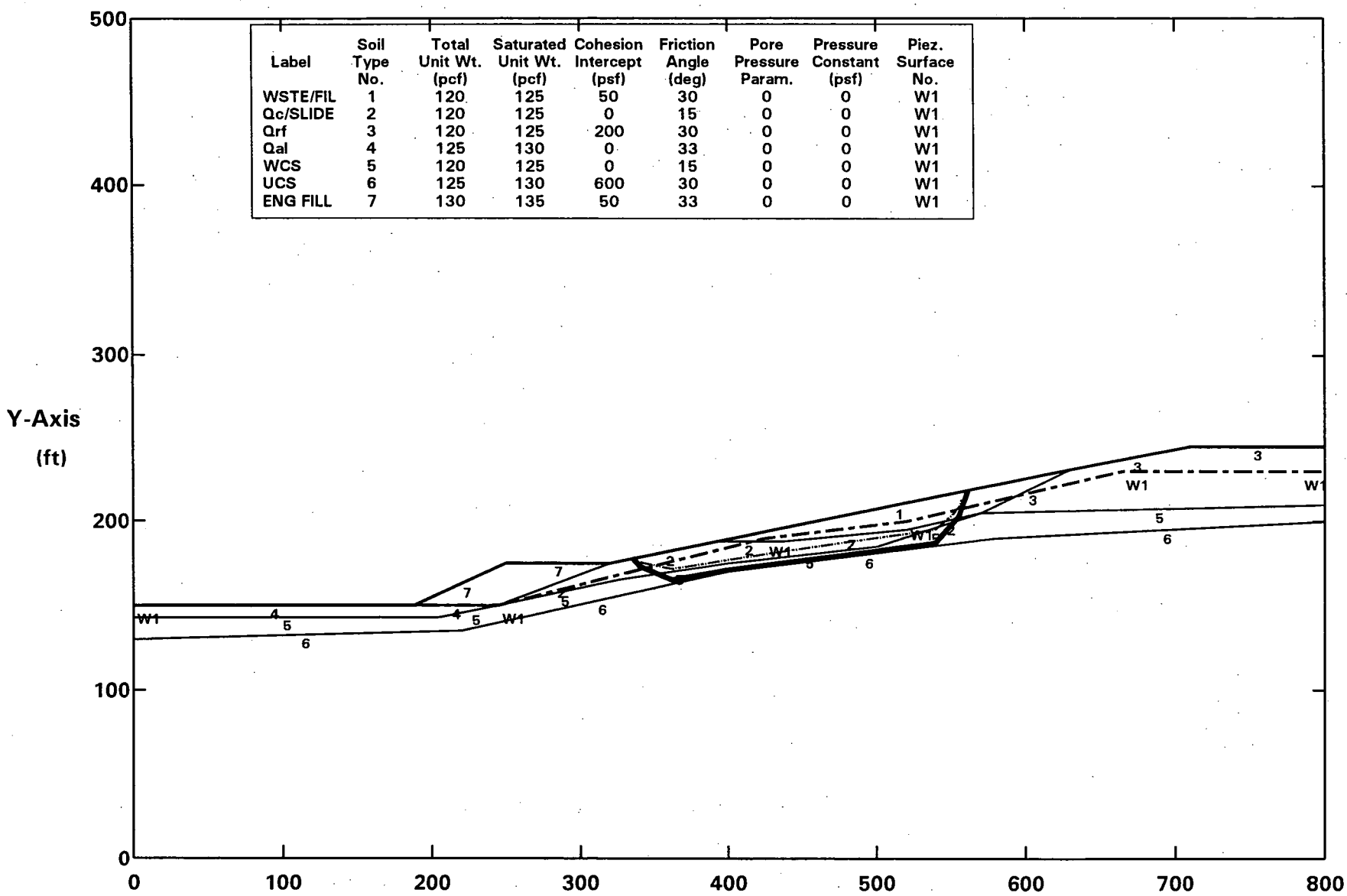
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.99 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

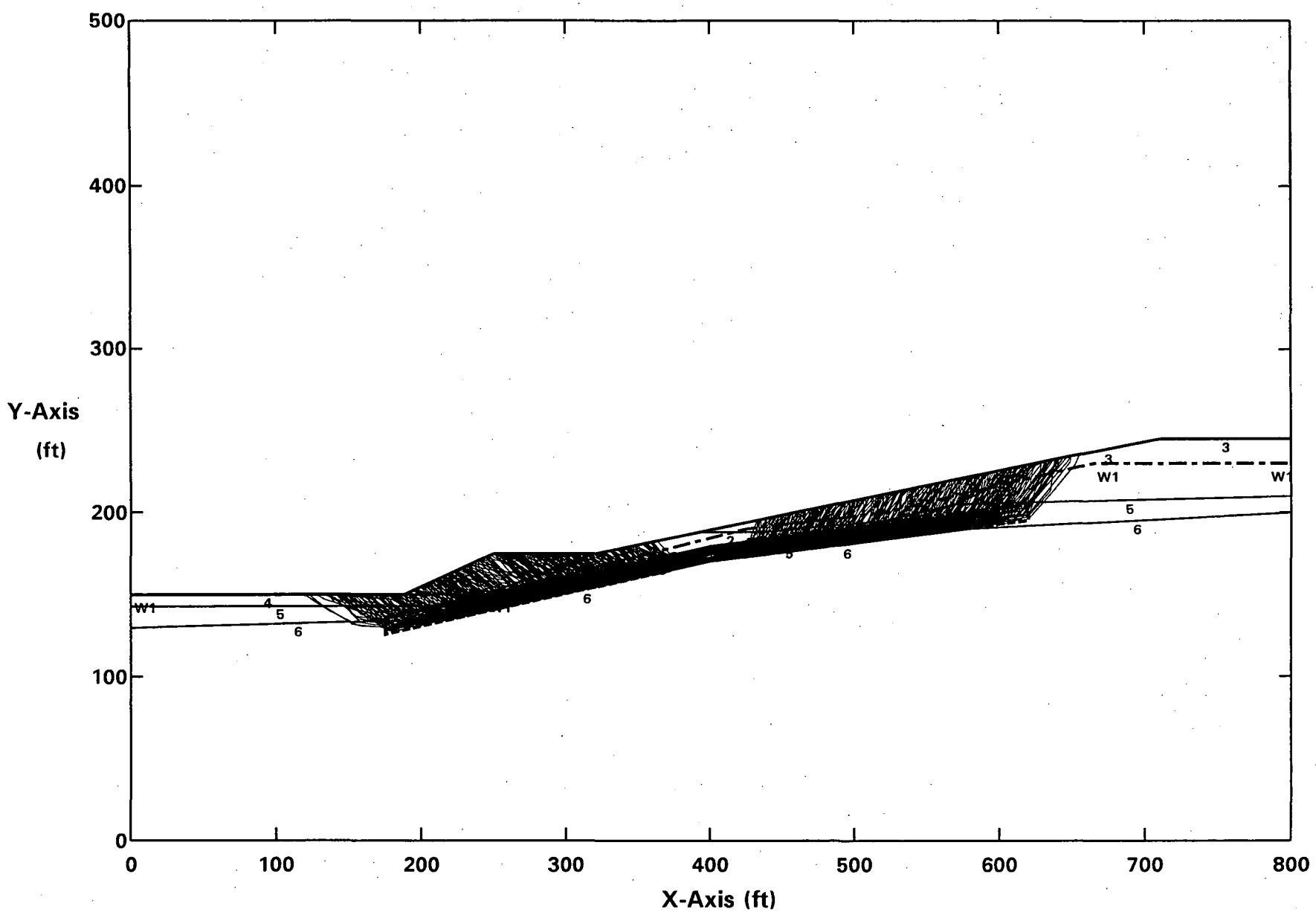
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.03g
Surface #1-ABHS03R.OUT. C:ABHS03RS.PLT By: STAN KLINE 04-13-05 10:09pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS = 1.04 Theta = 8.21 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

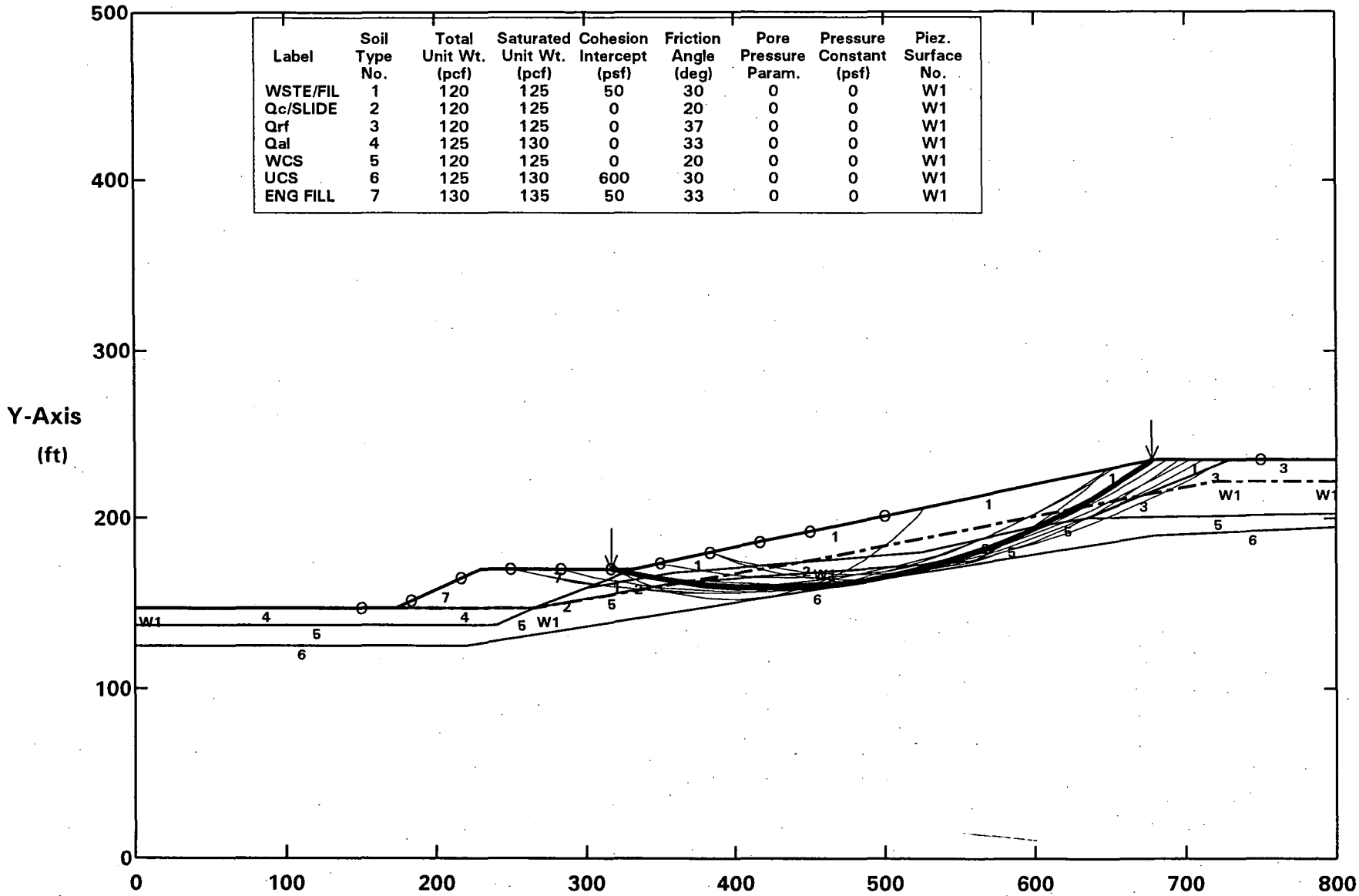
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.03g
All surfaces evaluated. C:ABHS03R.PLT By: STAN KLINE 04-13-05 10:07pm



Factors Of Safety Calculated By The Modified Janbu Method

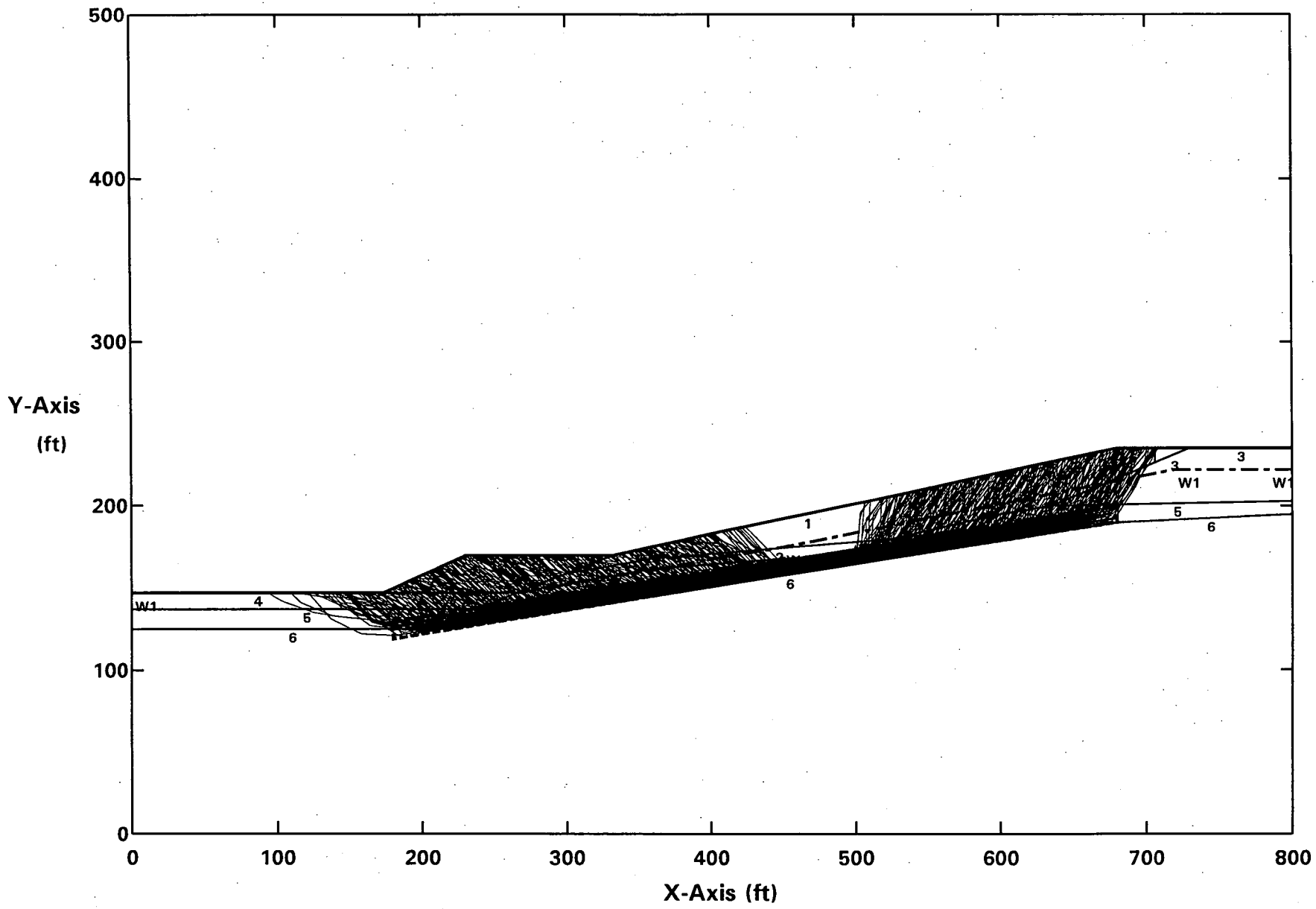
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:BBHCSR.PLT By: STAN KLINE 04-13-05 10:16pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.86 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

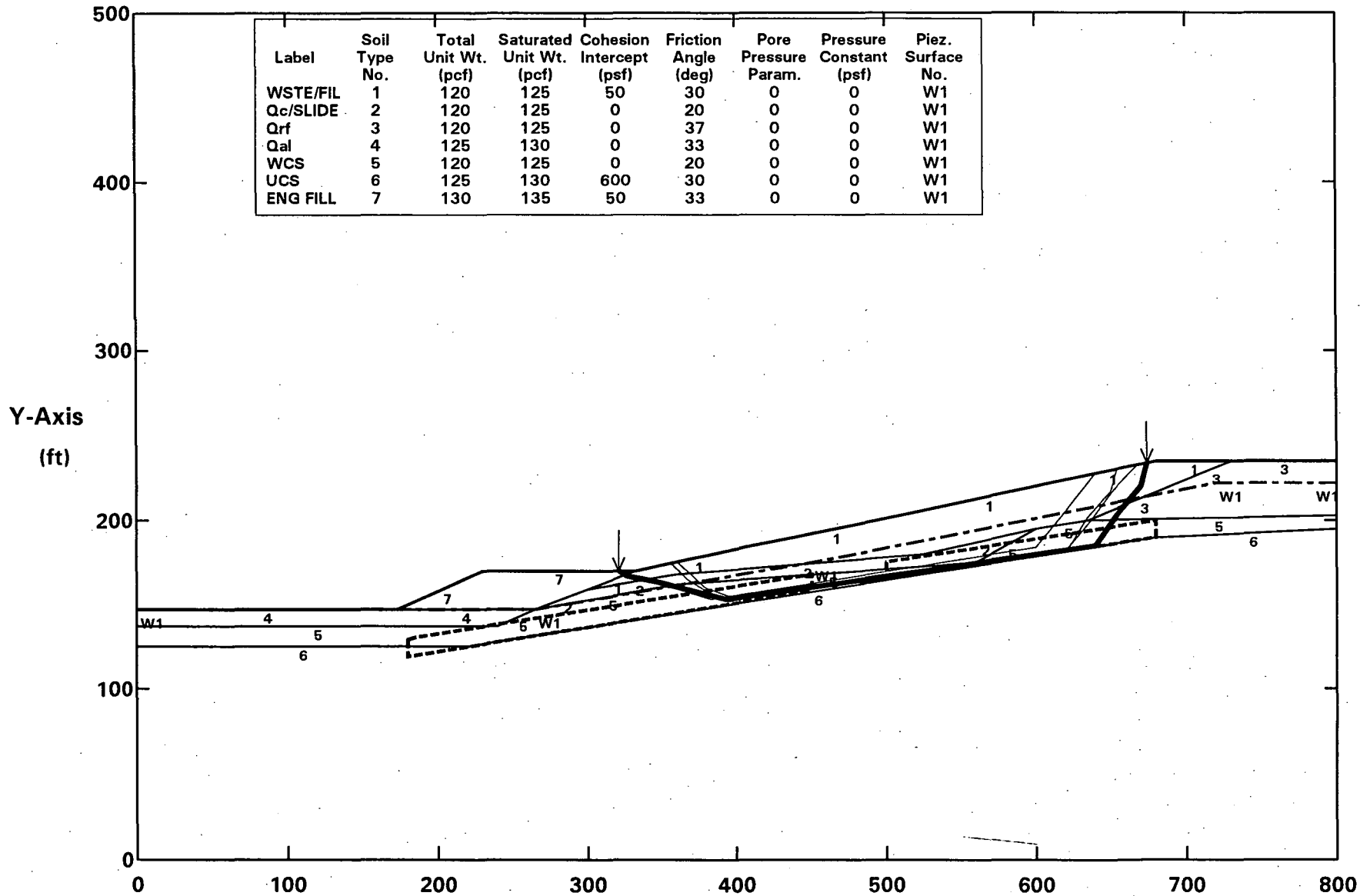
ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:BBHSSR.PLT By: STAN KLINE 04-13-05 10:18pm



Factors Of Safety Calculated By The Modified Janbu Method

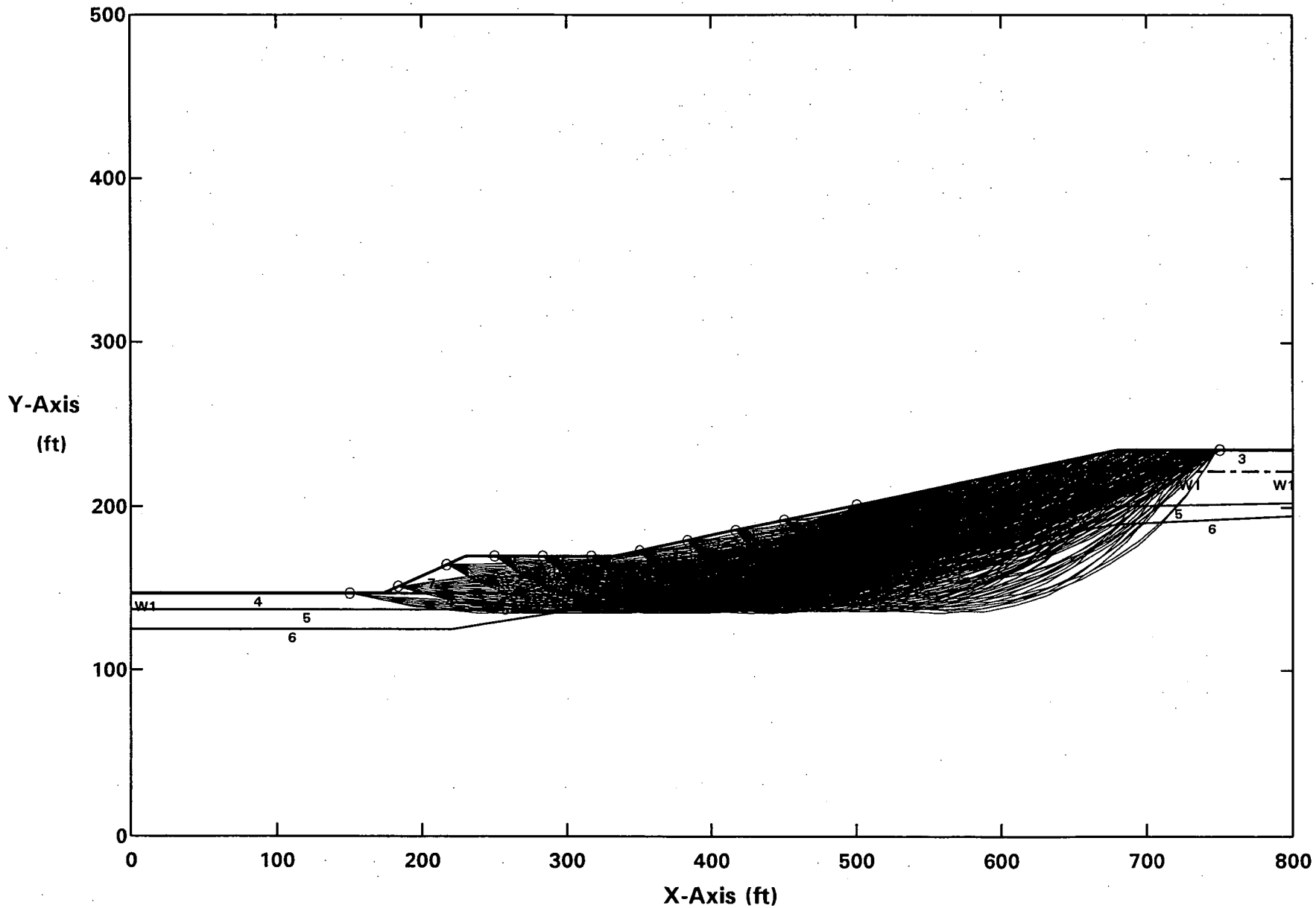
ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Ten Most Critical. C:BBHSSR.PLT By: STAN KLINE 04-13-05 10:18pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



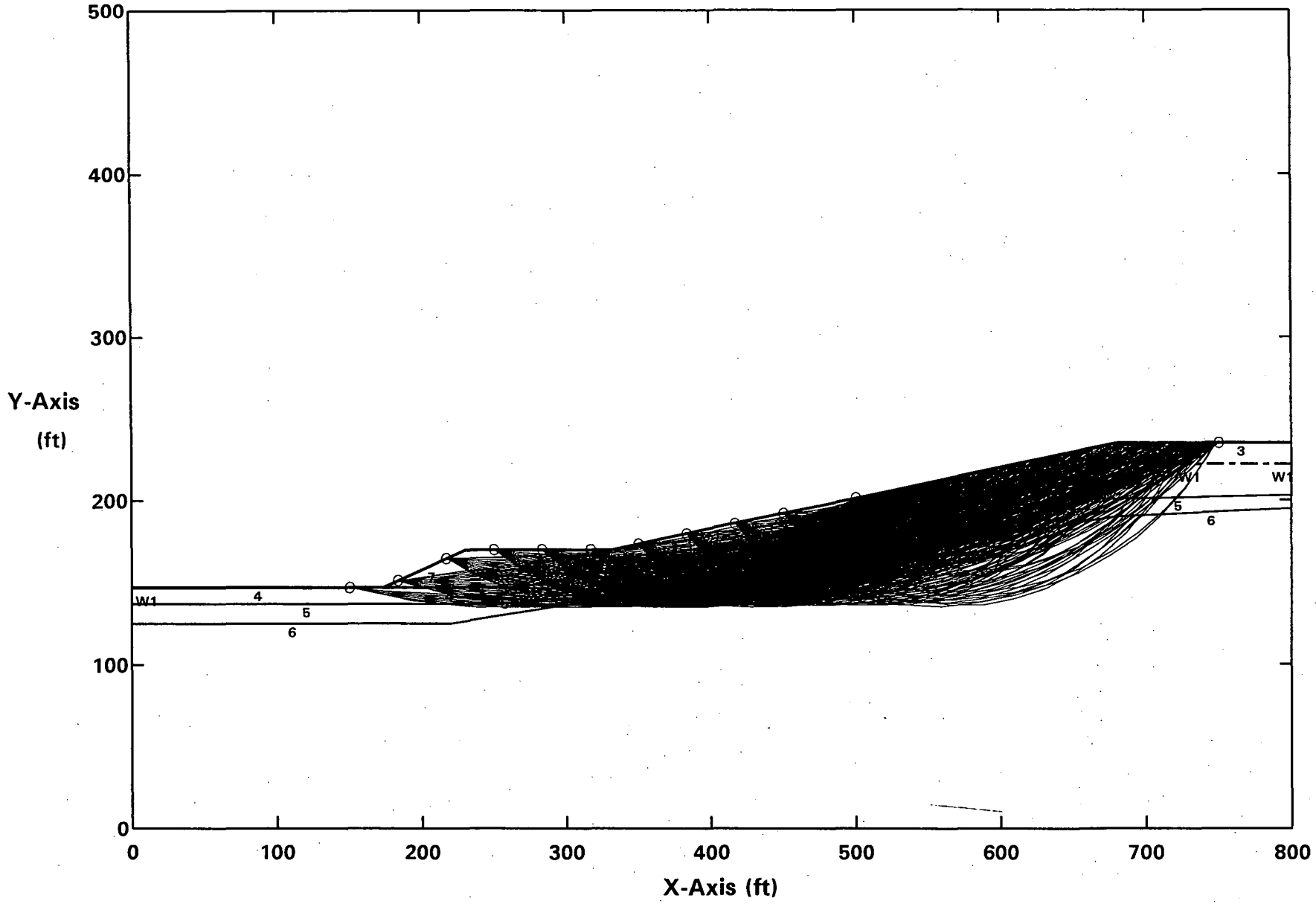
PCSTABL5M/SI FSmin=1.76 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:BBHCSR.PLT By: STAN KLINE 04-13-05 10:16pm



Factors Of Safety Calculated By The Modified Bishop Method

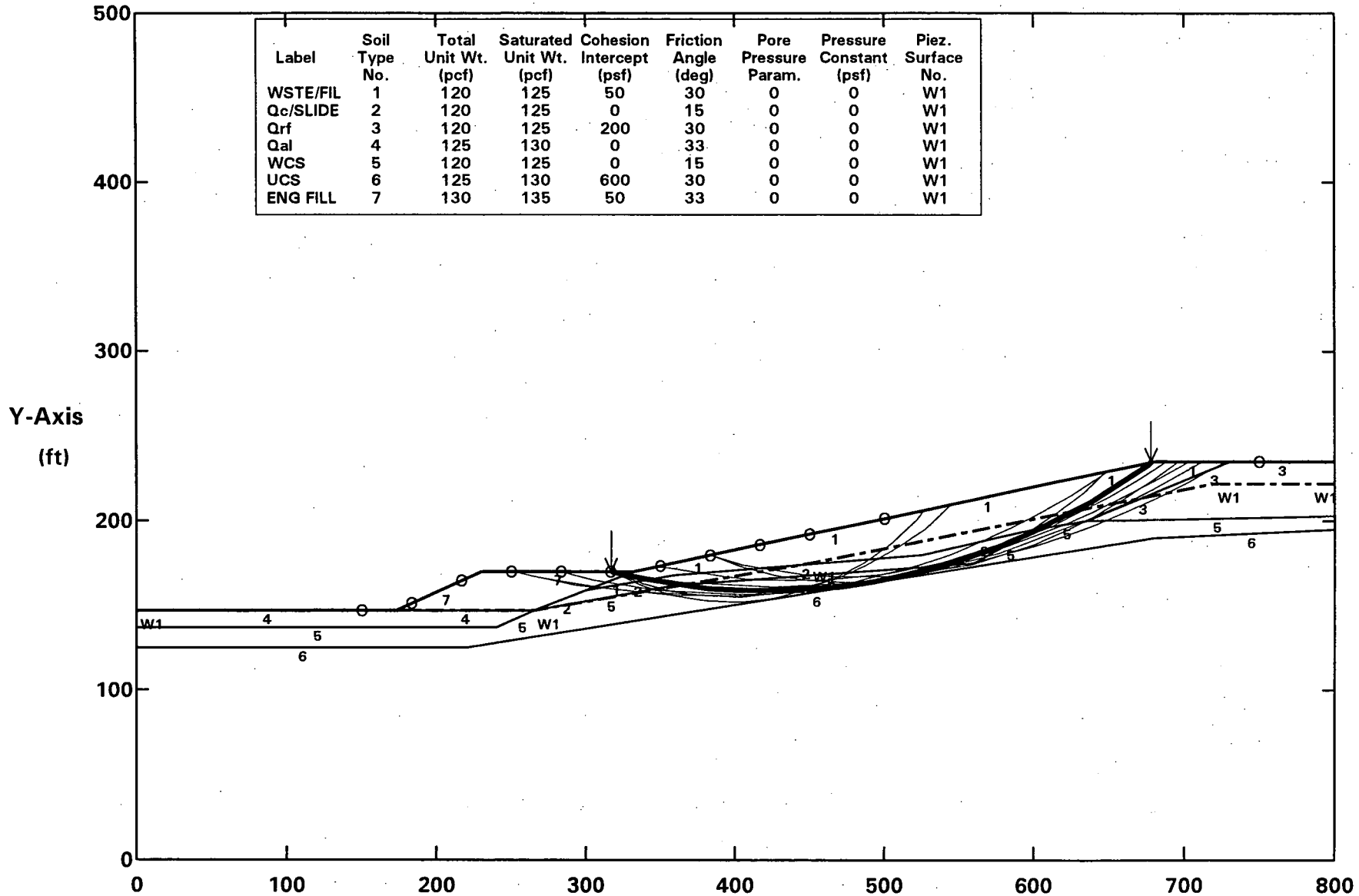
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:BBHC06R.PLT By: STAN KLINE 04-13-05 10:20pm



Factors Of Safety Calculated By The Modified Bishop Method

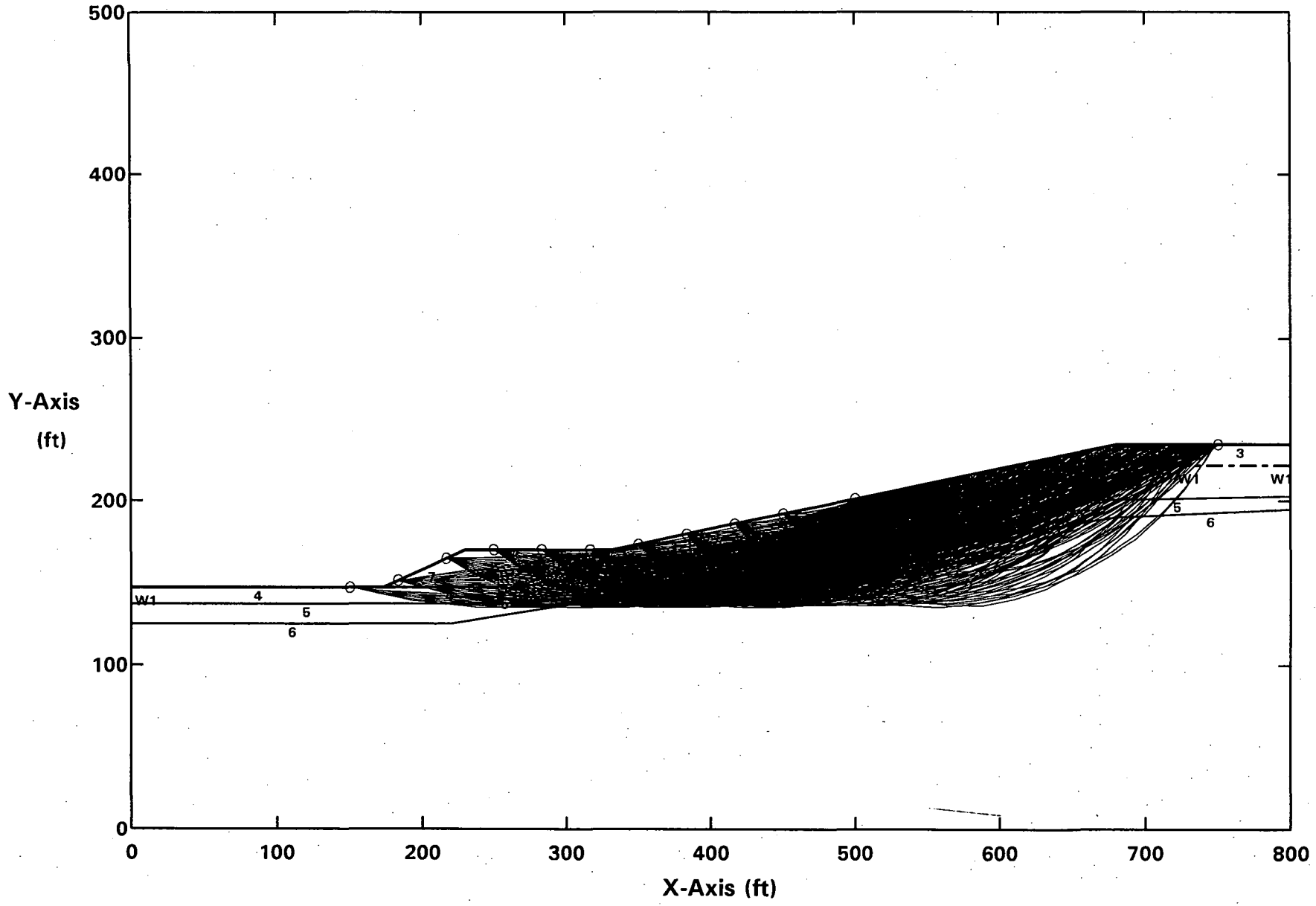
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:BBHC06R.PLT By: STAN KLINE 04-13-05 10:20pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.09 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

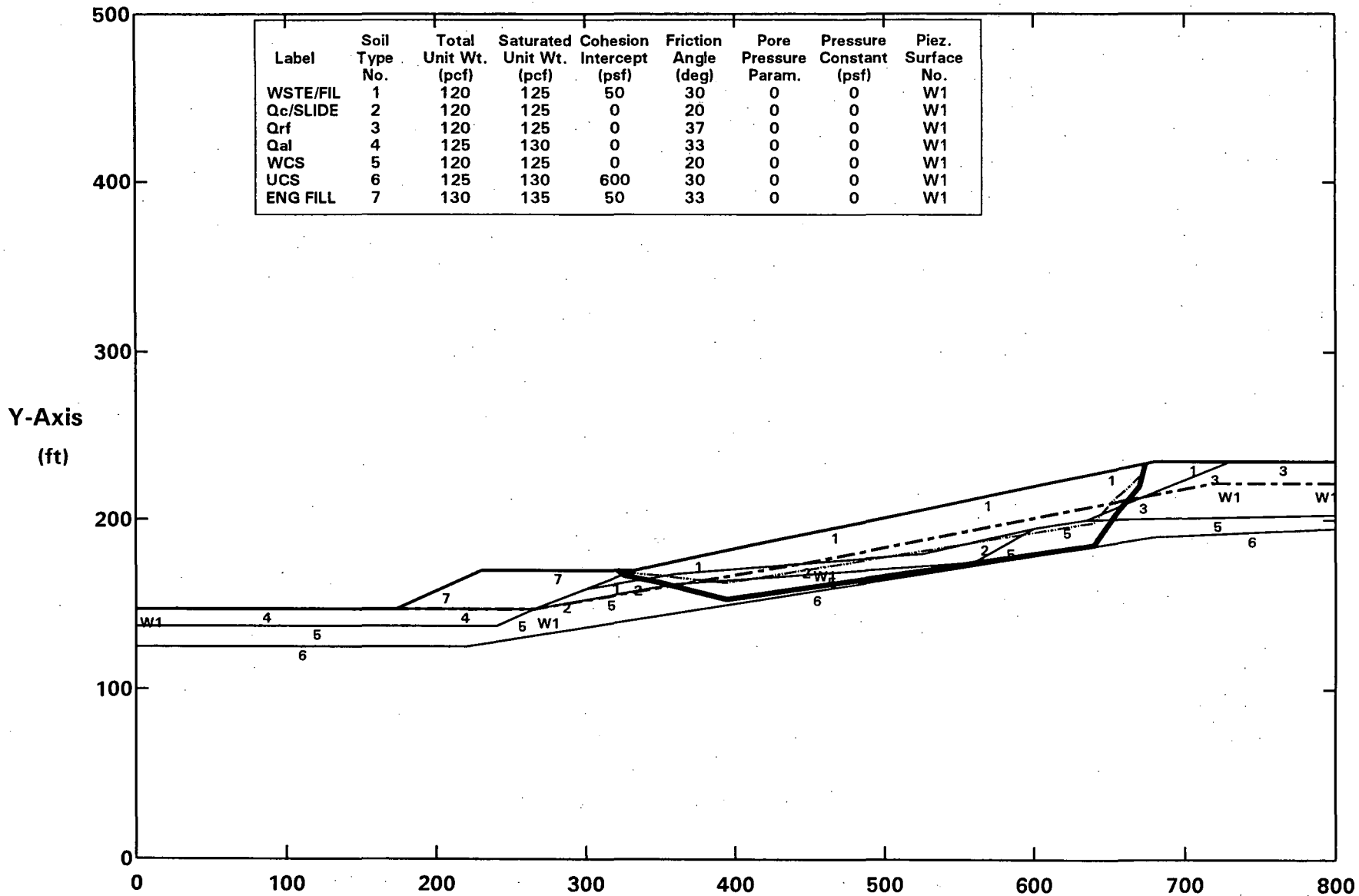
ROCKY FLATS OLF - M&E B 18%W/BM - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.08g
All surfaces evaluated. C:BBHC08R.PLT By: STAN KLINE 04-13-05 10:23pm



Factors Of Safety Calculated By The Modified Bishop Method

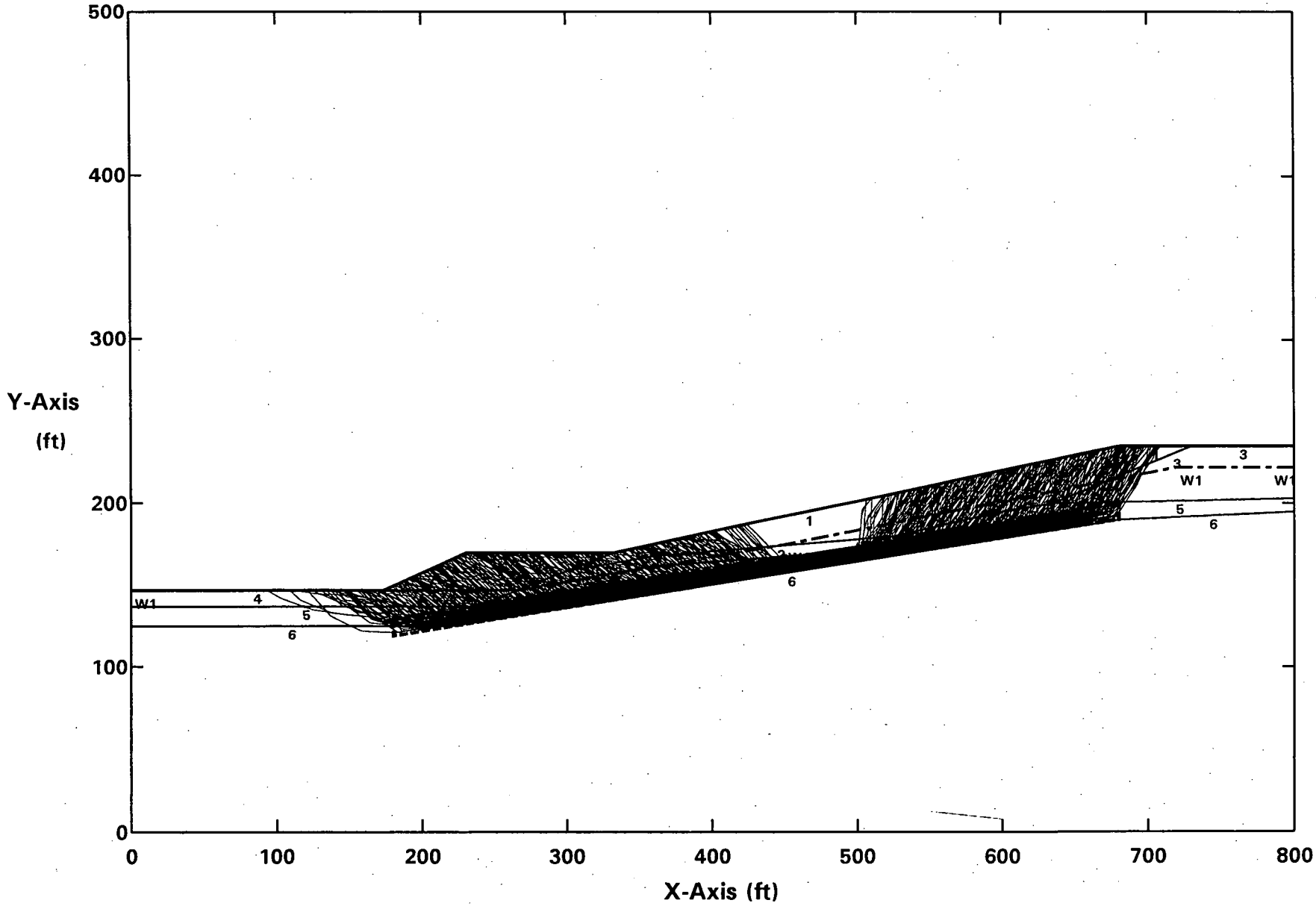
ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-BBHSSR.OUT. C:BBHSSRS.PLT By: STAN KLINE 04-13-05 10:19pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS=1.86 Theta=8.85 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

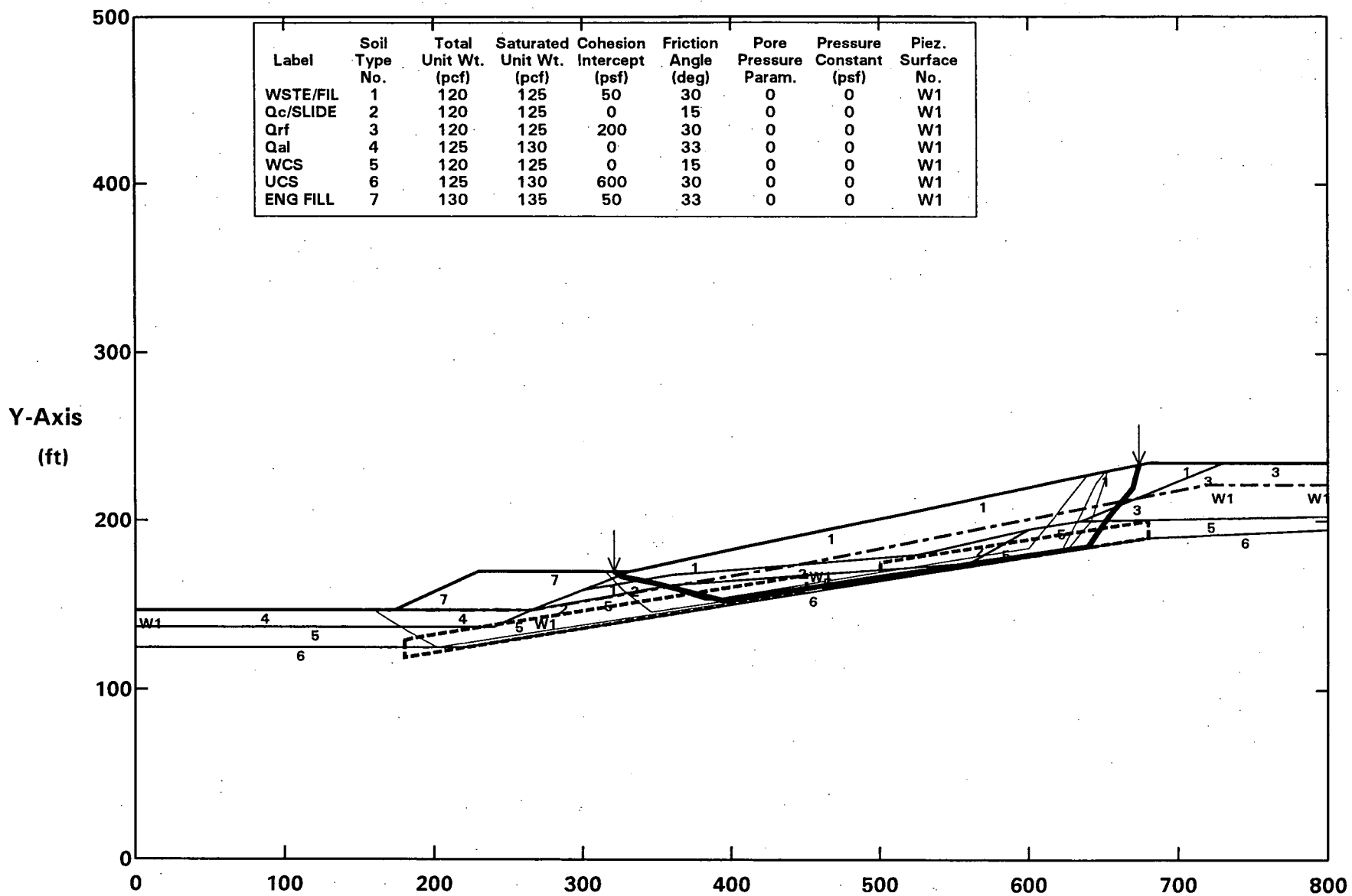
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:BBHS06R.PLT By: STAN KLINE 04-13-05 10:25pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Ten Most Critical. C:BBHS06R.PLT By: STAN KLINE 04-13-05 10:25pm

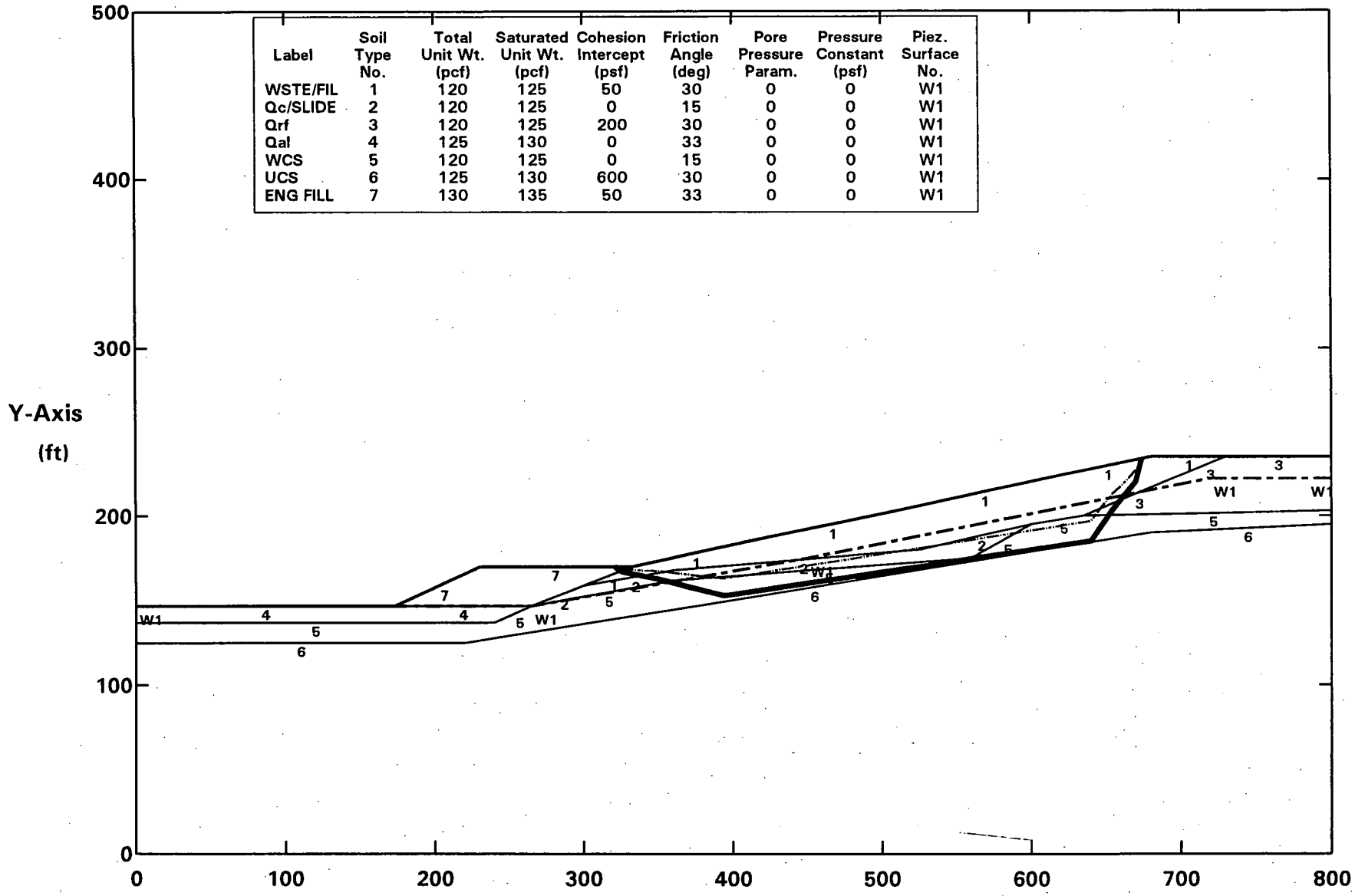
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.98 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-BBHS06R.OUT. C:BBHS06RS.PLT By: STAN KLINE 04-13-05 10:26pm

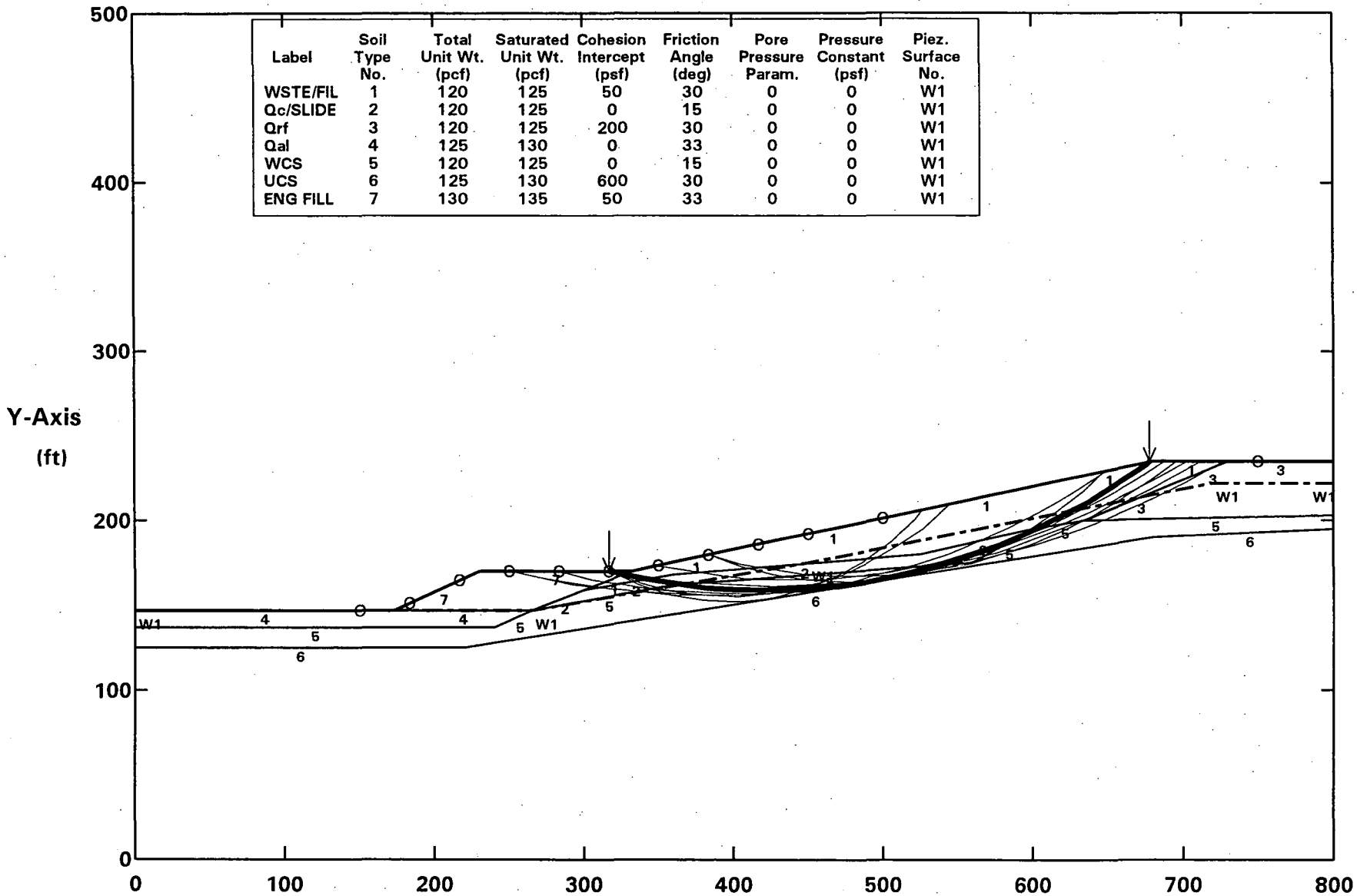
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS = 1.02 Theta = 7.89 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

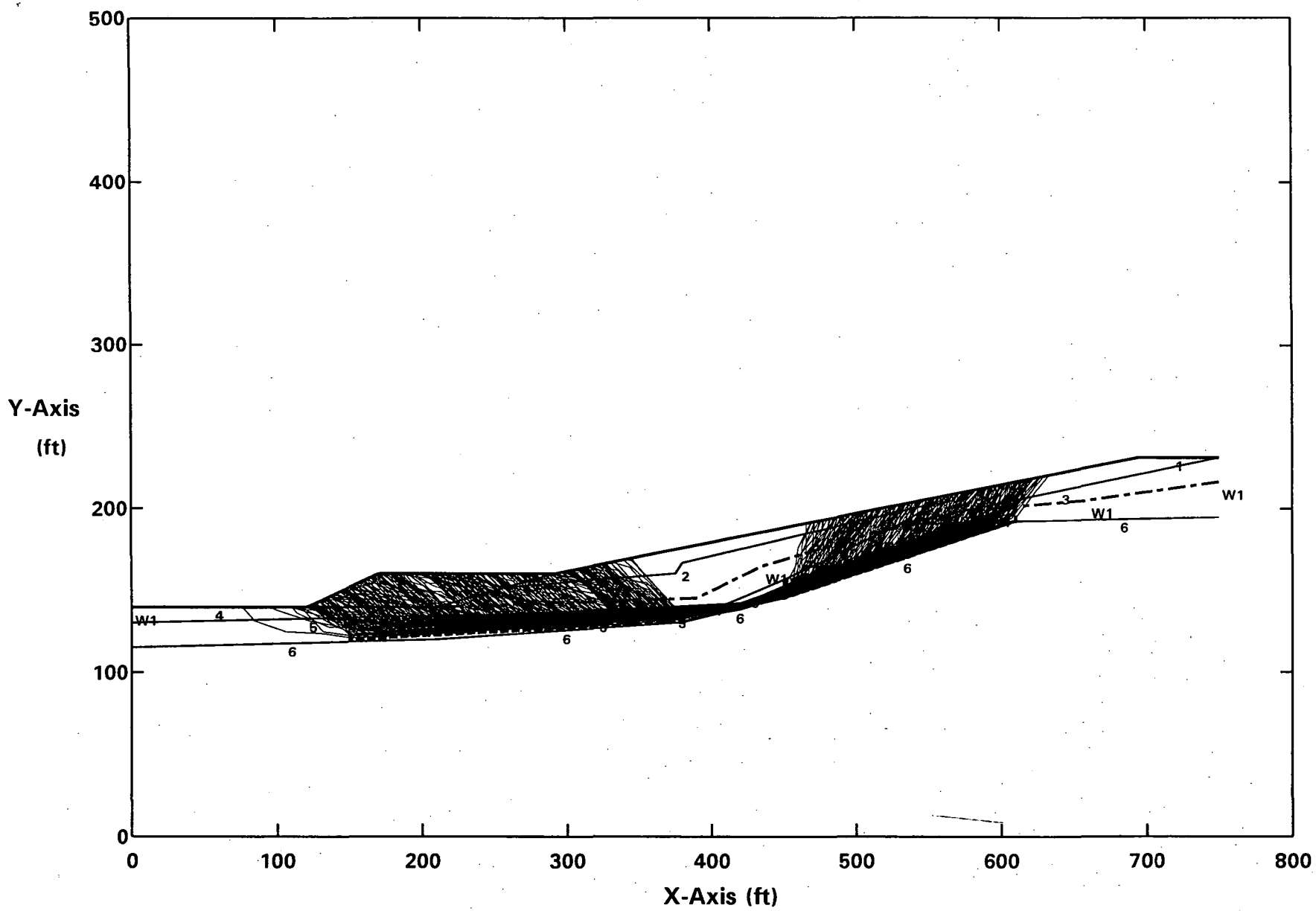
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.08g
Ten Most Critical. C:BBHC08R.PLT By: STAN KLINE 04-13-05 10:23pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.00 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

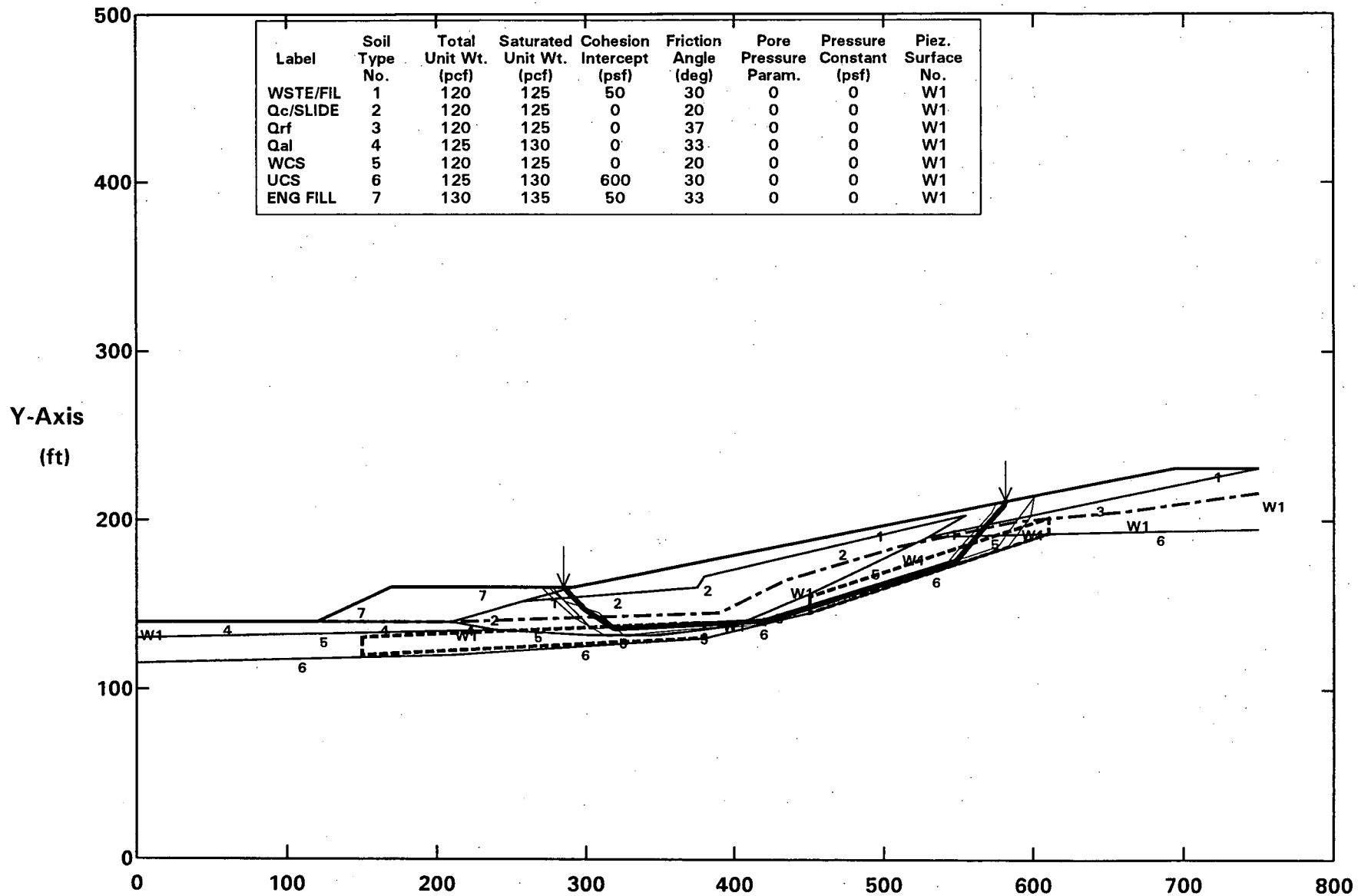
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:CBHSSR.PLT By: STAN KLINE 04-13-05 10:32pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Ten Most Critical. C:CBHSSR.PLT By: STAN KLINE 04-13-05 10:32pm

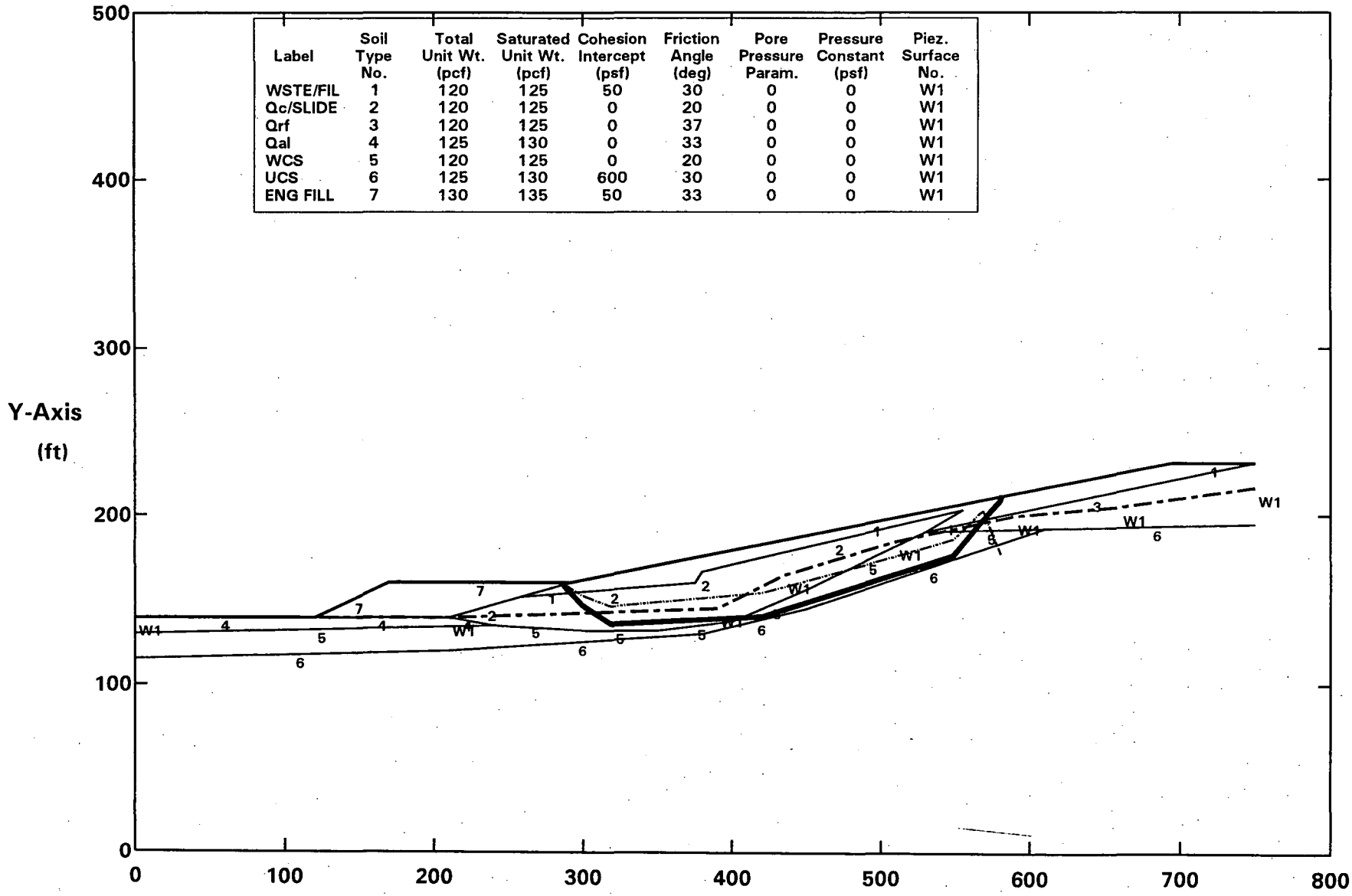
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin=1.87 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

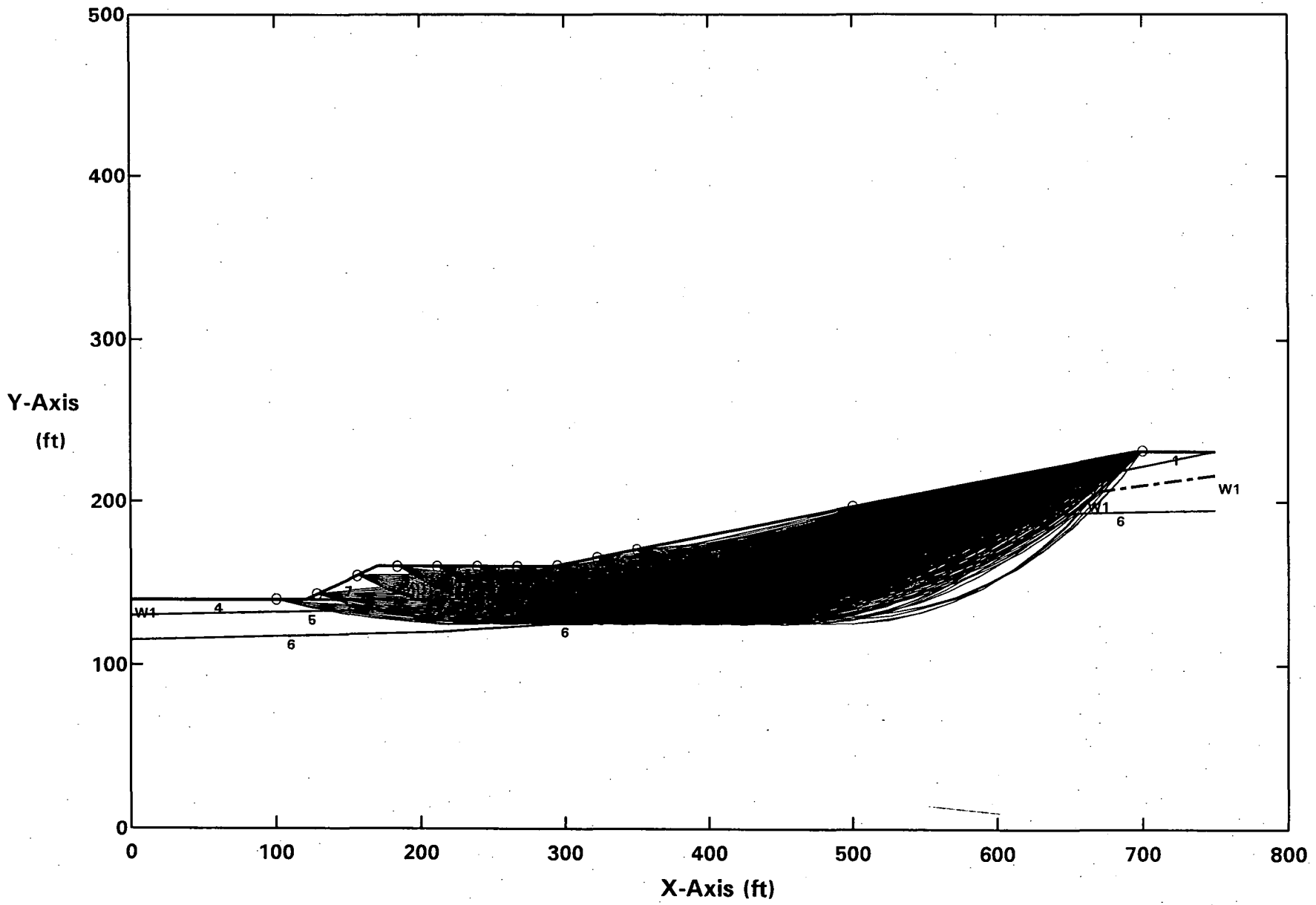
ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-CBHSSR.OUT. C:CBHSSRS.PLT By: STAN KLINE 04-13-05 10:33pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS=2.04 Theta=8.34 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

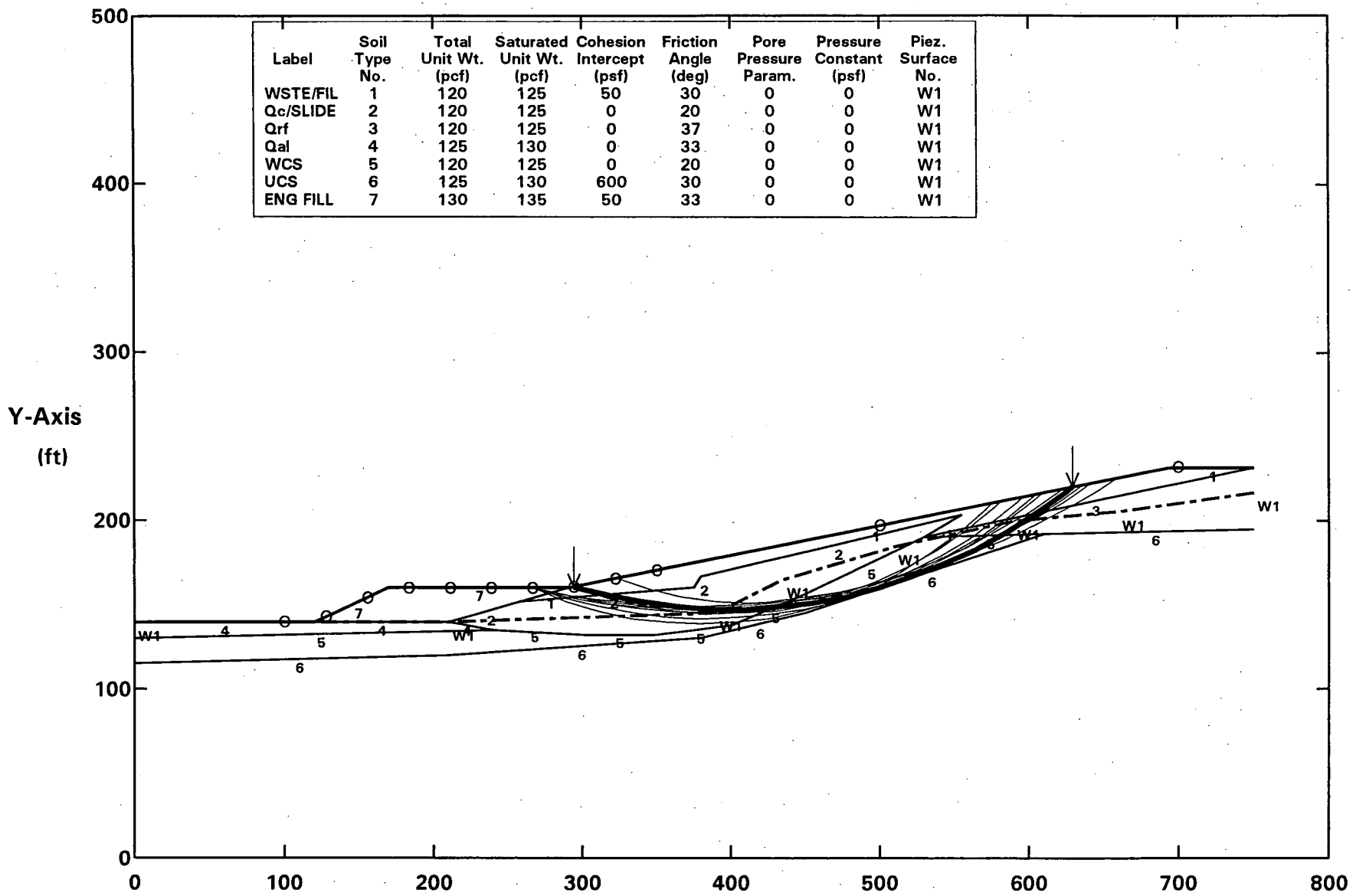
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:CBHCSR.PLT By: STAN KLINE 04-13-05 10:30pm



Factors Of Safety Calculated By The Modified Bishop Method

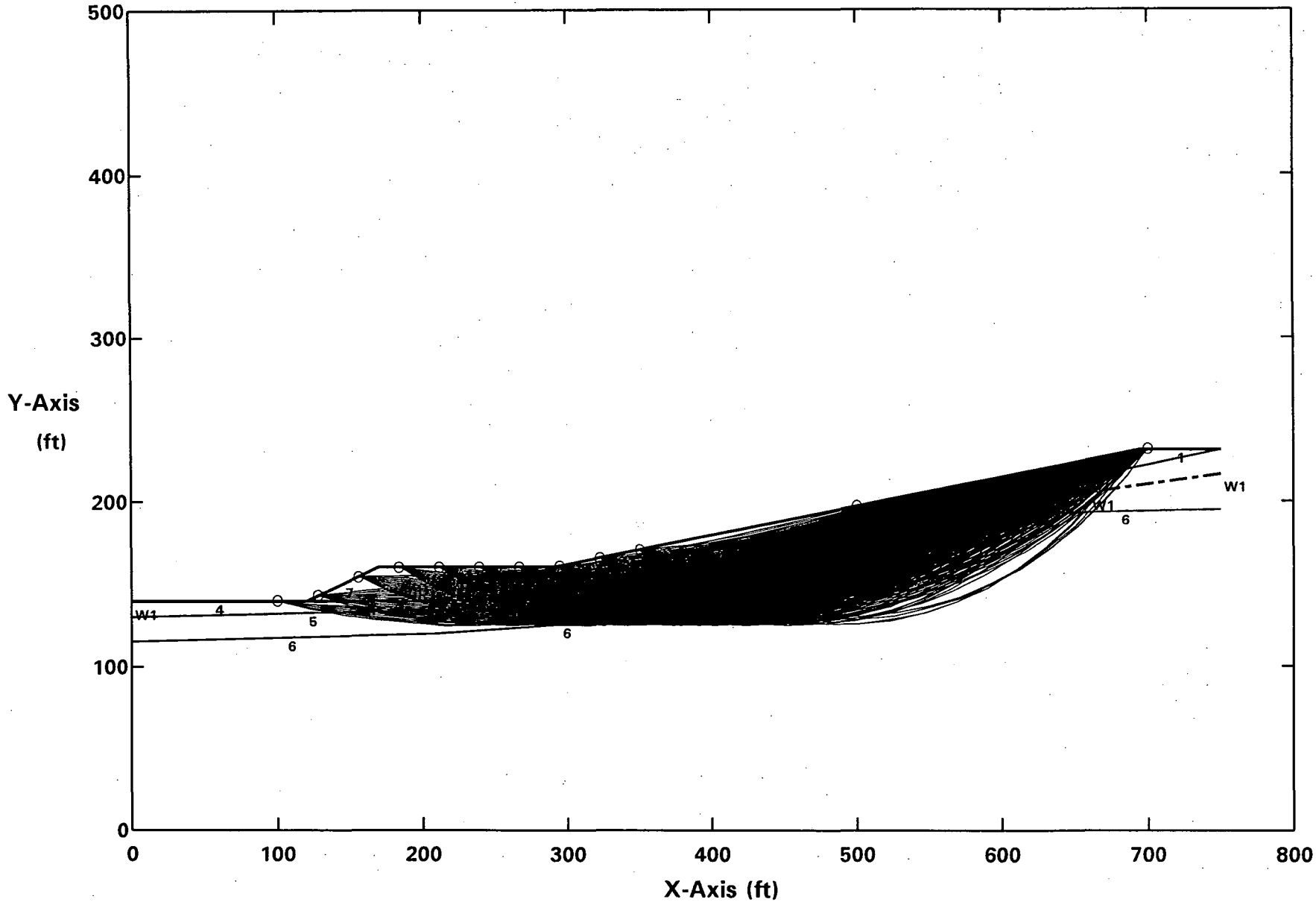
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:CBHCSR.PLT By: STAN KLINE 04-13-05 10:30pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.94 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

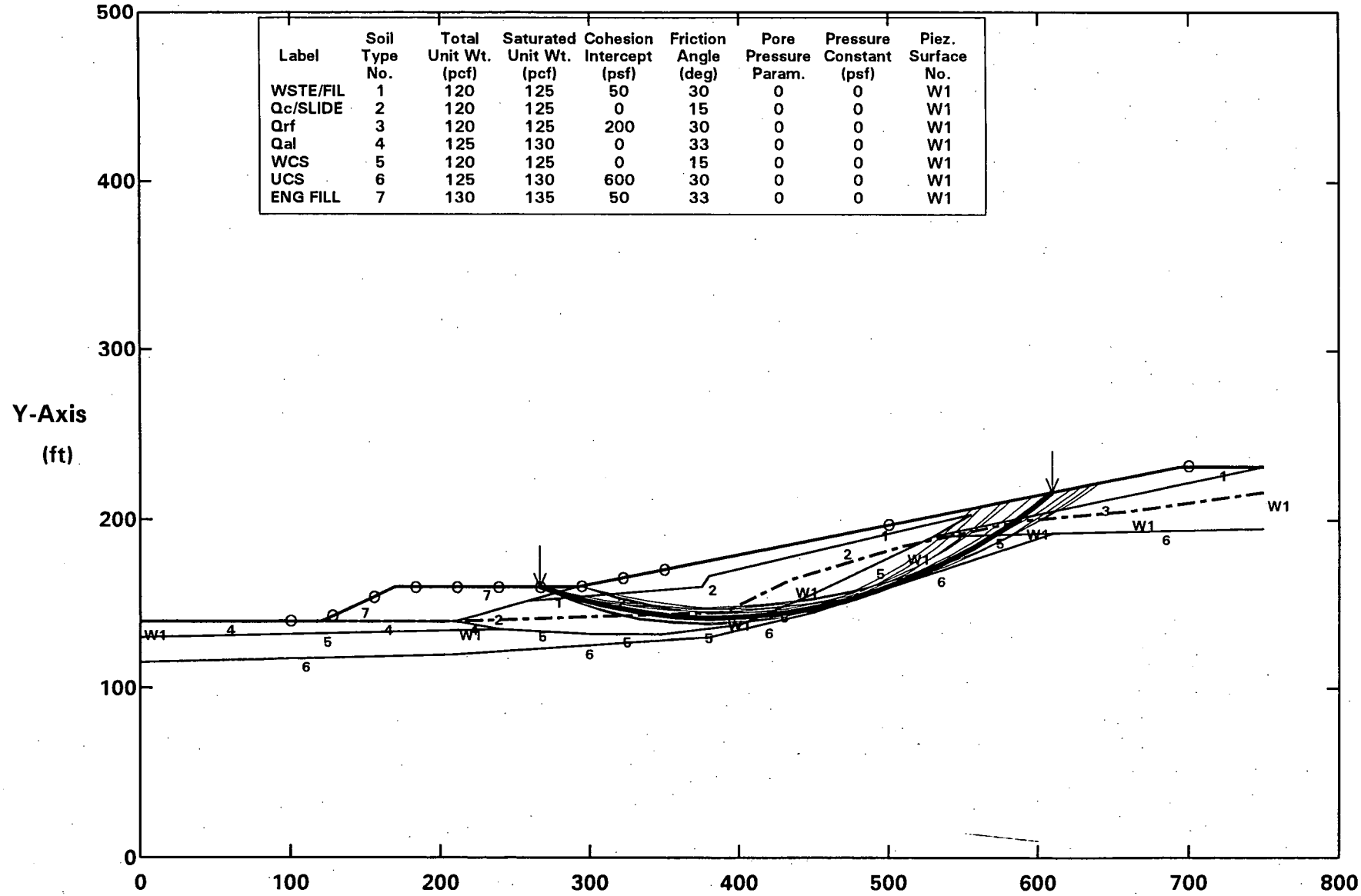
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.08g
All surfaces evaluated. C:CBHC08R.PLT By: STAN KLINE 04-13-05 10:38pm



Factors Of Safety Calculated By The Modified Bishop Method

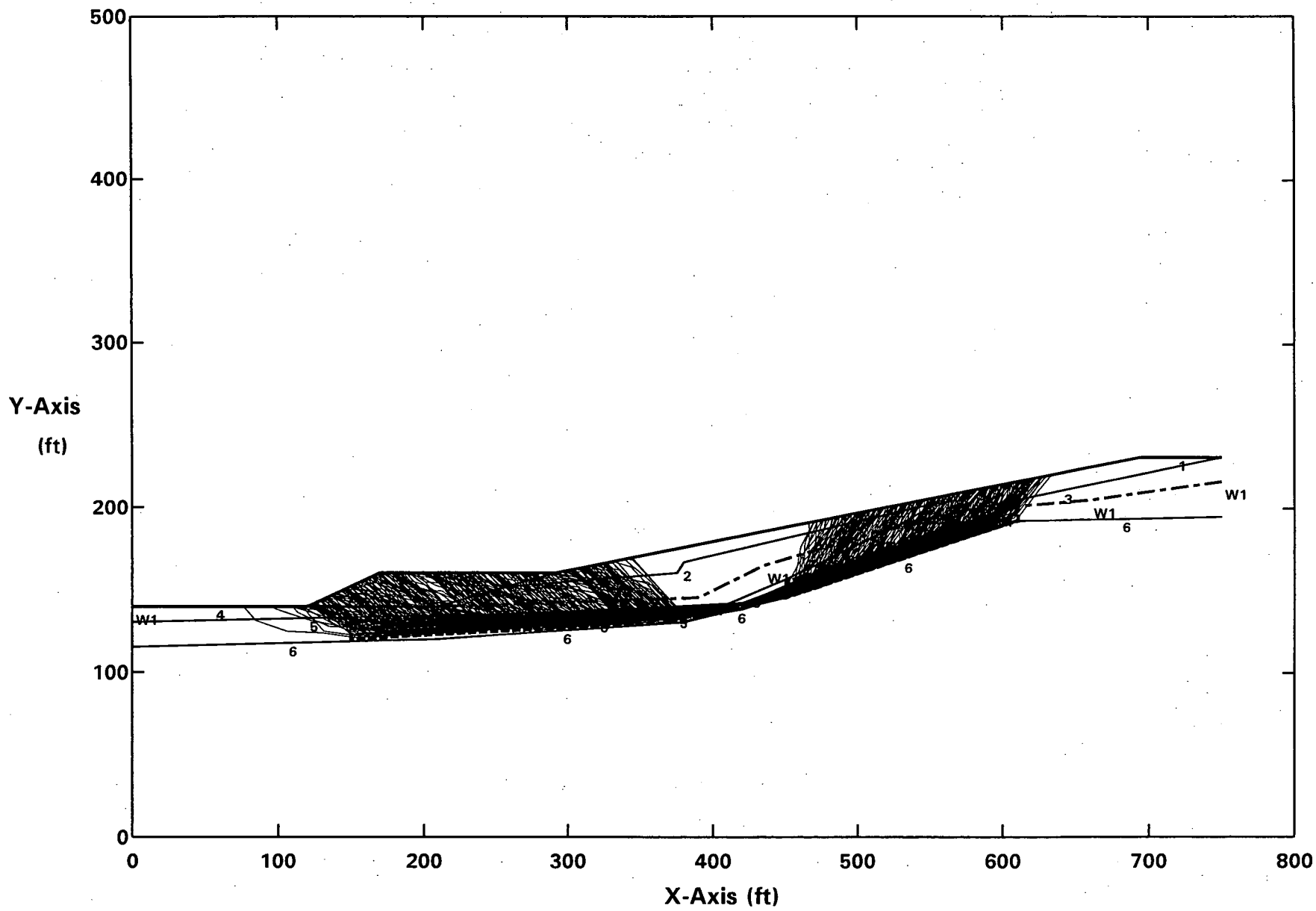
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.08g
Ten Most Critical. C:CBHC08R.PLT By: STAN KLINE 04-13-05 10:38pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



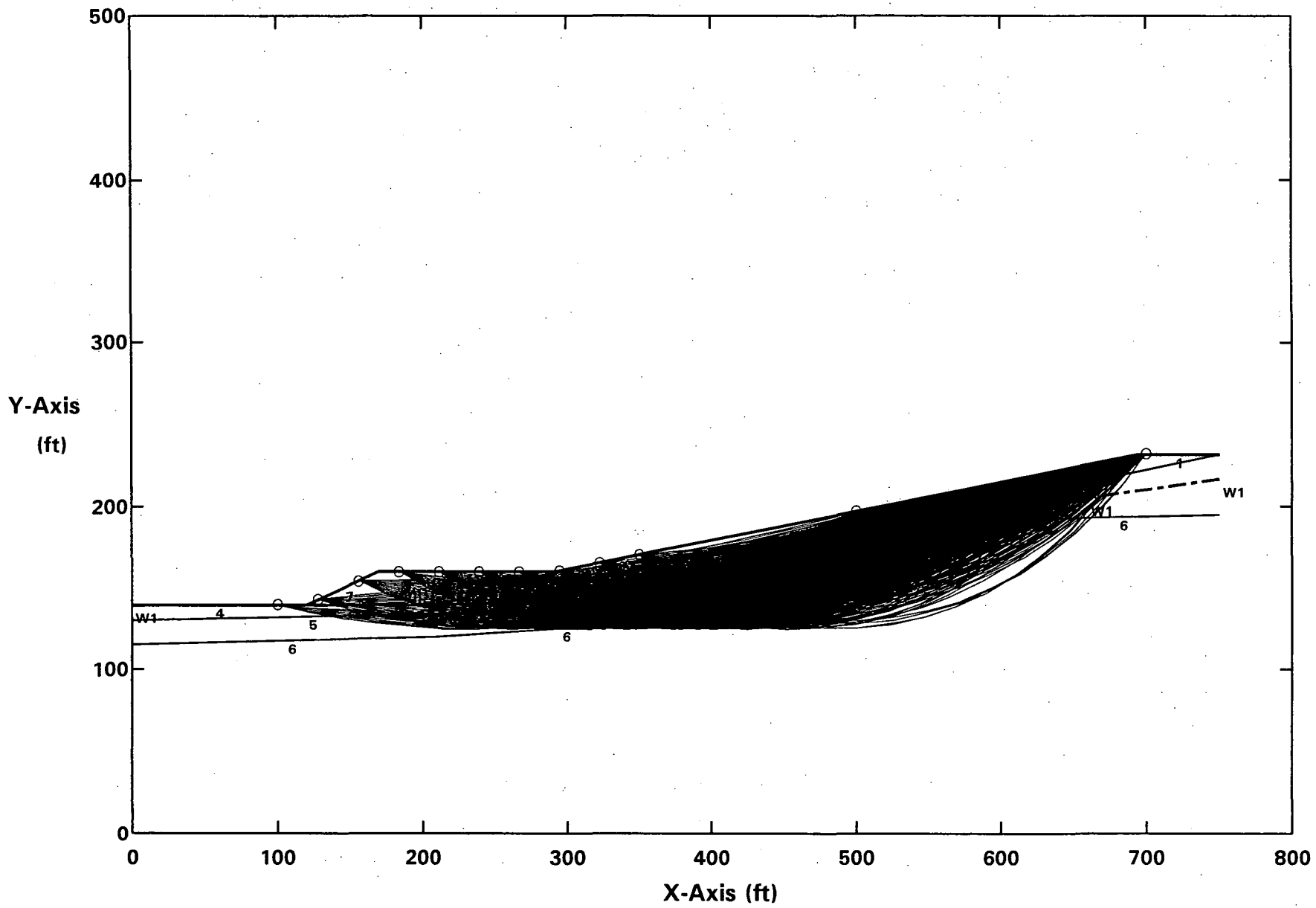
PCSTABL5M/SI FSmin = 1.01 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:CBHS06R.PLT By: STAN KLINE 04-13-05 10:46pm



Factors Of Safety Calculated By The Modified Janbu Method

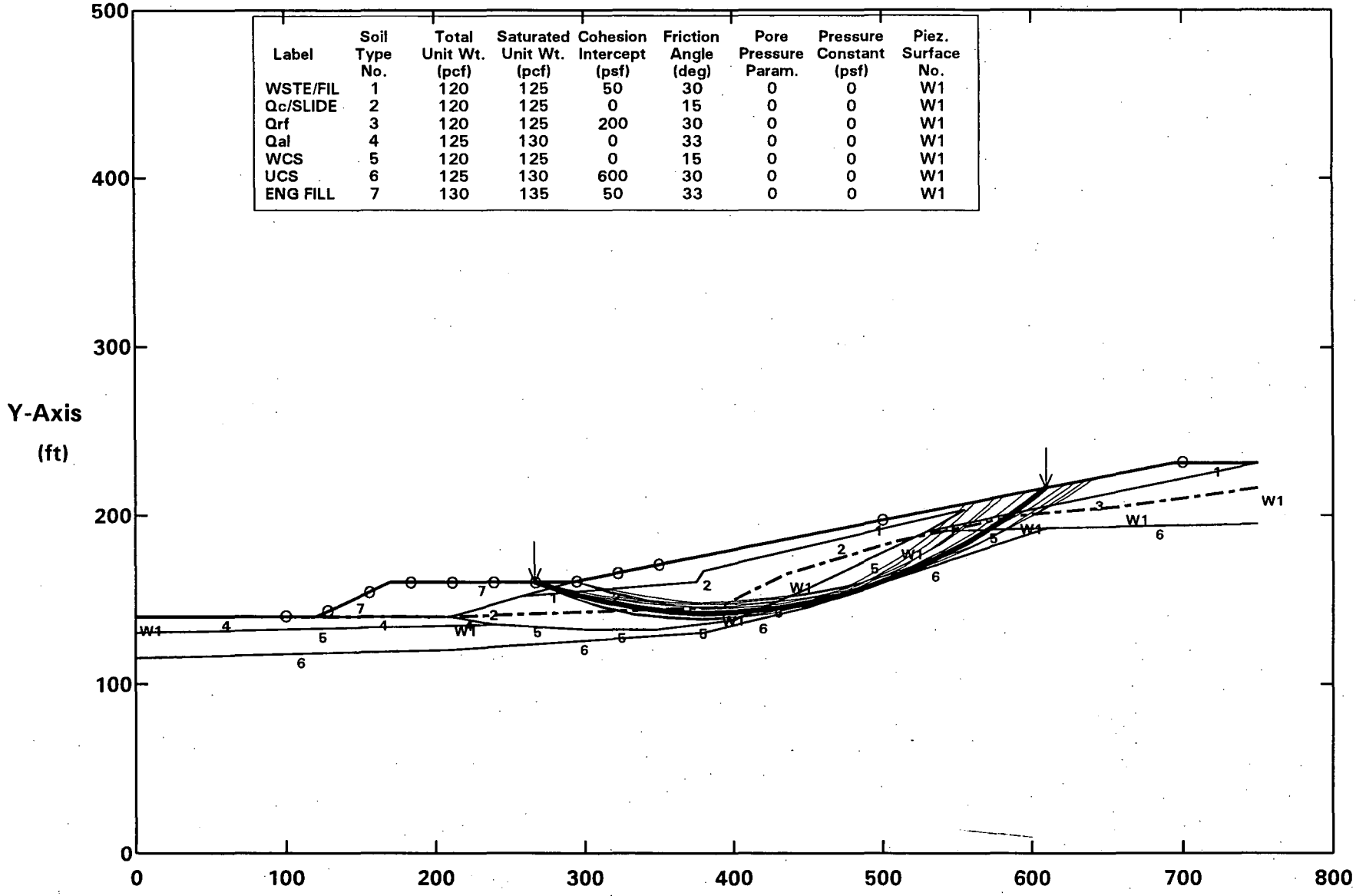
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:CBHC06R.PLT By: STAN KLINE 04-13-05 10:39pm



Factors Of Safety Calculated By The Modified Bishop Method

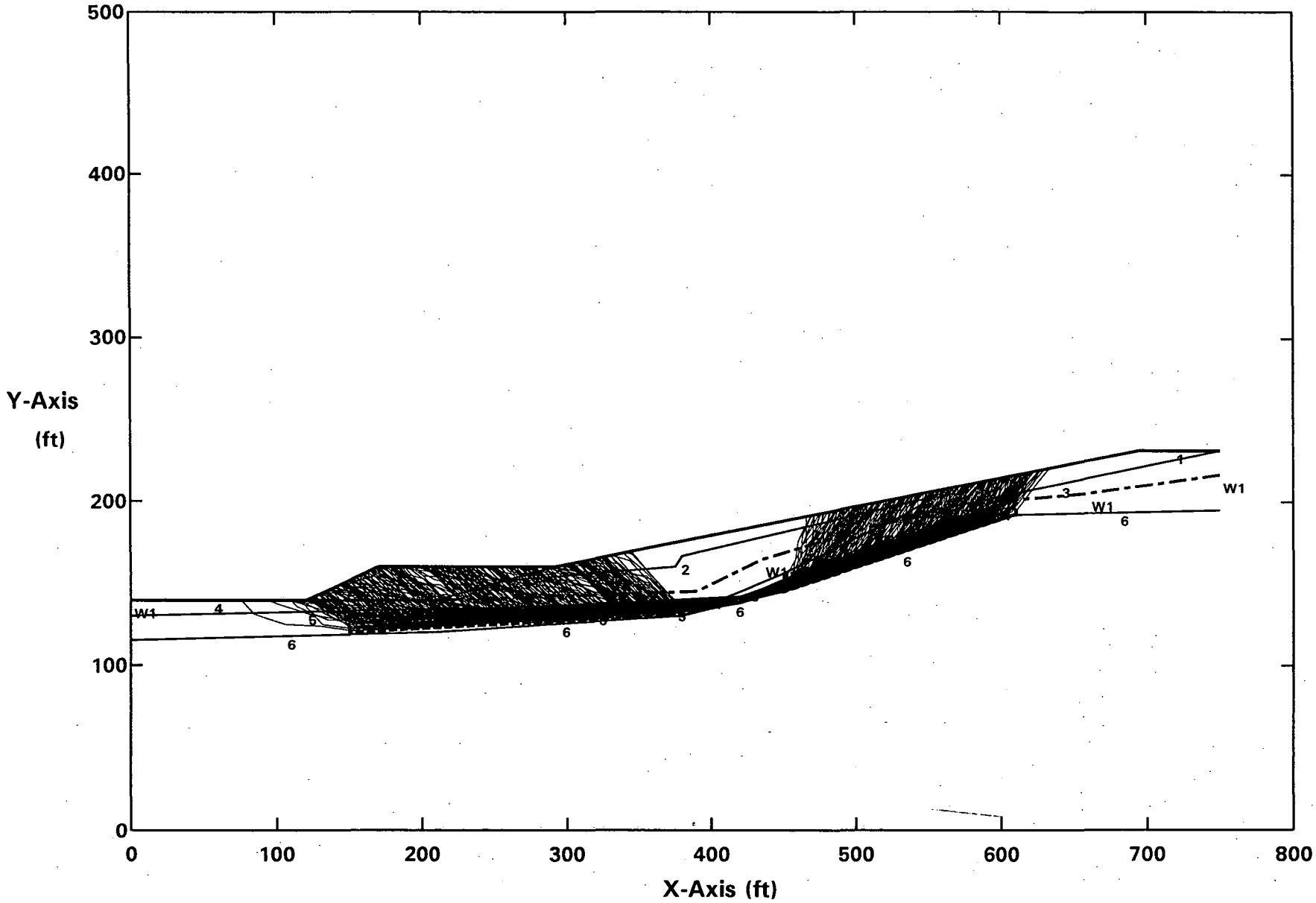
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:CBHC06R.PLT By: STAN KLINE 04-13-05 10:39pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.10 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

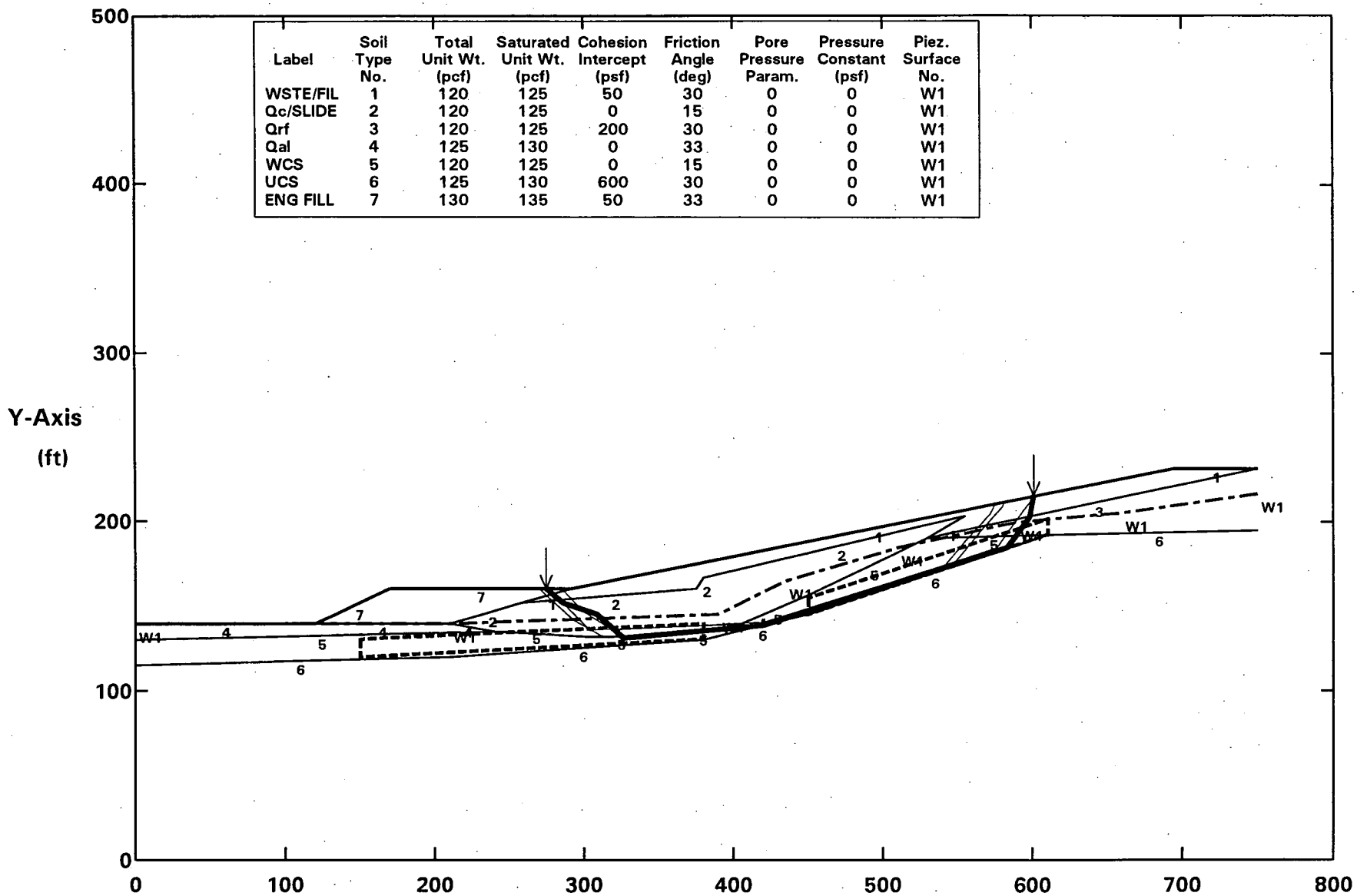
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.08g
All surfaces evaluated. C:CBHS08R.PLT By: STAN KLINE 04-13-05 10:44pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.08g
Ten Most Critical. C:CBHS08R.PLT By: STAN KLINE 04-13-05 10:44pm

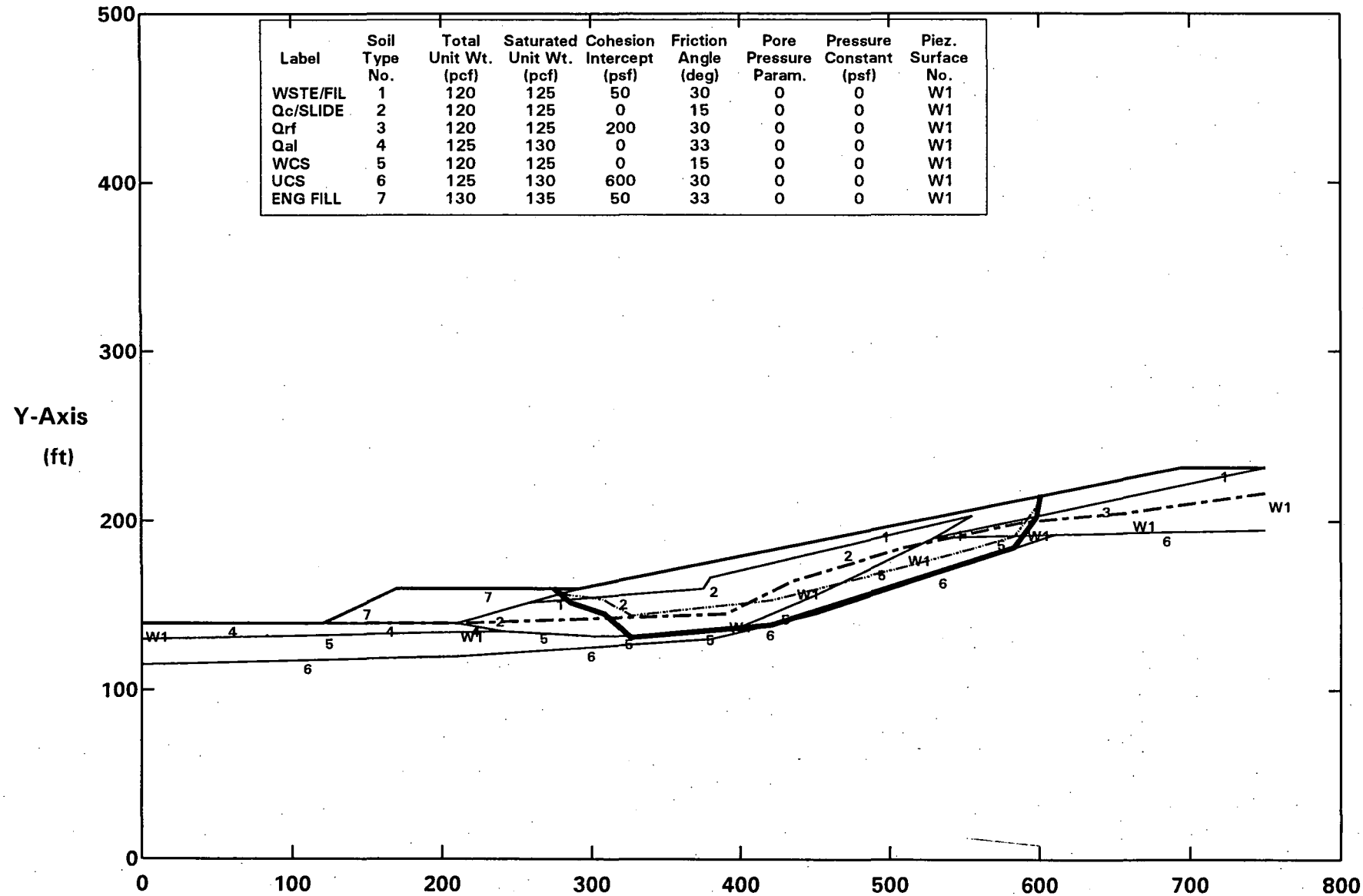
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.95 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.08g
Surface #1-CBHS08R.OUT. C:CBHS08RS.PLT By: STAN KLINE 04-13-05 10:45pm

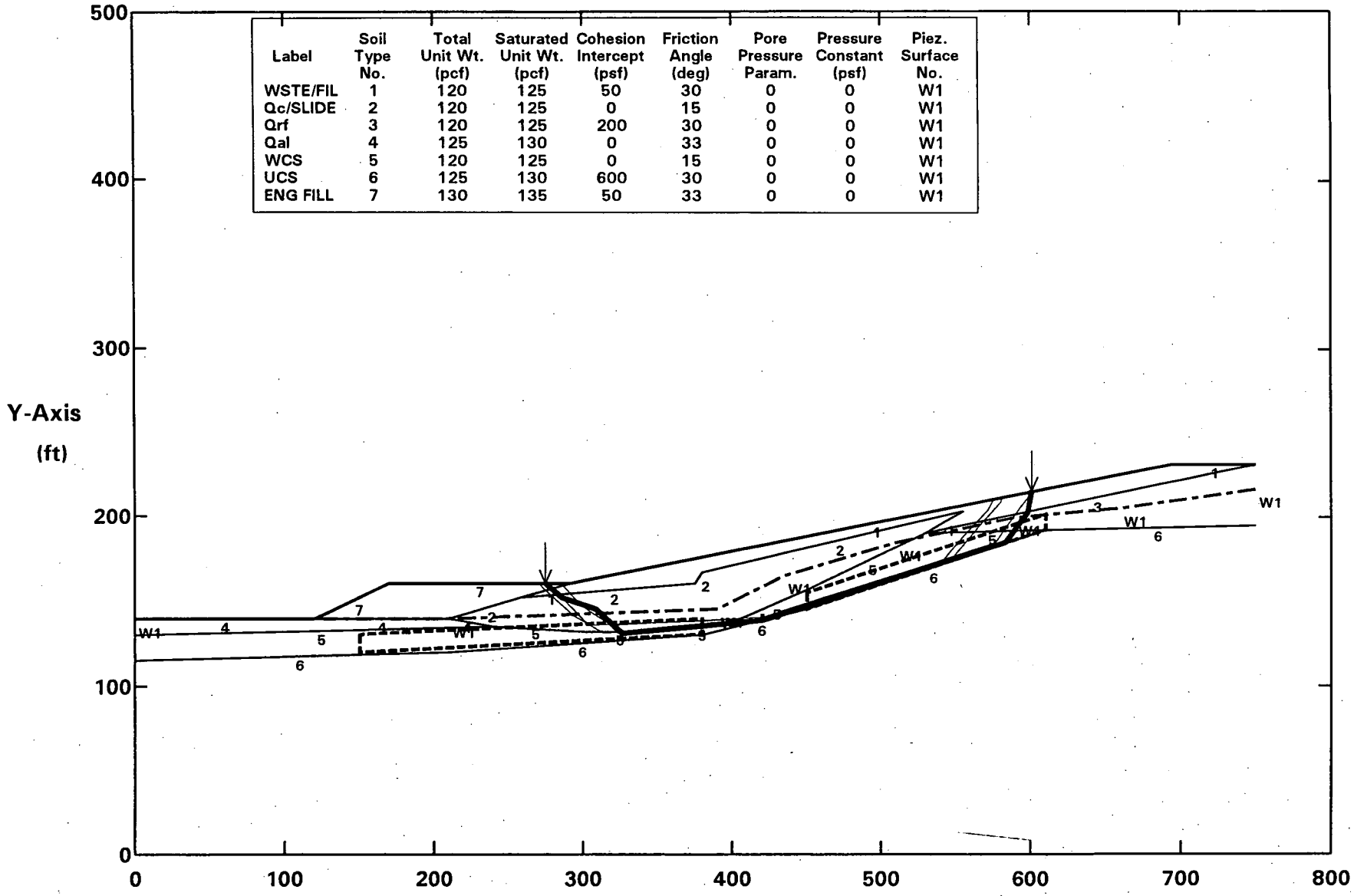
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS = 1.02 Theta = 7.42 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Ten Most Critical. C:CBHS06R.PLT By: STAN KLINE 04-13-05 10:46pm

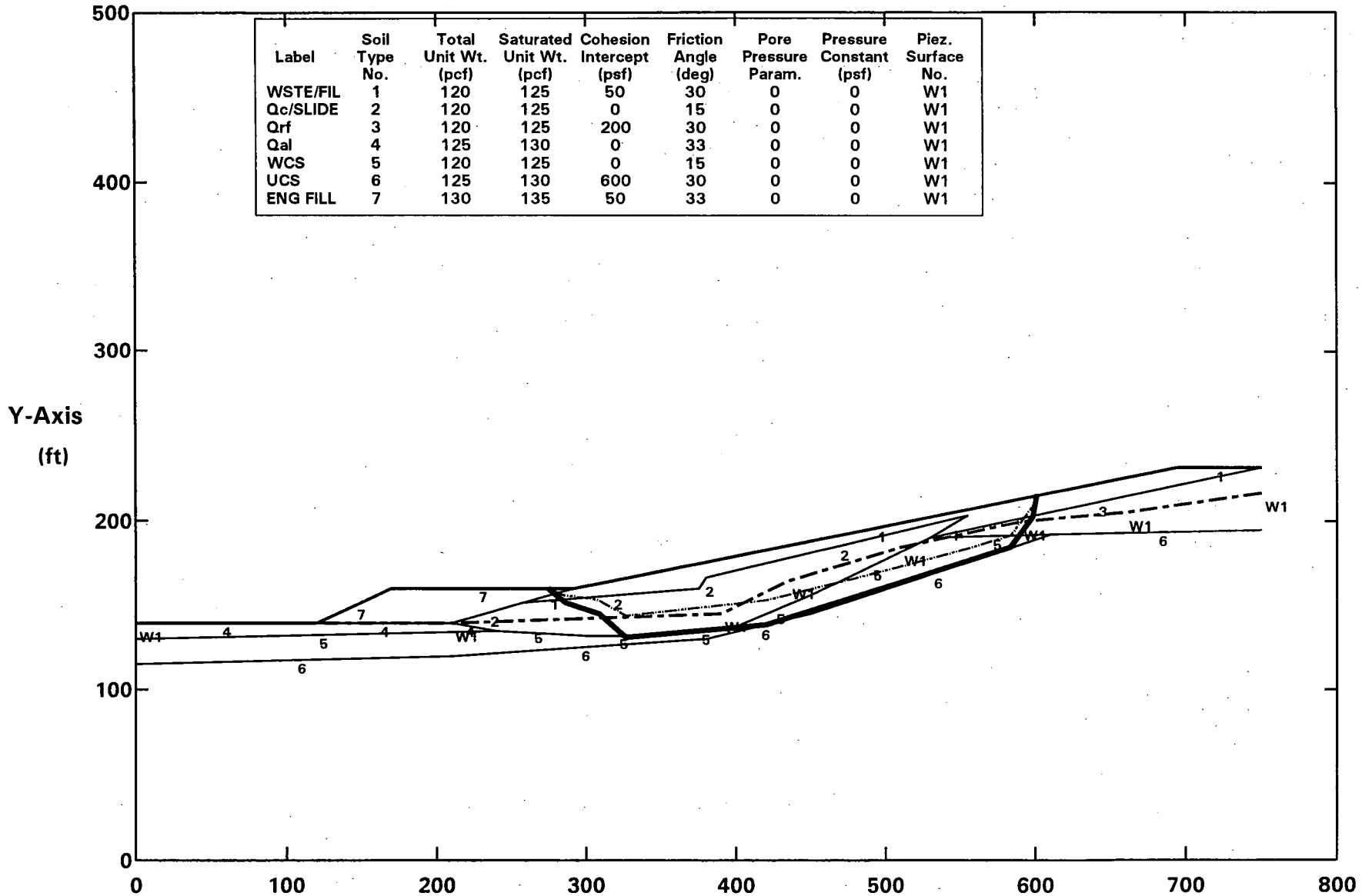
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.04 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

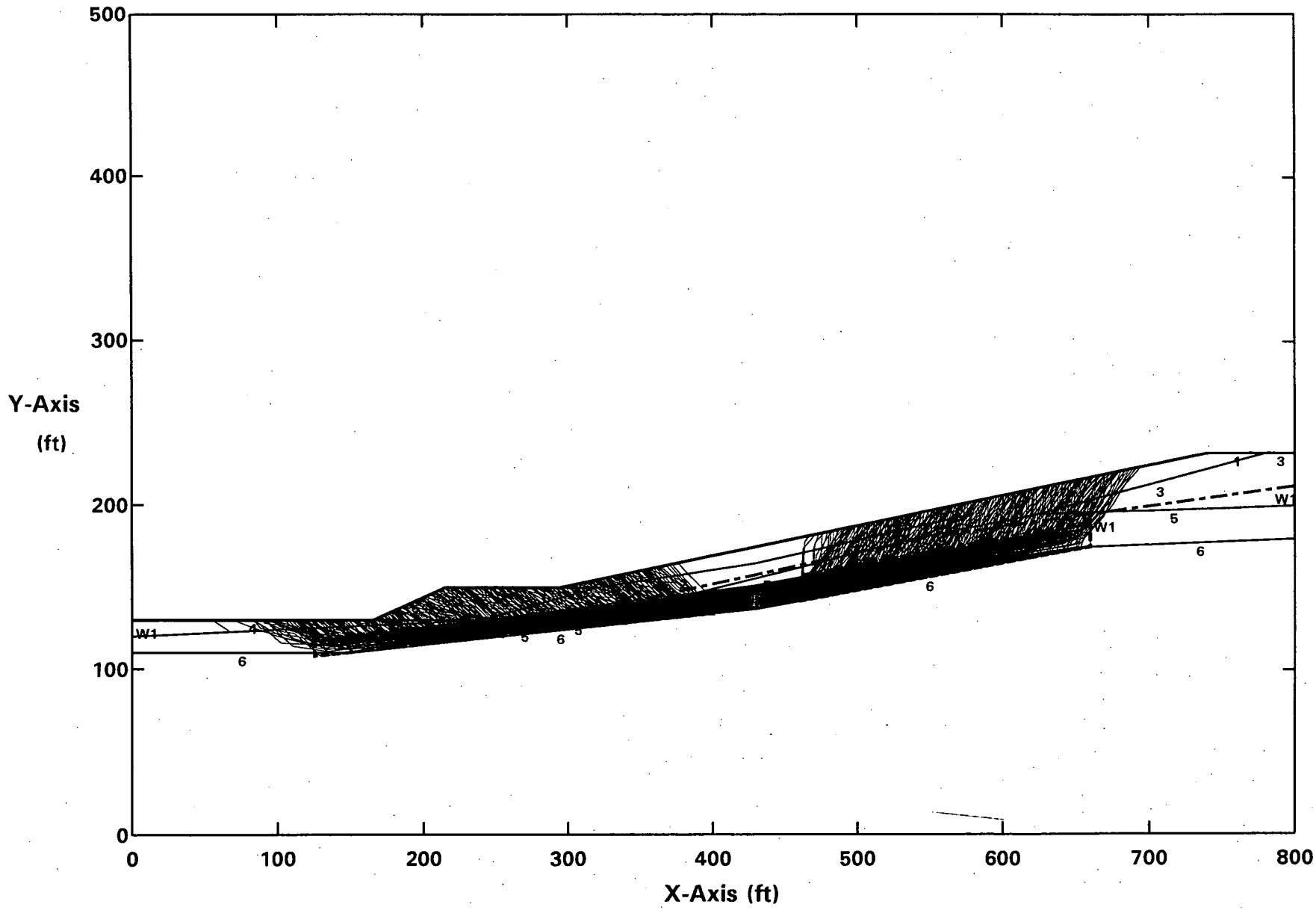
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-CBHS06R.OUT. C:CBHS06RS.PLT By: STAN KLINE 04-13-05 10:47pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS = 1.11 Theta = 7.57 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

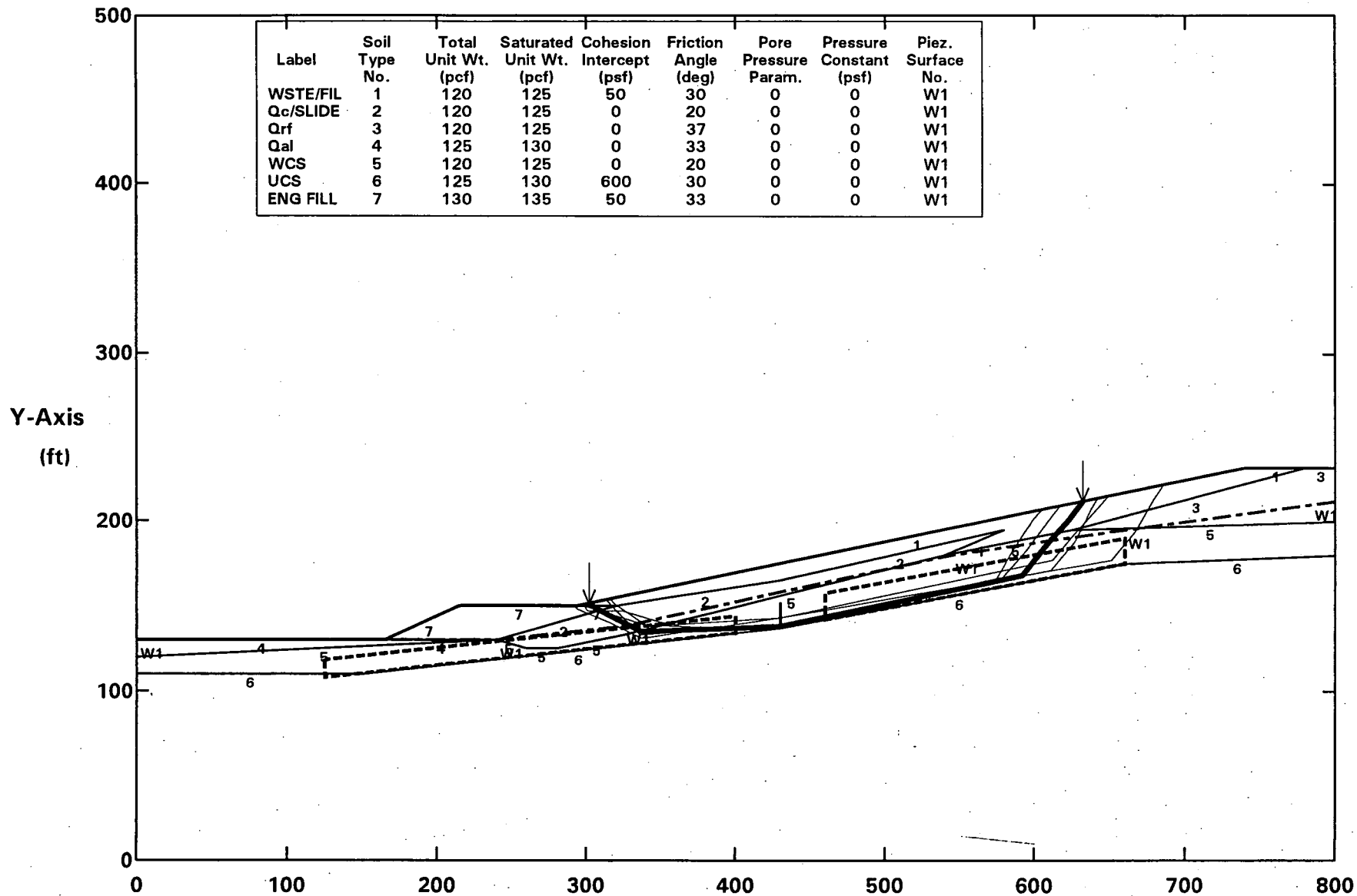
ROCKY FLATS OLF - M&E D 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:DBHSSR.PLT By: STAN KLINE 04-13-05 10:54pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Ten Most Critical. C:DBHSSR.PLT By: STAN KLINE 04-13-05 10:54pm

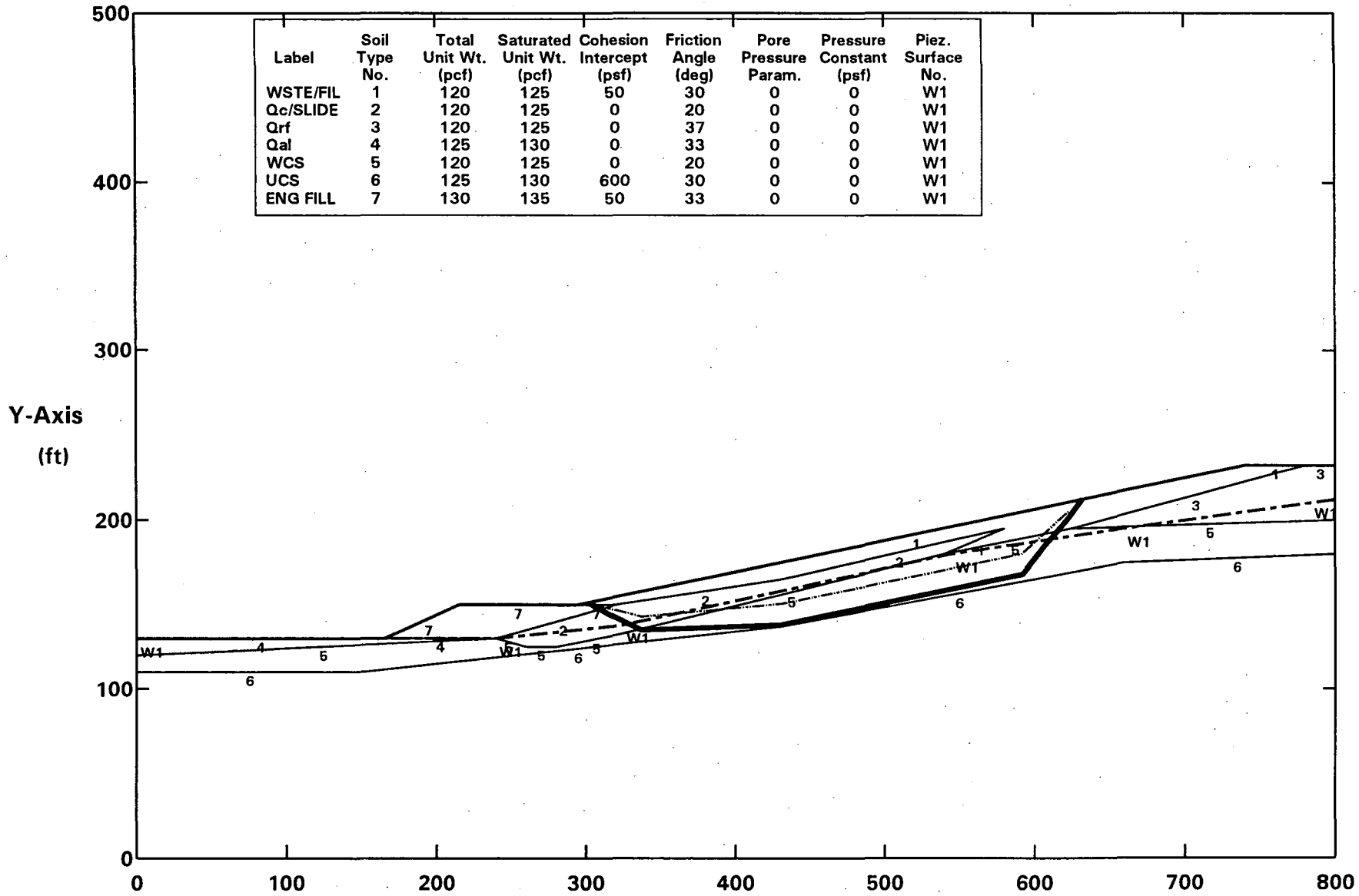
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin=1.67 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

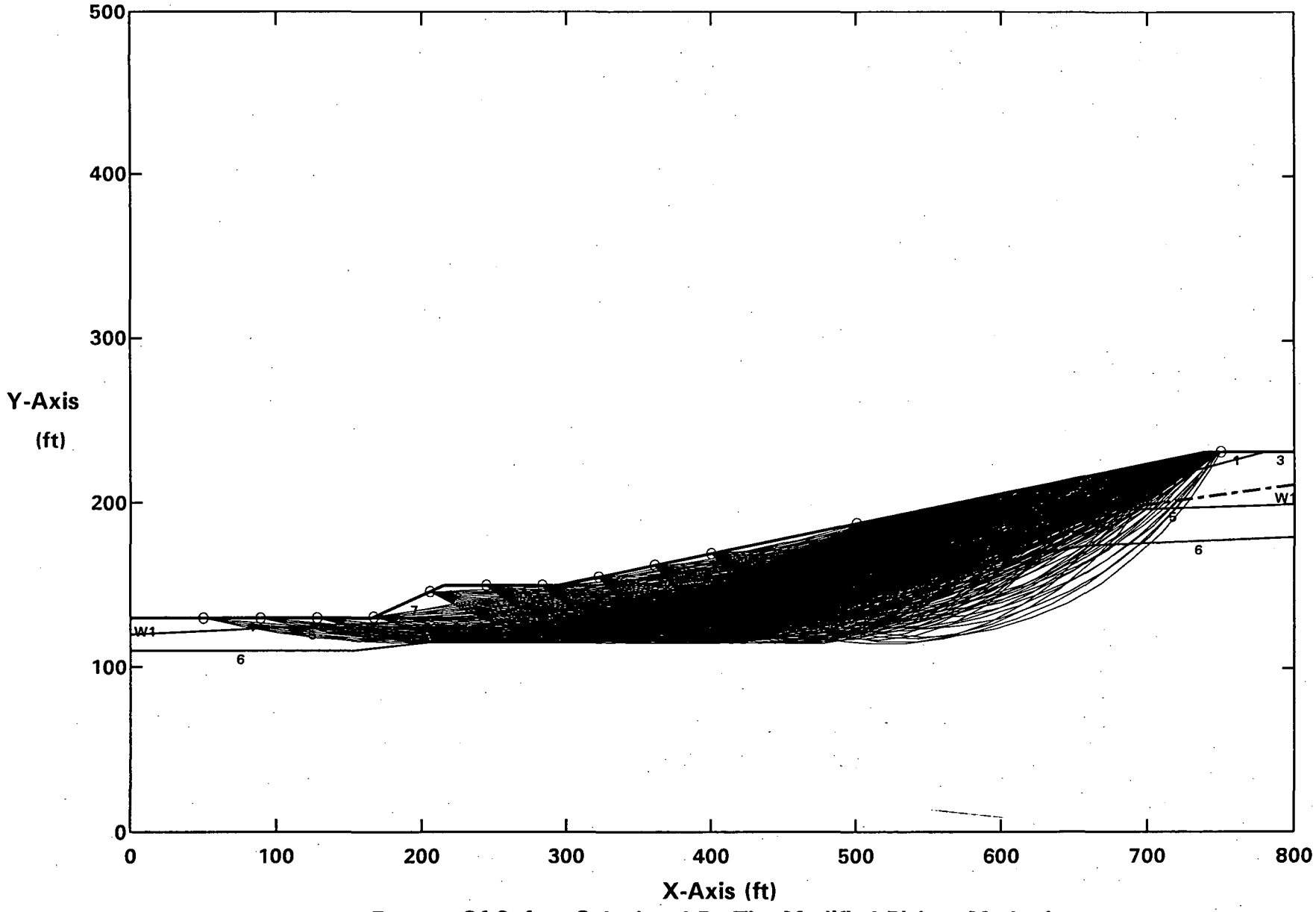
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20 deg - W/HIGHGW--SLIDING BLOCK - STATIC
Surface #1-DBHSSR.OUT. C:DBHSSRS.PLT By: STAN KLINE 04-13-05 10:55pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



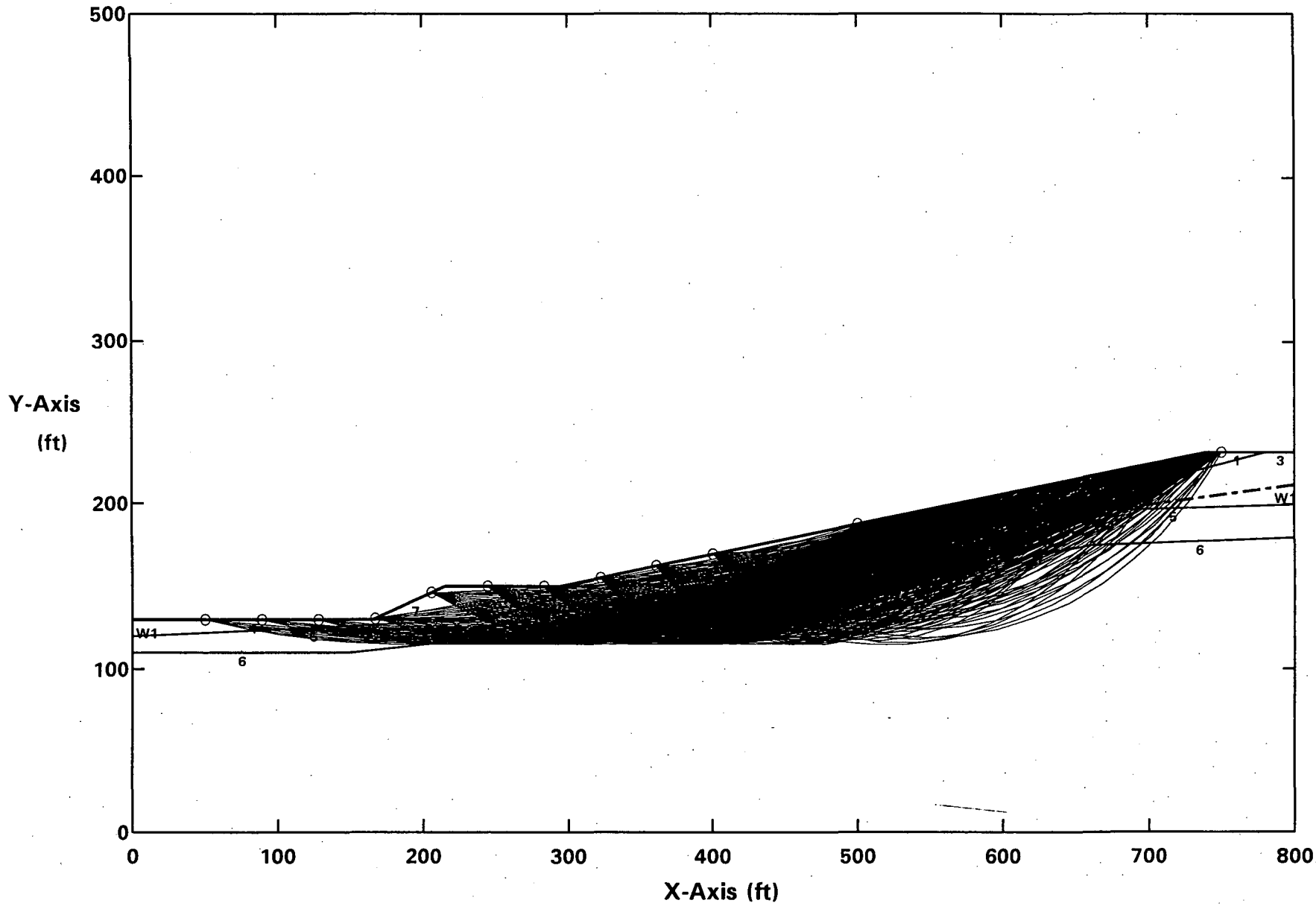
PCSTABL5M/SI FS = 1.78 Theta = 8.87 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:DBHC06R.PLT By: STAN KLINE 04-13-05 10:56pm



Factors Of Safety Calculated By The Modified Bishop Method

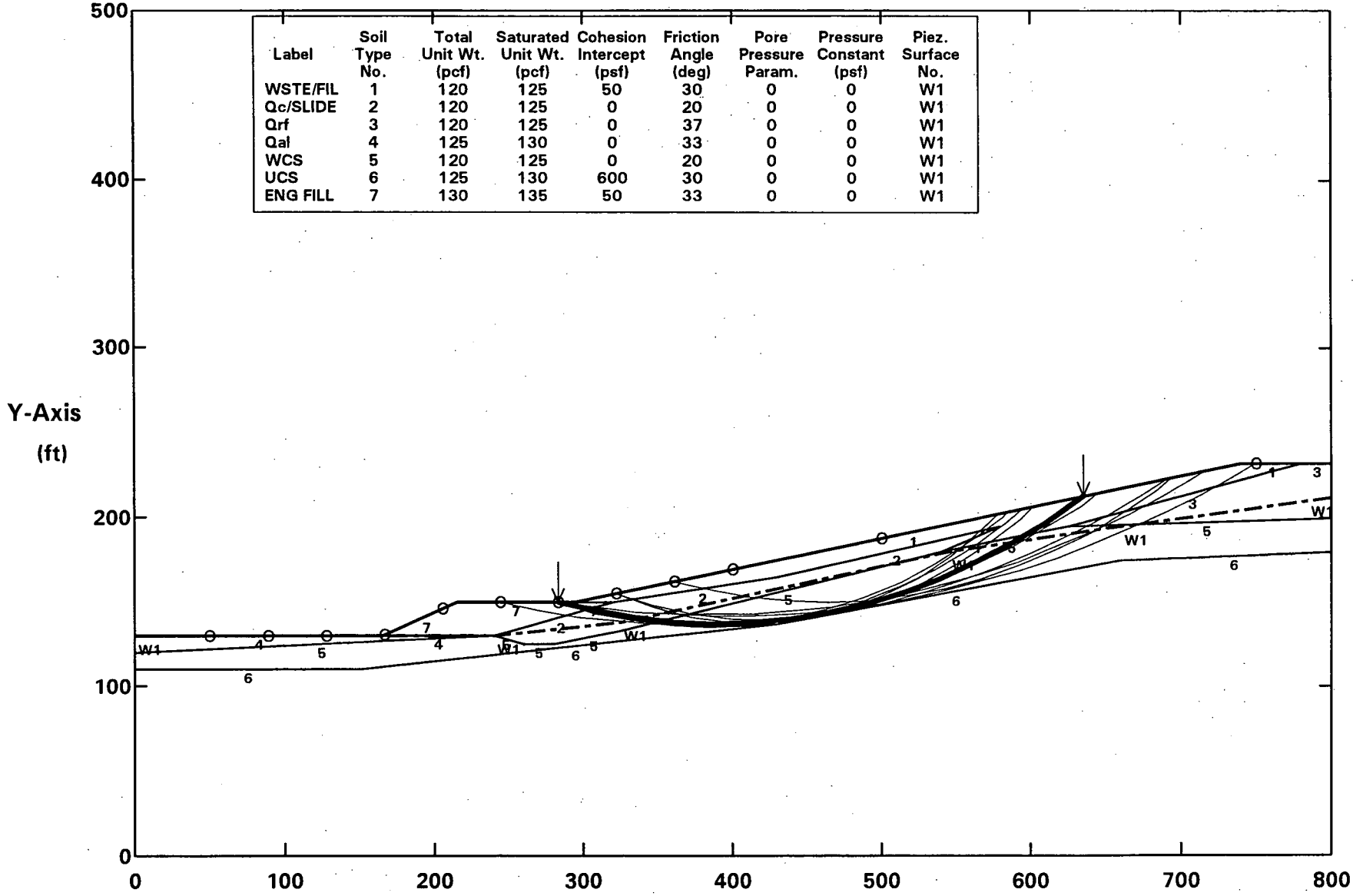
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:DBHCSR.PLT By: STAN KLINE 04-13-05 10:52pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:DBHCSR.PLT By: STAN KLINE 04-13-05 10:52pm

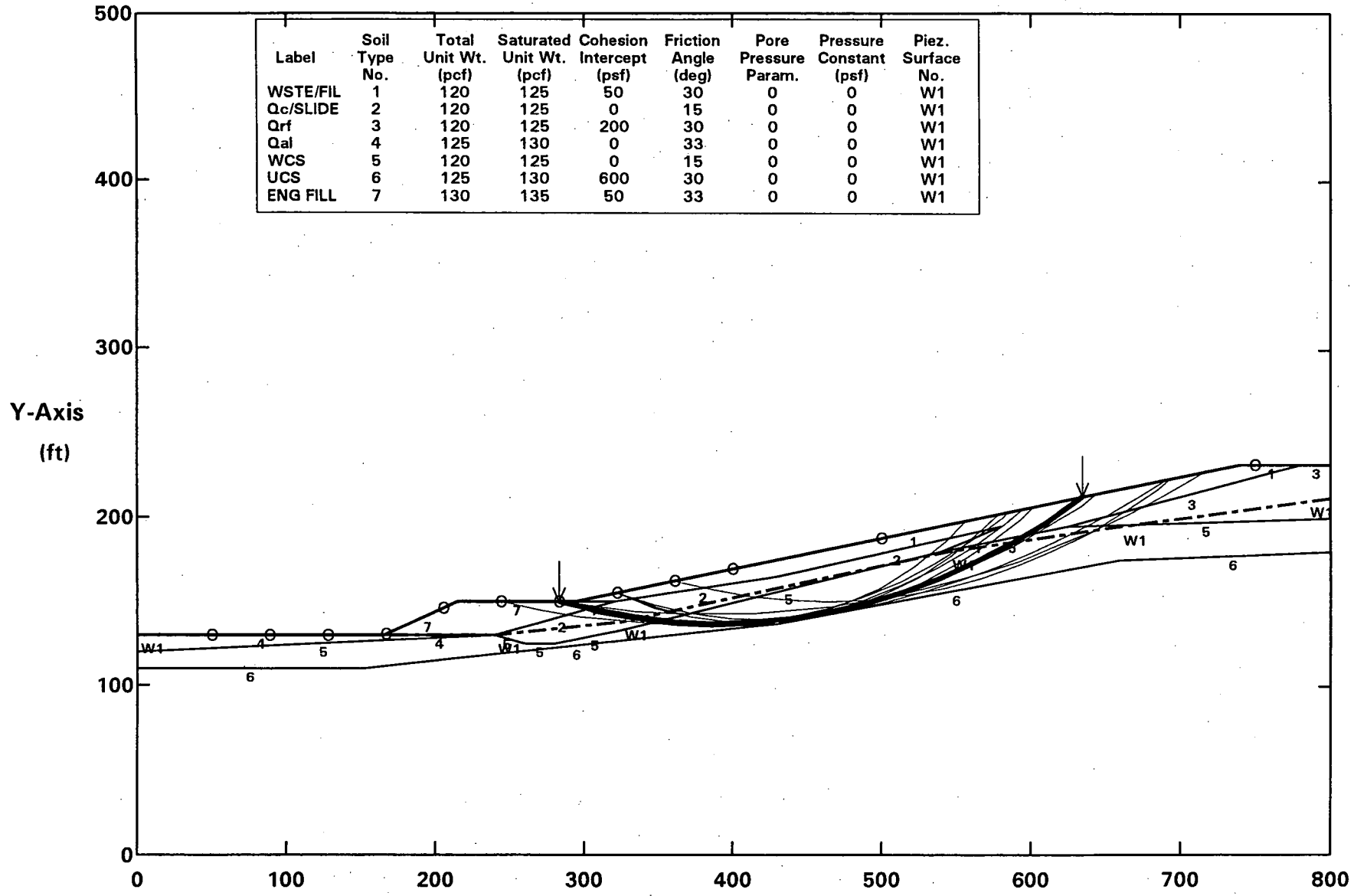
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.76 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

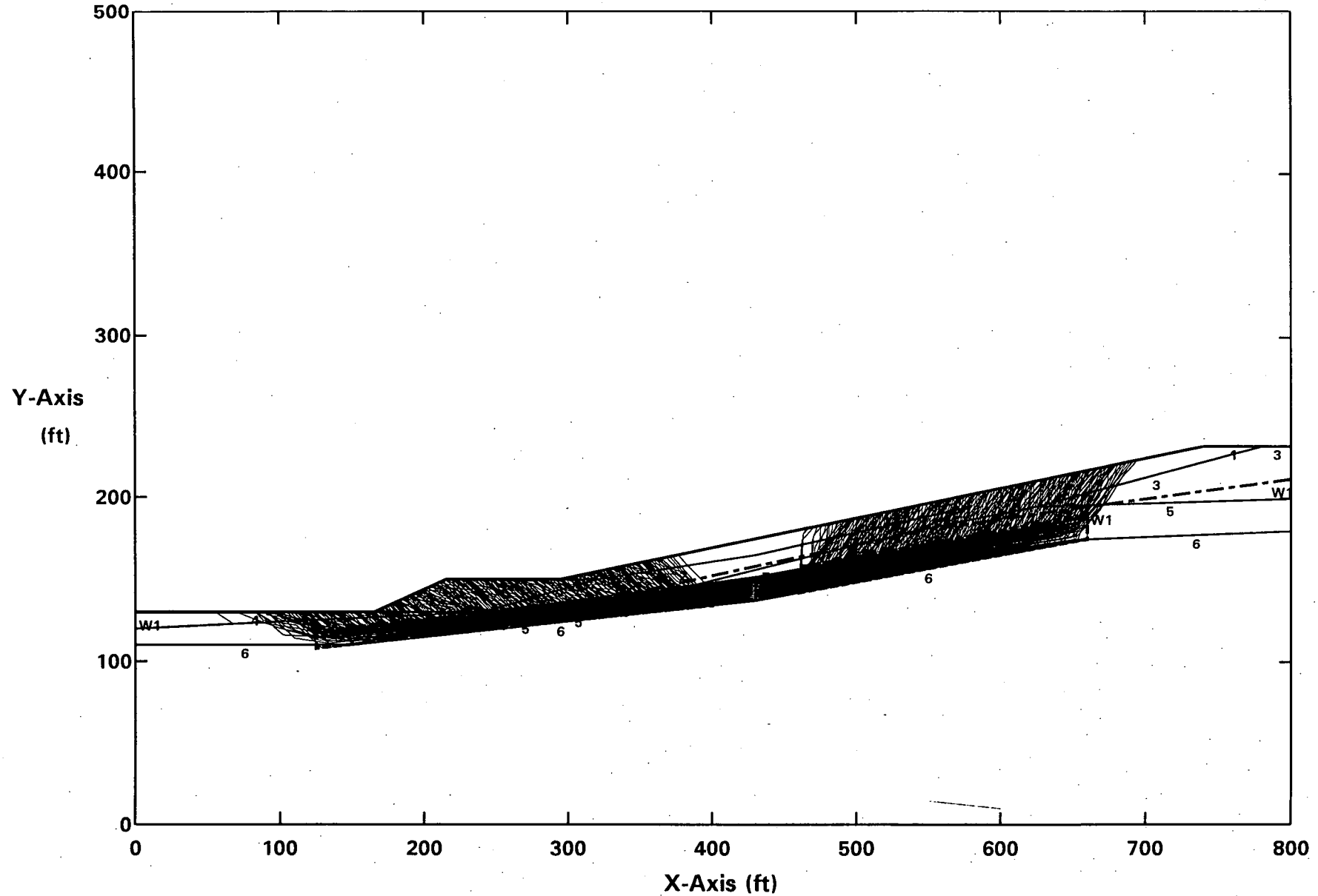
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.05g
Ten Most Critical. C:DBHC05R.PLT By: STAN KLINE 04-13-05 10:59pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.03 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

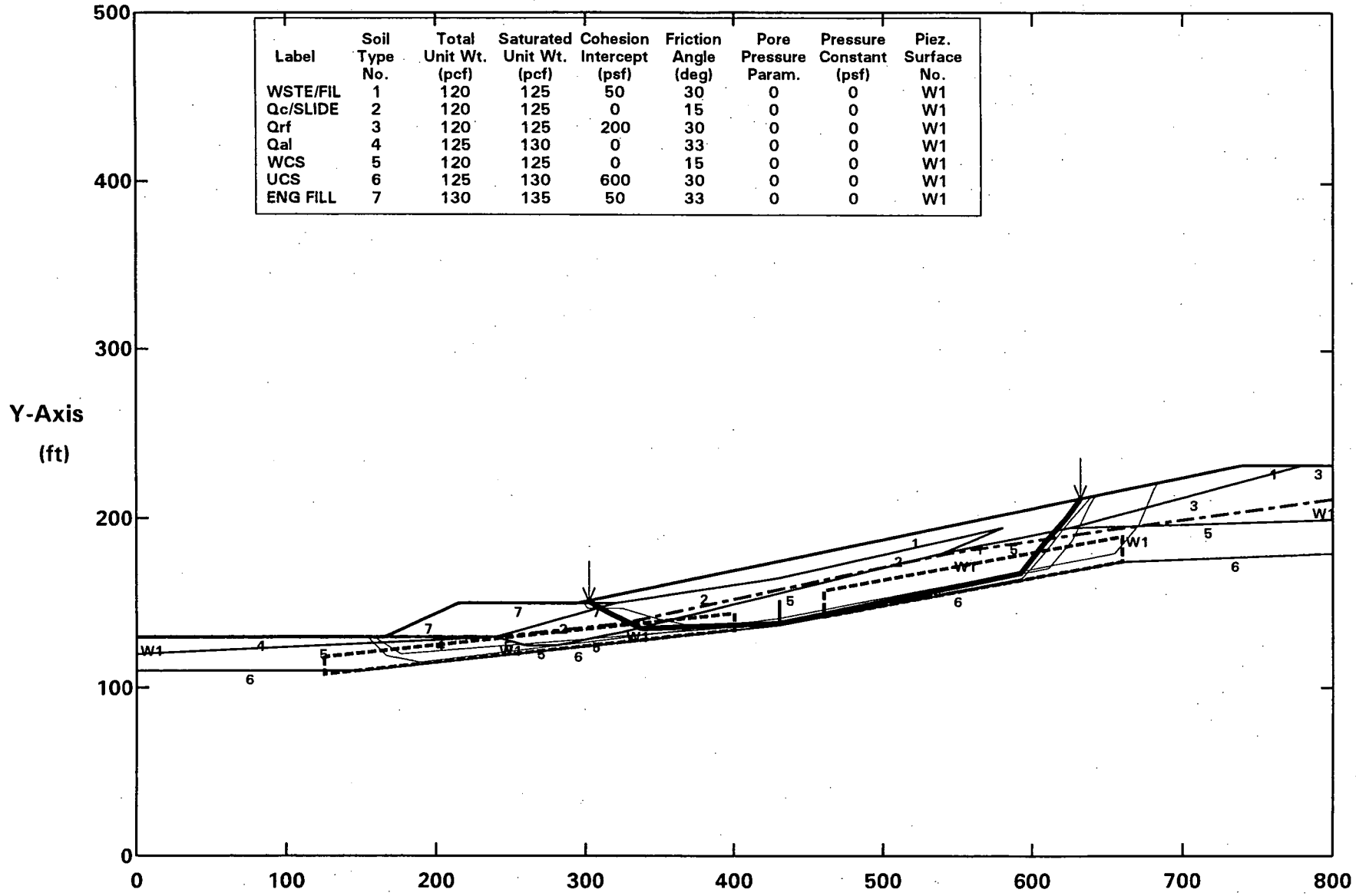
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:DBHS06R.PLT By: STAN KLINE 04-13-05 11:00pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Ten Most Critical. C:DBHS06R.PLT By: STAN KLINE 04-13-05 11:00pm

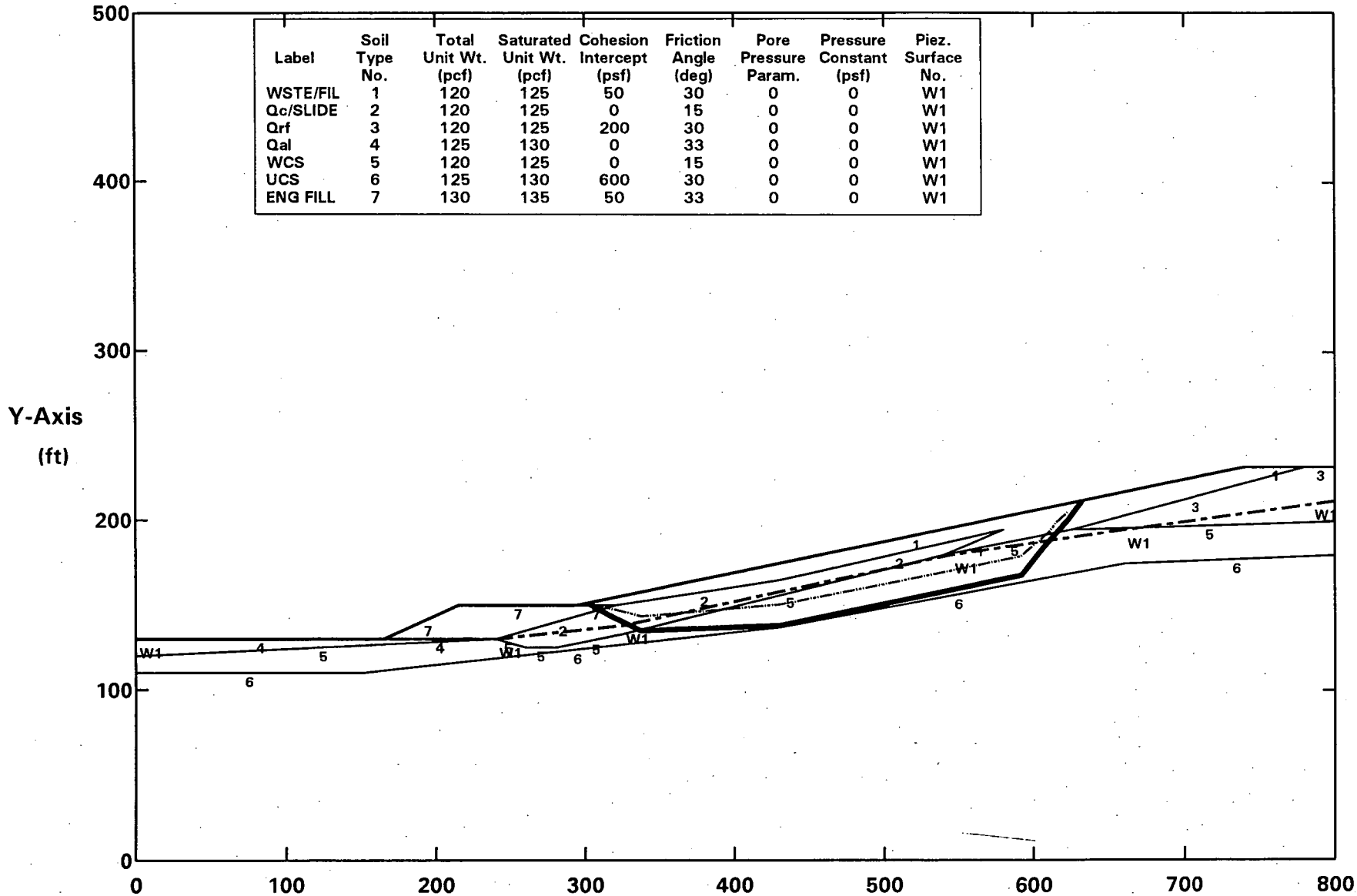
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.93 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-DBHS06R.OUT. C:DBHS06RS.PLT By: STAN KLINE 04-13-05 11:01pm

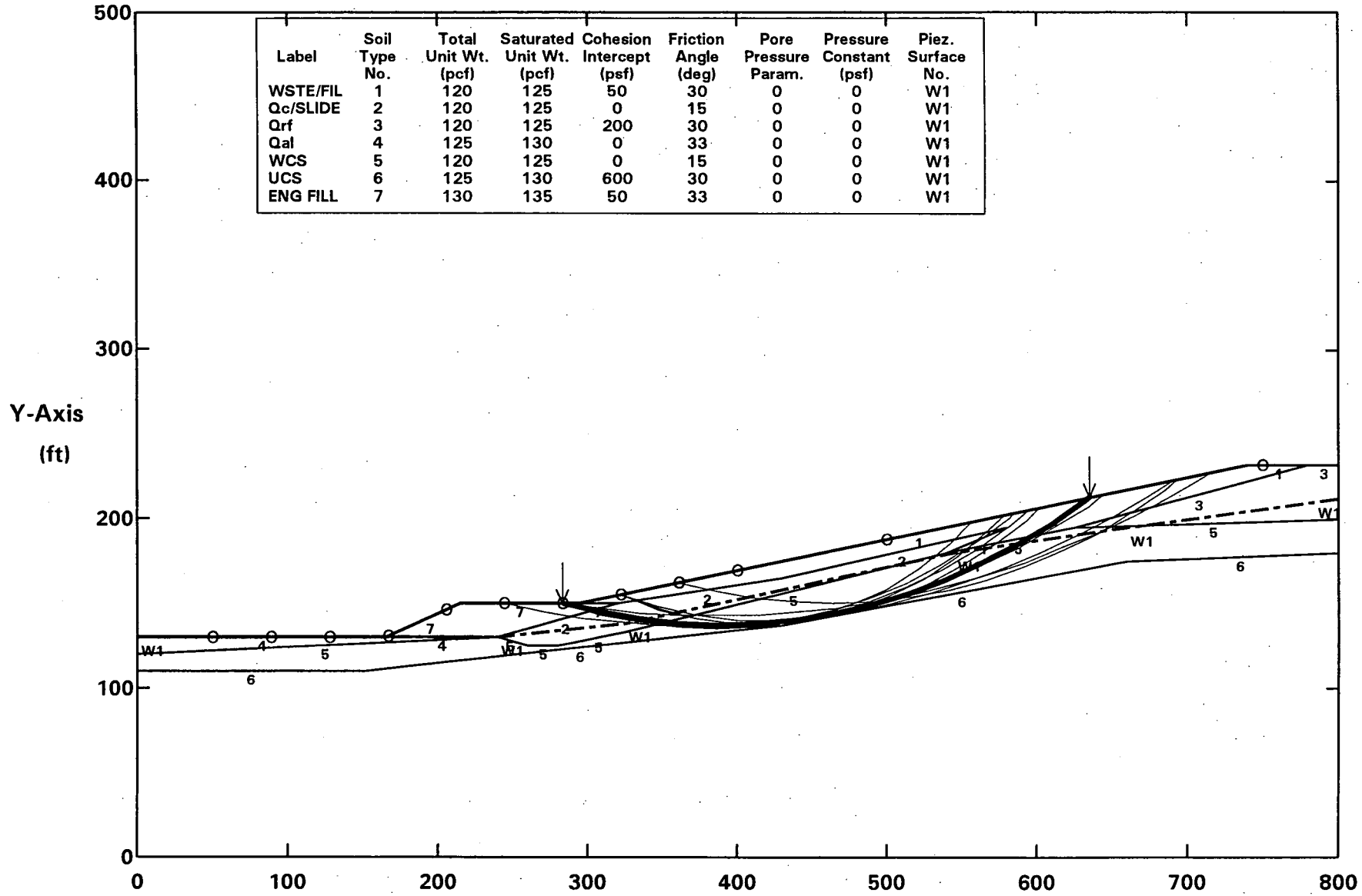
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS = 0.97 Theta = 8.17 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

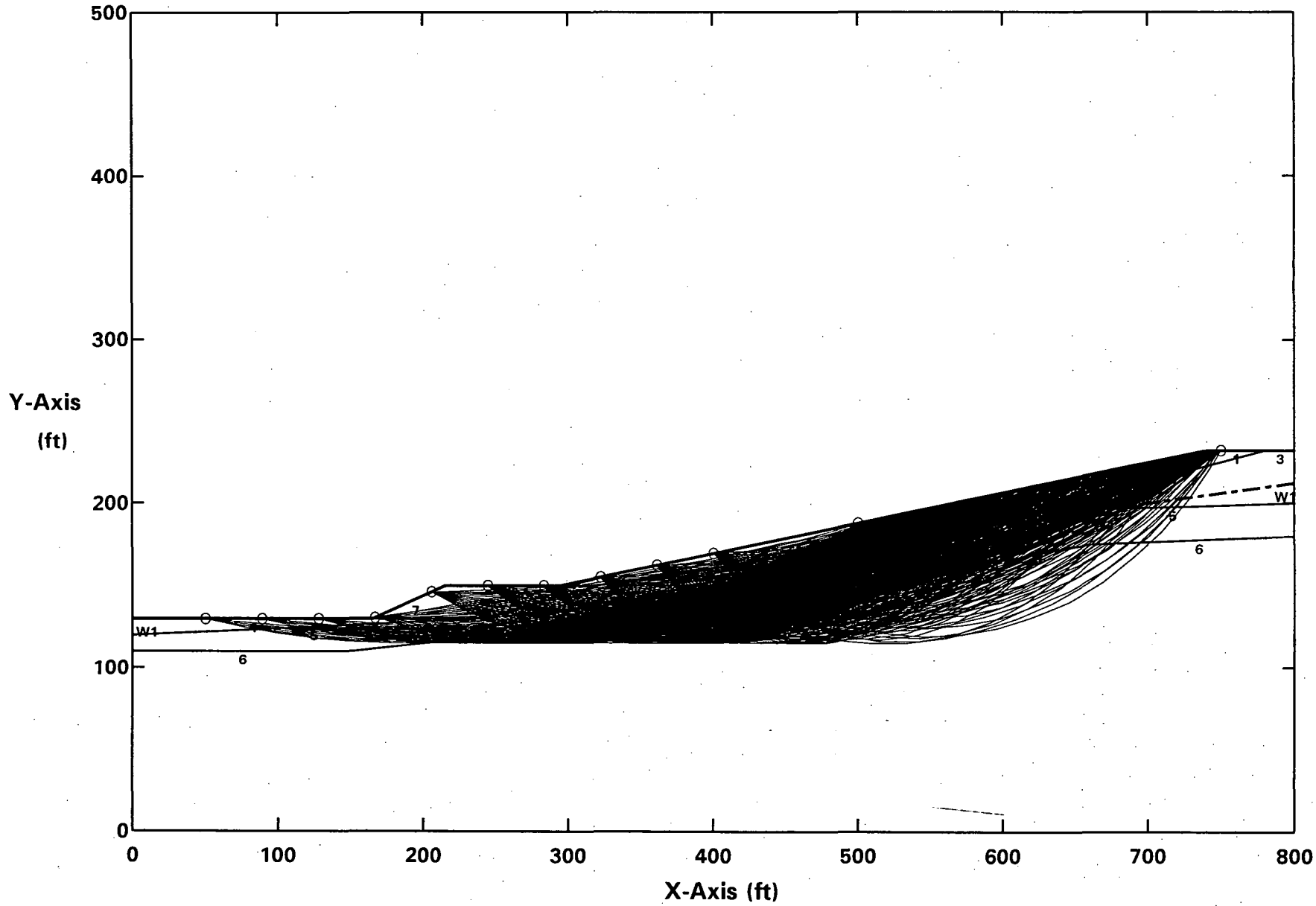
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:DBHC06R.PLT By: STAN KLINE 04-13-05 10:56pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.99 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

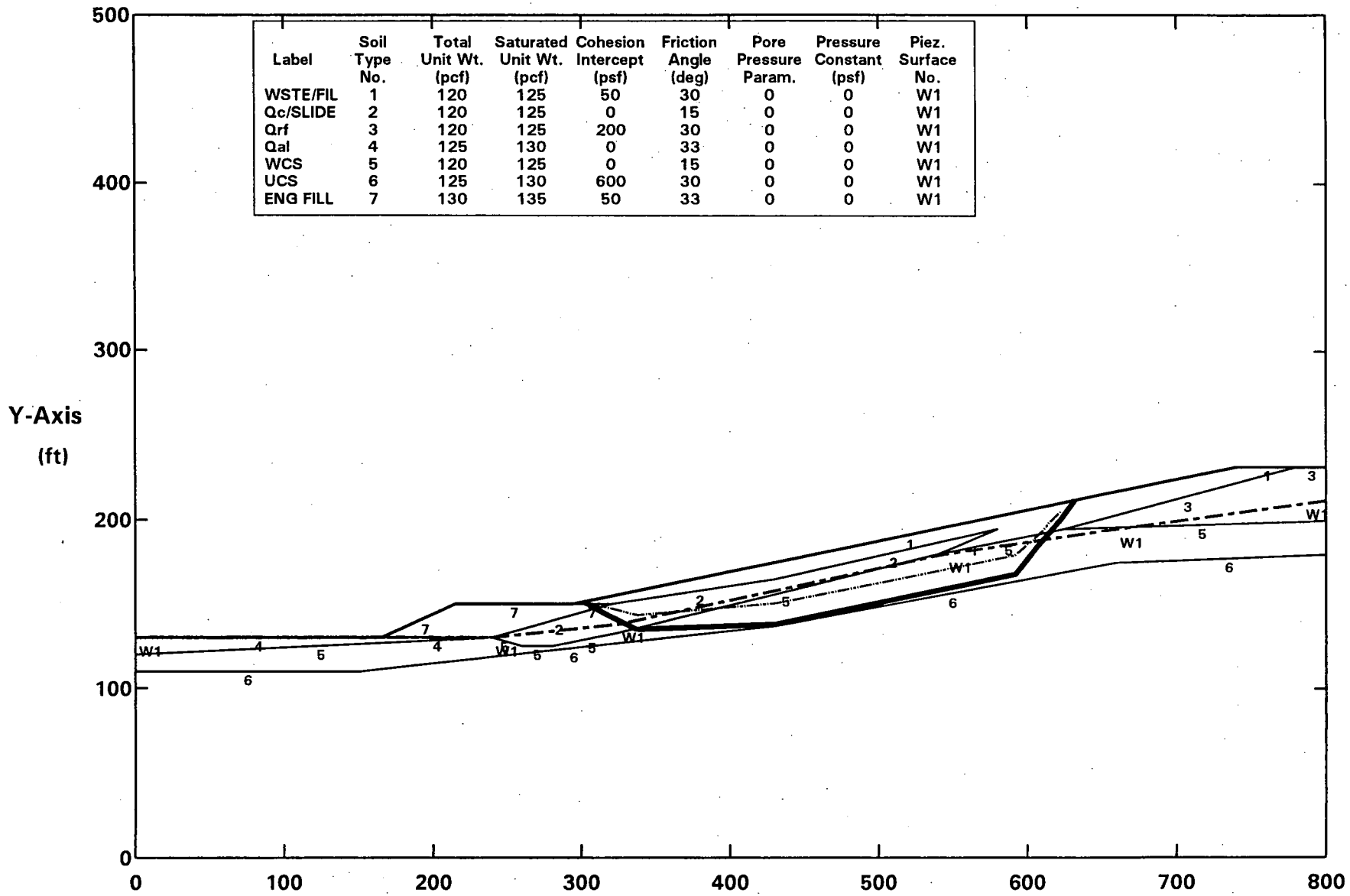
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.05g
All surfaces evaluated. C:DBHC05R.PLT By: STAN KLINE 04-13-05 10:59pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.05g
Surface #1-DBHS05R.OUT. C:DBHS05RS.PLT By: STAN KLINE 04-13-05 11:03pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FS = 1.02 Theta = 8.25 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

APPENDIX A

ATTACHMENT 6
COMPUTER RUNS – TOE/BUTTRESS STABILITY

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET

PAGE ____ OF ____

PROJECT NO. 57378.6030

CLIENT Kaiser Hill

SUBJECT Stability

Prepared By SAK DATE 3/5/05

PROJECT Rocky Flats OLF

CHECK FOR GRADING PLAN DESIGN REFINEMENTS

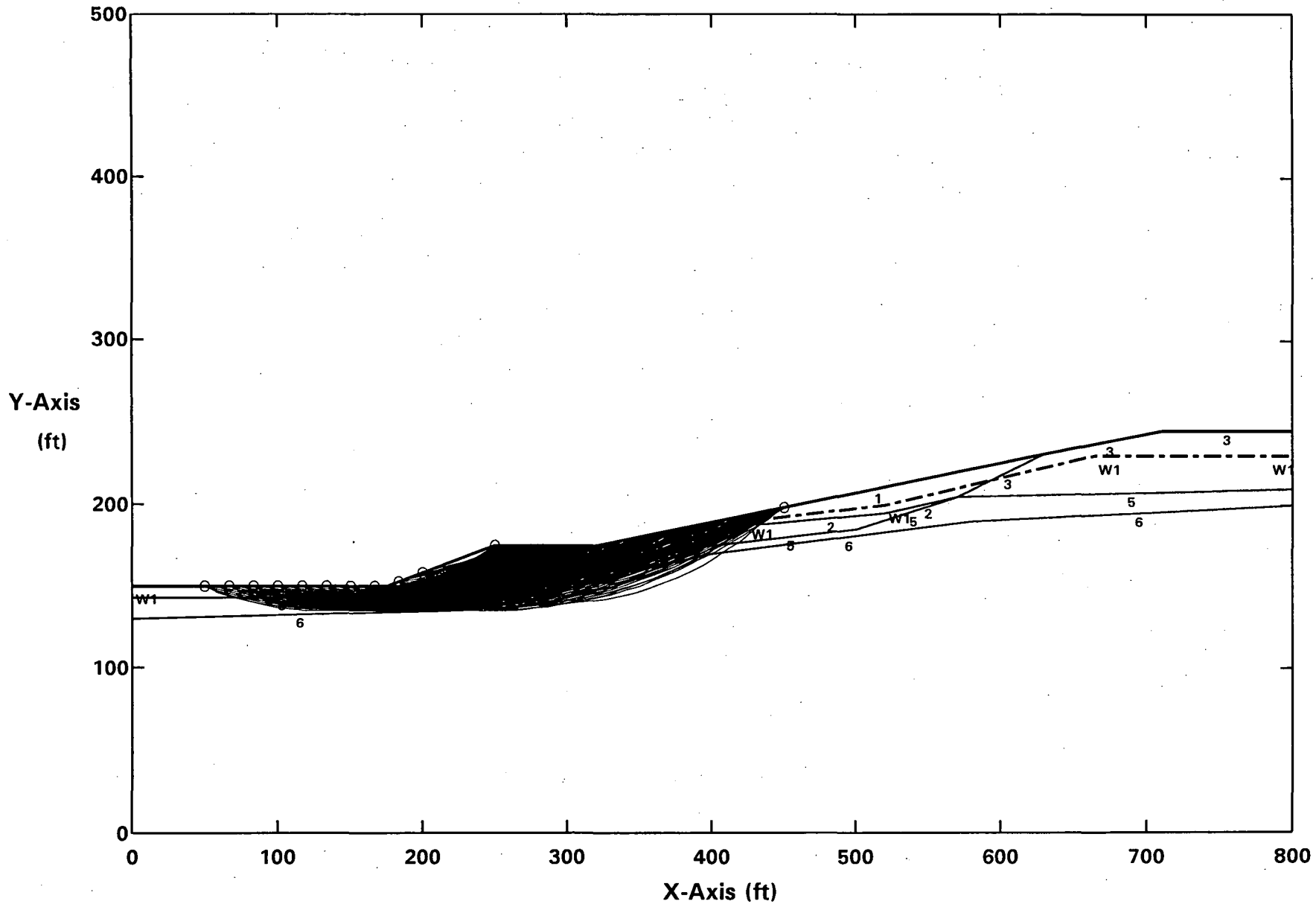
~~Reviewed~~ UPDATED By SAK DATE 4/14/05

