FINAL GEOTECHNICAL INVESTIGATION
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FLOOD RETARDING STRUCTURE NO. 1
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CONTRACT FCD 2003C014
WORK ASSIGNMENT NO. 2

PREPARED FOR:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
PHOENIX, ARIZONA

PREPARED BY:

AMEC EARTH & ENVIRONMENTAL, INC.
TEMPE, ARIZONA

JANUARY 7, 2005
AMEC JOB NO. 4-117-001021

amec

January 7, 2005
AMEC Job No. 4-117-001021

Brett A. Howey, P.E.
Project Engineer – Dam Safety
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399

Dear Mr. Howey:

Re: Supplemental Investigation of Transverse Cracks
Buckeye Flood Retarding Structure No. 1
Flood Control District of Maricopa County
Contract FCD 2003C014
Work Assignment No. 2

Transmitted herewith are six copies of the final version of the geotechnical investigation report for the referenced project. This report contains the findings of a supplemental investigation regarding the character and potential causes of transverse cracking in the vicinity of Station 721+00 of the Buckeye Flood Retarding Structure (FRS) No. 1. The content of this final report contains specific responses to comments generated by reviews of previous draft versions of the document. These comments were submitted by the Arizona Department of Water Resources (ADWR) on November 16, 2004, and by the Flood Control District of Maricopa County (District) on August 5, 2004.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

REGISTERED GEOLOGIST CERTIFICATE NO. 12999 RALPH E. WEEKS Date Signed 1/7/05 ARIZONA U.S.A.

Ralph E. Weeks, P.G.
Senior Geologist

Reviewed by:

Registered Professional Engineer (Civil) CERTIFICATE NO. 13872 LAWRENCE A. HANSEN Date Signed 1/7/05 ARIZONA, U.S.A.

Lawrence A. Hansen, Ph.D., P.E.
Senior Vice President

G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\Final Report\BuckeyeFinalReport.doc

c: Addressee (6)

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel +1 (480) 940-2320
Fax +1 (480) 785-0970 www.amec.com

amec

TABLE OF CONTENTS

Page

amec

TABLE OF CONTENTS

Page

LIST OF FIGURES

TABLE OF CONTENTS

Page

LIST OF APPENDICES

REGISTERED GEOLOGIST
CERTIFICATE NO.
12999
RALPH E.
WEEKS
Date Signed 1/7/05
ARIZONA U.S.A.

1.0 INTRODUCTION

This report presents the findings of a supplemental geotechnical investigation to characterize and subsequently evaluate the probable cause of embankment cracking in the vicinity of Station 721+00 of the Buckeye Flood Retarding Structure (FRS) No. 1, located approximately 12 miles northwest of Buckeye, Arizona. The investigation was designed to support the development of recommended repair techniques for the Station 721+00 location, and at three other locales with suspected severe cracking (Stations 624+35, 673+50 and 710+47), and to evaluate the adequacy and stability of the existing central filter drain. These areas of concern were originally identified during a previous study completed by AMEC in 2001 (AMEC, 2001)[1]. This more recent evaluation was also designed as an effort to validate and propose improvements to the exploratory techniques applied at Station 721+00, thereby optimizing planned investigations of the remaining segments of the dam affected by transverse cracking.

The investigation described herein was authorized by the Flood Control District of Maricopa County (District) during March of 2004 as Work Assignment No. 2 of Contract FCD 2003C014. The investigation involved both field and laboratory data collection. The goals of the work assignment included the local characterization of the geometry, extent, width and spacing of embankment cracks in the vicinity of Station 721+00, the geotechnical attributes of the underlying foundation soils, and the physical properties of the embankment soils and drain materials. Subsequent geotechnical appraisals regarding embankment integrity and safety followed, including an analysis of seepage behavior. Field activities included geological mapping, geophysical surveys, surficial cleaning and crack inspection, drilling, completion of test pits and test trenches, and the excavation and logging of a deep longitudinal test trench along the dam crest, resulting in the partial removal of the central filter drain. The laboratory program included a suite of physical characterization tests, and specialized procedures to evaluate the erosional characteristics of the aggregates used in the existing central filter drain within the dam.

As part of this work assignment, AMEC retained Mr. James Talbot to serve as a senior subconsultant on the project. During his past work with the Soil Conservation Service, Mr. Talbot contributed to the design of the Buckeye FRS No. 1 central filter drain, and is a recognized specialist in the design of sand and gravel filters. Mr. Talbot participated in the formulation of the work plans for this project, observed the site conditions during the course the field investigation, and commented on the content of this report.

[1] References are listed at the end of this report.

This report first presents a summary of the investigative methods applied, followed by a description of the local geology, the geotechnical profile of the dam foundation, the embankment materials, and the discontinuities detected within the dam structure. Discussions of the probable cause of embankment cracking are then presented, along with an appraisal regarding the performance of the central filter drain. The investigative procedures are critiqued, and recommendations regarding subsequent exploration are provided. An inclusive recommendation is then presented regarding the remaining three cracked embankment segments, involving both characterization and repair, with comments regarding the implications of the Station 721+00 discoveries upon the overall approach to assuring dam safety.

2.0 OVERVIEW OF BUCKEYE FRS

Buckeye FRS No. 1 was completed by M.M. Sundt Construction Company on March 1, 1974 under contract to the Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service). The facility is designed to prevent flooding of Interstate 10, and to protect property located south of I-10 near Palo Verde Road and I-10 east of the Hassayampa River. The embankment is 7.09-miles long, extending from Stations 555+00 to 931+80, with a maximum height of 33 feet. This homogeneous earthen embankment was constructed of surficial soils from the low-flow channel within its impoundment, and from sub-excavation of the native soils underlying the embankment. As depicted on the as-built plans for the structure (SCS, 1974), the embankment has an upstream slope of 3H:1V (horizontal to vertical), a downstream slope of 2H:1V and a crest width of 14 feet. The embankment geometry includes a centerline foundation cutoff trench with a bottom width of 15 feet and 2H:1V side slopes. The cutoff trench was designed to extend through the surface layer of softer Holocene deposits into the underlying cemented Late Pleistocene deposits (termed "siltstone or sandstone as approved by the engineer" on the project plans). The cutoff trench was constructed between Stations 590+00 and 907+70. The original design plans and a geologic investigation report (SCS, 1971) for the structure also specify that native materials having a "high to moderate consolidation potential" be stripped from the foundation area of the dam. The depth of stripping was to be determined by the engineer, but this detail is not clearly delineated on the as-built plans.

Project plans indicate that the principal outlet conduit for Buckeye FRS No. 1 is a 60-inch diameter reinforced concrete pipe with anti-seep collars at 16 feet on-center, located at Station 910+67 near the west end of the dam . The inlet channel to this principal outlet extends east to about Station 855+00, and the outlet directs flows to the Hassayampa River located about 1,200 feet to the west. An earth channel spillway is located at the western end of the structure at Station 931+80. Gated outlets extending through the dam are located at Stations 710+00 and 817+00. The project plans indicate these 12-inch diameter reinforced concrete pipes were constructed with anti-seep collars at 16 feet on-center and supported by concrete cradles. An irrigation outlet channel is located on the downstream side of the dam between Stations 710+00 and 798+00. Ungated outlets to this channel are located at Stations 764+50 and 796+50.

About 4 years after the completion of the Buckeye embankment, a routine inspection of the structure by the Arizona Water Commission (AWC, now the Arizona Department of Water Resources) on March 29, 1977 "revealed serious surface lineations of transverse cracks and at least one longitudinal crack" (AWC, 1979). The SCS and the AWC jointly investigated the cracking in January 1978 by excavating the discontinuities to evaluate their nature and extent. Fugro, Inc., Consulting Engineers and Geologists (Fugro) subsequently completed a detailed assessment of the extent of cracking within the FRS (Fugro, 1979). Their report concluded that 47 percent of the embankment length had experienced no cracking, 36 percent had a low degree of cracking and 17 percent had a moderate to severe degree of cracking. Their report also presented several alternatives to mitigate the possible effects of the cracking, including construction of a central filter drain connected to downstream outlet drains.

In 1980 a central filter drain was installed along the centerline of the FRS between Stations 565+00 and 801+00, constructed by excavating a trench from the dam crest and backfilling of the excavation with permeable material. As detailed in the as-built construction report and on the plans for the central filter drain (ERTEC, 1981), the drain is 2.5 feet wide and ranges in depth from 4.4 to 19.5 feet, but commonly is about 17 feet deep. Sixty-one outlet drains were installed at various intervals along the downstream side of the structure. The plans indicate the outlet drains are located at intervals of 500 feet between Stations 565+00 and 650+00, and at intervals of 1,000 feet between Stations 650+00 and 800+00. During construction, some scheduled outlets were moved and additional outlets were installed at locations where cracks were located within three feet of the excavation floor, or where 3/8-inch or wider cracks were encountered deeper than three feet from the top of the structure.

During construction of the central filter drain, a detailed geologic inspection of the downstream face of the excavation was performed to ensure that the trench intercepted all cracks, and to provide detailed records of the cracks. Detailed documentation of the cracks encountered was completed, including the type (transverse, longitudinal or oblique), width, length, depth and location. (ERTEC, 1981).

As previously mentioned, AMEC completed a field investigation in 2001 of selected features and cracks at the Buckeye FRS No. 1 (AMEC, 2001) to assess the cause of the cracking and the adequacy of backfilling the cracks and related features with ASTM C-33 sand. The study, which included trench flood testing, indicated that the cracking may extend below the depth of the central filter drain and outlet drains at a few locations, specifically Stations 624+35, 673+50, 710+47 and 721+00. The apparent continuity of cracking at these locations resulted in large seepage losses when water was introduced into trenches on the upstream face of the embankment. Conditions encountered at the present study area near Station 721+00, based on both the AMEC (2001) report and a subsequent AMEC (2002) evaluation, are summarized in

Section 5.1. At Station 721+00, the flood testing resulted in seepage occurring near the upstream toe of the embankment, which is below the bottom elevation of the central filter drain. Flood testing conducted as part of the previous Fugro (1979) investigation also measured high flows at two of the same general locations (Stations 710+47 and 721+00).

The previous AMEC study (AMEC, 2001) indicated that transverse cracking might extend to a depth in excess of the depth of the central filter drain. To further investigate this possibility, AMEC recommended that additional trenching be conducted in the vicinity of Station 721+00, where both significant seepage flows and seepage discharging near the upstream toe of the structure were observed. If a continuous crack to the full depth of the trench at this upstream location was encountered, then additional trenching nearer to the upstream crest of the embankment was recommended to further investigate the continuity of cracking with depth. Additional trenching at the other locations (Stations 673+50, 624+35 and 710+47) where toe seepage was observed was also recommended, if cracks extending vertically to the elevation of the upstream toe were encountered at Station 721+00.

3.0 INVESTIGATIVE APPROACH

The following discussion summarizes the investigative methods and data sets compiled for this evaluation. The approach included several components: 1) initial site inspection and geologic reconnaissance; 2) compilation of existing data and previous interpretations; 3) evaluation of pipe videos; 4) development of work and backfill plans; 5) a geophysical program of seismic refraction and shear wave profiling; 6) exploratory drilling; 7) upstream embankment cleaning and excavations; 8) excavation of a deep longitudinal trench that removed the central filter drain; 9) backfill and repair of drain, dam crest and embankment slope; 10) laboratory testing of representative samples; and 11) select seepage and stability analyses.

3.1 Initial Site Inspections and Geological Reconnaissance

An initial site visit and geologic reconnaissance was performed by Ralph Weeks, P.G. and Kenneth Fergason, P.G., both of AMEC. The length of the dam was traversed by vehicle, and ground reconnaissance was performed at and around Stations 624+35, 673+50, 710+47, and 721+00. Surficial manifestations of cracking were not evident in the vicinity of any of the above four locations, with the lack of those indications likely due to previous surficial treatment and crack repair efforts. The local geology was assessed in the field using the published mapping of Demsey (1989).

3.2 Compilation of Existing Data and Previous Interpretations

A review of previous crack investigation work, geotechnical characterization efforts, repair construction reports and related documentation for Buckeye FRS No.1 was performed for the area in and around Station 721+00. The following documents were reviewed as a part of this evaluation:

- Buckeye FRS No. 1 Investigation of Cracking - Work Assignment No.3, report submitted to the Flood Control District of Maricopa County, AMEC, 2002.
- Geotechnical Investigation Report, Buckeye FRS No. 1, report submitted to the Flood Control District of Maricopa County, AMEC, 2001.
- As-Built Report, Buckeye Site 1 Drain, Maricopa County, ERTEC , 1981.
- Crack Location Investigation, Buckeye No. 1 Flood Retarding Structure, Maricopa County, Fugro Inc., 1979.
- Report of Geologic Investigation, Buckeye Watershed, Floodwater Retarding Structure No. 1, Soil Conservation Service, 1971.

Pertinent data from these studies are included in Appendix A.

3.3 Evaluation of Pipe Videos

Inspection videos (DVD) of the two 12-inch diameter reinforced concrete pipe irrigation outlets located at Stations 710+00 and 817+00 of Buckeye FRS No.1 were obtained from the District. Both videotapes were reviewed and all pipe joints were closely examined to detect possible separations, deformation or other abnormalities. Descriptions of the outlet video inspections for both pipes are presented in Section 6.4 of this report, and the inspection reports for individual pipe joints for both pipes are provided in Appendix B. The original inspection videos (in CD) for both outlet pipes are also included in Appendix B. A review of the inspection videos of the principal spillway was not part of this work assignment.

3.4 Development of Work and Backfill Plans

Prior to full-scale implementation of the field work, a field exploration and laboratory testing work plan, and a proposed backfill plan were prepared by AMEC and submitted to the District and other agencies (ADWR, NRCS) for review and approval. The work was divided into three phases. Phase 1 included geological mapping, geophysical surveys, the cleaning and mapping of the embankment surface, and drilling. Phase 2 included the excavation of test trenches in the upstream embankment slope and in the longitudinal trench along the central filter drain. Phase 3 included the backfilling of the longitudinal trench and repair and reconstruction of the upstream slope. The work plan provided descriptions of field exploration methods, investigation procedures, the type and number of samples required for laboratory testing, and the number and location of borings and test trenches. The work plan also provided a proposed array of different laboratory tests deemed necessary to characterize the physical and mechanical properties of embankment and foundation materials. The final work plan and backfill plan were developed following discussions with and comments by the District.

A deep longitudinal trench was excavated parallel to the embankment axis. The longitudinal trench removed the central filter drain material, and was subsequently backfilled with selected aggregate material after the investigation was complete. The trenching exposed the upstream and downstream embankment profiles at the contact with the drain, and the embankment below the central filter drain. Prior to this work assignment, a filter analysis was performed to determine if the original drain material functions as a filter for the embankment soil, in accordance with Natural Resource Conservation Service (NRCS, 1994) criteria. The results of the filter analysis were presented in a previous report (AMEC, 2001). On the basis of this previous analysis, a suitable aggregate was selected for the backfill of the central filter drain trench based on NRCS filter criteria.

A backfill plan provided by AMEC earlier was modified for this project. The plan for this backfill and reconstruction was developed in consultation between AMEC, the District, ADWR, and NRCS representatives, with the support of independent consultant James R. Talbot. The interim findings of the crack investigation were discussed in a meeting held on May 5, 2004 at Day's Inn located three miles east of the site. The meeting took place at 3:00 p.m. following a field visit to the site at 1:00 p.m. by the representatives listed below.

Participant	Representing
Brett Howey	FCDMC
Michael Greenslade	FCDMC
Jon Benoist	ADWR
Michael Johnson	ADWR
Danny McCook	NRCS
Jim McHenry	NRCS
Jim Talbot	Independent Consultant
Ralph Weeks	AMEC
Bibhuti Panda	AMEC
Ken Fergason	AMEC

The goal of the backfill plan was to restore the dam height to the elevation specified in the design, and to temporarily mitigate the hazard of failure through the discontinuities in the embankment found during this investigation. It was agreed during the project meeting that these measures were interim in nature, intended to reduce the risk of dam breach until full-scale repair measures or other alternatives are selected, designed and implemented. The details regarding the backfilling and reconstruction of the embankment are discussed in Section 3.9 of this report.

At the time of the meeting referenced above, all participants present concurred that the conditions observed in the Station 721+00 study area did not represent an unsafe condition, and the appropriate course of action was to proceed with the tasks summarized in this report. Subsequently, the ADWR reclassified the dam as "unsafe non-emergency" as detailed in a May 25, 2004 letter to the District.

3.5 Seismic Refraction and Shear Wave Profiling

Eight 120-foot long seismic refraction and shear wave surveys (Lines 1 through 8) were completed by Michael L. Rucker, P.E. and Mr. Fergason, both with AMEC, on April 6, 2004. The purpose of these lines was to assist in characterizing the subsurface geotechnical profile, and to identify the presence or absence of potential discontinuities or fissures in the near vicinity of the Station 721+00 study area. A Geometrics S-12 Smartseis signal enhancement seismograph and geophone array were used. Lines 1 and 2 were positioned at the upstream toe, Lines 3 and 4 were positioned on the upstream slope, and Lines 7 and 8 were positioned along the downstream toe of the FRS. These six lines were overlapped to provide continuous profile coverage in the area of investigation. Line 5 was positioned on the FRS crest and Line 6 was positioned on the FRS downstream slope. These two lines were centered on a known and previously staked transverse crack in the embankment.

A sledgehammer energy source was used to collect compression wave (p-wave) data for seismic refraction analysis. Jogging alongside the geophone array was performed to generate energy for refraction microtremor analysis for a one-dimensional vertical shear wave (s-wave) profile at each seismic line. The seismic refraction data was fully interpreted to provide information regarding the underlying geotechnical profile, including lateral variations in the subsurface materials and within the embankment. The results of the refraction seismic surveys are presented in Appendix C, along with brief descriptions of the seismic refraction equipment and procedures used. Seismic line locations are shown on the site plan presented in Figure 2.

Seismic results were used to identify the presence or verify the absence of fissures in the foundation or significant discontinuities in the embankment. A method of visually examining seismic traces for a sudden decrease in signal amplitude (attenuation) and/or an anomalous increase in arrival time (time offset) of the seismic signal between adjacent geophones was employed. The presence of such anomalies in several data sets for each line, such as in both foreshot and backshot trace sets, was considered an indicator of an earth fissure or similar soil discontinuity. This method is detailed in Rucker and Keaton (1998) and has been used to identify and trace earth fissures at other sites in Arizona. Interpretation of the absence or presence of anomalies consistent with earth fissures or significant embankment discontinuities was made in the field during the performance of each seismic line. Location(s) of an anomaly interpretation(s) at a seismic line were staked in the field while the seismic line cabling was still deployed on the ground. Copies of seismic line traces with anomaly interpretations are presented in Appendix C.

3.6 Exploratory Drilling

Eight borings (Borings B-1 through B-8, inclusive) were completed at locations adjacent to the dam in the vicinity of Station 721+00, to depths of 40 feet below ground surface. The borings were advanced using a CME-95 drill rig utilizing 8-5/8-inch O.D. hollow stem auger, owned and operated by Heber Mining & Exploration Company. Standard penetration testing and sampling were performed at selected intervals in the borings. In addition, CME continuous sampling techniques were performed at selected intervals in the borings. CME samples were obtained in acrylic tubs, 2.5 feet in length with an O.D. of 3.0 inches. A total of 80 linear feet was sampled with CME sampling methods. The soils encountered during the investigation were continuously examined, visually classified and logged. Upon completion of the borings off the existing dam embankment, they were backfilled by the drilling subcontractor with the previously excavated drill cuttings mixed with bentonite chips.

Logs of the test borings are presented in Appendix D, including a brief description of drilling and sampling equipment and procedures. The boring locations are shown on Figure 2. The field investigation was supervised by Mr. Fergason.

3.7 Excavations in the Upstream Embankment Slope

Excavation and investigation of the transverse cracking in the upstream embankment proceeded in four stages: 1) initial cleaning of the upstream slope of the dam; 2) further cleaning of surfaces in targeted areas; 3) embankment benching; and 4) excavation of toe test trenches.

3.7.1 Initial Surficial Cleaning

A segment of the upstream embankment surface, approximately 150 feet long, was initially cleaned by District personnel using a John Deere 710D backhoe. The zone extended from the crest to the toe of the upstream embankment, and from about Station 720+25 to 721+75 (Figure 2). The upper 2 to 4 inches of the embankment soils were stripped off the surface and then cleaned by District personnel utilizing compressed air from a Sullair 125 cfm compressor. This initial cleaning proved to be insufficient for observing the transverse cracking in the embankment.

3.7.2 Targeted Surficial Cleaning

Three zones (Figure 2) were identified as areas for further investigation from existing data and seismic profiling. Zone 1 is located at about Station 720+80, Zone 2 at about Station 721+10, and Zone 3 at about Station 721+55. These areas were further excavated from the crest to the toe to a depth of 8 to 12 inches by District personnel utilizing a John Deere 710D backhoe, and cleaned using compressed air. Each of the zones are about 10 to 20 feet wide. A grid was staked and the cracks were mapped in detail. A log showing the location of the discontinuities and a CD with photographs of these zones are presented in Appendix E. The targeted surficial cleaning was supervised and crack mapping was completed by Mr. Fergason.

3.7.3 Embankment Benching

Following surficial logging of the three target zones, the zones were benched by District personnel utilizing a John Deere 710D backhoe. Four benches were excavated within each of the three target zones. Bench heights ranged from about 4 to 5 feet. Logs showing crack locations were created for both the vertical back wall and floor of each of the 16 benches. Samples of embankment material were obtained for laboratory testing. These logs and photographs (CD) are presented in Appendix E, with Figure E-2 showing the location and form of the excavated benches.

Supplemental to the embankment benching, the uppermost bench in each of the three zones was further excavated by District personnel utilizing a John Deere 710D backhoe. The benches were excavated back to the central filter drain to observe the contact of the transverse cracking with the drain material. In Zone 2, this excavation was performed before a log for the back wall of the uppermost bench could be completed. This excavation was closely observed and documented by Mr. Fergason and photographs are available as presented on Figures E-18 through E-20 and in the CD in Appendix E. Representatives of the District and the NRCS and Mr. Talbot observed the excavation on several occasions during the process.

3.7.4 Embankment Toe Test Trenches

One test trench was excavated at the toe of the embankment in each of the three target zones. The trenches were excavated by District personnel utilizing a John Deere 710D backhoe. The soils encountered during the investigation were continuously examined, visually classified and logged by Mr. Fergason. Locations of the test trenches and logs are presented in Appendix E (Figures E-7, E-12 and E-17).

3.8 Excavation of Central Filter Drain

A deep trench was excavated in the crest of the dam from about Stations 720+45 to 721+85 by District personnel using a Komatsu PC 160LC track hoe with a 36-inch bucket. The trench was excavated parallel to the embankment axis to expose the interface between drain aggregate and embankment soil on both sides of the drain where it intersected the most persistent transverse cracks included in the three zones. The primary goal of the deep embankment test trenching was to obtain detailed information about the transverse cracking, including determinations of the aperture, depth, extent, and connectivity of the cracks. In addition, it was important to ascertain whether the cracks were present beneath the central filter drain. The trench had vertical slopes on both its upstream and downstream sides. The other sides were sloped at about 1H:1V. The depth of the trench extended to about 4 to 12 inches beneath the central filter drain and ranged from 17 to 21 feet below the dam crest. Due to the maximum reach of the track hoe, the crest of the dam was excavated by District personnel using a CAT 950G front-end loader and a John Deere 710D backhoe to a depth of 3.5 to 4 feet below the dam crest before the trench was excavated. The trench proper had a maximum depth of about 17 feet and was 36 to 40 inches wide.

The embankment soils are predominantly clayey sands. The soils are fairly uniform, weakly to moderately cemented, and low to medium in plasticity. The soils and site conditions were characterized using the OSHA (OSHA Excavation Standard Handbook) classification system for shoring design, with the soil type in the embankment classified as Type B. Type B soil is a cohesive soil with an unconfined compressive strength greater than 0.5 tons per square foot (tsf) but less than 1.5 tsf. Type B soils also include granular cohesionless soils like angular gravel, silt, silt loam, sandy loam and sometimes silty clay loam and sandy clay loam.

The trench shoring support was designed and installed in accordance with OSHA Regulations (Standards – 29 CFR, Part 1926, Subpart P – Excavations, and subparts therein). Vertical aluminum hydraulic shoring or spot bracing was used for the support of the vertical slope. Minimum parameters were in accordance with Option 1 [1926.652(c)(1)] as follows for Type B soil:

- Maximum 5.5 feet horizontal spacing,
- Maximum 4 feet vertical spacing, and
- Minimum 2 inch diameter hydraulic cylinders.

A memo was prepared by Bibhuti B. Panda, Ph.D., P.E. of AMEC outlining the design of the shoring system for the trench and submitted to the District for review. The safety shoring was installed by Geomechanics Southwest, Inc. (GSI) personnel in accordance with OSHA regulations. In addition to shoring, an oxygen meter was on site and periodically used to ensure that sufficient oxygen levels were present in the trench. The trench crest was cleaned and scaled to remove falling hazards. The trench was secured by placing chain-link fence panels across its top, and fencing was installed at each end of the trench to limit access. A minimum of three ladders were spaced throughout the trench for entry and exit, and the ends of the trench were sloped to provide escape routes. The trench was periodically inspected by a registered professional engineer. Inspections were made by Dr. Panda, Lawrence Hansen, Ph.D., P.E., and Tony Freiman, P.E., all of AMEC. The appropriate OSHA and Arizona Division of Occupational Safety and Health regulations concerning excavation safety, including worker egress, were followed.

Logs were prepared of the cracking observable in the upstream and downstream walls and trench bottom within each of the three zones. Logs and photographs are presented in Appendix F and the location of the trench is shown in Figure 2. Six samples of the drain material and adjacent embankment material were obtained at varying depths at the two ends of the trench. Excavation of the trench and installation of the shoring was observed, samples obtained, and logs prepared by Mr. Fergason. With the trench at full depth, and with the shoring fully in place, the site conditions were observed by representatives of ADWR, NRCS and the District, and by Mr. Talbot on May 5 and 6, 2004.

3.9 Backfill of Longitudinal Trench and Reconstruction of Upstream Slope

A filter analysis was performed to select a suitable backfill material that would function as a filter for the embankment soil in accordance with NRCS (1994) criteria. NRCS (1994) presents criteria for determining the grain-size distribution (gradation) of sand and gravel filters needed to prevent internal erosion or piping of soil in embankments or foundations of hydraulic structures. These criteria are based on results of an extensive laboratory filter study carried out by NRCS. The laboratory filter study clearly demonstrated that properly graded filters designed in accordance with these criteria are capable of sealing a crack. The sealing begins when water flows through a crack or opening and carries soil particles eroded from the sides of the opening. The eroded soil particles collect at the face of the filter and seal the crack at the interface. In order to design the filter as a filtering media and drain, both filtration (maximum allowable D_{15} size of the filter) and permeability requirements (minimum allowable D_{15} of filter) have been defined by the NRCS criteria. The NRCS criteria define the width of the filter band and maximum (D_{100}) and minimum (D_5) particle size criteria to prevent gap-graded filters. The relationship between the maximum D_{90} and the Minimum D_{10} is also defined by the NRCS criteria to minimize segregation during construction.

The filter analysis performed earlier (AMEC, 2001) was reviewed and a suitable coarse aggregate (Filter Material A) was selected to satisfy the NRCS filter criteria for a base embankment soil representative of the compacted dam fill within the Station 721+00 study area. Filter Material A is a dry product combining 80 percent ¼-inch minus and 20 percent ⅜-inch washed rock, and was used as a backfill for the central filter drain longitudinal trench. Filter Material A was placed in a dry and un-compacted condition. The grain-size distribution for the filter, base embankment soil, embankment soil in the study area, and NRCS filter criteria are presented in Figure G-2. The grain-size distribution of the observed embankment soil within the Station 721+00 study area was found to be close to the base embankment soil previously used to design the filter (AMEC, 2001).

At each crack zone the toe of the dam was excavated to a depth of 4 feet to expose the native soil. The three benched areas were excavated to provide a relatively smooth base with a 3H:1V slope on the upstream side approximately 5.5 feet deep. A one foot thick layer of Filter Material B was placed on the base of upstream slope, and then compacted embankment material was placed on the top of the filter to reconstruct the upstream slope to its original geometry. The gradation for Filter Material B is equivalent to ASTM C33 concrete fine sand. The grain-size distribution for the filter and NRCS filter criteria are presented in Figure G-3. The filter was placed in a moist and un-compacted condition. The extent of the excavated area, in plan view, and a representative cross section are presented in Figure G-1. The specification for the gradation of the filter material, and the specification for the compaction of the embankment fill, are also presented in Figure G-1.

The backfill and reconstruction activities consisted of the following steps:

The bottom of the longitudinal trench at the crest was cleaned manually before being backfilled with Filter Material A.

- The filter material was placed using available equipment advancing from one end of the trench to the other end following the removal of shoring in stages. The filter material was placed in the longitudinal trench up to height of the excavated crest, which was 3.5 feet below the original crest height at the location of crack zones. In other areas where the crest had not been removed, the filter material was placed to a depth of 1 foot below the original crest.

- The upper 3.5 feet of the crest was then reconstructed in compacted 6-inch lifts using the embankment soil removed during trench excavation. The embankment material was placed and rolled with a Cat 950 loader and a Motor Grader 140G. The soils were compacted to a minimum of 95 percent of the ASTM D698 maximum dry density, with the moisture content as close as possible to optimum, but within the range of 1 percent above to 3 percent below optimum moisture content. In-situ density tests were performed at every 1-foot depth to verify conformance to the specification for fill compaction.

- A shallow trench was excavated for the entire length of the removed crest area above the central filter drain to expose the filter material. The trench was then backfilled with Filter Material A up to 1 foot below the original crest.

- The three benches above the upstream toe were excavated to provide a relatively smooth 3H:1V base slope on the upstream side starting from 4 feet below the toe to the crest of the dam within each crack zone.

- The entire base of the excavation was covered by 12 inches of Filter Material B, which was placed un-compacted.

- The original embankment soil was then placed on the filter material and compacted (as per specification described in a previous step) in 6-inch lifts to backfill the slope up to the top of the dam. The average thickness of the embankment soil above the filter on the upstream slope was measured to be approximately 4.5 feet. The upper bench was raised at the same time the upper 12 inches of the crest was raised back to its as-built elevations.

- The upper 12 inches of the longitudinal trench was then backfilled with the compacted embankment soil removed during trench excavation.

Soil compaction activities were regularly monitored by Brian Banks, an AMEC field technician. The field density was measured utilizing a nuclear gauge, and compaction specifications were met. The daily field observation reports and results of field density tests are presented in Appendix G, with selected photos of the backfill operation depicted in Figure G-4.

3.10 Laboratory Testing Program

The following subsections are comprised of descriptions of the laboratory tests performed for this work assignment. All laboratory test results are presented in Appendix H and summarized in Table H-1. The following table summarizes the number of each laboratory test performed for the current study.

Test Type	Test Designation	No. of Tests
Consolidation	ASTM D2435	5
Density of Ring Sample with Porosity Clod Density	ASTM D2937 Soil Survey Standard	8 11
Sieve Analysis	ASTM D2487 ASTM C136/C117	28 7
Liquid Limit and Plasticity Index	ASTM D2487 AASHTO T89 & T90	28 3
Moisture Content	ASTM D2216	29
Standard Proctor	ASTMD698A ARIZ 225A	6 3
Pinhole Dispersion Crumb Test	ASTM D647 USBR 5400-89	4 4
Calcium Carbonate	ADOT 732	5
Permeability (Flex Wall – Undisturbed)	ASTM 5084-90	2
Sodium Sulfate Soundness	ASTM C88	1
Unconfined Compressive Strength	ASTM D2166	3
Exchangeable Sodium	ARIZ 729a	1
Soil pH	ARIZ 236	2
Filter Test	Slot Test	2
Magnesium Sulfate Soundness	ASTM C88	1
Sand Equivalent	ASTM D2419	1

3.10.1 Index Properties

The laboratory testing program included index testing (grain-size distribution and Atterberg limits), moisture content, and determinations of moisture-density relationships (standard Proctor) for the embankment and foundation soils, and for the drain material.

3.10.2 Chemical Properties

The existing drain material was analyzed to characterize relevant chemical properties. The laboratory tests included determinations of calcium carbonate content, sodium sulfate soundness, magnesium sulfate soundness, exchangeable sodium and soil pH.

3.10.3 Strength, Consolidation and Density Tests

Densities of representative samples obtained from the test borings were performed to characterize the physical properties of the materials encountered in the dam foundation. One-dimensional consolidation-collapse tests were performed on samples of the foundation soils to measure the degree of collapse on wetting. Clod density tests were performed to approximate the bulk density of selected samples. Three unconfined compression strength tests were performed on the foundation soils.

3.10.4 Permeability Tests

Laboratory scale permeability tests were performed on samples of compacted embankment soils.

3.10.5 Dispersion Tests

Several pinhole and crumb tests were performed to characterize the possible dispersive nature of the embankment soil.

3.10.6 Filter Tests

Two filter tests were performed in accordance with the procedures described by Sherard and others (1984a and 1984b). In one test, the new drain material (Filter Material A) was the selected filter material and the embankment soil was the base material. In the second test, the embankment soil was the base material and the existing drain material was the filter material. The procedure for the filter test is presented in Appendix H. The typical filter test mold dimension and specimen details are presented in Figure H-1, and photographs of the test experiment and the soil specimens after the tests are presented in Figure H-2 in Appendix H.

3.11 Previous Seepage Testing and Dam Breach Modeling

The subsections that follow summarize the procedures and results of previous crack infiltration testing at several of the District's flood retarding structures, and an embankment dam breach model developed for the District. These summaries are provided as additional background to the issue of potential embankment seepage behavior at the subject facility.

3.11.1 Previous Ponding Tests

In 1979, Fugro conducted ponding tests in backhoe pits during crack investigations at Buckeye FRS No.1. During these studies, the flows into embankment cracks were estimated from the filling of 50- to 100-foot long trenches. The trenches were flooded with a 3,800-gallon water truck that had an output capacity of 200 gallons per minute. Of the 110 tests in the Fugro study, 88 measured little or no leakage. Water surfaced on the embankment at 15 of the sites, and in seven tests between Stations 706+00 and 719+00, leakage was so severe that the water level in the trench could not be maintained. The testing induced piping (turbid discharge and crack erosion) at Stations 711+15, 718+60, 767+27 and 579+47.

In 2001, AMEC also conducted several crack infiltration tests in small pits at Buckeye FRS No.1, where water was ponded to a depth of two to three feet in test pits on the upstream slope near the top of the dam (AMEC, 2001). The flood tests resulted in either high seepage through cracks or toe seepage at Stations 624+35, 673+ 50, 710+47 and 721+00. At Station 721+00, the flood testing by AMEC resulted in seepage occurring near the upstream toe of the embankment, which is below the bottom elevation of the drain system.

Twenty-one ponding tests were performed at McMicken Dam by Sergent, Hauskins, and Beckwith (SHB) in 1982 as a part of a dam safety and subsequent restoration study. Seepage through cracks and water seeping out of the upstream and downstream slopes were observed at several locations.

Trench flooding tests were performed at White Tanks FRS No. 3 by Fugro in 1979 using a 3,800-gallon water truck with a pumping capacity of 200 gallons per minute (Fugro, 1979). High seepage (trench could not be filled) was observed at a trench at Station 28+50. The flooding tests resulted in six occurrences of piping (sediment-laden water and exit erosion) created when water from the ponding test flowed out of cracks onto the embankment slope. Holes were found on both the upstream and downstream slopes. Piping through the cracks induced by the flooding tests occurred at Stations 18+78, 28+62, 28+87 and 42+20. Similar ponding tests were performed at White Tanks FRS No.4 by Fugro in 1979. During this water testing, leakage occurred mostly on the upstream embankment slope at 23 locations. Eroded holes conveyed water at Stations 34+60 and 60+00 at a rate greater than the pumping capacity of the supply tanker.

Ponding tests were performed at Powerline FRS by Engineering Testing Laboratories, Inc. (ETL, 1977) and also during a 1986 study by Sanders (1986). Water percolated to both the upstream and downstream slopes at several locations. Rapid water losses were experienced at several locations, including Stations 113+94 to 111+95, 63+30, between 54+90 and 54+40, and between 44+00 and 30+00. Aperture erosion and sediment transport within the cracks were not observed during the test program.

In 1970, SCS performed ponding tests at Vineyard FRS by injecting water into a longitudinal crack on the dam crest at Station 316+27 (SCS, 1970). Another ponding test was completed on a crack at Station 313+20. A 60-foot long longitudinal crack intersected several transverse cracks at this location, and water was pumped into the crack at the mid-point. Water appeared at several locations at the downstream toe. Fugro also conducted flooding tests in 99 trench segments during a crack investigation study in 1979 (Fugro, 1979). There were 210 cracks where water was observed to be flowing into the discontinuities, but only 17 of these displayed a discharge of water to the embankment surface. Water loss from 29 trench segments was so rapid that the trenches could not be filled at injection rates up to 200 gpm.

Additionally, SCS performed a full-scale field ponding test at the Vineyard Road FRS to test the centerline filter system constructed in 1982 (Arrington, 1988 and Leckband, 1983). The study was conducted using four separate test cells (Nos. 1, 2, 3, and 5). Three sides of each cell were constructed, with the dam embankment as the fourth side. The cells were 100 to 200 feet long and about 30 feet wide. The top elevation of each cell dike was at the same elevation as the dam crest. All of the cells were filled by August 5, 1983 and were maintained at full depth until at least September 1, 1983, with Cell 5 operated until October 11, 1983. The most significant finding of the full-scale ponding tests was that the filter system appeared to be effective in preventing water from entering cracks in the downstream shell of the dam. A soil cake appeared to form very rapidly on the upstream side of the filter and prevented appreciable flow into or through the filter. Additionally, it was found that the cracks swelled shut such that even in the test site that had no vertical filter element, no water escaped through open cracks in the dam, even though all the overburden was cleaned from the cracks on the upstream slope in the cell bottom.

Ponding tests in trenches were conducted at the Magma FRS (Fugro, 1979) and at the Florence FRS (SCS, 1977). A centerline trench was divided into 100-foot long segments that were filled with water. Rapid water loss and eroded discontinuities were observed in the Magma FRS embankment between Stations 106+60 and 226+70. Most of the leakage at the Florence FRS appeared on the downstream face of the dam.

3.11.2 Embankment Dam Breach Model

A computer program was developed by Engineering and Hydrosystems (E&H, 2003) to simulate dam breach formation as a function of time and space. The assumed dam breaching process is caused by seepage and subsequent erosion along transverse cracks through the embankment, or along earth fissures through the foundation soils of the dam. Particular emphasis in model development was placed on simulating the time required to breach and the maximum extent of the breach. These two parameters have a significant impact on the rate of water release, and the overall magnitude of downstream inundation.

The maximum extent of a breach and the time to complete the breach are dependent on the magnitude and spatial distribution of the erosive power of water, and on the erosional characteristics of the soil. The magnitude of the erosive power of water is a function of the potential energy of the water contained in the reservoir, and the geometric properties of the subject crack or fissure. The model calculates variations in the erosive power of the water in the discontinuity as a function of time due to changes in the water surface within the reservoir, and as a function of space due to changes in the dimensional characteristics of the breach, particularly it's width and width-depth ratio. Erosion rate not only depends on the magnitude of the erosive power of water, but on the erosive properties of the embankment and foundation soils.

Six breach models were developed (four for a no-drain embankment condition and two for modified or reconstructed embankment conditions with drains) to simulate breach formation resulting from vertically rectangular and square embankment cracks. The analytics then simulated the widening of a breach commencing as a vertical fracture by approximating the rate of erosion as a function of erosive power, and quantifying the resultant widening of the discontinuity. The computer program has been developed and verified by applying the results of erosion tests conducted on embankment soil samples obtained from the Vineyard FRS.

The dam breach model assumes flow and erosion along a single transverse crack. In reality multiple cracks or a network of transverse and longitudinal cracks are observed in most of the embankments investigated. In this recent investigation of Buckeye FRS No.1, a multiple crack network of longitudinal and transverse cracks was found along the excavated section of the embankment near station 721+00. The computer model developed by E&H (2003), though capable of simulating flow and erosion in a single transverse crack, is limited in its ability to simulate the effects of flow through a network of embankment cracks.

3.12 Transient Seepage Analysis

Transient seepage analysis through a dam section representative of Station 721+00 was completed to estimate the distance a wetted front would advance through the dam embankment under maximum impoundment conditions. The embankment was assumed to be a homogeneous porous media with no cracks present. The 2-dimensional finite element computer program SEEP/W (Geoslope International, Inc., 1998) was used. SEEP/W is a finite element program that can be used to model the saturated and unsaturated flow of water within porous materials. Analyses were completed using quadrilateral elements to develop the finite element mesh, and solutions were obtained using four-point integration techniques. A conceptual two-dimensional transient flow model was developed to model the infiltration of water into the embankment under constant head boundary conditions. In reality an unsaturated flow condition is created as the wetted front advances through the embankment. As unsaturated properties of the soil are complex and more difficult to develop, the analysis applied conservative assumptions related to the hydraulic properties of the soil and the boundary conditions of the model.

A conservative unsaturated hydraulic conductivity function was used for the embankment soil. The horizontal saturated hydraulic conductivity (Kx) value for embankment soil was assumed to be 0.3 feet per day (ft/d), which is higher than that obtained through laboratory testing. For the filter material (both central filter drain and upstream sand) Kx = 280 ft/d was assumed. The foundation material was conceptually divided into three layers (upper, middle and lower). The assumed Kx values are: upper = 0.3 ft/d, middle = 2.8 ft/d and lower = 0.03 ft/d. The results of the SEEP/W model are presented in Figure I-1 and are discussed in Section 6.3.

3.13 Static Stability Analysis Under Sudden Draw-Down Condition

Simplified stability analyses of the embankment under sudden draw-down from a maximum pool condition were completed. The analysis was performed using the computer program SLOPE/W (Geo-Slope International, 1998). The comprehensive formulation of SLOPE/W makes it possible to easily analyze both simple and complex slope stability problems using a variety of methods to calculate the factor of safety. The factor of safety (FOS) was computed using Bishop's method, which is conservative in comparison to solutions obtained by applying other limit equilibrium techniques.

A section representative of Station 721+00 was used in the stability analysis. The geotechnical parameters required for the slope stability analysis include unit weights and shear strengths of the materials present in the cross section. Conservative shear strengths were selected based on AMEC's experience with these and similar materials. The input parameters are included in Figure I-2. The results of the SEEP/W model are presented in Figure I-2 and are discussed in Section 6.3.

4.0 GEOLOGICAL SETTING

Buckeye FRS No. 1 is located in the eastern portion of the Lower Hassayampa River Valley, from the southern flank of the White Tank Mountains to the Hassayampa River. Buckeye FRS No. 1 is within the Sonoran region of the Basin and Range Physiographic Province. This region contains many broad, deeply founded, alluvium-filled basins, separated by structural highlands composed of competent bedrock. The White Tank Mountains are one of these uplifted highlands, composed of both metamorphic and granitoid bedrock (Reynolds, and others, 2002). The dam is founded mainly on unconsolidated and semi-consolidated Quaternary-Tertiary alluvial fan deposits composed of outwash from the White Tank Mountains and alluvial terrace deposits related to the Hassayampa River. These materials consist primarily of loose to very dense sand, silty sand, and clayey sand. Many small, southerly-flowing washes are intercepted by the dam. Although faults likely occur at the flanks of the basin, along the mountain fronts, there are no known faults at or near the dam site.

Buckeye FRS No. 1 traverses an extensive, south-sloping alluvial surface between the southern end of the White Tank Mountains and the Hassayampa River, as shown in Figure 1. Under the western two-thirds of the FRS alignment, Cooley (1973) estimates that the weakly indurated basin alluvium is in excess of 1200 feet in thickness. Further east towards the exposures of Precambrian metamorphic and granitic rock at the southern terminus of the White Tank Mountains, Cooley (1973) depicts rapid thinning of the alluvial section, culminating in bedrock exposed at the surface.

Recent geophysical surveys (Sweeney and Hill, 2001), in the form of Bouguer gravity anomaly plots, reveal the presence of a gravity low north of the western half of the FRS alignment, and a gravity high south of the western portion of the structure. These features in the gravity data could represent a region of thicker basin deposits north of the FRS, with a buried bedrock high and shallower alluvium south of the facility.

Anderson and others (1992) predicted that the predevelopment groundwater levels in the vicinity of the subject FRS were about 900 to 950 feet in elevation, about 100 feet below land surface. Schumann and Genualdi (1986) estimated that declines in the groundwater were from 0 to 100 feet in the site area during the period from about 1950 to the early to mid-1980s. Anderson and others (1992) estimate that declines have been less than 50 feet.

Figure 1 shows the surficial geology in the vicinity of Buckeye FRS No. 1. Development of this map was from Demsey (1989), supported in part by the field investigation. Only two units occur in the vicinity of Station 721+00, Holocene alluvial deposits and Latest to Late Pleistocene alluvial deposits (map units Qy and Qm_2, respectively).

Holocene Alluvial Deposits (Qy) – Outside the active braided channels, this unit is locally comprised of a limited thickness of silty to clayey sand and sandy silt, overlain by a thin mantle of aolian silty sand. Stage I carbonate cementation development is common in the lower sands, with the upper loess largely uncemented. Moderate to strong rubification (reddening) is common in this unit. Within the ephemeral channels, the upper aolian deposits are absent, with larger amounts of gravel and small cobbles present.

Latest to Late Pleistocene Alluvial Deposits (Qm_2) – This unit is locally comprised of moderately cemented (Stage II) clayey to silty sands, occasionally interbedded with silty to sandy gravels. These deposits usually display poor soil development and some rubification, with a prismatic to blocky texture.

5.0 GEOTECHNICAL AND EMBANKMENT CHARACTERIZATION

The following discussions present the findings of this appraisal, beginning with a summary of the relevant efforts of previous investigators. This discussion focuses on the three primary geotechnical features of the facility: the properties of the local alluvial soil profile under the dam, the characteristics of the embankment materials, and the distribution and nature of the discontinuities within the structure.

5.1 Review of Previous Studies

5.1.1 Embankment Cracking

A detailed geologic inspection of the downstream face of the excavation was performed during the construction of the central filter drain to ensure that the drain intercepted all cracks. A detailed record of the cracks encountered was compiled, including their type (transverse, longitudinal or oblique), width, length, depth and location (ERTEC, 1981). During construction, some scheduled outlets were relocated, and additional outlets were installed at locations where cracks were found within three feet of the excavation floor (bottom of the drain trench), or where 3/8-inch or wider cracks were encountered deeper than three feet from the top of the structure. These outlet drains were also designed to remove open or deep cracks that would render the central filter drain ineffective against piping. One such outlet drain was constructed at 710+53 near the study area to remove a wide, open crack in the downstream section of the dam. The greatest depth of cracking was 19.0 feet between Stations 710+53.5 and 710+57.5 and there were twenty cracks more than 16.0 feet deep between Stations 687+00 and 718+00. The two most prominent cracks encountered near the study area were at Stations 717+14 and 721+22, having crack depths of 18 feet and 16 feet, respectively.

AMEC reviewed the data presented in the ERTEC (1981) report and presented the information in the form of summary charts (AMEC, 2002). These summary charts contain plots of the average crack width, the average crack length, the maximum crack length, the maximum crack width and the crack intensity (in units of feet per crack) for each 200-foot interval of the structure. The summary chart for the 721+00 study area is presented as Table A-1. The exact location of maximum crack length for a distance of 200 feet is also shown in Figure A-1. The maximum crack width was less than 1.2 inches, except at a few locations, and typically was less than 0.3 inches. The crack intensity (embankment length per crack) typically was less than about 12.5 feet per crack, with several locations at about 4 feet per crack.