Approved By _____ DATE _____

STABILITY COMPUTER RUNS - TOE/BUTTRESS STABILITY

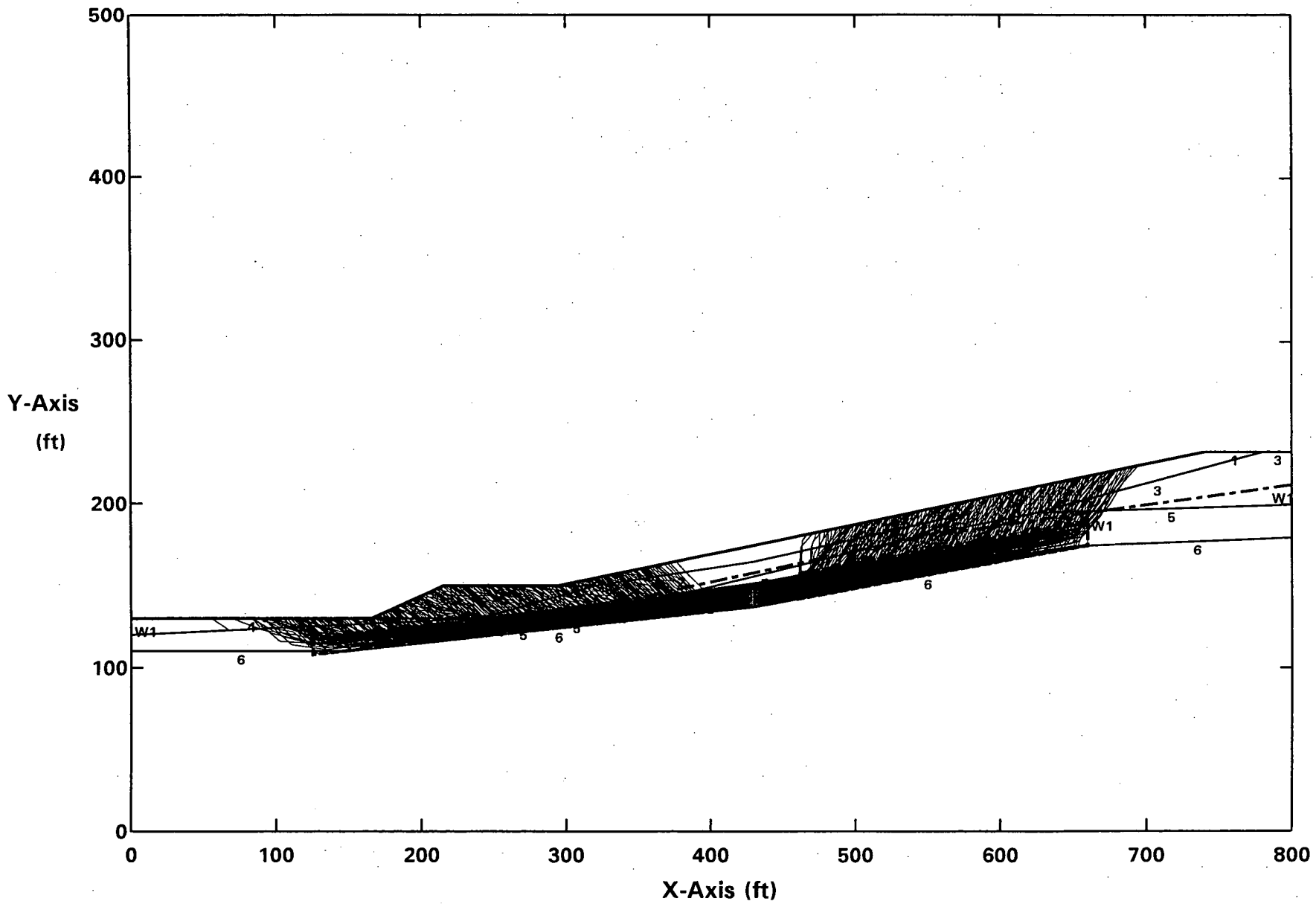
- SECTION A - STATIC - CIRCULAR
  - SEISMIC - CIRCULAR (0.06g & 0.05g)
- SECTION B - STATIC - CIRCULAR
  - SEISMIC - CIRCULAR (0.06g & 0.09g)
- SECTION C - STATIC - CIRCULAR
  - SEISMIC - CIRCULAR (0.06g & 0.~~11~~ 10g)
- SECTION A - STATIC - CIRCULAR
  - SEISMIC - CIRCULAR (0.06g & 0.0~~7~~ 5g)

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
All surfaces evaluated. C:ABHCST.PLT By: STAN KLINE 04-13-05 11:08pm



Factors Of Safety Calculated By The Modified Bishop Method

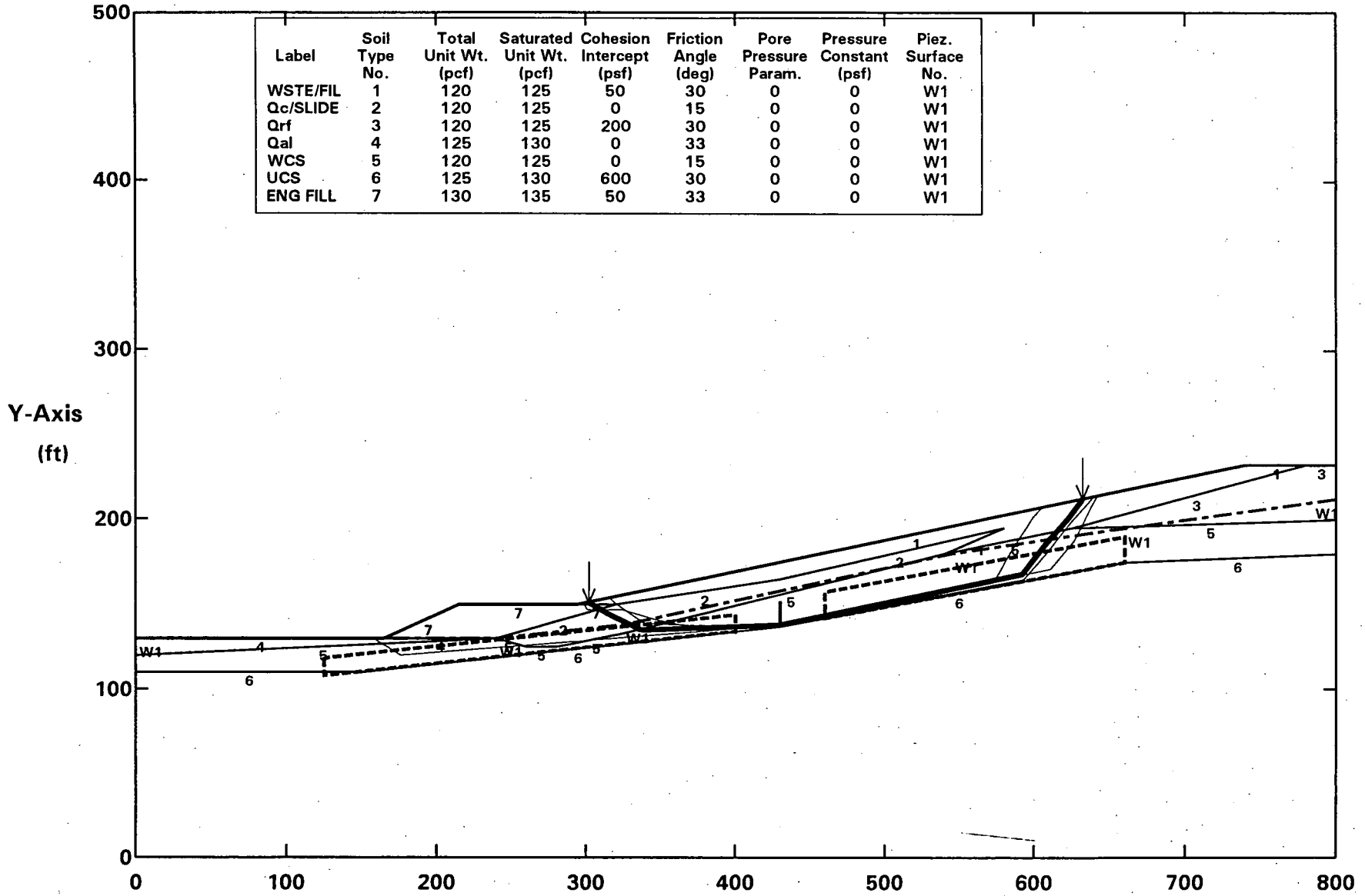
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.05g
All surfaces evaluated. C:DBHS05R.PLT By: STAN KLINE 04-13-05 11:02pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.05g
Ten Most Critical. C:DBHS05R.PLT By: STAN KLINE 04-13-05 11:02pm

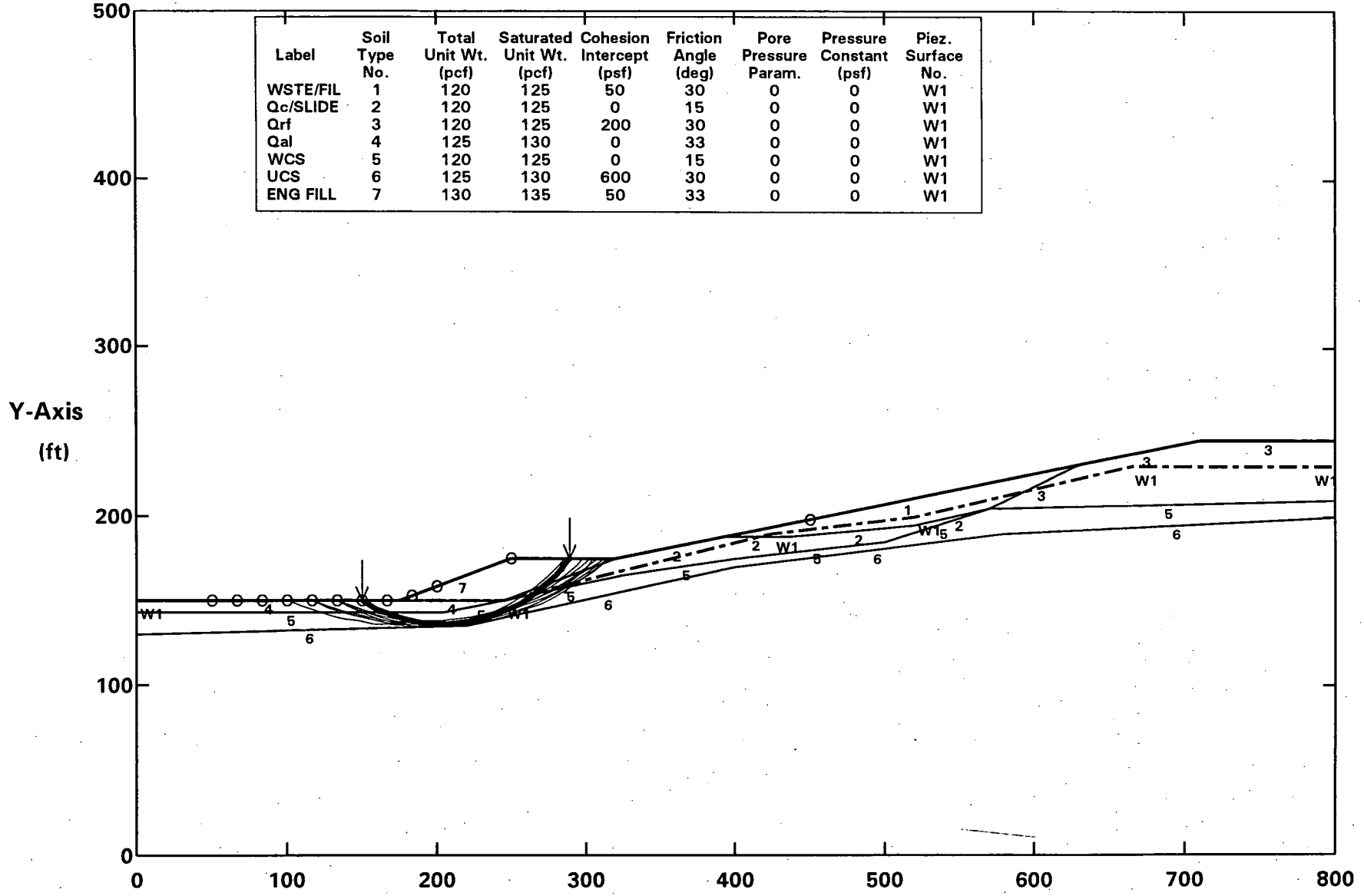
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.97 X-Axis (ft)
Factors Of Safety Calculated By The Modified Janbu Method

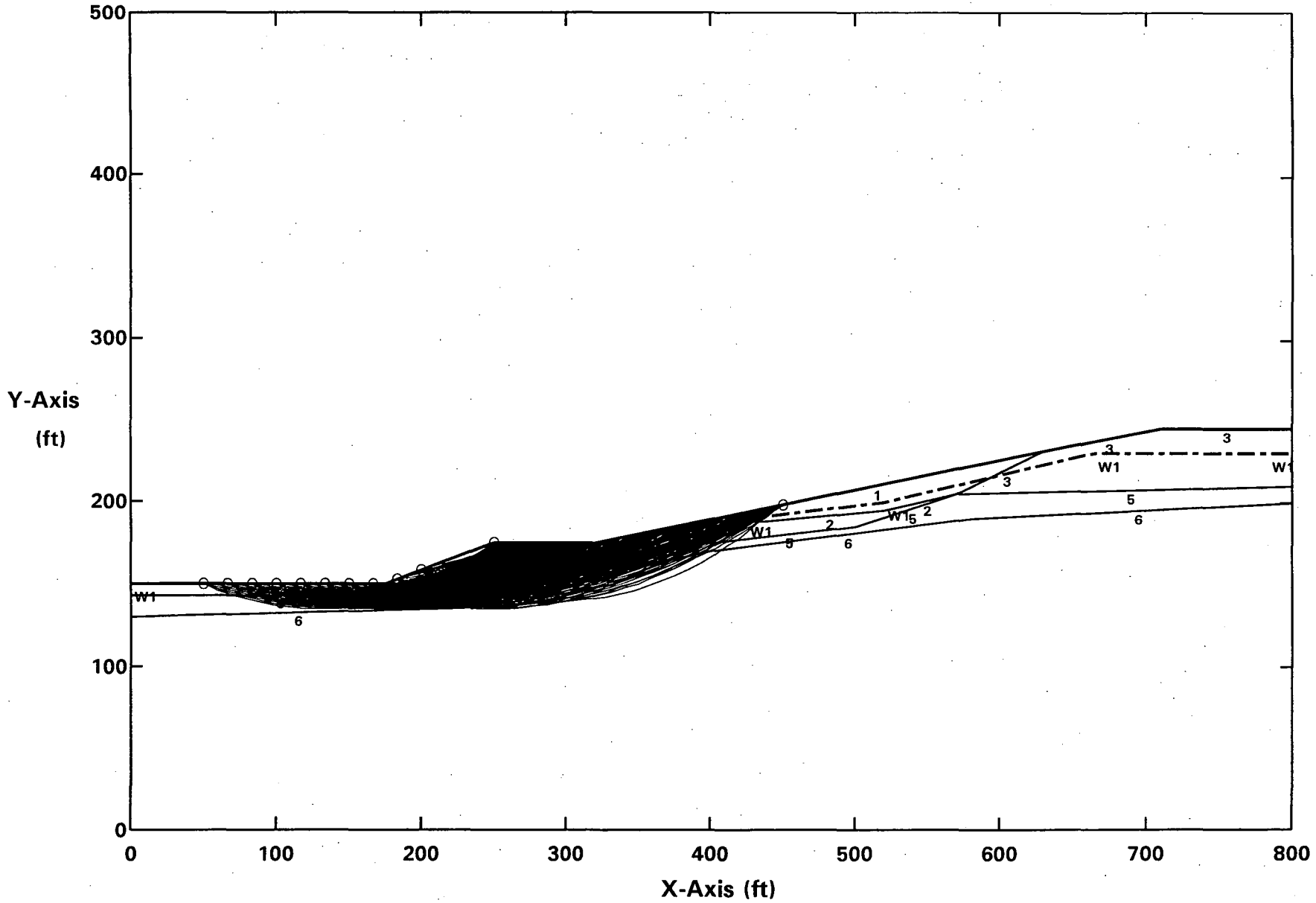
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g - TOE
Ten Most Critical. C:ABHC06T.PLT By: STAN KLINE 04-13-05 11:09pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.96 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

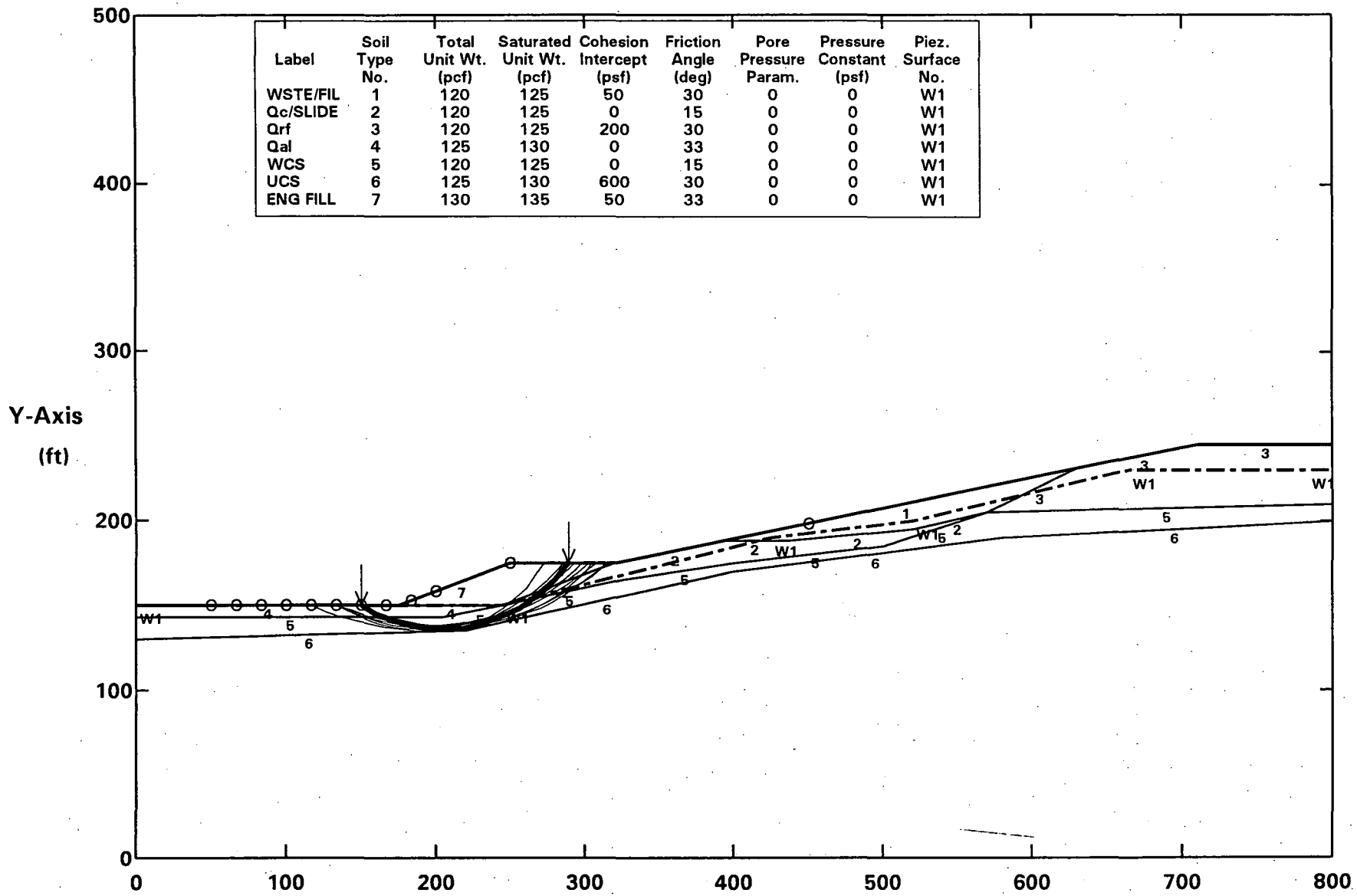
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.05g - TOE
All surfaces evaluated. C:ABHC05T.PLT By: STAN KLINE 04-13-05 11:11pm



Factors Of Safety Calculated By The Modified Bishop Method

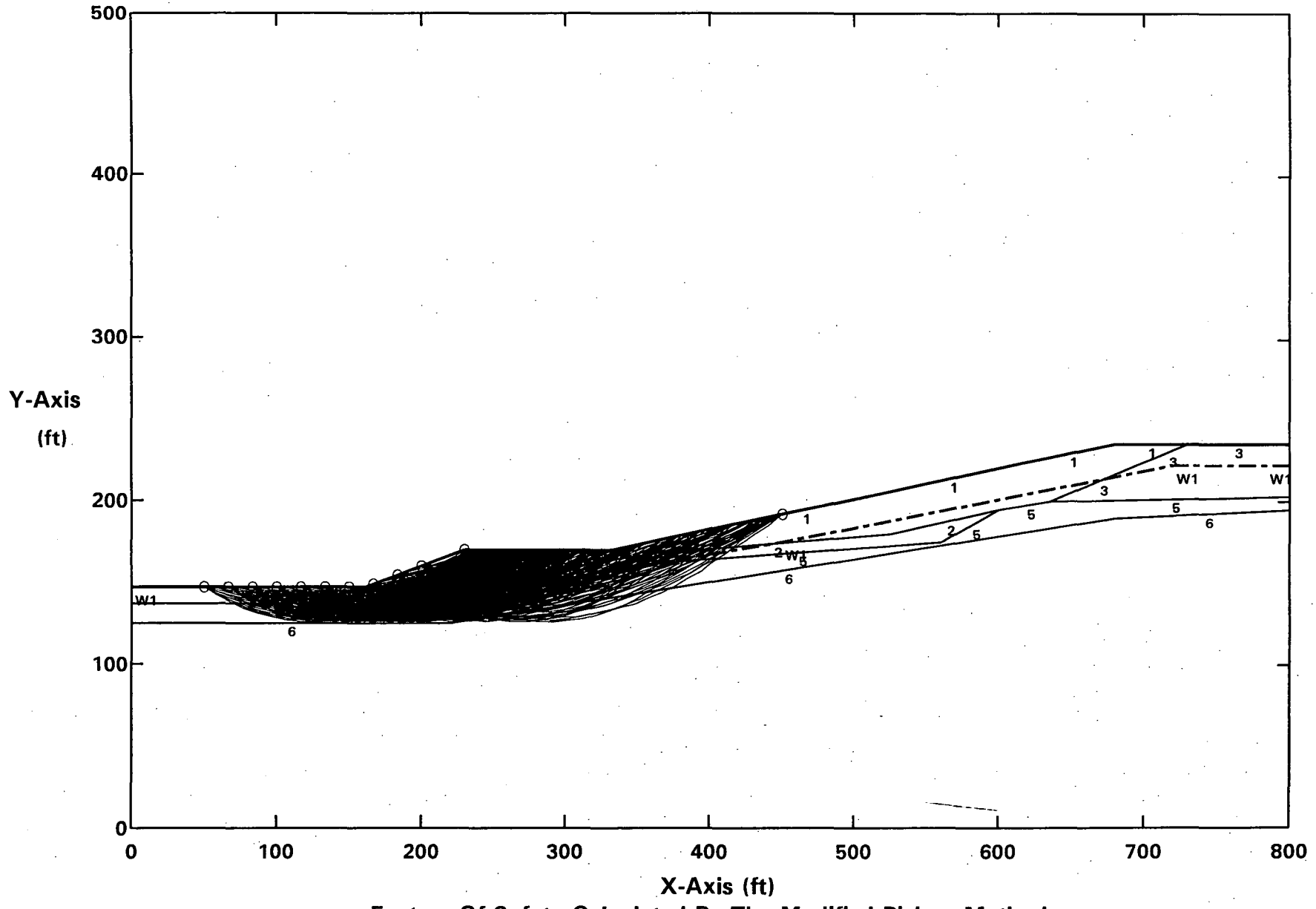
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.05g - TOE
Ten Most Critical. C:ABHC05T.PLT By: STAN KLINE 04-13-05 11:11pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.00 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

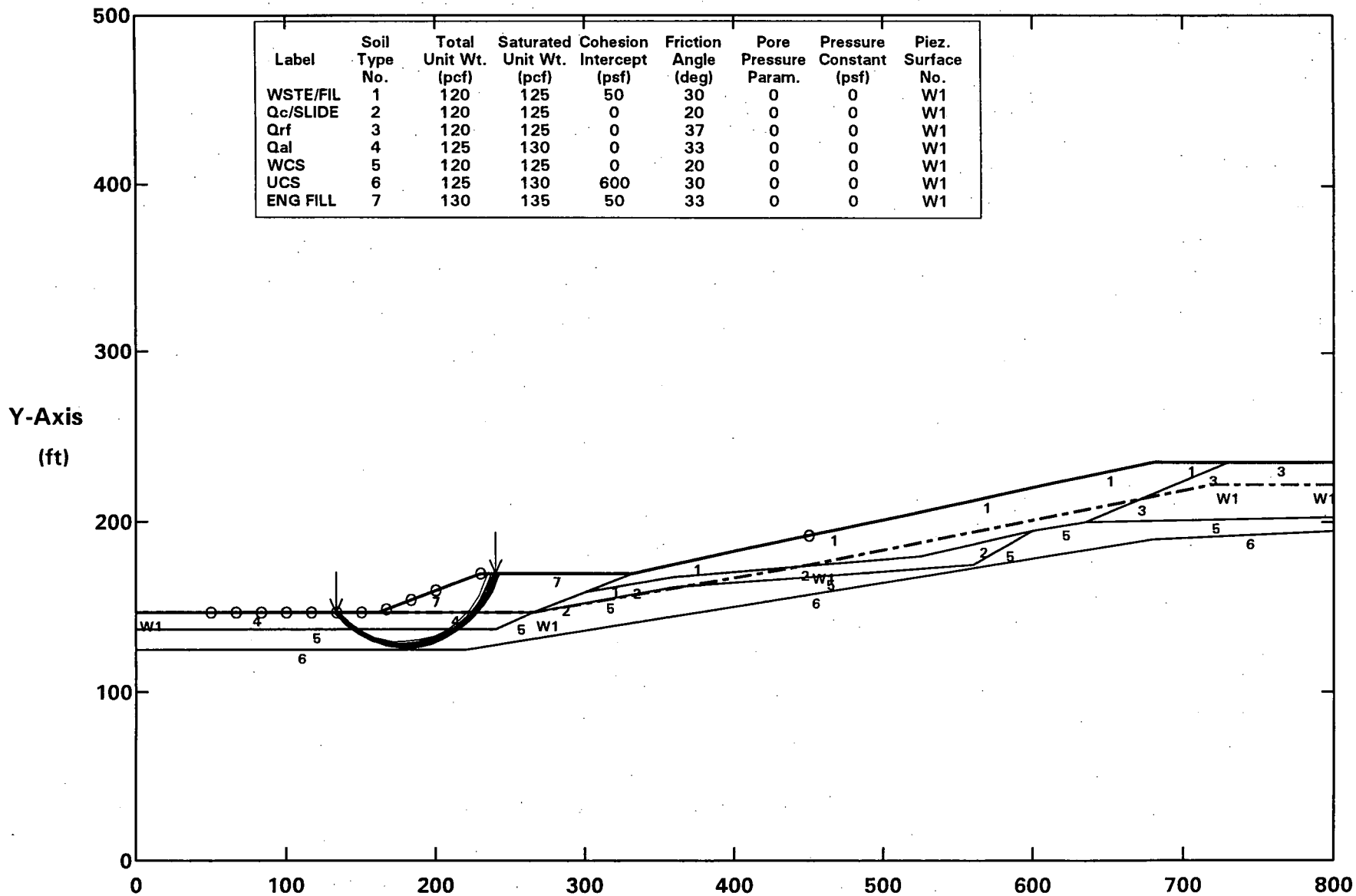
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
All surfaces evaluated. C:BBHCST.PLT By: STAN KLINE 04-13-05 11:12pm



Factors Of Safety Calculated By The Modified Bishop Method

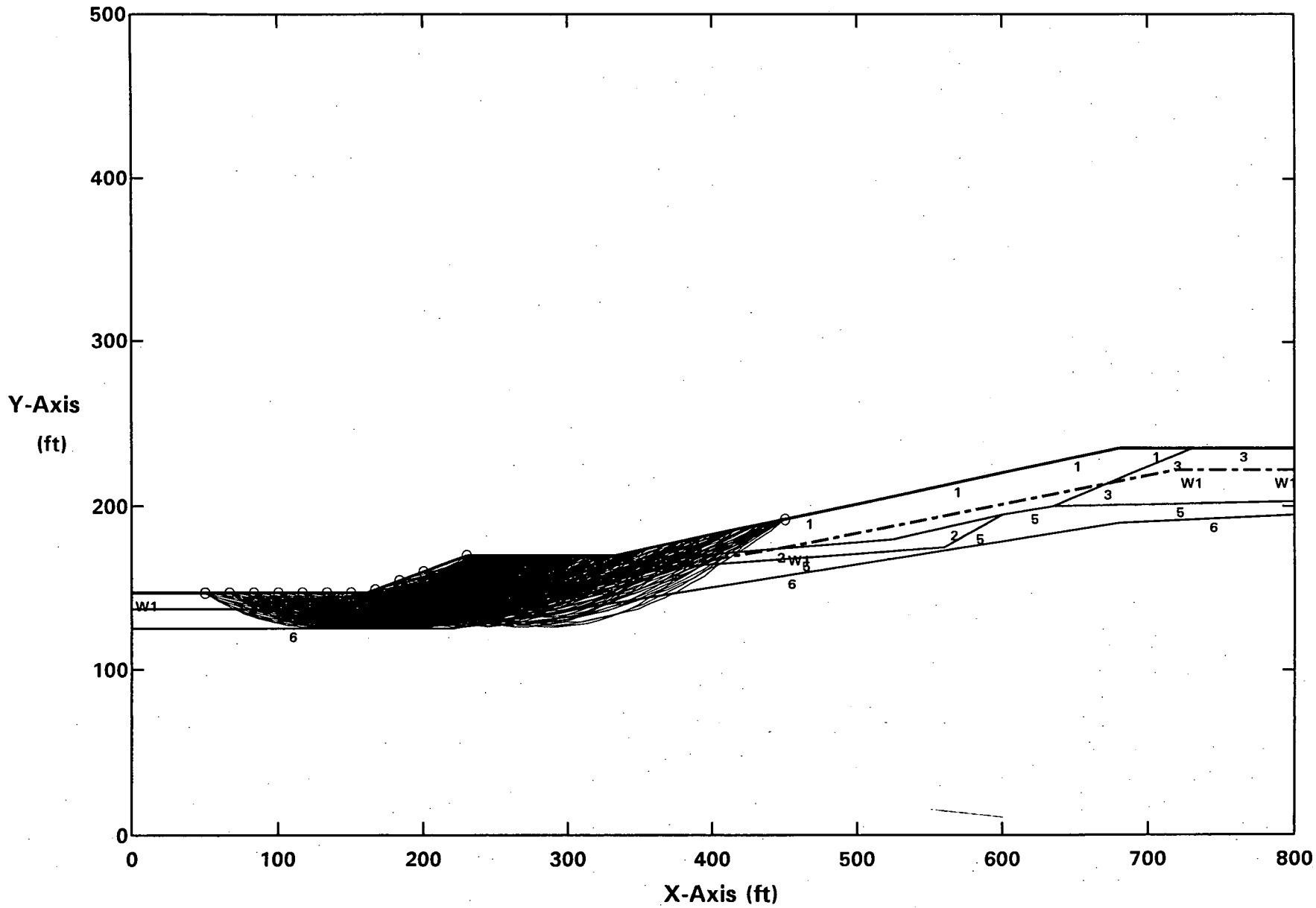
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
Ten Most Critical. C:BBHCST.PLT By: STAN KLINE 04-13-05 11:12pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.79 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

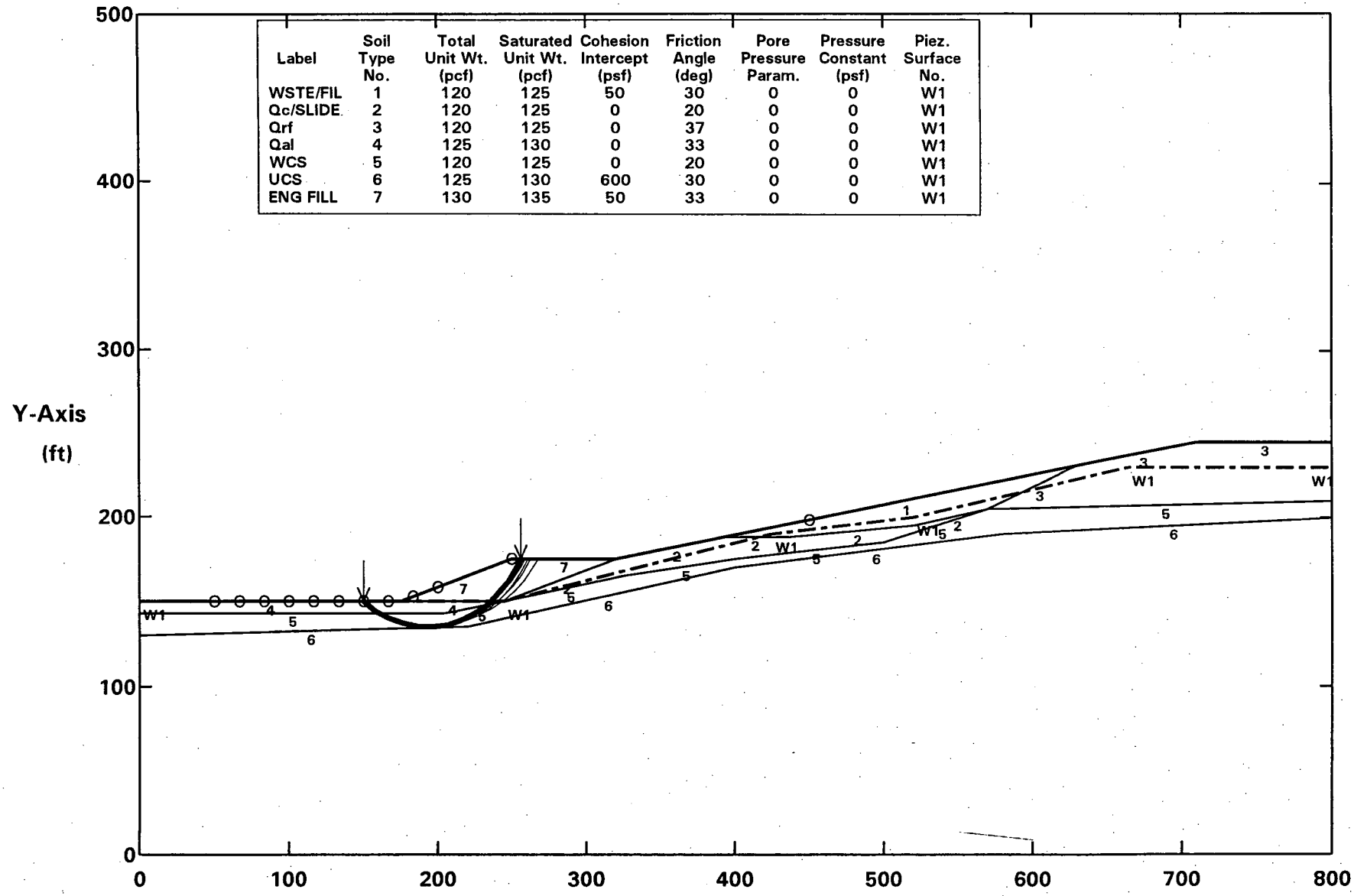
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g - TOE
All surfaces evaluated. C:BBHC06T.PLT By: STAN KLINE 04-13-05 11:13pm



Factors Of Safety Calculated By The Modified Bishop Method

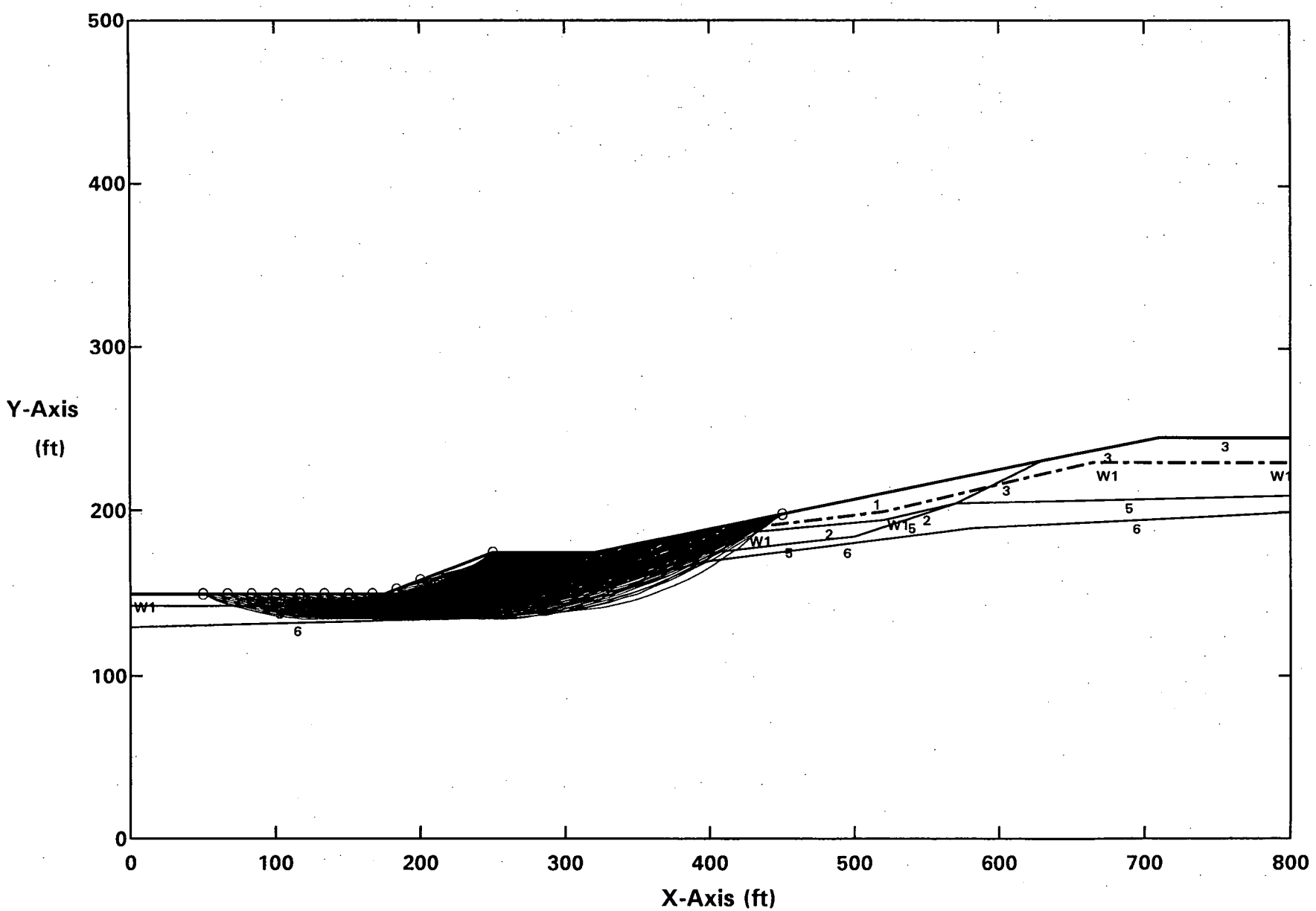
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
Ten Most Critical. C:ABHCST.PLT By: STAN KLINE 04-13-05 11:08pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.54 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

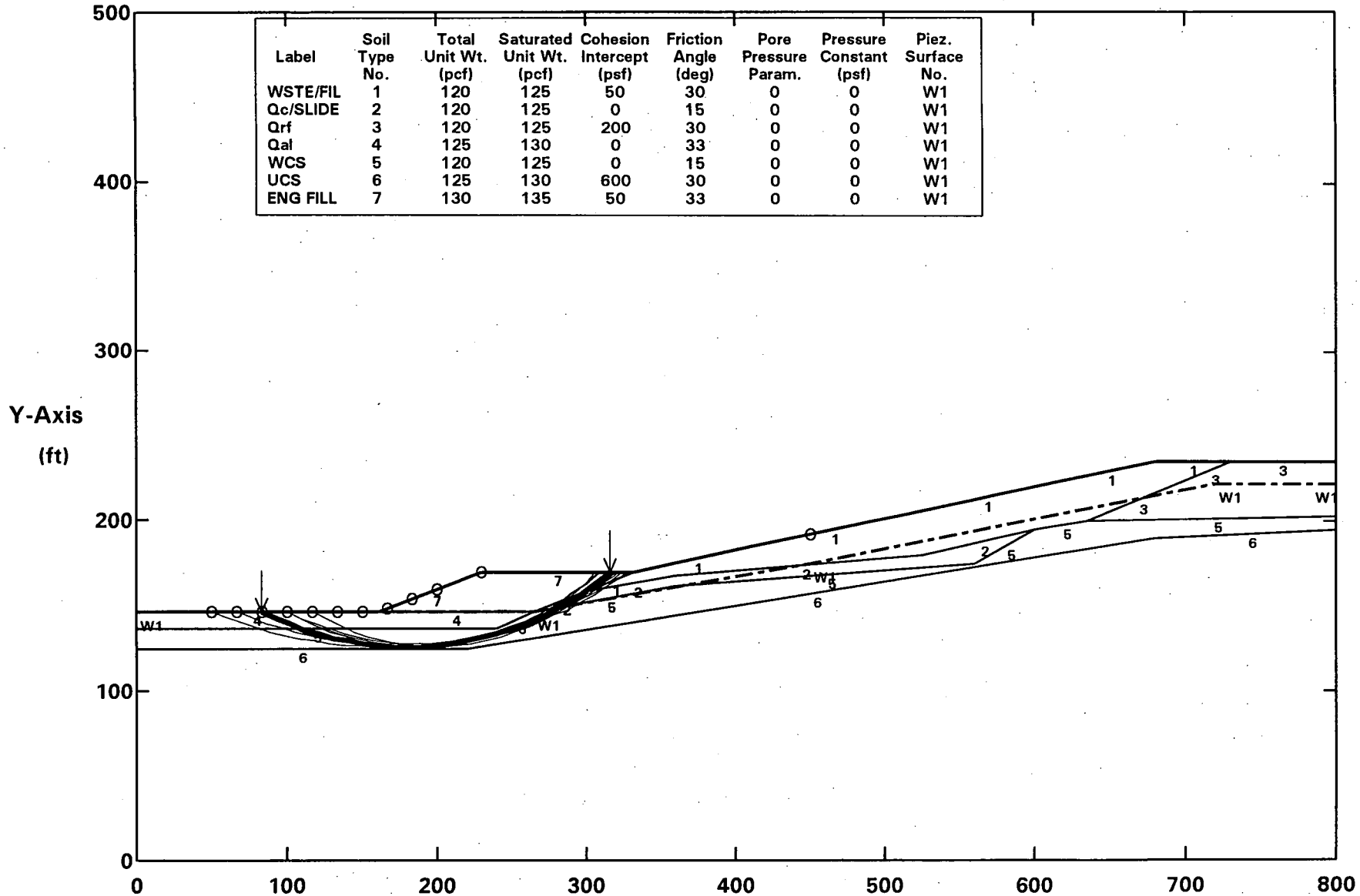
ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g - TOE
All surfaces evaluated. C:ABHC06T.PLT By: STAN KLINE 04-13-05 11:09pm



Factors Of Safety Calculated By The Modified Bishop Method

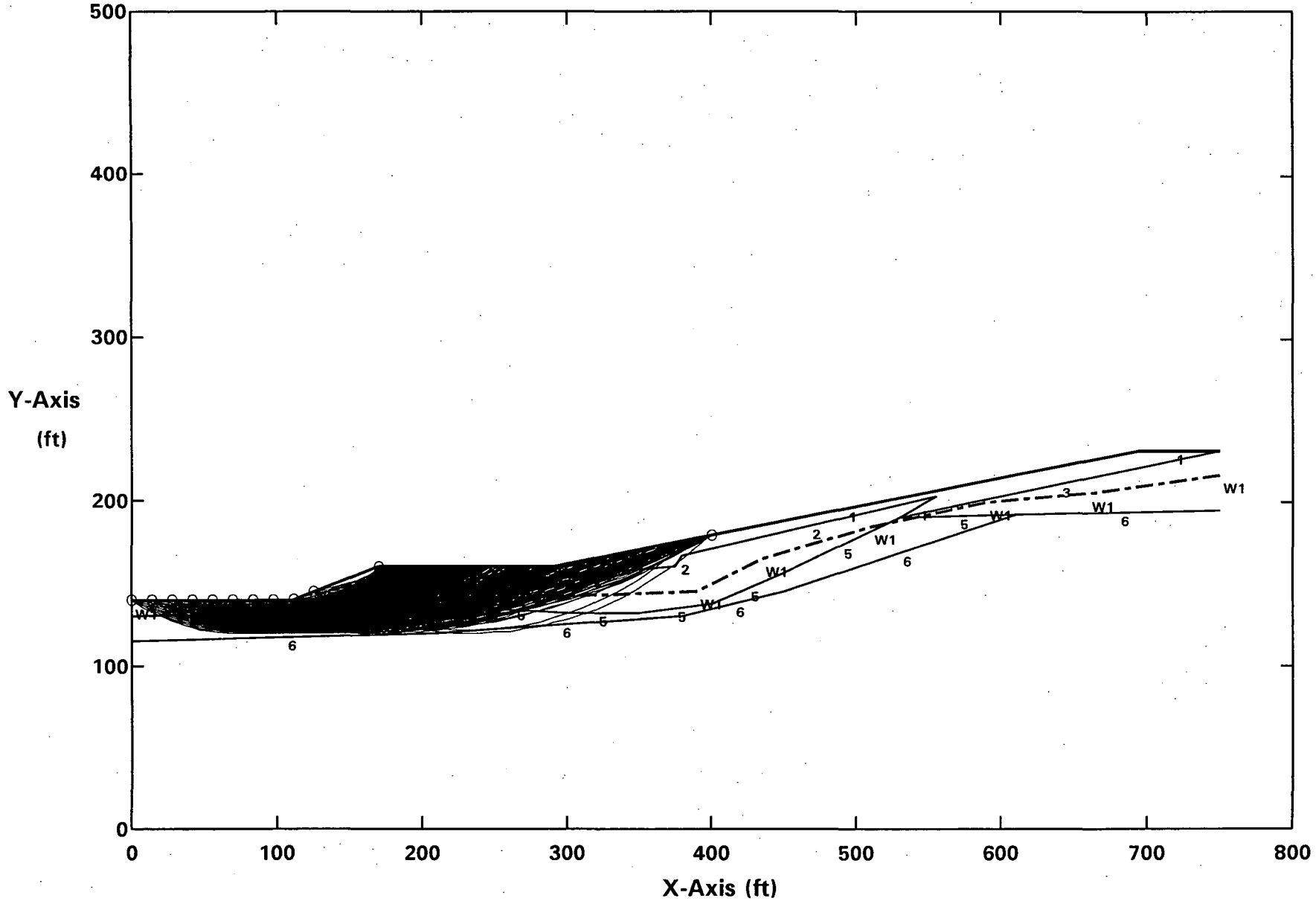
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.09g - TOE
Ten Most Critical. C:BBHC09T.PLT By: STAN KLINE 04-13-05 11:14pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



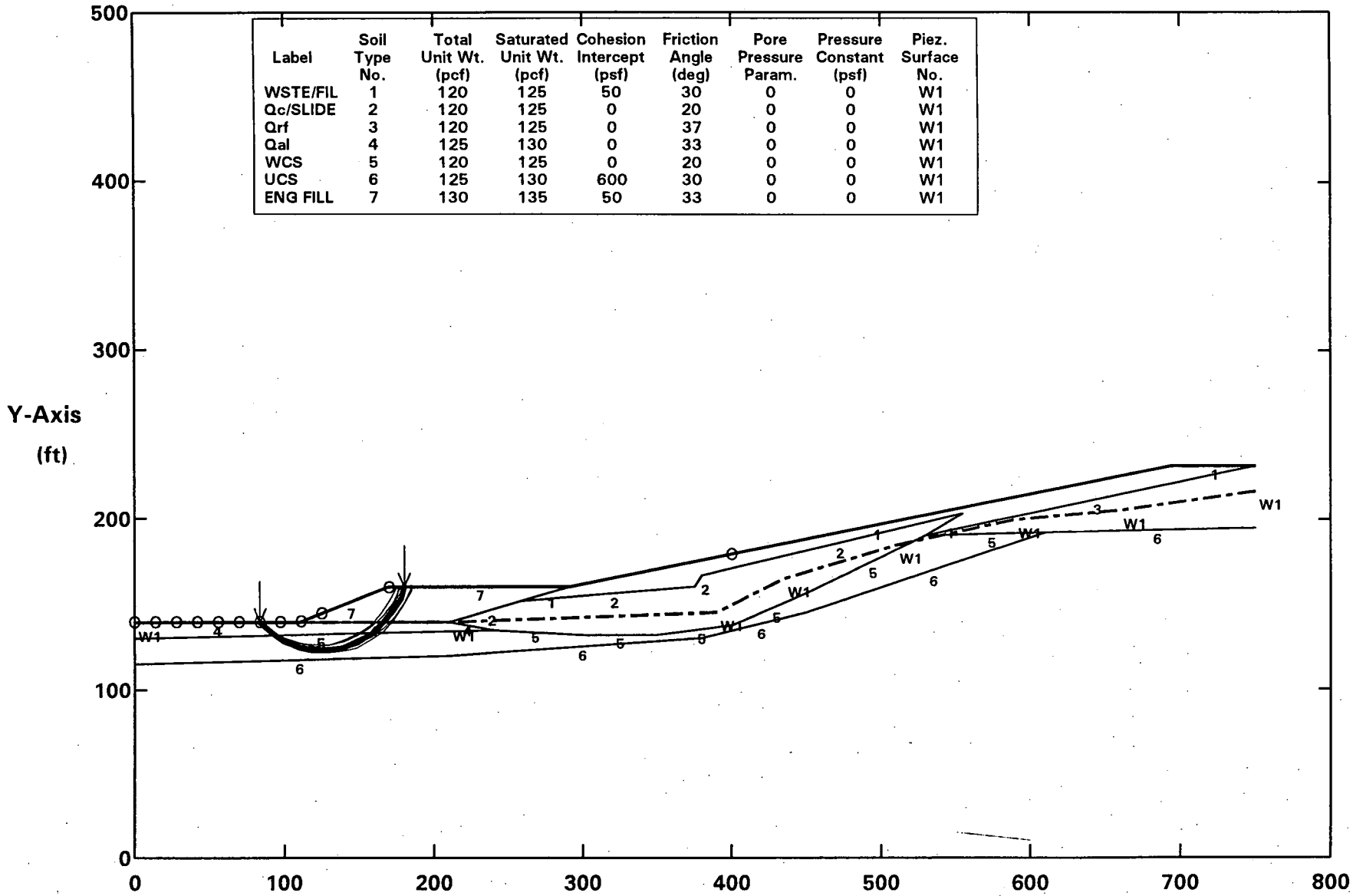
PCSTABL5M/SI FSmin = 1.00 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
All surfaces evaluated. C:CBHCST.PLT By: STAN KLINE 04-13-05 11:17pm



Factors Of Safety Calculated By The Modified Bishop Method

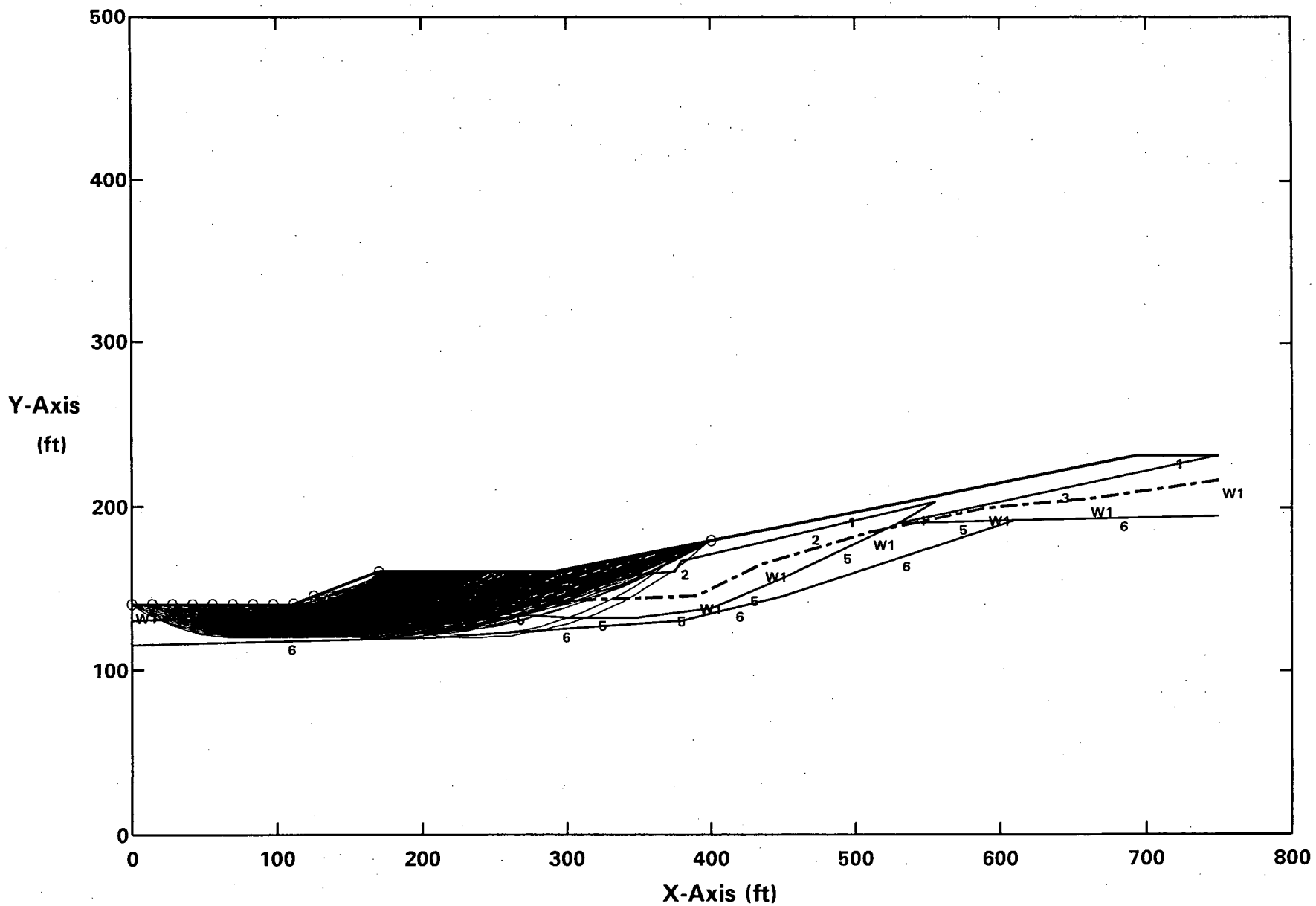
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
Ten Most Critical. C:CBHCST.PLT By: STAN KLINE 04-13-05 11:17pm



Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1

PCSTABL5M/SI FSmin = 1.73 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

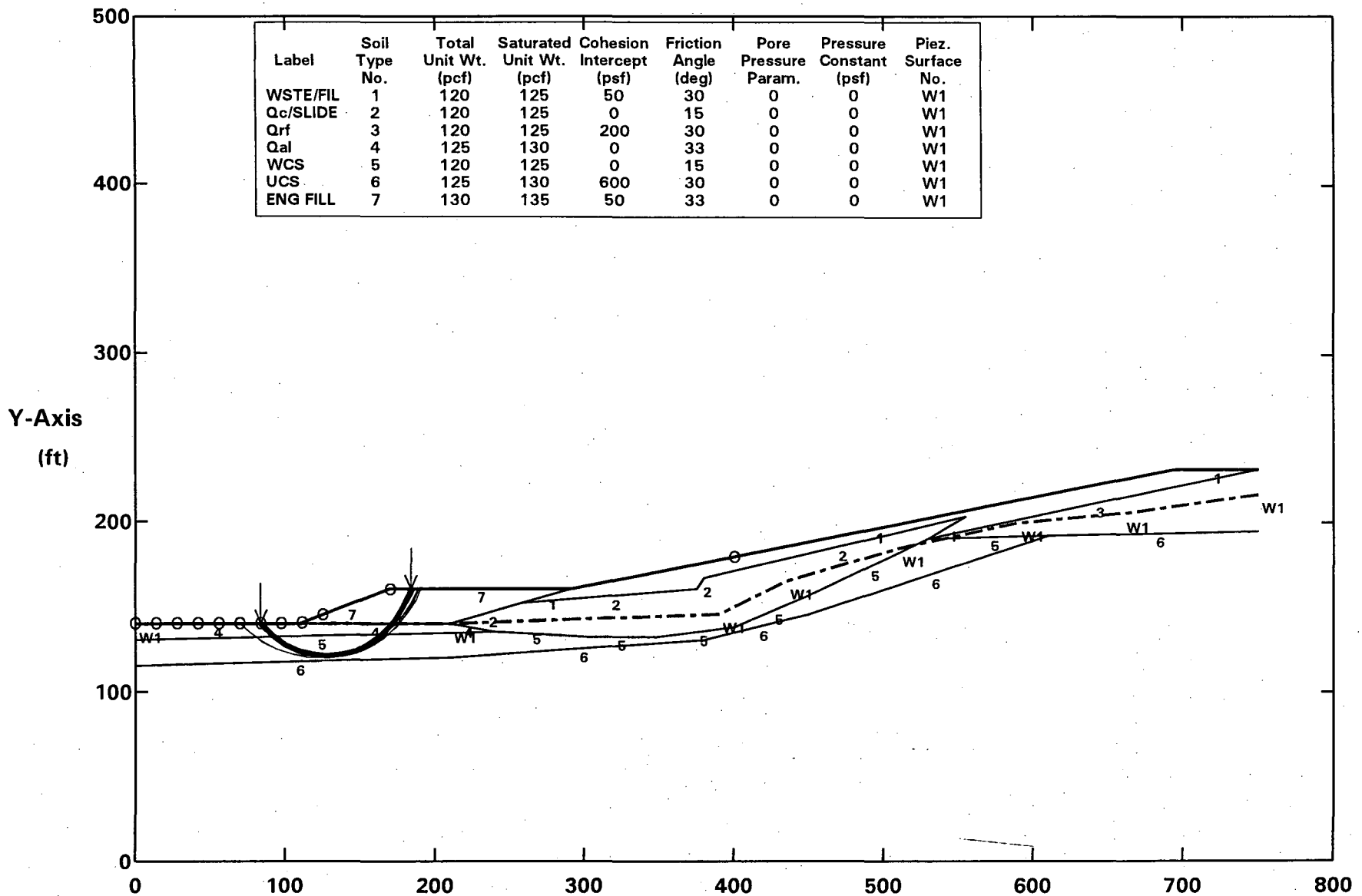
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW--CIRCULAR - 0.06g - TOE
All surfaces evaluated. C:CBHC06T.PLT By: STAN KLINE 04-13-05 11:18pm



Factors Of Safety Calculated By The Modified Bishop Method

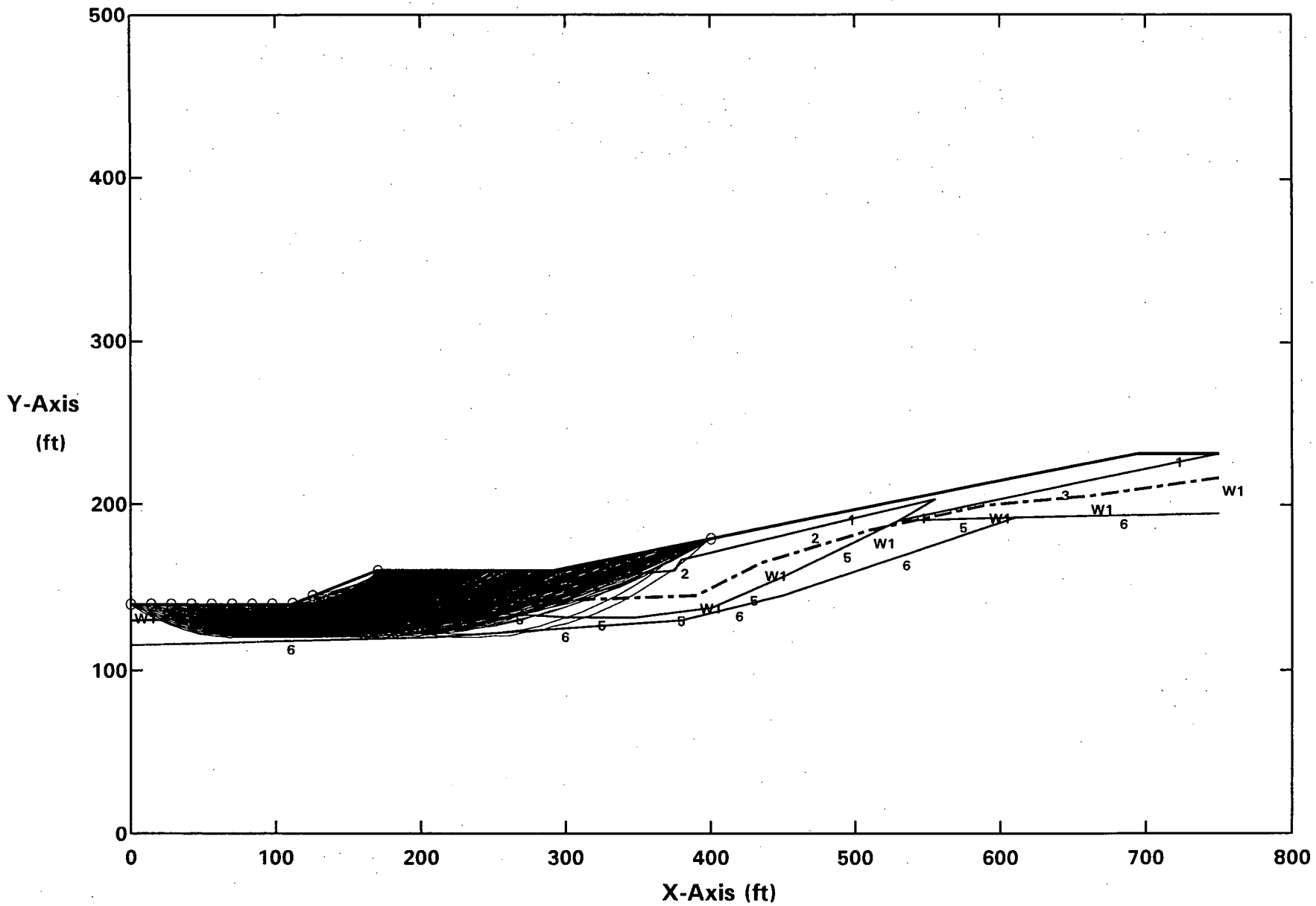
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g - TOE
Ten Most Critical. C:CBHC06T.PLT By: STAN KLINE 04-13-05 11:18pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.14 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

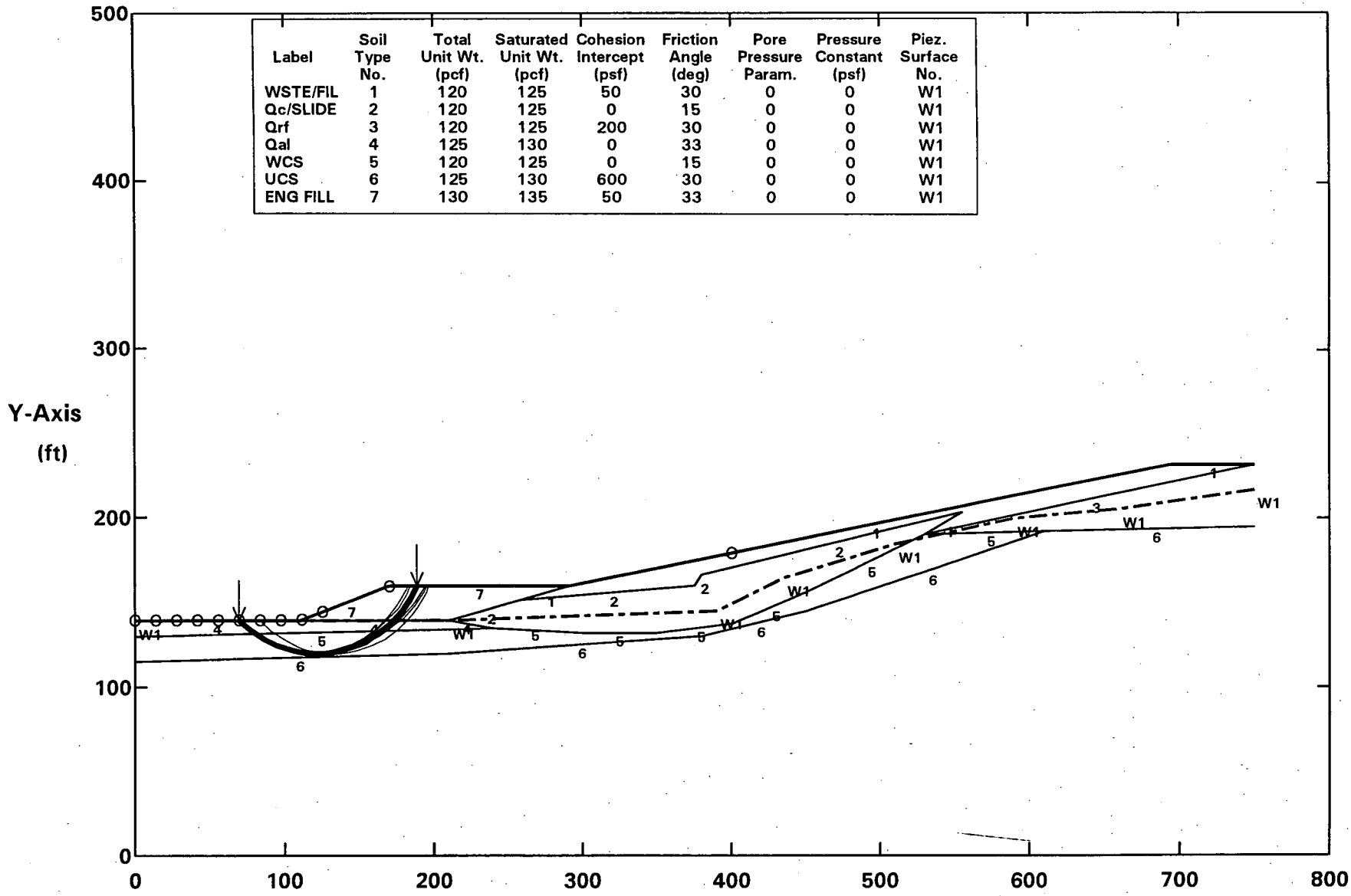
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW--CIRCULAR - 0.10g - TOE
All surfaces evaluated. C:CBHC10T.PLT By: STAN KLINE 04-13-05 11:22pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.10g - TOE
Ten Most Critical. C:CBHC10T.PLT By: STAN KLINE 04-13-05 11:22pm

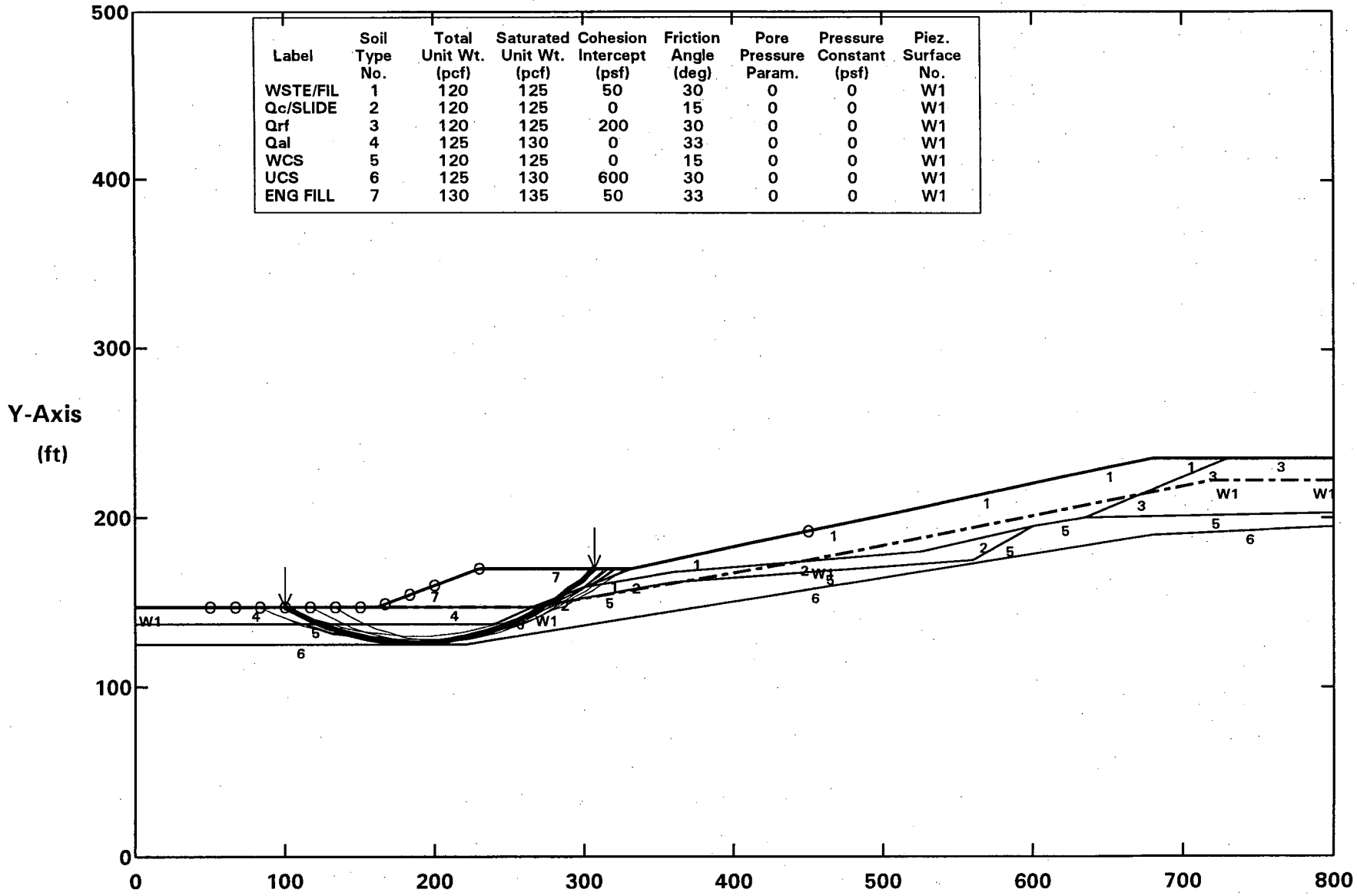
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.00 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

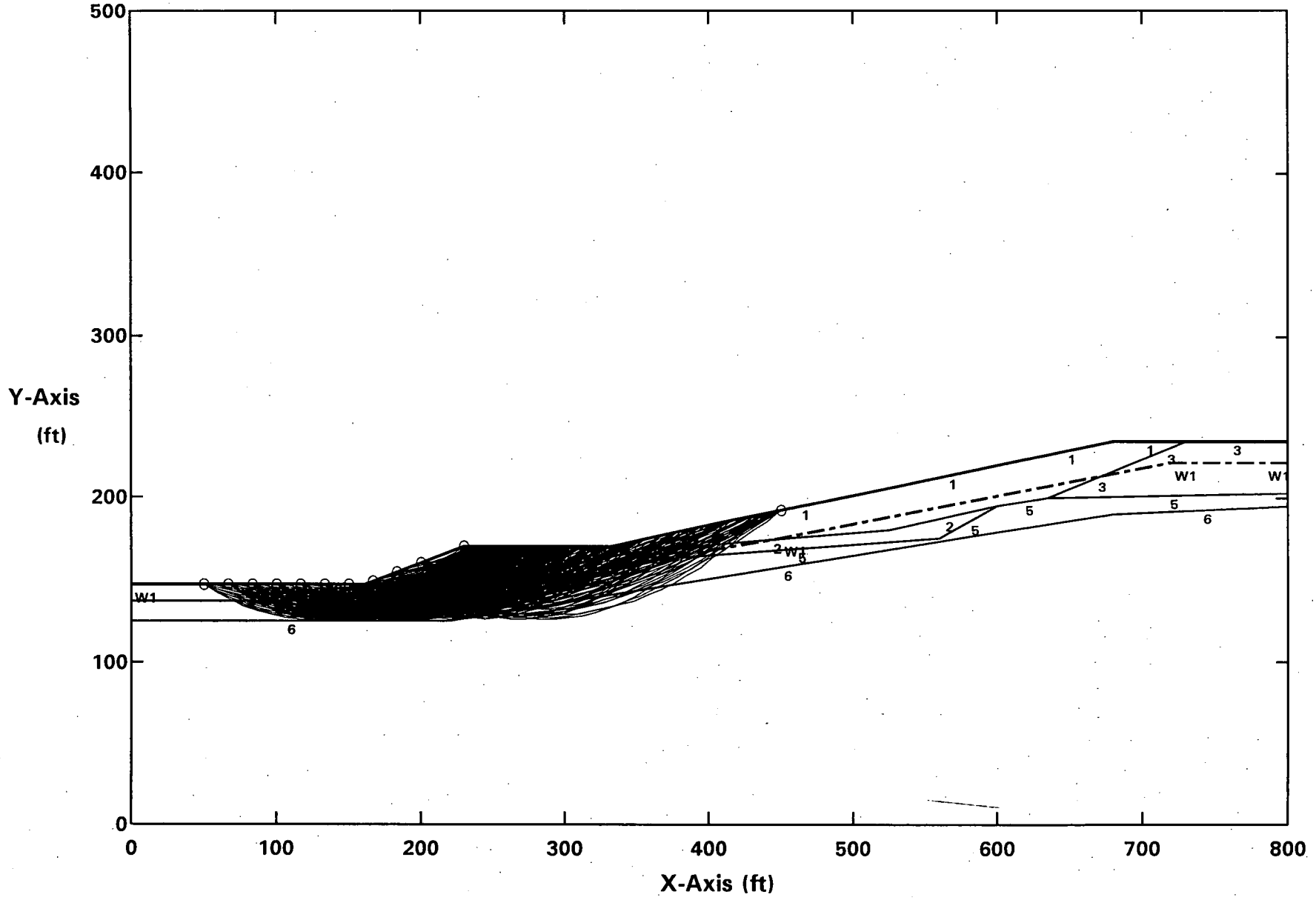
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g - TOE
Ten Most Critical. C:BBHC06T.PLT By: STAN KLINE 04-13-05 11:13pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



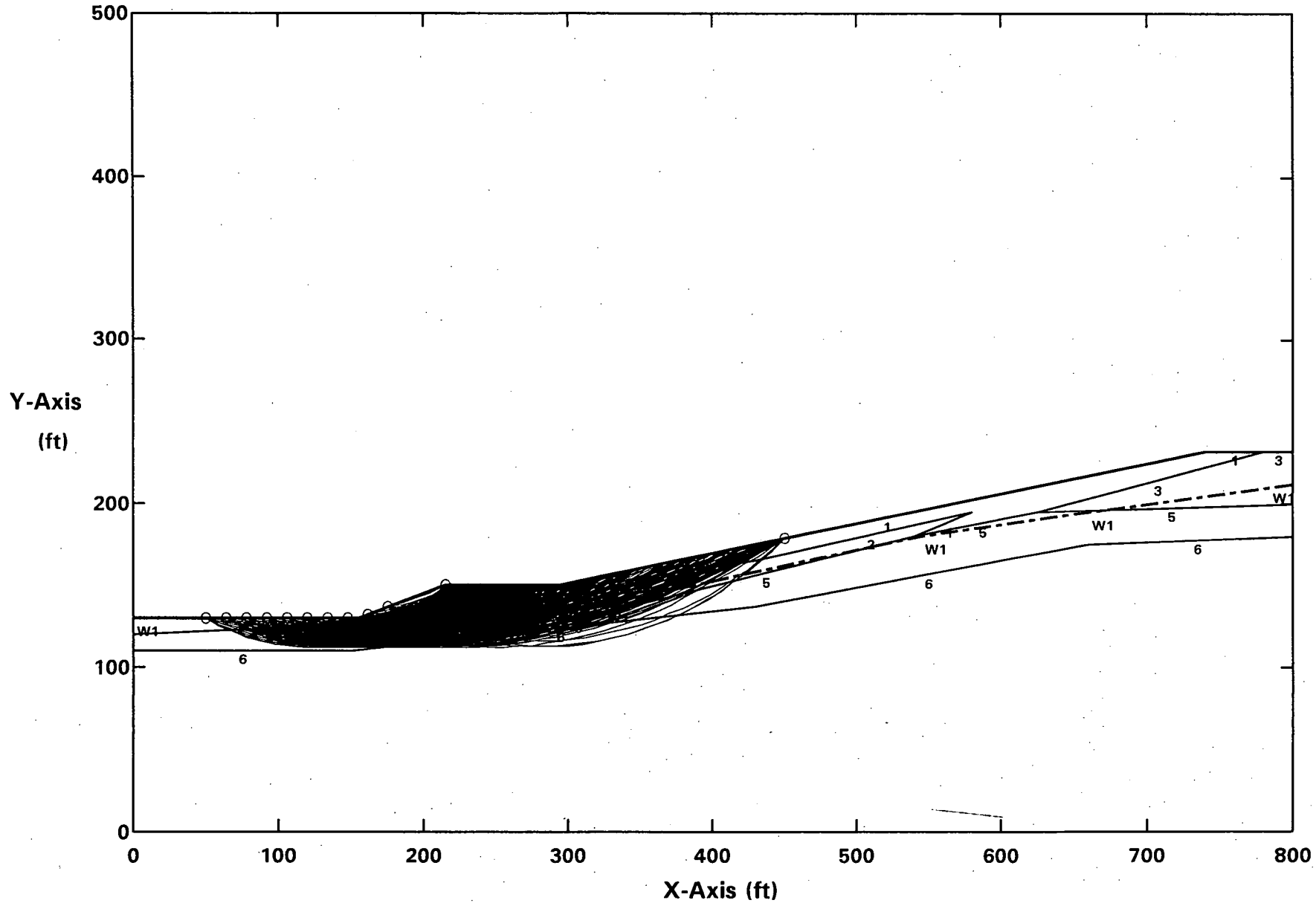
PCSTABL5M/SI FSmin = 1.15 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.09g - TOE
All surfaces evaluated. C:BBHC09T.PLT By: STAN KLINE 04-13-05 11:14pm



Factors Of Safety Calculated By The Modified Bishop Method

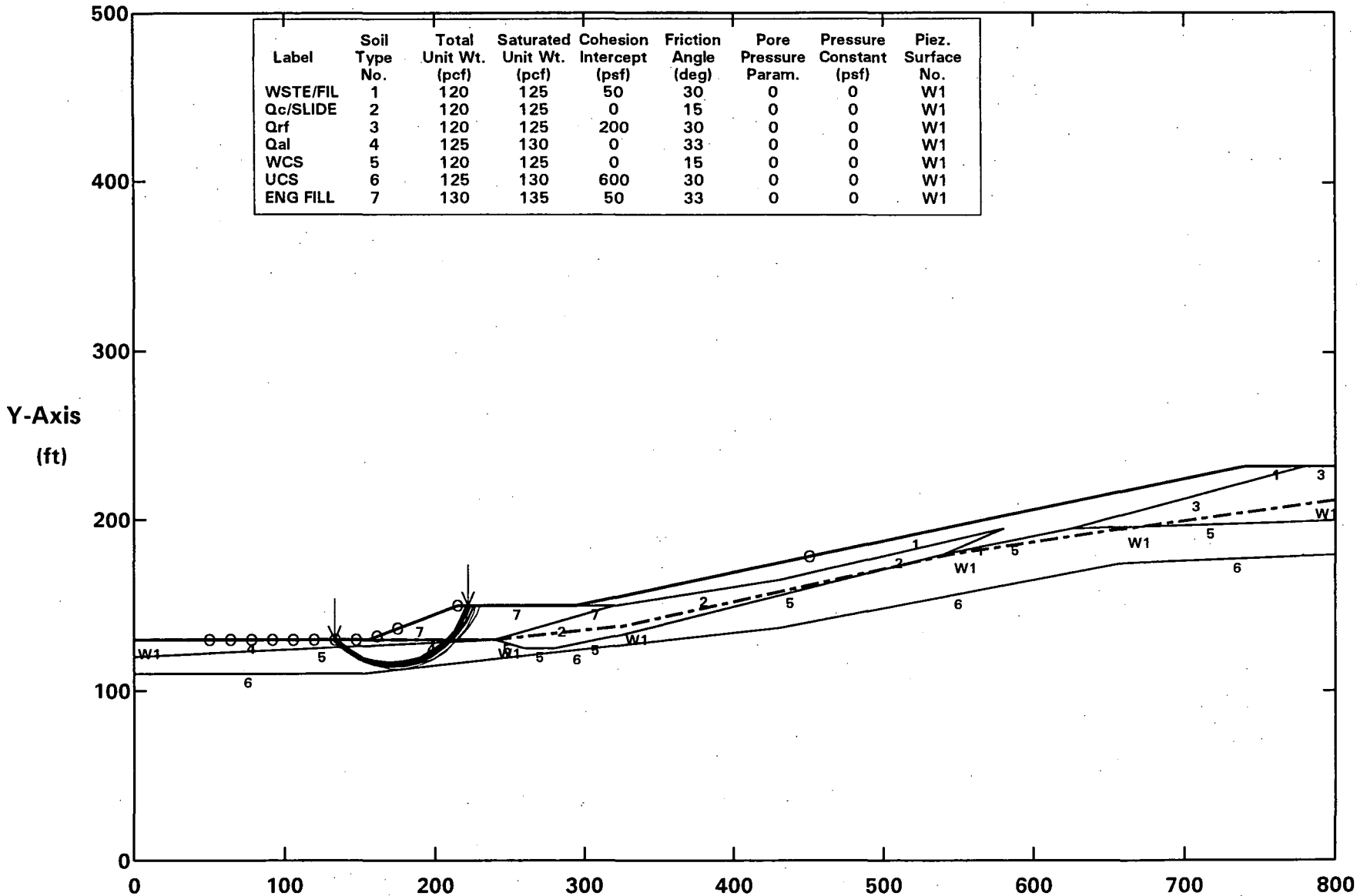
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g - TOE
All surfaces evaluated. C:DBHC06T.PLT By: STAN KLINE 04-13-05 11:26pm



Factors Of Safety Calculated By The Modified Bishop Method

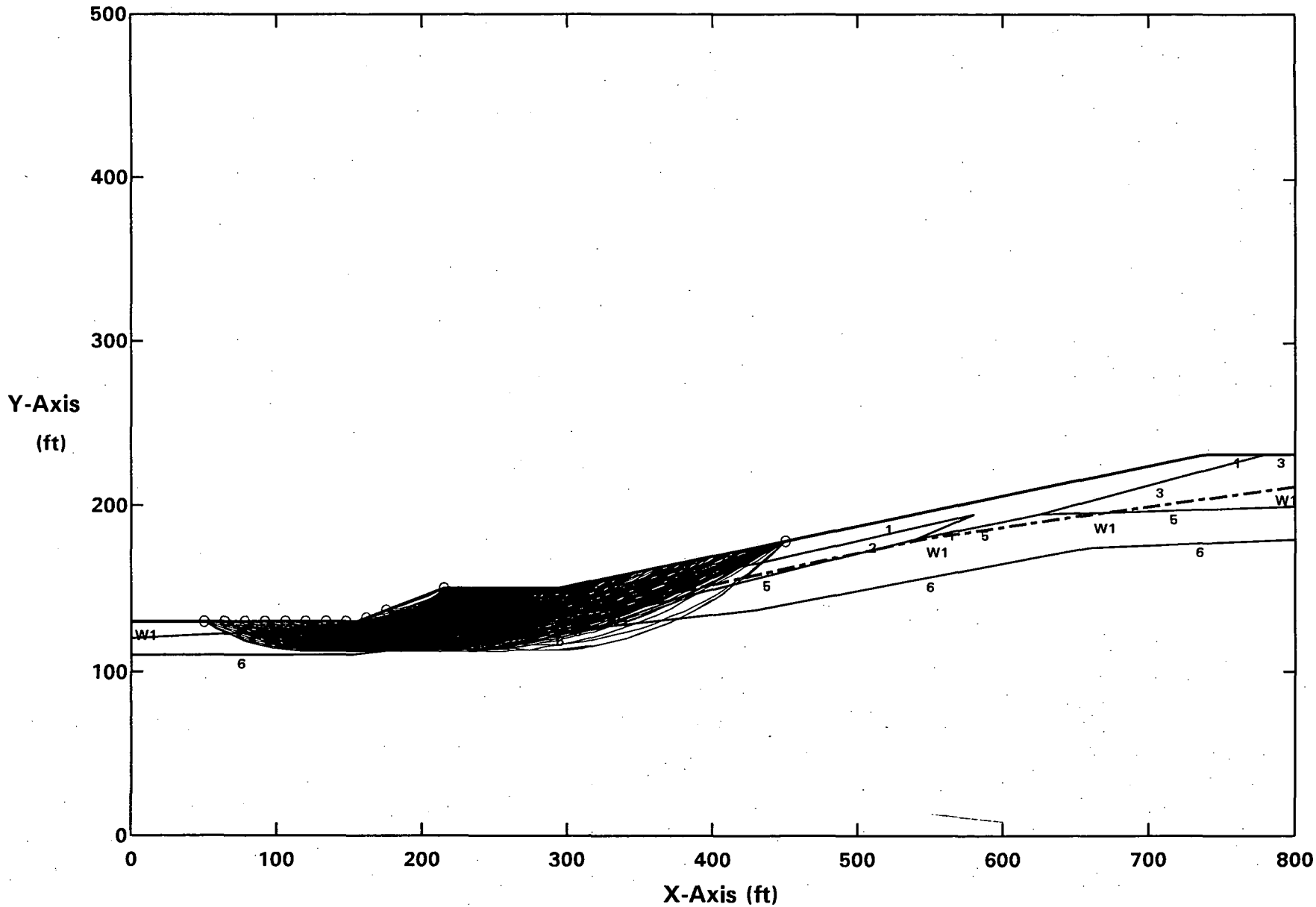
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g - TOE
Ten Most Critical. C:DBHC06T.PLT By: STAN KLINE 04-13-05 11:26pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 0.99 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

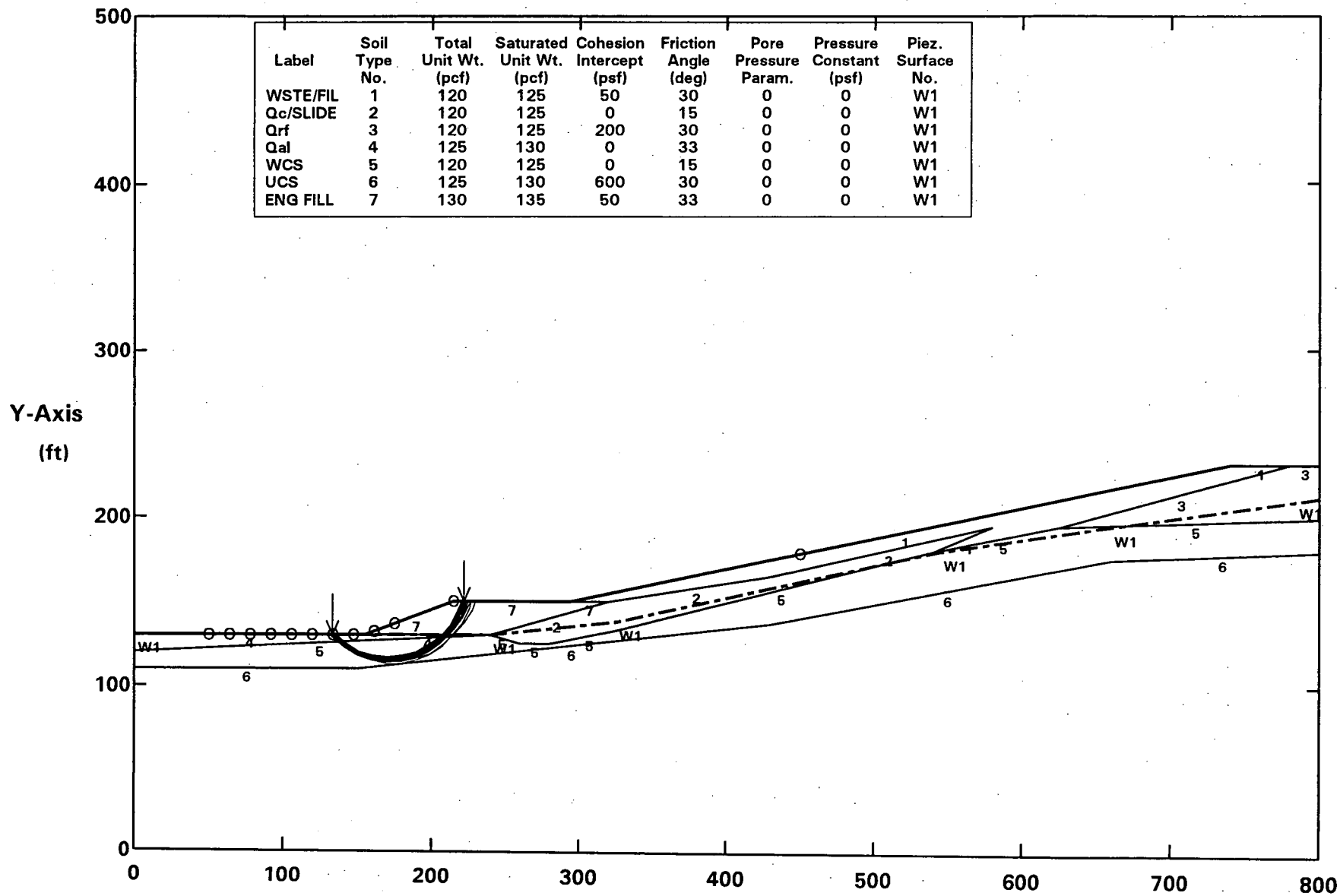
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.05g - TOE
All surfaces evaluated. C:DBHC05T.PLT By: STAN KLINE 04-13-05 11:28pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.05g - TOE
Ten Most Critical. C:DBHC05T.PLT By: STAN KLINE 04-13-05 11:28pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.02 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

APPENDIX A

ATTACHMENT 7
REGULATORY AGENCY REQUESTED MODEL

Regulatory Agency Requested Model Results

Cross Section A-A′ Buttress Toe Stability
Using Regulatory Suggested Strength Parameters and
Existing 3H:1V Slope Configuration

Groundwater Condition	Geometric Condition 3H:1V	Analysis Type[1]	Minimum Safety Factor	
			Static Analysis	Design Criteria
100-Year Wet Year	Local Toe/ Buttress Area	Circular Search	1.4	1.5

Cross Section D-D′ Buttress Toe Stability
Using Regulatory Suggested Strength Parameters and
Existing 3H:1V Slope Configuration

Groundwater Condition	Geometric Condition 3H:1V	Analysis Type[1]	Minimum Safety Factor	
			Static Analysis	Design Criteria
100-Year Wet Year	Local Toe/ Buttress Area	Circular Search	1.4	1.5

Cross Section A-A′ Buttress Toe Stability
Using Regulatory Suggested Strength Parameters and
Existing 3.1H:1V Slope Configuration

Groundwater Condition	Geometric Condition 3.1H:1V	Analysis Type[1]	Minimum Safety Factor	
			Static Analysis	Design Criteria
100-Year Wet Year	Local Toe/ Buttress Area	Circular Search	1.5	1.5

Cross Section D-D′ Buttress Toe Stability
Using Regulatory Suggested Strength Parameters and
Existing 3.1H:1V Slope Configuration

Groundwater Condition	Geometric Condition 3.1H:1V	Analysis Type[1]	Minimum Safety Factor	
			Static Analysis	Design Criteria
100-Year Wet Year	Local Toe/ Buttress Area	Circular Search	1.5	1.5

[1] Circular search results based on Bishop's Modified Method of Analysis. Sliding block search based on Janbu's Modified Method of Analysis, with results based on more rigorous and more accurate Spencer's Method of Analysis performed on the critical surface identified from the search.

TABLE 1
ROCKY FLATS/FIELD and LAB TESTING/CO
SUMMARY OF SOIL DATA

EFFECTIVE
ICU TRIAXIAL
TEST DATA
C' φ'
PSF DEGREES

Sample Type	Sample Number	Sample Depth (ft)	U.S.C.S. Soil Classification	Delivered Moisture (%)	Atterberg Limits			Grain Size Distribution			Specific Gravity	Moist/Den Relationship Standard Proctor		~~Additional Tests Comments~~ (See Notes)	
					LL	PL	PI	% Finer 3/4"	% Finer #4	% Finer #200		PCF (Dry)	Moist (%)		
Bulk	PF-1	1-2	SC	16.1	39	19	20	100	84	30	--	120.6*	10.7*	0	34.0
Bulk	PF-2	1-2	SC	10.3	43	19	24	100	85	29	--	119.9*	11.7*	137	30.7
Bulk	PF-3	1-2	SC	18.1	43	18	25	100	81	30	--	121.0*	10.9*	111	29.8
Bulk	PF-4	1-2	SC	17.4	35	16	19	100	89	30	--	122.9*	10.6*	185	32.2
Bulk	PF-5	1-2	SC	12.8	37	19	18	100	86	29	--	121.9*	10.8*	0	40.8
Bulk	PF5-Dup	1-2	SC	11.4	40	19	21	100	87	28	--	122.3*	11.1*		
Bulk	PF-6	1-2	SC	11.5	45	20	25	100	82	30	--	120.3*	12.5*	0	41.9
Bulk	PF-7	1-2	SC	13.5	35	18	17	100	87	24	--	125.1*	10.3*	166	31.1
Bulk	PF-8	1-2	SC	14.9	41	19	22	100	82	28	--	117.9*	11.9*	196	22.9
Bulk	PF-9	1-2	SC	13.8	38	18	20	100	87	25	--	125.1*	10.4*	72	37.0
Bulk	PF-10	1-2	SC	14.8	43	18	25	100	83	28	--	122.1*	11.0*	146	34.1
Spec	Foundation	NA	NA	NA	NA	NA	NA	100	81.3	20.5		NA	NA		
Spec	Cushion	NA	NA	NA	NA	NA	NA	100	81.3	20.5		NA	NA		

NOTES:
LL = LIQUID LIMIT
PL = PLASTIC LIMIT
PI = PLASTIC INDEX
SL = SHRINKAGE LIMIT

T = TRIAXIAL TEST
U = UNCONFINED COMPRESSION TEST
C = CONSOLIDATION TEST
DS = DIRECT SHEAR TEST
PERM = PERMEABILITY

* ASTM D4718

ROCKY FLATS ALLUVIUM PIT FORCES
FOR BUTTRESS ENGINEERED FILL

SAK 4/14/05
SAK 5/6/05

(4) (CONTINUED)

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

CALCULATION SHEET

PAGE ____ OF ____

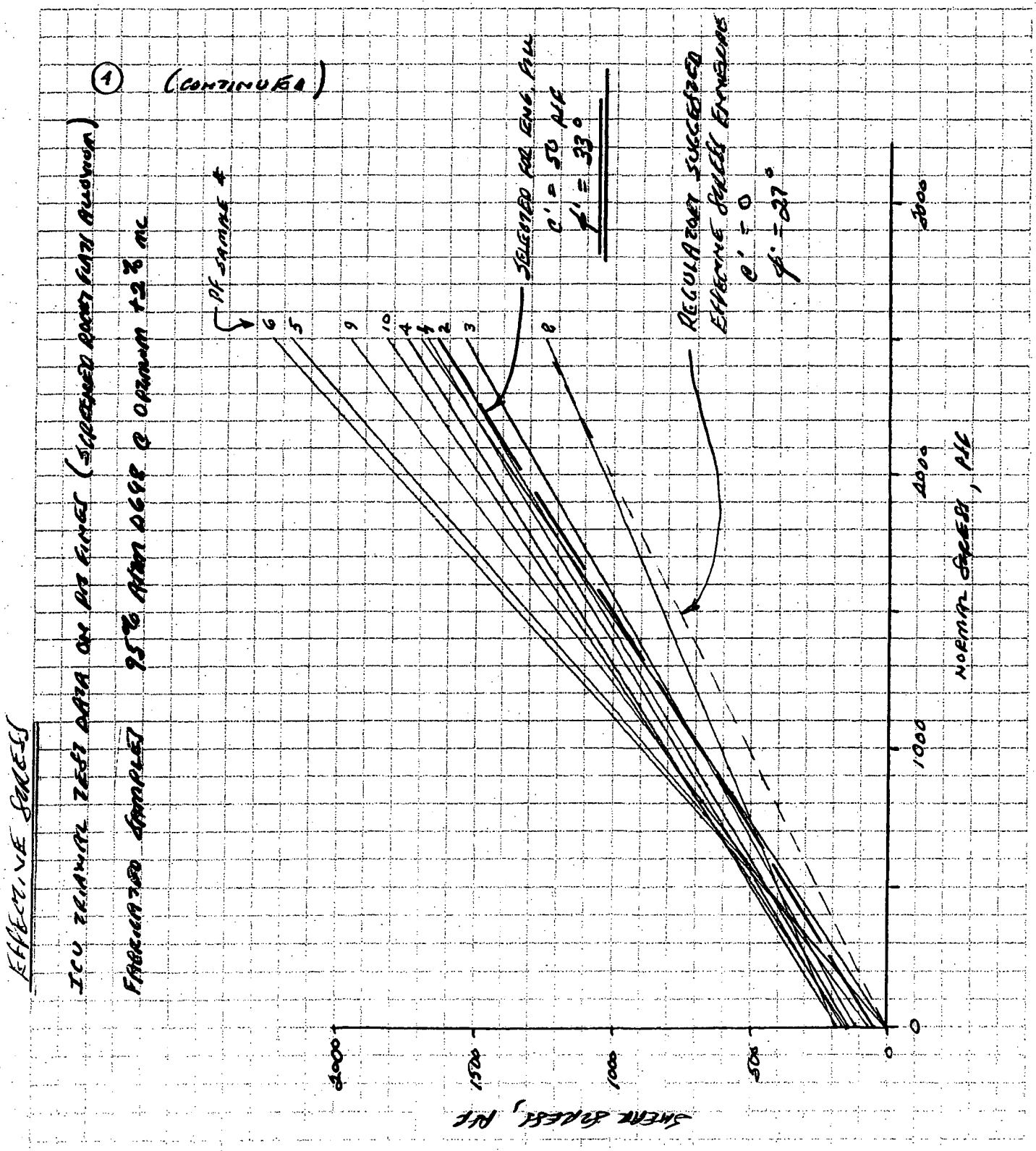
PROJECT NO. 57378.6040

CLIENT Kaiser Hill | SUBJECT Stability | Prepared By [illegible] | DATE 4/14/05

PROJECT Rocky Flats OLF | Check for Grading Plan | Reviewed By [illegible] | DATE 5/16/05

Design Refinements | Approved By ____ | DATE ____

(1) (Continued)



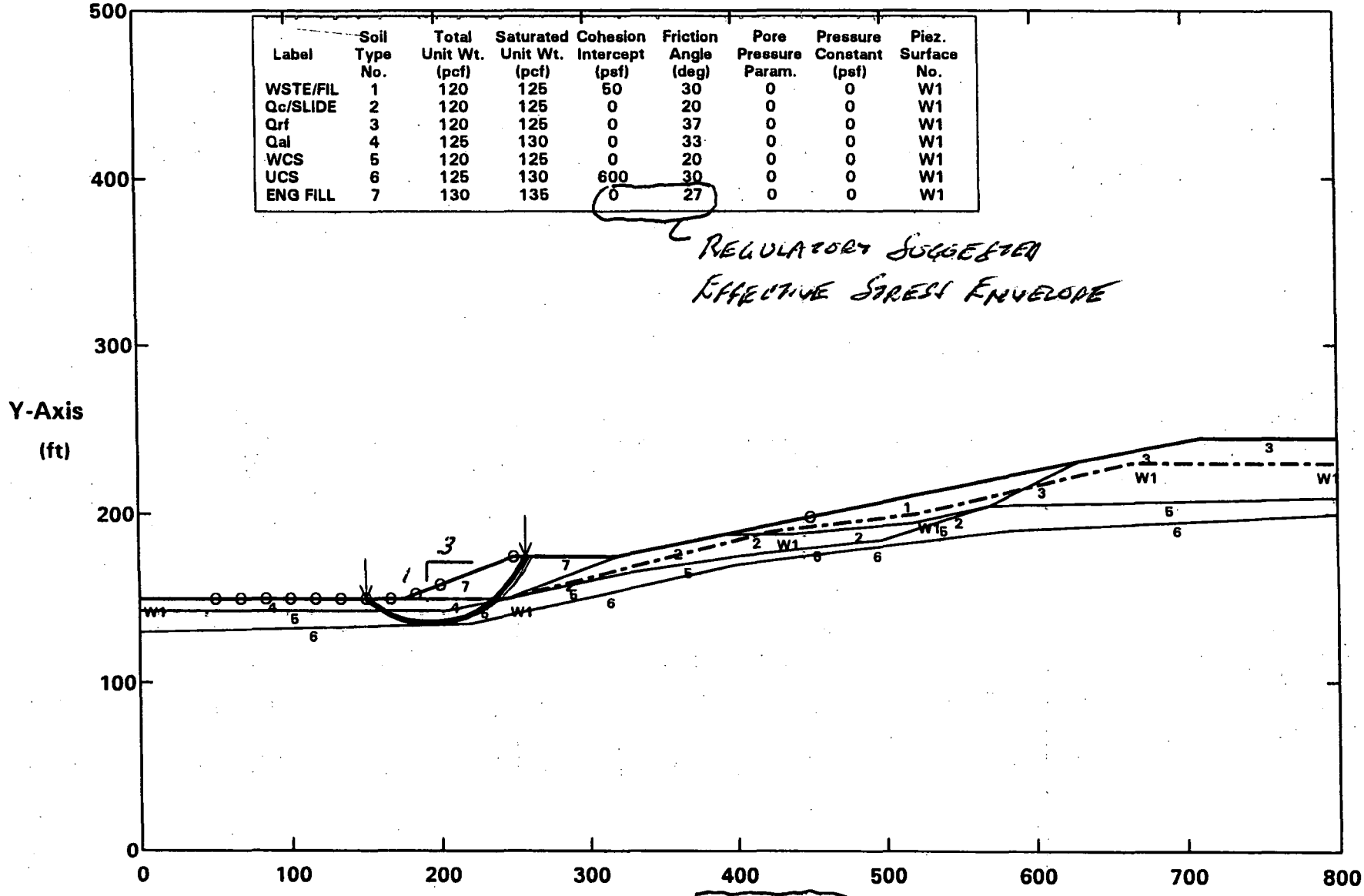
Rev. 2/00

SCALE: 5 sq./inch

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
Ten Most Critical. C:ABHCST.PLT By: STAN KLINE 05-06-05 1:52pm

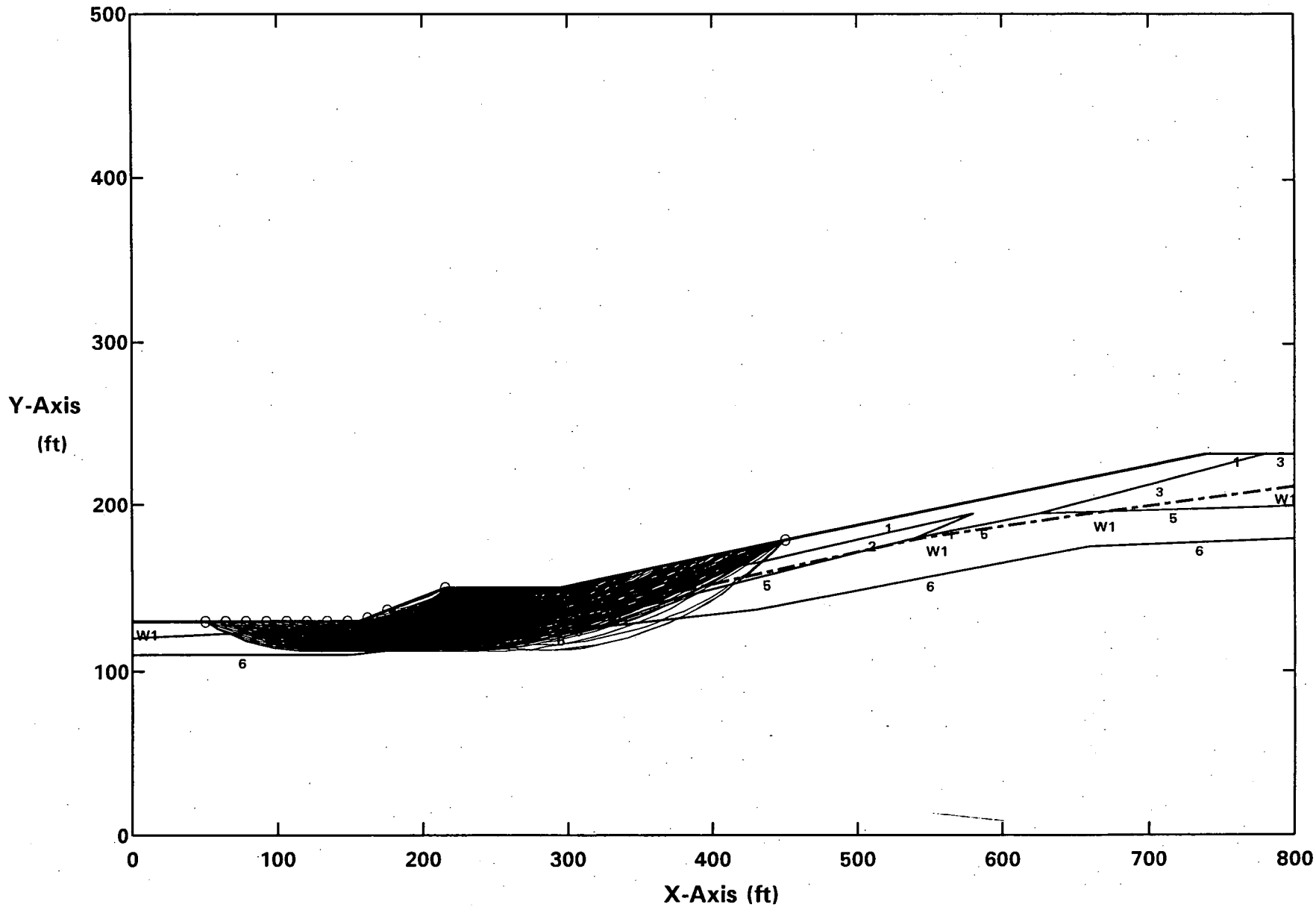
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	0	27	0	0	W1

REGULATORY SUGGESTED
EFFECTIVE STRESS ENVELOPE



PCSTABL5M/SI FSmin = 1.44 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

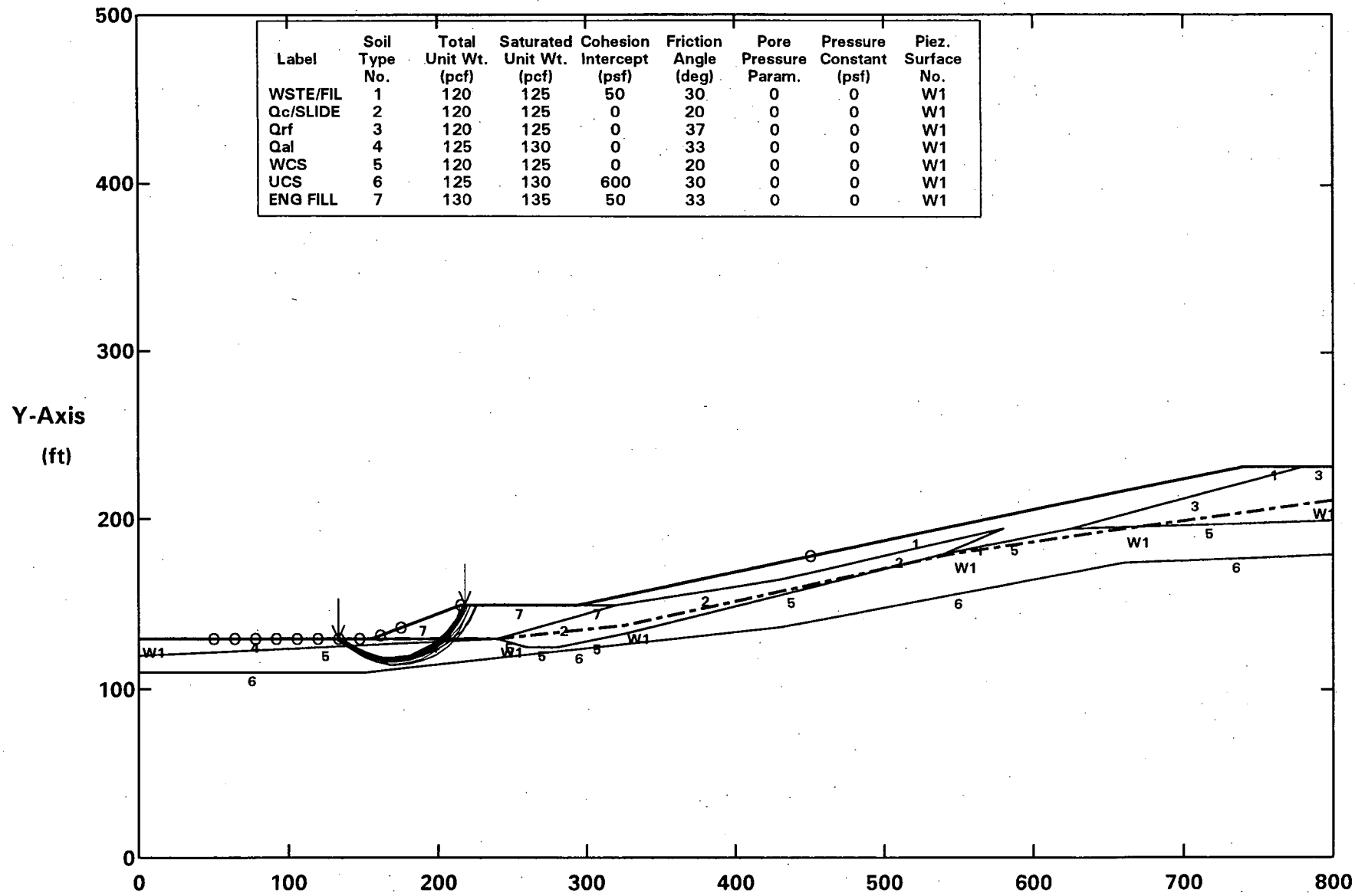
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
All surfaces evaluated. C:DBHCST.PLT By: STAN KLINE 04-13-05 11:25pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
Ten Most Critical. C:DBHCST.PLT By: STAN KLINE 04-13-05 11:25pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	50	33	0	0	W1



PCSTABL5M/SI FSmin = 1.53 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

** PCSTABL5M **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	05-11-05
Time of Run:	2:27pm
Run By:	STAN KLINE
Input Data Filename:	C:ABHCST.IN
Output Filename:	C:ABHCST.OUT
Unit:	
Plotted Output Filename:	C:ABHCST.PLT

PROBLEM DESCRIPTION ROCKY FLATS OLF - M&E A 18%W/BM - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC - TOE

BOUNDARY COORDINATES

7 Top Boundaries
24 Total Boundaries

3.1:1 Borrows Slope

Boundary No.	X-Left (ft,m)	Y-Left (ft,m)	X-Right (ft,m)	Y-Right (ft,m)	Soil Type Below Bnd
1	.00	150.00	172.50	150.00	4
2	172.50	150.00	250.00	175.00	7
3	250.00	175.00	320.00	175.00	7
4	320.00	175.00	392.40	188.00	2
5	392.40	188.00	630.00	230.60	1
6	630.00	230.60	710.00	245.00	3
7	710.00	245.00	800.00	245.00	3
8	392.40	188.00	435.00	188.00	2
9	435.00	188.00	520.00	195.00	2
10	520.00	195.00	570.00	205.00	2
11	570.00	205.00	630.00	230.60	3
12	172.50	150.00	245.00	150.00	4
13	245.00	150.00	320.00	175.00	2
14	.00	143.00	205.00	143.00	5
15	205.00	143.00	245.00	150.00	5
16	245.00	150.00	325.00	165.00	5
17	325.00	165.00	400.00	175.00	5
18	400.00	175.00	500.00	185.00	5
19	500.00	185.00	570.00	205.00	5
20	570.00	205.00	800.00	210.00	5
21	.00	130.00	220.00	135.00	6

22	220.00	135.00	400.00	170.00	6
23	400.00	170.00	580.00	190.00	6
24	580.00	190.00	800.00	200.00	6

ISOTROPIC SOIL PARAMETERS

7 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf,KN/m3)	Saturated Unit Wt. (pcf,KN/m3)	Cohesion Intercept (psf,KPa)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf,KPa)	Piez. Surface No.
1	120.0	125.0	50.0	30.0	.00	.0	1
2	120.0	125.0	.0	20.0	.00	.0	1
3	120.0	125.0	.0	37.0	.00	.0	1
4	125.0	130.0	.0	33.0	.00	.0	1
5	120.0	125.0	.0	20.0	.00	.0	1
6	125.0	130.0	600.0	30.0	.00	.0	1
7	130.0	135.0	.0	27.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 6 Coordinate Points

Point No.	X-Water (ft,m)	Y-Water (ft,m)
1	.00	150.00
2	245.00	150.00
3	425.00	190.00
4	520.00	200.00
5	665.00	230.00
6	800.00	230.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

1000 Trial Surfaces Have Been Generated.

100 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 50.00 (ft,m)
and X = 200.00 (ft,m)

Each Surface Terminates Between X = 250.00 (ft,m)
and X = 450.00 (ft,m)

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =135.00 (ft,m)

10.00 (ft,m) Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	150.00	150.00
2	158.41	144.58
3	167.48	140.38
4	177.04	137.46
5	186.92	135.88
6	196.92	135.68
7	206.85	136.86
8	216.52	139.40
9	225.75	143.24
10	234.37	148.31
11	242.20	154.53
12	249.11	161.76
13	254.95	169.88
14	257.66	175.00

Circle Center At X = 193.3 ; Y = 207.8 and Radius, 72.2

*** 1.463 ***

Individual data on the 19 slices

Water Force	Water Force	Tie Force	Tie Force	Earthquake Force	Surcharge

Slice No.	Width (ft,m)	Weight (lbs,kg)	Top (lbs,N)	Bot (lbs,N)	Norm (lbs,N)	Tan (lbs,N)	Hor (lbs,N)	Ver (lbs,N)	Load (lbs,N)
1	8.4	2959.4	.0	1689.8	.0	.0	.0	.0	.0
2	3.4	2756.3	.0	1458.4	.0	.0	.0	.0	.0
3	5.7	6074.8	.0	3233.9	.0	.0	.0	.0	.0
4	5.0	6696.8	.0	3403.5	.0	.0	.0	.0	.0
5	4.5	7320.9	.0	3512.1	.0	.0	.0	.0	.0
6	9.9	20725.4	.0	8317.2	.0	.0	.0	.0	.0
7	10.0	26257.4	.0	8870.7	.0	.0	.0	.0	.0
8	8.1	23909.8	.0	7027.9	.0	.0	.0	.0	.0
9	1.8	5710.4	.0	1537.5	.0	.0	.0	.0	.0
10	9.7	30530.9	.0	7407.0	.0	.0	.0	.0	.0
11	9.2	29043.9	.0	5417.8	.0	.0	.0	.0	.0
12	8.2	24267.5	.0	2580.1	.0	.0	.0	.0	.0
13	.4	1191.3	.0	55.4	.0	.0	.0	.0	.0
14	2.1	5841.8	.0	142.6	.0	.0	.0	.0	.0
15	5.7	14326.2	.0	.0	.0	.0	.0	.0	.0
16	6.9	13873.1	.0	.0	.0	.0	.0	.0	.0
17	.9	1444.1	.0	.0	.0	.0	.0	.0	.0
18	5.0	5514.4	.0	.0	.0	.0	.0	.0	.0
19	2.7	901.6	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	150.00	150.00
2	158.33	144.47
3	167.36	140.17
4	176.90	137.18
5	186.77	135.58
6	196.77	135.39
7	206.70	136.62
8	216.35	139.24
9	225.53	143.19
10	234.07	148.40
11	241.78	154.77
12	248.51	162.17
13	254.13	170.44
14	256.36	175.00

Circle Center At X = 193.0 ; Y = 205.6 and Radius, 70.3

*** 1.465 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)

1	150.00	150.00
2	158.38	144.54
3	167.41	140.24
4	176.93	137.19
5	186.77	135.43
6	196.76	135.01
7	206.72	135.93
8	216.47	138.17
9	225.83	141.69
10	234.63	146.43
11	242.72	152.31
12	249.96	159.21
13	256.21	167.02
14	261.00	175.00

Circle Center At X = 194.9 ; Y = 209.6 and Radius, 74.6

*** 1.465 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	150.00	150.00
2	158.49	144.71
3	167.61	140.62
4	177.20	137.79
5	187.09	136.28
6	197.09	136.12
7	207.02	137.31
8	216.70	139.82
9	225.95	143.62
10	234.60	148.63
11	242.51	154.76
12	249.51	161.89
13	255.49	169.91
14	258.30	175.00

Circle Center At X = 193.2 ; Y = 209.8 and Radius, 73.8

*** 1.465 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)

No.	(ft,m)	(ft,m)
1	150.00	150.00
2	158.41	144.59
3	167.46	140.33
4	176.98	137.28
5	186.82	135.49
6	196.81	135.01
7	206.77	135.83
8	216.55	137.95
9	225.96	141.32
10	234.86	145.88
11	243.08	151.57
12	250.49	158.29
13	256.97	165.91
14	262.39	174.31
15	262.72	175.00

Circle Center At X = 195.5 ; Y = 211.5 and Radius, 76.5

*** 1.467 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	150.00	150.00
2	158.48	144.69
3	167.60	140.59
4	177.19	137.77
5	187.08	136.28
6	197.08	136.14
7	207.00	137.37
8	216.66	139.94
9	225.89	143.80
10	234.50	148.89
11	242.34	155.09
12	249.27	162.31
13	255.14	170.40
14	257.61	175.00

Circle Center At X = 193.0 ; Y = 209.1 and Radius, 73.1

*** 1.467 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	150.00	150.00
2	158.53	144.78
3	167.68	140.75
4	177.29	137.97
5	187.18	136.51
6	197.18	136.37
7	207.11	137.57
8	216.79	140.09
9	226.04	143.87
10	234.71	148.86
11	242.64	154.96
12	249.68	162.06
13	255.70	170.04
14	258.50	175.00

Circle Center At X = 193.1 ; Y = 210.8 and Radius, 74.5

*** 1.467 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	150.00	150.00
2	158.47	144.69
3	167.59	140.58
4	177.18	137.75
5	187.07	136.27
6	197.07	136.15
7	206.99	137.39
8	216.65	139.98
9	225.87	143.87
10	234.46	148.97
11	242.28	155.21
12	249.18	162.45
13	255.02	170.57
14	257.36	175.00

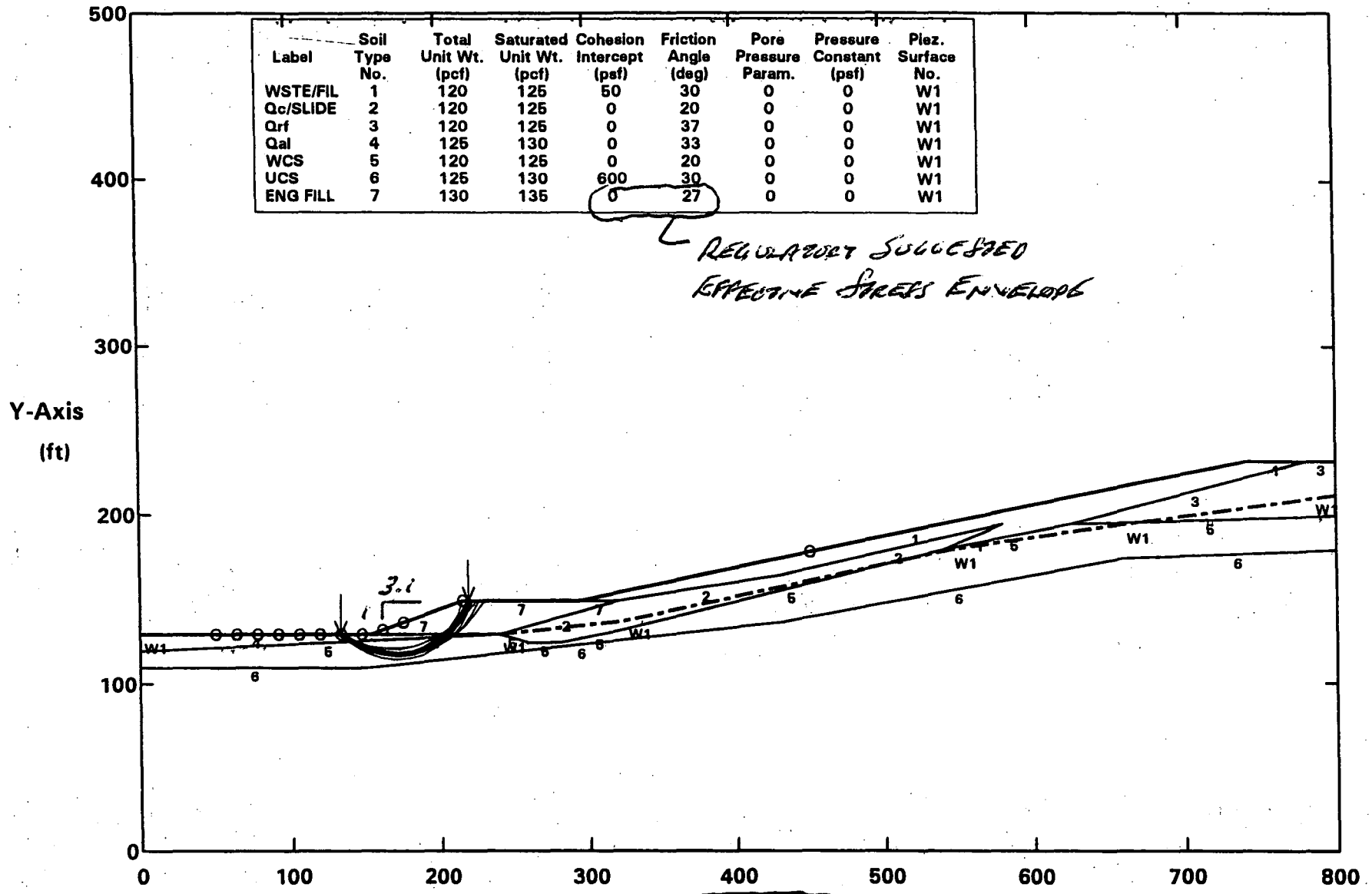
Circle Center At X = 192.9 ; Y = 208.8 and Radius, 72.8

*** 1.468 ***

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
Ten Most Critical. C:DBHCST.PLT By: STAN KLINE 05-06-05 2:34pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	0	27	0	0	W1

REGULATORY SUGGESTED
EFFECTIVE STRESS ENVELOPE



PCSTABL5M/SI FSmin = 1.45 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

** PCSTABL5M **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	05-11-05
Time of Run:	2:29pm
Run By:	STAN KLINE
Input Data Filename:	C:DBHCST.IN
Output Filename:	C:DBHCST.OUT
Unit:	
Plotted Output Filename:	C:DBHCST.PLT

PROBLEM DESCRIPTION ROCKY FLATS OLF - M&E D 18%W/BM - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC - TOE

3.1 : 1 BORROWS SLOPE

BOUNDARY COORDINATES

6 Top Boundaries
24 Total Boundaries

Boundary No.	X-Left (ft,m)	Y-Left (ft,m)	X-Right (ft,m)	Y-Right (ft,m)	Soil Type Below Bnd
1	.00	130.00	153.00	130.00	4
2	153.00	130.00	215.00	150.00	7
3	215.00	150.00	293.80	150.00	7
4	293.80	150.00	740.00	232.00	1
5	740.00	232.00	780.00	232.00	1
6	780.00	232.00	800.00	232.00	3
7	293.80	150.00	320.00	150.00	7
8	320.00	150.00	430.00	165.00	2
9	430.00	165.00	580.00	195.00	2
10	153.00	130.00	240.00	130.00	4
11	240.00	130.00	320.00	150.00	2
12	240.00	130.00	260.00	125.00	5
13	260.00	125.00	280.00	125.00	5
14	280.00	125.00	325.00	133.00	5
15	325.00	133.00	540.00	180.00	5
16	540.00	180.00	580.00	195.00	1
17	540.00	180.00	625.00	195.00	5
18	625.00	195.00	780.00	232.00	3
19	625.00	195.00	800.00	200.00	5
20	.00	120.00	240.00	130.00	5
21	.00	110.00	150.00	110.00	6

22	150.00	110.00	430.00	137.00	6
23	430.00	137.00	660.00	175.00	6
24	660.00	175.00	800.00	180.00	6

ISOTROPIC SOIL PARAMETERS

7 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf,KN/m3)	Saturated Unit Wt. (pcf,KN/m3)	Cohesion Intercept (psf,KPa)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf,KPa)	Piez. Surface No.
1	120.0	125.0	50.0	30.0	.00	.0	1
2	120.0	125.0	.0	20.0	.00	.0	1
3	120.0	125.0	.0	37.0	.00	.0	1
4	125.0	130.0	.0	33.0	.00	.0	1
5	120.0	125.0	.0	20.0	.00	.0	1
6	125.0	130.0	600.0	30.0	.00	.0	1
7	130.0	135.0	.0	27.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 6 Coordinate Points

Point No.	X-Water (ft,m)	Y-Water (ft,m)
1	.00	130.00
2	240.00	130.00
3	325.00	138.00
4	545.00	180.00
5	660.00	195.00
6	800.00	212.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

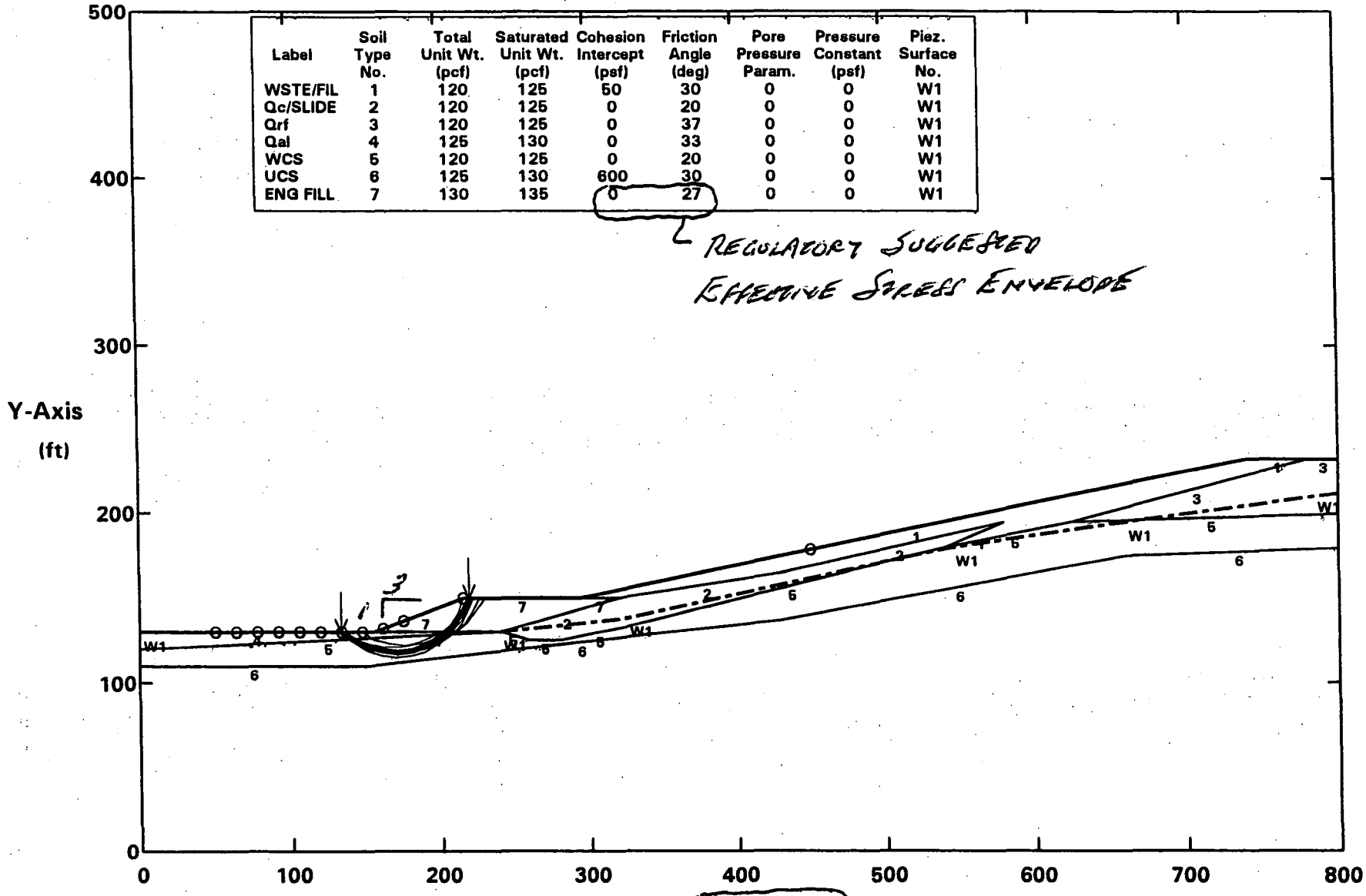
1000 Trial Surfaces Have Been Generated.

100 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 50.00 (ft,m)
and X = 175.00 (ft,m)

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
Ten Most Critical. C:DBHCST.PLT By: STAN KLINE 05-06-05 2:02pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	0	27	0	0	W1

REGULATORY SUGGESTED
EFFECTIVE STRESS ENVELOPE



PCSTABL5M/SI FSmin = 1.42 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

1	6.5	1767.7	.0	1007.5	.0	.0	.0	.0	.0
2	1.9	1177.8	.0	674.8	.0	.0	.0	.0	.0
3	9.2	8620.0	.0	4563.5	.0	.0	.0	.0	.0
4	2.0	2415.9	.0	1216.7	.0	.0	.0	.0	.0
5	7.7	11607.5	.0	5224.1	.0	.0	.0	.0	.0
6	10.0	20016.1	.0	7256.7	.0	.0	.0	.0	.0
7	9.9	23444.0	.0	6986.4	.0	.0	.0	.0	.0
8	9.5	23840.5	.0	5638.1	.0	.0	.0	.0	.0
9	8.9	21329.9	.0	3253.0	.0	.0	.0	.0	.0
10	1.6	3691.9	.0	292.2	.0	.0	.0	.0	.0
11	2.1	4572.4	.0	137.2	.0	.0	.0	.0	.0
12	4.2	8185.9	.0	.0	.0	.0	.0	.0	.0
13	6.7	10155.7	.0	.0	.0	.0	.0	.0	.0
14	1.3	1371.8	.0	.0	.0	.0	.0	.0	.0
15	4.1	2192.1	.0	.0	.0	.0	.0	.0	.0
16	.4	24.2	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	141.71	124.53
3	150.92	120.64
4	160.68	118.46
5	170.67	118.05
6	180.57	119.44
7	190.07	122.56
8	198.86	127.33
9	206.66	133.59
10	213.21	141.15
11	218.31	149.75
12	218.41	150.00

Circle Center At X = 167.9 ; Y = 173.8 and Radius, 55.8

*** 1.446 ***

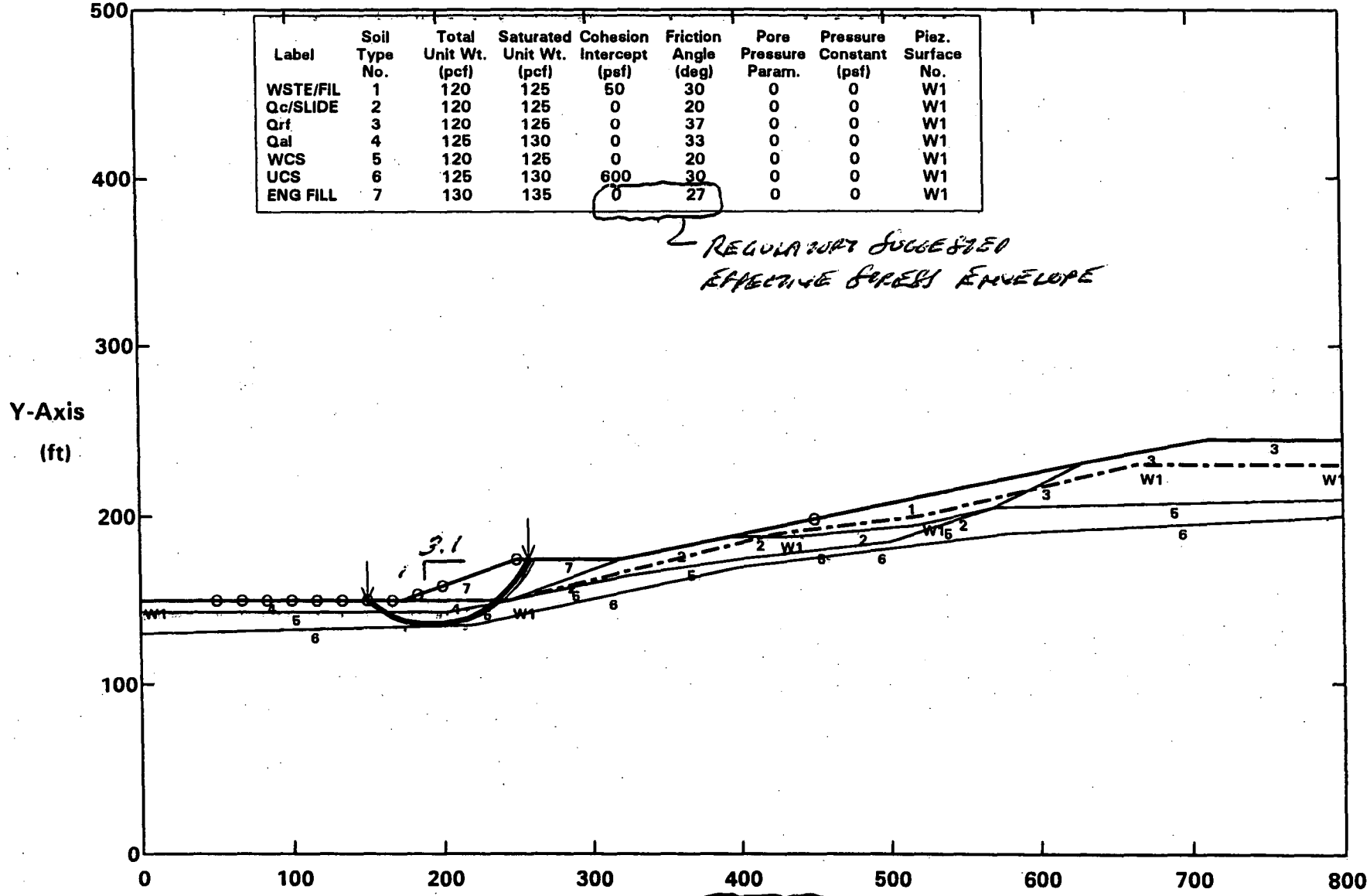
Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	142.34	125.65
3	151.89	122.69
4	161.78	121.19
5	171.78	121.17
6	181.67	122.65
7	191.23	125.58

ROCKY FLATS OLF - M&E A 18%W/BM - WCS = 20deg - W/HIGHGW - CIRCULAR - STATIC - TOE
Ten Most Critical. C:ABHCST.PLT By: STAN KLINE 05-06-05 2:32pm

Label	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.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	0	27	0	0	W1

REGULATORY SUGGESTED EFFECTIVE STRESS ENVELOPE



PCSTABL5M/SI FSmin = 1.46 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

12	221.87	150.00

Circle Center At X = 169.9 ; Y = 173.9 and Radius, 57.2

*** 1.464 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	141.46	124.17
3	150.55	120.01
4	160.28	117.68
5	170.27	117.27
6	180.15	118.79
7	189.56	122.19
8	198.13	127.33
9	205.55	134.04
10	211.54	142.04
11	215.37	150.00

Circle Center At X = 167.4 ; Y = 168.8 and Radius, 51.7

*** 1.467 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	141.69	124.51
3	150.82	120.43
4	160.49	117.88
5	170.44	116.91
6	180.42	117.56
7	190.17	119.80
8	199.43	123.59
9	207.96	128.81
10	215.53	135.33
11	221.96	142.99
12	226.14	150.00

Circle Center At X = 171.4 ; Y = 178.7 and Radius, 61.8

*** 1.469 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	141.26	123.90
3	150.15	119.33
4	159.72	116.42
5	169.66	115.29
6	179.63	115.95
7	189.33	118.40
8	198.43	122.55
9	206.63	128.27
10	213.68	135.37
11	219.33	143.61
12	222.19	150.00

Circle Center At X = 170.9 ; Y = 170.5 and Radius, 55.2

*** 1.481 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	142.06	125.11
3	151.39	121.52
4	161.14	119.31
5	171.11	118.52
6	181.09	119.17
7	190.87	121.24
8	200.25	124.70
9	209.04	129.48
10	217.05	135.46
11	224.12	142.53
12	229.70	150.00

Circle Center At X = 171.6 ; Y = 187.9 and Radius, 69.4

*** 1.487 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	142.50	126.01
3	152.13	123.32
4	162.04	121.97
5	172.04	122.00
6	181.95	123.40
7	191.56	126.14
8	200.71	130.17
9	209.22	135.42
10	216.93	141.79
11	223.70	149.16
12	224.28	150.00

Circle Center At X = 166.8 ; Y = 194.4 and Radius, 72.6

*** 1.489 ***

Appendix B

APPENDIX B

LANDFILL ENGINEERING – FINAL DESIGN SETTLEMENT ANALYSIS

1	150.00	150.00
2	158.51	144.74
3	167.64	140.67
4	177.24	137.86
5	187.13	136.36
6	197.12	136.20
7	207.05	137.38
8	216.74	139.88
9	226.00	143.65
10	234.67	148.63
11	242.60	154.73
12	249.64	161.83
13	255.66	169.81
14	258.58	175.00

Circle Center At X = 193.3 ; Y = 210.4 and Radius, 74.3

*** 1.465 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	150.00	150.00
2	158.25	144.35
3	167.23	139.95
4	176.75	136.89
5	186.62	135.24
6	196.61	135.03
7	206.54	136.26
8	216.18	138.92
9	225.34	142.93
10	233.82	148.23
11	241.45	154.69
12	248.07	162.19
13	253.53	170.56
14	255.59	175.00

Circle Center At X = 193.0 ; Y = 203.8 and Radius, 68.9

*** 1.466 ***

Failure Surface Specified By 15 Coordinate Points

Point	X-Surf	Y-Surf

LIST OF TABLES

Table B-1 Original Landfill - Anticipated Consolidation Pressures on Foundation Soils
Table B-2 Original Landfill - Primary Settlement Estimation of Waste Layer
Table B-3 Original Landfill - Long-Term Settlement Estimation of Waste Layer
Table B-4 Original Landfill - Settlement Estimation of Cover Components
Table B-5 Original Landfill - Total Settlement Summary

LIST OF ATTACHMENTS

Attachment 1 Location of Settlement Points
Attachment 2 Differential Settlement at Point A

APPENDIX B

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL

LANDFILL ENGINEERING – FINAL DESIGN SETTLEMENT ANALYSIS

1.0 INTRODUCTION

The purpose of this calculation is to estimate the amount of foundation layer, waste layer and cover settlement and what impact the potential settlement would have on the cover system performance.

2.0 LANDFILL DESCRIPTION AND LOCATION

The Original Landfill site is located south of Rocky Flats Environmental Technology Site (RFETS) Buildings 440 and 460, along the north hillside of a ravine in the Woman Creek drainage area, extending from approximate elevation 6,040 feet at the top to elevation 5,950 feet at its base. Waste operations began in the early 1950s and continued through 1968. The Original Landfill site footprint has a maximum length along the east-west direction of approximately 1,700 feet and approximately 500 feet in the north-south direction, with an approximate area on the order of 20 acres. Existing slope gradients range from approximately flatter than 6 to 1 (horizontal to vertical) to 2 to 1, with a total slope height from the top of the hillside to the Woman Creek drainage of about 90 feet.

As part of the accelerated action at the Original Landfill, the existing slopes will be regraded to overall 18 percent slope with a 2-foot soil cover and drainage improvements. In addition, a buttress at the toe of the landfill will be installed for stability enhancement.

Several geotechnical investigations have taken place at the Original Landfill. These settlement calculations use cross-sections A-A′, B-B′, and C-C′ developed by Metcalf & Eddy during a 1995 evaluation and further evaluated in 2004 by Earth Tech.

3.0 REFERENCES

1. RFETS Geotechnical Investigation Report for OU5. Metcalf & Eddy, September, 1995.

2. Chapter 6 – Engineering Properties of Municipal Solid Waste and Chapter 12 – Landfill Settlement, *"Geotechnical Aspects of Landfill Design and Construction,"* Xuede Qian, Robert M. Koerner, and Donald H. Gray; Prentice Hall, New Jersey, 2002.

3. Accelerated Action Design for the Original Landfill Geotechnical Investigation Phase 3 Stability Analysis Technical Support Memorandum, Earth Tech, November, 2004a.

4. Appendix B – Settlement Analyses, "*Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation,*" Hari D. Sharma and Sangeeta P. Lewis; John Wiley & Sons, Inc., New York, NY, 1994.

5. Accelerated Action Design for the Present Landfill RFETS, 95% Design - Revision 1 Submittal - Volume II of II. Earth Tech, August, 2004b.

4.0 DESIGN CRITERIA

These calculations were completed to evaluate the settlement of the proposed cover of the Original Landfill due to potential settlement of the landfill foundation, landfill waste, regrade material, and cover material. The settlement analysis will meet the following design criteria:

1. Total differential settlement cannot have a negative impact on the slope of the landfill causing depressions where surface water may collect.

2. Total differential settlement cannot allow the slopes to increase to the point of causing erosional problems.

5.0 CALCULATIONS

5.1 LANDFILL FOUNDATION SETTLEMENT ANALYSIS

A foundation analysis is conducted to determine if the claystones that exist in the foundation of the landfill could contribute to the overall settlement of the cover system. The analysis determines if the compressive strength of the claystones (severely weathered, moderately weathered, and unweathered) is greater than the force applied by the materials placed above. To conduct the analysis, The following assumptions were used:

- From Original Landfill borehole logs (Earth Tech 2004a), the compressive strength as determined by a pocket penetrometer for the severely weathered claystone ranges from 1.6 to 3.3 tons/square foot (ft^2). The compressive strength for the moderately weathered claystone ranges from 3.0 to greater than 5 tons/ft^2. Assume that the strength of the unweathered claystone is greater than the moderately weathered claystone.

- Rocky Flats Alluvium (RFA) will be used as the 2-foot cover and the regrade material. Assume maximum compaction, which will result in higher densities and greater forces. From RFA samples during Present Landfill cover construction (Earth Tech 2004b), the greatest unit weight at optimum moisture is 142.3 pounds per cubic foot (lb/ft^3).

- For Buttress Fill Material, Centennial or LaFarge Quarry "pit-fines" will be used. The greatest unit weight at optimum moisture is 138.0 lb/ft^3 (see PF-7 in Appendix G).

- For the waste, colluvium/slide, valley fill alluvium, and weathered claystone unit weights, use those found in Original Landfill Phase III Investigation (Earth Tech 2004a) of 125 lb/ft^3 for waste, colluvium/slide, and weathered claystone and 130 lb/ft^3 for valley fill alluvium.

The forces on the weathered claystone were calculated for the four points along section B-B′ (Points A, B, C, D), shown in Attachment 1. These points were chosen because Point A has the thickest section of regrade material added, which contributes to the forces causing settlement; Point B has the thickest amount of waste of the cross-sections; Point C has thick sections of both colluvium and weathered claystone; and Point D represents a point on the buttress over the valley fill alluvium. In addition, settlement was calculated at points lateral to section B-B′ located on section A-A′ (Point E) and C-C′ (Point F).

Table B-1

Original Landfill - Anticipated Consolidation Pressures on Foundation Soils

Point	Final Landfill Elevation (ft)	Thickness (ft)							Load on Weathered Bedrock (lbs/ft^2)
		Cover	Regrade	Buttress	Waste	Colluvium/Slide	Valley Fill Alluvium	Weathered Claystone	
A	6025	2	20	0	10	5	0	8	6005.6
B	6010	2	10	0	20	10	0	0	5457.7
C	5990	2	0	0	13	3	0	8	3284.8
D	5972	2	0	25	0	0	12	10	6544.8
E	6010	2	10	0	5	8	0	2	3582.6
F	5990	2	5	0	0	20	0	10	4746.1

The peak pressure acting upon the claystone bedrock foundation occurs at Point D and is estimated to be 6,544.8 lbs/ft^2 (approximately 3.3 tons/ft^2). As stated in section 5.1, the field compressive strength of the severely weathered claystone is 1.6 to 3.3 tons/ft^2. Therefore, some settlement of this material can be expected to occur due to the additional weight of the material placed above. The compressive strength of the moderately weathered claystone ranged from 3.0 to greater than 5 tons/ft^2, so settlement of this material may occur. For the purposes of this calculation, settlement in the moderately weathered claystone will be calculated.

Potential settlement rates within the waste and cover system are determined in the following sections.

5.2 LANDFILL WASTE SETTLEMENT

Primary settlement of the waste layer can be assumed to have already occurred during the approximate 30-year waste placement process, and the landfill has been closed for more than 10 years (Qian, Koerner and Gray 2002).

Continued settlement of the waste layer may occur through the placement of the regrade material and cover system and long-term secondary settlement (i.e., total settlement 30 years after closure). The determination of the amount of waste settlement due to the placement of the regrade material and cover is presented in the following procedures using the Sowers Method (Sharma and Lewis 1994):

$$\Delta H_p = H\frac{Cc}{1+e_o}\log\frac{P_o+\Delta P}{P_o}$$

Where:

- ΔH_p = Primary settlement of waste
- H = Initial waste thickness
- Cc = Primary Compression Index
  - The primary compression index used is that for solid waste though the waste fill material seen at the Original Landfill is mixed with fill material and a high unit weight of waste of 125 lbs/ft^3 is used. This is a conservative approach that will result in more calculated settlement than using a typical waste unit weight like 75 lbs/ft^3.
  - Cc is derived from Figure 6.10 in Reference 2. To use the chart, initial void ratio (e_o) ratio is needed.
  - e_o of 1.08 is found on Table 6.5 of Reference 2.
  - Using Figure 6.10 of Reference 2 with an initial void ratio of 1.08, the Cc is determined to be 0.3 for solid waste at a mid-level organic content.
- e_o = waste estimated void ratio = 1.08 (as discussed above)
- P_o = Effective stress at the center of the waste layer (Point A)
  - P_o = (thickness of waste/2)(125 lbs/ft^3) = 625 lb/ft^2
- ΔP = Change in overburden pressure due to cover system at the midlevel of the waste (Point A)
  - ΔP = (2.0)(142.3 lb/ft^3) + (20 ft)(142.3 lbs/ft^3) = 3130.6 lb/ft^2

Using the figure in Attachment 1, the waste layer settlement can be estimated at the locations (Points A through D) shown on the landfill cross-section:

Table B-2
Original Landfill - Primary Settlement Estimation of Waste Layer

Point Location	Thickness of Waste (feet)	P_o (lbs/ft^2)	ΔP (lbs/ft^2)	ΔH_p Primary Settlement (feet)
Point A	10	625	3130.6	1.12
Point B	20	1250	1707.6	1.08
Point C	13	812.5	284.7	0.24
Point D	0	0	0	0
Point E	5	312.5	284.6	0.20
Point F	0	0	0	0

Long-term secondary settlement is given Sowers Method (Equation B.8 Attachment 5):

$$\Delta H_s = H_o \frac{C_s}{1+e_o} \log \frac{t_2}{t_1}$$

Where:

- ΔH_s = Secondary settlement of waste
- C_s = Secondary compression index
  - C_s is determined from Figure 6.11 of Reference 2.
  - $C_s = 0.03(e_o) = 0.03(1.08) = 0.032$
- e_o = waste estimated void ratio = 1.08 (as discussed in primary settlement calculation)
- H_o = Initial thickness of waste layer after primary settlement
- t_1 = Starting time of secondary settlement (assumed to equal the completion of cover construction, i.e., year 1)
- t_2 = Ending time of secondary settlement = 30 years

Each Surface Terminates Between X = 215.00 (ft,m)
and X = 450.00 (ft,m)

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =112.00 (ft,m)

10.00 (ft,m) Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	141.76	124.61
3	150.99	120.77
4	160.75	118.59
5	170.74	118.15
6	180.65	119.46
7	190.19	122.47
8	199.05	127.10
9	206.97	133.21
10	213.71	140.60
11	219.06	149.05
12	219.45	150.00

Circle Center At X = 168.2 ; Y = 175.1 and Radius, 57.1

*** 1.445 ***

Individual data on the 16 slices

Slice No.	Width (ft,m)	Weight (lbs,kg)	Water Force Top (lbs,N)	Water Force Bot (lbs,N)	Tie Force Norm (lbs,N)	Tie Force Tan (lbs,N)	Earthquake Force Hor (lbs,N)	Earthquake Force Ver (lbs,N)	Surcharge Load (lbs,N)

EARTH TECH
A TYCO INTERNATIONAL LTD. COMPANY
5575 DTC Parkway, Suite 200
Englewood, Colorado 80111

Project: RFETS – Original Landfill Accelerated Action Project No. 57378.6030 Date: 5/11/05

Subject: Landfill Engineering – Settlement Analysis

By: RA Date: 4/11/05 Chk By: RT Date: 4/11/05 App By: RT Date: 4/11/05

Table B-4
Original Landfill - Settlement Estimation of Cover Components

Layer	Point Location	Thickness (ft)	P_o (lbs/ft^2)	ΔP (lbs/ft^2)	ΔH_p Primary Settlement (feet)
Cover	Point A	2	142.3	142.3	0.06
	Point B	2	142.3	142.3	0.06
	Point C	2	142.3	142.3	0.06
	Point D	2	142.3	142.3	0.06
	Point E	2	142.3	142.3	0.06
	Point F	2	142.3	142.3	0.06
Regrade	Point A	20	1423	284.6	0.15
	Point B	10	711.5	284.6	0.14
	Point C	0	0	0	0
	Point D	0	0	0	0
	Point E	10	711.5	284.6	0.14
	Point F	5	355.8	284.6	0.12
Buttress	Point A	0	0	0	0
	Point B	0	0	0	0
	Point C	0	0	0	0
	Point D	25	1725.0	284.6	0.16
	Point E	0	0	0	0
	Point F	0	0	0	0
Colluvium	Point A	5	312.5	4380.6	0.55
	Point B	10	625.0	4207.6	0.83
	Point C	3	187.5	1909.7	0.30
	Point D	0	0	0	0
	Point E	8	500.0	2332.6	0.57
	Point F	20	1250.0	996.1	0.48
Valley Fill Alluvium	Point A	0	0	0	0
	Point B	0	0	0	0
	Point C	0	0	0	0
	Point D	12	780.0	3734.8	0.86
	Point E	0	0	0	0
	Point F	0	0	0	0
Weathered Claystone	Point A	8	500.0	5005.6	0.78
	Point B	0	0	5457.6	0
	Point C	8	500.0	2284.7	0.56
	Point D	10	625	5924.8	0.92
	Point E	2	125.0	3332.6	0.27
	Point F	10	625.0	3496.1	0.77

Notes: Cc =0.130 from sample PF-8 and e_o = 0.386 from sample PF-7.

ΔP values for colluvium, valley fill alluvium, and weathered claystone include force of waste.

8	200.25	129.90
9	208.52	135.51
10	215.87	142.30
11	222.04	150.00

Circle Center At X = 166.9 ; Y = 188.0 and Radius, 67.0

*** 1.461 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	141.51	124.24
3	150.58	120.04
4	160.27	117.55
5	170.24	116.83
6	180.18	117.93
7	189.76	120.79
8	198.67	125.33
9	206.62	131.40
10	213.35	138.79
11	218.64	147.28
12	219.71	150.00

Circle Center At X = 169.1 ; Y = 171.9 and Radius, 55.1

*** 1.462 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft,m)	Y-Surf (ft,m)
1	133.33	130.00
2	141.55	124.31
3	150.64	120.12
4	160.31	117.58
5	170.28	116.76
6	180.23	117.67
7	189.88	120.30
8	198.93	124.56
9	207.10	130.33
10	214.14	137.42
11	219.85	145.63

In summary, the calculated settlement after construction of the Original Landfill is acceptable. Differential settlement is not expected to be problematic using this calculation but will be monitored during the monitoring and maintenance period not discussed in this design.

APPENDIX B

ATTACHMENT 1
LOCATION OF SETTLEMENT POINTS

APPENDIX B

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL

LANDFILL ENGINEERING – FINAL DESIGN
SETTLEMENT ANALYSIS

MAY 11, 2005

Prepared by:

Earth Tech, Inc.
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This calculation was performed by Earth Tech, Inc. Although each sheet comprising this calculation may or may not be initialed, it has nonetheless been reviewed and checked.

Prepared By:	RA	Date: 4/11/05
Checked By:	RT	Date: 4/11/05
Approved By:	RT	Date: 4/11/05

Table B-3

Original Landfill - Long-Term Settlement Estimation of Waste Layer

Point Location	H_o H - Primary Settlement (feet)	C_s	e_o Estimated Void Ratio of Waste Layer	t_2/t_1 (years)	ΔH_s Long-Term Settlement (feet)
Point A	8.88	0.032	1.08	30	0.20
Point B	18.93	0.032	1.08	30	0.43
Point C	12.76	0.032	1.08	30	0.29
Point D	0	0.032	1.08	30	0.00
Point E	4.80	0.032	1.08	30	0.11
Point F	0	0.032	1.08	30	0.00

The maximum total settlement of 1.51 feet of the waste layer occurs at Point B, where the waste is the deepest.

5.3 COVER SETTLEMENT

The settlement of the remaining layers, including the 2-foot cover, the regrade material, the buttress fill material, the colluvium material, the valley fill alluvium, and the weathered claystone, is calculated with equation B.2 of Reference 4. The equation is identical to that of the primary waste settlement only for cohesive soils; the equation calculates the total settlement (both primary and secondary). Compression index and initial void ratio data were taken from Centennial "pit-fine" consolidation tests (see Appendix G). "Pit-fines" are the portion of the RFA where 100% passes the 0.50-0.75-inch sieve. Settlement or consolidation of this size particle is assumed to occur and not on the larger portions of the RFA. For the buttress fill, "pit-fines" from the LaFarge Pit are proposed, which are screened identically to the fines from Centennial Pit. To calculate the maximum possible settlement, the highest compression index and lowest initial void ratios of the 10 tests taken are used. The values are used for all layers.

5.4 SETTLEMENT SUMMARY

A summary of the potential settlement of the Original Landfill waste, cover, and the subsequent decrease in top of landfill slope is provided in Table B-5.

Table B-5
Original Landfill - Total Settlement Summary

Point Location	Total Calculated Settlement (feet)	Distance Between Points (feet)	Design Final Grade Elevations at Point Locations (feet)	Design Slope Between Point Locations	Revised Top of Landfill Slope @ 30 Years (feet)	Revised Slope Between Point Locations
Point A	2.86		6025		6022.14	
		85		18%		17.3%
Point B	2.54		6010		6007.46	
		155		13%		12.2%
Point C	1.45		5990		5988.55	
		130		14%		14.3%
Point D	1.99		5972		5970.01	
Point A	2.86		6025		6022.14	
		310		5%		4.4%
Point E	1.34		6010		6008.66	
Point A	2.86		6025		6022.14	
		370		9.5%		9.1%
Point F	1.42		5990		5988.58	

Based on this analysis, the maximum settlement due to placement of the cover and 30-year post-closure period is approximately 2.86 feet at Point A. This results in minor slope changes along section B-B′ and laterally from Point A to Points E and F. The slope changes are not problematic and do not result in drainage problems.

However, differential settlement could affect erosion of the cover. If it is assumed that there is no settlement at Point A and the maximum settlement is at Point B of 2.54 feet, the resulting slope is 20.6%. Placing this slope into the RUSLE software discussed in Appendix C, the resulting rain erosion (assuming Rocky Flats Alluvium in a mature state) is 1.6 tons/acre/year or below RCRA/CERCLA guidance (wind erosion is 0.0 tons/acre/year). If it is assumed that Point A settles and lateral points E and F do not settle, the slopes are reduced to 3.9% and 8.7%, respectively, which is not enough to encourage ponding.

To further evaluate differential settlement, the point with the largest amount of settlement, Point A at 2.86 feet, was used to regenerate a contour map of the area, assuming the settlement radiates 50 feet from Point A. Attachment 2 shows the resulting grade in the area. The slopes change from 18% to a maximum of 26.0% and a minimum of 9.1% and will still promote drainage. The flow length at 26% is 30 feet, which results in minimal erosion of 0.25 ton/acre/year using the RUSLE similar to the conditions discussed above.

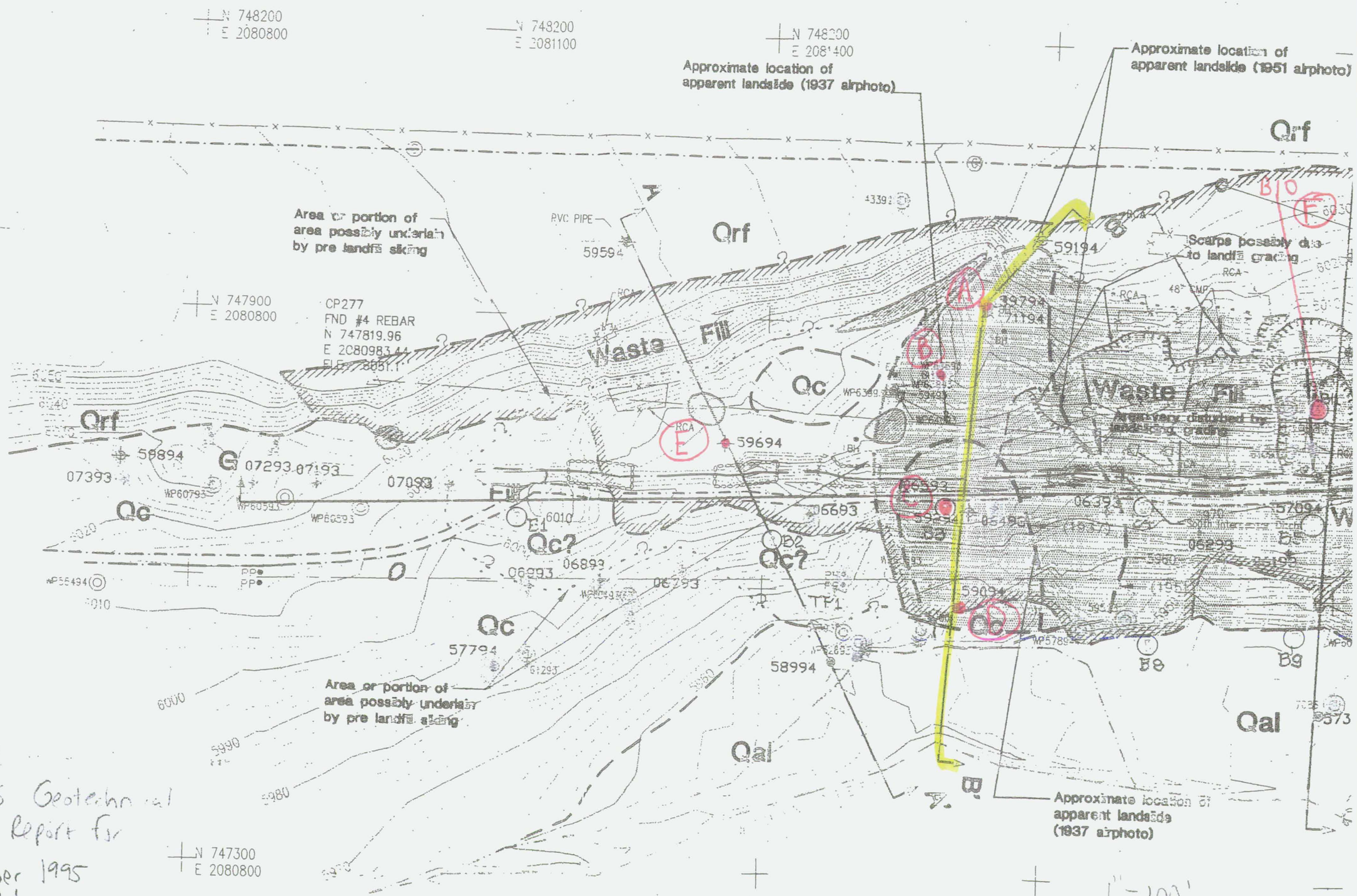
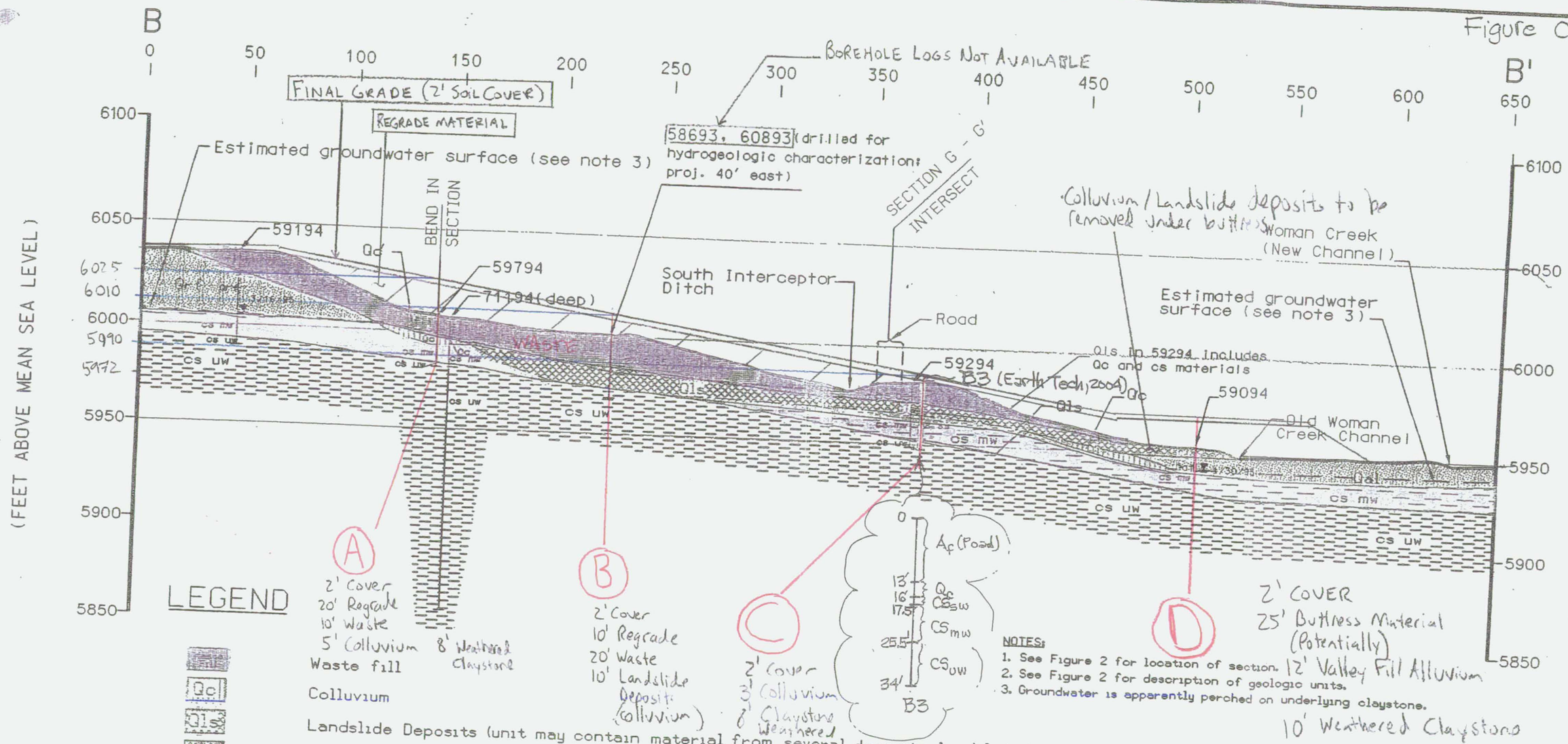


Figure 2
Draft RFETS Geotechnical Investigation Report for OU5. September 1995
Metcalf & Eddy

LEGEND

POINTS A, B, C, D

Figure C3



LEGEND

- Waste fill
- Qc — Colluvium
- Qls — Landslide Deposits (unit may contain material from several discrete landslides).
- Qal — Valley Fill Alluvium
- Qrf — Rocky Flats Alluvium
- cs — Laramie Formation Claystone:
  - sw — severely weathered
  - mw — moderately weathered
  - uw — unweathered

59194
Qrf 3/16/95
cs mw

Geotechnical boring, backfilled or with monitoring well, showing geologic units, groundwater elevation and date measured.