AMEC completed a field investigation of selected features and cracks at the Buckeye FRS No. 1 (AMEC, 2001), to assess the cause of the cracking and the adequacy of backfilling the discontinuities with ASTM C-33 sand. The study, which included trench flood testing, indicated that the cracking may extend below the depth of the central filter drain and outlet drains at a few locations, specifically Stations 624+35, 673+50, 710+47 and 721+53 as indicated by cracks found in the upstream slope below the bottom elevation of the central filter drain. The apparent continuity of cracking at these locations resulted in large seepage losses or in seepage emanating from the upstream face of the embankment from water ponded in test pits on the upstream slope near the crest. At Station 721+53, the water testing resulted in seepage occurring near the upstream toe of the embankment, which is below the bottom elevation of the drain system. It was concluded that the seepage could be indicative of cracks extending deeper than 19 feet from the crest of the dam, possibly below the depth of the central filter drain.

Conditions encountered at the present study area near Station 721+00, based on both the AMEC (2001) report and the AMEC (2002) report, are summarized in this paragraph. The cracks encountered in 1980-81 generally were a maximum of 0.45 inches in width, and extended to a maximum depth of 16 feet, or to within 3½ feet of the bottom of the central filter drain. A crack density of about 5 feet/crack was measured. About 12 feet of Holocene soils are present, and the centerline foundation cutoff trench probably fully penetrated these soils. Downstream outlet drains are located at Stations 714+56, 716+48, 717+14 and 720+00; no other outlet drains are located within about 900 feet. In the AMEC (2001) study, high seepage flows into test pits and natural features at Stations 719+42, 721+06 and 721+53 were noted, and seepage emanated from several locations on the upstream face of the embankment between the test pits and the upstream toe.

The summary of the crack investigation and flood tests within the present study area is provided in Table A-1. Results of the crack investigation work performed by ERTEC (1981) and AMEC (2001) are presented in Figure A-2. The field logs for selected test pits near Station 721+00 completed by AMEC (2001) are presented in Appendix A.

The AMEC (2001) study recommended further investigation of the zone of cracking at Station 721+00 to determine if cracks extend vertically to the elevation of the upstream toe or below the central filter drain. The crack investigation completed in 1981 indicated a crack extending from the crest to a depth of 15.9 feet at Station 721+22. This specific location was recommended for further investigation, since during a ponding test, seepage was observed emanating from the toe, which is about 23 feet below the crest of the FRS.

5.1.2 Foundation Conditions

The surface soils along the alignment of the FRS generally are comprised of recent alluvium transported from the White Tank Mountains by south to southwesterly flowing ephemeral streams. The surface soil layer (Holocene deposits) is predominantly silty sand and is probably 0.5 to 13 feet in thickness. In a previous report (SCS, 1971), this layer was described as "very loose at the surface to very dense beneath". The underlying soils were described as "consolidated and semi-consolidated alluvial deposits, including siltstone, caliche, sandstone and sand". The sandstone and siltstone were described as "poorly to moderately cemented". This description conforms to the characteristics that would be expected of Late Pleistocene deposits. Recent alluvium consisting of poorly graded sand, silty sand, sandy silt, silty gravel and gravel was encountered within the floodplains of the three washes intercepted by the western portion of the dam. These are located from about Stations 819+00 to 828+50, 842+50 to 843+50 and 890+25 to 892+75. These deposits typically are 5 to 6 feet thick.

The surface soils from depths of 0.5 to 11 feet were described as having a moderate to high consolidation potential, based in part on their having standard penetration blow counts of less than 30. Consolidation-collapse tests performed on four samples measured collapse potentials of 4 to 14 percent when saturated at a load of 2 tons per square foot. The coefficient of permeability of the silty sand was estimated to be in the range of 0.4 to 22 feet per day.

5.1.3 Embankment Conditions

The embankment soils have previously been characterized based on laboratory testing completed at the time Buckeye FRS No. 1 was constructed, when the central filter drain was installed (ERTEC, 1981) and as part of the AMEC (2001) investigation. There are, however, limitations to these data sets. Original construction data are available only for the area between about Stations 756+00 and 930+00. The ERTEC (1981) data is limited to the length of the central filter drain (Stations 565+00 to 801+00), and only the moisture content and Atterberg limits for the embankment materials in this area were reported. The AMEC (2001) study included only a minimum amount of laboratory testing, and did not include density testing of the embankment materials. The test pits excavated for the study were located between Stations 577+36 and 724+22.

Based on the available data, the embankment is fairly uniform and consists primarily of low to medium plasticity clayey sand, with some zones of nonplastic to low plasticity silty sand. Both the AMEC (2001) and ERTEC (1981) studies indicate the predominance of clayey sand, based on laboratory testing. However, the ERTEC (1981) field logs indicate a larger percentage of the soils to be silty sand or silty and clayey sand mixtures. The pre-construction geologic investigation (SCS, 1971) indicates a predominance of native silty sand, which was then used to construct the embankment.

Plasticity index values for fine-grained embankment soils determined by the AMEC (2001) investigation varied from about 5 to 24. In comparison, testing of samples collected when the central filter drain was installed in 1980-81 determined plasticity index values varying from about 2 to 23. The AMEC (2001) data indicate generally lower liquid limit values than the ERTEC (1981) data.

Most placement moisture contents in 1973 were in the range of 7 to 17 percent. In comparison, a majority of the moisture contents determined at the time the central filter drain was installed in 1980-81 were in the range of about 3 to 12 percent, and the distribution generally shows the moisture content increasing with depth. Moisture content data for the AMEC (2001) investigation were in the range of 2 to 7 percent.

At the time of placement, the degree of saturation of the embankment soils generally varied from about 45 to 95 percent. Similar to the placement moisture content data, there is a large amount of scatter, and there is no apparent trend with elevation. Testing necessary to determine degree of saturation was not performed during the ERTEC (1981) and AMEC (2001) investigations.

Dry density values varied from about 105 to 126 pcf. The higher values correspond to low plasticity, well-graded silty and clayey sands, and the lower values correspond to nonplastic to low plasticity sand-silt mixtures. Maximum dry density (ASTM D 698) ranges of 116.5 to 119.3 pcf and 122.9 to 124.9 pcf were the most frequently used, and were evenly distributed throughout the embankment, except between about Stations 860+00 and 885+00. With very few exceptions, the assumed construction specification was met, and the mean relative compaction was 97.9 percent.

5.2 Local Dam Foundation Soil Profile

Holocene alluvial deposits (map unit Qy) are the only unit found exposed in the immediate vicinity of Station 721+00. These deposits are predominantly fine-grained and range from silty or clayey sand to sandy silt or silty clay. The depths of these deposits are typically 5 feet or less. Deposits are uncemented at the surface but may develop weak cementation (Stage I to I+) below 1 foot. These deposits are generally soft to firm with N values that are typically less than 30, and often less than 15, and with low to medium plasticity. These deposits have moisture contents that are typically less than 7 percent. The dry densities of six samples in this unit varied from 117 pounds per cubic foot (pcf), and one unconfined compressive strength test yielded a result of 9 pounds per square inch (psi) for a sample at a depth of 5 feet in Boring B-4. Consolidation/collapse tests were performed on samples from Borings B-4 at 2.5 to 3.5 feet, B-5 at 4.5 to 5.5 feet, and B-8 at 4.5 to 5.5 feet. These tests determined consolidation on inundation of 3, 7, and 10.5 percent, respectively, with corresponding dry densities of 95.5, 94.4, and 91.8 pcf, respectively. One clod test was performed in this unit and yielded a bulk density of 117 pcf. Compression wave velocities in the surficial Holocene deposits range from about 600 to 1,300 feet per second (f/s). Shear wave velocities in the Holocene deposits are generally less than about 600 f/s.

Pleistocene deposits underlie the Holocene sediments throughout the study area. Generally, Pleistocene deposits begin at 3 to 6 feet below ground surface. These deposits generally consist of silty or clayey sand with occasional lenses of sand and sandy silt and clay to a depth of about 25 feet. Below 25 feet the deposits generally consist of clayey sand. These deposits are generally weakly to moderately cemented (Stage II to II+) to a depth of about 25 feet and moderately cemented (Stage II+ to III) below. These soils typically are very firm to hard with N values greater than 30 and typically over 50 below 25 feet. The moisture content of these soils is generally low, being 2 to 6 percent. In Boring B-1, the moisture content below 25 feet is significantly higher than elsewhere on the site, with values of 10 to 11 percent. Five calcium carbonate tests were performed at depths ranging from 8 to 35 feet and values ranged from 2 percent (at 30 feet) to 12 percent (at 8 feet), with calcium carbonate content generally decreasing with depth. Seven dry density tests were performed within this unit and values ranged from 96 to 113 pcf. Ten clod tests were performed in this unit and yielded bulk densities that range from 106 to 119 pcf. Two consolidation tests were performed on samples from this unit in Boring B-6 at depths of 9.5 to 10.5 and 14.5 to 15.5 feet. The resulting volume change on inundation was 0 and 3 percent, respectively, with corresponding dry densities of 98.6 and 95.6 pcf, respectively. Two unconfined compressive strength tests yielded results of 8 psi for a sample from 10 feet in Boring B-4 and 35 psi for a sample from 15 feet in Boring B-4. Compression wave velocities of the Pleistocene deposits range from about 800 to 1,200 f/s to depths of about 10 to 20 feet, and increase to about 2,300 to 4,100 f/s below depths of about 10 to 20 feet. Shear wave velocities of the Pleistocene deposits at depths less than 10 to 20 feet generally range from about 800 to 1,200 f/s, and at depths greater than 10 to 20 feet increase to about 1,700 to 2,700 f/s.

5.3 Embankment Soils

The embankment soils within the Station 721+00 study area are predominantly silty and clayey sands with some sandy clays. The embankment soils are light brown, weakly to moderately cemented, and low to medium in plasticity. The plasticity index of the soils varied from 2 to 28 and the percentage of fines (minus no. 200 sieve) varied from 18 to 46 percent. The soils in areas of significant cracking were comparatively soft, likely as a result of water infiltration. The majority of the cracks were filled with embankment soils or drain material. The crack infilling typically was sand with some finer-grained soils.

The permeability of the embankment soil was found to be very low. The laboratory permeability value ranged between 8.8e-5 ft/d (3e-8 cm/sec) to 1.0e-4 ft/d (3.5e-8 cm/sec).

The embankment soils may be classified as nondispersive. Four pinhole tests were performed and all tests identified the soils as nondispersive. Four crumb tests were performed. Two tests showed that the soils are nondispersive while other two tests grouped the soils in an intermediate category (slightly dispersive).

5.4 Central Filter Drain Material

The existing drain material consists of fine- to coarse-grained sand with some gravel. The particle-size distribution derived from testing during this study was similar to the previous test results (AMEC, 2001). The grain-size distribution for the previous analysis is presented in Figure A-3. Comparing to the original grain-size (as-built) distribution, it appears the drain material has not changed. The moisture content varies from 3.3 to 7.8 percent. The maximum dry density varies from 112.0 pcf to 124 pcf. The amount of exchangeable sodium was very low, and the soundness results were excellent. Additional characteristics of the existing central filter drain are discussed in detail in Section 6.2.

5.5 Embankment Discontinuities

As documented in 1980 during the construction of the central filter drain, further characterized by AMEC in 2001 (AMEC, 2001), and observed during this investigation, multiple, vertical transverse cracks are present in the Buckeye FRS No. 1 embankment between Stations 720+80 and 721+60. Due to adjustments in dam stationing, it is likely that the crack identified during drain construction at Station 721+23, extending previously to a depth of 16 feet, is the same discontinuity observed during this appraisal at Station 721+09. As with all the transverse cracks observed, describing this fracture as a single crack is for convenience only, in that the embankment distress is actually expressed as a complex of smaller discontinuities, occurring in discrete zones. In the case of the subject study area, three zones are present, spaced about 20 to 40 feet apart from east to west between Stations 720+80 and 721+60.

Several of the cracks, including the Station 721+09 feature in Zone 2, do persist vertically throughout the embankment for the full depth of the central filter drain, and beyond. In the case of the principal Station 721+09 crack, the crack has apparently deepened from the depth of 16 feet recorded in 1980 to a depth in excess of 20 feet, as observed during this investigation where it was found crossing under the central filter drain.

The primary discontinuity in Zone 3 was first identified during investigations by AMEC in 2001 (AMEC, 2001). As further characterized during this study, the Zone 3 complex of embankment cracks extend deep into the embankment, with the principal discontinuity crossing under the central filter drain and into the downstream shell. Towards the crest, the zone appears to be more diffuse, with several of the more prominent discontinuities being discordant to the predominantly transverse orientation of the crack complex as observed mid-slope in the upstream dam shell. Evidence of the compacted backfill of Test Pit TP-29 excavated by AMEC previously was exposed in the upstream slope. Cracking did not extend across the backfill, but some deflation and movement of backfill into the crack was noted.

The Zone 1 cracking apparently was not present at the time the central filter drain was constructed. An indication of the presence of embankment fractures in this zone was derived from an initial interpretation of seismic refraction data, on profiles completed on the downstream side of the dam crest, and mid-slope on the downstream side of the structure. As is the case in all zones, distress was observed on both walls of the excavated central filter drain to depth at and below the bottom of the central filter drain. The discovery of Zone 1 is an expression of this persistence, with the zone first detected downstream using seismic methods, followed by full disclosure within the upstream shell, and discontinuities observed on both walls of the longitudinal trench deep within the embankment.

The near-surface expression of the cracks observed in all three zones in the excavations of the upstream slope of the embankment is typified by a relatively prominent, dominant discontinuity, flanked by subordinate, smaller fractures. In several cases, the principal feature is segmented, consisting of an en echelon array of cracks. The segmented appearance of the cracking appears to be more prevalent in a lateral direction, down the upstream slope of the structure, in contrast to the more persistent conditions of the discontinuities observed vertically in the deep longitudinal trench. It appears that the arrays of principal discontinuities within all zones are not purely transverse, with a slight expression of stepping westward (up-station) as the fracture array is expressed down-slope towards the upstream toe of the embankment, or towards the retention basin.

It appears that uneroded crack apertures generally decrease with depth in all zones, but there appear to be some exceptions to this trend. At several locations in the walls of the excavated central filter drain, crack aperture decreases with depth in a particular fracture. That discontinuity then terminates, and another adjacent crack has slightly greater aperture. Then another transition to closure with depth occurs in this companion feature. This condition may be an expression of the degree to which one particular crack displays the total crack displacement within each distressed zone. It appears correct to assume that transverse crack aperture decreases with depth, with no apparent vertical displacement, just tensional response.

Both erosional widening of open crack aperture and infilling with primarily sandy soil were observed in some cracks in all three zones. In the upstream slope excavations, infilling of the embankment cracks was most pervasive in the lower half of the embankment section. These observations are of the soil profile of the outermost shell of embankment section, and may not be an expression of what lies deeper in the embankment. Erosional features associated with the transverse cracking within the longitudinal excavation deep in the embankment were not observed below a depth of 17 feet below the crest. Only the transverse crack at Zone 2 contained observable erosional features to this depth. All other observable erosional features associated with the transverse cracking were observed within the approximate upper 5 feet of embankment. Of the eroded cracks observed near the central filter drain, a maximum aperture of 1.5 inches was measured.

It is likely that the source of water responsible for erosion of the deeper Zone 2 transverse crack was from direct precipitation onto the slopes and crest of the dam. The location of the deepest crack erosion is well above the elevation of limited, past upstream retention of flood waters. The fate of the water migrating through the crack complex, and in particular, the deeper eroded transverse crack in Zone 2 is not known. It is possible that the water that eroded the deeper crack exited the dam along the slopes, if the crack was persistent at that time, or connected to other discontinuities. The influence of sediment transport and infilling during the process of crack erosion could cause plugging of small apertures at depth and cause a redirection of flow laterally, but this possibility is purely speculative regarding the true mechanics of this complex process.

Trenches were placed at the upstream embankment toe at the lower terminus of each excavated zone. In all cases, no cracks were observed migrating into the underlying foundation soils. At the embankment/foundation interface, no measurable aperture was observed, only hairline features.

Excavations near the crest of the dam at the intersection of the transverse zones with the existing central filter drain provided an opportunity to observe the interrelationship between the embankment cracks and the central filter drain. No indications of any discontinuities projecting from the upstream earthen shell into the central filter drain aggregate were observed. In addition, no migrations of fine sediment from the cracks into the drain were noted. During the early stage of removing the drain material longitudinally along the dam crest, an additional opportunity arose to observe the drain/shell interface within Zone 3 at a depth of about 7.5 feet. Essentially the same conditions to those noted above were observed.

A new discovery regarding embankment discontinuities was made in the bottom of the deep longitudinal trench, in the compacted embankment soils below the central filter drain. A persistent, open, longitudinal fracture was observed beneath the drain section, projecting vertically, and likely originating in the proximity of the lower, upstream corner of the drain. Unlike the transverse features, this longitudinal crack did not appear to be flanked by subordinate fractures, and the aperture was consistently open, averaging about 0.25 inches. The feature, however, is segmented, with the aperture stepping en echelon in a narrow zone less than 1 foot wide. The open fracture was probed to a maximum depth of 3.8 feet. No large-scale shearing or vertical displacement was observed, but the raggedy, stepped habit of the feature implies slight shear in a left-lateral sense. Very slight vertical offset may have been present near the west end of the exploratory trench, with the upstream or northern side down. Although concealed in some segments due to machine effects in the trench bottom, the longitudinal crack array was present throughout the entire length of the trench bottom, a distance of about 90 feet. However, the crack was more prominent in the western half of the trench bottom.

Within all three transverse zones, the longitudinal crack below the drain intercepted transverse discontinuities, with these intercepts observable in the bottom of the exploratory trench. In most cases observed, the transverse cracks were largely hairline features but with some measurable aperture to 0.05 inches where the longitudinal crack crossed. No indications of erosion were noted in association with the longitudinal feature, with the crack exhibiting a fresh appearance with no infilling. No central filter drain aggregate was found in the longitudinal discontinuity.

None of the transverse cracks observed in this investigation penetrated into the dam foundation material at the upstream toe of the embankment. Additionally, no seismic anomalies were detected at either toe, supporting the above observation.

6.0 DISCUSSIONS AND RECOMMENDATIONS

6.1 Probable Cause of Embankment Cracking

The discontinuities within the Buckeye FRS No. 1 embankment in the Station 721+00 study area possess characteristics that would result from deformation of the structure due to differential settlement within the dam foundation. Conditions amenable to the occurrence of differential consolidation within the shallow soil profile are present. The first of these favorable conditions is the natural lateral and vertical heterogeneity of the underlying alluvial deposits, resulting in an equally variable potential for settlement. On the basis of the limited collapse testing performed during this investigation, the apparent magnitude of the collapse potential of the shallow profile is pronounced (measured at 0 to 10.5 percent). It is likely that limited foundation preparation of the original dam footprint, combined with the inherent geotechnical properties of foundation soils, creates a setting in which pronounced settlement of the earthen embankment has occurred. Although considered to be a secondary mechanism associated with embankment cracking, it is likely that any shrinkage of the embankment would occur along discontinuities originally formed due to settlement.

A likely prerequisite to the occurrence of substantial consolidation of the cemented soil profile under the dam is the introduction of water. The investigation of the local geotechnical profile revealed a slight increase in the ambient moisture content of soils at depth within Boring B-1, located upstream and on the northwestern corner of the study area. A slight topographic low occurs in this area, possibly associated with an original drainage swale now intercepted by the dam embankment. It is possible that runoff has historically ponded against the embankment in this locale, and within many low swales of a similar nature along the upstream toe of the structure. Variable soil moisture conditions, and hence, consolidation responses could have resulted.

As depicted in photographs acquired by the District in February 2003 (Appendix J), water within the temporary retention basin has reached the embankment toe in the past. This retention provided not only water for shallow retention in the low swales discussed above, but for wetting the shallow soil profile adjacent to and under the dam along large reaches of the structure.

The geometry of the network of embankment cracks, and the probable sense of movement of those displacements lend credence to the concept of differential foundation settlement. Both the transverse cracks and the deep longitudinal crack appear to have slight shearing components, and there may be a minor amount of vertical displacement in the western segment of the longitudinal discontinuity. The shear appears to be left-lateral in the longitudinal zones, and right-lateral in the transverse zones. It is plausible that greater settlement towards the northwest corner of the study area would result in an expression of displacements of a similar nature. In order for the largely tensional parting of the longitudinal crack to occur without significant vertical displacement, tipping or north-south bending of the structure is needed. With the deeper embankment cross section in its center due to the cutoff, greater settlement may have occurred in those areas susceptible to moisture increases and containing a thicker, shallower, possibly softer soil profile under the upstream toe of the structure. With greater collapse there, tipping of the structure toward the basin would result, with a focus of the ensuing strain concentrating at the bottom of the cohesionless central filter drain profile.

The likelihood of the probable settlement behavior discussed above is also supported by the geometry of the original dam foundation preparation, with a deeper central cutoff, flanked by regions towards the dam toes where a greater thickness of more collapse-susceptible, shallow soils were likely left in place in the dam foundation footprint. Upon consolidation, these flanking soil conditions would account for the embankment stress necessary to form a longitudinal crack at centerline, with the location of the ensuing discontinuity dictated by the presence of the cohensionless, central filter drain.

In the process of assimilating the available data to render an opinion regarding the causal mechanisms of embankment distress, several select observations surface repeatedly as having significance in supporting a crack genesis related to foundation settlement. The first of these observations is the gross pattern of transverse cracking. The grouping of the discontinuities into zones spaced at roughly equi-dimensional intervals may be an indication that the causal mechanisms are exterior to the structure. It also appears that both the depth of the principal discontinuity in Zone 2 has increased since the early 1980's, and new zones of cracking have developed since the early 1980's. Both of these observations are compatible with a theory of ongoing foundation settlement as the primary mechanism responsible for the cracked embankment. The third and last observation of some significance is the vertical termination of the transverse cracks at the interface between the embankment materials and the foundation soils at the upstream toe of the structure. This condition would be expected, given the likelihood that the embankment cracks are caused by settlement of the underlying mass.

6.2 Performance of Existing Central Filter Drain

The filtering characteristics of the central filter drain material against the base embankment soil are discussed in this section. Laboratory filter tests were conducted to test the filter materials. Other analytical methods are discussed that compare the gradation of filter material with that of the base embankment soil. Field observations regarding the condition of the central filter drain at crack locations in the upstream embankment shell near the dam crest are also discussed.

6.2.1 Filter Test

AMEC performed two filter tests to evaluate whether the central filter drain materials are adequate in providing filter protection to the embankment soil. The existing drain material and the new filter material (Filter Material A) recently used as central filter drain backfill at Station 721+00 were tested. The filter test procedures and results are presented in Appendix G, and summarized below.

- **Filter Test 1**. The new filter material (Filter Material A) was tested. The filter test was performed under an average water pressure of 50 psi. Cloudy water was observed exiting the sample within the first 30 seconds of the test. The water became slightly cloudy after 4 minutes and eventually became clear after 7 minutes. Initially the flow rate was 5.8 ml/sec, and the flow rate then reduced within 10 minutes and the water became clear. The flow was constant after 10 minutes at a rate of 4 ml/s. The slot area was slightly larger after the test sequence. Initially the slot size was 0.06 inch, with the final slot size at approximately 0.2 inch. The end of the slot exhibited no severe erosion, and the opening was not filled with any material. Very little loss of fine soils was observed.

- **Filter Test 2.** The existing drain material (Filter Material B) was tested. The filter test was performed under an average water pressure of 54 psi. Cloudy water was observed exiting the sample for the first 30 seconds of the test. The water became slightly cloudy after 3 minutes and eventually became clear after 5 minutes. Initially the flow rate was 7.2 ml/sec, but the flow rate reduced within 10 minutes and the water became clear. The flow was constant after 10 minutes at 3.5 ml/s. The slot area was slightly larger at the inlet end and was nearly closed at the outlet end after the test. Very little loss of fine soils was observed.

For tests with successful filters, the flow rate decreases and water becomes progressively clear with time. During both filter tests the water became clear with a reduced flow rate. Hence, the tests were successful and it is unlikely that the embankment soil will pass through either the existing or new drain material.

6.2.2 Internal Stability

In past years, researchers have attempted to formulate a theoretical basis for the methods used to select filter gradations within dams. Kenney and others (1985) discussed the concept of the controlling constriction size. The controlling constriction size (D_c) is defined as the maximum possible size of the particle that can be transported through a filter of specific thickness. The thickness of the filter is not a significant factor because the practical width of filters far exceeds the thickness required for filtering action. Analytical and experimental research indicates that the controlling constriction size is related to the fine fraction of the filter ($Dc \le 0.2\ D_{15}$).