NOTES:

1. See Figure 2 for location of section.
2. See Figure 2 for description of geologic units.
3. Groundwater is apparently perched on underlying claystone.

50 0 50
SCALE IN FEET

DRAFT

PROJECT #:	32242
ORIG. DATE:	MAY, 1995
PREP. BY:	R. RIDENOUR
REV. BY:	R. HARLAN
SCALE:	AS NOTED

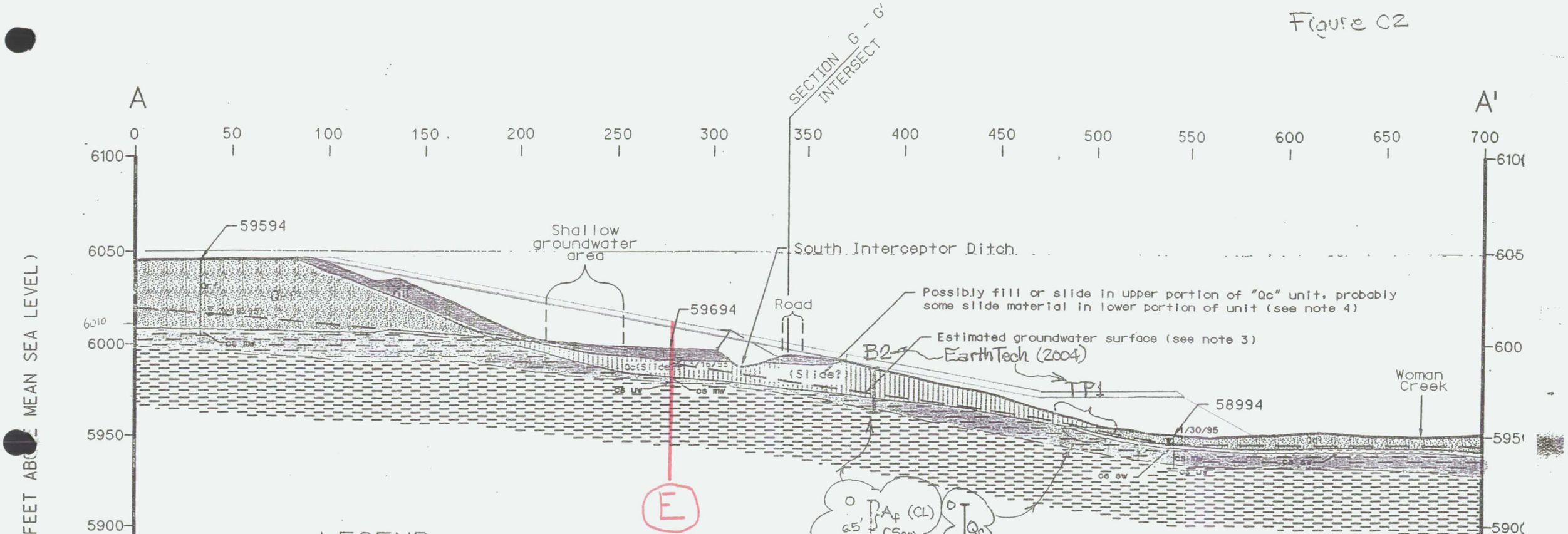
Prepared for:
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN COLORADO

PREPDATE: SEPTEMBER 1995

FIGURE 5
OU-5 GEOTECHNICAL INVESTIGATION

POINT E

Figure C2



LEGEND

- Waste fill
- Qc — Colluvium
- Qal — Valley Fill Alluvium
- Qrf — Rocky Flats Alluvium
- CS — Laramie Formation Claystone:
  - severely weathered
  - moderately weathered
  - unweathered

59694
Qc 3/16/95
cs mw

Geotechnical boring, backfilled or with monitoring well, showing geologic units, groundwater elevation and date measured.

NOTES:

1. See Figure 2 for location of section.
2. See Figure 2 for description of geologic units.
3. Groundwater is apparently perched on underlying claystone.
4. Interpretation of the unit shown as Qc on this section is tentative and based on materials encountered in 59694; the location of pre-landfill ground surface along this section is needed to more confidently interpret origin of these materials.

50 0 50
SCALE IN FEET

DRAFT

PROJECT #:	32242
ORIG. DATE:	MAY, 1995
PREP. BY:	R. RIDENOUR
REV. BY:	R. HARLAN
SCALE:	1" = 50'
FILE NAME:	N:*...\ROCKY\AA.DGN

Prepared for:
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN COLO

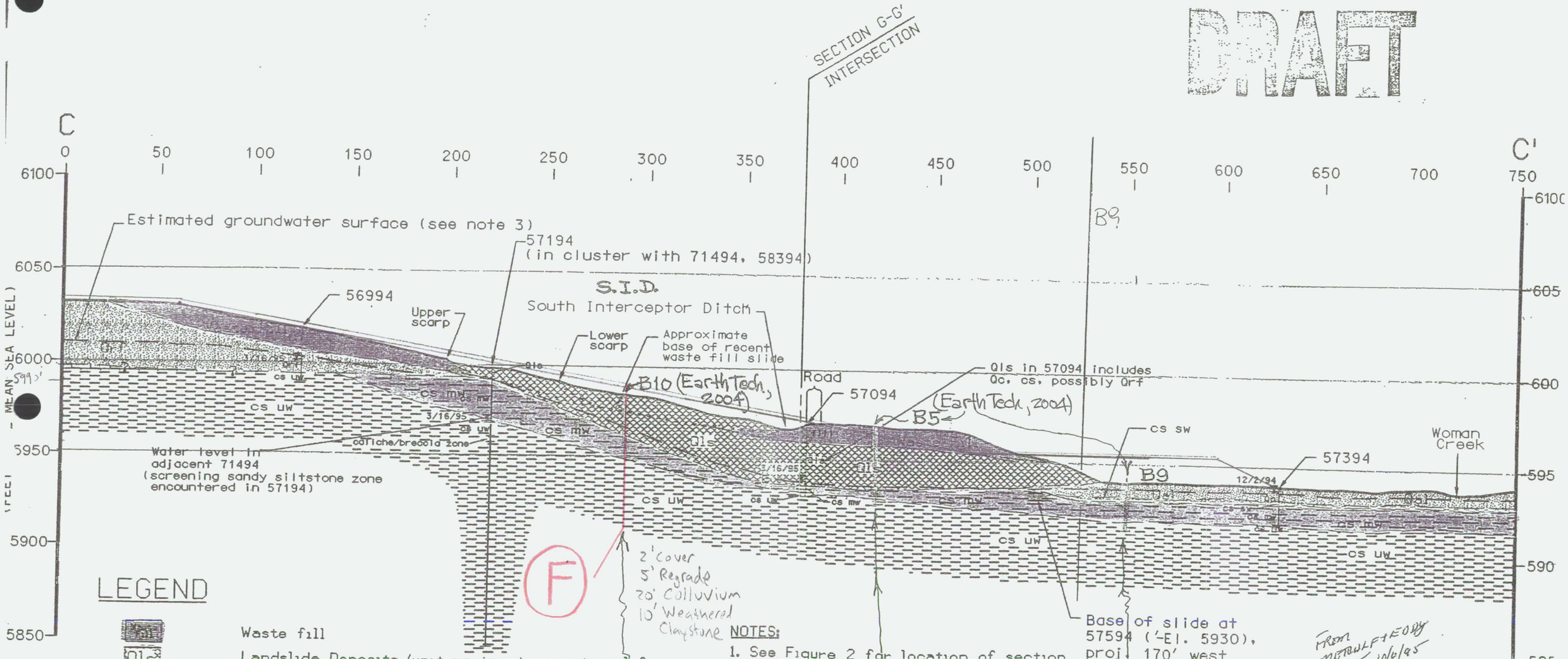
PREPDATE: SEPTEMBER 1995

FIGURE 4
OU-5 GEOTECHNICAL INVESTIG
SECTION A-A'

POINT F

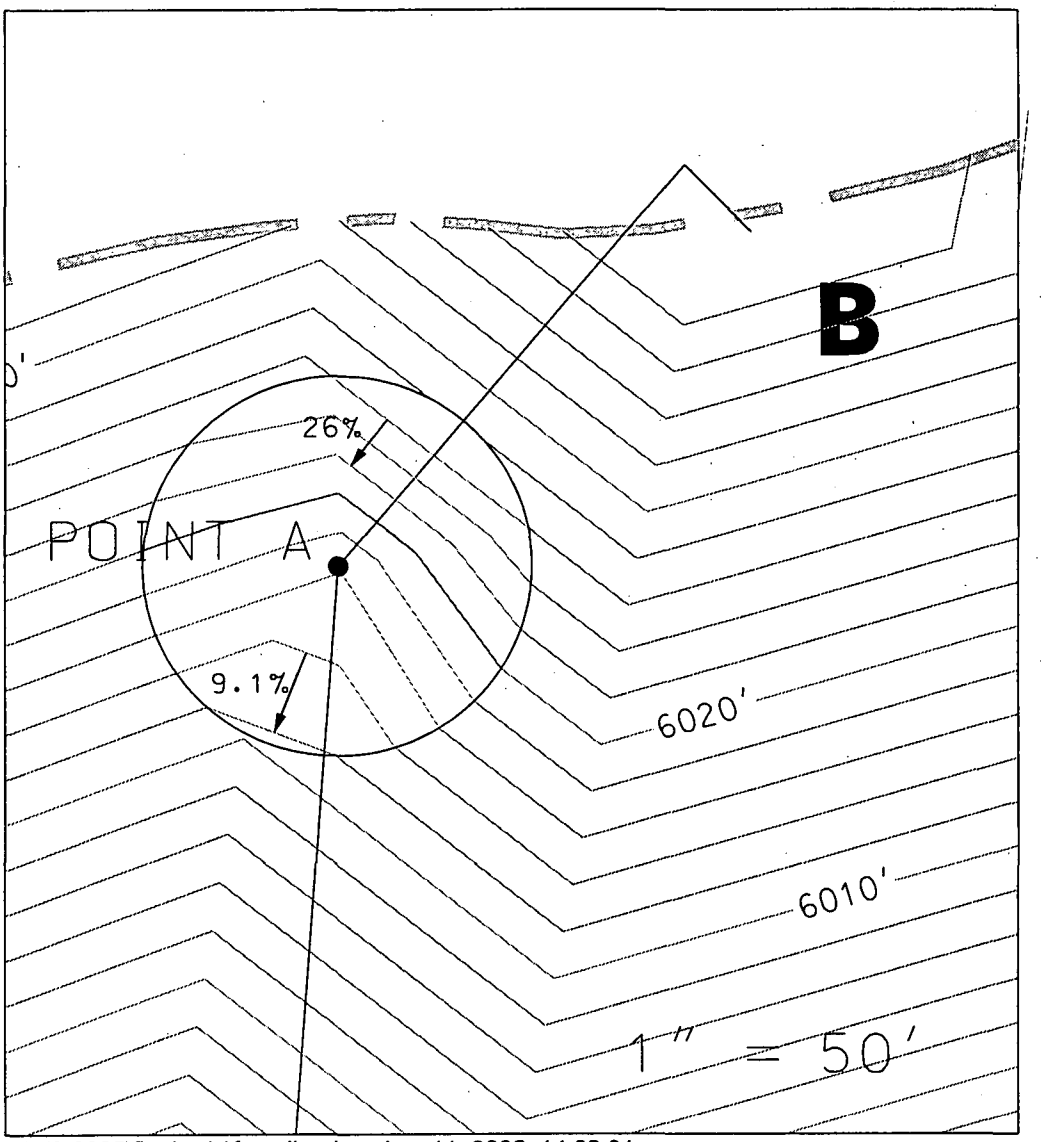
Figure C4

DRAFT



APPENDIX B

ATTACHMENT 2
DIFFERENTIAL SETTLEMENT AT POINT A



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Appendix C

APPENDIX C

LANDFILL ENGINEERING – FINAL DESIGN
RAINFALL SOIL EROSION AND WIND EROSION LOSS CALCULATION

APPENDIX C

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL

LANDFILL ENGINEERING – FINAL DESIGN
RAINFALL SOIL EROSION AND WIND EROSION LOSS CALCULATIONS

MAY 11, 2005

Prepared by:

Earth Tech, Inc.
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This calculation was performed by Earth Tech, Inc. Although each sheet composing this calculation may or may not be initialed, it has nonetheless been reviewed and checked.

Prepared By:	RA	Date: 5/10/05
Checked By:	RT	Date: 5/10/05
Approved By:	RT	Date: 5/10/05

LIST OF TABLES

Table C-1	Original Landfill – Rain Erosion
Table C-2	Original Landfill – Wind Erosion
Table C-3	Original Landfill – Total Erosion

LIST OF ATTACHMENTS

Attachment 1	RUSLE Input/Output
Attachment 2	National Agronomy Manual
Attachment 3	Soil Survey of Golden Area, Colorado
Attachment 4	Prevailing Wind Information
Attachment 5	Geotechnical Data

APPENDIX C

LANDFILL ENGINEERING – FINAL DESIGN
RAINFALL SOIL EROSION AND WIND EROSION LOSS CALCULATIONS

1.0 INTRODUCTION

The purpose of this calculation is to determine the erosion following seeding, the erosion after the vegetation has been established, and the long term erosion if vegetation does not establish on the final cover slopes at the Original Landfill located on the Rocky Flats Environmental and Technology Site (RFETS).

2.0 LANDFILL DESCRIPTION AND LOCATION

The Original Landfill site is located south of RFETS Buildings 440 and 460, along the north hillside of a ravine in the Woman Creek drainage area, extending from approximate Elevation 6,040 feet at the top to Elevation 5,950 feet at its base. Waste operations began in the early 1950s and continued through 1968. The Original Landfill site footprint has a maximum length along the east-west direction of approximately 1,700 feet, and approximately 500 feet in the north-south direction, with an approximate area on the order of 20 acres. Existing slope gradients range from approximately flatter than 6 to 1 (horizontal to vertical) to 2 to 1, with a total slope height from the top of the hillside to the Woman Creek drainage of about 90 feet.

As part of the accelerated action at the Original Landfill, the existing slopes will be regraded to overall 18 percent slope with 2-foot soil cover and drainage improvements. In addition, a buttress fill at the toe of the landfill will be installed for stability enhancements.

3.0 REFERENCES

Potential erosion for the Original Landfill was evaluated using guidelines provided in the following documents:

1. "Technical Guidance For RCRA/CERCLA Final Covers." U.S. EPA, Office of Solid Waste and Emergency Response, April 2002.

2. "Regulations Pertaining to Solid Waste Disposal Sites and Facilities" (Regulations). 6 Colorado Code of Regulations (CCR) 1007-2, Colorado Department of Public Health and Environment.

3. "Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE)." Version 1.06. Terrance J. Toy and George R. Foster, August 1998.

4. "National Agronomy Manual." United States Department of Agriculture (USDA), October 2002.

5. Soil Survey of Golden Area, Colorado. USDA, 1980.

4.0 DESIGN CRITERIA

The attached calculations were used to evaluate the potential for rainfall and wind erosion at the Original Landfill and to determine whether additional erosion control measures are required. Evaluation of potential rainfall and wind erosion of the Original Landfill was based on the following design criteria:

1. The Original Landfill consists of an 18% slope and a maximum drainage distance of approximately 150 feet using diversion berms. The diversion berm spacing was determined in Appendix D to minimize diversion berm watershed areas to allow the use of check dams to control sediment.

2. The buttress fill consist of a 3H:1V (33%) sideslopes and a maximum drainage distance of 30 feet using diversion berms. Erosion from channel sideslopes will be less than buttress fill sideslopes due to smaller flow lengths and the use of Rocky Flats Alluvium (RFA) which has a greater percentage of rocks. Therefore, any calculation done for the buttress sideslope can be assumed to be the same as the channel sideslopes.

3. As guidance only, the design erosion rate shall not exceed 2.0 tons/acre/year per Section 2.2.5.3 of the Technical Guidance for RCRA/CERCLA Final Covers (EPA 2002).

4. A.) The annual production of native grasses at RFETS is 1.26 grams per square meter (g/m^2) or 1,128 lbs/acre, based on data provided by Jody Nelson, Senior Ecologist at RFETS. The number was derived from a 1993/1994 study when the annual rainfall was 12.0-12.5 inches or below the average of 15 inches.

   B.) Erosion calculations will be performed on the cover soils without vegetation to understand the significance or lack of significance of vegetation on the long term integrity of the soil cover.

5.0 CALCULATIONS

5.1 RAINFALL EROSION CALCULATION METHODOLOGY

The soil erosion rate due to rainfall was calculated using the Revised Universal Soil Loss Equation (RUSLE). The RUSLE predicts the average soil losses in runoff from a given site based on specific physical and management erosion variables. The soil loss equation is as follows:

$$\mathbf{A = R \times K \times LS \times C \times P}$$

Where:

- **A** is the computed soil loss per unit area in tons per acre per year
- **R** is the rainfall and runoff factor which varies with location and climate
- **K** is the soil erodibility factor

- **LS** is the topographic factor (slope-length factor/slope steepness factor) that accounts for the site slope gradient and length of slope
- **C** is the cover and management factor that accounts for the ground cover (grass, weeds, etc.)
- **P** is the support practice factor that accounts for contouring, terracing, or other runoff control devices

The USDA has developed a program that computes rainfall soil erosion using data for different sections of the country. This data is contained in databases that have been incorporated into the RUSLE program. Input values for the RUSLE software program are based on site-specific information and a database of information that is part of the RUSLE program. Version 2 of the RUSLE program was downloaded from http://bioengrgr.ag.utk.edu/rusle2/ for use in these calculations. Use of this software is suggested by the Technical Guidance for RCRA/CERCLA Final Covers (EPA 2002).

5.1.1 RAINFALL EROSION CALCULATIONS

All RUSLE factors are determined by the software or entered manually and the tons/acre/year of rainfall erosion is then computed. The factors used are as follows:

R Determination

The rainfall and runoff factor is the average annual total of the storm energy and intensity values in a given location. The R factor for the Denver, Colorado area is 40.

$R = 40$

K Determination

Sieve analysis results from the Centennial Quarry (potential borrow area) of RFA with rock fragments removed shows, according to the USDA system (USCS sieve data and USDA textural triangle found in Attachment 5 – APR-1 used due to a greater percentage of fines), a classification of sandy loam. For this analysis, a classification of sandy loam with 30% rock fraction is used as a conservative approach resulting in an erodibility factor of 0.283. However, the sieve analyses show that the fraction of rock larger than 1-inch in the RFA is greater than 40%.

$K_{RFA} = 0.283$

Alternatively, the K factor for RFA to determine the long-term erodibility can be determined from the Soil Survey of Golden Area, Colorado (USDA 1980). As shown on the map from the Soil Survey (Attachment 3), the RFA falls under the number 45 soil type. Table 15 (Attachment 3) of the Soil Survey shows a K factor of 0.05 for the undisturbed or natural state of the top 13 inches of type 45 soils. This K factor is used to determine the long term rain erosion if the planted vegetation does not fully establish and the soil has returned to a natural state with higher percentages of rock exposed.

$K_{RFA\text{-}mature} = 0.05$

The design proposes the use of a clayey sand for construction of the buttress fill. The material will be brought from the same local borrow sources as those used for construction of the Present Landfill. Two samples of the material are shown in Attachment 5. These are also converted to USDA classification and sample CUP-3 is selected for the erosion calculation due to its larger percentage of fines.

$K_{BUTTRESS} = 0.225$

LS Determination

The LS factor is a combination of the slope length factor and the slope steepness factor. The software uses the input slope length and input slope steepness or grade to calculate the LS. In addition, the software accounts for the changes in the length factor based on erosional rill or small erosional channel development. For this reason, the LS factors vary for each condition, i.e. bare, mulch, or grass. The mulch condition begins with higher ridges on the surface, which increases the size of the erosion rills, and therefore increases the LS factor to greater than that of the bare condition. The soil erodibility factor, K, has no affect on the LS determination resulting in identical LS factors for bare with K equal to 0.283 and bare with K equal to 0.05. The cover slope is a maximum of 150 feet with an 18% assuming diversion berms are placed every 150 feet. The buttress fill sideslope is 30 feet with a 33% slope. The LS is then computed.

$LS_{cover\text{ - }bare} = 3.44$ $LS_{buttress\text{ - }bare} = 3.00$
$LS_{cover\text{ - }mulch} = 3.55$ $LS_{buttress\text{ -}mulch} = 2.90$
$LS_{cover\text{ - }grass} = 3.25$ $LS_{buttress\text{ - }grass} = 3.22$

C Determination

To calculate the cover management factor, the software requires input of the management of the soil. The cover will be bladed, seeded, and mulched. Once the vegetation is established, the management factor is based on "dense grass" or the grass condition typical at Rocky Flats as described the Section 4.0, number 4. The soil erodibility factor, K, has no affect on the C determination resulting in identical C factors for bare with K equal to 0.283 and bare with K equal to 0.05.

$C_{cover\text{ - }bare} = 0.191$ $C_{buttress\text{ - }bare} = 0.432$
$C_{cover\text{ - }mulch} = 0.086$ $C_{buttress\text{ - }mulch} = 0.084$
$C_{cover\text{ - }grass} = 0.051$ $C_{buttress\text{ - }grass} = 0.051$

P Determination

The support practice factor accounts for any runoff control devices such as contours or terraces (diversion berms). P is also affected by ridges caused by depositing sediment on the slope when runoff is occurring. The soil erodibility factor, K, has no affect on the P determination resulting in identical P factors for bare with K equal to 0.283 and bare with K equal to 0.05. These ridges are only a small factor and therefore the numbers are close to 1.00 and have little affect on the calculation.

$P_{cover\text{-}bare} = 0.985$
$P_{cover\text{-}mulch} = 1.02$
$P_{cover\text{-}grass} = 0.985$

$P_{buttress\text{-}bare} = 1.00$
$P_{buttress\text{-}mulch} = 1.00$
$P_{buttress\text{-}grass} = 1.00$

A Determination

The factors are then used to obtain the soil loss in tons/acre/year. RUSLE software input and output can be found in Attachment 1. The "dense grass" condition represents 1,120 lbs/acre of native grass (see Section 4.0). The K factors were varied to represent erosion using the RUSLE software and the SCS numbers. RUSLE software output is as follows:

Table C-1
Original Landfill - Rain Erosion

CONDITION	COVER SLOPE RFA (K=0.283)	COVER SLOPE RFA (K=0.05)	BUTTRESS SIDESLOPE (K=0.225)
Bare Disturbed soil immediately after construction with no erosion control	7.5 tons/acre/year	1.3 tons/acre/year	12 tons/acre/year
Seed/Mulch Disturbed soil immediately after construction with seed and mulch	3.6 tons/acre/year	NA	2.2 tons/acre/year
Temporary Erosion Control Disturbed soil immediately after construction with seed, mulch and temporary erosion mat	0.53 tons/acre/year	NA	0.72 tons/acre/year
Established Vegetation	1.9 tons/acre/year	0.34 ton/acre/year	1.5 tons/acre/year

As evident in the RUSLE output, using a K of 0.283 for the cover slope results in rain erosion above or near the guidance criteria with bare conditions and following seed/mulch. Because the see/mulch condition is above the guidance, temporary erosion control must be used following seeding. Mulch application is not required since erosion mat will be used though it may be mulched during the project. Once vegetation is established the rain erosion will decrease from 1.9 tons/acre/year to 0.34 tons/acre/year after RFA reaches a mature state. If vegetation does not establish, the erosion rate will decrease to 1.3 tons/acre/year.

With the used of the diversion berms, the buttress sideslope rain erosion is below the guidance under grass conditions. Prior to grass establishment erosion mat will be used to minimize erosion. Since the erosion mat will be used, mulch is not necessary though it may be used. NAG C125 or equivalent erosion mat will be placed on the buttress and though not required as determined in Appendix E, NAG C350 or equivalent will be placed 10-feet up the bottom slope as an enhancement to erosion control due to Woman Creek flow.

5.2 WIND EROSION LOSS CALCULATION METHODOLOGY

Wind erosion on the Original Landfill was determined with the Wind Erosion Equation (WEQ) using the methodology provided in the National Agronomy Manual (NAM) (USDA 2002) (Attachment 2).

5.2.1 WEQ CALCULATIONS

The following determination of wind erosion uses the WEQ found in the NAM (Attachment 2). The WEQ is not a straight-line mathematical relationship but is a function of several factors. The WEQ is as follows:

$E = f(IKCLV)$

Where:

- E = estimated average annual soil loss due to wind (tons/acre/year)
- f = function of (not a straight-line mathematical relationship)
- I = soil erodibility index
- K = soil surface roughness factor
- C = climatic factor
- L = the unsheltered distance
- V = the vegetative cover factor

I Determination

The Soil Survey of Golden Area, Colorado (USDA 1980) was used to help determine the soil erodibility index or I factor. As shown on the map from the Soil Survey (Attachment 3), RFA falls under the number 45 soil type. Table 15 (Attachment 3) of the Soil Survey shows a wind erodibility group (WEG) of 8 for the type 45 soil.

The I factor is then determined using Exhibit 502-2 of the NAM (Attachment 2). As shown on Exhibit 502-2, WEG 8 is not susceptible to wind erosion. However, it is assumed that wind erosion of disturbed soil immediately after construction will occur at the OLF so a different WEG is selected. Sieve analysis results from Centennial Quarry RFA with rock fragments removed (Attachment 5) shows, according to the USDA system, a sandy loam falls under WEG 3 which has a soil erodibility index of 86 tons/acre/year.

$I_{WEG\ 3} = 86$

WEG 8 is used to determine the long term wind erosion if the planted vegetation does not fully establish and the soil has returned to a natural state with higher percentages of rock exposed.

$I_{WEG\ 8} = 0$

Buttress fill material falls under the sandy clay loam classification and is therefore WEG 5.

$I_{WEG5} = 56$

K Determination

The soil roughness factor (K) considers both ridge roughness (K_{rd}) and random roughness (K_{rr}) values. Values closer to 1.0 for both the K_{rd} and the K_{rr} equate to shorter ridge heights and less wind dissipation by random roughness. Shorter ridge heights and less random roughness lead to greater soil wind erosion because ridges absorb and deflect wind energy and trap moving particles (NAM Section 502.32). Figure 502-4 (page 502-10 of the NAM) shows that at a 0 inch ridge height, K_{rd} is equal to 1.00. Exhibit 502-6 (Table 502-6) shows that at a short random roughness of 0.2 the K_{rr} is 1.00. The K factor is obtained by multiplying K_{rd} by K_{rr}.

$K = (K_{rd})(K_{rr})$
$K = (1.00)(1.00) = 1.00$

K = 1.00 (conservative approach)

C Determination

The climatic factor (C) is an index of the factor accounting for wind speed and surface soil moisture of a given region (NAM Section 502.33). As outlined in Section 502.33 of the NAM, the C factor is determined by use of isoline maps found at the NRCS/USDA website. The figure at the end of Attachment 2 shows the isoline map for the Rocky Flats area.

C = 30

L Determination

The L factor is the unsheltered distance along the prevailing wind erosion direction. Wind-rose diagrams for Rocky Flats found in Attachment 5 show a prevailing wind of W-NW. As shown in Attachment 4, the longest distance on the OLF from the W-NW is 1070 feet.

L = 1070 feet

V Determination

The vegetative cover factor (V) is the equivalent in pounds per acre of small-grain residue provided by the cover crop. Using the tables in Exhibit 502-10, Figure a-1 for mulch (flat winter wheat residue) and Figure d-8 for ungrazed mixtures of grass, the V factor is determined. For bare conditions, the V factor is assumed to be 0. For mulch or flat winter wheat residue, the V factor is determined by assuming 3,000 lbs/acre of mulch or small grain residue will be applied (4,000 lbs/acre will actually be placed). This 3,000 lbs/acre of small grain residue results in an equivalent flat small grain residue (V factor) of 3,700 lbs/acre. For the native grasses, 1,128-lbs/acre yield (rounded down to 1,100 lbs/acre) discussed in Section 4.0 is used which results in an equivalent flat small grain residue (V factor) of 2,600 lbs/acre.

V_{Bare} = 0 lbs/acre
V_{Mulch} = 3,700 lbs/acre
V_{Grass} = 2,600 lbs/acre

E Determination

As discussed in Section 502.30 of the NAM, the soil loss due to wind erosion, or E factor, is determined using E tables found on the Kansas State University website.

The table matching the factors determined for the OLF (I=86, K=1.00, C=30, L=1070, and V=0, 2,600, and 3,700) is shown at the end of Attachment 2 (Subpart G – Exhibits). The tables do not include V factors above 1,500 lbs/acre because the wind erosion with these factors is negligible. Therefore, a V factor of 1,500 lbs/acre is assumed for both mulch and established grass on the cover slope. For the buttress sideslope (I=56, K=1.00, C=30, L=1070, and V=0, 2,600, and 3,700) a V factor of 1,250 lbs/acre is assumed for both mulch and established grass. For both the cover slope and the buttress, it is assumed that wind erosion with erosion mat is the same as that of mulch. Using these factors the wind erosion is as follows:

Table C-2
Original Landfill - Wind Erosion

CONDITION	COVER SLOPE RFA (WEG=3)	COVER SLOPE RFA (WEG=8)	BUTTRESS SIDESLOPE (WEG=5)
Bare Disturbed soil immediately after construction with no erosion control	21.6 tons/acre/year	0.0 tons/acre/year	11.8 tons/acre/year
Seed/Mulch Disturbed soil immediately after construction with seed and mulch	0.60 tons/acre/year	NA	0.40 tons/acre/year
Temporary Erosion Control Disturbed soil immediately after construction with seed, mulch and temporary erosion mat	0.60 tons/acre/year	NA	0.40 tons/acre/year
Established Vegetation	0.60 tons/acre/year	0.0 tons/acre/year	0.40 tons/acre/year

6.0 CONCLUSIONS

The table below presents the results of both the rain and wind erosion calculations:

Table C-3
Original Landfill - Total Erosion

CONDITION	COVER SLOPE RFA (tons/acre/year)	COVER SLOPE MATURE RFA (tons/acre/year)	BUTTRESS SIDESLOPE (tons/acre/year)
Bare Disturbed soil immediately after construction with no erosion control	Rain: 7.50 Wind: 21.6 Total: 29.1	Rain: 1.30 Wind: 0.00 Total: 1.30	Rain: 12.0 Wind: 11.8 Total: 23.8
Seed/Mulch Disturbed soil immediately after construction with seed and mulch	Rain: 3.60 Wind: 0.60 Total: 4.20	NA	Rain: 2.20 Wind: 0.40 Total: 2.60
Temporary Erosion Control Disturbed soil immediately after construction with seed, mulch and temporary erosion mat	Rain: 0.53 Wind: 0.60 Total: 1.13	NA	Rain: 0.72 Wind: 0.40 Total: 1.12
Established Vegetation	Rain: 1.90 Wind: 0.60 Total: 2.50	Rain: 0.34 Wind: 0.00 Total: 0.34	Rain: 1.50 Wind: 0.40 Total: 1.90

Cover Slope

On the cover slope, the design of the Original Landfill (including diversion berms) will meet the guidance criteria for erosion of 2 tons/ac/yr with Rocky Flats Alluvium in its mature state. The following is recommended until this condition is reached:

- The initial disturbed soil will be seeded and covered with 3-year longevity erosion control mat.
- As vegetation establishes, the erosion mat degrades, the total erosion is predicted at 1.13 tons/acre/year.
- As the surface matures, exposing more of the rock fraction of the RFA, the erosion rate is predicted to be 0.34 tons/ac/year if vegetation is established and 1.30 if not.
- Should the vegetation not establish or climatic conditions exist to reduce the vegetation, the erosion rate will not increase beyond that of the bare, mature Rocky Flats Alluvium of 1.30 tons/ac/year (below the guidance criteria).

Buttress Fill Sideslopes

The buttress fill sideslopes (including diversion berms) will meet guidance criteria when grass has established. The following is recommended until this state is reached:

- The initial disturbed soil will be seeded and temporary erosion mat will be applied to the surface resulting in a predicted total erosion rate of 1.12 tons/acre/year.
- When vegetation establishes the total erosion is predicted at 1.90 tons/acre/year (below the guidance criteria).

Summary

The erosion calculations demonstrate that when the two feet of RFA on the cover reaches a mature state, vegetation is not required to meet the EPA guidance criteria of 2 tons/acre/year and to protect the soil cover. However, the design of the soil cover will include seeding, mulching, and erosion mat to develop vegetation as discussed in the Original Landfill IM/IRA. On the buttress sideslopes, guidance criteria is met using diversion berms with grass established and in the interim with temporary erosion mat.

APPENDIX C

ATTACHMENT 1
RUSLE INPUT/OUTPUT

COVER SLOPE EROSION (K = 0.283)

Tract # RFETS OLF
Owner name RFETS OLF
Field # RFETS OLF
Info

Compare management alternatives for a single hillslope profile | Compare individual hillslope profiles | Compute avg. soil loss for a field/watershed

Location Colorado\Denver
Soil z OSM\sandy loam-20% stone
Slope length (horiz), ft 150
Avg. slope steepness, % 18

Slope Topography

Segment	Steepness, %	Length along slope, ft
1	18	152

Insert control...
Copy bitmap

Management alternative table

Temp. scenario	Base management	Residue burial level	General yield level	Contouring	Strips/barriers	Diversion/terrace, sediment ba	Surf. cov. values	Detachment on slope, t/ac/yr	Soil loss erod. portion, t/ac	Soil loss for cons. plan, t/ac/yr	Sediment delivery, t/ac/yr
Profile	bare	Normal	Normal	default	(none)	(none)	.... cover	7.5	7.5	7.5	7.5
Profile	..M\blade fill, seed, straw mulch	Normal	Normal	default	(none)	(none)	.... cover	3.6	3.6	3.6	3.6
Profile	dense grass	Normal	Normal	default	(none)	(none)	.... cover	1.9	1.9	1.9	1.9

COVER SLOPE EROSION (K = 0.05)

Tract # RFETS OLF
Owner name RFETS OLF
Field # RFETS OLF
Info

Compare management alternatives for a single hillslope profile | Compare individual hillslope profiles | Compute avg. soil loss for a field/watershed

Location Colorado\Denver
Soil z OSM\sandy loam-20% stone
Slope length (horiz), ft 150
Avg. slope steepness, % 18

Slope Topography

Segment	Steepness, %	Length along slope, ft
1	18	152

Management alternative table

Temp. scenario	Base management	Residue burial level	General yield level	Contouring	Strips/barriers	Diversion/terrace, sediment ba	Surf. cov. values	Detachment on slope, t/ac/yr	Soil loss erod. portion, t/ac	Soil loss for cons. plan, t/ac/yr	Sediment delivery, t/ac/yr
Profile	bare	Normal	Normal	default	(none)	(none)	.... cover	1.3	1.3	1.3	1.3
Profile	dense grass	Normal	Normal	default	(none)	(none)	.... cover	0.34	0.34	0.34	0.34

COVER SLOPE EROSION WITH TEMPORARY EROSION MAT

The RUSLE software does not contain erosion mat as an alternative for "Base management". North American Green C125 temporary erosion mat has a cover factor (C in the RUSLE) of 0.07 (NAG C125 Performance Specification for slopes >50 feet). To calculate the soil loss on the cover with C125, the "bare" cover erosion is multiplied by an additional cover factor of 0.07. This simulates the condition following seeding with C125 applied to the soil cover.

A (bare) = (7.5 ton/ac/yr)(0.07) = 0.53 ton/ac/yr

BUTTRESS FILL SIDESLOPES (K=0.225)

Tract # RFETS OLF
Owner name RFETS OLF
Field # RFETS OLF
Info

Compare management alternatives for a single hillslope profile | Compare individual hillslope profiles | Compute avg. soil loss for a field/watershed

Location Colorado\Denver
Soil ...andy clay loam (low-mod OM)
Slope length (horiz), ft 30
Avg. slope steepness, % 33

Slope Topography

Segment	Steepness, %	Length along slope, ft
1	33	32

Management alternative table

Temp. scenario	Base management	Residue burial level	General yield level	Contouring	Strips/barriers	Diversion/terrace, sediment ba	Surf. cov. values	Detachment on slope, t/ac/yr	Soil loss erod. portion, t/ac	Soil loss for cons. plan, t/ac/yr	Sediment delivery, t/ac/yr
Profile	bare	Normal	Normal	default	(none)	(none)	.... cover	12	12	12	12
Profile	...M\blade fill, seed, straw mulch	Normal	Normal	default	(none)	(none)	.... cover	2.2	2.2	2.2	2.2
Profile	dense grass	Normal	Normal	default	(none)	(none)	.... cover	1.5	1.5	1.5	1.5

BUTTRESS SIDESLOPE PERMANENT EROSION MAT

Due to addition of the diversion berms, established vegetation is sufficient to minimize erosion. Temporary erosion mat will be required until this condition is reached. North American Green C125 temporary erosion mat has a cover factor (C in the RUSLE) of 0.07 (NAG C125 Performance Specification for 3:1 slopes and 20-50 foot flow distance). To calculate the soil loss on the cover with C125, the "bare" cover erosion is multiplied by an additional cover factor of 0.06. This simulates the condition following seeding with C125 applied to the soil cover.

A (bare) = (12 ton/ac/yr)(0.06) = 0.72 ton/ac/yr

APPENDIX C

ATTACHMENT 2
NATIONAL AGRONOMY MANUAL

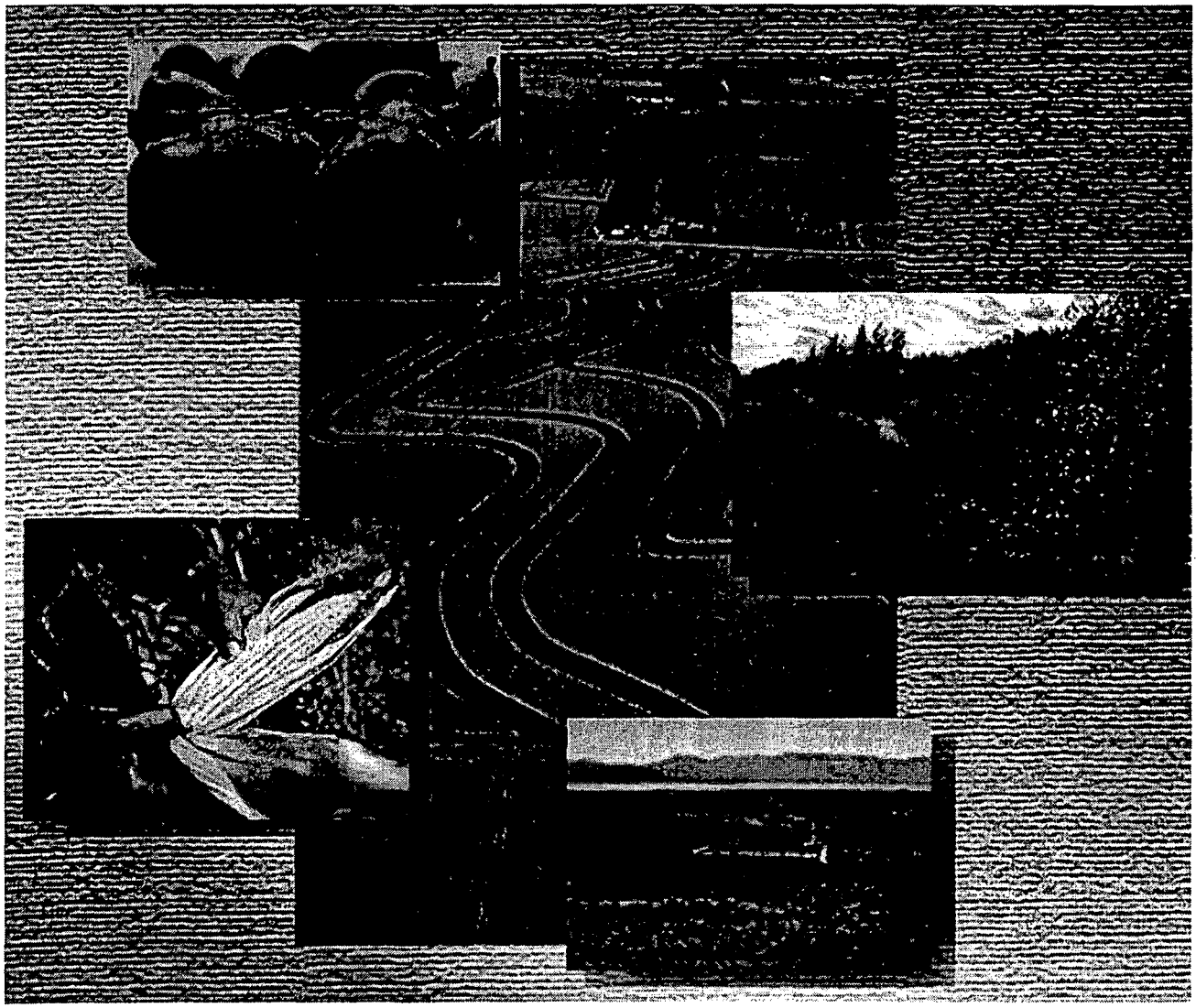
USDA NRCS

Natural Resources Conservation Service

United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

Nationa Agronomy Manual



National
Agronomy
Manual

October 2002

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(190-V-NAM, 3rd Ed., October 2002)

Part 500 Authorities, Policies, and Responsibilities

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Part 500 Authorities, Policies, and Responsibilities

Subpart 500A Authority

500.00 Soil Conservation and Domestic Allotment Act of 1935

The basic legislation for soil and water conservation programs by the Natural Resources Conservation Service (NRCS) is the Soil Conservation and Domestic Allotment Act, Public Law 74–46 of 1935 (16 U.S.C. 590a-590f). This original act recognized that agronomy, the science of field crop production, is essential in fulfilling the agency's responsibilities. The Buchanan Amendment to the Agricultural Appropriations Bill for FY 1930 (Public Law 70-769) led to the enactment of Public Law 74-46. In 1933, the Soil Erosion Service was established as a temporary agency of the Department of the Interior. The agency was transferred to USDA in 1935 and named the Soil Conservation Service (SCS). In 1994, the Natural Resources Conservation Service was established by Public Law 103–354, the Department of Agriculture Reorganization Act (7 U.S.C. 6962).

The NRCS combines the authorities of the former Soil Conservation Service as well as five natural resource conservation cost-share programs previously administered by other USDA agencies. The mission of the NRCS is to provide leadership in a partnership effort to help people conserve, maintain and improve our natural resources and environment. NRCS provides technical assistance through local conservation districts on a voluntary basis to land users, communities, watershed groups, Federal and State agencies, and other cooperators. The agency's work focuses on erosion reduction, water quality improvement, wetland restoration and protection, fish and wildlife habitat improvement, range management, stream restoration, water management, and other natural resource problems.

500.01 Purpose of the Agronomy Manual

The National Agronomy Manual (NAM) contains policy for agronomy activities and provides technical procedures for uniform implementation of agronomy tools and applications.

Subpart 500B Agronomic policies

500.10 Location of policy

Agronomic policies are contained in specific parts and subparts of this National Agronomy Manual as appropriate.

500.11 Amendments to NAM

The NAM will be amended as needed, as additional research is completed, existing methods or procedures are updated, or as new technology is developed and approved for use in the NRCS. The national agronomist is responsible for updating this manual.

Subpart 500C Responsibilities of agronomists

500.20 Responsibilities of national, State, area, and field agronomists

The national agronomist, nutrient management, and pest management specialists at the national level, cooperating scientists for agronomy, and agronomists on the institutes and center staffs provide staff assistance in all NRCS programs and provide national leadership on NRCS agronomy related activities. They are responsible for:

- assisting upper management in formulating and recommending national policies, procedures, and standards;
- technical leadership and guidance; quality control;
- national coordination of agronomy with other NRCS technical fields; and
- promoting and maintaining relations with groups and agencies that have common interest in agronomy.

State agronomists provide staff assistance to the State Conservationist for all agronomy and related functions. They are responsible for:

- Assisting in developing State policies, procedures, and instructions, and coordinating them with other States within the region.
- Providing technical leadership and guidance to other agronomists and appropriate personnel within the State.
- Collaborating with other State staff members to ensure interdisciplinary action in all NRCS programs.
- Training field personnel.
- Participating in agronomy components of appraisals and reviews.
- Maintaining working relations with research centers and other cooperating agencies.
- Developing and revising of all aspects of Field Office Technical Guides related to agronomy.
- Providing assistance in interdisciplinary technical reviews of project plans, environmental impact statements, and other technical materials.
- Coordinating agronomy functions with other States in the region and across regional boundaries as appropriate.

Area or zone agronomists provide staff assistance in all NRCS programs. They are responsible for carrying out the requirements of conservation agronomy consistent with technical proficiency, training, interdisciplinary action, and quality control within their administrative area. In some cases, these agronomists may carry out some of the responsibilities of the state agronomists if so delegated.

Field office agronomists are usually in training positions. Training is provided by agronomists at the area or State level.

Agronomists in the above positions may provide specific functions through team or ad hoc assignments at a national, regional, or State level.

Each agronomist has the responsibility to develop their training needs inventory and to work with their supervisor to obtain technical training to improve their overall agronomic expertise.

Standards of performance for agronomists are contained in the NRCS Personnel Manual.

500.30 Technical information—preparing, transferring, and training

Agronomists use technical information that has been developed at centers, institutes, national, or State level and maintain technical materials for the administrative area they serve. State staff agronomists develop and review field office technical guide materials and ensure materials are technically correct, comprehensive, and useful to the end user. NRCS policy on preparing and maintaining technical guides is in Title 450-GM, Part 401. In addition, state agronomists are responsible for technical notes and other agronomy technical materials that are applicable to the State.

Agronomists issue technical information at the area, state, or national level. This may include original information, research notes, papers, or excerpts of such material. Agronomists are encouraged to submit articles for publication or presentation at professional meetings. Technical information presented or prepared for publication shall have an appropriate technical and or administrative review and include crediting of appropriate references.

Agronomists receive and provide training necessary to maintain technical competency at all administrative levels. Training includes but is not limited to National Employee Development Courses, workshops, conferences, and university courses.

500.40 Certification

Agronomists at all levels of the agency are encouraged to obtain professional certification(s). Examples of certification programs include the Certified Crop Adviser (CCA) and Certified Professional Agronomists (CPAg) under ARCPACS of the American Society of Agronomy, Certified Professional in Erosion and Sediment Control (CPESC) of the Soil and Water Conservation Society, and state pesticide applicator licenses. Continuing educational requirements of most certification programs provide excellent opportunities to stay abreast of advances in technology.

500.50 Affiliation with professional organizations

Agronomists at all levels are encouraged to be active members of professional scientific societies, such as the American Society of Agronomy, Soil Science Society of America, Crop Science Society of America, the Soil and Water Conservation Society. These organizations provide opportunities to interact with researchers at the national and State level and to stay current on the latest technology.

Part 501 Water Erosion

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Part 501 Water Erosion

Subpart 501A Introduction

501.00 Overview of Content in Part 501 Water Erosion

Part 501 presents Natural Resources Conservation Service (NRCS) policy and procedures for estimating soil erosion by water. It explains the types, the method used to estimate, and the control of soil erosion by water. NRCS technical guidance related to water erosion shall conform to policy and procedures set forth in this part.

The Agricultural Research Service (ARS) has primary responsibility for erosion prediction research within the U.S. Department of Agriculture (USDA). ARS is the lead agency for developing erosion prediction technology, including the Revised Universal Soil Loss Equation (RUSLE). The technology in RUSLE is documented to the publication Predicting Soil Erosion by Water: A Guide to Conservation Planning With Revised Universal Soil Loss Equation, U.S. Department of Agriculture Handbook 703, hereafter referred to as Agriculture Handbook 703.

Subpart 501B Water erosion

501.10 Forms of water erosion

Forms of soil erosion by water include sheet and rill, ephemeral gully, classical gully, and streambank. Each succeeding type is associated with the progressive concentration of runoff water into channels as it moves downslope. Sheet erosion, sometimes referred to as interrill erosion, is the detachment of soil particles by raindrop impact and the removal of thin layers of soil from the land surface by the action of rainfall and runoff. Rill erosion is the formation of small, generally parallel channels formed by runoff water. Rills usually do not re-occur in the same place. Ephemeral gullies are concentrated flow channels formed when rills converge to form shallow channels. They are alternately filled with soil by tillage operations and re-formed in the same general location by subsequent runoff events. Classical gullies are also concentrated flow channels formed when rills converge. These are well defined, permanent incised drainageways that cannot be crossed by ordinary farming operations.

Other forms of erosion that are related to soil erosion by water include stream channel and geologic. Stream channel erosion refers to the degradation of channels and waterways. Geologic erosion refers to long-term erosion effects, as opposed to accelerated erosion events discussed in the Subpart.

No reliable methods exist for predicting the rate of ephemeral gully, classical gully, stream channel, or geologic erosion. The remainder of this part deals only with prediction and control of sheet and rill erosion.

501.11 The water erosion process

The processes of sheet and rill erosion are detachment, transport, and deposition of soil particles caused by raindrop impact and surface runoff.

Detachment is the removal of particles from the soil mass and is expressed in units, such as tons per acre. When soil particles are removed from the mass, they are referred to as sediment.

The movement of sediment downslope is sediment transport. A measure of sediment transport is sediment load. Sediment load on a slope increases with distance downslope as long as detachment is occurring. That is, detachment adds to the sediment load.

Where runoff is slowed at the base of a slope or by dense vegetation, deposition occurs, which is the transfer of sediment from the sediment load to the soil mass. That is, deposition removes sediment from the sediment load, and accumulates on the soil surface.

Two types of deposition, remote and local, occur. Remote deposition occurs some distance away from the origin of the sediment. Deposition at the toe of a concave slope, on the uphill side of vegetative strips, and in terrace channels are examples of remote deposition. Local deposition is where sediment is deposited near, within several inches, of where it is detached. Deposition in microdepressions and in low gradient furrows are examples of local deposition.

Subpart 501C Estimating sheet and rill erosion

501.20 How, why, and by whom water erosion is estimated

NRCS estimates soil erosion by water as part of its technical assistance to land users. In conservation planning, erosion estimates are made for an existing management system and compared with alternative systems and with soil loss tolerance, T, values.

In addition, soil loss estimates are used to inventory natural resources, evaluate the effectiveness of conservation programs and land treatment, and estimate sediment production from fields that might become sediment yield in watersheds.

In March 1995, NRCS adopted RUSLE as the official tool for predicting soil erosion by water. NRCS continues to use USLE for certain provisions of Farm Bill programs and for the NRCS National Resources Inventory (NRI).

501.21 Methods of estimating sheet and rill erosion

Efforts to predict soil erosion by water started in the 1930's. Cook (1936) identified the major variables that affect erosion by water. Zingg (1940) published the first equation for calculating field soil loss. Smith and Whitt (1947) presented an erosion-estimating equation that included most of the factors present in modern soil loss equations. The Musgrave equation (Musgrave 1947) was a soil loss equation developed for farm planning. Finally, an effort was initiated to develop a national equation from the various state and regional equations that existed in the 1950's. In 1954, the Agricultural Research Service established the National Runoff and Soil Loss Data Center at Purdue University in West Lafayette, Indiana, to consolidate all available erosion data. Using the data assembled at the Data Center, Wischmeier and Smith (1965) developed the Universal Soil Loss Equation (USLE).

The USLE was a consolidation of several regional soil loss equations, and was based on summarizing and statistical analyses of more than 10,000 plot-years of basic runoff and soil loss data from 49 U.S. locations (Agriculture Handbook 703, 1997; Wischmeier and Smith 1965, 1978).

The USLE was designed to provide a convenient working tool for conservationists. It quantifies soil erosion as a product of six factors representing rainfall and runoff erosiveness, soil erodibility, slope length, slope steepness, cover-management practices, and supporting practices.

501.22 The Revised Universal Soil Loss Equation

Since March 1995, the Revised Universal Soil Loss Equation (RUSLE) has been used by NRCS to estimate soil loss by water (Agriculture Handbook 703.).

RUSLE predicts long-term average annual soil loss from sheet and rill erosion. RUSLE is an update of the Universal Soil Loss Equation (USLE) as described in Agriculture Handbook 537 (Wischmeier and Smith 1978). RUSLE utilizes a computer program to facilitate the calculations. RUSLE technology reflects the analysis of research data that were unavailable when Agricultural Handbook 282 (Wischmeier and Smith 1965) and Agriculture Handbook 537 were completed.

501.23 Limitations of the equation

The term *Universal* distinguishes the USLE and RUSLE from State and regionally based models that preceded them. However, the use of the USLE and RUSLE is limited to situations where factors can be accurately evaluated and to conditions for which they can be reliably applied (Wischmeier 1978; Agriculture Handbook 703, 1997).

RUSLE predicts long-term average annual soil loss carried by runoff from specific field slopes under specified cover and management systems. It is substantially less accurate for the prediction of specific erosion events associated with single storms and short-term random fluctuations.

RUSLE also estimates sediment yield for the amount of eroded soil leaving the end of a slope with certain support practices (see 501.35). It does not predict sediment yield for the amount of sediment that is delivered to a point in a watershed, such as the edge of a field, that is remote from the origin of the detached soil particles. Nor does RUSLE predict erosion that occurs in concentrated flow channels.

501.24 Alternative methods of applying RUSLE

ARS released RUSLE in 1992 as a computer program in the DOS environment. The model calculates soil loss from a field slope using values for each factor and using data elements from climate, plant, and field operation data bases.

Since 1993, RUSLE has been implemented in many NRCS field offices in hardcopy form in the Field Office Technical Guide (FOTG). State and area agronomists have developed tables and charts containing values for each of the RUSLE factors. Since the RUSLE module in Field Office Computing System (FOCS) is no longer supported by the Information Technology Center, NRCS will continue to implement RUSLE technology using charts and tables in the FOTG.

501.25 Data needed to support RUSLE

RUSLE uses soil erodibility, K, values from the NASIS Soils Database. Climatic data is obtained from National Weather Service weather stations with reliable long-term data. State and area agronomists have developed cover and management factor, C, values for common cropping systems.

The crop data base in the DOS RUSLE program contains plant growth and residue production parameters. These variables for key crops are listed in chapter 7 of Agriculture Handbook 703. Values for many of these parameters are available in a data base for a wide variety of plants. A user interface, the Crop Parameter Intelligent Data System (CPIDS) (Deer-Ascough et al. 1995), allows the user to search the data base. The USDA, ARS, National Soil Erosion Research Laboratory, West Lafayette, Indiana, maintains CPIDS.

Development and maintenance of data bases used by NRCS in erosion prediction models are the responsibility of NRCS agronomists at the State and national levels. Refer to Part 509 in this Manual for more detailed information on data base management and instructions. The national agronomist maintains a data base management plan that identifies the process of developing and maintaining data bases needed to support RUSLE. Data bases for some States are available in electronic format on the Fort Worth server.

501.26 Tools for using RUSLE

Maps of rainfall and runoff factors, R and R_{eq} (see part 501.31) for the continental United States plus Hawaii are available in Agriculture Handbook 703, figures 2-1 to 2-5 and figures 2-15 and 2-16. Additional climate-related data and inputs are available in this chapter. Most states and Basin Areas have developed county-based climatic maps for their areas. These contain the greater detail that is desired when applying RUSLE to specific field situations, and are available in NRCS State offices.

Soil erodibility factor, K, values for RUSLE are available in the NASIS Soils Database and in other soils data bases and tables. In areas of the United States where K values are adjusted to account for seasonal variability, (Agriculture Handbook 703) tables are available in State offices that show how the values are rounded to the nearest class and subclass.

Four slope length and steepness, L and S, table options are available in RUSLE. LS values can be obtained from tables 4-1 to 4-4 in Agriculture Handbook 703. The RUSLE computer program also calculates LS factor values for both uniform and complex slopes.

Cover and management factor, C, values are available in electronic table format in tables in most State offices and in the Field Office Technical Guide. Hardcopy tables are available in most State offices.

Support practice factor, P, values are calculated using tables available in the FOTG in many states. Copies, where available, can be obtained from the State office. Table values for common stripcropping and buffer strip systems are available in the FOTG of some states.

Subpart 501D RUSLE factors

501.30 The average annual soil loss estimate, A

The long time average annual soil loss, A, is the computed spatial average soil loss and temporal average soil loss per unit of area, expressed in the units for K and for the period selected for R.

As applied by NRCS, the units for K and the period for R are selected so that A is expressed in tons per acre per year. RUSLE predicts the soil loss carried by runoff from specific field slopes in specified cover and management systems.

501.31 The rainfall and runoff erosivity factor, R

The rainfall and runoff erosivity factor, R, is the product of total storm energy times the maximum 30-minute intensity. Stated another way, the average annual total of the storm energy and intensity values in a given location is the rainfall erosion index, R, for the locality. The R factor represents the long-term average annual summation of the Erosivity Index (EI) for extended period of record.

In dryland cropping areas of the Northwest Wheat and Range Region, the effect of melting snow, rain on snow, and/or rain on thawing soil poses unique problems. An equivalent R value, R_{eq}, is calculated for these areas to account for this added runoff.

501.32 The soil erodibility factor, K

The soil erodibility factor, K, is a measure of erodibility for a standard condition. This standard condition is the unit plot, which is an erosion plot 72.6 feet (22.1) long on a 9 percent slope, maintained in continuous fallow, tilled up and down hill periodically to control weeds and break crusts that form on the soil surface. The erodibility factor K represents the combined effect of susceptibility of soil to detachment, transport of sediment and the amount and rate of runoff caused by a particular rainfall event. Soil properties that affect soil erodibility include texture, structure, per-

meability and organic matter content. Values for K should be selected from those given in the NRCS soil survey database in NASIS or in published reports the RUSLE soil erodibility nomograph can also be used to estimate K values for most soils. Soil erodibility K varies by season. It tends to be high in early spring during and immediately following thawing, and other periods when the soil is wet. NRCS further modifies the seasonally adjusted K by rounding the value to the nearest K factor class or half-class (exhibit 501-1).

Rock fragments in the soil profile affect the soil erodibility factor [1/]. The K value is adjusted upwards to account for rock fragments in the soil profile of sandy soils that reduce infiltration. No adjustment to the K value is recommended by NRCS for rocks in the profile of medium and heavy textured soils.

501.33 The slope length and steepness factors, L and S

The slope length factor, L, is the ratio of soil loss from the field slope length to soil loss from a 72.6-foot length under identical conditions.

The slope steepness factor, S, is the ratio of soil loss from the field slope gradient to soil loss from a 9 percent slope under otherwise identical conditions.

In erosion prediction as used by NRCS, the factors L and S are evaluated together, and LS values for uniform slopes can be selected from tables 4–1, 4–2, 4–3, and 4–4 in Agriculture Handbook 703.

The slope length is defined as the horizontal distance from the origin of overland flow to the location of either concentrated flow or deposition. Slope lengths normally do not exceed 400 feet because sheet and rill flows will almost always coalesce into concentrated flow paths within that distance. Lengths longer than 1,000 feet should not be used in RUSLE.

Slope length and steepness determinations are best made in the field. In conservation planning, the hillslope profile representing a significant portion of the field having the most severe erosion is often chosen. Slope lengths are best determined by pacing out flow paths and making measurements directly on the ground. Steep slopes should be converted to horizontal distances. Slope steepness determinations are best made in the field using a clinometer, Abney level or similar device. Chapter 4, Agriculture Handbook 703 contains additional guides for choosing and measuring slopes.

Most naturally occurring hillslope profiles are irregular in shape. When the slope profile is significantly curved (convex or concave, or sigmoid.convex at the shoulder and concave at the toe), the conservationist should represent it as a series of slope segments, using the irregular slope procedure in the RUSLE computer program.

501.34 The cover-management factor, C

The cover-management factor, C, is the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow. The C factor is used most often to compare the relative impacts of management options on conservation plans.

The impacts of cover and management on soil losses are divided into a series of subfactors in RUSLE. These include the impacts of previous vegetative cover and management, canopy cover, surface roughness, and in some cases the impact of soil moisture.

In RUSLE, these subfactors are assigned values, and when multiplied together yield a soil loss ratio (SLR). Individual SLR values are calculated for each period over which the important parameters are assumed to remain constant. Each SLR value is then weighted by the fraction of rainfall and runoff erosivity, EI, associated with the corresponding period, and these weighted values are combined (summed) into an overall C factor value.

501.35 The support practice factor, P

The support practice factor, P, is the ratio of soil loss with a support practice like contouring, stripcropping, or terracing to soil loss with straight-row farming up and down the slope.

The contour P subfactor accounts for the beneficial effects of redirected runoff that modifies the flow pattern because of ridges or oriented roughness that are partially or completely oriented along the contour.

1/ Rock fragments on the soil surface are accounted for in the C factor.

The contour P subfactor includes the effects of storm severity, ridge height, off-grade contouring, slope length and steepness, infiltration, and soil cover and roughness.

The stripcropping P subfactor is a support practice where strips of clean-tilled or nearly clean-tilled crops are alternated with strips of close growing vegetation, or strips with relatively smooth tilled soil surfaces are alternated with strips with rough tilled surfaces.

The stripcropping P subfactor evaluates what are variously described as contour stripcropping, cross-slope stripcropping, field stripcropping, buffer strips and vegetated filter strips.

Terraces in RUSLE are support practices where high and large ridges of soil are constructed across the slope at intervals. These ridges and their accompanying channels intercept runoff and divert it around the slope or into a closed outlet. Terraces can affect sheet and rill erosion by reducing slope length and cause deposition in the terrace channel.

Tile drainage, under optimum conditions, can reduce erosion by reducing runoff. Because of a lack of support data, NRCS does not use the tile drainage subfactor in RUSLE, except in the Willamette Valley in the Oregon and Puget Sound basin in Washington.

In addition to the support practice factor, P, used in conservation planning, RUSLE estimates sediment yield for contour strips and terraces. The sediment yield, or delivery ratio, used in RUSLE is the ratio to the amount of sediment leaving the end of the slope length to the amount of sediment produced on the slope length.

Subpart 501E Principles of water erosion control

501.40 Overview of principles

The principle factors that influence soil erosion by water are climate, soil properties, topography, vegetative cover, and conservation practices. Climate and soil properties are conditions of the site and are not modified by ordinary management measures. Conservation treatment primarily involves manipulation of vegetative cover, modification of topography, and manipulation of soil conditions in the tillage zone.

The greatest deterrent to soil erosion by water is vegetative cover, living or dead, on the soil surface. Cover and cultural practices influence both the detachment of soil particles and their transport. Growing plants and plant residue absorb the energy of raindrops, decrease the velocity of runoff water, and help create soil conditions that resist erosion. Cultural practices that affect vegetative cover include crop rotations, cover crops, management of crop residue, and tillage practices.

501.41 Relation of control to RUSLE factors

In conservation planning, the cover and management factor, C, and the support practices factor, P, can be manipulated in RUSLE to develop alternatives for erosion reduction. In addition, where slope length is reduced with some terrace and diversion systems, the slope length and steepness factor, LS, will be reduced.
Using RUSLE technology, estimates of erosion reduction are illustrated in the subfactors of factor C.
Benefits to erosion control are achieved in the:

- prior land use subfactor by increasing the mass of roots and buried residue and increasing periods since soil disturbance,
- canopy cover subfactor by increasing the canopy cover of the field area and low raindrop fall height from the canopy,
- surface cover subfactor by increasing the ground cover of plant residue, and by permanent cover such as rock fragments,
- surface roughness subfactor by increasing the random surface roughness that ponds water, and thereby reduces the erosive effect of raindrops and traps sediment, and

- soil moisture subfactor by growing moisture-depleting crops. This benefit is only applied in RUSLE in the Northwest Wheat and Range Region of the western United States.

When support practices are applied, they become integral parts of a resource management system for controlling soil erosion by water. Contour farming, contour stripcropping, and conservation buffers form ridges on or near the contour that slow runoff and trap sediment. Terraces and diversions intercept concentrated runoff flows and, in many cases, shorten the length of slope.

Some erosion control practices, such as grassed waterways and water control structures, do not substantially reduce sheet and rill erosion. While these can be effective erosion control practices in a resource management system, they are not a part of the soil loss reduction that is estimated by RUSLE.

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Exhibit 501-1 Acceptable class and half-class factor K values for use in RUSLE where K values are adjusted for seasonal variability.

Original K value 1/	Minimum value 2/	Maximum value 3/	Acceptable class and half-class K factor values 4/					
0.02	0.016	0.024	0.02					
0.05	0.04	0.06	0.05					
0.10	0.08	0.12	0.08	0.10	0.12			
0.15	0.12	0.18	0.12	0.15	0.17			
0.17	0.136	0.204	0.15	0.17	0.20			
0.20	0.16	0.24	0.17	0.20	0.22	0.24		
0.24	0.192	0.288	0.20	0.22	0.24	0.26	0.28	
0.28	0.224	0.336	0.24	0.26	0.28	0.30	0.32	
0.32	0.256	0.384	0.26	0.28	0.30	0.32	0.35	0.37
0.37	0.296	0.444	0.30	0.32	0.35	0.37	0.40	0.43
0.43	0.344	0.516	0.35	0.37	0.40	0.43	0.46	0.49
0.49	0.392	0.588	0.40	0.43	0.46	0.49	0.52	0.55
0.55	0.44	0.66	0.46	0.49	0.52	0.55	0.60	0.64
0.64	0.512	0.768	0.52	0.55	0.60	0.64	0.70	0.76

1/ Original K value from the soils data base for a specific map unit or soil component.
2/ Minimum value is 80% of the original K value, and is the cap for acceptable minimum class and half-class values.
3/ Maximum value is 120% of the original K value, and is the cap for the acceptable maximum class and half-class values.
4/ Acceptable class and half-class K factor values, were approved 4/15/94 by a joint committee of NRCS soil scientists and agronomists, under the leadership of H.R. Sinclair, lead soil scientist.

Part 502 Wind Erosion

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Part 502 Wind Erosion

Subpart 502A Introduction

502.00 Overview

Part 502 presents Natural Resources Conservation Service (NRCS) policy and procedures for estimating wind erosion. It explains the Wind Erosion Equation (WEQ) and provides guidance and reference on wind erosion processes, prediction, and control. NRCS technical guidance related to wind erosion conforms to policy and procedures in this part.

This part will be amended as additional research on wind erosion and its control is completed and published. The national agronomist is responsible for updating this chapter and coordinating wind erosion guidance with Agricultural Research Service (ARS).

NRCS cooperating scientists may supplement this manual. However, appropriate supplements prepared by cooperating scientists are to be submitted to the national agronomist for review and concurrence before issuance. State supplements are to be reviewed and approved by the national agronomist before being issued to field offices.

Understanding the erosive forces of wind is essential to the correct use of the Wind Erosion Equation and interpretation of wind erosion data. NRCS predicts erosion rates, assesses potential damage, and plans control systems for wind erosion.

The Agricultural Research Service has primary responsibility for erosion prediction research within the U.S. Department of Agriculture (USDA). Wind erosion research is conducted by the Wind Erosion Research Unit at Manhattan, Kansas, and the Cropping Systems Research Unit at Big Spring, Texas.

Subpart 502B Wind erosion

502.10 The wind erosion problem

Wind is an erosive agent. It detaches and transports soil particles, sorts the finer from the coarser particles, and deposits them unevenly. Loss of the fertile topsoil in eroded areas reduces the rooting depth and, in many places, reduces crop yield. Abrasion by airborne soil particles damages plants and constructed structures. Drifting soil causes extensive damage also. Sand and dust in the air can harm animals, humans, and equipment.

Some wind erosion has always occurred as a natural landforming process, but it has become detrimental as a result of human activities. This *accelerated* erosion is primarily caused by improper use and management of the land (Stallings 1951).

Few regions are entirely safe from wind erosion. Wherever the soil surface is loose and dry, vegetation is sparse or absent, and the wind sufficiently strong, erosion will occur unless control measures are applied (1957 Yearbook of Agriculture). Soil erosion by wind in North America is generally most severe in the Great Plains. The NRCS annual report of wind erosion conditions in the Great Plains shows that wind erosion damages from 1 million to more than 15 million acres annually, averaging more than 4 million acres per year in the 10-state area. USDA estimated that nearly 95 percent of the 6.5 million acres put out of production during the 1930's suffered serious wind erosion damage (Woodruff 1975). Other major regions subject to damaging wind erosion are the Columbia River plains; some parts of the Southwest and the Colorado Basin, the muck and sandy areas of the Great Lakes region, and the sands of the Gulf, Pacific, and Atlantic seaboards.

In some areas, the primary problem caused by wind erosion is crop damage. Some crops are tolerant enough to withstand or recover from erosion damage. Other crops, including many vegetables and specialty crops, are especially vulnerable to wind erosion damage. Wind erosion may cause significant short-term economic loss in areas where erosion rates are below the soil loss tolerance (T) when the crops grown in that area are easily damaged by blowing soil (table 502–4).

502.11 The wind erosion process

The wind erosion process is complex. It involves detaching, transporting, sorting, abrading, avalanching, and depositing of soil particles. Turbulent winds blowing over erodible soils cause wind erosion. Field conditions conducive to erosion include

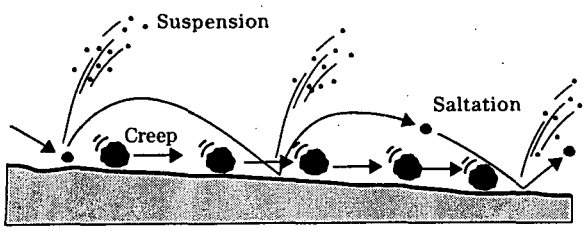
- loose, dry, and finely granulated soil;
- smooth soil surface that has little or no vegetation present;
- sufficiently large area susceptible to erosion; and
- sufficient wind velocity to move soil.

Winds are considered erosive when they reach 13 miles per hour at 1 foot above the ground or about 18 miles per hour at a 30 foot height. This is commonly referred to as the threshold wind velocity (Lyles and Krauss 1971).

The wind transports primary soil particles or stable aggregates, or both, in three ways (fig. 502–1):

Saltation—Individual particles/aggregates ranging from 0.1 to 0.5 millimeter in diameter lift off the surface at a 50- to 90-degree angle and follow distinct trajectories under the influence of air resistance and gravity. The particles/aggregates return to the surface at impact angles of 6 to 14 degrees from the horizontal. Whether they rebound or embed themselves, they initiate movement of other particles/aggregates to create the *avalanching* effect. Saltating particles are the abrading *bullets* that remove the protective soil crusts and clods. Most saltation occurs within 12 inches above the soil surface and typically, the length of a saltating particle trajectory is about 10 times the height. From 50 to 80 percent of total transport is by saltation.

Figure 502-1 The wind erosion process



Suspension—The finer particles, less than 0.1 millimeter in diameter, are dislodged from an eroding area by saltation and remain in the air mass for an extended period. Some suspension-sized particles or aggregates are present in the soil, but many are created by abrasion of larger aggregates during erosion. From 20 percent to more than 60 percent of an eroding soil may be carried in suspension, depending on soil texture. As a general rule, suspension increases downwind, and on long fields can easily exceed the amount of soil moved in saltation and creep.

Surface creep—Sand-sized particles/aggregates are set in motion by the impact of saltating particles. Under high winds, the whole soil surface appears to be creeping slowly forward as particles are pushed and rolled by the saltation flow. Surface creep may account for 7 to 25 percent of total transport (Chepil 1945 and Lyles 1980).

Saltation and creep particles are deposited in vegetated strips, ditches, or other areas sheltered from the wind, as long as these areas have the capacity to hold the sediment. Particles in suspension, however, may be carried a great distance.

The rate of increase in soil flow along the wind direction varies directly with erodibility of field surfaces. The increase in erosion downwind (avalanching) is associated with the following processes:

- the increased concentration of saltating particles downwind increases the frequency of impacts and the degree of breakdown of clods and crusts, and
- accumulation of erodible particles and breakdown of clods tends to produce a smoother (and more erodible) surface.

The distance required for soil flow to reach a maximum for a given soil is the same for any erosive wind. The more erodible the surface, the shorter the distance in which maximum flow is reached. Any factor that influences the erodibility of the surface influences the increase in soil flow.

Subpart 502C Estimating wind erosion

502.20 How, why, and by whom wind erosion is estimated

Using the Wind Erosion Equation (WEQ), NRCS estimates erosion rates to

- provide technical assistance to land users,
- inventory natural resources, and
- evaluate the effectiveness of conservation programs and conservation treatment applied to the land.

Wind erosion is difficult to measure. Wind moves across the land in a turbulent, erratic fashion. Soil may blow into, within, and out of a field in several directions in a single storm. The direction, velocity, duration, and variability of the wind all affect the erosion that occurs from a wind storm. Much of the soil eroding from a field bounces or creeps near the surface; however, some of the soil blown from a field may be high above the ground in a dust cloud by the time it reaches the edge of a field (Chepil 1963).

502.21 Methods of estimating wind erosion

No precise method of measuring wind erosion has been developed. However, various dust collectors, remote and in-place sensors, wind tunnels, sediment samplers, and microtopographic surveys before and after erosion have been used. Each method has its limitations. Research is continuing on new techniques and new devices, on modifications to older ones, and on means to measure wind erosion.

Estimates of wind erosion can be developed by assigning numerical values to the site conditions that govern wind erosion and expressing their relationships mathematically. This is the basis of the current Wind Erosion Equation (WEQ) that considers soil erodibility, ridge and random roughness, climate, unsheltered distance, and vegetative cover.

502.22 The wind erosion equation

The Wind Erosion Equation (WEQ) erosion model is designed to predict long-term average annual soil losses from a field having specific characteristics. With appropriate selection of factor values, the equation will estimate average annual erosion or erosion for specific time periods.

Development of the wind erosion equation

Drought and wind erosion during the 19th century caused wind erosion to be recognized as an important geologic phenomenon. By the late 1930's, systematic and scientific research into wind erosion was being pioneered in California, South Dakota, Texas, and in Canada and England. This research produced information on the mechanics of soil transport by wind, the influence of cultural treatment on rates of movement, and the influence of windbreaks on windflow patterns. The publication, *The Physics of Blown Sand and Desert Dunes*, (Bagnold 1941), is considered a classic by wind erosion researchers.

In 1947, USDA began the Wind Erosion Research Program at Manhattan, Kansas, in cooperation with Kansas State University. That program was started under the leadership of Austin W. Zingg, who was soon joined by W.S. Chepil, a pioneer in wind erosion research in Canada. The research project's primary purposes were to study the mechanics of wind erosion, delineate major influences on that erosion, and devise and develop methods to control it.

By 1954, Chepil and his coworkers began to publish results of their research in the form of wind erosion prediction equations (Chepil 1954; Chepil 1957; Chepil et al. 1955; Woodruff and Chepil 1956).

In 1959, Chepil released an equation

$$E = IRKFBWD$$

where:

E = quantity of erosion
I = soil cloddiness
R = residue
K = roughness
F = soil abradability
B = wind barrier
W = width of field
D = wind direction

Wind velocity at geographic locations was not addressed in this equation (Chepil 1959).

In 1962, Chepil's group released the equation

$$E = \int(ACKLV)$$

where:

A = percentage of soil fractions greater than 0.84 millimeter.

Factors C, K, L, and V were the same as in the present equation although they were not handled the same (Chepil 1962). A C-factor map for the western half of the United States was also published in 1962 (Chepil et al. 1962).

In 1963, the current form of the equation, $E = f(ICKLV)$ was first released (Chepil 1963).

In 1965, the concept of preponderance in assessing wind erosion forces was introduced. See 502.34 for details on preponderance (Skidmore 1965 and Skidmore and Woodruff 1968).

In 1968, monthly climatic factors were published (Woodruff and Armbrust 1968). These are no longer used by NRCS. Instead, NRCS adopted a proposal for computing soil erosion by periods using wind energy distribution which was published in 1980 (Bondy et al. 1980). (See 502.24.) In 1981, the Wind Erosion Research Unit provided NRCS with data on the distribution of erosive wind energy for the United States and in 1982 provided updated annual C factors. (See exhibit 502-8.)

Although the present equation has significant limitations (see 502.23), it is the best tool currently available for making reasonable estimates of wind erosion. Currently, research and development of improved procedures for estimating wind erosion are underway.

The present Wind Erosion Equation is expressed as:

$$E = \int(IKCLV)$$

where:

E = estimated average annual soil loss in tons per acre per year
f = indicates relationships that are not straight-line mathematical calculations
I = soil erodibility index
K = soil surface roughness factor
C = climatic factor
L = the unsheltered distance
V = the vegetative cover factor

The **I** factor, expressed as the average annual soil loss in tons per acre per year from a field area, accounts for the inherent soil properties affecting erodibility. These properties include texture, organic matter, and calcium carbonate percentage. **I** is the potential annual wind erosion for a given soil under a given set of field conditions. The given set of field conditions for which **I** is referenced is that of an isolated, unsheltered, wide, bare, smooth, level, loose, and non-crusted soil surface, and at a location where the climatic factor (C) is equal to 100. (For details on the **I** factor see 502.31).

The K factor is a measure of the effect of ridges and cloddiness made by tillage and planting implements. It is expressed as a decimal from 0.1 to 1.0. (For details on the K factor see 502.32.)

The C factor for any given locality characterizes climatic erosivity, specifically windspeed and surface soil moisture. This factor is expressed as a percentage of the C factor for Garden City, Kansas, which has a value of 100. (For details on the C factor see 502.33.)

The L factor considers the unprotected distance along the prevailing erosive wind direction across the area to be evaluated and the preponderance of the prevailing erosive winds. (For details on the L factor see 502.34.)

The V factor considers the kind, amount, and orientation of vegetation on the surface. The vegetative cover is expressed in pounds per acre of a flat small-grain residue equivalent. (For details on the V factor see 502.35.)

Solving the equation involves five successive steps. Steps 1, 2 and 3 can be solved by multiplying the factor values. Determining the effects of L and V (steps 4 and 5) involves more complex functional relationships.

Step 1: $E_1 = I$

Factor I is established for the specific soil. I may be increased for knolls less than 500 feet long facing into the prevailing wind, or decreased to account for surface soil crusting, and irrigation.

Step 2: $E_2 = IK$

Factor K adjusts E_1 for tillage-induced oriented roughness, K_{rd} (ridges) and random roughness, K_{rr} (cloddiness). The value of K is calculated by multiplying K_{rd} times K_{rr}. ($K = K_{rd} \times K_{rr}$).

Step 3: $E_3 = IKC$
Factor C adjusts E_2 for the local climatic factor.

Step 4: $E_4 = IKCL$
Factor L adjusts E_3 for unsheltered distance.

Step 5: $E_5 = IKCLV$
Factor V adjusts E_4 for vegetative cover.

502.23 Limitations of the equation

When the unsheltered distance, L, *is sufficiently long, the transport capacity of the wind for saltation and creep is reached.* If the wind is moving all the soil it can carry across a given surface, the inflow into a downwind area of the field is equal to the outflow from that same area of the field, for saltation and creep. The net soil loss from this specific area of the field is then only the suspension component. This does not imply a reduced soil erosion problem because, theoretically, there is still the estimated amount of soil loss in creep, saltation, and suspension leaving the downwind edge of the field.

Surface armoring by nonerodible gravel is not usually addressed in the I factor.

The equation does not account for snow cover or seasonal changes in soil erodibility. The equation does not estimate erosion from single storm events.

502.24 Alternative procedures for using the WEQ

The WEQ Critical Period Procedure is based on use of the Wind Erosion Equation as described by Woodruff and Siddoway in 1965 (Woodruff and Siddoway 1965). The conditions during the critical wind erosion period are used to derive the estimate of annual wind erosion.

- The Critical Wind Erosion Period is described as the period of the year when the greatest amount of wind erosion can be expected to occur from a field under an identified management system. It is the period when vegetative cover, soil surface conditions, and expected erosive winds result in the greatest potential for wind erosion.
- Erosion estimates developed using the critical period procedure are made using a single set of factor values (IKCL & V) in the equation to describe the critical wind erosion period conditions.
- The critical period procedure is currently used for resource inventories. NRCS usually provides specific instructions on developing wind erosion estimates for resource inventories.

The WEQ Management Period Procedure was published by Bondy, Lyles, and Hayes in 1980. It solves the equation for situations where site conditions have significant variation during the year or planning period where the soil is exposed to soil erosion for short periods, and where crop damage is the foremost conservation conern, rather than the extent of soil loss. The management period procedure is described as being more responsive to changing conditions throughout the cropping year but is not considered more accurate than the critical period procedure.

Comparisons should not be made between the soil erosion predictions made by the management period procedure and the critical period procedure. In other words, where a conservation system has been determined to be acceptable by the management period procedure and placed in a conservation plan or the FOTG, then only the management period procedure will be used to determine if other conservation systems, planned or applied, provide equivalent treatment.

Factor values are selected to describe management periods when cover and management effects are approximately uniform. The cropping system is divided into as many management periods as is necessary to describe the year or planning period accurately. Erosive wind energy (EWE) distribution is used to derive a weighted estimate of soil loss for the period. The general procedure is as follows:

- Solve for E in the basic equation ($E = f(IKCLV)$) using management period values for I, K, L, and V, and the local annual value for C.
- Multiply the annual soil loss rate E obtained from management period values by the percentage of annual erosive wind energy that occurs during the management period to estimate average erosion for that management period.
- Add the management period amounts for the crop year, or add the period amounts for a total crop sequence and divide by the number of years in the sequence to estimate average annual wind erosion.

Exhibit 502–7a is an example of tables showing the expected monthly distribution of erosive wind energy at specific locations. The complete table is available for downloading at

http://www.weru.ksu.edu/nrcs/windparm.doc

Exhibit 502–7b shows how these values are used in the management period method computations. Erosive wind energy values are entered on the form in the column identified **% EWE**.

Estimates for management periods less than 1 year in duration are often useful in conservation planning. Examples include

- When crop damage (crop tolerance) during sensitive growth stages is the major concern.
- When a system or practice is evaluated for short-term effects.

States will use critical period or the management period procedure, within published guidelines, for conservation planning. The management period procedure will not be used for resource inventories unless specifically stated in instructions. Refer to individual program manuals for more specific instructions pertaining to the use of the Wind Erosion Equation.

Adjustments to the WEQ soil erodibility factor, **I**, can be made for temporary conditions that include irrigation or crusts, but such adjustments are to be used only with the management period procedure. The use of monthly preponderance data to determine equivalent field width is also applicable only to the management period procedure.

502.25 Data to support the WEQ

ARS has developed benchmark values for each of the factors in the WEQ. However, the NRCS is responsible for developing procedures and additional factor values for use of the equation. Field Office Technical Guides will include the local data needed to make wind erosion estimates.

ARS has computed benchmark C factors for locations where adequate weather data are available (Lyles 1983). C factors used in the field office are to reflect local conditions as they relate to benchmark C factors. Knowledge of local terrain features and local climate is needed to determine how point data can be extended and how interpolation between points should be done. See 502.33 for guidance.

ARS has developed soil erodibility **I** values based on size distribution of soil aggregates. Soils have been grouped by texture classes into wind erodibility groups. Wind erodibility group numbers are included in the soil survey data base in NASIS.

For further discussion of benchmark data supporting factor values, refer to subpart 502D, WEQ factors.

502.26 Using WEQ estimates with USLE or RUSLE calculations

The WEQ provides an estimate of average annual wind erosion from the field width along the prevailing wind erosion direction (L) entered in the calculation; USLE or RUSLE provide an estimate of average annual sheet and rill erosion from the slope length (L) entered into the model. Although both wind and water erosion estimates are in tons per acre per year, they are not additive unless the two equations represent identical flow paths across identical areas.

502.27 Tools for using the WEQ

Graphs and tables for determining factor values are in Subpart 502G Exhibits.

E tables

The ARS WEROS (Wind Erosion) computer program has produced tables that give estimated erosion (E values) for most of the possible combinations of I, K, C, L, and V. Exhibit 502–1 is an example. See 502.30 for procedures to download E tables.

Use of the management period procedure can be simplified through the use of worksheets on which information for each management period is documented. Subpart 502F is to include sample wind erosion computations using the Management Period Procedure.

An acceptable WEQ calculator has been developed in Microsoft Excel, and is being adapted for use in many states. A copy of this spreadsheet can be obtained from the NRCS state agronomist in Albuquerque, New Mexico. Exhibit 502.7B shows an example of this spread sheet.

Trade names mentioned are for specific information and do not constitute a guarantee or warranty of the product by the Department of Agriculture or an endorsement by the Department over other products not mentioned.

Subpart 502D WEQ Factors

502.30 The wind erosion estimate, E

The wind erosion estimate, E, is the estimate of average annual tons of soil per acre that the wind will erode from an area represented by an unsheltered distance L and for the soil, climate, and site conditions represented by I, K, C, and V. The equation is an empirical formula. It was initially developed by relating wind tunnel data to observed field erosion for 3 years in the mid 1950's (Woodruff et al. 1976). The field data was normalized to reflect long-term average annual erosion assuming given conditions during the critical period without reference to change in those conditions through the year. The estimate arrived at by using the critical period procedure for estimating wind erosion does not track specific changes brought about by management and crop development; nor does it assume that critical period conditions exist all year. The calibration procedure accounted for minor changes expected to occur during a normal crop year at that time in history. The WEQ annual E is based on an annual C and field conditions during the critical wind erosion period of the year. This procedure does not account for all the effects of management.

The management period procedure for estimating wind erosion involves assigning factor values to represent field conditions expected to occur during specified time periods. Using annual wind energy distribution data, erosion can be estimated for each period of time being evaluated. The period estimates are summed to arrive at an annual estimate. Cropping sequences involving more than 1 year can be evaluated using this procedure. It also allows for a more thorough analysis of a management system and how management techniques affect the erosion estimate.

The new E tables can be downloaded from the WERU server, Manhattan, Kansas. These tables can be accessed in two ways:

- Through your WWW browser. To view, direct your web browser to: **http://www.weru.ksu.edu/nrcs**

  Download the Adobe Acrobat Reader (if not already installed on your computer) by clicking on the icon and installing per the installation instructions. (Trade names mentioned are for specific information and do not constitute a guarantee or warranty of the product by the Department of Agriculture or an endorsement by the Department over other products not mentioned.) When the Adobe Acrobat Reader is running on your browser you can click the PDF icon to view and print the table. When on the WERU Web page, copies of the files can be downloaded by clicking on the hypertext for the following:

  etab.pdf for PDF or
  etab.wpd (for WordPerfect) or
  etab.ps for Postscript

- Through FTP—For those without a web browser but have FTP access, FTP to: **ftp.weru.ksu.edu** go to the appropriate directory, for example

  cd pub/nrcs/etables

  Be sure that you are in binary mode.

To download the table format of your choice, type:

get etab.pdf for PDF or
get etab.wpd for WordPerfect or
get etab.ps for Postscript

The appropriate E table will download to your computer. Exhibit 502-1 shows an example of an E table.

502.31 Soil erodibility index, I

I is the erodibility factor for the soil on the site. It is expressed as the average annual soil loss in tons per acre that would occur from wind erosion, when the site is:

- **Isolated** – incoming saltation is absent
- **Level** – knolls are absent
- **Smooth** – ridge roughness effects are absent and cloddiness is minimal
- **Unsheltered** – barriers are absent.
- At a location where the **C factor is 100**
- **Bare** – vegetative cover is absent
- **Wide** – the distance at which the flow of eroding soil reaches its maximum and does not increase with field size
- **Loose** – and non-crusted, aggregates not bound together, and surface not sealed.

The I factor is related to the percentage of nonerodible surface soil aggregates larger than 0.84 millimeters in diameter. For most NRCS uses, the I value is assigned for named soils based on wind erodibility groups (WEG). The WEG is included in the soil survey data base in NASIS. If the soil name is not known, exhibit 502–2 can be used to determine the WEG from the surface soil texture.

To determine erodibility for field conditions during various management periods throughout the year, follow the sieving instructions in exhibit 502–3. (Do not use this procedure to determine average annual **I** values.)

A soil erodibility index based solely on the percentage of aggregates larger than 0.84 millimeters has several potential sources of error. Some of these follow:

- Relative erodibility of widely different soils may change with a change in wind velocity over the surface of the soil.
- Calibration of the equation is based on the volume of soil removed, but the erodibility index is based on weight.
- Differences in size of aggregates have considerable influence on erodibility but no distinction for this influence is made in table 1, exhibit 502–3.
- Stability of surface aggregates influences erodibility; large durable aggregates can become a *surface armor*; less stable aggregates can be abraded into smaller, more erodible particles.
- Surface crusting may greatly reduce erodibility; erodibility may increase again as the crust deteriorates (Chepil 1958).

Knoll erodibility—Knolls are topographic features characterized by short, abrupt windward slopes. Wind erosion potential is greater on knoll slopes than on level or gently rolling terrain because wind flowlines are compressed and wind velocity increases near the crest of the knolls. Erosion that begins on knolls often affects field areas downwind.

Adjustments of the Soil Erodibility Index (**I**) are used where windward-facing slopes are less than 500 feet long and the increase in slope gradient from the adjacent landscape is 3 percent or greater. Both slope length and slope gradient change are determined along the direction of the prevailing erosive wind (fig. 502–2).

Table 502–1 Knoll erodibility adjustment factor for **I**

Percent slope change in prevailing wind erosion direction	A Knoll adjustment of I	B Increase at crest area where erosion is most severe
3	1.3	1.5
4	1.6	1.9
5	1.9	2.5
6	2.3	3.2
8	3.0	4.8
10 and greater	3.6	6.8

Table 502-1 contains knoll erodibility adjustment factors for the Soil Erodibility Index **I**. The **I** value for the Wind Erodibility Group is multiplied by the factor shown in column A. This adjustment expresses the average increase in erodibility along the knoll slope. For comparison, column B shows the increased erodibility near the crest (about the upper 1/3 of the slope), where the effect is most severe.

No adjustment of **I** for knoll erodibility is made on level fields, or on rolling terrain where slopes are longer and slope changes are less abrupt. Where these situations occur, the wind flow pattern tends to conform to the surface and does not exhibit the flow constriction typical of knolls.

Surface crusting—Erodibility of surface soil varies with changing tillage practices and environmental conditions (Chepil 1958). A surface crust forms when a bare soil is wetted and dried. Although the crust may be so weak that it has virtually no influence on the size distribution of dry aggregates determined by sieving, it can make the soil less erodible. The resistance of the crust to erosion depends on the nature of the soil, intensity of rainfall, and the kind and amount of cover on the soil surface. A fully crusted soil may erode only one-sixth as much as non-crusted soil. However, a smooth crusted soil with loose sand grains on the surface is more erodible than the same field with a cloddy or ridged surface.

Table 502-2 **I** adjustment guidelines for crusts

WEG	I	Max. adj. mgt prd. factor 1/	Calculated I	Rounded I
1	310	.7	217	220
1	250	.7	175	180
1	220	.7	154	160
1	180	.7	126	134
1	160	.7	112	134
2	134	.7	67	86
3	86	.4	34	38
4	86	.4	34	38
4L	86	.4	34	38
5	56	.3	17	21
6	48	.3	14	21
7	38	.3	11	12

1/ The management period adjustment to **I** has not been validated by research and is based on NRCS judgment.

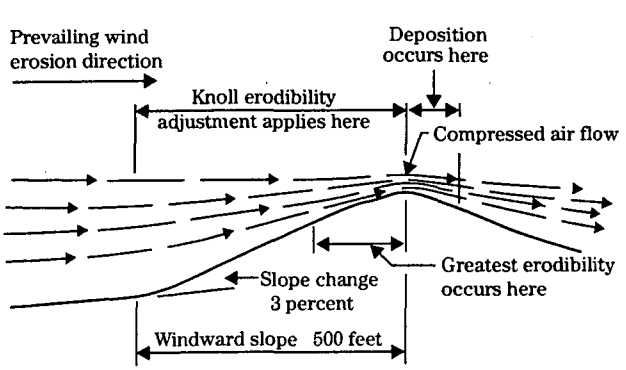
Under erosive conditions, the surface crust and surface clods on fine sands and loamy fine sands tend to break down readily. On silt loams and silty clay loams the surface crust and surface clods may be preserved, and the relative erosion may be as little as one-sixth of **I**. Other soils react somewhere between these two extremes (Chepil 1959).

Because of the temporary nature of crusts, no adjustment for crusting is made for annual estimates based on the critical wind erosion period method (Woodruff and Siddoway 1973). However, crust characteristics may be estimated and adjustment to **I** may be made for management period estimates when no traffic, tillage, or other breaking of crusts is anticipated. Such adjustments may be up to, but may not exceed the percentages shown in table 502–2.

Irrigation adjustments—The **I** values for irrigated soils, as shown in exhibit 502–2, are applicable throughout the year. **I** adjustments for irrigation are applicable only where assigned **I** values are 180 or less.

Adjustments based on dry sieving—Temporal changes in the surface fraction > 0.84 millimeter may be measured by dry sieving. These measurements may be used to establish a basis for adjusting **I** for conservation planning when sieving has been performed for each management period and for 3 years or more. The adjustment to **I** applies only to the respective time periods when the soil surface is influenced by changes in the nonerodible fraction. Therefore, the adjustment is used only with the management period procedure of estimating wind erosion. The procedure does expand the applicability of the equation to a management effect not previously addressed. When the **I** factor is adjusted based on the results of sieving, no additional adjustment to **I** will be made for irrigated fields. Adjustments to **I**, based on sieving, should not be used without adequate supporting data. These adjustments reflect specific soil and management conditions and are only applicable in the area(s) from which samples were obtained and in areas that have similar soil and management conditions.

Figure 502–2 Graphic of knoll erodibility



Use of adjusted soil erodibility **I** factor, arrived at by using standard rotary sieving procedures, is warranted provided it represents soil surface conditions during the appropriate management period. Adjustments may be made up to, but should not exceed, limits assigned for crusting in table 502-2.

The **I** factor adjustment may be used where applicable in determining whether an adequate conservation system is being followed. However, **I** factor adjustments are not to be used in the erodibility index (CI/T) when determining highly erodible land because this index is the potential erodibility and not an estimate of actual erosion.

Current instructions for the National Resources Inventory (NRI) are to be followed. These instructions do not allow for any adjustment of the **I** factor. This ensures uniformity between States and allows for trend analysis.

Studies to adjust **I** should be made systematically and include all related soil in a given area. Multiple-year soil sieving data is required before adjustments are to be considered.

The National Soil Survey Center must review and concur in any proposal to adjust **I** and arrange for laboratory assistance. Adjustments to **I** must also be approved by the National Soil Survey Center and correlated across state and regional boundaries before implementation. Any adjustment to **I** must be within the framework of the existing E tables.

Surface stability—A significant limitation of the **I** factor is that it does not account for changes in the soil surface over time that are caused by the dynamics of wind erosion. The erodibility of a bare soil surface is based on the interaction of the following:

- Soils that have both erodible and nonerodible particles on the surface tend to stabilize if there is no incoming saltation. As the wind direction changes, the surface is disturbed, or the wind velocity increases, erosion may begin again.
- Saltation destroys crusts, clods, and ridges by abrasion.

- Fields tend to become more erodible as finer soil particles, which provide bonding for aggregation, are carried off in suspension.
- If the surface soil contains a high percentage of gravel or other nonerodible particles that are resistant to abrasion, the surface will become increasingly armored as the erodible particles are carried away. Desert pavement is the classic example of surface armoring. A surface with only nonerodible aggregates exposed to the wind will not erode further except as the aggregates are abraded.
- A surface may be virtually nonerodible and yet allow saltation and creep to cross unabated. A paved highway is an example. Other surfaces may be relatively stable and trap some, or all, of zthe incoming soil flow. Examples of this type of stability usually relate to some roughness, sheltering, or vegetative cover. A ridged field may trap a significant portion of the incoming soil flow until the furrows are filled and the surface loses its trapping capability. A vegetated barrier will provide a sheltered area downwind until the barrier is filled with sediment.

502.32 Soil roughness factor K, ridge and random roughness

K_{rd} is a measure of the effect of ridges made by tillage and planting implements. Ridges absorb and deflect wind energy and trap moving soil particles (fig. 502–3).

The K_r value is based on a standard ridge height to ridge spacing ratio of 1:4. Because of the difficulty of determining surface roughness by measuring surface obstructions, a standard roughness calibration using nonerodible gravel ridges in a wind tunnel was developed. This calibration led to the development of curves (fig. 502–4 and exhibit 502–

Figure 502–3 Detachment, transport, and deposition on ridges and furrows

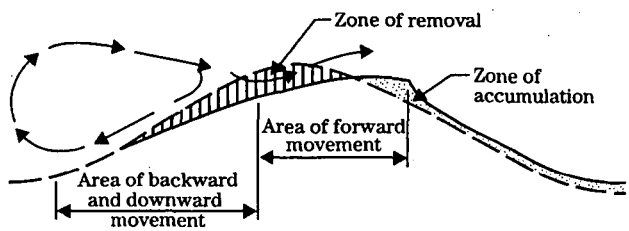
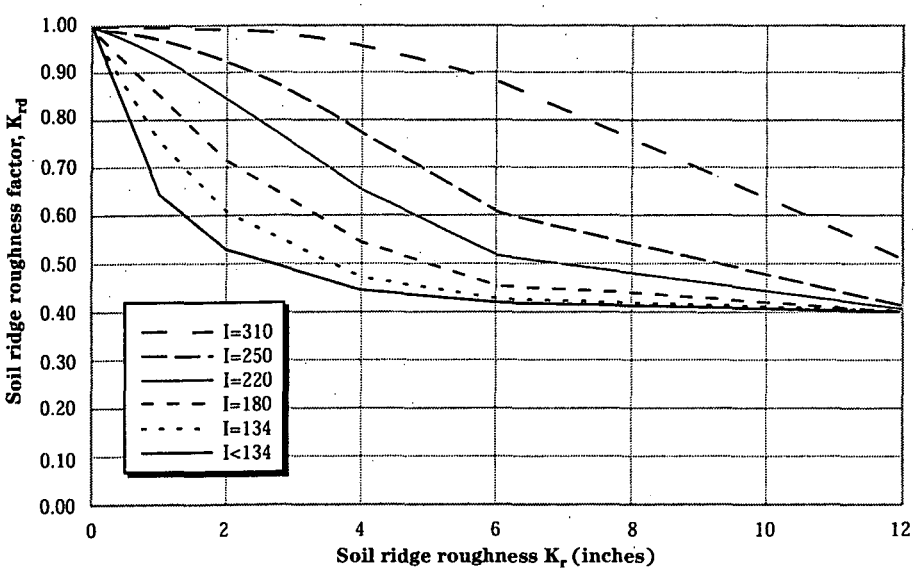


Figure 502–4 Chart to determine soil ridge roughness factor, K_{rd}, from ridge roughness, K_r, (inches). Only this chart, representing an angle of deviation of 0°, will be used for the WEQ **critical period procedure**. When using the **management period procedure**, see exhibit 502–4 for graphs representing additional angles of deviation. Note: This graph represents erosive wind energy 60% parallel and 40% perpendicular to the prevailing erosive wind. —Hagen 1996



Kr=4(hxh)/s h=ridge height in inches s=ridge spacing in inches

$$K_r = \frac{4(h \times h)}{s}$$

where:
h = ridge height in inches
s = ridge spacing in inches

4) that relate ridge roughness, K_r, to a soil ridge roughness factor, K_{rd}, (Skidmore 1965; Skidmore and Woodruff 1968; Woodruff and Siddoway 1965; and Hagen 1996).

The K_r curves are the basis for charts and tables used to determine K_{rd} factor values in the field (exhibits 502–4 and 502–5). The effect of ridges varies as the wind direction and erodibility of the soil change. To take into account the change in wind directions across a field, we consider the angle of deviation. The angle of deviation is the angle between the prevailing wind erosion direction and a line perpendicular to the row direction. The angle of deviation is 0 (zero) degrees when the wind is perpendicular to the row and is 90 degrees when the wind is parallel to the row. Following is an example of how the angle of deviation affects K_{rd} values: when evaluating a soil with an assigned **I** value of <134, and the prevailing erosive wind direction is perpendicular to ridges 4 inches high and 30 inches apart, then K_{rd} is 0.5. But when the prevailing erosive wind direction is parallel to those ridges, the K_{rd} value is 0.7. Random roughness, particularly in the furrows, significantly reduces wind erosion occurring from erosive winds blowing parallel to the ridges.

In 1996, ARS scientists provided a method for adjusting the WEQ K_{rd} factor with consideration for preponderance (erosive wind energy 60% parallel and 40% perpendicular to prevailing erosive wind direction) when using the Management Period Procedure. The use of preponderence recognizes that during the periods when the prevailing erosive winds are parallel to ridges, there are other erosive winds during the same period which are not parallel, thus making ridges effective during part of each period. Preponderance keeps the K factor value less than 1.0, when the **I** factor values are 134 or less. When estimating wind erosion rates by management periods, without the aid of a computer model, the prevailing wind erosion direction and a *default* preponderance are used for each period. This procedure more adequately addresses the effects of the ridges in wind erosion control since erosive wind directions may vary within each management period.

Note: When using the WEQ Excel spreadsheet model, the actual preponderance, up to and including a value of 4, for the period will be used, rather than a default value.

The WEQ K_{rr} factor accounts for random roughness. Random roughness is the nonoriented surface roughness that is sometimes referred to as cloddiness. Random roughness is usually created by the action of tillage implements. It is described as the standard deviation (in inches) of the soil surface elevations, measured at regular intervals from a fixed, arbitrary plane above a tilled soil surface, after oriented (ridge) roughness has been accounted for. Random roughness can reduce erosion significantly. Note: The random roughness factor will only be used with the WEQ management period procedure.

Random roughness values have been developed for various levels of WEQ **I** factor values and surface random roughness (exhibit 502–6). Random roughness curves only adjust the K factors of a soil that has an **I** factor value of 134 and less.

The random roughness values used in the WEQ are the same random roughness values used in RUSLE. Random roughness (inches) from the machine operations data base in RUSLE can be used to determine WEQ random roughness values (table 502–7). However, keep in mind that these RUSLE random roughness values were determined for medium textured soils tilled at optimum moisture conditions for creating random roughness. Under most circumstances random roughness is determined by comparing a field surface to the random roughness (standard deviation) photos in the RUSLE handbook (Agriculture Handbook 703, appendix C).

The photos in Agriculture Handbook 703, appendix C, may be downloaded from:

http://www.nrcs.usda.gov/technical/ECS/agronomy/roughness.html

State agronomists should download, reproduce, and distribute the photographs to field offices.

When both random roughness and ridge roughness are present in the field, they are complimentary. When both are present, the K_{rd} factor for ridges and K_{rr} factor for random roughness will be multiplied together to obtain the total roughness K-factor.

Example problem: Take into consideration just one WEQ management period. The soil in the field being evaluated has an **I** value of 86. The field has just been fertilized with anhydrous ammonia using a knife applicator. Considering the height and spacing of the oriented roughness, the ridge roughness K_{rd} factor was determined to be 0.8. Using table 502–7, under random roughness (inches), the anhydrous applicator has a core value of 0.6. Going into the random roughness (inches) graph (exhibit 502–6), on the hori-

zontal axis to 0.6, and then vertically to the line representing an I factor of 86, the K_{rr} factor is rounded to 0.8. The total roughness value (K factor) is 0.8 x 0.8 = 0.64, then rounded to 0.6.

The major effects of random roughness on wind erosion are to raise the threshold wind speed at which erosion begins and to provide some sheltered area among the clods where moving soil can be trapped. Hence, when the effectiveness of random roughness increases the total K-value decreases.

Random roughness, particularly in the furrows, significantly reduces wind erosion occurring from erosive winds blowing parallel to the ridges.

Random roughness is subject to much faster degradation by rain or wind erosion than large tillage ridges. Therefore the WEQ management period, where random roughness is effective, may be of short duration.

For fields being broken out of sod, such as CRP, random roughness will be credited for erosion control. The field surface is usually covered with the crowns of plants, their associated roots, and adhering soil. The total random roughness of the field should be compared to the photos in the RUSLE handbook and credited appropriately.

Surface roughening (emergency tillage)—In some situations, there is a need to control erosion on bare fields where the surface crust has been destroyed or where loose grains are on the surface and can abrade an existing crust. One method to reduce the erosion hazard on such fields is emergency or planned tillage to roughen the surface or increase nonerodible clods on the surface (random roughness). This may be accomplished by one or more of the following:

- Soil that characteristically forms a crust with loose sand grains on the surface may be worked to create clods. The loose grains fall into the crevices between clods. This is the principle of sand fighting used in some emergency tillage.
- The soil may be deep tilled to bring up finer textured soil material that will form more persistent clods.
- Irrigation increases the nonerodible fraction of a soil (exhibit 502–2).
- The surface may be worked into a ridge-furrow configuration that will trap loose, moving soil.
- The soil may be tilled in strips or in widely spaced rows to provide some degree of ridge and random roughness to break the flow of saltation and creep.

502.33 Climatic factor, C

The C factor is an index of climatic erosivity, specifically windspeed and surface soil moisture. The factor for any given location is based on long-term climatic data and is expressed as a percentage of the C factor for Garden City, Kansas, which has been assigned a value of 100 (Lyles 1983). In an area with a C factor of 50, for example, the IKC value would be only half of the IKC for Garden City, Kansas.

The climatic factor equation is expressed as:

$$C = 34.48 \times \frac{v^3}{(PE)^2}$$

where:

C = annual climatic factor
V = average annual wind velocity
PE = precipitation-effectiveness index of Thornthwaite
34.48 = constant used to adjust local values to a common base (Garden City, Kansas)

The basis for the windspeed term of the climatic factor is that the rate of soil movement is proportional to windspeed cubed. Several researchers have reported that when windspeed exceeds threshold velocity, the soil movement is directly proportional to friction velocity cubed which, in turn, is related to mean windspeed cubed (Skidmore 1976).

The basis for the soil moisture term of the climatic factor is that the rate of soil movement varies inversely with the equivalent surface soil moisture. Effective surface soil moisture is assumed to be proportional to the Thornthwaite precipitation-effective- ness index (PE) (Thornthwaite 1931). The annual PE index is the sum of the 12 monthly precipitation effectiveness indices. The formula is expressed as follows:

$$PE = \sum^{12} 115 \times \left[\frac{P}{(T-10)}\right]^{\frac{10}{9}}$$

where:

PE = the annual precipitation effectiveness index
P = average monthly precipitation
T = average monthly temperature

The C factor isoline map developed by NRCS in 1987 can accessed at:

http://data4.ftw.nrcs.usda.gov/website/c-values

Complete instructions for viewing the map are given in exhibit 502-8. The map displays C factors for all areas of the conterminous United States and Alaska. The isolines were drafted to conform with local C factors calculated from 1951–80 weather data and were correlated across state and regional boundaries. Procedures for developing local C factors are explained in exhibit 502–9.

1. Interpolation of WEQ climatic factors (C)— States may interpolate between county assigned C values to the nearest 5 units based on the National C Factor Isoline Map or the state C Factor Isoline Map in the Field Office Technical Guide (FOTG). When interpolating between values, knowledge of the local climatic and topographic conditions is extremely useful since climatic conditions can vary disproportionately between C factor value isolines.

2. Where WEQ soil loss (E) tables have been developed with C factor increments greater than 5 units, a straight line interpolation to the nearest C factor value of 5 may be made from existing E tables. Straight line interpolations can also be made from the soil losses (E) calculated with approved WEQ computer software, when C factors programmed into the model are in increments greater than 5 units.

3. C factor interpolations are for the purpose of conservation planning only and are NOT to be used in determining or adjusting previous highly erodible land (HEL) designations. However, they may be used during status reviews to determine if an individual is actively applying a conservation system. Previous national policy, regarding the changing of prior HEL designations, remains in effect.

Effects of irrigation water on the C factor—When irrigation water is applied to a dry soil surface, a reduction in wind erosion can be expected. A specific procedure to directly adjust the climatic factor C for irrigation is not available. However, a procedure has been developed by researchers to adjust the Erosive Wind Energy (EWE) by the fraction of time during which the soil is considered wet and nonerodible because of irrigation. See 502.31 and exhibit 502–2.

The procedures that follow adjust the Erosive Wind Energy (EWE) value which planners are to use when estimating wind erosion on irrigated fields. This adjustment is for the WEQ Management Period Procedure. States where wind erosion is a concern should replace previous methods used to adjust for the effects of irrigation and utilize this procedure and the procedure for adjusting the I factor, for all plan revisions or new planning activities. This new procedure, however, does not impact designated highly erodible lands (HEL) or new determinations since management practices are not considered in the HEL formula.

Note: Irrigation adjustments to EWE and to the I factor, apply to fully irrigated fields and to fields that receive *supplemental* irrigation water.

- Research scientists have developed an Irrigation Factor (IF) that adjusts the EWE or period erosion loss to account for the effect of irrigation wetting the soil surface and making it less erodible. The IF takes into account the number of days in a management period, number of irrigation events during a management period, and a Texture Wetness Factor (TWF).
- To account for the *nonerodible wet* condition of various soil textures after irrigation, a TWF of 1, 2, or 3 is assigned to coarse, medium, and fine textured soil, respectively. See exhibit 502.2 for values assigned to the various soil groups.
- The IF is calculated with the following equation:
  IF = number of days in period minus (–) nonerodible wet days in period (NEWD), divided by the number of days in period.
  Nonerodible Wet Days (NEWD) are equal to the Texture Wetness Factor (TWF) times the number of irrigation events in the period.
- When using the WEQ to account for the effects of irrigation, multiply the EWE for the period by the IF.
- Example: A fine textured soil was irrigated three times during 45 days. Twelve percent of the annual EWE occurs during this period. Therefore:
  TWF = 3 for fine textured soil
  Number of irrigations during the period = 3
  NEWD = (3)(3) = 9
  IF = (45 days – 9)/45 = 0.80

  The adjusted EWE for 45 days is then determined by multiplying IF times the percentage of annual erosion wind energy during the period being evaluated.
  Adjusted EWE = (.80)(12%) = 9.6 %

  Note: The EWE shall not be adjusted for any management period where irrigation does not occur.
- The WEQ factors (C & I) used to determine the Erodibility Index (EI), will not be adjusted when determining highly erodible land (HEL) on cropland that is irrigated.

502.34 Unsheltered distance, L

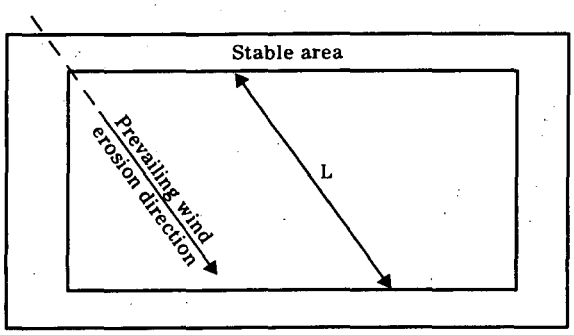
The L factor represents the unsheltered distance along the prevailing wind erosion direction for the field or area to be evaluated. Its place in the equation is to relate the *isolated, unsheltered, and wide* field condition of I to the size and shape of the field for which the erosion estimate is being prepared. Because V is considered after L in the 5-step solution of the equation (502.22), the unsheltered distance is always considered as if the field were bare except for vegetative barriers.

1. L begins at a point upwind where no saltation or surface creep occurs and ends at the downwind edge of the area being evaluated (figure 502–5). The point may be at a field border or stable area where vegetation is sufficient to eliminate the erosion process. An area should be considered stable only if it is able to trap or hold virtually all expected saltation and surface creep from upwind. If vegetative barriers, grassed waterways, or other stable areas divide an agricultural field being evaluated, each subdivision will be *isolated* and shall be evaluated as a separate *field*. Refer to the appropriate NRCS Conservation Practice Standards to determine when practices are of adequate width, height, spacing, and density to create a stable area.

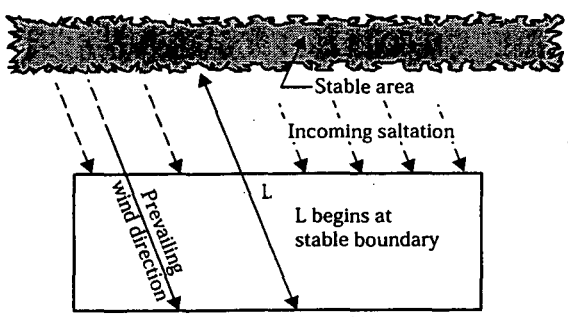
2. When erosion estimates are being calculated for cropland or other relatively unstable conditions, upwind pasture or rangeland should be considered a stable border. However, if the estimate is being made for a pasture or range area, L should be determined by measuring from the nearest stable point upwind of the area or field in question (figure 502–6). The only case where L is equal to zero is where the area is fully sheltered by a barrier.

3. When a barrier is present on the upwind side of a field, measure L across the field along the prevailing wind erosion direction and subtract the distance sheltered by the barrier. Use 10 times the barrier height for the sheltered distance (figure 502–7).

Figure 502–5 Unsheltered distance L

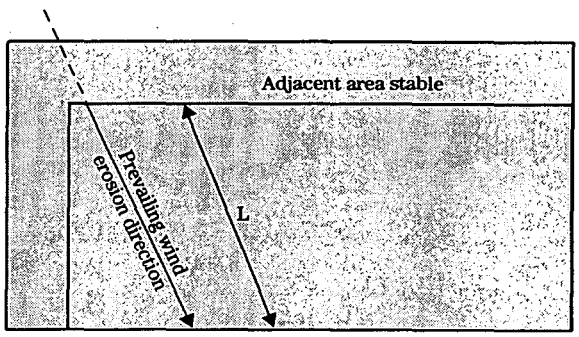


Isolated field



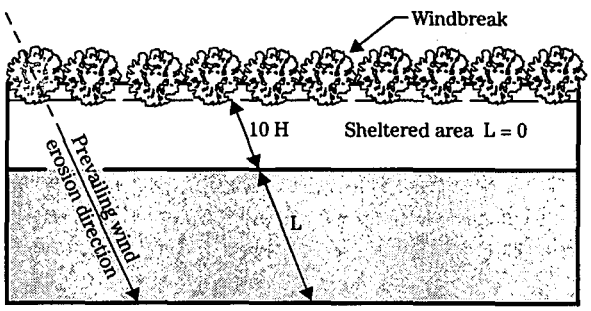
Field not isolated

Figure 502–6 Unsheltered distance L, perennial vegetation (pasture or range)



Unsheltered distance "L" perennial vegetation (pasture or range)

Figure 502-7 Unsheltered distaqnce L – windbreak or barrier



4. When a properly designed wind stripcropping system is applied, alternate strips are protected during critical wind erosion periods by a growing crop or by crop residue. These strips are considered stable. L is measured across each erosion-susceptible strip, along the prevailing wind erosion direction (figure 502–8).

The prevailing wind erosion direction is the direction from which the greatest amount of erosion occurs during the critical wind erosion period. The direction is usually expressed as one of the 16 compass points. When predicting erosion by management periods, the prevailing wind erosion direction may be different for each period (exhibit 502–7a).

Preponderance is a ratio between wind erosion forces parallel and perpendicular to the prevailing wind erosion direction. Wind forces parallel to the prevailing wind erosion direction include those coming from the exact opposite direction (180°). A preponderance of 1.0 indicates that as much wind erosion force is exerted perpendicular to the prevailing direction as along that direction. A higher preponderance indicates that more of the force is along the prevailing wind erosion direction. Wind patterns are complex; low preponderance indicates high complexity and as a result, less wind will be from the prevailing erosive wind direction than locations that have a high preponderance.

L can be measured directly on a map or calculated using a wind erosion direction factor:

- For uses of the Wind Erosion Equation involving a single annual calculation, L should be the measured distance across the area in the prevailing wind erosion direction from the stable upwind edge of the field to the downwind edge of the field. When the prevailing wind erosion direction is at an angle that is not perpendicular to the long side of the field, L can be determined by multiplying the width of the field by the appropriate conversion factor obtained from table 502-3.

- For management period calculations, wind erosion direction factors based on preponderance are to be used instead of a measured distance to determine L except
  - Where irregular fields cannot be adequately represented by a circle, square, or rectangle.
  - Where preponderance data are not available.

Steps to determine L for management period estimates:

1. Obtain local values for prevailing the wind erosion direction and preponderance (exhibit 502–7a).
2. Measure actual length and width of the field and determine the ratio of length to width.
3. Determine angle of deviation between prevailing wind erosion direction and an imaginary line perpendicular to the long side of the field.

Using data from steps 1 through 3, determine the wind erosion direction factor from wind erosion direction factor tables, tables 502–81a-e. These are adjustment factors that account for prevailing wind erosion direction, preponderance of wind erosion forces, and size and shape of the field.

Multiply the width of the field by the wind erosion direction factor. This is the L for the field.

If a barrier is on the upwind side of the field, reduce L by a distance equal to 10 times the height of the barrier.

For circular fields, L = 0.915 times the diameter, regardless of the prevailing wind erosion direction or preponderance.

Figure 502–8 Unsheltered distance L, stripcropping system

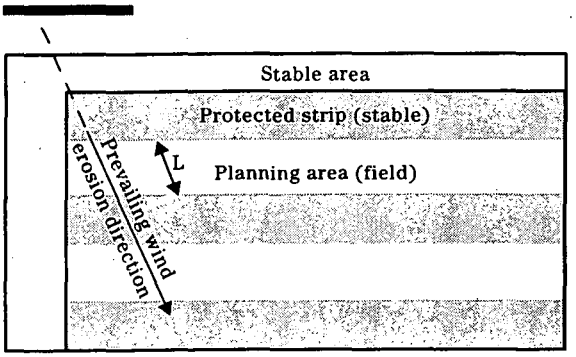


Table 502-3 Wind erosion direction factors [1/]

Angle of deviation [2/]	Adjustment factor
0	1.00
22.5°	1.08
45°	1.41
67.5°	2.61
90°	L = Length of field

1/ These adjustment factors are applicable when preponderance is not considered. L cannot exceed the longest possible measured distance across the field.

2/ Angle of deviation of the prevailing erosive wind from a direction perpendicular to the long side of the field.

502.35 Vegetative cover factor, V

The effect of vegetative cover in the Wind Erosion Equation is expressed by relating the kind, amount, and orientation of vegetative material to its equivalent in pounds per acre of small grain residue in reference condition Small Grain Equivalent (SGe). This condition is defined as 10 inch long stalks of small grain, parallel to the wind, lying flat in rows spaced 10 inches apart, perpendicular to the wind. Several crops have been tested in the wind tunnel to determine their SGe. For other crops, small grain equivalency has been computed using various regression techniques (Armbrust and Lyles 1985; Lyles and Allison 1980; Lyles 1981; Woodruff et al. 1974; Woodruff and Siddoway 1965). NRCS personnel have estimated SGe curves for other crops. SGe curves are in exhibit 502–10.

Position and anchoring of residue is important. In general, the finer and more upright the residue, the more effective it is for reducing wind erosion. Knowledge of these and other relationships can be used with benchmark values to estimate additional SGe values.

Research is underway to develop a method of estimating the relative erosion control value of short woody plants and other growing crops.

Several methods are used to estimate the kind, amount, and orientation of vegetation in the field. Often the task is to predict what will be in the field in some future season or seasons. Amounts of vegetation may be predicted from production records or estimates and these amounts are then reduced by the expected or planned tillage. It may be desirable to sample and measure existing residue to determine quantity of residue. Local data should be developed to estimate surface residue per unit of crop yield and crop residue losses caused by tillage.

The crown of a plant, its associated roots, and adhering soil should also be credited when doing transects to determine residue cover. Employees will need to use their best judgment when deciding which crop curve to use when converting from percent ground cover to mass and then selecting a curve to convert the residue mass to SGe.

If you encounter a crop, residue, or a type of vegetation for which an SGe curve has not been developed. exhibits 502–11 and 502–12 give procedures to develop an interim SGe curve. Any SGe curve developed in this way must be submitted to the National Agronomists or the Cooperating Scientist for wind erosion for approval.

Subpart 502E Principles of wind erosion control

502.40 General

Five principles of wind erosion control have been identified (Lyles and Swanson 1976; Woodruff et al. 1972; and Woodruff and Siddoway 1965). These are as follows:

- Establish and maintain adequate vegetation or other land cover.
- Reduce unsheltered distance along wind erosion direction.
- Produce and maintain stable clods or aggregates on the land surface.
- Roughen the land with ridge and/or random roughness.
- Reshape the land to reduce erosion on knolls where converging windflow causes increased velocity and shear stress.

The *cardinal rule* of wind erosion control is to strive to keep the land covered with vegetation or crop residue at all times (Chepil 1956). This leads to several principles that should be paramount as alternative controls are considered:

- Return all land unsuited to cultivation to permanent cover.
- Maintain maximum possible cover on the surface during wind erosion periods.
- Maintain stable field borders or boundaries at all times.

502.41 Relation of control to WEQ factors

The Wind Erosion Equation (WEQ) was developed to relate specific field conditions to estimated annual soil loss. Of the five factors, two (**I** and C) are often considered to be *fixed* while the other three (K, L, and V) are generally considered *variable* or management factors. This is not precisely true.

The **I** factor is related to the percentage of dry surface soil fractions greater than 0.84 millimeters. Its derivation is usually based on the Wind Erodibility Group.

However, if a special management condition is going to be maintained, such as crusts or irrigation, a modification of **I** is appropriate. Also, **I** is increased by a knoll erodibility factor where appropriate. See 502.31. This adjustment is not appropriate if the knoll condition is modified through landforming or use of barriers to protect the knoll.

Knoll erodibility adjustments to **I** relate to wind direction; low preponderance indicates that knoll erodibility will vary widely as wind direction changes.

Total K reflects the tilled ridge roughness and random roughness in a field. This is a management factor. Stability of tilled roughness is related, however, to soil erodibility, climate, and the other erosion factors.

Ridge roughness relates to ridge spacing in the wind erosion direction. Even with optimum orientation of rows, some of the winds will be blowing parallel to the rows when preponderance is low.

Random roughness relates to the nonoriented surface roughness that is often referred to as cloddiness. Random roughness is described as the standard deviation of elevation from a plane across a tilled area after taking into account oriented (ridge) roughness.

The C factor is based on long-term weather records. Conservation treatment should be planned to address the critical climatic conditions when high seasonal erosive wind energy is coupled with highly erodible field conditions.

The unsheltered distance L is a management factor that can be changed by altering field arrangement, stripcropping, or establishing windbreaks or other barriers. L is a function of field layout as it relates to prevailing wind direction and preponderance of erosive winds in the prevailing direction.

When preponderance values are high (more than 2.5 and approaching 4.0), conservation treatment should be concentrated on addressing potential erosion from the prevailing wind erosion direction.

When preponderance values are low (approaching 1.0), knowledge of local seasonal wind patterns becomes more important in planning treatment. Conservation treatment should be planned to allow for the effect of seasonal changes in the prevailing wind erosion direction.

A stable strip across an agricultural field divides the area into separate fields. Examples of stable areas include grass waterways, hedges and their sheltered area, brushy draws or ravines, roadways with grass borders, grass strips, and drainage or irrigation ditches.

To be considered stable, an area must be able to stop and hold virtually all of the expected saltation and surface creep. Be aware that an area may be stable during one crop stage, but not stable in other seasons.

V is the equivalent vegetative cover maintained on the soil surface. It is directly related to the management functions of crop establishment, tillage, harvesting, grazing, mowing, or burning.

502.42 Tolerances in wind erosion control

In both planning and inventory activities, NRCS compares estimated erosion to soil loss tolerance (T). T is expressed as the average annual soil erosion rate (tons/acre/year) that can occur in a field with little or no long-term degradation of the soil resource, thus permitting crop productivity to be sustained for an indefinite period.

Soil loss tolerances for a named soil are recorded in the soil survey data base in NASIS.

The normal planning objective is to reduce soil loss by wind or water to T or lower. In situations where treatment for both wind and water erosion is needed, soil loss estimates using the WEQ and USLE or RUSLE are not added together to compare to T.

Additional impacts of wind erosion that should be considered are potential offsite damages, such as air and water pollution and the deposition of soil particles.

Crop tolerance to soil blowing may also be an important consideration in wind erosion control. Wind or blowing soil, or both, can have an adverse effect on growing crops. Most crops are more susceptible to abrasion or other wind damage at certain growth stages than at others. Damage can result from desiccation and twisting of plants by the wind.

Crop tolerance can be defined as the maximum wind erosion that a growing crop can tolerate, from crop emergence to field stabilization, without an economic loss to crop stand, crop yield, or crop quality.

(a) Blowing soil effects on crops

Some of the adverse effects of soil erosion and blowing soil on crops include:

- Excessive wind erosion that removes planted seeds, tubers, or seedlings.
- Exposure of plant root systems.
- Sand blasting and plant abrasion resulting in
  - crop injury
  - crop mortality
  - lower crop yields
  - lower crop quality
  - wind damage to seedlings, vegetables, and orchard crops.
- Burial of plants by drifting soil.

(b) Crop tolerance to blowing soil or wind

Many common crops have been categorized based on their tolerance to blowing soil. These categories of some typical crops are listed in table 502-4. Crops may tolerate greater amounts of blowing soil than shown in table 502–4, but yield and quality will be adversely affected.

(c) The effects of wind erosion on water quality

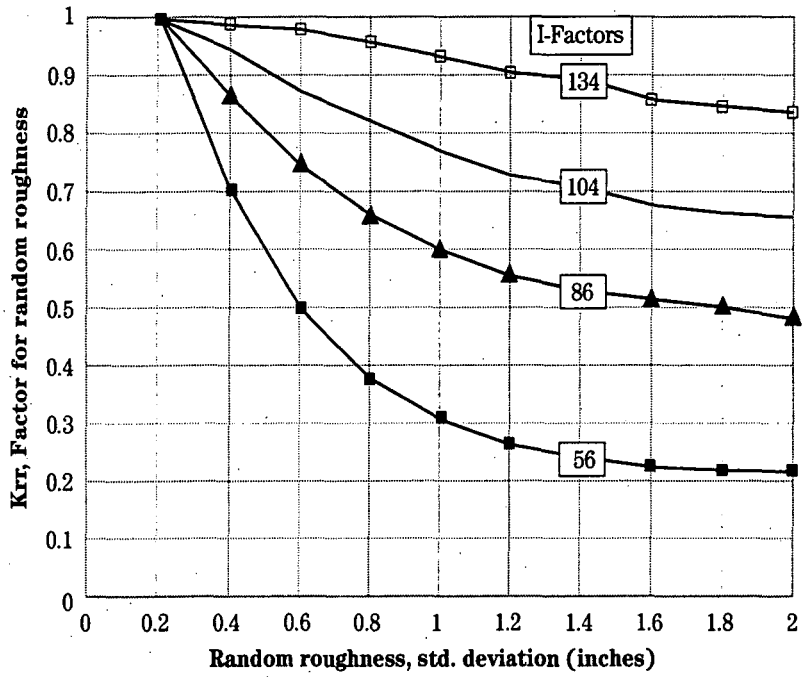
Some of the adverse effects of wind erosion on water quiality include:

- Deposition of phosphorus (P) into surface water
- Increased Biochemical Oxygen Demand (BOD) in surface water
- Reduced stream conveyance capacity because of deposited sediment in streams and drainage canals

Local water quality guidelines under Total Maximum Daily Loads (TDML) for nutrients may require that wind erosion losses be less than the soil loss tolerance (T) in order to achieve local phosphorus (P) or other pollutant reduction goals.

For a phosphorus (P) intrapment estimation procedure, see the Core 4 manual, chapter 3C, Cross Wind Trap Strips.

Exhibit 502–6 Random roughness factor, K_{rr}, graph



Graph to convert random roughness heights (standard deviation in inches) to WEQ K-subfactors for random roughness. K subfactors vary by **I** factors assigned to soil groups.

Random roughness is defined as the standard deviation (in inches) of the soil surface elevations, measured at regular intervals from a fixed arbitary plane above a tilled soil surface, after oriented roughness has been considered.

Random roughness photos and associated random roughness (standard deviation) values are in Predicting Soil Erosion by Water: A Guide to Conservation Planning With Revised Universal Soil Loss Equation (RUSLE), 1997, Agriculture Handbook 703, appendix C, or can be downloaded at

http:/www.nrcs.usda.gov/technical/ECS/agronomy/roughness.html

Table 502–6 Table converts random roughness heights (standard deviation in inches) to WEQ **K** subfactors (K_{rr}) for random roughness. K_{rr} values vary by **I** factors assigned to soil Wind Erodibility Groups.

	Random roughness (standard deviation, inches)									
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
I Factors					K_{rr} values					
>134	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
134	1.00	0.99	0.98	0.96	0.93	0.91	0.98	0.96	0.85	0.84
104	1.00	0.94	0.88	0.82	0.78	0.74	0.71	0.69	0.67	0.66
86	1.00	0.87	0.76	0.67	0.61	0.57	0.54	0.52	0.50	0.48
56 or less	1.00	0.71	0.50	0.38	0.31	0.27	0.25	0.23	0.23	0.22

ArcIMS HTML Viewer Map

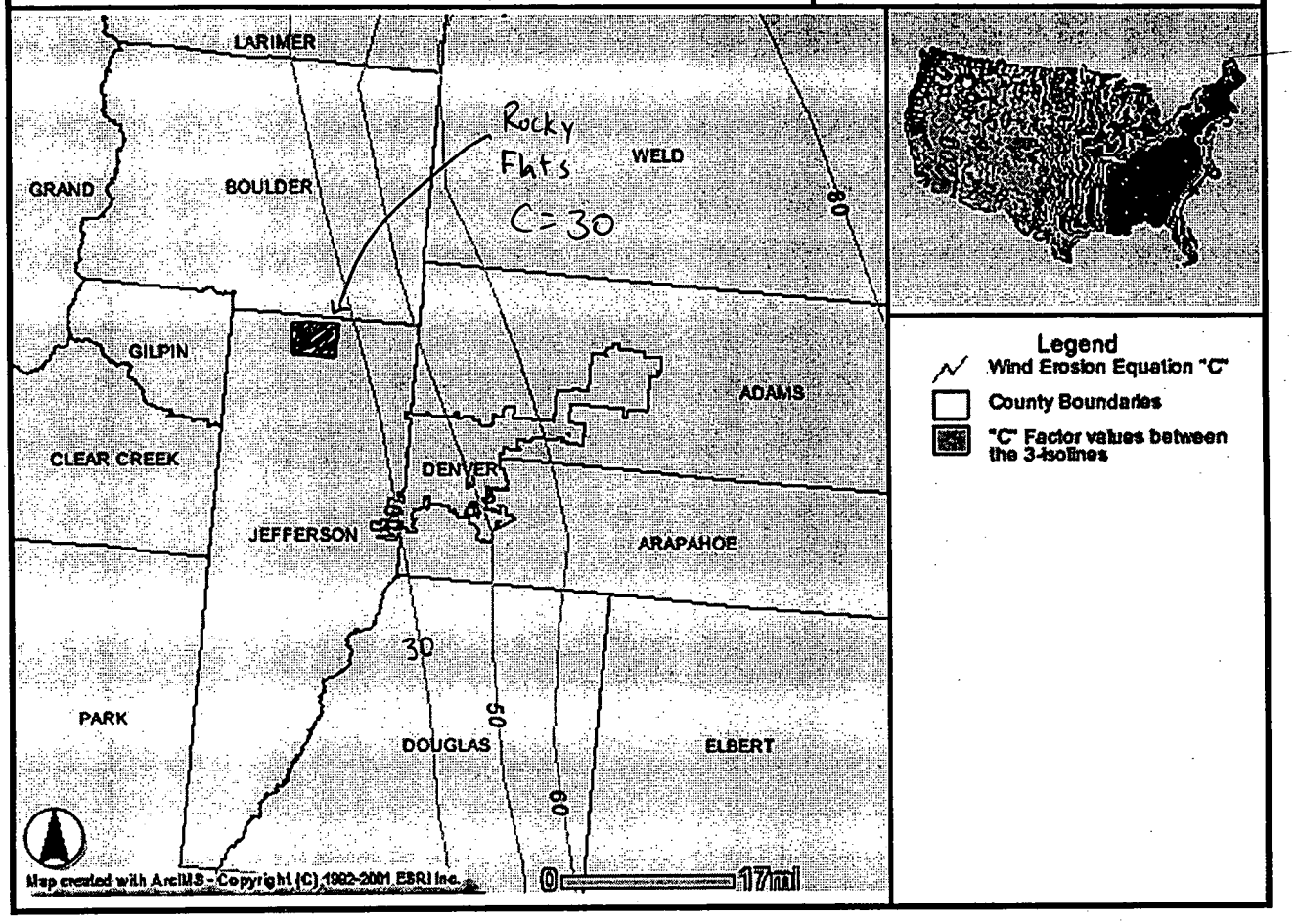


Exhibit 502–2 Wind erodibility groups and wind erodibility index

Soil texture [1]	EWE texture wetness factor [2]	Predominant soil texture class of surface layer	Wind Erodibility Group (WEG) [3]	Soil Erodibility Index (I) (ton/ac/yr) [4, 5]	Soil Erodibility Index (I) for irrigated soils (ton/ac/yr) [4]
C	1	Very fine sand, fine sand, sand, or coarse sand	1	310 [4] 250 220 180 160	310 250 220 160 134
C	1	Loamy very fine sand, loamy fine sand, loamy sand, loamy coarse sand, sapric organic soil materials, and all horizons that meet andic [6] soil properties as per Criteria 2 in Soil Taxonomy, regardless of the fine earth texture	2	134	104
C	1	Very fine sandy loam, fine sandy loam, sandy loam, coarse sandy loam, and noncalcareous silt loam with 35 to 50% very fine sand and <10% clay	3	86	56
F	3	Clay, silty clay, non-calcareous clay loam, or silty clay loam with more than 35% clay	4	86	56
M	2	Calcareous [7] loam and silt loam or calcareous clay loam and silty clay loam	4L	86	56
M	2	Non-calcareous loam and silt loam with more than 20% clay (but does not meet WEG 3 criteria), or sandy clay loam, sandy clay, and hemic organic soil materials	5	56	38
M	2	Non-calcareous loam and silt loam with more than 20% clay, or non-calcareous clay loam with less than 35% clay or silty clay loam with less than 35% clay	6	48	21
M	2	Silt and fibric organic soil material	7	38	21
—	—	Soils not susceptible to wind erosion because of surface rock and pararock fragments or wetness	8	—	—

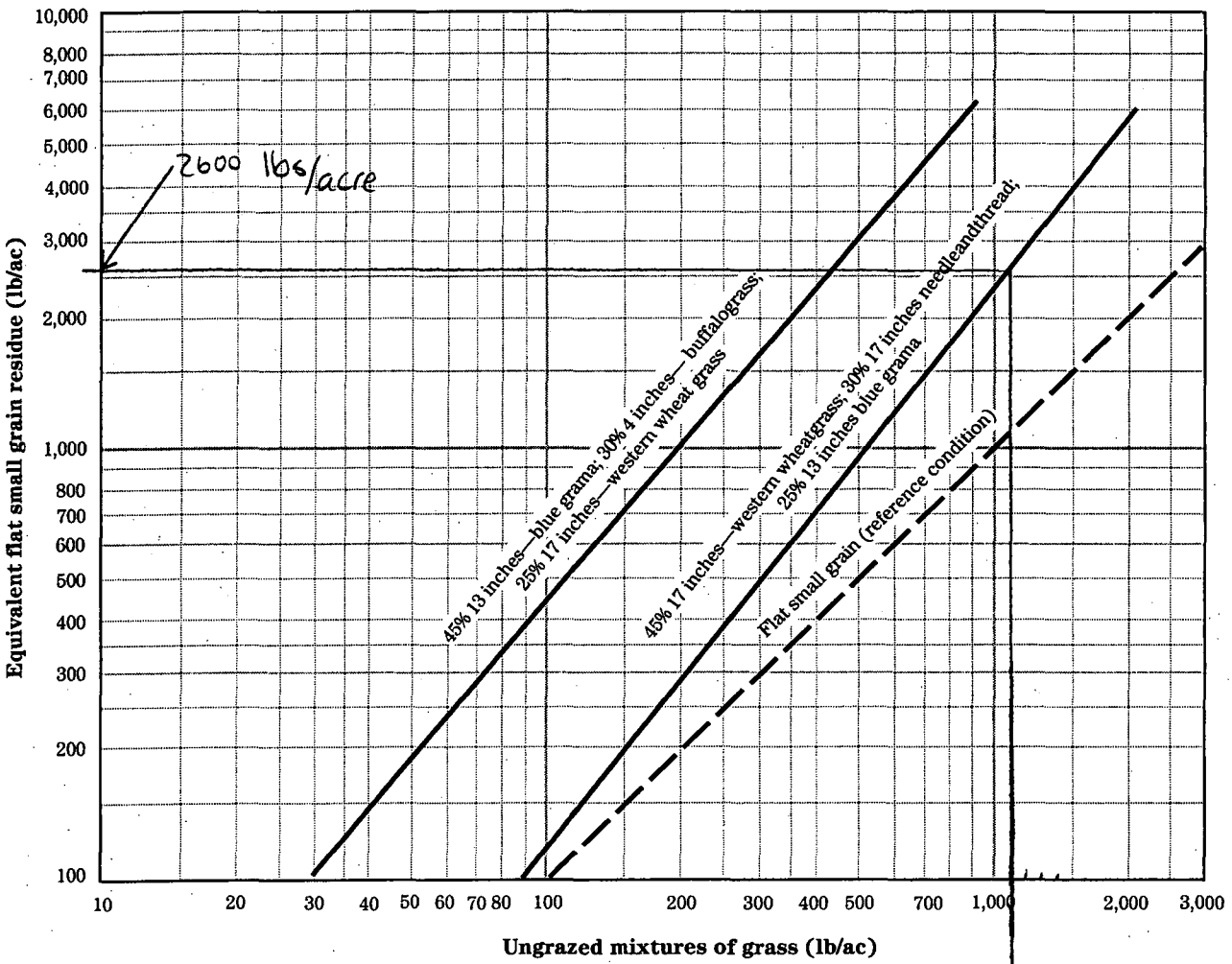
RFA Conservative I-Value

Buttress Fill material

RFA According to Soil Survey, Golden Area

1/ Soil texture, C = Coarse; M = Medium; F = Fine
2/ Texture wetness factor for adjustment of Erosive Wind Energy (EWE) for the period (Irrigated fields only).
3/ For all WEGs except sand and loamy sand textures, if percent rock and pararock fragments (>2mm) by volume is 15-35, reduce I value by one group with more favorable rating. If percent rock and pararock fragments by volume is 35-60, reduce I value by two favorable groups except for sands and loamy sand textures which are reduced by one group with more favorable rating. If percent rock and pararock fragments by volume is more than 60, use I value of zero for all textures except sands and loamy sand textures which are reduced by three groups with more favorable rating.
4/ The wind erodibility index is based on the relationship of dry soil aggregates greater than 0.84 millimeters to potential soil erosion. Value for irrigated soils is applicable throughout the year. Values for irrigated soils determined by Dr. E.L. Skidmore, USDA, ARS, Wind Erosion Research Unit, Manhattan, Kansas.
5/ The I factor for WEG 1 vary from 160 for coarse sands to 310 for very fine sands. Use an I value of 220 as an average figure.
6/ Vitrandic, Vitritorrandic, and Vitrxerandic Subgroups with ashy textural modifiers move one group with less favorable rating.
7/ Calcareous is a strongly or violently effervescent reaction of the fine-earth fraction to cold dilute (IN) HCL.

Figure d–8 Flat small grain equivalents of ungrazed western wheatgrass, needleandthread, blue grama, and buffalograss mixtures



Reference condition: Dry small grain stalks 10 inches long, lying flat on the soils surface in 10 inch rows perpendicular to wind direction, stalks oriented to wind direction.

Source: Lyles and Allison, 1980, Journal Range Management, 33(2), pages 143–146.

1100 lbs/acre per RFETs Senior Ecologist (Dense grass)

RFA

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 30

SURFACE - K =1.00 — I = 86

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	25.8	21.5	15.7	10.3	5.1	2.1	0.8						
8000	25.8	21.5	15.7	10.3	5.1	2.1	0.8						
6000	25.8	21.5	15.7	10.3	5.1	2.1	0.8						
4000	25.8	21.5	15.7	10.3	5.1	2.1	0.8						
3000	25.5	21.3	15.6	10.2	5.0	2.1	0.8						
2000	24.3	20.2	14.7	9.6	4.6	1.9	0.7						
1000	21.6	17.9	12.9	8.3	3.9	1.6	0.6						
800	20.6	17.1	12.2	7.8	3.7	1.4	0.5						
600	18.3	15.1	10.7	6.7	3.1	1.2							
400	15.2	12.5	8.7	5.4	2.4	0.9							
300	13.5	11.0	7.6	4.6	2.0	0.7							
200	11.0	8.9	6.1	3.6	1.5	0.3							
150	8.7	7.0	4.7	2.7	1.1	0.2							
100	6.5	5.1	3.4	1.9	0.6								
80	5.0	3.9	2.5	1.3	0.4								
60	3.8	3.0	1.9	0.9									
50	3.1	2.4	1.5	0.7									
40	2.3	1.8	1.1	0.5									
30	1.7	1.3	0.7										
20	1.0	0.6											
10													

$V_{MULCH} = 3700$
$V_{GRASS} = 2600$
Both values not represented
So assume V=1500

Bare Conditions

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 30

SURFACE - K =0.90 — I = 86

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

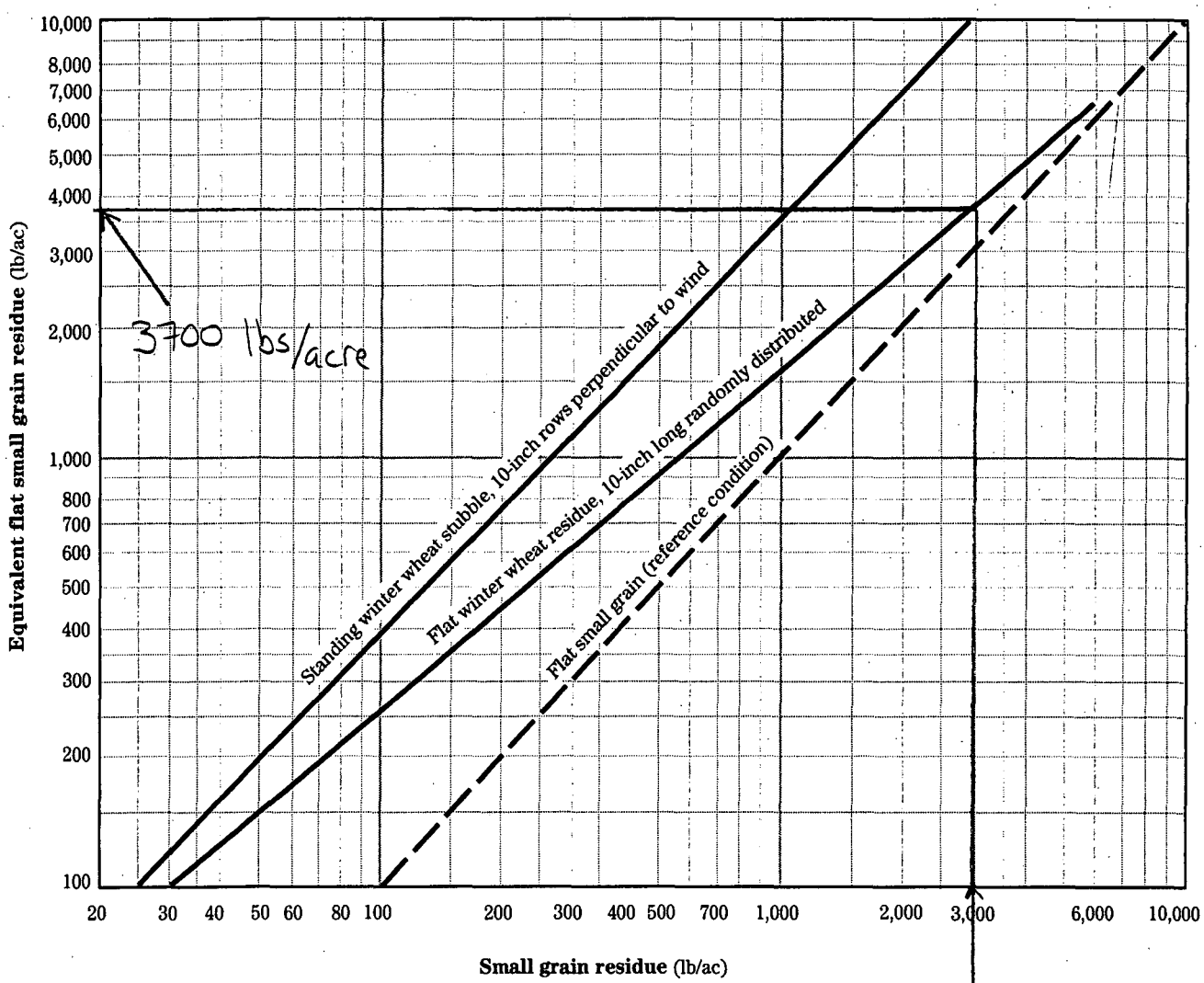
(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	23.2	19.3	14.0	9.1	4.4	1.8	0.7						
8000	23.2	19.3	14.0	9.1	4.4	1.8	0.7						
6000	23.2	19.3	14.0	9.1	4.4	1.8	0.7						
4000	22.9	19.1	13.8	8.9	4.3	1.7	0.6						
3000	22.5	18.7	13.5	8.7	4.2	1.7	0.6						
2000	21.4	17.7	12.8	8.2	3.9	1.5	0.6						
1000	18.6	15.3	10.9	6.9	3.2	1.2							
800	17.5	14.4	10.2	6.4	2.9	1.1							
600	15.3	12.5	8.8	5.4	2.4	0.9							
400	13.3	10.8	7.5	4.5	2.0	0.4							
300	11.7	9.5	6.5	3.8	1.6	0.3							
200	9.2	7.4	5.0	2.9	1.2	0.3							
150	7.0	5.5	3.6	2.0	0.7								
100	4.9	3.8	2.4	1.3	0.4								
80	4.1	3.2	2.0	1.1	0.4								
60	3.0	2.3	1.4	0.7									
50	2.3	1.7	1.0	0.5									
40	1.8	1.4	0.7										
30	1.3	1.0	0.5										
20	0.8	0.5											
10													

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

MULCH (RESIDUE)

Figure a–1 Flat small grain equivalents of small grain residue (use for wheat, barley, rye, oats)



Reference condition: Dry small grain stalks 10 inches long, lying flat on the soil surface in 10-inch rows, rows perpendicular to wind direction, stalks oriented to wind direction. Residue is washed, air dried, and placed as described for the wind tunnel tests.

Source: Lyles and Allison— Trans. ASAE 1981, 24 (2): 405-408.

Mulch application rate is 2 ton/acre. Use 3000 lb/acre for conservative estimate

APPENDIX C

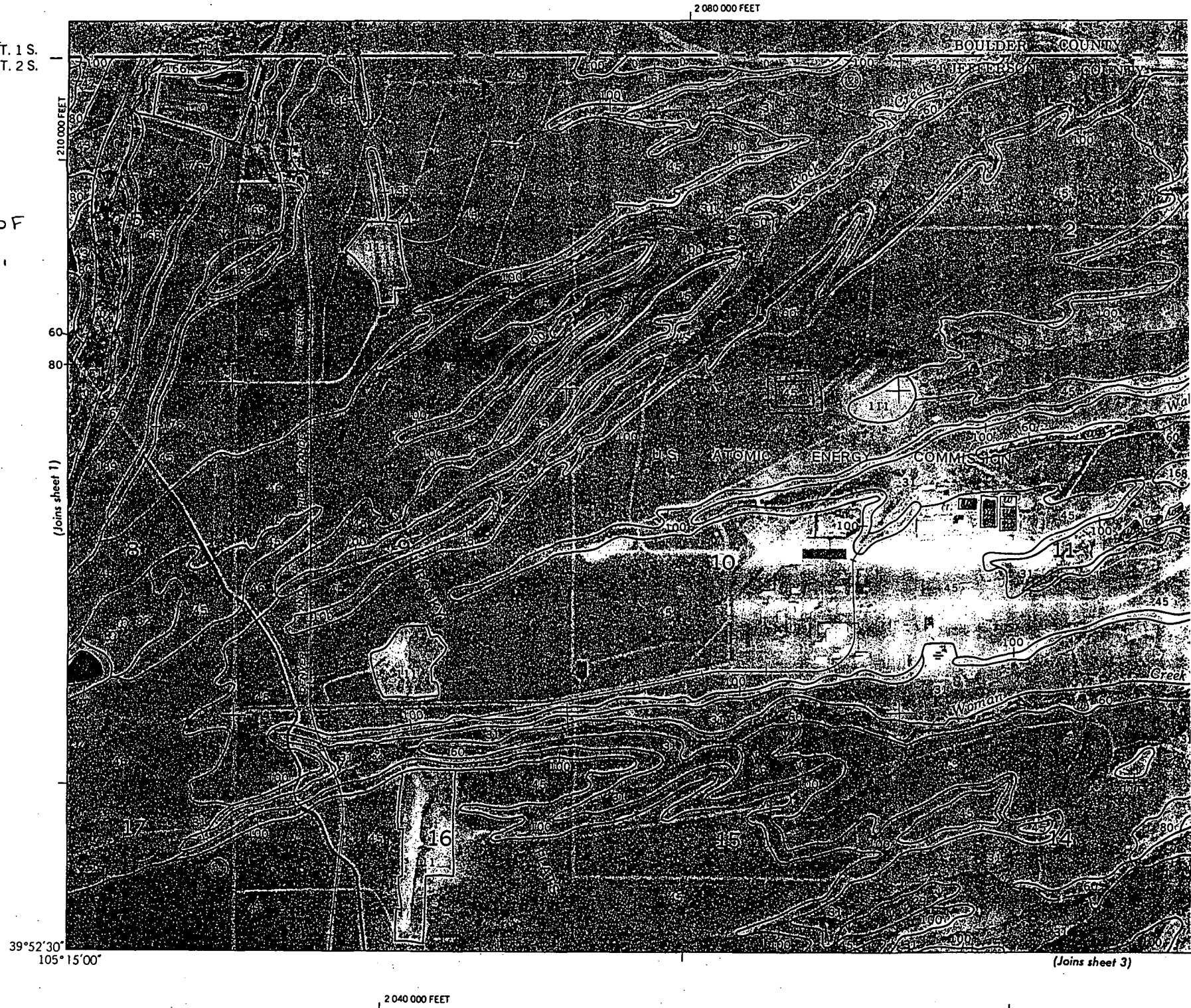
ATTACHMENT 3
SOIL SURVEY OF GOLDEN AREA, COLORADO

SHEET No. 1

SOIL SURVEY OF GOLDEN AREA, COLORADO
USDA 1980

ROCKY FLATS ALLUVIAL SOIL

TYPE = 45



BUTTRESS

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 30

I = 56

SURFACE - K =1.00

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	16.8	13.8	9.7	6.1	2.8	1.0							
8000	16.8	13.8	9.7	6.1	2.8	1.0							
6000	16.8	13.8	9.7	6.1	2.8	1.0							
4000	16.0	13.2	9.2	5.7	2.6	0.9							
3000	15.2	12.5	8.7	5.4	2.4	0.9							
2000	14.3	11.6	8.1	4.9	2.2	0.8							
1000	11.8	9.6	6.6	3.9	1.7	0.4							
800	11.0	8.9	6.1	3.6	1.5	0.3							
600	9.4	7.5	5.1	2.9	1.2	0.3							
400	7.5	6.0	4.0	2.2	0.7								
300	5.9	4.7	3.0	1.6	0.5								
200	4.3	3.3	2.1	1.1	0.4								
150	3.3	2.5	1.6	0.7									
100	2.2	1.7	1.0	0.5									
80	1.8	1.3	0.7										
60	1.2	0.9	0.5										
50	0.9	0.5											
40	0.8	0.4											
30													
20													
10													

$V_{MULCH} = 3700$
$V_{GRASS} = 2600$
Both values not represented
so assume $V = 1250$

Bare Conditions

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 30

I = 56

SURFACE - K =0.90

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

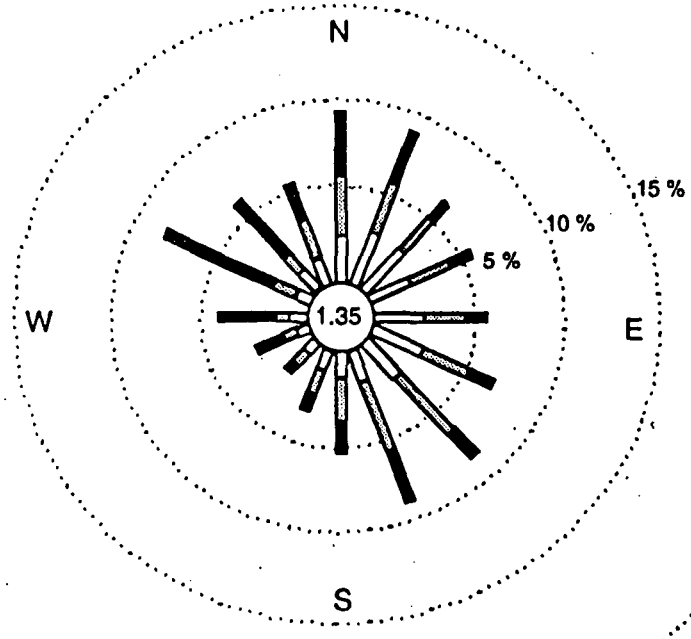
(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	15.1	12.4	8.7	5.3	2.4	0.9							
8000	15.1	12.4	8.7	5.3	2.4	0.9							
6000	15.1	12.4	8.7	5.3	2.4	0.9							
4000	14.3	11.7	8.2	5.0	2.2	0.8							
3000	13.7	11.2	7.8	4.7	2.1	0.7							
2000	12.8	10.4	7.2	4.3	1.9	0.4							
1000	10.5	8.5	5.8	3.4	1.4	0.3							
800	9.4	7.6	5.1	3.0	1.2	0.3							
600	7.9	6.3	4.2	2.4	0.8								
400	6.1	4.9	3.2	1.7	0.6								
300	4.8	3.8	2.4	1.3	0.4								
200	3.6	2.8	1.7	0.8									
150	2.5	1.9	1.2	0.5									
100	1.7	1.3	0.7										
80	1.4	1.1	0.6										
60	0.9	0.5											
50	0.8	0.4											
40	0.6	0.4											
30													
20													
10													

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

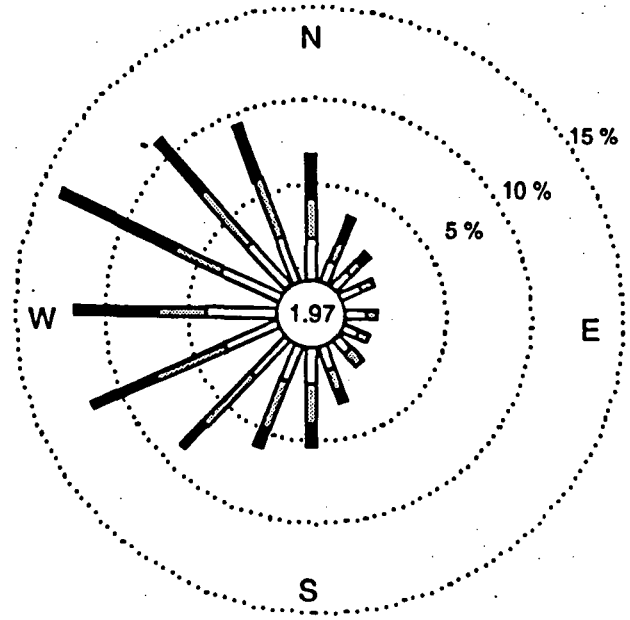
** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

APPENDIX C

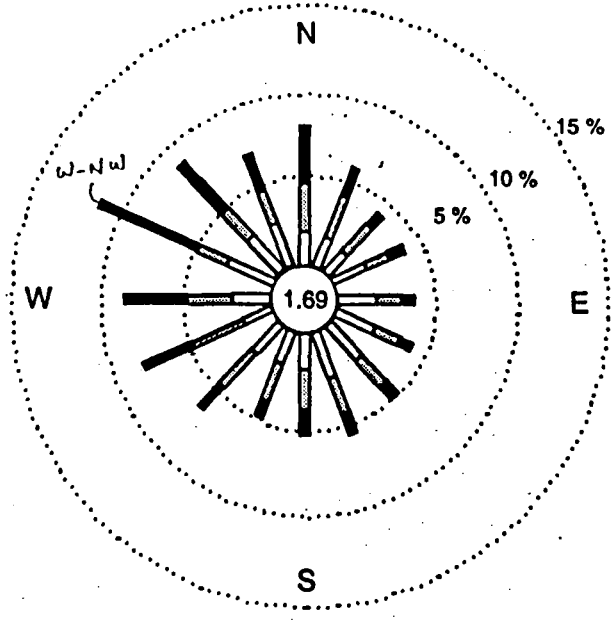
ATTACHMENT 4
PREVAILING WIND INFORMATION



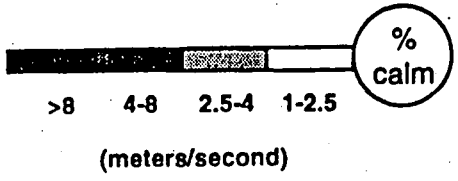
1992 Day



1992 Night



1992 Total



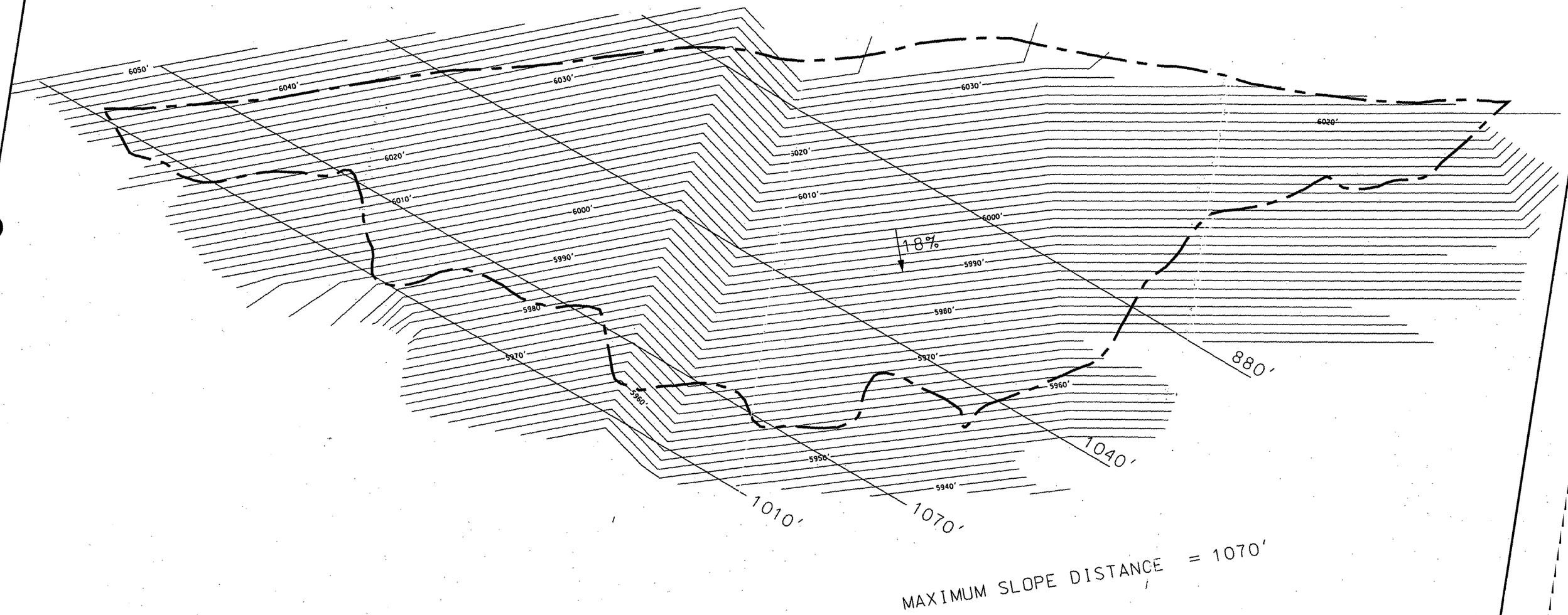
U.S. DEPARTMENT OF ENERGY
Rocky Flats Site, Golden, Colorado

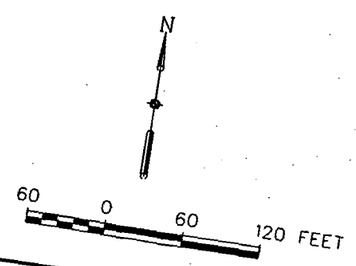
1992 Wind-Rose Diagrams for the Rocky Flats Site

Revised Work Plan | Operable Unit No. 7

Date: April 1994 | Figure 2-4

M\ES\wind rose.mdw\4-5-94





EARTH TECH

SLOPE DISTANCES PREVAILING

Appendix C - Erosion\MDA 2/8/05

SOIL SURVEY OF GOLDEN AREA, COLORADO
USDA 1980

K WEG

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group	Organic matter
	In	Pct	In/hr	In/in	pH	Mmhos/cm					Pct
31*:											
Midway----------	0-3	30-40	0.2-0.6	0.14-0.18	6.6-8.4	2-4	Moderate	0.43	1	4L	.5-2
	3-14	35-45	0.06-0.2	0.14-0.18	7.4-9.0	2-8	High------	0.43			
	14	---	---	---	---	---	----------	----			
32*, 33*:											
Denver----------	0-6	27-40	0.2-0.6	0.16-0.20	6.6-7.8	<2	Moderate	0.28	5	4	2-4
	6-29	40-60	0.06-0.2	0.14-0.18	7.4-8.4	<2	High------	0.28			
	29-60	35-60	0.06-0.6	0.14-0.18	7.9-8.4	<2	High------	0.28			
Kutch----------	0-3	27-35	0.2-0.6	0.15-0.20	6.6-7.8	<2	High------	0.32	2	6	2-4
	3-26	35-45	0.06-0.2	0.18-0.20	6.6-8.4	<4	High------	0.24			
	26	---	---	---	---	---	----------	----			
Urban land.											
34*, 35*, 36*:											
Denver----------	0-6	27-40	0.2-0.6	0.16-0.20	6.6-7.8	<2	Moderate	0.28	5	4	2-4
	6-29	40-60	0.06-0.2	0.14-0.18	7.4-8.4	<2	High------	0.28			
	29-60	35-60	0.06-0.6	0.14-0.18	7.9-8.4	<2	High------	0.28			
Urban land.											
37---------- Earcree	0-60	10-18	2.0-6.0	0.10-0.13	6.1-7.3	<2	Low-------	0.10	5	3	2-4
38, 39---------- Earcree Variant	0-33	8-18	6.0-20	0.03-0.05	6.1-7.3	<2	Low-------	0.10	5	8	2-4
	33-60	8-15	6.0-20	0.03-0.05	6.1-7.3	<2	Low-------	0.10			
Earcree Variant-	0-33	8-18	6.0-20	0.03-0.05	6.1-7.3	<2	Low-------	0.10	5	8	2-4
	33-60	8-15	6.0-20	0.03-0.05	6.1-7.3	<2	Low-------	0.10			
Venable----------	0-5	15-25	0.6-2.0	0.18-0.20	6.1-7.3	<2	Low-------	0.28	5	8	3-6
	5-43	18-35	0.6-2.0	0.16-0.18	6.1-7.3	<2	Low-------	0.28			
	43-60	10-20	2.0-6.0	0.12-0.14	6.6-7.3	<2	Low-------	0.20			
41, 42---------- Englewood	0-9	28-40	0.2-0.6	0.17-0.20	6.6-7.8	<2	Moderate	0.24	5	4	2-4
	9-60	35-50	0.06-0.2	0.14-0.16	6.6-8.4	<2	High------	0.28			
43---------- Englewood	0-9	27-40	0.2-0.6	0.17-0.20	6.6-7.3	<2	Moderate	0.24	5	4	2-4
	9-47	40-50	0.06-0.2	0.14-0.16	6.6-7.8	<2	High------	0.28			
	47-60	28-45	0.06-0.6	0.14-0.17	7.4-8.4	2-4	High------	0.28			
44*:											
Englewood-------	0-9	28-40	0.2-0.6	0.17-0.20	6.6-7.3	<2	Moderate	0.24	5	4	2-4
	9-60	35-50	0.06-0.2	0.14-0.16	6.6-8.4	<2	High------	0.28			
Urban land.											
45, 46, 47, 48, 49---------- Flatirons	0-13	8-20	2.0-6.0	0.07-0.10	6.1-7.8	<2	Low-------	0.05	5	8	2-3
	13-47	35-60	0.06-0.2	0.08-0.10	5.6-7.3	<2	Moderate	0.15			
	47-60	20-35	0.6-2.0	0.08-0.10	6.1-7.8	<2	Low-------	0.05			
50*. Fluvaquents											
51---------- Fondis	0-5	20-27	0.6-2.0	0.18-0.21	6.6-7.8	<2	Low-------	0.28	5	6	2-4
	5-25	35-50	0.06-0.2	0.15-0.18	6.6-7.8	<2	High------	0.32			
	25-60	30-40	0.2-0.6	0.16-0.18	7.4-8.4	<2	Moderate	0.32			
52, 53---------- Garber Variant	0-25	8-20	6.0-20	0.08-0.10	6.1-7.3	<2	Low-------	0.15	5	8	2-4
	25-60	5-18	6.0-20	0.05-0.07	6.1-7.3	<2	Low-------	0.10			

See footnote at end of table.