Kenney and Lau (1985) investigated the internal stability of granular materials. Their research showed that, when samples with several grain-size distributions were subjected to through flow, some grain-size distributions experienced loss of fine particles and could be considered unstable. Other size distributions did not experience such loss of fine material. They defined a boundary between stable and unstable behavior and proposed the use of this method to evaluate the internal stability of a given material. The boundary is defined by:

$$H = F$$

where,

H = percent of mass between two grain sizes: d and 4d
F = percent of mass finer

As very little loss of fines was observed during the filter tests performed for this study, an evaluation of the internal stability is not needed.

6.2.3 Criteria for No-Erosion Boundary

Foster and Fell (2001) present a method for assessing the particle size distribution of filters in a dam as compared to the soil that the filter is protecting. The approach was designed to determine whether the filters are sufficiently fine to result in no excessive and continuing erosion. Their method is based on the analysis of the results of laboratory tests and characteristics of dams that have experienced piping incidents. Their study recommended the establishment of a no-erosion boundary based on the statistical analysis of experimental data. The embankment soils near Station 721+00 (base soils) were compared with the existing filter drain materials. The base soils can be grouped into two categories (Group 2A – fines between 35 to 85 percent and Group 4A – fines between 15 to 35 percent). The existing filter drain and new filter material were compared to these soil groups. The filter requirement (DF_{15}) satisfies the proposed criteria for a no-erosion boundary for both soil groups. This derivation is compatible with the filter test results, where very little soil erosion was observed.

6.2.4 NRCS Filter Criteria

The suitable NRCS (1994) design of a filter for the representative base embankment soil near Station 721+00 has been discussed in Section 3.9, and is graphically presented in Figure G-2. The result of the filter analysis was presented in an earlier report (AMEC, 2001). The filter analysis was employed to develop the design of new filter material (Filter Material A) that meets the NRCS filter criteria. This material was used as backfill for the central filter drain near Station 721+00. In addition, the existing drain material satisfies both filter and permeability criteria, but the drain material is more broadly graded than the design filter based on NRCS criteria (Figure A-3).

6.2.5 Field Observations

Careful excavations were made at the interface of the embankment soil with the central filter drain at crack locations near the crest of the dam and to a depth of about 5 feet. These careful excavations were made to determine if the cracks propagated into or through the drain. There was no evidence of cracking in the central filter drain. The filter material appeared to be completely free flowing with no binder or cementation of any kind. There were no signs of weathering or alteration of the drain materials. The filter was found to be moist. The filter material and it's gradation appear to be unchanged since construction.

6.2.6 Selection of Filter Material

Two different filter materials (Filter Materials A and B) were utilized during the partial reconstruction of the embankment. The Filter Material A is coarser than Filter Material B. Filter Material A was used to reconstruct the central filter drain, which acts as an intercept for the observed transverse cracks within the embankment soils. The function of Filter Material A is to intercept and subsequently seal the crack by filtering transported fine sediments at the interface of filter and embankment material, while draining the excess water. The filter was installed dry and uncompacted to minimize any potential for crack propagation through the drain, and to limit particle-size segregation during placement.

Somewhat In contrast to the utility of the central filter drain discussed above is the function of the filter blanket placed on the upstream slope. This blanket serves as a filter over the transverse cracks with no need for drainage. Filter Material B was installed to optimize the filtering properties of the blanket, and the material was placed wet to enhance density and improve stability.

The selection and subsequent installation of the filter material on the upstream slope were an integral part of the overall rehabilitation of the partially excavated embankment. The previously benched areas on the upstream slope were first excavated to a smooth base to a depth of approximately 5.5 feet. A one-foot thick layer of Filter Material B was then placed in a moist and uncompacted condition. Embankment soils were then compacted on the top of the filter to reconstruct the upstream slope to its original geometry.

The defensive strategy for the upstream component of the interim safety improvement can be described as follows:

- The principal intent was to backfill the three upstream transverse crack investigation locations utilizing methods that restored the original as-built geometry to a "better" condition than previously existed prior to the investigation trenching.

- The upper segment of all transverse cracks at the upstream slope were removed by excavating to a depth of about 5.5 feet, thereby removing the connectivity of any remaining transverse cracks below 5.5 feet with the surface of the upstream slope

- The base of the excavated portion of upstream slope was backfilled with a layer of filter sand because it's not cohesive and it is unlikely that a crack could maintain aperture through the sand.

- The filter sand would limit the transport of water through the blanket, likely to a magnitude that would moderate erosive exit velocities and stream power, thereby limiting piping into the crack, and to some extent sealing the opening. This design approach does not consider crack size.

- The compacted soil cover placed above the sand will limit flow into the sand and provide a layer of soil devoid of cracks for the interim time period. It has been demonstrated through a conservative transient seepage analysis (Section 6.3.1) that significant flow into the sand layer is unlikely unless a new crack formed in the reconstructed upper soil layer of upstream slope.

As an interim measure, the approach is deemed adequate, in that it is reasonable to assume that new crack formation or any appreciable widening of the now buried discontinuities is unlikely over the term of the interim measure and that the upstream embankment has been restored to a "better" condition than existed prior to the investigation activities.

6.3 Results of Seepage and Stability Analyses

6.3.1 Transient Seepage Analysis

A transient seepage analysis of the section representing maximum height near Station 721+00 was performed using the computer code SEEP/W. This section represents the profile of the embankment that is consistent with the interim repair completed during this work assignment. The analyzed flow section is based on the typical section presented in Figure G-1 that represents the as-built of embankment repair.

The analyses were extended to 30 days, with the location of the wetted front plotted for 1, 3, 5, 8,10, 20 and 30 days to estimate trends. In comparison, the time to drain the reservoir impounded by Buckeye FRS No. 1 through its primary and emergency spillways is estimated to be 10 days. The analyses assume the full impoundment level throughout the 30 days, with no gradual lowering of the level. The migration of the wetted front is shown in Figure I-1 in Appendix-I.

The analyses generally indicate that a wetted front will not advance to the downstream toe of the embankment during the estimated 10-day impoundment period, even for the conservative hydraulic conductivity values (higher than laboratory value) assumed for the materials comprising the embankment soils. The analyses do not explicitly include the impact of cracking of the embankment soils, since the two-dimensional plane strain finite element model cannot incorporate such features. The analysis represents a possible scenario in the section of dam that is devoid of any cracks.

6.3.2 Static Stability Analysis

The result of the stability analysis for a typical cross section (25 feet high) is shown on the Figure I-2 in Appendix-I. The stability analysis was performed for a slope condition under sudden draw-down from a maximum pool elevation. The transient seepage analysis predicted that the wetted front moves only to a few feet even after 30 days under maximum pool conditions. The stability analysis conservatively assumed a saturated condition for the whole dam section under maximum pool conditions.

The minimum factor of safety for the most critical failure surface was determined for static conditions using the program's search features. The minimum factor of safety for the embankment slope was found to be 1.47, which is higher than the value of 1.3 considered adequate for the embankment fill slope under sudden draw-down conditions. The slope appears to be stable under a sudden draw-down condition considering the conservative assumptions used in the stability analysis.

6.4 Condition of Pipes

The video tape of the two 12-inch diameter reinforced concrete pipe irrigation outlets located at stations 710+00 and 817+00 provided by the District was reviewed. The video inspections of pipes at both stations were performed on April 15, 2003 by Mr. J. Setelin from ProPipe Services. All pipe joints were closely examined to determine possible separations, deformation or any other abnormalities.

- **Station 710+00**. The total length of pipe photographed was 155 feet and the starting access point was at 4 feet. The pipe joints were at 10.8', 17.8', 22.8', 34.6', 46.8', 59.0', 70.7', 82.7', 94.5', 105.3', 117.3', 129.4', 141.4' and 151.6'. The pipe joints were intact to slightly deformed and separated (elongated, but well within the allowable joint extension). The pipe joint conditions were relatively good at locations 117.3', 129.4' and 151.6'. At some locations, a few minor, insignificant cracks were observed at the joints. Small black spots (possibly minor holes or debris) or cracks were observed on the pipe wall at locations 5.1', 44.4' and 151.6'. At places some objects hanging from the wall along with spider webs were found. The pipe was dry except between locations from 117.3' to 141.0' where water inside the pipe was observed.

- **Station 817+00**. The total length of pipe photographed was 170 feet and the starting access point was at 4 feet. The pipe joints were at 11.6', 23.2', 35.0', 47.0', 59.0', 71.1', 83.3', 94.9', 107.1', 105.3', 119.4', 131.4', 143.9', 155.4', and 166.6'. The pipe joints were slightly deformed and separated. The pipe joint was relatively more deformed at location 131.4'. At some locations a few minor cracks were observed at the joints. A big crack was observed on the pipe wall at location 166.6'. At places some objects hanging from the wall along with spider webs were found. Numerous spider webs were observed between locations 155.5' and 160.0'. An uprooted tree trunk was observed near pipe joint location 143.9'. No water was observed inside the pipe at any location.

On the basis of the video tape inspection, both pipes appear to be in an acceptable condition, constituting no apparent threat to the integrity of the embankment. The uprooted tree trunk within the outlet pipe at Station 817+00 does not appear to pose any risk to the structure.

6.5 Critique of Investigative Approach

The following discussions focus on the adequacy and effectiveness of the methods employed during this study to explore and characterize the physical attributes of the geotechnical foundation profile, dam materials and embankment discontinuities of the Station 721+00 study area. This discussion is provided to facilitate improvements and subsequently guide the planning of future geotechnical investigations of Buckeye FRS No.1 and similar district facilities designed to quantify the magnitude and nature of cracking, and the cause(s) of that cracking.

6.5.1 Exploration of Foundation Conditions

The exploration drilling undertaken in this investigation proved to be sufficient to obtain necessary data regarding the geotechnical profile. The utilization of CME continuous sampling techniques, however, is less clear. Recovery of CME samples generally ranged from 50 to 70% and full recovery was never achieved. The resulting samples were somewhat disturbed. CME sampling techniques appear to be more successful in moist environments with higher clay content. Soil coring techniques would likely yield greater recovery with less disturbance. However, water is introduced during soil coring and measuring accurate moisture content is not possible, and blow counts may be less representative.

The rather high density of the borings in this investigation was necessary to observe subtle, lateral differences in the geotechnical conditions over a relatively small distance. The depth of the investigation also appears to have been appropriate. All borings penetrated over 10 feet of more competent, hard soils before being terminated.

6.5.2 Crack Detection Utilizing Seismic Refraction Method

Seismic signal traces indicating the presence of significant discontinuities are presented in Appendix C. Arrival time trends were examined for sudden delays in arrival time that indicated an abrupt increase in travel distance for the first arrival signal. Such a condition was consistent with an organized fracture or crack in the embankment, requiring the signal to travel below or around before arriving at the next geophone. Gains for the signal traces were adjusted in the field to create traces of a relatively uniform height. Relative signal amplitudes, measured in decibels, could then be compared. At geophones more than 20 to 30 feet from the energy source, a sudden increase in decibel gain was consistent with a loss of signal energy across a soil or embankment discontinuity. The lateral location of an organized discontinuity along a seismic line was determined by comparing the locations of either arrival time and/or sudden attenuation in the forward (foreshot or fs, forward quartershot or fms, midshot or ms) and reverse (midshot, reverse quartershot or bms, backshot or bs) directions of the data traces. An anomaly location was interpreted to be between the forward and reverse indications in the trace data.

Lines 1, 2, 7 and 8 were completed adjacent to the FRS embankment upstream and downstream toes on native ground where no soil discontinuities were identified. Beyond 20 to 30 feet from the energy source, the refracted seismic energy had passed through the underlying soils where an earth fissure would be present. Trace first arrival times followed a consistent trend. Once gains were set and signal trace heights were similar, decibel gain increases were moderate at increasing distances. Moderate gain increases, or attenuation, were typically less than 12 decibels (dB) between geophone spacings. Each change in gain of 6 dB indicated a change by a factor of two. A gain increase of 12 dB indicated signal attenuation by a factor of four. A gain increase of 12 dB or more between geophones far from the energy source was normally a strong indicator of a crack-type soil discontinuity. Alternatively, a significant increase in signal noise prior to the first arrival could be a strong indicator of a crack-type discontinuity.

Lines 3, 4, 5 and 6 were completed on the FRS. First arrival time delays and/or significant loss of signal quality were apparent in many of the traces for these lines. The presence of these seismic anomalies indicated the existence and at least some locations of transverse cracking in the embankment. For example, at the Line 3 reverse quartershot traces (bms), typical time arrival differences between each geophone at geophones 9 to 3 and geophones 2 to 1 were 3 to 5 milliseconds. Between geophones 3 and 2, however, the arrival time difference was about 18 milliseconds. At Line 5 between geophones 6 and 7, the signal quality degraded significantly at both the reverse quartershot and backshot traces (bms and bs). Similarly, at Line 6, a significant arrival time delay and signal attenuation was indicated at geophone 4 in the midshot, reverse quartershot and backshot traces (ms, bms and bs), while an arrival time delay was indicated between geophones 7 and 8 in the forward quartershot (fms).

Based on the preliminary results of this brief application of the seismic refraction technique to the problem of detecting embankment discontinuities, the technique holds great promise. More testing will be required to prove its continuing reliability.

6.5.3 Upstream Slope Excavations

It is clear from this investigation that it is necessary to remove at least the upper 8 inches of the embankment to properly observe embankment discontinuities. Due to the necessity of removal of at least 8 inches, identification of key zones is important to focus the removal process. Detailed review of both previous investigations and seismic surveys can aid in the identification of key zones. Compressed air has proved to be a valuable tool in the efficient cleaning of the slope for crack mapping and observations, and should be utilized.

Notching does not appear to be necessary in the excavation procedure, but it was adequate for the goals of the project. Cracking is often more evident in plan view and easier to observe. It would be sufficient to slot 'trench' in crack zones to observe cracks at the desired depths.

An additional method of mapping cracks and identifying key zones for surficial removal is the lowering and cleaning of the crest. This allows for the observation of the interaction of the transverse cracks and the central filter drain, and allows for increased reach of excavation equipment if the removal of the central filter drain is desired. Notching down the crest in a careful manner proved to be valuable for observing the cracks interaction with the central filter drain and could be incorporated into the lowering of the crest.

6.5.4 Removal of Central Filter Drain

The deep longitudinal trench and removal of the central filter drain proved to be the most enlightening and valuable exercise in this investigation, highlighted by the discovery of the longitudinal crack at the bottom of the drain. Investigating the depth of this longitudinal crack could prove to be somewhat difficult. The equipment used in the investigation was at its maximum reach, so greater excavation depths would require greater removal of more than 4 feet of the crest. Larger equipment could yield a greater reach, but the increased weight may cause instability of the embankment.

The construction of a ramp for equipment access on the upstream embankment proved to be of great value for site access. Likewise, spoiling material on the downstream slope worked well and allowed for the creation of a ramp that expedited the backfill process.

The safety shoring design and installation worked well. The use of a knowledgeable subcontractor for the installation of the shoring increased the efficiency of the work activities. The stability of the trench was never in question and OSHA requirements were met. The cleaning of the bottom and sides was sufficient as was the sloping of the trench ends. The use of security fencing to cover the trench and prohibit vehicular access to the trench was adequate.

6.5.5 Backfilling and Embankment Restoration Efforts

The deep longitudinal trench removed the drain material from the center of the crest to a depth of 19 feet and also the embankment material to a depth of 3.5 feet. The upstream test trenches removed the embankment material along three crack zones to a depth of 5.5 feet along the slope. The existing central filter drain material was replaced with suitable filter material (Filter Material A), and a one-foot layer of another filter material (Filter Material B) was placed on the excavated slope on the upstream side. Filter Material A was placed in a dry condition inside the central filter drain from one side following the removal of the shoring system. No noticeable segregation was observed during the placement of filter material. The filter material was placed without any compaction. The backfill operation was efficient with no major constraints encountered.

Filter Material B was placed in the bottom of the excavations on the upstream slope in a wet and un-compacted condition to cover the exposed cracks. The filter was then covered with previously removed and re-compacted embankment material. The purpose of the filter in this location is to intercept seepage through the soil overburden on the upstream slope before it enters the open cracks, preventing migration of fines into the cracks with any seepage that may occur. The compaction activity was monitored regularly and the embankment was restored to its original integrity. The compaction effort met the specified criteria throughout the backfill operation. The restoration of the crest and linking that construction to the repairs of the upstream slope were performed without complications.

The only concern related to the backfill operation is the integration of original slope with the backfill slope on the upstream side. There was a vertical wall between the two slopes and the repaired boundary may be the focus of future cracking. It was observed that the two slopes integrated fairy well during backfill operation. It is recommended that in future operations, the undisturbed wall on the side of the excavated slope should be sloped instead of vertical.

The function of central filter drain is to provide drainage capacity, while preventing uncontrolled crack erosion by developing a filter cake at the upstream soil/drain interface, and preventing crack propagation. The reconstructed central filter drain was placed in a dry and uncompacted state to assure the integrity of the drain. In this condition, the drain will not support a crack aperture, and the material was less prone to segregation upon placement. If moisture was added to the drain materials during placement, it could aid compaction, with the possibility of reducing the permeability of system and affecting the drainage capacity.

On the other hand, the filter on the upstream slope was placed moist and uncompacted. The main function of Filter Material B is to provide an intervening filter medium. Compacting the material would have been difficult due to the slope of the blanket, and this action would not have appreciably enhanced its desired characteristics. As the filter is not required to function as a drain, it was placed wet to improve its density and improve the stability of the upstream slope.

6.6 Recommended Approach for Subsequent Phase

Subsequent actions by the District, associated with the issues of cracking of the Buckeye FRS No. 1 embankment, can be viewed as being associated with three interrelated, but distinct objectives. The first of these objectives would be to gain further insights into the characteristics of the distressed embankment, with a focus on the distribution and geometry of the discontinuities. Additional information regarding the cracking may be useful in ultimately assessing risk and selecting feasible, long-term repair or facility alternatives. A second goal relates to any opportunity to further test the effectiveness of the center central filter drain system, the existing crack defense in the dam. Such testing could be useful in quantifying the protective contribution made by the existing central filter drain, and to what degree this system would need to be augmented. The third and final action under consideration is adjunct to the investigative objectives mentioned above, in that it relates to the need for interim protective measures, either at Station 721+00 or the other three zones of pronounced cracking. These measures are viewed as being both procedural and physical, with the need for further construction-related actions at Station 721+00 deemed unnecessary at this time, but appropriate at the other problem locations. A further discussion of these recommendations and others related to both investigative and interim repair activities are presented in the following sections.

6.6.1 Site Characterization of Three Remaining Areas

During the initial stage of formulating the scope of this investigation, it was anticipated that an exploratory program of a similar magnitude as that reported herein would be completed at the remaining three problem areas of the embankment, as part of a subsequent work assignment. The focus of any additional investigations of the remaining sites should be moderately adjusted, with the primary objective shifting to interim repair, with characterization somewhat adjunct to that effort, but benefiting because of the required cleaning and inspection during repair.

The District has options regarding any further investigation of the possibility of deep longitudinal cracking under the central filter drain. If further insights into the cause and persistence of such cracking are desired, then additional deep trenching to remove the drain may be required. As will be discussed below, it may be prudent to first investigate the potential usefulness of geophysics before proceeding with additional deep trenching.

In anticipation of selecting the best sites for testing, and preparing the three remaining areas for repair, it is recommended that the upstream slope of each area be subjected to surficial cleaning, inspection and over-excavation of the persistent transverse cracks. The two most significant transverse cracks exposed should then be targeted for the ponded crack infiltration testing discussed in the report section to follow. At the termination of the ponded tests, partial, relatively shallow removal of the central filter drain to observe moisture penetration and crack erosion could be accomplished in the narrow zones encompassing the two tested cracks. No additional excavation of the center central filter drain may be required. Backfilling procedures adopted for the Station 721+00 site should be employed to return the central filter drain to service.

The question remains whether the limited program of characterizing the problem embankment sections described above, occurring in conjunction with ponding tests and repair, should be augmented with an investigation of the underlying foundation conditions using geophysical and drilling programs. The purpose of such work would be to once again search for the causal mechanisms of embankment cracking. The degree of confidence regarding the likely differential consolidation of the shallow soil profile has improved, and additional rigorous characterization of the dam foundation may not be necessary at this phase of the project. A reduced program of auger drilling, laboratory testing, and surface geophysics is recommended.

6.6.2 Investigation of Western Segment of Dam Structure

From the perspective of dam safety for the entire FRS, it would be beneficial to investigate the shallow soil profile under the previously uncracked portion of the dam between Stations 801+00 and its western terminus. This reach is geologically mapped as being underlain by older, more cemented Quaternary alluvium than the deposits present under the cracked embankment. A limited subsurface program could further support the proposal of a foundation-related cause for embankment cracking by identifying less compressible conditions under the uncracked portion of the structure. An abbreviated exploratory program is recommended, when compared to that completed in the Station 721+00 study area. Four hollow-stem auger borings with drive sampling to depths of 40 feet are recommended, augmented with intervening seismic refraction and shear wave profiling. A limited suite of laboratory tests should ensue, with a focus on the moisture, density and consolidation/collapse characteristics of the shallow soil profile.

At the time that the central filter drain was installed, the density and depth of transverse embankment cracks were defined, with limited portions of the structure apparently free of discontinuities. The drain was not constructed in these crack-free segments between Stations 555+00 and 565+00, and between 801+00 and 931+80, for a total distance of 13,080 feet, representing about 35 percent of the 7.1-mile embankment. It is recommended that the region previously free of discontinuities be investigated, with the purpose of redefining that portion of the dam in need of attention should the structure require a full restoration. The investigation of that portion of the dam previously free of discontinuities should be accomplished by visual inspection, followed by seismic refraction profiling and limited shallow trenches to verify select geophysical indications of embankment fractures. Due to the discoveries made in the Station 721+00 study area, it is assumed that major changes in areas previously identified as containing numerous discontinuities include deepening of many cracks, and formation of new fractures. Little would be gained from a new investigation of these reaches of the embankment, with the likely confirmation of the assumption stated.

The discovery of the deep longitudinal crack below the central filter drain in the Station 721+00 study area, and the recent detection of pervasive longitudinal cracking along the crest of the Spook Hill FRS raises the possibility of a shallow longitudinal feature in the Station 801+00 – 931+80 reach of the Buckeye FRS No. 1 structure. This portion of the dam is devoid of the central filter drain; therefore, conditions approximate those present at the Spook Hill FRS, with its strain expressed as a prominent, centered longitudinal crack exposed along the crest of the dam. It is recommended that the possibility of longitudinal cracking in the subject reach be investigated, utilizing transverse seismic refraction profiling, followed by confirmatory trenching.

Although the investigations summarized above, and other work on the embankment, including pond testing and repair, could be accomplished safely during any time of the year, there is inherently less risk of compromising the flood retention function of the structure during drier seasons of the year. Certainly, retention of a flood pool could hinder or curtail either investigative or construction activities, but with contingencies implemented, the risk of dam breach caused by the investigation or repair appears remote. The most preferable timing for the investigations, testing and repair is between mid-October and early-December, or between mid-April and late-June. These times avoid the typical wet periods, including the summer monsoons and the regional winter cycle.

6.6.3 Ponded Crack Infiltration Testing

For regions of the dam structure where cracks do not pass under the central filter drain, both filter testing and observations within the Station 721+00 study area indicate the probable adequacy of the existing drain. The central filter drain appears capable of arresting crack propagation due to its lack of cohesion, with filtering properties that would limit crack flow and sediment transport, and provide adequate drainage capacity. Further quantification of this apparent adequacy could influence the degree to which this existing protective component will be considered in selecting and designing additional defenses, should the District opt to implement a full repair of the structure.

Full-scale, relatively long-term pond testing of the style performed on Vineyard FRS by the Soil Conservation Service is recommended at two crack locations on the Buckeye FRS No. 1 embankment. These two locations should be selected to be the most potentially detrimental conditions known in the dam structure, likely within the other three remaining problem zones, but possibly at other locations of known, prominent cracking. Procedures for the test setup and operation are discussed in Section 3.11.1 of this report, in general conformance with the approach taken by the SCS at the Vineyard FRS. A test duration of 30 days is recommended. As previously mentioned, the District should consider the subsequent removal of a shallow segment of the central filter drain after completion of each ponding test to observe the wetted front and the erosional conditions within the central filter drain section and the adjacent embankment crack previously inundated. The upstream slope should also be trenched.

6.6.4 Interim Repair

As previously mentioned, no additional interim protective or defensive measures are recommended for the Station 721+00 location, with one exception described below. The upstream filter blanket and the re-compacted slope backfill should provide adequate protection in the interim against damaging crack erosion. Following the placement of the upstream slope filter and the overlying compacted embankment soils, the dam's condition in the investigated reach is deemed comparable or likely better than the remainder of the structure. It is recommended that the same slope treatment be constructed in the other three problem areas as an interim measure.

Repairs in the Station 624+35, 673+50 and 710+47 areas should begin subsequent to the limited characterization of the excavated upstream slopes and the ponding tests. Backfill procedures and the material types similar to those employed at the Station 721+00 site to restore the dam profile should be applied to repair the three remaining areas. The design of this repair and materials used are summarized in Section 3.9, and an as-built drawing is presented in Appendix G.

For all four problem areas, the District should consider regrading the terrain adjacent to the upstream slope, thereby eliminating any local ponding and providing positive drainage away from the region of concern. This regrading should be accomplished using clayey borrow in a further attempt to reduce infiltration. These actions could lessen the wetting of the foundation soils in the future, and the resultant underlying settlement of the soil profile and embankment distress.

6.6.5 Monitoring and Surveillance

The four areas of concern should be periodically inspected for surficial signs of distress, on a quarterly basis following the interim repairs. An inspection should also occur within one week of the retention of water in the flood pool behind the dam. No further monitoring actions are recommended.

REFERENCES

AMEC Earth & Environmental, Inc., 2002, Buckeye FRS No. 1 Investigation of Cracking - Work Assignment No.3, report submitted to the Flood Control District of Maricopa County, AMEC Job No. 0-117-001122, May 7.

AMEC Earth & Environmental, Inc., 2001, Geotechnical Investigation Report, Buckeye FRS No. 1, report submitted to the Flood Control District of Maricopa County, AMEC Job No. 0-117-001044, March 14.

Anderson,T.W., Freethey, G.W. and Tucci, P., 1992, Geohydrology and Water Resources of Alluvial Basins in South-Central Arizona and Parts of Adjacent States, U.S. Geological Survey Professional Paper 1406-B.

Arizona Water Commission, 1979, Phase I Investigation Report, National Dam Safety Program, Buckeye Flood Retarding Structure No. 1, AZ Dam, April 3.

Arrington, Ralph. (1988). 'Detection of Seepage in Cracked Dam.' Soil and Water Division of American Society of Agricultural Engineers. ASAE Paper No. 86-2613.

Cooley, M.E., 1973, Map Showing Distribution and Estimated Thickness of Alluvial Deposits in the Phoenix Area, Arizona, U.S. Geological Survey Miscellaneous Investigations Series Map MF-I-845C.

Demsey, K.A., 1989, Geologic Map of Quaternary and Upper Tertiary Alluvium in the Phoenix South 30'X60' Quadrangle, Arizona. Arizona Geological Survey Open-file Report OFR-89-7.

Engineering and Hydrosystems Inc., (2003), Embankment Dam Breach Model, Development and Testing. Prepared for the Flood Control District of Maricopa County, Phoenix, Arizona. September 12, 2003.

Engineers Testing Laboratories, Inc. (ETL). (1977). 'Evaluation of Powerline, Vineyard, and Rittenhouse Floodwater Retarding Structures, Pinal County, Arizona.' Prepared for the Flood Control District of Maricopa County, Phoenix, Arizona. July 1, 1977.

ERTEC, Inc., Consulting Engineers and Geologists, 1981, As-Built Report, Buckeye Site 1 Drain, Maricopa County, report submitted to U.S. Department of Agriculture, Soil Conservation Service, ERTEC Project No. 80-200, March 29.

Foster M., and R. Fell, 2001, Assessing Embankment Dam filters that do not Satisfy Design criteria, Journal of Geotechnical and Environmental Engineering, Vol. 127 No. 5, pp. 398-407.

Fugro, Inc., Consulting Engineers and Geologists, 1979, Crack Location Investigation, Buckeye No. 1 Flood Retarding Structure, Maricopa County, Arizona, report submitted to U.S. Department of Agriculture, Soil Conservation Service, Fugro Project No. 78-308, April 16.

Geo-Slope International, Ltd., 1998, User's Manual for SEEP/W Version 4, Calgary, Alberta, Canada.

Geo-Slope International, Ltd., 1998, Slope Stability Computer Program SLOPE/W, Version 4, Calgary, Alberta, Canada.

Kenney, T.C., Chahal, E., Chiu, G.I., et al. 1985, Controlling Constriction sizes of Granular Filters, Canadian Geotechnical Journal, 22, 32-43.

Kenney, T.C., and Lau, D.,1985, Internal Stability of Granular Filters, Canadian Geotechnical Journal, 22, 215-225.

Leckband, Susan (1983). Vineyard Test Cell Summary. Correspondence to Dick Raymond of the USBR. United States Department of Agriculture-Soil Conservation Service, November, 21, 1983.

Natural Resources Conservation Service, 1994, Chapter 26, Gradation Design of Sand and Gravel Filters, Part 633, National Engineering Handbook.

Reynolds, S.J., Wood, S.E., Pearthree, P.A. and Field, J.J., 2002, Geologic Map of the White Tank Mountains, Central Arizona. Arizona Geological Survey Digital Geologic Map DGM-14.

Rucker, M.L. and Keaton, J.R., 1998, Tracing an Earth Fissure Using Seismic-Refraction Methods with Physical Verification, in Land Subsidence Case Studies and Current Research: Proceedings of the Dr. Joseph F. Poland Symposium on Land Subsidence, Edited by Borchers, J.W., Special Publication No. 8, Association of Engineering Geologists, Star Publishing Company, Belmont, California, p. 207-216.

Sanders, Aubrey C. (1986). 'Crack Location Investigation. Powerline Flood Retarding Structure, Pinal County, Arizona.' United States Department of Agriculture-Soil Conservation Service, Phoenix, Arizona. May 20, 1986.

Schumann, H.H. and Genualdi, R.B., 1986, Land Subsidence, Earth fissures, and Water-Level Change in Southern Arizona, Arizona Bureau of Geology and Mineral Technology Open File Report 86-4, Tucson, Arizona.

Sergent, Hauskins, and Beckwith (1982). McMicken Dam Restoration Study. Completed for the Flood Control District of Maricopa County. July, 1982.

Sherard, J.L., L.P. Dunnigan, J.R. Talbot, 1984a. "Basic properties of sand and gravel filters," ASCE Journal of Geotechnical Engineering, vol.110, No.6, pp. 684-700.

Sherard, J.L., L.P. Dunnigan, J.R. Talbot, 1984b. "Filters for silts and clays," ASCE Journal of Geotechnical Engineering, vol.110, No.6, pp. 701-718.

Soil Conservation Service (SCS), 1974, Plans for the Construction of Site I Diversion Structure, Buckeye Watershed Protection and Flood Prevention Project, Maricopa County, Arizona, prepared for the Flood Control District of Maricopa County, Drawing No. 7-E-22084, Sheets 1 through 31.

Soil Conservation Service (SCS), 1971, Report of Geologic Investigation, Buckeye Watershed, Floodwater Retarding Structure No. 1, undated.

Soil Conservation Service (SCS), (1970). 'Special Report. Embankment Cracking-Vineyard Road Dam, Williams Chandler Watershed. United States Department of Agriculture Soil Conservation Service.

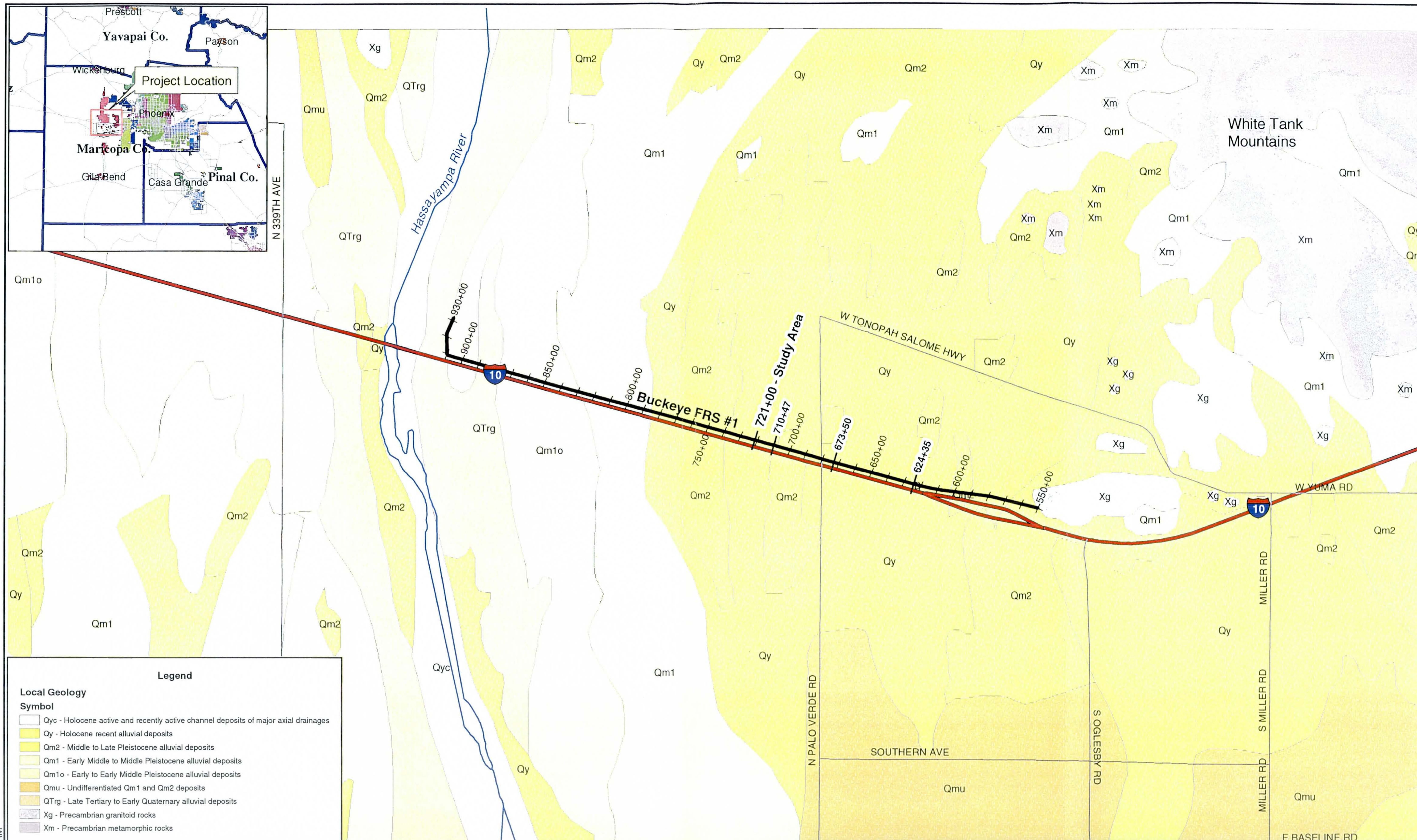
Soil Conservation Service (SCS), (1977). 'Cracking of Dams in Arizona.' Interim Report of the Crack Study Team-United States Department of Agriculture Soil Conservation Service. July 21, 1977.

Soil Conservation Service (SCS), (1982). Vineyard Road FRS Drain Design Report. Completed by Jack Doyle, SCS Wyoming State Engineer. United States Department of Agriculture-Soil Conservation Service, May 10, 1982.

Sweeney, R.E. and Hill, P.L., 2001, Arizona Aeromagnetic and Gravity Maps and Data, U.S. Geological Survey Open-File Report 01-0081.

amec

FIGURES



Note: Geologic contacts from Demsey (1989)

1 0.5 0 1 2 Miles

N

JOB NO.:	4-117-001021
DESIGN:	KCF
DRAWN:	EMP
DATE:	6/15/04
SCALE:	1" = 1 mile

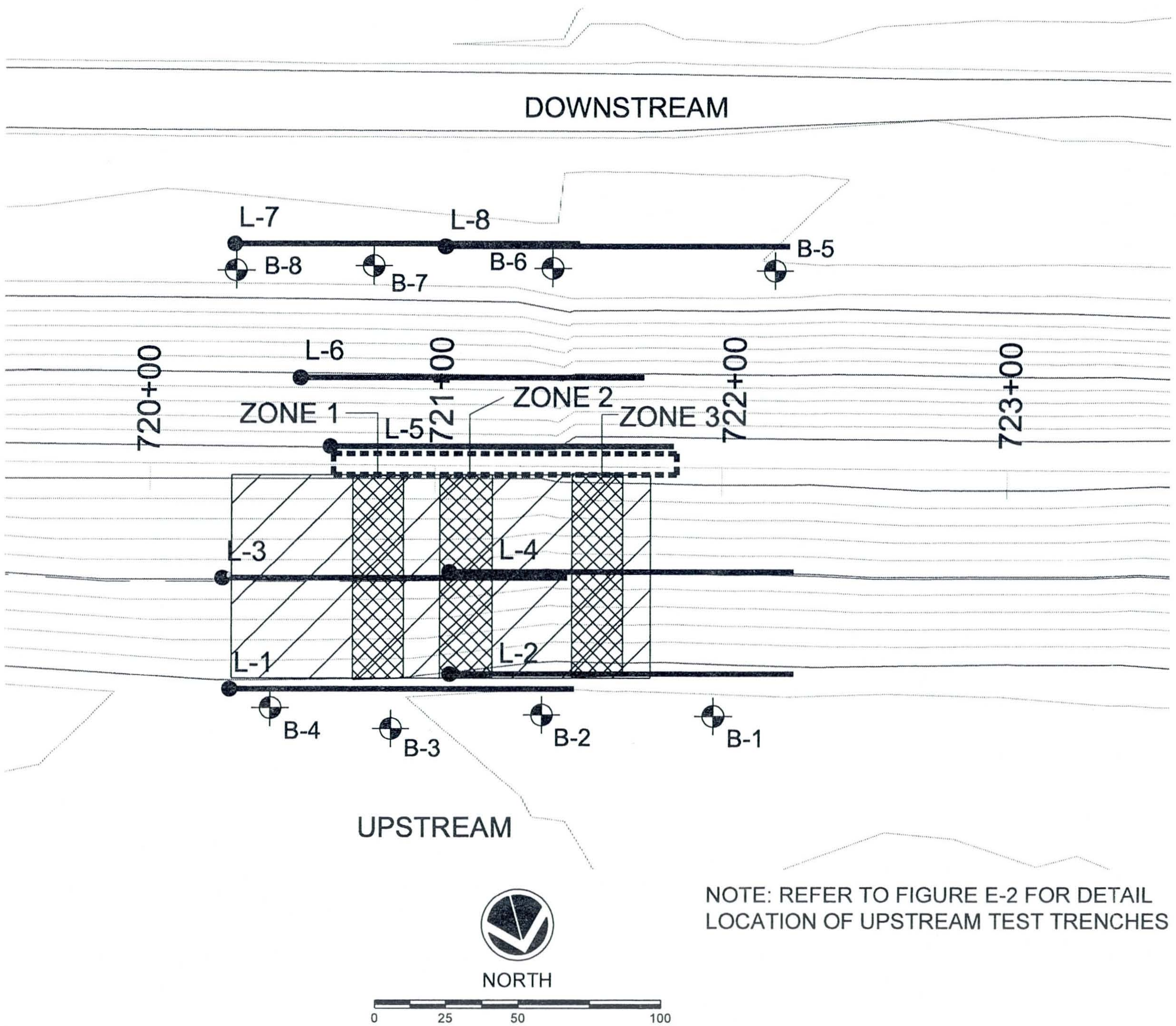
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO. 1
CONTRACT FCD2003C014 - WORK ASSIGNMENT NO. 2

VICINITY MAP
& LOCAL GEOLOGY

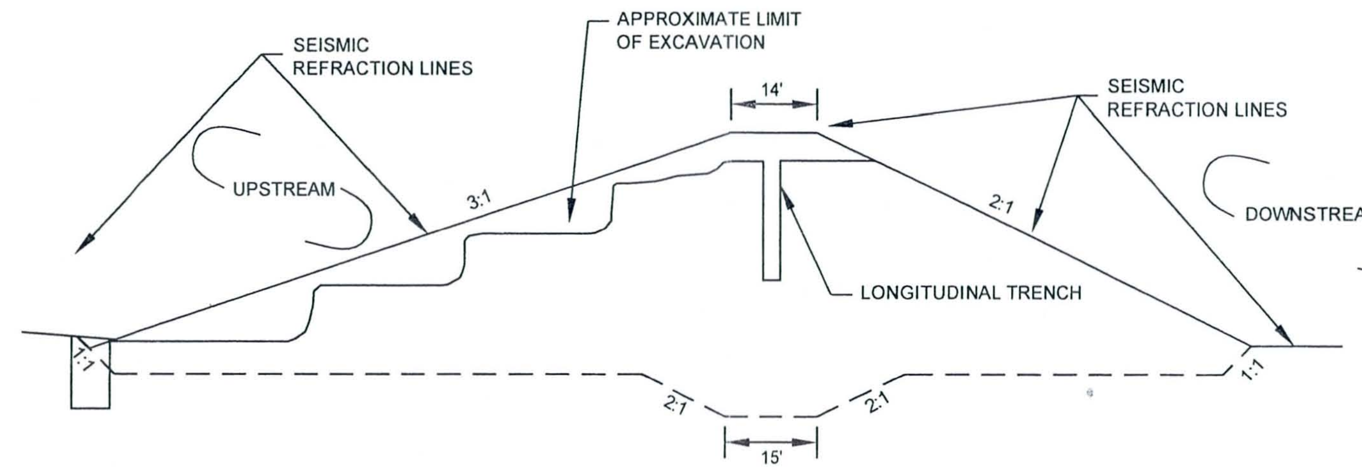
FIGURE
1

amec

Map Document: (G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\GIS\Buckeye_geology.mxd)
06/02/2004 -- 9:18:01 AM



NOTE: REFER TO FIGURE E-2 FOR DETAIL LOCATION OF UPSTREAM TEST TRENCHES



TYPICAL PROFILE — SCALE: 1" = 30'

LEGEND

- HOLLOW STEM AUGER BORING
- SEISMIC REFRACTION/REMI PROFILES (DOT REPRESENTS FORESHOT)
- APPROXIMATE AREA OF INITIAL SURFICIAL CLEANING
- EMBANKMENT TRENCHING
- LONGITUDINAL TRENCH ALONG CENTER DRAIN

JOB NO. 4-117-001021	SITE PLAN & TYPICAL PROFILE		amec
DESIGN: KCF			
DRAWN: GWH			
DATE: 6/2004	BUCKEYE FRS NO. 1 SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS CONTRACT FCD 2003C014 - WORK ASSIGNMENT NO. 2	FIGURE 2	
SCALE: AS SHOWN			

APPENDIX A

COMPILATION OF PREVIOUS DATA

TABLE A-1

Summary of Previous Crack Data
Station 721+00 Study Area

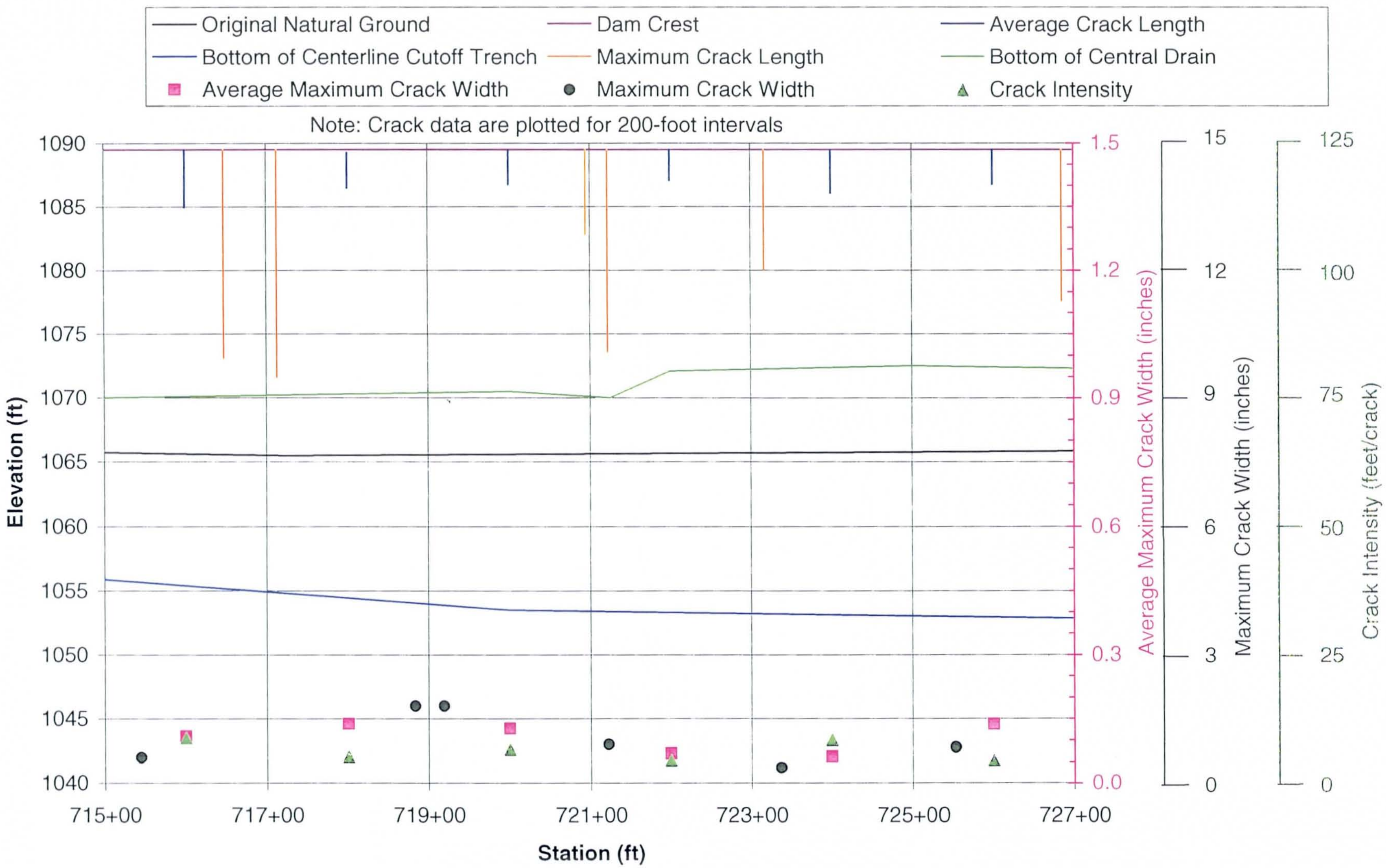
Test Pit #	Station	Location	Possible Crack Depth (feet)	Flood Test
TP-27	719+40	US	20	Toe Seepage
TP-28	721+06	CDS	17.5	High Flow
TP-29	721+53	US	21	Toe Seepage
TP-30	723+00	CC	3	No Test
TP-31	724+12	US	7	No Test
TP-32	724+22	CC	4	No Test

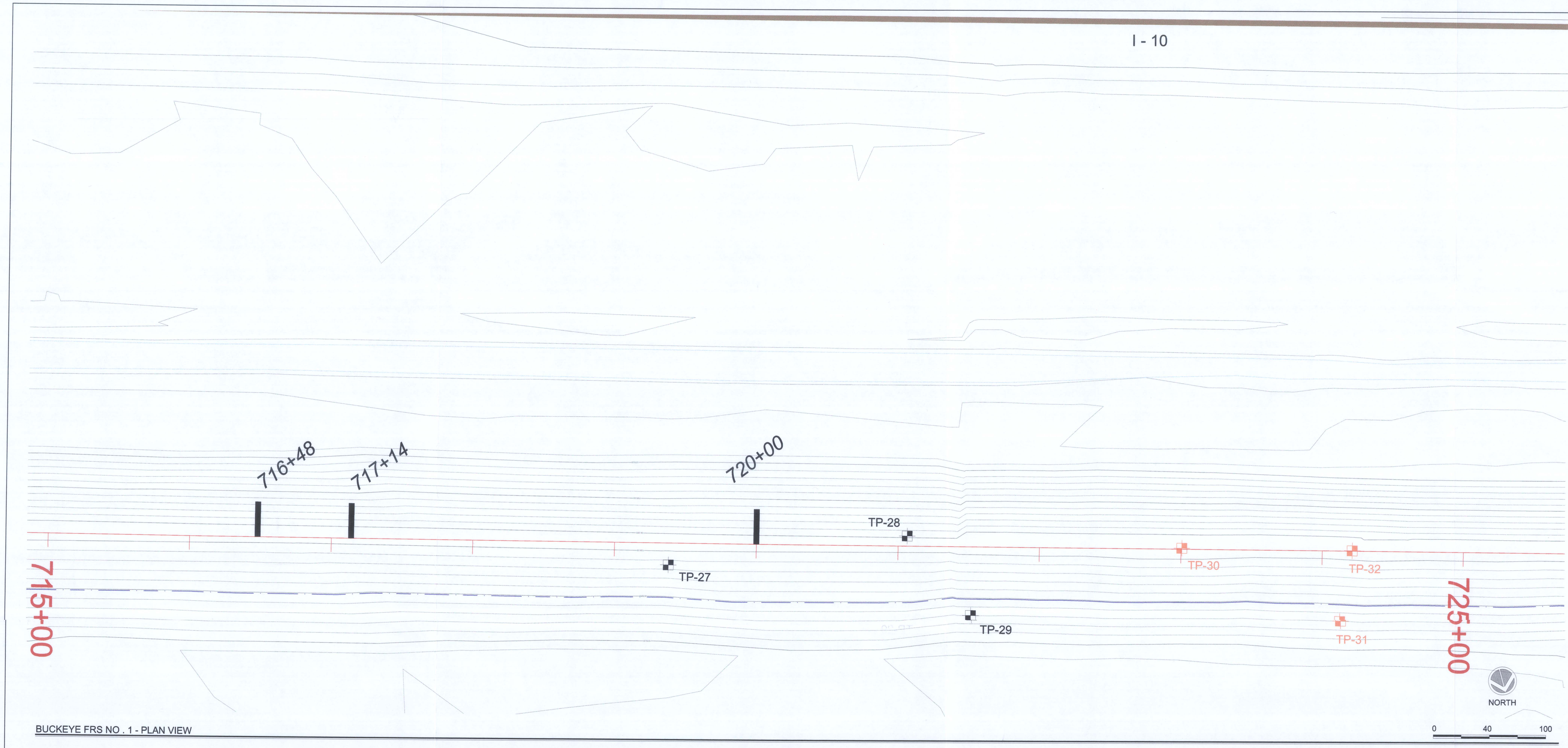
CUS - Crest at upstream side.
CC - Crest at center.
CDS - Crest at downstream side.
DS - Downstream slope.
US - Upstream slope.