October-04 043-2246.0001

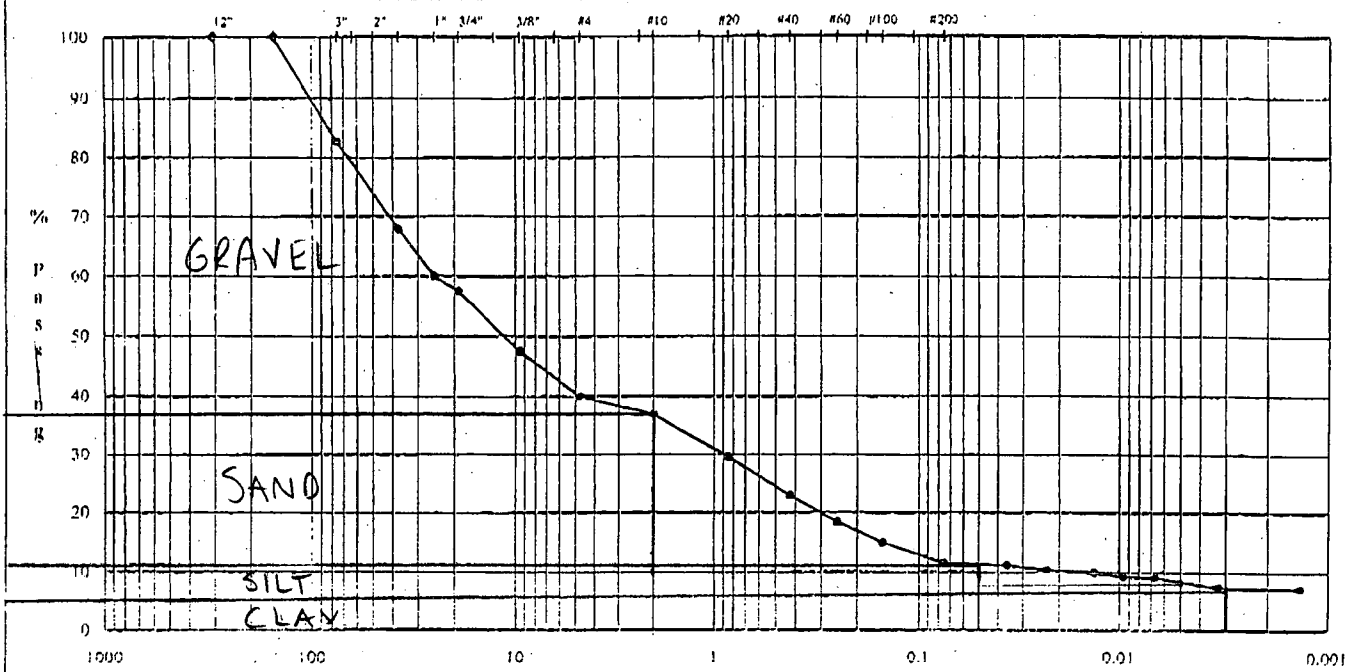
USDA CONVERSION

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

APR-1

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: APR-1 Depth (ft): –
TYPE: BULK



COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

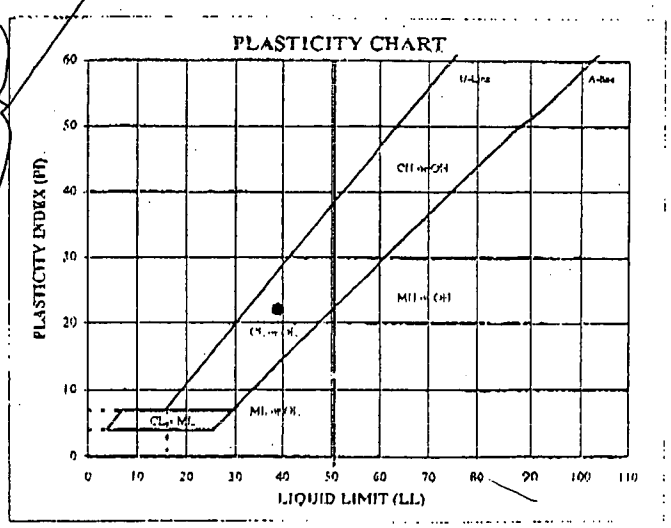
Gravel >1" = 42.6%

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	17.40
6.0"	154.2	100.0		
6.0"	154.2	100.0		
3.0"	75.0	82.6		
1.5"	37.5	67.7		
1.0"	25.0	60.0	Coarse Gravel	25.22
0.75"	19.0	57.4		
0.375"	9.5	47.4		
#4	4.8	39.9	Fine Gravel	17.51
#10	2.00	36.9	Coarse Sand	2.98
#20	0.85	29.5		
#40	0.43	22.8	Medium Sand	14.07
#60	0.25	18.3		
#100	0.15	14.9		
#200	0.075	11.4	Fine Sand	11.38

Hydrometer Analysis

(mm)	%Finer		
0.036	11.1		
0.023	10.2		
0.013	9.8	Fines	
0.0095	9.2	Silt or Clay	11.44
0.0067	9.0		
0.0033	7.3		
0.0014	7.0		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG (assumed)
10.4	39	17	22	2.70

63% GRAVEL
26% SAND
6% SILT
5% CLAY

DESCRIPTION: Strong brown (7.55 YR 5/6) clayey gravel with sand

USCS: GC

TECH: JR
DATE: 11/3/2004
REVIEW: MB

October-04 043-2246.0001

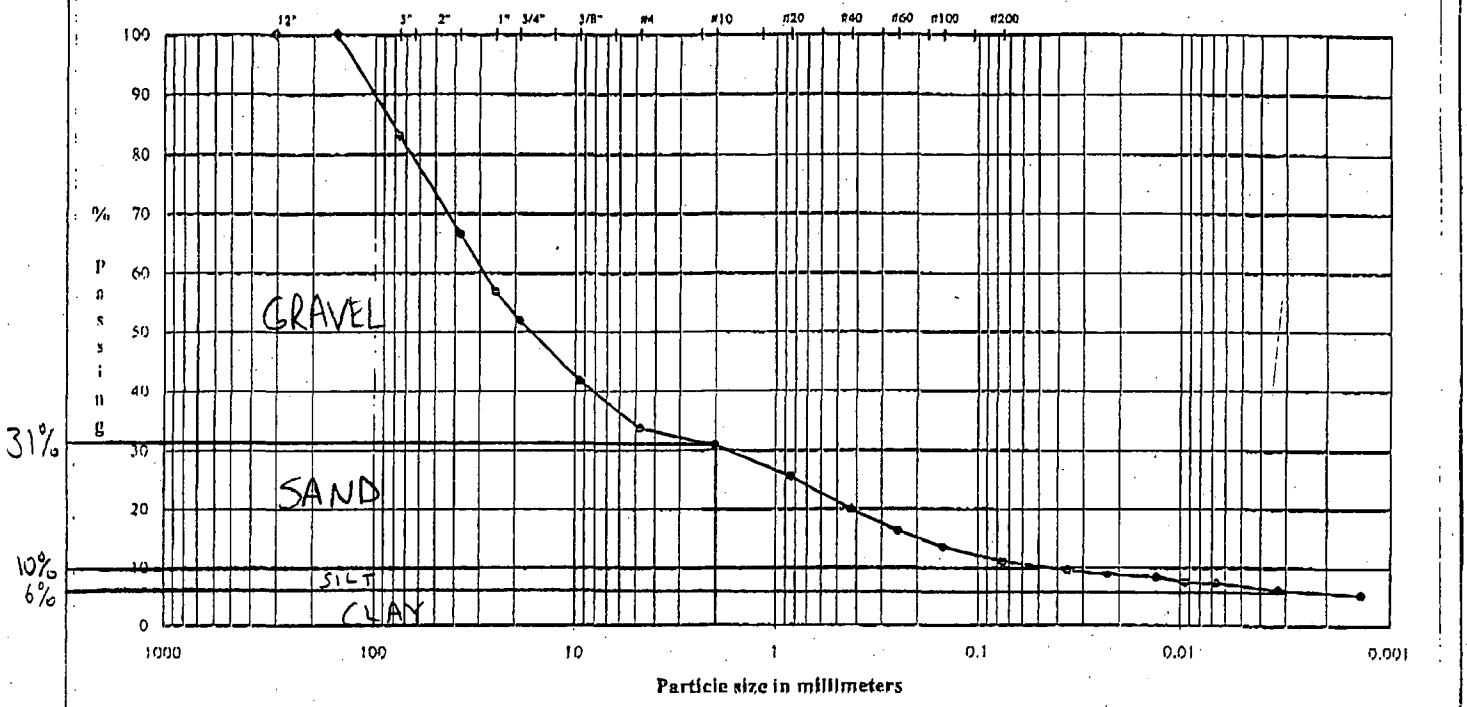
VSDA CONVERSION

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

APR-2

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: APR-2 Depth (ft): –
TYPE: BULK



COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

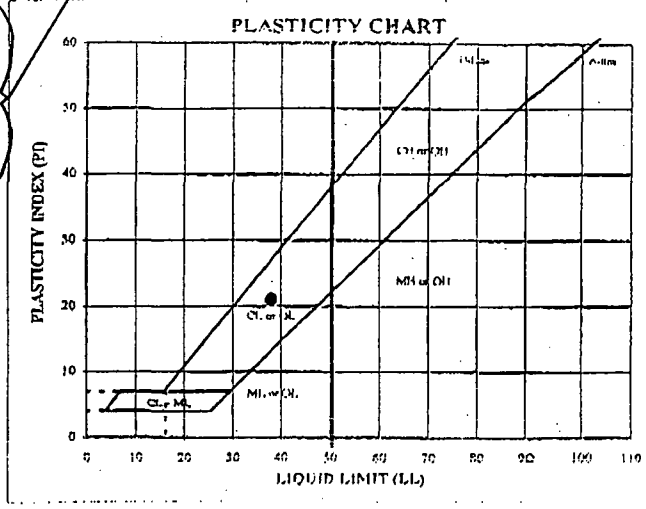
Gravel > 1" = 49.12 %

U.S. Standard Sieves Sizes and Numbers

Particle Size	(mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	16.90
6.0"	154.2	100.0		
6.0"	154.2	100.0		
3.0"	75.0	83.1		
1.5"	37.5	66.5		
1.0"	25.0	56.7	Coarse Gravel	31.22
0.75"	19.0	51.9		
0.375"	9.5	41.7		
#4	4.8	33.7	Fine Gravel	18.23
#10	2.00	30.9	Coarse Sand	2.77
#20	0.85	25.6		
#40	0.43	19.9	Medium Sand	11.03
#60	0.25	16.3		
#100	0.15	13.4		
#200	0.075	10.9	Fine Sand	8.91

Hydrometer Analysis

(mm)	%Finer		
0.036	9.6		
0.023	8.9		
0.013	8.4	Fines	
0.0094	7.5	Silt or Clay	10.94
0.0067	7.3		
0.0033	6.1		
0.0014	5.2		



ATTERBERG LIMITS

M,	LL	PL	PI	SpG (assumed)
9.8	38	17	21	2.70

69% GRAVEL
21% SAND
4% SILT
6% CLAY

DESCRIPTION: Strong brown (7.55 YR 5/6) clayey gravel with sand

USCS: GC

TECH: JR
DATE: 11/3/2004
REVIEW: MB

January-05

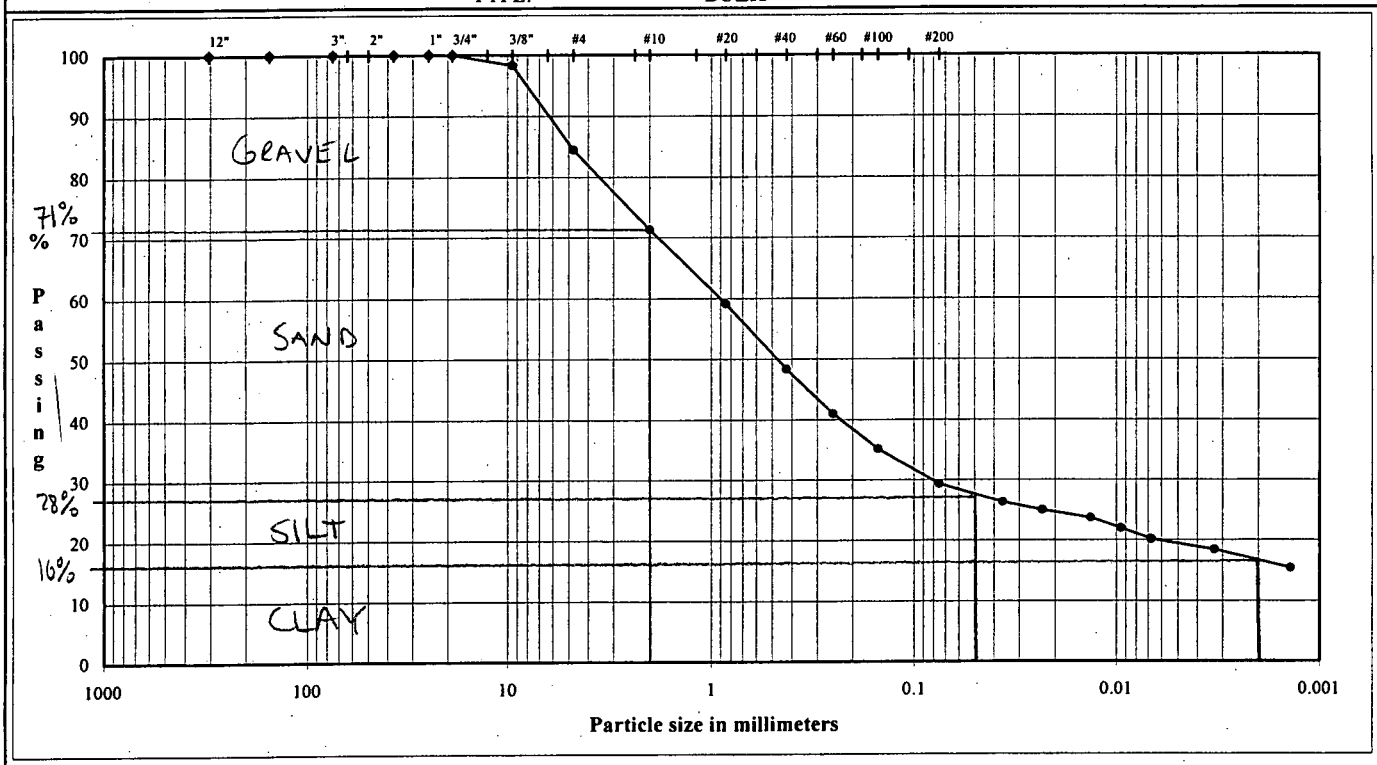
043-2246.0002

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

CUP-2

PROJECT NAME: **Rocky Flats/Field & Lab Testing/CO**
SAMPLE ID: **CUP-2** Depth (ft): --
TYPE: **BULK**



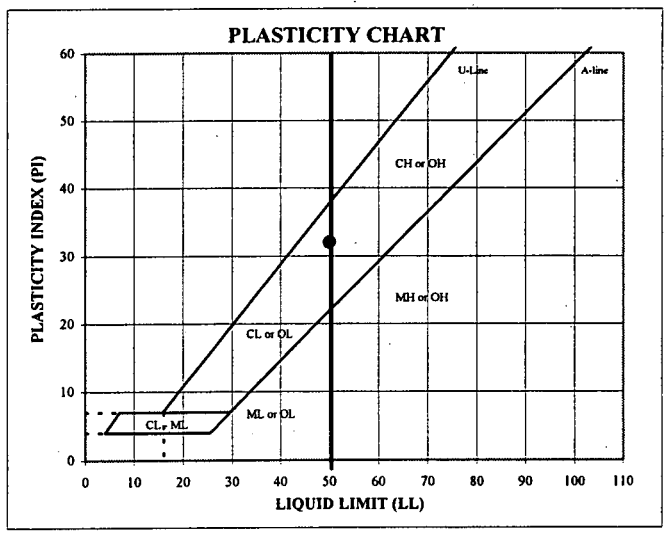
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
6.0"	154.2	100.0		
6.0"	154.2	100.0		
3.0"	75.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	98.3		
#4	4.8	84.5	Fine Gravel	15.51
#10	2.00	71.3	Coarse Sand	13.18
#20	0.85	59.1		
#40	0.43	48.4	Medium Sand	22.94
#60	0.25	41.0		
#100	0.15	35.2		
#200	0.075	29.3	Fine Sand	19.02

Hydrometer Analysis

(mm)	%Finer		
0.036	26.4		
0.023	25.0		
0.013	23.7	Fines	
0.0095	22.0	Silt or Clay	29.34
0.0068	20.2		
0.0033	18.4		
0.0014	15.4		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
–	50	18	32	–

29% Gravel
43% Sand
12% Silt
16% Clay

DESCRIPTION: Moderate yellowish brown (10YR 4/4) clayey sand with gravel

USCS: SC

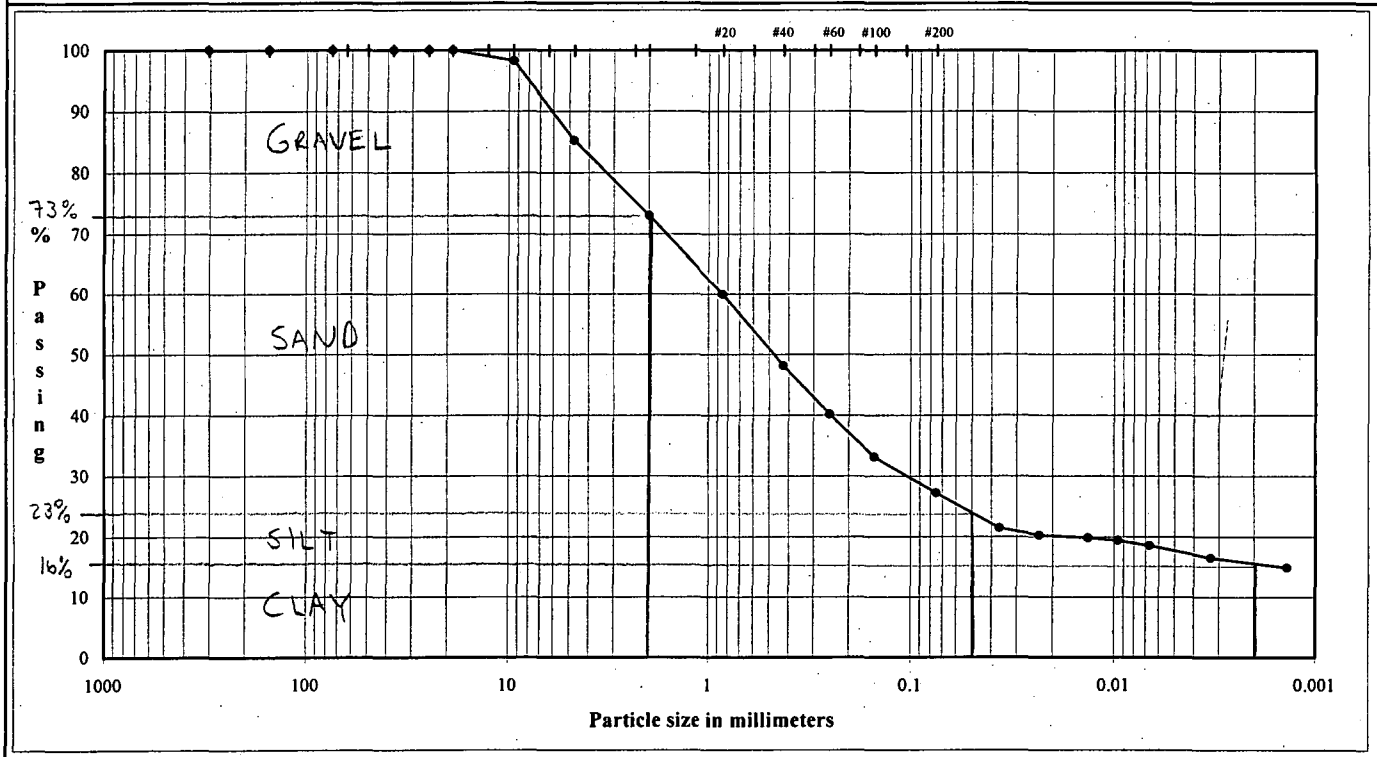
TECH	MKS
DATE	1/31/2005
REVIEW	MB

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

CUP-3

PROJECT NAME: **Rocky Flats/Field & Lab Testing/CO**
SAMPLE ID: **CUP-3** Depth (ft): --
TYPE: **BULK**



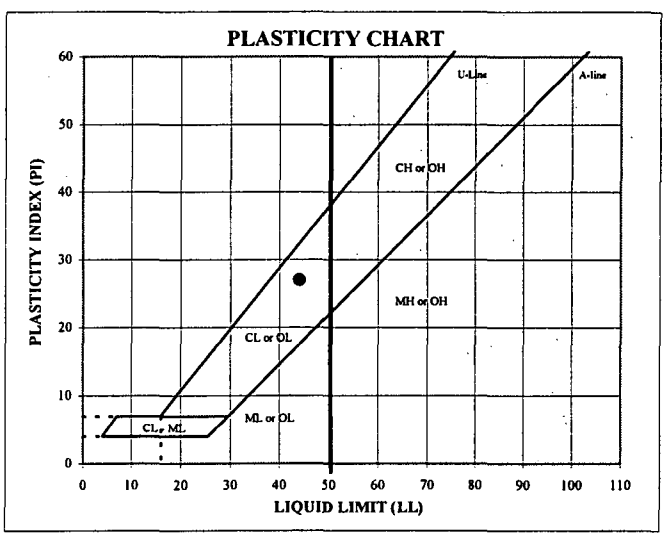
	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
6.0"	154.2	100.0		
6.0"	154.2	100.0		
3.0"	75.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	98.3		
#4	4.8	85.3	Fine Gravel	14.73
#10	2.00	73.0	Coarse Sand	12.26
#20	0.85	59.9		
#40	0.43	48.1	Medium Sand	24.86
#60	0.25	40.1		
#100	0.15	33.2		
#200	0.075	27.2	Fine Sand	20.91

Hydrometer Analysis

(mm)	%Finer		
0.037	21.5		
0.023	20.2		
0.013	19.8	Fines	
0.0096	19.4	Silt or Clay	27.24
0.0067	18.6		
0.0033	16.5		
0.0014	14.9		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
--	44	17	27	--

27% Gravel
50% Sand
7% Silt
16% Clay

DESCRIPTION: Moderate yellowish brown (10YR 5/4) clayey sand

USCS: SC

TECH	MKS
DATE	1/29/2005
REVIEW	MB

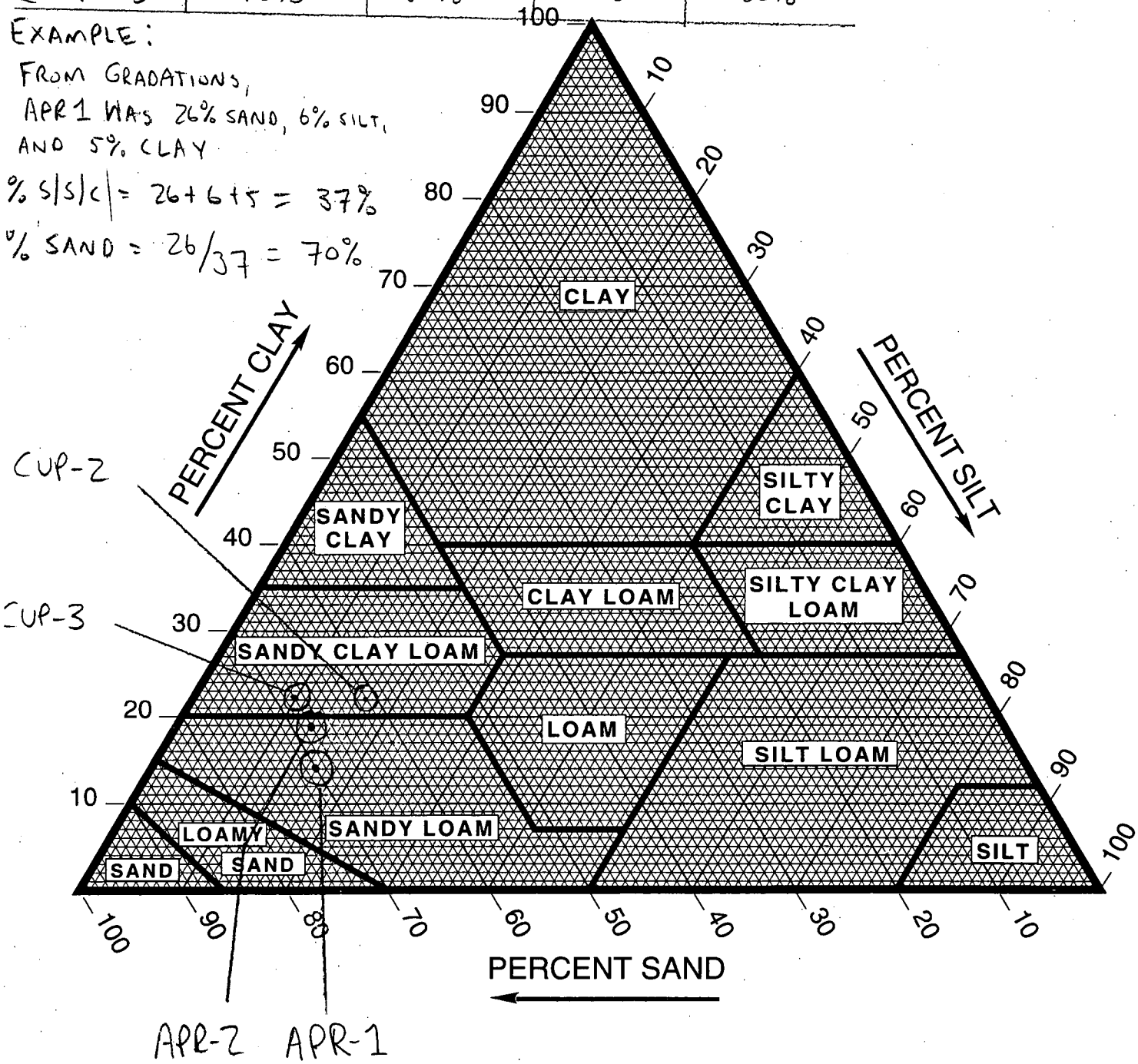
SAMPLE	% S/S/C	% SAND	% SILT	% CLAY
APR-1	37%	70%	16%	14%
APR-2	31%	68%	13%	19%
CUP-2	71%	61%	17%	22%
CUP-3	73%	68%	10%	22%

EXAMPLE:

FROM GRADATIONS,
APR 1 WAS 26% SAND, 6% SILT,
AND 5% CLAY

% S/S/C = 26 + 6 + 5 = 37%

% SAND = 26/37 = 70%



APPENDIX C

ATTACHMENT 5
GEOTECHNICAL DATA

APPENDIX D

LANDFILL ENGINEERING – FINAL DESIGN
SURFACE WATER MANAGEMENT SYSTEM ASSESSMENT

APPENDIX D

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL

LANDFILL ENGINEERING – FINAL DESIGN
SURFACE WATER MANAGEMENT SYSTEM ASSESSMENT

MAY 11, 2005

Prepared by:

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This calculation was performed by Earth Tech, Inc. Although each sheet composing this calculation may or may not be initialed, it has nonetheless been reviewed and checked.

Prepared By: RA Date: 5/11/05

Checked By: RT Date: 5/11/05

Approved By: RT Date: 5/11/05

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Table D-2 Original Landfill – Check Dams
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Attachment 1 Surface Water Drainage Map
Attachment 2 SEDCAD Reports
Attachment 3 NAG Reports

1.0 INTRODUCTION

This Surface Water Management Plan was developed to address potential storm water impacts the Original Landfill Accelerated Action may have to the surrounding area.

This Plan addresses two elements:

1. Surface water control structures that will be required to adequately convey the run-on to and run-off from the Original Landfill due to a 100-year 24-hour storm event with freeboard capacity to handle the 1000-year 24-hour storm event.

2. Reduce sediment transport following construction while the landfill area is disturbed. Once vegetation is established, conditions will be similar to surrounding areas.

2.0 LANDFILL DESCRIPTION, LOCATION AND DRAINAGE

The Original Landfill site is located south of RFETS Buildings 440 and 460, along the north hillside of a ravine in the Woman Creek drainage area, extending from approximate Elevation 6,040 feet at the top to Elevation 5,950 feet at its base. Waste operations began in the early 1950s and continued through 1968. The Original Landfill site footprint has a maximum length along the east-west direction of approximately 1,700 feet, and approximately 500 feet in the north-south direction, with an approximate area on the order of 20 acres.

Due to the canyon-fill nature of the Original Landfill, minimal surface water run-on is expected to occur. Run-off from the cover will be controlled by the construction of 7 diversion berms which route water to lined channels on the west and east side. The berms were spaced no greater than 150 feet to limit sediment transport from the cover to the side channels. To reduce erosion on the buttress sideslope, without using permanent erosion controls, diversion berms spaced no greater than 30 feet apart (see Appendix C) have been designed. The proposed surface water management plan is shown on Attachment 1

3.0 REFERENCES

The surface water management system for the Original Landfill was evaluated using guidelines provided in the following documents:

1. "SEDCAD 4 for Windows 95/98 & NT". Design Manual and User's Guide. 2001.

2. "Regulations Pertaining to Solid Waste Disposal Sites and Facilities" (Regulations), 6 CCR 1007-2, Colorado Department of Public Health and Environment.

3. "Urban Storm Drainage Criteria Manual" (Drainage Manual), Denver Urban Drainage and Flood Control District.

4. "Erosion Control Materials Design Software Version 4.2 for Windows". North American Green (NAG). 2002.

4.0 DESIGN CRITERIA

The attached model was used to evaluate the existing drainage characteristics at the Original Landfill and to size appropriate drainage structures for the Original Landfill. Evaluation and design of the Original Landfill surface water control system will meet the following design criteria:

1. Collect and control surface water run-on flow onto the closed landfill as a result of the 100-year 24-hour storm event with freeboard capacity to handle the 1000-year 24-hour storm event;
2. Collect and control surface water run-off from the landfill as a result of the 100-year 24-hour storm event with freeboard capacity to handle the 1000-year 24-hour storm event;
3. Comply with any provisions of the RFETS storm water discharge permit requirements including reduction of sediment transport;
4. Minimize site erosion;
5. Protect the integrity and effectiveness of the landfill cover; and
6. Minimize surface water management post-closure maintenance requirements.

5.0 HYDROLOGIC AND HYDRAULIC DESIGN APPROACH

The design process used to locate and size the surface water management structures at the Original Landfill is as follows:

1. The goal of the surface water management structures is to reduce the sediment delivered to Woman Creek from the disturbed areas or roughly the area between the west and east channels. The areas outside the channels will remain in native-type condition and the sediment currently generated from these native areas will not change after construction. The first step is to therefore place enough diversion berms on the cover to create smaller subwatersheds where sediment can be contained on the cover. The sediment will be controlled within the diversion berms with the use of removable geosynthetic check dams. It was determined that 10 diversion berms are needed to reduce sediment based on the 25-year 24-hour storm.
2. The 100-year 24-hour storm is then modeled to calculate the required height of the diversion berm and the channels which route the diversion berm water below the buttress fill.
3. The peak flows are modeled with NAG software to determine the required diversion berm and channel lining as well as the maximum slope and minimum bend radius of the channels.
4. The 1000-year 24-hour event is then modeled to check the freeboard capacity of the structures.

As shown in Attachment 1, overland flow is greater than 200 feet in the southern portion but the gradual slope at the top of the buttress fill reduces erosion. A check using the RUSLE shows that 220-feet of overland flow at 5% results in 1.50 tons/acre/year and 225-feet of overland flow at 2.75% results in 0.82 tons/acre/year (bare conditions – RFA prior to mature state). The top of the buttress will be lined with NAG C125 erosion mat following construction further reducing erosion.

SEDCAD4 software was used for surface water modeling at the Original Landfill. SEDCAD uses the National Resource Conservation Service (NRCS) approach for rainfall distribution and the NRCS curve number/unit

Appendix D

Table D-1
Original Landfill – Structure Design

Structure	Slope	Shape	Minimum Bend Radius	Sideslopes	Minimum Height or Depth	Permanent Lining	Temporary Lining
West Diversion Berm 1	2%	Triangular	5 feet	5.6H:1V Uphill 3H:1V Downhill	3 feet	Grass	Erosion Mat (NAG C125)
West Diversion Berm 2	2%	Triangular	5 feet	5.6H:1V Uphill 3H:1V Downhill	3 feet	Grass	Erosion Mat (NAG C125)
West Diversion Berm 3	2%	Triangular	5 feet	5.6H:1V Uphill 3H:1V Downhill	3 feet	Grass	Erosion Mat (NAG C125)
West Channel	2-12%	Trapezoidal Min. 10-foot bottom	105 feet	3H:1V	2 feet	Erosion Mat (NAG P550)	Erosion Mat (P550) / Grass
East Diversion Berm 1	2%	Triangular	5 feet	5.6H:1V Uphill 3H:1V Downhill	3 feet	Grass	Erosion Mat (NAG C125)
East Diversion Berm 2	2%	Triangular	5 feet	5.6H:1V Uphill 3H:1V Downhill	3 feet	Grass	Erosion Mat (NAG C125)
East Diversion Berm 3	2%	Triangular	5 feet	5.6H:1V Uphill 3H:1V Downhill	3 feet	Grass	Erosion Mat (NAG C125)
East Diversion Berm 4	2%	Triangular	5 feet	5.6H:1V Uphill 3H:1V Downhill	3 feet	Grass	Erosion Mat (NAG C125)
East Channel	2-12%	Trapezoidal Min. 18-foot bottom	200 feet	3H:1V	2 feet	Erosion Mat (NAG P550)	Erosion Mat (P550) / Grass
Typical Downstream Channel	33%	Triangular	NA	3H:1V	3 feet	Erosion Mat (NAG C125)	Grass
Buttress Diversion Berm 1	3.5%	Triangular	5 feet	1H:1V	3 feet	Grass	Erosion Mat (NAG C125)
Buttress Diversion Berm 2	3.5%	Triangular	5 feet	1H:1V	3 feet	Grass	Erosion Mat (NAG C125)
Buttress Diversion Berm 3	3.5%	Triangular	5 feet	1H:1V	3 feet	Grass	Erosion Mat (NAG C125)

Sediment reduction load was determined by placing the minimum amount of check dams within the diversion berm until the downstream dams overtop. The following was calculated based on five check dams in each diversion berm. Values are a minimum and more can be placed per berm in accordance with manufacturer's recommendations.

Table D-2
Original Landfill – Check Dam

Area	Sediment Load without Check Dams	Sediment Load with Check Dams	Minimum Check Dam Spacing
West Subwatersheds	9.5 tons	3.0 tons	130 feet
East Subwatersheds	9.0 tons	2.7 tons	200 feet
Buttress Sideslope	10.0 tons	2.0 tons	130 feet

5.2 1000-YEAR 24-HOUR STORM

To determine if the freeboard capacity of the 100-year 24-hour storm is sufficient to handle the 1000-year 24-hour storm, the design was conducted with a rainfall depth of 6.4 inches. The output is provided in Attachment 2. A summary of the findings is found in the following table:

Table D-3
Original Landfill – 1000-Year 24-Hour Comparison

Structure	100-Year Flow Depth with Freeboard (ft)	1000-Year Flow Depth without freeboard (ft)
West Diversion Berm 1	2.49	1.60
West Diversion Berm 2	2.64	1.75
West Diversion Berm 3	2.53	1.64
West Channel	1.46	0.54
East Diversion Berm 1	2.67	1.79
East Diversion Berm 2	2.67	1.79
East Diversion Berm 3	2.67	1.79
East Diversion Berm 4	2.67	1.79
East Channel	1.44	0.53
Buttress Diversion Berm 1	2.38	1.48
Buttress Diversion Berm 2	3.09	2.24
Buttress Diversion Berm 3	3.05	2.19/

As shown in Table D-3, the design based on the 100-year 24-hour storm with freeboard is sufficient to handle surface water from the 1000-year 24-hour storm for the diversion berms and the channels.

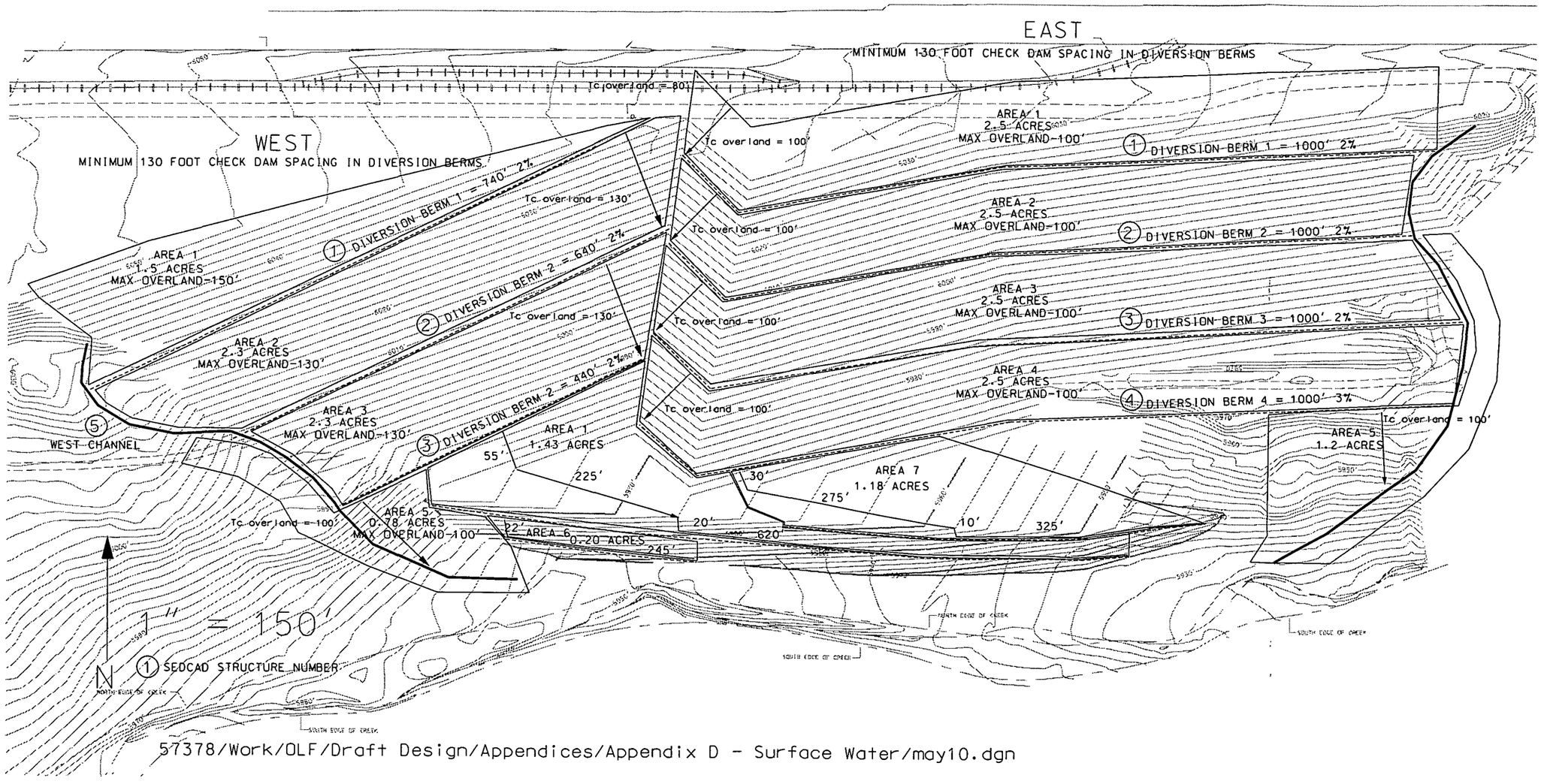
6.0 CONCLUSIONS

Surface water management features required at the Original Landfill to achieve the design criteria listed in Section 4.0 include the following:

- Ten diversion berms with check dams to capture overland flow, reduce sediment load, and route it to channels.
- A permanent erosion control lined channel on the west to convey stormwater to below the buttress fill.
- A permanent erosion control/vegetation lined channel on the east to convey stormwater to below the buttress fill.

APPENDIX D

ATTACHMENT 1
SURFACE WATER DRAINGE MAP



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APPENDIX D

ATTACHMENT 2
SEDCAD REPORTS

hydrograph to predict peak flows. The NRCS Storm Type Distributions are considered very conservative leading to higher peak flows than almost any actual measured storm (SEDCAD 4 User's Manual).

Input into the SEDCAD software include:

- A 100-year 24-hour design storm according to the Regulations;
- A 1000-year 24-hour design storm to check freeboard capacity;
- An NRCS Type II storm;
- A rainfall depth of 5.0 inches according to the Drainage Manual for the 100-year 24-hour storm and 6.4 inches for the 1000-year 24-hour storm and 3.25 for the 25-year 24-hour storm;
- A conservative NRCS curve number of 86; and,
- A medium hydrograph response.

NAG software calculates flow depth, velocity, and hydraulic radius using the continuity equation (Q=VA) and Manning's equation. Once these are known, the shear stress on the lining material is calculated including any channel bend.

5.1 SURFACE WATER DESIGN RESULTS

The design is organized into nine models:

- West channel sediment reduction;
- West channel 100-year 24-hour design;
- West channel 1000-year 24-hour check;
- East channel sediment reduction;
- East channel 100-year 24-hour design;,
- East channel 1000-year 24-hour check;
- Buttress sediment reduction;
- Buttress sideslope 100-year 24-hour design; and,
- Buttress sideslope 1000-year 24-hour design.

Please see Attachment 1 for the SEDCAD models and Attachment 2 for NAG results. Since the west subwatersheds are similar, the sediment reduction model to space the check dams is based on only one of the watersheds. The same methodology was used on the east side. Results are summarized in the following table.

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	0.460	0.018	0.000	0.000	86.000	M	1.47	0.072
	Σ	**0.460**						**1.47**	**0.072**
#2	Σ	**0.460**						**1.47**	**0.072**
#3	1	0.460	0.018	0.000	0.000	86.000	M	1.47	0.072
	Σ	**0.920**						**2.94**	**0.144**
#4	Σ	**0.920**						**2.94**	**0.144**
#5	1	0.460	0.018	0.000	0.000	86.000	M	1.47	0.072
	Σ	**1.380**						**4.41**	**0.216**
#6	Σ	**1.380**						**4.41**	**0.216**
#7	1	0.460	0.018	0.000	0.000	86.000	M	1.47	0.072
	Σ	**1.840**						**5.88**	**0.288**
#8	Σ	**1.840**						**5.88**	**0.288**
#9	1	0.460	0.018	0.000	0.000	86.000	M	1.47	0.072
	Σ	**2.300**						**7.35**	**0.360**
#10	Σ	**2.300**						**7.35**	**0.360**
#11	Σ	**2.300**						**7.35**	**0.360**

From Appendix C

FROM NAC cut sheets APP C

SEDIMENT FROM 1 SUBWATERSHED

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.283	130.00	18.00	0.0700	0.9850	1	1.9	40,772	29.95	2.67
	Σ							**1.9**	**40,772**	**29.95**	**2.67**
#2	Σ							**1.9**	**40,772**	**29.95**	**2.67**
#3	1	0.283	130.00	18.00	0.0700	0.9850	1	1.9	40,772	29.95	2.67
	Σ							**2.0**	**22,515**	**15.33**	**1.36**
#4	Σ							**2.0**	**22,515**	**15.33**	**1.36**
#5	1	0.283	130.00	18.00	0.0700	0.9850	1	1.9	40,772	29.95	2.67
	Σ							**2.2**	**16,363**	**10.40**	**0.92**

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#6	Σ							**2.2**	**16,363**	**10.40**	**0.92**
#7	1	0.283	130.00	18.00	0.0700	0.9850	1	1.9	40,772	29.95	2.67
	Σ							**2.7**	**14,806**	**9.15**	**0.81**
#8	Σ							**2.7**	**14,806**	**9.15**	**0.81**
#9	1	0.283	130.00	18.00	0.0700	0.9850	1	1.9	40,772	29.95	2.67
	Σ							**3.0**	**13,202**	**7.87**	**0.69**
#10	Σ							**3.0**	**13,202**	**7.87**	**0.69**
#11	Σ							**3.0**	**13,202**	**7.87**	**0.69**

TOTAL SED w/o DAMS = 1.9(5) = 9.5 w/out check dams
TOTAL WITH DAMS = 3

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	3. Short grass pasture	18.00	23.40	130.00	3.390	0.010
		8. Large gullies, diversions, and low flowing streams	2.00	2.60	130.00	4.240	0.008
#1	**1**	**Time of Concentration:**					**0.018**
#3	1	3. Short grass pasture	18.00	23.40	130.00	3.390	0.010
		8. Large gullies, diversions, and low flowing streams	2.00	2.60	130.00	4.240	0.008
#3	**1**	**Time of Concentration:**					**0.018**
#5	1	3. Short grass pasture	18.00	23.40	130.00	3.390	0.010
		8. Large gullies, diversions, and low flowing streams	2.00	2.60	130.00	4.240	0.008
#5	**1**	**Time of Concentration:**					**0.018**
#7	1	3. Short grass pasture	18.00	23.40	130.00	3.390	0.010
		8. Large gullies, diversions, and low flowing streams	2.00	2.60	130.00	4.240	0.008
#7	**1**	**Time of Concentration:**					**0.018**
#9	1	3. Short grass pasture	18.00	23.40	130.00	3.390	0.010
		8. Large gullies, diversions, and low flowing streams	2.00	2.60	130.00	4.240	0.008
#9	**1**	**Time of Concentration:**					**0.018**

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RFETS-100 YEAR

WEST CHANNEL

Ryan Archibald

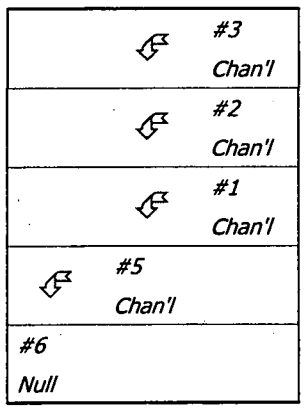
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	100 yr - 24 hr
Rainfall Depth:	5.000 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#5	0.032	0.417	
Channel	#2	==>	#5	0.032	0.417	
Channel	#3	==>	#5	0.032	0.417	
Channel	#5	==>	#6	0.000	0.000	
Null	#6	==>	End	0.000	0.000	



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	8.00	80.00	1,000.00	8.48	0.032
#1	**Muskingum K:**					**0.032**
#2	8. Large gullies, diversions, and low flowing streams	8.00	80.00	1,000.00	8.48	0.032
#2	**Muskingum K:**					**0.032**
#3	8. Large gullies, diversions, and low flowing streams	8.00	80.00	1,000.00	8.48	0.032
#3	**Muskingum K:**					**0.032**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#3	1.700	1.700	9.76	0.49
#2	2.300	2.300	13.21	0.66
#1	1.500	1.500	8.61	0.43
#5	1.000	6.500	37.33	1.88
#6	0.000	6.500	37.33	1.88

Structure Detail:

Structure #3 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	9.76 cfs		9.76 cfs	
Depth:	0.99 ft	1.99 ft	1.53 ft	2.53 ft
Top Width:	8.55 ft	17.15 ft	13.19 ft	21.79 ft
Velocity:	2.30 fps		0.96 fps	
X-Section Area:	4.25 sq ft		10.12 sq ft	
Hydraulic Radius:	0.484		0.747	
Froude Number:	0.57		0.19	
Roughness Coefficient:	0.0564		0.1796	

Structure #2 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	13.21 cfs		13.21 cfs	
Depth:	1.09 ft	2.09 ft	1.64 ft	2.64 ft
Top Width:	9.34 ft	17.94 ft	14.10 ft	22.70 ft

RFETS

WEST CHANNEL SEDIMENT

Ryan Archibald

	w/o Freeboard	w/ Freeboard
Design Discharge:	37.33 cfs	
Depth:	0.46 ft	1.46 ft
Top Width:	12.73 ft	18.73 ft
Velocity:	7.21 fps	
X-Section Area:	5.18 sq ft	
Hydraulic Radius:	0.402	
Froude Number:	1.99	

Structure #6 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#3	1	1.700	0.036	0.000	0.000	86.000	M	9.76	0.491
	Σ	**1.700**						**9.76**	**0.491**
#2	1	2.300	0.051	0.000	0.000	86.000	M	13.21	0.665
	Σ	**2.300**						**13.21**	**0.665**
#1	1	1.500	0.048	0.000	0.000	86.000	M	8.61	0.433
	Σ	**1.500**						**8.61**	**0.433**
#5	1	1.000	0.008	0.000	0.000	86.000	M	5.74	0.289
	Σ	**6.500**						**37.33**	**1.878**
#6	Σ	**6.500**						**37.33**	**1.878**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.00	14.79	739.50	4.240	0.048
#1	**1**	**Time of Concentration:**					**0.048**
#2	1	3. Short grass pasture	18.00	23.40	130.00	3.390	0.010
		8. Large gullies, diversions, and low flowing streams	2.00	12.79	639.50	4.240	0.041
#2	**1**	**Time of Concentration:**					**0.051**
#3	1	3. Short grass pasture	18.00	18.00	99.99	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	8.80	440.00	4.240	0.028
#3	**1**	**Time of Concentration:**					**0.036**
#5	1	3. Short grass pasture	18.00	18.00	99.99	3.390	0.008
#5	**1**	**Time of Concentration:**					**0.008**

RFETS-1000 YEAR

WEST CHANNEL

Ryan Archibald

Structure Detail:

Structure #3 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	13.23 cfs		13.23 cfs	
Depth:	1.09 ft	2.09 ft	1.64 ft	2.64 ft
Top Width:	9.35 ft	17.95 ft	14.10 ft	22.70 ft
Velocity:	2.60 fps		1.14 fps	
X-Section Area:	5.08 sq ft		11.57 sq ft	
Hydraulic Radius:	0.529		0.799	
Froude Number:	0.62		0.22	
Roughness Coefficient:	0.0529		0.1585	

Structure #2 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	17.91 cfs		17.91 cfs	
Depth:	1.19 ft	2.19 ft	1.75 ft	2.75 ft
Top Width:	10.22 ft	18.82 ft	15.08 ft	23.68 ft

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Velocity:	2.95 fps		1.35 fps	
X-Section Area:	6.07 sq ft		13.23 sq ft	
Hydraulic Radius:	0.579		0.854	
Froude Number:	0.67		0.25	
Roughness Coefficient:	0.0495		0.1401	

Structure #1 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	11.68 cfs		11.68 cfs	
Depth:	1.05 ft	2.05 ft	1.60 ft	2.60 ft
Top Width:	9.01 ft	17.61 ft	13.73 ft	22.33 ft
Velocity:	2.47 fps		1.07 fps	
X-Section Area:	4.72 sq ft		10.95 sq ft	
Hydraulic Radius:	0.510		0.777	
Froude Number:	0.60		0.21	
Roughness Coefficient:	0.0543		0.1669	

Structure #5 (Nonerodible Channel)

Trapezoidal Nonerodible Channel Inputs:

Material: Plastic

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
10.00	3.0:1	3.0:1	12.0	0.0390	1.00		

Nonerodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	50.60 cfs	
Depth:	0.54 ft	1.54 ft
Top Width:	13.26 ft	19.26 ft
Velocity:	8.01 fps	
X-Section Area:	6.32 sq ft	
Hydraulic Radius:	0.470	
Froude Number:	2.04	

Structure #6 (Null)

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RFETS

EAST CHANNEL SEDIMENT

Ryan Archibald

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Velocity:	2.60 fps		1.14 fps	
X-Section Area:	5.07 sq ft		11.57 sq ft	
Hydraulic Radius:	0.529		0.799	
Froude Number:	0.62		0.22	
Roughness Coefficient:	0.0529		0.1587	

Structure #1 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	8.61 cfs		8.61 cfs	
Depth:	0.96 ft	1.96 ft	1.49 ft	2.49 ft
Top Width:	8.24 ft	16.84 ft	12.83 ft	21.43 ft
Velocity:	2.18 fps		0.90 fps	
X-Section Area:	3.95 sq ft		9.57 sq ft	
Hydraulic Radius:	0.467		0.727	
Froude Number:	0.56		0.18	
Roughness Coefficient:	0.0580		0.1890	

Structure #5 (Nonerodible Channel)

Trapezoidal Nonerodible Channel Inputs:

Material: Plastic

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
10.00	3.0:1	3.0:1	12.0	0.0390	1.00		

Nonerodible Channel Results:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	Σ							**2.1**	**14,127**	**8.98**	**0.79**
#6	Σ							**2.1**	**14,127**	**8.98**	**0.79**
#7	1	0.283	100.00	18.00	0.0700	0.9850	1	1.8	35,249	25.89	2.30
	Σ							**2.6**	**13,250**	**8.27**	**0.73**
#8	Σ							**2.6**	**13,250**	**8.27**	**0.73**
#9	1	0.283	100.00	18.00	0.0700	0.9850	1	1.8	35,249	25.89	2.30
	Σ							**2.7**	**10,846**	**6.35**	**0.56**
#10	Σ							**2.7**	**10,846**	**6.35**	**0.56**
#11	Σ							**2.7**	**10,846**	**6.35**	**0.56**

TOTAL SED W/O DAMS : 1.8(5) = 9 tons
TOTAL W/ DAMS : 2.7 tons

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	3. Short grass pasture	18.00	18.00	99.99	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	4.00	200.00	4.240	0.013
#1	**1**	**Time of Concentration:**					**0.021**
#3	1	3. Short grass pasture	18.00	18.00	99.99	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	4.00	200.00	4.240	0.013
#3	**1**	**Time of Concentration:**					**0.021**
#5	1	3. Short grass pasture	18.00	18.00	100.00	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	4.00	200.00	4.240	0.013
#5	**1**	**Time of Concentration:**					**0.021**
#7	1	3. Short grass pasture	18.00	18.00	100.00	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	4.00	200.00	4.240	0.013
#7	**1**	**Time of Concentration:**					**0.021**
#9	1	3. Short grass pasture	18.00	18.00	100.00	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	4.00	200.00	4.240	0.013
#9	**1**	**Time of Concentration:**					**0.021**

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RFETS-100 YEAR

EAST CHANNEL

Ryan Archibald

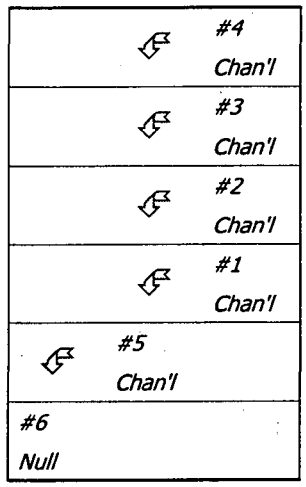
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	100 yr - 24 hr
Rainfall Depth:	5.000 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#5	0.032	0.417	
Channel	#2	==>	#5	0.032	0.417	
Channel	#3	==>	#5	0.032	0.417	
Channel	#4	==>	#5	0.032	0.417	
Channel	#5	==>	#6	0.000	0.000	
Null	#6	==>	End	0.000	0.000	



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	8.00	80.00	1,000.00	8.48	0.032
#1	**Muskingum K:**					**0.032**
#2	8. Large gullies, diversions, and low flowing streams	8.00	80.00	1,000.00	8.48	0.032
#2	**Muskingum K:**					**0.032**
#3	8. Large gullies, diversions, and low flowing streams	8.00	80.00	1,000.00	8.48	0.032
#3	**Muskingum K:**					**0.032**
#4	8. Large gullies, diversions, and low flowing streams	8.00	80.00	1,000.00	8.48	0.032
#4	**Muskingum K:**					**0.032**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#4	2.500	2.500	14.36	0.72
#3	2.500	2.500	14.36	0.72
#2	2.500	2.500	14.36	0.72
#1	2.500	2.500	14.36	0.72
#5	1.000	11.000	63.18	3.18
#6	0.000	11.000	63.18	3.18

Structure Detail:

Structure #4 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	14.36 cfs		14.36 cfs	
Depth:	1.11 ft	2.11 ft	1.67 ft	2.67 ft
Top Width:	9.57 ft	18.17 ft	14.36 ft	22.96 ft
Velocity:	2.70 fps		1.20 fps	
X-Section Area:	5.33 sq ft		11.99 sq ft	
Hydraulic Radius:	0.542		0.813	
Froude Number:	0.64		0.23	
Roughness Coefficient:	0.0519		0.1533	

Structure #3 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	14.36 cfs		14.36 cfs	
Depth:	1.11 ft	2.11 ft	1.67 ft	2.67 ft
Top Width:	9.57 ft	18.17 ft	14.36 ft	22.96 ft

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Velocity:	2.70 fps		1.20 fps	
X-Section Area:	5.33 sq ft		11.99 sq ft	
Hydraulic Radius:	0.542		0.813	
Froude Number:	0.64		0.23	
Roughness Coefficient:	0.0519		0.1533	

Structure #2 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	14.36 cfs		14.36 cfs	
Depth:	1.11 ft	2.11 ft	1.67 ft	2.67 ft
Top Width:	9.57 ft	18.17 ft	14.36 ft	22.96 ft
Velocity:	2.70 fps		1.20 fps	
X-Section Area:	5.33 sq ft		11.99 sq ft	
Hydraulic Radius:	0.542		0.813	
Froude Number:	0.64		0.23	
Roughness Coefficient:	0.0519		0.1533	

Structure #1 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	0.500	0.021	0.000	0.000	86.000	M	1.60	0.078
	Σ	**0.500**						**1.60**	**0.078**
#2	Σ	**0.500**						**1.60**	**0.078**
#3	1	0.500	0.021	0.000	0.000	86.000	M	1.60	0.078
	Σ	**1.000**						**3.20**	**0.157**
#4	Σ	**1.000**						**3.20**	**0.157**
#5	1	0.500	0.021	0.000	0.000	86.000	M	1.60	0.078
	Σ	**1.500**						**4.80**	**0.235**
#6	Σ	**1.500**						**4.80**	**0.235**
#7	1	0.500	0.021	0.000	0.000	86.000	M	1.60	0.078
	Σ	**2.000**						**6.39**	**0.313**
#8	Σ	**2.000**						**6.39**	**0.313**
#9	1	0.500	0.021	0.000	0.000	86.000	M	1.60	0.078
	Σ	**2.500**						**7.99**	**0.391**
#10	Σ	**2.500**						**7.99**	**0.391**
#11	Σ	**2.500**						**7.99**	**0.391**

APP C NAG APPC

SEDIMENT FROM 1 SUBWATERSHED

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.283	100.00	18.00	0.0700	0.9850	1	1.8	35,249	25.89	2.30
	Σ							**1.8**	**35,249**	**25.89**	**2.30**
#2	Σ							**1.8**	**35,249**	**25.89**	**2.30**
#3	1	0.283	100.00	18.00	0.0700	0.9850	1	1.8	35,249	25.89	2.30
	Σ							**1.9**	**19,446**	**13.24**	**1.17**
#4	Σ							**1.9**	**19,446**	**13.24**	**1.17**
#5	1	0.283	100.00	18.00	0.0700	0.9850	1	1.8	35,249	25.89	2.30

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#4	1	2.500	0.073	0.000	0.000	86.000	M	14.36	0.722
	Σ	**2.500**						**14.36**	**0.722**
#3	1	2.500	0.073	0.000	0.000	86.000	M	14.36	0.722
	Σ	**2.500**						**14.36**	**0.722**
#2	1	2.500	0.073	0.000	0.000	86.000	M	14.36	0.722
	Σ	**2.500**						**14.36**	**0.722**
#1	1	2.500	0.073	0.000	0.000	86.000	M	14.36	0.722
	Σ	**2.500**						**14.36**	**0.722**
#5	1	1.000	0.008	0.000	0.000	86.000	M	5.74	0.289
	Σ	**11.000**						**63.18**	**3.178**
#6	Σ	**11.000**						**63.18**	**3.178**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	3. Short grass pasture	18.00	18.00	99.99	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	20.00	1,000.00	4.240	0.065
#1	**1**	**Time of Concentration:**					**0.073**
#2	1	3. Short grass pasture	18.00	18.00	100.00	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	20.00	1,000.00	4.240	0.065
#2	**1**	**Time of Concentration:**					**0.073**
#3	1	3. Short grass pasture	18.00	18.00	100.00	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	20.00	1,000.00	4.240	0.065
#3	**1**	**Time of Concentration:**					**0.073**
#4	1	3. Short grass pasture	18.00	18.00	100.00	3.390	0.008
		8. Large gullies, diversions, and low flowing streams	2.00	20.00	1,000.00	4.240	0.065
#4	**1**	**Time of Concentration:**					**0.073**
#5	1	3. Short grass pasture	18.00	18.00	99.99	3.390	0.008
#5	**1**	**Time of Concentration:**					**0.008**

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RFETS-1000 YEAR

EAST CHANNEL

Ryan Archibald

Structure Detail:

Structure #4 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	19.46 cfs		19.46 cfs	
Depth:	1.22 ft	2.22 ft	1.79 ft	2.79 ft
Top Width:	10.47 ft	19.07 ft	15.37 ft	23.97 ft
Velocity:	3.06 fps		1.42 fps	
X-Section Area:	6.37 sq ft		13.73 sq ft	
Hydraulic Radius:	0.593		0.870	
Froude Number:	0.69		0.26	
Roughness Coefficient:	0.0486		0.1354	

Structure #3 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	19.46 cfs		19.46 cfs	
Depth:	1.22 ft	2.22 ft	1.79 ft	2.79 ft
Top Width:	10.47 ft	19.07 ft	15.37 ft	23.97 ft

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Velocity:	3.06 fps		1.42 fps	
X-Section Area:	6.37 sq ft		13.73 sq ft	
Hydraulic Radius:	0.593		0.870	
Froude Number:	0.69		0.26	
Roughness Coefficient:	0.0486		0.1354	

Structure #2 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	19.46 cfs		19.46 cfs	
Depth:	1.22 ft	2.22 ft	1.79 ft	2.79 ft
Top Width:	10.47 ft	19.07 ft	15.37 ft	23.97 ft
Velocity:	3.06 fps		1.42 fps	
X-Section Area:	6.37 sq ft		13.73 sq ft	
Hydraulic Radius:	0.593		0.870	
Froude Number:	0.69		0.26	
Roughness Coefficient:	0.0486		0.1354	

Structure #1 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	5.6:1	2.0	D, B	1.00			5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	19.46 cfs		19.46 cfs	
Depth:	1.22 ft	2.22 ft	1.79 ft	2.79 ft
Top Width:	10.47 ft	19.07 ft	15.37 ft	23.97 ft
Velocity:	3.06 fps		1.42 fps	
X-Section Area:	6.37 sq ft		13.73 sq ft	
Hydraulic Radius:	0.593		0.870	
Froude Number:	0.69		0.26	
Roughness Coefficient:	0.0486		0.1354	

Structure #5 (Nonerodible Channel)

Trapezoidal Nonerodible Channel Inputs:

Material: Plastic

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
18.00	3.0:1	3.0:1	12.0	0.0390	1.00		

Nonerodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	85.64 cfs	
Depth:	0.53 ft	1.53 ft
Top Width:	21.19 ft	27.19 ft
Velocity:	8.21 fps	
X-Section Area:	10.43 sq ft	
Hydraulic Radius:	0.488	
Froude Number:	2.06	

Structure #6 (Null)

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RFETS

BUTTRESS SEDIMENT

Ryan Archibald

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	0.400	0.057	0.000	0.000	86.000	M	1.28	0.063
	Σ	**0.400**						**1.28**	**0.063**
#2	Σ	**0.400**						**1.28**	**0.063**
#3	1	0.400	0.057	0.000	0.000	86.000	M	1.28	0.063
	Σ	**0.800**						**2.56**	**0.125**
#4	Σ	**0.800**						**2.56**	**0.125**
#5	1	0.400	0.057	0.000	0.000	86.000	M	1.28	0.063
	Σ	**1.200**						**3.84**	**0.188**
#6	Σ	**1.200**						**3.84**	**0.188**
#7	1	0.400	0.057	0.000	0.000	86.000	M	1.28	0.063
	Σ	**1.600**						**5.12**	**0.250**
#8	Σ	**1.600**						**5.12**	**0.250**
#9	1	0.400	0.057	0.000	0.000	86.000	M	1.28	0.063
	Σ	**2.000**						**6.39**	**0.313**
#10	Σ	**2.000**						**6.39**	**0.313**
#11	Σ	**2.000**						**6.39**	**0.313**

Sediment from 1 subwatershed

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.283	275.00	2.75	0.0700	0.9850	1	0.2	5,172	3.80	0.37
	Σ							**0.2**	**5,172**	**3.80**	**0.37**
#2	Σ							**0.2**	**5,172**	**3.80**	**0.37**
#3	1	0.283	275.00	2.75	0.0700	0.9850	1	0.2	5,172	3.80	0.37
	Σ							**0.2**	**2,838**	**1.93**	**0.19**
#4	Σ							**0.2**	**2,838**	**1.93**	**0.19**
#5	1	0.283	275.00	2.75	0.0700	0.9850	1	0.2	5,172	3.80	0.37
	Σ							**0.2**	**2,061**	**1.31**	**0.13**

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	14.36 cfs		14.36 cfs	
Depth:	1.11 ft	2.11 ft	1.67 ft	2.67 ft
Top Width:	9.57 ft	18.17 ft	14.36 ft	22.96 ft
Velocity:	2.70 fps		1.20 fps	
X-Section Area:	5.33 sq ft		11.99 sq ft	
Hydraulic Radius:	0.542		0.813	
Froude Number:	0.64		0.23	
Roughness Coefficient:	0.0519		0.1533	

Structure #5 (Nonerodible Channel)

Trapezoidal Nonerodible Channel Inputs:

Material: Plastic

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
18.00	3.0:1	3.0:1	12.0	0.0390	1.00		

Nonerodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	63.18 cfs	
Depth:	0.44 ft	1.44 ft
Top Width:	20.67 ft	26.67 ft
Velocity:	7.34 fps	
X-Section Area:	8.60 sq ft	
Hydraulic Radius:	0.413	
Froude Number:	2.01	

Structure #6 (Null)

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RFETS-100 YEAR

BUTTRESS SIDESLOPE

Ryan Archibald

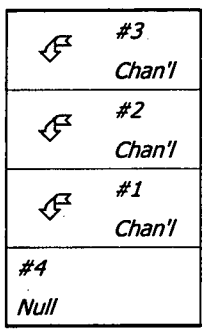
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	100 yr - 24 hr
Rainfall Depth:	5.000 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#4	0.000	0.000	
Channel	#2	==>	#4	0.000	0.000	
Channel	#3	==>	#4	0.000	0.000	
Null	#4	==>	End	0.000	0.000	



Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#3	1.180	1.180	6.78	0.34
#2	1.300	1.300	7.47	0.38
#1	0.200	0.200	1.15	0.06
#4	0.000	2.680	15.39	0.77

Structure Detail:

Structure #3 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
1.0:1	1.0:1	3.5	D, B	1.00			4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	6.78 cfs		6.78 cfs	
Depth:	1.39 ft	2.39 ft	2.05 ft	3.05 ft
Top Width:	2.78 ft	4.78 ft	4.10 ft	6.10 ft
Velocity:	3.51 fps		1.61 fps	
X-Section Area:	1.93 sq ft		4.20 sq ft	
Hydraulic Radius:	0.491		0.724	
Froude Number:	0.74		0.28	
Roughness Coefficient:	0.0494		0.1392	

Structure #2 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
1.0:1	1.0:1	3.5	D, B	1.00			4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	7.47 cfs		7.47 cfs	
Depth:	1.43 ft	2.43 ft	2.09 ft	3.09 ft
Top Width:	2.86 ft	4.86 ft	4.19 ft	6.19 ft

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Velocity:	3.66 fps		1.70 fps	
X-Section Area:	2.04 sq ft		4.38 sq ft	
Hydraulic Radius:	0.505		0.740	
Froude Number:	0.76		0.29	
Roughness Coefficient:	0.0483		0.1338	

Structure #1 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
1.0:1	1.0:1	3.5	D, B	1.00			4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	1.15 cfs		1.15 cfs	
Depth:	0.82 ft	1.82 ft	1.38 ft	2.38 ft
Top Width:	1.65 ft	3.65 ft	2.77 ft	4.77 ft
Velocity:	1.69 fps		0.60 fps	
X-Section Area:	0.68 sq ft		1.92 sq ft	
Hydraulic Radius:	0.291		0.489	
Froude Number:	0.46		0.13	
Roughness Coefficient:	0.0724		0.2882	

Structure #4 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#3	1	1.180	0.074	0.000	0.000	86.000	M	6.78	0.341
	Σ	**1.180**						**6.78**	**0.341**
#2	1	1.300	0.080	0.000	0.000	86.000	M	7.47	0.376
	Σ	**1.300**						**7.47**	**0.376**
#1	1	0.200	0.012	0.000	0.000	86.000	M	1.15	0.058
	Σ	**0.200**						**1.15**	**0.058**
#4	Σ	**2.680**						**15.39**	**0.774**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	3. Short grass pasture	33.00	7.26	22.00	4.590	0.001
		8. Large gullies, diversions, and low flowing streams	4.00	9.80	245.00	6.000	0.011
#1	**1**	**Time of Concentration:**					**0.012**
#2	1	3. Short grass pasture	18.00	9.90	55.00	3.390	0.004
		3. Short grass pasture	2.75	6.18	224.72	1.320	0.047
		3. Short grass pasture	33.00	6.60	19.99	4.590	0.001
		8. Large gullies, diversions, and low flowing streams	4.00	24.80	620.00	6.000	0.028
#2	**1**	**Time of Concentration:**					**0.080**
#3	1	3. Short grass pasture	18.00	5.40	30.00	3.390	0.002
		3. Short grass pasture	2.75	7.56	274.90	1.320	0.057
		3. Short grass pasture	33.00	3.30	9.99	4.590	0.000
		8. Large gullies, diversions, and low flowing streams	4.00	13.00	325.00	6.000	0.015
#3	**1**	**Time of Concentration:**					**0.074**

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#6	Σ							**0.2**	**2,061**	**1.31**	**0.13**
#7	1	0.283	275.00	2.75	0.0700	0.9850	1	0.2	5,172	3.80	0.37
	Σ							**0.3**	**1,670**	**1.00**	**0.10**
#8	Σ							**0.3**	**1,670**	**1.00**	**0.10**
#9	1	0.283	275.00	2.75	0.0700	0.9850	1	0.2	5,172	3.80	0.37
	Σ							**0.3**	**1,432**	**0.81**	**0.08**
#10	Σ							**0.3**	**1,432**	**0.81**	**0.08**
#11	Σ							**0.1**	**667**	**0.21**	**0.02**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	3. Short grass pasture	2.75	7.56	275.00	1.320	0.057
#1	**1**	**Time of Concentration:**					**0.057**
#3	1	3. Short grass pasture	2.75	7.56	275.00	1.320	0.057
#3	**1**	**Time of Concentration:**					**0.057**
#5	1	3. Short grass pasture	2.75	7.56	275.00	1.320	0.057
#5	**1**	**Time of Concentration:**					**0.057**
#7	1	3. Short grass pasture	2.75	7.56	275.00	1.320	0.057
#7	**1**	**Time of Concentration:**					**0.057**
#9	1	3. Short grass pasture	2.75	7.56	274.90	1.320	0.057
#9	**1**	**Time of Concentration:**					**0.057**

Structure Detail:

Structure #3 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
1.0:1	1.0:1	3.5	D, B	1.00			4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	9.19 cfs		9.19 cfs	
Depth:	1.52 ft	2.52 ft	2.19 ft	3.19 ft
Top Width:	3.04 ft	5.04 ft	4.38 ft	6.38 ft
Velocity:	3.98 fps		1.91 fps	
X-Section Area:	2.31 sq ft		4.80 sq ft	
Hydraulic Radius:	0.537		0.775	
Froude Number:	0.81		0.32	
Roughness Coefficient:	0.0462		0.1229	

Structure #2 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
1.0:1	1.0:1	3.5	D, B	1.00			4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	10.12 cfs		10.12 cfs	
Depth:	1.56 ft	2.56 ft	2.24 ft	3.24 ft
Top Width:	3.13 ft	5.13 ft	4.48 ft	6.48 ft

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Velocity:	4.14 fps		2.02 fps	
X-Section Area:	2.44 sq ft		5.01 sq ft	
Hydraulic Radius:	0.553		0.792	
Froude Number:	0.83		0.34	
Roughness Coefficient:	0.0453		0.1181	

Structure #1 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
1.0:1	1.0:1	3.5	D, B	1.00			4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	1.56 cfs		1.56 cfs	
Depth:	0.90 ft	1.90 ft	1.48 ft	2.48 ft
Top Width:	1.80 ft	3.80 ft	2.96 ft	4.96 ft
Velocity:	1.92 fps		0.71 fps	
X-Section Area:	0.81 sq ft		2.19 sq ft	
Hydraulic Radius:	0.319		0.523	
Froude Number:	0.50		0.15	
Roughness Coefficient:	0.0678		0.2544	

Structure #4 (Null)

APPENDIX D

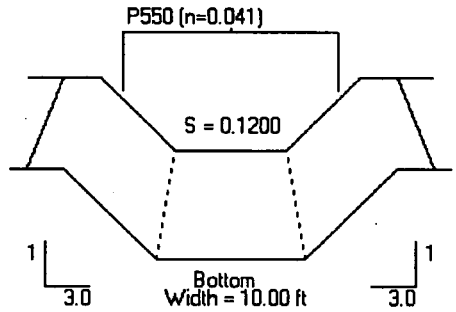
ATTACHMENT 3
NAG REPORTS

WEST CHANNEL

North American Green - ECMDS Version 4.2		3/23/200 04:53 PM	COMPUTED BY:
PROJECT NAME: RFETS-OLF		PROJECT NO.:	
FROM STATION/REACH:	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
37.0	1.5	6.94	5.33	0.41	0.47



Not to Scale

BEND RESULTS

Bend Radius (ft)	Length Protection (ft)	Super Elevation Depth (ft)
105.0	5.2	0.7

LINER RESULTS

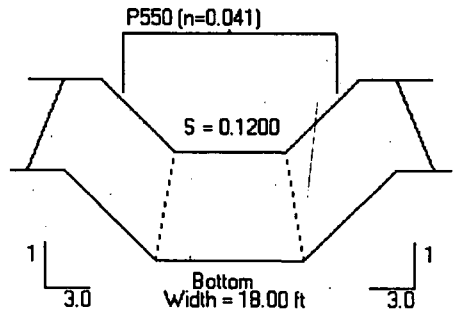
Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	P550	Unvegetated	1				3.50	3.50	1.00	STABLE
	Staple E									
Bend	P550	Unvegetated	1				3.50	3.50	1.00	STABLE
	Staple E									

EAST CHANNEL

North American Green - ECMDS Version 4.2		3/23/200 04:54 PM	COMPUTED BY:
PROJECT NAME: RFETS-OLF		PROJECT NO.:	
FROM STATION/REACH:	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
63.0	1.5	7.10	8.88	0.42	0.46



Not to Scale

BEND RESULTS

Bend Radius (ft)	Length Protection (ft)	Super Elevation Depth (ft)
200.0	5.4	0.6

LINER RESULTS

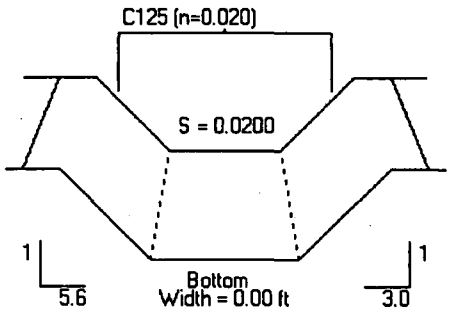
Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	P550	Unvegetated	1				3.50	3.43	1.02	STABLE
	Staple E									
Bend	P550	Unvegetated	1				3.50	3.43	1.02	STABLE
	Staple E									

DIVERSION BERMS

North American Green - ECMDS Version 4.2		3/23/200 04:57 PM	COMPUTED BY:
PROJECT NAME: RFETS-OLF		PROJECT NO.:	
FROM STATION/REACH:	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
14.4	2.0	5.41	2.66	0.38	0.79



Not to Scale

BEND RESULTS

Bend Radius (ft)	Length Protection (ft)	Super Elevation Depth (ft)
5.0	9.6	2.0

LINER RESULTS

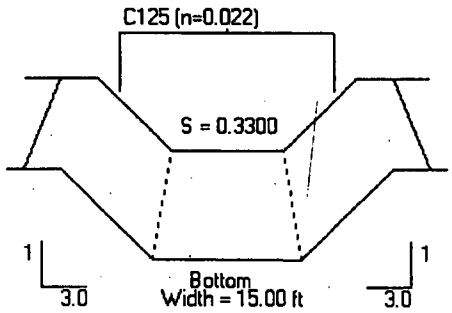
Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	C125	Unvegetated					2.25	0.98	2.29	STABLE
	Staple D									
Bend	C125	Unvegetated					2.25	0.98	2.29	STABLE
	Staple D									

DOWNSLOPE CHANNEL

North American Green - ECMDS Version 4.2	3/23/200 05:01 PM	COMPUTED BY:	
PROJECT NAME: RFETS-OLF		PROJECT NO.:	
FROM STATION/REACH:	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
14.4	2.0	8.68	1.66	0.11	0.11



Not to Scale

LINER RESULTS

Reach	Matting Type	Stability Analysis	Vegetation Characteristics				Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
	Staple Pattern		Phase	Class	Type	Density				
Straight	C125	Unvegetated					2.25	2.23	1.01	STABLE
	Staple D									

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RFETS-1000 YEAR

BUTTRESS SIDESLOPE

Ryan Archibald

Appendix E

APPENDIX E

LANDFILL ENGINEERING – FINAL DESIGN
BUTTRESS SUB-DRAIN

APPENDIX E

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL

LANDFILL ENGINEERING – FINAL DESIGN
BUTTRESS SUB-DRAIN

MAY 11, 2005

Prepared by:

Earth Tech, Inc.
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Englewood, Colorado 80111
(303) 694-6660

This calculation was performed by Earth Tech, Inc. Although each sheet composing this calculation may or may not be initialed, it has nonetheless been reviewed and checked.

Prepared By:	CB	Date: 5/9/05
Checked By:	RT	Date: 5/9/05
Approved By:	RT	Date: 5/9/05

LIST OF ATTACHMENTS

Attachment 1	Discharge Calc Sheet
Attachment 2	Product Specification Structural Geogrid BX 1200
Attachment 3	Geotextile Selection
Attachment 4	Infiltration Calculation Sheet – Drainage Rock into Valley Floor Alluvium

1.0 INTRODUCTION

This buttress sub-drain system was developed to address potential groundwater drainage issues at the Original Landfill (OLF) Accelerated Action, specifically at the buttress fill location at the southern toe of the OLF. The buttress sub-drain addresses groundwater flow below the buttress fill, directing it to the subsurface infiltration gallery in the stream alluvium of Woman Creek.

2.0 LANDFILL DESCRIPTION, LOCATION AND DRAINAGE

The OLF site is located south of Rocky Flats Environmental Technology Site Buildings 440 and 460, along the north hillside of a ravine in the Woman Creek drainage area, extending from an approximate elevation of 6,040 feet at the top to an elevation of 5,950 feet at its base. Waste operations began in the early 1950s and continued through 1968. The OLF site footprint has a maximum length along the east-west direction of approximately 1,700 feet and approximately 500 feet in the north-south direction, with an approximate area on the order of 20 acres.

3.0 REFERENCES

The buttress sub-drain system for the OLF was evaluated using guidelines provided in the following documents:

1. "Groundwater Hydrology," Todd, 1980
2. "Groundwater and Wells," Driscoll, 1986.
3. Integrated Flow and VOC fate and transport modeling for the OLF, Integrated Hydro System, December 2004.

4.0 DESIGN CRITERIA

The attached calculations were used to evaluate the transmissivity of a well-sorted material to discharge groundwater below the buttress fill.

Evaluation and design of the OLF buttress drain system will meet the following design criteria:

1. Pass a maximum discharge of 1 gallon per minute (gpm) based on the discharge rate presented in the Integrated Flow and VOC Fate and Transport Modeling, (Integrated Hydro Systems, 2004).

2. Minimize sedimentation of the buttress drainage system from native materials and buttress fill materials.

5.0 HYDROGEOLOGIC DESIGN APPROACH

Darcy's Law was used to estimate groundwater discharge rates below the buttress (see Attachment 1). Typical hydraulic conductivities were evaluated using a worst-case scenario of ¾-inch gravel to provide an extra margin of flow capacities. The designed sub-drain material is a well-sorted material with a D_{max} of 1-½ inches and a D_{10} of ¾ inch, which correlates to a gravel. This material will be constructed using durable sub-angular rock that provides adequate porosity and a suitable contact surface with the buttress fill material and the granular soils of

the stream alluvium. This fill zone will be placed on top of geogrid (Tensar BX1200 or equivalent – see Attachment 2) to provide a stable platform on top of the weathered claystone. Once the drain rock has been placed, a non-woven geotextile, such as Nilex NW80 or equivalent, will be placed between the drain rock and the buttress material to minimize fine materials clogging the pore space of the drain rock. See Attachment 3 for geotextile determination. To simulate a worst-case scenario, an assumption was made that 6 inches of drain rock material could be effectively lost due to compaction into adjacent surfaces.

The following assumptions were made for calculations of discharge below the buttress:

- Buttress drain length is from top of buttress to downstream discharge point below buttress.
- A well-sorted durable angular drain material ¾-inch to 1-½-inch gravel will be used.
- K for a worst-case scenario from a compacted gravel, K = 2760 gallons per day per square foot will be used.
- Minimum thickness of permeable layer = 12 inches (6 in. of usable material).

Infiltration into the valley floor alluvium was estimated using the mean conductivity of the alluvium calculated from falling head tests in bore holes. The mean conductivity for the valley floor alluvium is 2.57 meters per day or 239 gallons per day per square foot. The mean value was fed back into Darcy's Equation to estimate infiltration rates. The head, or driving force from the sub-drain, was estimated to be no more than 1 foot from standing water in the large pore space of the drainage rock. The area was based on the footprint of the buttress on the valley alluvium with the assumption that only 10% of that area contains the mean value of conductivity due to bedding conditions. The calculation in Attachment 4 show that the valley floor alluvium could accept over 1,000 gpm, which is three orders of magnitude greater than the design needs. This is further supported by the fact that the design inflow below the buttress is less than the current conditions due to surface water diversions, diverting storm water away from the landfill and into side channels, minimizing infiltration and therefore minimizing groundwater flow below the buttress. Current conditions, i.e,. a lack of springs or seeps in the area of the landfill, indicate that the alluvium is capable of accepting the current discharge rates.

6.0 CONCLUSIONS

A suitable sub-drain design uses sub-angular rock that is well sorted with a diameter ranging from ¾ inch to 1-½ inch. This design successfully passed a 1.0-gpm maximum discharge scenario. The calculations show that the design has the capability of passing 112 gpm through a 6-inch zone across the buttress. This provides a 2-order-of-magnitude safety factor compared to the model-predicted flow rate of 1 gpm, which will account for any sedimentation blockage over time.

The calculations show that the valley floor alluvium is capable of accepting the flow from the sub-drain.

APPENDIX E

ATTACHMENT 1
DISCHARGE CALC SHEET

Rocky Flats OLF Buttress Sub-Drain Date: 4/18/2005

Designed by: CAB

Given

Using Darcy's Law $Q = -KA \{d(h)/d(l)\}$

Where Q = discharge (gpd/ft^2)

K = hydraulic conductivity (gpd/ft^2)

A = area (ft^2)

{d(h)/d(l)} = hydraulic gradient (ft/ft)

From Summary of *Hydrologic and Physical Properties of Rock and Soil Materials, as Analyzed by the Hydrologic Laboratory of the U.S.G.S.* 1948-60 USGS Water-Supply Paper 1839-D 1967.

	m/day	gpd/ft^2	Diam. (in)	Sieve #
K(Gravel)	450	11043	0.5250	1/2

Minimum Design Criteria: Q = 1 gal/min

Assumptions:

Buttress drain length is from top of buttress to downstream discharge point below buttress.

A well-sorted angular durable fill material from .75 inches to 1.5 inch is used.

Minimum thickness of permeable layer = 12 inches to allow drain material to be packed into adjacent surfaces.

Assume 6 inches of material is lost due to compaction in to adjacent surfaces.

	X-Sec A-A′	X-Sec B-B′	X-Sec C-C′	X-Sec D-D′	**Average**
Elevation at top of buttress (ft msl)	5,974	5,970	5,962	5,953	5,965 msl
Elevation at bottom of buttress (ft msl)	5,950	5,948	5,940	5,934	5,943 msl
Length of buttress drain (ft)	145	185	175	165	168 ft.
Width of cross section (ft)					900 ft.
Change in elevation (ft)	24	22	22	19	22 ft.
Area of representative buttress drain (900ft X 1 foot thick)/2 (loss of 6 inches from compaction)					450 ft^2

Solving for Q $Q = -KA (d(h)/d(l))$

	Natural Compaction	Compacted Fill*
K (GPD/ft^2)=	11043.0	2,760.8
A (Ft^2)	450.0	450.0
d(h) (ft)	21.8	21.8
d(l) (ft)	167.5	167.5
Q (gal. / day)	645,273.8	161,318.5
Q (Gal / minute) =	**448.1**	**112.0**

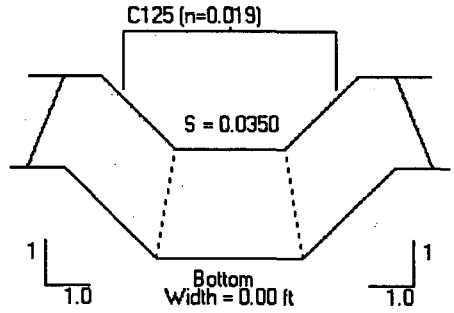
*This material may become compacted during construction of the buttress. With sufficient compaction, this material may have its K value reduced by 75% due to the rearrangement of particles.

BUTTRESS SIDESLOPE BERMS
3.5%

North American Green - ECMDS Version 4.2	5/11/200	12:04 PM	COMPUTED BY:
PROJECT NAME: RFETS OLF		PROJECT NO.:	
FROM STATION/REACH:	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
7.5	1.5	7.29	1.03	0.36	1.01



Not to Scale

LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics				Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
			Phase	Class	Type	Density				
Straight	C125	Unvegetated					2.25	2.21	1.02	STABLE
	Staple D									

Product Specification - Structural Geogrid BX1200

Tensar Earth Technologies, Inc. reserves the right to change its product specifications at any time. It is the responsibility of the specifier and purchaser to ensure that product specifications used for design and procurement purposes are current and consistent with the products used in each instance. Please contact Tensar Earth Technologies, Inc. at 800-836-7271 for assistance

The structural geogrid shall be an integrally formed grid structure manufactured of a stress resistant polypropylene material with molecular weight and molecular characteristics which impart: (a) high resistance to loss of load capacity or structural integrity when the geogrid is subjected to mechanical stress in installation; (b) high resistance to deformation when the geogrid is subjected to applied force in use; and (c) high resistance to loss of load capacity or structural integrity when the geogrid is subjected to long-term environmental stress.

The structural geogrid shall accept applied force in use by positive mechanical interlock (i.e. by direct mechanical keying) with: (a) compacted soil or construction fill materials; (b) contiguous sections of itself when overlapped and embedded in compacted soil or construction fill materials; and (c) rigid mechanical connectors such as bodkins, pins or hooks. The structural geogrid shall possess sufficient cross sectional profile to present a substantial abutment interface to compacted soil or particulate construction fill materials and to resist movement relative to such materials when subject to applied force. The structural geogrid shall possess sufficient true initial modulus to cause applied force to be transferred to the geogrid at low strain levels without material deformation of the reinforced structure. The structural geogrid shall possess complete continuity of all properties throughout its structure and shall be suitable for reinforcement of compacted soil or particulate construction fill materials to improve their long term stability in structural load bearing applications such as earth retention systems. The structural geogrid shall otherwise have the following characteristics:

Product Type: **Integrally Formed Structural Geogrid**
Load Transfer Mechanism: **Positive Mechanical Interlock**

Product Properties

Index Properties	Units	MD Values[1]	XMD Values[1]
• Aperture Dimensions[2]	mm (in)	25 (1.0)	33 (1.3)
• Minimum Rib Thickness[2]	mm (in)	1.27 (0.05)	1.27 (0.05)
Load Capacity			
• True Initial Modulus in Use[3]	kN/m(lb/ft)	400 (27,420)	650 (44,550)
• True Tensile Strength @2% Strain[3]	kN/m(lb/ft)	6.0 (410)	9.0 (620)
• True Tensile Strength @5% Strain[3]	kN/m(lb/ft)	11.8 (810)	19.6 (1,340)
Structural Integrity			
• Junction Efficiency[4]	%	93	
• Flexural Stiffness[5]	mg-cm	750,000	
• Aperture Stability[6]	kg-cm/deg	6.5	
Durability			
• Resistance to Installation Damage[7]	%SC / %SW / %GP	95 / 93 / 90	
• Resistance to Long Term Degradation[8]	%	100	

Dimensions and Delivery

The structural geogrid shall be delivered to the jobsite in roll form with each roll individually identified and nominally measuring 3.0 meters (9.8 feet) or 4.0 meters (13.1 feet) in width and 50.0 meters (164 feet) in length. A typical truckload quantity is 165 to 220 rolls. On special request, the structural geogrid may also be custom cut to specific lengths or widths to suit site specific engineering designs.

Notes

1. Unless indicated otherwise, values shown are minimum average roll values determined in accordance with ASTM D-4759. Brief descriptions of test procedures are given in the following notes. Complete descriptions of test procedures are available on request from Tensar Earth Technologies, Inc.
2. Nominal Dimensions.
3. True resistance to elongation when initially subjected to a load measured via ASTM D6637 without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.
4. Load transfer capability measured via GRI-GG2-87. Expressed as a percentage of ultimate tensile strength.
5. Resistance to bending force measured via ASTM D-5732-95, using specimens of width two ribs wide, with transverse ribs cut flush with exterior edges of longitudinal ribs (as a "ladder"), and of length sufficiently long to enable measurement of the overhang dimension. The overall Flexural Stiffness is calculated as the square root of the product of machine-and cross-machine-direction Flexural Stiffness values.
6. Resistance to in-plane rotational movement measured by applying a 20 kg-cm moment to the central junction of a 9 inch x 9 inch specimen restrained at its perimeter (U.S. Army Corps of Engineers Methodology for measurement of Torsional Rigidity).
7. Resistance to loss of load capacity or structural integrity when subjected to mechanical installation stress in clayey sand (SC), well graded sand (SW), and crushed stone classified as poorly graded gravel (GP). The geogrid shall be sampled in accordance with ASTM D5818 and load capacity shall be measured in accordance with ASTM D6637.
8. Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments measured via EPA 9090 immersion testing.

Tensar Earth Technologies, Inc.
5883 Glenridge Drive, Suite 200
Atlanta, Georgia 30328-5363
(800) 836-7271

December 22, 2004
This product specification supersedes all prior specifications for the product described above and is not applicable to any products shipped prior to December 22, 2004.

APPENDIX E

ATTACHMENT 3
GEOTEXTILE SELECTION

EARTH TECH

A Tyco Infrastructure Services Company

CALCULATION SHEET

PROJECT NO. 57378.6040

CLIENT K-H

PROJECT RFETS OLF

SUBJECT Geotextile Selection

Prepared By REA DATE 4/15/05

Reviewed By _____ DATE _____

Approved By _____ DATE _____

Required puncture resistance from Figure 7.32 is 500N or 113 lb. The Figure assume a total FS = 2.0 so assume the Nilex W300 woven or the NW80 non-woven or above is appropriate. See attached cut sheets.

Filtration

Soil Retention Criteria: Use Figure 7.4 from "Designing w/ Geosynthetics" From figure O_{95} (AOS) < 0.21mm to meet soil retention criteria

Woven W300 AOS = 0.3 mm > 0.21mm ← Does not meet criteria
Nonwoven NW80 AOS = 0.180 mm < 0.21mm

Conclusion: woven geotextiles from Nilex & Amoco do not meet soil retention criteria.

Porosity/Permeability Criteria: 8oz nonwoven geotextiles meet porosity/permeability criteria. See Appendix J of the PLF Design.

CONCLUSION

An 8oz/yd² non-woven geotextile or greater (i.e. 10 oz, 12 oz) is appropriate for use as the separation geotextile between the drain rock and buttress. Non-woven provide similar puncture strength to woven and better elongation to woven.

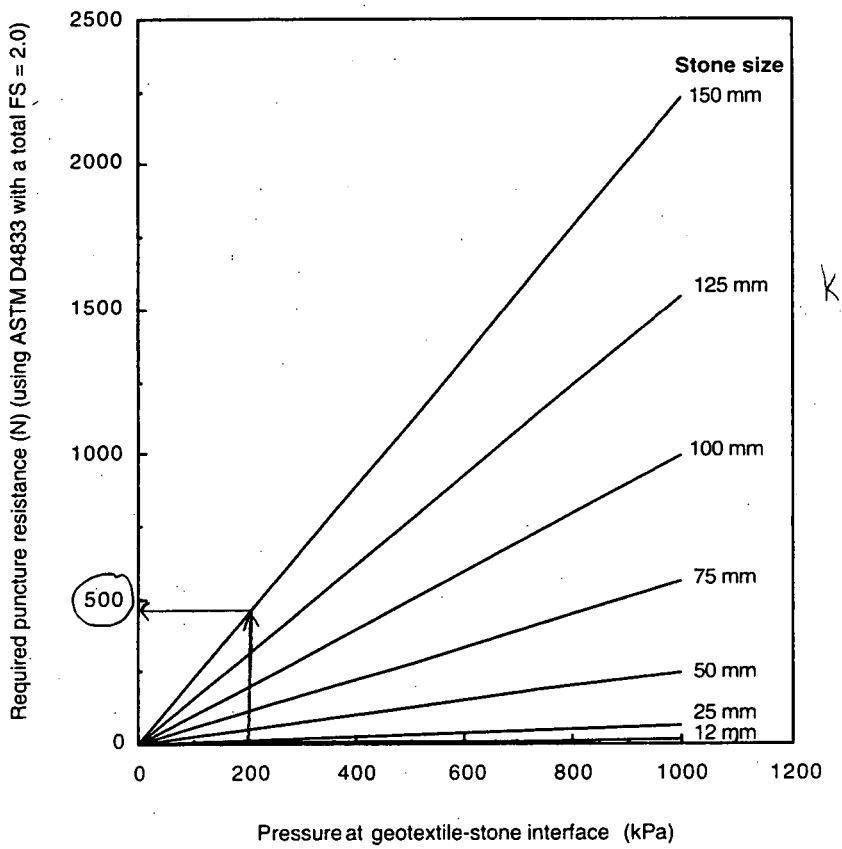
Solution: Using the full stress on the geotextile of 550 kPa and the values 0.33, 0.15, and 0.6 for the factors S_1, S_2, and S_3, respectively,

$$F_{reqd} = p' d_a^2 S_1 S_2 S_3$$
$$= (550)(1000)(50 \times 0.001)^2(0.33)(0.15)(0.6)$$
$$= 40.8 \text{ N}$$

Assuming that the cumulative reduction factors are 2.0, the factor of safety is as follows:

$$FS = \frac{F_{allow}}{F_{reqd}}$$
$$= \frac{200/2.0}{40.8}$$
$$= 2.4 \quad \text{which is acceptable}$$

Using the following assumptions (which can be modified as desired), a design guide can be developed as shown in Figure 2.32: the geotextile has an angular subgrade



kPa = 1788 say 200

Figure 2.32 Puncture resistance design guide based on cumulative reduction factors of 2.0, a factor of safety of 2.0, and conditions stated in text.

From: "Designing with Geosynthetics" Fourth Edition Robert M. Koerner 1999

NILEX NONWOVEN GEOTEXTILES

www.nilex.com

TECHNICAL SPECIFICATIONS

NILEX has Solutions

NILEX

Nilex Corporation 15171 E. Fremont Drive, Centennial, CO 80112 (303) 766-2000
Nilex Inc. Edmonton (780) 463-9535 • Calgary (403) 543-5454 • Vancouver (604) 420-6433 • Winnipeg (204) 925-4466

PROPERTY	TEST	UNITS	VALUE	NW35	NW40	NW45	NW60	NW70	NW80	NW100	NW120	NW160
PHYSICAL												
Unit	ASTM	oz/yd²	English	3.5	4.0	4.5	6.0	7.0	8.0	10.0	12.0	16.0
Weight	D-5261	g/m²	Metric	119	136	153	203	237	271	339	407	542
Grab Tensile	ASTM	lbs	English	95	110	120	160	180	205	250	300	380
Strength	D-4632	kN	Metric	0.422	0.489	0.533	0.711	0.800	0.911	1.110	1.33	1.69
Grab Elongation	ASTM D-4632	%	-	50	50	50	50	50	50	50	50	50
Puncture	ASTM	lbs	English	60	65	70	90	105	130	160	180	240
Strength	D-4833	kN	Metric	0.267	0.289	0.311	0.400	0.467	0.578	0.711	0.800	1.070
Mullen	ASTM	psi	English	200	215	240	315	350	400	520	600	800
Burst	D-3786	kPa	Metric	1378	1481	1654	2170	2412	2756	3583	4134	5512
Trapezoidal	ASTM	lbs	English	40	50	50	65	75	85	100	115	145
Tear	D-4533	kN	Metric	0.178	0.222	0.222	0.289	0.333	0.378	0.444	0.511	0.644
HYDRAULIC												
Apparent	ASTM	US Sieve	English	50	70	70	80	80	80	80	100	100
Opening Size	D-4751	mm	Metric	0.30	0.212	0.212	0.18	0.180	0.180	0.180	0.150	0.150
Permittivity	ASTM D-4491	sec^{-1}	-	2.2	2.0	1.8	1.6	1.5	1.4	1.2	1.0	0.7
Permeability	ASTM D-4491	cm/sec	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water Flow	ASTM	gpm/ft²	English	150	140	120	110	100	90	80	75	50
Rate	D-4491	l/min/m²	Metric	6095.00	5689	4885	4480	4074	3657	3251	3055	2035
ENDURANCE												
UV Resistance	ASTM D-4355	% Ret.	@ 500 hrs.	70	70	70	70	70	70	70	70	70
STANDARD PACKAGING												
Roll Width	Measured	ft	English	12.5 / 15	12.5 / 15	12.5 / 15	15	15	15	15	15	15
	Measured	m	Metric	3.8 / 4.6	3.8 / 4.6	3.8 / 4.6	4.6	4.6	4.6	4.6	4.6	4.6
Roll Length	Measured	ft	English	360	360	360	300	300	300	300	300	300
	Measured	m	Metric	110	110	110	91	91	91	91	91	91
Gross Weight	Measured	lbs	English	130/155	146/172	152/180	195	220	250	320	375	500
	Measured	kg	Metric	61/73	69/81	72/85	92	104	118	151	177	236
Roll Area	Calculated	yd²	English	500/600	500/600	500/600	500	500	500	500	500	500
	Calculated	m²	Metric	418 / 506	418 / 506	418 / 506	418	418	418	418	418	418

Notes: Values are MARV, reported in weaker principle direction. "MARV" indicates minimum average roll value calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample taken during quality assurance testing will exceed the value reported. * Reported in typical values

Permeability of Nilex Supplied NW 8 oz Amoco = 0.30 cm/sec

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Nilex Inc. Edmonton (780) 463-9535 • Calgary (403) 543-5454 • Vancouver (604) 420-6433 • Winnipeg (204) 925-4466

PROPERTY	TEST	UNITS	VALUE	W200	W300
MECHANICAL					
Grab Tensile	ASTM	lbs	English	200	300
Strength	D-4632	kN	Metric	0.889	1.33
Grab Elongation	ASTM D-4632	%	-	15	15
Puncture	ASTM	lbs	English	100	120
Strength	D-4833	kN	Metric	0.444	0.533
Mullen	ASTM	psi	English	400	600
Burst	D-3786	kPa	Metric	2756	4134
Trapezoidal	ASTM	lbs	English	75	100
Tear	D-4533	kN	Metric	0.333	0.444
HYDRAULIC					
App. Opening	ASTM	US Sieve	English	40-50	50
Size	D-4751	mm	Metric	0.425-0.30	0.3
Permittivity	ASTM D-4491	sec^{-1}	-	0.05	0.05
Water Flow Rate	ASTM	gpm/ft^2	English	4	4
	D-4491	$l/min/m^2$	Metric	163	163
ENDURANCE					
UV Resistance	ASTM	%Retained	English	70	70
	D-4355	@ 500 hrs	Metric	70	70
STANDARD PACKAGING					
Roll Width	Measured	ft	Typical	12.5 / 15	12.5 / 15
	Measured	m	Typical	3.8 / 4.6	3.8 / 4.6
Roll Length	Measured	ft	Typical	360	360
	Measured	m	Typical	110	110
Gross Weight	Measured	lbs	Typical	130/155	130/155
	Measured	kg	Typical	61/73	61/73
Roll Area	Calculated	yd^2	Typical	500/600	500/600
	Calculated	m^2	Typical	418 / 506	418 / 506

Notes: Values are MARV, reported in weaker principle direction. "MARV" indicates minimum average roll value calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample taken during quality assurance testing will exceed the value reported

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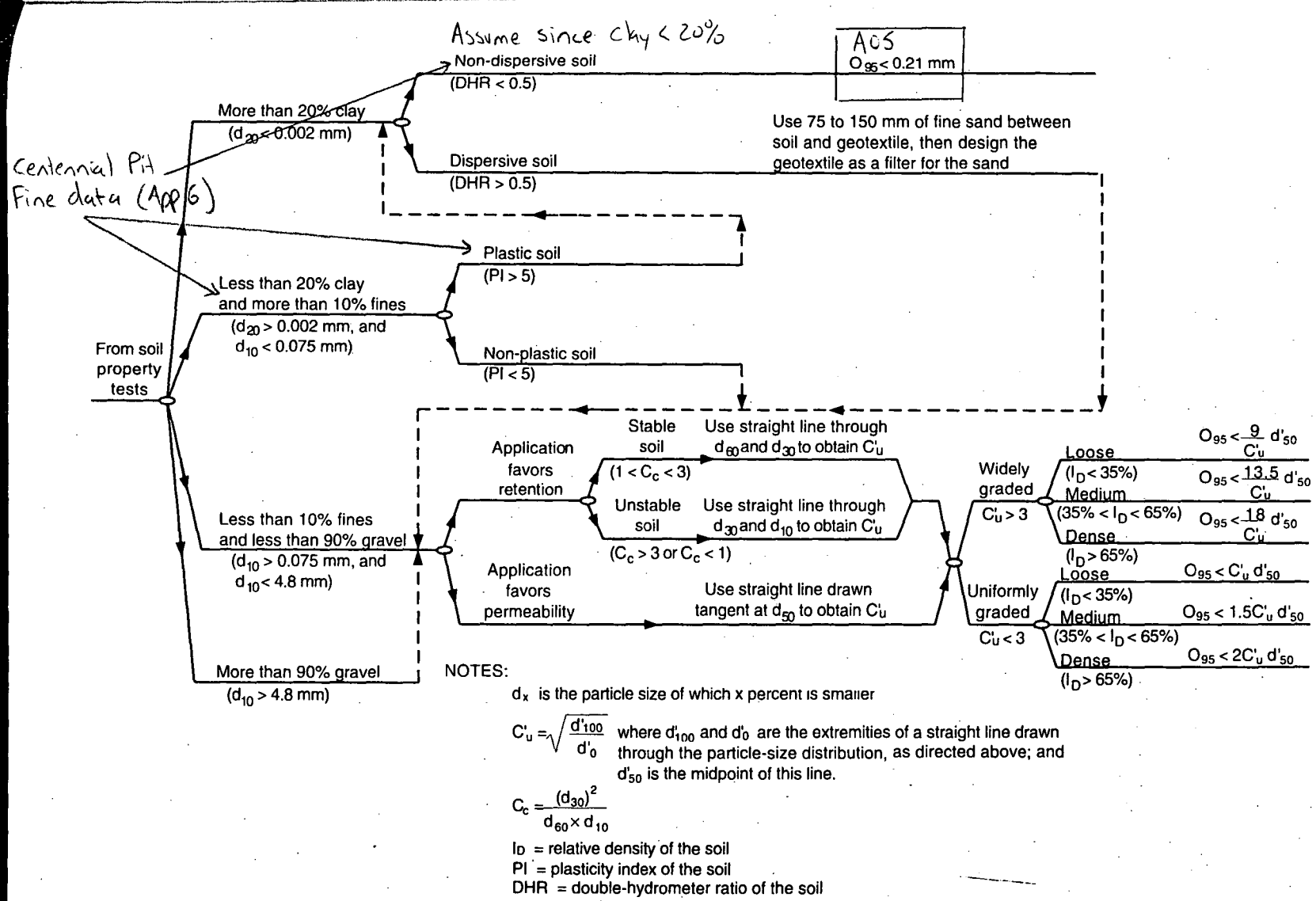


Figure 2.4 (a) Soil retention criteria for geotextile filter design using steady-state flow conditions. (After Luettich et al. [6])

APPENDIX E

ATTACHMENT 4

INFILTRATION CALCULATION SHEET
DRAINAGE ROCK INTO VALLEY FLOOR ALLUVIUM

INFILTRATION CALC SHEET
DRAINAGE ROCK INTO VALLEY FLOOR ALLUVIUM

Rocky Flats OLF Infiltration Zone — Date: 4/29/2005

Designed by: CAB

Given

Using Darcy's Law $Q = -KA \{d(h)/d(l)\}$

Where
- Q = discharge (gpd/ft^2)
- K = hydraulic conductivity (gpd/ft^2)
- A = area (ft^2)
- {d(h)/d(l)} = hydraulic gradient (ft/ft) or head

Conductivity varies in a fluvial system due to interconnected beds or layers of silty clay and clayey sand and gravels.
Mean hydraulic conductivity = 9.74 m/day

	m/day	gpd/ft^2
K (mean value from permeability test)	9.738144	238.9740538
Minimum Design Criteria: Q = 1 gal/min		
Area of representative infiltration zone		62,400 ft^2

Assumptions* - Only 10% of the high conductivity beds or layers will be directly connected to the drain rock.

Adjusted infiltration area due to minimal contact with high infiltration zone = 6,240 ft^2

Solving for Q $Q = -KA (d(h)/d(l))$

K (gpd/ft^2)=	238.9741
A (ft^2) - adjusted to 10%	6,240.0
d(h) (ft)	1.0
d(l) (ft)	1.0
Q (gal. / day)=	1,491,198.1
Q (gal / minute) =	**1,035.5542**

Average conductivity rates were based on slug test, pump test and recovery test from the following well IDs 00293, 00491, 13491, 1586, 3586, 3886, 5686, 6586, 6886, 7086, B102289, B202489, B202589, B302889, O-1, O-2, O-3, I-1, I-2.

APPENDIX E

ATTACHMENT 2
PRODUCT SPECIFICATION STRUCTURAL GEOGRID BX 1200

EARTH TECH

A Tyco Infrastructure Services Company

CALCULATION SHEET

PROJECT NO. 57378.6040

CLIENT K-H

PROJECT RFETS OLF

SUBJECT Geotextile Selection

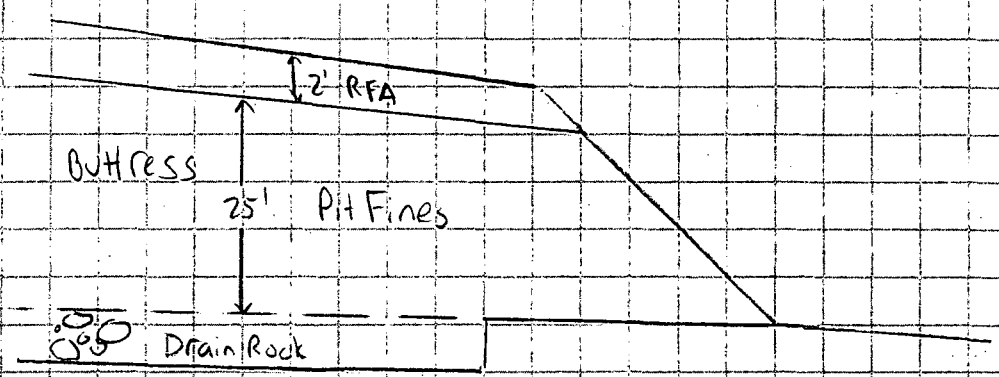
Prepared By REA DATE 4/15/05

Reviewed By RCT DATE 4/15/05

Approved By RCT DATE 4/15/05

Purpose: Determine appropriate separation geotextile type and weight for installation between buttress and drain rock.

Given:



Layer	Material	Thickness	Unit Weight (lb/ft^3)
Buttress	Pit Fines	25' see Drawing 004 (add ~5' to maximum)	138.0 see Appendix B
Soil Cover	RFA	2'	142.3 see Appendix B

Puncture Strength

Determine required puncture strength of geotextile using Figure 2.32 of "Designing with Geosynthetics" Fourth Edition Koerner. See attached

Pressure at geotextile-rock interface:

$$2\,ft\left(142.3\,\frac{lb}{ft^3}\right) + 25\,ft\left(138.0\,\frac{lb}{ft^3}\right) = 3734.6\,\frac{lb}{ft^2} \approx 178.8\ KPa$$

INFILTRATION CALC SHEET
DRAINAGE ROCK INTO VALLEY FLOOR ALLUVIUM USING TWO WELLS NEAR THE OLF BUTTRESS AND WOMAN CREEK

The permeability tests from nineteen wells were originally evaluated for infiltration into the valley floor alluvium. From these nineteen wells, two wells, located near the buttress and Woman Creek were evaluated to address concerns of using wells outside of the buttress area. The calculations are shown below.

Rocky Flats OLF infiltration zone - Wells 7086 & 5686 Date: 5/11/2005

Designed by: CAB

Using Darcy's Law Q = -KA {d(h)/d(l)}

Where Q = Discharge (GPD/ft^2)

K = hydraulic conductivity (GPD/ft^2)

A = Area Ft^2)

{d(h)/d(l)} = hydraulic gradient (ft/ft) or Head

Conductivity varies in a fluvial system due to interconnected beds or layers of silty clay and clayey sand and gravels.

Well ID	Zone tested	Saturated Thickness	Depth to Water	K cm/sec	K ft/day	m/day	Gal/day/ft
5686	6.16-9.6'	3.44	6.16	5.43E-06	0.0154		
				3.20E-04	0.907		
				3.20E-04	0.907		
			Average	2.15E-04	0.61	0.19	4.56
7086	1.7-7.9'	6.16	1.74	1.50E-04	0.425		
				2.10E-04	0.595		
			Average	1.80E-04	5.10E-01	0.16	3.82
					Average	0.17	4.19

Minimum Design Criteria: Q = 1 Gal/min

Area of representative infiltration zone 62,400 ft^2

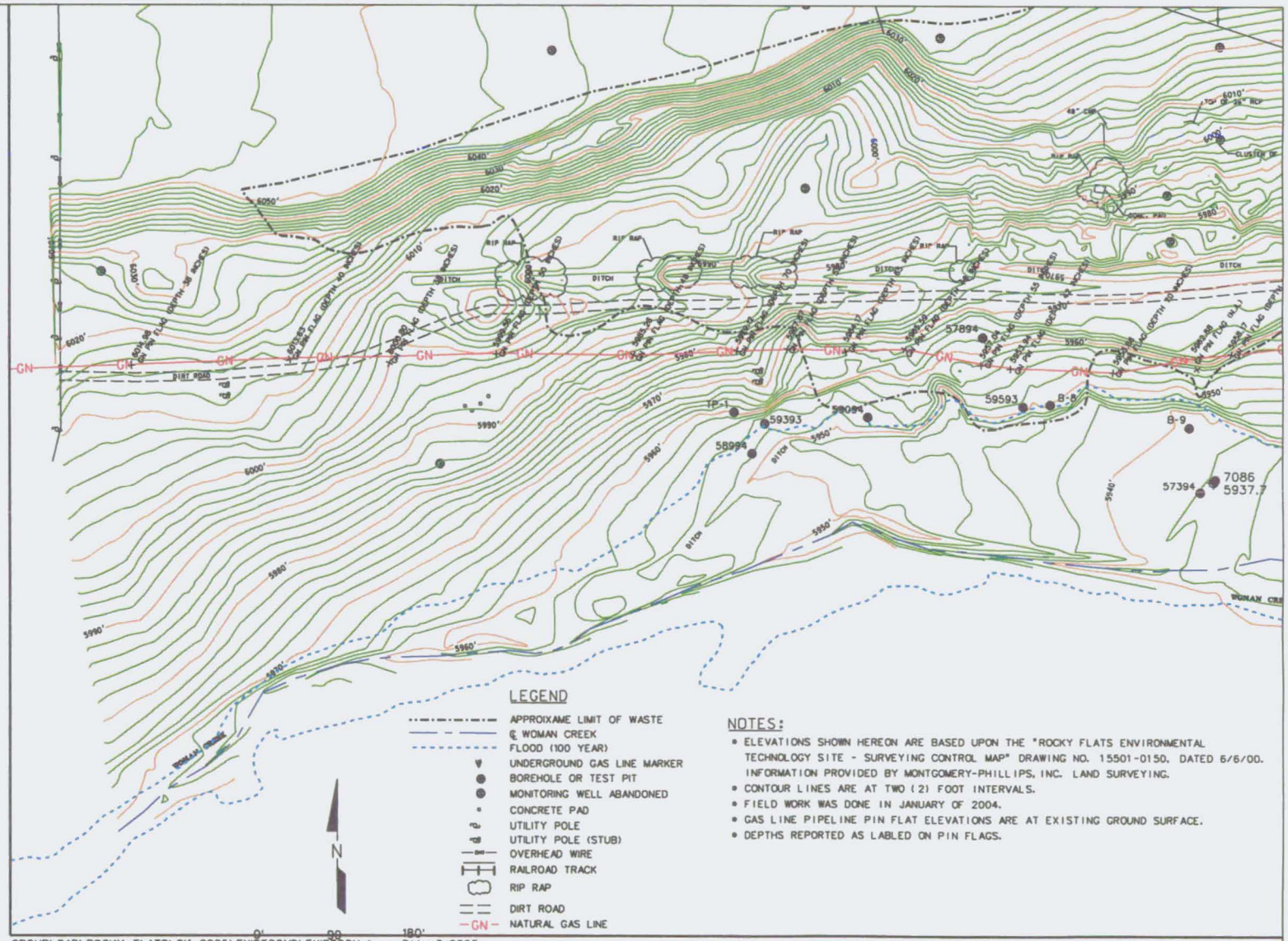
Assumptions* - Only 10% of the high conductivity beds or layers will be directly connected to the drain rock

Adjusted infiltration area due to minimal contact with high infiltration zone = 6,240 ft^2

Solving for Q = -KA (d(h)/d(l))

K (GPD/ft^2)=	4.17
A (Ft^2) - adjusted to 10%	6240.0
d(h) (ft)	1.0
d(l) (ft)	1.0
Q (gal. / day)=	26,020.8
Q= Gal / minute	**18.07**

**Calculated using test from wells 7086 and 5686. A total of 5 test were completed that were determined usable. An average conductivity from these 2 wells were used to calculate infiltration rates using the same 10% area exposed to areas of these infiltration zones.



NOTES:

- ELEVATIONS SHOWN HEREON ARE BASED UPON THE "ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE - SURVEYING CONTROL MAP" DRAWING NO. 15501-0150, DATED 6/6/00. INFORMATION PROVIDED BY MONTGOMERY-PHILLIPS, INC. LAND SURVEYING.
- CONTOUR LINES ARE AT TWO (2) FOOT INTERVALS.
- FIELD WORK WAS DONE IN JANUARY OF 2004.
- GAS LINE PIPELINE PIN FLAT ELEVATIONS ARE AT EXISTING GROUND SURFACE.
- DEPTHS REPORTED AS LABLED ON PIN FLAGS.

5686
5987.5

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Appendix F

APPENDIX F

LANDFILL ENGINEERING – FINAL DESIGN
EVALUATION OF 100-YEAR EVENT FROM WOMAN CREEK
ON THE TOE OF THE BUTTRESS

APPENDIX F

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE ACCELERATED ACTION DESIGN FOR THE ORIGINAL LANDFILL

LANDFILL ENGINEERING – FINAL DESIGN EVALUATION OF 100-YEAR EVENT FROM WOMAN CREEK ON THE TOE OF THE BUTTRESS

MAY 11, 2005

Prepared by:

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(303) 694-6660

This calculation was performed by Earth Tech, Inc. Although each sheet composing this calculation may or may not be initialed, it has nonetheless been reviewed and checked.

Prepared By: CB Date: 4/12/05

Checked By: RT Date: 4/12/05

Approved By: RT Date: 4/12/05

LIST OF TABLES

Table F-1 Original Landfill – Channel Stability

LIST OF ATTACHMENTS

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Attachment 2 Calculations for Cross-Section C-C′ Using V=Q/A and Chezy's Equation
Attachment 3 North American Green ECMS Calculations Cross Sections A-A′ through D-D′

1.0 INTRODUCTION

This evaluation of a 100-year storm event on the buttress was developed to address potential storm water impacts on the Original Landfill (OLF) Accelerated Action that may arise from Woman Creek's flood plain.

This evaluation addresses the following element:

1. The erosion surface at the toe of the buttress at the OLF Accelerated Action Site.

2.0 LANDFILL DESCRIPTION, LOCATION AND DRAINAGE

The OLF site is located south of Rocky Flats Environmental Technology Site (RFETS) Buildings 440 and 460, along the north hillside of a ravine in the Woman Creek drainage area, extending from an approximate elevation of 6,040 feet at the top to an elevation of 5,950 feet at its base. Waste operations began in the early 1950s and continued through 1968. The OLF site footprint has a maximum length along the east-west direction of approximately 1,700 feet and approximately 500 feet in the north-south direction, with an approximate area on the order of 20 acres.

3.0 REFERENCES

The surface water management system for the OLF was evaluated using guidelines provided in the following documents:

1. "SEDCAD 4 for Windows 95/98 & NT," Design Manual and User's Guide, 2001.
2. "Urban Storm Drainage Criteria Manual" (Drainage Manual), Denver Urban Drainage and Flood Control District.
3. "Erosion Control Materials Design Software Version 4.2 for Windows," North American Green, 2002.
4. "Applied Hydrology and Sedimentology for Disturbed Areas," B.J. Barfield, R.C. Warner and C.T. Haan, 1981.

4.0 EVALUATION CRITERIA

The attached North American Green model was used to evaluate the existing drainage characteristics of Woman Creek's 100-year flood plain. The model evaluated the following.

1. Encroachment of the OLF buttress on the Woman Creek 100-year flood plain. See Attachment 1 for the estimated 100-year flood plain.
2. Effectiveness of the buttress cover from erosion from Woman Creek's 100-year flood plain.

5.0 HYDROLOGIC AND HYDRAULIC DESIGN APPROACH

Velocities in Woman Creek during the 100-year event were evaluated using three separate methodologies. The first methodology, being the simplest and least accurate, was Q=AV to determine the overall velocities in the channel. The second methodology used Chezy's equations to take into consideration the channel configuration (using the wetted perimeter as depicted on the 100-year event map) and the channel roughness due to vegetation. The final analysis was completed using the North American Green model, which uses a modified Chezy's equation to incorporated different side slopes and vegetation. See Attachment 2 for the calculations.

To understand the variability of the three methods, cross-section C-C′ was evaluated to validate each of the methods. At cross-section C-C′ the three different techniques showed that velocities ranged from 1.1 feet per second (fps) for V=Q/A, to 4.8 fps based on Chezy's equation, and the North American Green model showed 3.0 fps.

It was determined that the North American Green model would more closely model natural conditions by allowing input of both right and left bank slopes along with channel characteristics.

Four cross-sections were completed across Woman Creek to the buttress. Cross-sections A-A′ through C-C′ were spaced throughout the native channel configurations. A forth cross-section, D-D′, was created at the narrowest point in the valley using the buttress design location. This cross section was used to evaluate a worst-case scenario. A comparative analysis was completed at cross-sections A-A′ through C-C′ using the assumption that the channel bottom was narrowed due to constriction from the buttress. Table F-1 summarizes these analyses (see Attachment 3).

Table F-1
Original Landfill – Channel Stability

Natural Channel							
Evaluated Cross Section	**Channel Width**	**Left Side Slope**	**Right Side Slope**	**Channel Bottom**	**Design Depth**	**Average Stream Velocities**	**Stability**
A-A′	208	12:1	60:1	64	1.57	2.55	Stable
B-B′	216	19:1	12:1	136	1.10	2.86	Stable
C-C′	160	17:1	12:1	48	1.96	3.05	Stable
D-D′	NA	NA	NA	NA	NA	NA	NA

Channel with Buttress							
Evaluated Cross Section	**Channel Width**	**Left Side Slope**	**Right Side Slope**	**Channel Bottom**	**Design Depth**	**Average Stream Velocities**	**Stability**
A-A′	152	3:1	60:1	24	2.02	2.71	Stable
B-B′	140	3:1	12:1	80	1.32	4.06	Stable
C-C′	160	17:1	12:1	48	1.21	4.2	Stable
D-D′	132	3:1	24:1	104	1.21	3.31	Stable

6.0 CONCLUSIONS

Calculations were based on the 480-cubic-foot-per-second (cfs) discharge rate provided to Earth Tech via Mike Keating from Diana Woods and the site topography (State Plain Coordinate projection (3476) NAD 27) as depicted on the CH2MHill map also provided to Earth Tech on 3/14/2005. The recent OLF topography survey (January 2004) did not extend up the opposite side of Woman Creek; therefore, the old base map topography was used.

In each of these cross-sections, the buttress remained stable under the modeled parameters, which did not model the use of erosional mats. Although not required from this analysis to aid in this stabilization, C350 Permanent Turf reinforcement will cover the toe of the buttress to aid in stabilizing the soil until sufficient vegetation is established due to the construction of the buttress. Revegetative species may include short woody species such as willow in this valley fill area.

Although the 100-year flood plain map indicated the depth reaches over 4 feet, this could not be duplicated in this evaluation. These increased depths may be due to hydraulic control outside of the analysis area. Given a discharge of 480 cfs, if the depth did increase, the velocities would decrease to balance Q = AV.

This analysis indicates minimal erosion and the buttress's side slope will remain stable during the 100-year event from Woman Creek.

Calculation by: CA Boudreau

Evaluation of V=Q/A and Chezy's Equation

Given:

Q = 480 cubic feet per second
A = cross-sectional area of 100-year flood plain map at given cross-section
S = channel slope
WP = wetted perimeter of channel cross-section
R = A/WP
N = 0.10 for a very weedy reach (min 0.075 to max 0.15)

V = Q/A

V=480cfs/437.5ft^2 = 1.1 fps

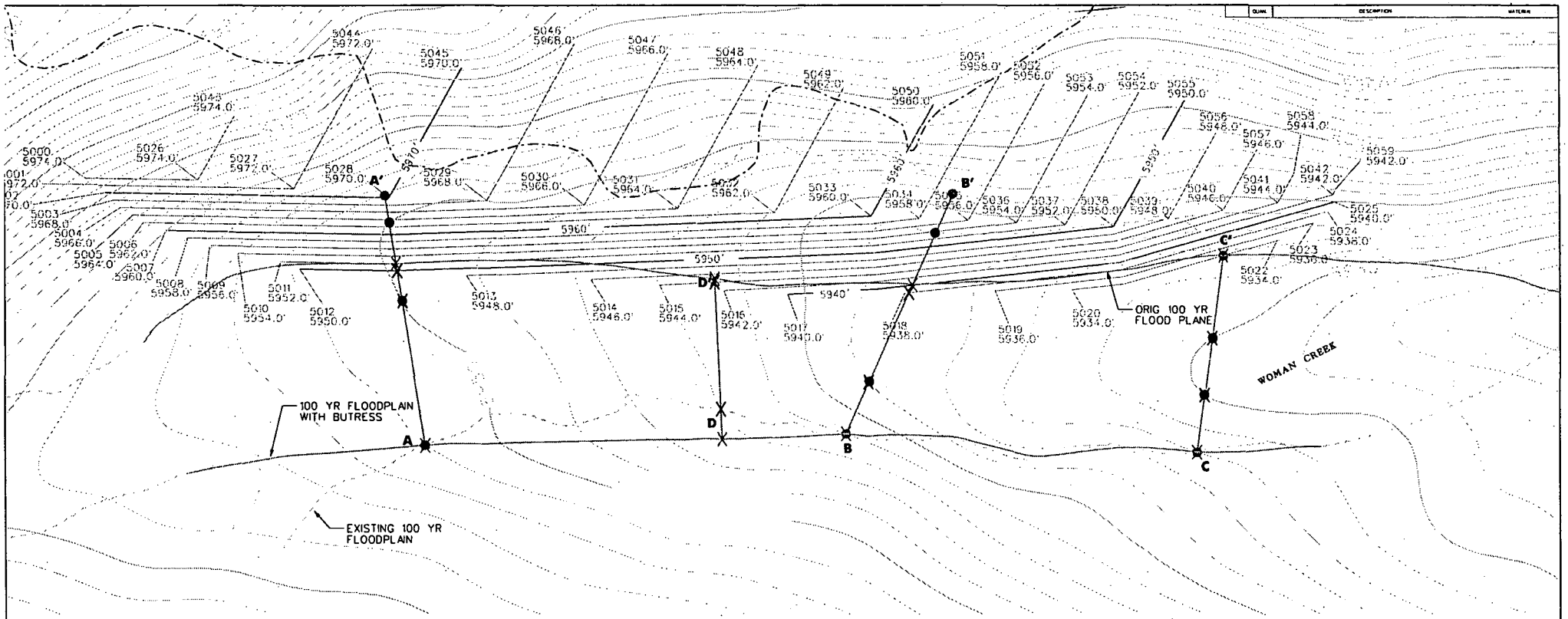
Chezy's Equation

WP = 437.5/164.4 = 2.66

V = 1.49/N*(R)^0.666*(S)^0.5
V = 1.49/.1*(2.66)^0.666*(0.0284)^0.5 = 4.8 fps

APPENDIX F

ATTACHMENT 1
ESTIMATED 100-YEAR FLOOD PLAIN



LEGEND

- ● NATURAL CHANNEL BOTTOM
- X CHANNEL BOTTOM WITH BUTTRESS
- ● NATURAL CHANNEL WIDTH
- X CHANNEL WIDTH WITH BUTTRESS
- - - - EXISTING 100 YR FLOODPLAIN
- —— FLOODPLAIN WITH BUTTRESS

N

0' 40 80'

REVISION DESCRIPTION										
ISSUE	DESIGN COMPANY	DATE	DSGN	DWN	CHKD	EN	APVD		CLASS	PROJECT/CHARGE NO.
0	ORIGINAL ISSUE									

KEYWORDS
1.
2.
3.
4.
5.

DESCRIPTION

DESIGN COMPANY

DESIGNED BY R. ARCHIBALD 2/18/04
DRAWN BY A. BROTHER
CHECKED BY R. THOMPSON
REVIEWED BY S. LAWRENCE
APPROVED BY R. THOMPSON
CLASSIFIED
LANDLORD

TOLERANCES
FRACT ±
DEC ±
ANGLES ±
REMOVE BURRS AND SHARP EDGES
NA
SCALE: AS SHOWN

PROJECT/WO NO. 89693
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS OFFICE GOLDEN, COLORADO
Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

100 YEAR STORM WATER ANALYSIS OF WOMAN CREEK
ORIGINAL LANDFILL ACCELERATED ACTION DESIGN

SIZE B | DRAWING NUMBER | ISSUE 0

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APPENDIX F

ATTACHMENT 2
CALCULATIONS FOR CROSS-SECTION C-C′ USING V=Q/A AND CHEZY'S EQUATION

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY
5575 DTC Parkway, Suite 200
Englewood, Colorado 80111

Sheet F2-1

Project: Rocky Flats Environmental Technology Site – Original Landfill Closure Project No. 57378.4001 Date: 5/9/05

Subject: Landfill Engineering – Surface Water Management System Assessment

By: REA Date: 5/9/05 Chk By: _____ Date: _____ App By: _____ Date: _____

Calculation by: CA Boudreau

Evaluation of V=Q/A and Chezy's Equation

Given:

Q = 480 cubic feet per second
A = cross-sectional area of 100-year flood plain map at given cross-section
S = channel slope
WP = wetted perimeter of channel cross-section
R = A/WP
N = 0.10 for a very weedy reach (min 0.075 to max 0.15)

V = Q/A

$V = 480CFS/437.5ft^2 =$ 1.1 fps

Chezy's Equation

WP = 437.5/164.4 = 2.66

V = 1.49/N*(R)^0.666*(S)^0.5
V = 1.49/.1*(2.66)^0.666*(0.0284)^0.5 = 4.8 fps

APPENDIX F

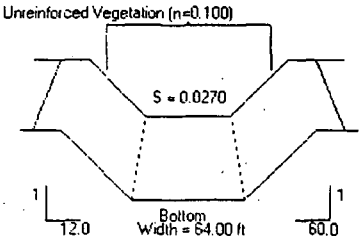
ATTACHMENT 3
NORTH AMERICAN GREEN ECMS CALCULATIONS
CROSS-SECTIONS A-A′ THROUGH D-D′

North American Green - ECMDS Version 4.3		4/11/2005 01:08 PM	COMPUTED BY: CAB
PROJECT NAME: Rocky Flats - OLF		PROJECT NO.: NATURAL	
FROM STATION/REACH: A-A''	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY: 100 YR

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
480.0	5.0	2.55	188.41	1.07	1.57

Unreinforced Vegetation (n=0.100)



Not to Scale

LINER RESULTS

Reach	Matting Type	Stability Analysis	Vegetation Characteristics				Permissible Shear Stress (psf)	Calcuated Shear Stress (psf)	Safety Factor	Remarks
	Staple Pattern		Phase	Class	Type	Density				
Straight	Unreinforced	Vegetation		B	Mix	75-95%	5.73	2.64	2.17	STABLE
		Soil	Sandy Loam				0.035	0.016	2.18	STABLE

Back to Input Screen

```
"*************************************************************************
NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.3
NORTH AMERICAN GREEN CHANNEL PROTECTION - ENGLISH/S.I.
USER SPECIFIED CHANNEL LINING BACK-UP COMPUTATIONS
*************************************************************************

PROJECT NAME: Rocky Flats - OLF          PROJECT NO.: Natural Channel
COMPUTED BY: CAB                         DATE: 4/11/2005
FROM STATION/REACH: A-A'                 TO STATION/REACH:
DRAINAGE AREA:                           DESIGN FREQUENCY: 100 YR

*************************************************************************
                          INPUT PARAMETERS
*************************************************************************

Channel Discharge     : 480.0 cfs  (13.58 m^3/s)
Peak Flow Period      : 5  hours
Channel Slope         : 0.027 ft/ft  (0.027 m/m)
Channel Bottom Width  : 64.0 ft (19.51 m)
Left Side Slope       : 12:1
Right Side Slope      : 60:1

Channel Lining : Unreinforced Vegetation  Mix 75-95%
Permi. Shear(Tp) :5.73 psf (274.4 Pa)
               Phase = 1
               Class = B Vegetation
               Soil  = Sandy Loam
               Allowable Soil Shear(Ta):0.035 psf (1.67580000713468 Pa)

*************************************************************************
                           CALCULATIONS
*************************************************************************

Initial Depth Estimate = 0.16 * (480.0 /(0.027^0.5))^0.375 = 3.19 ft (.97 m)
Final Channel Depth (after 9 iterations)                   = 1.57 ft (0.48 m)
Flow Area = (64.0 * 1.6)+(0.5 *1.57^2 * (12.0+60.0))       = 188.4 sq.ft (17.5 m^2)
Wet Per. =64.0 +(1.6*(((12.0^2)+1)^.5 +((60.0^2)+1)^.5))   = 176.8 ft (53.9 m)
Hydraulic Radius = (188.4 / 176.8)                         = 1.1 ft (0.3 m)
Channel Velocity =(1.486/0.100)*(1.1^0.667)*(0.027^.5)     = 2.5 fps (0.8 m/s)

Channel Effective Manning's Roughness                      = 0.100
Calculated Shear (Td) = 62.4 * 1.57 * 0.027                = 2.64 psf (126.3 Pa)
Safety Factor = (Tp/Td) = (5.73 /2.64)                     = 2.17

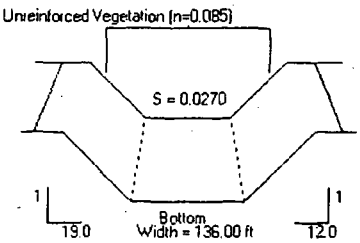
Effective Stress on Soil (Te)=2.6*(1-0.75)*(0.0156/0.100)^2 =0.02 psf (0.8 Pa)
Safety Factor = (Ta/Te) = (0.04 /0.016)                    =  2.18
```

North American Green - ECMDS Version 4.3	4/12/2005	02:59 PM	COMPUTED BY: CAB
PROJECT NAME: Rocky Flats OLF	PROJECT NO.: Natural		
FROM STATION/REACH: B-B'	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY: 100 yr

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
480.0	5.0	2.86	168.03	0.99	1.10

Unreinforced Vegetation (n=0.085)



Not to Scale

LINER RESULTS

Reach	Matting Type	Stability Analysis	Vegetation Characteristics				Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
	Staple Pattern		Phase	Class	Type	Density				
Straight	Unreinforced	Vegetation		B	Mix	75-95%	5.73	1.85	3.10	STABLE
		Soil	Sandy Loam				0.035	0.016	2.23	STABLE

Back to Input Screen

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"*************************************************************************
NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.3
NORTH AMERICAN GREEN CHANNEL PROTECTION - ENGLISH/S.I.
USER SPECIFIED CHANNEL LINING BACK-UP COMPUTATIONS
*************************************************************************

PROJECT NAME: Rocky Flats OLF              PROJECT NO.: Natural
COMPUTED BY: CAB                           DATE: 4/12/2005
FROM STATION/REACH: B-B'                   TO STATION/REACH:
DRAINAGE AREA:                             DESIGN FREQUENCY: 100 yr

*************************************************************************
                          INPUT PARAMETERS
*************************************************************************

Channel Discharge     : 480.0 cfs  (13.58 m^3/s)
Peak Flow Period      : 5  hours
Channel Slope         : 0.027 ft/ft  (0.027 m/m)
Channel Bottom Width  : 136.0 ft (41.45 m)
 ft Side Slope        : 19:1
Right Side Slope      : 12:1

Channel Lining : Unreinforced Vegetation  Mix 75-95%
Permi. Shear(Tp) :5.73 psf (274.4 Pa)
               Phase = 1
               Class = B Vegetation
               Soil  = Sandy Loam
               Allowable Soil Shear(Ta):0.035 psf (1.67580000713468 Pa)

*************************************************************************
                           CALCULATIONS
*************************************************************************

Initial Depth Estimate = 0.16 * (480.0 /(0.027^0.5))^0.375 = 3.19 ft (.97 m)
Final Channel Depth (after 10 iterations)                  = 1.1 ft (0.33 m)
Flow Area = (136.0 * 1.1)+(0.5 *1.10^2 * (19.0+12.0))      = 168.0 sq.ft (15.6 m^2)
Wet Per. =136.0 +(1.1*(((19.0^2)+1)^.5 +((12.0^2)+1)^.5)) = 170.1 ft (51.9 m)
Hydraulic Radius = (168.0 / 170.1)                         = 1.0 ft (0.3 m)
Channel Velocity =(1.486/0.085)*(1.0^0.667)*(0.027^.5)     = 2.9 fps (0.9 m/s)

Channel Effective Manning's Roughness                      = 0.085
Calculated Shear (Td) = 62.4 * 1.10 * 0.027                = 1.85 psf (88.6 Pa)
Safety Factor = (Tp/Td) = (5.73 /1.85)                     = 3.10

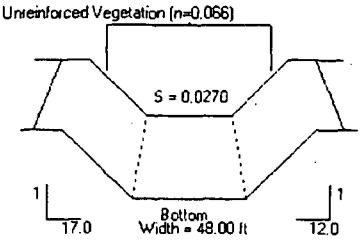
Effective Stress on Soil (Te)=1.9*(1-0.75)*(0.0156/0.085)^2 =0.02 psf (0.7 Pa)
 afety Factor = (Ta/Te) = (0.04 /0.016)                    =  2.23
```

North American Green : ECMDS Version 4.3	4/12/2005 03:18 PM	COMPUTED BY: CAB	
PROJECT NAME: Rocky Flats OLF		PROJECT NO.: Natural	
FROM STATION/REACH: C-C'	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY: 100 yr

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq ft)	Hydraulic Radius(ft)	Normal Depth (ft)
480.0	5.0	4.20	114.19	1.21	1.60

Unreinforced Vegetation (n=0.066)



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LINER RESULTS

Reach	Matting Type	Stability Analysis	Vegetation Characteristics				Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
	Staple Pattern		Phase	Class	Type	Density				
Straight	Unreinforced	Vegetation		B	Mix	75-95%	5.73	2.70	2.12	STABLE
		Soil	Sandy Loam				0.035	0.038	0.92	UNSTABLE

Back to Input Screen

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"*************************************************************************
NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.3
NORTH AMERICAN GREEN CHANNEL PROTECTION - ENGLISH/S.I.
USER SPECIFIED CHANNEL LINING BACK-UP COMPUTATIONS
*************************************************************************

PROJECT NAME: Rocky Flats OLF            PROJECT NO.: Natural
COMPUTED BY: CAB                         DATE: 4/12/2005
FROM STATION/REACH: C-C'                 TO STATION/REACH:
DRAINAGE AREA:                           DESIGN FREQUENCY: 100 yr

*************************************************************************
                          INPUT PARAMETERS
*************************************************************************

Channel Discharge     : 480.0 cfs  (13.58 m^3/s)
Peak Flow Period      : 5  hours
Channel Slope         : 0.027 ft/ft  (0.027 m/m)
 hannel Bottom Width  : 48.0 ft (14.63 m)
 eft Side Slope       : 17:1
Right Side Slope      : 12:1

Channel Lining : Unreinforced Vegetation  Mix 75-95%
Permi. Shear(Tp) :5.73 psf (274.4 Pa)
               Phase = 1
               Class = B Vegetation
               Soil  = Sandy Loam
               Allowable Soil Shear(Ta):0.035 psf (1.67580000713468 Pa)

*************************************************************************
                           CALCULATIONS
*************************************************************************

Initial Depth Estimate = 0.16 * (480.0 /(0.027^0.5))^0.375 = 3.19 ft (.97 m)
Final Channel Depth (after 9 iterations)                   = 1.6 ft (0.49 m)
Flow Area = (48.0 * 1.6)+(0.5 *1.60^2 * (17.0+12.0))       = 114.2 sq.ft (10.6 m^2)
Wet Per. =48.0 +(1.6*(((17.0^2)+1)^.5 +((12.0^2)+1)^.5))   = 94.6 ft (28.8 m)
Hydraulic Radius = (114.2 / 94.6)                          = 1.2 ft (0.4 m)
Channel Velocity =(1.486/0.066)*(1.2^0.667)*(0.027^.5)     = 4.2 fps (1.3 m/s)

Channel Effective Manning's Roughness                      = 0.066
Calculated Shear (Td) = 62.4 * 1.60 * 0.027                = 2.70 psf (129.3 Pa)
Safety Factor = (Tp/Td) = (5.73 /2.70)                     = 2.12

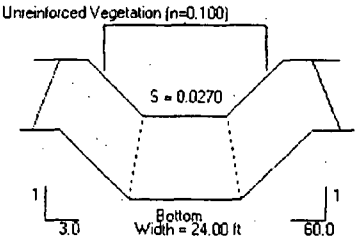
ffective Stress on Soil (Te)=2.7*(1-0.75)*(0.0156/0.066)^2 =0.04 psf (1.8 Pa)
 afety Factor = (Ta/Te) = (0.04 /0.038)                    =  0.92
```

North American Green - ECMDS Version 4.3	4/11/2005 01:07 PM	COMPUTED BY: CAB	
PROJECT NAME: Rocky Flats - OLF		PROJECT NO.: WITH BUTTRESS	
FROM STATION/REACH: A-A"	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY: 100 YR

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
480.0	5.0	2.71	177.22	1.17	2.02

Unreinforced Vegetation (n=0.100)



Not to Scale

LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Unreinforced	Vegetation		B	Mix	75-95%	5.73	3.41	1.68	STABLE
		Soil	Sandy Loam				0.035	0.021	1.69	STABLE

Back to Input Screen

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"*************************************************************************
NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.3
NORTH AMERICAN GREEN CHANNEL PROTECTION - ENGLISH/S.I.
USER SPECIFIED CHANNEL LINING BACK-UP COMPUTATIONS
*************************************************************************

PROJECT NAME: Rocky Flats - OLF          PROJECT NO.: WITH BUTTRESS
COMPUTED BY: CAB                         DATE: 4/11/2005
FROM STATION/REACH: A-A""                 TO STATION/REACH:
DRAINAGE AREA:                           DESIGN FREQUENCY: 100 YR

*************************************************************************
                          INPUT PARAMETERS
*************************************************************************

Channel Discharge     : 480.0 cfs  (13.58 m^3/s)
Peak Flow Period      : 5  hours
Channel Slope         : 0.027 ft/ft  (0.027 m/m)
Channel Bottom Width  : 24.0 ft (7.32 m)
  ft Side Slope       : 3:1
Right Side Slope      : 60:1

Channel Lining : Unreinforced Vegetation  Mix 75-95%
Permi. Shear(Tp) :5.73 psf (274.4 Pa)
               Phase = 1
               Class = B Vegetation
               Soil  = Sandy Loam
               Allowable Soil Shear(Ta):0.035 psf (1.67580000713468 Pa)

*************************************************************************
                           CALCULATIONS
*************************************************************************

Initial Depth Estimate = 0.16 * (480.0 /(0.027^0.5))^0.375 = 3.19 ft (.97 m)
Final Channel Depth (after 8 iterations)                   = 2.02 ft (0.62 m)
Flow Area = (24.0 * 2.0)+(0.5 *2.02^2 * (3.0+60.0))        = 177.2 sq.ft (16.5 m^2)
Wet Per. =24.0 +(2.0*(((3.0^2)+1)^.5 +((60.0^2)+1)^.5))    = 151.7 ft (46.2 m)
Hydraulic Radius = (177.2 / 151.7)                         = 1.2 ft (0.4 m)
Channel Velocity =(1.486/0.100)*(1.2^0.667)*(0.027^.5)     = 2.7 fps (0.8 m/s)

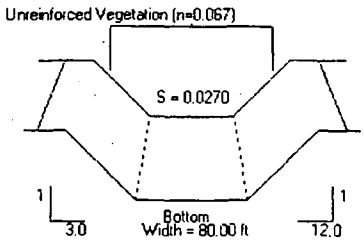
Channel Effective Manning's Roughness                      = 0.100
Calculated Shear (Td) = 62.4 * 2.02 * 0.027                = 3.41 psf (163.1 Pa)
Safety Factor = (Tp/Td) = (5.73 /3.41)                     = 1.68

Effective Stress on Soil (Te)=3.4*(1-0.75)*(0.0156/0.100)^2 =0.02 psf (1.0 Pa)
 Safety Factor = (Ta/Te) = (0.04 /0.021)                   =  1.69
```

North American Green : ECMDS Version 4.3	4/12/2005 03:05 PM	COMPUTED BY: CAB	
PROJECT NAME: Rocky Flats OLF		PROJECT NO.: With Buttress	
FROM STATION/REACH: B-8'	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY: 100 yr

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
480.0	5.0	4.06	118.32	1.18	1.32



Not to Scale

LINER RESULTS

Reach	Matting Type	Stability Analysis	Vegetation Characteristics				Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
	Staple Pattern		Phase	Class	Type	Density				
Straight	Unreinforced	Vegetation		B	Mix	75-95%	5.73	2.22	2.58	STABLE
		Soil	Sandy Loam				0.035	0.030	1.18	STABLE

Back to Input Screen

```
"*************************************************************************
NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.3
NORTH AMERICAN GREEN CHANNEL PROTECTION - ENGLISH/S.I.
USER SPECIFIED CHANNEL LINING BACK-UP COMPUTATIONS
*************************************************************************

PROJECT NAME: Rocky Flats OLF            PROJECT NO.: With Buttress
COMPUTED BY: CAB                         DATE: 4/12/2005
FROM STATION/REACH: B-B'                 TO STATION/REACH:
DRAINAGE AREA:                           DESIGN FREQUENCY: 100 yr

*************************************************************************
                          INPUT PARAMETERS
*************************************************************************

Channel Discharge     : 480.0 cfs  (13.58 m^3/s)
Peak Flow Period      : 5  hours
Channel Slope         : 0.027 ft/ft  (0.027 m/m)
  annel Bottom Width  : 80.0 ft (24.38 m)
 .ft Side Slope       : 3:1
Right Side Slope      : 12:1

Channel Lining : Unreinforced Vegetation  Mix 75-95%
Permi. Shear(Tp) :5.73 psf (274.4 Pa)
               Phase = 1
               Class = B Vegetation
               Soil  = Sandy Loam
               Allowable Soil Shear(Ta):0.035 psf (1.67580000713468 Pa)

*************************************************************************
                           CALCULATIONS
*************************************************************************

Initial Depth Estimate = 0.16 * (480.0 /(0.027^0.5))^0.375 = 3.19 ft (.97 m)
Final Channel Depth (after 10 iterations)                  = 1.32 ft (0.40 m)
Flow Area = (80.0 * 1.3)+(0.5 *1.32^2 * (3.0+12.0))        = 118.3 sq.ft (11.0 m^2)
Wet Per. =80.0 +(1.3*(((3.0^2)+1)^.5 +((12.0^2)+1)^.5))    = 100.0 ft (30.5 m)
Hydraulic Radius = (118.3 / 100.0)                         = 1.2 ft (0.4 m)
Channel Velocity =(1.486/0.067)*(1.2^0.667)*(0.027^.5)     = 4.1 fps (1.2 m/s)

Channel Effective Manning's Roughness                      = 0.067
Calculated Shear (Td) = 62.4 * 1.32 * 0.027                = 2.22 psf (106.2 Pa)
Safety Factor = (Tp/Td) = (5.73 /2.22)                     = 2.58

 ffective Stress on Soil (Te)=2.2*(1-0.75)*(0.0156/0.067)^2 =0.03 psf (1.4 Pa)
 afety Factor = (Ta/Te) = (0.04 /0.030)                    =  1.18
"
```

North American Green : ECMDS Version 4.3 | 4/12/2005 03:06 PM | COMPUTED BY: CAB

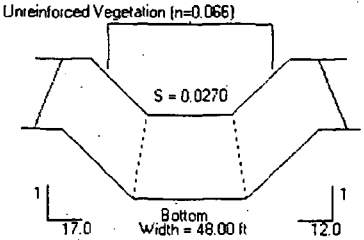
PROJECT NAME: Rocky Flats OLF | PROJECT NO.: With Buttress

FROM STATION/REACH: C-C' | TO STATION/REACH: | DRAINAGE AREA: | DESIGN FREQUENCY: 100 yr

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
480.0	5.0	4.20	114.19	1.21	1.60

Unreinforced Vegetation (n=0.066)



Not to Scale

LINER RESULTS

Reach	Matting Type	Stability Analysis	Vegetation Characteristics				Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
	Staple Pattern		Phase	Class	Type	Density				
Straight	Unreinforced	Vegetation		B	Mix	75-95%	5.73	2.70	2.12	STABLE
		Soil	Sandy Loam				0.035	0.038	0.92	UNSTABLE

Back to Input Screen

```
"*************************************************************************
NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.3
NORTH AMERICAN GREEN CHANNEL PROTECTION - ENGLISH/S.I.
USER SPECIFIED CHANNEL LINING BACK-UP COMPUTATIONS
*************************************************************************


PROJECT NAME: Rocky Flats OLF            PROJECT NO.: With Buttress
COMPUTED BY: CAB                         DATE: 4/12/2005
FROM STATION/REACH: C-C'                 TO STATION/REACH:
DRAINAGE AREA:                           DESIGN FREQUENCY: 100 yr

*************************************************************************
                          INPUT PARAMETERS
*************************************************************************

Channel Discharge     : 480.0 cfs  (13.58 m^3/s)
Peak Flow Period      : 5  hours
Channel Slope         : 0.027 ft/ft  (0.027 m/m)
 annel Bottom Width : 48.0 ft (14.63 m)
Left Side Slope       : 17:1
Right Side Slope      : 12:1

Channel Lining : Unreinforced Vegetation  Mix 75-95%
Permi. Shear(Tp) :5.73 psf (274.4 Pa)
               Phase = 1
               Class = B Vegetation
               Soil  = Sandy Loam
               Allowable Soil Shear(Ta):0.035 psf (1.67580000713468 Pa)

*************************************************************************
                           CALCULATIONS
*************************************************************************

Initial Depth Estimate = 0.16 * (480.0 /(0.027^0.5))^0.375 = 3.19 ft (.97 m)
Final Channel Depth (after 9 iterations)                   = 1.6 ft (0.49 m)
Flow Area = (48.0 * 1.6)+(0.5 *1.60^2 * (17.0+12.0))       = 114.2 sq.ft (10.6 m^2)
Wet Per. =48.0 +(1.6*(((17.0^2)+1)^.5 +((12.0^2)+1)^.5))   = 94.6 ft (28.8 m)
Hydraulic Radius = (114.2 / 94.6)                          = 1.2 ft (0.4 m)
Channel Velocity =(1.486/0.066)*(1.2^0.667)*(0.027^.5)     = 4.2 fps (1.3 m/s)

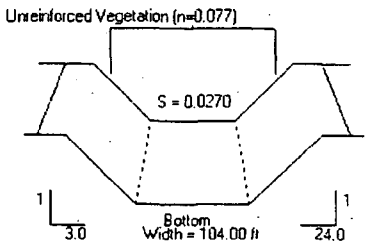
Channel Effective Manning's Roughness                      = 0.066
Calculated Shear (Td) = 62.4 * 1.60 * 0.027                = 2.70 psf (129.3 Pa)
Safety Factor = (Tp/Td) = (5.73 /2.70)                     = 2.12

 fective Stress on Soil (Te)=2.7*(1-0.75)*(0.0156/0.066)^2 =0.04 psf (1.8 Pa)
afety Factor = (Ta/Te) = (0.04 /0.038)                     =  0.92
"
```

North American Green - ECMDS Version 4.3	4/12/2005 03:07 PM	COMPUTED BY: CAB	
PROJECT NAME: Rocky Flats OLF		PROJECT NO.: With Buttress	
FROM STATION/REACH: D-D'	TO STATION/REACH:	DRAINAGE AREA:	DESIGN FREQUENCY: 100 yr

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
480.0	5.0	3.31	145.14	1.06	1.21



Not to Scale

LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Unreinforced	Vegetation		B	Mix	75-95%	5.73	2.03	2.82	STABLE
		Soil	Sandy Loam				0.035	0.021	1.67	STABLE

Back to Input Screen

```
"*****************************************************************************
NORTH AMERICAN GREEN EROSION CONTROL MATERIALS DESIGN SOFTWARE VERSION 4.3
NORTH AMERICAN GREEN CHANNEL PROTECTION - ENGLISH/S.I.
USER SPECIFIED CHANNEL LINING BACK-UP COMPUTATIONS
*****************************************************************************


PROJECT NAME: Rocky Flats OLF              PROJECT NO.: With Buttress
COMPUTED BY: CAB                           DATE: 4/12/2005
FROM STATION/REACH: D-D'                   TO STATION/REACH:
DRAINAGE AREA:                             DESIGN FREQUENCY: 100 yr

*****************************************************************************
                          INPUT PARAMETERS
*****************************************************************************

Channel Discharge     : 480.0 cfs  (13.58 m^3/s)
Peak Flow Period      : 5  hours
Channel Slope         : 0.027 ft/ft  (0.027 m/m)
 hannel Bottom Width : 104.0 ft (31.70 m)
 ft Side Slope        : 3:1
Right Side Slope      : 24:1

Channel Lining : Unreinforced Vegetation  Mix 75-95%
Permi. Shear(Tp) :5.73 psf (274.4 Pa)
               Phase = 1
               Class = B Vegetation
               Soil  = Sandy Loam
               Allowable Soil Shear(Ta):0.035 psf (1.67580000713468 Pa)

*****************************************************************************
                           CALCULATIONS
*****************************************************************************

Initial Depth Estimate = 0.16 * (480.0 /(0.027^0.5))^0.375 = 3.19 ft (.97 m)
Final Channel Depth (after 10 iterations)                  = 1.21 ft (0.37 m)
Flow Area = (104.0 * 1.2)+(0.5 *1.21^2 * (3.0+24.0))       = 145.1 sq.ft (13.5 m^2)
Wet Per. =104.0 +(1.2*(((3.0^2)+1)^.5 +((24.0^2)+1)^.5))   = 136.8 ft (41.7 m)
Hydraulic Radius = (145.1 / 136.8)                         = 1.1 ft (0.3 m)
Channel Velocity =(1.486/0.077)*(1.1^0.667)*(0.027^.5)     = 3.3 fps (1.0 m/s)