From: Summary of Field Investigation (AMEC, 2001)

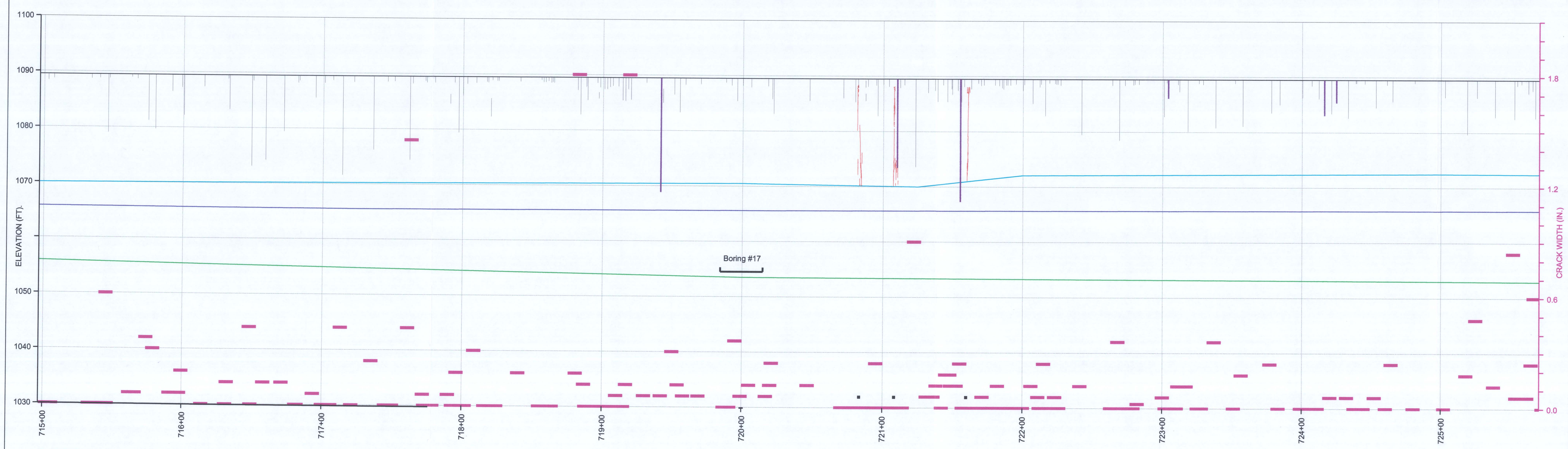
Figure A-1

Buckeye FRS No. 1 Summary of Cracking





BUCKEYE FRS NO . 1 - PLAN VIEW



BUCKEYE FRS NO. 1 - PROFILE

VERTICAL EXAGGERATION X2

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

BUCKEYE FRS NO. 1
CONTRACT NO. 2000C006
WORK ASSIGNMENT NO. 3

LEGEND

PLAN VIEW

- INDEX CONTOUR (10' INTERVAL)
- INTERMEDIATE CONTOUR (2' INTERVAL)
- CENTERLINE OF DAM WITH STATIONING
- ROADS (PAVED AND UNPAVED)
- EARTH CHANNEL OUTLET CREST (1079.8 FT)
- DRAIN OUTLET WITH STATION
- TP-27 TEST PIT NUMBER & LOCATION OF FLOOD TEST (AMEC, 2001)
- TP-30 TEST PIT NUMBER & LOCATION (NO FLOOD TEST), (AMEC, 2001)

PROFILE

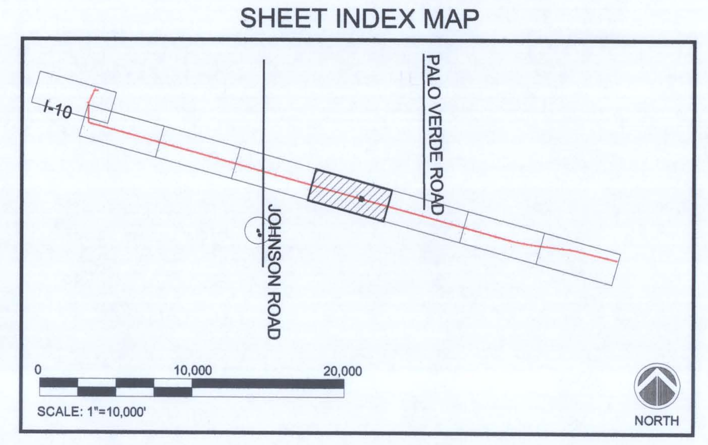
- DAM CREST (1089.5 FT)
- BOTTOM ELEVATION OF CENTERLINE CUTOFF TRENCH
- BOTTOM ELEVATION OF CENTRAL DRAIN
- BOTTOM ELEVATION OF HOLOCENE SOILS BASED ON 1971 SCS BORING LOGS
- ORIGINAL NATURAL GRADE ELEVATION AT EMBANKMENT CENTERLINE
- LOCATION OF VERTICAL CRACK (DEPTH INDICATED ON DRAWING)
- LOCATION OF VERTICAL CRACK (PROBABLE DEPTH) (AMEC, 2001)
- CRACK WIDTH (CORRESPONDING TO VERTICAL CRACKS)
- LOCATION OF VERTICAL CRACK (AMEC 2004)
- CRACK WIDTH (CORRESPONDING TO VERTICAL CRACKS) (AMEC 2004)

NOTES

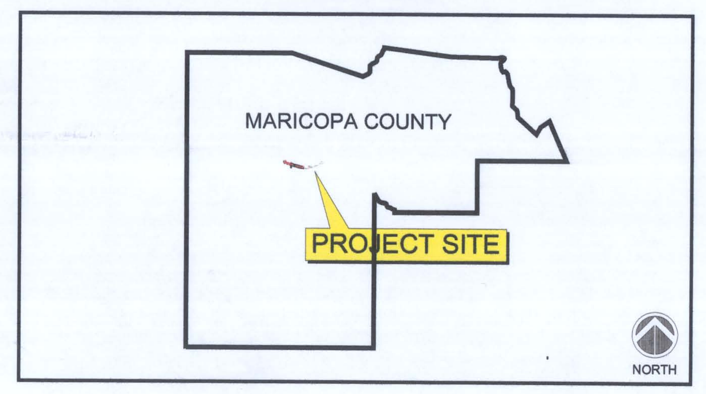
1. CRACK AND CONSTRUCTION DATA FROM: ERTEC, INC. 1981, "AS-BUILT REPORT, BUCKEYE SITE 1 DRAIN, MARICOPA COUNTY, ARIZONA," ERTEC PROJECT NO. 80-200, SCS CONTRACT NO. 52-8402-0-00113, MARCH 29.
2. BASE MAP INFORMATION FROM: FLOOD CONTROL DISTRICT OF MARICOPA COUNTY, 2001, COMPACT DISK "GIS FILES FOR BUCKEYE FLOOD RETENTION STRUCTURE NO. 1," MAY 3. BASE MAP TOPOGRAPHY BASED ON 1988 NAVD.
3. DAM CREST ELEVATION SHOWN ON CROSS-SECTION IS BASED ON ORIGINAL DESIGN DRAWINGS (1929 NGVD). FOR ELEVATIONS REGARDING BORINGS, CRACKS, CUTOFF TRENCHES, HOLOCENE SOILS AND ORIGINAL NATURAL GRADE USE THE FOLLOWING EQUATION TO CONVERT ELEVATIONS TO 1988 NAVD (BASE MAP DATA).

   1988 NAVD ELEVATION = 1929 NGVD ELEVATION + 2.025'
4. THE CRACK LOCATION FOR AMEC 2004 INVESTIGATION START FROM APPROXIMATELY 3'6" BELOW THE CREST OF THE DAM. DETAILS OF CRACK INVESTIGATION GIVEN ON FIGURE F-1 TO F-6. THE LARGEST FEATURE OBSERVED ON EITHER UPSTREAM WALL OR DOWNSTREAM WALL AT A GIVEN CRACK LOCATION IS PRESENTED HERE.

SHEET INDEX MAP



VICINITY MAP

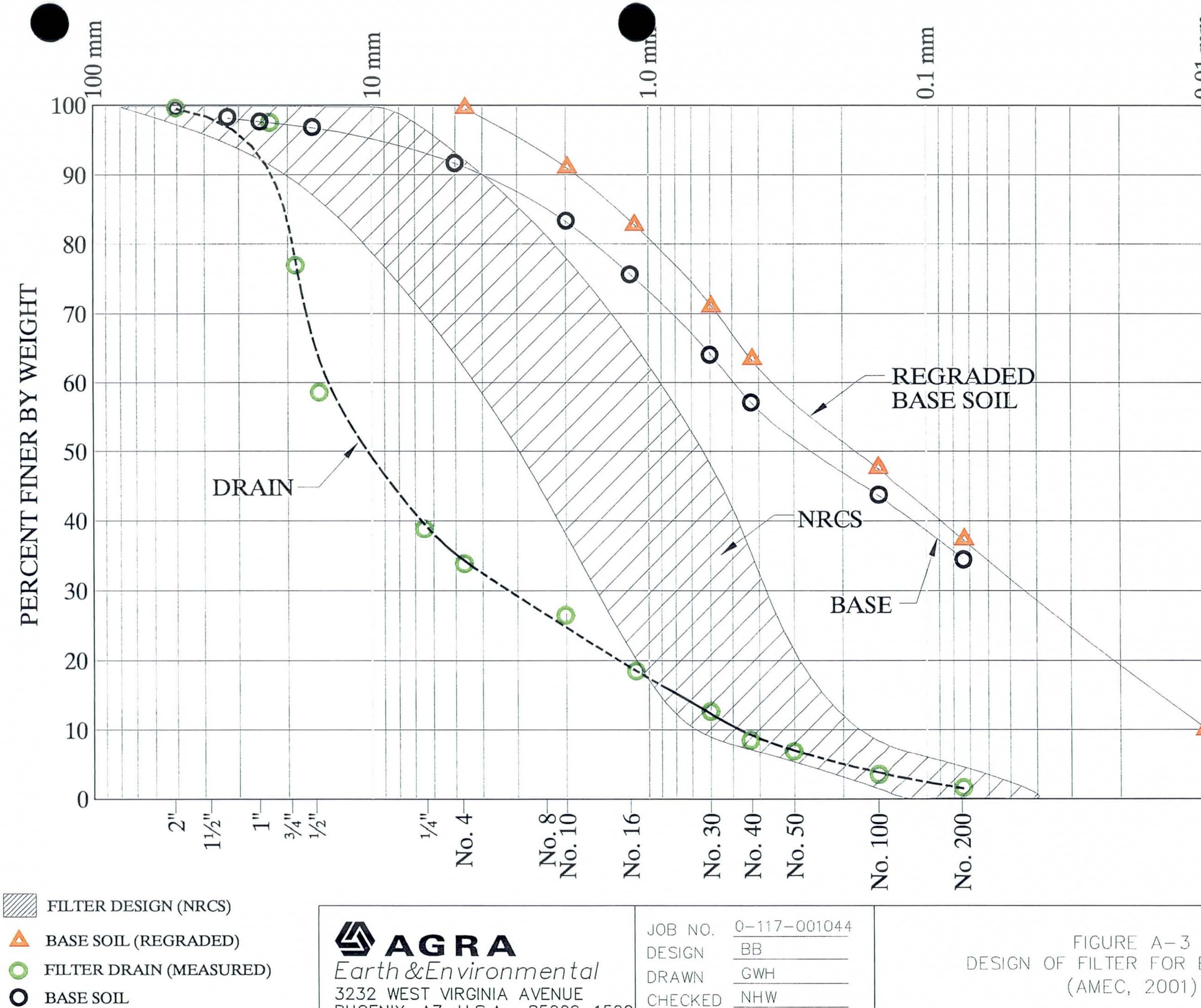


AMEC Earth & Environmental, Inc.
3232 W. Virginia Ave.
Phoenix, Arizona 85009
Tel: (602) 272-6848
Fax: (602) 272-7239
www.amec.com

amec

JOB No.	4-117-001021	FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
DESIGN	BB/REW	RECOMMENDED BY: DATE
DESIGN CHK.	BB/REW	APPROVED BY: DATE
DRAWN	GWH	CHIEF ENGINEER AND GENERAL MANAGER
DATE	12/2004	SHEET FIGURE A-2

I:\Engineering-Development\2000Projects\0-117-001122 Structures Assessment-Ph II\Task 3 - Buckeye FRS #1\CAD\profile - from excel.dwg



AGRA
Earth & Environmental
3232 WEST VIRGINIA AVENUE
PHOENIX, AZ, U.S.A. 85009-1502

JOB NO.	0-117-001044
DESIGN	BB
DRAWN	GWH
CHECKED	NHW
DATE	7/00

FIGURE A-3
DESIGN OF FILTER FOR BASE SOIL
(AMEC, 2001)

G:\Engineering-Development\2000Projects\0-117-001044 Buckeye FRS #1\filter design fig1.dwg

PROJECT Buckeye FRS #1

JOB NO. 0-117-001044 DATE 5/31/00

BACKHOE TYPE Backhoe
LOCATION Sta. 719+40, upstream slope
SURFACE ELEV.
DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	SOIL DESCRIPTION
0							One large (11" by 7") and several small holes were observed on the upstream slope at a location about 20' above the toe. Water was introduced into the large hole prior to excavating the test pit and seeped out near the toe area. The crack was exposed on both walls and the bottom of the test pit. The depth of the crack possibly is about 20', considering the location of the toe seepage. The zone of wet soil related to the water experiment was confined to the crack.
4.5		▨	A				
5							Stopped Backhoe at 5'
10							

SAMPLE TYPE
B - Undisturbed Block Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-27

PROJECT Buckeye FRS #1

JOB NO. 0-117-001044 DATE 5/30/00

BACKHOE TYPE Backhoe

LOCATION Sta. 721+06, downstream side of crest

SURFACE ELEV.

DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	SOIL DESCRIPTION
0							Two holes were observed at the downstream side of the crest. The crack was exposed on the walls and bottom of the test pit. It was 0.5" to 1" wide and filled with sandy soil. A flood test was performed with a high seepage observed. After the flood test, the crack became wider and by probing it was determined that the crack extended at least 6' below the bottom of the test pit. A sample of the material infilling the crack was collected.
4		(sample)	A				
4.5							Stopped Backhoe at 4'6"
10							

SAMPLE TYPE

B - Undisturbed Block Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-28

PROJECT Buckeye FRS #1

JOB NO. 0-117-001044 **DATE** 5/30/00

BACKHOE TYPE Backhoe

LOCATION Sta. 721+53, upstream slope 20' above toe

SURFACE ELEV.

DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	SOIL DESCRIPTION
0							Two small holes were observed about 20' above the upstream toe. The crack was exposed on the walls and bottom of the test pit. The crack was a maximum of 1" wide and was filled with fine soil. A flood test was performed with high a seepage rate observed, and seepage from a few holes at the embankment toe noted.
1							
2							
3		▨	A				
							Stopped Backhoe at 3'2 1/2"
4							
5							
6							
7							
8							
9							
10							

SAMPLE TYPE

B - Undisturbed Block Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-29

PROJECT Buckeye FRS #1

JOB NO. 0-117-001044 **DATE** 5/30/00

amec

BACKHOE TYPE Backhoe
LOCATION Sta. 723+00, near center drain
SURFACE ELEV.
DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	SOIL DESCRIPTION
0–2.5							Two small aligned cracks were observed at the crest near its center. The crack was exposed at the bottom and on the upstream wall of the test pit. The crack was a maximum of 1" wide. The crack terminated near the center drain. The center drain was exposed and the width of the crack was smaller on the downstream side.
2.5–10							Stopped Backhoe at 3'6"

SAMPLE TYPE
B - Undisturbed Block Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-30

PROJECT Buckeye FRS #1

amec

JOB NO. 0-117-001044 **DATE** 5/30/00

BACKHOE TYPE Backhoe

LOCATION Sta. 724+12, upstream slope

SURFACE ELEV.

DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	SOIL DESCRIPTION
0							A large crack was observed on the upstream slope about 6' above the toe. The crack was exposed on the walls and bottom of the test pit. The crack had a maximum width of 1" and was filled with fine soil. Probing indicated the crack extended about 2' below the bottom of the test pit.
1							
2							
3							
4							
		▨	A				
5							Stopped Backhoe at 5'
6							
7							
8							
9							
10							

SAMPLE TYPE

B - Undisturbed Block Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-31

PROJECT Buckeye FRS #1

JOB NO. 0-117-001044 DATE 5/30/00

amec

BACKHOE TYPE Backhoe

LOCATION Sta. 724+22, 8' from south end near center dra

SURFACE ELEV.

DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	SOIL DESCRIPTION
0 – 3.5							Two 1" diameter holes were observed at the crest. The crack was exposed on the downstream wall and bottom of the test pit. The crack was a maximum of 0.5" wide and was filled with sandy soil. Probing indicated the crack extended only 6" below the bottom of the test pit.
3.5 – 10							Stopped Backhoe at 3'6"

SAMPLE TYPE

B - Undisturbed Block Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-32

amec

APPENDIX B

PIPE OBSERVATIONS

Pro Pipe Services
2222 W. Grant Street
Phoenix, AZ 85009
Tel: (602)-861-3944, Fax: (602) 861-1423

Inspection report

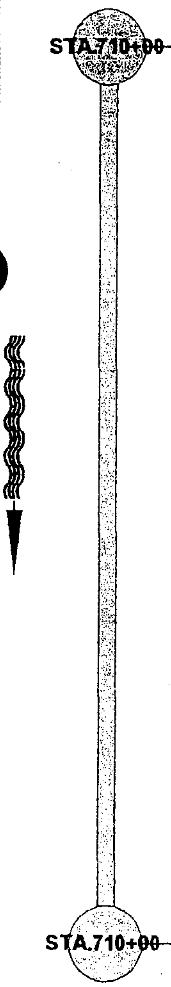
Date:	P.O.#	Weather:	Surveyor/Cert #:	section number:	PLR:
20030415		1	J. SETELIN/02-218	6	
Tot Pipe Length:	Survey Customer: FLOOD CONTROL	System Owner: MARICOPA COUNTY	Clean Date:	Pre-Cleaned:	rate:

Street: BUCKEYE I	Flow Control:	MH: STA.710+00
City: BUCKEKYE	Year Renewed	MH: STA.710+00
Location Code: Z Other	Tape/Media #: 54-1	pipe length: 155 ft

Reason for inspection: A Maintenance Related	Dia/Ht: C Circular 12"
Use: SW Storm Water	Material: RCP Reinforced concrete pipe Pipe Jt: 10ft
Drainage Area:	Lining Material: :

Remark::

1:400	position	code	observation	photo
STA.710+00	0.00	A	Access point	
STA.710+00	155.00	A	Access point/GATE	



Station : 710+00
NO: 6
Date : 4-15-2003
Time : 13:58
Surveyer : J. Setelin /02-218
City : Buckeye
Street : Buckeye I
Location : Z Other
Weather : 1
flow : d/s
Use : SW storm water.
Dia/Ht : C Circular 12"
Pipe Joint : 10 ft.

Pro Pipe Services
2222 W. Grant Street
Phoenix, AZ 85009
Tel: (602)-861-3944, Fax: (602) 861-1423

Inspection report

Date:	P.O.#	Weather:	Surveyor/Cert #:	section number:	PLR:
20030415		1	J. SETELIN/02-218	6	
Tot Pipe Length:	Survey Customer: FLOOD CONTROL	System Owner: MARICOPA COUNTY	Clean Date:	Pre-Cleaned:	rate:

Street: BUCKEYE I	Flow Control:	MH: STA.710+00
City: BUCKEKYE	Year Renewed	MH: STA.710+00
Location Code: Z Other	Tape/Media #: 54-1	pipe length: 155 ft

Reason for inspection: A Maintenance Related	Dia/Ht: C Circular 12"
Use: SW Storm Water	Material: RCP Reinforced concrete pipe Pipe Jt: 10ft
Drainage Area:	Lining Material: :

Remark::

1:400	position	code	observation	photo
STA.710+00	0.00	A	Access point — 4.0'	

@ 5.1' one small hole

@ 10.8' pipe joint - slightly deformed and separated. slightly cracked.

@ 17.8' spider web present

@ 22.8' - Joint - slightly deformed, cracked. object hanging from above.

@ 34.6' - Joint - slightly deformed. and cracked.

@ 44.4' - few cracks on the wall

@ 48.8' - Joint - slightly deformed and separated.