Channel Effective Manning's Roughness                      = 0.077
Calculated Shear (Td) = 62.4 * 1.21 * 0.027                = 2.03 psf (97.3 Pa)
Safety Factor = (Tp/Td) = (5.73 /2.03)                     = 2.82

 ffective Stress on Soil (Te)=2.0*(1-0.75)*(0.0156/0.077)^2 =0.02 psf (1.0 Pa)
 afety Factor = (Ta/Te) = (0.04 /0.021)                    =  1.67
"
```

Appendix G

APPENDIX G

LANDFILL ENGINEERING – FINAL DESIGN GEOTECHNICAL DATA AND BOREHOLE AND TEST PIT LOGS

E A R T H T E C H
A tyco INTERNATIONAL LTD. COMPANY
5575 DTC Parkway, Suite 200
Englewood, Colorado 80111

Project: RFETS – Original Landfill Accelerated Action Project No. 57378.6020 Date: 5/10/05

Subject: Landfill Engineering – Geotechnical Data

LIST OF ATTACHMENTS

Attachment 1	Centennial Quarry Pit Fines
Attachment 2	Centennial Rocky Flats Alluvium
Attachment 3	Test Pit and Borehole Logs

NOTES

Centennial Quarry Pit Fine geotechnical samples were taken from a stockpile located at the Centennial Quarry. The stockpile has since been used for construction of the Present Landfill cover and is no longer available. Therefore, a map indicating the sample locations is irrelevant and not included. Centennial Rocky Flats Alluvium samples were taken as part of the quality control program for construction of the Present Landfill cover. Samples were taken as the soil was brought to the site so the sample locations are irrelevant and also not included. As part of the Original Landfill cover construction, potential borrow area will be characterized and geotechnical data will be submitted with maps identifying sampling locations.

Sampling methods for Centennial Quarry geotechnical data include:

- ASTM D 422 - Standard Test Method for Particle Size Analysis of Soils
- ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)
- ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (Standard Proctor)
- ASTM D 4767 - Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (with pore pressure measurements)
- ASTM D 2435 - Standard Test Method for One-Dimensional Consolidation Properties of Soils

APPENDIX G

ATTACHMENT 1
CENTENNIAL QUARRY PIT FINES

TABLE 1
ROCKY FLATS/FIELD and LAB TESTING/CO
SUMMARY OF SOIL DATA

Sample Type	Sample Number	Sample Depth (ft)	U.S.C.S. Soil Classi-fication	Delivered Moisture (%)	Atterberg Limits			Grain Size Distribution			Specific Gravity	Moist/Den Relationship Standard Proctor		Additional Tests Comments (See Notes)
					LL	PL	PI	% Finer 3/4"	% Finer #4	% Finer #200		PCF (Dry)	Moist (%)	
Bulk	PF-1	1-2	SC	16.1	39	19	20	100	84	30	--	120.6*	10.7*	
Bulk	PF-2	1-2	SC	10.3	43	19	24	100	85	29	--	119.9*	11.7*	
Bulk	PF-3	1-2	SC	18.1	43	18	25	100	81	30	--	121.0*	10.9*	
Bulk	PF-4	1-2	SC	17.4	35	16	19	100	89	30	--	122.9*	10.6*	
Bulk	PF-5	1-2	SC	12.8	37	19	18	100	86	29	--	121.9*	10.8*	
Bulk	PF5-Dup	1-2	SC	11.4	40	19	21	100	87	28	--	122.3*	11.1*	
Bulk	PF-6	1-2	SC	11.5	45	20	25	100	82	30	--	120.3*	12.5*	
Bulk	PF-7	1-2	SC	13.5	35	18	17	100	87	24	--	125.1*	10.3*	
Bulk	PF-8	1-2	SC	14.9	41	19	22	100	82	28	--	117.9*	11.9*	
Bulk	PF-9	1-2	SC	13.8	38	18	20	100	87	25	--	125.1*	10.4*	
Bulk	PF-10	1-2	SC	14.8	43	18	25	100	83	28	--	122.1*	11.0*	
Spec	Foundation	NA	NA	NA	NA	NA	NA	100	81.3	20.5		NA	NA	
Spec	Cushion	NA	NA	NA	NA	NA	NA	100	81.3	20.5		NA	NA	

NOTES:

LL = LIQUID LIMIT
PL = PLASTIC LIMIT
PI = PLASTIC INDEX
SL = SHRINKAGE LIMIT

T = TRIAXIAL TEST
U = UNCONFINED COMPRESSION TEST
C = CONSOLIDATION TEST
DS = DIRECT SHEAR TEST
PERM = PERMEABILITY

* ASTM D4718

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	774.19
Wt. Dry Soil & Tare (gm)	680.87
Wt. of Tare (gm)	102.91
Wt. of Water (gm)	93.32
Weight of Dry Soil (gm)	577.96
Moisture Content (%)	16.15

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-1
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION

Number of Blows		
Weight of Wet Soil & T	27.78	25.86
Weight of Dry Soil & T	25.85	24.25
Weight of Tare (gm)	15.59	15.60
Weight of Water (gm)	1.93	1.61
Weight of Dry Soil (gm)	10.26	8.65
Water Content %	18.81	18.61

LIQUID LIMIT DETERMINATION

29	20	15
29.09	24.67	33.01
25.48	21.64	29.52
15.98	14.32	21.81
3.61	3.03	3.49
9.50	7.32	7.71
38.00	41.39	45.27

PLASTIC LIMIT (PL) 19

LIQUID LIMIT (LL) 39

PLASTICITY INDEX (PI) 20

BLOWS	MC		
29	38.00	3.37	25
20	41.39	3.00	0.00
15	45.27	2.71	-2
0	0.00	#NUM!	

	3 POINTS			3-POINTS
	25.00	25.00	10.00	39
38.00	45.27	39.42	39.42	19
-2	46.00	39.42		20

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS		LIQUID LIMITS	
Weight of Wet Soil & Tare (gm)				
Weight of Dry Soil & Tare (gm)				
Weight of Tare (gm)				
Weight of Water (gm)	0.00	0.00		
Weight of Dry Soil (gm)	0.00	0.00	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!	0.00	0.00
			#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL)

LIQUID LIMIT (LL)

PLASTICITY INDEX (PI)

NON-PLASTIC

Number of Blows	PLASTIC LIMITS		LIQUID LIMITS	
Weight of Wet Soil & Tare (gm)				
Weight of Dry Soil & Tare (gm)				
Weight of Tare (gm)				
Weight of Water (gm)	0.00	0.00	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

NP

PLASTIC LIMIT (PL) NP

LIQUID LIMIT (LL) NP

PLASTICITY INDEX (PI) NP

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	774.19
Wt. Dry Soil & Tare (gm)	680.87
Wt. of Tare (gm)	102.91
Wt. of Water (gm)	93.32
Weight of Dry Soil (gm)	577.96
Moisture Content (%)	16.1

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-1 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	177.89
Dry Soil & Tare (gm)	170.13
Tare Weight (gm)	28.91
Moisture Content (%)	5.5

LL	39	TEST BY	JR
PL	19	DATE SET UP	7/15/2004
PI	20	REVIEW BY	NG

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	21690.40 (before separating on the #4 sieve)
Tare Weight (gm)	
Total Weight (gm)	20560.60

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00	
coarse gravel	0.00	
fine gravel	16.46	16.46
coarse sand	5.37	
medium sand	23.88	
fine sand	23.85	53.10
fines	30.44	
		100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	477.10	2.3	97.7
#4	3383.60	16.5	83.5

BACK SIEVE

Tare Weight: 0.00

				% PASSING
#10	3.14	3.1	6.43	78.2
#20	9.65	9.7	19.75	67.0
#40	17.11	17.1	35.01	54.3
#60	22.46	22.5	45.96	45.1
#100	26.80	26.8	54.85	37.7
#200	31.06	31.1	63.56	30.4

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 51.55

DATE	TIME	READING R	TEMP T	HYD. COR. Cc
7/16/2004	10:12			
7/16/2004	10:14	21.0	22.90	6.00
7/16/2004	10:17	19.5	22.90	6.00
7/16/2004	10:27	19.0	22.80	6.00
7/16/2004	10:42	18.8	22.40	6.00
7/16/2004	11:12	18.0	22.10	6.00
7/16/2004	14:22	17.3	20.80	6.00
7/17/2004	10:12	16.5	21.50	6.00

(mm)	%Finer
0.034	25.39
0.022	22.85
0.013	22.00
0.009	21.58
0.006	20.31
0.003	19.04
0.001	17.77

!!!!!

2.7 WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

6

Calculated Dry Wt. used in test (gm)	48.86
Hydrometer Bulb Number	624378
%Pass #4 Sieve for whole sample	83.5433

HYDROMETER CALCULATIONS

Time (min)	Hydr. Cor. Kc	Reading C	Effective Length	A
2.00	0.013126	15.00	13.8	0.99
5.00	0.013126	13.50	14.2	0.99
15.00	0.013126	13.00	14.3	0.99
30.00	0.013126	12.25	14.3	0.99
60.00	0.013126	12.00	14.3	0.99
250.00	0.013446	11.25	14.5	0.99
1440.00	0.013283	10.50	14.7	0.99

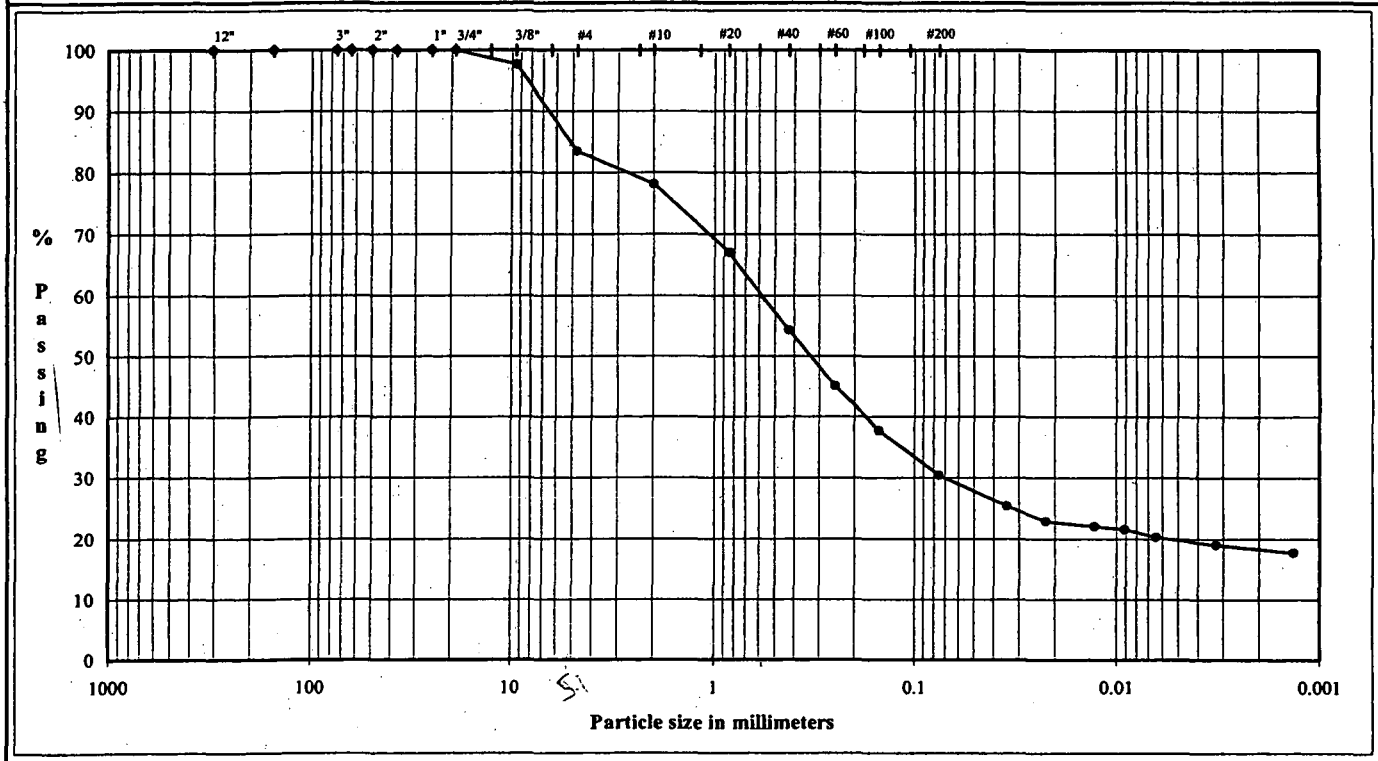
	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	97.7
#4	4.750	83.5
#10	2.000	78.2
#20	0.850	67.0
#40	0.425	54.3
#60	0.250	45.1
#100	0.150	37.7
#200	0.075	30.4
	0.0344	25.4
	0.0221	22.8
	0.0128	22.0
	0.0091	21.6
	0.0064	20.3
	0.0032	19.0
	0.0013	17.8

Check By NG

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-1 Depth (ft): -
TYPE: BULK



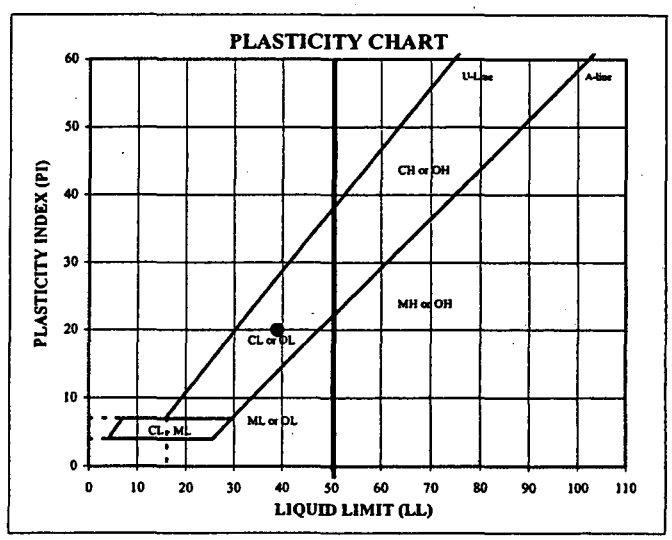
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	97.7		
#4	4.8	83.5	Fine Gravel	16.46
#10	2.00	78.2	Coarse Sand	5.37
#20	0.85	67.0		
#40	0.43	54.3	Medium Sand	23.88
#60	0.25	45.1		
#100	0.15	37.7		
#200	0.075	30.4	Fine Sand	23.85

Hydrometer Analysis

(mm)	%Finer		
0.034	25.4		
0.022	22.8		
0.013	22.0	Fines	
0.0091	21.6	Silt or Clay	30.44
0.0064	20.3		
0.0032	19.0		
0.0013	17.8		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
16.1	39	19	20	

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

TECH: JR
DATE: 7/15/2004
REVIEW: NG

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO			TEST TYPE	D 698 D 4718
PROJECT NUMBER	043-2246.0001			PROCEDURE	METHOD A
SAMPLE IDENTITY	PF-1	-	-		
SAMPLE TYPE	BULK				

MOLD NUMBER	217
MOLD WEIGHT (gm)	2271.5
MOLD DIAMETER (in)	4.000
MOLD HEIGHT (in)	4.575
MOLD VOLUME (cu.ft)	0.0333

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	177.89
Dry Wt Tare & Soil	(W2)	492.88	170.13
Wt Tare	(W3)	0.00	28.91
Wt Moisture	(W4=W1-W2)	11.19	7.76
Wt Dry Soil	(W5=W2-W3)	492.88	141.22
Water Content (dec)	(wc=W4/W5)	0.0227	0.0549
Water Content (%)	(W4/W5)*100	2.3%	5.5%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	21690.40
TOTAL WEIGHT, DRY (COARSE & FINE)	20560.60
WEIGHT RETAINED ON # 4 SIEVE (WET)	3383.60
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	16.09%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4010.3	4194.0	4233.1	4231.4	4189.6		
Weight of Mold	(W2)	2271.50	2271.50	2271.50	2271.50	2271.50		
Wt. Of Wet Soil	(W3=W1-W2)	1738.80	1922.50	1961.60	1959.90	1918.10		
Wet Density, wd (pcf)	(W3/453.6*Vm)	115.22	127.39	129.98	129.87	127.10		
WATER CONTENTS								
Wt Tare & Soil	(W4)	680.59	613.87	697.53	623.27	604.74		
Wt Tare & Soil	(W5)	628.53	561.24	626.08	555.47	533.03		
Wt Tare	(W6)	104.24	101.34	100.46	103.18	100.83		
Wt Moisture	(W7=W4-W5)	52.06	52.63	71.45	67.80	71.71		
Wt Dry Soil	(W8=W5-W6)	524.29	459.90	525.62	452.29	432.20		
Water Content (%)	(W7/W8)*100	9.9%	11.4%	13.6%	15.0%	16.6%		
Dry Density (pcf)	(wd/(1+wc))	104.8	114.3	114.4	112.9	109.0		

MAXIMUM DRY DENSITY (pcf)	115.8
OPTIMUM MOISTURE CONTENT (%)	12.7
Corrected Maximum Dry Density (pcf)	120.6
Corrected Optimum Moisture (%)	10.7

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

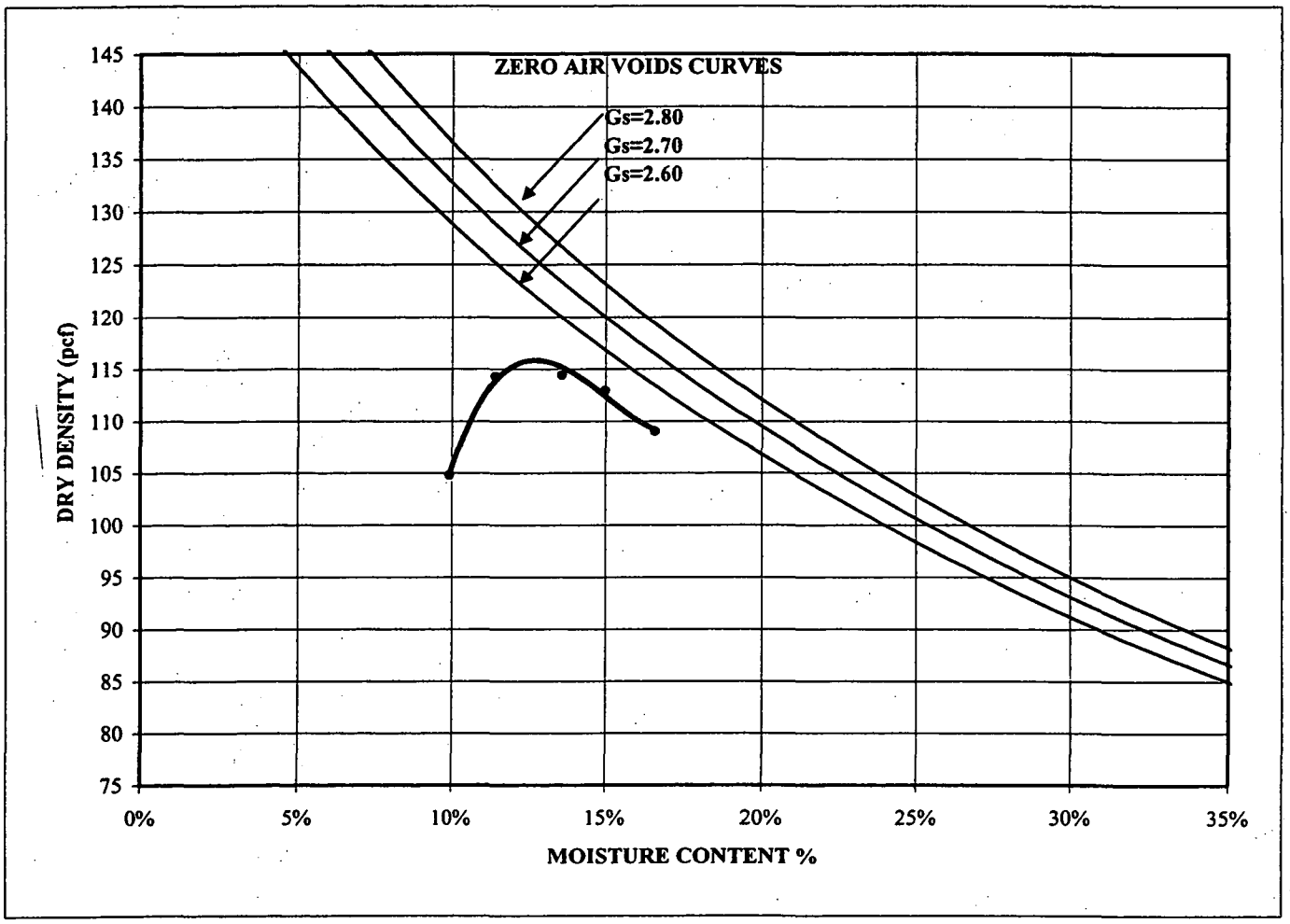
Weight of Oven Dry Sample (gm)	A	504.07			
Weight of Saturated-Surface-Dry (gm)	B	506.40			
Weight of Saturated Sample in Water (gm)	C	301.90			
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46			
Bulk Specific Gravity	A/(B-C)	2.465			

LL	39
PL	19
PI	20
MC	16.1%

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	DT
DATE	7/16/04
REVIEW	NG

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	115.8	Corrected Maximum Dry Density (pcf)	120.6
OPTIMUM MOISTURE (%)	12.7	Corrected Optimum Moisture (%)	10.7

SAMPLE ID	PF-1
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	39
PL	19
PI	20
MC	16.1%

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand with gravel
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	DT
DATE	7/16/04
REVIEW	NG

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	544.40
Wt. Dry Soil & Tare (gm)	503.10
Wt. of Tare (gm)	103.50
Wt. of Water (gm)	41.30
Weight of Dry Soil (gm)	399.60
Moisture Content (%)	10.34

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-2
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION

Number of Blows		
Weight of Wet Soil & T	22.76	21.69
Weight of Dry Soil & T	21.66	20.75
Weight of Tare (gm)	15.96	15.88
Weight of Water (gm)	1.10	0.94
Weight of Dry Soil (gm)	5.70	4.87
Water Content %	19.30	19.30

LIQUID LIMIT DETERMINATION

32	25	17
23.72	24.10	23.15
20.87	21.11	20.21
13.99	14.13	13.83
2.85	2.99	2.94
6.88	6.98	6.38
41.42	42.84	46.08

PLASTIC LIMIT (PL) 19

LIQUID LIMIT (LL) 43

PLASTICITY INDEX (PI) 24

BLOWS	MC		
32	41.42	3.47	25
25	42.84	3.22	0.00
17	46.08	2.83	-2
0	0.00	#NUM!	

	3 POINTS			
	25.00	25.00	10.00	3-POINTS
41.42	46.08	43.10	43.10	43
-2	48.00	43.10		19
				24

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS		LIQUID LIMITS	
Weight of Wet Soil & Tare (gm)				
Weight of Dry Soil & Tare (gm)				
Weight of Tare (gm)				
Weight of Water (gm)	0.00	0.00		
Weight of Dry Soil (gm)	0.00	0.00	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!	0.00	0.00
			#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL)

LIQUID LIMIT (LL)

PLASTICITY INDEX (PI)

NON-PLASTIC

Number of Blows	PLASTIC LIMITS		LIQUID LIMITS	
Weight of Wet Soil & Tare (gm)				
Weight of Dry Soil & Tare (gm)				
Weight of Tare (gm)				
Weight of Water (gm)	0.00	0.00	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

PLASTIC LIMIT (PL) NP

LIQUID LIMIT (LL) NP

PLASTICITY INDEX (PI) NP

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	544.40
Wt. Dry Soil & Tare (gm)	503.10
Wt. of Tare (gm)	103.50
Wt. of Water (gm)	41.30
Weight of Dry Soil (gm)	399.60
Moisture Content (%)	10.3

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-2 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	65.31
Dry Soil & Tare (gm)	64.35
Tare Weight (gm)	13.82
Moisture Content (%)	1.9

LL	43
PL	19
PI	24

TEST BY	DT
DATE SET UP	7/21/2004
REVIEW BY	MB

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	20693.40 (before separating on the #4 sieve)
Tare Weight (gm)	
Total Weight (gm)	20307.58

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00	
coarse gravel	0.00	
fine gravel	14.78	14.78
coarse sand	11.45	
medium sand	23.86	
fine sand	21.03	56.35
fines	28.88	
		100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	421.30	2.1	97.9
#4	3000.90	14.8	85.2

BACK SIEVE

Tare Weight: 0.00

				% PASSING
#10	6.68	6.7	13.44	73.8
#20	13.91	13.9	27.98	61.4
#40	20.60	20.6	41.44	49.9
#60	25.31	25.3	50.91	41.8
#100	29.07	29.1	58.47	35.4
#200	32.87	32.9	66.12	28.9

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 50.66

DATE	TIME	READING	TEMP	HYD. COR.
7/22/2004	10:11	R	T	Cc
7/22/2004	10:13	20.3	22.70	6.50
7/22/2004	10:16	20.0	22.70	6.50
7/22/2004	10:26	19.0	22.60	6.50
7/22/2004	10:41	18.5	22.50	6.50
7/22/2004	11:11	18.3	22.00	6.50
7/22/2004	14:21	17.3	20.80	6.50
7/23/2004	10:11	16.5	20.10	6.50

(mm)	%Finer
0.035	23.33
0.022	22.91
0.013	21.21
0.009	20.36
0.006	19.94
0.003	18.24
0.001	16.97

!!!!!

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt. used in test (gm)	49.72
Hydrometer Bulb Number	624378
% Pass #4 Sieve for whole sample	85.2223

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	62.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	97.9
#4	4.750	85.2
#10	2.000	73.8
#20	0.850	61.4
#40	0.425	49.9
#60	0.250	41.8
#100	0.150	35.4
#200	0.075	28.9
	0.0350	23.3
	0.0221	22.9
	0.0128	21.2
	0.0091	20.4
	0.0065	19.9
	0.0033	18.2
	0.0014	17.0

HYDROMETER CALCULATIONS

ET (mm)	TEMP COR K	READING R	EFFECTIVE LENGTH L	A
2.00	0.013126	41.85	14.2	0.99
5.00	0.013126	33.50	14.3	0.99
15.00	0.013126	22.00	14.3	0.99
30.00	0.013126	12.00	14.3	0.99
60.00	0.013126	21.85	14.3	0.99
1250.00	0.013446	20.75	14.7	0.99
1440.00	0.013446	10.00	14.7	0.99

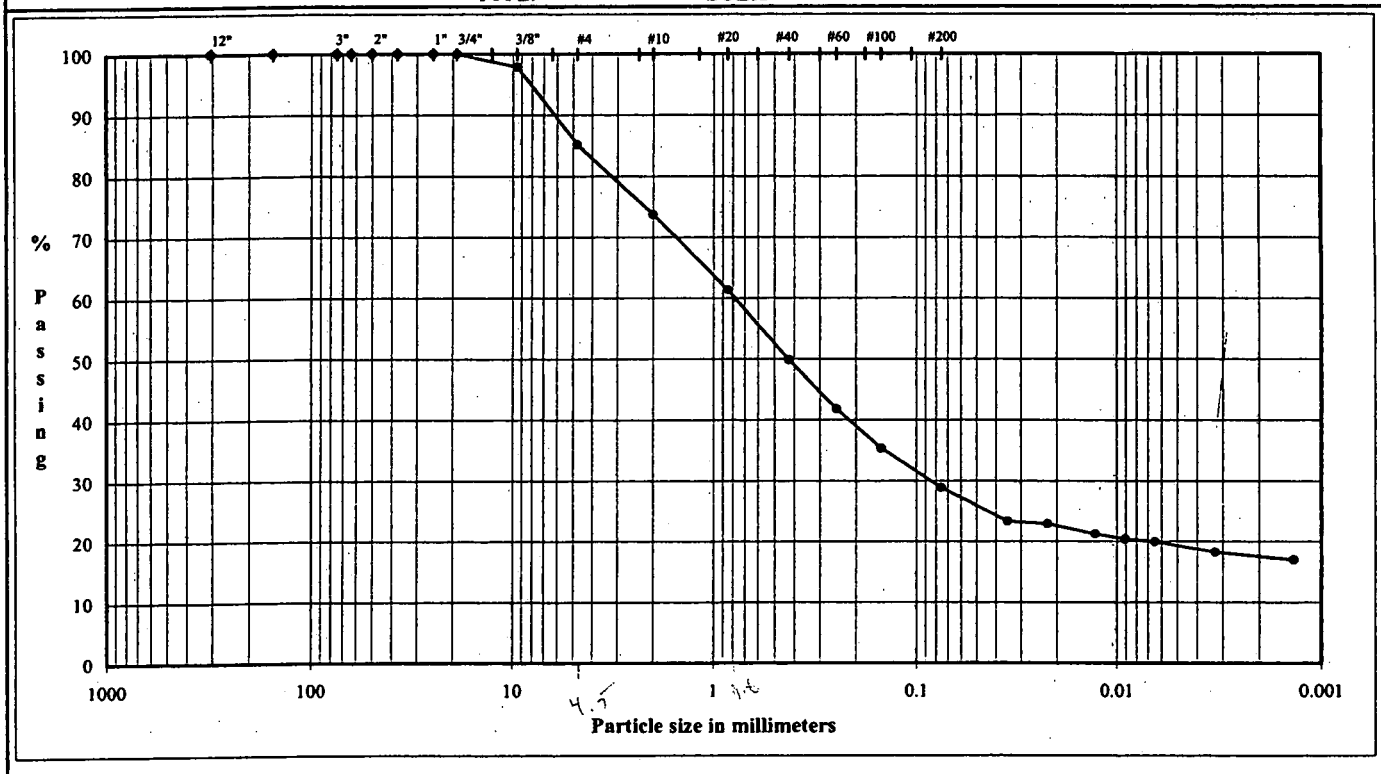
Check By NG

July-94 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-2 Depth (ft): -
TYPE: BULK



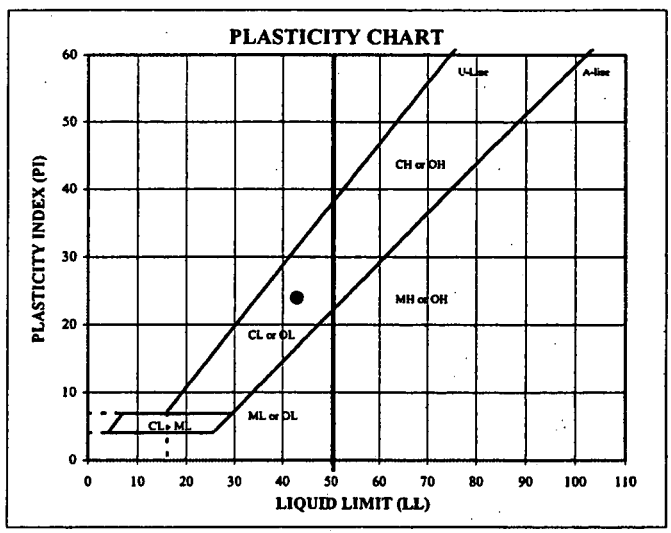
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	97.9		
#4	4.8	85.2	Fine Gravel	14.78
#10	2.00	73.8	Coarse Sand	11.45
#20	0.85	61.4		
#40	0.43	49.9	Medium Sand	23.86
#60	0.25	41.8		
#100	0.15	35.4		
#200	0.075	28.9	Fine Sand	21.03

Hydrometer Analysis

(mm)	%Finer		
0.035	23.3		
0.022	22.9		
0.013	21.2	Fines	
0.0091	20.4	Silt or Clay	28.88
0.0065	19.9		
0.0033	18.2		
0.0014	17.0		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
10.3	43	19	24	

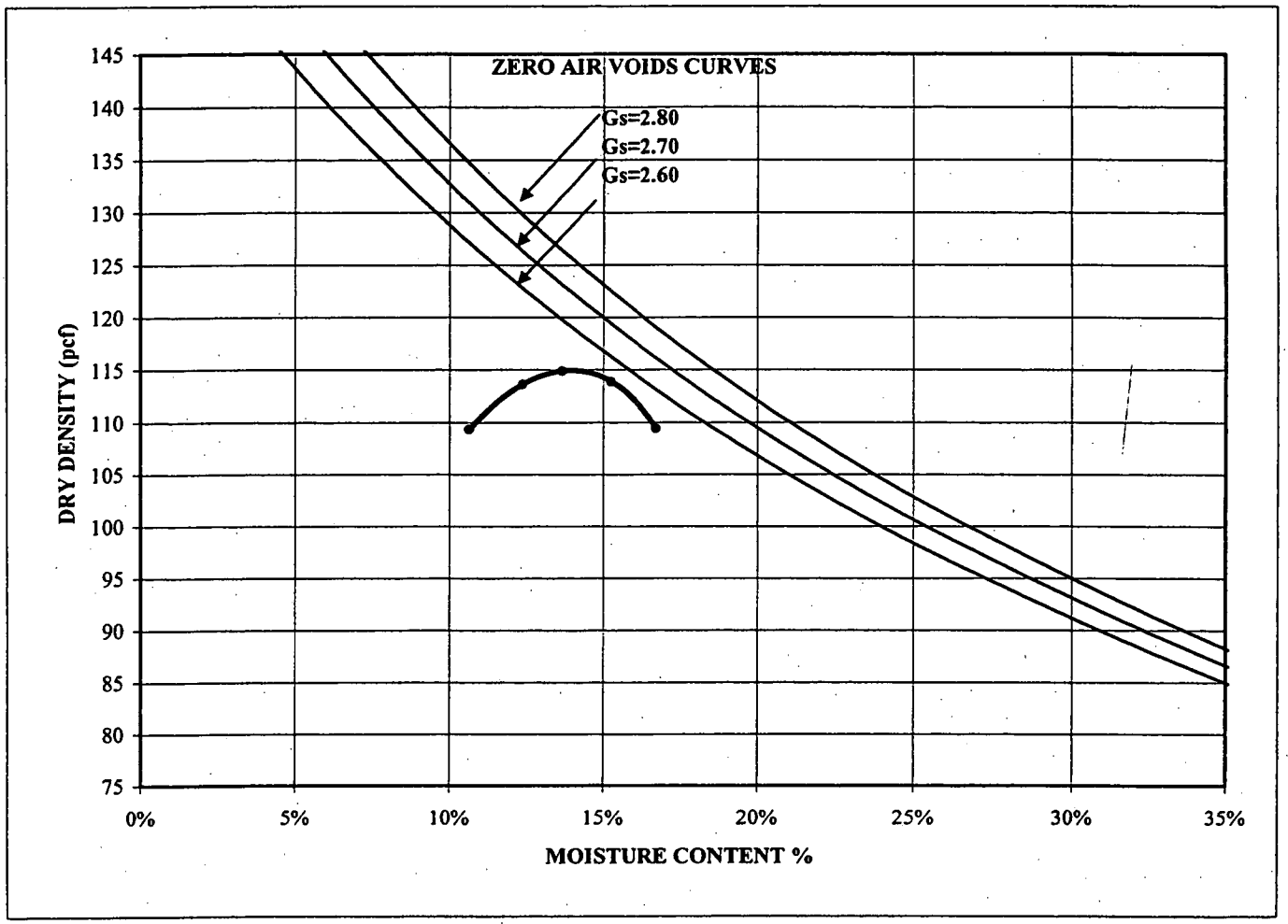
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

TECH: DT
DATE: 7/21/2004
REVIEW: MB

Golder Associates Inc.

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	114.9	Corrected Maximum Dry Density (pcf)	119.9
OPTIMUM MOISTURE (%)	13.9	Corrected Optimum Moisture (%)	11.7

SAMPLE ID	PF-2
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	43
PL	19
PI	24
MC	10.3

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	DT
DATE	7-22-04
REVIEW	MB

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	724.70
Wt. Dry Soil & Tare (gm)	629.18
Wt. of Tare (gm)	101.82
Wt. of Water (gm)	95.52
Weight of Dry Soil (gm)	527.36
Moisture Content (%)	18.11

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-3
TYPE	BULK

4 OR 3 POINT ATTERBERG

	PLASTIC LIMIT DETERMINATION		LIQUID LIMIT DETERMINATION		
Number of Blows			30	22	15
Weight of Wet Soil & T	26.00	24.67	28.03	25.68	25.15
Weight of Dry Soil & T	24.13	22.99	23.99	22.09	21.70
Weight of Tare (gm)	13.98	13.76	14.22	14.03	14.32
Weight of Water (gm)	1.87	1.68	4.04	3.59	3.45
Weight of Dry Soil (gm)	10.15	9.23	9.77	8.06	7.38
Water Content %	18.42	18.20	41.35	44.54	46.75

PLASTIC LIMIT (PL): 18

LIQUID LIMIT (LL): 43

PLASTICITY INDEX (PI): 25

BLOWS	MC		
30	41.35	3.40	25
22	44.54	3.09	0.00
15	46.75	2.71	-2
0	0.00	#NUM!	

3 POINTS

				3-POINTS
	25.00	25.00	10.00	43
41.35	46.75	43.04	43.04	18
-2	48.00	43.04		25

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS		LIQUID LIMITS	
Weight of Wet Soil & Tare (gm)				
Weight of Dry Soil & Tare (gm)				
Weight of Tare (gm)				
Weight of Water (gm)	0.00	0.00		
Weight of Dry Soil (gm)	0.00	0.00	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!	0.00	0.00
			#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

Number of Blows	PLASTIC LIMITS		LIQUID LIMITS	
Weight of Wet Soil & Tare (gm)				
Weight of Dry Soil & Tare (gm)				
Weight of Tare (gm)				
Weight of Water (gm)	0.00	0.00	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

NP

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

PLASTICITY INDEX (PI): NP

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	724.70
Wt. Dry Soil & Tare (gm)	629.18
Wt. of Tare (gm)	101.82
Wt. of Water (gm)	95.52
Weight of Dry Soil (gm)	527.36
Moisture Content (%)	18.1

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-3 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	193.23
Dry Soil & Tare (gm)	186.84
Tare Weight (gm)	28.14
Moisture Content (%)	4.0

LL	43	TEST BY	JR
PL	18	DATE SET UP	7/15/2004
PI	25	REVIEW BY	NG

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	22098.50	(before separating on the #4 sieve)
Tare Weight (gm)		
Total Weight (gm)	21243.15	

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00		
coarse grave	0.00		
fine gravel	18.76	18.76	
coarse sand	6.03		
medium sand	23.07		
fine sand	22.53	51.63	
fines	29.62		
			100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	363.70	1.7	98.3
#4	3984.40	18.8	81.2

BACK SIEVE

Tare Weight: 0.00

				% PASSING
#10	3.68	3.7	7.43	75.2
#20	10.53	10.5	21.25	64.0
#40	17.75	17.8	35.82	52.1
#60	23.01	23.0	46.43	43.5
#100	27.28	27.3	55.05	36.5
#200	31.49	31.5	63.55	29.6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 51.55

DATE 7/16/2004	TIME 10:08	READING R	TEMP T	HYD. COR. Cc
7/16/2004	10:10	20.5	22.80	6.00
7/16/2004	10:13	19.3	22.90	6.00
7/16/2004	10:23	18.8	22.60	6.00
7/16/2004	10:38	18.3	22.50	6.00
7/16/2004	11:08	17.5	22.10	6.00
7/16/2004	14:18	17.3	20.80	6.00
7/17/2004	10:08	16.5	21.50	6.00

(mm)	%Finer
0.035	23.53
0.022	21.51
0.013	20.69
0.009	19.88
0.006	18.67
0.003	18.26
0.001	17.04

!!!!!

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt. used in test (gm)	49.55
Hydrometer Bulb Number	624378
%Pass #4 Sieve for whole sample	81.2438

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	98.3
#4	4.750	81.2
#10	2.000	75.2
#20	0.850	64.0
#40	0.425	52.1
#60	0.250	43.5
#100	0.150	36.5
#200	0.075	29.6
	0.0317	23.5
	0.0221	21.5
	0.0128	20.7
	0.0091	19.9
	0.0065	18.7
	0.0032	18.3
	0.0013	17.0

HYDROMETER CALCULATIONS

Time (min)	TEMP COR. K	READING R	EFFECTIVE LENGTH L	A
2.00	0.013226	14.50	14.8	0.99
5.00	0.013226	13.25	14.2	0.99
15.00	0.013226	12.75	14.3	0.99
30.00	0.013226	12.25	14.3	0.99
60.00	0.013226	11.50	14.5	0.99
250.00	0.013226	11.25	14.5	0.99
1440.00	0.013283	10.50	14.7	0.99

Check By NG

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO			TEST TYPE	D 698 D 4718
PROJECT NUMBER	043-2246.0001			PROCEDURE	METHOD A
SAMPLE IDENTITY	PF-2	-	-		
SAMPLE TYPE	BULK				

MOLD NUMBER	AH-1
MOLD WEIGHT (gm)	2265.0
MOLD DIAMETER (in)	3.991
MOLD HEIGHT (in)	4.581
MOLD VOLUME (cu.ft)	0.0332

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	65.31
Dry Wt Tare & Soil	(W2)	492.88	64.35
Wt Tare	(W3)	0.00	13.82
Wt Moisture	(W4=W1-W2)	11.19	0.96
Wt Dry Soil	(W5=W2-W3)	492.88	50.53
Water Content (dec)	(wc=W4/W5)	0.0227	0.0190
Water Content (%)	(W4/W5)*100	2.3%	1.9%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	20693.40
TOTAL WEIGHT, DRY (COARSE & FINE)	20307.58
WEIGHT RETAINED ON # 4 SIEVE (WET)	3440.90
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	16.57%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4084.9	4186.2	4229.3	4239.2	4186.3		
Weight of Mold	(W2)	2265.00	2265.00	2265.00	2265.00	2265.00		
Wt. Of Wet Soil	(W3=W1-W2)	1819.90	1921.20	1964.30	1974.20	1921.30		
Wet Density, wd (pcf)	(W3/453.6*Vm)	120.98	127.71	130.58	131.23	127.72		
WATER CONTENTS								
Wt Tare & Soil	(W4)	626.95	622.13	620.65	693.33	636.60		
Wt Tare & Soil	(W5)	576.67	564.98	558.62	615.08	559.97		
Wt Tare	(W6)	104.79	104.36	105.25	101.88	102.18		
Wt Moisture	(W7=W4-W5)	50.28	57.15	62.03	78.25	76.63		
Wt Dry Soil	(W8=W5-W6)	471.88	460.62	453.37	513.20	457.79		
Water Content (%)	(W7/W8)*100	10.7%	12.4%	13.7%	15.2%	16.7%		
Dry Density (pcf)	(wd/(1+wc))	109.3	113.6	114.9	113.9	109.4		

MAXIMUM DRY DENSITY (pcf)	114.9
OPTIMUM MOISTURE CONTENT (%)	13.9
Corrected Maximum Dry Density (pcf)	119.9
Corrected Optimum Moisture (%)	11.7

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

Weight of Oven Dry Sample (gm)	A	504.07			
Weight of Saturated-Surface-Dry (gm)	B	506.40			
Weight of Saturated Sample in Water (gm)	C	301.90			
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46			
Bulk Specific Gravity	A/(B-C)	2.465			

LL	43
PL	19
PI	24
MC	10.3

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	DT
DATE	7-22-04
REVIEW	MB

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO		
PROJECT NUMBER	043-2246.0001		
SAMPLE IDENTITY	PF-3	-	-
SAMPLE TYPE	BULK		

TEST TYPE: D 698 D 4718
PROCEDURE: METHOD A

MOLD NUMBER	217
MOLD WEIGHT (gm)	2271.5
MOLD DIAMETER (in)	4.000
MOLD HEIGHT (in)	4.575
MOLD VOLUME (cu.ft)	0.0333

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	193.23
Dry Wt Tare & Soil	(W2)	492.88	186.84
Wt Tare	(W3)	0.00	28.14
Wt Moisture	(W4=W1-W2)	11.19	6.39
Wt Dry Soil	(W5=W2-W3)	492.88	158.70
Water Content (dec)	(wc=W4/W5)	0.0227	0.0403
Water Content (%)	(W4/W5)*100	2.3%	4.0%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	22098.50
TOTAL WEIGHT, DRY (COARSE & FINE)	21243.15
WEIGHT RETAINED ON # 4 SIEVE (WET)	3984.40
WEIGHT RETAINED ON 3/8" SIEVE (WET)	363.70
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	18.34%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	1.67%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4207.5	3977.7	4068.4	4238.3	4257.2	4158.9	
Weight of Mold	(W2)	2271.50	2271.50	2271.50	2271.50	2271.50	2271.50	
Wt. Of Wet Soil	(W3=W1-W2)	1936.00	1706.20	1796.90	1966.80	1985.70	1887.40	
Wet Density, wd (pcf)	(W3/453.6*Vm)	128.28	113.06	119.07	130.33	131.58	125.06	
WATER CONTENTS								
Wt Tare & Soil	(W4)	634.51	662.50	592.22	619.45	615.25	656.04	
Wt Tare & Soil	(W5)	560.41	621.16	548.79	560.57	552.90	601.65	
Wt Tare	(W6)	104.43	101.19	103.76	103.95	103.99	102.31	
Wt Moisture	(W7=W4-W5)	74.10	41.34	43.43	58.88	62.35	54.39	
Wt Dry Soil	(W8=W5-W6)	455.98	519.97	445.03	456.62	448.91	499.34	
Water Content (%)	(W7/W8)*100	16.3%	8.0%	9.8%	12.9%	13.9%	10.9%	
Dry Density (pcf)	(wd/(1+wc))	110.4	104.7	108.5	115.4	115.5	112.8	

MAXIMUM DRY DENSITY (pcf)	115.5
OPTIMUM MOISTURE CONTENT (%)	13.2
Corrected Maximum Dry Density (pcf)	121.0
Corrected Optimum Moisture (%)	10.9

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

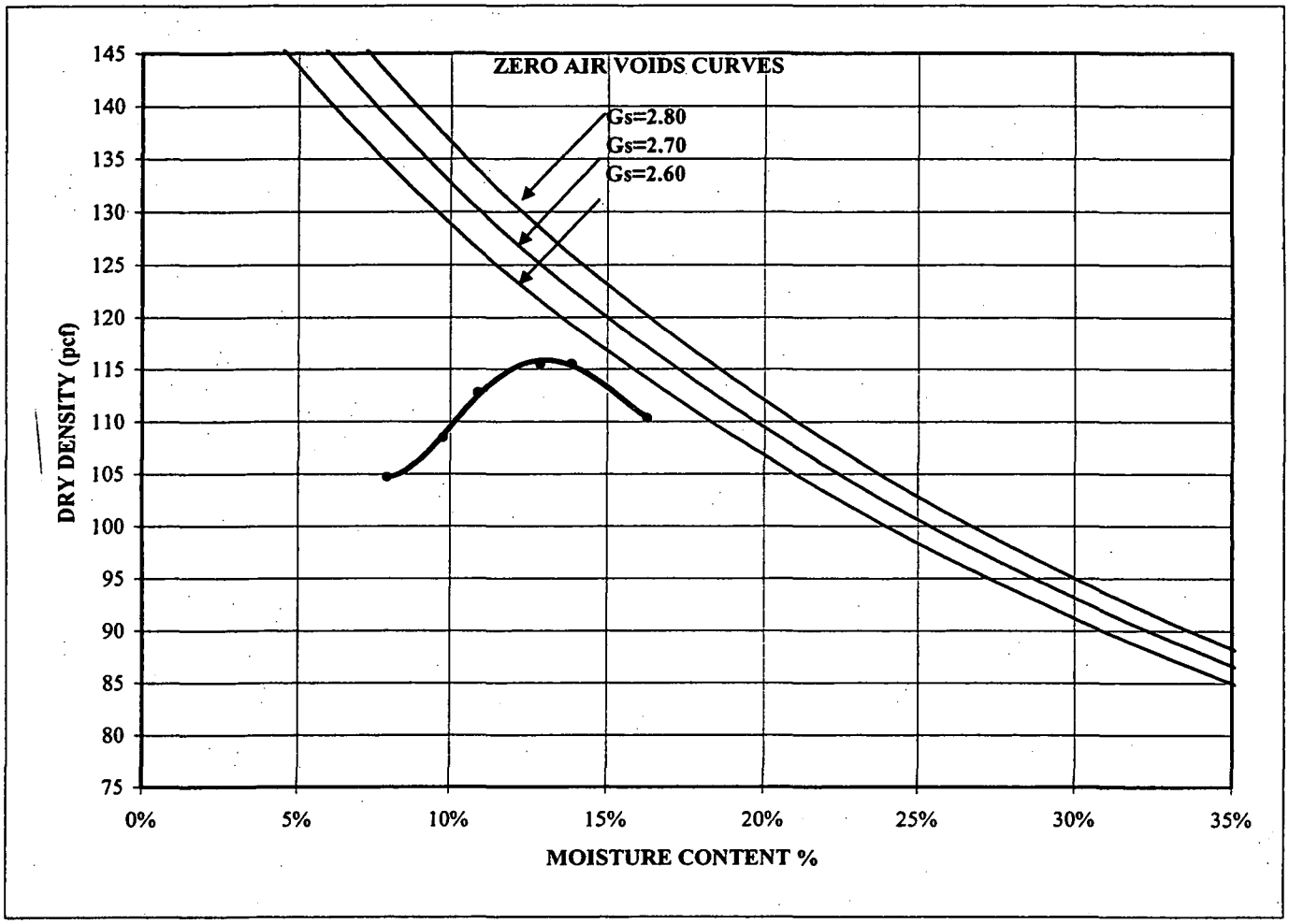
Weight of Oven Dry Sample (gm)	A	504.02		
Weight of Saturated-Surface-Dry (gm)	B	506.40		
Weight of Saturated Sample in Water (gm)	C	301.90		
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.47		
Bulk Specific Gravity	A/(B-C)	2.465		

LL	43
PL	18
PI	25
MC	18.10%

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	DT
DATE	7/16/04
REVIEW	NG

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	115.5	Corrected Maximum Dry Density (pcf)	121.0
OPTIMUM MOISTURE (%)	13.2	Corrected Optimum Moisture (%)	10.9

SAMPLE ID	PF-3
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	43
PL	18
PI	25
MC	18.1%

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand with gravel
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	DT
DATE	7/16/04
REVIEW	NG

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	827.30
Wt. Dry Soil & Tare (gm)	720.01
Wt. of Tare (gm)	103.55
Wt. of Water (gm)	107.29
Weight of Dry Soil (gm)	616.46
Moisture Content (%)	17.40

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-4
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION

Number of Blows		
Weight of Wet Soil & T	19.80	22.30
Weight of Dry Soil & T	18.93	21.39
Weight of Tare (gm)	13.52	15.63
Weight of Water (gm)	0.87	0.91
Weight of Dry Soil (gm)	5.41	5.76
Water Content %	16.08	15.80

LIQUID LIMIT DETERMINATION

30	24	15
33.01	30.48	28.02
28.17	26.63	24.00
13.82	15.87	13.89
4.84	3.85	4.02
14.35	10.76	10.11
33.73	35.78	39.76

PLASTIC LIMIT (PL): 16

LIQUID LIMIT (LL): 35

PLASTICITY INDEX (PI): 19

BLOWS	MC		
30	33.73	3.40	25
24	35.78	3.18	0.00
15	39.76	2.71	-2
0	0.00	#NUM!	

	3 POINTS			
	25.00	25.00	10.00	3-POINTS
33.73	39.76	35.36	35.36	35
-2	40.00	35.36		16
				19

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS

0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS

0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

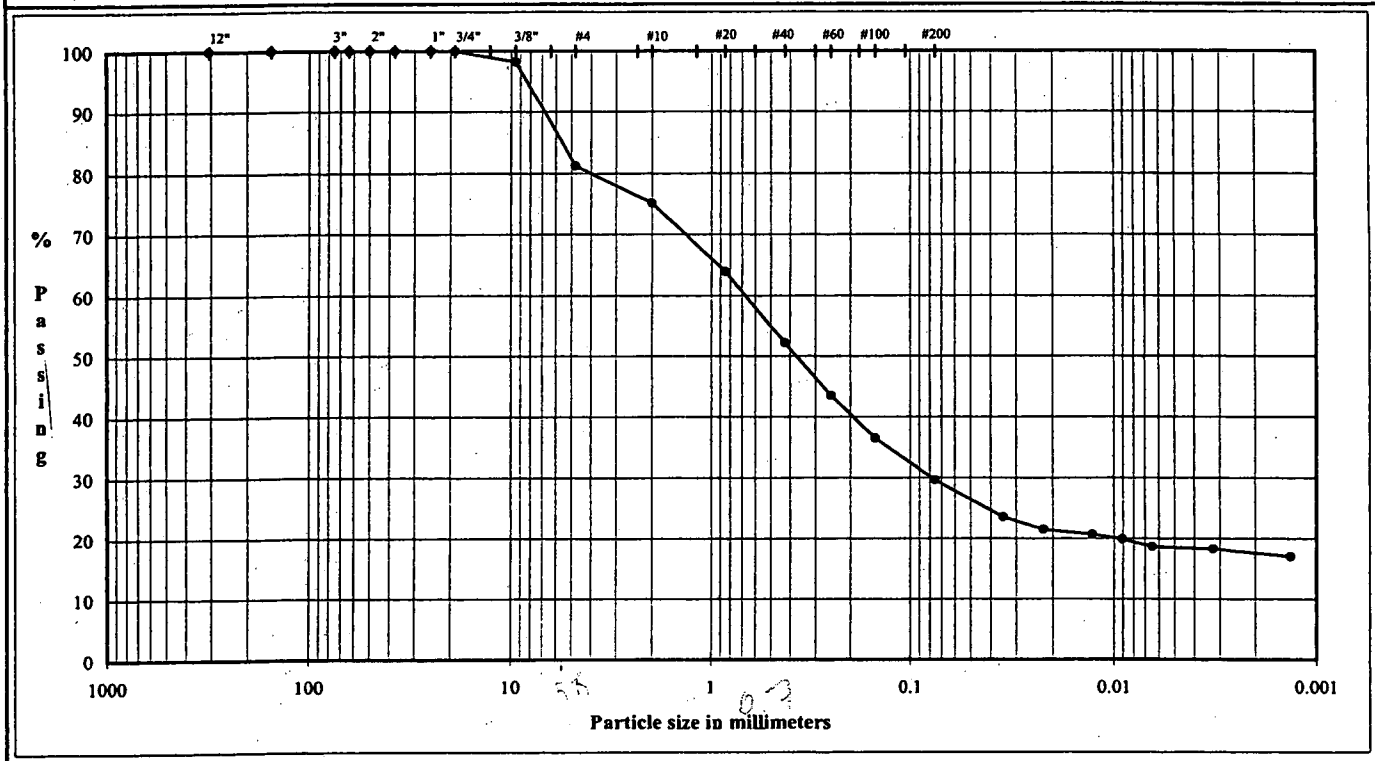
PLASTICITY INDEX (PI): NP

July-04 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-3 Depth (ft): -
TYPE: BULK



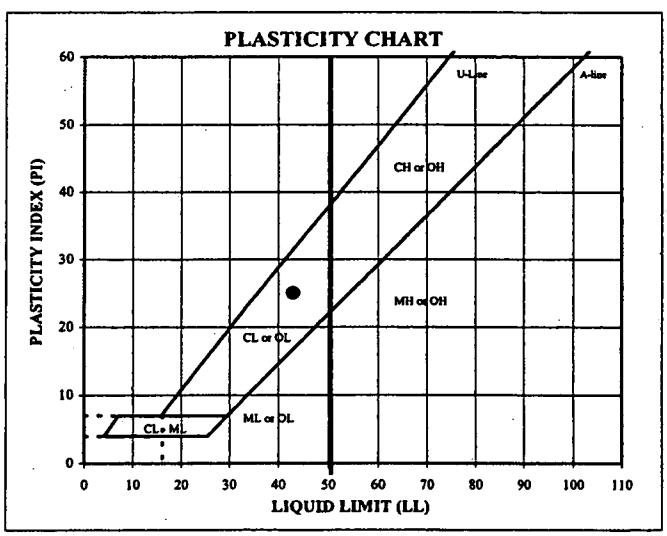
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	98.3		
#4	4.8	81.2	Fine Gravel	18.76
#10	2.00	75.2	Coarse Sand	6.03
#20	0.85	64.0		
#40	0.43	52.1	Medium Sand	23.07
#60	0.25	43.5		
#100	0.15	36.5		
#200	0.075	29.6	Fine Sand	22.53

Hydrometer Analysis

(mm)	%Finer		
0.035	23.5		
0.022	21.5		
0.013	20.7	Fines	
0.0091	19.9	Silt or Clay	29.62
0.0065	18.7		
0.0032	18.3		
0.0013	17.0		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
18.1	43	18	25	–

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

TECH: JR
DATE: 7/15/2004
REVIEW: NG

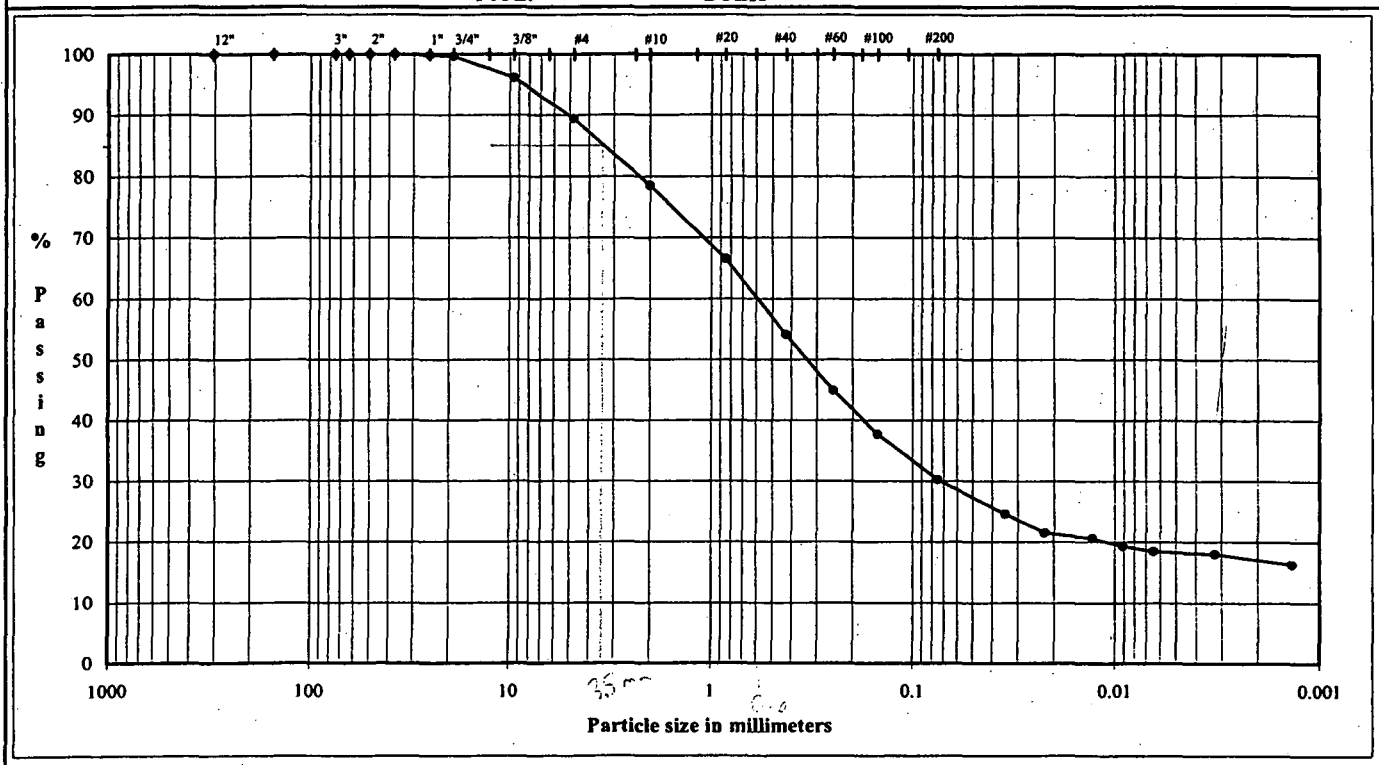
Golder Associates Inc.

July-04 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-4 Depth (ft): -
TYPE: BULK



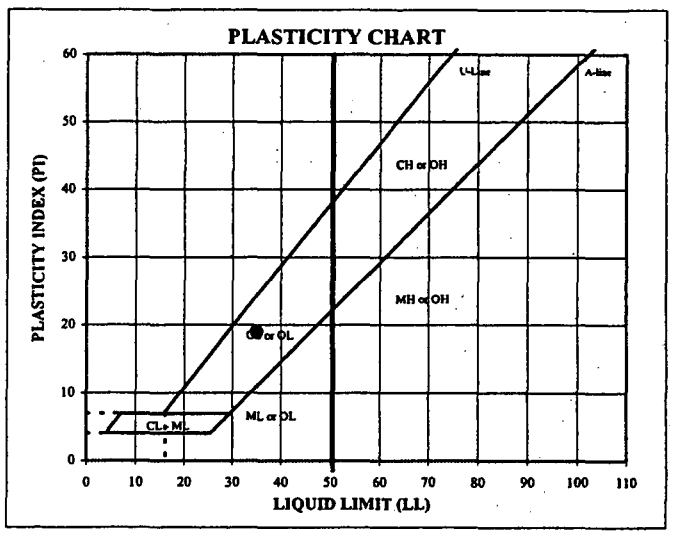
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	99.9	Coarse Gravel	0.34
0.75"	19.0	99.7		
0.375"	9.5	96.2		
#4	4.8	89.4	Fine Gravel	10.21
#10	2.00	78.6	Coarse Sand	10.87
#20	0.85	66.6		
#40	0.43	54.1	Medium Sand	24.43
#60	0.25	45.0		
#100	0.15	37.8		
#200	0.075	30.3	Fine Sand	23.89

Hydrometer Analysis

(mm)	%Finer		
0.035	24.6		
0.022	21.5		
0.013	20.7	Fines	
0.0091	19.3	Silt or Clay	30.25
0.0064	18.5		
0.0032	18.0		
0.0014	16.3		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
17.4	35	16	19	

DESCRIPTION: Yellowish brown (10YR 5/8) clayey sand

USCS: SC

TECH: JR
DATE: 7/19/2004
REVIEW: MB

Golder Associates Inc.

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO	TEST TYPE	D 698 D 4718
PROJECT NUMBER	043-2246.0001	PROCEDURE	METHOD A
SAMPLE IDENTITY	PF-4 - -		
SAMPLE TYPE	BULK		

MOLD NUMBER	AH-1	TYPE COMPACTOR	Mechanical
MOLD WEIGHT (gm)	2265.8	PREPARATION	Wet Method
MOLD DIAMETER (in)	3.991	TYPE PROCTOR	Standard
MOLD HEIGHT (in)	4.581		
MOLD VOLUME (cu.ft)	0.0332		

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	114.09
Dry Wt Tare & Soil	(W2)	492.88	113.02
Wt Tare	(W3)	0.00	21.80
Wt Moisture	(W4=W1-W2)	11.19	1.07
Wt Dry Soil	(W5=W2-W3)	492.88	91.22
Water Content (dec)	(wc=W4/W5)	0.0227	0.0117
Water Content (%)	(W4/W5)*100	2.3%	1.2%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED	
TOTAL WEIGHT, WET (COARSE & FINE)	23483.70
TOTAL WEIGHT, DRY (COARSE & FINE)	23211.43
WEIGHT RETAINED ON # 4 SIEVE (WET)	4348.10
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	18.32%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4070.6	4226.9	4270.5	4242.8	4209.7	4166.9	
Weight of Mold	(W2)	2265.80	2265.80	2265.80	2265.80	2265.80	2265.80	
Wt. Of Wet Soil	(W3=W1-W2)	1804.80	1961.10	2004.70	1977.00	1943.90	1901.10	
Wet Density, wd (pcf)	(W3/453.6*Vm)	119.97	130.36	133.26	131.42	129.22	126.38	
WATER CONTENTS								
Wt Tare & Soil	(W4)	546.43	459.33	425.63	537.69	466.35	504.17	
Wt Tare & Soil	(W5)	510.23	421.84	387.39	480.76	414.14	442.34	
Wt Tare	(W6)	100.45	103.77	105.11	104.61	101.83	99.91	
Wt Moisture	(W7=W4-W5)	36.20	37.49	38.24	56.93	52.21	61.83	
Wt Dry Soil	(W8=W5-W6)	409.78	318.07	282.28	376.15	312.31	342.43	
Water Content (%)	(W7/W8)*100	8.8%	11.8%	13.5%	15.1%	16.7%	18.1%	
Dry Density (pcf)	(wd/(1+wc))	110.2	116.6	117.4	114.1	110.7	107.0	

MAXIMUM DRY DENSITY (pcf)	117.6	DESCRIPTION	Yellowish brown (10YR 5/8) clayey sand
OPTIMUM MOISTURE CONTENT (%)	12.9		
Corrected Maximum Dry Density (pcf)	122.9		
Corrected Optimum Moisture (%)	10.6	USCS	SC

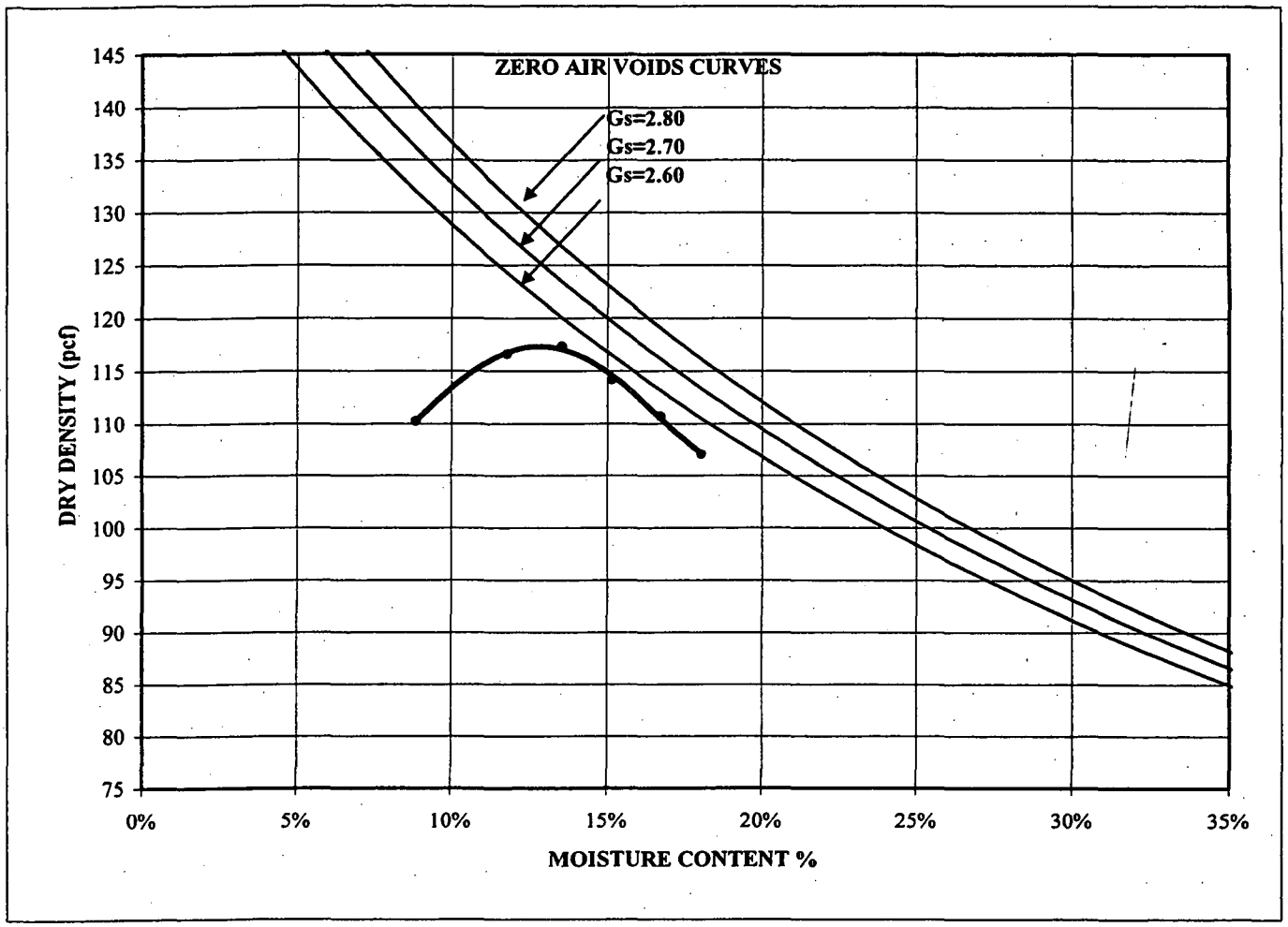
Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

Weight of Oven Dry Sample (gm)	A	504.07			LL	35
Weight of Saturated-Surface-Dry (gm)	B	506.40			PL	16
Weight of Saturated Sample in Water (gm)	C	301.90			PI	19
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46			MC	1.2%
Bulk Specific Gravity	A/(B-C)	2.465				

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	JR
DATE	7-20-04
REVIEW	MB

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	117.6	Corrected Maximum Dry Density (pcf)	122.9
OPTIMUM MOISTURE (%)	12.9	Corrected Optimum Moisture (%)	10.6

SAMPLE ID	PF-4
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	35
PL	16
PI	19
MC	1.2%

DESCRIPTION	Yellowish brown (10YR 5/8) clayey sand
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	JR
DATE	7-20-04
REVIEW	MB

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	827.30
Wt. Dry Soil & Tare (gm)	720.01
Wt. of Tare (gm)	103.55
Wt. of Water (gm)	107.29
Weight of Dry Soil (gm)	616.46
Moisture Content (%)	17.4

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-4 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10YR 5/8) clayey sand

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	114.09
Dry Soil & Tare (gm)	113.02
Tare Weight (gm)	21.80
Moisture Content (%)	1.2

LL	35
PL	16
PI	19

TEST BY	JR
DATE SET UP	7/19/2004
REVIEW BY	MB

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	23483.70 (before separating on the #4 sieve)
Tare Weight (gm)	
Total Weight (gm)	23211.43

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00	
coarse gravel	0.34	
fine gravel	10.21	10.55
coarse sand	10.87	
medium sand	24.43	
fine sand	23.89	59.20
fines	30.25	
		100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	34.50	0.1	99.9
0.75"	78.00	0.3	99.7
0.375"	890.00	3.83	96.2
#4	2449.00	10.55	89.4

BACK SIEVE

Tare Weight: 0.00

				% PASSING
#10	6.12	6.1	12.16	78.6
#20	12.87	12.9	25.56	66.6
#40	19.87	19.9	39.46	54.1
#60	25.02	25.0	49.69	45.0
#100	29.10	29.1	57.80	37.8
#200	33.32	33.3	66.18	30.3

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 50.94

DATE	TIME	READING R	TEMP T	HYD. COR. Cc
7/22/2004	9:26			
7/22/2004	9:28	20.5	22.70	6.50
7/22/2004	9:31	18.8	22.70	6.50
7/22/2004	9:41	18.3	22.70	6.50
7/22/2004	9:56	17.5	22.80	6.50
7/22/2004	10:26	17.0	23.10	6.50
7/22/2004	13:36	16.8	21.60	6.50
7/23/2004	9:26	15.8	20.50	6.50

(mm)	%Finer
0.035	24.62
0.022	21.55
0.013	20.67
0.009	19.35
0.006	18.47
0.003	18.03
0.001	16.27

1111

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt. used in test (gm)	50.35
Hydrometer Bulb Number	624378
%Pass #4 Sieve for whole sample	89.4492

HYDROMETER CALCULATIONS

EL (mm)	TEMP COR K	READING R	EFFECTIVE LENGTH	A
2.00	0.013128	14.00	14.8	0.99
5.00	0.013128	12.25	14.5	0.99
15.00	0.013128	11.75	14.5	0.99
30.00	0.013128	11.00	14.5	0.99
60.00	0.013128	10.50	14.5	0.99
250.00	0.013128	10.25	14.5	0.99
1440.00	0.013128	9.25	14.8	0.99

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	99.9
0.75"	19.000	99.7
0.375"	9.500	96.2
#4	4.750	89.4
#10	2.000	78.6
#20	0.850	66.6
#40	0.425	54.1
#60	0.250	45.0
#100	0.150	37.8
#200	0.075	30.3
	0.0347	24.6
	0.0222	21.5
	0.0129	20.7
	0.0091	19.3
	0.0064	18.5
	0.0032	18.0
	0.0014	16.3

Check By NG

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	586.89
Wt. Dry Soil & Tare (gm)	532.23
Wt. of Tare (gm)	103.94
Wt. of Water (gm)	54.66
Weight of Dry Soil (gm)	428.29
Moisture Content (%)	12.8

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-5 Depth (ft) -
TYPE	BULK
Description	Yellowish brown (10 YR 5/8)
USCS	SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	157.87
Dry Soil & Tare (gm)	153.29
Tare Weight (gm)	32.34
Moisture Content (%)	3.8

LL	37	TEST BY	JR
PL	19	DATE SET UP	7/19/2004
PI	18	REVIEW BY	MB

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	18706.10 (before separating on the #4 sieve)
Tare Weight (gm)	
Total Weight (gm)	18023.60

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00	
coarse gravel	0.00	
fine gravel	14.49	14.49
coarse sand	6.66	
medium sand	25.79	
fine sand	24.21	56.67
fines	28.84	
		100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	258.90	1.44	98.6
#4	2612.40	14.49	85.5

BACK SIEVE

Tare Weight: 0.00

			% PASSING
#10	3.72	3.7	7.79	78.8
#20	10.65	10.7	22.31	66.4
#40	18.12	18.1	37.95	53.1
#60	23.38	23.4	48.97	43.6
#100	27.52	27.5	57.64	36.2
#200	31.64	31.6	66.27	28.8

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 49.55

DATE	TIME	READING	TEMP	HYD. COR.
7/22/2004	9:59	R	T	Cc
7/22/2004	10:01	20.3	22.80	6.50
7/22/2004	10:04	19.0	22.90	6.50
7/22/2004	10:14	18.8	23.00	6.50
7/22/2004	10:29	18.0	23.00	6.50
7/22/2004	10:59	17.5	22.50	6.50
7/22/2004	14:09	17.0	21.10	6.50
7/23/2004	9:59	16.3	20.20	6.50

(mm)	%Finer
0.035	24.38
0.022	22.16
0.013	21.72
0.009	20.39
0.006	19.50
0.003	18.62
0.001	17.29

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt. used in test (gm)	47.74
Hydrometer Bulb Number	624878
%Pass #4 Sieve for whole sample	85.5057

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.800	100.0
1.5"	37.500	100.0
1.0"	25.400	100.0
0.75"	19.000	100.0
0.375"	9.500	98.6
#4	4.750	85.5
#10	2.000	78.8
#20	0.850	66.4
#40	0.425	53.1
#60	0.250	43.6
#100	0.150	36.2
#200	0.075	28.8
	0.0350	24.4
	0.0222	22.2
	0.0127	21.7
	0.0090	20.4
	0.0065	19.5
	0.0032	18.6
	0.0014	17.3

HYDROMETER CALCULATIONS

RT (mm)	TEMP COR K	READING R	EFFECTIVE LENGTH	AS
2.00	0.013126	33.75	14.2	0.99
5.00	0.013126	32.50	14.3	0.99
15.00	0.012973	32.25	14.3	0.99
30.00	0.012973	31.50	14.5	0.99
60.00	0.013126	31.00	14.5	0.99
250.00	0.013283	18.50	14.7	0.99
1440.00	0.013446	5.75	14.8	0.99

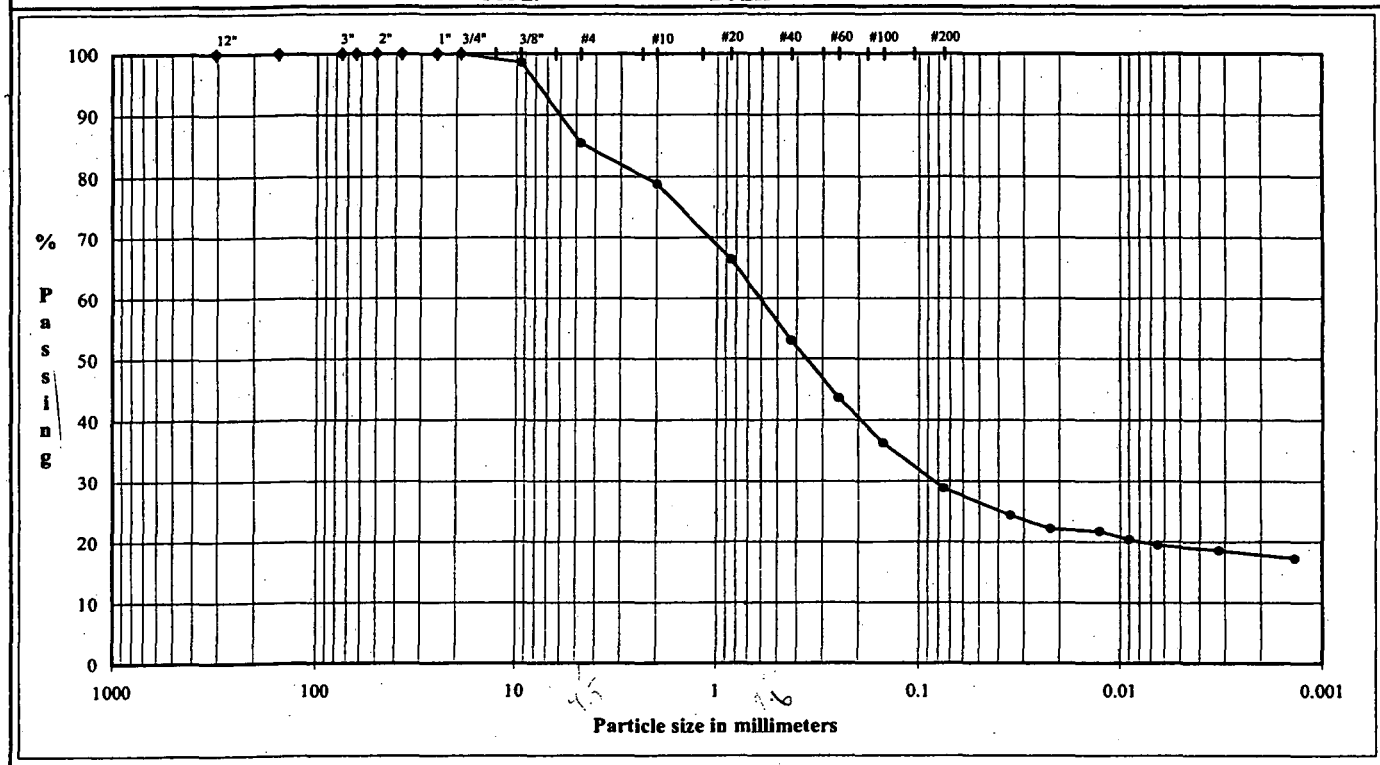
Check By NG

July-04 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-5 Depth (ft): -
TYPE: BULK



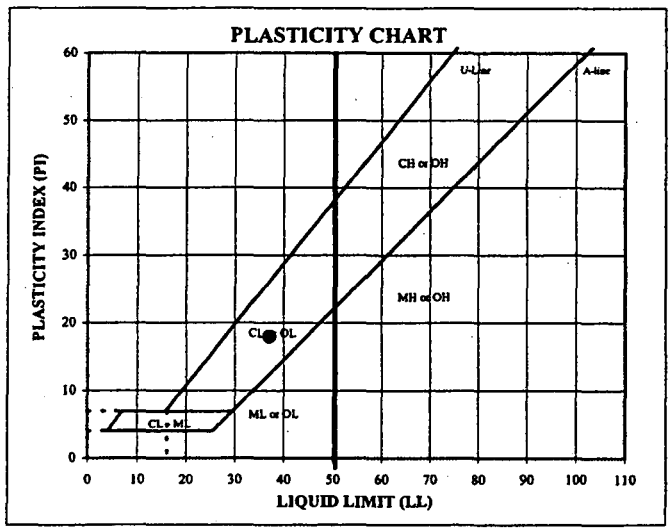
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	98.6		
#4	4.8	85.5	Fine Gravel	14.49
#10	2.00	78.8	Coarse Sand	6.66
#20	0.85	66.4		
#40	0.43	53.1	Medium Sand	25.79
#60	0.25	43.6		
#100	0.15	36.2		
#200	0.075	28.8	Fine Sand	24.21

Hydrometer Analysis

(mm)	%Finer		
0.035	24.4		
0.022	22.2		
0.013	21.7	Fines	
0.0090	20.4	Silt or Clay	28.84
0.0065	19.5		
0.0032	18.6		
0.0014	17.3		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
12.8	37	19	18	

DESCRIPTION: Yellowish brown (10 YR 5/8)

USCS: SC

TECH: JR
DATE: 7/19/2004
REVIEW: MB

Golder Associates Inc.

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO	TEST TYPE	D 698 D 4718
PROJECT NUMBER	043-2246.0001	PROCEDURE	METHOD A
SAMPLE IDENTITY	PF-5 - -		
SAMPLE TYPE	BULK		

MOLD NUMBER	AH-1
MOLD WEIGHT (gm)	2265.0
MOLD DIAMETER (in)	3.991
MOLD HEIGHT (in)	4.581
MOLD VOLUME (cu.ft)	0.0332

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	157.87
Dry Wt Tare & Soil	(W2)	492.88	153.29
Wt Tare	(W3)	0.00	32.34
Wt Moisture	(W4=W1-W2)	11.19	4.58
Wt Dry Soil	(W5=W2-W3)	492.88	120.95
Water Content (dec)	(wc=W4/W5)	0.0227	0.0379
Water Content (%)	(W4/W5)*100	2.3%	3.8%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	18706.10
TOTAL WEIGHT, DRY (COARSE & FINE)	18023.60
WEIGHT RETAINED ON # 4 SIEVE (WET)	2871.30
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	15.58%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4032.1	4118.9	4238.1	4253.8	4244.5		
Weight of Mold	(W2)	2265.00	2265.00	2265.00	2265.00	2265.00		
Wt. Of Wet Soil	(W3=W1-W2)	1767.10	1853.90	1973.10	1988.80	1979.50		
Wet Density, wd (pcf)	(W3/453.6*Vm)	117.47	123.24	131.16	132.21	131.59		
WATER CONTENTS								
Wt Tare & Soil	(W4)	643.01	612.82	649.00	658.69	647.98		
Wt Tare & Soil	(W5)	598.18	563.91	589.34	592.03	577.19		
Wt Tare	(W6)	103.94	102.20	101.89	103.14	104.41		
Wt Moisture	(W7=W4-W5)	44.83	48.91	59.66	66.66	70.79		
Wt Dry Soil	(W8=W5-W6)	494.24	461.71	487.45	488.89	472.78		
Water Content (%)	(W7/W8)*100	9.1%	10.6%	12.2%	13.6%	15.0%		
Dry Density (pcf)	(wd/(1+wc))	107.7	111.4	116.9	116.3	114.5		

MAXIMUM DRY DENSITY (pcf)	117.4
OPTIMUM MOISTURE CONTENT (%)	12.7
Corrected Maximum Dry Density (pcf)	121.9
Corrected Optimum Moisture (%)	10.8

DESCRIPTION: Yellowish brown (10 YR 5/8)

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

Weight of Oven Dry Sample (gm)	A	504.07		
Weight of Saturated-Surface-Dry (gm)	B	506.40		
Weight of Saturated Sample in Water (gm)	C	301.90		
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46		
Bulk Specific Gravity	A/(B-C)	2.465		

LL	37
PL	19
PI	18
MC	12.8

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	JR
DATE	7-20-04
REVIEW	MB

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	586.89
Wt. Dry Soil & Tare (gm)	532.23
Wt. of Tare (gm)	103.94
Wt. of Water (gm)	54.66
Weight of Dry Soil (gm)	428.29
Moisture Content (%)	12.76

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-5
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION		
Number of Blows		
Weight of Wet Soil & T	30.39	25.73
Weight of Dry Soil & T	28.10	23.84
Weight of Tare (gm)	15.97	13.56
Weight of Water (gm)	2.29	1.89
Weight of Dry Soil (gm)	12.13	10.28
Water Content %	18.88	18.39

LIQUID LIMIT DETERMINATION		
35	26	19
26.48	25.44	26.62
23.22	22.48	23.15
14.30	14.53	14.11
3.26	2.96	3.47
8.92	7.95	9.04
36.55	37.23	38.38

PLASTIC LIMIT (PL): 19

LIQUID LIMIT (LL): 37

PLASTICITY INDEX (PI): 18

BLOWS	MC		
35	36.55	3.56	25
26	37.23	3.26	0.00
19	38.38	2.94	-2
0	0.00	#NUM!	

	3 POINTS			3-POINTS
	25.00	25.00	10.00	37
36.55	38.38	37.49	37.49	19
-2	40.00	37.49		18

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS	
0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS	
0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

NP

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

PLASTICITY INDEX (PI): NP

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	732.79
Wt. Dry Soil & Tare (gm)	668.31
Wt. of Tare (gm)	103.82
Wt. of Water (gm)	64.48
Weight of Dry Soil (gm)	564.49
Moisture Content (%)	11.42

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-5 Dup
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION		
Number of Blows		
Weight of Wet Soil & T	25.67	22.76
Weight of Dry Soil & T	24.17	21.36
Weight of Tare (gm)	15.89	13.98
Weight of Water (gm)	1.50	1.40
Weight of Dry Soil (gm)	8.28	7.38
Water Content %	18.12	18.97

LIQUID LIMIT DETERMINATION		
35	23	16
24.47	23.64	23.70
21.59	20.85	20.92
14.01	13.98	14.52
2.88	2.79	2.78
7.58	6.87	6.40
37.99	40.61	43.44

PLASTIC LIMIT (PL): 19

LIQUID LIMIT (LL): 40

PLASTICITY INDEX (PI): 21

BLOWS	MC		
35	37.99	3.56	25
23	40.61	3.14	0.00
16	43.44	2.77	-2
0	0.00	#NUM!	

	3 POINTS			3-POINTS
	25.00	25.00	10.00	40
37.99	43.44	40.23	40.23	19
-2	44.00	40.23		21

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS	
0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS	
0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

PLASTICITY INDEX (PI): NP

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	732.79
Wt. Dry Soil & Tare (gm)	668.31
Wt. of Tare (gm)	103.82
Wt. of Water (gm)	64.48
Weight of Dry Soil (gm)	564.49
Moisture Content (%)	11.4

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-5 Dup Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	83.44
Dry Soil & Tare (gm)	81.65
Tare Weight (gm)	21.77
Moisture Content (%)	3.0

LL	40	TEST BY	JR
PL	19	DATE SET UP	7/21/2004
PI	21	REVIEW BY	MB

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	19173.70	(before separating on the #4 sieve)
Tare Weight (gm)		
Total Weight (gm)	18617.17	

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00		
coarse gravel	0.00		
fine gravel	12.78	12.78	
coarse sand	10.68		
medium sand	26.21		
fine sand	21.97	58.86	
fines	28.36		
			100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	263.40	1.4	98.6
#4	2378.50	12.8	87.2

BACK SIEVE

Tare Weight: 0.00

				% PASSING
#10	5.97	6.0	12.25	76.5
#20	13.69	13.7	28.08	62.7
#40	20.62	20.6	42.30	50.3
#60	25.44	25.4	52.18	41.7
#100	29.21	29.2	59.91	35.0
#200	32.90	32.9	67.48	28.4

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 50.21

DATE	TIME	READING	TEMP	HYD. COR.
7/22/2004	10:43	R	T	Cc
7/22/2004	10:45	19.8	22.50	6.50
7/22/2004	10:48	18.5	22.50	6.50
7/22/2004	10:58	18.3	22.10	6.50
7/22/2004	11:13	17.8	22.00	6.50
7/22/2004	11:43	17.3	21.60	6.50
7/22/2004	14:53	16.8	20.30	6.50
7/23/2004	10:43	15.8	19.80	6.50

(mm)	%Finer
0.035	23.47
0.022	21.25
0.013	20.81
0.009	19.93
0.007	19.04
0.003	18.16
0.001	16.38

!!!!!

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt used in test (gm)	48.75
Hydrometer Bulb Number	624378
% Pass #4 Sieve for whole sample	87.2242

HYDROMETER CALCULATIONS

TIME (min)	TEMP COR K	READING C	EFFECTIVE LENGTH	% Finer
2.00	0.013126	19.25	14.3	0.99
5.00	0.013126	12.00	14.3	0.99
15.00	0.013126	11.25	14.3	0.99
30.00	0.013126	11.00	14.3	0.99
60.00	0.013126	10.75	14.3	0.99
250.00	0.013446	10.25	14.7	0.99
1440.00	0.013613	9.25	14.8	0.99

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	152.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	98.6
#4	4.750	87.2
#10	2.000	76.5
#20	0.850	62.7
#40	0.425	50.3
#60	0.250	41.7
#100	0.150	35.0
#200	0.075	28.4
	0.0350	23.5
	0.0222	21.3
	0.0129	20.8
	0.0091	19.9
	0.0066	19.0
	0.0033	18.2
	0.0014	16.4

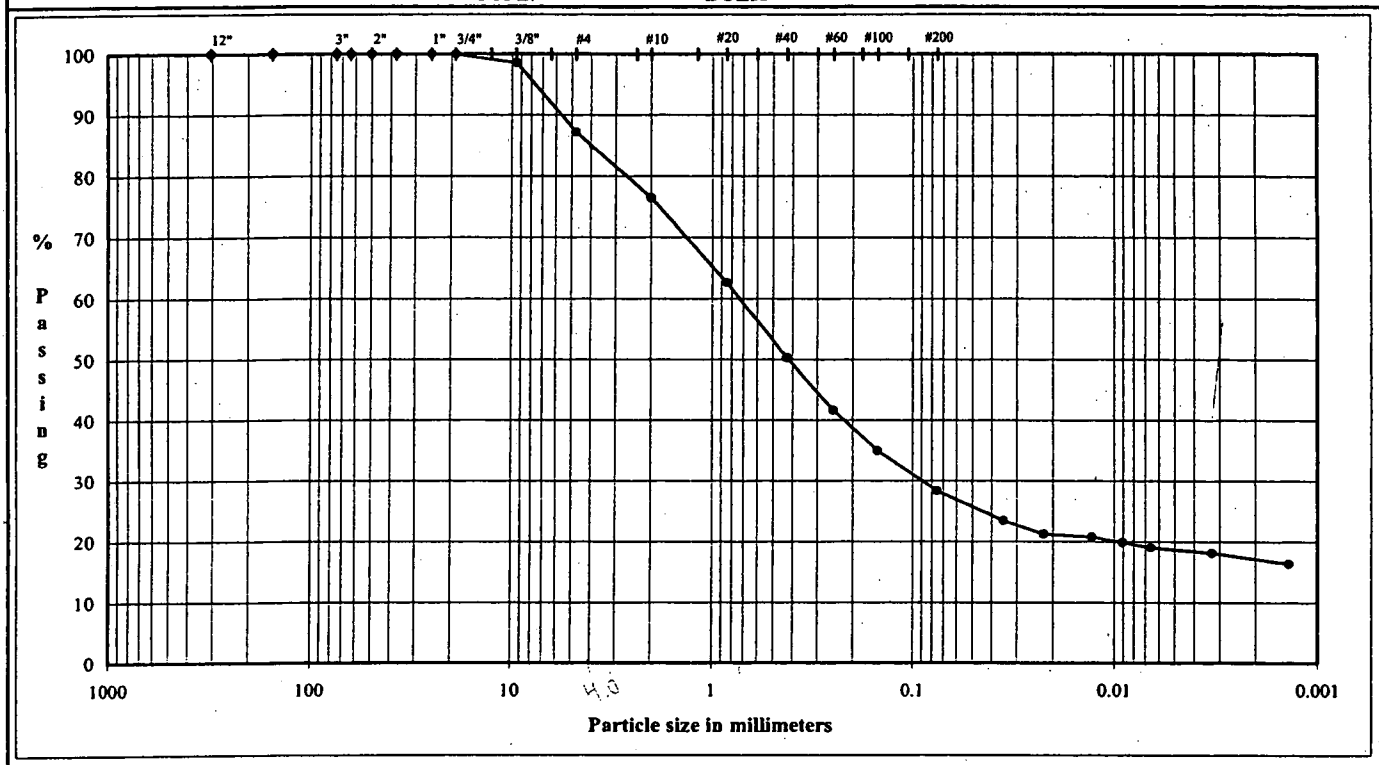
Check By NG

July-04 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **Rocky Flats/Field & Lab Testing/CO**
SAMPLE ID: **PF-5 Dup** Depth (ft): -
TYPE: **BULK**



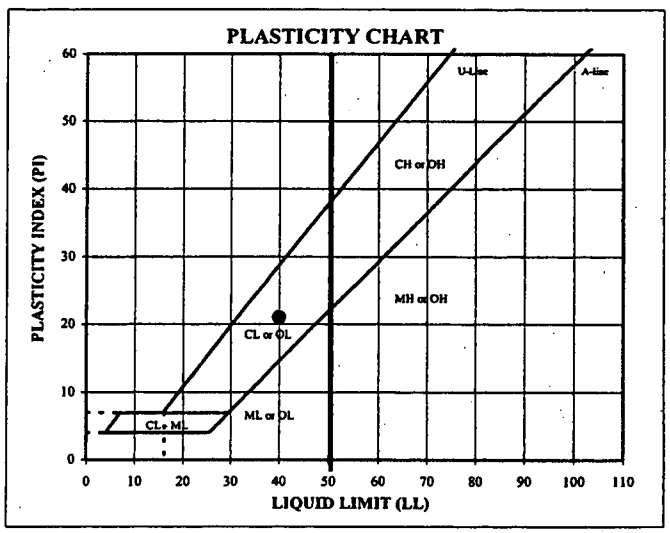
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	98.6		
#4	4.8	87.2	Fine Gravel	12.78
#10	2.00	76.5	Coarse Sand	10.68
#20	0.85	62.7		
#40	0.43	50.3	Medium Sand	26.21
#60	0.25	41.7		
#100	0.15	35.0		
#200	0.075	28.4	Fine Sand	21.97

Hydrometer Analysis

(mm)	%Finer		
0.035	23.5		
0.022	21.3		
0.013	20.8	Fines	
0.0091	19.9	Silt or Clay	28.36
0.0066	19.0		
0.0033	18.2		
0.0014	16.4		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
11.4	40	19	21	

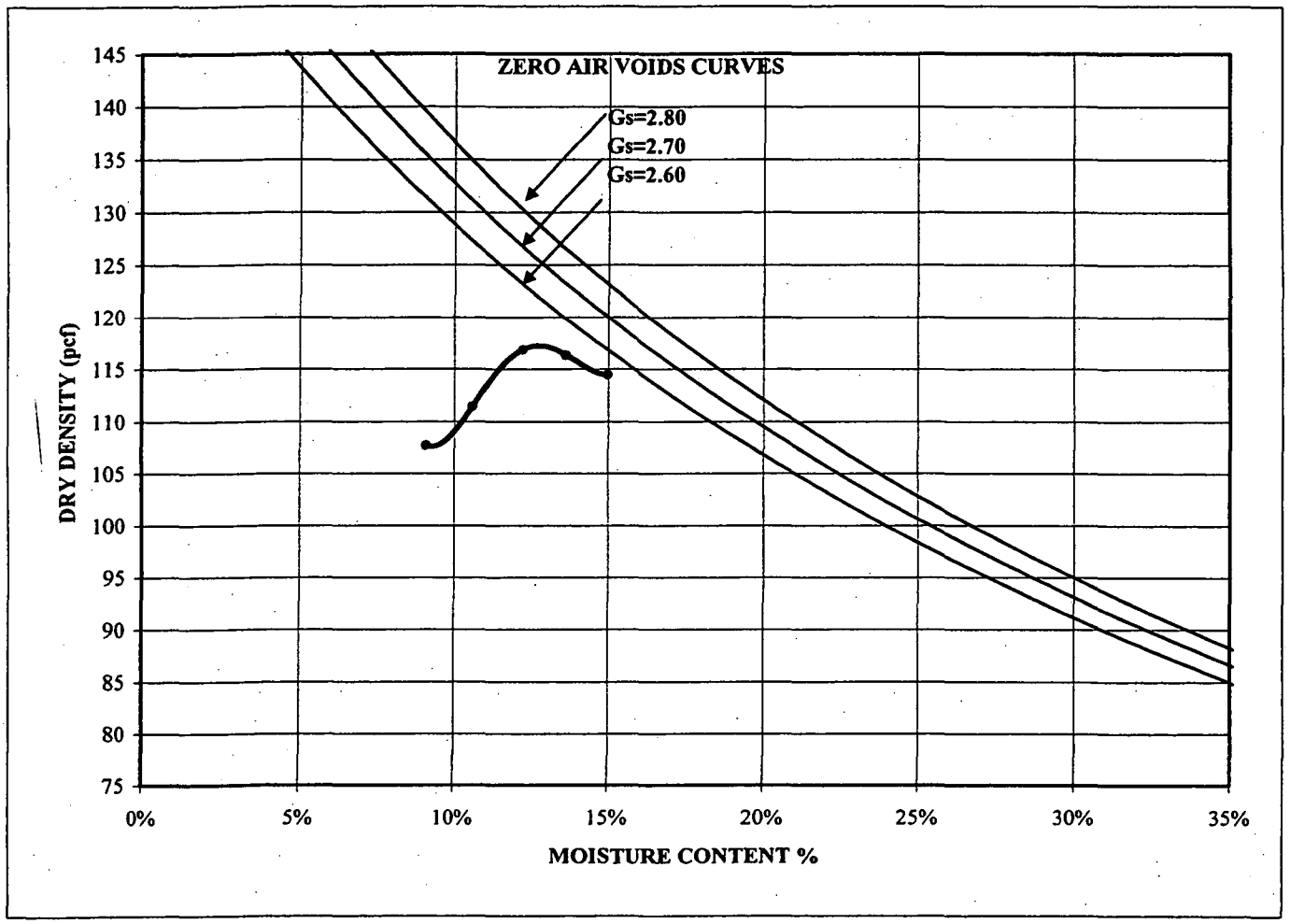
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

TECH: JR
DATE: 7/21/2004
REVIEW: MB

Golder Associates Inc.

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	117.4	Corrected Maximum Dry Density (pcf)	121.9
OPTIMUM MOISTURE (%)	12.7	Corrected Optimum Moisture (%)	10.8

SAMPLE ID	PF-5
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

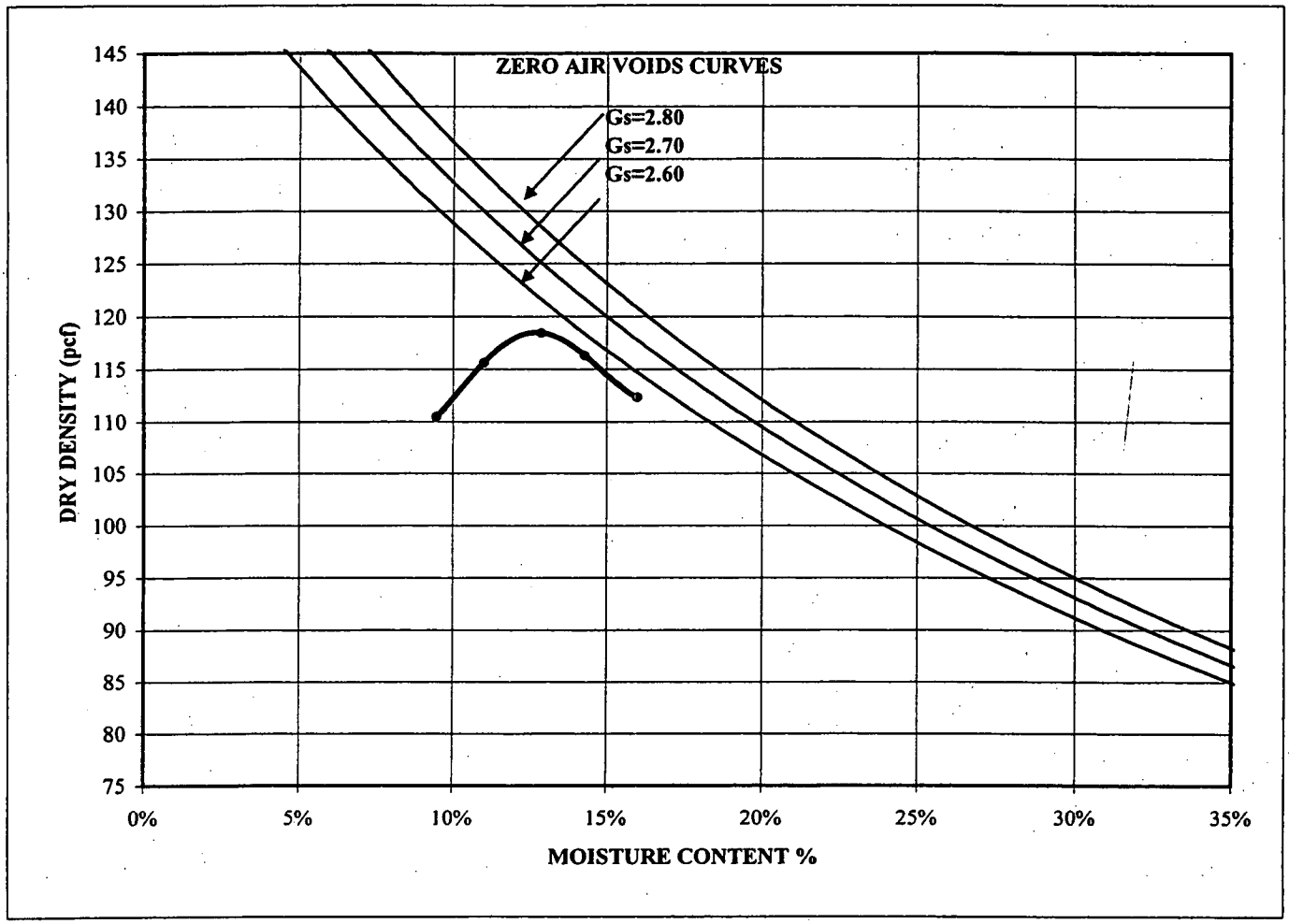
LL	37
PL	19
PI	18
MC	12.8

DESCRIPTION	Yellowish brown (10 YR 5/8)
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	JR
DATE	7-20-04
REVIEW	MB

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	118.4	Corrected Maximum Dry Density (pcf)	122.3
OPTIMUM MOISTURE (%)	12.8	Corrected Optimum Moisture (%)	11.1

SAMPLE ID	PF-5 Dup
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	40
PL	19
PI	21
MC	11.4

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	DT
DATE	7-22-04
REVIEW	MB

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	656.82
Wt. Dry Soil & Tare (gm)	599.96
Wt. of Tare (gm)	104.75
Wt. of Water (gm)	56.86
Weight of Dry Soil (gm)	495.21
Moisture Content (%)	11.48

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-6
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION

Number of Blows		
Weight of Wet Soil & T	20.16	20.55
Weight of Dry Soil & T	19.12	19.53
Weight of Tare (gm)	13.72	14.53
Weight of Water (gm)	1.04	1.02
Weight of Dry Soil (gm)	5.40	5.00
Water Content %	19.26	20.40

LIQUID LIMIT DETERMINATION

35	27	17
27.43	26.25	26.47
23.94	22.56	22.34
15.81	14.27	13.79
3.49	3.69	4.13
8.13	8.29	8.55
42.93	44.51	48.30

PLASTIC LIMIT (PL): 20

LIQUID LIMIT (LL): 45

PLASTICITY INDEX (PI): 25

BLOWS	MC		
35	42.93	3.56	25
27	44.51	3.30	0.00
17	48.30	2.83	-2
0	0.00	#NUM!	

	3 POINTS			
	25.00	25.00	10.00	3-POINTS
42.93	48.30	45.32	45.32	45
-2	50.00	45.32		20
				25

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS

0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS

0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

NP

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

PLASTICITY INDEX (PI): NP

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	656.82
Wt. Dry Soil & Tare (gm)	599.96
Wt. of Tare (gm)	104.75
Wt. of Water (gm)	56.86
Weight of Dry Soil (gm)	495.21
Moisture Content (%)	11.5

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-6 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand with gravel.

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	92.59
Dry Soil & Tare (gm)	91.44
Tare Weight (gm)	21.82
Moisture Content (%)	1.7

LL	45	TEST BY	JR
PL	20	DATE SET UP	7/19/2004
PI	25	REVIEW BY	MB

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	19522.40 (before separating on the #4 sieve)
Tare Weight (gm)	
Total Weight (gm)	19205.16

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00		
coarse gravel	0.00		
fine gravel	17.91	17.91	
coarse sand	9.58		
medium sand	22.15		
fine sand	20.38	52.11	
fines	29.98		
			100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	261.70	1.36	98.6
#4	3439.70	17.91	82.1

BACK SIEVE

Tare Weight: 0.00

				% PASSING
#10	5.69	5.7	11.67	72.5
#20	12.05	12.1	24.71	61.8
#40	18.85	18.9	38.65	50.4
#60	23.53	23.5	48.24	42.5
#100	26.24	26.2	53.80	37.9
#200	30.96	31.0	63.48	30.0

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 49.58

DATE	TIME	READING R	TEMP T	HYD. COR. Cc
7/22/2004	10:07			
7/22/2004	10:09	21.5	22.80	6.50
7/22/2004	10:12	20.3	22.80	6.50
7/22/2004	10:22	19.8	22.90	6.50
7/22/2004	10:37	19.0	22.60	6.50
7/22/2004	11:07	18.8	22.40	6.50
7/22/2004	14:17	18.0	21.00	6.50
7/23/2004	10:07	17.3	20.10	6.50

(mm)	%Finer
0.034	24.99
0.022	22.91
0.013	22.08
0.009	20.83
0.006	20.41
0.003	19.16
0.001	17.91

!!!!

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt used in test (gm)	48.77
Hydrometer Bulb Number:	624378
%Pass #4 Sieve for whole sample:	82.0897

HYDROMETER CALCULATIONS

t (min)	TEMP COR K	READING R	EFFECTIVE LENGTH L	% N
2.00	0.013126	16.90	13.8	0.99
5.00	0.013126	13.75	14.2	0.99
15.00	0.013126	12.25	14.2	0.99
30.00	0.013126	12.00	14.3	0.99
60.00	0.013126	12.25	14.3	0.99
239.00	0.013283	11.20	14.5	0.99
1440.00	0.013446	10.75	14.7	0.99

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	98.6
#4	4.750	82.1
#10	2.000	72.5
#20	0.850	61.8
#40	0.425	50.4
#60	0.250	42.5
#100	0.150	37.9
#200	0.075	30.0
	0.0345	25.0
	0.0221	22.9
	0.0138	22.1
	0.0091	20.8
	0.0064	20.4
	0.0032	19.2
	0.0014	17.9

Check By NG

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO		
PROJECT NUMBER	043-2246.0001		
SAMPLE IDENTITY	PF-5 Dup	-	-
SAMPLE TYPE	BULK		

TEST TYPE: D 698 D 4718
PROCEDURE: METHOD A

MOLD NUMBER	AH-1
MOLD WEIGHT (gm)	2265.0
MOLD DIAMETER (in)	3.991
MOLD HEIGHT (in)	4.581
MOLD VOLUME (cu.ft)	0.0332

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT

		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	83.44
Dry Wt Tare & Soil	(W2)	492.88	81.65
Wt Tare	(W3)	0.00	21.77
Wt Moisture	(W4=W1-W2)	11.19	1.79
Wt Dry Soil	(W5=W2-W3)	492.88	59.88
Water Content (dec)	(wc=W4/W5)	0.0227	0.0299
Water Content (%)	(W4/W5)*100	2.3%	3.0%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	19173.70
TOTAL WEIGHT, DRY (COARSE & FINE)	18617.17
WEIGHT RETAINED ON # 4 SIEVE (WET)	2641.90
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	13.88%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)

		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4084.2	4195.2	4276.4	4264.4	4224.3		
Weight of Mold	(W2)	2265.00	2265.00	2265.00	2265.00	2265.00		
Wt. Of Wet Soil	(W3=W1-W2)	1819.20	1930.20	2011.40	1999.40	1959.30		
Wet Density, wd (pcf)	(W3/453.6*Vm)	120.93	128.31	133.71	132.91	130.24		
WATER CONTENTS								
Wt Tare & Soil	(W4)	608.70	619.31	612.87	617.89	607.36		
Wt Tare & Soil	(W5)	564.88	567.90	554.51	553.19	537.89		
Wt Tare	(W6)	102.14	100.28	101.59	100.18	103.17		
Wt Moisture	(W7=W4-W5)	43.82	51.41	58.36	64.70	69.47		
Wt Dry Soil	(W8=W5-W6)	462.74	467.62	452.92	453.01	434.72		
Water Content (%)	(W7/W8)*100	9.5%	11.0%	12.9%	14.3%	16.0%		
Dry Density (pcf)	(wd/(1+wc))	110.5	115.6	118.4	116.3	112.3		

MAXIMUM DRY DENSITY (pcf)	118.4
OPTIMUM MOISTURE CONTENT (%)	12.8
Corrected Maximum Dry Density (pcf)	122.3
Corrected Optimum Moisture (%)	11.1

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

Weight of Oven Dry Sample (gm)	A	504.07		
Weight of Saturated-Surface-Dry (gm)	B	506.40		
Weight of Saturated Sample in Water (gm)	C	301.90		
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46		
Bulk Specific Gravity	A/(B-C)	2.465		

LL	40
PL	19
PI	21
MC	11.4

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	DT
DATE	7-22-04
REVIEW	MB

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO			TEST TYPE	D 698 D 4718
PROJECT NUMBER	043-2246.0001			PROCEDURE	METHOD B
SAMPLE IDENTITY	PF-6	-	-		
SAMPLE TYPE	BULK				

MOLD NUMBER	AH-1
MOLD WEIGHT (gm)	2265.8
MOLD DIAMETER (in)	3.991
MOLD HEIGHT (in)	4.581
MOLD VOLUME (cu.ft)	0.0332

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	656.82
Dry Wt Tare & Soil	(W2)	492.88	599.96
Wt Tare	(W3)	0.00	104.75
Wt Moisture	(W4=W1-W2)	11.19	56.86
Wt Dry Soil	(W5=W2-W3)	492.88	495.21
Water Content (dec)	(wc=W4/W5)	0.0227	0.1148
Water Content (%)	(W4/W5)*100	2.3%	11.5%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	19522.40
TOTAL WEIGHT, DRY (COARSE & FINE)	17511.71
WEIGHT RETAINED ON # 4 SIEVE (WET)	3701.40
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	20.67%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4078.5	4224.4	4287.2	4293.9	4283.1		
Weight of Mold	(W2)	2265.80	2265.80	2265.80	2265.80	2265.80		
Wt. Of Wet Soil	(W3=W1-W2)	1812.70	1958.60	2021.40	2028.10	2017.30		
Wet Density, wd (pcf)	(W3/453.6*Vm)	120.50	130.20	134.37	134.82	134.10		
WATER CONTENTS								
Wt Tare & Soil	(W4)	719.66	750.24	738.64	527.43	662.30		
Wt Tare & Soil	(W5)	670.73	686.65	671.13	476.83	587.82		
Wt Tare	(W6)	101.16	102.62	101.61	100.97	103.19		
Wt Moisture	(W7=W4-W5)	48.93	63.59	67.51	50.60	74.48		
Wt Dry Soil	(W8=W5-W6)	569.57	584.03	569.52	375.86	484.63		
Water Content (%)	(W7/W8)*100	8.6%	10.9%	11.9%	13.5%	15.4%		
Dry Density (pcf)	(wd/(1+wc))	111.0	117.4	120.1	118.8	116.2		

MAXIMUM DRY DENSITY (pcf)	120.3
OPTIMUM MOISTURE CONTENT (%)	12.5
Corrected Maximum Dry Density (pcf)	120.3
Corrected Optimum Moisture (%)	12.5

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

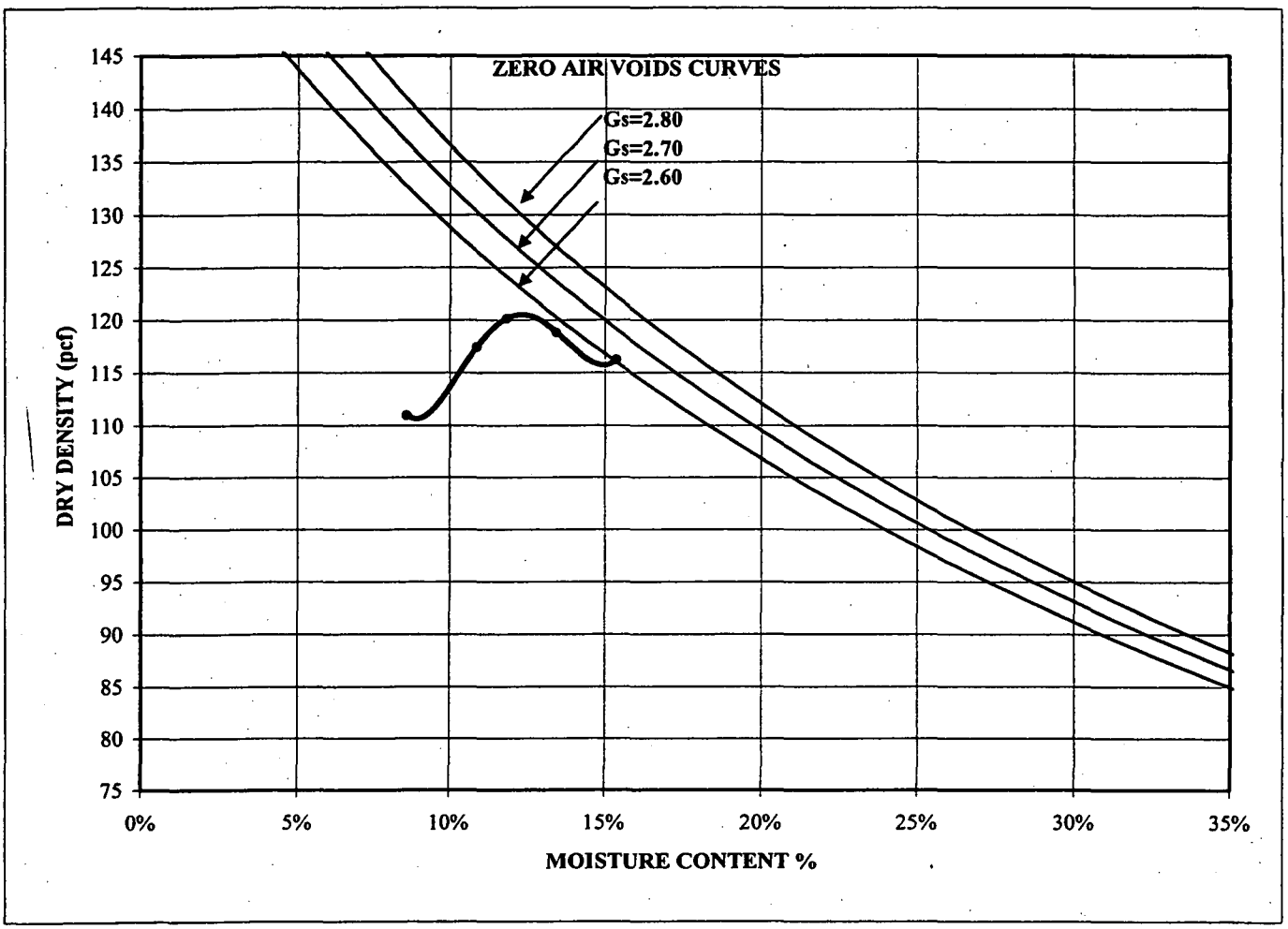
Weight of Oven Dry Sample (gm)	A	504.07			
Weight of Saturated-Surface-Dry (gm)	B	506.40			
Weight of Saturated Sample in Water (gm)	C	301.90			
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46			
Bulk Specific Gravity	A/(B-C)	2.465			

LL	45
PL	20
PI	25
MC	11.5%

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	JR
DATE	7-20-04
REVIEW	MB

MOISTURE / DRY DENSITY CURVE
D 698 METHOD B



MAXIMUM DRY DENSITY (pcf)	120.3	Corrected Maximum Dry Density (pcf)	120.3
OPTIMUM MOISTURE (%)	12.5	Corrected Optimum Moisture (%)	12.5

SAMPLE ID	PF-6
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	45
PL	20
PI	25
MC	11.5%

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand with gravel
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	JR
DATE	7-20-04
REVIEW	MB

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	688.89
Wt. Dry Soil & Tare (gm)	619.14
Wt. of Tare (gm)	102.36
Wt. of Water (gm)	69.75
Weight of Dry Soil (gm)	516.78
Moisture Content (%)	13.50

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-7
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION

Number of Blows		
Weight of Wet Soil & T	21.55	24.36
Weight of Dry Soil & T	20.41	23.06
Weight of Tare (gm)	13.91	16.10
Weight of Water (gm)	1.14	1.30
Weight of Dry Soil (gm)	6.50	6.96
Water Content %	17.54	18.68

LIQUID LIMIT DETERMINATION

27	25	16
23.92	24.86	23.40
21.35	22.44	20.85
13.79	15.69	14.23
2.57	2.42	2.55
7.56	6.75	6.62
33.99	35.85	38.52

PLASTIC LIMIT (PL): 18

LIQUID LIMIT (LL): 35

PLASTICITY INDEX (PI): 17

BLOWS	MC		
27	33.99	3.30	25
25	35.85	3.22	0.00
16	38.52	2.77	-2
0	0.00	#NUM!	

	3 POINTS			
	25.00	25.00	10.00	3-POINTS
33.99	38.52	35.17	35.17	35
-2	40.00	35.17		18
				17

ONE POINT ATTERBERG

PLASTIC LIMITS

Number of Blows		
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS

0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

PLASTIC LIMITS

Number of Blows		
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS

0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

NP

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

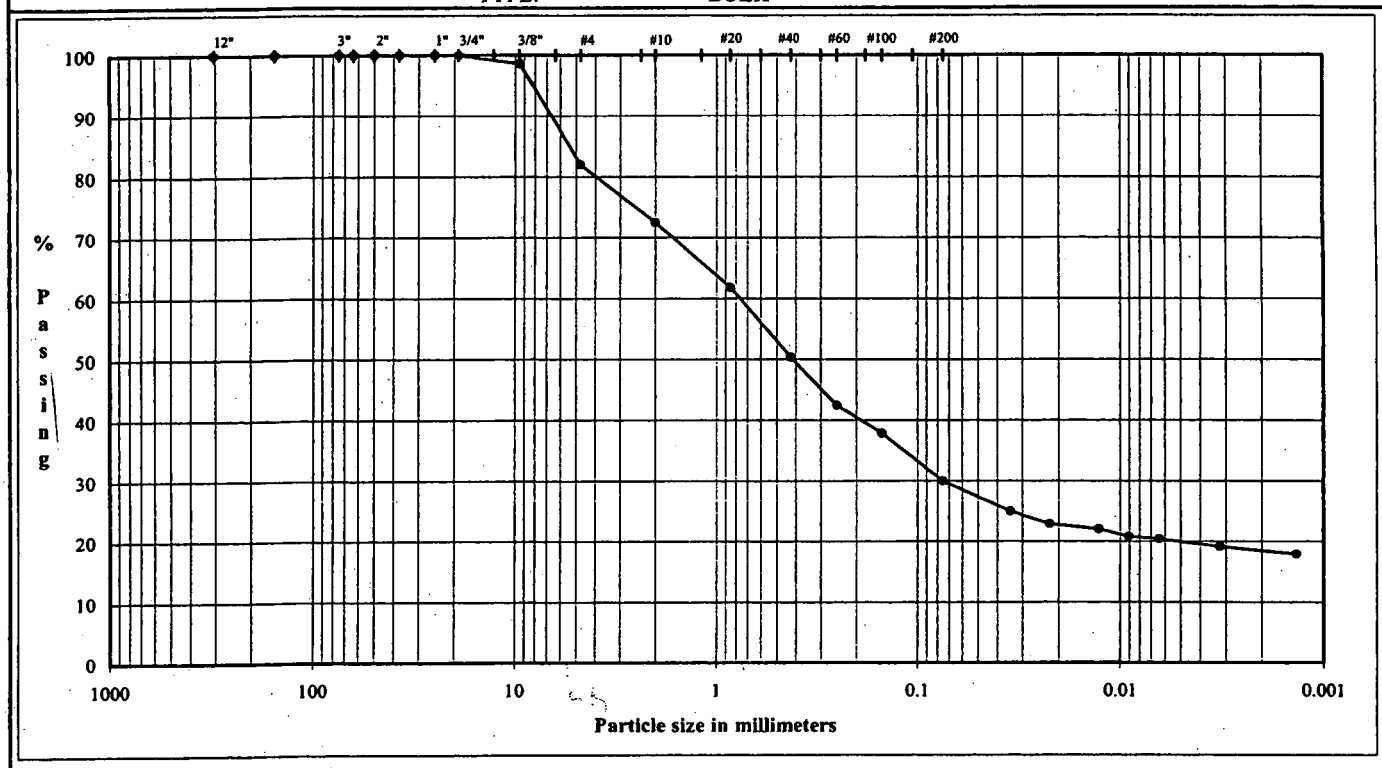
PLASTICITY INDEX (PI): NP

July-04 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-6 Depth (ft): -
TYPE: BULK



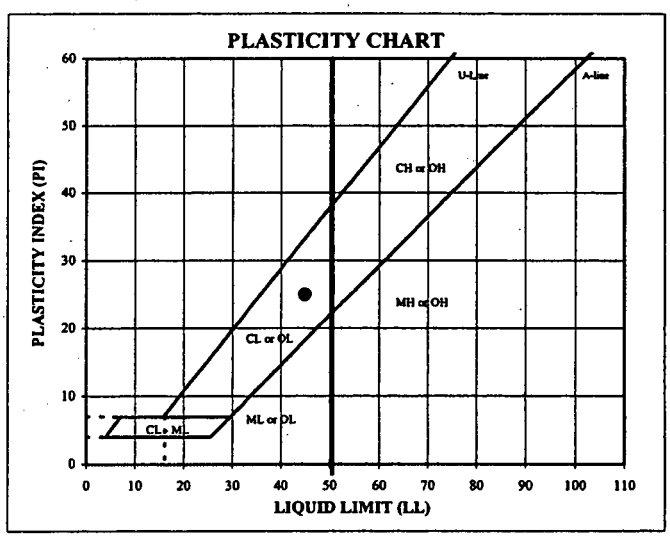
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	98.6		
#4	4.8	82.1	Fine Gravel	17.91
#10	2.00	72.5	Coarse Sand	9.58
#20	0.85	61.8		
#40	0.43	50.4	Medium Sand	22.15
#60	0.25	42.5		
#100	0.15	37.9		
#200	0.075	30.0	Fine Sand	20.38

Hydrometer Analysis

(mm)	%Finer		
0.034	25.0		
0.022	22.9		
0.013	22.1	Fines	
0.0091	20.8	Silt or Clay	29.98
0.0064	20.4		
0.0032	19.2		
0.0014	17.9		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
11.5	45	20	25	

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

TECH: JR
DATE: 7/19/2004
REVIEW: MB

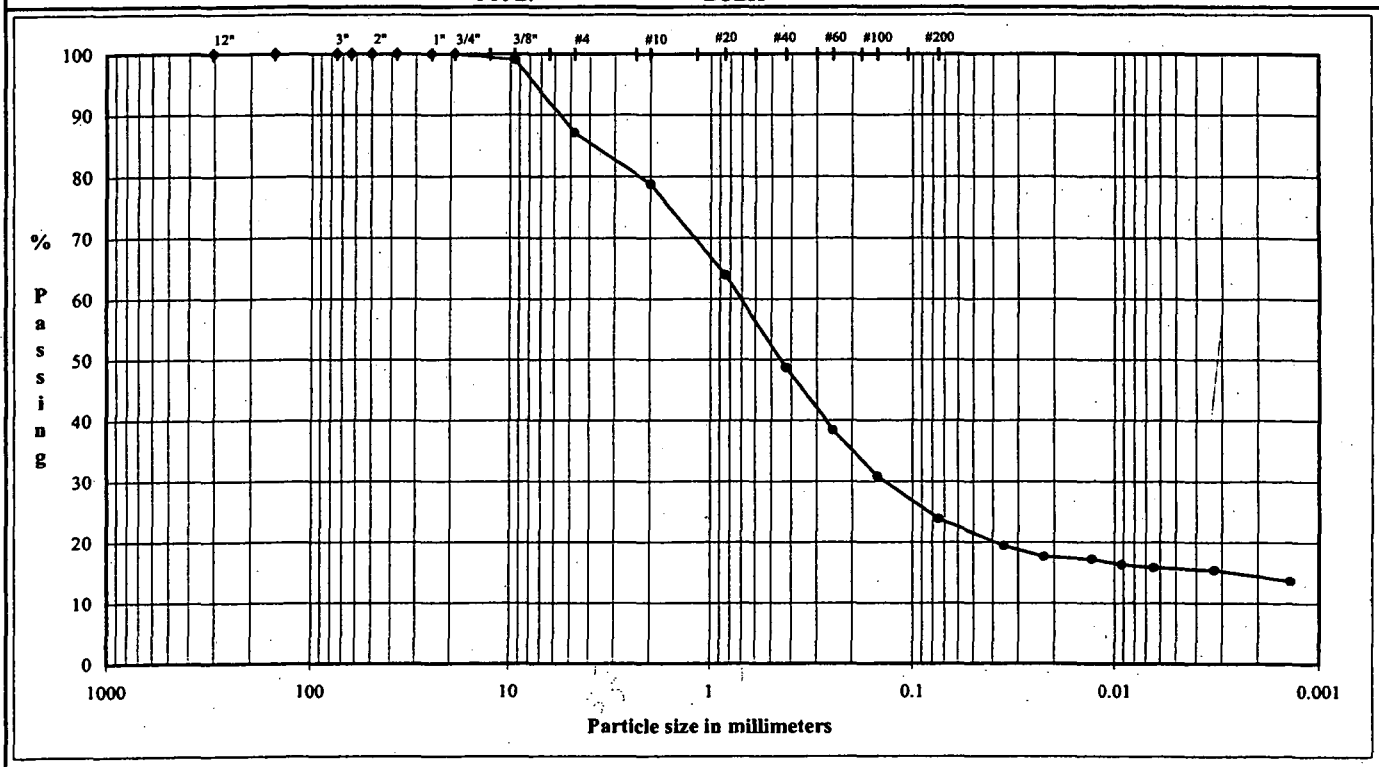
Golder Associates Inc.

July-04 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-7 Depth (ft): -
TYPE: BULK



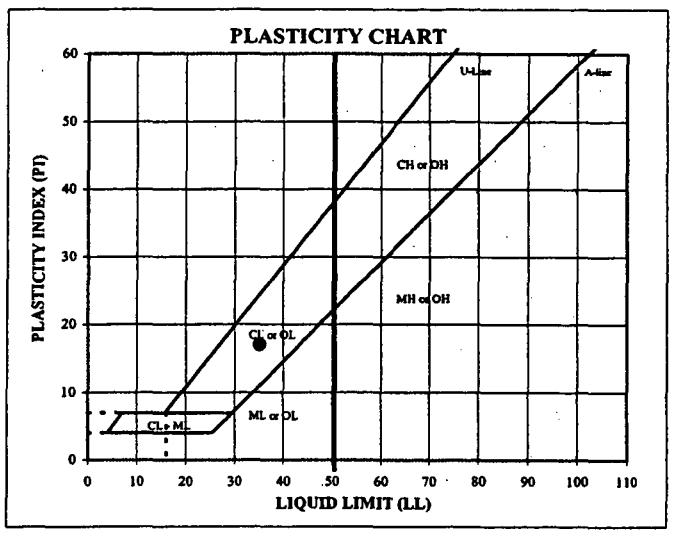
	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	99.1		
#4	4.8	87.1	Fine Gravel	12.89
#10	2.00	78.8	Coarse Sand	8.34
#20	0.85	64.0		
#40	0.43	48.7	Medium Sand	30.05
#60	0.25	38.5		
#100	0.15	30.8		
#200	0.075	23.8	Fine Sand	24.87

Hydrometer Analysis

(mm)	%Finer		
0.035	19.4		
0.023	17.7		
0.013	17.2	Fines	
0.0092	16.3	Silt or Clay	23.85
0.0064	15.9		
0.0033	15.4		
0.0014	13.7		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
13.5	35	18	17	

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

TECH: JR
DATE: 7/19/2004
REVIEW: MB

Golder Associates Inc.

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO		
PROJECT NUMBER	043-2246.0001		
SAMPLE IDENTITY	PF-7	-	-
SAMPLE TYPE	BULK		

TEST TYPE: D 698 D 4718
PROCEDURE: METHOD A

MOLD NUMBER	AH-1
MOLD WEIGHT (gm)	2265.8
MOLD DIAMETER (in)	3.991
MOLD HEIGHT (in)	4.581
MOLD VOLUME (cu.ft)	0.0332

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT

		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	688.89
Dry Wt Tare & Soil	(W2)	492.88	619.14
Wt Tare	(W3)	0.00	102.36
Wt Moisture	(W4=W1-W2)	11.19	69.75
Wt Dry Soil	(W5=W2-W3)	492.88	516.78
Water Content (dec)	(wc=W4/W5)	0.0227	0.1350
Water Content (%)	(W4/W5)*100	2.3%	13.5%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	24507.30
TOTAL WEIGHT, DRY (COARSE & FINE)	21592.90
WEIGHT RETAINED ON # 4 SIEVE (WET)	3334.60
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	15.10%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)

		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4169.7	4256.5	4307.6	4280.3	4235.0		
Weight of Mold	(W2)	2265.80	2265.80	2265.80	2265.80	2265.80		
Wt. Of Wet Soil	(W3=W1-W2)	1903.90	1990.70	2041.80	2014.50	1969.20		
Wet Density, wd (pcf)	(W3/453.6*Vm)	126.56	132.33	135.73	133.91	130.90		
WATER CONTENTS								
Wt Tare & Soil	(W4)	448.82	530.22	572.48	449.13	519.70		
Wt Tare & Soil	(W5)	418.71	488.84	520.15	407.59	463.88		
Wt Tare	(W6)	100.42	103.49	102.37	102.96	102.26		
Wt Moisture	(W7=W4-W5)	30.11	41.38	52.33	41.54	55.82		
Wt Dry Soil	(W8=W5-W6)	318.29	385.35	417.78	304.63	361.62		
Water Content (%)	(W7/W8)*100	9.5%	10.7%	12.5%	13.6%	15.4%		
Dry Density (pcf)	(wd/(1+wc))	115.6	119.5	120.6	117.8	113.4		

MAXIMUM DRY DENSITY (pcf)	121.1
OPTIMUM MOISTURE CONTENT (%)	12.0
Corrected Maximum Dry Density (pcf)	125.1
Corrected Optimum Moisture (%)	10.3

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

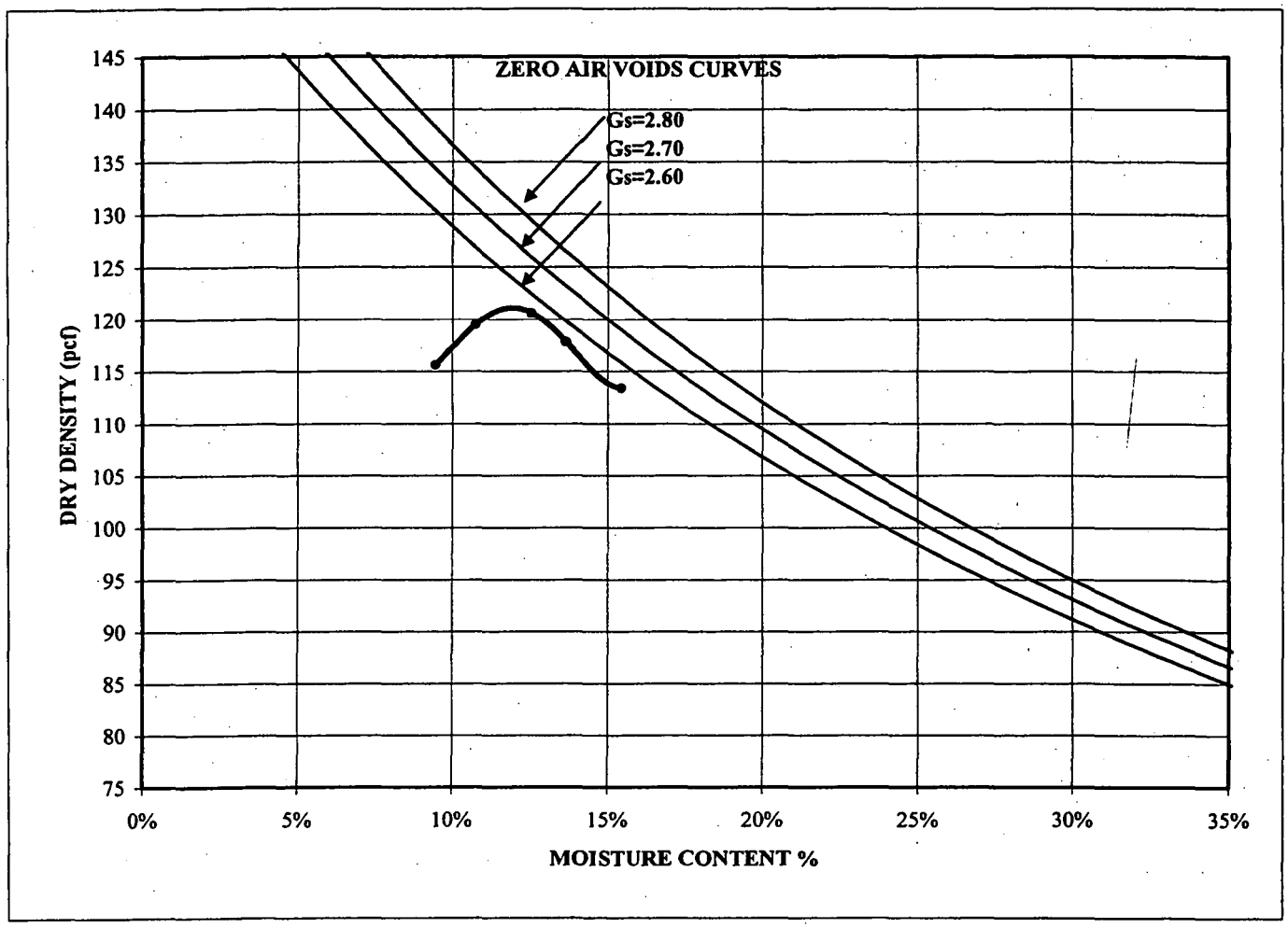
Weight of Oven Dry Sample (gm)	A	504.07			
Weight of Saturated-Surface-Dry (gm)	B	506.40			
Weight of Saturated Sample in Water (gm)	C	301.90			
Absorption of Oversize Particles (%)	|(B-A)/A|*100	0.46			
Bulk Specific Gravity	A/(B-C)	2.465			

LL	35
PL	18
PI	17
MC	13.5

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	JR
DATE	7-20-04
REVIEW	MB

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	121.1	Corrected Maximum Dry Density (pcf)	125.1
OPTIMUM MOISTURE (%)	12.0	Corrected Optimum Moisture (%)	10.3

SAMPLE ID	PF-7
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	35
PL	18
PI	17
MC	13.5

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	JR
DATE	7-20-04
REVIEW	MB

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	688.89
Wt. Dry Soil & Tare (gm)	619.14
Wt. of Tare (gm)	102.36
Wt. of Water (gm)	69.75
Weight of Dry Soil (gm)	516.78
Moisture Content (%)	13.5

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-7 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	71.56
Dry Soil & Tare (gm)	70.96
Tare Weight (gm)	24.84
Moisture Content (%)	1.3

LL	35
PL	18
PI	17

TEST BY	JR
DATE SET UP	7/19/2004
REVIEW BY	MB

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	24507.30 (before separating on the #4 sieve)
Tare Weight (gm)	
Total Weight (gm)	24192.57

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00	
coarse gravel	0.00	
fine gravel	12.89	12.89
coarse sand	8.34	
medium sand	30.05	
fine sand	24.87	63.26
fines	23.85	
		100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	217.30	0.90	99.1
#4	3117.80	12.89	87.1

BACK SIEVE

Tare Weight: 0.00

			% PASSING
#10	4.68	4.7	9.58	78.8
#20	12.94	12.9	26.49	64.0
#40	21.53	21.5	44.07	48.7
#60	27.29	27.3	55.86	38.5
#100	31.56	31.6	64.60	30.8
#200	35.48	35.5	72.62	23.8

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 49.49

DATE	TIME	READING R	TEMP T	HYD. COR. Cc
7/22/2004	9:35			
7/22/2004	9:37	17.5	22.70	6.50
7/22/2004	9:40	16.5	22.70	6.50
7/22/2004	9:50	16.3	22.80	6.50
7/22/2004	10:05	15.8	22.90	6.50
7/22/2004	10:35	15.5	23.00	6.50
7/22/2004	13:45	15.3	21.40	6.50
7/23/2004	9:35	14.3	20.40	6.50

(mm)	%Finer
0.035	19.42
0.023	17.65
0.013	17.21
0.009	16.33
0.006	15.89
0.003	15.45
0.001	13.68

1111

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST:

Calculated Dry Wt. used in test (gm)	48.85
Hydrometer Bulb Number	624378
%Pass #4 Sieve for whole sample	87.1126

HYDROMETER CALCULATIONS

EF (mm)	TEMP COR K	READING R	EFFECTIVE LENGTH	%
2.00	0.014126	11.00	14.5	0.99
5.00	0.013126	10.00	14.7	0.99
15.00	0.013126	9.75	14.8	0.99
30.00	0.013126	9.25	14.8	0.99
61.00	0.012973	9.00	14.8	0.99
256.00	0.012283	8.75	15	0.99
1440.00	0.013446	7.75	15.2	0.99

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	99.1
#4	4.750	87.1
#10	2.000	78.8
#20	0.850	64.0
#40	0.425	48.7
#60	0.250	38.5
#100	0.150	30.8
#200	0.075	23.8
	0.0353	19.4
	0.0225	17.7
	0.0130	17.2
	0.0092	16.3
	0.0064	15.9
	0.0033	15.4
	0.0014	13.7

Check By NG

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	765.57
Wt. Dry Soil & Tare (gm)	679.38
Wt. of Tare (gm)	102.55
Wt. of Water (gm)	86.19
Weight of Dry Soil (gm)	576.83
Moisture Content (%)	14.9

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-8 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	201.32
Dry Soil & Tare (gm)	193.36
Tare Weight (gm)	27.98
Moisture Content (%)	4.8

LL	41	TEST BY	JR
PL	19	DATE SET UP	7/15/2004
PI	22	REVIEW BY	NG

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	22528.80 (before separating on the #4 sieve)
Tare Weight (gm)	
Total Weight (gm)	21494.25

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00	
coarse gravel	0.00	
fine gravel	17.65	17.65
coarse sand	7.03	
medium sand	25.41	
fine sand	21.57	54.01
fines	28.34	
		100.00

PLUS #4 MATERIAL SIEVE — Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	584.30	2.7	97.3
#4	3793.30	17.6	82.4

BACK SIEVE — Tare Weight: 0.00

				% PASSING
#10	4.15	4.2	8.54	75.3
#20	11.85	11.9	24.38	62.3
#40	19.15	19.2	39.39	49.9
#60	23.95	24.0	49.27	41.8
#100	27.85	27.9	57.29	35.2
#200	31.88	31.9	65.58	28.3

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 50.95

DATE 7/16/2004	TIME 10:16	READING R	TEMP T	HYD. COR. Cc
7/16/2004	10:18	22.3	22.20	6.00
7/16/2004	10:21	19.8	22.30	6.00
7/16/2004	10:31	19.3	22.10	6.00
7/16/2004	10:46	18.5	22.00	6.00
7/16/2004	11:16	18.0	21.70	6.00
7/16/2004	14:26	17.8	20.80	6.00
7/17/2004	10:16	16.8	21.50	6.00

(mm)	%Finer
0.034	27.25
0.022	23.06
0.013	22.22
0.009	20.96
0.006	20.13
0.003	19.71
0.001	18.03

!!!!!

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt. used in test (gm)	48.61
Hydrometer Bulb Number	624378
%Pass #4 Sieve for whole sample	82.352

HYDROMETER CALCULATIONS

L (mm)	TEMP COR. K	READING G	EFFECTIVE LENGTH	A
1.00	0.013126	18.25	13.7	0.99
5.00	0.013126	13.25	14.2	0.99
15.00	0.013126	13.25	14.2	0.99
30.00	0.013126	12.50	14.3	0.99
60.00	0.013126	12.00	14.3	0.99
250.00	0.013126	11.75	14.5	0.99
1440.00	0.013126	10.25	14.7	0.99

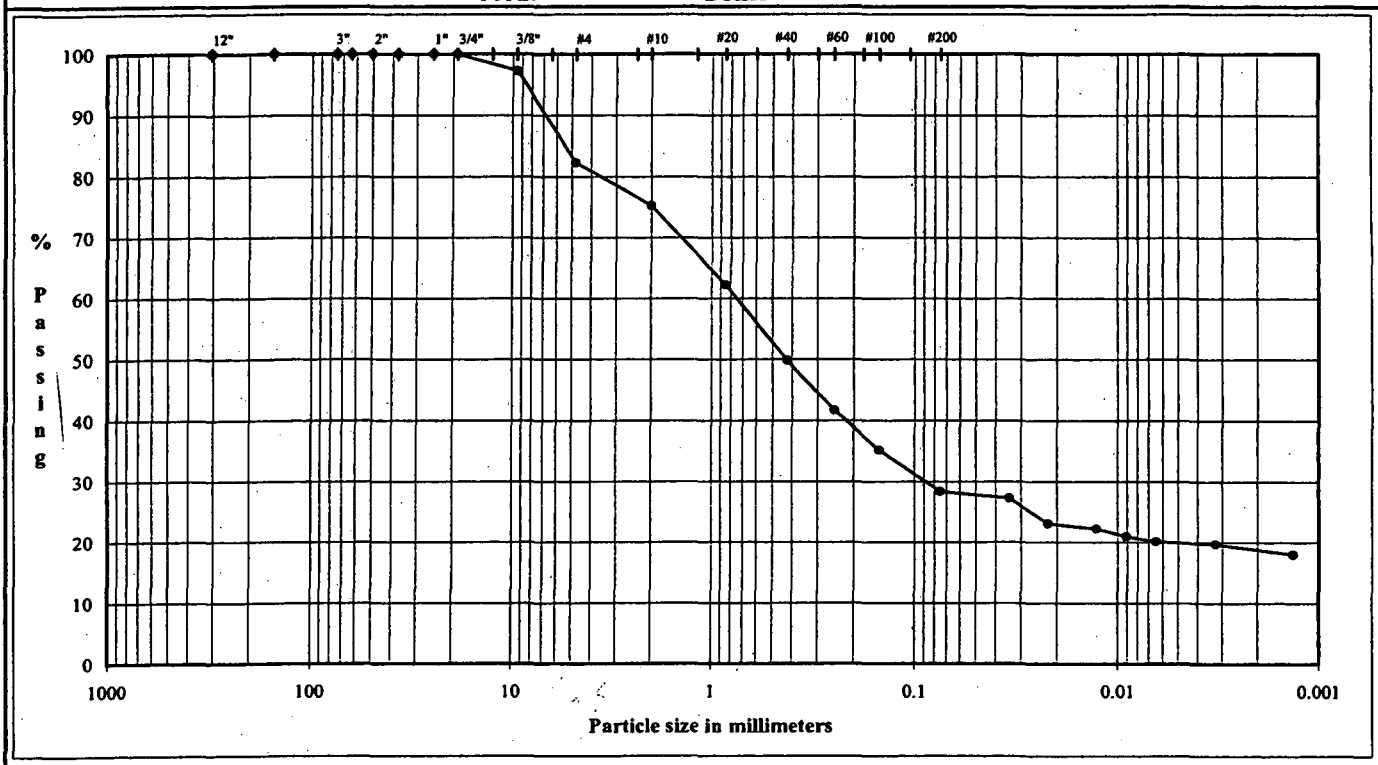
	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	97.3
#4	4.750	82.4
#10	2.000	75
#20	0.850	62.3
#40	0.425	49.9
#60	0.250	41.8
#100	0.150	35.2
#200	0.075	28.3
	0.0544	27.2
	0.0221	23.1
	0.0128	22.2
	0.0091	21.0
	0.0065	20.1
	0.0032	19.7
	0.0013	18.0

Check By NG

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-8 Depth (ft): -
TYPE: BULK



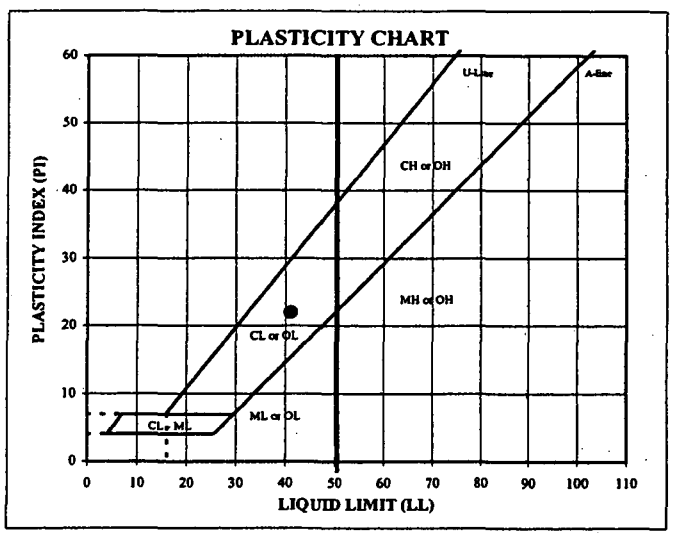
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	97.3		
#4	4.8	82.4	Fine Gravel	17.65
#10	2.00	75.3	Coarse Sand	7.03
#20	0.85	62.3		
#40	0.43	49.9	Medium Sand	25.41
#60	0.25	41.8		
#100	0.15	35.2		
#200	0.075	28.3	Fine Sand	21.57

Hydrometer Analysis

(mm)	%Finer		
0.034	27.3		
0.022	23.1		
0.013	22.2	Fines	
0.0091	21.0	Silt or Clay	28.34
0.0065	20.1		
0.0032	19.7		
0.0013	18.0		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
14.9	41	19	22	--

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

TECH: JR
DATE: 7/15/2004
REVIEW: NG

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO		
PROJECT NUMBER	043-2246.0001		
SAMPLE IDENTITY	PF-8	-	-
SAMPLE TYPE	BULK		

TEST TYPE: D 698 D 4718
PROCEDURE: METHOD B

MOLD NUMBER	217
MOLD WEIGHT (gm)	2271.5
MOLD DIAMETER (in)	4.000
MOLD HEIGHT (in)	4.575
MOLD VOLUME (cu.ft)	0.0333

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	201.32
Dry Wt Tare & Soil	(W2)	492.88	193.36
Wt Tare	(W3)	0.00	27.98
Wt Moisture	(W4=W1-W2)	11.19	7.96
Wt Dry Soil	(W5=W2-W3)	492.88	165.38
Water Content (dec)	(wc=W4/W5)	0.0227	0.0481
Water Content (%)	(W4/W5)*100	2.3%	4.8%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	22528.80
TOTAL WEIGHT, DRY (COARSE & FINE)	21494.25
WEIGHT RETAINED ON # 4 SIEVE (WET)	3793.30
WEIGHT RETAINED ON 3/8" SIEVE (WET)	584.30
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	17.26%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	2.66%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4025.7	4181.1	4248.1	4254.7	4237.2		
Weight of Mold	(W2)	2271.50	2271.50	2271.50	2271.50	2271.50		
Wt. Of Wet Soil	(W3=W1-W2)	1754.20	1909.60	1976.60	1983.20	1965.70		
Wet Density, wd (pcf)	(W3/453.6*Vm)	116.24	126.54	130.98	131.41	130.25		
WATER CONTENTS								
Wt Tare & Soil	(W4)	705.92	707.97	637.96	628.56	640.23		
Wt Tare & Soil	(W5)	656.51	650.42	580.68	564.04	569.73		
Wt Tare	(W6)	102.19	101.58	101.86	100.81	103.29		
Wt Moisture	(W7=W4-W5)	49.41	57.55	57.28	64.52	70.50		
Wt Dry Soil	(W8=W5-W6)	554.32	548.84	478.82	463.23	466.44		
Water Content (%)	(W7/W8)*100	8.9%	10.5%	12.0%	13.9%	15.1%		
Dry Density (pcf)	(wd/(1+wc))	106.7	114.5	117.0	115.3	113.2		

MAXIMUM DRY DENSITY (pcf)	117.2
OPTIMUM MOISTURE CONTENT (%)	12.2
Corrected Maximum Dry Density (pcf)	117.9
Corrected Optimum Moisture (%)	11.9

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

Weight of Oven Dry Sample (gm)	A	504.07			
Weight of Saturated-Surface-Dry (gm)	B	506.40			
Weight of Saturated Sample in Water (gm)	C	301.90			
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46			
Bulk Specific Gravity	A/(B-C)	2.465			

LL	41
PL	19
PI	22
MC	14.9%

AVERAGE ABSORPTION	0.5
AVERAGE BULK SPECIFIC GRAVITY	2.46

TECH	DT
DATE	7/16/04
REVIEW	NG

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	765.57
Wt. Dry Soil & Tare (gm)	679.38
Wt. of Tare (gm)	102.55
Wt. of Water (gm)	86.19
Weight of Dry Soil (gm)	576.83
Moisture Content (%)	14.94

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-8
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION		
Number of Blows		
Weight of Wet Soil & T	26.90	24.78
Weight of Dry Soil & T	24.85	23.05
Weight of Tare (gm)	13.73	13.83
Weight of Water (gm)	2.05	1.73
Weight of Dry Soil (gm)	11.12	9.22
Water Content %	18.44	18.76

LIQUID LIMIT DETERMINATION		
35	30	21
26.34	24.33	24.98
22.91	21.25	21.69
13.86	13.57	13.89
3.43	3.08	3.29
9.05	7.68	7.80
37.90	40.10	42.18

PLASTIC LIMIT (PL): 19

LIQUID LIMIT (LL): 41

PLASTICITY INDEX (PI): 22

BLOWS	MC		
35	37.90	3.56	25
30	40.10	3.40	0.00
21	42.18	3.04	-2
0	0.00	#NUM!	

	3 POINTS			3-POINTS
	25.00	25.00	10.00	
37.90	42.18	40.97	40.97	41
-2	44.00	40.97		19
				22

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS	
0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS	
0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

NP

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

PLASTICITY INDEX (PI): NP

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	836.00
Wt. Dry Soil & Tare (gm)	747.14
Wt. of Tare (gm)	101.30
Wt. of Water (gm)	88.86
Weight of Dry Soil (gm)	645.84
Moisture Content (%)	13.76

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-9
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION

Number of Blows		
Weight of Wet Soil & T	22.40	23.40
Weight of Dry Soil & T	21.13	22.27
Weight of Tare (gm)	14.26	15.86
Weight of Water (gm)	1.27	1.13
Weight of Dry Soil (gm)	6.87	6.41
Water Content %	18.49	17.63

LIQUID LIMIT DETERMINATION

35	24	17
24.30	24.69	25.96
21.54	22.22	23.09
13.89	15.81	15.89
2.76	2.47	2.87
7.65	6.41	7.20
36.08	38.53	39.86

PLASTIC LIMIT (PL): 18

LIQUID LIMIT (LL): 38

PLASTICITY INDEX (PI): 20

BLOWS	MC		
35	36.08	3.56	25
24	38.53	3.18	0.00
17	39.86	2.83	-2
0	0.00	#NUM!	

3 POINTS

				3-POINTS
	25.00	25.00	10.00	
36.08	39.86	38.00	38.00	38
-2	40.00	38.00		18
				20

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS		LIQUID LIMITS	
Weight of Wet Soil & Tare (gm)				
Weight of Dry Soil & Tare (gm)				
Weight of Tare (gm)				
Weight of Water (gm)	0.00	0.00		
Weight of Dry Soil (gm)	0.00	0.00	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!	0.00	0.00
			#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

Number of Blows	PLASTIC LIMITS		LIQUID LIMITS	
Weight of Wet Soil & Tare (gm)				
Weight of Dry Soil & Tare (gm)				
Weight of Tare (gm)				
Weight of Water (gm)	0.00	0.00	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

NP

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

PLASTICITY INDEX (PI): NP

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	836.00
Wt. Dry Soil & Tare (gm)	747.14
Wt. of Tare (gm)	101.30
Wt. of Water (gm)	88.86
Weight of Dry Soil (gm)	645.84
Moisture Content (%)	13.8

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-9 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

LL	38
PL	18
PI	20

TEST BY	JR
DATE SET UP	7/19/2004
REVIEW BY	MB

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	108.14
Dry Soil & Tare (gm)	107.10
Tare Weight (gm)	21.80
Moisture Content (%)	1.2

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	24033.23 (before separating on the #4 sieve)
Tare Weight (gm)	
Total Weight (gm)	23743.74

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00	
coarse gravel	0.00	
fine gravel	12.85	12.85
coarse sand	9.38	
medium sand	27.47	
fine sand	25.38	62.23
fines	24.92	
		100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	232.20	0.98	99.0
#4	3050.30	12.85	87.2

BACK SIEVE

Tare Weight: 0.00

				% PASSING
#10	5.45	5.5	10.77	77.8
#20	12.87	12.9	25.43	65.0
#40	21.40	21.4	42.28	50.3
#60	27.43	27.4	54.20	39.9
#100	31.87	31.9	62.97	32.3
#200	36.14	36.1	71.40	24.9

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 51.23

DATE	TIME	READING R	TEMP T	HYD. COR. Cc
7/22/2004	9:18			
7/22/2004	9:20	17.5	22.70	6.50
7/22/2004	9:23	16.3	22.70	6.50
7/22/2004	9:33	16.3	22.70	6.50
7/22/2004	9:48	16.0	22.60	6.50
7/22/2004	10:18	15.5	23.10	6.50
7/22/2004	13:28	15.3	21.60	6.50
7/23/2004	9:18	14.1	20.50	6.50

(mm)	%Finer
0.035	18.75
0.023	16.62
0.013	16.62
0.009	16.20
0.006	15.34
0.003	14.92
0.001	12.96

!!!!!

2.7

6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt. used in test (gm)	50.61
Hydrometer Bulb Number	624378
%Pass #4 Sieve for whole sample	87.1532

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	99.0
#4	4.750	87.2
#10	2.000	77.8
#20	0.850	65.0
#40	0.425	50.3
#60	0.250	39.9
#100	0.150	32.3
#200	0.075	24.9
	0.0353	18.8
	0.0226	16.6
	0.0130	16.6
	0.0092	16.2
	0.0064	15.3
	0.0033	14.9
	0.0014	13.0

HYDROMETER CALCULATIONS

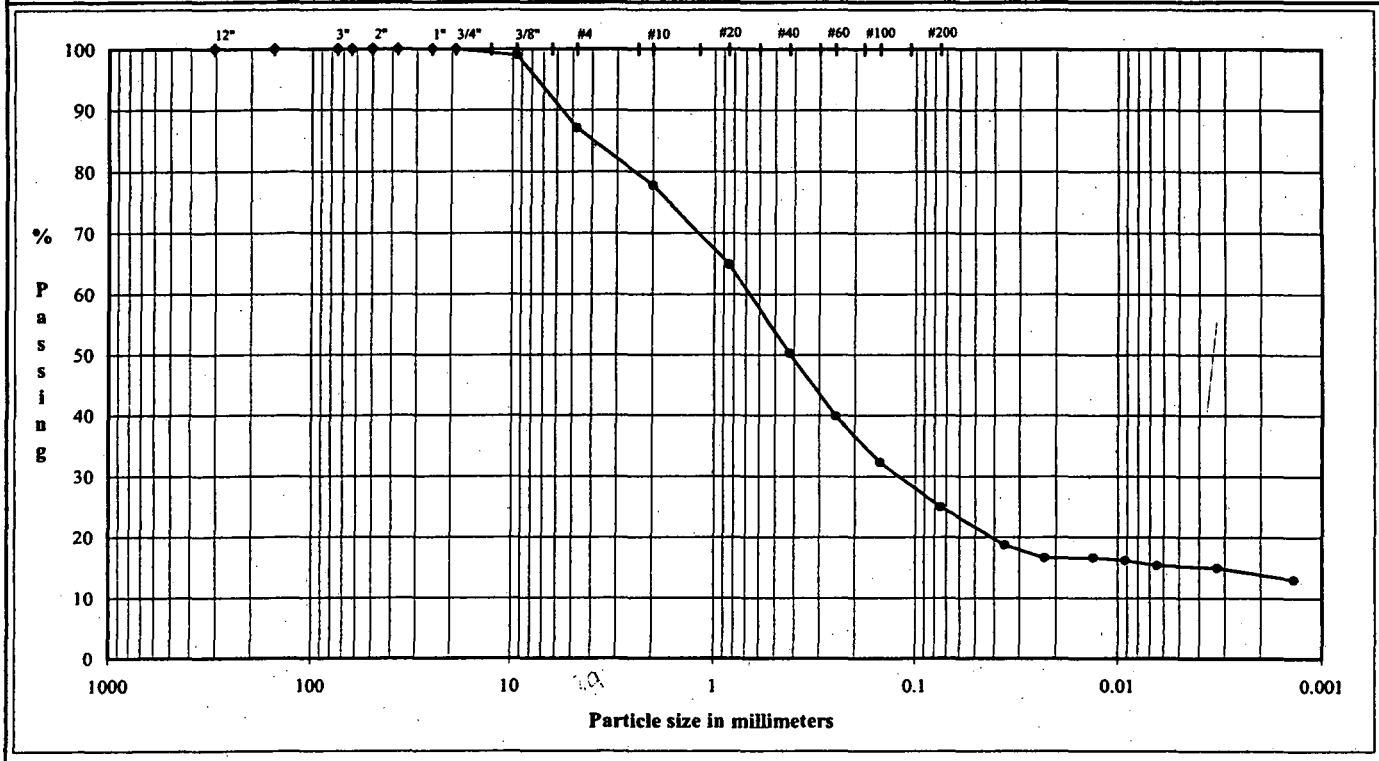
ET (mm)	TEMP COR K	READING C	EFFECTIVE LENGTH	A
2.00	0.013126	11.00	14.5	0.99
5.00	0.013126	9.75	14.8	0.99
15.00	0.013126	9.75	14.8	0.99
30.00	0.013126	9.50	14.8	0.99
60.00	0.012973	9.00	14.8	0.99
250.00	0.013283	8.75	15	0.99
1440.00	0.013446	7.60	15.2	0.99

Check By NG

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **Rocky Flats/Field & Lab Testing/CO**
SAMPLE ID: **PF-9** Depth (ft): -
TYPE: **BULK**



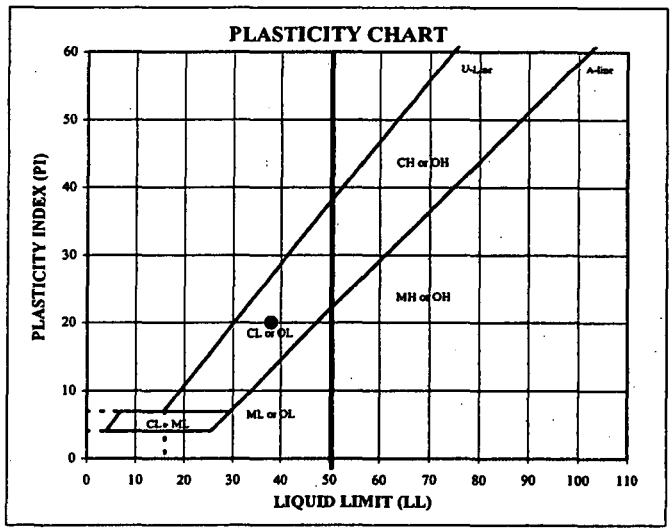
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	99.0		
#4	4.8	87.2	Fine Gravel	12.85
#10	2.00	77.8	Coarse Sand	9.38
#20	0.85	65.0		
#40	0.43	50.3	Medium Sand	27.47
#60	0.25	39.9		
#100	0.15	32.3		
#200	0.075	24.9	Fine Sand	25.38

Hydrometer Analysis

(mm)	%Finer		
0.035	18.8		
0.023	16.6		
0.013	16.6	Fines	
0.0092	16.2	Silt or Clay	24.92
0.0064	15.3		
0.0033	14.9		
0.0014	13.0		



ATTERBERG LIMITS

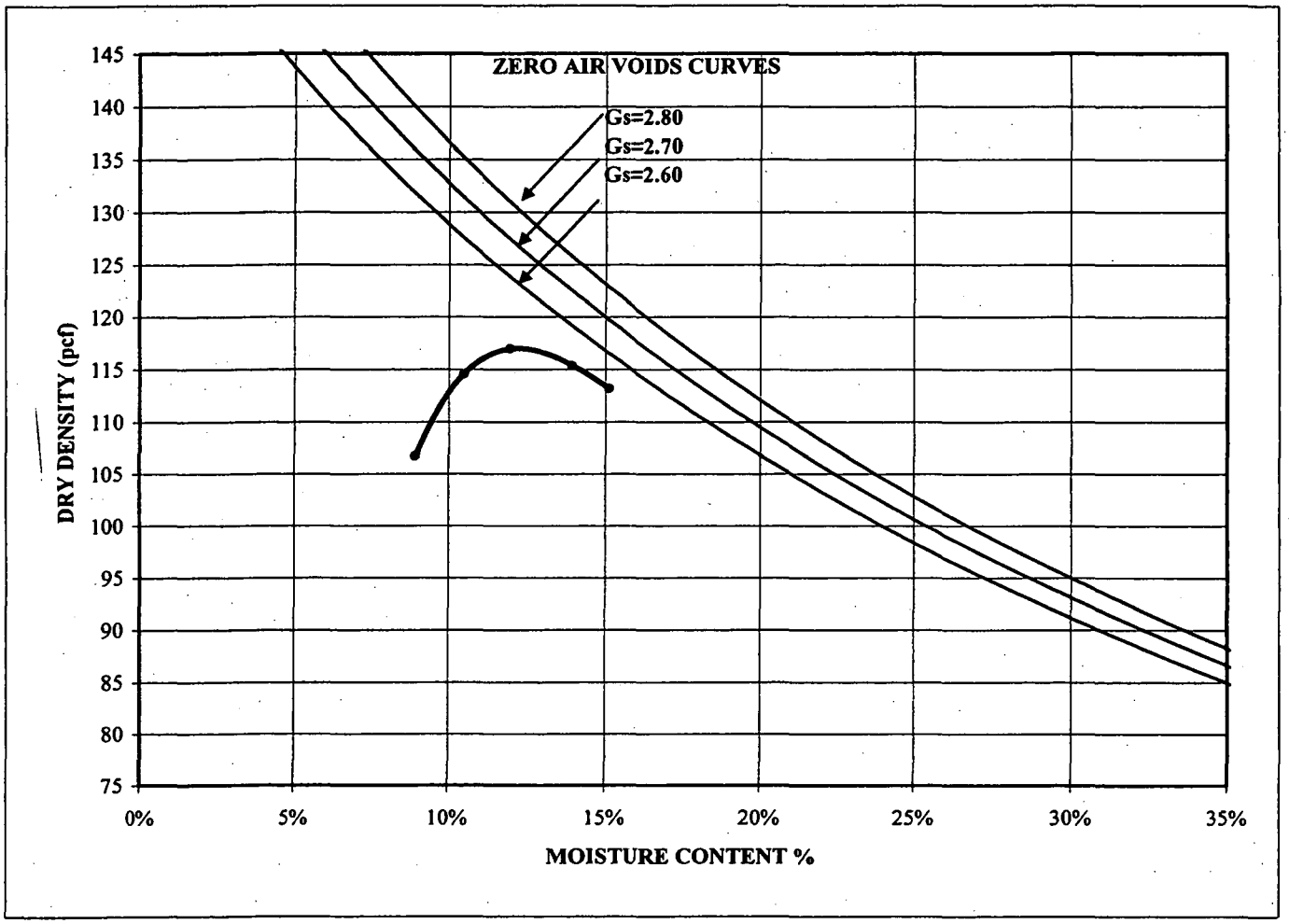
M_c	LL	PL	PI	SpG
13.8	38	18	20	

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

TECH: JR
DATE: 7/19/2004
REVIEW: MB

MOISTURE / DRY DENSITY CURVE
D 698 METHOD B



MAXIMUM DRY DENSITY (pcf)	117.2	Corrected Maximum Dry Density (pcf)	117.9
OPTIMUM MOISTURE (%)	12.2	Corrected Optimum Moisture (%)	11.9

SAMPLE ID	PF-8
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

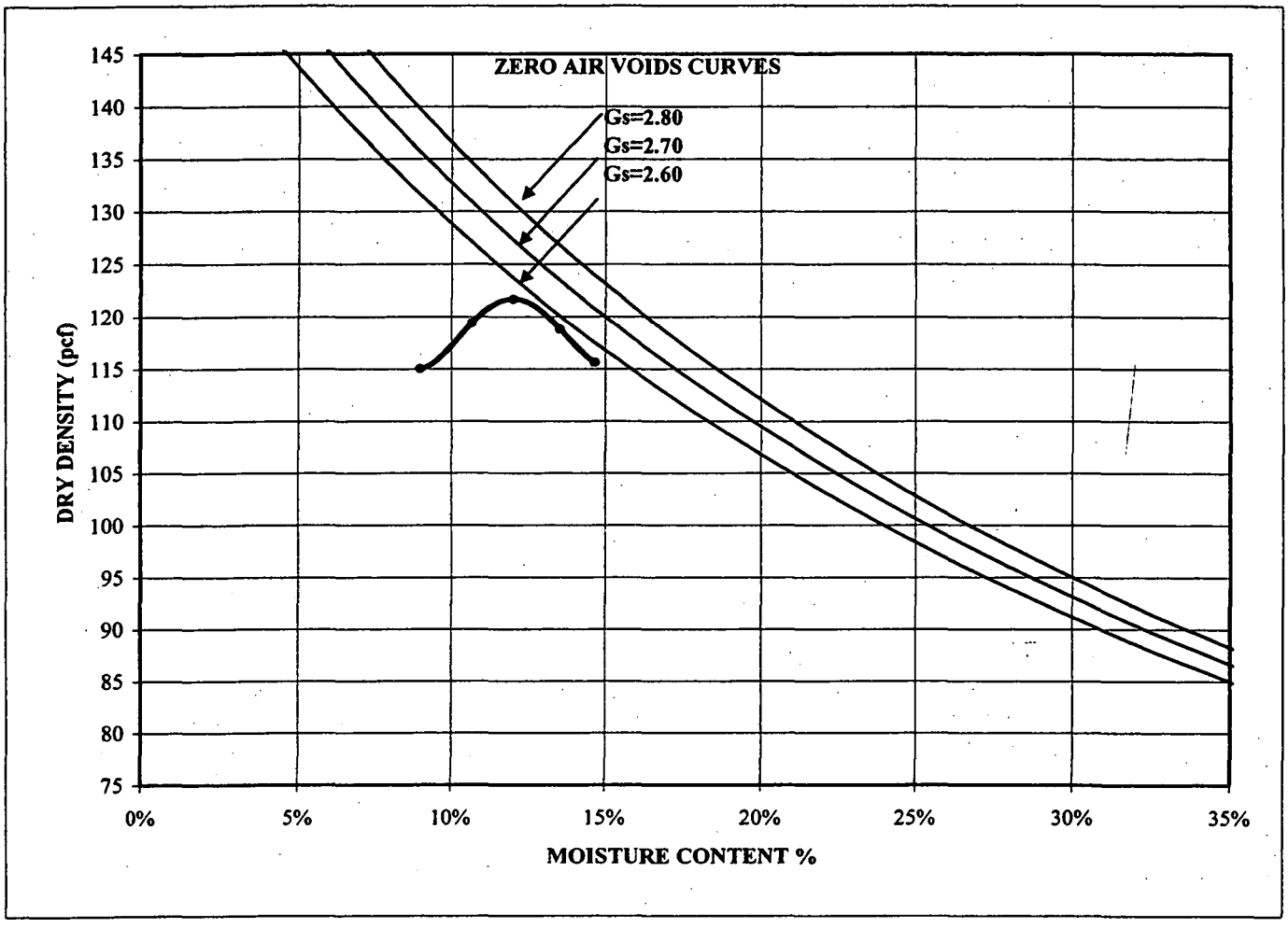
LL	41
PL	19
PI	22
MC	14.9%

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand with gravel
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	DT
DATE	7/16/04
REVIEW	NG

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	121.6	Corrected Maximum Dry Density (pcf)	125.1
OPTIMUM MOISTURE (%)	12.0	Corrected Optimum Moisture (%)	10.4

SAMPLE ID	PF-9
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	38
PL	18
PI	20
MC	13.8%

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	JR
DATE	7-20-04
REVIEW	MB

ATTERBERG LIMITS

AS RECEIVED WATER CONTENT	
Tare No.	
Wt. Wet Soil & Tare (gm)	731.59
Wt. Dry Soil & Tare (gm)	650.49
Wt. of Tare (gm)	102.96
Wt. of Water (gm)	81.10