1:400	position	code	observation	photo
STA.710+00	155.00	A	Access point GATE	

Pro Pipe Services
2222 W. Grant Street
Phoenix, AZ 85009
Tel: (602)-861-3944, Fax: (602) 861-1423

Inspection report

Date: 20030415	P.O.#	Weather: 1	Surveyor/Cert #: J. SETELIN/02-218	section number: 6	PLR:
Tot Pipe Length:	Survey Customer: FLOOD CONTROL	System Owner: MARICOPA COUNTY	Clean Date:	Pre-Cleaned:	rate:

Street: BUCKEYE I	Flow Control:	MH: STA.710+00
City: BUCKEKYE	Year Renewed	MH: STA.710+00
Location Code: Z Other	Tape/Media #: 54-1	pipe length: 155 ft

Reason for inspection: A Maintenance Related	Dia/Ht: C Circular 12"
Use: SW Storm Water	Material: RCP Reinforced concrete pipe Pipe Jt: 10ft
Drainage Area:	Lining Material: :

Remark::

1:400	position	code	observation	photo
STA.710+00	0.00	A	Access point	
			@ 59.0' Joint - slightly deformed and separated. Small cracks present.	
			@ 70.7' - Joint - slightly deformed, separated and cracked.	
			@ 82.7' — Joint slightly deformed.	
			@ 94.5' - Joint - slightly deformed and separated.	
			@ 105.3' - Joint - slightly deformed and separated.	
STA.710+00	155.00	A	Access point/GATE	

4/4

Pro Pipe Services
2222 W. Grant Street
Phoenix, AZ 85009
Tel: (602)-861-3944, Fax: (602) 861-1423

Inspection report

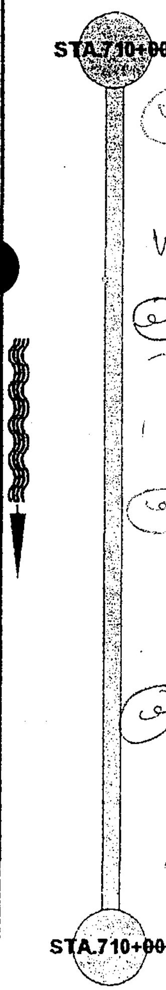
Date:	P.O.#	Weather:	Surveyor/Cert #:	section number:	PLR:
20030415		1	J. SETELIN/02-218	6	
Tot Pipe Length:	Survey Customer: FLOOD CONTROL	System Owner: MARICOPA COUNTY	Clean Date:	Pre-Cleaned:	rate:

Street:	BUCKEYE I	Flow Control:		MH:	STA.710+00
City:	BUCKEKYE	Year Renewed		MH:	STA.710+00
Location Code:	Z Other	Tape/Media #:	54-1	pipe length:	155 ft

Reason for inspection:	A Maintenance Related	Dia/Ht:	C Circular 12"
Use:	SW Storm Water	Material:	RCP Reinforced concrete pipe Pipe Jt: 10ft
Drainage Area:		Lining Material:	
		:	

Remark::

1:400	position	code	observation	photo
STA.710+00	0.00	A	Access point	



@ 117.3' – Joint – slightly deformed No separation.
Water inside pipe from @117.5' – 141.8'
@ 129.4' – Joint – partially deformed otherwise No separation looks good. Water inside pipe. Spider web.
@ 141.4' – Joint – slightly deformed and separated. Spider web. No water.
@ 151.6' – Joint – very little deformation at few places! otherwise intact looks good!. Crack on the wall.
Video stopped @ 155

STA.710+00	155.00	A	Access point/GATE	

Pro Pipe Services
2222 W. Grant Street
Phoenix, AZ 85009
Tel: (602)-861-3944, Fax: (602) 861-1423

Inspection report

Date: 20030415	P.O.#	Weather: 1	Surveyor/Cert #: J. SETELIN/02-218	section number: 5	PLR:
Tot Pipe Length:	Survey Customer: FLOOD CONTROL	System Owner: MARICOPA COUNTY	Clean Date:	Pre-Cleaned:	rate:

Street:	BUCKEYE I	Flow Control:		MH:	STA.817+00
City:	BUCKEKYE	Year Renewed		MH:	STA. 817+00
Location Code:	Z Other	Tape/Media #:	54-1	pipe length:	170.1 ft

Reason for inspection:	A Maintenance Related	Dia/Ht:	C Circular 12"
Use:	SW Storm Water	Material:	RCP Reinforced concrete pipe Pipe Jt: 10ft
Drainage Area:		Lining Material:	

Remark::

1:425 position code observation photo

STATION: 817+00

STA.817+00 0.00 A Access point

No. 5
Date: 4-15-2003
Time: 13:13
Surveyor: J. Setlin/02-218
City: Buckeye
Street: Buckeye I
Location: Z other
Weather: 1
flow: d/s
Use: SW Storm water.
Material: RCP Reinforced Concrete
Dia/Ht: C circular 18"
pipe joint: 10 ft

STA. 817+00 A Access point DATE

2/4

Pro Pipe Services
2222 W. Grant Street
Phoenix, AZ 85009
Tel: (602)-861-3944, Fax: (602) 861-1423

Inspection report

Date: 20030415	P.O#	Weather: 1	Surveyor/Cert #: J. SETELIN/02-218	section number: 5	PLR:
Tot Pipe Length:	Survey Customer: FLOOD CONTROL	System Owner: MARICOPA COUNTY	Clean Date:	Pre-Cleaned:	rate:

Street:	BUCKEYE I	Flow Control:		MH:	STA.817+00
City:	BUCKEKYE	Year Renewed		MH:	STA. 817+00
Location Code:	Z Other	Tape/Media #:	54-1	pipe length:	170.1 ft

Reason for inspection:	A Maintenance Related	Dia/Ht:	C Circular 12"
Use:	SW Storm Water	Material:	RCP Reinforced concrete pipe Pipe Jt: 10ft
Drainage Area:		Lining Material:	

Remark::

1:425	position	code	observation	photo
STA.817+00	0.00	A	Access point 4.0'	

@ 5.5' feet spider web present.

@ 11.6' - pipe joint - slightly deformed and separated. spider web present.

@ 14.6' spider web

@ 23.2' - pipe joint - slightly deformed and separated spider web. *

@ 35.0' - pipe joint - slightly deformed and separated.

@ 47.0' - pipe joint - slightly deformed and separated.

@ 59.0' - pipe joint - slightly deformed and separated.

STA. 817+00	170.10	A	Access point/GATE	

3/4

Pro Pipe Services
2222 W. Grant Street
Phoenix, AZ 85009
Tel: (602)-861-3944, Fax: (602) 861-1423

Inspection report

Date:	P.O.#	Weather:	Surveyor/Cert #:	section number:	PLR:
20030415		1	J. SETELIN/02-218	5	
Tot Pipe Length:	**Survey Customer:**	**System Owner:**	**Clean Date:**	**Pre-Cleaned:**	**rate:**
	FLOOD CONTROL	MARICOPA COUNTY			

Street:	BUCKEYE I	Flow Control:		MH:	STA.817+00
City:	BUCKEKYE	Year Renewed		MH:	STA. 817+00
Location Code:	Z Other	Tape/Media #:	54-1	pipe length:	170.1 ft

Reason for inspection:	A Maintenance Related	Dia/Ht:	C Circular 12"
Use:	SW Storm Water	Material:	RCP Reinforced concrete pipe Pipe Jt: 10ft
Drainage Area:		Lining Material:	
		:	

Remark::

1:425	position	code	observation	photo
STA.817+00	0.00	A	Access point	
			@ 71.1' - pipe joint - slightly deformed and separated.	
			@ 83.3' - pipe joint - slightly deformed and separated, rope present.	
			@ 94.9' - pipe joint - slightly deformed	
			@ 107.1' - pipe joint - slightly deformed. and separated. Wooden Lath present.	
			@ 119.4' - pipe joint - little more deformed and slightly separated.	
			@ 131.4' - pipe joint - more deformed.	
STA. 817+00	172.10	A	Access point/GATE	

4/4

PRO

Pro Pipe Services
2222 W. Grant Street
Phoenix, AZ 85009
Tel: (602)-861-3944, Fax: (602) 861-1423

Inspection report

Date: 20030415	P.O.#	Weather: 1	Surveyor/Cert #: J. SETELIN/02-218	section number: 5	PLR:
Tot Pipe Length:	Survey Customer: FLOOD CONTROL	System Owner: MARICOPA COUNTY	Clean Date:	Pre-Cleaned:	rate:

Street:	BUCKEYE I	Flow Control:		MH:	STA.817+00
City:	BUCKEKYE	Year Renewed		MH:	STA. 817+00
Location Code: Z Other		Tape/Media #:	54-1	pipe length:	170.1 ft

Reason for inspection:	A Maintenance Related	Dia/Ht:	C Circular 12"
Use:	SW Storm Water	Material:	RCP Reinforced concrete pipe Pipe Jt: 10ft
Drainage Area:		Lining Material:	:

Remark::

1:425 position code observation photo

STA.817+00 0.00 A Access point

@ 143.9' - pipe joint - slightly deformed. uprooted tree is present
many minor cracks present

@ 155.1' - pipe joint - little more deformed and slightly separated.
Spider web.
numerous spider web between 155.5' and 160'

@ 166.6' - pipe joint - slightly deformed
No separation -
Big crack present - 6"
length - upto 4'

Video stopped @ 170.1'

STA. 817+00 170.10 A Access point/GATE

amec

APPENDIX C

GEOPHYSICAL SURVEYS & INTERPRETATIONS

REFRACTION SEISMIC EQUIPMENT & PROCEDURES

Refraction seismic surveys are performed in general conformance with the guidelines presented in ASTM D5777-95 Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation for refraction surveys using compression waves (p-waves). ASTM D5777 does not address shear wave (s-wave) surveys; standard practice is followed for refraction surveys using s-waves. In some investigations, such as seeking and tracing earth fissures or other significant discontinuities (Rucker and Keaton, 1998), non-standard procedures and analyses, such as signal amplitude analysis, are used as part of the investigation process.

Seismic Equipment - Refraction seismic surveys are performed using a Geometrics ES-1225 or Smartseis S-12 signal enhancement seismograph. These instruments have the capability to simultaneously record 12 channels of geophone data and produce hard copies of that data. The Smartseis also has the capability of digitally storing geophone data. Signal enhancement capability permits the use of a sledgehammer as the seismic energy source. A timing sensor is attached to the hammer, and for p-waves, a metal plate is set securely on the ground surface and struck. Generating horizontally polarized s-waves typically involves setting the plate against the end of a wooden plank or railroad tie oriented perpendicular to the axis of the geophone array and striking with a horizontal motion of the sledgehammer. A truck is usually driven onto the plank or tie to effectively couple the plank or tie to the ground.

Because of the signal enhancement capability, signals from several or many strikes can be added together to increase the total signal available relative to noise to obtain the seismic record. Although explosives can also be used as a p-wave seismic energy source, a sledgehammer does not require licenses or permits, or involve special limitations, regulations and liabilities. Explosive energy sources may be needed for long geophone arrays. Geophone cables with 12 geophone takeouts at 10-foot, 20-foot or 20-meter spacings are presently used. Vertical geophones are used to obtain p-wave data and horizontal geophones are used to obtain s-wave data. The seismograph system is extremely portable. In areas where vehicular access is not possible, the equipment can be mobilized by various means, including backpacking, packhorse, helicopter and canoe.

Field Procedures - The field operations are directed by our experienced engineer or geologist, who operates the equipment, prepares the records and examines the data in the field. Refraction seismic lines are generally laid out using the standard spacings on the geophone cables. A maximum depth of investigation of about 75 to 100 feet may be possible using a 300-foot array. For shorter lines with improved near-surface resolution, 10-foot spacings between geophones with a 120-foot array have a maximum depth of investigation of about 30 to 40 feet. Other geophone spacings can also be used. To improve the resolution of near-surface interfaces, energy source positions generally are set at 12.5 feet from the ends of a 25-foot spacing geophone array or at 5 feet from the ends of a 10-foot geophone spacing array. Several shots locations are utilized along the length of an array. When three shots are obtained, there is a foreshot and a backshot at the array ends and a midshot at the array center. The midshot is usually placed midway between the two centermost geophones. When five shots are obtained, the additional shotpoints are located midway between the foreshot-midshot and the midshot-backshot. These multiple shot points permit interpretation of near-surface interfaces at various locations along the array as well as near the endpoints for variable subsurface profiles, and permits more refined overall interpretations of shallow and mid-depth subsurface velocities and interfaces. In cases when both enhanced depth of investigation and improved shallow resolution are needed, multiple 12-geophone arrays are completed end to end and combined into longer composite 24- or more geophone arrays with greater depths of investigation. Additional energy shotpoints are then, at a minimum, performed at the midpoint and far endpoint of each adjacent 12-geophone array to provide seismic energy travel path coverage over the extended array.

amec

REFRACTION SEISMIC EQUIPMENT & PROCEDURES (Cont.)

P-wave data are recorded for general exploration work. S-wave data are also recorded when dynamic subsurface material properties are desired. An s-wave arrival is verified by obtained two sets of horizontal data that are 180 degrees out of phase. The phase reversal is obtained by either reversing the horizontal geophone orientation or reversing the hammer impact direction. Hard copy printouts of all field data are made and inspected as the information is collected. Field notes, including line number and orientation, topographic variations and other notes as appropriate are made on the hard copy printout. Locations and other notes are made on site maps and in notebooks as appropriate. Initial first arrival picks are made in the field and array endpoint arrival times are checked for immediate data adequacy verification as part of the quality control process.

Interpretation - Although preliminary or quality control initial refraction seismic data interpretations may sometimes be performed in the field, full interpretations are completed in the office. At the present time, two interpretation methods are being used; the intercept time method (ITM) and an optimization software routine based on finite difference optimization software. ITM breaks an interpretation into several distinct layers. It is simple, can be performed with a calculator, and can provide excellent interpretations of near surface layer depths and velocities. Optimization provides a continuously variable velocity interpretation through a discrete grid. Interpretations using optimization also indicate zones where interpretation has occurred, thus providing quality control on the depths to which the interpretation can be relied upon. However, the discrete grid used by optimization results in a low resolution near surface interpretation. The combination of both ITM and, when appropriate, optimization methods provides two separate interpretations with complimentary strengths and cross-checking capability. These interpretation methods are applied as appropriate to a particular project.

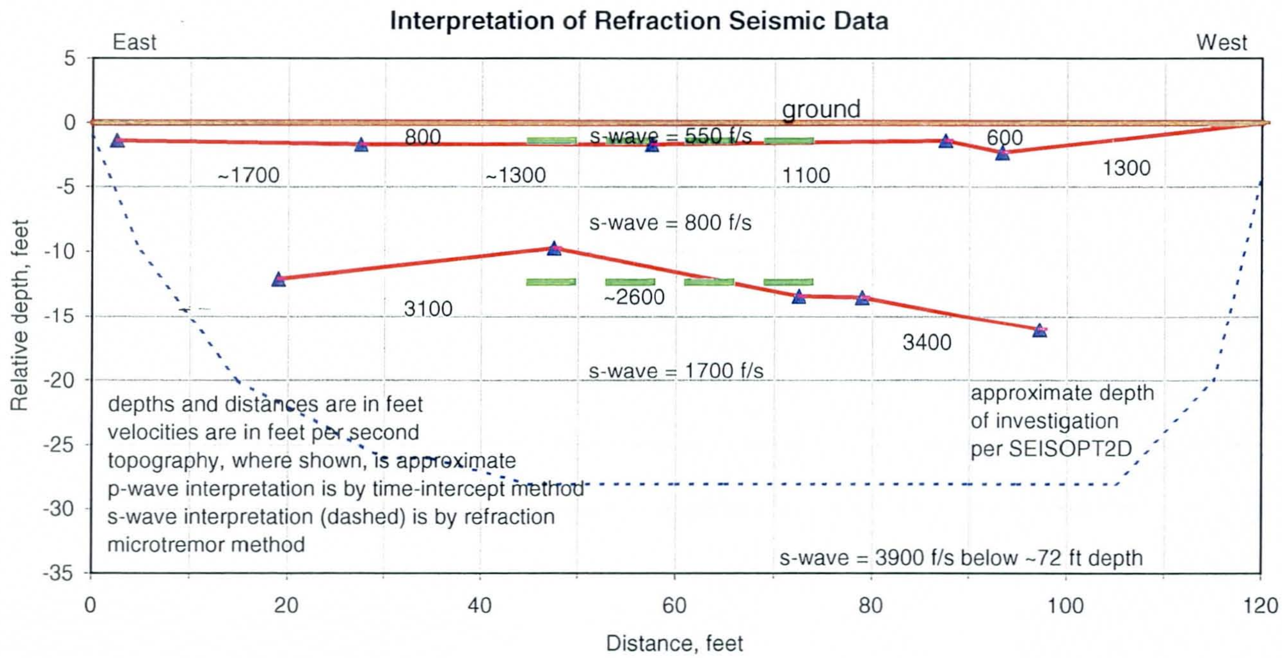
Refraction seismic data interpretation using the intercept time method is detailed by Mooney (1973). A personal computer spreadsheet is used to perform the necessary calculations to obtain depths and layer velocities, and print out time-distance plots and depth interpretations. This method is used for interpretations of up to three layers. It is considered that more than three layers cannot be effectively interpreted using twelve geophone data points. Interpretations are then completed manually to produce a final interpreted geologic profile and layer depths.

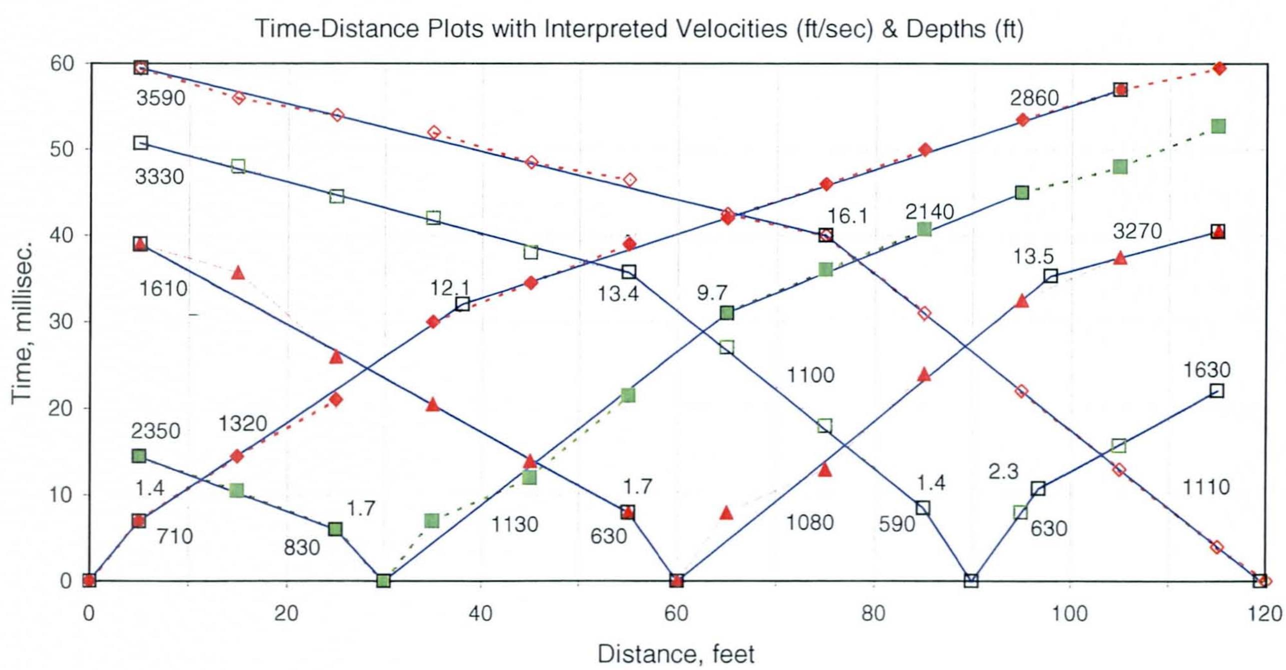
Refraction seismic data interpretation using optimization is performed using the SeisOpt2D software package by Optim, L.L.C., 1999, of Reno, Nevada. Energy source and geophone receiver locations and elevations, and first arrival times are entered into the software package, and first arrival travel times are optimized through a process of repeated (typically 10,000 to 100,000) iterations. Multiple seismic lines combined end to end into a longer composite line can be effectively interpreted using this software. Model grid dimensions and element sizes are selected, with larger grids containing smaller elements providing greater potential resolution. However, very large grids containing small elements may become unstable, and several runs may need to be made to obtain stable, robust interpretations. Once a robust interpretation has been obtained, the resulting seismic velocity profile is printed out with varying colors indicating the interpreted velocities.

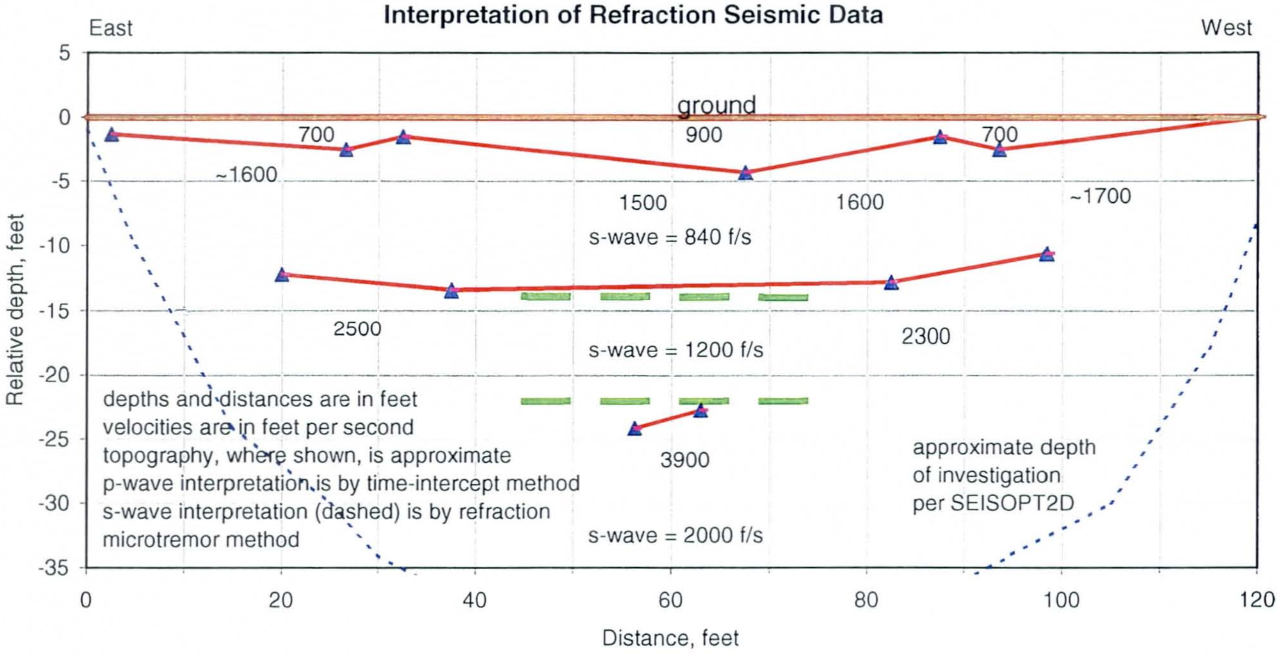
References:

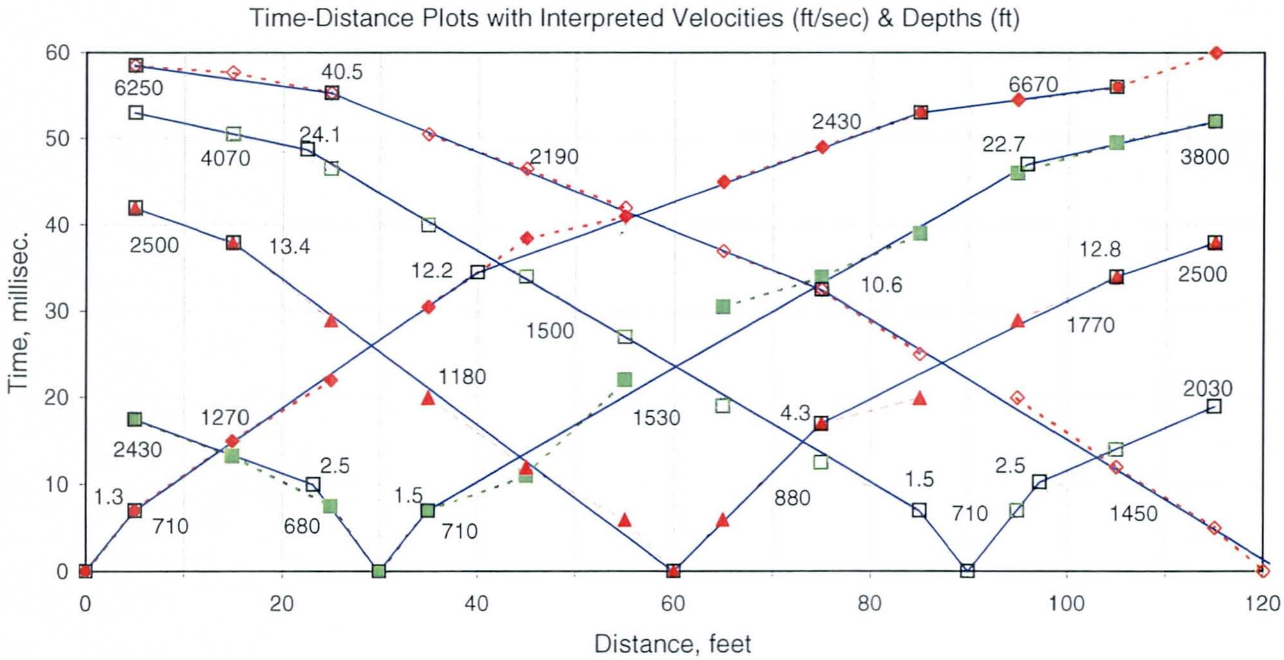
Mooney, H.M., 1973, Engineering Seismology Using Refraction Methods, Bison Instruments, Inc., Minneapolis, Minnesota.