Weight of Dry Soil (gm)	547.53
Moisture Content (%)	14.81

PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-10
TYPE	BULK

4 OR 3 POINT ATTERBERG

PLASTIC LIMIT DETERMINATION		
Number of Blows		
Weight of Wet Soil & T	20.72	21.47
Weight of Dry Soil & T	19.68	20.37
Weight of Tare (gm)	13.78	14.22
Weight of Water (gm)	1.04	1.10
Weight of Dry Soil (gm)	5.90	6.15
Water Content %	17.63	17.89

LIQUID LIMIT DETERMINATION		
32	23	16
25.31	24.69	23.65
22.00	21.36	20.57
13.94	13.84	13.86
3.31	3.33	3.08
8.06	7.52	6.71
41.07	44.28	45.90

PLASTIC LIMIT (PL): 18

LIQUID LIMIT (LL): 43

PLASTICITY INDEX (PI): 25

BLOWS	MC		
32	41.07	3.47	25
23	44.28	3.14	0.00
16	45.90	2.77	-2
0	0.00	#NUM!	

	3 POINTS			
	25.00	25.00	10.00	3-POINTS
41.07	45.90	43.10	43.10	43
-2	46.00	43.10		18
				25

ONE POINT ATTERBERG

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS	
0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

	TRIAL 1	TRIAL 2
BLOWS:	0	0
K VALUE:	#N/A	#N/A

PLASTIC LIMIT (PL):

LIQUID LIMIT (LL):

PLASTICITY INDEX (PI):

NON-PLASTIC

Number of Blows	PLASTIC LIMITS	
Weight of Wet Soil & Tare (gm)		
Weight of Dry Soil & Tare (gm)		
Weight of Tare (gm)		
Weight of Water (gm)	0.00	0.00
Weight of Dry Soil (gm)	0.00	0.00
Water Content %	#DIV/0!	#DIV/0!

LIQUID LIMITS	
0.00	0.00
0.00	0.00
#DIV/0!	#DIV/0!

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

PLASTICITY INDEX (PI): NP

HYDROMETER DATA ENTRY SHEET

AS RECEIVED WATER CONTENT

Tare No.	
Wt. Wet Soil & Tare (gm)	731.59
Wt. Dry Soil & Tare (gm)	650.49
Wt. of Tare (gm)	102.96
Wt. of Water (gm)	81.10
Weight of Dry Soil (gm)	547.53
Moisture Content (%)	14.8

MONTH AND YEAR	July-04
PROJECT NAME	Rocky Flats/Field & Lab Testing/CO
PROJECT NUMBER:	043-2246.0001
SAMPLE ID:	PF-10 Depth (ft) -
TYPE	BULK

Description: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

HYDROSCOPIC MOISTURE FOR SIEVE SAMPLE

Wt. Soil & Tare (gm)	69.25
Dry Soil & Tare (gm)	67.73
Tare Weight (gm)	13.80
Moisture Content (%)	2.8

LL	43	TEST BY	JR
PL	18	DATE SET UP	7/21/2004
PI	25	REVIEW BY	MB

Total Weight of Sample Used For Sieve Analysis Corrected for Hydroscopic Moisture

Wt. + Tare (gm)	20571.30	(before separating on the #4 sieve)
Tare Weight (gm)		
Total Weight (gm)	20007.40	

HYDROMETER ANALYSIS

Specific Gravity (ass'd)	2.7
Specific Gravity (tested)	
Amount Dispersing Agent (ml)	125.00
Type Dispersion Device	Mechanical
Length of Dispersion Period	1 Minute

cobbles	0.00		
coarse gravel	0.00		
fine gravel	17.34	17.34	
coarse sand	8.92		
medium sand	24.10		
fine sand	21.13	54.15	
fines	28.52		
			100.00

PLUS #4 MATERIAL SIEVE

Tare Weight: 0.00

	(Wt. + Tare)	% RETAINED	% PASSING
12.0"	0.00	0.0	100.0
6.0"	0.00	0.0	100.0
3.0"	0.00	0.0	100.0
2.5"	0.00	0.0	100.0
2.0"	0.00	0.0	100.0
1.5"	0.00	0.0	100.0
1.0"	0.00	0.0	100.0
0.75"	0.00	0.0	100.0
0.375"	421.30	2.1	97.9
#4	3468.50	17.3	82.7

BACK SIEVE

Tare Weight: 0.00

				% PASSING
#10	5.26	5.3	10.79	73.7
#20	12.53	12.5	25.70	61.4
#40	19.47	19.5	39.94	49.6
#60	24.20	24.2	49.64	41.6
#100	28.07	28.1	57.58	35.1
#200	31.93	31.9	65.50	28.5

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Wt. of Sample Wet or Dry (gm): 50.12

DATE 7/22/2004	TIME 9:22	READING R	TEMP T	HYD. COR. Cc
7/22/2004	9:24	21.3	22.80	6.50
7/22/2004	9:27	20.3	22.80	6.50
7/22/2004	9:37	19.3	22.80	6.50
7/22/2004	9:52	18.5	22.80	6.50
7/22/2004	10:22	17.8	23.10	6.50
7/22/2004	13:32	17.3	21.60	6.50
7/23/2004	9:22	16.5	20.60	6.50

(mm)	%Finer
0.035	24.76
0.022	23.08
0.013	21.41
0.009	20.15
0.006	18.89
0.003	18.05
0.001	16.79

2.7
6

WEIGHT OF SAMPLE USED FOR HYDROMETER TEST

Calculated Dry Wt. used in test (gm)	48.75
Hydrometer Bulb Number	624378
%Pass #4 Sieve for whole sample	82.6639

HYDROMETER CALCULATIONS

ET (mm)	TEMP COR K	READING C	EFFECTIVE LENGTH L	L/t
2.00	0.013126	14.75	14.2	0.99
5.00	0.013126	13.75	14.2	0.99
15.00	0.013126	12.75	14.3	0.99
30.00	0.013126	12.00	14.3	0.99
60.00	0.012973	11.25	14.5	0.99
250.00	0.013283	10.75	14.7	0.99
1440.00	0.013446	10.00	14.9	0.99

	X-AXIS	Y-AXIS
12.0"	304.800	100.0
6.0"	154.200	100.0
3.0"	75.000	100.0
2.5"	63.500	100.0
2.0"	50.000	100.0
1.5"	37.500	100.0
1.0"	25.000	100.0
0.75"	19.000	100.0
0.375"	9.500	97.9
#4	4.750	82.7
#10	2.000	73.7
#20	0.850	61.4
#40	0.425	49.6
#60	0.250	41.6
#100	0.150	35.1
#200	0.075	28.5
	0.0347	24.8
	0.0221	23.3
	0.0128	21.4
	0.0091	20.1
	0.0064	18.9
	0.0032	18.0
	0.0014	16.8

Check By NG

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO		
PROJECT NUMBER	043-2246.0001		
SAMPLE IDENTITY	PF-9	-	-
SAMPLE TYPE	BULK		

TEST TYPE: D 698 D 4718
PROCEDURE: METHOD A

MOLD NUMBER	AH-1
MOLD WEIGHT (gm)	2265.8
MOLD DIAMETER (in)	3.991
MOLD HEIGHT (in)	4.581
MOLD VOLUME (cu.ft)	0.0332

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	108.14
Dry Wt Tare & Soil	(W2)	492.88	107.10
Wt Tare	(W3)	0.00	21.80
Wt Moisture	(W4=W1-W2)	11.19	1.04
Wt Dry Soil	(W5=W2-W3)	492.88	85.30
Water Content (dec)	(wc=W4/W5)	0.0227	0.0122
Water Content (%)	(W4/W5)*100	2.3%	1.2%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED

TOTAL WEIGHT, WET (COARSE & FINE)	24033.23
TOTAL WEIGHT, DRY (COARSE & FINE)	23743.74
WEIGHT RETAINED ON # 4 SIEVE (WET)	3282.23
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	13.52%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4151.7	4253.3	4315.8	4294.8	4260.4		
Weight of Mold	(W2)	2265.80	2265.80	2265.80	2265.80	2265.80		
Wt. Of Wet Soil	(W3=W1-W2)	1885.90	1987.50	2050.00	2029.00	1994.60		
Wet Density, wd (pcf)	(W3/453.6*Vm)	125.36	132.12	136.27	134.88	132.59		
WATER CONTENTS								
Wt Tare & Soil	(W4)	469.40	615.07	610.13	490.54	487.21		
Wt Tare & Soil	(W5)	439.34	565.63	555.65	444.01	437.71		
Wt Tare	(W6)	104.80	102.26	102.55	100.64	100.34		
Wt Moisture	(W7=W4-W5)	30.06	49.44	54.48	46.53	49.50		
Wt Dry Soil	(W8=W5-W6)	334.54	463.37	453.10	343.37	337.37		
Water Content (%)	(W7/W8)*100	9.0%	10.7%	12.0%	13.6%	14.7%		
Dry Density (pcf)	(wd/(1+wc))	115.0	119.4	121.6	118.8	115.6		

MAXIMUM DRY DENSITY (pcf)	121.6
OPTIMUM MOISTURE CONTENT (%)	12.0
Corrected Maximum Dry Density (pcf)	125.1
Corrected Optimum Moisture (%)	10.4

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

Weight of Oven Dry Sample (gm)	A	504.07			
Weight of Saturated-Surface-Dry (gm)	B	506.40			
Weight of Saturated Sample in Water (gm)	C	301.90			
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46			
Bulk Specific Gravity	A/(B-C)	2.465			

LL	38
PL	18
PI	20
MC	13.8%

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	JR
DATE	7-20-04
REVIEW	MB

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	Rocky Flats/Field & Lab Testing/CO		
PROJECT NUMBER	043-2246.0001		
SAMPLE IDENTITY	PF-10	-	-
SAMPLE TYPE	BULK		

TEST TYPE: D 698 D 4718
PROCEDURE: METHOD A

MOLD NUMBER	AH-1
MOLD WEIGHT (gm)	2265.0
MOLD DIAMETER (in)	3.991
MOLD HEIGHT (in)	4.581
MOLD VOLUME (cu.ft)	0.0332

TYPE COMPACTOR: Mechanical

PREPARATION: Wet Method

TYPE PROCTOR: Standard

5.5 -lbf. RAMMER WITH 12 INCH DROP

METHOD A: 20% OR LESS RETAINED ON #4

METHOD B: > 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"

METHOD C: > 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wet Wt Tare & Soil	(W1)	504.07	69.25
Dry Wt Tare & Soil	(W2)	492.88	67.73
Wt Tare	(W3)	0.00	13.80
Wt Moisture	(W4=W1-W2)	11.19	1.52
Wt Dry Soil	(W5=W2-W3)	492.88	53.93
Water Content (dec)	(wc=W4/W5)	0.0227	0.0282
Water Content (%)	(W4/W5)*100	2.3%	2.8%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED	
TOTAL WEIGHT, WET (COARSE & FINE)	20571.30
TOTAL WEIGHT, DRY (COARSE & FINE)	20007.40
WEIGHT RETAINED ON # 4 SIEVE (WET)	3889.80
WEIGHT RETAINED ON 3/8" SIEVE (WET)	
WEIGHT RETAINED ON 3/4" SIEVE (WET)	
PERCENT RETAINED ON # 4 SIEVE (DRY)	19.01%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.00%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.00%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	4039.4	4136.7	4240.6	4243.1	4216.1		
Weight of Mold	(W2)	2265.00	2265.00	2265.00	2265.00	2265.00		
Wt. Of Wet Soil	(W3=W1-W2)	1774.40	1871.70	1975.60	1978.10	1951.10		
Wet Density, wd (pcf)	(W3/453.6*Vm)	117.95	124.42	131.33	131.49	129.70		
WATER CONTENTS								
Wt Tare & Soil	(W4)	679.64	620.58	634.98	615.78	671.62		
Wt Tare & Soil	(W5)	626.89	566.98	573.43	550.55	592.60		
Wt Tare	(W6)	103.88	100.42	101.25	103.12	102.16		
Wt Moisture	(W7=W4-W5)	52.75	53.60	61.55	65.23	79.02		
Wt Dry Soil	(W8=W5-W6)	523.01	466.56	472.18	447.43	490.44		
Water Content (%)	(W7/W8)*100	10.1%	11.5%	13.0%	14.6%	16.1%		
Dry Density (pcf)	(wd/(1+wc))	107.1	111.6	116.2	114.8	111.7		

MAXIMUM DRY DENSITY (pcf)	116.4
OPTIMUM MOISTURE CONTENT (%)	13.5
Corrected Maximum Dry Density (pcf)	122.1
Corrected Optimum Moisture (%)	11.0

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

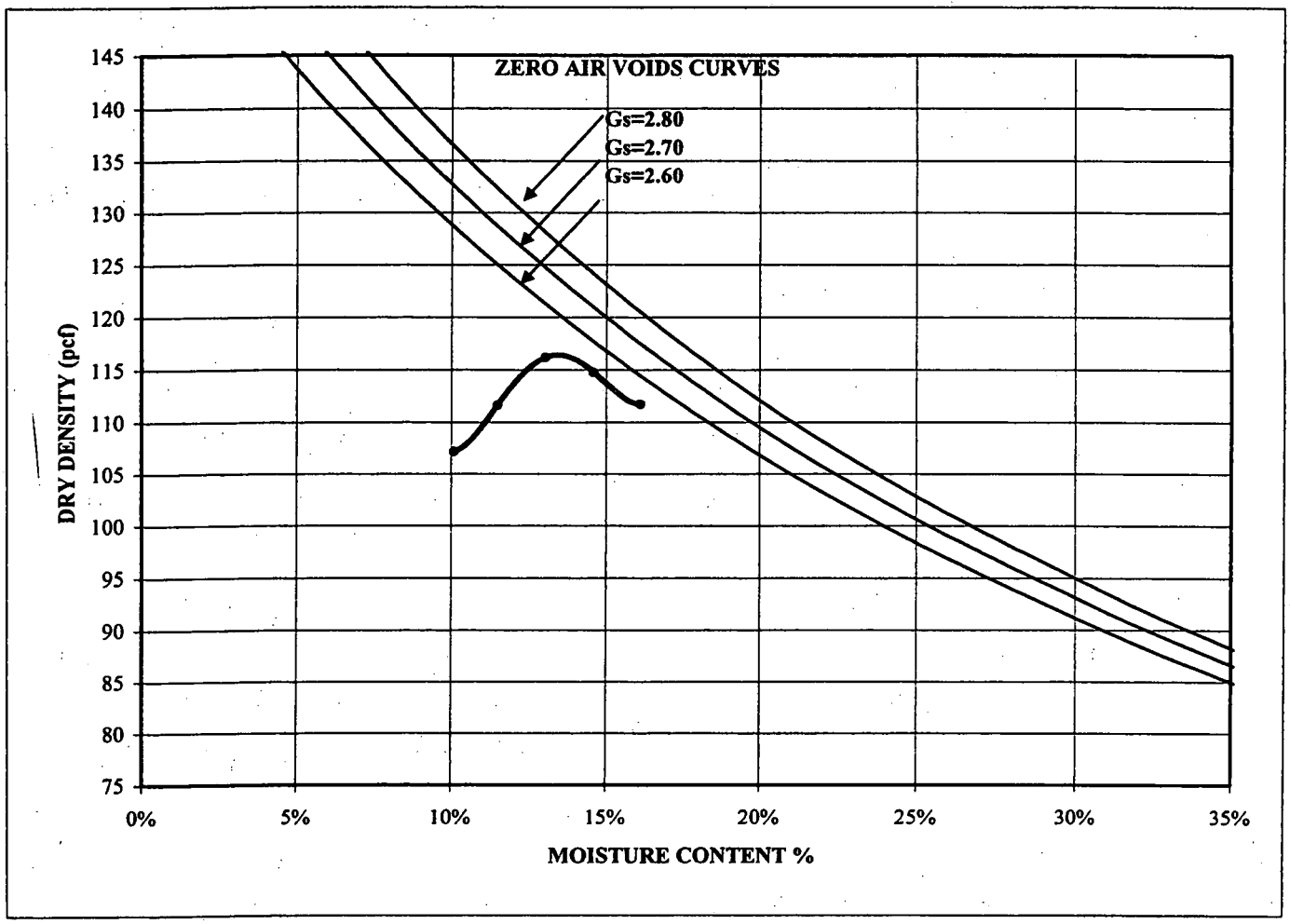
Weight of Oven Dry Sample (gm)	A	504.07			
Weight of Saturated-Surface-Dry (gm)	B	506.40			
Weight of Saturated Sample in Water (gm)	C	301.90			
Absorption of Oversize Particles (%)	[(B-A)/A]*100	0.46			
Bulk Specific Gravity	A/(B-C)	2.465			

LL	43
PL	18
PI	25
MC	14.8

AVERAGE ABSORPTION (assumed)	0.5
AVERAGE BULK SPECIFIC GRAVITY (assumed)	2.46

TECH	DT
DATE	7-22-04
REVIEW	MB

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	116.4	Corrected Maximum Dry Density (pcf)	122.1
OPTIMUM MOISTURE (%)	13.5	Corrected Optimum Moisture (%)	11.0

SAMPLE ID	PF-10
SAMPLE TYPE	BULK
SAMPLE DEPTH	-

LL	43
PL	18
PI	25
MC	14.8

DESCRIPTION	Yellowish brown (10 YR 5/8) clayey sand with gravel
USCS	SC

Rocky Flats/Field & Lab Testing/CO
043-2246.0001

TECH	DT
DATE	7-22-04
REVIEW	MB

Golder Associates Inc.

44 Union Boulevard, Suite 300
Lakewood, CO USA 80228
Telephone (303) 980-0540
Fax (303) 985-2080
www.golder.com

TRANSMITTAL LETTER

DATE: 043-2246

PROJECT NO.: September 2, 2004

TO: S.M. Stoller Corporation
990 S. Public Rd., Suite A
Lafayette, Colorado 80226

Attention: Steve Brinkman

SENT VIA: Federal Express (priority)

QUANTITY	ITEM	DESCRIPTION
1	Set	Consolidation and Triaxial Test Results

REMARKS: Please find one set of consolidation and triaxial test results for the cushion stockpile at Rocky Flats.

Per Mark McClain

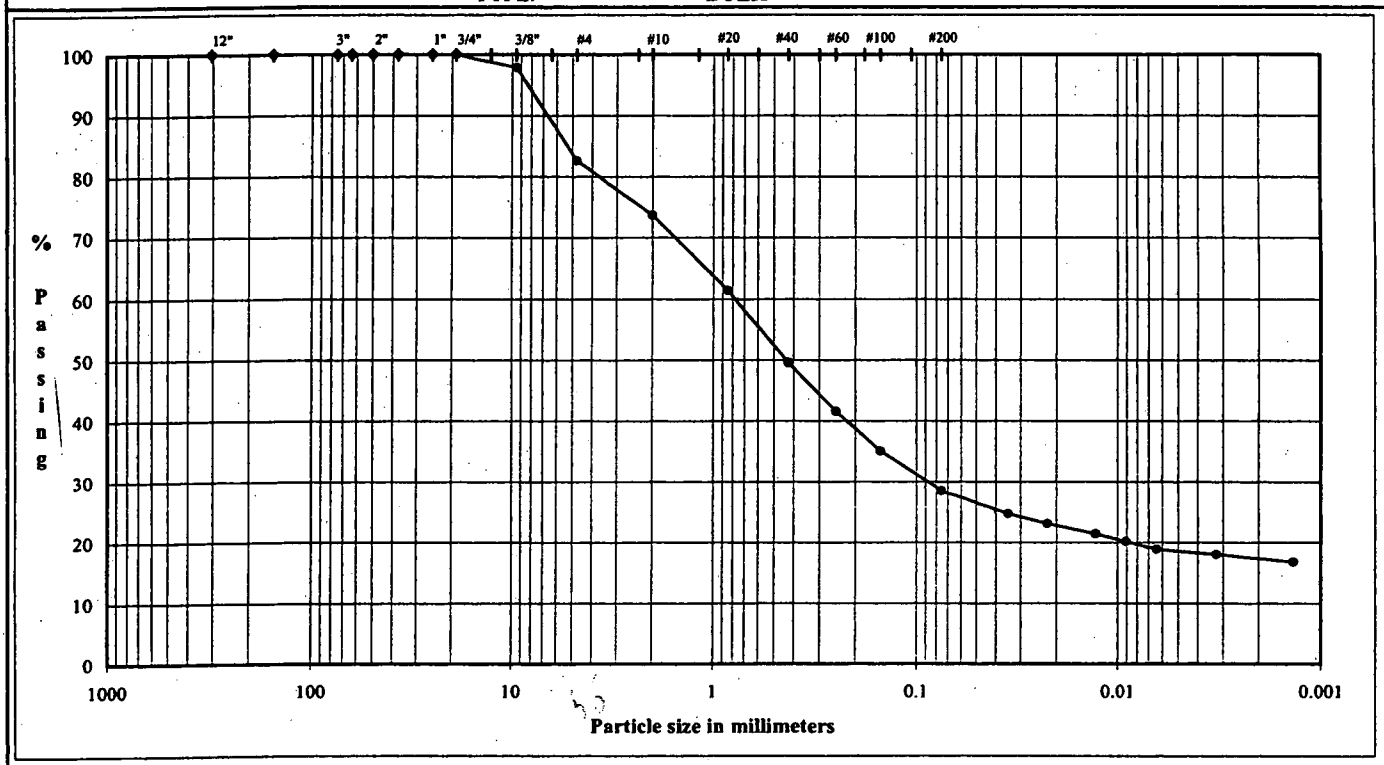
I:\043\2246\0100\0432246.0100.12058.DOC

July-04 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: PF-10 Depth (ft): -
TYPE: BULK



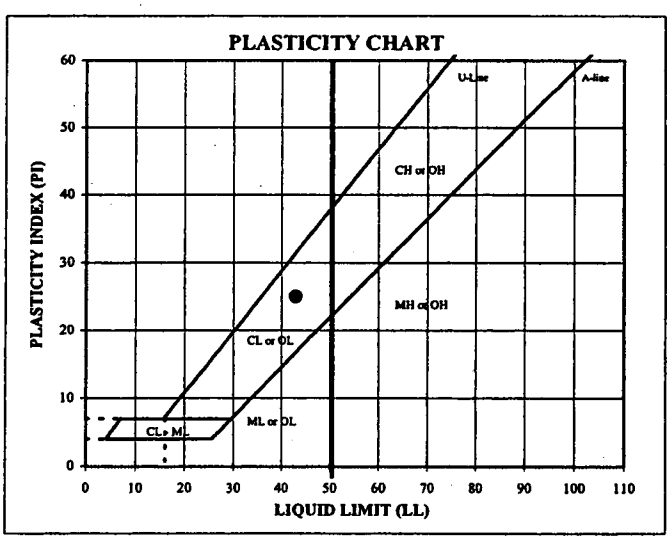
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	0.00
3.0"	75.0	100.0		
2.5"	63.5	100.0		
2.0"	50.0	100.0		
1.5"	37.5	100.0		
1.0"	25.0	100.0	Coarse Gravel	0.00
0.75"	19.0	100.0		
0.375"	9.5	97.9		
#4	4.8	82.7	Fine Gravel	17.34
#10	2.00	73.7	Coarse Sand	8.92
#20	0.85	61.4		
#40	0.43	49.6	Medium Sand	24.10
#60	0.25	41.6		
#100	0.15	35.1		
#200	0.075	28.5	Fine Sand	21.13

Hydrometer Analysis

(mm)	%Finer		
0.035	24.8		
0.022	23.1		
0.013	21.4	Fines	
0.0091	20.1	Silt or Clay	28.52
0.0064	18.9		
0.0032	18.0		
0.0014	16.8		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG
14.8	43	18	25	

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

USCS: SC

TECH: JR
DATE: 7/21/2004
REVIEW: MB

Golder Associates Inc.

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-1	DATE	8/4/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9960
diameter (in)	2.497
area (in^2)	4.897
volume (in^3)	4.877
specimen weight,wet (g)	165.18
specimen weight,dry (g)	148.17
water weight (g)	17.01

SAMPLE DATA, INITIAL

total height (in)	0.996
height of solids (in)	0.691
height of voids (in)	0.305
void ratio	0.441
dry density (pcf)	115.47
moist density (pcf)	129.01

SAMPLE DATA, FINAL

total height (in)	0.9600
height of solids (in)	0.691
height of voids (in)	0.269
void ratio	0.389
dry density (pcf)	120.07
moist density (pcf)	139.70

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand with gravel

LL:	39	
PL:	19	
PI:	20	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	F3
wt soil&tare,moist	49.69
wt soil&tare,dry	47.55
wt tare	28.91
wt moisture	2.14
wt dry soil	18.64
% moisture	11.48%

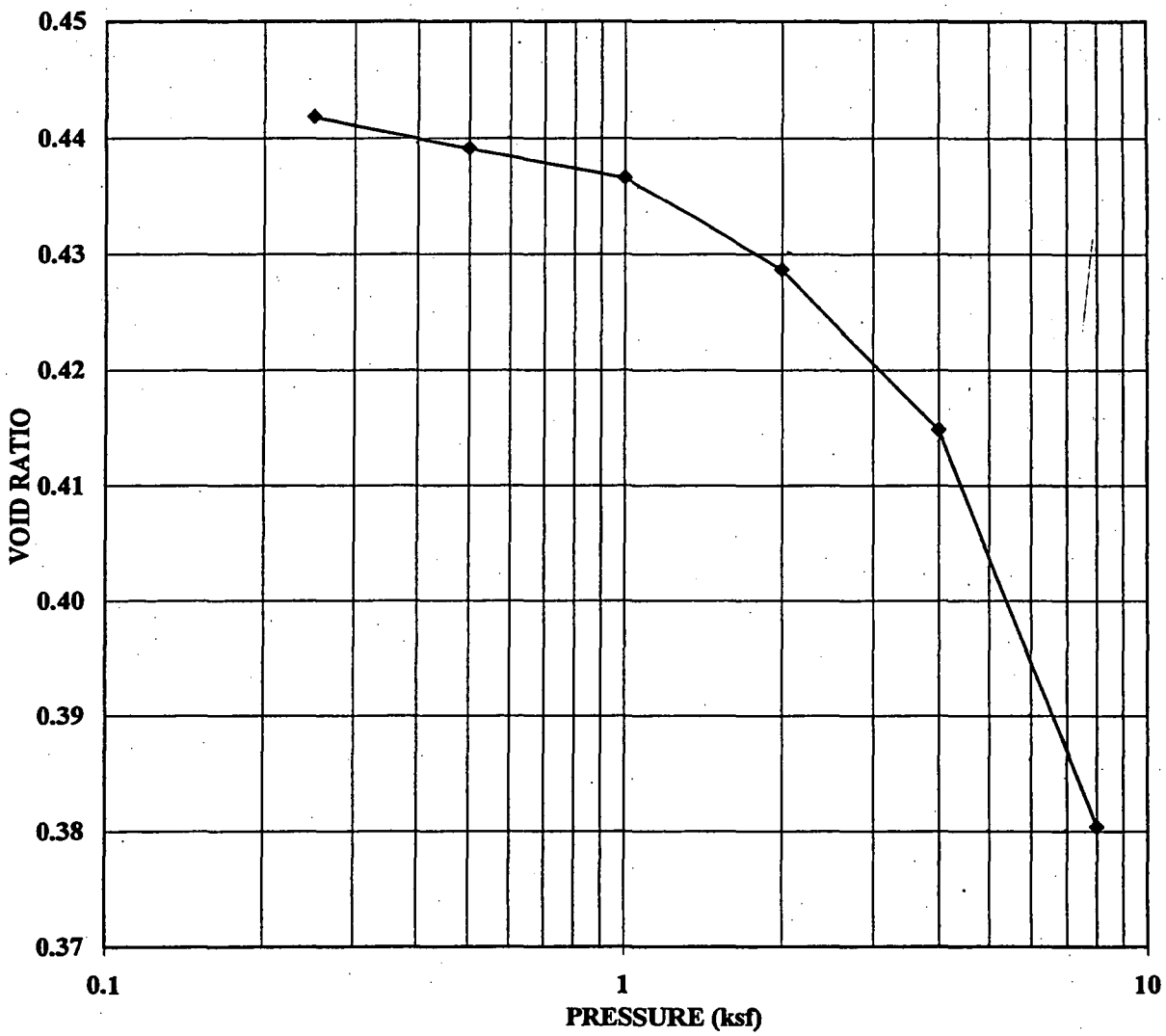
MOISTURE CONTENT, FINAL

tare #	F19
wt soil&tare,moist	203.26
wt soil&tare,dry	179.25
wt tare	32.38
wt moisture	24.01
wt dry soil	146.87
% moisture	16.35%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.25	0.9953	-	-	115.6	0.442	-	-	-	-	-	-	
0.50	0.9934	-	-	115.8	0.439	-	-	-	-	-	-	
0.50	0.9934	-	-	115.8	0.439	-	-	-	-	-	-	
1.0	0.9917	0.9920	0.197	116.0	0.437	0.4960	1.2598	0.2460	1.5872	2.64E-02	2.46E+00	0.008
2.0	0.9862	0.9871	0.227	116.6	0.429	0.4935	1.2536	0.2436	1.5715	2.27E-02	2.12E+00	0.026
4.0	0.9766	0.9783	0.204	117.8	0.415	0.4892	1.2425	0.2393	1.5438	2.49E-02	2.32E+00	0.046
8.0	0.9529	0.9564	0.209	120.7	0.380	0.4782	1.2146	0.2287	1.4752	2.31E-02	2.16E+00	0.114

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-1

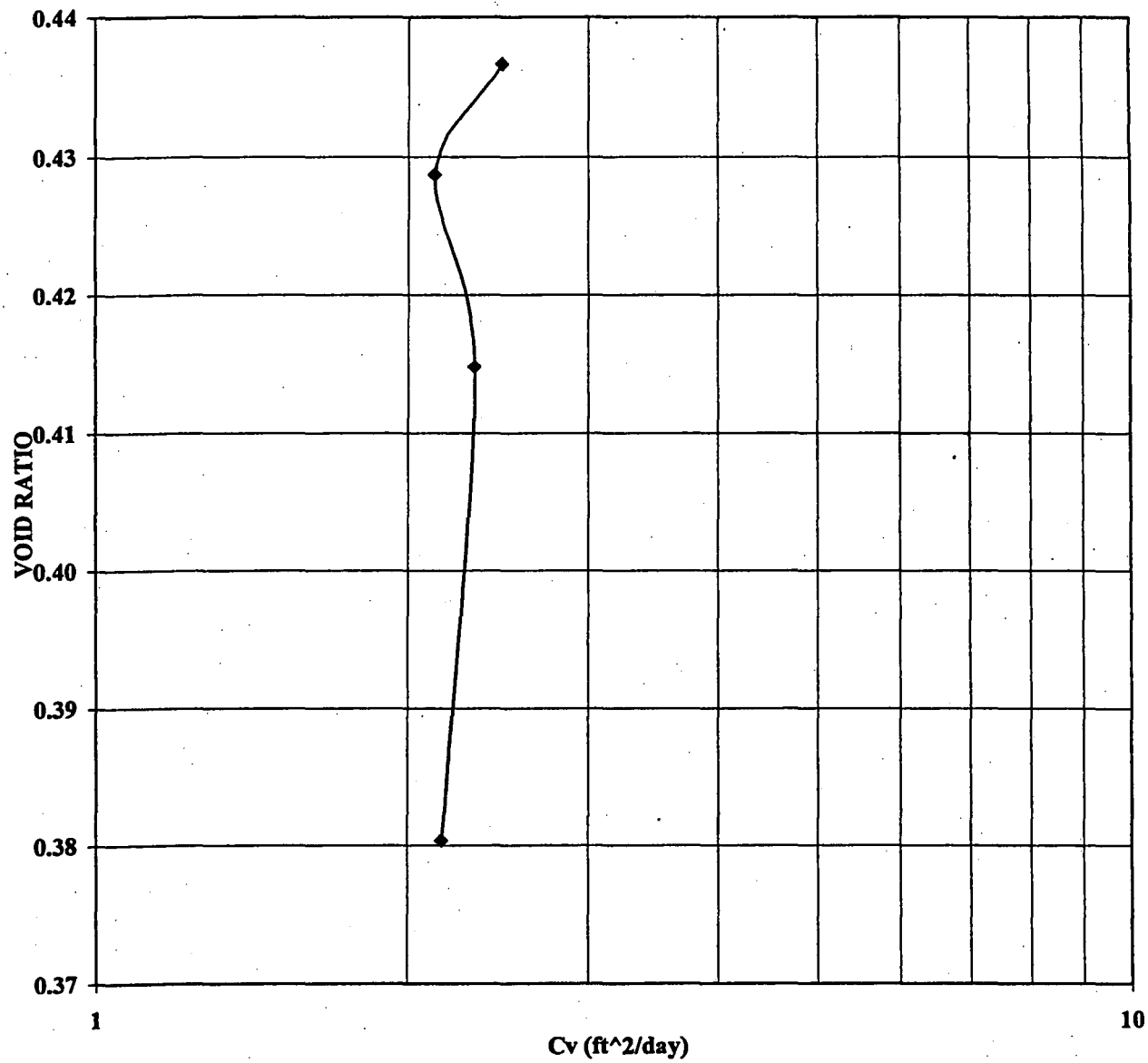
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-1

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-2	DATE	8/4/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9960
diameter (in)	2.497
area (in^2)	4.897
volume (in^3)	4.877
specimen weight,wet (g)	166.16
specimen weight,dry (g)	148.18
water weight (g)	17.98

SAMPLE DATA, INITIAL

total height (in)	0.996
height of solids (in)	0.684
height of voids (in)	0.312
void ratio	0.457
dry density (pcf)	115.48
moist density (pcf)	129.78

SAMPLE DATA, FINAL

total height (in)	0.9634
height of solids (in)	0.684
height of voids (in)	0.280
void ratio	0.409
dry density (pcf)	119.65
moist density (pcf)	138.39

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand

LL:	43	
PL:	19	
PI:	24	
Gs:	2.70	Assumed

MOISTURE CONTENT, INITIAL

tare #	S5
wt soil&tare,moist	99.05
wt soil&tare,dry	91.33
wt tare	27.72
wt moisture	7.72
wt dry soil	63.61
% moisture	12.14%

MOISTURE CONTENT, FINAL

tare #	8A
wt soil&tare,moist	204.64
wt soil&tare,dry	181.44
wt tare	33.29
wt moisture	23.20
wt dry soil	148.15
% moisture	15.66%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.100	0.9940	-	-	115.7	0.456	-	-	-	-	-	-	
0.500	0.9916	-	-	116.0	0.453	-	-	-	-	-	-	
0.500	0.9913	-	-	116.0	0.452	-	-	-	-	-	-	
1.0	0.9886	0.9892	0.217	116.3	0.448	0.4946	1.2563	0.2446	1.5782	2.39E-02	2.23E+00	0.013
2.0	0.9825	0.9836	0.236	117.1	0.439	0.4918	1.2492	0.2419	1.5604	2.17E-02	2.03E+00	0.030
4.0	0.9751	0.9763	0.257	118.0	0.428	0.4882	1.2400	0.2383	1.5375	1.96E-02	1.83E+00	0.036
8.0	0.9660	0.9672	0.208	119.1	0.415	0.4836	1.2284	0.2339	1.5089	2.38E-02	2.22E+00	0.044

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

GEOTECHNICAL LABORATORY SAMPLE TEST REQUEST

DATE SUBMITTED: SAMPLED BY: [X] = Requested Test

PROJECT NAME (SHORT TITLE): PROJECT NUMBER:

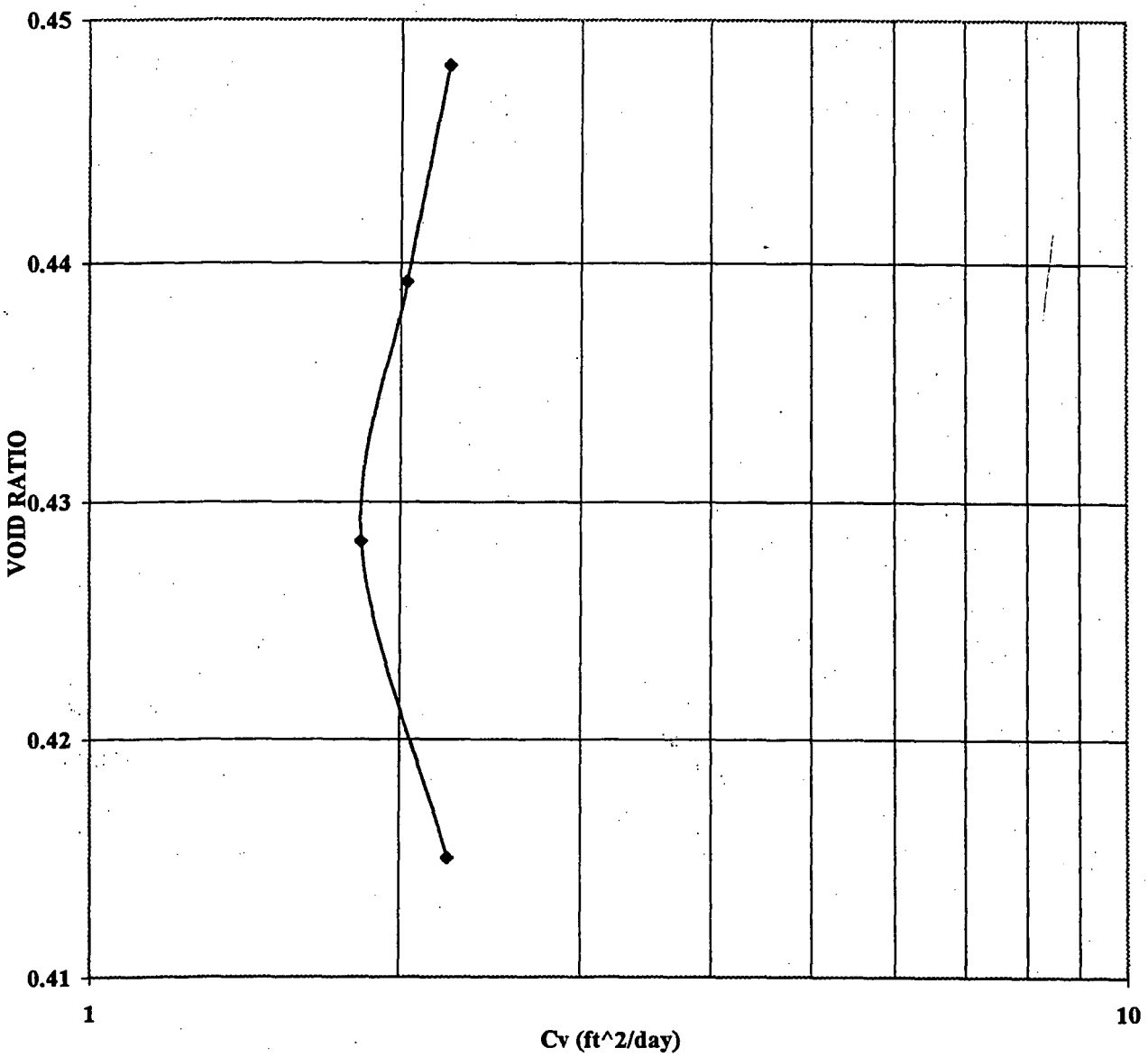
SAMPLE TYPE: (J) - Jar, (T) - Tube, (CR)-Core, (b) - bag, (B) - 5-gal Bucket, (O) - Other

TEST	WATER CONTENT	ATTERBERG LIMITS	SIEVE (3" THRU #200)	- #200 SIEVE (Passing)	HYDROMETER / SIEVE	UNIT WEIGHT	SPECIFIC GRAVITY	PROCTOR (Standard)	PROCTOR (Modified)	UNCONFINED COMPRESSION*	TRIAXIAL UU*	TRIAXIAL CU* with Pore Pressure	DIRECT SHEAR*	PERMEABILITY (Flex Wall)*	PERMEABILITY (Rigid Wall)*	CONSOLIDATION*	SWELL*	EXPANSION INDEX	pH LEVEL	ORGANIC CONTENT	RESISTIVITY				SPECIAL INSTRUCTIONS TO LAB (* Include Test Parameters)
TEST METHOD	D 2216	D 4318		D 1140	D 422		D 854	D 698	D 1557	D 2166	D 2850	D 4767	D 3080	D 5084	D 2434	D 2435	D 4546			D 2974	G 57				
SAMPLE #/Time Collected / SAMPLE TYPE																									
PF-1 11:00 Bulk	X	X			X			X				X				X									Hold Bucket 2
PF-2 11:05 Bulk	X	X			X			X				X				X									
PF-3 11:15 Bulk	X	X			X			X				X				X									Hold Buck 2
PF-4 11:20 Bulk	X	X			X			X				X				X									
PF-5 11 22 Bulk	X	X			X			X				X				X									
PF-5Dup 11:22 Bulk	X	X			X			X				X				X									
PF-6 11:35 Bulk	X	X			X			X				X				X									
PF-7 11:40 Bulk	X	X			X			X				X				X									
PF-8 11:45 Bulk	X	X			X			X				X				X									Hold Bucket 2
PF-9 11:48 Bulk	X	X			X			X				X				X									
PF-10 11:53 Bulk	X	X			X			X				X				X									

SEND RESULTS TO: Phone:

Collected by: [signature] Date: 7/9/04 Time: 11:48 AM Accepted By (Lab): mBowa Date: 7/9/04 Time: 1330 hrs

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-2

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-3	DATE	8/4/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9980
diameter (in)	2.500
area (in^2)	4.909
volume (in^3)	4.899
specimen weight,wet (g)	167.08
specimen weight,dry (g)	148.28
water weight (g)	18.80

SAMPLE DATA, INITIAL

total height (in)	0.998
height of solids (in)	0.690
height of voids (in)	0.308
void ratio	0.446
dry density (pcf)	115.05
moist density (pcf)	129.92

SAMPLE DATA, FINAL

total height (in)	0.9700
height of solids (in)	0.690
height of voids (in)	0.280
void ratio	0.406
dry density (pcf)	118.64
moist density (pcf)	136.94

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand with gravel

LL:	43	
PL:	18	
PI:	25	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	K10
wt soil&tare,moist	59.28
wt soil&tare,dry	55.06
wt tare	21.77
wt moisture	4.22
wt dry soil	33.29
% moisture	12.68%

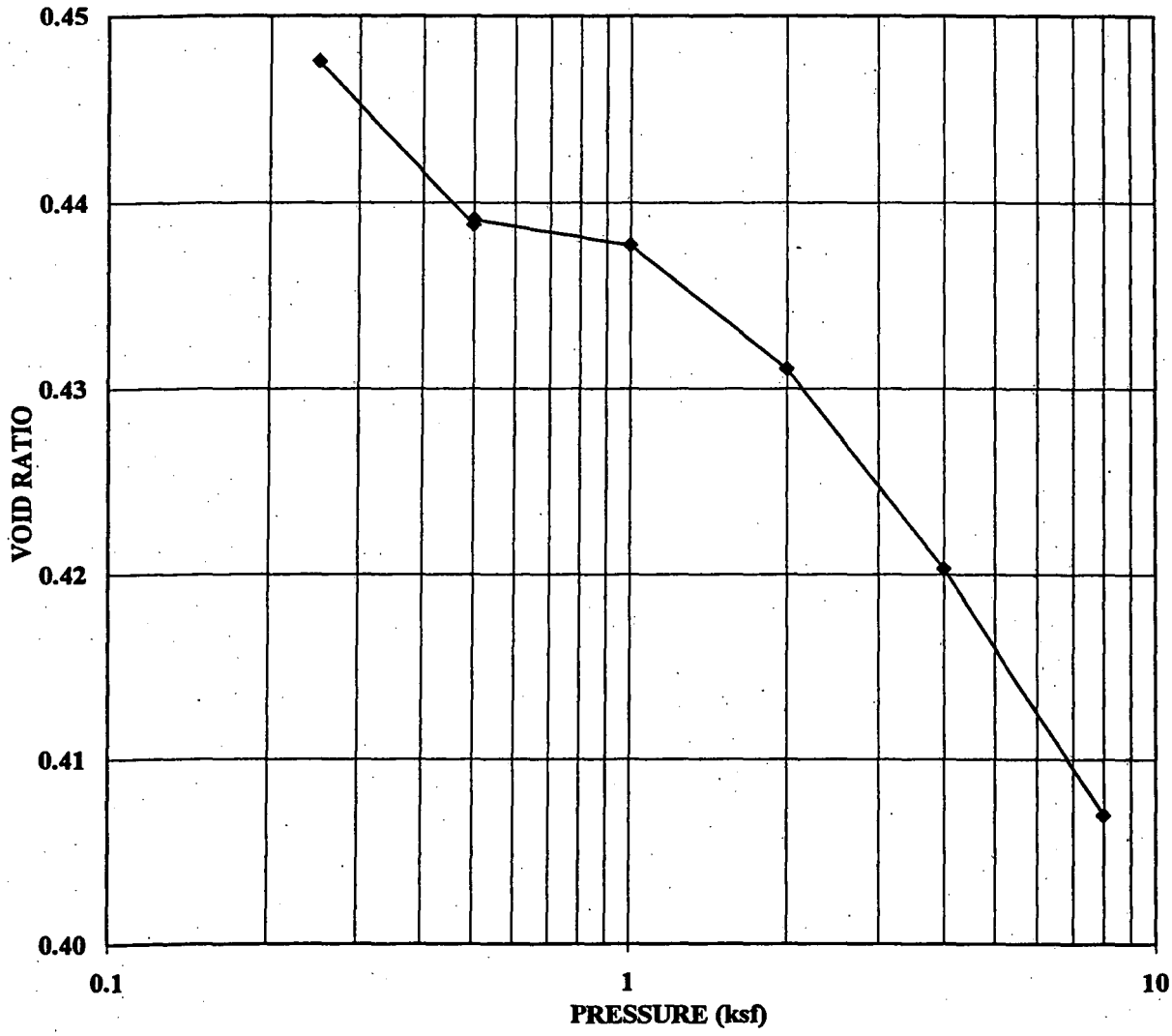
MOISTURE CONTENT, FINAL

tare #	F22
wt soil&tare,moist	204.05
wt soil&tare,dry	181.10
wt tare	32.38
wt moisture	22.95
wt dry soil	148.72
% moisture	15.43%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.25	0.9976	-	-	115.1	0.448	-	-	-	-	-	-	
0.50	0.9916	-	-	115.8	0.439	-	-	-	-	-	-	
0.50	0.9918	-	-	115.8	0.439	-	-	-	-	-	-	
1.0	0.9908	0.9910	0.2011	115.9	0.438	0.4955	1.2586	0.2455	1.5841	2.59E-02	2.41E+00	0.005
2.0	0.9863	0.9870	0.2262	116.4	0.431	0.4935	1.2534	0.2435	1.5711	2.28E-02	2.13E+00	0.022
4.0	0.9788	0.9800	0.2470	117.3	0.420	0.4900	1.2446	0.2401	1.5489	2.06E-02	1.92E+00	0.036
8.0	0.9696	0.9710	0.2131	118.4	0.407	0.4855	1.2332	0.2357	1.5207	2.34E-02	2.19E+00	0.044

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-3

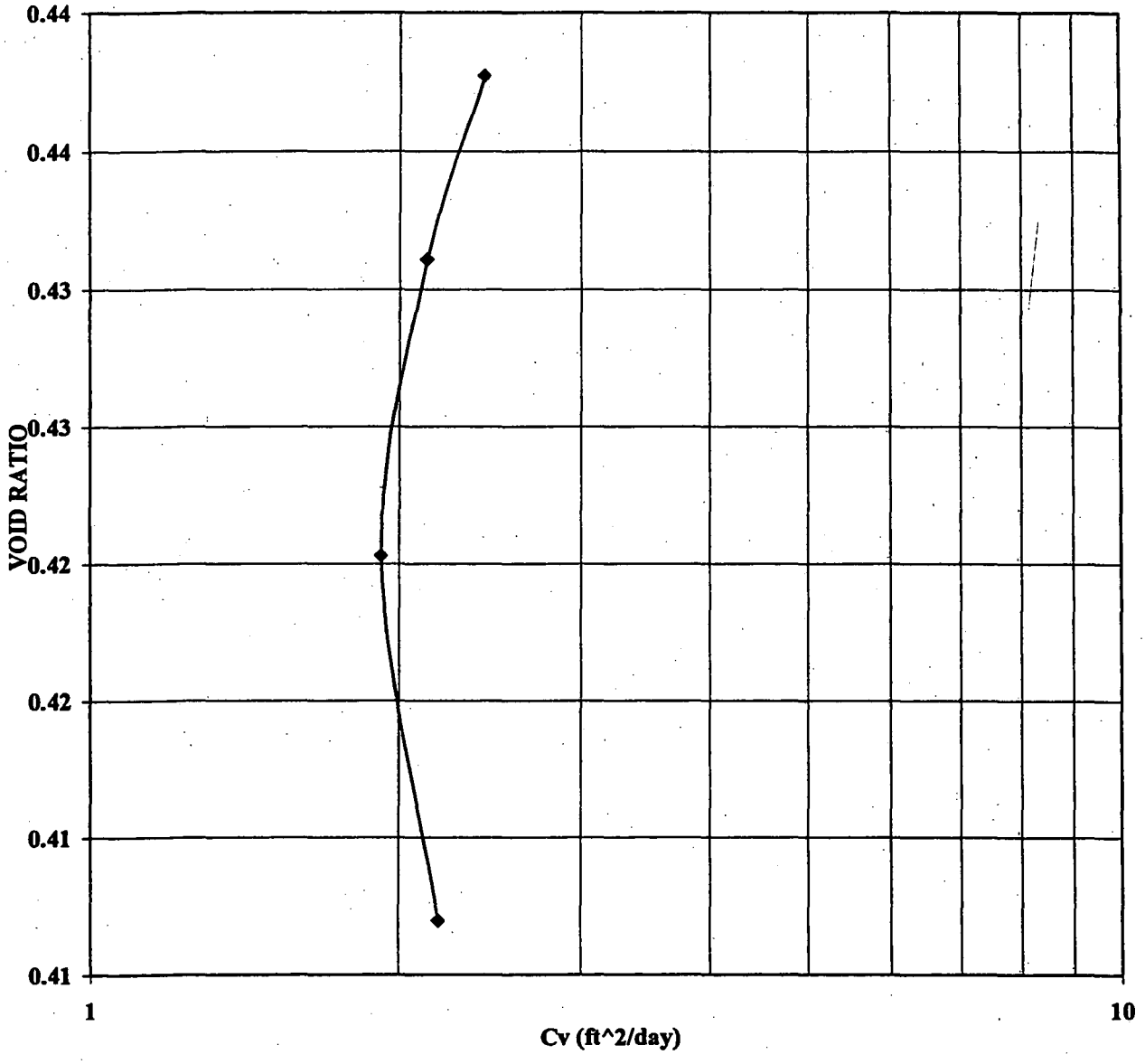
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-3

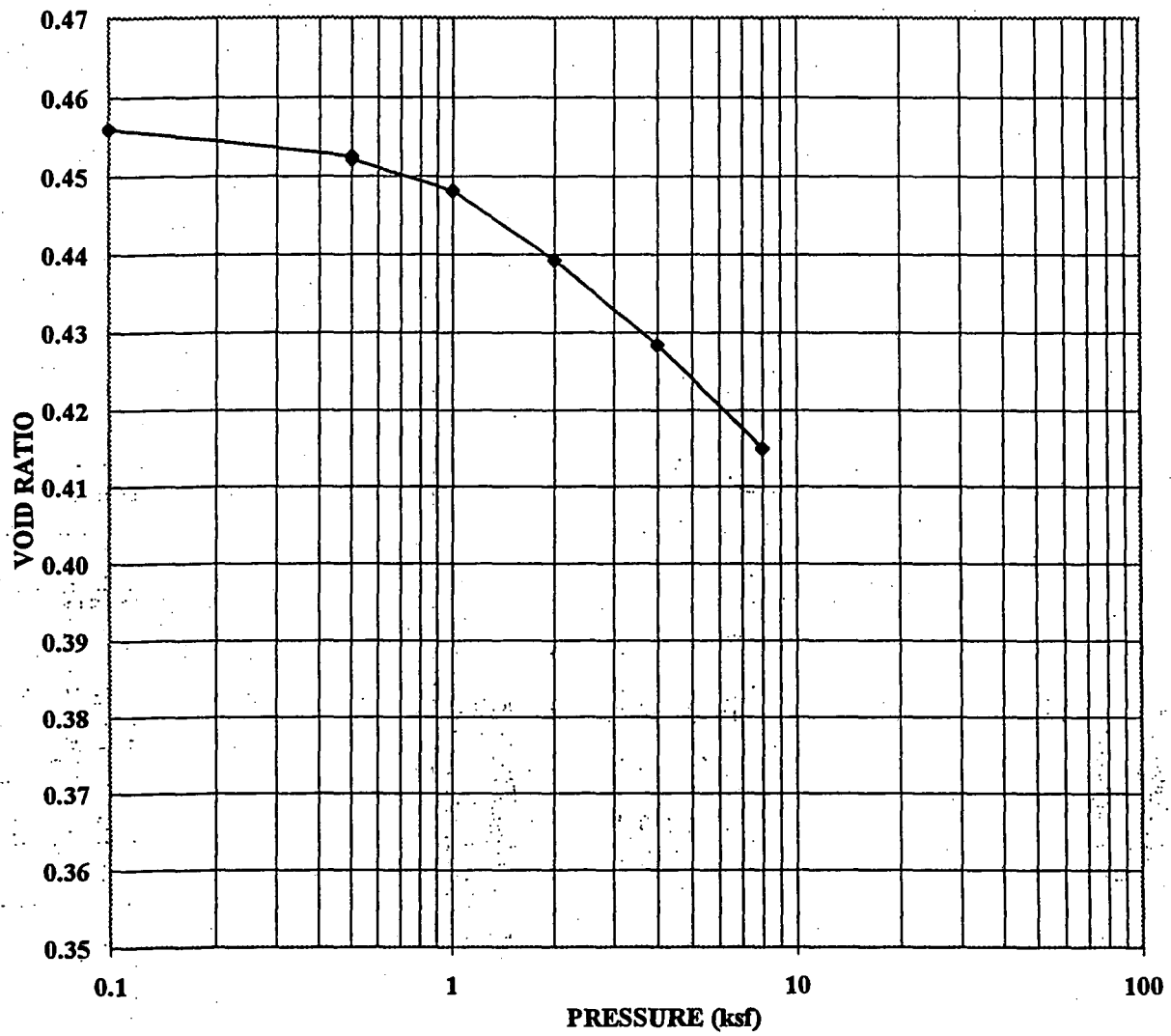
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-2

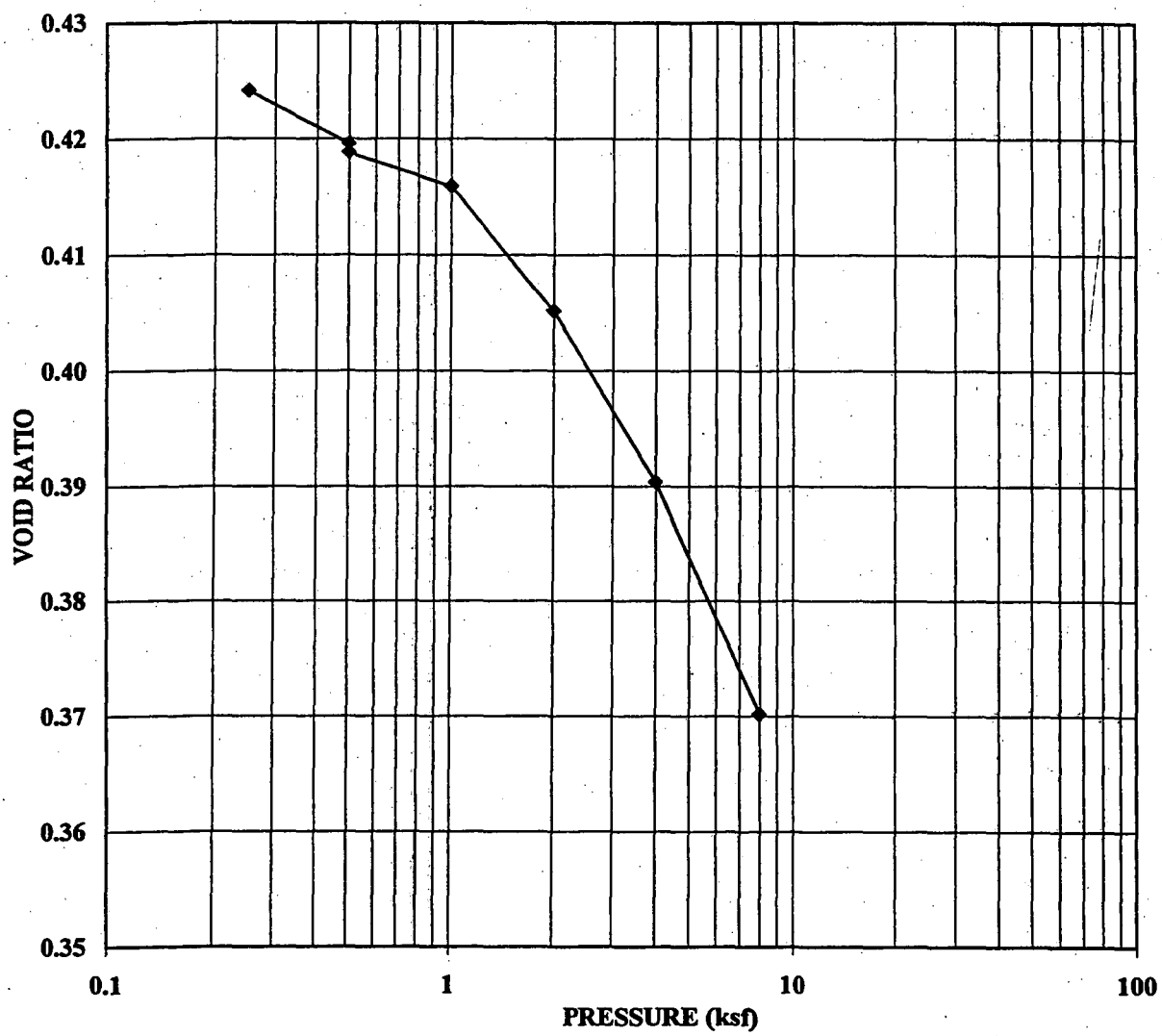
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-4

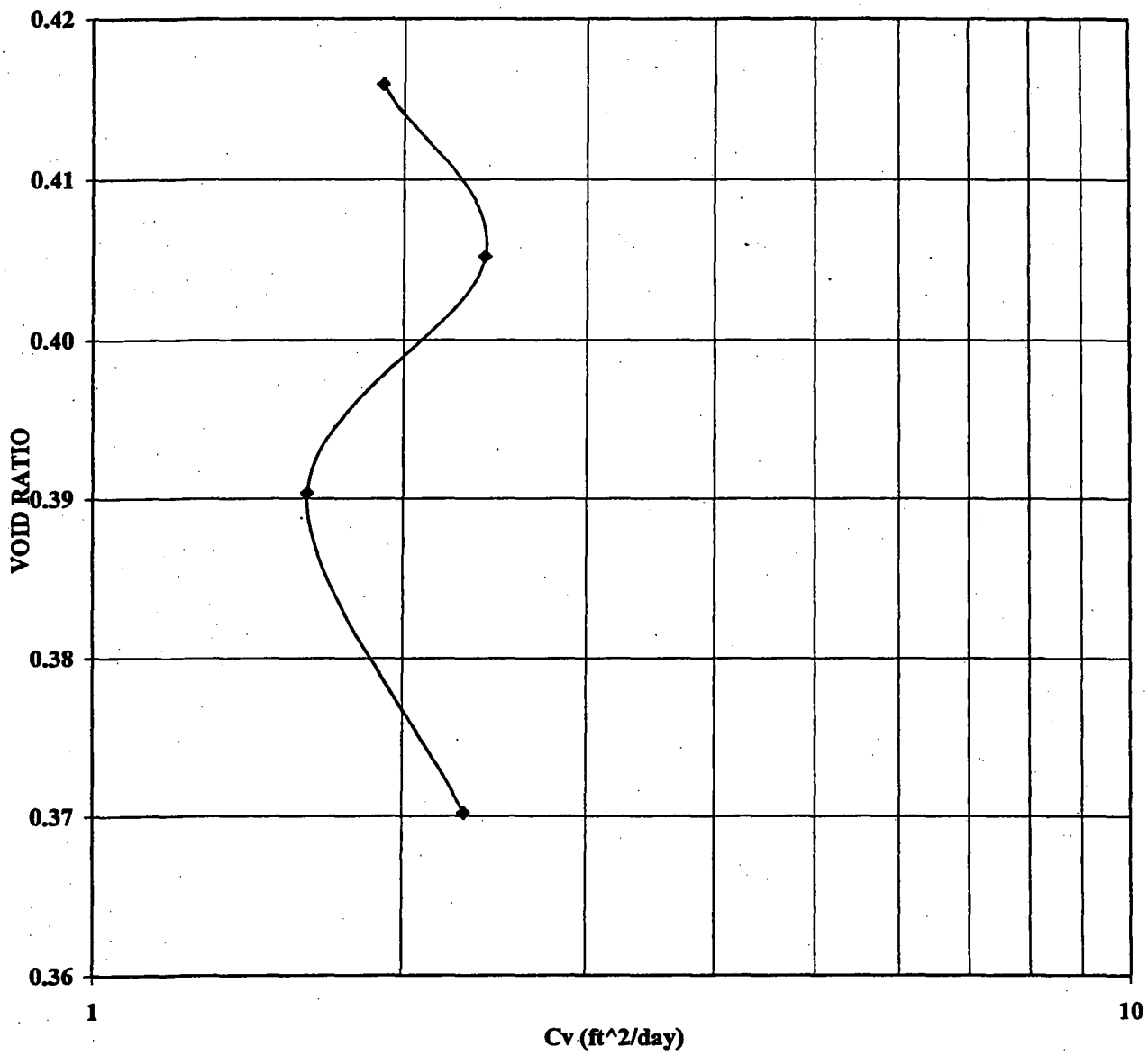
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand (SC)

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-4

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand (SC)

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-5	DATE	8/12/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9970
diameter (in)	2.499
area (in^2)	4.905
volume (in^3)	4.890
specimen weight,wet (g)	168.40
specimen weight,dry (g)	150.37
water weight (g)	18.03

SAMPLE DATA, INITIAL

total height (in)	0.997
height of solids (in)	0.700
height of voids (in)	0.297
void ratio	0.424
dry density (pcf)	116.89
moist density (pcf)	131.19

SAMPLE DATA, FINAL

total height (in)	0.9547
height of solids (in)	0.700
height of voids (in)	0.254
void ratio	0.363
dry density (pcf)	122.33
moist density (pcf)	140.32

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

LL:	37	
PL:	19	
PI:	18	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	AZ
wt soil&tare,moist	96.11
wt soil&tare,dry	88.94
wt tare	29.13
wt moisture	7.17
wt dry soil	59.81
% moisture	11.99%

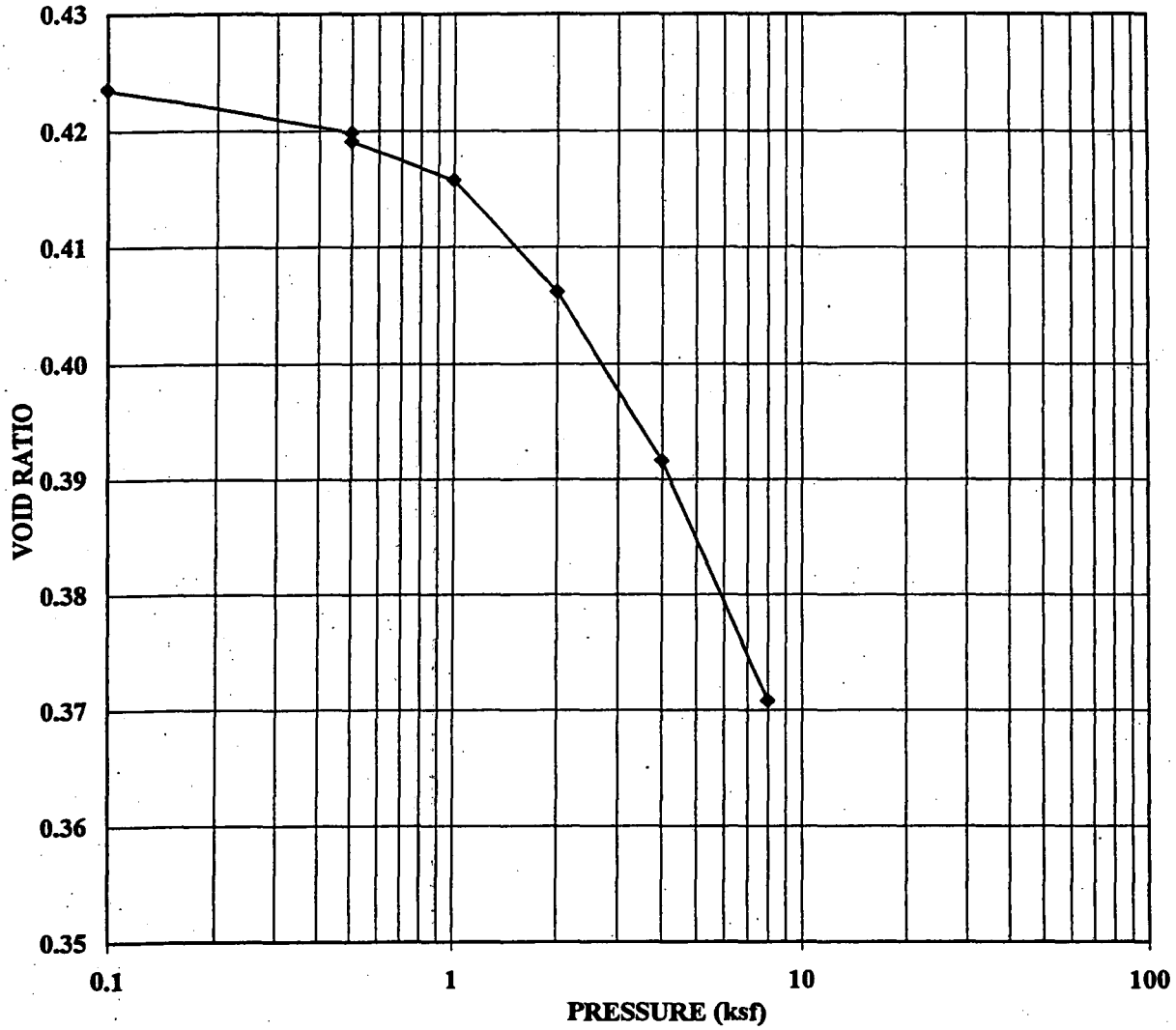
MOISTURE CONTENT, FINAL

tare #	F24
wt soil&tare,moist	201.73
wt soil&tare,dry	179.65
wt tare	29.48
wt moisture	22.08
wt dry soil	150.17
% moisture	14.70%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.100	0.9957	-	-	117.0	0.424	-	-	-	-	-	-	
0.500	0.9931	-	-	117.3	0.420	-	-	-	-	-	-	
0.500	0.9926	-	-	117.4	0.419	-	-	-	-	-	-	
1.0	0.9903	0.9909	0.421	117.7	0.416	0.4954	1.2584	0.2455	1.5836	1.24E-02	1.15E+00	0.011
2.0	0.9836	0.9846	0.210	118.5	0.406	0.4923	1.2505	0.2424	1.5638	2.44E-02	2.28E+00	0.032
4.0	0.9733	0.9747	0.222	119.7	0.392	0.4874	1.2379	0.2375	1.5325	2.27E-02	2.11E+00	0.049
8.0	0.9588	0.9609	0.180	121.5	0.371	0.4804	1.2203	0.2308	1.4892	2.71E-02	2.53E+00	0.069

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-5

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

DATE	8/12/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-4	DATE	8/4/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9980
diameter (in)	2.497
area (in^2)	4.897
volume (in^3)	4.887
specimen weight,wet (g)	169.32
specimen weight,dry (g)	150.10
water weight (g)	19.22

SAMPLE DATA, INITIAL

total height (in)	0.998
height of solids (in)	0.700
height of voids (in)	0.298
void ratio	0.425
dry density (pcf)	116.74
moist density (pcf)	131.98

SAMPLE DATA, FINAL

total height (in)	0.9547
height of solids (in)	0.700
height of voids (in)	0.255
void ratio	0.364
dry density (pcf)	122.31
moist density (pcf)	140.81

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand (SC)

LL:	35	
PL:	16	
PI:	19	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	Z2
wt soil&tare,moist	108.21
wt soil&tare,dry	99.13
wt tare	28.22
wt moisture	9.08
wt dry soil	70.91
% moisture	12.80%

MOISTURE CONTENT, FINAL

tare #	F19
wt soil&tare,moist	205.94
wt soil&tare,dry	183.10
wt tare	32.11
wt moisture	22.84
wt dry soil	150.99
% moisture	15.13%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.25	0.9959	-	-	117.0	0.424	-	-	-	-	-	-	
0.50	0.9927	-	-	117.4	0.420	-	-	-	-	-	-	
0.50	0.9922	-	-	117.4	0.419	-	-	-	-	-	-	
1.0	0.9902	0.9906	0.2544	117.7	0.416	0.4953	1.2581	0.2453	1.5828	2.04E-02	1.91E+00	0.010
2.0	0.9826	0.9836	0.1999	118.6	0.405	0.4918	1.2492	0.2419	1.5605	2.56E-02	2.39E+00	0.036
4.0	0.9723	0.9736	0.2905	119.8	0.390	0.4868	1.2364	0.2369	1.5287	1.73E-02	1.61E+00	0.049
8.0	0.9582	0.9601	0.1989	121.6	0.370	0.4801	1.2194	0.2305	1.4868	2.45E-02	2.29E+00	0.067

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-5 Dup	DATE	8/12/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9960
diameter (in)	2.498
area (in^2)	4.901
volume (in^3)	4.881
specimen weight,wet (g)	168.10
specimen weight,dry (g)	148.03
water weight (g)	20.07

SAMPLE DATA, INITIAL

total height (in)	0.996
height of solids (in)	0.690
height of voids (in)	0.306
void ratio	0.444
dry density (pcf)	115.27
moist density (pcf)	131.19

SAMPLE DATA, FINAL

total height (in)	0.9450
height of solids (in)	0.690
height of voids (in)	0.255
void ratio	0.370
dry density (pcf)	121.76
moist density (pcf)	139.81

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand (SC)

LL:	40	
PL:	19	
PI:	21	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	R3
wt soil&tare,moist	90.94
wt soil&tare,dry	83.94
wt tare	32.31
wt moisture	7.00
wt dry soil	51.63
% moisture	13.56%

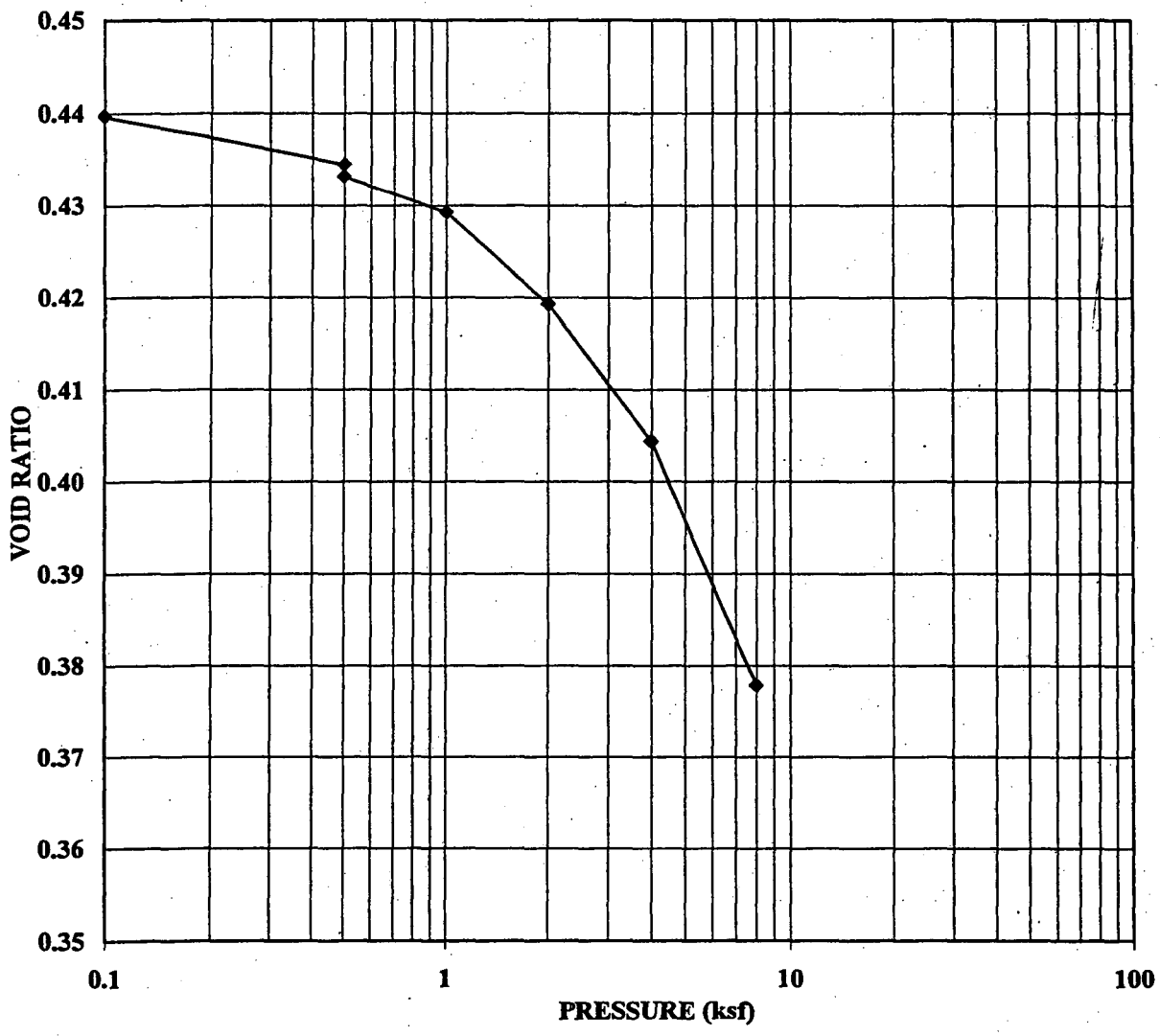
MOISTURE CONTENT, FINAL

tare #	DC3
wt soil&tare,moist	204.30
wt soil&tare,dry	182.30
wt tare	33.86
wt moisture	22.00
wt dry soil	148.44
% moisture	14.82%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.100	0.9921	-	-	115.7	0.440	-	-	-	-	-	-	
0.500	0.9885	-	-	116.1	0.434	-	-	-	-	-	-	
0.500	0.9876	-	-	116.3	0.433	-	-	-	-	-	-	
1.0	0.9849	0.9854	0.218	116.6	0.429	0.4927	1.2514	0.2427	1.5660	2.35E-02	2.20E+00	0.013
2.0	0.9780	0.9790	0.227	117.4	0.419	0.4895	1.2434	0.2396	1.5460	2.24E-02	2.09E+00	0.033
4.0	0.9678	0.9694	0.214	118.6	0.404	0.4847	1.2312	0.2350	1.5158	2.33E-02	2.17E+00	0.049
8.0	0.9495	0.9529	0.327	120.9	0.378	0.4765	1.2102	0.2270	1.4646	1.47E-02	1.37E+00	0.088

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-5 Dup

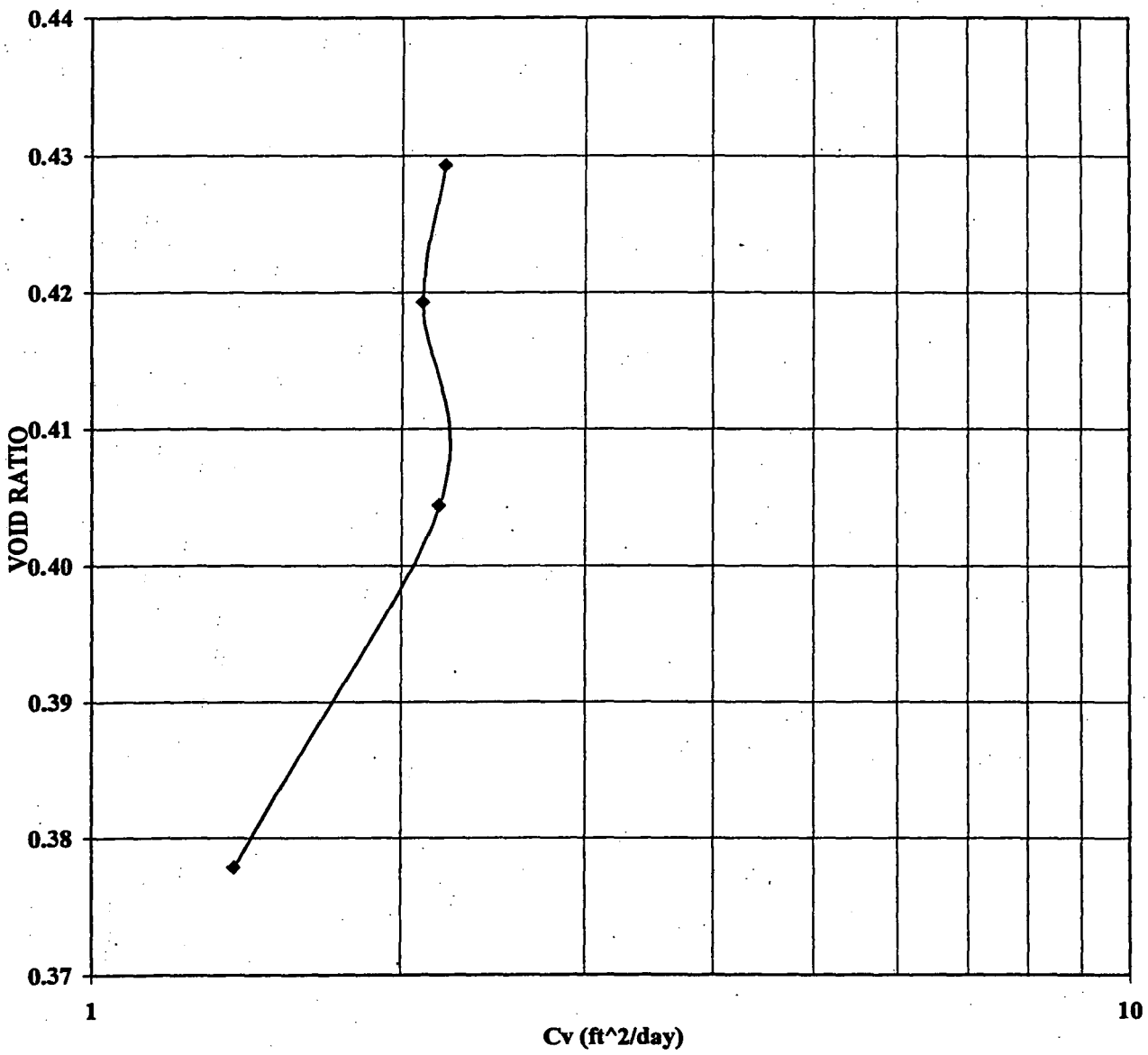
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand (SC)

DATE	8/12/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-5 Dup

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand (SC)

DATE	8/12/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-6	DATE	8/4/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9950
diameter (in)	2.497
area (in^2)	4.897
volume (in^3)	4.872
specimen weight,wet (g)	167.67
specimen weight,dry (g)	146.07
water weight (g)	21.60

SAMPLE DATA, INITIAL

total height (in)	0.995
height of solids (in)	0.681
height of voids (in)	0.314
void ratio	0.460
dry density (pcf)	113.95
moist density (pcf)	131.09

SAMPLE DATA, FINAL

total height (in)	0.9400
height of solids (in)	0.681
height of voids (in)	0.259
void ratio	0.380
dry density (pcf)	120.89
moist density (pcf)	140.53

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand with gravel

LL:	45	
PL:	20	
PI:	25	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	19B
wt soil&tare,moist	105.86
wt soil&tare,dry	95.40
wt tare	24.65
wt moisture	10.46
wt dry soil	70.75
% moisture	14.78%

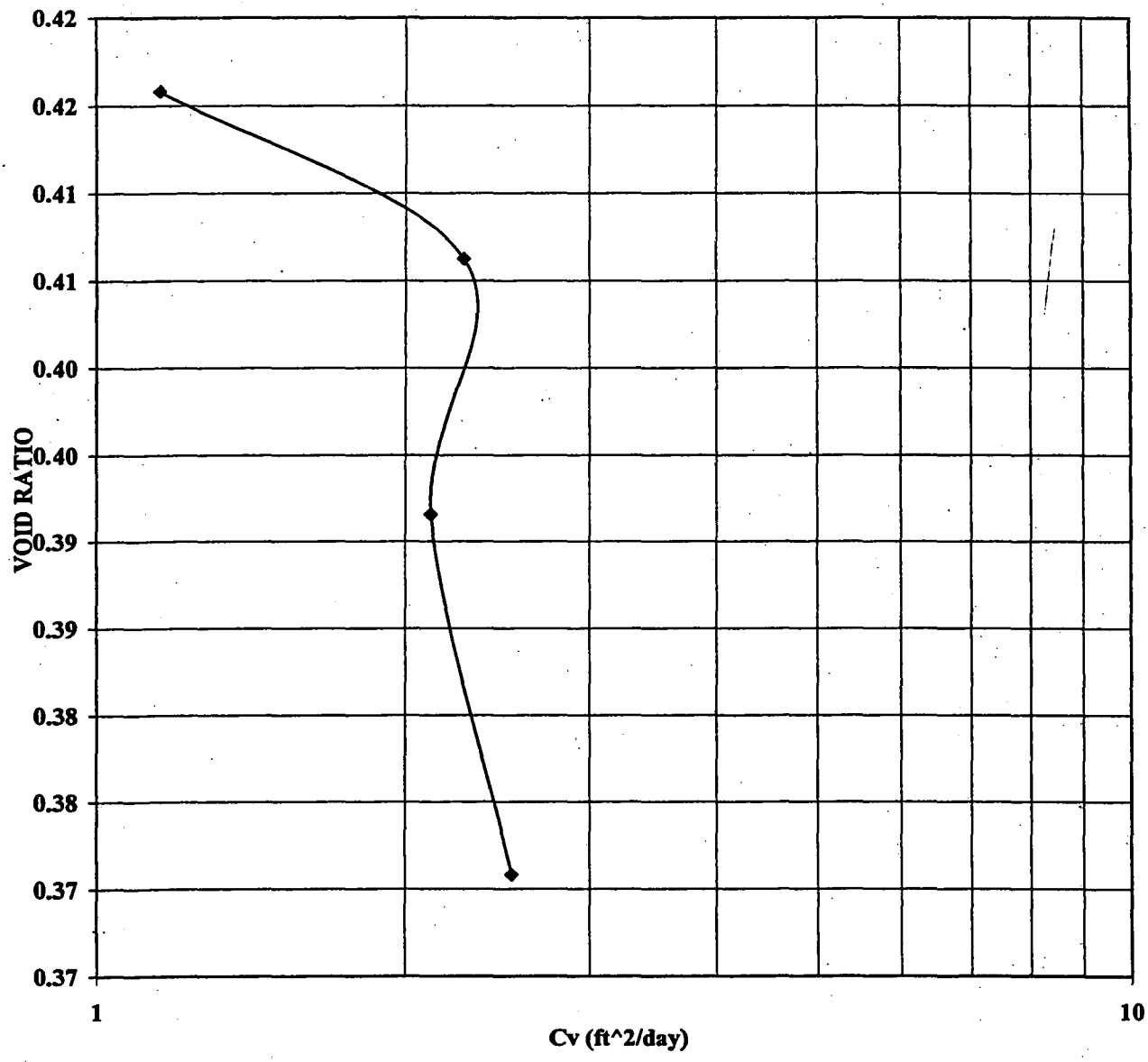
MOISTURE CONTENT, FINAL

tare #	C5L
wt soil&tare,moist	203.43
wt soil&tare,dry	179.67
wt tare	33.45
wt moisture	23.76
wt dry soil	146.22
% moisture	16.25%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.250	0.9891	-	-	114.6	0.453	-	-	-	-	-	-	
0.500	0.9842	-	-	115.2	0.446	-	-	-	-	-	-	
0.500	0.9836	-	-	115.3	0.445	-	-	-	-	-	-	
1.0	0.9818	0.9822	0.2545	115.5	0.443	0.4911	1.2474	0.2412	1.5561	2.01E-02	1.87E+00	0.009
2.0	0.9752	0.9763	0.1780	116.3	0.433	0.4881	1.2398	0.2383	1.5372	2.84E-02	2.65E+00	0.032
4.0	0.9632	0.9655	0.2242	117.7	0.415	0.4828	1.2262	0.2331	1.5036	2.20E-02	2.05E+00	0.058
8.0	0.9400	0.9444	0.4444	120.6	0.381	0.4722	1.1995	0.2230	1.4387	1.06E-02	9.92E-01	0.113

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-5

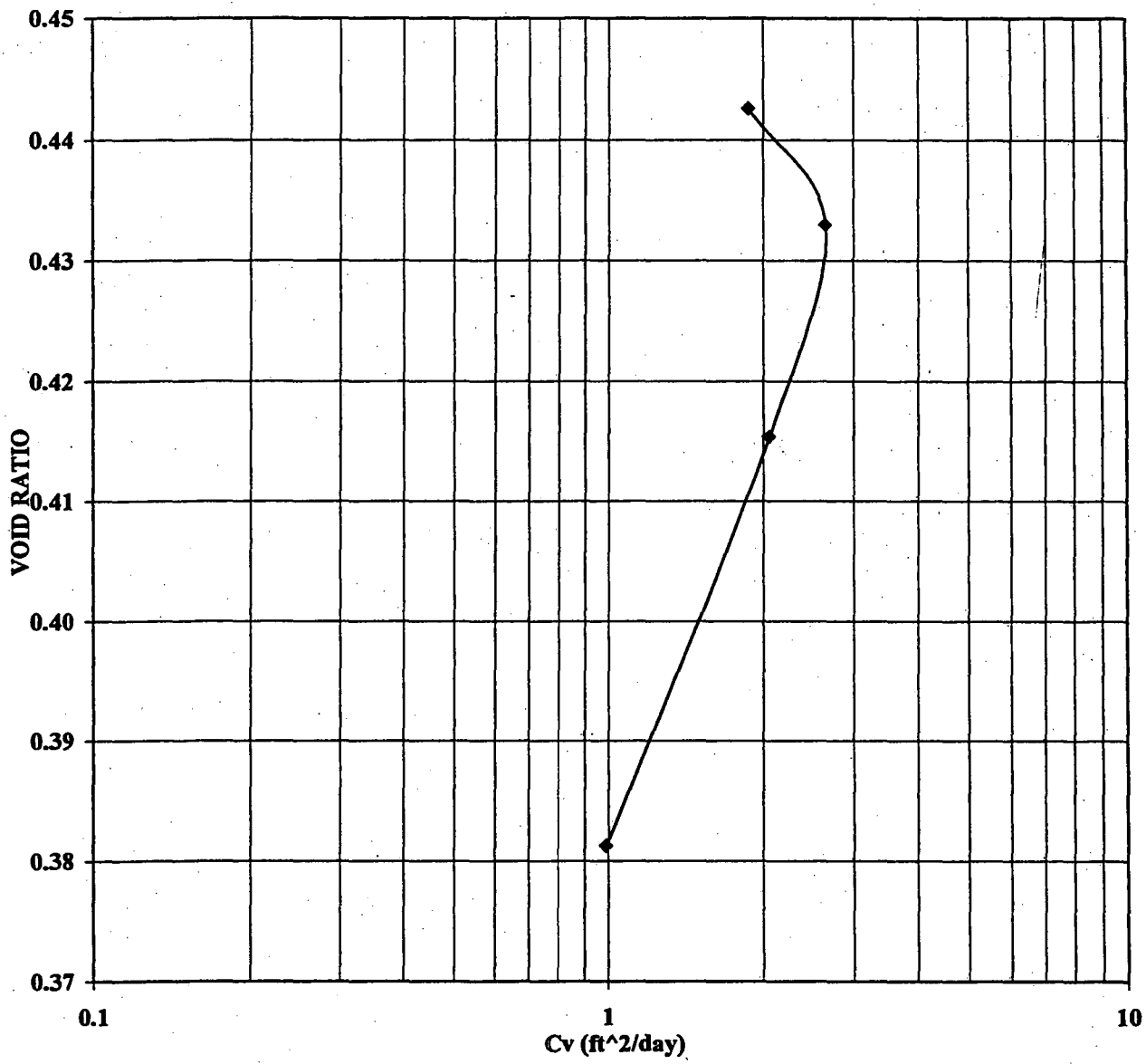
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

DATE	8/12/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-6

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-7	DATE	8/4/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9960
diameter (in)	2.498
area (in^2)	4.901
volume (in^3)	4.881
specimen weight,wet (g)	172.91
specimen weight,dry (g)	154.21
water weight (g)	18.70

SAMPLE DATA, INITIAL

total height (in)	0.996
height of solids (in)	0.719
height of voids (in)	0.277
void ratio	0.386
dry density (pcf)	120.09
moist density (pcf)	134.94

SAMPLE DATA, FINAL

total height (in)	0.9682
height of solids (in)	0.719
height of voids (in)	0.249
void ratio	0.347
dry density (pcf)	123.81
moist density (pcf)	141.03

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand (SC)

LL:	35	
PL:	18	
PI:	17	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	K3
wt soil&tare,moist	75.07
wt soil&tare,dry	69.33
wt tare	21.99
wt moisture	5.74
wt dry soil	47.34
% moisture	12.13%

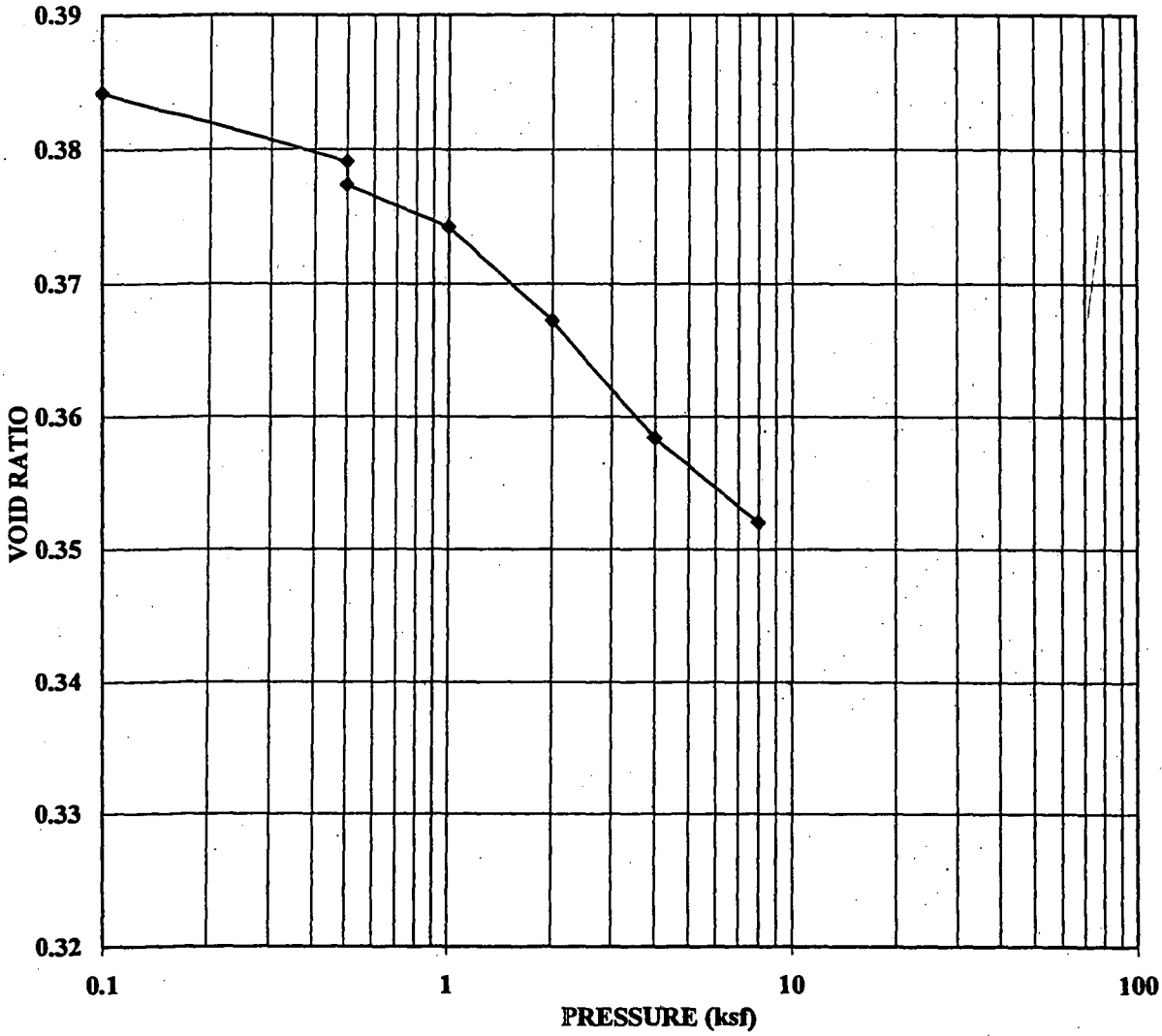
MOISTURE CONTENT, FINAL

tare #	F18
wt soil&tare,moist	210.79
wt soil&tare,dry	189.27
wt tare	34.56
wt moisture	21.52
wt dry soil	154.71
% moisture	13.91%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.100	0.9937	-	-	120.4	0.384	-	-	-	-	-	-	
0.500	0.9900	-	-	120.8	0.379	-	-	-	-	-	-	
0.500	0.9888	-	-	121.0	0.377	-	-	-	-	-	-	
1.0	0.9865	0.9869	0.3428	121.2	0.374	0.4935	1.2534	0.2435	1.5710	1.50E-02	1.40E+00	0.011
2.0	0.9815	0.9821	0.2173	121.9	0.367	0.4911	1.2473	0.2411	1.5557	2.35E-02	2.19E+00	0.023
4.0	0.9751	0.9760	0.2546	122.7	0.358	0.4880	1.2395	0.2381	1.5364	1.98E-02	1.85E+00	0.030
8.0	0.9706	0.9717	0.2321	123.2	0.352	0.4858	1.2340	0.2360	1.5229	2.15E-02	2.01E+00	0.021

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-7

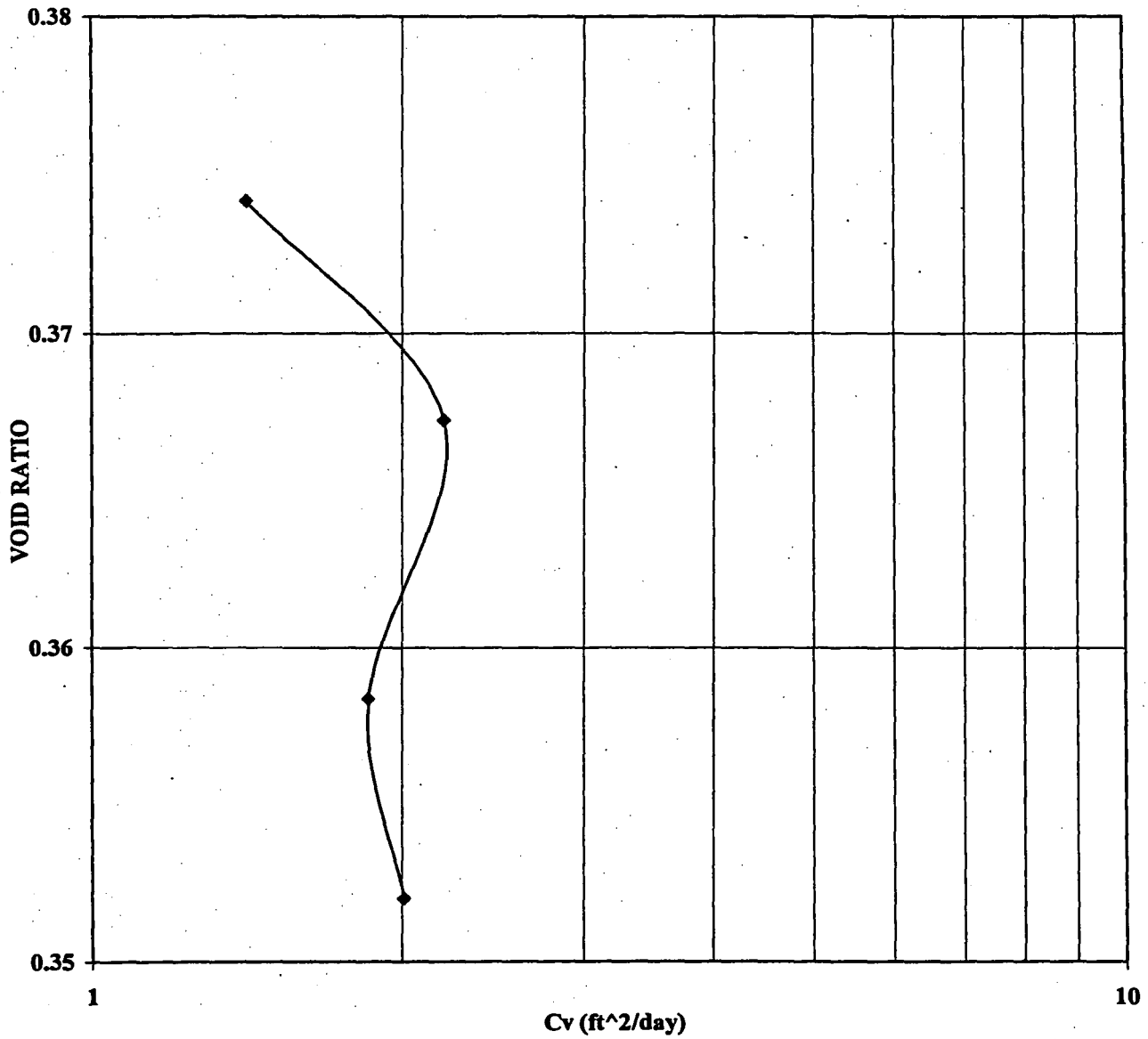
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand (SC)

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-7

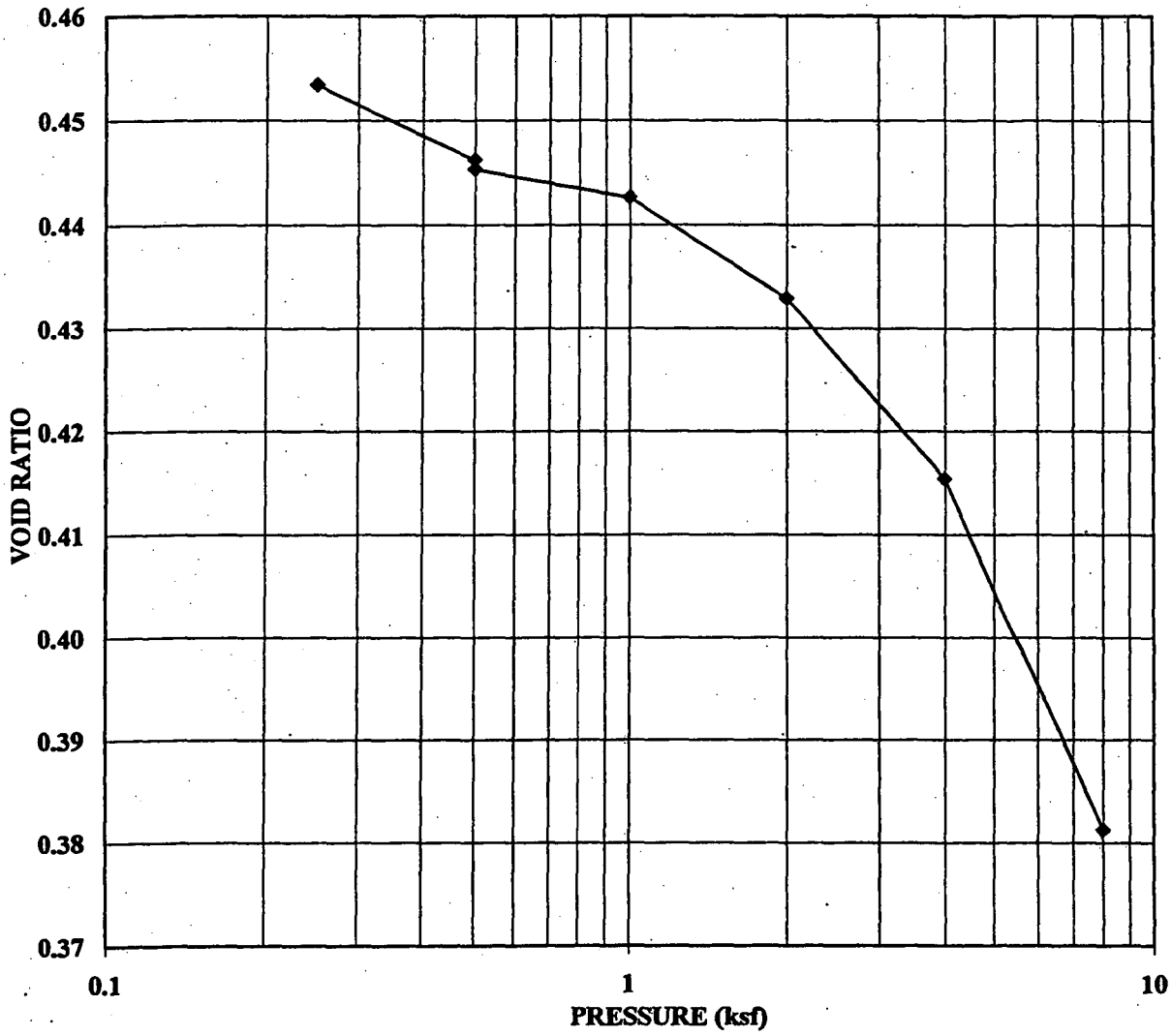
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand (SC)

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-6

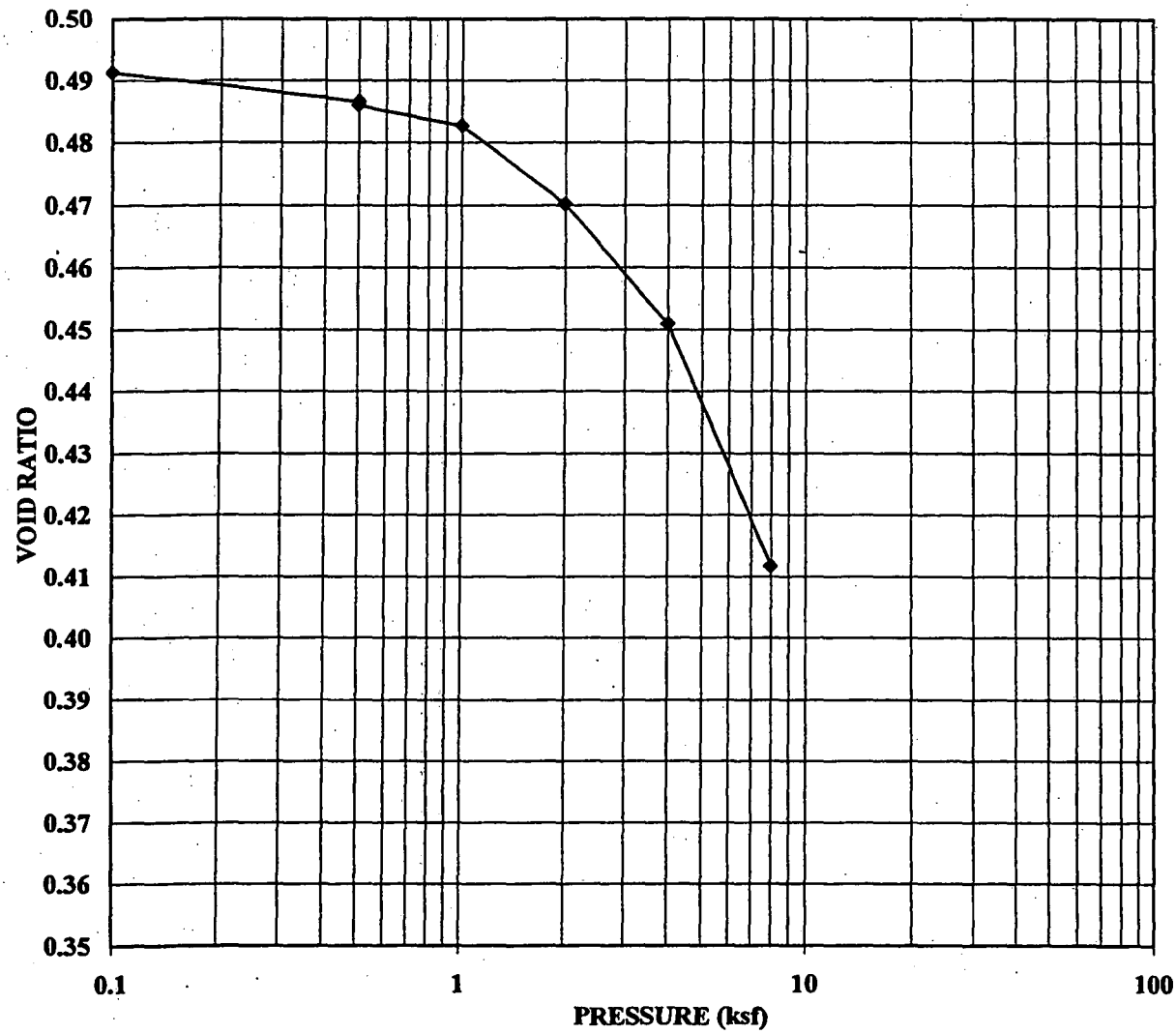
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-8

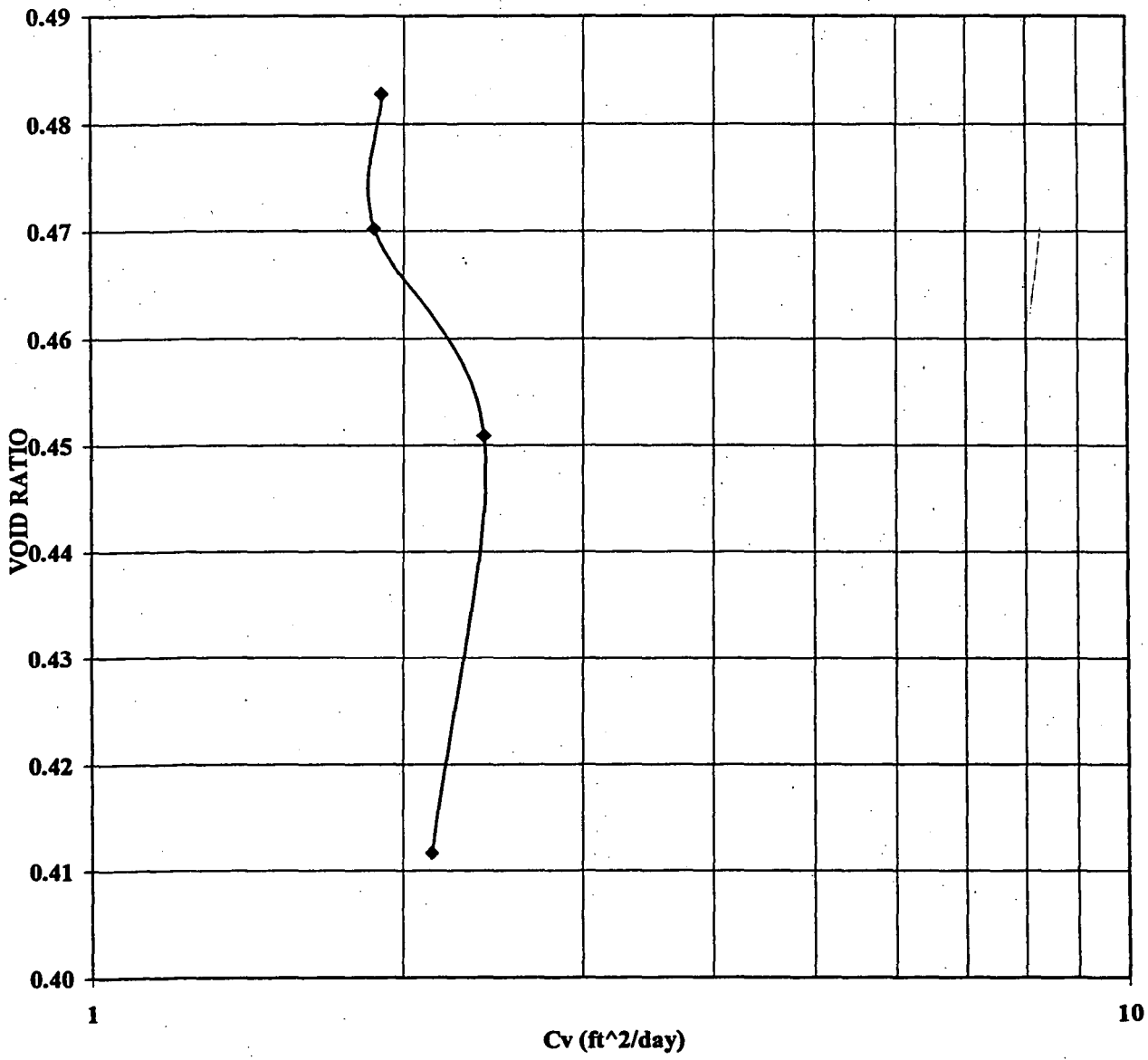
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

DATE	8/12/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-8

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

DATE	8/12/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-9	DATE	8/4/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9920
diameter (in)	2.498
area (in^2)	4.901
volume (in^3)	4.862
specimen weight,wet (g)	171.10
specimen weight,dry (g)	152.84
water weight (g)	18.26

SAMPLE DATA, INITIAL

total height (in)	0.992
height of solids (in)	0.712
height of voids (in)	0.280
void ratio	0.392
dry density (pcf)	119.50
moist density (pcf)	134.07

SAMPLE DATA, FINAL

total height (in)	0.9714
height of solids (in)	0.712
height of voids (in)	0.259
void ratio	0.364
dry density (pcf)	122.30
moist density (pcf)	138.47

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand

LL:	38	
PL:	18	
PI:	20	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	K20
wt soil&tare,moist	102.29
wt soil&tare,dry	93.70
wt tare	21.79
wt moisture	8.59
wt dry soil	71.91
% moisture	11.95%

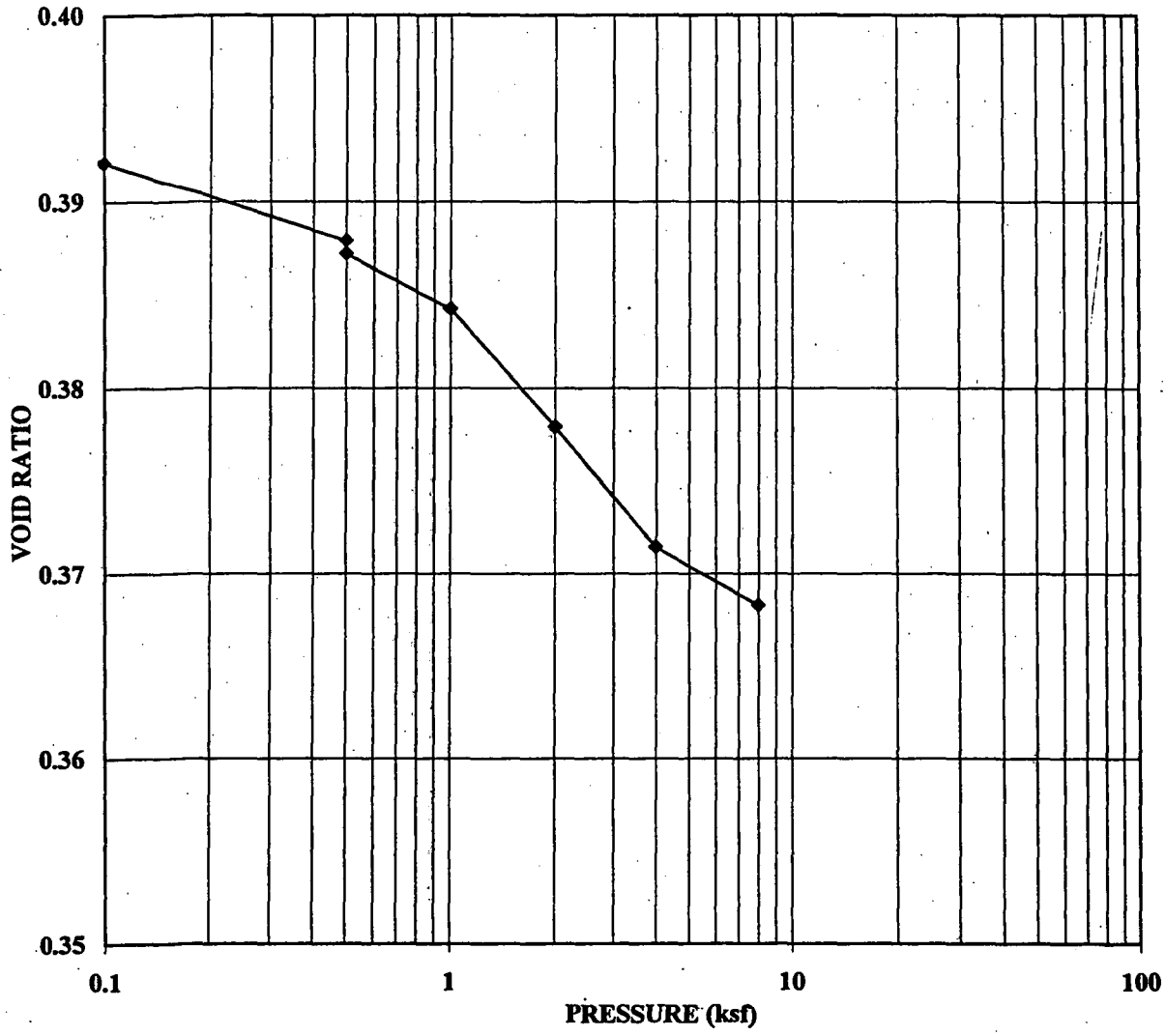
MOISTURE CONTENT, FINAL

tare #	4A
wt soil&tare,moist	206.51
wt soil&tare,dry	186.28
wt tare	33.19
wt moisture	20.23
wt dry soil	153.09
% moisture	13.21%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.100	0.9905	-	-	119.7	0.392	-	-	-	-	-	-	
0.500	0.9875	-	-	120.0	0.388	-	-	-	-	-	-	
0.500	0.9870	-	-	120.1	0.387	-	-	-	-	-	-	
1.0	0.9849	0.9854	0.2185	120.4	0.384	0.4927	1.2514	0.2427	1.5660	2.35E-02	2.20E+00	0.010
2.0	0.9804	0.9810	0.2546	120.9	0.378	0.4905	1.2459	0.2406	1.5523	2.00E-02	1.87E+00	0.021
4.0	0.9758	0.9762	0.2599	121.5	0.371	0.4881	1.2398	0.2383	1.5371	1.94E-02	1.81E+00	0.021
8.0	0.9735	0.9743	0.1964	121.8	0.368	0.4872	1.2374	0.2373	1.5311	2.56E-02	2.39E+00	0.010

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-9

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-8	DATE	8/12/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9970
diameter (in)	2.498
area (in^2)	4.901
volume (in^3)	4.886
specimen weight,wet (g)	163.81
specimen weight,dry (g)	143.39
water weight (g)	20.42

SAMPLE DATA, INITIAL

total height (in)	0.997
height of solids (in)	0.668
height of voids (in)	0.329
void ratio	0.492
dry density (pcf)	111.54
moist density (pcf)	127.71

SAMPLE DATA, FINAL

total height (in)	0.9368
height of solids (in)	0.668
height of voids (in)	0.268
void ratio	0.402
dry density (pcf)	118.97
moist density (pcf)	137.85

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

LL:	41	
PL:	19	
PI:	22	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	19B
wt soil&tare,moist	87.78
wt soil&tare,dry	79.91
wt tare	24.66
wt moisture	7.87
wt dry soil	55.25
% moisture	14.24%

MOISTURE CONTENT, FINAL

tare #	3A
wt soil&tare,moist	199.91
wt soil&tare,dry	177.12
wt tare	33.51
wt moisture	22.79
wt dry soil	143.61
% moisture	15.87%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	DRAINAGE PATH (DOUBLE DRAINAGE) H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	COEFFICIENT OF CONSOLIDATION (ft^2/day)	Cc
0.100	0.9954	-	-	111.7	0.491	-	-	-	-	-	-	
0.500	0.9923	-	-	112.1	0.487	-	-	-	-	-	-	
0.500	0.9919	-	-	112.1	0.486	-	-	-	-	-	-	
1.0	0.9897	0.9903	0.255	112.4	0.483	0.4951	1.2576	0.2452	1.5817	2.04E-02	1.90E+00	0.011
2.0	0.9813	0.9828	0.255	113.3	0.470	0.4914	1.2482	0.2415	1.5580	2.01E-02	1.87E+00	0.042
4.0	0.9684	0.9710	0.194	114.8	0.451	0.4855	1.2332	0.2357	1.5207	2.57E-02	2.40E+00	0.064
8.0	0.9423	0.9462	0.207	118.0	0.412	0.4731	1.2017	0.2238	1.4440	2.29E-02	2.14E+00	0.130

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

ROCKY FLATS/FIELD & LAB TEST/CO 043-2246-0001	SAMPLE: PF-10	DATE	8/12/2004
		TECH	NG
		REVIEW	JEO

SAMPLE DATA, GENERAL

height (in)	0.9980
diameter (in)	2.498
area (in^2)	4.901
volume (in^3)	4.891
specimen weight,wet (g)	168.18
specimen weight,dry (g)	149.12
water weight (g)	19.06

SAMPLE DATA, INITIAL

total height (in)	0.998
height of solids (in)	0.695
height of voids (in)	0.303
void ratio	0.436
dry density (pcf)	115.89
moist density (pcf)	130.99

SAMPLE DATA, FINAL

total height (in)	0.9362
height of solids (in)	0.695
height of voids (in)	0.241
void ratio	0.347
dry density (pcf)	123.81
moist density (pcf)	142.30

DESCRIPTION

Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

LL:	43	
PL:	18	
PI:	25	
Gs:	2.67	Assumed

MOISTURE CONTENT, INITIAL

tare #	D4
wt soil&tare,moist	90.35
wt soil&tare,dry	83.39
wt tare	28.94
wt moisture	6.96
wt dry soil	54.45
% moisture	12.78%

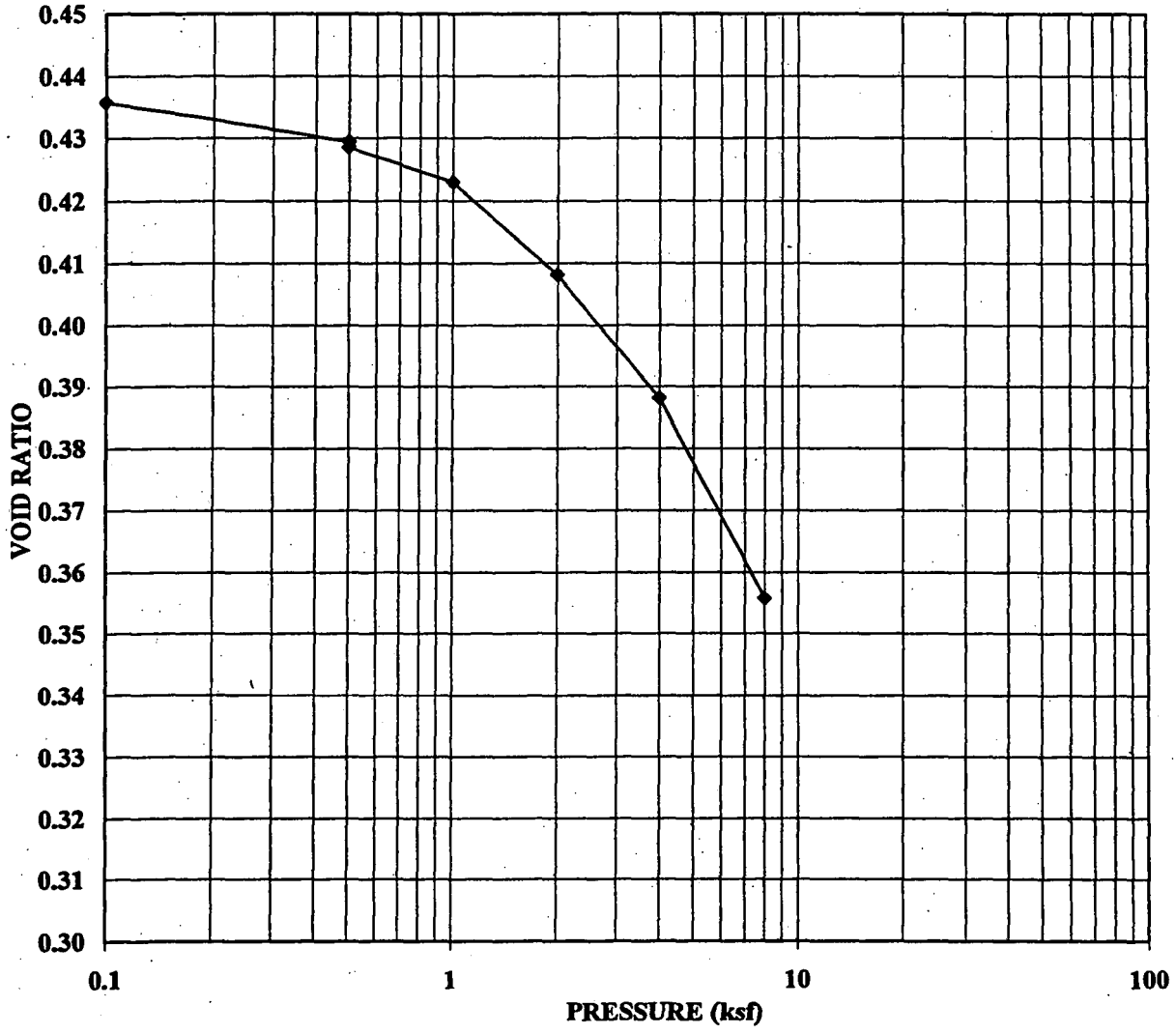
MOISTURE CONTENT, FINAL

tare #	X15
wt soil&tare,moist	204.16
wt soil&tare,dry	181.88
wt tare	32.70
wt moisture	22.28
wt dry soil	149.18
% moisture	14.93%

PRESSURE (ksf)	h100 Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	(ft^2/day)	Cc
0.100	0.9967	-	-	116.0	0.436	-	-	-	-	-	-	
0.500	0.9923	-	-	116.6	0.429	-	-	-	-	-	-	
0.500	0.9917	-	-	116.6	0.429	-	-	-	-	-	-	
1.0	0.9878	0.9886	0.343	117.1	0.423	0.4943	1.2556	0.2444	1.5765	1.51E-02	1.41E+00	0.019
2.0	0.9775	0.9789	0.254	118.3	0.408	0.4894	1.2432	0.2396	1.5455	2.00E-02	1.86E+00	0.050
4.0	0.9636	0.9656	0.191	120.0	0.388	0.4828	1.2264	0.2331	1.5040	2.58E-02	2.41E+00	0.066
8.0	0.9411	0.9439	0.208	122.9	0.356	0.4719	1.1987	0.2227	1.4369	2.26E-02	2.11E+00	0.108

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-10

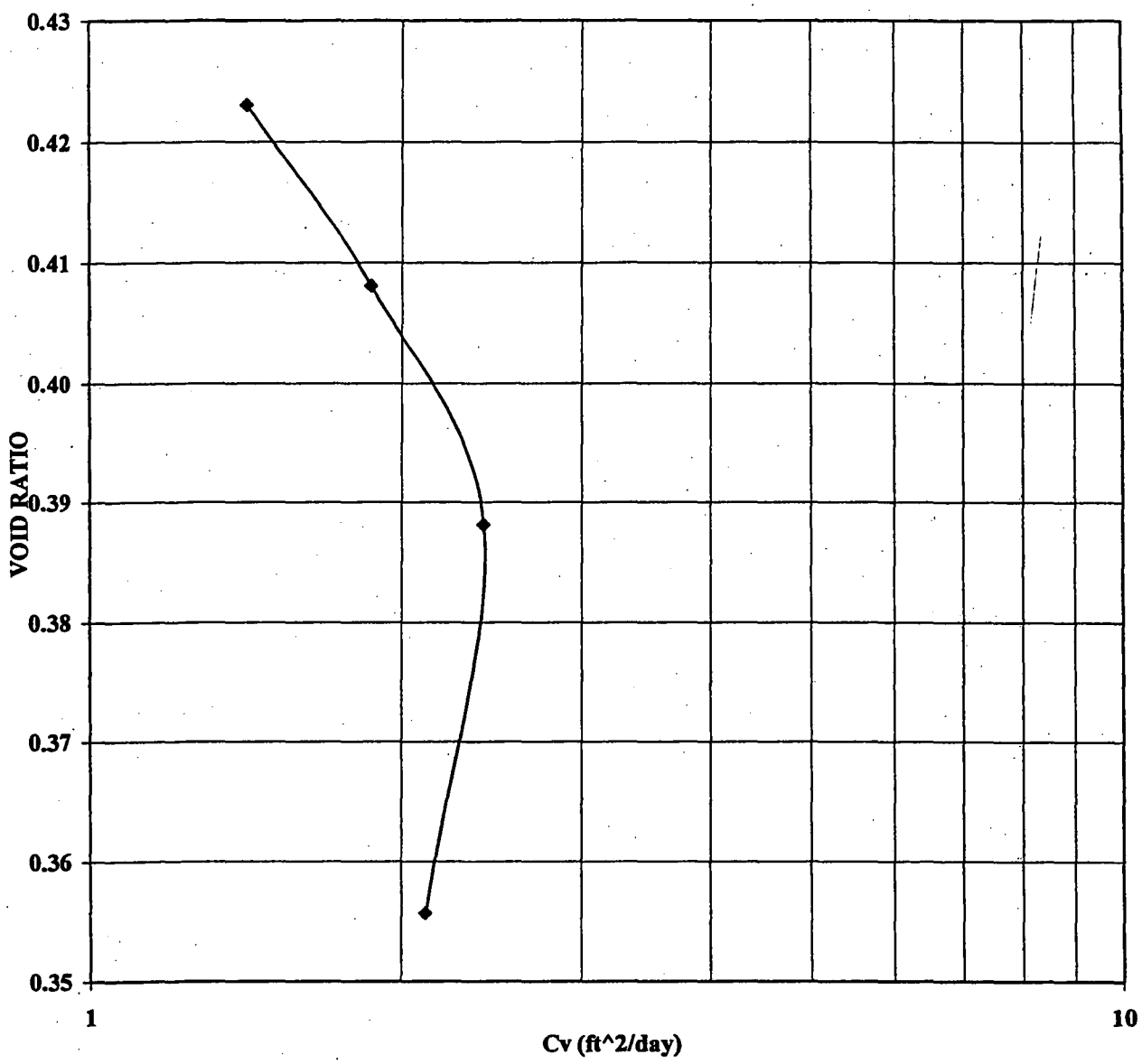
DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

DATE	8/12/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: PF-10

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand with gravel (SC)

DATE	8/12/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

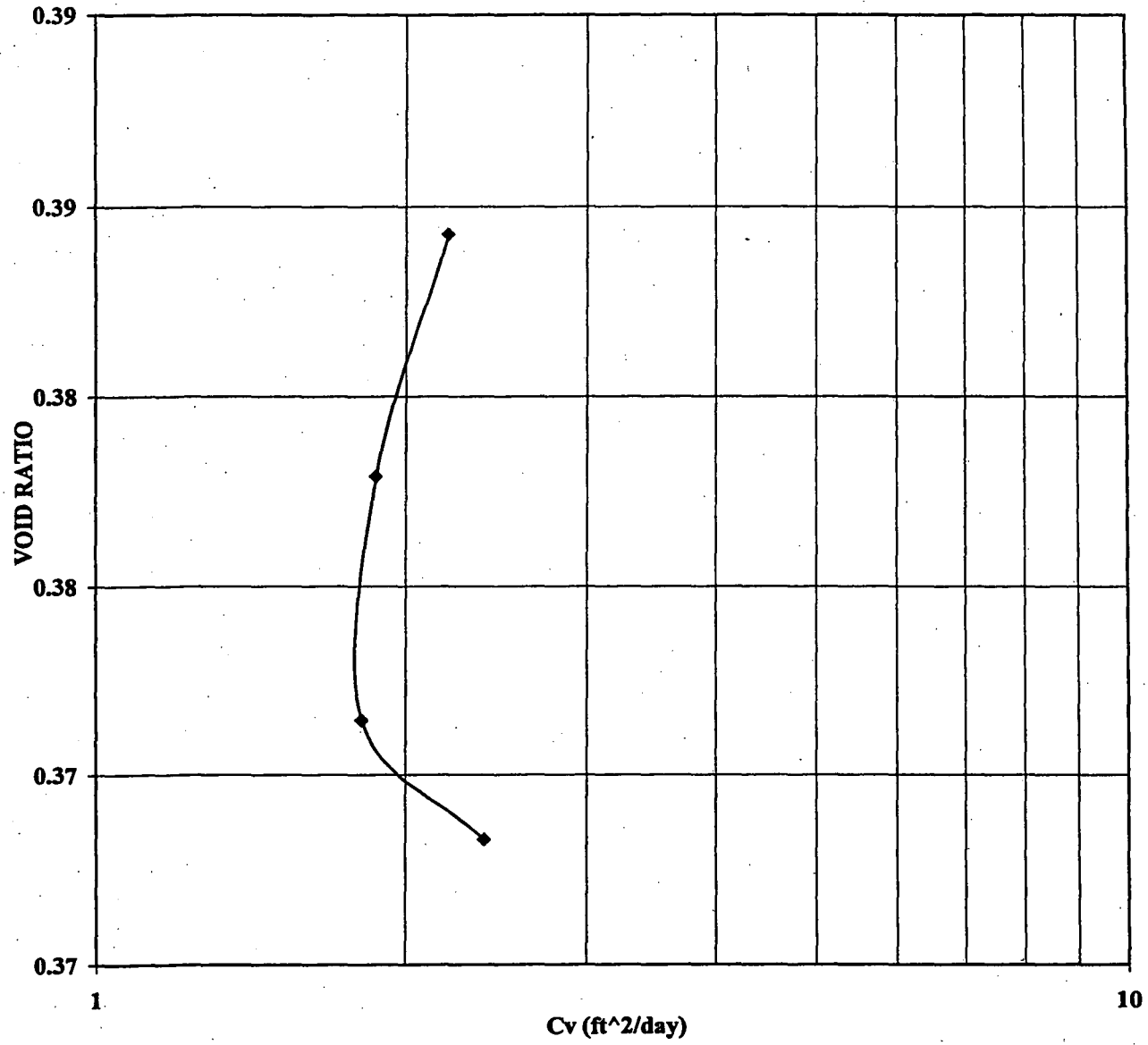
GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

Sample # =	PF-1		Sample # =	PF-1		Sample # =	PF-1	
Point # =	1		Point # =	2		Point # =	3	
	Initial			Initial			Initial	
Length =	14.66	cm	Length =	14.72	cm	Length =	14.76	cm
Diameter =	7.30	cm	Diameter =	7.30	cm	Diameter =	7.30	cm
Wet Weight =	1274.70	g	Wet Weight =	1273.80	g	Wet Weight =	1273.70	g
Area =	41.9	sq.cm	Area =	41.9	sq.cm	Area =	41.9	sq.cm
Sample Area =	6.49	sq. in.	Sample Area =	6.49	sq. in.	Sample Area =	6.49	sq. in.
Volume =	613.6	cc	Volume =	616.1	cc	Volume =	617.7	cc
Moisture Content =	12.7%		Moisture Content =	12.7%		Moisture Content =	12.7%	
Specific Gravity =	na		Specific Gravity =	na		Specific Gravity =	na	
Dry Weight of Solids =	1131.06	g	Dry Weight of Solids =	1130.26	g	Dry Weight of Solids =	1130.17	g
Wet Density =	2.08	g/cc	Wet Density =	2.07	g/cc	Wet Density =	2.06	g/cc
Dry Density =	1.84	g/cc	Dry Density =	1.83	g/cc	Dry Density =	1.83	g/cc
Wet Density =	129.6	pcf	Wet Density =	129.0	pcf	Wet Density =	128.7	pcf
Dry Density =	115.0	pcf	Dry Density =	114.5	pcf	Dry Density =	114.2	pcf
Cell Pressure =	100	psi	Cell Pressure =	100	psi	Cell Pressure =	100	psi
Back Pressure =	97	psi	Back Pressure =	94	psi	Back Pressure =	91	psi
Confining Pressure =	3	psi	Confining Pressure =	6	psi	Confining Pressure =	9	psi

Notes:
1. Sample remolded to 95% of maximum dry density (120.6 pcf) and +2% of optimum (12.7%) moisture content
2. Yellowish brown (10 YR 5/8) clayey sand with gravel SC

Golder Associates, Inc. **Denver, Colorado**	Title: **TRIAXIAL SHEAR TEST REPORT** **SAMPLE DATA AND CALCULATIONS**			
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO				
Sample No. **PF-1**	Reviewed: TJS	Date: 7/29/2004	Job Number: 043-2246.0001	Figure: 1

ONE-DIMENSIONAL CONSOLIDATION



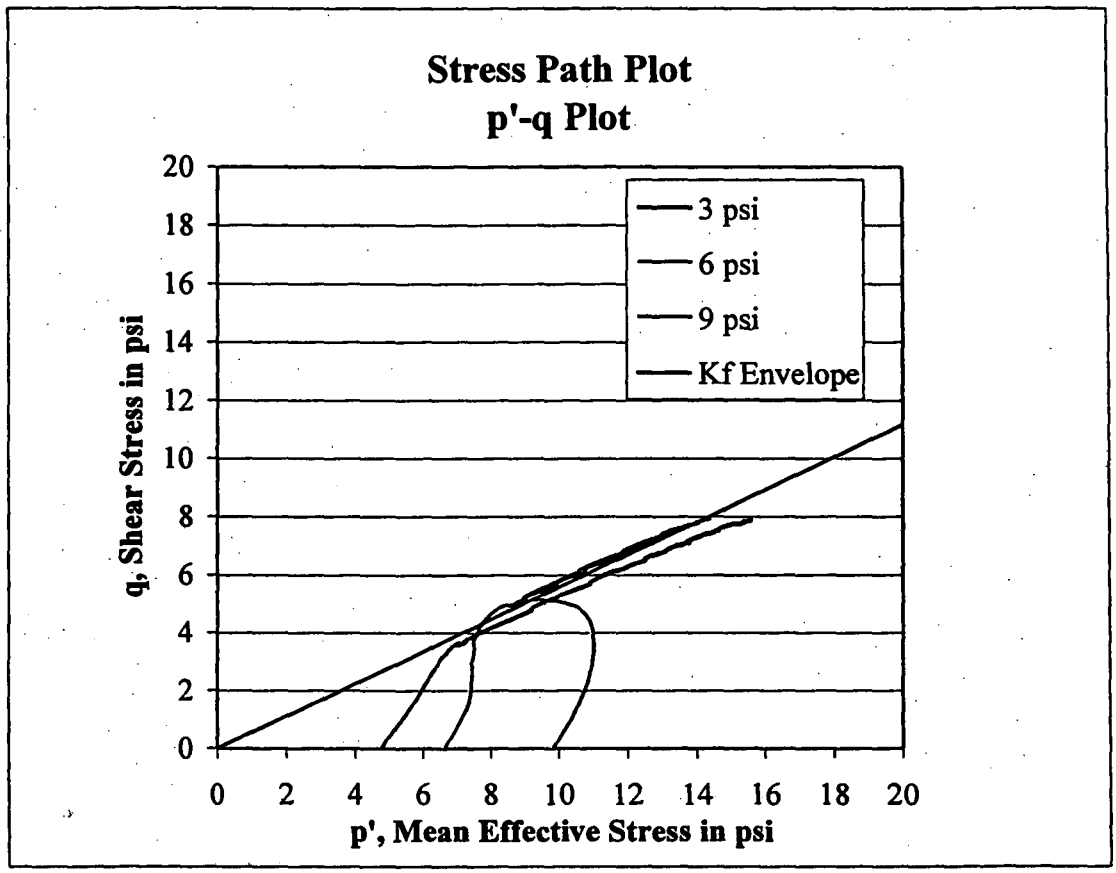
SAMPLE #: PF-9

DESCRIPTION: Yellowish brown (10 YR 5/8) clayey sand

DATE	8/4/2004
TECH	NG
REVIEW	JEO

ROCKY FLATS/FIELD & LAB TEST/CO
043-2246-0001

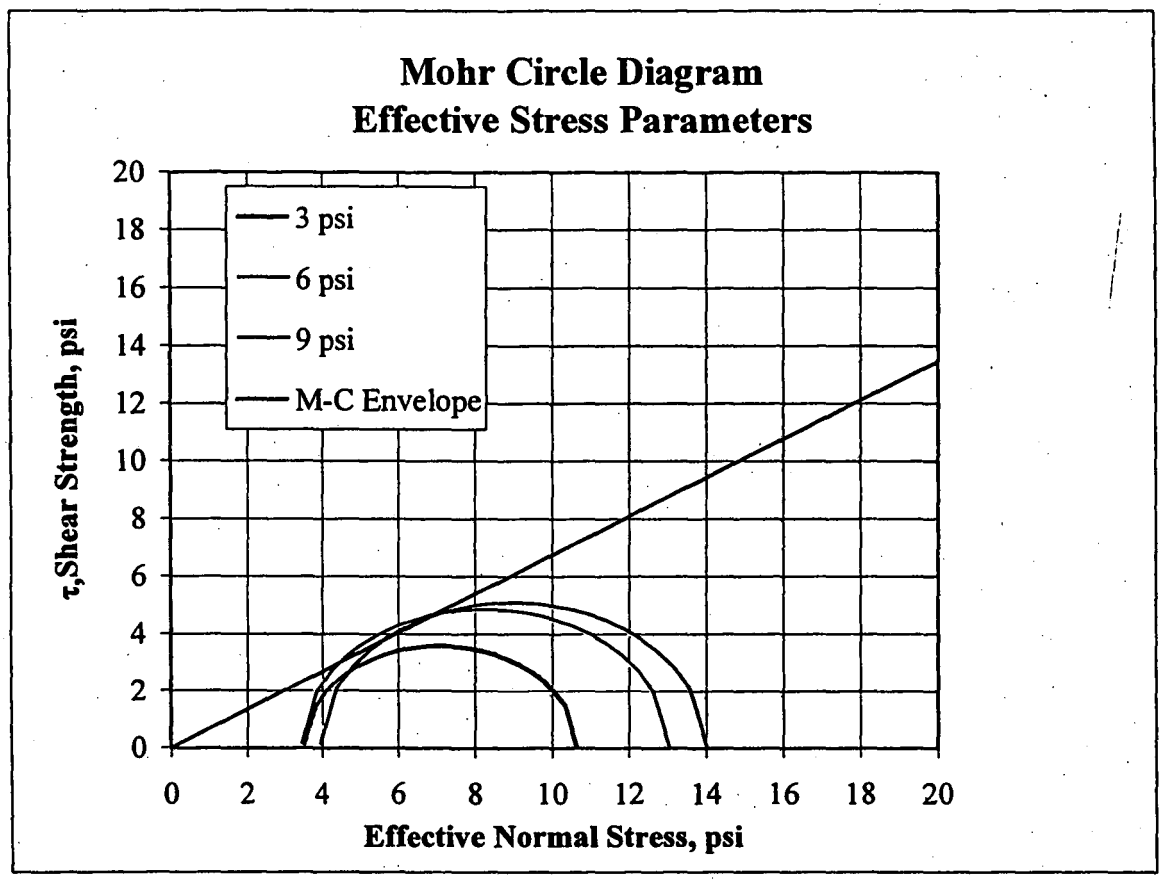
GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO



Stress Path Parameters

$\psi' =$ 29.2 degrees
a' = 0.0 psi

Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA STRESS PATH PLOT			
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO				
Sample No. PF-1	Reviewed: TJS	Date: 7/29/2004	Job Number: 043-2246.0001	Figure: 3



Mohr-Coulomb Parameters

$\phi' =$ 34.0 degrees
$c' =$ 0.0 psi

Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA MOHR CIRCLE DIAGRAM				
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO					
Sample No. PF-1	Depth 0	Reviewed: TJS	Date: 7/29/2004	Job Number: 043-2246.0001	Figure: 4

Consolidated Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.

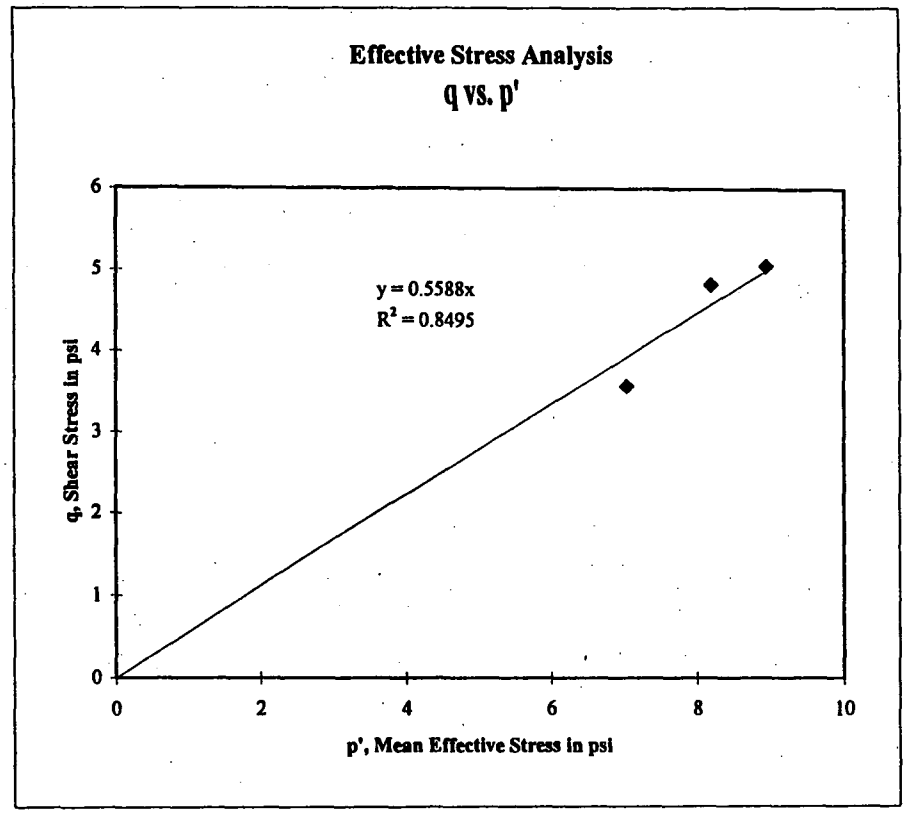
Project: ROCKY FLATS/FIELD & LAB TESTING/CO
Project Number: 043-2246.0001

Sample Number	PF-1
Depth	0
Effective Stress Analysis	

Point Number	P' (psi)	q (psi)
1	7	4
2	8	5
3	9	5

$\tan(\psi') =$ 0.5588
$a' =$ 0

$\phi' =$ 34.0 degrees
$c' =$ 0.0 psi



Notes: 1. Failure is taken to corespond to the maximum deviator stress at an axial strain of 1%. This small strain failure criteria was chosen due to the dilative nature of the material.

Consolidated Undrained Triaxial Lab Data

From: GOLDER ASSOCIATES INC.

Project: **ROCKY FLATS/FIELD & LAB TESTING/CO**

Project Number: **043-2246.0001**

Sample Number	PF-1
Depth	0
Total Stress Analysis	

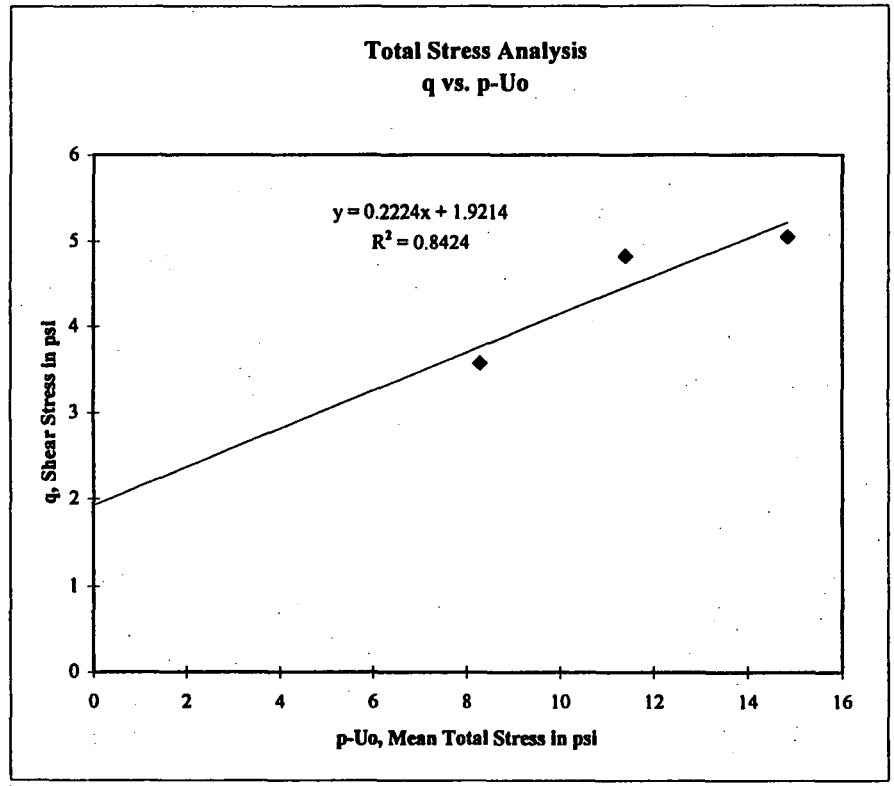
Point Number	P-Uo (psi)	q (psi)
1	8	4
2	11	5
3	15	5

$\tan(\psi) =$ 0.2224

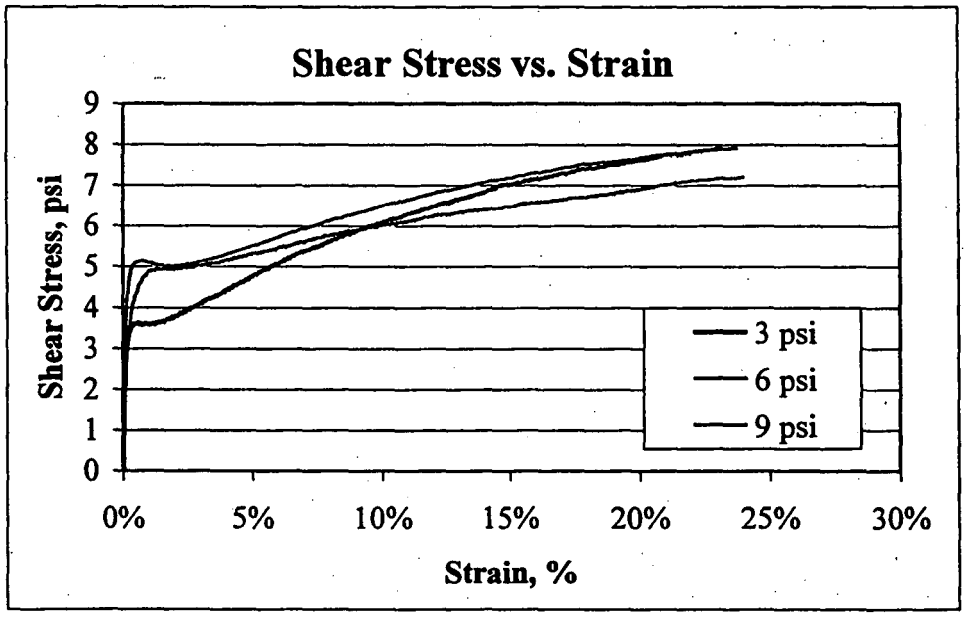
a = 1.9214

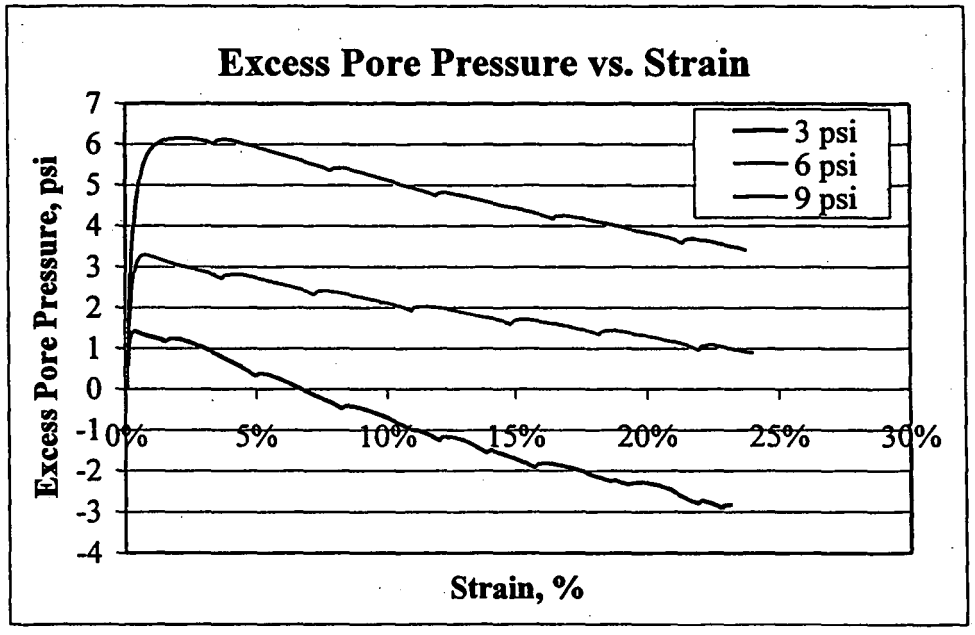
$\phi =$ 12.9 degrees

c = 2.0 psi



Notes: 1. Failure is taken to corespond to the maximum deviator stress at an axial strain of 1%. This small strain failure criteria was chosen due to the dilative nature of the material.





Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA STRESS AND Δ PORE PRESSURE PLOTS			
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO				
Sample No. PF-1	Reviewed: TJS	Date: 07/29/04	Job Number: 043-2246.0001	Figure: 2

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

PROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER	043-2246-0001
SAMPLE ID	PF - 2
SAMPLE TYPE	Bulk
DEPTH INTERVAL	-
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.10
CELL PRESSURE (psi)	83.0
SAMPLE PRESSURE (psi)	80.0
EFF. CONSOLIDATION PRESSURE, σ_3 (psi)	3.0
PRESSURE, σ_3 (psf)	432.0
FINAL "B" VALUE	1.00
t_{50} (minutes)	0.21
Mounting Method	Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.248	6.003	5.987
DIAMETER	7.087	2.790	2.785
AREA	39.44	6.11	6.09
VOLUME	601.41	36.70	36.47
WEIGHT (g)	1246.76		1282.06
% MOISTURE	13.7		16.95
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	129.4		
DRY DENSITY, calc (pcf)	113.7		
VOLUME OF SOLIDS	406.02		
VOLUME OF VOIDS	195.38		
VOID RATIO	0.481		
SATURATION	77.0		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	114.4
VOLUME OF SOLIDS	406.02
VOLUME OF VOIDS	191.68
VOID RATIO	0.472

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1282.06
WT SOIL & TARE, DRY (g)	1096.26
WT TARE (g)	0.00
WT MOISTURE (g)	185.80
WT DRY SOIL (g)	1096.26
% MOISTURE	16.95

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	22	80.1	0.0	0.00	1.00	6.09	5.987	0.0	432.0	432.0	432.0	1.00	432.0	0.0	0.00
0.5	0.003	32	80.6	72.0	0.05	1.00	6.10	5.984	236.2	668.2	596.2	360.0	1.66	478.1	118.1	0.30
1.0	0.006	38	80.8	100.8	0.10	1.00	6.10	5.981	377.8	809.8	709.0	331.2	2.14	520.1	188.9	0.27
1.5	0.009	43	81.0	129.6	0.15	1.00	6.10	5.978	495.6	927.6	798.0	302.4	2.64	550.2	247.8	0.26
2.0	0.012	47	81.1	144.0	0.20	1.00	6.10	5.975	589.7	1021.7	877.7	288.0	3.05	582.9	294.9	0.24
2.5	0.015	50	81.2	158.4	0.25	1.00	6.11	5.972	660.2	1092.2	933.8	273.6	3.41	603.7	330.1	0.24
4.2	0.025	60	81.3	172.8	0.42	1.00	6.12	5.962	894.4	1326.4	1153.6	259.2	4.45	706.4	447.2	0.19
8.3	0.050	69	81.0	129.6	0.84	0.99	6.14	5.937	1101.6	1533.6	1404.0	302.4	4.64	853.2	550.8	0.12
12.5	0.075	72	80.6	72.0	1.25	0.99	6.17	5.912	1167.0	1599.0	1527.0	360.0	4.24	943.5	583.5	0.06
17.3	0.104	74	80.3	28.8	1.74	0.98	6.20	5.883	1207.8	1639.8	1611.0	403.2	4.00	1007.1	603.9	0.02
21.5	0.129	75	80.2	14.4	2.15	0.98	6.23	5.858	1225.7	1657.7	1643.3	417.6	3.94	1030.5	612.9	0.01
26.7	0.160	75	80.0	-14.4	2.67	0.97	6.26	5.827	1219.3	1651.3	1665.7	446.4	3.73	1056.0	609.6	-0.01
29.2	0.175	75	80.0	-14.4	2.92	0.97	6.28	5.812	1216.1	1648.1	1662.5	446.4	3.72	1054.5	608.1	-0.01
34.8	0.209	77	79.9	-28.8	3.49	0.97	6.31	5.778	1254.6	1686.6	1715.4	460.8	3.72	1088.1	627.3	-0.02
41.7	0.250	79	79.8	-43.2	4.18	0.96	6.36	5.737	1291.0	1723.0	1766.2	475.2	3.72	1120.7	645.5	-0.03
51.7	0.310	79	79.7	-57.6	5.18	0.95	6.42	5.677	1277.5	1709.5	1767.1	489.6	3.61	1128.4	638.8	-0.05
58.3	0.350	80	79.7	-57.6	5.85	0.94	6.47	5.637	1290.8	1722.8	1780.4	489.6	3.64	1135.0	645.4	-0.04
66.7	0.400	83	79.6	-72.0	6.68	0.93	6.53	5.587	1345.5	1777.5	1849.5	504.0	3.67	1176.8	672.8	-0.05
75.0	0.450	85	79.5	-86.4	7.52	0.92	6.59	5.537	1377.2	1809.2	1895.6	518.4	3.66	1207.0	688.6	-0.06
83.3	0.500	87	79.4	-100.8	8.35	0.92	6.65	5.487	1408.1	1840.1	1940.9	532.8	3.64	1236.8	704.0	-0.07
91.7	0.550	90	79.3	-115.2	9.19	0.91	6.71	5.437	1459.6	1891.6	2006.8	547.2	3.67	1277.0	729.8	-0.08
100.0	0.600	92	79.2	-129.6	10.02	0.90	6.77	5.387	1488.7	1920.7	2050.3	561.6	3.65	1306.0	744.4	-0.09
108.3	0.650	94	79.2	-129.6	10.86	0.89	6.83	5.337	1517.1	1949.1	2078.7	561.6	3.70	1320.1	758.5	-0.09
116.7	0.700	95	79.1	-144.0	11.69	0.88	6.90	5.287	1523.7	1955.7	2099.7	576.0	3.65	1337.9	761.9	-0.09
125.0	0.750	99	79.1	-144.0	12.53	0.87	6.96	5.237	1592.0	2024.0	2168.0	576.0	3.76	1372.0	796.0	-0.09
133.3	0.800	100	79.0	-158.4	13.36	0.87	7.03	5.187	1597.3	2029.3	2187.7	590.4	3.71	1389.1	798.7	-0.10
141.7	0.850	102	78.9	-172.8	14.20	0.86	7.10	5.137	1622.5	2054.5	2227.3	604.8	3.68	1416.0	811.2	-0.11
150.0	0.900	104	78.9	-172.8	15.03	0.85	7.17	5.087	1646.8	2078.8	2251.6	604.8	3.72	1428.2	823.4	-0.10
158.3	0.950	105	78.8	-187.2	15.87	0.84	7.24	5.037	1650.5	2082.5	2269.7	619.2	3.67	1444.5	825.3	-0.11
166.7	1.000	107	78.8	-187.2	16.70	0.83	7.31	4.987	1673.5	2105.5	2292.7	619.2	3.70	1456.0	836.8	-0.11

DU @ FAILURE	129.60	DEVIATORIC STRESS @ FAILURE	1101.64	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.64

TECH	PWM/DA
DATE	8/2/04
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 2
AMPLE TYPE	Bulk
EPTH INTERVAL	-
ACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	86.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	6.0
RESSURE, σ_3 (psf)	864.0
INAL "B" VALUE	0.99
$_{50}$ (minutes)	0.26

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.250	6.004	5.975
DIAMETER	7.087	2.790	2.780
AREA	39.44	6.11	6.07
VOLUME	601.51	36.71	36.27
WEIGHT (g)	1247.27		1278.17
% MOISTURE	13.9		16.70
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	129.4		
DRY DENSITY, calc (pcf)	113.6		
VOLUME OF SOLIDS	405.64		
VOLUME OF VOIDS	195.86		
VOID RATIO	0.483		
SATURATION	77.6		

Mounting Method: Wet

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	115.0
VOLUME OF SOLIDS	405.64
VOLUME OF VOIDS	188.76
VOID RATIO	0.465

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1278.17
WT SOIL & TARE, DRY (g)	1095.24
WT TARE (g)	0.00
WT MOISTURE (g)	182.93
WT DRY SOIL (g)	1095.24
% MOISTURE	16.70

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P')	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	17	80.6	0.0	0.00	1.00	6.07	5.975	0.0	864.0	864.0	864.0	1.00	864.0	0.0	0.00
0.5	0.003	40	82.3	244.8	0.05	1.00	6.07	5.972	545.3	1409.3	1164.5	619.2	1.88	891.8	272.6	0.45
0.8	0.005	46	82.6	288.0	0.08	1.00	6.08	5.970	687.3	1551.3	1263.3	576.0	2.19	919.7	343.7	0.42
1.5	0.009	52	82.9	331.2	0.15	1.00	6.08	5.966	829.0	1693.0	1361.8	532.8	2.56	947.3	414.5	0.40
2.0	0.012	60	83.2	374.4	0.20	1.00	6.08	5.963	1017.9	1881.9	1507.5	489.6	3.08	998.6	509.0	0.37
2.5	0.015	62	83.3	388.8	0.25	1.00	6.09	5.960	1064.7	1928.7	1539.9	475.2	3.24	1007.6	532.4	0.37
4.2	0.025	69	83.4	403.2	0.42	1.00	6.10	5.950	1228.3	2092.3	1689.1	460.8	3.67	1074.9	614.1	0.33
8.3	0.050	73	83.5	417.6	0.84	0.99	6.12	5.925	1317.2	2181.2	1763.6	446.4	3.95	1105.0	658.6	0.32
12.5	0.075	77	83.5	417.6	1.26	0.99	6.15	5.900	1405.3	2269.3	1851.7	446.4	4.15	1149.1	702.7	0.30
17.5	0.105	79	83.5	417.6	1.76	0.98	6.18	5.870	1444.8	2308.8	1891.2	446.4	4.24	1168.8	722.4	0.29
22.2	0.133	79	83.5	417.6	2.23	0.98	6.21	5.842	1437.9	2301.9	1884.3	446.4	4.22	1165.4	719.0	0.29
25.0	0.150	80	83.5	417.6	2.51	0.97	6.23	5.825	1456.9	2320.9	1903.3	446.4	4.26	1174.8	728.4	0.29
29.2	0.175	80	83.3	388.8	2.93	0.97	6.25	5.800	1450.6	2314.6	1925.8	475.2	4.05	1200.5	725.3	0.27
33.3	0.200	82	83.3	388.8	3.35	0.97	6.28	5.775	1490.2	2354.2	1965.4	475.2	4.14	1220.3	745.1	0.26
41.7	0.250	84	83.2	374.4	4.18	0.96	6.34	5.725	1522.8	2386.8	2012.4	489.6	4.11	1251.0	761.4	0.25
50.0	0.300	86	83.0	345.6	5.02	0.95	6.39	5.675	1554.5	2418.5	2072.9	518.4	4.00	1295.7	777.3	0.22
58.3	0.350	89	82.9	331.2	5.86	0.94	6.45	5.625	1607.8	2471.8	2140.6	532.8	4.02	1336.7	803.9	0.21
66.7	0.400	90	82.9	331.2	6.69	0.93	6.51	5.575	1615.7	2479.7	2148.5	532.8	4.03	1340.6	807.8	0.20
75.0	0.450	92	82.8	316.8	7.53	0.92	6.57	5.525	1645.0	2509.0	2192.2	547.2	4.01	1369.7	822.5	0.19
84.7	0.508	94	82.7	302.4	8.50	0.91	6.63	5.467	1671.2	2535.2	2232.8	561.6	3.98	1397.2	835.6	0.18
91.7	0.550	95	82.6	288.0	9.21	0.91	6.69	5.425	1679.9	2543.9	2255.9	576.0	3.92	1415.9	839.9	0.17
100.0	0.600	97	82.5	273.6	10.04	0.90	6.75	5.375	1707.1	2571.1	2297.5	590.4	3.89	1443.9	853.5	0.16
108.3	0.650	100	82.5	273.6	10.88	0.89	6.81	5.325	1754.6	2618.6	2345.0	590.4	3.97	1467.7	877.3	0.16
116.7	0.700	102	82.5	273.6	11.72	0.88	6.88	5.275	1780.0	2644.0	2370.4	590.4	4.01	1480.4	890.0	0.15
125.0	0.750	104	82.4	259.2	12.55	0.87	6.94	5.225	1804.6	2668.6	2409.4	604.8	3.98	1507.1	902.3	0.14
133.3	0.800	105	82.3	244.8	13.39	0.87	7.01	5.175	1807.9	2671.9	2427.1	619.2	3.92	1523.1	903.9	0.14
141.7	0.850	107	82.3	244.8	14.23	0.86	7.08	5.125	1831.1	2695.1	2450.3	619.2	3.96	1534.8	915.6	0.13
151.3	0.908	110	82.3	244.8	15.20	0.85	7.16	5.067	1870.7	2734.7	2489.9	619.2	4.02	1554.6	935.4	0.13
158.3	0.950	110	82.2	230.4	15.90	0.84	7.22	5.025	1855.2	2719.2	2488.8	633.6	3.93	1561.2	927.6	0.12
166.7	1.000	114	82.1	216.0	16.74	0.83	7.29	4.975	1915.8	2779.8	2563.8	648.0	3.96	1605.9	957.9	0.11

DU @ FAILURE	417.6	DEVIATORIC STRESS @ FAILURE	1444.8	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.24

TECH	PWM/DA
DATE	8/2/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 3
AMPLE TYPE	Bulk
EPTH INTERVAL	-
ACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	83.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION	
RESSURE, σ_3 (psi)	3.0
RESSURE, σ_3 (psf)	432.0
INAL "B" VALUE	0.99
$_{50}$ (minutes)	0.28

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.286	6.018	6.014
DIAMETER	7.087	2.790	2.786
AREA	39.44	6.11	6.09
VOLUME	602.91	36.79	36.65
WEIGHT (g)	1249.48		1289.18
% MOISTURE	12.7		16.28
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	129.3		
DRY DENSITY, calc (pcf)	114.7		
VOLUME OF SOLIDS	410.61		
VOLUME OF VOIDS	192.29		
VOID RATIO	0.468		
SATURATION	73.2		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	115.2
VOLUME OF SOLIDS	410.61
VOLUME OF VOIDS	189.99
VOID RATIO	0.463

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1289.18
WT SOIL & TARE, DRY (g)	1108.66
WT TARE (g)	0.00
WT MOISTURE (g)	180.52
WT DRY SOIL (g)	1108.66
% MOISTURE	16.28

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	18	79.9	0.0	0.00	1.00	6.09	6.014	0.0	432.0	432.0	432.0	1.00	432.0	0.0	0.00
0.5	0.003	33	80.6	100.8	0.05	1.00	6.10	6.011	354.3	786.3	685.5	331.2	2.07	508.3	177.1	0.28
1.0	0.006	43	80.9	144.0	0.10	1.00	6.10	6.008	590.1	1022.1	878.1	288.0	3.05	583.1	295.1	0.24
1.5	0.009	48	81.0	158.4	0.15	1.00	6.10	6.005	707.8	1139.8	981.4	273.6	3.59	627.5	353.9	0.22
2.0	0.012	52	81.1	172.8	0.20	1.00	6.11	6.002	801.8	1233.8	1061.0	259.2	4.09	660.1	400.9	0.22
2.5	0.015	55	81.1	172.8	0.25	1.00	6.11	5.999	872.1	1304.1	1131.3	259.2	4.36	695.2	436.0	0.20
4.2	0.025	54	81.1	172.8	0.42	1.00	6.12	5.989	847.1	1279.1	1106.3	259.2	4.27	682.7	423.5	0.20
8.3	0.050	53	81.2	187.2	0.83	0.99	6.15	5.964	820.1	1252.1	1064.9	244.8	4.35	654.9	410.1	0.23
12.5	0.075	52	81.3	201.6	1.25	0.99	6.17	5.939	793.3	1225.3	1023.7	230.4	4.44	627.1	396.7	0.25
16.7	0.100	50	81.4	216.0	1.66	0.98	6.20	5.914	743.5	1175.5	959.5	216.0	4.44	587.8	371.8	0.29
20.8	0.125	48	81.5	230.4	2.08	0.98	6.22	5.889	694.1	1126.1	895.7	201.6	4.44	548.7	347.1	0.33
25.0	0.150	48	81.6	244.8	2.49	0.98	6.25	5.864	691.2	1123.2	878.4	187.2	4.69	532.8	345.6	0.35
29.2	0.175	48	81.6	244.8	2.91	0.97	6.28	5.839	688.2	1120.2	875.4	187.2	4.68	531.3	344.1	0.36
33.3	0.200	47	81.7	259.2	3.33	0.97	6.30	5.814	662.4	1094.4	835.2	172.8	4.83	504.0	331.2	0.39
41.7	0.250	47	81.7	259.2	4.16	0.96	6.36	5.764	656.7	1088.7	829.5	172.8	4.80	501.2	328.4	0.39
50.0	0.300	48	81.7	259.2	4.99	0.95	6.41	5.714	673.5	1105.5	846.3	172.8	4.90	509.5	336.7	0.38
58.3	0.350	48	81.7	259.2	5.82	0.94	6.47	5.664	667.6	1099.6	840.4	172.8	4.86	506.6	333.8	0.39
66.7	0.400	48	81.7	259.2	6.65	0.93	6.53	5.614	661.7	1093.7	834.5	172.8	4.83	503.7	330.9	0.39
75.0	0.450	48	81.7	259.2	7.48	0.93	6.59	5.564	655.8	1087.8	828.6	172.8	4.80	500.7	327.9	0.40
83.3	0.500	50	81.7	259.2	8.31	0.92	6.65	5.514	693.2	1125.2	866.0	172.8	5.01	519.4	346.6	0.37
91.7	0.550	50	81.7	259.2	9.15	0.91	6.71	5.464	687.0	1119.0	859.8	172.8	4.98	516.3	343.5	0.38
100.0	0.600	52	81.7	259.2	9.98	0.90	6.77	5.414	723.2	1155.2	896.0	172.8	5.19	534.4	361.6	0.36
108.3	0.650	53	81.7	259.2	10.81	0.89	6.83	5.364	737.6	1169.6	910.4	172.8	5.27	541.6	368.8	0.35
116.7	0.700	53	81.7	259.2	11.64	0.88	6.90	5.314	730.7	1162.7	903.5	172.8	5.23	538.2	365.4	0.35
125.0	0.750	55	81.7	259.2	12.47	0.88	6.96	5.264	765.2	1197.2	938.0	172.8	5.43	555.4	382.6	0.34
133.3	0.800	58	81.6	244.8	13.30	0.87	7.03	5.214	819.4	1251.4	1006.6	187.2	5.38	596.9	409.7	0.30
141.7	0.850	58	81.6	244.8	14.13	0.86	7.10	5.164	811.6	1243.6	998.8	187.2	5.34	593.0	405.8	0.30
150.0	0.900	60	81.6	244.8	14.97	0.85	7.17	5.114	843.9	1275.9	1031.1	187.2	5.51	609.1	421.9	0.29
158.3	0.950	62	81.5	230.4	15.80	0.84	7.24	5.064	875.4	1307.4	1077.0	201.6	5.34	639.3	437.7	0.26
166.7	1.000	64	81.5	230.4	16.63	0.83	7.31	5.014	906.2	1338.2	1107.8	201.6	5.49	654.7	453.1	0.25

DU @ FAILURE	172.80	DEVIATORIC STRESS @ FAILURE	872.07	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.36

TECH	PWM/SDM
DATE	7/28/04
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 2
AMPLE TYPE	Bulk
EPTH INTERVAL	-
ACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	89.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	9.0
RESSURE, σ_3 (psf)	1296.0
INAL "B" VALUE	0.99
$_{50}$ (minutes)	0.31

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.250	6.004	5.976
DIAMETER	7.087	2.790	2.775
AREA	39.44	6.11	6.05
VOLUME	601.51	36.71	36.13
WEIGHT (g)	1247.03		1275.63
% MOISTURE	14.0		16.62
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	129.4		
DRY DENSITY, calc (pcf)	113.5		
VOLUME OF SOLIDS	405.12		
VOLUME OF VOIDS	196.38		
VOID RATIO	0.485		
SATURATION	78.0		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	115.3
VOLUME OF SOLIDS	405.12
VOLUME OF VOIDS	186.98
VOID RATIO	0.462

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1275.63
WT SOIL & TARE, DRY (g)	1093.83
WT TARE (g)	0.00
WT MOISTURE (g)	181.80
WT DRY SOIL (g)	1093.83
% MOISTURE	16.62

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	13	81.2	0.0	0.00	1.00	6.05	5.976	0.0	1296.0	1296.0	1296.0	1.00	1296.0	0.0	0
0.5	0.003	31	82.3	158.4	0.05	1.00	6.05	5.973	433.2	1729.2	1570.8	1137.6	1.38	1354.2	216.6	0.37
1.0	0.006	43	83.0	259.2	0.10	1.00	6.05	5.970	723.3	2019.3	1760.1	1036.8	1.70	1398.4	361.6	0.36
1.3	0.008	52	83.5	331.2	0.13	1.00	6.05	5.968	925.2	2221.2	1890.0	964.8	1.96	1427.4	462.6	0.36
2.0	0.012	59	83.9	388.8	0.20	1.00	6.06	5.964	1081.5	2377.5	1988.7	907.2	2.19	1447.9	540.7	0.36
2.5	0.015	64	84.1	417.6	0.25	1.00	6.06	5.961	1199.7	2495.7	2078.1	878.4	2.37	1478.3	599.9	0.35
3.5	0.021	70	84.5	475.2	0.35	1.00	6.07	5.955	1348.0	2644.0	2168.8	820.8	2.64	1494.8	674.0	0.35
7.7	0.046	80	85.4	604.8	0.77	0.99	6.09	5.930	1571.6	2867.6	2262.8	691.2	3.27	1477.0	785.8	0.38
11.7	0.070	81	85.9	676.8	1.17	0.99	6.12	5.906	1591.1	2887.1	2210.3	619.2	3.57	1414.8	795.6	0.43
15.2	0.091	82	86.2	720.0	1.52	0.98	6.14	5.885	1606.6	2902.6	2182.6	576.0	3.79	1379.3	803.3	0.45
20.3	0.122	83	86.3	734.4	2.04	0.98	6.17	5.854	1621.4	2917.4	2183.0	561.6	3.89	1372.3	810.7	0.45
24.3	0.146	83	86.3	734.4	2.44	0.98	6.20	5.830	1628.7	2924.7	2190.3	561.6	3.90	1376.0	814.4	0.45
28.5	0.171	84	86.3	734.4	2.86	0.97	6.22	5.805	1637.9	2933.9	2199.5	561.6	3.92	1380.6	819.0	0.45
32.7	0.196	85	86.2	720.0	3.28	0.97	6.25	5.780	1653.9	2949.9	2229.9	576.0	3.87	1403.0	827.0	0.44
36.2	0.217	86	86.2	720.0	3.63	0.96	6.27	5.759	1666.3	2962.3	2242.3	576.0	3.89	1409.1	833.1	0.43
45.3	0.272	88	86.1	705.6	4.55	0.95	6.33	5.704	1709.5	3005.5	2299.9	590.4	3.90	1445.1	854.7	0.41
53.5	0.321	90	86.0	691.2	5.37	0.95	6.39	5.655	1733.1	3029.1	2337.9	604.8	3.87	1471.3	866.5	0.40
62.0	0.372	93	85.9	676.8	6.22	0.94	6.45	5.604	1777.8	3073.8	2397.0	619.2	3.87	1508.1	888.9	0.38
70.5	0.423	94	85.8	662.4	7.08	0.93	6.51	5.553	1801.4	3097.4	2435.0	633.6	3.84	1534.3	900.7	0.37
78.2	0.469	96	85.7	648.0	7.85	0.92	6.56	5.507	1821.6	3117.6	2469.6	648.0	3.81	1558.8	910.8	0.36
87.0	0.522	99	85.7	648.0	8.73	0.91	6.62	5.454	1860.6	3156.6	2508.6	648.0	3.87	1578.3	930.3	0.35
95.3	0.572	101	85.6	633.6	9.57	0.90	6.69	5.404	1884.5	3180.5	2546.9	662.4	3.84	1604.6	942.2	0.34
103.8	0.623	103	85.6	633.6	10.43	0.90	6.75	5.353	1924.3	3220.3	2586.7	662.4	3.91	1624.5	962.1	0.33
112.2	0.673	105	85.5	619.2	11.26	0.89	6.81	5.303	1952.8	3248.8	2629.6	676.8	3.89	1653.2	976.4	0.32
120.0	0.720	107	85.4	604.8	12.05	0.88	6.87	5.256	1966.9	3262.9	2658.1	691.2	3.85	1674.7	983.5	0.31
129.0	0.774	110	85.4	604.8	12.95	0.87	6.95	5.202	2006.8	3302.8	2698.0	691.2	3.90	1694.6	1003.4	0.30
137.0	0.822	111	85.3	590.4	13.76	0.86	7.01	5.154	2015.0	3311.0	2720.6	705.6	3.86	1713.1	1007.5	0.29
145.8	0.875	114	85.2	576.0	14.64	0.85	7.08	5.101	2053.2	3349.2	2773.2	720.0	3.85	1746.6	1026.6	0.28
154.0	0.924	116	85.1	561.6	15.46	0.85	7.15	5.052	2079.8	3375.8	2814.2	734.4	3.83	1774.3	1039.9	0.27
166.7	1.000	119	85.0	547.2	16.73	0.83	7.26	4.976	2102.1	3398.1	2850.9	748.8	3.81	1799.8	1051.0	0.26

DU @ FAILURE	734.4	DEVIATORIC STRESS @ FAILURE	1637.9	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	3.92	TECH	PWM/DA
						DATE	8/2/2004
						CHECKED	
						REVIEWED	

Consolidated Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: ROCKY FLATS/FIELD & LAB TESTING/CO
Project Number: 043-2246.0001
Explination of Terminology

Mohr-Coulomb Failure Criteria:

$$\tau_{ff} = c' + \sigma_{ff}' \tan \phi'$$
$$\tau_{ff} = c + \sigma_{ff} \tan \phi$$

Where:
c', c = effective and total cohesive intercept
ϕ', ϕ = effective and total friction angle
τ^{ff} = Shear Strength on the failure surface at failure
σ'^{ff}, σ^{ff} = effective and total normal stress on the failure surface at failure

Stress Path Space:

$$q = \frac{\sigma_1 - \sigma_3}{2} \qquad p' = \frac{\sigma_1' + \sigma_3'}{2} \qquad p = \frac{\sigma_1 + \sigma_3}{2}$$

Where:
q = shear stress
p', p = mean effective and total stress
σ'^1, σ^1 = Effective and Total Axial Stress
σ'^3, σ^3 = Effective and Total Confining Stress

$$q = a + p' \tan \psi$$
$$q = a + (p - u_0) \tan \psi$$

Where:
a', a = intercept of the q-axis in effective stress of total stress space
ψ', ψ = angle of the failure line in effective stress of total stress space
p' = mean effective stress
p-Uo = mean total minus the initial pore pressure

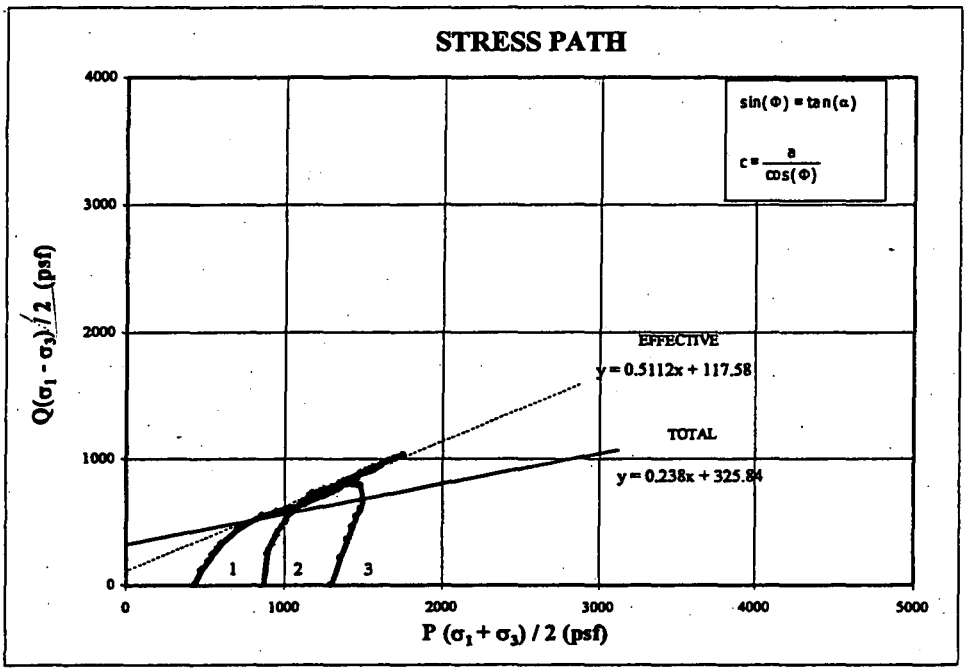
with the relationship between ψ and ϕ and a and c are as follows:

$$\tan(\psi) = \sin(\phi)$$

$$a = c * \cos(\phi)$$

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

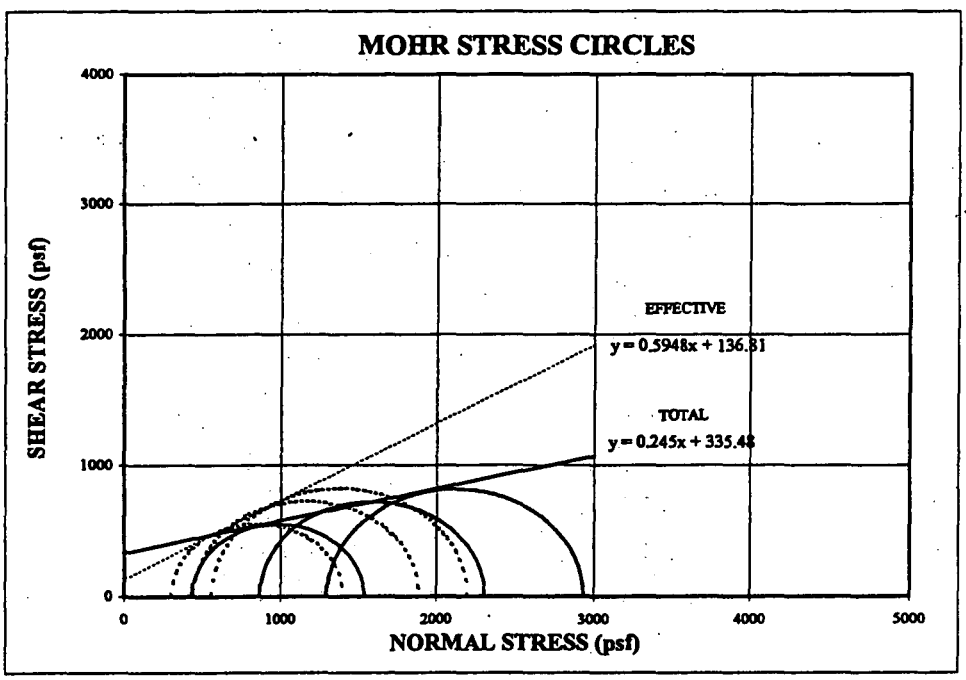
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 2 DEPTH: - Sample Type: Bulk



Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	113.7	13.7
2	864	113.6	13.9
3	1296	113.5	14.0

Specimen	Strain Rate (%)	Initial Saturation (%)	Saturation Before Shearing (%)
1	0.10	77.0	96.9
2	0.10	77.6	96.9
3	0.10	78.0	97.2

STRESS PATH			MOHR CIRCLES		
*TOTAL STRESS PARAMETER			*TOTAL STRENGTH PARAMETER		
α	=	13.4 *	ϕ	=	13.8 *
a	=	325.8 psf	c	=	335.5 psf
* EFFECTIVE STRESS PARAMETER			*EFFECTIVE STRENGTH PARAMETER		
α'	=	27.1 *	ϕ'	=	30.7 *
a'	=	117.6 psf	c'	=	136.8 psf



Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

*** Failure based on effective stress ratio or 15% strain.**

CHECK
REVIEW

CONSOLIDATED UNDRAINED TRIAXIAL STRENGTH								CONSOLIDATED UNDRAINED TRI		
MOHR CIRCLE GENERATION SPREADSHEET								MOHR CIRCLE GENERATION SPRE		
	PF - 2	-	B	C	A				PF - 2	-
CONFINING PRESSURE USED (S3)			432	864	1296	psf		CONFINING PRESSURE USED (S3)		
CONFINING PRESSURE USED (S3)			432	864	1296	psi		CONFINING PRESSURE USED (S3)		
MAXIMUM DEVIATOR STRESS (PS			1101.6	1444.8	1637.9	psf		MAXIMUM DEVIATOR STRESS (PS		
(or load at 15% strain)								(or load at 15% strain)		
dU AT FAIL	(S1-S3)/2	(S1'+S3')/2		coh	sin phi	phi		dU AT FAIL	(S1-S3)/2	(S1'+S3')/2
129.6	550.8	853.2	COH 1&2	90	0.543700758	33		129.6	550.8	982.8
417.6	722.4	1168.8	COH 1&3	120	0.508487048	31		417.6	722.4	1586.4
734.4	819.0	1380.6	COH 2&3	190	0.456010858	27		734.4	819.0	2115.0
		EFFECTIVE								TOTAL
TA POINTS	A	B	C					DATA POINTS	A	B
	MOHR,1	MOHR,2	MOHR,3						MOHR,1	MOHR,2
X	Y,1	Y,2	Y,3					X	Y,1	Y,2
0	#NUM!	#NUM!	#NUM!					0	#NUM!	#NUM!
10	#NUM!	#NUM!	#NUM!					10	#NUM!	#NUM!
20	#NUM!	#NUM!	#NUM!					20	#NUM!	#NUM!
30	#NUM!	#NUM!	#NUM!					30	#NUM!	#NUM!
40	#NUM!	#NUM!	#NUM!					40	#NUM!	#NUM!
50	#NUM!	#NUM!	#NUM!					50	#NUM!	#NUM!
60	#NUM!	#NUM!	#NUM!					60	#NUM!	#NUM!
70	#NUM!	#NUM!	#NUM!					70	#NUM!	#NUM!
80	#NUM!	#NUM!	#NUM!					80	#NUM!	#NUM!
90	#NUM!	#NUM!	#NUM!					90	#NUM!	#NUM!
100	#NUM!	#NUM!	#NUM!					100	#NUM!	#NUM!
110	#NUM!	#NUM!	#NUM!					110	#NUM!	#NUM!
120	#NUM!	#NUM!	#NUM!					120	#NUM!	#NUM!
130	#NUM!	#NUM!	#NUM!					130	#NUM!	#NUM!
140	#NUM!	#NUM!	#NUM!					140	#NUM!	#NUM!
150	#NUM!	#NUM!	#NUM!					150	#NUM!	#NUM!
160	#NUM!	#NUM!	#NUM!					160	#NUM!	#NUM!
170	#NUM!	#NUM!	#NUM!					170	#NUM!	#NUM!
180	#NUM!	#NUM!	#NUM!					180	#NUM!	#NUM!
190	#NUM!	#NUM!	#NUM!					190	#NUM!	#NUM!
200	#NUM!	#NUM!	#NUM!					200	#NUM!	#NUM!
210	#NUM!	#NUM!	#NUM!					210	#NUM!	#NUM!
220	#NUM!	#NUM!	#NUM!					220	#NUM!	#NUM!
230	#NUM!	#NUM!	#NUM!					230	#NUM!	#NUM!
240	#NUM!	#NUM!	#NUM!					240	#NUM!	#NUM!
250	#NUM!	#NUM!	#NUM!					250	#NUM!	#NUM!
260	#NUM!	#NUM!	#NUM!					260	#NUM!	#NUM!
270	#NUM!	#NUM!	#NUM!					270	#NUM!	#NUM!
280	#NUM!	#NUM!	#NUM!					280	#NUM!	#NUM!
290	#NUM!	#NUM!	#NUM!					290	#NUM!	#NUM!
300	#NUM!	#NUM!	#NUM!					300	#NUM!	#NUM!
310	91	#NUM!	#NUM!					310	#NUM!	#NUM!
320	138	#NUM!	#NUM!					320	#NUM!	#NUM!
330	172	#NUM!	#NUM!					330	#NUM!	#NUM!
340	200	#NUM!	#NUM!					340	#NUM!	#NUM!
350	224	#NUM!	#NUM!					350	#NUM!	#NUM!
360	245	#NUM!	#NUM!					360	#NUM!	#NUM!

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

PROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER	043-2246-0001
SAMPLE ID	PF - 3
SAMPLE TYPE	Bulk
DEPTH INTERVAL	-
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.10
CELL PRESSURE (psi)	86.0
SAMPLE PRESSURE (psi)	80.0
EFF. CONSOLIDATION PRESSURE, σ_3 (psi)	6.0
PRESSURE, σ_3 (psf)	864.0
FINAL "B" VALUE	0.99
t_{50} (minutes)	0.23

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.253	6.005	5.992
DIAMETER	7.087	2.790	2.780
AREA	39.44	6.11	6.07
VOLUME	601.61	36.71	36.38
WEIGHT (g)	1249.09		1285.69
% MOISTURE	12.9		16.25
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	129.6		
DRY DENSITY, calc (pcf)	114.7		
VOLUME OF SOLIDS	409.60		
VOLUME OF VOIDS	192.00		
VOID RATIO	0.469		
SATURATION	74.6		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	115.7
VOLUME OF SOLIDS	409.60
VOLUME OF VOIDS	186.60
VOID RATIO	0.456

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1285.69
WT SOIL & TARE, DRY (g)	1105.93
WT TARE (g)	0.00
WT MOISTURE (g)	179.76
WT DRY SOIL (g)	1105.93
% MOISTURE	16.25

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	17	80.5	0.0	0.00	1.00	6.07	5.992	0.0	864.0	864.0	864.0	1.00	864.0	0.0	0.00
0.5	0.003	40	81.9	201.6	0.05	1.00	6.07	5.989	545.2	1409.2	1207.6	662.4	1.82	935.0	272.6	0.37
1.0	0.006	48	82.4	273.6	0.10	1.00	6.08	5.986	734.5	1598.5	1324.9	590.4	2.24	957.6	367.2	0.37
1.5	0.009	52	82.6	302.4	0.15	1.00	6.08	5.983	828.8	1692.8	1390.4	561.6	2.48	976.0	414.4	0.36
2.0	0.012	58	82.9	345.6	0.20	1.00	6.08	5.980	970.4	1834.4	1488.8	518.4	2.87	1003.6	485.2	0.36
2.5	0.015	62	83.0	360.0	0.25	1.00	6.09	5.977	1064.5	1928.5	1568.5	504.0	3.11	1036.3	532.3	0.34
4.2	0.025	67	83.3	403.2	0.42	1.00	6.10	5.967	1180.8	2044.8	1641.6	460.8	3.56	1051.2	590.4	0.34
8.3	0.050	65	83.7	460.8	0.83	0.99	6.12	5.942	1128.9	1992.9	1532.1	403.2	3.80	967.6	564.4	0.41
12.5	0.075	62	84.1	518.4	1.25	0.99	6.15	5.917	1053.9	1917.9	1399.5	345.6	4.05	872.5	526.9	0.49
16.7	0.100	58	84.4	561.6	1.67	0.98	6.17	5.892	956.1	1820.1	1258.5	302.4	4.16	780.5	478.1	0.59
20.8	0.125	58	84.6	590.4	2.09	0.98	6.20	5.867	952.1	1816.1	1225.7	273.6	4.48	749.6	476.0	0.62
25.0	0.150	55	84.7	604.8	2.50	0.97	6.23	5.842	878.6	1742.6	1137.8	259.2	4.39	698.5	439.3	0.69
29.2	0.175	55	84.8	619.2	2.92	0.97	6.25	5.817	874.9	1738.9	1119.7	244.8	4.57	682.2	437.4	0.71
33.3	0.200	55	84.8	619.2	3.34	0.97	6.28	5.792	871.1	1735.1	1115.9	244.8	4.56	680.4	435.6	0.71
41.7	0.250	55	84.9	633.6	4.17	0.96	6.34	5.742	863.6	1727.6	1094.0	230.4	4.75	662.2	431.8	0.73
50.0	0.300	55	84.9	633.6	5.01	0.95	6.39	5.692	856.1	1720.1	1086.5	230.4	4.72	658.4	428.0	0.74
58.3	0.350	58	84.9	633.6	5.84	0.94	6.45	5.642	915.6	1779.6	1146.0	230.4	4.97	688.2	457.8	0.69
66.7	0.400	58	84.9	633.6	6.68	0.93	6.51	5.592	907.4	1771.4	1137.8	230.4	4.94	684.1	453.7	0.70
75.0	0.450	60	84.9	633.6	7.51	0.92	6.56	5.542	943.2	1807.2	1173.6	230.4	5.09	702.0	471.6	0.67
83.3	0.500	62	84.8	619.2	8.34	0.92	6.62	5.492	978.2	1842.2	1223.0	244.8	5.00	733.9	489.1	0.63
91.7	0.550	64	84.8	619.2	9.18	0.91	6.69	5.442	1012.3	1876.3	1257.1	244.8	5.14	751.0	506.2	0.61
100.0	0.600	65	84.7	604.8	10.01	0.90	6.75	5.392	1024.4	1888.4	1283.6	259.2	4.95	771.4	512.2	0.59
108.3	0.650	67	84.6	590.4	10.85	0.89	6.81	5.342	1057.2	1921.2	1330.8	273.6	4.86	802.2	528.6	0.56
116.7	0.700	67	84.6	590.4	11.68	0.88	6.88	5.292	1047.3	1911.3	1320.9	273.6	4.83	797.2	523.6	0.56
125.0	0.750	70	84.5	576.0	12.52	0.87	6.94	5.242	1099.6	1963.6	1387.6	288.0	4.82	837.8	549.8	0.52
133.3	0.800	70	84.4	561.6	13.35	0.87	7.01	5.192	1089.1	1953.1	1391.5	302.4	4.60	847.0	544.6	0.52
141.7	0.850	72	84.4	561.6	14.19	0.86	7.08	5.142	1119.3	1983.3	1421.7	302.4	4.70	862.1	559.7	0.50
150.0	0.900	74	84.3	547.2	15.02	0.85	7.15	5.092	1148.8	2012.8	1465.6	316.8	4.63	891.2	574.4	0.48
158.3	0.950	75	84.2	532.8	15.85	0.84	7.22	5.042	1157.4	2021.4	1488.6	331.2	4.49	909.9	578.7	0.46
166.7	1.000	77	84.2	532.8	16.69	0.83	7.29	4.992	1185.5	2049.5	1516.7	331.2	4.58	923.9	592.7	0.45

DU @ FAILURE	590.4	DEVIATORIC STRESS @ FAILURE	952.1	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.48

TECH	PWM/SDM
DATE	7/28/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

PROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER	043-2246-0001
SAMPLE ID	PF - 3
SAMPLE TYPE	Bulk
DEPTH INTERVAL	-
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.10
CELL PRESSURE (psi)	89.0
SAMPLE PRESSURE (psi)	80.0
EFF. CONSOLIDATION PRESSURE, σ_3 (psi)	9.0
PRESSURE, σ_3 (psf)	1296.0
FINAL "B" VALUE	1.00
t_{50} (minutes)	0.11

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.174	5.974	5.949
DIAMETER	7.087	2.790	2.774
AREA	39.44	6.11	6.04
VOLUME	598.50	36.52	35.95
WEIGHT (g)	1251.14		1286.74
% MOISTURE	12.7		15.92
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	130.4		
DRY DENSITY, calc (pcf)	115.7		
VOLUME OF SOLIDS	411.10		
VOLUME OF VOIDS	187.40		
VOID RATIO	0.456		
SATURATION	75.3		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	117.6
VOLUME OF SOLIDS	411.10
VOLUME OF VOIDS	178.00
VOID RATIO	0.433

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1286.74
WT SOIL & TARE, DRY (g)	1109.98
WT TARE (g)	0.00
WT MOISTURE (g)	176.76
WT DRY SOIL (g)	1109.98
% MOISTURE	15.92

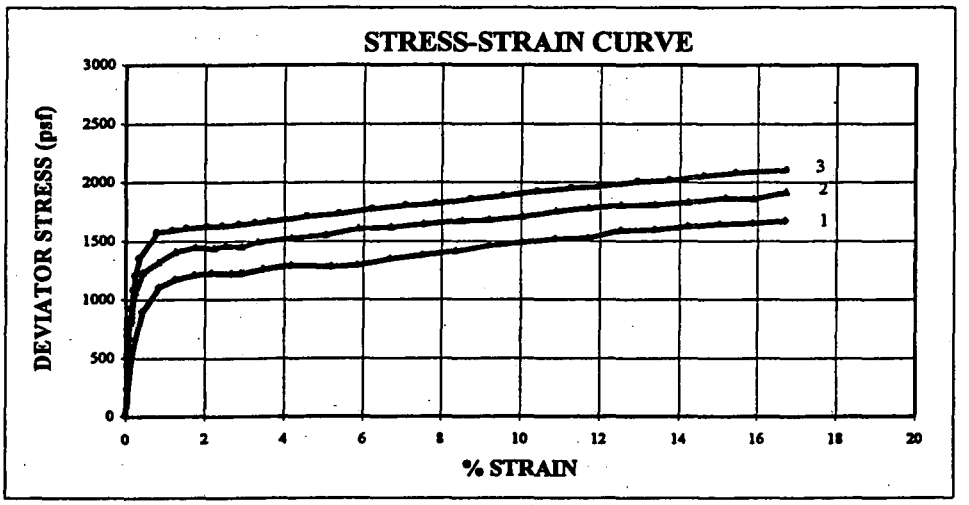
TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	20	80.9	0.0	0.00	1.00	6.04	5.949	0.0	1296.0	1296.0	1296.0	1.00	1296.0	0.0	0
0.5	0.003	38	82.1	172.8	0.05	1.00	6.05	5.946	428.7	1724.7	1551.9	1123.2	1.38	1337.6	214.4	0.40
1.0	0.006	56	83.5	374.4	0.10	1.00	6.05	5.943	857.0	2153.0	1778.6	921.6	1.93	1350.1	428.5	0.44
1.5	0.009	58	83.6	388.8	0.15	1.00	6.05	5.940	904.2	2200.2	1811.4	907.2	2.00	1359.3	452.1	0.43
2.0	0.012	63	83.9	432.0	0.20	1.00	6.06	5.937	1022.6	2318.6	1886.6	864.0	2.18	1375.3	511.3	0.42
2.5	0.015	69	84.3	489.6	0.25	1.00	6.06	5.934	1164.7	2460.7	1971.1	806.4	2.44	1388.8	582.4	0.42
4.2	0.025	80	84.7	547.2	0.42	1.00	6.07	5.924	1423.8	2719.8	2172.6	748.8	2.90	1460.7	711.9	0.38
8.3	0.050	92	85.1	604.8	0.84	0.99	6.09	5.899	1701.3	2997.3	2392.5	691.2	3.46	1541.9	850.7	0.36
12.5	0.075	92	85.3	633.6	1.26	0.99	6.12	5.874	1694.1	2990.1	2356.5	662.4	3.56	1509.5	847.1	0.37
16.7	0.100	90	85.4	648.0	1.68	0.98	6.15	5.849	1640.0	2936.0	2288.0	648.0	3.53	1468.0	820.0	0.40
20.8	0.125	89	85.6	676.8	2.10	0.98	6.17	5.824	1609.7	2905.7	2228.9	619.2	3.60	1424.0	804.8	0.42
25.0	0.150	89	85.7	691.2	2.52	0.97	6.20	5.799	1602.8	2898.8	2207.6	604.8	3.65	1406.2	801.4	0.43
29.2	0.175	89	85.8	705.6	2.94	0.97	6.23	5.774	1595.9	2891.9	2186.3	590.4	3.70	1388.3	797.9	0.44
33.3	0.200	89	85.8	705.6	3.36	0.97	6.25	5.749	1589.0	2885.0	2179.4	590.4	3.69	1384.9	794.5	0.44
41.7	0.250	90	85.8	705.6	4.20	0.96	6.31	5.699	1598.0	2894.0	2188.4	590.4	3.71	1389.4	799.0	0.44
50.0	0.300	90	85.8	705.6	5.04	0.95	6.36	5.649	1584.0	2880.0	2174.4	590.4	3.68	1382.4	792.0	0.45
58.3	0.350	92	85.9	720.0	5.88	0.94	6.42	5.599	1614.8	2910.8	2190.8	576.0	3.80	1383.4	807.4	0.45
66.7	0.400	94	85.8	705.6	6.72	0.93	6.48	5.549	1644.8	2940.8	2235.2	590.4	3.79	1412.8	822.4	0.43
75.0	0.450	95	85.8	705.6	7.56	0.92	6.54	5.499	1652.0	2948.0	2242.4	590.4	3.80	1416.4	826.0	0.43
83.3	0.500	97	85.7	691.2	8.40	0.92	6.60	5.449	1680.7	2976.7	2285.5	604.8	3.78	1445.1	840.3	0.41
95.8	0.575	100	85.6	676.8	9.67	0.90	6.69	5.374	1722.1	3018.1	2341.3	619.2	3.78	1480.3	861.1	0.39
100.0	0.600	102	85.6	676.8	10.09	0.90	6.72	5.349	1757.0	3053.0	2376.2	619.2	3.84	1497.7	878.5	0.39
108.3	0.650	104	85.5	662.4	10.93	0.89	6.78	5.299	1783.0	3079.0	2416.6	633.6	3.81	1525.1	891.5	0.37
116.7	0.700	105	85.5	662.4	11.77	0.88	6.85	5.249	1787.2	3083.2	2420.8	633.6	3.82	1527.2	893.6	0.37
125.0	0.750	107	85.4	648.0	12.61	0.87	6.91	5.199	1811.8	3107.8	2459.8	648.0	3.80	1553.9	905.9	0.36
133.3	0.800	110	85.3	633.6	13.45	0.87	6.98	5.149	1856.3	3152.3	2518.7	662.4	3.80	1590.5	928.1	0.34
141.7	0.850	112	85.2	619.2	14.29	0.86	7.05	5.099	1879.1	3175.1	2555.9	676.8	3.78	1616.3	939.5	0.33
150.0	0.900	114	85.1	604.8	15.13	0.85	7.12	5.049	1901.1	3197.1	2592.3	691.2	3.75	1641.8	950.6	0.32
158.3	0.950	115	85.0	590.4	15.97	0.84	7.19	4.999	1902.3	3198.3	2607.9	705.6	3.70	1656.8	951.2	0.31
169.2	1.015	117	84.9	576.0	17.06	0.83	7.29	4.934	1917.1	3213.1	2637.1	720.0	3.66	1678.6	958.6	0.30

DU @ FAILURE	633.6	DEVIATORIC STRESS @ FAILURE	1694.1	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	3.56

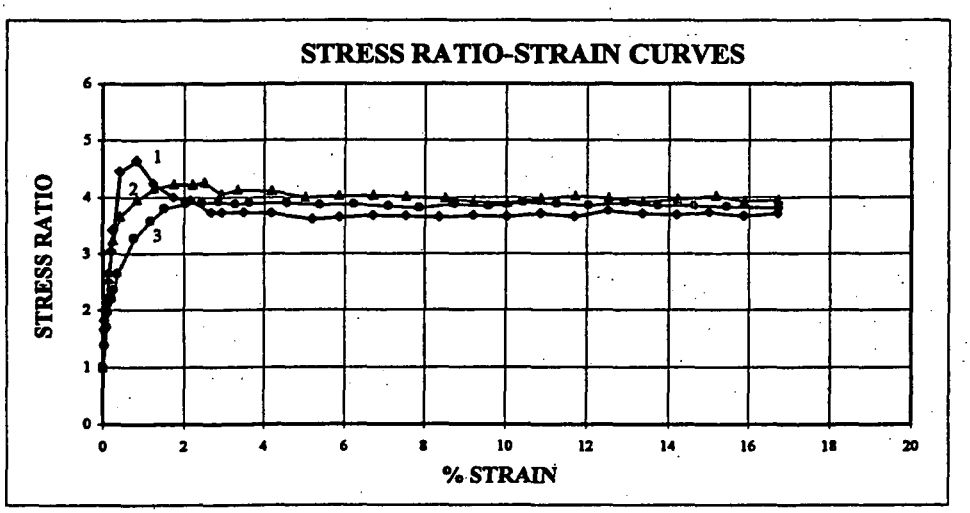
TECH	PWM/SDM
DATE	7/28/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

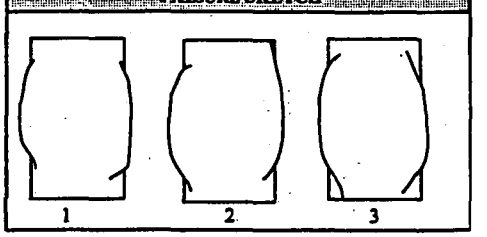
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 2 DEPTH: - Sample Type: Bulk

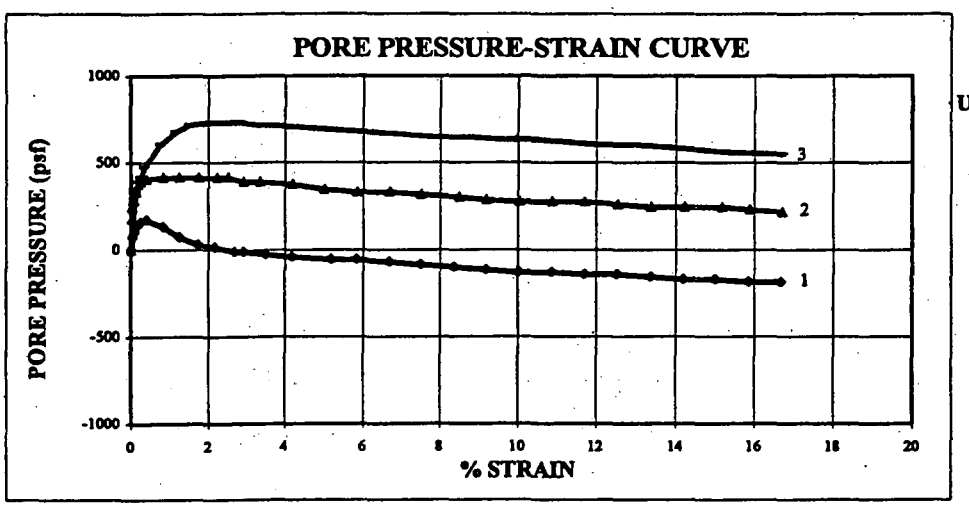


Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	113.7	13.7
2	864	113.6	13.9
3	1296	113.5	14.0
	Average	113.6	13.9



FAILURE SKETCH





Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

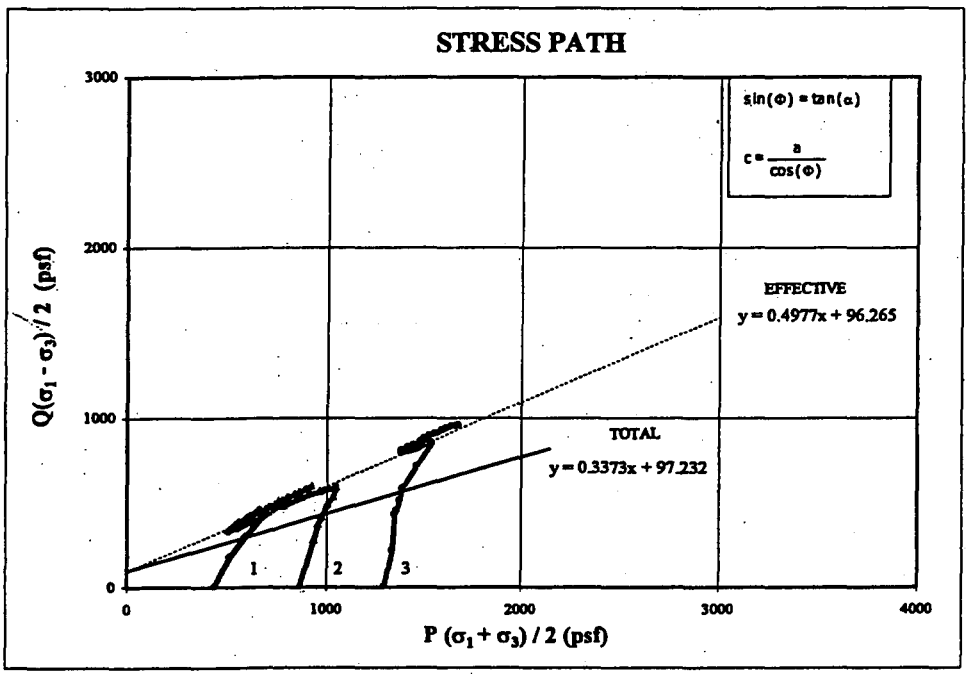
Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

* Failure based on effective stress ratio or 15% strain.

CHECK
REVIEW

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

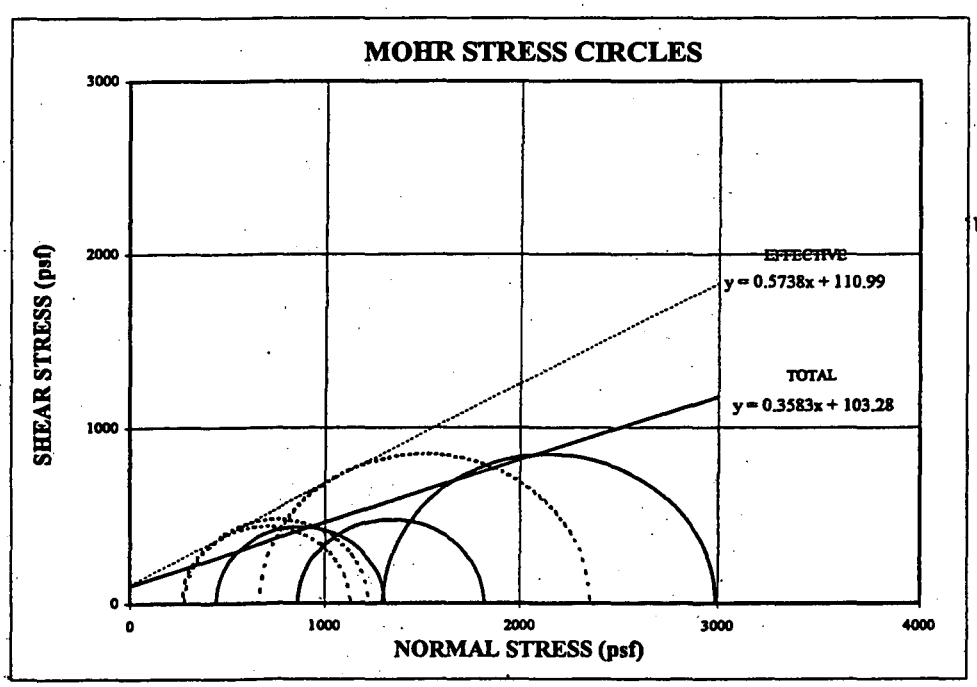
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 3 DEPTH: - Sample Type: Bulk



Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	114.7	12.7
2	864	114.7	12.9
3	1296	115.7	12.7

Specimen	Strain Rate (%)	Initial Saturation (%)	Saturation Before Shearing (%)
1	0.10	73.2	95.0
2	0.10	74.6	96.3
3	0.10	75.3	99.3

STRESS PATH			MOHR CIRCLES		
*TOTAL STRESS PARAMETER			*TOTAL STRENGTH PARAMETER		
α	=	18.6 °	ϕ	=	19.7 °
a	=	97.2 psf	c	=	103.3 psf
*EFFECTIVE STRESS PARAMETER			*EFFECTIVE STRENGTH PARAMETER		
α'	=	26.5 °	ϕ'	=	29.8 °
a'	=	96.3 psf	c'	=	111.0 psf



Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

*** Failure based on effective stress ratio or 15% strain.**

CHECK
REVIEW

CONSOLIDATED UNDRAINED TRIAXIAL STRENGTH								CONSOLIDATED UNDRAINED TRI		
MOHR CIRCLE GENERATION SPREADSHEET								MOHR CIRCLE GENERATION SPRE		
	PF - 3	-	B	C	A				PF - 3	-
CONFINING PRESSURE USED (S3)			432	864	1296	psf		CONFINING PRESSURE USED (S3)		
CONFINING PRESSURE USED (S3)			432	864	1296	psi		CONFINING PRESSURE USED (S3)		
MAXIMUM DEVIATOR STRESS (PS			872.1	952.1	1694.1	psf		MAXIMUM DEVIATOR STRESS (PS		
(or load at 15% strain)								(or load at 15% strain)		
dU AT FAIL	(S1-S3)/2	(S1'+S3')/2		coh	sin phi	phi		dU AT FAIL	(S1-S3)/2	(S1'+S3')/2
172.8	436.0	695.2	COH 1&2	-80	0.735278001	47		172.8	436.0	868.0
590.4	476.0	749.6	COH 1&3	90	0.504800156	30		590.4	476.0	1340.0
633.6	847.1	1509.5	COH 2&3	110	0.488299892	29		633.6	847.1	2143.1
		EFFECTIVE								TOTAL
TA POINTS	A	B	C					DATA POINTS	A	B
	MOHR,1	MOHR,2	MOHR,3						MOHR,1	MOHR,2
X	Y,1	Y,2	Y,3					X	Y,1	Y,2
0	#NUM!	#NUM!	#NUM!					0	#NUM!	#NUM!
10	#NUM!	#NUM!	#NUM!					10	#NUM!	#NUM!
20	#NUM!	#NUM!	#NUM!					20	#NUM!	#NUM!
30	#NUM!	#NUM!	#NUM!					30	#NUM!	#NUM!
40	#NUM!	#NUM!	#NUM!					40	#NUM!	#NUM!
50	#NUM!	#NUM!	#NUM!					50	#NUM!	#NUM!
60	#NUM!	#NUM!	#NUM!					60	#NUM!	#NUM!
70	#NUM!	#NUM!	#NUM!					70	#NUM!	#NUM!
80	#NUM!	#NUM!	#NUM!					80	#NUM!	#NUM!
90	#NUM!	#NUM!	#NUM!					90	#NUM!	#NUM!
100	#NUM!	#NUM!	#NUM!					100	#NUM!	#NUM!
110	#NUM!	#NUM!	#NUM!					110	#NUM!	#NUM!
120	#NUM!	#NUM!	#NUM!					120	#NUM!	#NUM!
130	#NUM!	#NUM!	#NUM!					130	#NUM!	#NUM!
140	#NUM!	#NUM!	#NUM!					140	#NUM!	#NUM!
150	#NUM!	#NUM!	#NUM!					150	#NUM!	#NUM!
160	#NUM!	#NUM!	#NUM!					160	#NUM!	#NUM!
170	#NUM!	#NUM!	#NUM!					170	#NUM!	#NUM!
180	#NUM!	#NUM!	#NUM!					180	#NUM!	#NUM!
190	#NUM!	#NUM!	#NUM!					190	#NUM!	#NUM!
200	#NUM!	#NUM!	#NUM!					200	#NUM!	#NUM!
210	#NUM!	#NUM!	#NUM!					210	#NUM!	#NUM!
220	#NUM!	#NUM!	#NUM!					220	#NUM!	#NUM!
230	#NUM!	#NUM!	#NUM!					230	#NUM!	#NUM!
240	#NUM!	#NUM!	#NUM!					240	#NUM!	#NUM!
250	#NUM!	#NUM!	#NUM!					250	#NUM!	#NUM!
260	26	#NUM!	#NUM!					260	#NUM!	#NUM!
270	96	#NUM!	#NUM!					270	#NUM!	#NUM!
280	133	78	#NUM!					280	#NUM!	#NUM!
290	161	124	#NUM!					290	#NUM!	#NUM!
300	184	156	#NUM!					300	#NUM!	#NUM!
310	204	183	#NUM!					310	#NUM!	#NUM!
320	222	205	#NUM!					320	#NUM!	#NUM!
330	238	225	#NUM!					330	#NUM!	#NUM!
340	253	243	#NUM!					340	#NUM!	#NUM!
350	266	259	#NUM!					350	#NUM!	#NUM!
360	279	273	#NUM!					360	#NUM!	#NUM!

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

PROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER	043-2246-0001
SAMPLE ID	PF - 4
SAMPLE TYPE	Bulk
DEPTH INTERVAL	-
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.10
CELL PRESSURE (psi)	83.0
SAMPLE PRESSURE (psi)	80.0
EFF. CONSOLIDATION PRESSURE, σ_3 (psi)	3.0
PRESSURE, σ_3 (psf)	432.0
FINAL "B" VALUE	1.00
t_{50} (minutes)	0.21

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.225	5.994	5.982
DIAMETER	7.087	2.790	2.785
AREA	39.44	6.11	6.09
VOLUME	600.50	36.65	36.45
WEIGHT (g)	1266.11		1300.91
% MOISTURE	12.8		15.91
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	131.6		
DRY DENSITY, calc (pcf)	116.6		
VOLUME OF SOLIDS	415.68		
VOLUME OF VOIDS	184.83		
VOID RATIO	0.445		
SATURATION	77.8		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	117.2
VOLUME OF SOLIDS	415.68
VOLUME OF VOIDS	181.63
VOID RATIO	0.437

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1300.91
WT SOIL & TARE, DRY (g)	1122.33
WT TARE (g)	0.00
WT MOISTURE (g)	178.58
WT DRY SOIL (g)	1122.33
% MOISTURE	15.91

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	13	81.4	0.0	0.00	1.00	6.09	5.982	0.0	432.0	432.0	432.0	1.00	432.0	0.0	0.00
0.5	0.003	34	82.8	201.6	0.05	1.00	6.10	5.979	507.8	939.8	738.2	230.4	3.20	484.3	253.9	0.40
1.3	0.008	42	83.0	230.4	0.13	1.00	6.10	5.974	691.5	1123.5	893.1	201.6	4.43	547.4	345.8	0.33
1.8	0.011	46	83.1	244.8	0.18	1.00	6.10	5.971	780.8	1212.8	968.0	187.2	5.17	577.6	390.4	0.31
2.3	0.014	49	83.2	259.2	0.23	1.00	6.11	5.968	858.2	1290.2	1031.0	172.8	5.97	601.9	429.1	0.30
2.7	0.016	52	83.2	259.2	0.27	1.00	6.11	5.966	926.3	1358.3	1099.1	172.8	6.36	635.9	463.1	0.28
3.2	0.019	54	83.1	244.8	0.32	1.00	6.11	5.963	980.0	1412.0	1167.2	187.2	6.24	677.2	490.0	0.25
3.8	0.023	57	83.1	244.8	0.38	1.00	6.12	5.959	1038.2	1470.2	1225.4	187.2	6.55	706.3	519.1	0.24
8.0	0.048	71	82.4	144.0	0.80	0.99	6.14	5.934	1380.8	1812.8	1668.8	288.0	5.79	978.4	690.4	0.10
12.2	0.073	80	81.5	14.4	1.22	0.99	6.17	5.909	1578.1	2010.1	1995.7	417.6	4.78	1206.6	789.0	0.01
15.8	0.095	85	80.8	-86.4	1.59	0.98	6.19	5.887	1683.8	2115.8	2202.2	518.4	4.25	1360.3	841.9	-0.05
20.2	0.121	87	80.4	-144.0	2.02	0.98	6.22	5.861	1734.3	2166.3	2310.3	576.0	4.01	1443.1	867.1	-0.08
24.7	0.148	89	80.2	-172.8	2.47	0.98	6.25	5.834	1770.1	2202.1	2374.9	604.8	3.93	1489.8	885.0	-0.10
28.8	0.173	91	80.1	-187.2	2.89	0.97	6.27	5.809	1801.5	2233.5	2420.7	619.2	3.91	1520.0	900.8	-0.10
33.2	0.199	92	80.0	-201.6	3.33	0.97	6.30	5.783	1825.4	2257.4	2459.0	633.6	3.88	1546.3	912.7	-0.11
37.0	0.222	94	80.0	-201.6	3.71	0.96	6.33	5.760	1854.6	2286.6	2488.2	633.6	3.93	1560.9	927.3	-0.11
45.5	0.273	96	79.8	-230.4	4.56	0.95	6.38	5.709	1878.8	2310.8	2541.2	662.4	3.84	1601.8	939.4	-0.12
54.0	0.324	98	79.6	-259.2	5.42	0.95	6.44	5.658	1906.7	2338.7	2597.9	691.2	3.76	1644.5	953.3	-0.14
62.2	0.373	100	79.6	-259.2	6.24	0.94	6.50	5.609	1932.3	2364.3	2623.5	691.2	3.80	1657.3	966.1	-0.13
70.5	0.423	102	79.5	-273.6	7.07	0.93	6.56	5.559	1965.6	2397.6	2671.2	705.6	3.79	1688.4	982.8	-0.14
78.5	0.471	104	79.5	-273.6	7.87	0.92	6.61	5.511	1998.7	2430.7	2704.3	705.6	3.83	1704.9	999.3	-0.14
87.2	0.523	106	79.3	-302.4	8.74	0.91	6.68	5.459	2016.5	2448.5	2750.9	734.4	3.75	1742.6	1008.2	-0.15
95.7	0.574	108	79.3	-302.4	9.60	0.90	6.74	5.408	2029.7	2461.7	2764.1	734.4	3.76	1749.2	1014.8	-0.15
104.0	0.624	110	79.3	-302.4	10.43	0.90	6.80	5.358	2057.5	2489.5	2791.9	734.4	3.80	1763.1	1028.7	-0.15
112.5	0.675	112	79.1	-331.2	11.28	0.89	6.87	5.307	2086.1	2518.1	2849.3	763.2	3.73	1806.3	1043.1	-0.16
120.2	0.721	115	79.0	-345.6	12.05	0.88	6.93	5.261	2134.6	2566.6	2912.2	777.6	3.75	1844.9	1067.3	-0.16
129.0	0.774	117	79.0	-345.6	12.94	0.87	7.00	5.208	2139.8	2571.8	2917.4	777.6	3.75	1847.5	1069.9	-0.16
137.5	0.825	119	78.8	-374.4	13.79	0.86	7.07	5.157	2159.6	2591.6	2966.0	806.4	3.68	1886.2	1079.8	-0.17
145.8	0.875	121	78.8	-374.4	14.63	0.85	7.14	5.107	2183.0	2615.0	2989.4	806.4	3.71	1897.9	1091.5	-0.17
154.5	0.927	123	78.8	-374.4	15.50	0.85	7.21	5.055	2208.7	2640.7	3015.1	806.4	3.74	1910.8	1104.4	-0.17

DU @ FAILURE	244.80	DEVIATORIC STRESS @ FAILURE	1038.20	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	6.55

TECH	PWM/SDM
DATE	8/5/04
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

PROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER	043-2246-0001
SAMPLE ID	PF - 4
SAMPLE TYPE	Bulk
DEPTH INTERVAL	-
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.10
CELL PRESSURE (psi)	86.0
SAMPLE PRESSURE (psi)	80.0
EFF. CONSOLIDATION PRESSURE, σ_3 (psi)	6.0
PRESSURE, σ_3 (psf)	864.0
FINAL "B" VALUE	0.99
t_{50} (minutes)	0.19

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.243	6.001	5.989
DIAMETER	7.087	2.790	2.778
AREA	39.44	6.11	6.06
VOLUME	601.21	36.69	36.31
WEIGHT (g)	1266.07		1297.87
% MOISTURE	12.9		15.70
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	131.4		
DRY DENSITY, calc (pcf)	116.4		
VOLUME OF SOLIDS	415.45		
VOLUME OF VOIDS	185.76		
VOID RATIO	0.447		
SATURATION	77.7		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	117.6
VOLUME OF SOLIDS	415.45
VOLUME OF VOIDS	179.56
VOID RATIO	0.432

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1297.87
WT SOIL & TARE, DRY (g)	1121.71
WT TARE (g)	0.00
WT MOISTURE (g)	176.16
WT DRY SOIL (g)	1121.71
% MOISTURE	15.70

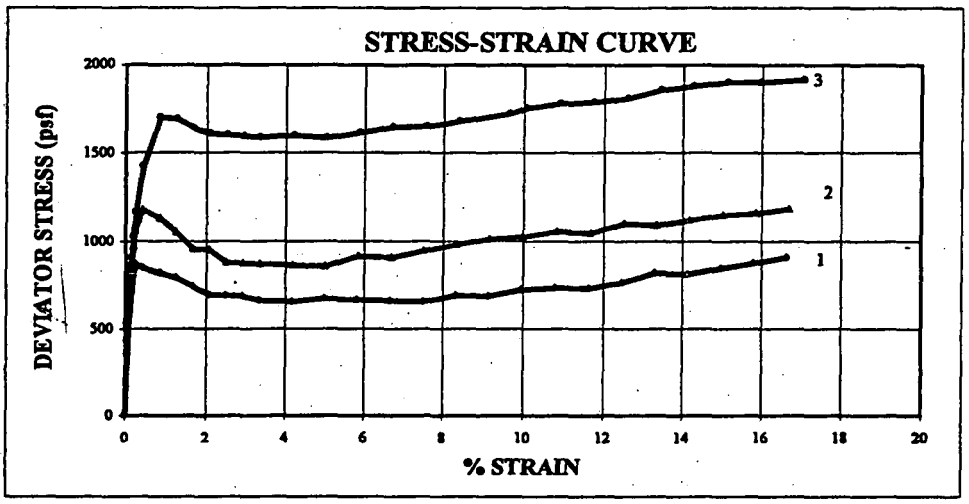
TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	13	81.1	0.0	0.00	1.00	6.06	5.989	0.0	864.0	864.0	864.0	1.00	864.0	0.0	0.00
0.5	0.003	41	82.7	230.4	0.05	1.00	6.07	5.986	662.3	1526.3	1295.9	633.6	2.05	964.8	331.2	0.35
0.8	0.005	46	83.0	273.6	0.08	1.00	6.07	5.984	776.0	1640.0	1366.4	590.4	2.31	978.4	388.0	0.35
1.3	0.008	54	83.4	331.2	0.13	1.00	6.07	5.981	972.5	1836.5	1505.3	532.8	2.83	1019.1	486.3	0.34
2.2	0.013	65	83.9	403.2	0.22	1.00	6.08	5.976	1239.5	2103.5	1700.3	460.8	3.69	1080.6	619.8	0.33
2.8	0.017	70	84.0	417.6	0.28	1.00	6.08	5.972	1342.9	2206.9	1789.3	446.4	4.01	1117.9	671.5	0.31
3.3	0.020	74	84.1	432.0	0.33	1.00	6.08	5.969	1446.4	2310.4	1878.4	432.0	4.35	1155.2	723.2	0.30
3.8	0.023	78	84.1	432.0	0.38	1.00	6.09	5.966	1533.2	2397.2	1965.2	432.0	4.55	1198.6	766.6	0.28
8.2	0.049	99	83.5	345.6	0.82	0.99	6.11	5.940	2033.0	2897.0	2551.4	618.4	4.92	1534.9	1016.5	0.17
12.3	0.074	107	82.8	244.8	1.24	0.99	6.14	5.915	2198.0	3062.0	2817.2	619.2	4.55	1718.2	1099.0	0.11
16.0	0.096	107	82.5	201.6	1.60	0.98	6.16	5.893	2210.9	3074.9	2873.3	662.4	4.34	1767.9	1105.5	0.09
20.7	0.124	109	82.3	172.8	2.07	0.98	6.19	5.865	2228.3	3092.3	2919.5	691.2	4.22	1805.4	1114.2	0.08
24.8	0.149	110	82.2	158.4	2.49	0.98	6.22	5.840	2239.7	3103.7	2945.3	705.6	4.17	1825.4	1119.8	0.07
29.0	0.174	110	82.1	144.0	2.91	0.97	6.24	5.815	2243.9	3107.9	2963.9	720.0	4.12	1842.0	1122.0	0.06
33.0	0.198	110	82.0	129.6	3.31	0.97	6.27	5.791	2241.5	3105.5	2975.9	734.4	4.05	1855.2	1120.8	0.06
36.8	0.221	111	81.9	115.2	3.69	0.96	6.29	5.768	2253.2	3117.2	3002.0	748.8	4.01	1875.4	1126.6	0.05
45.7	0.274	113	82.0	129.6	4.58	0.95	6.35	5.715	2271.0	3135.0	3005.4	734.4	4.09	1869.9	1135.5	0.06
53.8	0.323	115	81.9	115.2	5.39	0.95	6.41	5.666	2289.8	3153.8	3038.6	748.8	4.06	1893.7	1144.9	0.05
62.5	0.375	117	81.9	115.2	6.26	0.94	6.47	5.614	2317.7	3181.7	3066.5	748.8	4.10	1907.7	1158.9	0.05
70.8	0.425	119	81.8	100.8	7.10	0.93	6.53	5.564	2332.4	3196.4	3095.6	763.2	4.06	1929.4	1166.2	0.04
78.5	0.471	120	81.8	100.8	7.86	0.92	6.58	5.518	2354.7	3218.7	3117.9	763.2	4.09	1940.6	1177.4	0.04
87.3	0.524	123	81.7	86.4	8.75	0.91	6.64	5.465	2390.6	3254.6	3168.2	777.6	4.07	1972.9	1195.3	0.04
95.8	0.575	125	81.6	72.0	9.60	0.90	6.71	5.414	2404.8	3268.8	3196.8	792.0	4.04	1994.4	1202.4	0.03
104.2	0.625	128	81.5	57.6	10.44	0.90	6.77	5.364	2448.5	3312.5	3254.9	806.4	4.04	2030.7	1224.3	0.02
112.7	0.676	131	81.3	28.8	11.29	0.89	6.83	5.313	2484.3	3348.3	3319.5	835.2	3.97	2077.3	1242.1	0.01
120.5	0.723	132	81.2	14.4	12.07	0.88	6.90	5.266	2481.1	3345.1	3330.7	849.6	3.92	2090.1	1240.5	0.01
129.3	0.776	136	81.1	0.0	12.96	0.87	6.97	5.213	2538.8	3402.8	3402.8	864.0	3.94	2133.4	1269.4	0.00
137.7	0.826	137	80.9	-28.8	13.79	0.86	7.03	5.163	2547.2	3411.2	3440.0	892.8	3.85	2166.4	1273.6	-0.01
146.2	0.877	140	80.9	-28.8	14.64	0.85	7.10	5.112	2586.9	3450.9	3479.7	892.8	3.90	2186.3	1293.5	-0.01
154.7	0.928	143	80.8	-43.2	15.50	0.85	7.17	5.061	2613.3	3477.3	3520.5	907.2	3.88	2213.9	1306.7	-0.02

DU @ FAILURE	345.6	DEVIATORIC STRESS @ FAILURE	2033.0	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.92

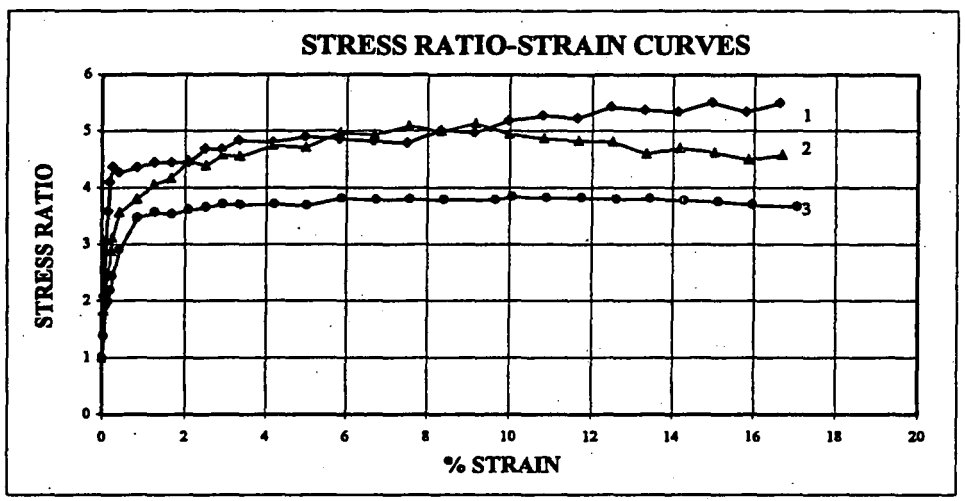
TECH	PWM/SDM
DATE	8/5/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

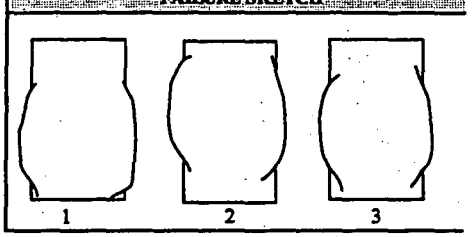
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 3 DEPTH: - Sample Type: Bulk

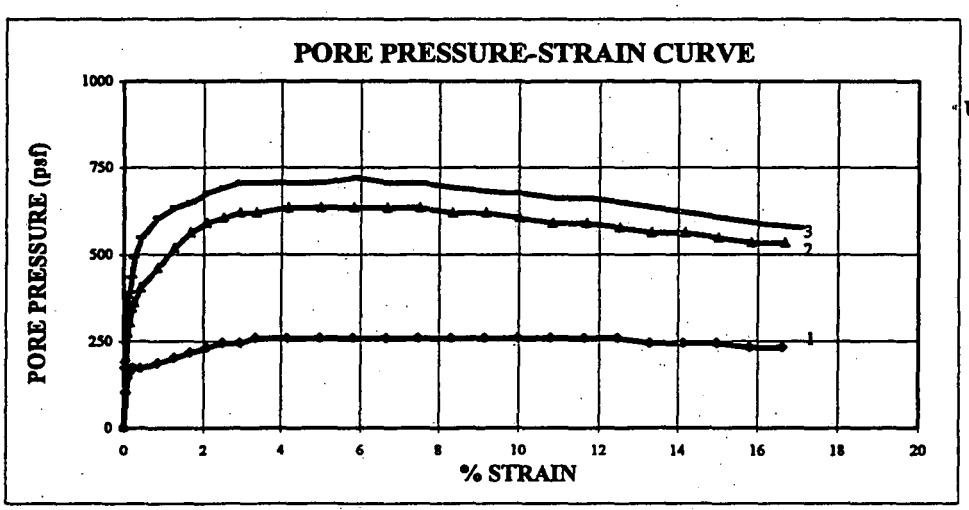


Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	114.7	12.7
2	864	114.7	12.9
3	1296	115.7	12.7
	Average	115.1	12.8



FAILURE SKETCH





Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

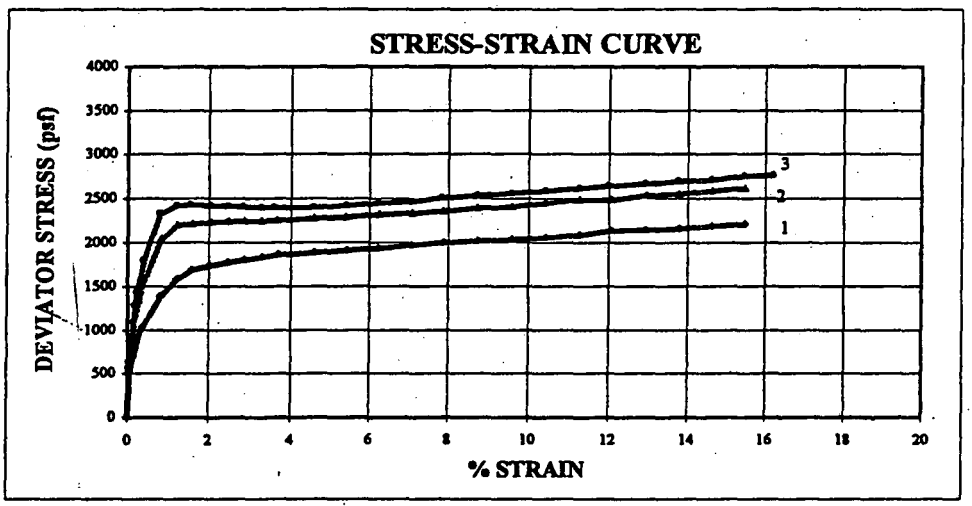
Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

* Failure based on effective stress ratio or 15% strain.

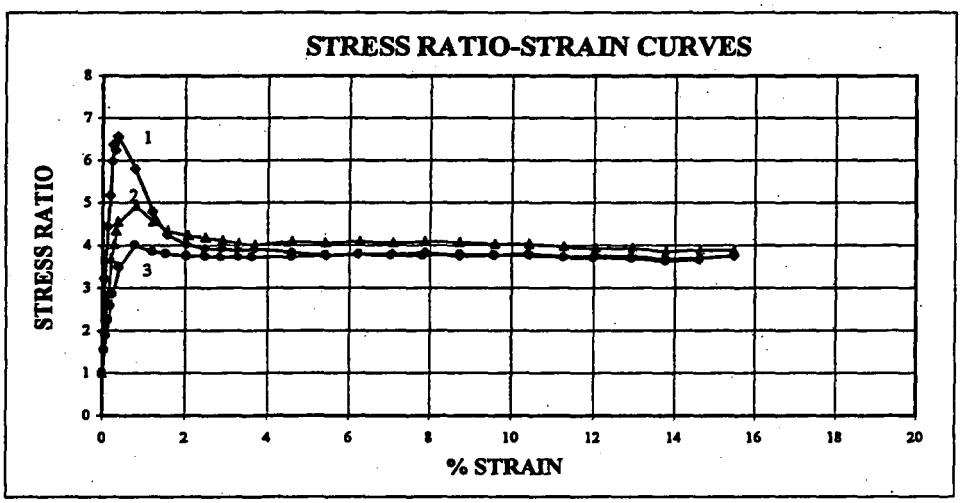
CHECK
REVIEW

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

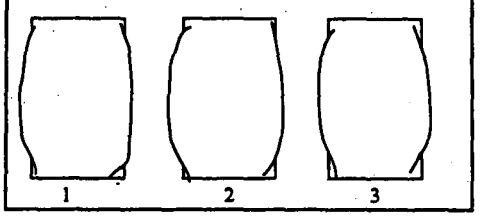
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 4 DEPTH: - Sample Type: Bulk

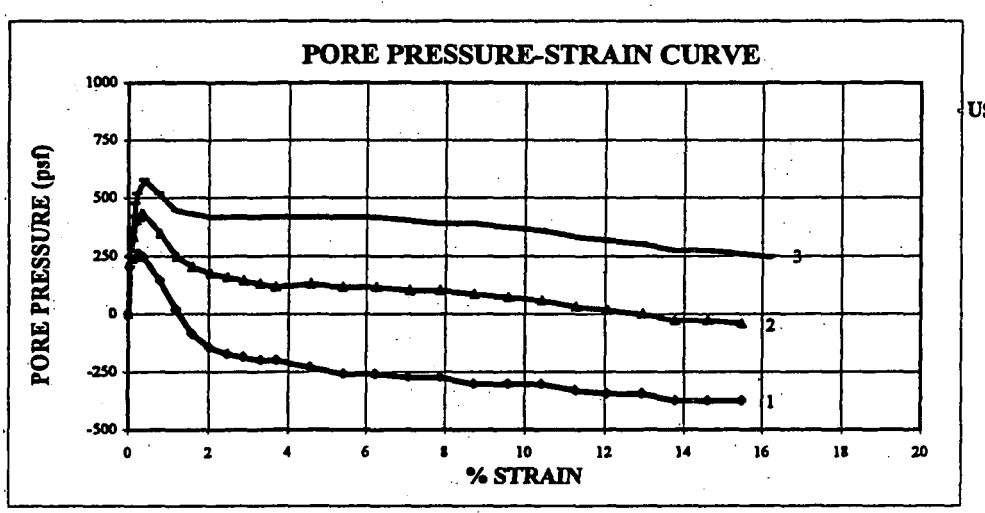


Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	116.6	12.8
2	864	116.4	12.9
3	1296	116.6	12.6
	Average	116.6	12.8



FAILURE SKETCH





Soil Description

Reddish Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

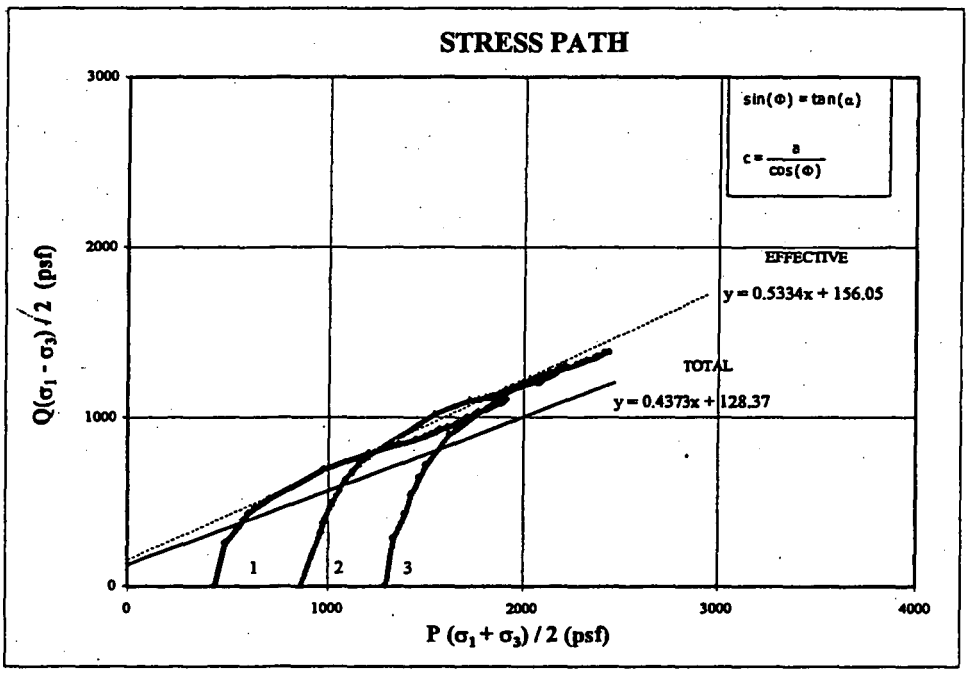
Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

* Failure based on effective stress ratio or 15% strain.

CHECK
REVIEW

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

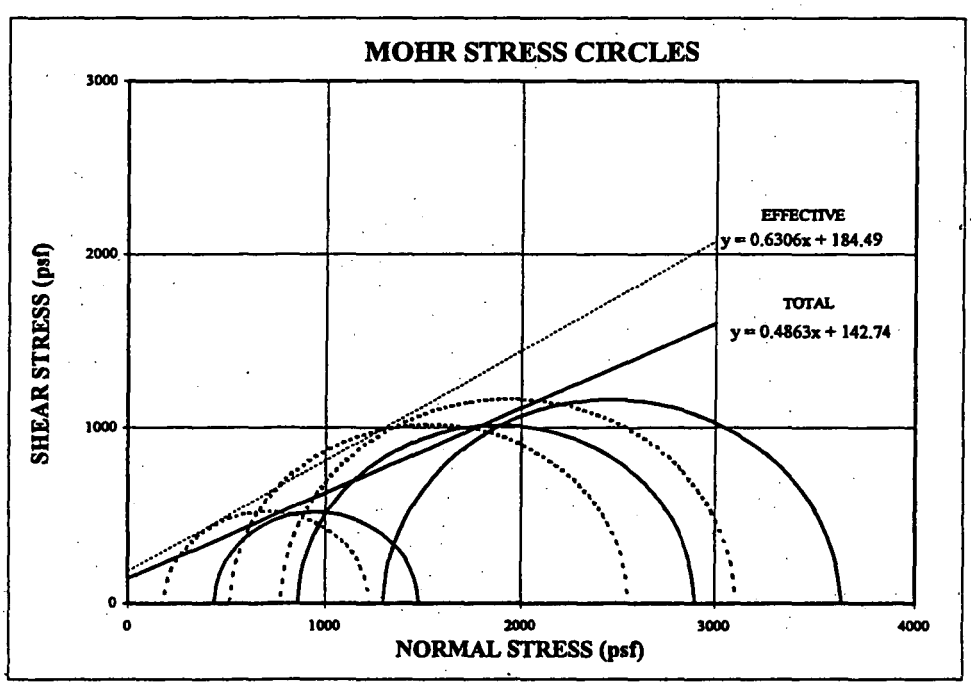
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 4 DEPTH: - Sample Type: Bulk



Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	116.6	12.8
2	864	116.4	12.9
3	1296	116.6	12.6

Specimen	Strain Rate (%)	Initial Saturation (%)	Saturation Before Shearing (%)
1	0.10	77.8	98.3
2	0.10	77.7	98.1
3	0.10	76.7	97.0

STRESS PATH			MOHR CIRCLES		
*TOTAL STRESS PARAMETER			*TOTAL STRENGTH PARAMETER		
α	=	23.6 °	ϕ	=	25.9 °
a	=	128.4 psf	c	=	142.7 psf
* EFFECTIVE STRESS PARAMETER			*EFFECTIVE STRENGTH PARAMETER		
α'	=	28.1 °	ϕ'	=	32.2 °
a'	=	156.1 psf	c'	=	184.5 psf



Soil Description

Reddish Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

*** Failure based on effective stress ratio or 15% strain.**

CHECK
REVIEW

CONSOLIDATED UNDRAINED TRIAXIAL STRENGTH								CONSOLIDATED UNDRAINED TRI		
MOHR CIRCLE GENERATION SPREADSHEET								MOHR CIRCLE GENERATION SPRE		
	PF - 4	-	B	C	A				PF - 4	-
CONFINING PRESSURE USED (S3)			432	864	1296	psf		CONFINING PRESSURE USED (S3)		
CONFINING PRESSURE USED (S3)			432	864	1296	psi		CONFINING PRESSURE USED (S3)		
MAXIMUM DEVIATOR STRESS (PS			1038.2	2033.0	2327.1	psf		MAXIMUM DEVIATOR STRESS (PS		
(or load at 15% strain)								(or load at 15% strain)		
dU AT FAIL	(S1-S3)/2	(S1'+S3')/2		coh	sin phi	phi		dU AT FAIL	(S1-S3)/2	(S1'+S3')/2
244.8	519.1	706.3	COH 1&2	100	0.600292991	37		244.8	519.1	951.1
345.6	1016.5	1534.9	COH 1&3	150	0.521880864	31		345.6	1016.5	1880.5
518.4	1163.5	1941.1	COH 2&3	460	0.361940546	21		518.4	1163.5	2459.5
		EFFECTIVE								TOTAL
TA POINTS	A	B	C					DATA POINTS	A	B
	MOHR,1	MOHR,2	MOHR,3						MOHR,1	MOHR,2
X	Y,1	Y,2	Y,3					X	Y,1	Y,2
0	#NUM!	#NUM!	#NUM!					0	#NUM!	#NUM!
10	#NUM!	#NUM!	#NUM!					10	#NUM!	#NUM!
20	#NUM!	#NUM!	#NUM!					20	#NUM!	#NUM!
30	#NUM!	#NUM!	#NUM!					30	#NUM!	#NUM!
40	#NUM!	#NUM!	#NUM!					40	#NUM!	#NUM!
50	#NUM!	#NUM!	#NUM!					50	#NUM!	#NUM!
60	#NUM!	#NUM!	#NUM!					60	#NUM!	#NUM!
70	#NUM!	#NUM!	#NUM!					70	#NUM!	#NUM!
80	#NUM!	#NUM!	#NUM!					80	#NUM!	#NUM!
90	#NUM!	#NUM!	#NUM!					90	#NUM!	#NUM!
100	#NUM!	#NUM!	#NUM!					100	#NUM!	#NUM!
110	#NUM!	#NUM!	#NUM!					110	#NUM!	#NUM!
120	#NUM!	#NUM!	#NUM!					120	#NUM!	#NUM!
130	#NUM!	#NUM!	#NUM!					130	#NUM!	#NUM!
140	#NUM!	#NUM!	#NUM!					140	#NUM!	#NUM!
150	#NUM!	#NUM!	#NUM!					150	#NUM!	#NUM!
160	#NUM!	#NUM!	#NUM!					160	#NUM!	#NUM!
170	#NUM!	#NUM!	#NUM!					170	#NUM!	#NUM!
180	#NUM!	#NUM!	#NUM!					180	#NUM!	#NUM!
190	54	#NUM!	#NUM!					190	#NUM!	#NUM!
200	115	#NUM!	#NUM!					200	#NUM!	#NUM!
210	152	#NUM!	#NUM!					210	#NUM!	#NUM!
220	182	#NUM!	#NUM!					220	#NUM!	#NUM!
230	206	#NUM!	#NUM!					230	#NUM!	#NUM!
240	228	#NUM!	#NUM!					240	#NUM!	#NUM!
250	247	#NUM!	#NUM!					250	#NUM!	#NUM!
260	265	#NUM!	#NUM!					260	#NUM!	#NUM!
270	281	#NUM!	#NUM!					270	#NUM!	#NUM!
280	296	#NUM!	#NUM!					280	#NUM!	#NUM!
290	310	#NUM!	#NUM!					290	#NUM!	#NUM!
300	323	#NUM!	#NUM!					300	#NUM!	#NUM!
310	335	#NUM!	#NUM!					310	#NUM!	#NUM!
320	347	#NUM!	#NUM!					320	#NUM!	#NUM!
330	358	#NUM!	#NUM!					330	#NUM!	#NUM!
340	368	#NUM!	#NUM!					340	#NUM!	#NUM!
350	378	#NUM!	#NUM!					350	#NUM!	#NUM!
360	387	#NUM!	#NUM!					360	#NUM!	#NUM!

Sample # =	PF-5		Sample # =	PF-5		Sample # =	PF-5	
Point # =	1		Point # =	2		Point # =	3	
	Initial			**Initial**			**Initial**	
Length =	14.74	cm	Length =	14.80	cm	Length =	14.75	cm
Diameter =	7.30	cm	Diameter =	7.30	cm	Diameter =	7.30	cm
Wet Weight =	1287.10	g	Wet Weight =	1286.90	g	Wet Weight =	1287.60	g
Area =	41.9	sq.cm	Area =	41.9	sq.cm	Area =	41.9	sq.cm
Sample Area =	6.49	sq. in.	Sample Area =	6.49	sq. in.	Sample Area =	6.49	sq. in.
Volume =	616.9	cc	Volume =	619.4	cc	Volume =	617.3	cc
Moisture Content =	12.1%		Moisture Content =	12.1%		Moisture Content =	12.1%	
Specific Gravity =	na		Specific Gravity =	na		Specific Gravity =	na	
Dry Weight of Solids =	1148.17	g	Dry Weight of Solids =	1147.99	g	Dry Weight of Solids =	1148.62	g
Wet Density =	2.09	g/cc	Wet Density =	2.08	g/cc	Wet Density =	2.09	g/cc
Dry Density =	1.86	g/cc	Dry Density =	1.85	g/cc	Dry Density =	1.86	g/cc
Wet Density =	130.2	pcf	Wet Density =	129.6	pcf	Wet Density =	130.2	pcf
Dry Density =	116.1	pcf	Dry Density =	115.6	pcf	Dry Density =	116.1	pcf
Cell Pressure =	100	psi	Cell Pressure =	100	psi	Cell Pressure =	100	psi
Back Pressure =	97	psi	Back Pressure =	94	psi	Back Pressure =	91	psi
Confining Pressure =	3	psi	Confining Pressure =	6	psi	Confining Pressure =	9	psi

Notes:
1. Sample remolded to 95% of corrected maximum dry density (121.9 pcf) and +2% of corrected optimum moisture content (10.8%).
2. Yellowish brown (10 YR 5/8) clayey sand with gravel (SC).

Golder Associates, Inc. **Denver, Colorado**	Title: **TRIAXIAL SHEAR TEST REPORT** **SAMPLE DATA AND CALCULATIONS**			
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO				
Sample No. **PF-5**	Reviewed: JEO	Date: 8/8/2004	Job Number: 043-2246.0001	Figure: 1

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

PROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER	043-2246-0001
SAMPLE ID	PF - 4
SAMPLE TYPE	Bulk
DEPTH INTERVAL	-
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.10
CELL PRESSURE (psi)	89.0
SAMPLE PRESSURE (psi)	80.0
EFF. CONSOLIDATION PRESSURE, σ_3 (psi)	9.0
PRESSURE, σ_3 (psf)	1296.0
FINAL "B" VALUE	0.97
t_{50} (minutes)	0.43

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.253	6.005	5.981
DIAMETER	7.087	2.790	2.778
AREA	39.44	6.11	6.06
VOLUME	601.61	36.71	36.24
WEIGHT (g)	1266.20		1296.50
% MOISTURE	12.6		15.32
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	131.3		
DRY DENSITY, calc (pcf)	116.6		
VOLUME OF SOLIDS	416.38		
VOLUME OF VOIDS	185.23		
VOID RATIO	0.445		
SATURATION	76.7		

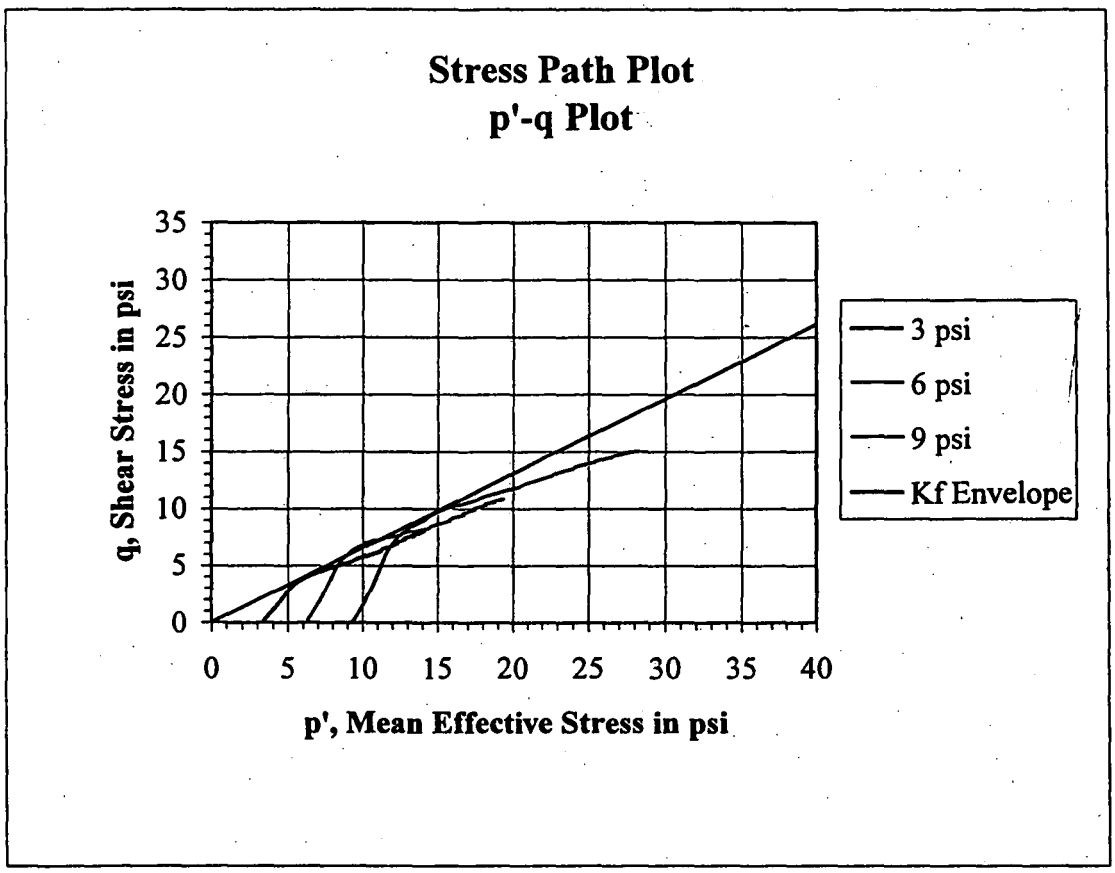
CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	118.1
VOLUME OF SOLIDS	416.38
VOLUME OF VOIDS	177.53
VOID RATIO	0.426

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1296.50
WT SOIL & TARE, DRY (g)	1124.22
WT TARE (g)	0.00
WT MOISTURE (g)	172.28
WT DRY SOIL (g)	1124.22
% MOISTURE	15.32

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	13	80.8	0.0	0.00	1.00	6.06	5.981	0.0	1296.0	1296.0	1296.0	1.00	1296.0	0.0	0
0.5	0.003	37	82.5	244.8	0.05	1.00	6.06	5.978	562.9	1858.9	1614.1	1051.2	1.54	1332.7	281.5	0.43
1.0	0.006	49	83.1	331.2	0.10	1.00	6.07	5.975	849.9	2145.9	1814.7	964.8	1.88	1389.7	424.9	0.39
1.5	0.009	59	83.7	417.6	0.15	1.00	6.07	5.972	1091.5	2387.5	1969.9	878.4	2.24	1424.1	545.7	0.38
1.8	0.011	67	84.1	475.2	0.18	1.00	6.07	5.970	1283.3	2579.3	2104.1	820.8	2.56	1462.4	641.6	0.37
2.3	0.014	74	84.4	518.4	0.23	1.00	6.07	5.967	1434.4	2730.4	2212.0	777.6	2.84	1494.8	717.2	0.36
4.0	0.024	89	84.8	576.0	0.40	1.00	6.08	5.957	1791.7	3087.7	2511.7	720.0	3.49	1615.9	895.9	0.32
7.8	0.047	112	84.4	518.4	0.79	0.99	6.11	5.934	2327.1	3623.1	3104.7	777.6	3.99	1941.1	1163.5	0.22
12.2	0.073	116	83.9	446.4	1.22	0.99	6.13	5.908	2417.8	3713.8	3267.4	849.6	3.85	2058.5	1208.9	0.18
15.5	0.093	117	83.8	432.0	1.55	0.98	6.16	5.888	2426.0	3722.0	3290.0	864.0	3.81	2077.0	1213.0	0.18
20.3	0.122	117	83.7	417.6	2.04	0.98	6.19	5.859	2416.4	3712.4	3294.8	878.4	3.75	2086.6	1208.2	0.17
24.8	0.149	117	83.7	417.6	2.49	0.98	6.21	5.832	2409.9	3705.9	3288.3	878.4	3.74	2083.3	1204.9	0.17
28.7	0.172	117	83.7	417.6	2.88	0.97	6.24	5.809	2402.7	3698.7	3281.1	878.4	3.74	2079.7	1201.3	0.17
33.0	0.198	118	83.7	417.6	3.31	0.97	6.27	5.783	2394.2	3690.2	3272.6	878.4	3.73	2075.5	1197.1	0.17
36.2	0.217	118	83.7	417.6	3.63	0.96	6.29	5.764	2400.1	3696.1	3278.5	878.4	3.73	2078.5	1200.1	0.17
45.5	0.273	119	83.7	417.6	4.56	0.95	6.35	5.708	2399.5	3695.5	3277.9	878.4	3.73	2078.1	1199.7	0.17
53.8	0.323	121	83.7	417.6	5.40	0.95	6.41	5.658	2418.9	3714.9	3297.3	878.4	3.75	2087.9	1209.5	0.17
62.2	0.373	123	83.7	417.6	6.24	0.94	6.46	5.608	2446.6	3742.6	3325.0	878.4	3.79	2101.7	1223.3	0.17
70.3	0.422	125	83.6	403.2	7.06	0.93	6.52	5.559	2462.7	3758.7	3355.5	892.8	3.76	2124.2	1231.4	0.16
78.0	0.468	128	83.5	388.8	7.82	0.92	6.57	5.513	2508.1	3804.1	3415.3	907.2	3.76	2161.2	1254.0	0.16
87.2	0.523	130	83.5	388.8	8.74	0.91	6.64	5.458	2537.3	3833.3	3444.5	907.2	3.80	2175.8	1268.6	0.15
95.5	0.573	132	83.4	374.4	9.58	0.90	6.70	5.408	2557.0	3853.0	3478.6	921.6	3.77	2200.1	1278.5	0.15
104.0	0.624	135	83.3	360.0	10.43	0.90	6.77	5.357	2586.1	3882.1	3522.1	936.0	3.76	2229.0	1293.0	0.14
112.5	0.675	138	83.1	331.2	11.29	0.89	6.83	5.306	2618.4	3914.4	3583.2	964.8	3.71	2274.0	1309.2	0.13
119.7	0.718	140	83.0	316.8	12.00	0.88	6.89	5.263	2643.2	3939.2	3622.4	979.2	3.70	2300.8	1321.6	0.12
129.0	0.774	142	82.9	302.4	12.94	0.87	6.96	5.207	2668.8	3964.8	3662.4	993.6	3.69	2328.0	1334.4	0.11
137.3	0.824	145	82.7	273.6	13.78	0.86	7.03	5.157	2692.4	3988.4	3714.8	1022.4	3.63	2368.6	1346.2	0.10
145.8	0.875	147	82.7	273.6	14.63	0.85	7.10	5.106	2712.4	4008.4	3734.8	1022.4	3.65	2378.6	1356.2	0.10
154.3	0.926	150	82.6	259.2	15.48	0.85	7.17	5.055	2753.6	4049.6	3790.4	1036.8	3.66	2413.6	1376.8	0.09
161.7	0.970	152	82.5	244.8	16.22	0.84	7.23	5.011	2763.5	4059.5	3814.7	1051.2	3.63	2433.0	1381.8	0.09

DU @ FAILURE	518.4	DEVIATORIC STRESS @ FAILURE	2327.1	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	3.99

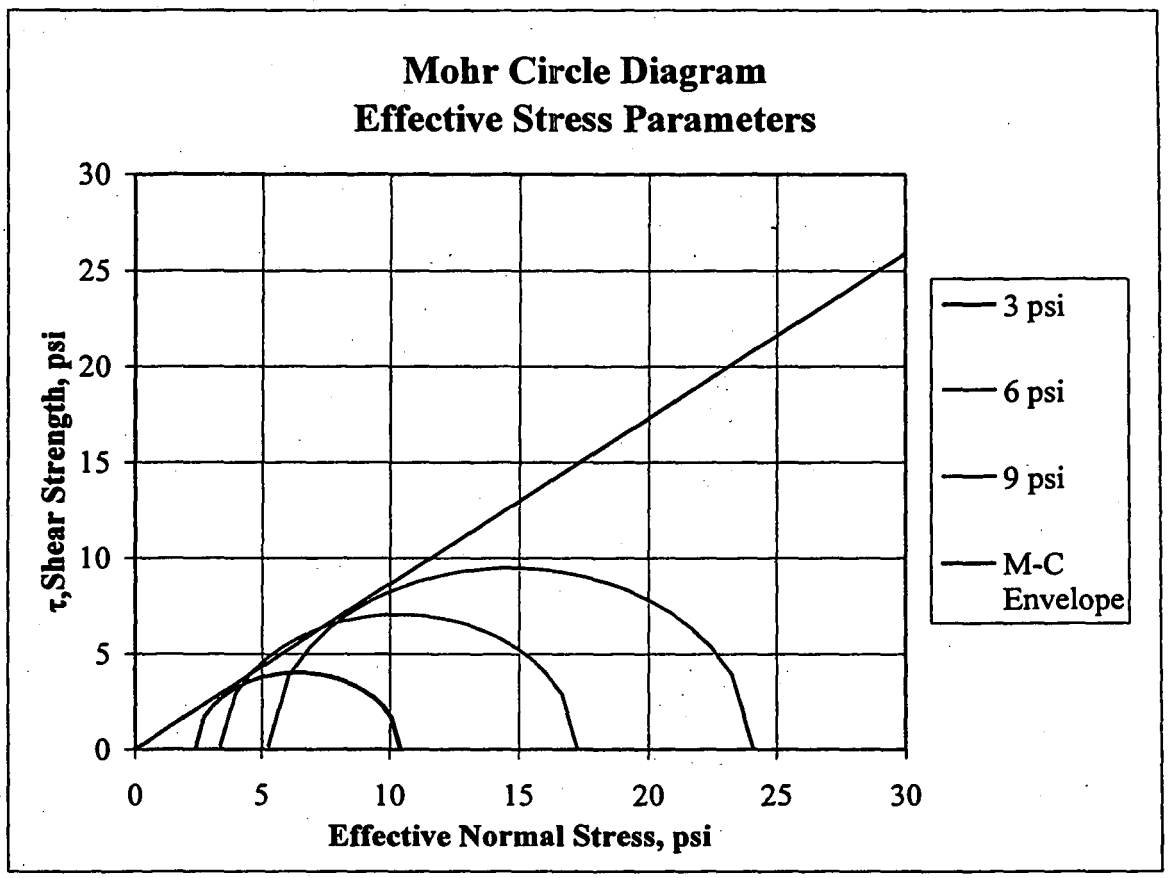
TECH	PWM/SDM
DATE	8/5/2004
CHECKED	
REVIEWED	



Stress Path Parameters

ψ' = 33.2 degrees
a' = 0.0 psi

Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA STRESS PATH PLOT			
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO				
Sample No. PF-5	Reviewed: JEO	Date: 8/8/2004	Job Number: 043-2246.0001	Figure: 3



Mohr-Coulomb Parameters

$\phi' =$ 40.8 degrees
$c' =$ 0.0 psi

Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA MOHR CIRCLE DIAGRAM				
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO					
Sample No. PF-5	Depth	Reviewed: JEO	Date: 8/8/2004	Job Number: 043-2246.0001	Figure: 4

Consolidated Undrained Triaxial Lab Data

From: GOLDER ASSOCIATES INC.

Project: ROCKY FLATS/FIELD & LAB TESTING/CO

Project Number: 043-2246.0001

Sample Number	PF-5
Depth	
Effective Stress Analysis	

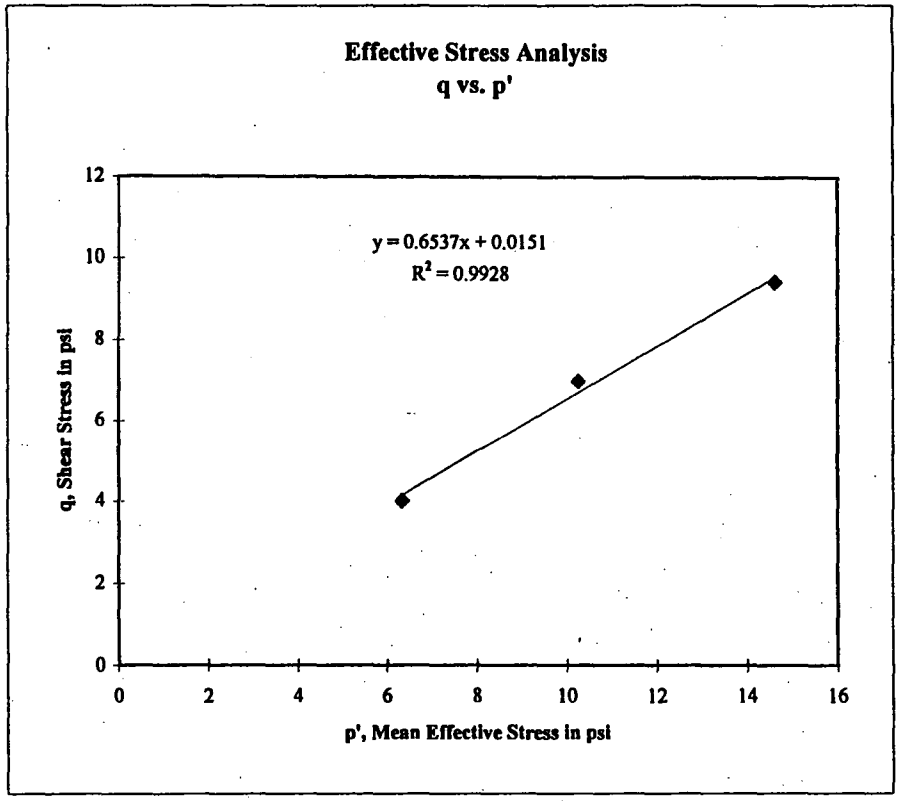
Point Number	P' (psi)	q (psi)
1	6.3	4.0
2	10.3	7.0
3	14.6	9.4

$\tan(\psi') =$ 0.6537

$a' =$ 0.0151

$\phi' =$ 40.8 degrees

$c' =$ 0.0 psi



Consolidated Undrained Triaxial Lab Data

From: GOLDER ASSOCIATES INC.

Project: **ROCKY FLATS/FIELD & LAB TESTING/CO**

Project Number: **043-2246.0001**

Sample Number	PF-5
Depth	
Total Stress Analysis	

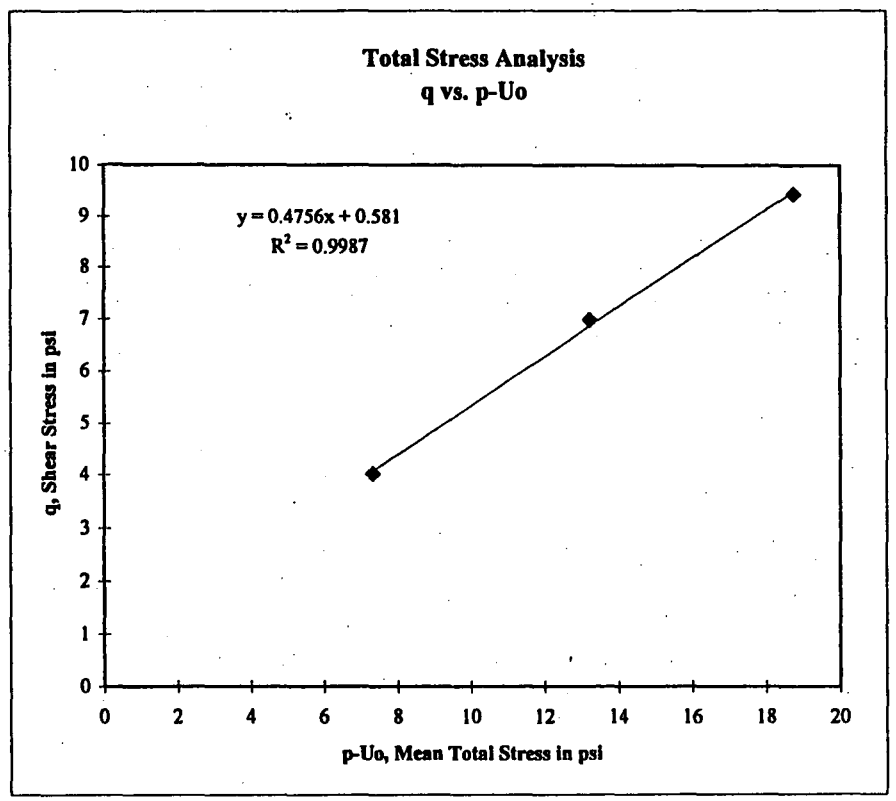
Point Number	P-Uo (psi)	q (psi)
1	7.3	4.0
2	13.2	7.0
3	18.8	9.4

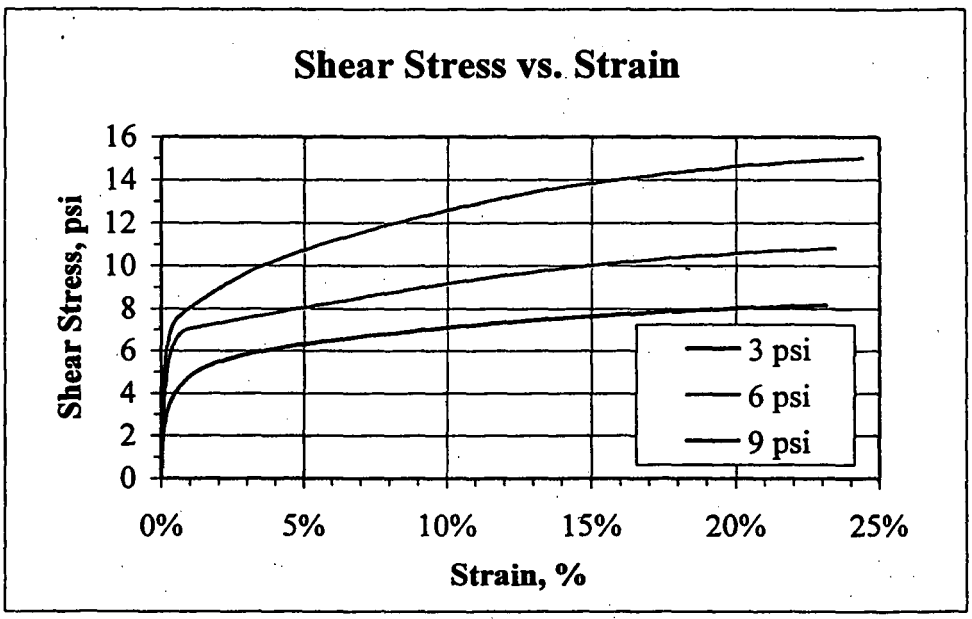
$\tan(\psi) =$ 0.4756

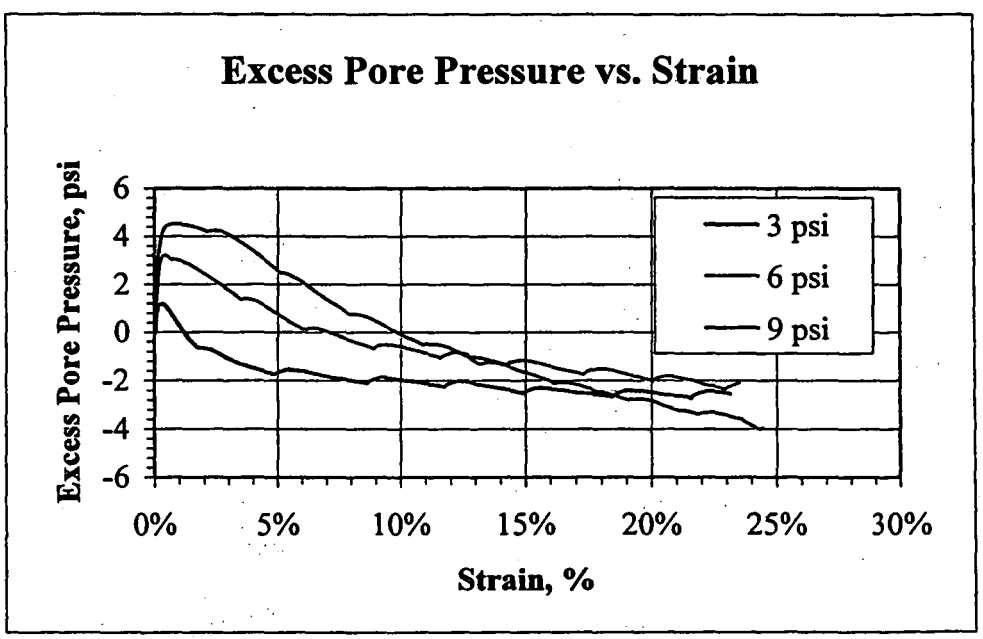
a = 0.581

$\phi =$ 28.4 degrees

c = 0.7 psi





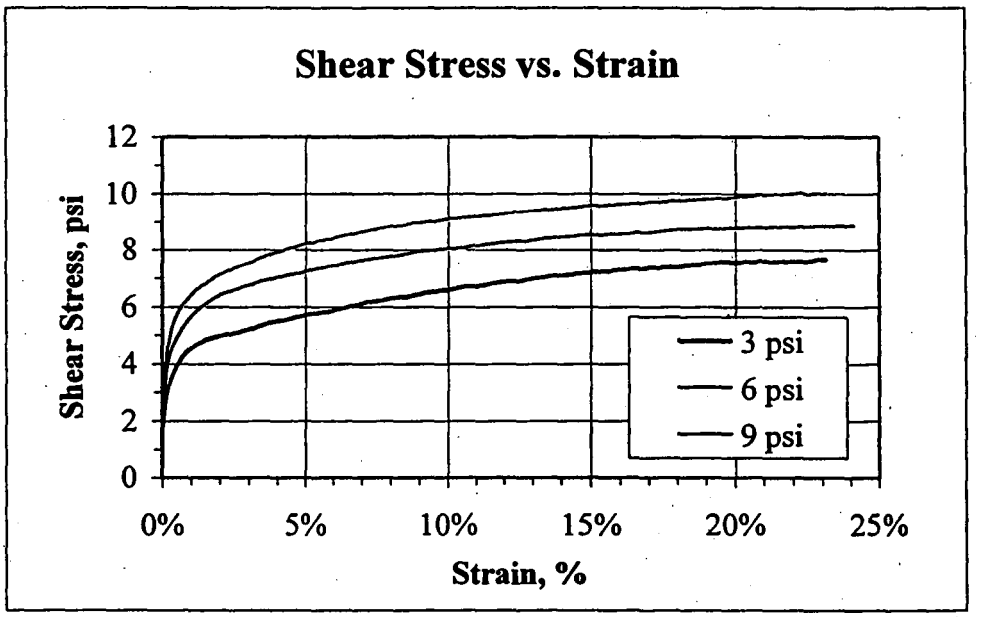


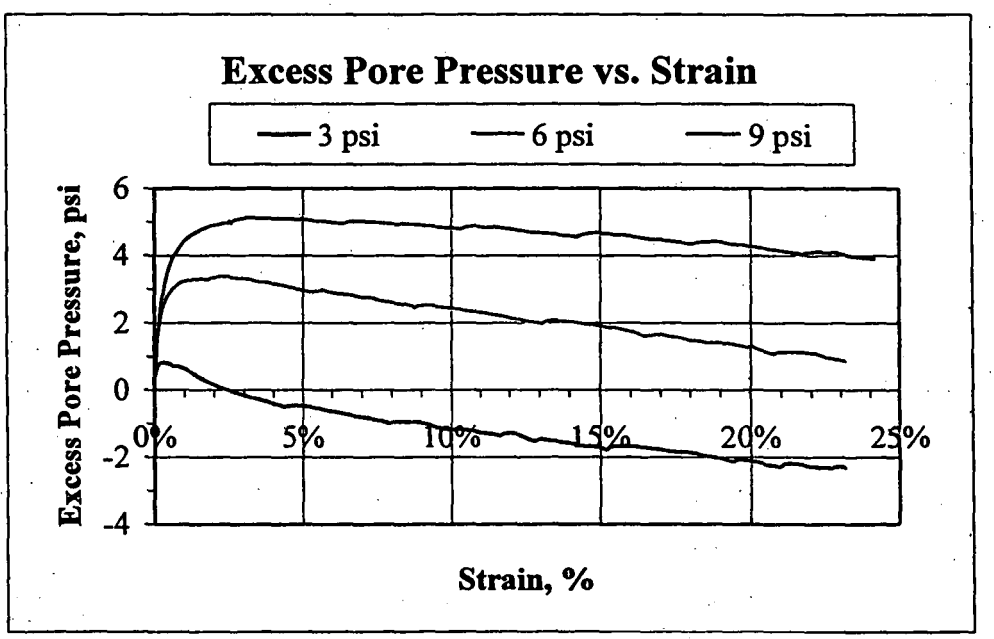
Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA STRESS AND Δ PORE PRESSURE PLOTS			
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO				
Sample No. PF-5	Reviewed: JEO	Date: 08/08/04	Job Number: 043-2246.0001	Figure: 2

Sample # =	PF-6		Sample # =	PF-6		Sample # =	PF-6	
Point # =	1		Point # =	2		Point # =	3	
	Initial			Initial			Initial	
Length =	14.68	cm	Length =	14.68	cm	Length =	14.83	cm
Diameter =	7.30	cm	Diameter =	7.30	cm	Diameter =	7.30	cm
Wet Weight =	1291.00	g	Wet Weight =	1290.50	g	Wet Weight =	1294.00	g
Area =	41.9	sq.cm	Area =	41.9	sq.cm	Area =	41.9	sq.cm
Sample Area =	6.49	sq. in.	Sample Area =	6.49	sq. in.	Sample Area =	6.49	sq. in.
Volume =	614.4	cc	Volume =	614.4	cc	Volume =	620.7	cc
Moisture Content =	14.0%		Moisture Content =	14.0%		Moisture Content =	14.0%	
Specific Gravity =	na		Specific Gravity =	na		Specific Gravity =	na	
Dry Weight of Solids =	1132.46	g	Dry Weight of Solids =	1132.02	g	Dry Weight of Solids =	1135.09	g
Wet Density =	2.10	g/cc	Wet Density =	2.10	g/cc	Wet Density =	2.08	g/cc
Dry Density =	1.84	g/cc	Dry Density =	1.84	g/cc	Dry Density =	1.83	g/cc
Wet Density =	131.1	pcf	Wet Density =	131.1	pcf	Wet Density =	130.1	pcf
Dry Density =	115.0	pcf	Dry Density =	115.0	pcf	Dry Density =	114.1	pcf
Cell Pressure =	100	psi	Cell Pressure =	100	psi	Cell Pressure =	100	psi
Back Pressure =	97	psi	Back Pressure =	94	psi	Back Pressure =	91	psi
Confining Pressure =	3	psi	Confining Pressure =	6	psi	Confining Pressure =	9	psi

Notes:
1. Sample remolded to 95% of maximum dry density (120.3 pcf) and +2% of optimum (12.5%) moisture content
2. Yellowish brown (10 YR 5/8) clayey sand with gravel SC

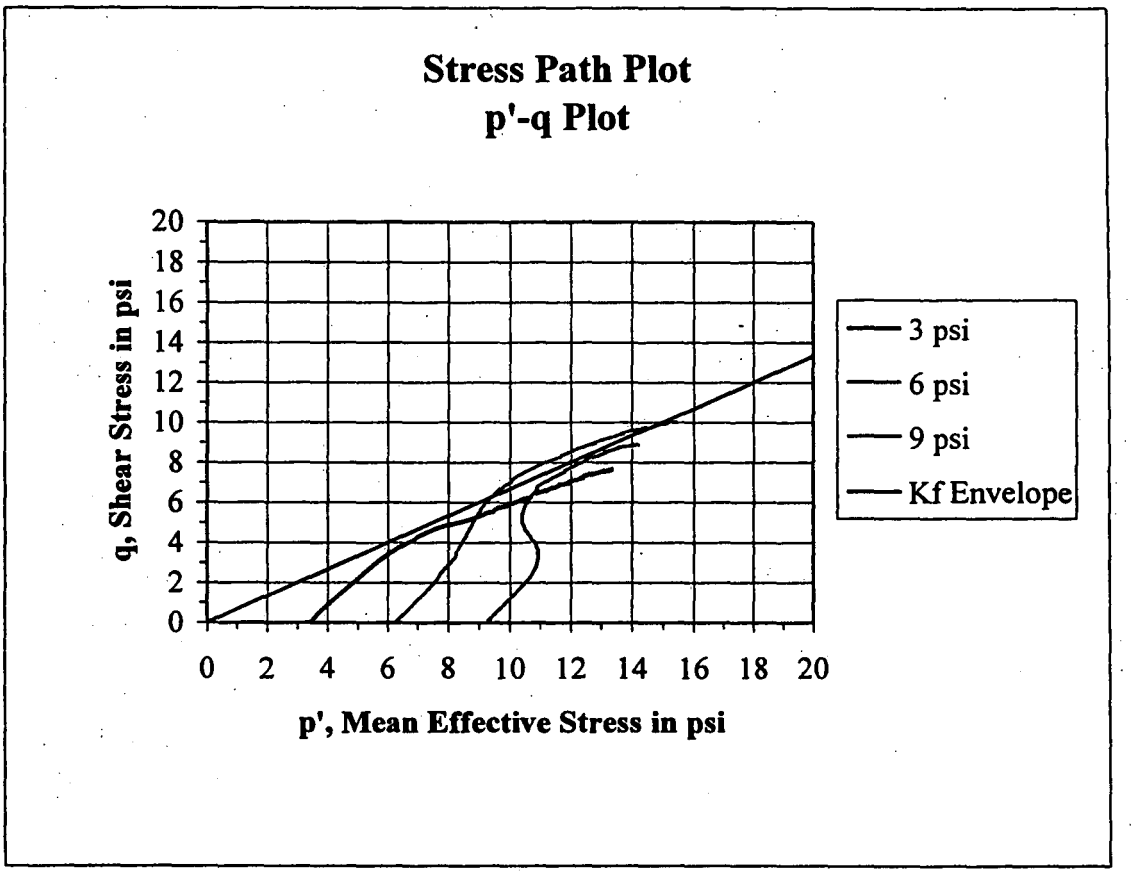
Golder Associates, Inc. **Denver, Colorado**	Title: **TRIAXIAL SHEAR TEST REPORT** **SAMPLE DATA AND CALCULATIONS**				
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO					
Sample No. **PF-6**	Reviewed: JEO	Date: 8/1/2004	Job Number: 043-2246.0001	Figure: 1	





Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA STRESS AND Δ PORE PRESSURE PLOTS
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO	

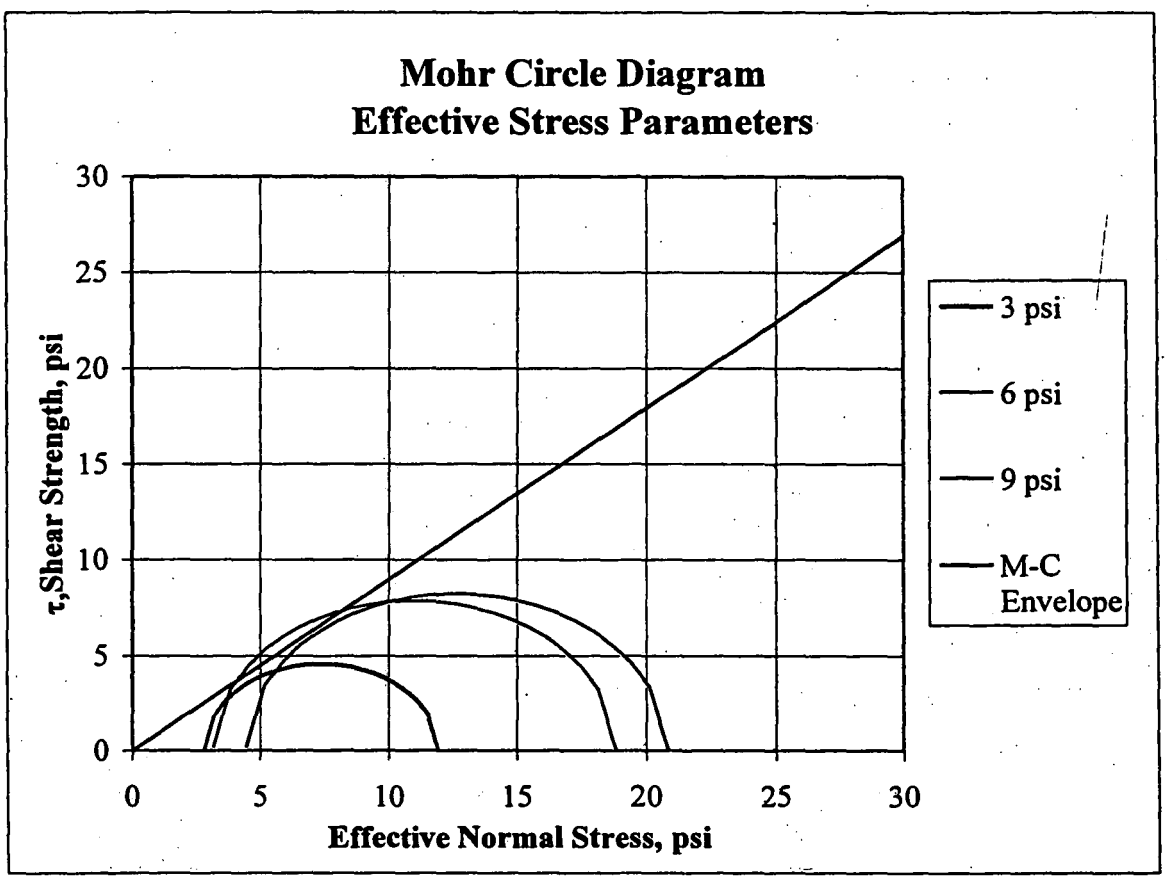
Sample No.	Reviewed:	Date:	Job Number:	Figure:
PF-6	JEO	08/01/04	043-2246.0001	2



Stress Path Parameters

ψ' = 33.7 degrees
a' = 0.0 psi

Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA STRESS PATH PLOT			
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO				
Sample No. PF-6	Reviewed: JEO	Date: 8/1/2004	Job Number: 043-2246.0001	Figure: 3



Mohr-Coulomb Parameters

$\phi' =$ 41.9 degrees
$c' =$ 0.0 psi

Golder Associates, Inc. Denver, Colorado	Title: CU TRIAXIAL SHEAR DATA MOHR CIRCLE DIAGRAM				
Job Short Title: ROCKY FLATS/FIELD & LAB TESTING/CO					
Sample No. PF-6	Depth 0	Reviewed: JEO	Date: 8/1/2004	Job Number: 043-2246.0001	Figure: 4

Consolidated Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: ROCKY FLATS/FIELD & LAB TESTING/CO
Project Number: 043-2246.0001
Explination of Terminology

Mohr-Coulomb Failure Criteria:

$$\tau_{ff} = c' + \sigma_{ff}' \tan \phi'$$
$$\tau_{ff} = c + \sigma_{ff} \tan \phi$$

Where:
c', c = effective and total cohesive intercept
ϕ', ϕ = effective and total friction angle
τ^{ff} = Shear Strength on the failure surface at failure
σ'^{ff}, σ^{ff} = effective and total normal stress on the failure surface at failure

Stress Path Space:

$$q = \frac{\sigma_1 - \sigma_3}{2} \qquad p' = \frac{\sigma'_1 + \sigma'_3}{2} \qquad p = \frac{\sigma_1 + \sigma_3}{2}$$

Where:
q = shear stress
p', p = mean effective and total stress
σ'^1, σ^1 = Effective and Total Axial Stress
σ'^3, σ^3 = Effective and Total Confining Stress

$$q = a + p' \tan \psi$$
$$q = a + (p - u_0) \tan \psi$$

Where:
a', a = intercept of the q-axis in effective stress of total stress space
ψ', ψ = angle of the failure line in effective stress of total stress space
p' = mean effective stress
p-Uo = mean total minus the initial pore pressure

with the relationship between ψ and ϕ and a and c are as follows:

$$\tan(\psi) = \sin(\phi)$$

$$a = c * \cos(\phi)$$

Consolidated Undrained Triaxial Lab Data

From: GOLDER ASSOCIATES INC.

Project: **ROCKY FLATS/FIELD & LAB TESTING/CO**

Project Number: **043-2246.0001**

Sample Number	PF-6
Depth	
Total Stress Analysis	

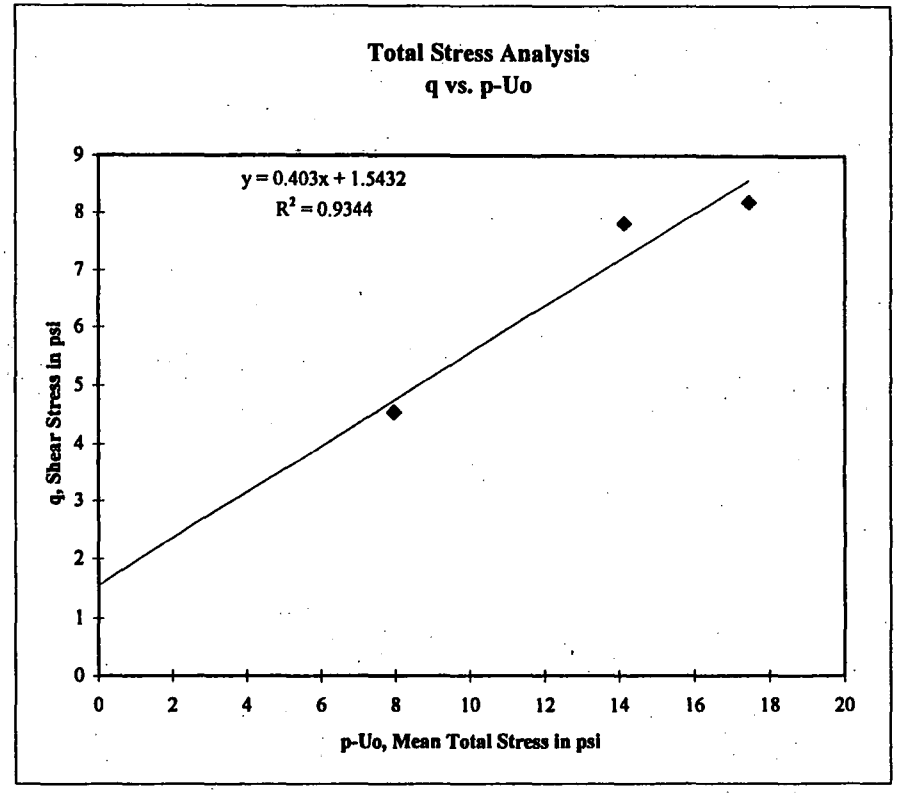
Point Number	P-Uo (psi)	q (psi)
1	8.0	4.6
2	14.1	7.8
3	17.4	8.2

$\tan(\psi) =$ 0.403

a = 1.5432

$\phi =$ 23.8 degrees

c = 1.7 psi



Consolidated Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: **ROCKY FLATS/FIELD & LAB TESTING/CO**
Project Number: 043-2246.0001
Explination of Terminology

Mohr-Coulomb Failure Criteria:

$$\tau_{ff} = c' + \sigma_{ff}' \tan\phi'$$
$$\tau_{ff} = c + \sigma_{ff} \tan\phi$$

Where:
c', c = effective and total cohesive intercept
ϕ', ϕ = effective and total friction angle
τ^{ff} = Shear Strength on the failure surface at failure
σ'^{ff}, σ^{ff} = effective and total normal stress on the failure surface at failure

Stress Path Space:

$$q = \frac{\sigma_1 - \sigma_3}{2} \qquad p' = \frac{\sigma'_1 + \sigma'_3}{2} \qquad p = \frac{\sigma_1 + \sigma_3}{2}$$

Where:
q = shear stress
p', p = mean effective and total stress
σ'^1, σ^1 = Effective and Total Axial Stress
σ'^3, σ^3 = Effective and Total Confining Stress

$$q = a + p' \tan\psi$$
$$q = a + (p - u_0) \tan\psi$$

Where:
a', a = intercept of the q-axis in effective stress of total stress space
ψ', ψ = angle of the failure line in effective stress of total stress space
p' = mean effective stress
p-Uo = mean total minus the initial pore pressure

with the relationship between ψ and ϕ and a and c are as follows:

$$\tan(\psi) = \sin(\phi)$$

$$a = c * \cos(\phi)$$

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

PROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER	043-2246-0001
SAMPLE ID	PF - 7
SAMPLE TYPE	Bulk
DEPTH INTERVAL	-
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.10
CELL PRESSURE (psi)	83.0
SAMPLE PRESSURE (psi)	80.0
EFF. CONSOLIDATION PRESSURE, σ_3 (psi)	3.0
PRESSURE, σ_3 (psf)	432.0
FINAL "B" VALUE	0.98
t_{50} (minutes)	0.15

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.248	6.003	5.983
DIAMETER	7.087	2.790	2.788
AREA	39.44	6.11	6.11
VOLUME	601.41	36.70	36.54
WEIGHT (g)	1285.27		1312.57
% MOISTURE	12.3		14.66
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	133.4		
DRY DENSITY, calc (pcf)	118.8		
VOLUME OF SOLIDS	423.99		
VOLUME OF VOIDS	177.41		
VOID RATIO	0.418		
SATURATION	79.2		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	119.3
VOLUME OF SOLIDS	423.99
VOLUME OF VOIDS	174.71
VOID RATIO	0.412

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1312.57
WT SOIL & TARE, DRY (g)	1144.78
WT TARE (g)	0.00
WT MOISTURE (g)	167.79
WT DRY SOIL (g)	1144.78
% MOISTURE	14.66

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	17	79.9	0.0	0.00	1.00	6.11	5.983	0.0	432.0	432.0	432.0	1.00	432.0	0.0	0.00
0.5	0.003	33	80.8	129.6	0.05	1.00	6.11	5.980	377.1	809.1	679.5	302.4	2.25	491.0	188.6	0.34
1.0	0.006	40	81.0	158.4	0.10	1.00	6.11	5.977	541.8	973.8	815.4	273.6	2.98	544.5	270.9	0.29
1.5	0.009	45	81.2	187.2	0.15	1.00	6.12	5.974	659.3	1091.3	904.1	244.8	3.69	574.4	329.6	0.28
2.0	0.012	50	81.3	201.6	0.20	1.00	6.12	5.971	776.6	1208.6	1007.0	230.4	4.37	618.7	388.3	0.26
2.5	0.015	53	81.3	201.6	0.25	1.00	6.12	5.968	846.8	1278.8	1077.2	230.4	4.68	653.8	423.4	0.24
4.2	0.025	65	81.2	187.2	0.42	1.00	6.13	5.958	1127.2	1559.2	1372.0	244.8	5.60	808.4	563.6	0.17
8.3	0.050	89	80.2	43.2	0.84	0.99	6.16	5.933	1683.7	2115.7	2072.5	388.8	5.33	1230.6	841.8	0.03
12.5	0.075	102	79.2	-100.8	1.25	0.99	6.18	5.908	1979.3	2411.3	2512.1	532.8	4.71	1522.4	989.6	-0.05
16.7	0.100	107	78.8	-158.4	1.67	0.98	6.21	5.883	2086.9	2518.9	2677.3	590.4	4.53	1633.8	1043.4	-0.08
22.5	0.135	112	78.3	-230.4	2.26	0.98	6.25	5.848	2189.7	2621.7	2852.1	662.4	4.31	1757.2	1094.8	-0.11
25.0	0.150	115	78.0	-273.6	2.51	0.97	6.26	5.833	2253.0	2685.0	2958.6	705.6	4.19	1832.1	1126.5	-0.12
29.2	0.175	119	77.7	-316.8	2.92	0.97	6.29	5.808	2334.9	2766.9	3083.7	748.8	4.12	1916.3	1167.5	-0.14
33.3	0.200	122	77.5	-345.6	3.34	0.97	6.32	5.783	2393.3	2825.3	3170.9	777.6	4.08	1974.2	1196.6	-0.14
41.7	0.250	125	77.0	-417.6	4.18	0.96	6.37	5.733	2440.4	2872.4	3290.0	849.6	3.87	2069.8	1220.2	-0.17
52.5	0.315	129	76.9	-432.0	5.26	0.95	6.45	5.668	2502.1	2934.1	3366.1	864.0	3.90	2115.0	1251.0	-0.17
58.3	0.350	134	76.7	-460.8	5.85	0.94	6.49	5.633	2597.6	3029.6	3490.4	892.8	3.91	2191.6	1298.8	-0.18
66.7	0.400	137	76.5	-489.6	6.69	0.93	6.54	5.583	2640.6	3072.6	3562.2	921.6	3.87	2241.9	1320.3	-0.19
75.0	0.450	140	76.4	-504.0	7.52	0.92	6.60	5.533	2682.4	3114.4	3618.4	936.0	3.87	2277.2	1341.2	-0.19
83.3	0.500	142	76.3	-518.4	8.36	0.92	6.66	5.483	2701.3	3133.3	3651.7	950.4	3.84	2301.1	1350.7	-0.19
99.0	0.594	149	76.1	-547.2	9.93	0.90	6.78	5.389	2803.7	3235.7	3782.9	979.2	3.86	2381.1	1401.9	-0.20
100.0	0.600	149	76.0	-561.6	10.03	0.90	6.79	5.383	2800.6	3232.6	3794.2	993.6	3.82	2393.9	1400.3	-0.20
108.3	0.650	154	76.0	-561.6	10.86	0.89	6.85	5.333	2879.7	3311.7	3873.3	993.6	3.90	2433.4	1439.8	-0.20
116.7	0.700	157	75.9	-576.0	11.70	0.88	6.92	5.283	2915.1	3347.1	3923.1	1008.0	3.89	2465.6	1457.6	-0.20
125.0	0.750	159	75.8	-590.4	12.54	0.87	6.98	5.233	2928.8	3360.8	3951.2	1022.4	3.86	2486.8	1464.4	-0.20
133.3	0.800	162	75.7	-604.8	13.37	0.87	7.05	5.183	2962.1	3394.1	3998.9	1036.8	3.86	2517.8	1481.0	-0.20
141.7	0.850	164	75.7	-604.8	14.21	0.86	7.12	5.133	2974.0	3406.0	4010.8	1036.8	3.87	2523.8	1487.0	-0.20
150.0	0.900	167	75.6	-619.2	15.04	0.85	7.19	5.083	3005.1	3437.1	4056.3	1051.2	3.86	2553.8	1502.6	-0.21
158.3	0.950	171	75.5	-633.6	15.88	0.84	7.26	5.033	3054.9	3486.9	4120.5	1065.6	3.87	2593.1	1527.5	-0.21
166.7	1.000	172	75.4	-648.0	16.71	0.83	7.33	4.983	3044.2	3476.2	4124.2	1080.0	3.82	2602.1	1522.1	-0.21

DU @ FAILURE	187.20	DEVIATORIC STRESS @ FAILURE	1127.18	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	5.60

TECH	PWM/SDM
DATE	8/4/04
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 7
AMPLE TYPE	Bulk
EPTH INTERVAL	-
ACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	86.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	6.0
RESSURE, σ_3 (psf)	864.0
INAL "B" VALUE	0.99
$_{50}$ (minutes)	0.64

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.243	6.001	5.975
DIAMETER	7.087	2.790	2.781
AREA	39.44	6.11	6.07
VOLUME	601.21	36.69	36.30
WEIGHT (g)	1284.57		1308.17
% MOISTURE	12.3		14.36
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	133.3		
DRY DENSITY, calc (pcf)	118.7		
VOLUME OF SOLIDS	423.68		
VOLUME OF VOIDS	177.52		
VOID RATIO	0.419		
SATURATION	79.2		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	120.0
VOLUME OF SOLIDS	423.68
VOLUME OF VOIDS	171.12
VOID RATIO	0.404

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1308.17
WT SOIL & TARE, DRY (g)	1143.94
WT TARE (g)	0.00
WT MOISTURE (g)	164.23
WT DRY SOIL (g)	1143.94
% MOISTURE	14.36

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	20	80.8	0.0	0.00	1.00	6.07	5.975	0.0	864.0	864.0	864.0	1.00	864.0	0.0	0.00
0.5	0.003	43	82.3	216.0	0.05	1.00	6.08	5.972	544.9	1408.9	1192.9	648.0	1.84	920.5	272.5	0.40
1.0	0.006	52	82.6	259.2	0.10	1.00	6.08	5.969	757.8	1621.8	1362.6	604.8	2.25	983.7	378.9	0.34
1.5	0.009	58	82.8	288.0	0.15	1.00	6.08	5.966	899.4	1763.4	1475.4	576.0	2.56	1025.7	449.7	0.32
2.0	0.012	64	83.0	316.8	0.20	1.00	6.09	5.963	1040.9	1904.9	1588.1	547.2	2.90	1067.6	520.4	0.30
2.5	0.015	67	83.1	331.2	0.25	1.00	6.09	5.960	1111.3	1975.3	1644.1	532.8	3.09	1088.5	555.7	0.30
4.2	0.025	79	83.1	331.2	0.42	1.00	6.10	5.950	1392.7	2256.7	1925.5	532.8	3.61	1229.1	696.3	0.24
8.3	0.050	95	82.6	259.2	0.84	0.99	6.13	5.925	1762.9	2626.9	2367.7	604.8	3.91	1486.3	881.5	0.15
12.5	0.075	105	82.1	187.2	1.26	0.99	6.15	5.900	1989.6	2853.6	2666.4	676.8	3.94	1671.6	994.8	0.09
16.7	0.100	112	81.6	115.2	1.67	0.98	6.18	5.875	2144.3	3008.3	2893.1	748.8	3.86	1820.9	1072.1	0.05
20.8	0.125	115	81.5	100.8	2.09	0.98	6.20	5.850	2204.8	3068.8	2968.0	763.2	3.89	1865.6	1102.4	0.05
25.0	0.150	119	81.3	72.0	2.51	0.97	6.23	5.825	2287.8	3151.8	3079.8	792.0	3.89	1935.9	1143.9	0.03
29.2	0.175	122	81.1	43.2	2.93	0.97	6.26	5.800	2347.0	3211.0	3167.8	820.8	3.86	1994.3	1173.5	0.02
33.3	0.200	125	81.0	28.8	3.35	0.97	6.29	5.775	2405.6	3269.6	3240.8	835.2	3.88	2038.0	1202.8	0.01
41.7	0.250	129	80.8	0.0	4.18	0.96	6.34	5.725	2475.7	3339.7	3339.7	864.0	3.87	2101.8	1237.8	0.00
50.0	0.300	134	80.5	-43.2	5.02	0.95	6.40	5.675	2566.6	3430.6	3473.8	907.2	3.83	2190.5	1283.3	-0.02
58.3	0.350	137	80.3	-72.0	5.86	0.94	6.45	5.625	2610.9	3474.9	3546.9	936.0	3.79	2241.5	1305.5	-0.03
66.7	0.400	142	80.1	-100.8	6.69	0.93	6.51	5.575	2698.3	3562.3	3663.1	964.8	3.80	2314.0	1349.2	-0.04
75.0	0.450	145	80.0	-115.2	7.53	0.92	6.57	5.525	2739.9	3603.9	3719.1	979.2	3.80	2349.1	1369.9	-0.04
83.3	0.500	149	79.8	-144.0	8.37	0.92	6.63	5.475	2802.0	3666.0	3810.0	1008.0	3.78	2409.0	1401.0	-0.05
91.7	0.550	155	79.6	-172.8	9.21	0.91	6.69	5.425	2905.5	3769.5	3942.3	1036.8	3.80	2489.6	1452.8	-0.06
100.0	0.600	160	79.4	-201.6	10.04	0.90	6.75	5.375	2985.3	3849.3	4050.9	1065.6	3.80	2558.3	1492.7	-0.07
110.0	0.660	164	79.3	-216.0	11.05	0.89	6.83	5.315	3036.4	3900.4	4116.4	1080.0	3.81	2598.2	1518.2	-0.07
116.7	0.700	167	79.1	-244.8	11.72	0.88	6.88	5.275	3076.3	3940.3	4185.1	1108.8	3.77	2646.9	1538.1	-0.08
125.0	0.750	172	78.8	-288.0	12.55	0.87	6.95	5.225	3150.8	4014.8	4302.8	1152.0	3.74	2727.4	1575.4	-0.09
133.3	0.800	176	78.7	-302.4	13.39	0.87	7.01	5.175	3202.8	4066.8	4369.2	1166.4	3.75	2767.8	1601.4	-0.09
143.7	0.862	179	78.5	-331.2	14.43	0.86	7.10	5.113	3225.2	4089.2	4420.4	1195.2	3.70	2807.8	1612.6	-0.10
150.0	0.900	182	78.4	-345.6	15.06	0.85	7.15	5.075	3261.7	4125.7	4471.3	1209.6	3.70	2840.4	1630.8	-0.11
158.3	0.950	186	78.2	-374.4	15.90	0.84	7.22	5.025	3309.3	4173.3	4547.7	1238.4	3.67	2893.0	1654.6	-0.11
166.7	1.000	189	78.2	-374.4	16.74	0.83	7.30	4.975	3335.6	4199.6	4574.0	1238.4	3.69	2906.2	1667.8	-0.11

DU @ FAILURE	187.2	DEVIATORIC STRESS @ FAILURE	1989.6	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	3.94

TECH	PWM/SDM
DATE	8/4/2004
CHECKED	
REVIEWED	

Consolidated Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.

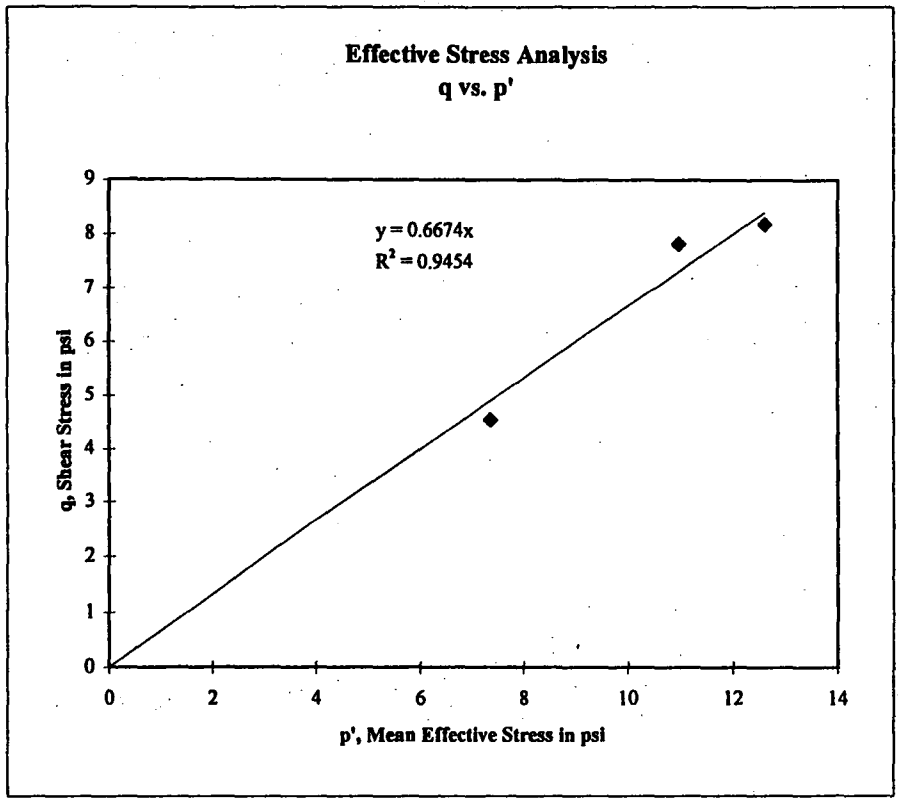
Project: ROCKY FLATS/FIELD & LAB TESTING/CO
Project Number: 043-2246.0001

Sample Number	PF-6
Depth	
Effective Stress Analysis	

Point Number	P' (psi)	q (psi)
1	7.4	4.6
2	11.0	7.8
3	12.6	8.2

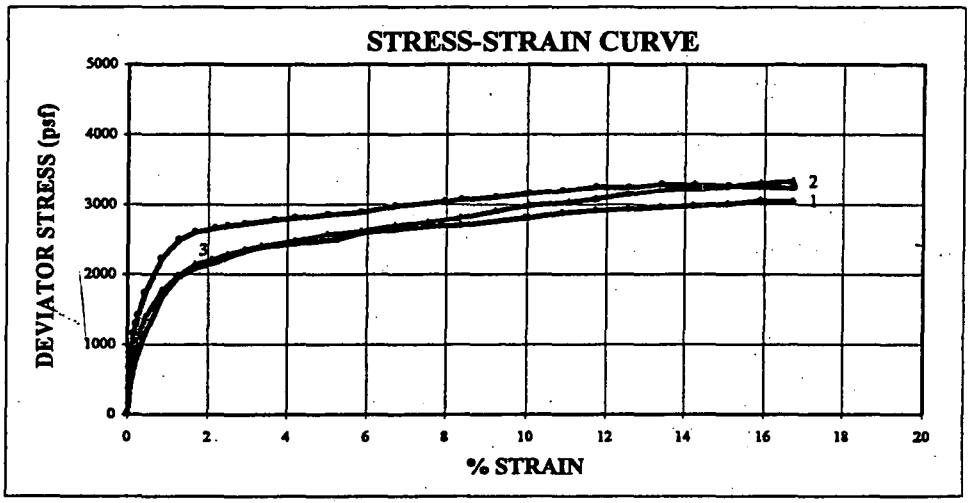
tan(ψ') = 0.6674
a' =

ϕ' = 41.9 degrees
c' = 0.0 psi

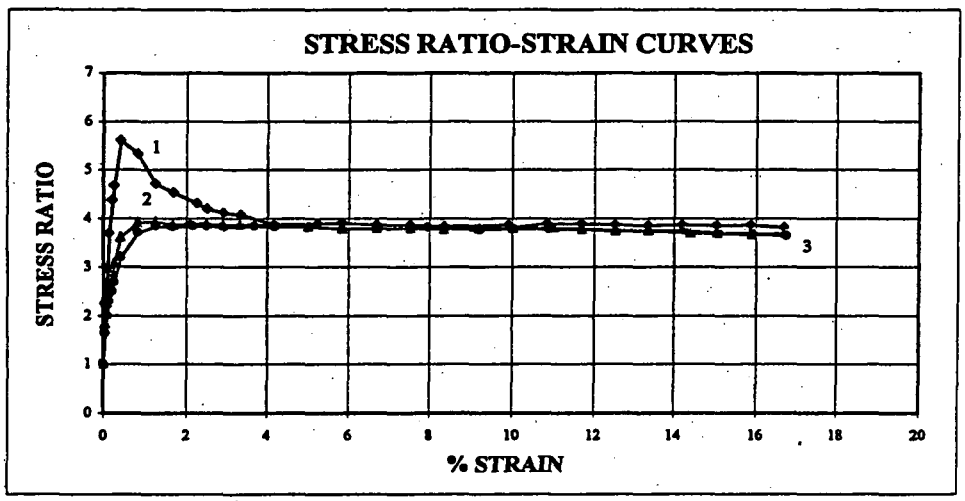


TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

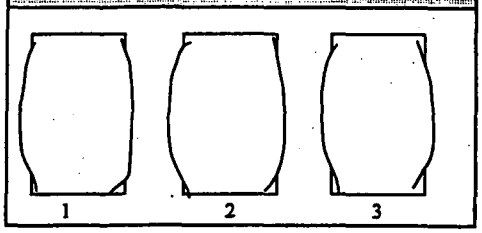
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 7 DEPTH: - Sample Type: Bulk

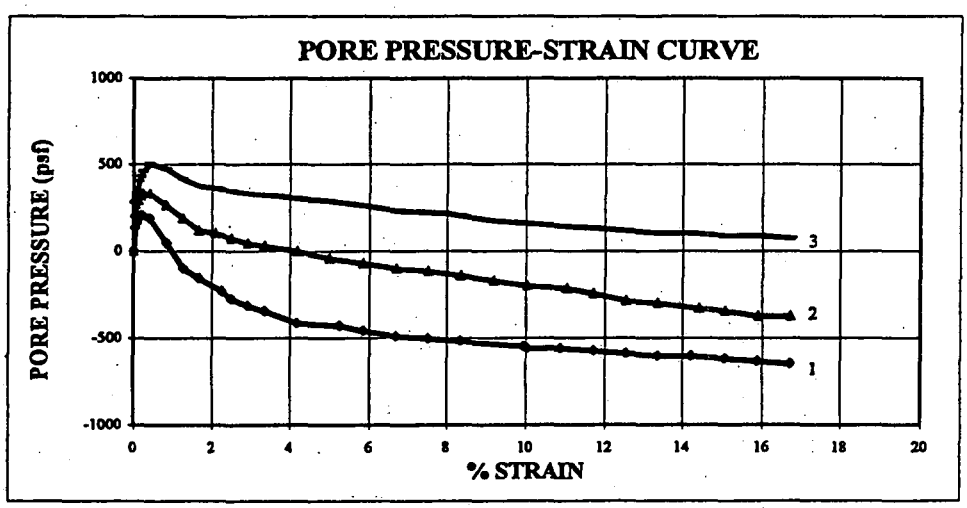


Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	118.8	12.3
2	864	118.7	12.3
3	1296	118.7	12.2
	Average	118.7	12.3



FAILURE SKETCH





Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

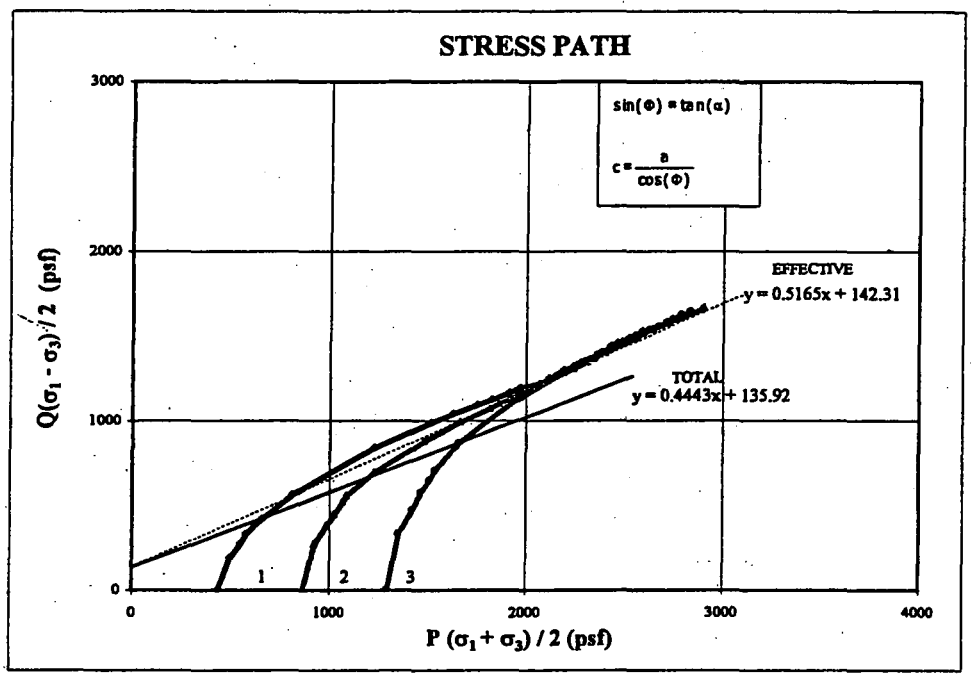
Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

* Failure based on effective stress ratio or 15% strain.

CHECK
REVIEW

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

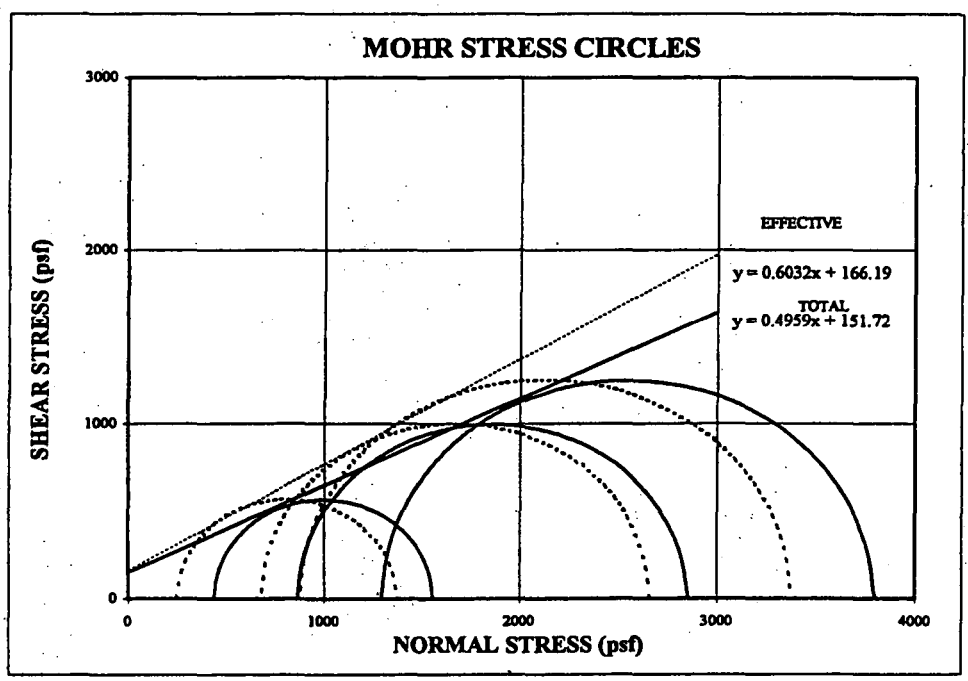
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 7 DEPTH: - Sample Type: Bulk



Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	118.8	12.3
2	864	118.7	12.3
3	1296	118.7	12.2

Specimen	Strain Rate (%)	Initial Saturation (%)	Saturation Before Shearing (%)
1	0.10	79.2	96.0
2	0.10	79.2	96.0
3	0.10	78.7	95.5

STRESS PATH			MOHR CIRCLES		
*TOTAL STRESS PARAMETER			*TOTAL STRENGTH PARAMETER		
α	=	24.0 °	ϕ	=	26.4 °
a	=	135.9 psf	c	=	151.7 psf
* EFFECTIVE STRESS PARAMETER			*EFFECTIVE STRENGTH PARAMETER		
α'	=	27.3 °	ϕ'	=	31.1 °
a'	=	142.3 psf	c'	=	166.2 psf



Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

*** Failure based on effective stress ratio or 15% strain.**

CHECK
REVIEW

CONSOLIDATED UNDRAINED TRIAXIAL STRENGTH								CONSOLIDATED UNDRAINED TRI		
MOHR CIRCLE GENERATION SPREADSHEET								MOHR CIRCLE GENERATION SPRE		
	PF - 7	-	B	C	A				PF - 7	-
CONFINING PRESSURE USED (S3)			432	864	1296	psf		CONFINING PRESSURE USED (S3)		
CONFINING PRESSURE USED (S3)			432	864	1296	psi		CONFINING PRESSURE USED (S3)		
MAXIMUM DEVIATOR STRESS (PS			1127.2	1989.6	2494.8	psf		MAXIMUM DEVIATOR STRESS (PS		
(or load at 15% strain)								(or load at 15% strain)		
dU AT FAIL	(S1-S3)/2	(S1'+S3')/2		coh	sin phi	phi		dU AT FAIL	(S1-S3)/2	(S1'+S3')/2
187.2	563.6	808.4	COH 1&2	160	0.499535201	30		187.2	563.6	995.6
187.2	994.8	1671.6	COH 1&3	140	0.519057351	31		187.2	994.8	1858.8
417.6	1247.4	2125.8	COH 2&3	70	0.556157545	34		417.6	1247.4	2543.4
		EFFECTIVE								TOTAL
TA POINTS	A	B	C					DATA POINTS	A	B
	MOHR,1	MOHR,2	MOHR,3						MOHR,1	MOHR,2
X	Y,1	Y,2	Y,3					X	Y,1	Y,2
0	#NUM!	#NUM!	#NUM!					0	#NUM!	#NUM!
10	#NUM!	#NUM!	#NUM!					10	#NUM!	#NUM!
20	#NUM!	#NUM!	#NUM!					20	#NUM!	#NUM!
30	#NUM!	#NUM!	#NUM!					30	#NUM!	#NUM!
40	#NUM!	#NUM!	#NUM!					40	#NUM!	#NUM!
50	#NUM!	#NUM!	#NUM!					50	#NUM!	#NUM!
60	#NUM!	#NUM!	#NUM!					60	#NUM!	#NUM!
70	#NUM!	#NUM!	#NUM!					70	#NUM!	#NUM!
80	#NUM!	#NUM!	#NUM!					80	#NUM!	#NUM!
90	#NUM!	#NUM!	#NUM!					90	#NUM!	#NUM!
100	#NUM!	#NUM!	#NUM!					100	#NUM!	#NUM!
110	#NUM!	#NUM!	#NUM!					110	#NUM!	#NUM!
120	#NUM!	#NUM!	#NUM!					120	#NUM!	#NUM!
130	#NUM!	#NUM!	#NUM!					130	#NUM!	#NUM!
140	#NUM!	#NUM!	#NUM!					140	#NUM!	#NUM!
150	#NUM!	#NUM!	#NUM!					150	#NUM!	#NUM!
160	#NUM!	#NUM!	#NUM!					160	#NUM!	#NUM!
170	#NUM!	#NUM!	#NUM!					170	#NUM!	#NUM!
180	#NUM!	#NUM!	#NUM!					180	#NUM!	#NUM!
190	#NUM!	#NUM!	#NUM!					190	#NUM!	#NUM!
200	#NUM!	#NUM!	#NUM!					200	#NUM!	#NUM!
210	#NUM!	#NUM!	#NUM!					210	#NUM!	#NUM!
220	#NUM!	#NUM!	#NUM!					220	#NUM!	#NUM!
230	#NUM!	#NUM!	#NUM!					230	#NUM!	#NUM!
240	#NUM!	#NUM!	#NUM!					240	#NUM!	#NUM!
250	76	#NUM!	#NUM!					250	#NUM!	#NUM!
260	130	#NUM!	#NUM!					260	#NUM!	#NUM!
270	167	#NUM!	#NUM!					270	#NUM!	#NUM!
280	196	#NUM!	#NUM!					280	#NUM!	#NUM!
290	221	#NUM!	#NUM!					290	#NUM!	#NUM!
300	243	#NUM!	#NUM!					300	#NUM!	#NUM!
310	263	#NUM!	#NUM!					310	#NUM!	#NUM!
320	281	#NUM!	#NUM!					320	#NUM!	#NUM!
330	298	#NUM!	#NUM!					330	#NUM!	#NUM!
340	313	#NUM!	#NUM!					340	#NUM!	#NUM!
350	328	#NUM!	#NUM!					350	#NUM!	#NUM!
360	341	#NUM!	#NUM!					360	#NUM!	#NUM!

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 8
AMPLE TYPE	Bulk
EPTH INTERVAL	-
ACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	83.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION	
RESSURE, σ_3 (psi)	3.0
RESSURE, σ_3 (psf)	432.0
INAL "B" VALUE	1.00
) (minutes)	0.11

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.187	5.979	5.954
DIAMETER	7.087	2.790	2.783
AREA	39.44	6.11	6.08
VOLUME	599.00	36.55	36.22
WEIGHT (g)	1229.25		1261.25
% MOISTURE	13.8		16.77
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	128.1		
DRY DENSITY, calc (pcf)	112.5		
VOLUME OF SOLIDS	400.05		
VOLUME OF VOIDS	198.95		
VOID RATIO	0.497		
SATURATION	75.0		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	113.6
VOLUME OF SOLIDS	400.05
VOLUME OF VOIDS	193.45
VOID RATIO	0.484

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1261.25
WT SOIL & TARE, DRY (g)	1080.13
WT TARE (g)	0.00
WT MOISTURE (g)	181.12
WT DRY SOIL (g)	1080.13
% MOISTURE	16.77

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	13	81.3	0.0	0.00	1.00	6.08	5.954	0.0	432.0	432.0	432.0	1.00	432.0	0.0	0.00
0.3	0.002	30	81.8	72.0	0.03	1.00	6.08	5.952	411.8	843.8	771.8	360.0	2.14	565.9	205.9	0.17
1.0	0.006	35	82.0	100.8	0.10	1.00	6.09	5.948	534.5	966.5	865.7	331.2	2.61	598.4	267.2	0.19
1.5	0.009	38	82.1	115.2	0.15	1.00	6.09	5.945	609.8	1041.8	926.6	316.8	2.92	621.7	304.9	0.19
2.0	0.012	42	82.2	129.6	0.20	1.00	6.10	5.942	692.2	1124.2	994.6	302.4	3.29	648.5	346.1	0.19
2.5	0.015	45	82.2	129.6	0.25	1.00	6.10	5.939	758.0	1190.0	1060.4	302.4	3.51	681.4	379.0	0.17
3.5	0.021	49	82.2	129.6	0.35	1.00	6.10	5.933	853.9	1285.9	1156.3	302.4	3.82	729.4	427.0	0.15
7.7	0.046	55	81.9	86.4	0.77	0.99	6.13	5.908	1007.7	1439.7	1353.3	345.6	3.92	849.5	503.9	0.09
11.7	0.070	55	81.9	86.4	1.18	0.99	6.16	5.884	1001.3	1433.3	1346.9	345.6	3.90	846.2	500.6	0.09
15.3	0.092	56	81.8	72.0	1.55	0.98	6.18	5.862	1002.2	1434.2	1362.2	360.0	3.78	861.1	501.1	0.07
20.2	0.121	56	81.7	57.6	2.03	0.98	6.21	5.833	1001.9	1433.9	1376.3	374.4	3.68	875.3	500.9	0.06
24.3	0.146	56	81.7	57.6	2.45	0.98	6.24	5.808	993.0	1425.0	1367.4	374.4	3.65	870.9	496.5	0.06
28.7	0.172	56	81.7	57.6	2.89	0.97	6.26	5.782	1009.2	1441.2	1383.6	374.4	3.70	879.0	504.6	0.06
32.5	0.195	56	81.6	43.2	3.28	0.97	6.29	5.759	1005.2	1437.2	1394.0	388.8	3.59	891.4	502.6	0.04
36.5	0.219	57	81.5	28.8	3.68	0.96	6.32	5.735	1019.3	1451.3	1422.5	403.2	3.53	912.8	509.6	0.03
45.0	0.270	58	81.3	0.0	4.53	0.95	6.37	5.684	1035.0	1467.0	1467.0	432.0	3.40	949.5	517.5	0.00
53.2	0.319	59	81.3	0.0	5.36	0.95	6.43	5.635	1041.8	1473.8	1473.8	432.0	3.41	952.9	520.9	0.00
61.7	0.370	60	81.3	0.0	6.21	0.94	6.49	5.584	1061.2	1493.2	1493.2	432.0	3.46	962.6	530.6	0.00
70.3	0.422	61	81.2	-14.4	7.09	0.93	6.55	5.532	1075.6	1507.6	1522.0	446.4	3.41	984.2	537.8	-0.01
78.3	0.470	63	81.2	-14.4	7.89	0.92	6.60	5.484	1101.1	1533.1	1547.5	446.4	3.47	997.0	550.6	-0.01
86.7	0.520	63	81.2	-14.4	8.73	0.91	6.67	5.434	1091.1	1523.1	1537.5	446.4	3.44	991.9	545.5	-0.01
94.5	0.567	64	81.2	-14.4	9.52	0.90	6.72	5.387	1107.3	1539.3	1553.7	446.4	3.48	1000.1	553.7	-0.01
103.5	0.621	66	81.2	-14.4	10.43	0.90	6.79	5.333	1125.9	1557.9	1572.3	446.4	3.52	1009.4	563.0	-0.01
111.8	0.671	67	81.2	-14.4	11.27	0.89	6.86	5.283	1142.7	1574.7	1589.1	446.4	3.56	1017.7	571.3	-0.01
120.0	0.720	68	81.2	-14.4	12.09	0.88	6.92	5.234	1157.0	1589.0	1603.4	446.4	3.59	1024.9	578.5	-0.01
128.8	0.773	69	81.0	-43.2	12.98	0.87	6.99	5.181	1155.6	1587.6	1630.8	475.2	3.43	1053.0	577.8	-0.04
136.2	0.817	71	81.0	-43.2	13.72	0.86	7.05	5.137	1184.6	1616.6	1659.8	475.2	3.49	1067.5	592.3	-0.04
145.5	0.873	70	81.0	-43.2	14.66	0.85	7.13	5.081	1169.7	1601.7	1644.9	475.2	3.46	1060.0	584.8	-0.04
153.8	0.923	71	81.0	-43.2	15.50	0.84	7.20	5.031	1176.2	1608.2	1651.4	475.2	3.48	1063.3	588.1	-0.04
166.7	1.000	72	80.9	-57.6	16.80	0.83	7.31	4.954	1172.0	1604.0	1661.6	489.6	3.39	1075.6	586.0	-0.05

DU @ FAILURE	86.40	DEVIATORIC STRESS @ FAILURE	1007.72	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	3.92

TECH	PWM/SDM
DATE	7/30/04
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 7
AMPLE TYPE	Bulk
'EPTH INTERVAL	-
IACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	89.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	9.0
RESSURE, σ_3 (psf)	1296.0
INAL "B" VALUE	0.99
$_0$ (minutes)	0.23

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.258	6.007	5.962
DIAMETER	7.087	2.790	2.787
AREA	39.44	6.11	6.10
VOLUME	601.81	36.72	36.36
WEIGHT (g)	1284.97		1308.97
% MOISTURE	12.2		14.32
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	133.2		
DRY DENSITY, calc (pcf)	118.7		
VOLUME OF SOLIDS	424.09		
VOLUME OF VOIDS	177.72		
VOID RATIO	0.419		
SATURATION	78.7		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	119.9
VOLUME OF SOLIDS	424.09
VOLUME OF VOIDS	171.72
VOID RATIO	0.405

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1308.97
WT SOIL & TARE, DRY (g)	1145.03
WT TARE (g)	0.00
WT MOISTURE (g)	163.94
WT DRY SOIL (g)	1145.03
% MOISTURE	14.32

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	20	80.7	0.0	0.00	1.00	6.10	5.962	0.0	1296.0	1296.0	1296.0	1.00	1296.0	0.0	0
0.5	0.003	48	82.6	273.6	0.05	1.00	6.10	5.959	660.8	1956.8	1683.2	1022.4	1.65	1352.8	330.4	0.41
1.0	0.006	60	83.1	345.6	0.10	1.00	6.10	5.956	943.6	2239.6	1894.0	950.4	1.99	1422.2	471.8	0.37
1.5	0.009	69	83.5	403.2	0.15	1.00	6.11	5.953	1155.3	2451.3	2048.1	892.8	2.29	1470.4	577.6	0.35
2.0	0.012	75	83.7	432.0	0.20	1.00	6.11	5.950	1296.1	2592.1	2160.1	864.0	2.50	1512.0	648.0	0.33
2.5	0.015	80	83.9	460.8	0.25	1.00	6.11	5.947	1413.2	2709.2	2248.4	835.2	2.69	1541.8	706.6	0.33
4.2	0.025	94	84.2	504.0	0.42	1.00	6.12	5.937	1740.0	3036.0	2532.0	792.0	3.20	1662.0	870.0	0.29
8.3	0.050	115	84.0	475.2	0.84	0.99	6.15	5.912	2224.4	3520.4	3045.2	820.8	3.71	1933.0	1112.2	0.21
12.5	0.075	127	83.6	417.6	1.26	0.99	6.18	5.887	2494.8	3790.8	3373.2	878.4	3.84	2125.8	1247.4	0.17
16.7	0.100	132	83.3	374.4	1.68	0.98	6.20	5.862	2600.3	3896.3	3521.9	921.6	3.82	2221.7	1300.1	0.14
21.7	0.130	135	83.2	360.0	2.18	0.98	6.23	5.832	2656.3	3952.3	3592.3	936.0	3.84	2264.1	1328.1	0.14
25.0	0.150	137	83.1	345.6	2.52	0.97	6.26	5.812	2693.2	3989.2	3643.6	950.4	3.83	2297.0	1346.6	0.13
29.2	0.175	139	83.0	331.2	2.94	0.97	6.28	5.787	2727.5	4023.5	3692.3	964.8	3.83	2328.5	1363.7	0.12
36.7	0.220	142	82.9	316.8	3.69	0.96	6.33	5.742	2774.5	4070.5	3753.7	979.2	3.83	2366.4	1387.2	0.11
41.7	0.250	144	82.8	302.4	4.19	0.96	6.37	5.712	2805.2	4101.2	3798.8	993.6	3.82	2396.2	1402.6	0.11
50.0	0.300	147	82.7	288.0	5.03	0.95	6.42	5.662	2847.9	4143.9	3855.9	1008.0	3.83	2432.0	1424.0	0.10
58.3	0.350	150	82.5	259.2	5.87	0.94	6.48	5.612	2889.5	4185.5	3926.3	1036.8	3.79	2481.5	1444.7	0.09
66.7	0.400	155	82.3	230.4	6.71	0.93	6.54	5.562	2973.9	4269.9	4039.5	1065.6	3.79	2552.5	1486.9	0.08
79.2	0.475	160	82.2	216.0	7.97	0.92	6.63	5.487	3042.4	4338.4	4122.4	1080.0	3.82	2601.2	1521.2	0.07
83.3	0.500	162	82.1	201.6	8.39	0.92	6.66	5.462	3071.8	4367.8	4166.2	1094.4	3.81	2630.3	1535.9	0.07
91.7	0.550	165	81.9	172.8	9.23	0.91	6.72	5.412	3108.0	4404.0	4231.2	1123.2	3.77	2677.2	1554.0	0.06
100.0	0.600	169	81.8	158.4	10.06	0.90	6.78	5.362	3164.3	4460.3	4301.9	1137.6	3.78	2719.7	1582.1	0.05
108.3	0.650	172	81.7	144.0	10.90	0.89	6.84	5.312	3197.9	4493.9	4349.9	1152.0	3.78	2750.9	1598.9	0.05
116.7	0.700	176	81.6	129.6	11.74	0.88	6.91	5.262	3251.1	4547.1	4417.5	1166.4	3.79	2792.0	1625.6	0.04
125.0	0.750	177	81.5	115.2	12.58	0.87	6.98	5.212	3240.9	4536.9	4421.7	1180.8	3.74	2801.2	1620.4	0.04
133.3	0.800	181	81.4	100.8	13.42	0.87	7.04	5.162	3291.6	4587.6	4486.8	1195.2	3.75	2841.0	1645.8	0.03
141.7	0.850	182	81.4	100.8	14.26	0.86	7.11	5.112	3279.9	4575.9	4475.1	1195.2	3.74	2835.2	1640.0	0.03
150.0	0.900	183	81.3	86.4	15.10	0.85	7.18	5.062	3267.9	4563.9	4477.5	1209.6	3.70	2843.5	1633.9	0.03
158.3	0.950	184	81.3	86.4	15.93	0.84	7.25	5.012	3255.5	4551.5	4465.1	1209.6	3.69	2837.3	1627.7	0.03
166.7	1.000	185	81.2	72.0	16.77	0.83	7.33	4.962	3242.6	4538.6	4466.6	1224.0	3.65	2845.3	1621.3	0.02

DU @ FAILURE	417.6	DEVIATORIC STRESS @ FAILURE	2494.8	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	3.84

TECH	PWM/SDM
DATE	8/4/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 8
AMPLE TYPE	Bulk
EPTH INTERVAL	-
IACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	89.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	9.0
RESSURE, σ_3 (psf)	1296.0
INAL "B" VALUE	1.00
o (minutes)	0.13

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.245	6.002	5.961
DIAMETER	7.087	2.790	2.763
AREA	39.44	6.11	5.99
VOLUME	601.31	36.69	35.74
WEIGHT (g)	1229.74		1262.04
% MOISTURE	13.5		16.45
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	127.6		
DRY DENSITY, calc (pcf)	112.5		
VOLUME OF SOLIDS	401.38		
VOLUME OF VOIDS	199.93		
VOID RATIO	0.498		
SATURATION	73.0		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	115.5
VOLUME OF SOLIDS	401.38
VOLUME OF VOIDS	184.23
VOID RATIO	0.459

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1262.04
WT SOIL & TARE, DRY (g)	1083.72
WT TARE (g)	0.00
WT MOISTURE (g)	178.32
WT DRY SOIL (g)	1083.72
% MOISTURE	16.45

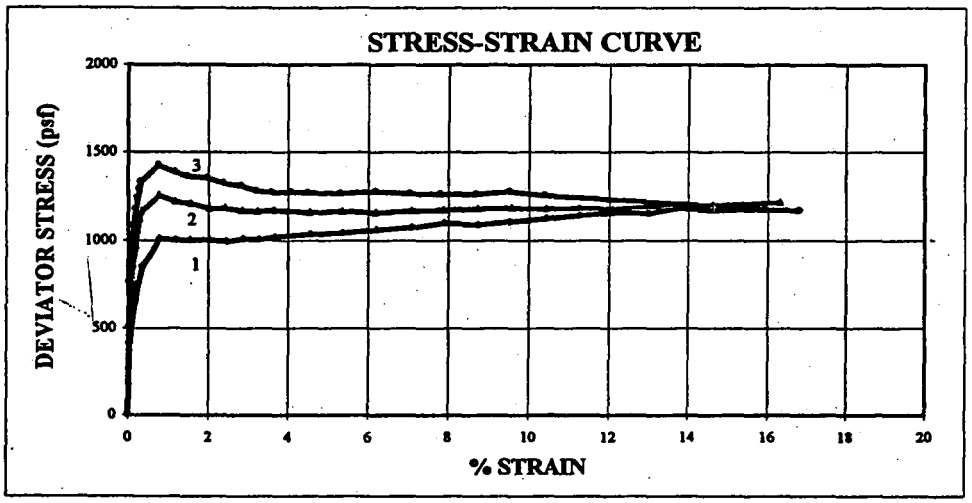
TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	14	81.3	0.0	0.00	1.00	5.99	5.961	0.0	1296.0	1296.0	1296.0	1.00	1296.0	0.0	0
0.3	0.002	45	83.2	273.6	0.03	1.00	6.00	5.959	761.2	2057.2	1783.6	1022.4	1.74	1403.0	380.6	0.36
0.8	0.005	53	83.6	331.2	0.08	1.00	6.00	5.956	948.0	2244.0	1912.8	964.8	1.98	1438.8	474.0	0.35
1.3	0.008	59	83.9	374.4	0.13	1.00	6.00	5.953	1081.9	2377.9	2003.5	921.6	2.17	1462.5	540.9	0.35
1.8	0.011	63	84.1	403.2	0.18	1.00	6.01	5.950	1177.2	2473.2	2070.0	892.8	2.32	1481.4	588.6	0.34
2.3	0.014	65	84.3	432.0	0.23	1.00	6.01	5.947	1241.3	2537.3	2105.3	864.0	2.44	1484.7	620.7	0.35
2.8	0.017	68	84.5	460.8	0.29	1.00	6.01	5.944	1293.4	2589.4	2128.6	835.2	2.55	1481.9	646.7	0.36
3.2	0.019	69	84.7	489.6	0.32	1.00	6.01	5.942	1333.7	2629.7	2140.1	806.4	2.65	1473.2	666.8	0.37
7.3	0.044	73	85.4	590.4	0.74	0.99	6.04	5.917	1428.2	2724.2	2133.8	705.6	3.02	1419.7	714.1	0.41
11.5	0.069	72	85.7	633.6	1.16	0.99	6.07	5.892	1388.9	2684.9	2051.3	662.4	3.10	1356.9	694.5	0.46
14.7	0.088	71	85.9	662.4	1.48	0.99	6.08	5.873	1365.5	2661.5	1999.1	633.6	3.16	1316.4	682.8	0.49
19.7	0.118	71	86.0	676.8	1.98	0.98	6.12	5.843	1356.2	2652.2	1975.4	619.2	3.19	1297.3	678.1	0.50
23.8	0.143	70	86.1	691.2	2.40	0.98	6.14	5.818	1324.6	2620.6	1929.4	604.8	3.19	1267.1	662.3	0.52
28.2	0.169	70	86.2	705.6	2.84	0.97	6.17	5.792	1311.7	2607.7	1902.1	590.4	3.22	1246.2	655.8	0.54
32.0	0.192	69	86.2	705.6	3.22	0.97	6.19	5.769	1283.2	2579.2	1873.6	590.4	3.17	1232.0	641.6	0.55
35.8	0.215	69	86.3	720.0	3.61	0.96	6.22	5.746	1275.8	2571.8	1851.8	576.0	3.21	1213.9	637.9	0.56
40.5	0.243	69	86.3	720.0	4.08	0.96	6.25	5.718	1276.5	2572.5	1852.5	576.0	3.22	1214.2	638.2	0.56
44.5	0.267	69	86.4	734.4	4.48	0.96	6.28	5.694	1271.1	2567.1	1832.7	561.6	3.26	1197.2	635.6	0.58
52.8	0.317	69	86.4	734.4	5.32	0.95	6.33	5.644	1266.8	2562.8	1828.4	561.6	3.26	1195.0	633.4	0.58
61.3	0.368	70	86.4	734.4	6.17	0.94	6.39	5.593	1280.1	2576.1	1841.7	561.6	3.28	1201.7	640.1	0.57
69.8	0.419	70	86.4	734.4	7.03	0.93	6.45	5.542	1268.4	2564.4	1830.0	561.6	3.26	1195.8	634.2	0.58
77.5	0.465	71	86.4	734.4	7.80	0.92	6.50	5.496	1262.4	2558.4	1824.0	561.6	3.25	1192.8	631.2	0.58
86.3	0.518	71	86.4	734.4	8.69	0.91	6.57	5.443	1265.5	2561.5	1827.1	561.6	3.25	1194.4	632.8	0.58
94.7	0.568	72	86.4	734.4	9.53	0.90	6.63	5.393	1277.8	2573.8	1839.4	561.6	3.28	1200.5	638.9	0.57
103.3	0.620	72	86.4	734.4	10.40	0.90	6.69	5.341	1256.9	2552.9	1818.5	561.6	3.24	1190.0	628.4	0.58
150.0	0.900	72	86.4	734.4	15.10	0.85	7.06	5.061	1193.0	2489.0	1754.6	561.6	3.12	1158.1	596.5	0.62
158.3	0.950	72	86.4	734.4	15.94	0.84	7.13	5.011	1181.2	2477.2	1742.8	561.6	3.10	1152.2	590.6	0.62
166.7	1.000	72	86.4	734.4	16.78	0.83	7.20	4.961	1169.5	2465.5	1731.1	561.6	3.08	1146.3	584.7	0.63
0.0				-11707.2	0.00	1.00	5.99	5.961	-324.3	971.7	12678.9	13003.2	0.98	12841.1	-162.1	36.10
0.0				-11707.2	0.00	1.00	5.99	5.961	-324.3	971.7	12678.9	13003.2	0.98	12841.1	-162.1	36.10

DU @ FAILURE	676.8	DEVIATORIC STRESS @ FAILURE	1356.2	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	3.19

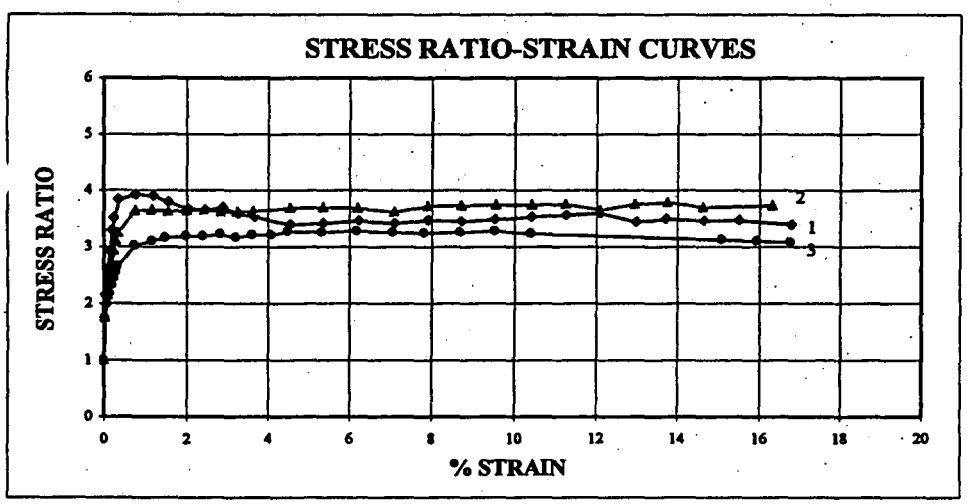
TECH	PWM/SDM
DATE	7/30/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

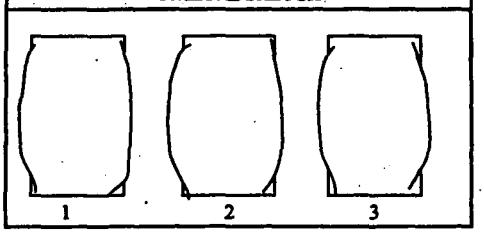
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 8 DEPTH: - Sample Type: Bulk

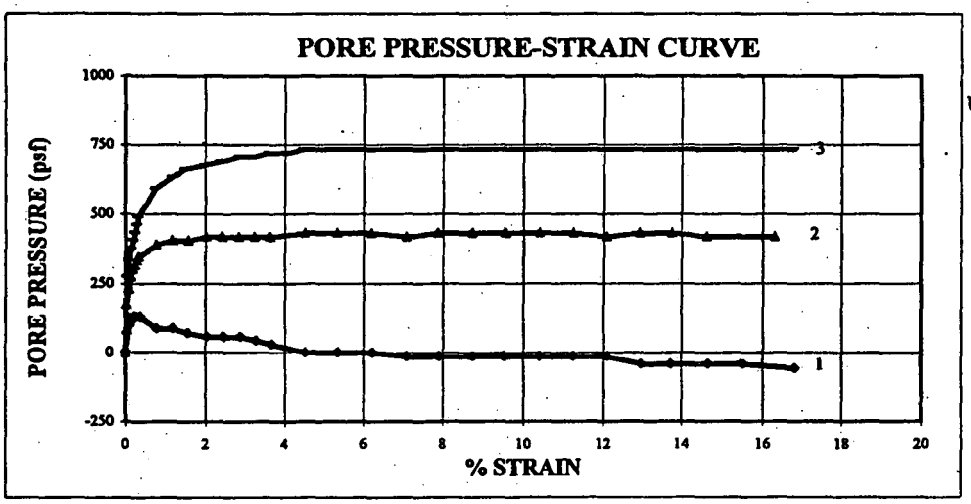


Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	112.5	13.8
2	864	112.3	13.6
3	1296	112.5	13.5
	Average	112.4	13.6



FAILURE SKETCH





Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

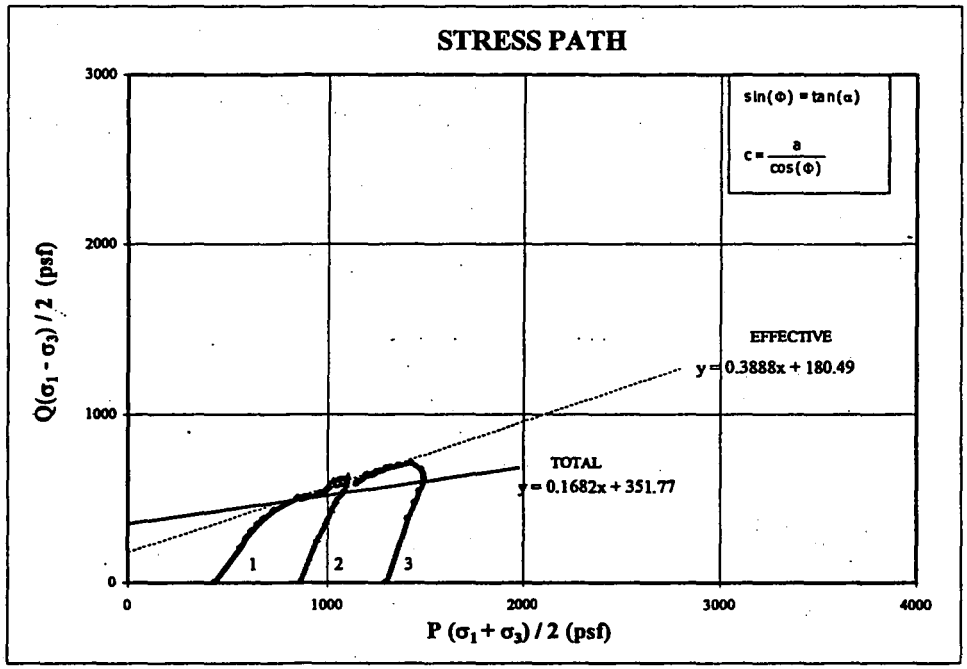
Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

* Failure based on effective stress ratio or 15% strain.

CHECK
REVIEW

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

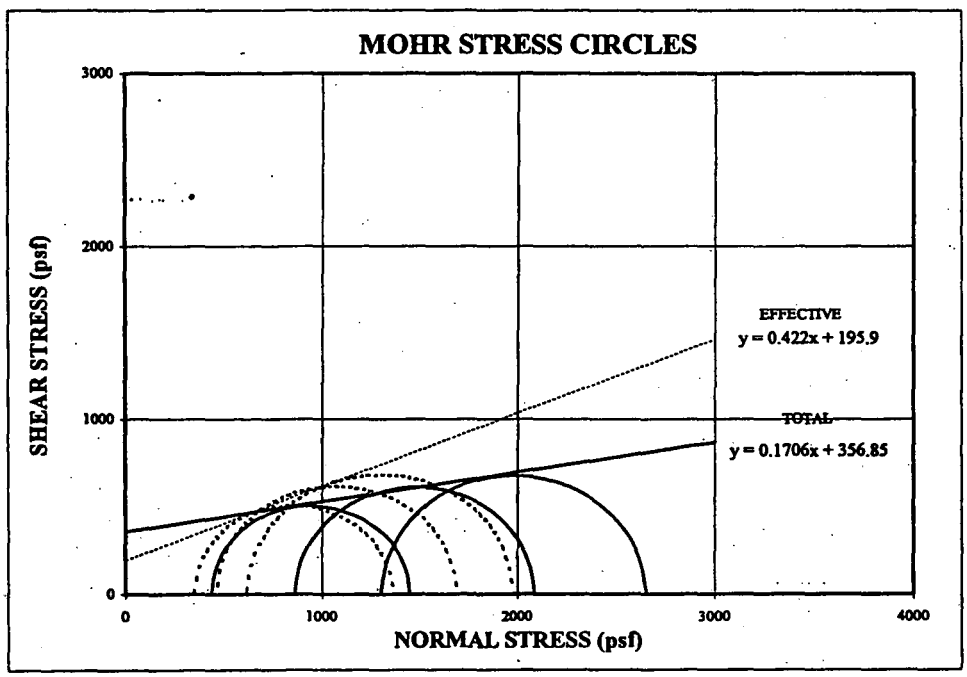
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 8 DEPTH: - Sample Type: Bulk



Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	112.5	13.8
2	864	112.3	13.6
3	1296	112.5	13.5

Specimen	Strain Rate (%)	Initial Saturation (%)	Saturation Before Shearing (%)
1	0.10	75.0	93.6
2	0.10	73.4	93.6
3	0.10	73.0	96.8

STRESS PATH			MOHR CIRCLES		
*TOTAL STRESS PARAMETER			*TOTAL STRENGTH PARAMETER		
α	=	9.5 °	φ	=	9.7 °
a	=	351.8 psf	c	=	356.9 psf
* EFFECTIVE STRESS PARAMETER			*EFFECTIVE STRENGTH PARAMETER		
α'	=	21.2 °	φ'	=	22.9 °
a'	=	180.5 psf	c'	=	195.9 psf



Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

*** Failure based on effective stress ratio or 15% strain.**

CHECK
REVIEW

CONSOLIDATED UNDRAINED TRIAXIAL STRENGTH								CONSOLIDATED UNDRAINED TRI		
MOHR CIRCLE GENERATION SPREADSHEET								MOHR CIRCLE GENERATION SPRE		
	PF - 8	-	B	C	A				PF - 8	-
CONFINING PRESSURE USED (S3)			432	864	1296	psf		CONFINING PRESSURE USED (S3)		
CONFINING PRESSURE USED (S3)			432	864	1296	psi		CONFINING PRESSURE USED (S3)		
MAXIMUM DEVIATOR STRESS (PS			1007.7	1222.1	1356.2	psf		MAXIMUM DEVIATOR STRESS (PS		
(or load at 15% strain)								(or load at 15% strain)		
dU AT FAIL	(S1-S3)/2	(S1'+S3')/2		coh	sin phi	phi		dU AT FAIL	(S1-S3)/2	(S1'+S3')/2
86.4	503.9	849.5	COH 1&2	90	0.481968751	29		86.4	503.9	935.9
403.2	611.0	1071.8	COH 1&3	170	0.389052893	23		403.2	611.0	1475.0
676.8	678.1	1297.3	COH 2&3	290	0.297401663	17		676.8	678.1	1974.1
		EFFECTIVE								TOTAL
TA POINTS	A	B	C					DATA POINTS	A	B
	MOHR,1	MOHR,2	MOHR,3						MOHR,1	MOHR,2
X	Y,1	Y,2	Y,3					X	Y,1	Y,2
0	#NUM!	#NUM!	#NUM!					0	#NUM!	#NUM!
10	#NUM!	#NUM!	#NUM!					10	#NUM!	#NUM!
20	#NUM!	#NUM!	#NUM!					20	#NUM!	#NUM!
30	#NUM!	#NUM!	#NUM!					30	#NUM!	#NUM!
40	#NUM!	#NUM!	#NUM!					40	#NUM!	#NUM!
50	#NUM!	#NUM!	#NUM!					50	#NUM!	#NUM!
60	#NUM!	#NUM!	#NUM!					60	#NUM!	#NUM!
70	#NUM!	#NUM!	#NUM!					70	#NUM!	#NUM!
80	#NUM!	#NUM!	#NUM!					80	#NUM!	#NUM!
90	#NUM!	#NUM!	#NUM!					90	#NUM!	#NUM!
100	#NUM!	#NUM!	#NUM!					100	#NUM!	#NUM!
110	#NUM!	#NUM!	#NUM!					110	#NUM!	#NUM!
120	#NUM!	#NUM!	#NUM!					120	#NUM!	#NUM!
130	#NUM!	#NUM!	#NUM!					130	#NUM!	#NUM!
140	#NUM!	#NUM!	#NUM!					140	#NUM!	#NUM!
150	#NUM!	#NUM!	#NUM!					150	#NUM!	#NUM!
160	#NUM!	#NUM!	#NUM!					160	#NUM!	#NUM!
170	#NUM!	#NUM!	#NUM!					170	#NUM!	#NUM!
180	#NUM!	#NUM!	#NUM!					180	#NUM!	#NUM!
190	#NUM!	#NUM!	#NUM!					190	#NUM!	#NUM!
200	#NUM!	#NUM!	#NUM!					200	#NUM!	#NUM!
210	#NUM!	#NUM!	#NUM!					210	#NUM!	#NUM!
220	#NUM!	#NUM!	#NUM!					220	#NUM!	#NUM!
230	#NUM!	#NUM!	#NUM!					230	#NUM!	#NUM!
240	#NUM!	#NUM!	#NUM!					240	#NUM!	#NUM!
250	#NUM!	#NUM!	#NUM!					250	#NUM!	#NUM!
260	#NUM!	#NUM!	#NUM!					260	#NUM!	#NUM!
270	#NUM!	#NUM!	#NUM!					270	#NUM!	#NUM!
280	#NUM!	#NUM!	#NUM!					280	#NUM!	#NUM!
290	#NUM!	#NUM!	#NUM!					290	#NUM!	#NUM!
300	#NUM!	#NUM!	#NUM!					300	#NUM!	#NUM!
310	#NUM!	#NUM!	#NUM!					310	#NUM!	#NUM!
320	#NUM!	#NUM!	#NUM!					320	#NUM!	#NUM!
330	#NUM!	#NUM!	#NUM!					330	#NUM!	#NUM!
340	#NUM!	#NUM!	#NUM!					340	#NUM!	#NUM!
350	66	#NUM!	#NUM!					350	#NUM!	#NUM!
360	120	#NUM!	#NUM!					360	#NUM!	#NUM!

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 8
AMPLE TYPE	Bulk
EPTH INTERVAL	-
ACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	86.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION	
RESSURE, σ_3 (psi)	6.0
RESSURE, σ_3 (psf)	864.0
INAL "B" VALUE	1.00
(minutes)	0.41

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.240	6.000	5.968
DIAMETER	7.087	2.790	2.777
AREA	39.44	6.11	6.06
VOLUME	601.11	36.68	36.14
WEIGHT (g)	1229.05		1261.25
% MOISTURE	13.6		16.56
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	127.6		
DRY DENSITY, calc (pcf)	112.3		
VOLUME OF SOLIDS	400.75		
VOLUME OF VOIDS	200.36		
VOID RATIO	0.500		
SATURATION	73.4		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	114.0
VOLUME OF SOLIDS	400.75
VOLUME OF VOIDS	191.56
VOID RATIO	0.478
WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1261.25
WT SOIL & TARE, DRY (g)	1082.02
WT TARE (g)	0.00
WT MOISTURE (g)	179.23
WT DRY SOIL (g)	1082.02
% MOISTURE	16.56

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	14	81.4	0.0	0.00	1.00	6.06	5.968	0.0	864.0	864.0	864.0	1.00	864.0	0.0	0.00
0.3	0.002	36	82.6	172.8	0.03	1.00	6.06	5.966	520.5	1384.5	1211.7	691.2	1.75	951.5	260.3	0.33
0.8	0.005	44	83.0	230.4	0.08	1.00	6.06	5.963	722.2	1586.2	1355.8	633.6	2.14	994.7	361.1	0.32
1.3	0.008	50	83.3	273.6	0.13	1.00	6.06	5.960	861.9	1725.9	1452.3	590.4	2.46	1021.4	431.0	0.32
1.8	0.011	55	83.5	302.4	0.18	1.00	6.07	5.957	968.3	1832.3	1529.9	561.6	2.72	1045.7	484.1	0.31
2.3	0.014	58	83.6	316.8	0.23	1.00	6.07	5.954	1057.9	1921.9	1605.1	547.2	2.93	1076.2	529.0	0.30
2.8	0.017	61	83.7	331.2	0.28	1.00	6.07	5.951	1121.4	1985.4	1654.2	532.8	3.10	1093.5	560.7	0.30
3.3	0.020	63	83.8	345.6	0.34	1.00	6.08	5.948	1165.9	2029.9	1684.3	518.4	3.25	1101.3	582.9	0.30
7.5	0.045	67	84.1	388.8	0.75	0.99	6.10	5.923	1255.4	2119.4	1730.6	475.2	3.64	1102.9	627.7	0.31
11.5	0.069	66	84.2	403.2	1.16	0.99	6.13	5.899	1222.1	2086.1	1682.9	460.8	3.65	1071.8	611.0	0.33
15.5	0.093	65	84.2	403.2	1.56	0.98	6.15	5.875	1210.1	2074.1	1670.9	460.8	3.63	1065.8	605.0	0.33
20.0	0.120	64	84.3	417.6	2.01	0.98	6.18	5.848	1178.9	2042.9	1625.3	446.4	3.64	1035.8	589.4	0.35
24.2	0.145	65	84.3	417.6	2.43	0.98	6.21	5.823	1183.1	2047.1	1629.5	446.4	3.65	1038.0	591.6	0.35
28.3	0.170	64	84.3	417.6	2.85	0.97	6.23	5.798	1168.8	2032.8	1615.2	446.4	3.62	1030.8	584.4	0.36
32.3	0.194	64	84.3	417.6	3.25	0.97	6.26	5.774	1166.3	2030.3	1612.7	446.4	3.61	1029.5	583.1	0.36
36.2	0.217	65	84.3	417.6	3.64	0.96	6.28	5.751	1173.1	2037.1	1619.5	446.4	3.63	1032.9	586.5	0.36
45.0	0.270	65	84.4	432.0	4.52	0.95	6.34	5.698	1157.7	2021.7	1589.7	432.0	3.68	1010.9	578.9	0.37
53.2	0.319	66	84.4	432.0	5.35	0.95	6.40	5.649	1165.8	2029.8	1597.8	432.0	3.70	1014.9	582.9	0.37
61.5	0.369	66	84.4	432.0	6.18	0.94	6.46	5.599	1159.9	2023.9	1591.9	432.0	3.69	1012.0	580.0	0.37
70.3	0.422	67	84.3	417.6	7.07	0.93	6.52	5.546	1168.8	2032.8	1615.2	446.4	3.62	1030.8	584.4	0.36
78.3	0.470	67	84.4	432.0	7.88	0.92	6.57	5.498	1174.1	2038.1	1606.1	432.0	3.72	1019.0	587.0	0.37
86.7	0.520	68	84.4	432.0	8.71	0.91	6.63	5.448	1178.6	2042.6	1610.6	432.0	3.73	1021.3	589.3	0.37
95.0	0.570	69	84.4	432.0	9.55	0.90	6.70	5.398	1182.8	2046.8	1614.8	432.0	3.74	1023.4	591.4	0.37
103.7	0.622	69	84.4	432.0	10.42	0.90	6.76	5.346	1182.1	2046.1	1614.1	432.0	3.74	1023.0	591.0	0.37
112.0	0.672	70	84.4	432.0	11.26	0.89	6.82	5.296	1185.8	2049.8	1617.8	432.0	3.74	1024.9	592.9	0.36
120.2	0.721	70	84.3	417.6	12.08	0.88	6.89	5.247	1181.1	2045.1	1627.5	446.4	3.65	1036.9	590.5	0.35
128.7	0.772	71	84.4	432.0	12.94	0.87	6.96	5.196	1190.3	2054.3	1622.3	432.0	3.76	1027.1	595.1	0.36
136.8	0.821	72	84.4	432.0	13.76	0.86	7.02	5.147	1201.6	2065.6	1633.6	432.0	3.78	1032.8	600.8	0.36
145.5	0.873	73	84.3	417.6	14.63	0.85	7.09	5.095	1201.7	2065.7	1648.1	446.4	3.69	1047.2	600.8	0.35
162.2	0.973	75	84.3	417.6	16.30	0.84	7.24	4.995	1215.9	2079.9	1662.3	446.4	3.72	1054.3	607.9	0.34

DU @ FAILURE	403.2	DEVIATORIC STRESS @ FAILURE	1222.1	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	3.65

TECH	PWM/SDM
DATE	7/30/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 9
AMPLE TYPE	Bulk
EPTH INTERVAL	-
IACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	86.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	6.0
RESSURE, σ_3 (psf)	864.0
INAL "B" VALUE	1.00
$_0$ (minutes)	0.16
Mounting Method	Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.248	6.003	5.981
DIAMETER	7.087	2.790	2.780
AREA	39.44	6.11	6.07
VOLUME	601.41	36.70	36.31
WEIGHT (g)	1286.57		1310.17
% MOISTURE	12.5		14.60
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	133.5		
DRY DENSITY, calc (pcf)	118.6		
VOLUME OF SOLIDS	423.44		
VOLUME OF VOIDS	177.97		
VOID RATIO	0.420		
SATURATION	80.5		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	119.9
VOLUME OF SOLIDS	423.44
VOLUME OF VOIDS	171.57
VOID RATIO	0.405
WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1310.17
WT SOIL & TARE, DRY (g)	1143.28
WT TARE (g)	0.00
WT MOISTURE (g)	166.89
WT DRY SOIL (g)	1143.28
% MOISTURE	14.60

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	13	81.5	0.0	0.00	1.00	6.07	5.981	0.0	864.0	864.0	864.0	1.00	864.0	0.0	0.00
0.5	0.003	38	83.1	230.4	0.05	1.00	6.07	5.978	597.4	1461.4	1231.0	633.6	1.94	932.3	298.7	0.39
0.8	0.005	43	83.3	259.2	0.08	1.00	6.08	5.976	701.5	1565.5	1306.3	604.8	2.16	955.6	350.8	0.37
1.5	0.009	52	83.7	316.8	0.15	1.00	6.08	5.972	921.3	1785.3	1468.5	547.2	2.68	1007.9	460.7	0.34
2.0	0.012	59	83.9	345.6	0.20	1.00	6.08	5.969	1086.6	1950.6	1605.0	518.4	3.10	1061.7	543.3	0.32
2.5	0.015	65	84.1	374.4	0.25	1.00	6.09	5.966	1230.4	2094.4	1720.0	489.6	3.51	1104.8	615.2	0.30
3.0	0.018	70	84.1	374.4	0.30	1.00	6.09	5.963	1340.9	2204.9	1830.5	489.6	3.74	1160.0	670.4	0.28
4.0	0.024	79	84.2	388.8	0.40	1.00	6.10	5.957	1554.5	2418.5	2029.7	475.2	4.27	1252.5	777.3	0.25
8.3	0.050	106	83.4	273.6	0.84	0.99	6.12	5.931	2178.1	3042.1	2768.5	590.4	4.69	1679.5	1089.1	0.13
11.8	0.071	119	82.4	129.6	1.19	0.99	6.14	5.910	2489.2	3353.2	3223.6	734.4	4.39	1979.0	1244.6	0.05
15.8	0.095	129	81.7	28.8	1.59	0.98	6.17	5.886	2700.8	3564.8	3536.0	835.2	4.23	2185.6	1350.4	0.01
20.3	0.122	134	81.2	-43.2	2.04	0.98	6.20	5.859	2809.3	3673.3	3716.5	907.2	4.10	2311.8	1404.6	-0.02
24.5	0.147	137	80.9	-86.4	2.46	0.98	6.22	5.834	2873.6	3737.6	3824.0	950.4	4.02	2387.2	1436.8	-0.03
28.8	0.173	139	80.7	-115.2	2.89	0.97	6.25	5.808	2900.0	3764.0	3879.2	979.2	3.96	2429.2	1450.0	-0.04
32.7	0.196	140	80.6	-129.6	3.28	0.97	6.28	5.785	2902.3	3766.3	3895.9	993.6	3.92	2444.7	1451.1	-0.04
37.0	0.222	142	80.5	-144.0	3.71	0.96	6.30	5.759	2941.7	3805.7	3949.7	1008.0	3.92	2478.9	1470.9	-0.05
45.5	0.273	144	80.4	-158.4	4.56	0.95	6.36	5.708	2954.2	3818.2	3976.6	1022.4	3.89	2499.5	1477.1	-0.05
53.5	0.321	145	80.4	-158.4	5.37	0.95	6.42	5.660	2954.0	3818.0	3976.4	1022.4	3.89	2499.4	1477.0	-0.05
62.3	0.374	148	80.3	-172.8	6.25	0.94	6.48	5.607	2999.7	3863.7	4036.5	1036.8	3.89	2536.7	1499.9	-0.06
70.7	0.424	150	80.3	-172.8	7.09	0.93	6.53	5.557	3017.1	3881.1	4053.9	1036.8	3.91	2545.3	1508.5	-0.06
78.8	0.473	152	80.2	-187.2	7.91	0.92	6.59	5.508	3038.5	3902.5	4089.7	1051.2	3.89	2570.5	1519.3	-0.06
87.5	0.525	154	80.2	-187.2	8.78	0.91	6.65	5.456	3057.4	3921.4	4108.6	1051.2	3.91	2579.9	1528.7	-0.06
95.3	0.572	156	80.0	-216.0	9.56	0.90	6.71	5.409	3074.0	3938.0	4154.0	1080.0	3.85	2617.0	1537.0	-0.07
104.2	0.625	160	80.0	-216.0	10.45	0.90	6.78	5.356	3126.7	3990.7	4206.7	1080.0	3.90	2643.4	1563.4	-0.07
112.7	0.676	163	79.9	-230.4	11.30	0.89	6.84	5.305	3151.7	4015.7	4246.1	1094.4	3.88	2670.2	1575.8	-0.07
120.7	0.724	166	79.8	-244.8	12.10	0.88	6.91	5.257	3189.9	4053.9	4298.7	1108.8	3.88	2703.7	1594.9	-0.08
129.5	0.777	169	79.7	-259.2	12.99	0.87	6.98	5.204	3219.6	4083.6	4342.8	1123.2	3.87	2733.0	1609.8	-0.08
137.2	0.823	171	79.6	-273.6	13.76	0.86	7.04	5.158	3232.1	4096.1	4369.7	1137.6	3.84	2753.6	1616.0	-0.08
146.0	0.876	175	79.5	-288.0	14.65	0.85	7.11	5.105	3277.8	4141.8	4429.8	1152.0	3.85	2790.9	1638.9	-0.09
154.5	0.927	178	79.4	-302.4	15.50	0.85	7.18	5.054	3305.2	4169.2	4471.6	1166.4	3.83	2819.0	1652.6	-0.09

DU @ FAILURE	273.6	DEVIATORIC STRESS @ FAILURE	2178.1	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.69

TECH	PWM/SDM
DATE	8/2/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 9
AMPLE TYPE	Bulk
EPTH INTERVAL	-
IACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	89.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	9.0
RESSURE, σ_3 (psf)	1296.0
INAL "B" VALUE	0.99
$_0$ (minutes)	0.34

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.250	6.004	5.977
DIAMETER	7.087	2.790	2.782
AREA	39.44	6.11	6.08
VOLUME	601.51	36.71	36.34
WEIGHT (g)	1286.60		1310.60
% MOISTURE	12.5		14.57
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	133.5		
DRY DENSITY, calc (pcf)	118.7		
VOLUME OF SOLIDS	423.68		
VOLUME OF VOIDS	177.82		
VOID RATIO	0.420		
SATURATION	80.2		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	119.9
VOLUME OF SOLIDS	423.68
VOLUME OF VOIDS	171.82
VOID RATIO	0.406
WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1310.60
WT SOIL & TARE, DRY (g)	1143.94
WT TARE (g)	0.00
WT MOISTURE (g)	166.66
WT DRY SOIL (g)	1143.94
% MOISTURE	14.57

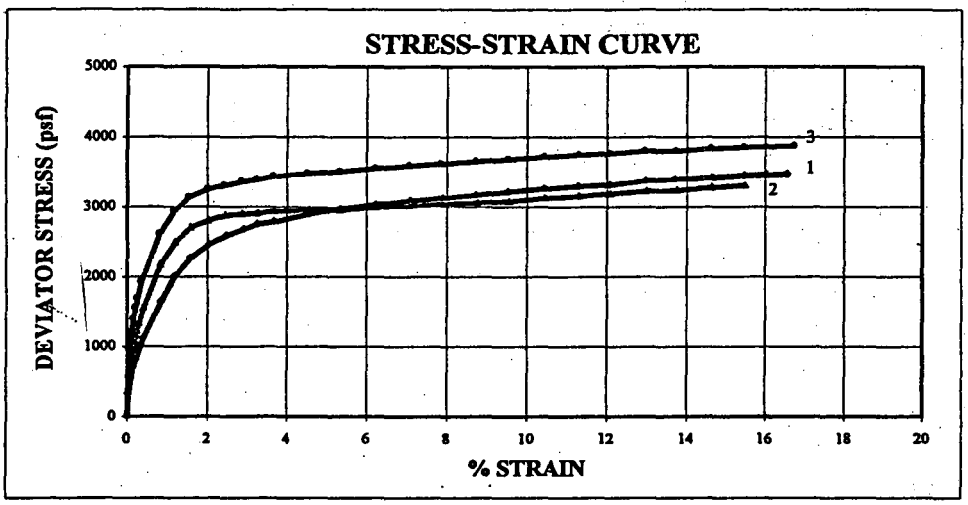
TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	14	80.3	0.0	0.00	1.00	6.08	5.977	0.0	1296.0	1296.0	1296.0	1.00	1296.0	0.0	0
0.5	0.003	55	82.8	360.0	0.05	1.00	6.08	5.974	963.5	2259.5	1899.5	936.0	2.03	1417.7	481.7	0.37
1.0	0.006	65	83.4	446.4	0.10	1.00	6.09	5.971	1204.3	2500.3	2053.9	849.6	2.42	1451.8	602.2	0.37
1.7	0.010	74	83.7	489.6	0.17	1.00	6.09	5.967	1399.8	2695.8	2206.2	806.4	2.74	1506.3	699.9	0.35
2.0	0.012	80	84.0	532.8	0.20	1.00	6.09	5.965	1552.9	2848.9	2316.1	763.2	3.03	1539.7	776.5	0.34
2.5	0.015	86	84.2	561.6	0.25	1.00	6.10	5.962	1693.9	2989.9	2428.3	734.4	3.31	1581.4	847.0	0.33
3.5	0.021	96	84.4	590.4	0.35	1.00	6.10	5.956	1932.9	3228.9	2638.5	705.6	3.74	1672.1	966.5	0.31
8.0	0.048	125	83.8	504.0	0.80	0.99	6.13	5.929	2603.1	3899.1	3395.1	792.0	4.29	2093.6	1301.6	0.19
11.7	0.070	140	82.9	374.4	1.17	0.99	6.15	5.907	2944.6	4240.6	3866.2	921.6	4.20	2393.9	1472.3	0.13
15.3	0.092	149	82.3	288.0	1.54	0.98	6.18	5.885	3136.5	4432.5	4144.5	1008.0	4.11	2576.3	1568.3	0.09
20.2	0.121	155	81.9	230.4	2.02	0.98	6.21	5.856	3251.0	4547.0	4316.6	1065.6	4.05	2691.1	1625.5	0.07
24.2	0.145	157	81.6	187.2	2.43	0.98	6.23	5.832	3302.4	4598.4	4411.2	1108.8	3.98	2760.0	1651.2	0.06
28.5	0.171	161	81.4	158.4	2.86	0.97	6.26	5.806	3363.6	4659.6	4501.2	1137.6	3.96	2819.4	1681.8	0.05
32.3	0.194	162	81.3	144.0	3.25	0.97	6.28	5.783	3389.2	4685.2	4541.2	1152.0	3.94	2846.6	1694.6	0.04
36.5	0.219	165	81.1	115.2	3.66	0.96	6.31	5.758	3436.2	4732.2	4617.0	1180.8	3.91	2898.9	1718.1	0.03
45.0	0.270	168	81.0	100.8	4.52	0.95	6.37	5.707	3482.6	4778.6	4677.8	1195.2	3.91	2936.5	1741.3	0.03
53.2	0.319	171	80.9	86.4	5.34	0.95	6.42	5.658	3504.3	4800.3	4713.9	1209.6	3.90	2961.7	1752.1	0.02
62.0	0.372	174	80.8	72.0	6.22	0.94	6.48	5.605	3553.6	4849.6	4777.6	1224.0	3.90	3000.8	1776.8	0.02
70.3	0.422	178	80.7	57.6	7.06	0.93	6.54	5.555	3592.4	4888.4	4830.8	1238.4	3.90	3034.6	1796.2	0.02
78.3	0.470	180	80.6	43.2	7.86	0.92	6.60	5.507	3615.9	4911.9	4868.7	1252.8	3.89	3060.7	1807.9	0.01
87.0	0.522	184	80.5	28.8	8.73	0.91	6.66	5.455	3655.2	4951.2	4922.4	1267.2	3.88	3094.8	1827.6	0.01
95.0	0.570	186	80.4	14.4	9.54	0.90	6.72	5.407	3676.6	4972.6	4958.2	1281.6	3.87	3119.9	1838.3	0.00
103.8	0.623	190	80.3	0.0	10.42	0.90	6.79	5.354	3714.9	5010.9	5010.9	1296.0	3.87	3153.4	1857.4	0.00
112.3	0.674	193	80.2	-14.4	11.28	0.89	6.85	5.303	3744.6	5040.6	5055.0	1310.4	3.86	3182.7	1872.3	0.00
120.2	0.721	195	80.1	-28.8	12.06	0.88	6.91	5.256	3761.4	5057.4	5086.2	1324.8	3.84	3205.5	1880.7	-0.01
128.8	0.773	199	80.0	-43.2	12.93	0.87	6.98	5.204	3798.4	5094.4	5137.6	1339.2	3.84	3238.4	1899.2	-0.01
136.7	0.820	200	80.0	-43.2	13.72	0.86	7.05	5.157	3796.8	5092.8	5136.0	1339.2	3.84	3237.6	1898.4	-0.01
145.7	0.874	204	79.9	-57.6	14.62	0.85	7.12	5.103	3833.9	5129.9	5187.5	1353.6	3.83	3270.6	1917.0	-0.02
154.0	0.924	207	79.8	-72.0	15.46	0.85	7.19	5.053	3852.4	5148.4	5220.4	1368.0	3.82	3294.2	1926.2	-0.02
166.7	1.000	211	79.7	-86.4	16.73	0.83	7.30	4.977	3871.4	5167.4	5253.8	1382.4	3.80	3318.1	1935.7	-0.02

DU @ FAILURE	504.0	DEVIATORIC STRESS @ FAILURE	2603.1	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.29

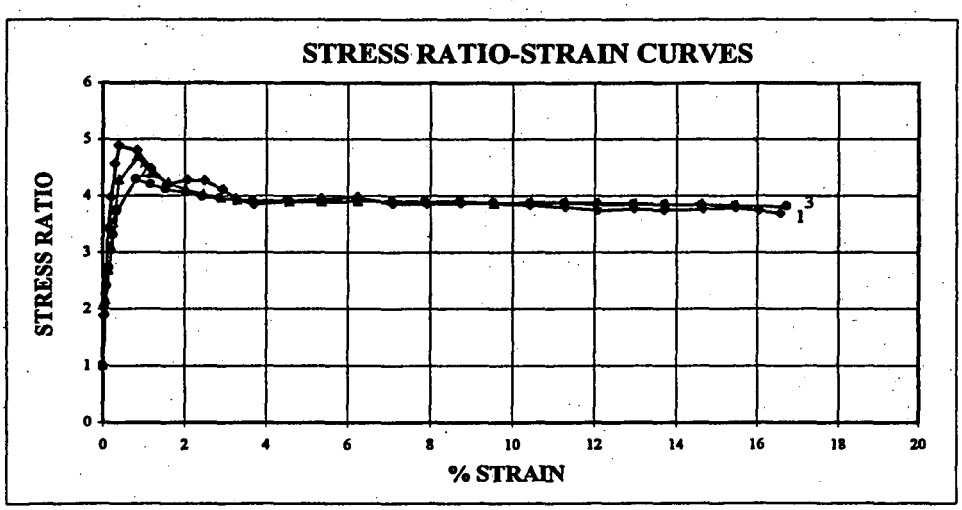
TECH	PWM/SDM
DATE	8/2/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

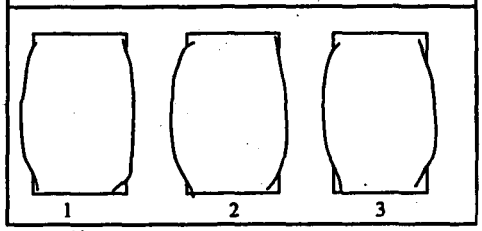
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 9 DEPTH: - Sample Type: Bulk

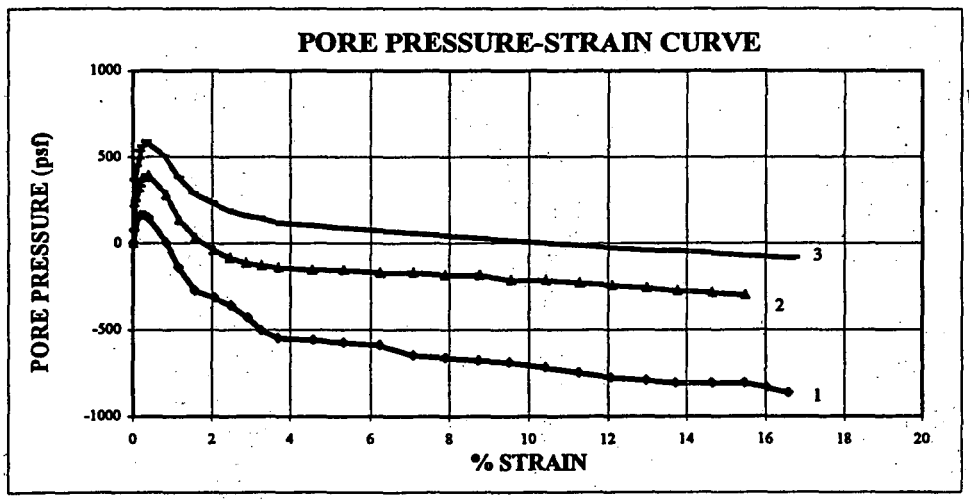


Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	118.8	12.4
2	864	118.6	12.5
3	1296	118.7	12.5
	Average	118.7	12.5



FAILURE SKETCH





Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

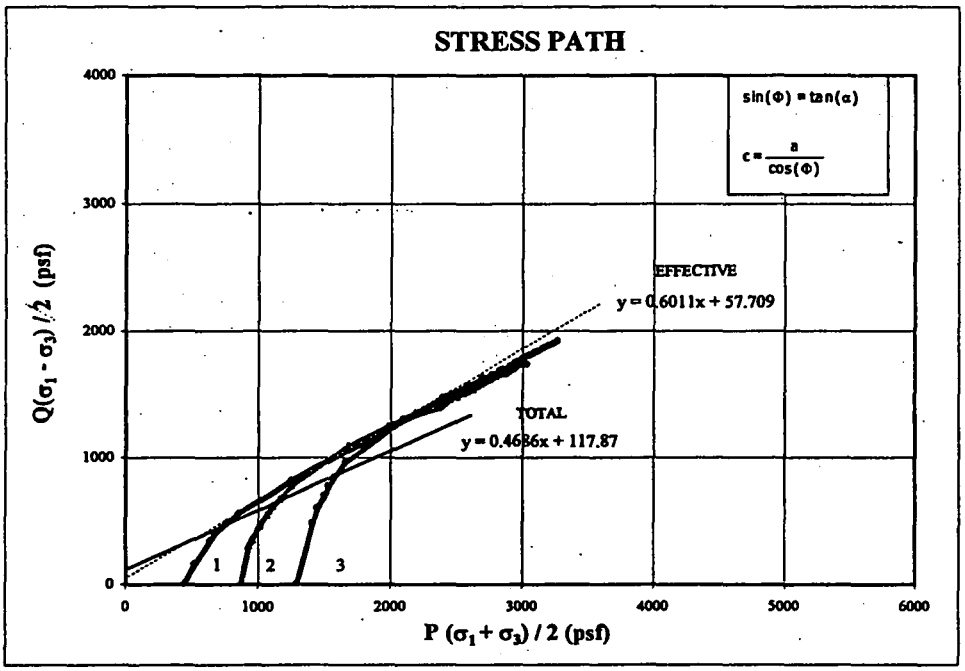
Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

* Failure based on effective stress ratio or 15% strain.

CHECK
REVIEW

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

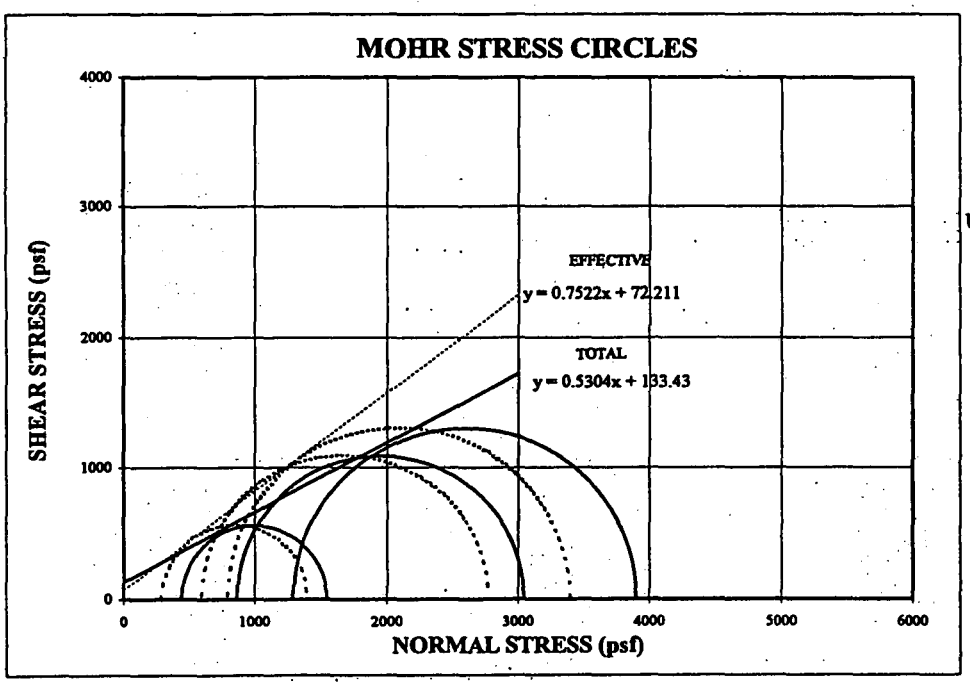
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 9 DEPTH: - Sample Type: Bulk



Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	118.8	12.4
2	864	118.6	12.5
3	1296	118.7	12.5

Specimen	Strain Rate (%)	Initial Saturation (%)	Saturation Before Shearing (%)
1	0.10	80.2	97.1
2	0.10	80.5	97.3
3	0.10	80.2	97.0

STRESS PATH			MOHR CIRCLES		
*TOTAL STRESS PARAMETER			*TOTAL STRENGTH PARAMETER		
α	=	25.1 *	ϕ	=	27.9 *
a	=	117.9 psf	c	=	133.4 psf
* EFFECTIVE STRESS PARAMETER			*EFFECTIVE STRENGTH PARAMETER		
α'	=	31.0 *	ϕ'	=	37.0 *
a'	=	57.7 psf	c'	=	72.2 psf



Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

*** Failure based on effective stress ratio or 15% strain.**

CHECK
REVIEW

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 9
AMPLE TYPE	Bulk
EPTH INTERVAL	-
IACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	83.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	3.0
RESSURE, σ_3 (psf)	432.0
INAL "B" VALUE	1.00
$_0$ (minutes)	0.15
Mounting Method	Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.240	6.000	5.983
DIAMETER	7.087	2.790	2.788
AREA	39.44	6.11	6.10
VOLUME	601.11	36.68	36.52
WEIGHT (g)	1286.68		1313.98
% MOISTURE	12.4		14.80
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	133.6		
DRY DENSITY, calc (pcf)	118.8		
VOLUME OF SOLIDS	423.90		
VOLUME OF VOIDS	177.20		
VOID RATIO	0.418		
SATURATION	80.2		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	119.3
VOLUME OF SOLIDS	423.90
VOLUME OF VOIDS	174.50
VOID RATIO	0.412

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1313.98
WT SOIL & TARE, DRY (g)	1144.54
WT TARE (g)	0.00
WT MOISTURE (g)	169.44
WT DRY SOIL (g)	1144.54
% MOISTURE	14.80

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	13	81.4	0.0	0.00	1.00	6.10	5.983	0.0	432.0	432.0	432.0	1.00	432.0	0.0	0.00
0.3	0.002	26	81.9	72.0	0.03	1.00	6.11	5.981	316.0	748.0	676.0	360.0	1.88	518.0	158.0	0.23
1.3	0.008	42	82.4	144.0	0.13	1.00	6.11	5.975	695.1	1127.1	983.1	288.0	3.41	635.5	347.5	0.21
2.0	0.012	47	82.5	158.4	0.20	1.00	6.12	5.971	810.0	1242.0	1083.6	273.6	3.96	678.6	405.0	0.20
3.0	0.018	54	82.5	158.4	0.30	1.00	6.12	5.965	976.2	1408.2	1249.8	273.6	4.57	761.7	488.1	0.16
4.0	0.024	60	82.4	144.0	0.40	1.00	6.13	5.959	1120.9	1552.9	1408.9	288.0	4.89	848.4	560.4	0.13
8.3	0.050	83	81.4	0.0	0.84	0.99	6.15	5.933	1642.4	2074.4	2074.4	432.0	4.80	1253.2	821.2	0.00
11.7	0.070	98	80.4	-144.0	1.17	0.99	6.18	5.913	2002.9	2434.9	2578.9	576.0	4.48	1577.5	1001.5	-0.07
15.7	0.094	110	79.5	-273.6	1.57	0.98	6.20	5.889	2261.9	2693.9	2967.5	705.6	4.21	1836.5	1130.9	-0.12
20.5	0.123	119	79.2	-316.8	2.06	0.98	6.23	5.860	2456.4	2888.4	3205.2	748.8	4.28	1977.0	1228.2	-0.13
24.7	0.148	125	78.9	-360.0	2.47	0.98	6.26	5.835	2586.3	3018.3	3378.3	792.0	4.27	2085.1	1293.1	-0.14
29.2	0.175	130	78.4	-432.0	2.92	0.97	6.29	5.808	2682.0	3114.0	3546.0	864.0	4.10	2205.0	1341.0	-0.16
32.5	0.195	133	77.9	-504.0	3.26	0.97	6.31	5.788	2750.3	3182.3	3686.3	936.0	3.94	2311.2	1375.2	-0.18
36.8	0.221	135	77.6	-547.2	3.69	0.96	6.34	5.762	2783.4	3215.4	3762.6	979.2	3.84	2370.9	1391.7	-0.20
45.7	0.274	141	77.5	-561.6	4.58	0.95	6.40	5.709	2892.9	3324.9	3886.5	993.6	3.91	2440.0	1446.4	-0.19
53.3	0.320	145	77.4	-576.0	5.35	0.95	6.45	5.663	2967.8	3399.8	3975.8	1008.0	3.94	2491.9	1483.9	-0.19
62.2	0.373	150	77.3	-590.4	6.23	0.94	6.51	5.610	3035.2	3467.2	4057.6	1022.4	3.97	2540.0	1517.6	-0.19
70.7	0.424	153	76.9	-648.0	7.09	0.93	6.57	5.559	3084.3	3516.3	4164.3	1080.0	3.86	2622.2	1542.2	-0.21
78.8	0.473	156	76.8	-662.4	7.91	0.92	6.63	5.510	3122.3	3554.3	4216.7	1094.4	3.85	2655.6	1561.2	-0.21
87.2	0.523	160	76.7	-676.8	8.74	0.91	6.69	5.460	3171.5	3603.5	4280.3	1108.8	3.86	2694.5	1585.7	-0.21
95.0	0.570	163	76.6	-691.2	9.53	0.90	6.75	5.413	3216.8	3648.8	4340.0	1123.2	3.86	2731.6	1608.4	-0.21
104.0	0.624	167	76.4	-720.0	10.43	0.90	6.81	5.359	3260.8	3692.8	4412.8	1152.0	3.83	2782.4	1630.4	-0.22
112.5	0.675	170	76.2	-748.8	11.28	0.89	6.88	5.308	3300.9	3732.9	4481.7	1180.8	3.80	2831.2	1650.4	-0.23
120.5	0.723	173	76.0	-777.6	12.08	0.88	6.94	5.260	3318.7	3750.7	4528.3	1209.6	3.74	2869.0	1659.4	-0.23
129.3	0.776	177	75.9	-792.0	12.97	0.87	7.01	5.207	3379.8	3811.8	4603.8	1224.0	3.76	2913.9	1689.9	-0.23
136.7	0.820	179	75.8	-806.4	13.71	0.86	7.07	5.163	3398.0	3830.0	4636.4	1238.4	3.74	2937.4	1699.0	-0.24
146.2	0.877	183	75.8	-806.4	14.66	0.85	7.15	5.106	3424.9	3856.9	4663.3	1238.4	3.77	2950.9	1712.5	-0.24
154.3	0.926	186	75.8	-806.4	15.48	0.85	7.22	5.057	3453.9	3885.9	4692.3	1238.4	3.79	2965.3	1726.9	-0.23
160.0	0.960	187	75.6	-835.2	16.05	0.84	7.27	5.023	3464.3	3896.3	4731.5	1267.2	3.73	2999.4	1732.2	-0.24
165.3	0.992	189	75.4	-864.0	16.58	0.83	7.32	4.991	3471.8	3903.8	4767.8	1296.0	3.68	3031.9	1735.9	-0.25

DU @ FAILURE	144.00	DEVIATORIC STRESS @ FAILURE	1120.88	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.89

TECH	PWM/SDM
DATE	8/2/04
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 10
AMPLE TYPE	Bulk
EPTH INTERVAL	-
IACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	83.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION	
RESSURE, σ_3 (psi)	3.0
RESSURE, σ_3 (psf)	432.0
INAL "B" VALUE	1.00
$_0$ (minutes)	0.07

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.265	6.010	6.002
DIAMETER	7.087	2.790	2.786
AREA	39.44	6.11	6.09
VOLUME	602.11	36.74	36.58
WEIGHT (g)	1262.36		1294.66
% MOISTURE	13.2		16.05
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	130.8		
DRY DENSITY, calc (pcf)	115.6		
VOLUME OF SOLIDS	413.18		
VOLUME OF VOIDS	188.93		
VOID RATIO	0.457		
SATURATION	77.7		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	116.1
VOLUME OF SOLIDS	413.18
VOLUME OF VOIDS	186.23
VOID RATIO	0.451
WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1294.66
WT SOIL & TARE, DRY (g)	1115.59
WT TARE (g)	0.00
WT MOISTURE (g)	179.07
WT DRY SOIL (g)	1115.59
% MOISTURE	16.05

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	15	79.9	0.0	0.00	1.00	6.09	6.002	0.0	432.0	432.0	432.0	1.00	432.0	0.0	0.00
0.5	0.003	30	80.7	115.2	0.05	1.00	6.10	5.999	354.3	786.3	671.1	316.8	2.12	493.9	177.1	0.33
1.0	0.006	38	81.0	158.4	0.10	1.00	6.10	5.996	542.9	974.9	816.5	273.6	2.98	545.1	271.5	0.29
1.5	0.009	43	81.2	187.2	0.15	1.00	6.10	5.993	660.6	1092.6	905.4	244.8	3.70	575.1	330.3	0.28
2.0	0.012	48	81.4	216.0	0.20	1.00	6.11	5.990	778.2	1210.2	994.2	216.0	4.60	605.1	389.1	0.28
2.5	0.015	50	81.5	230.4	0.25	1.00	6.11	5.987	824.9	1256.9	1026.5	201.6	5.09	614.1	412.5	0.28
4.2	0.025	60	81.5	230.4	0.42	1.00	6.12	5.977	1058.9	1490.9	1260.5	201.6	6.25	731.0	529.4	0.22
8.3	0.050	69	81.1	172.8	0.83	0.99	6.15	5.952	1265.3	1697.3	1524.5	259.2	5.88	891.9	632.7	0.14
12.5	0.075	72	80.7	115.2	1.25	0.99	6.17	5.927	1330.0	1762.0	1646.8	316.8	5.20	981.8	665.0	0.09
16.7	0.100	74	80.5	86.4	1.67	0.98	6.20	5.902	1370.9	1802.9	1716.5	345.6	4.97	1031.0	685.4	0.06
22.5	0.135	75	80.2	43.2	2.25	0.98	6.23	5.867	1385.8	1817.8	1774.6	388.8	4.56	1081.7	692.9	0.03
25.0	0.150	75	80.2	43.2	2.50	0.98	6.25	5.852	1382.3	1814.3	1771.1	388.8	4.56	1079.9	691.1	0.03
29.2	0.175	77	80.1	28.8	2.92	0.97	6.28	5.827	1422.3	1854.3	1825.5	403.2	4.53	1114.3	711.1	0.02
33.3	0.200	79	80.0	14.4	3.33	0.97	6.30	5.802	1461.8	1893.8	1879.4	417.6	4.50	1148.5	730.9	0.01
41.7	0.250	82	79.8	-14.4	4.17	0.96	6.36	5.752	1517.2	1949.2	1963.6	446.4	4.40	1205.0	758.6	-0.01
52.5	0.315	85	79.5	-57.6	5.25	0.95	6.43	5.687	1567.2	1999.2	2056.8	489.6	4.20	1273.2	783.6	-0.04
58.3	0.350	87	79.4	-72.0	5.83	0.94	6.47	5.652	1602.1	2034.1	2106.1	504.0	4.18	1305.0	801.0	-0.04
66.7	0.400	90	79.3	-86.4	6.66	0.93	6.53	5.602	1654.0	2086.0	2172.4	518.4	4.19	1345.4	827.0	-0.05
75.0	0.450	92	79.1	-115.2	7.50	0.93	6.59	5.552	1683.0	2115.0	2230.2	547.2	4.08	1388.7	841.5	-0.07
83.3	0.500	94	79.0	-129.6	8.33	0.92	6.65	5.502	1711.2	2143.2	2272.8	561.6	4.05	1417.2	855.6	-0.08
91.7	0.550	95	79.0	-129.6	9.16	0.91	6.71	5.452	1717.1	2149.1	2278.7	561.6	4.06	1420.1	858.5	-0.08
100.0	0.600	97	78.9	-144.0	10.00	0.90	6.77	5.402	1743.9	2175.9	2319.9	576.0	4.03	1447.9	871.9	-0.08
108.3	0.650	100	78.8	-158.4	10.83	0.89	6.83	5.352	1790.9	2222.9	2381.3	590.4	4.03	1485.9	895.5	-0.09
116.7	0.700	102	78.7	-172.8	11.66	0.88	6.90	5.302	1815.9	2247.9	2420.7	604.8	4.00	1512.8	908.0	-0.10
125.0	0.750	104	78.7	-172.8	12.50	0.88	6.96	5.252	1840.2	2272.2	2445.0	604.8	4.04	1524.9	920.1	-0.09
133.3	0.800	105	78.6	-187.2	13.33	0.87	7.03	5.202	1843.1	2275.1	2462.3	619.2	3.98	1540.8	921.6	-0.10
141.7	0.850	107	78.5	-201.6	14.16	0.86	7.10	5.152	1866.0	2298.0	2499.6	633.6	3.95	1566.6	933.0	-0.11
150.0	0.900	110	78.4	-216.0	15.00	0.85	7.17	5.102	1908.1	2340.1	2556.1	648.0	3.94	1602.1	954.1	-0.11
158.3	0.950	112	78.4	-216.0	15.83	0.84	7.24	5.052	1929.2	2361.2	2577.2	648.0	3.98	1612.6	964.6	-0.11
166.7	1.000	114	78.3	-230.4	16.66	0.83	7.31	5.002	1949.5	2381.5	2611.9	662.4	3.94	1637.1	974.7	-0.12

DU @ FAILURE	230.40	DEVIATORIC STRESS @ FAILURE	1058.86	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	6.25

TECH	PWM/SDM
DATE	8/2/04
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 10
AMPLE TYPE	Bulk
EPTH INTERVAL	-
IACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	86.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION	
RESSURE, σ_3 (psi)	6.0
RESSURE, σ_3 (psf)	864.0
INAL "B" VALUE	1.00
$_0$ (minutes)	0.52

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.235	5.998	5.983
DIAMETER	7.087	2.790	2.779
AREA	39.44	6.11	6.06
VOLUME	600.91	36.67	36.28
WEIGHT (g)	1262.55		1291.15
% MOISTURE	13.3		15.82
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	131.1		
DRY DENSITY, calc (pcf)	115.8		
VOLUME OF SOLIDS	412.89		
VOLUME OF VOIDS	188.01		
VOID RATIO	0.455		
SATURATION	78.6		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	117.0
VOLUME OF SOLIDS	412.89
VOLUME OF VOIDS	181.61
VOID RATIO	0.440
WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1291.15
WT SOIL & TARE, DRY (g)	1114.81
WT TARE (g)	0.00
WT MOISTURE (g)	176.34
WT DRY SOIL (g)	1114.81
% MOISTURE	15.82

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	17	80.5	0.0	0.00	1.00	6.06	5.983	0.0	864.0	864.0	864.0	1.00	864.0	0.0	0.00
0.5	0.003	43	82.1	230.4	0.05	1.00	6.07	5.980	617.1	1481.1	1250.7	633.6	1.97	942.2	308.6	0.37
1.0	0.006	52	82.5	288.0	0.10	1.00	6.07	5.977	830.3	1694.3	1406.3	576.0	2.44	991.2	415.2	0.35
1.5	0.009	62	83.0	360.0	0.15	1.00	6.07	5.974	1067.1	1931.1	1571.1	504.0	3.12	1037.5	533.5	0.34
2.0	0.012	68	83.2	388.8	0.20	1.00	6.08	5.971	1208.7	2072.7	1683.9	475.2	3.54	1079.6	604.4	0.32
2.5	0.015	72	83.3	403.2	0.25	1.00	6.08	5.968	1302.9	2166.9	1763.7	460.8	3.83	1112.2	651.4	0.31
4.2	0.025	82	83.4	417.6	0.42	1.00	6.09	5.958	1537.2	2401.2	1983.6	446.4	4.44	1215.0	768.6	0.27
8.3	0.050	100	82.7	316.8	0.84	0.99	6.11	5.933	1954.6	2818.6	2501.8	547.2	4.57	1524.5	977.3	0.16
12.5	0.075	107	82.1	230.4	1.25	0.99	6.14	5.908	2110.5	2974.5	2744.1	633.6	4.33	1688.9	1055.3	0.11
16.7	0.100	114	81.6	158.4	1.67	0.98	6.17	5.883	2265.1	3129.1	2970.7	705.6	4.21	1838.1	1132.5	0.07
20.8	0.125	117	81.2	100.8	2.09	0.98	6.19	5.858	2325.2	3189.2	3088.4	763.2	4.05	1925.8	1162.6	0.04
25.0	0.150	119	81.0	72.0	2.51	0.97	6.22	5.833	2361.6	3225.6	3153.6	792.0	3.98	1972.8	1180.8	0.03
29.2	0.175	122	80.7	28.8	2.92	0.97	6.25	5.808	2420.6	3284.6	3255.8	835.2	3.90	2045.5	1210.3	0.01
33.3	0.200	124	80.5	0.0	3.34	0.97	6.27	5.783	2456.1	3320.1	3320.1	864.0	3.84	2092.0	1228.0	0.00
41.7	0.250	129	80.3	-28.8	4.18	0.96	6.33	5.733	2548.6	3412.6	3441.4	892.8	3.85	2167.1	1274.3	-0.01
50.0	0.300	130	80.1	-57.6	5.01	0.95	6.38	5.683	2549.0	3413.0	3470.6	921.6	3.77	2196.1	1274.5	-0.02
58.3	0.350	134	79.9	-86.4	5.85	0.94	6.44	5.633	2616.0	3480.0	3566.4	950.4	3.75	2258.4	1308.0	-0.03
66.7	0.400	137	79.8	-100.8	6.69	0.93	6.50	5.583	2659.2	3523.2	3624.0	964.8	3.76	2294.4	1329.6	-0.04
75.0	0.450	140	79.6	-129.6	7.52	0.92	6.56	5.533	2701.3	3565.3	3694.9	993.6	3.72	2344.3	1350.7	-0.05
83.3	0.500	142	79.5	-144.0	8.36	0.92	6.62	5.483	2720.4	3584.4	3728.4	1008.0	3.70	2368.2	1360.2	-0.05
91.7	0.550	145	79.4	-158.4	9.19	0.91	6.68	5.433	2760.3	3624.3	3782.7	1022.4	3.70	2402.6	1380.2	-0.06
100.0	0.600	148	79.3	-172.8	10.03	0.90	6.74	5.383	2799.0	3663.0	3835.8	1036.8	3.70	2436.3	1399.5	-0.06
110.0	0.660	150	79.1	-201.6	11.03	0.89	6.82	5.323	2810.1	3674.1	3875.7	1065.6	3.64	2470.6	1405.0	-0.07
116.7	0.700	155	79.0	-216.0	11.70	0.88	6.87	5.283	2893.8	3757.8	3973.8	1080.0	3.68	2526.9	1446.9	-0.07
125.0	0.750	157	78.9	-230.4	12.54	0.87	6.93	5.233	2907.9	3771.9	4002.3	1094.4	3.66	2548.4	1454.0	-0.08
133.3	0.800	160	78.8	-244.8	13.37	0.87	7.00	5.183	2941.9	3805.9	4050.7	1108.8	3.65	2579.7	1470.9	-0.08
141.7	0.850	162	78.7	-259.2	14.21	0.86	7.07	5.133	2954.3	3818.3	4077.5	1123.2	3.63	2600.3	1477.1	-0.09
150.0	0.900	165	78.6	-273.6	15.04	0.85	7.14	5.083	2986.0	3850.0	4123.6	1137.6	3.62	2630.6	1493.0	-0.09
158.3	0.950	167	78.5	-288.0	15.88	0.84	7.21	5.033	2996.6	3860.6	4148.6	1152.0	3.60	2650.3	1498.3	-0.10
166.7	1.000	169	78.4	-302.4	16.71	0.83	7.28	4.983	3006.4	3870.4	4172.8	1166.4	3.58	2669.6	1503.2	-0.10

DU @ FAILURE	316.8	DEVIATORIC STRESS @ FAILURE	1954.6	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.57

TECH	PWM/SDM
DATE	8/2/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST (ASTM D 4767) CONSOLIDATED UNDRAINED WITH PORE PRESSURE

ROJECT TITLE	ROCKY FLATS/FIELD AND LAB TESTING/CO
ROJECT NUMBER	043-2246-0001
AMPLE ID	PF - 10
AMPLE TYPE	Bulk
EPTH INTERVAL	-
IACHINE SPEED (in/min)	0.006
TRAIN RATE (%/min)	0.10
ELL PRESSURE (psi)	89.0
AMPLE PRESSURE (psi)	80.0
FF. CONSOLIDATION RESSURE, σ_3 (psi)	9.0
RESSURE, σ_3 (psf)	1296.0
INAL "B" VALUE	0.99
$_0$ (minutes)	0.34

Mounting Method: Wet

INITIAL SAMPLE DATA	cm	in	corrected
HEIGHT	15.253	6.005	5.988
DIAMETER	7.087	2.790	2.780
AREA	39.44	6.11	6.07
VOLUME	601.61	36.71	36.35
WEIGHT (g)	1262.28		1291.28
% MOISTURE	13.0		15.58
SPECIFIC GRAVITY	2.70		
MOIST DENSITY (pcf)	130.9		
DRY DENSITY, calc (pcf)	115.9		
VOLUME OF SOLIDS	413.79		
VOLUME OF VOIDS	187.81		
VOID RATIO	0.454		
SATURATION	77.2		

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	117.1
VOLUME OF SOLIDS	413.79
VOLUME OF VOIDS	181.81
VOID RATIO	0.439

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1291.28
WT SOIL & TARE, DRY (g)	1117.24
WT TARE (g)	0.00
WT MOISTURE (g)	174.04
WT DRY SOIL (g)	1117.24
% MOISTURE	15.58

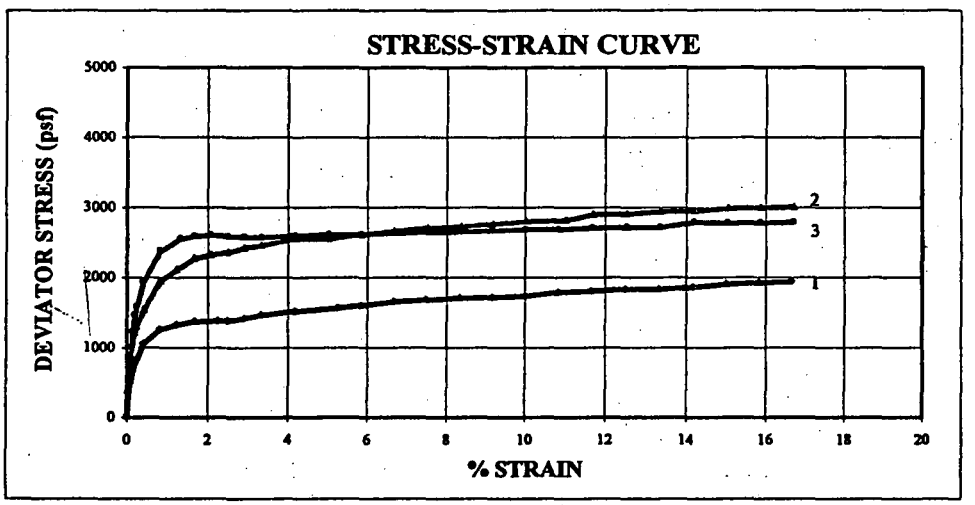
TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	PWP change DU (psf) (acc)	ε % STRAIN (%)	(1-ε)	CORR. AREA (in 2)	CORR. HEIGHT (in)	DEV. STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	EFF.PRN STR RATIO (σ_1'/σ_3')	$\frac{(\sigma_1'+\sigma_3')}{2}$ (P)	$\frac{(\sigma_1-\sigma_3)}{2}$ (Q)	(A)
0.0	0.000	18	80.5	0.0	0.00	1.00	6.07	5.988	0.0	1296.0	1296.0	1296.0	1.00	1296.0	0.0	0
0.5	0.003	40	82.1	230.4	0.05	1.00	6.07	5.985	521.7	1817.7	1587.3	1065.6	1.49	1326.4	260.8	0.44
1.0	0.006	53	82.9	345.6	0.10	1.00	6.08	5.982	829.5	2125.5	1779.9	950.4	1.87	1365.2	414.8	0.42
1.5	0.009	70	83.7	460.8	0.15	1.00	6.08	5.979	1231.8	2527.8	2067.0	835.2	2.47	1451.1	615.9	0.37
2.0	0.012	80	84.3	547.2	0.20	1.00	6.08	5.976	1467.9	2763.9	2216.7	748.8	2.96	1482.8	734.0	0.37
2.5	0.015	85	84.6	590.4	0.25	1.00	6.09	5.973	1585.5	2881.5	2291.1	705.6	3.25	1498.4	792.8	0.37
4.2	0.025	100	85.0	648.0	0.42	1.00	6.10	5.963	1937.2	3233.2	2585.2	648.0	3.99	1616.6	968.6	0.33
8.3	0.050	119	84.5	576.0	0.84	0.99	6.12	5.938	2376.1	3672.1	3096.1	720.0	4.30	1908.1	1188.1	0.24
13.3	0.080	127	83.8	475.2	1.34	0.99	6.15	5.908	2551.4	3847.4	3372.2	820.8	4.11	2096.5	1275.7	0.19
16.7	0.100	129	83.6	446.4	1.67	0.98	6.17	5.888	2589.4	3885.4	3439.0	849.6	4.05	2144.3	1294.7	0.17
20.8	0.125	130	83.4	417.6	2.09	0.98	6.20	5.863	2601.6	3897.6	3480.0	878.4	3.96	2179.2	1300.8	0.16
25.0	0.150	130	83.3	403.2	2.51	0.97	6.23	5.838	2590.5	3886.5	3483.3	892.8	3.90	2188.1	1295.3	0.16
29.2	0.175	130	83.2	388.8	2.92	0.97	6.25	5.813	2579.4	3875.4	3486.6	907.2	3.84	2196.9	1289.7	0.15
33.3	0.200	130	83.1	374.4	3.34	0.97	6.28	5.788	2568.3	3864.3	3489.9	921.6	3.79	2205.8	1284.2	0.15
41.7	0.250	132	83.1	374.4	4.18	0.96	6.33	5.738	2591.6	3887.6	3513.2	921.6	3.81	2217.4	1295.8	0.14
50.0	0.300	134	83.0	360.0	5.01	0.95	6.39	5.688	2614.1	3910.1	3550.1	936.0	3.79	2243.0	1307.0	0.14
58.3	0.350	135	83.0	360.0	5.85	0.94	6.45	5.638	2613.5	3909.5	3549.5	936.0	3.79	2242.7	1306.7	0.14
66.7	0.400	137	82.9	345.6	6.68	0.93	6.50	5.588	2634.6	3930.6	3585.0	950.4	3.77	2267.7	1317.3	0.13
79.2	0.475	139	82.8	331.2	7.93	0.92	6.59	5.513	2642.9	3938.9	3607.7	964.8	3.74	2286.2	1321.4	0.13
83.3	0.500	140	82.8	331.2	8.35	0.92	6.62	5.488	2652.6	3948.6	3617.4	964.8	3.75	2291.1	1326.3	0.12
91.7	0.550	142	82.7	316.8	9.19	0.91	6.68	5.438	2671.6	3967.6	3650.8	979.2	3.73	2315.0	1335.8	0.12
100.0	0.600	144	82.6	302.4	10.02	0.90	6.75	5.388	2689.7	3985.7	3683.3	993.6	3.71	2338.4	1344.8	0.11
108.3	0.650	145	82.6	302.4	10.86	0.89	6.81	5.338	2685.9	3981.9	3679.5	993.6	3.70	2336.5	1342.9	0.11
116.7	0.700	147	82.6	302.4	11.69	0.88	6.87	5.288	2702.6	3998.6	3696.2	993.6	3.72	2344.9	1351.3	0.11
125.0	0.750	149	82.5	288.0	12.53	0.87	6.94	5.238	2718.6	4014.6	3726.6	1008.0	3.70	2367.3	1359.3	0.11
133.3	0.800	150	82.5	288.0	13.36	0.87	7.01	5.188	2713.2	4009.2	3721.2	1008.0	3.69	2364.6	1356.6	0.11
141.7	0.850	155	82.4	273.6	14.20	0.86	7.07	5.138	2788.8	4084.8	3811.2	1022.4	3.73	2416.8	1394.4	0.10
150.0	0.900	156	82.4	273.6	15.03	0.85	7.14	5.088	2781.8	4077.8	3804.2	1022.4	3.72	2413.3	1390.9	0.10
158.3	0.950	157	82.4	273.6	15.87	0.84	7.21	5.038	2774.5	4070.5	3796.9	1022.4	3.71	2409.6	1387.2	0.10
166.7	1.000	159	82.3	259.2	16.70	0.83	7.29	4.988	2786.4	4082.4	3823.2	1036.8	3.69	2430.0	1393.2	0.09

DU @ FAILURE	576.0	DEVIATORIC STRESS @ FAILURE	2376.1	EFFECTIVE PRINCIPLE STRESS RATIO @ FAILURE	4.30

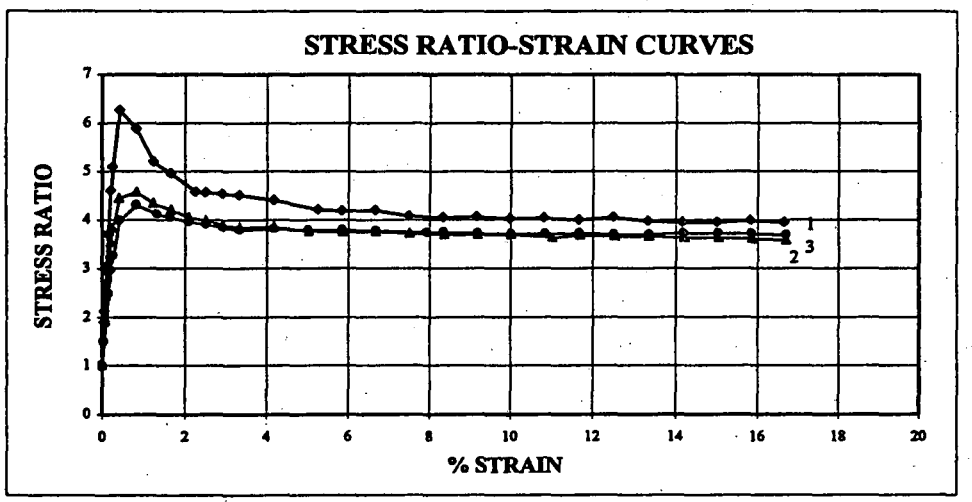
TECH	PWM/SDM
DATE	8/2/2004
CHECKED	
REVIEWED	

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

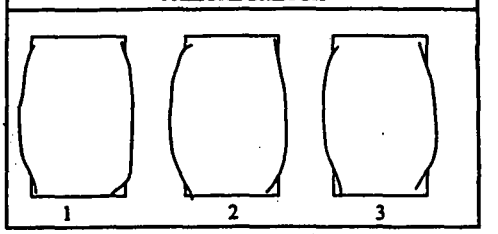
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 10 DEPTH: - Sample Type: Bulk

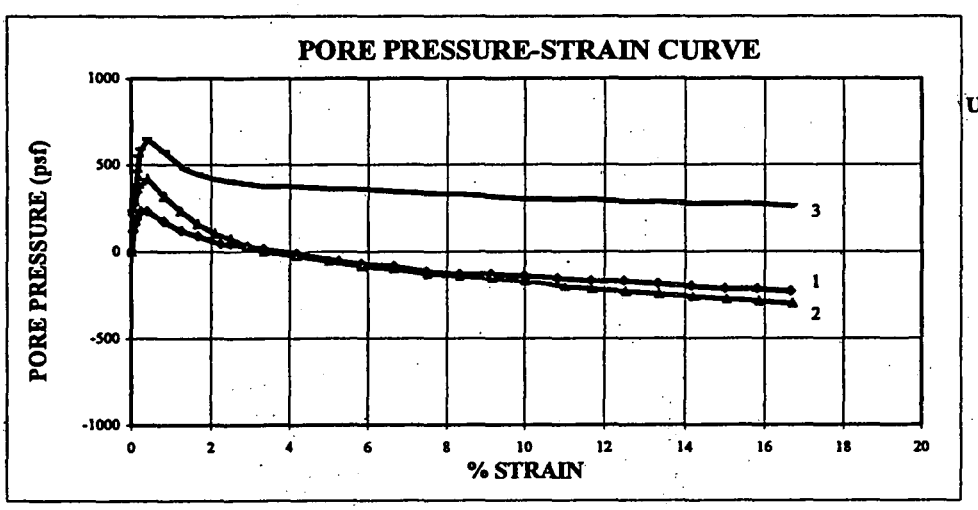


Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	115.6	13.2
2	864	115.8	13.3
3	1296	115.9	13.0
	Average	115.8	13.1



FAILURE SKETCH





Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

* Failure based on effective stress ratio or 15% strain.

CHECK
REVIEW

CONSOLIDATED UNDRAINED TRIAXIAL STRENGTH								CONSOLIDATED UNDRAINED TRI		
MOHR CIRCLE GENERATION SPREADSHEET								MOHR CIRCLE GENERATION SPRE		
	PF - 9	-	B	C	A				PF - 9	-
CONFINING PRESSURE USED (S3)			432	864	1296	psf		CONFINING PRESSURE USED (S3)		
CONFINING PRESSURE USED (S3)			432	864	1296	psi		CONFINING PRESSURE USED (S3)		
MAXIMUM DEVIATOR STRESS (PS			1120.9	2178.1	2603.1	psf		MAXIMUM DEVIATOR STRESS (PS		
(or load at 15% strain)								(or load at 15% strain)		
dU AT FAIL	(S1-S3)/2	(S1'+S3')/2		coh	sin phi	phi		dU AT FAIL	(S1-S3)/2	(S1'+S3')/2
144.0	560.4	848.4	COH 1&2	20	0.636108748	40		144.0	560.4	992.4
273.6	1089.1	1679.5	COH 1&3	60	0.595223682	37		273.6	1089.1	1953.1
504.0	1301.6	2093.6	COH 2&3	230	0.513178269	31		504.0	1301.6	2597.6
		EFFECTIVE								TOTAL
TA POINTS	A	B	C					DATA POINTS	A	B
	MOHR,1	MOHR,2	MOHR,3						MOHR,1	MOHR,2
X	Y,1	Y,2	Y,3					X	Y,1	Y,2
0	#NUM!	#NUM!	#NUM!					0	#NUM!	#NUM!
10	#NUM!	#NUM!	#NUM!					10	#NUM!	#NUM!
20	#NUM!	#NUM!	#NUM!					20	#NUM!	#NUM!
30	#NUM!	#NUM!	#NUM!					30	#NUM!	#NUM!
40	#NUM!	#NUM!	#NUM!					40	#NUM!	#NUM!
50	#NUM!	#NUM!	#NUM!					50	#NUM!	#NUM!
60	#NUM!	#NUM!	#NUM!					60	#NUM!	#NUM!
70	#NUM!	#NUM!	#NUM!					70	#NUM!	#NUM!
80	#NUM!	#NUM!	#NUM!					80	#NUM!	#NUM!
90	#NUM!	#NUM!	#NUM!					90	#NUM!	#NUM!
100	#NUM!	#NUM!	#NUM!					100	#NUM!	#NUM!
110	#NUM!	#NUM!	#NUM!					110	#NUM!	#NUM!
120	#NUM!	#NUM!	#NUM!					120	#NUM!	#NUM!
130	#NUM!	#NUM!	#NUM!					130	#NUM!	#NUM!
140	#NUM!	#NUM!	#NUM!					140	#NUM!	#NUM!
150	#NUM!	#NUM!	#NUM!					150	#NUM!	#NUM!
160	#NUM!	#NUM!	#NUM!					160	#NUM!	#NUM!
170	#NUM!	#NUM!	#NUM!					170	#NUM!	#NUM!
180	#NUM!	#NUM!	#NUM!					180	#NUM!	#NUM!
190	#NUM!	#NUM!	#NUM!					190	#NUM!	#NUM!
200	#NUM!	#NUM!	#NUM!					200	#NUM!	#NUM!
210	#NUM!	#NUM!	#NUM!					210	#NUM!	#NUM!
220	#NUM!	#NUM!	#NUM!					220	#NUM!	#NUM!
230	#NUM!	#NUM!	#NUM!					230	#NUM!	#NUM!
240	#NUM!	#NUM!	#NUM!					240	#NUM!	#NUM!
250	#NUM!	#NUM!	#NUM!					250	#NUM!	#NUM!
260	#NUM!	#NUM!	#NUM!					260	#NUM!	#NUM!
270	#NUM!	#NUM!	#NUM!					270	#NUM!	#NUM!
280	#NUM!	#NUM!	#NUM!					280	#NUM!	#NUM!
290	47	#NUM!	#NUM!					290	#NUM!	#NUM!
300	115	#NUM!	#NUM!					300	#NUM!	#NUM!
310	155	#NUM!	#NUM!					310	#NUM!	#NUM!
320	187	#NUM!	#NUM!					320	#NUM!	#NUM!
330	213	#NUM!	#NUM!					330	#NUM!	#NUM!
340	236	#NUM!	#NUM!					340	#NUM!	#NUM!
350	256	#NUM!	#NUM!					350	#NUM!	#NUM!
360	275	#NUM!	#NUM!					360	#NUM!	#NUM!

APPENDIX G

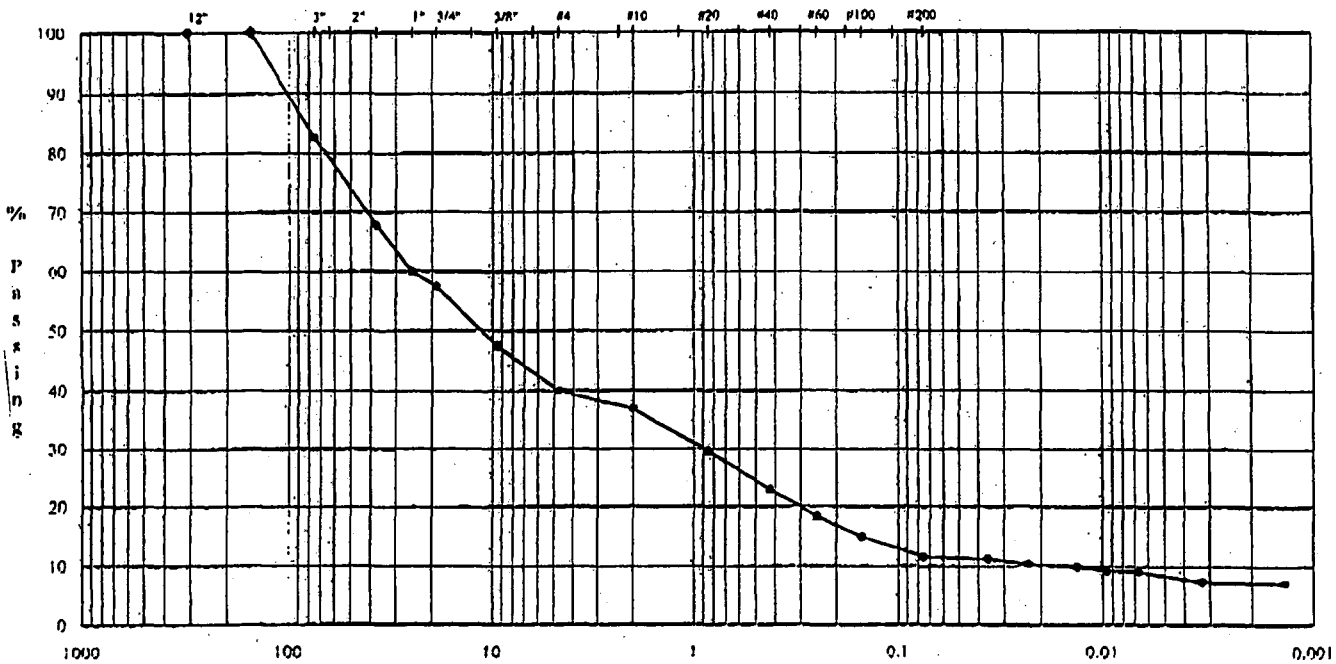
ATTACHMENT 2
CENTENNIAL ROCKY FLATS ALLUVIUM

October-04 | 043-2246.0001

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: APR-1 Depth (ft): --
TYPE: BULK



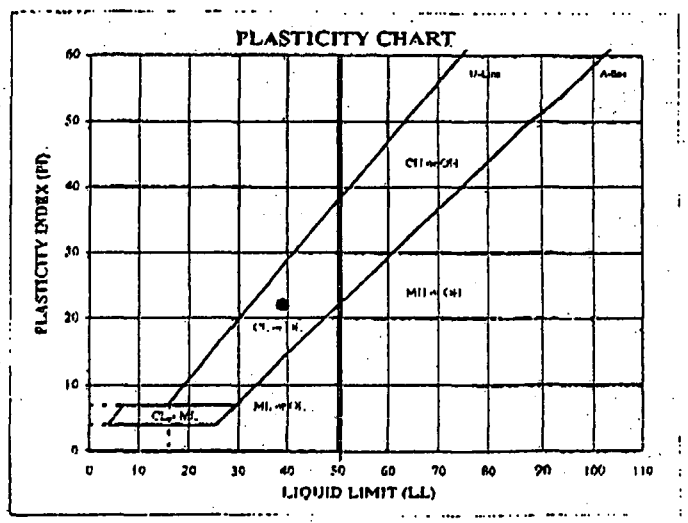
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0" 304.8	100.0		
6.0" 154.2	100.0	Cobbles	17.40
6.0" 154.2	100.0		
6.0" 154.2	100.0		
3.0" 75.0	82.6		
1.5" 37.5	67.7		
1.0" 25.0	60.0	Coarse Gravel	25.22
0.75" 19.0	57.4		
0.375" 9.5	47.4		
#4 4.8	39.9	Fine Gravel	17.51
#10 2.00	36.9	Coarse Sand	2.98
#20 0.85	29.5		
#40 0.43	22.8	Medium Sand	14.07
#60 0.25	18.3		
#100 0.15	14.9		
#200 0.075	11.4	Fine Sand	11.38

Hydrometer Analysis

(mm)	%Finer		
0.036	11.1		
0.023	10.2		
0.013	9.8	Fines	
0.0095	9.2	Silt or Clay	11.44
0.0067	9.0		
0.0033	7.3		
0.0014	7.0		



ATTERBERG LIMITS

M_c	LL	PL	PI	SpG (assumed)
10.4	39	17	22	2.70

DESCRIPTION: Strong brown (7.55 YR 5/6) clayey gravel with sand

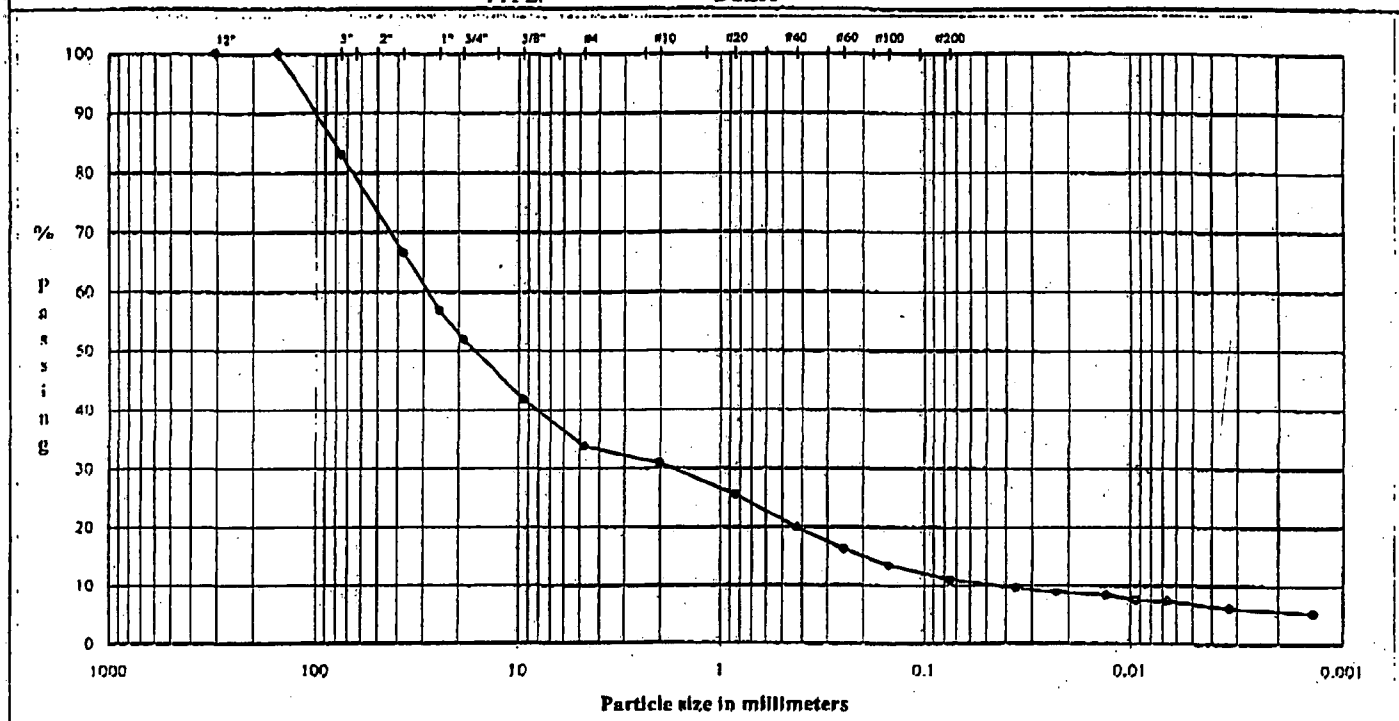
USCS: GC

TECH: JR
DATE: 11/3/2004
REVIEW: MB

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: Rocky Flats/Field & Lab Testing/CO
SAMPLE ID: APR-2 Depth (ft): --
TYPE: BULK



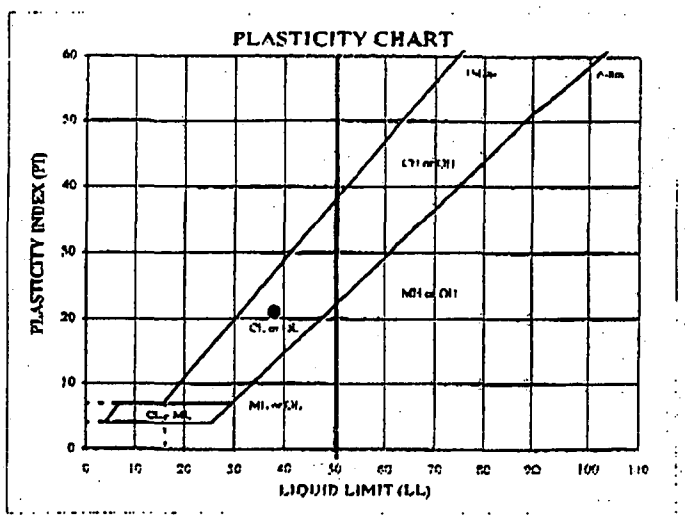
COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

Particle Size	(mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	100.0		
6.0"	154.2	100.0	Cobbles	16.90
6.0"	154.2	100.0		
6.0"	154.2	100.0		
3.0"	75.0	83.1		
1.5"	37.5	66.5		
1.0"	25.0	56.7	Coarse Gravel	31.22
0.75"	19.0	51.9		
0.375"	9.5	41.7		
#4	4.8	33.7	Fine Gravel	18.23
#10	2.00	30.9	Coarse Sand	2.77
#20	0.85	25.6		
#40	0.43	19.9	Medium Sand	11.03
#60	0.25	16.3		
#100	0.15	13.4		
#200	0.075	10.9	Fine Sand	8.91

Hydrometer Analysis

(mm)	%Finer		
0.036	9.6		
0.023	8.9		
0.013	8.4	Fines	
0.0094	7.5	Silt or Clay	10.94
0.0067	7.3		
0.0033	6.1		
0.0014	5.2		



ATTERBERG LIMITS

M,	LL	PL	PI	SpG (assumed)
9.8	38	17	21	2.70

DESCRIPTION: Strong brown (7.55 YR 5/6) clayey gravel with sand

USCS: GC

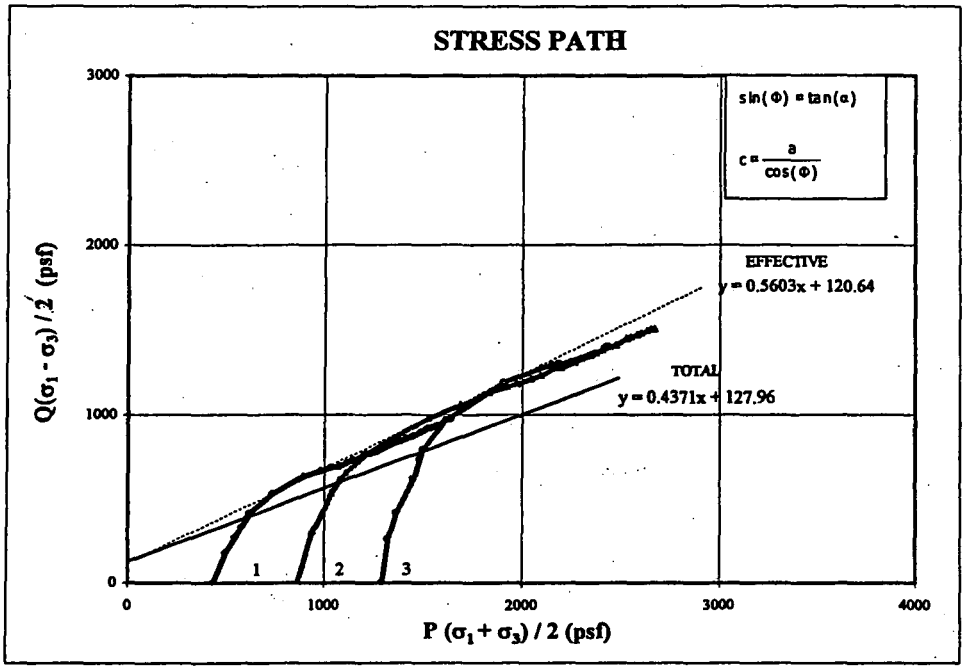
TECH: JR
DATE: 11/3/2004
REVIEW: MB

APPENDIX G

ATTACHMENT 3
TEST PIT AND BOREHOLE LOGS

TRIAXIAL COMPRESSION TEST - CONSOLIDATED UNDRAINED WITH PORE PRESSURE
ASTM D 4767

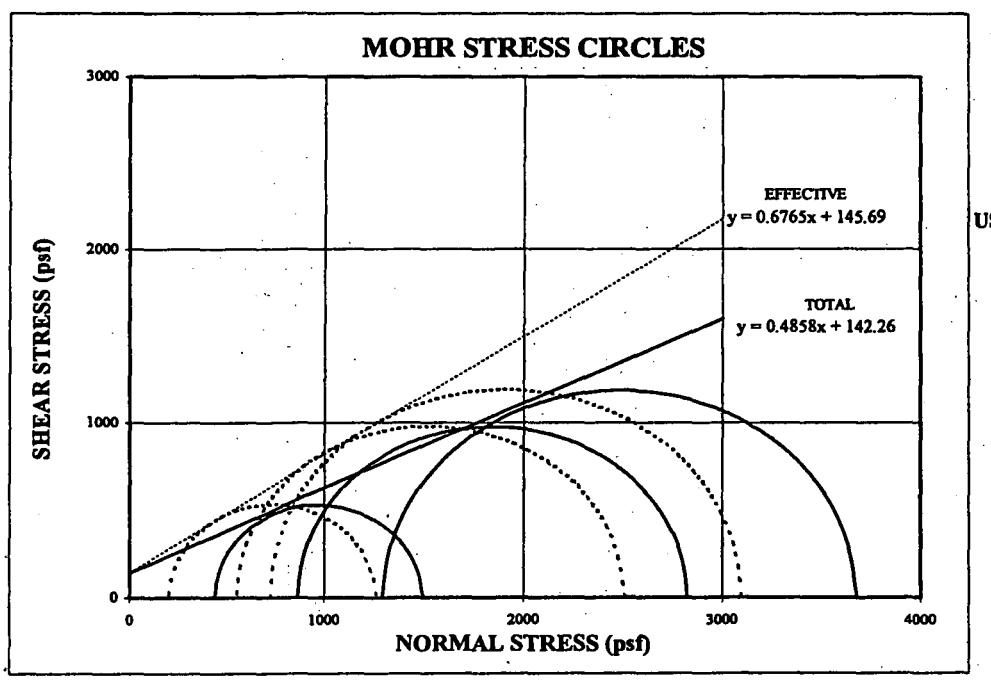
PROJECT NAME: ROCKY FLATS/FIELD AND LAB TESTING/CO
PROJECT NUMBER: 043-2246-0001
SAMPLE ID: PF - 10 DEPTH: - Sample Type: Bulk



Specimen	Effective Confining Pressure (psf)	Initial Dry Density (pcf)	Initial Moisture Content (%)
1	432	115.6	13.2
2	864	115.8	13.3
3	1296	115.9	13.0

Specimen	Strain Rate (%)	Initial Saturation (%)	Saturation Before Shearing (%)
1	0.10	77.7	96.2
2	0.10	78.6	97.1
3	0.10	77.2	95.7

STRESS PATH			MOHR CIRCLES		
*TOTAL STRESS PARAMETER			*TOTAL STRENGTH PARAMETER		
α	=	23.6 °	ϕ	=	25.9 °
a	=	128.0 psf	c	=	142.3 psf
* EFFECTIVE STRESS PARAMETER			*EFFECTIVE STRENGTH PARAMETER		
α'	=	29.3 °	ϕ'	=	34.1 °
a'	=	120.7 psf	c'	=	145.7 psf



Soil Description

Brown, COARSE TO FINE SAND, some fine gravel, some silty clay.

USCS (SC)

LL	PL	PI
-	-	-

Comments

Sample was remolded to approx. 95% of the Max. Dry Density, @ Opt. Moisture Content +2%.

*** Failure based on effective stress ratio or 15% strain.**

CHECK
REVIEW

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

B8a 0'-4.5' B8b 0'-17' B8c 0'-25

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF ___

Borehole Number: B8b+c
Location - North: ___ East: ___
Date: 7/1/04
Geologist: Rick Heldrick
Drilling Equip.: CME 75 All Terrain Rig

Surface Elevation: ~5950
Area: Woman Creek
Total Depth: 25'
Company: ___ Project No.: 57378
Sample Type: ___

RMRS LOGGING SUPERVISOR APPROVAL ___ DATE G.W. @ 9.2' on 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
										COLLUVIUM Qc Qls
X-1	Run 1	4.5/5	C-1				Qls/Qc	1		0'-1.5' LEAN CLAY; med brn; 90% med plstc clay; 10% fn sand; moist; stiff pp=1½ (CL)
								2		1.5'-8.0' SANDY CLAY w/ GRAVEL: (CL) med brn; 50% med plstc clay; 30% fn-cse gravel to 3"; 20% fn-cse sand; damp; occ cobbles + boulders.
								3		
								4		
						B8c		5		
X-2	Run 2	3.5'/5.0	B8C 7'-10' Core Box	P	2.2/2.4	S1 300		6		slide zone? 6'-8' LEAN CLAY; med. gray; 90% med plstc clay; 10% fn sand locally fr oxidized; moist; v. stiff; PP=2.3 tsf TV=8
						505 Qa	Qa	7		
								8		dep. contact? slide zone? slide zone contact?
								9		8.0'-14.5' ALLUVIUM SANDY CLAYEY GRAVEL; dk brn; 50% rounded fn-cse gravel; 30% high plstc clay; 20% fn to cse sand; wet; med dense, 9'-10' PP=0.7 > TV=2.0 60% gravel 13'-20% sand, 20% clay
								10		
	DR	0.5'/1.5	L1	10 8 10				11		
	DR	0.5'/1.0	L2	21 50/5				12		
X-3	Run 3	1.5'/1.5	C-1			B8c		13		
								14		BEDROCK No slide plane
	DR	0.6'/1.5	L3	12 12 19	DR 5 4/8	NR	CSSW	15		14.5'-18' CLAYSTONE; med gray w/ orange mottling; v. soft to soft; plstc to friable; crushed pieces in soft clay matrix; v. stiff med-high plsty PP=2.4 moist to wet
	DR	NR		29 30 38	2.1/8.4	S2 P 600 psi		16		
								17		soil-like
								18		
B8c X-2	Run 4				C-1	2.0/2.0	CSSW	19		18'-22' CLAYSTONE; dk gray w/ some orange; mod weathered; soft; weak; Fe O2 on frac. surfs. laminated bedding; intensely fracd.; in place
								20		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

(4011-4)0-01)(L-4)(X)(Form GT.1A)(03/01/97)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B8
Location - North: _____ East: _____
Date: _____
Geologist: _____
Drilling Equip.: _____

Surface Elevation: _____
Area: _____
Total Depth: _____
Company: _____ Project No.: 57378
Sample Type: _____

RMRS LOGGING SUPERVISOR
APPROVAL _____ DATE _____

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
B8C X-2	Run #5	5.0/5.0'	C-1				CSMW		CSMW	20-22' FeO2 stain'd throughout matrix.
								21		
							CSUW	22	CSUW	22'-25' CLAYSTONE; dk gray; fresh/unweathered; no discoloration; soft to mod. hard; weak to mod. strong; thinly laminated @ 20°; sltly carbonaceous; in place; little frac'd.
								23		
								24		
								25		Backfilled w/ bentonite chips.
								26		
								27		
								28		
								29		
								30		
								31		
								32		
								33		
								34		
								35		
								36		
								37		
								38		
								39		
								40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B-9 (B9a offset)
Location - North: East:
Date: 7/6/04 + 7/7
Geologist: Rick Heidrick
Drilling Equip.: All Terrain CME-75

Surface Elevation: ~5950
Area: Women Creek
Total Depth: 23'
Company:
Project No.: 57378
Sample Type:

RMRS LOGGING SUPERVISOR APPROVAL

DATE GW @ 4.4' on 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
					B9a					ALLUVIUM
X-1	Run 1	5.0' / 5.0'	C-1	C			Qa	1		0'-6.7' SANDY LEAN CLAY; v. dk brn.; ~70% med. plstc clay; 30% fn to csc sand; moist; firm; PP=0.5-1.0 TV=4.0. Wet @ 4.5'; occ. rounded gravel to 1½".
				P 0psi	S1	1.5' / 2.4'		2		
								3		
				DR	L-1 L-2 L-3	2 4 7	1.3' / 1.5'	4		
								5		
X-2	DR	1.2' / 1.5'	L-1 L-2 L-3	2 6 23				6		6' becomes gravelly; 50% clay; 30% sand; 20% fn. gravel.
	C	1.0 / 1.5	L4 L5	26 6 12			CSSW	7	CSSW	BEDROCK
								8		6.7'-11' CLAYSTONE; med. gray; sev. wthrd to residual soil; v. soft; calcite nodules; plstc.; no bedding. Soil-like lean to Fat Clay w/ sand: PP=2.2; TV=7.0
	DR	1.3 / 1.5'	L-6 L-7 L-8	18 9 13				9		
								10		
	P	1.5 / 1.5	S-1	300 500 600 psi				11		
							CSMW		CSMW	
X-3	Run 2	4.0' / 4.0'	C-1					12		9' becomes crushed in clay matrix. PP=1.5 TV=7
								13		11 Shelby refusal.
								14		
								15		11'-15' Some slks on frac sfc's; water on frac sfcs
X-4	Run 3	5.0' / 5.0'	C-1					16		11'-23' CLAYSTONE; med. gray; mod. wthrd; soft; weak; faint thinly laminated 20° bedding; crushed pieces in clay matrix; some slks on frac. sfc's. wet on frac. sfc's. PP=5+. Some FeO_2 stains on vert. frac's. Some Carbon.
								17		
								18		
								19		
								20		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B9
Location - North: / East:
Date: 7/7/04
Geologist:
Drilling Equip.:

Surface Elevation:
Area:
Total Depth:
Company:
Project No.: 57378
Sample Type:

RMRS LOGGING SUPERVISOR
APPROVAL _____ DATE _____

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
X-5	Run 4	4.5'/5.0'	C-1					21	CSMW	
								22		
								23	CSUW	23'-25' CLAYSTONE; black; unweathered; soft to mod. hard; mod. strong; thinly laminated; in place.
								24		
								25		
								26		
								27		
								28		
								29		
								30		
								31		
								32		
								33		
								34		
								35		
								36		
								37		
								38		
								39		
								40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

8/8

EARTH TECH
A TYCO INTERNATIONAL LTD. COMPANY

TRENCH NO. TP-2
SHEET 1 OF 1

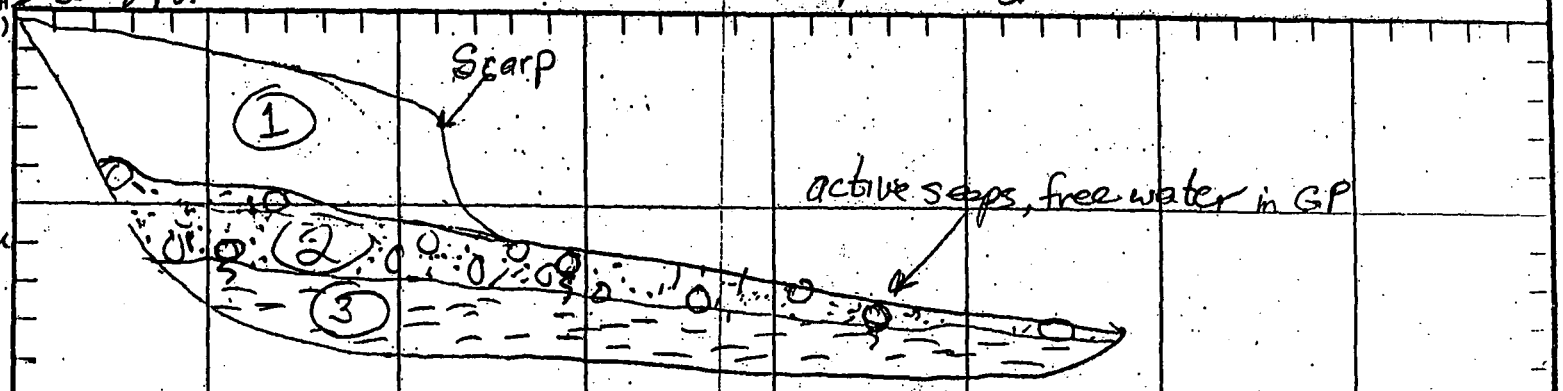
LOCATION: Rocky Flats Environmental Technology Site, Original Landfill
NOTES:

UNITS			STRUCTURE			
DEPTH	NO.	DESCRIPTION COLLUVIUM	NO:	STRIKE	DIP	TYPE
0'-4'	1	Qc (CL) SANDY CLAY w/ GRAVEL; dk. brn.; 60% med. plstc. clay; ~25% fn. sand; 15% fn. gravel moist.	No	Samples	Collected	
		VALLEY FILL ALLUVIUM				
4'-6.5'	2	Qal (GW) SANDY GRAVEL; med. brn.; 60% fn. to cse gravel, cobbles + boulders to 2'; 40% cse grained sand; wet; active seeps.				
		BEDROCK				
6.5'-9'	3	CSSW (CL) CLAYSTONE; med. gray; 9 ev. w third.; soft; plstc. w/ third to soil; moist; med plsty mottled w/ FeO2, carbon, + caliche; absence of slide plane or zone.				

STATION → T.P. / survey pt.
DEPTH (EL.)

6/24/04
DATE

R. Heidrich
LOGGED BY



1" 5'
SCALE, FT.

N.10°E
BEARING

GRAPHIC TRENCH LOG

PROJECT NO. 57378
DATE
FIGURE NO.

8/8

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

TRENCH NO. TP-1
SHEET 1 OF 1

LOCATION: Rocky Flats Environmental Technology Site, Original Landfill
NOTES:

UNITS			STRUCTURE			
DEPTH	NO.	DESCRIPTION	NO.	STRIKE	DIP	TYPE
0'-8.5' 11'-12.5'	1	COLLUVIUM (GW/SM) SANDY SILTY GRAVEL / GRAVELLY SILTY SAND; reddish brown 40% fn to med. sand; 40% fn+cse gravel + cobbles; 5.5'-8.5' becomes dk. brn, moist; free water + seeps @ contact w/ CSSW	A	TP1 L1-L4 Liner samples collected @ A aligned in E-W @ 6" below GW+CSSW contact. massive slicks dipping 10° N. Liners driven w/ slide hammer		
8.5'-11.0'	2	ALLUVIUM: (SC) CLAYEY SAND; dk. brn.; ~60% fn+med. sand; 40% low plastic clay; moist; appears v. dense; tight + undisturbed.		L1 L2	L3 L4	
12.5'-14.5'	3	(CSSW) CLAYSTONE; med gray + reddish brown; sev. wthrd.; moist to wet; soft, plastic; numerous massive slickensid. sfcs ~ 12"x18"; ~50% FeO2 stained, top 6" caliche deposits in veins + nodules top 6" CSSW imbedded w/ cobbles; free water @ top of contact;				

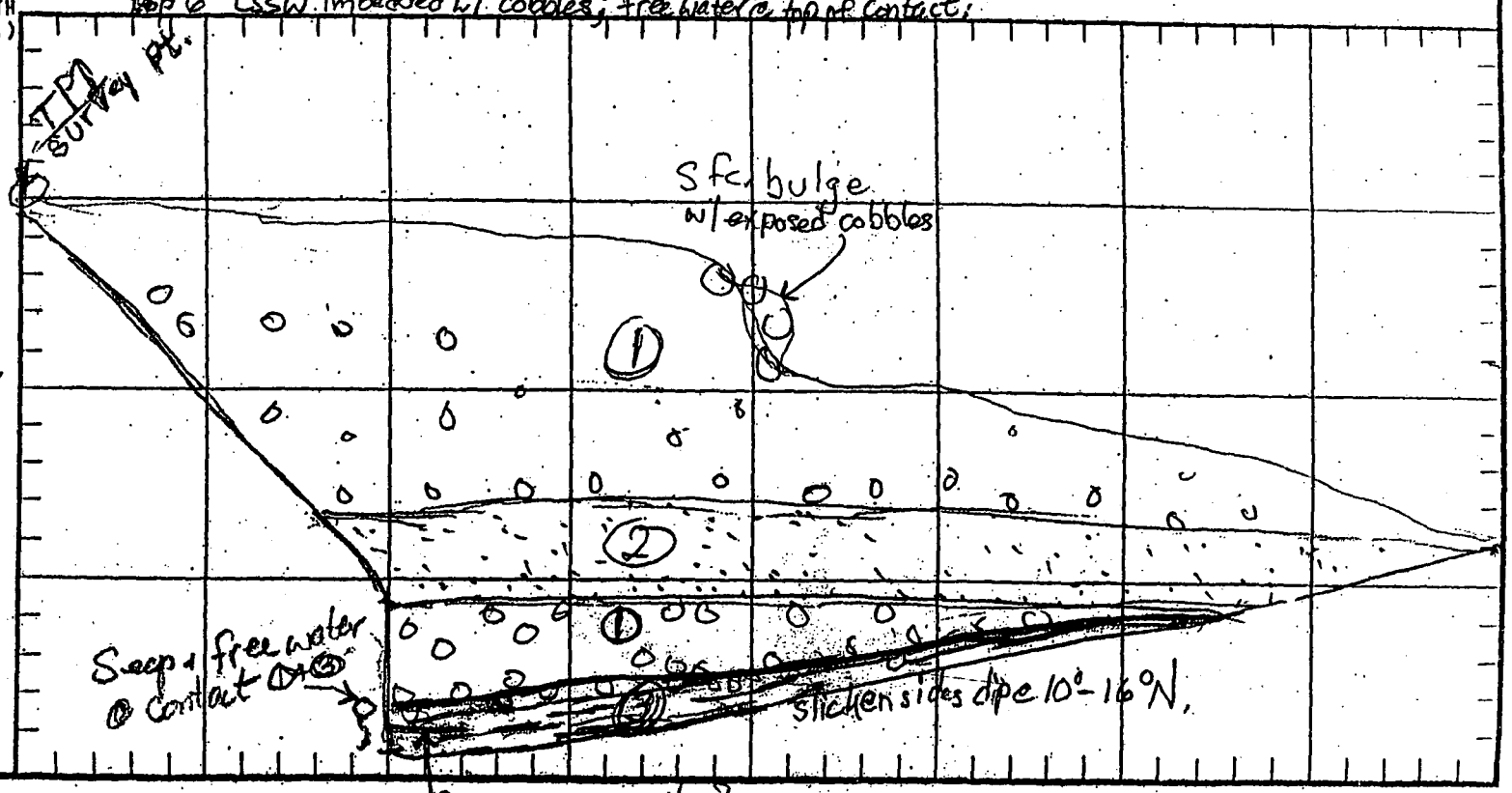
STATION →
DEPTH (EL.)

6/21/04
DATE

R. Heidrich
LOGGED BY

1" 5'
SCALE, FT.

N.15°E
BEARING



A P.P. = 2.4, T.V. = 9.0 @ A

GRAPHIC TRENCH LOG

PROJECT NO. 57378
DATE
FIGURE NO.

Borehole	Cross Section Location	Depth to First Granular Soils (alluvium)	Clay layer	Depth from Surface to Weathered Bedrock	Northing	Easting
B-8	B/C	8.0	0	14.5	747579.366	2081816.55
B-9	C	6.0	0	6.5	747553.228	2081975.53
TP-2	D	4.0	0	6.5	747570.318	2081455.05
TP-1	A	0.0	0	12.5	747543.592	2082153.42
58994	A	0.0	0	4.5	747523	2081476
59094	B	0.0	2.2-4.0	11.5	747565	2081609
57394	C	0.0	6.0-7.4	7.4	747479	2081988
57594	D	silt and clay to bedrock	4.0-16.5	16.5	747590	2082153
59393	A	0.5	5.3-7.5	7.5	747555	2081489
5786	B	silty clay to bedrock	6.0-12.0	9+ (not encountered)	not available	
57894	B	3.2	0-3.2	10+ (not encountered)	747656	2081740
59593	B/C	3.0	0-3.0	14.4	747577	2081786
7086	C	0.5	layered to 9	9	not available	
59793	D	9.3	0-9.3	13.3	747553	2082128
58094	D	0.0	0	10	747452	2082247

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 19.30	GROUND ELEVATION (FT)	5952.10	PROJECT NUMBER	015-RFI/RI	LOG OF BORING NUMBER
NORTH	747523	AREA (MSS)	CASING DIAMETER (IN)		GEOLOGIST	P. J. JORDAN	58994
EAST	2081476	LOCATION NUMBER	BOREHOLE DIAMETER (IN)	6.50	DATE DRILLED	12/05/94	

REMARKS: DRILLING EQUIPMENT: MOBILE DRILL B-57 ASI RIG GEOLOGIST: P. J. JORDAN

SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	ELEVATION (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
			1.80/1.80	5942	10			SILTY CLAYSTONE	10.0'-16.3' Silty Claystone with some v.f.g. Sandstone laminae (10.9'-14.1'). Predom. thin to thick laminae of claystone and siltstone. Some thin beds of claystone and sandy siltstone (13.3'-13.5'). Fe oxide nodules. Caliche nodules. Core indurated. Mod. to slightly friable.
				5941	11				No recovery (12.4-13.3'), and (14.6-14.8')
			1.30/1.30	5940	12				
			0.00/0.50	5939	13				
			0.80/1.00	5938	14				
			2.00/2.00	5937	15				
				5936	16				
			1.50/2.00	5935	17			SILTY CLAYSTONE	16.3'-19.3' Top of Unweathered Bedrock at 16.3'. Silty Claystone. Olive gray (5 Y 4/1). Very hard. Broken and disturbed from Moss sampler. Damp. Hard.
				5934	18				No recovery (17.8-18.3')
			1.00/1.00	5933	19				
					20				Total Depth Drilled 19.30

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 17.00	GROUND ELEVATION (FT)	5951.80	PROJECT NUMBER	015-R01/R1	LOG OF BORING NUMBER
NORTH	747565	AREA TMSS 115	CASING DIAMETER (IN)		GEOLOGIST	P. J. JORDAN	59094
EAST	2081609	LOCATION NUMBER 17	BOREHOLE DIAMETER (IN)	6.00	DATE DRILLED	01/30/95	

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 AST RIG GEOLOGIST P. J. JORDAN

DEPTH	GRADATIONAL	SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
					1.90/2.00	5951	1			SC	0.0'-2.2' Gravelly Sand with some Clay and trace Silt. Mod. brown (5 YR 3/4) to pale yellowish orange (10 YR 8/6). Grades to pale olive (10 Y 6/2) matrix with some mod. yellowish brown (10 YR 5/4) at 1.0'. Gravel is fine to coarse, max. 3.0 in., avg. 0.50 in., well graded. Sand is c.g. to f.g., well graded, sub-angular to sub-rounded. Low plasticity. Abundt. micaceous material. Some rock flour and pulverized rock. 38% gravel, 45% sand, 4% silt, 13% clay No recovery (1.9'-2.0')
					2.00/2.00	5950	2				
					1.20/1.20	5949	3			SANDY CLAY	2.2'-4.0' Sandy Clay with trace Silt (Hanksville material). Dark yellowish orange (10 YR 6/6) to light olive gray (5 Y 6/1) to med. gray (N5). Highly weathered. Sand is m.g. to v.f.g., well sorted, well rounded. Low plasticity. Trace caliche. Indications of disturbed sediments, locally brecciated. Mod. to high porosity. Trace roots. 36% sand, 4% silt, 61% clay
					1.80/1.80	5948	4				
					0.00/1.00	5947	5			SC	4.0'-5.2' Gravelly Sand with some Clay. Same as above (reference interval 0.0'-1.9'). Dark yellowish brown (10 YR 4/2). Core taken for Shelby tube, sample description taken from Well Site Field Log.
					0.00/1.00	5946	6				
					0.00/1.00	5945	7			SC	5.2'-6.0' Gravelly Sand with some Clay and trace Silt. Same as above (reference interval 0.0'-1.9'). Dark yellowish brown (10 YR 4/2). Trace cobbles. 38% gravel, 47% sand, 5% silt, 10% clay No recovery (6.0'-10.0') and (10.0'-11.0')
					0.00/1.00	5944	8				
					0.00/2.00	5943	9				
						5942	10				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 17.00	GROUND ELEVATION (FT) 5951.80	PROJECT NUMBER 035-RFI/RI	LOG OF BORING NUMBER	
NORTH 749585	AREA IHSS 115	CASING DIAMETER (IN)	GEOLOGIST P. J. JORDAN	59094	
EAST 2081609	LOCATOR NUMBER 17	BOREHOLE DIAMETER (IN) 8.00	DATE DRILLED 01/30/95		

REMARKS: DRILLING EQUIPMENT: MOBILE DRILL B-57 ASI RIG GEOLOGIST P. J. JORDAN

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
GR SC	100% GR 100%	0.00/1.00	5941	10 11			SC	11.0'-11.5' Gravelly Sand with some Clay and trace Silt. Same as above (reference interval 0.0'-1.9').
		1.00/2.00	5940	12			CLAYSTONE	11.5'-17.0' Top of Bedrock at 11.5'. Claystone with some f-g Sand. Dark yellowish brown (10 YR 4/2) grades to olive gray (5 Y 4/1). 11.5'-12.0' core appears brecciated, at 11.9' healed 90 degree fracture filled with FeO2. Water level at 12.4'. Mod. to highly weathered. Dry to moist. Trace coliche. Disturbed sediments around 14.8'. Fe oxide along fractures (bedding planes at 80 to 85 degrees) at 16.25'. Bedding massive to thinly laminated. Mod. to slightly friable. 16% sand, 83% clay.
		1.80/2.00	5939	13				
		0.80/1.00	5938	14				
		1.00/1.00	5937	15				
			5936	16				
			5935	17				Total Depth Drilled 17.00
			5934	18				
			5933	19				
			5932	20				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 23.00	GROUND ELEVATION (FT) 5929.20	PROJECT NUMBER 805-RETAIL	LOG OF BORING NUMBER
NORTH 749479	HOLE DIAM 115	CASING DIAMETER (IN)	GEOLOGIST P. J. JORDAN	57394
EAST 2081986	LOCATION NUMBER TT	BOREHOLE DIAMETER (IN) 6.50	DATE DRILLED 12/01/94	

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 AST RIG GEOLOGIST P. J. JORDAN

SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY INTERVAL	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
			1.10/2.00	12/01/94		SC	0.0'-3.5' Gravelly Sand with some Clay and Silt. Dark brown (10 YR 2/2) to dark yellowish brown (10 YR 4/2). Gravel is coarse to fine, well graded, sub-angular, max. 3.5 in., avg. 0.75-1.0 in. Sand is c.g. to f.g., well graded, sub-angular to sub-rounded. Non-plastic. Trace cobbles. Core medium dense. Core moist to wet. Water at 2.0' 20% gravel, 65% sand, 6% silt, 9% clay No recovery (1.1-2.0') and (3.5-4.0')
			1.00/1.00				
			0.50/1.00				
			1.40/1.40			SW	4.0'-5.9' Gravelly Sand with some Clay and trace Silt. Dark yellowish brown (10 YR 4/2). Sand and gravel well graded, predom. f.g., sub-angular to sub-rounded. Non plastic. Dense to very dense. Some cobbles. Wet (SW-SC) 31% gravel, 59% sand, 3% silt, 7% clay
			1.00/2.00			CL	5.9'-6.4' Sandy Clay with some Gravel. Mod. yellowish brown (10 YR 5/4). Gravel is fine, sub-rounded. Core soft, mod. to low plasticity. Sand is m.g. to f.g., well sorted. 7% gravel, 13% sand, 80% clay No recovery (6.4-7.4')
			1.30/2.50			CLAYSTONE	7.4'-10.0' Top of Weathered Bedrock at 7.4'. Claystone with trace Silt. Dark yellowish orange (10 YR 6/6) to yellowish brown (10 YR 5/4). Traces of calcareous material (caliche). Bedding massive. Mod. friable. 3% silt, 97% clay

STATE PLANE COORDINATE		TOTAL DEPTH (FT)	20.00	GROUND ELEVATION (FT)	5926.00	PROJECT NUMBER	[illegible]	LOG OF BORING NUMBER
NORTH	747479	AREA (MSS 115		CASING DIAMETER (IN)		GEOLOGIST	P. J. JORDAN	57394
EAST	3081988	LOCATION NUMBER	[illegible]	BOREHOLE DIAMETER (IN)	6.50	DATE DRILLED	12/01/94	

REMARKS: DRILLING EQUIPMENT: MOBILE DRILL B-57 4SX RIG GEOLOGIST: P. J. JORDAN

GRADATIONAL DEPTH	SAMPLE TYPE	SAMPLE TYPE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
0		50	100% 0% 100%			10			CLAYSTONE	10.0'-11.9' Claystone with trace Silt. Same as above (reference interval 7.4'-10.0') Grayish brown (5 YR 3/2) Dry. Trace organics. Bedding not apparent No recovery (11.9-12.0')
				1.90/2.00	5926	11				
					5927	12				
					5925	13			CLAYSTONE	12.0'-16.0' Claystone with trace Silt. Same as above (reference interval 7.4'-10.0') Slightly to mod. weathered Dry. Trace organics, carbonaceous material. Bedding massive
				2.00/2.00	5926	14				
					5924	15				
				2.00/2.00	5923	16				
					5922	17			CLAYSTONE	16.0'-17.7' Claystone. Dusky yellowish brown (10 YR 2/2) Slightly weathered. Dry. Thinly laminated to thinly bedded No recovery (17.7-18.0')
				1.70/2.00	5921	18				
					5920	19			CLAYSTONE	18.0'-19.8' Claystone. Olive gray (5 Y 4/1). Becomes unweathered at 19.5'. Slightly friable. Thinly laminated, soft sediment deformation structures (18.0-19.8') No recovery (19.8-20.0')
				1.80/2.00	5919	20				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 23.00	GROUND ELEVATION (FT) 5938.20	PROJECT NUMBER	005-RFI/RI	LOG OF BORING NUMBER
NORTH [illegible]479	AREA IHSS 115	CASING DIAMETER (IN)	GEOLOGIST	P. J. JORDAN	57394
EAST [illegible]1988	LOCATION NUMBER 17	BOREHOLE DIAMETER (IN) 6.50	DATE DRILLED	12/01/94	

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 AST RIG GEOLOGIST P. J. JORDAN

SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	ELEVATION (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
				5918	20			CLAYSTONE	20.0'-21.0' Claystone. Grayish black (N2). Some carbonaceous material (lignite). Bedding not apparent.
			2.00 / 2.00	5917	21			CLAYSTONE	21.0'-23.0' Claystone. Olive gray (5 Y 4/1). Unweathered. Mod hard. Massive, dry.
			1.00 / 1.00	5916	22				
				5915	23				Total Depth Drilled 23.00
				5914	24				
				5913	25				
				5912	26				
				5911	27				
				5910	28				
				5909	29				
					30				

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 19.30	GROUND ELEVATION (FT) 5952.10	PROJECT NUMBER 005-RFI/RI	LOG OF BORING NUMBER
NORTH	747523	AREA 1HSS 115	CASING DIAMETER (IN)	GEOLOGIST P. J. JORDAN	58994
EAST	2081976	LOCATOR NUMBER 17	BOREHOLE DIAMETER (IN) 6.50	DATE DRILLED 12/05/94	

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 AST RIG GEOLOGIST P. J. JORDAN

DEPTH	GRADATIONAL	SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
					0.50/2.00	5951	1			GC	0.0'-4.5' Sandy Gravel with some Clay and trace Silt. Dark yellowish brown (10 YR 4/2). Gravel max: 2.0 in., avg: 0.75 in. Fine to coarse, sub-angular to sub-rounded. Sand is c.g. to f.g., well graded, sub-angular to sub-rounded. Upper 0.2 in., top soil, roots. Low plasticity. Dense. Becomes wet at 4.4', perched water on top of bedrock. 51% gravel, 38% sand, 9% clay, 2% silt.
					0.00/1.00	5950	2				No recovery (0.5-2.0'), (2.0-3.0'), and (3.5-4.3')
					0.50/1.00	5949	3				
					0.00/0.30	5948	4				
					1.00/2.00	5947	5			CLAYSTONE	4.5'-10.0' Top of Weathered Bedrock at 4.5'. Claystone with trace Silt. Highly weathered. Light olive gray (5 Y 6/1), dark yellowish orange (10 YR 6/6) to pale yellowish brown (10 YR 6/2). Abundant caliche. Moist. At 9.6' bedding horizontal, indications of soft sediment structures. Mottled laminations. 4% silt, 96% clay.
						5946	6				
					1.00/2.50	5945	7				
						5944	8				
					1.00/0.50	5943	9				No recovery (5.3-6.3') and (7.9-9.3')
							10				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 105 9'	GROUND ELEVATION (FT) [illegible]	PROJECT NUMBER [illegible]	LOG OF BORING NUMBER	
NORTH 747590	AREA DISS 115	CASING DIAMETER (IN) 2 00	GEOLOGIST J. W. HARRELL	57594	
EAST 2362153	LOCATION NUMBER J1	BOREHOLE DIAMETER (IN) 5 50	DATE DRILLED [illegible] 06/94		

REMARKS: DRILLING EQUIPMENT MOBILE DRILL B-57 ASI RIG GEOLOGIST J. W. HARRELL PROTECTIVE CASING LENGTH 3 0' GROUND WAS TO HARD TO DRIVE ANY FURTHER THAN 0 3'

UNIFIED SOIL CLASSIFICATION OR ROCK TYPE	DESCRIPTION
CL	10 0'-13 5' Clay with some Silt Mottled pale olive gray (10 Y 6/2), dusky brown (5 YR 2/2) and dark yellowish orange (10 YR 6/6) Strongly brecciated with claystone fragments, fine to coarse gravel size, angular with some angular ironstone clasts, trace organics and caliche Highly weathered Very stiff Dry to moist Strongly brecciated with abundant iron staining at 11 25'-12 0' Becomes hard, appears to be landslide breccia 7% silt, 93% clay
CL	13 5'-14 25' Gravelly Clay Mottled dark yellowish orange (10 YR 6/6), med yellowish brown (10 YR 5/4) and light olive gray (5 Y 6/1) Soft to stiff Wet to saturated Fine to coarse gravel, angular to sub-rounded f g to c g sand, sub-rounded to sub-angular, predom metamorphic gneiss and quartzite 27% gravel, 10% sand, 9% silt, 54% clay No recovery (13 7-14 0')
CL	14 25'-16 0' Clay, (landslide breccia) Same as above (reference interval 10 0'-13 5')
CL	16 0'-16 5' Gravelly Clay Same as above (reference interval 13 5'-14 25') Possible slough
CLAYSTONE	16 5'-20 0' Top of Weathered Bedrock at 16 5' Claystone Mod weathered Some dark yellowish orange (10 YR 6/6), predom yellow gray (5 Y 7/2) to med gray (N5) Some carbonaceous material Bedding massive Hard Mod indurated Moist 80 degree open fractures with MnO2 and FeO2 from 16 75' to 17 8' and 17 8' to 19 25' 60 degree fracture, open from 19 25' to 19 75' 0 degree horizontal fracture at 19 9'

STATE PLANE COORDINATE	TOTAL DEPTH [illegible]	GROUND ELEVATION (FT)	5916 20'	PROJECT NUMBER	[illegible]
NORTH [illegible]45590	AREA [illegible]	CASING DIAMETER (IN)	2 00	GEOLOGIST	[illegible]
EAST 1360153	LOCATION NUMBER [illegible]	BOREHOLE DIAMETER (IN)	5 60	DATE DRILLED	[illegible]

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 [illegible] GEOLOGIST [illegible] PROTECTIVE CASING LENGTH 3 0' GROUND WAS TO HARD TO DRIVE ANY FURTHER THAN 0 3'

57594

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	SEAL OF PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
				20				20 0'-20 6' Core in box is grout from setting surface casing
				21			NO RECOVERY	No recovery (20 6-24 9')
				22				
		0 60 / 4 90		23				
				24				
				25			CLAYSTONE	24 9'-28 0' Claystone Med dark gray (N4) Some carbonaceous material Massive to finely laminated at 25 0' Moist Slightly friable At 26 5' silt content increases Abundant organics Some fe nodules to 26 0' Predom unweathered
				26				
				27				No recovery (28 0-30 0')
		3 10 / 5 00		28				
				29				
				30				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 104.90	GROUND ELEVATION (FT) 594.20	PROJECT NUMBER [illegible]	LOG OF BORING NUMBER
NORTH 7590	AREA THSS 115	CASING DIAMETER (IN) 2.00	GEOLOGIST J. W. HARDELL	57594
EAST 1082153	LOCATION NUMBER J7	BOREHOLE DIAMETER (IN) 5.60	DATE DRILLED [illegible]/08/94	

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 ASI RIG GEOLOGIST J. W. HARDELL PROTECTIVE CASING LENGTH [illegible] GROUND WAS TO HARD TO DRIVE ANY FURTHER THAN 0.3'

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY INTERVAL	ELEVATION (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
CL SS	100.0% 100%	29.0/5.00	594.15	30			CLAYSTONE	30.0'-37.5' Claystone Same as above (reference interval 24.9'-28.0') Med dark gray (N4) Slickensides at 33.5', approx 60 degrees At 33.7' amount of organics decreases to trace amount Fractured Very stiff Slightly friable Massive
			594.14	31				
			594.13	32				No recovery (34.1-34.9'), and (37.9-40.0')
			594.12	33				
			594.11	34				
			594.10	35				
			594.09	36				
			594.08	37				
			594.07	38				
		30.0/5.00		39				
				40				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 54.9	GROUND ELEVATION (FT) [illegible]	PROJECT NUMBER [illegible]	LOG OF BORING NUMBER	
NORTH 74590	AREA [illegible]	CASING DIAMETER (IN) [illegible]	GEOLOGIST J. W. HARRELL	57594	
EAST 1082153	LOCATION NUMBER [illegible]	BOREHOLE DIAMETER (IN) [illegible]	DATE DRILLED [illegible]/06/94		

REMARKS: DRILLING EQUIPMENT: MOBILE DRILL B-57 ASST RIG GEOLOGIST J. W. HARRELL PROTECTIVE CASING LENGTH 3.0 GROUND WAS TO HARD TO DRIVE ANY FURTHER THAN 0.3'

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY INTERVAL	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
0	100% 0 100%	34.0-5.00	40 5906 5905 5904 5903 5902 5901 5900 5899 5898 5897 50			SILTY CLAYSTONE	40.0'-54.2' Silty Claystone Light olive gray (5 Y 6/1) Well cemented, very stiff, dense Some organics Massive Slightly friable Dry to moist Vertical fracture at approx 45.1' Interval 50.0'-54.2' is mod porosity Thinly laminated to thin bedded, trace cross-bedding 26% silt, 74% clay No recovery (43.4-44.9'), and (54.2-54.9')

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 105.90		GROUND ELEVATION (FT) 5994.20		PROJECT NUMBER 005-RF2052	LOG OF BORING NUMBER
NORTH	74590	AREA DESS 115		CASING DIAMETER (IN) 2.00		GEOLOGIST J. W. HIRSELL	57594
EAST	1030153	LOCATION NUMBER 37		BOREHOLE DIAMETER (IN) 5.50		DATE DRILLED 11/06/94	

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 ASI RIG GEOLOGIST J. W. HIRSELL PROTECTIVE CASING LENGTH 3.0' SECOND PAS TO HARD TO DRIVE AND FURTHER THAN 0.3'

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
	100%			50				
			5996					
			5995	51				
		4.20/5.00	5994	52				
			5993	53				
			5992	54				
			5991	55			CLAYSTONE	54.9'-58.0' Claystone Red dark gray (N4) Unweathered Sediments appear slightly disturbed. Slickensides occurred through interval at 55.5', 55.7' and 56.0', almost vertical at 80 degrees (approx.)
			5990	56				
		4.80/5.80	5989	57				
			5988	58			SILTY CLAYSTONE	58.0'-61.0' Silty Claystone Same as above (reference interval 40.0'-54.2') Exhibits conchoidal fracture. Some small burrow holes. Trace fossils at 59.4' No recovery (59.7'-59.9')
			5987	59				
				60				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 164.90	GROUND ELEVATION (FT) 5994.20	PROJECT NUMBER 115-RFI/RI	LOG OF BORING NUMBER	
NORTH 747590	AREA TRSS 115	CASING DIAMETER (IN) 2.00	GEOLOGIST J. W. HARWELL	57594	
EAST 2082150	LOCATION NUMBER JT	BOREHOLE DIAMETER (IN) 5.60	DATE DRILLED 11/08/94		

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 ASI RIG GEOLOGIST J. W. HARWELL PROTECTIVE CASING LENGTH 3.0' GROUND WAS TO HARD TO DRIVE AND FURTHER THAN 0.3'

SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	INTERVAL DRILLING	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
		100% 100%		5986	60				
				5985	61			CLAYSTONE	61.0'-66.2' Claystone Same as above (reference interval 54.9'-58.0') No recovery (62.1-64.9')
			2.35/5.00	5984	62				
				5983	63				
				5982	64				
				5981	65				
				5980	66			SILTY CLAYSTONE	66.2'-67.2' Silty Claystone Same as above (reference interval 50.0'-54.2')
			5.00/5.00	5979	67			CLAYSTONE	67.2'-80.7' Claystone Same as above (reference interval 54.9'-58.0') Some fractures Sand on outside of core due to the addition of sand to the borehole to aid in the retrieval of drill rod (see WSFL) Massive to thinly bedded in areas Slickensides at 69.2', approx 80 degrees Some organics Exhibits conchoidal fracture No recovery (73.9-79.9'), and (80.7-81.4')
				5978	68				
				5977	69				
					70				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) [illegible]	GROUND ELEVATION (FT) [illegible]	PROJECT NUMBER	005-RF1/RI	LOG OF BORING NUMBER
NORTH [illegible]	AREA [illegible]	CASING DIAMETER (IN) [illegible]	GEOLOGIST	J. W. HARWELL	57594
EAST [illegible]	LOCATION NUMBER [illegible]	BOREHOLE DIAMETER (IN) [illegible]	DATE DRILLED	11/06/9[illegible]	

REMARKS: DRILLING EQUIPMENT: MOBILE DRILL B-57. AST RIG GEOLOGIST: J. W. HARWELL. PROTECTIVE CASING LENGTH 3.0'. GROUND WAS TO HARD TO DRIVE ANY FURTHER THAN 0.3'

SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	INTERVAL	ELEVATION	DEPTH	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
BH00079S			10.0/10.0	5946	0			ML	0.0'-1.0' Sandy Silt with some Clay and Gravel. Dark yellowish brown (10 YR 4/2). Sand is f.g. to m.g., sub-rounded to rounded, well sorted. Gravel is coarse to fine, sub-rounded. Some caliche. Some roots. Bedding not apparent. Low plasticity. 7% gravel, 41% sand, 42% silt, 10% clay No recovery (1.0-2.0')
			10.0/10.0	5945	1				
BH00078S			10.0/10.0	5944	2			ML	2.0'-3.3' Sandy Silt with some Clay and Gravel. Same as above (reference interval 10.0'-1.0'). Dark yellowish brown (10 YR 4/2) to olive gray (5 Y 6/1). Massive. Stiff. Dry to moist. Some caliche. Clay content increases. No recovery (3.3-4.0')
BH00080S			10.0/10.0	5943	3				
			10.0/10.0	5942	4			CL	4.0'-7.0' Sandy Clay with some Gravel and trace Silt. Color varies from dark yellowish orange (10 YR 6/6) to pale yellowish brown (10 YR 6/2) to mod. yellowish brown (10 YR 5/4). Sand is f.g. to m.g., sub-rounded to sub-angular, well sorted. Gravel is fine, sub-angular to sub-rounded. Some micaceous fragments. Some carbonaceous material. Some caliche and FeO concretions. Massive. Low plasticity. Moist. 7% gravel, 44% sand, 3% silt, 46% clay No recovery (5.7-6.0')
			10.0/10.0	5941	5				
BH00081S			10.0/10.0	5940	6				
			10.0/10.0	5939	7			CL	7.0'-9.7' Clay with trace Silt (landslide block). Dark yellowish orange (10 YR 6/6) to light olive gray (5 Y 6/1). Some dusky brown (5 YR 2/2). Trace calcareous nodules. Trace c.g. sand. Some Fe and Mn staining. Fe staining is banded, some FeO concretions. 10% claystone fragments, angular. Mod. to slightly friable. Dry to moist. Interval 8.0'-9.7' is broken and brecciated. Trace fine gravel, angular, claystone gravel clasts in a clay matrix. 4% silt, 96% clay No recovery (7.4-8.0'), and (9.7-10.0')
BH00083S			10.0/10.0	5938	8				
			10.0/10.0	5937	9				
					10				

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 104.92	GROUND ELEVATION (FT)	[illegible]	PROJECT NUMBER	015-RFI/RI	LOG OF BORING NUMBER
NORTH	749590	AREA THISS 115	CASING DIAMETER (IN)	[illegible]	GEOLOGIST	J. W. HARWELL	57594
EAST	1000158	LOCATION NUMBER [illegible]	BOREHOLE DIAMETER (IN)	[illegible]	DATE DRILLED	11/08/94	

REMARKS: DRILLING EQUIPMENT MOBILE DRILL B-57 ASI RIG GEOLOGIST J. W. HARWELL PROTECTIVE CASING LEAST - [illegible] GROUND WAS TO HARD TO DRIVE AND FURTHER THAN 0.3'

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/THROUGH	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
		0.80/1.50	80, 81				
		2.40/3.50	82, 83, 84			SILTY CLAYSTONE	81.4'-89.8' Silty Claystone Med dark gray (N4) Visible laminations of silt Trace FeO nodules Slight deformation of sedimentation Cemented Lignite fragments Slightly friable No recovery (83.8-84.89')
		5.00/5.00	85, 86, 87, 88, 89, 90			CLAYEY SANDSTONE	84.9'-90.8' Clayey Sandstone Med dark gray (N4) Sand is v f c, rounded to sub-rounded, well sorted Massive to laminated Well cemented Local crossbedding Exhibits conchoidal fracture at 87.8', 89.2' and 89.8' in thin claystone laminae and thin claystone interbeds, nearly horizontal

STATE PLANE COORDINATE	TOTAL DEPTH (FT) [illegible]	GROUND ELEVATION (FT) [illegible]	PROJECT NUMBER [illegible]	[illegible] OF BORING NUMBER	
NORTH [illegible]7590	AREA DISS 115	CASING DIAMETER (IN) [illegible]	GEOLOGIST J. W. HARWELL	57594	
EAST [illegible]2152	LOCATION NUMBER [illegible]	BOREHOLE DIAMETER (IN) [illegible]	DATE DRILLED [illegible]/06/94		

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 FIELD GEOLOGIST J. W. HARWELL PROTECTIVE CASING LENGTH 3.0' GROUND WAS TO HARD TO DRIVE ANY FURTHER THAN 0.3'

GRADATIONAL S	DEPTH	SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
	90		SCR	100%			90			CLAYSTONE	90.0'-99.2' Claystone with trace Silt Dark red gray (N4) Abundant organics, leaf imprints and stem imprints at 95.0' Massive to thinly laminated Slightly friable Exhibits conchoidal fracture at 95.0'-96.5' More leaf imprints and organics from 95.0'-96.0' Sediments slightly disturbed soft sediment at approx 96.0' Dry, very stiff, dense 4% silt, 96% clay No recovery (99.2-100.0')
					5.00/5.00'	5956					
						5955	91				
						5954	92				
						5953	93				
						5952	94				
						5951	95				
						5950	96				
					4.30/5.00'	5949	97				
						5948	98				
						5947	99				
							100				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 104.90	GROUND ELEVATION (FT) 5946.20	PROJECT NUMBER [illegible]	LOG OF BORING NUMBER
NORTH 745590	AREA THSS 115	CASING DIAMETER (IN) 3.00	GEOLOGIST J. W. HARWELL	57594
EAST 2082153	LOCATOR NUMBER JT	BOREHOLE DIAMETER (IN) 5.50	DATE DRILLED [illegible]/96	

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 ASI RIG GEOLOGIST J. W. HARWELL PROTECTIVE CASING LENGTH 3.0' GROUND WAS TO HARD TO DRIVE AND FURTHER THAN 0.3'

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
GR SAND	100% 100%	4.30/5.00	5946	100			CLAYSTONE	100.0'-104.2' Claystone with trace silt. Same as above (reference interval 90.0'-99.2') Visible silty interbeds and laminae. Thinly bedded to massive. Some organics. Dry. Well consolidated, very hard. Some calcareous material. Some clasts of clay.
			5945	101				No recovery (104.2-104.9')
			5944	102				
			5943	103				
			5942	104				
			5941	105				Total Depth Drilled 104.90 Total Depth Casing 92.20 Bottom of Filter Pack 92.20
			5940	106				
			5939	107				
			5938	108				
			5937	109				
				110				

STATE PLANE COORDINATE | TOTAL DEPTH (FT) 12.40 | GROUND ELEVATION (FT) | PROJECT NUMBER | DRILLING NUMBER
NORTH [illegible] | AREA [illegible] | CASING DIAMETER (IN) 2.00 | GEOLOGIST | DRILLING
EAST 2081499 | LOCATION NUMBER 17 | BOREHOLE DIAMETER (IN) 10.00 | DATE DRILLED 06/10/92

59393

REMARKS: DRILLING EQUIPMENT CME 750 ATV HSA SUG GEOLOGIST [illegible] PRESSURE GRAVEL-DRILLING NOTE: CORE LOSS (NO RECOVERY) INTERVALS LESS THAN 0.2' NOT SHOWN

DRAFT

Lithology	Unified Soils Classification or Rock Type	Description
	ML	0.0'-0.1' Sandy Silt with abundt Clay. Mod yellowish brown (10 YR 5/4). Pred f.g., sub-rounded, quartzose sand with trace m.g. sand. Some roots, possibly thinly bedded, no apparent fractures, dry, low plasticity, slightly calcareous. 27% sand, 47% silt, 26% clay
	SC	0.1'-1.2' Clayey Sand with some Silt, trace Gravel. Dark yellowish brown (10 YR 4/2). Sub-angular gravel: f.g. to m.g., mod. graded, sub-rounded, quartz sand, some c.g., sub-angular sand. Some roots, no apparent bedding or fractures, dry, slightly calcareous. <5% gravel, 60% sand, 17% silt, 18% clay. No recovery (1.2-2.0')
	GP	2.0'-2.9' Broken Cobbles. Quartzite with some micaceous and feldspathic partings. 100% cobbles
	SC	2.9'-3.0' Clayey Sand with some Silt. Mod. brown (5 YR 3/4). f.g. to c.g., well graded, sub-rounded, quartzose sand with trace mafics. Trace Fibrous mineral (actinolite? chrysotyle?). No apparent bedding or fractures. Dry, low plasticity fines, non-calcareous. 58% sand, 10% silt, 32% clay. No recovery (3.0-4.0')
	SC	4.0'-5.3' Clayey Sand with some Silt and trace Gravel. Mod. brown (5 YR 3/4). Sub-angular, quartzite, metamorphic gravel. f.g. to c.g., well graded, sub-rounded, pred. quartz sand with some mafics. No apparent bedding. Moist to wet, low plasticity fines, non-calcareous. 5% gravel, 55% sand, 8% silt, 32% clay
	CL	5.30'-5.40' Sandy Clay with some Silt, trace Gravel. Pred. light olive gray (5 Y 5/2), mottled with mod. yellowish brown (10 YR 4/4), and light brown (5 YR 5/6), appears to be Reworked Claystone intermixed with coarser alluvium. Sub-rounded gravel up to 1.5 in. f.g. to c.g., well graded, sub-rounded, quartzose sand. No apparent bedding structures or fractures. Moist to wet, low to mod. plasticity, slightly calcareous (esp. claystone). 5% gravel, 41% sand, 11% silt, 43% clay. No recovery (5.4-6.0')
	CL	6.0'-7.5' Sandy Clay with some Silt, trace Gravel. Same as above, reference interval 5.3 to 5.4 ft. Appears to be Reworked Claystone. Approx. 0.25 in. Fe stained layers at approx. 6.5 and 6.9 ft. Generally coarser grained layer between 7.0 and 7.4 ft with pred. cobbles between 7.4 and 7.5 ft
	CLAYSTONE	7.5'-8.5' Top of Bedrock at 7.5 ft. Claystone with trace Silt and Sand. Pred. light olive gray (5 Y 5/4), mottled with Fe stained blotches. Trace calcite patches. Slightly carbonaceous, moist to wet, trace [illegible] ironstone nodules at approx. 7.6 ft. White, [illegible] g sand [illegible] in thin layers and patches between 8.0 and approx. [illegible] ft. At approx. 8.3 ft brown organic piece approx. [illegible] cm around. <5% sand, 5% silt, 90% clay

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 12.40	GROUND ELEVATION (FT) [illegible]	PROJECT NUMBER [illegible]		LOG OF BORING NUMBER	
NORTH [illegible]	AREA 106, [illegible]	CASING DIAMETER (IN) 2.00	GEOLOGIST T. S. SPEELING		59393	
EAST 2081999	LOCATION NUMBER 17	BOREHOLE DIAMETER (IN) 10.00	DATE DRILLED 06/10/93			

REMARKS: DRILLING EQUIPMENT CME 750 ATV ASSISTING GEOLOGIST THERESA SANTANGELO-DRILLING NOTE: CORE LOSS (NO RECOVERY) INTERVALS LESS THAN 0.2' NOT SHOWN

DRAFT

SAMPLE GRAPH	PENETRATION RESISTANCE	RECOVERY/INTERVAL	DATUM (FT) DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
		1.50/2.40	2768 10 2767 11 2766 12 2765 13 2764 14 2763 15 2762 16 2761 17 2760 18 2759 19 2758 20			CLAYSTONE	8.5'-10.0' Claystone with abundt carbonaceous material (coal), as near horiz laminae between 8.5 and 9.0 Ft and as larger near vertical structures below 9.0 Ft. Pred olive gray (5 Y 4/1), with abundt Fe staining. Lignite is black (N1). No apparent bedding or fractures. Non-calcareous except trace of caliche at approx 9.9 Ft. Lightly weathered, moist. <5% silt, >95% clay
							10.0'-11.5' Lignite with some Claystone in upper 0.7 Ft. Highly friable. Black (N1). No apparent bedding or fractures. Non-calcareous, moist. No recovery (11.5-12.4')

Total Depth Drilled 12.40 Total Depth Casing 10.00
Bottom of Filter Pack 7.80

LOG OF BORING NO. 57-86

GEOLOGIST(S): LAA
DATE: 8/15/89

PROJECT NO: 1667-1122

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
	0.0							1 2 3 4 5		No Sample
Box 1 of	6.0	(1) 1.8				Clay, trace	CL	6 7 8		~~See Next page~~ page LA Silty Clay Dk. yellowish orange (10yr 6/6) and yellowish gray (mottled) Some v.f.g. to v.c.g. sand and gravel toward top of interval.
	9.0							9		See next page for description
	10 to 12.0									

NOTES: General: USCS is modified for this log as follows:
Material amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT

FIGURE NO.

STATE PLANE COORDINATE | TOTAL DEPTH (FT) 104.50 | GROUND ELEVATION (FT) 1594.30 | PROJECT NUMBER 005-RFI/RI | HOLE OR BORING NUMBER

NORTH 74550 | AREA 1400-115 | CASING DIAMETER (IN) 2.00 | GEOLOGIST J. W. HARWELL

EAST 1300150 | LOCATION NUMBER J1 | BOREHOLE DIAMETER (IN) 5.50 | DATE DRILLED 11/08/94

57594

REMARKS DRILLING EQUIPMENT MOBILE DRILL B-57 ASI RIG GEOLOGIST J. W. HARWELL PROTECTIVE CASING LENGTH 3.0' GROUND WAS TO HARD TO DRIVE 4X1 FURTHER THAN 0.3'

GRADATIONAL SAMPLE DEPTH	SAMPLE NUMBER	SAMPLE DATA SIZE	PERCENT RECOVERY	DRILLING RATE (MIN/FOOT)	DATUM DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
					70				
					71				
					72				
				4.30/5.00					
					73				
					74				
					75				
					76				
				0.30/5.00	77				
					78				
					79				
					80				

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 10.00	GROUND ELEVATION (FT)	5949.90	PROJECT NUMBER	005-RFI/RI	LOG OF BORING NUMBER
NORTH	747565	AREA IHSS 115	CASING DIAMETER (IN)	0.50	GEOLOGIST	J. W. HARDELL	57894
EAST	2081741	LOCATION NUMBER 17	BOREHOLE DIAMETER (IN)	1.49	DATE DRILLED	05/27/95	

REMARKS DRILLING EQUIPMENT HURRICANE ASI RIG GEOLOGIST J. W. HARDELL AND L. A. HOST

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	ELEVATION (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROD TYPE	DESCRIPTION
CL SC	100% 100%	1.80/2.00	5949	0			CL	0.0-3.2' Sandy Clay with trace Gravel. Pale yellowish brown (10 YR 6/2) and dark yellowish orange (10 YR 6/6) grades to dark yellowish brown (10 YR 4/2). Some Mn staining and FeO staining. Sand is f.g., well sorted, sub-angular. Bedding massive. Low plasticity. Core is stiff and dry. 2% gravel, 22% sand, 76% clay No recovery (1.8-2.0')
			5948	2				
		2.00/2.00	5947	3			GC	3.2'-4.0' Sandy Gravel with some Clay. Matrix is pale yellowish brown (10 YR 6/2). Sand is m.g. to f.g., well graded, sub angular to sub-rounded. Gravel is coarse to fine, max 0.50 in., sub-angular. Core massive. Low plasticity. Dry. 53% gravel, 36% sand, 11% clay
			5946	4			SC	4.0'-4.8': There is no core in core box representing this interval. Sample description taken from the Well Site Field Log. Sand. Very pale orange (10 YR 8/2) to grayish orange (10 YR 7/4) grading to mod. yellowish brown (10 YR 5/4) at 4.4'
		1.10/2.00	5945	5			SC	4.8'-5.1': Clayey Sand. Sand is sub-angular to sub-rounded, well-sorted throughout interval No recovery (5.1-6.0')
			5944	6			GC	6.0'-6.9': Sandy Gravel. Same as above (reference interval 3.2'-4.0')
		1.30/2.00	5943	7			ML	6.9'-7.2': Sandy Silt with trace Gravel and some Clay. Brownish black (5 YR 2/1). Gravel is fine, sub-angular, well sorted. Sand is f.g., sub-angular to sub-rounded, well sorted. Low plasticity. Bedding massive. Dry. 3% gravel, 37% sand, 42% silt, 9% clay
			5942	8			GC	7.2'-8.0': Sandy Gravel. Same as above (reference interval 3.2-4.0). Some caliche No recovery (7.3-8.0)
		1.10/2.00	5941	9			CL	8.0'-9.1': Sample description for this interval taken from the Well Site Field Log. Silty Clay. Mod. yellowish brown (10 YR 5/4). Core is wet. No recovery (9.1-10.0')
			5940	10				Total Depth Drilled 10.00 Total Depth Casing 10.00 Bottom of Filter Pack 10.00

STATE PLANE COORDINATE	TOTAL DEPTH (FT) [illegible]	GROUND ELEVATION (FT) [illegible]	PROJECT NUMBER [illegible]	LOG OF BORING NUMBER
NORTH [illegible]	[illegible]	CASING DIAMETER (IN) [illegible]	GEOLOGIST [illegible]	59593
EAST 2061786	LOCATION NUMBER [illegible]	BOREHOLE DIAMETER (IN) [illegible]	DATE DRILLED 06/15/93	

REMARKS: Drilling Equipment CME 750 ATV ASI Rig Geologist T Santangelo-Drilling NOTE: Core loss (no recovery) intervals less than 0.2 ft not shown

DRAFT

Sample Grade Size	Percent Recovery	Recovery/Interval	Datum (ft)	Depth (ft)	Well or Piezometer Construction	Lithology	Unified Soils Classification or Rock Type	Description
		1.00/2.00	5961	1			CL	0.0'-1.0' Sandy Clay with some Gravel. Pred. mod. yellowish brown (10 YR 5/4), abundt. roots, stiff, dry. Description from Field log due to no core in box. No recovery (1.0-2.0')
		1.20/2.00	5960	2			CL	2.0'-3.0' Clay with some Silt and trace Gravel. Pred. dark yellowish brown (10 YR 4/2). Gravel up to 0.75 in. No apparent bedding or fractures. Dry, low to mod. plasticity, non-calcareous. 8% silt, 92% clay
		1.00/2.00	5959	3			SC	3.0'-6.5' Clayey Sand with some Gravel and Silt. Dark yellowish brown (10 YR 4/2). Fine, sub-angular to sub-rounded gravel. Pred. f.g. and m.g., sub-rounded quartz sand with trace mafics. No apparent bedding or fractures. Dry, low plasticity fines, non-calcareous. Broken cobble at 3.0 ft. 20% gravel, 52% sand, 7% silt, 21% clay. No recovery (3.2-4.0') and (5.0-6.0')
		1.20/2.00	5958	4				
		1.00/2.00	5957	5				
		1.20/2.00	5956	6				
		1.20/2.00	5955	7	06/15/93		CL	6.5'-7.0' Clay with trace Silt. Pred. light olive gray (5 Y 5/2) with abundt. Fe staining. No apparent bedding or fractures. Moist, mod. plasticity, non-calcareous. <5% silt, >95% clay
		1.60/2.00	5954	8			SC	7.0'-9.6' Gravelly Sand with some Silt and Clay. Grayish brown (5 YR 3/2). Sub-rounded c. gravel and cobbles up to 3.0 in. f.g. to c.g., well graded, sub-rounded quartz sand with some mafics and mica, some roots. No apparent bedding or fractures. Wet, low plasticity fines, non-calcareous. Possible broken mica schist cobble at 9.6 ft. 25% gravel, 55% sand, 10% silt, 10% clay. No recovery (7.2-8.0') and (9.6-10.0')
			5953	9				
			5952	10				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 17 90	GROUND ELEVATION (FT) 5551 30	PROJECT NUMBER 315-4[illegible]	LOG OF BORING NUMBER	
NORTH 7[illegible]577	[illegible] 305, DASS 115	CASING DIAMETER (IN) 2 50	GEOLOGIST F S DRILLING	59593	
EAST 2281765	LOCATION NUMBER 17	BORE-HOLE DIAMETER (IN) 10 00	DATE DRILLED 06/15/93		

REMARKS Drilling Equipment CME 750 ATV ASI Rig Geologist T Santangelo-Drilling NOTE Core loss (no recovery) intervals less than 0 2 ft not shown

DRAFT

Depth	Sample Number	Sample Grain Size	Percent Recovery	Recovery Interval	Unified Soil Classification	Well or Piezometer Construction	Lithology	Unified Soils Classification or Rock Type	Description
10								SC	10 0'-11 1' Gravelly Sand with some Silt and Clay Same as above (reference interval 8 0 to 9 6 ft) Cobble at approx 10 2 ft Driller estimates top of Bedrock at 13 0 ft No recovery (11 1-12 0'), (12 0-14 0'), and (14 0-14 9')
11	D6505-495			1 10/2 00					
12				0 00/2 00					
13									
14				0 00/2 00					
15				1 00/2 00				CLAYSTONE	14 9'-16 2' Claystone with trace Silt Light olive gray (5 Y6/1) mottled with mod yellowish brown (10 YR 5/4) Some carbonaceous material, some caliche filled random fractures Micro-fractures indicate possible soft sediment deformation Wet, highly calcareous No recovery (16 2-16 9')
16	D6505-496								
17				1 30/2 50				CLAYSTONE	16 9'-17 7' Claystone with trace Silt Same as above (reference interval 14 9 to 16.2 Ft), except decrease in micro-fracture texture Few 1 mm laminae of black carbonaceous material Caliche is along longer and more continuous fractures No recovery (17 7-17 9')
18									Total Depth Drilled 17 90 Total Depth Casing 15 35 Bottom of Filter Pack 13 50
19									
20									

LOG OF BORING NO. 70-86

GEOLOGIST(S):
DATE:

PROJECT NO:

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
0.0 ↓	0.0 to 2.0	NO				>50% Clay	CL			Clay, dark yellowish brown (10 YR 5/4), low to moderate plasticity, some silt and plant detritus.
						>50% Gravel	GC	1		Gravel, dominantly light gray (N7), angular to subangular, poorly graded, max. size 5cm, some silt and clay
	2.0 to 2.85	NO				>50% Clay	CL	2		Gravelly Clay, dark yellowish brown (10 YR 5/4), low to moderate plasticity, some silt.
Box 1 of 2	2.85 to 4.0	0						3		No Sample
	4.0 to 4.5	NO				40% Clay 30/30	CL	4		Gravelly Silty Clay, light gray (N7) dominantly dark yellowish orange (10 YR 6/6), low plasticity, abundant iron staining.
	4.5 to 5.0	0						5		No Sample
	5.0 to 7.0	NO				>50% Gravel	GC	6		Clayey Gravel, dominantly medium gray (N5) matrix is light gray (N7), angular to subrounded, poorly graded, max size 6cm, local iron staining.
	7.0 to 9.0					>50% Clay	CL	7, 8		Clay, light olive gray (5 Y 6/1), moderately high plasticity some silt.
	9.0 to 11.0					>50% Clay		9		Claystone, light brownish gray (5 YR 6/1), bedding not apparent, highly weathered, highly to moderately friable, localized iron staining

NOTES: General USCS is modified for this log as follows:
Material amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT

FIGURE NO.

LOG OF BORING NO. 70-86

GEOLOGIST(S): DCB
DATE: 8/16/89

PROJECT NO: 667-11.22

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
Box 1 of 2 ↑ 11.0	7.0 to 11.0	NO						11		As above color grades to medium dark gray at ~10.5 ft.
11.0 ↓ 2 of 2 Box 1 13.0								12		
								13		Bottom of Box 2 of 2 at 13.0 ft.
								14		

NOTES: General USCS is modified for this log as follows:
Material amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT

FIGURE NO.

STATE PLANE COORDINATE | TOTAL DEPTH (FT) 18 30 | GROUND ELEVATION (FT) 5994 30 | PROJECT NUMBER 305-[illegible] | [illegible] NUMBER

NORTH [illegible] | HOLE 305 3455 115 | CASING DIAMETER (IN) 2 30 | GEOLOGIST T S [illegible]

EAST 2382128 | LOCATION NUMBER J7 | BOREHOLE DIAMETER (IN) 10 00 | DATE DRILLED 06/11/93

59793

REMARKS Drilling Equipment CME 750 ATV ASI Rig Geologist Theresa Santangelo-Drelling Note Core loss into recovery intervals less than 0 2' not shown

Stratigraphic Unit	Sample Number	Sample Grain Size	Percent Recovery	Recovery Interval	Depth (ft)	Well or Piezometer Construction	Lithology	Unified Soils Classification or Rock Type	Description
	0S0M0B5			1 10 / 2 00	0–1			CL	0 0'-1 1' No core in box Description from Field Sandy Clay Dark yellowish brown (10 YR 4/2) Abundt roots Dry, stiff No recovery (1 1-2 0')
	0S0M0B6 0S0M0B7			1 20 / 2 00 0 80 / 1 30	2–4			CL	2 0'-3 2' Sandy Clay with some Silt and trace Gravel Light brown (5 YR 5/6) Fred f g, sub-rounded, quartz sand, trace roots No apparent bedding or fractures Dry, low plasticity, non-calcareous Note Dark yellowish brown Sandy Clay in this interval at top is likely from 0 0 to 1 1 ft interval 29% sand, 18% silt, 53% clay No recovery (3.2-4 0') and (4 0-5 3')
	0S0M0B8			1 20 / 2 00	5–7			CL	5 3'-8 7' Sandy Clay with some Silt and trace Gravel Light olive gray (5 Y 6/1), mottled with light brown (5 YR 5/6) Fred. f g, sub-rounded, quartz sand No apparent bedding or fractures Moist, low to mod plasticity, slightly calcareous Pink conglomerate cobble at 8 5 ft 14% sand, 9% silt, 77% clay No recovery (6 5-7.3') and (8 7-9 3')
	0S0M0B9 0S0M0C0			1 10 / 2 00	8–10			SC	9 3'-10 8' Clayey Sand with some Silt and trace Gravel Light olive gray (5 Y 6/1) Rounded f gravel up to approx 0 5 in Fred. f g with some m g and c g, sub-rounded, quartz sand No apparent bedding or fractures Moist, low plasticity fines, non-calcareous Rounded cobbles at 10 5 to 10 8 ft 5% gravel, 59% sand, 7% silt, 29% clay No recovery (10 8-11 3') and (11 3-13 3')

LOG OF BORING NO. 5786

GEOLOGIST(S): WAA
DATE: 8/15/89

PROJECT NO: 667-1122

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	LITHOLOGIC DESCRIPTION
	9.0									Silty Clay. Lt. olive gray to grayish orange (10yr 7/4). Est. plast. low to moderate. Trace carb. material. Trace $CaCO_3$ toward bottom of interval.
	to	3.6(1)				Clay 75%	CL	11		
12.0	12.0							12		
										Bottom of Box
								13		
								14		

NOTES: General USCS is modified for this log as follows:
Material amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT

FIGURE NO.

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 12.00	GROUND ELEVATION (FT) 5929.60	PROJECT NUMBER 005-RI1/RI	LOG OF BORING NUMBER
NORTH 749452	AREA IHSS 115	CASING DIAMETER (IN) 6.50	GEOLOGIST L. A. HOST	58094
EAST 2362247	LOCATOR NUMBER J7	BOREHOLE DIAMETER (IN) 3.90	DATE DRILLED 10/12/94	

REMARKS: DRILLING EQUIPMENT HURRICANE ASI RIG GEOLOGIST L. A. HOST

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
		1.00/2.00	5929	0			SM	0.0'-6.0' Silty Sand with some Gravel and Clay. Dark yellowish brown (10 YR 4/2). Sand and Gravel very pale orange (10 YR 8/2). Sand and gravel well graded, coarse to fine, sub-angular. Abundt pulverized rock. Core loose. Unconsolidated. Dry. Bedding not apparent. Top 0.2 in top soil, grass, roots. Low plasticity. / Color grades to pale brown (5 YR 5/2) at 5.0' and core is damp. 12% gravel, 52% sand, 29% silt, 7% clay /
		1.50/2.00	5928	1				No recovery (1.0-2.0') and (3.5-4.0')
		2.00/2.00	5927	2	10/20/94			
		1.00/2.00	5926	3	10/12/94		ML	6.0'-10.0' Sandy Silt. Dusky yellowish brown (10 YR 2/2). Sand is f.g., sub-rounded to sub-angular, well sorted. Trace of FeO staining. Some micaceous material. Bedding massive. Core wet. Low plasticity. 40% sand, 60% silt
		0.90/2.00	5925	4				No recovery (7.0-8.0'), and (8.9-10.0')
			5924	5				
			5923	6				
			5922	7				
			5921	8				
			5920	9				
				10				

Clay Stone @ 10

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 11.90	GROUND ELEVATION (FT)	5929.60	PROJECT NUMBER	035-RF1/R1	LOG OF BORING NUMBER
NORTH	747452	AREA IHSS 115	CASING DIAMETER (IN)	8.50	GEOLOGIST	L. A. HOST	58094
EAST	2082297	LOCATION NUMBER J7	BOREHOLE DIAMETER (IN)	1.40	DATE DRILLED	10/12/94	

REMARKS DRILLING EQUIPMENT HURRICANE #11 RIG GEOLOGIST L. A. HOST

SAMPLE NUM	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	ELEVATION (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
		100%	1.90/2.00	5919	10			CLAYSTONE	10.0'-11.9' Top of Bedrock at 10.0' Claystone with some Silt. Brownish gray (5 YR 4/1) and some dark yellowish orange (10 YR 6/6) where FeO stained. Core wet. Some carbonaceous material. Bedding massive. Slightly friable. Strong MnO2 and FeO staining at 11.9' 9% silt, 91% clay
				5918	11				
				5917	12				Total Depth Drilled 11.90 Total Depth Casing 11.00 Bottom of Filter Pack 11.90
				5916	13				
				5915	14				
				5914	15				
				5913	16				
				5912	17				
				5911	18				
				5910	19				
					20				

STATE PLANE COORDINATE	TOTAL DEPTH (FT) 18 30	GROUND ELEVATION (FT) 5944 90	PROJECT NUMBER 305-RFT/RI	JOB & WORK ORDER NUMBER	
NORTH 740553	AREA 306, DIES 125	CASING DIAMETER (IN) 2 00	GEOLOGIST T S SHELLENGER		
EAST 2082328	LOCATOR NUMBER J7	BOREHOLE DIAMETER (IN) 10 00	DATE DRILLED 06/11/93		

59793

REMARKS Drilling Equipment CME 750 ATV RST Rig Geologist Theresa Santangelo-Drexling Note Core loss (no recovery) intervals less than 0 2' not shown

DRAFT

SAMPLE GRADE SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
		1 50 /2 00	10–11				
		0 80 /2 00	11–13				
		2 00 /2 00	13–16			CLAYSTONE	13.3'-16 1' Top of Bedrock at 13 3' Claystone with trace Silt Light olive gray (5 Y5/2) Trace v f g., sub-rounded, quartz sand. Mod to highly weathered Some Fe staining, some caliche, some carbonaceous material, mod. calcareous. No apparent bedding or fractures Interval between approx. 13 6 to 13 8 ft contains approx 20% f g. to c g., rounded, quartz sand. Fe staining is not as abundt below approx 15 3 ft <5% silt, >95% clay. No recovery (16.1-17 3')
		0 80 /2 00	16–17				
		1 00 /1 00	17–18			CLAYSTONE	17 3'-18 3' Claystone as from 13.3 to 16 1 ft with occasional decomposed ironstone nodules approx. 1. to 2 mm Some near vertical Fe stained healed fractures No apparent bedding Non-calcareous.
			18–20				Total Depth Drilled 18 30 Total Depth Casing 16 50 Bottom of Filter Pack 14 00