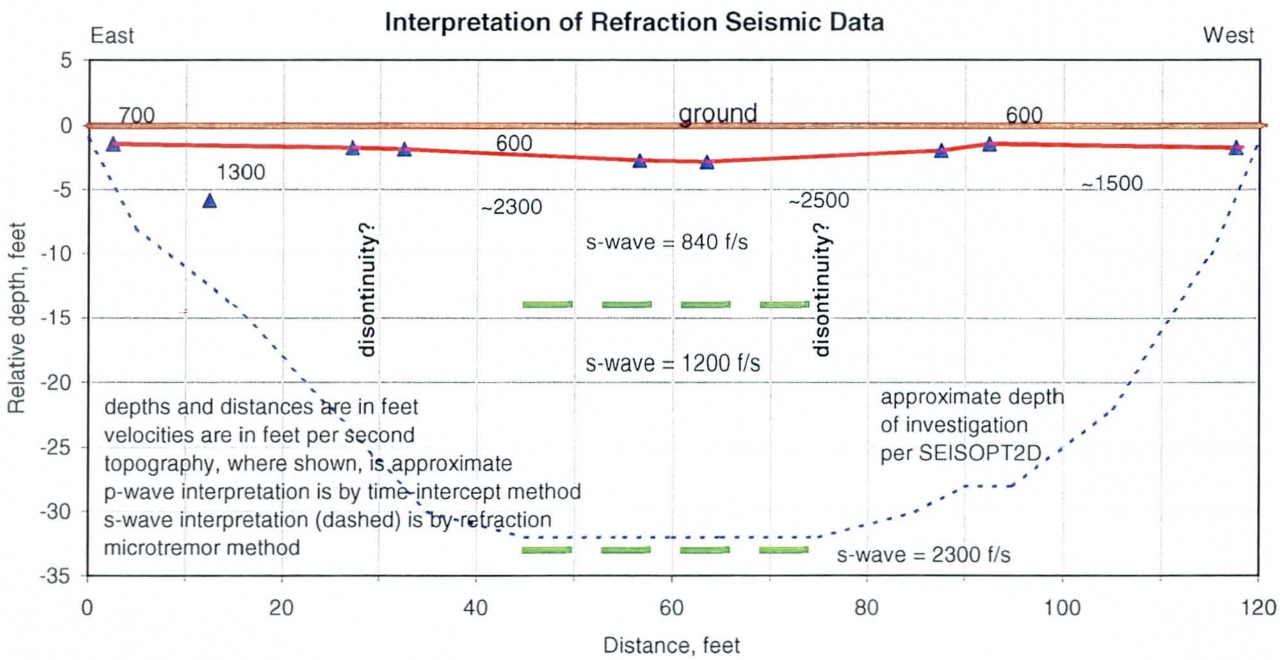
Rucker, M.L. and Keaton, J.R., 1998, Tracing an Earth Fissure Using Seismic-Refraction Methods with Physical Verification, in Land Subsidence Case Studies and Current Research: Proceedings of the Dr. Joseph F. Poland Symposium on Land Subsidence, Edited by Borchers, J.W., Special Publication No. 8, Association of Engineering Geologists, Star Publishing Company, Belmont, California, p. 207-216.

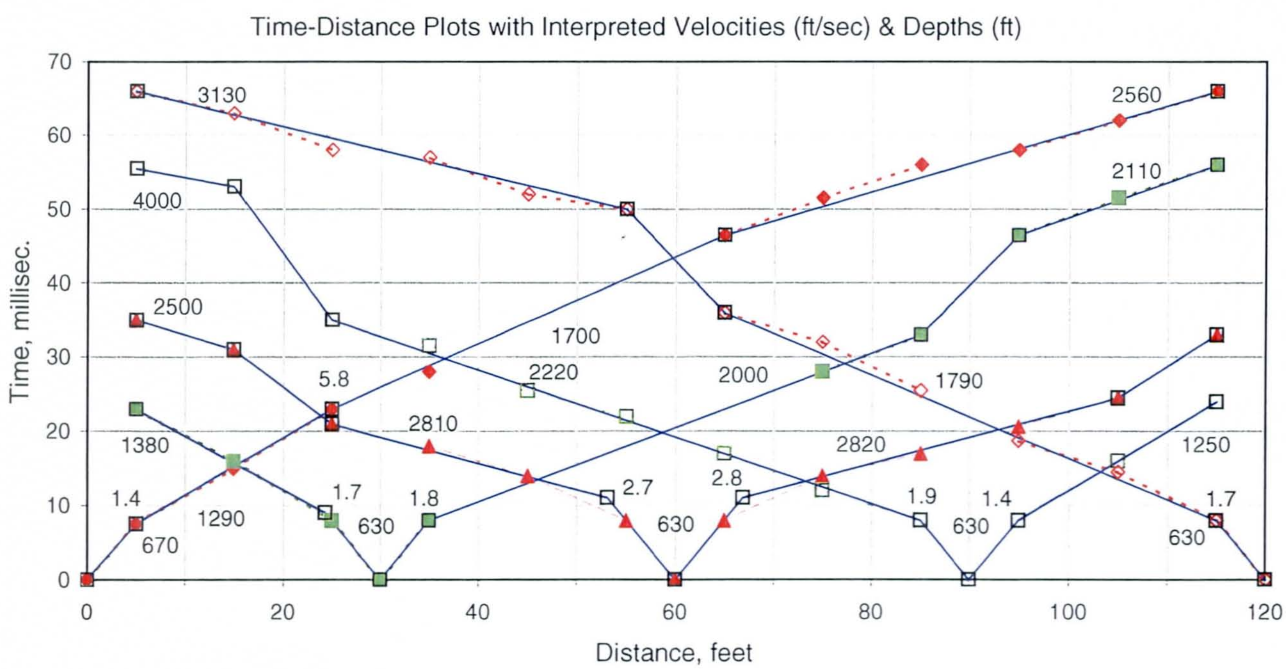

Interpretation of Refraction Seismic Data
East
West
ground
800
s-wave = 550 f/s
600
~1700
~1300
1100
1300
s-wave = 800 f/s
3100
~2600
3400
s-wave = 1700 f/s
depths and distances are in feet
velocities are in feet per second
topography, where shown, is approximate
p-wave interpretation is by time-intercept method
s-wave interpretation (dashed) is by refraction
microtremor method
approximate depth
of investigation
per SEISOPT2D
s-wave = 3900 f/s below ~72 ft depth
Relative depth, feet
Distance, feet

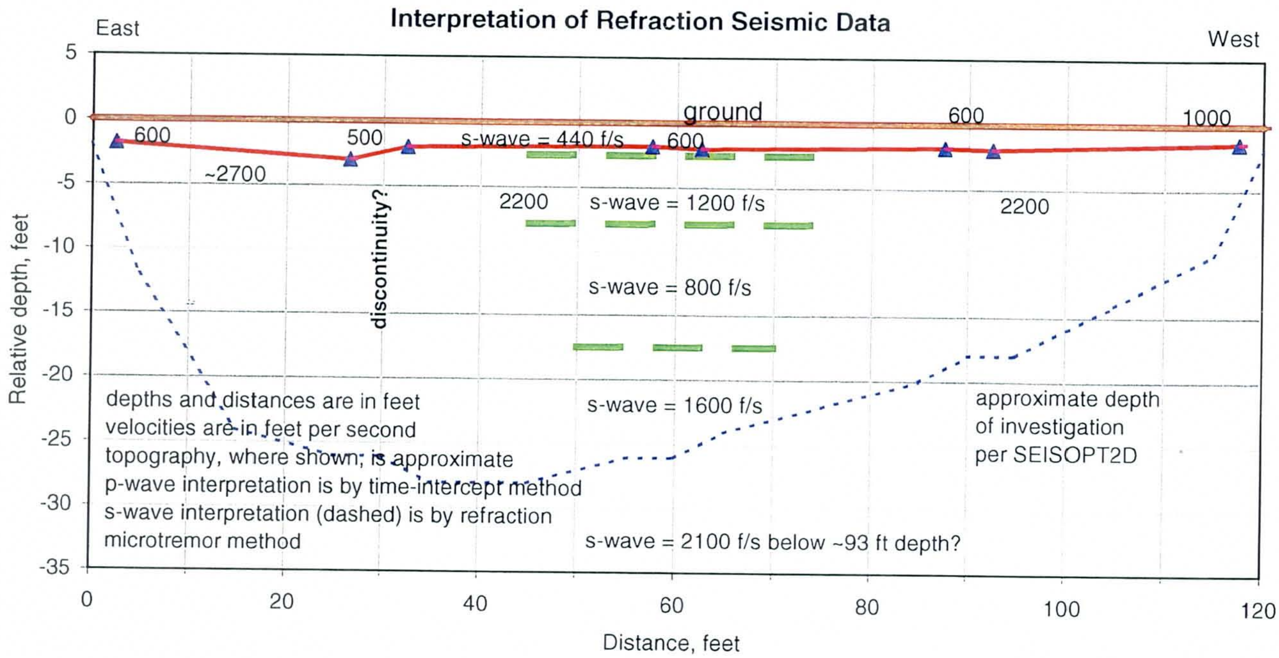

Time-Distance Plots with Interpreted Velocities (ft/sec) & Depths (ft)
3590
2860
3330
16.1
2140
3270
13.5
1610
12.1
13.4
9.7
1100
1630
2350
1320
1.4
1.7
1.7
1.4
2.3
1110
710
830
1130
630
1080
590
630
Time, millisec.
Distance, feet

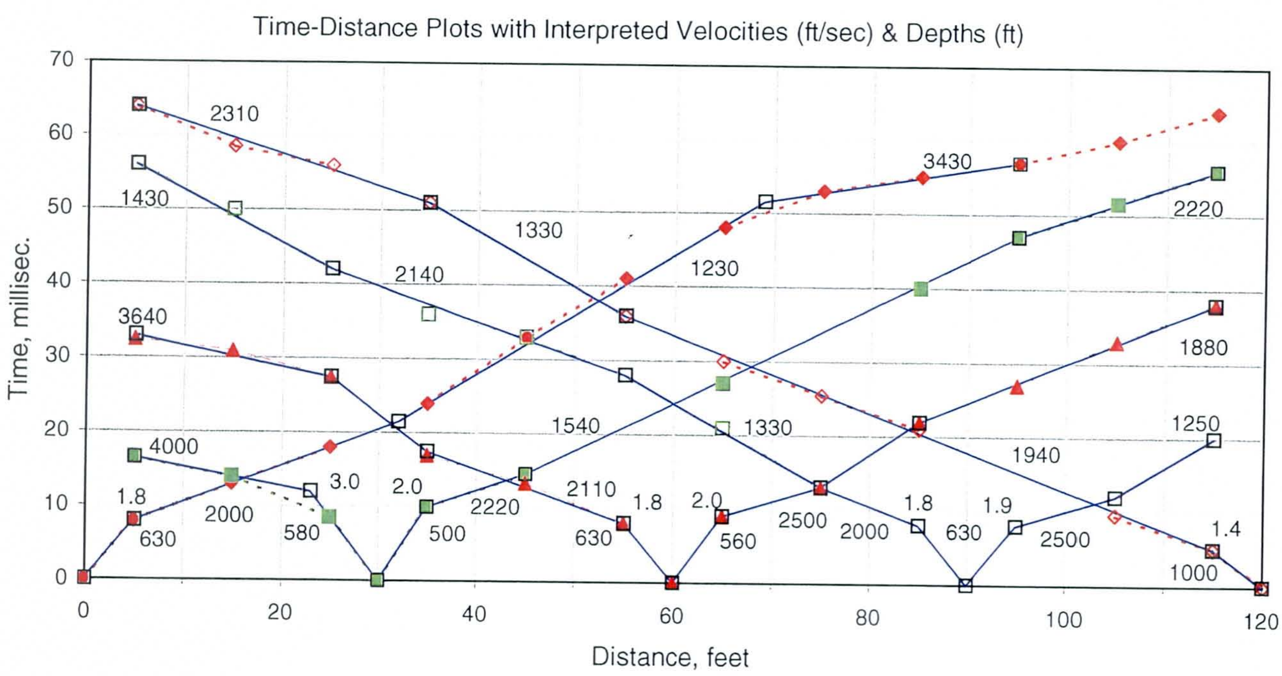

Interpretation of Refraction Seismic Data
East
West
ground
700
900
700
~1600
1500
1600
~1700
s-wave = 840 f/s
2500
s-wave = 1200 f/s
2300
depths and distances are in feet
velocities are in feet per second
topography, where shown, is approximate
p-wave interpretation is by time-intercept method
s-wave interpretation (dashed) is by refraction microtremor method
3900
approximate depth of investigation per SEISOPT2D
s-wave = 2000 f/s
Relative depth, feet
Distance, feet

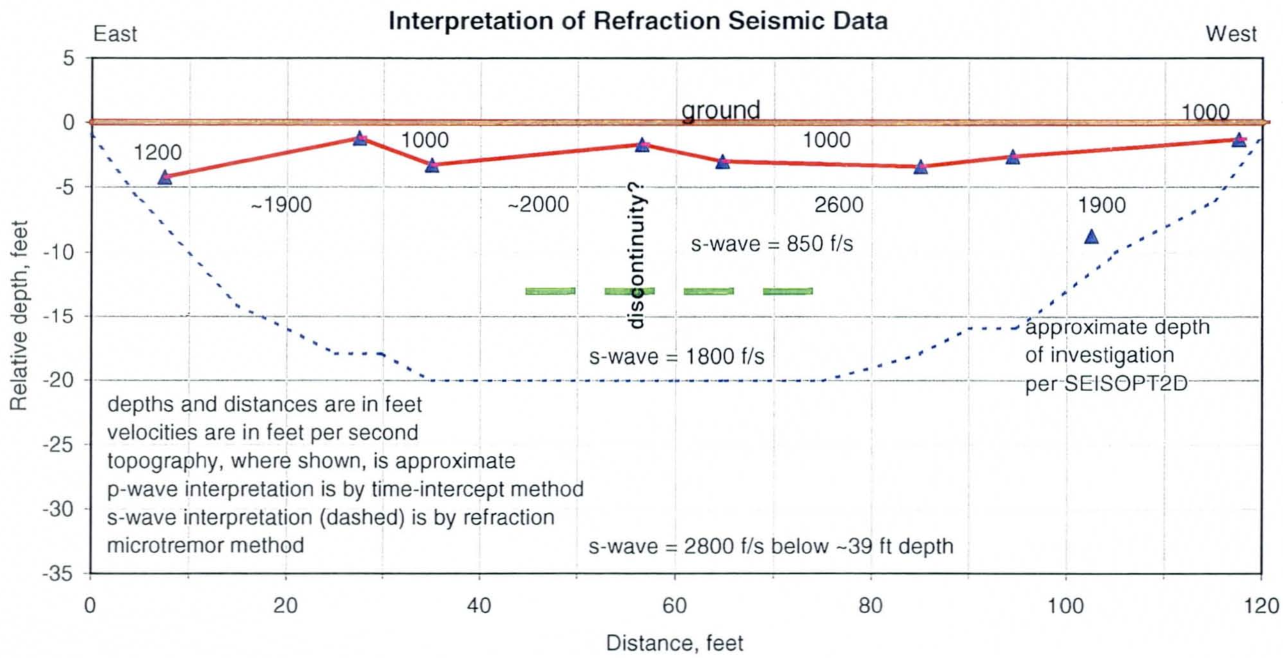

Time-Distance Plots with Interpreted Velocities (ft/sec) & Depths (ft)
6250
40.5
4070
24.1
2190
2430
6670
22.7
3800
2500
13.4
12.2
1500
10.6
12.8
2500
1770
1180
1530
4.3
2030
1270
2430
2.5
1.3
710
680
1.5
710
880
1.5
710
2.5
1450
Time, millisec.
Distance, feet

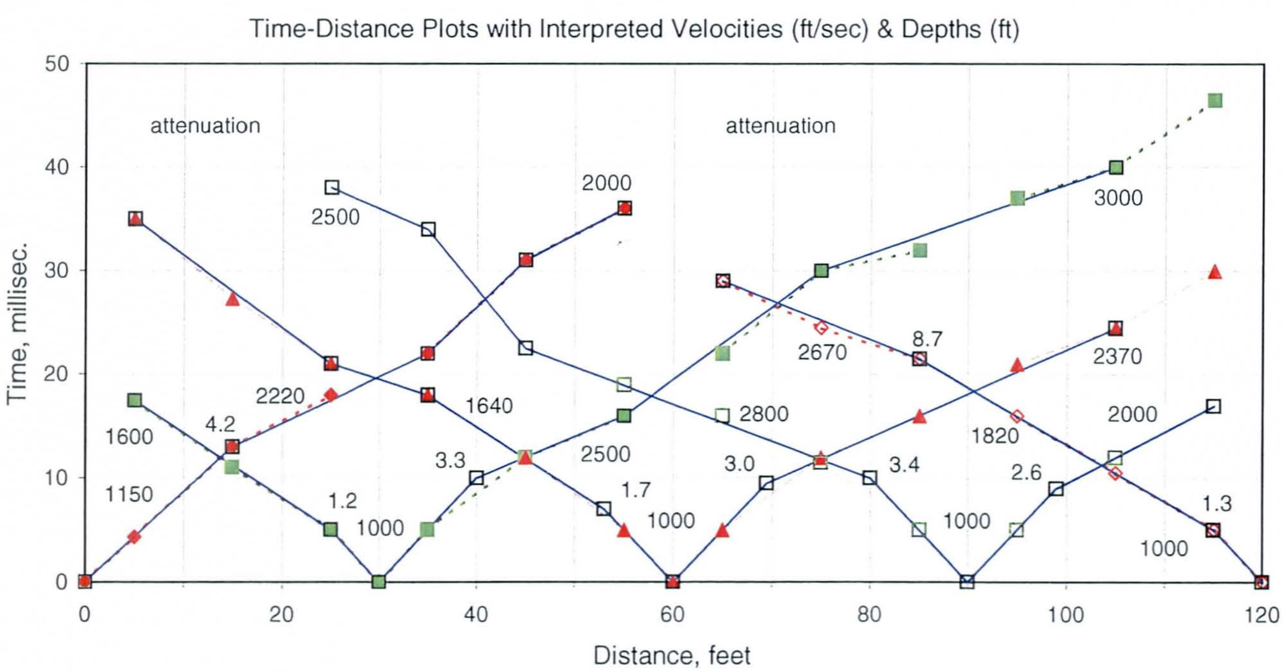

Interpretation of Refraction Seismic Data
East
West
ground
700
600
600
1300
~2300
~2500
~1500
disontinuity?
discontinuity?
s-wave = 840 f/s
s-wave = 1200 f/s
s-wave = 2300 f/s
depths and distances are in feet
velocities are in feet per second
topography, where shown, is approximate
p-wave interpretation is by time-intercept method
s-wave interpretation (dashed) is by refraction microtremor method
approximate depth of investigation per SEISOPT2D
Relative depth, feet
Distance, feet


Time-Distance Plots with Interpreted Velocities (ft/sec) & Depths (ft)
3130
2560
4000
2110
2500
1700
2220
2000
1790
5.8
2810
2820
1380
1250
1.4
1.7
1.8
2.7
2.8
1.9
1.4
1.7
670
1290
630
630
630
630
Time, millisec.
Distance, feet


Interpretation of Refraction Seismic Data
East
West
ground
600
500
600
600
1000
~2700
s-wave = 440 f/s
discontinuity?
2200
s-wave = 1200 f/s
2200
s-wave = 800 f/s
s-wave = 1600 f/s
depths and distances are in feet
velocities are in feet per second
topography, where shown, is approximate
p-wave interpretation is by time-intercept method
s-wave interpretation (dashed) is by refraction microtremor method
approximate depth of investigation per SEISOPT2D
s-wave = 2100 f/s below ~93 ft depth?
Relative depth, feet
Distance, feet


Time-Distance Plots with Interpreted Velocities (ft/sec) & Depths (ft)
2310
3430
1430
1330
2220
2140
1230
3640
1880
1540
1330
1250
4000
1940
1.8
3.0
2.0
2110
1.8
2.0
2500
2000
1.8
1.9
1.4
2000
2220
630
580
500
630
560
630
2500
1000
Time, millisec.
Distance, feet

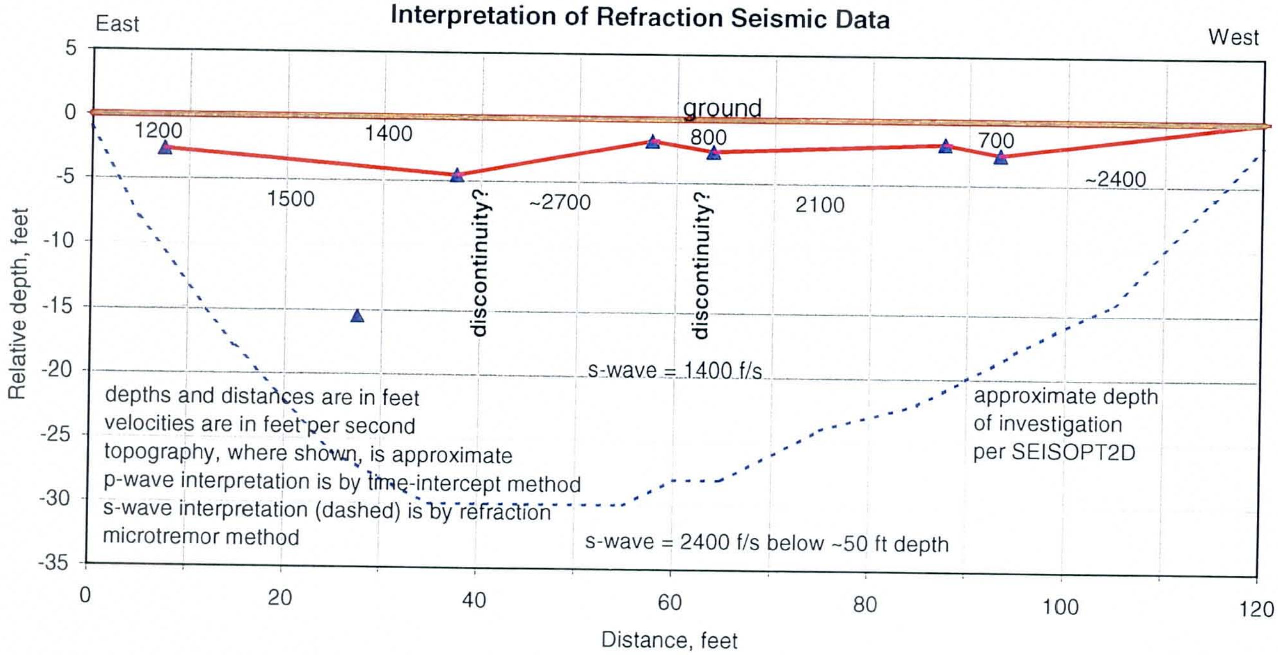

Interpretation of Refraction Seismic Data
East
West
ground
1200
1000
1000
1000
~1900
~2000
2600
1900
discontinuity?
s-wave = 850 f/s
s-wave = 1800 f/s
approximate depth of investigation per SEISOPT2D
depths and distances are in feet
velocities are in feet per second
topography, where shown, is approximate
p-wave interpretation is by time-intercept method
s-wave interpretation (dashed) is by refraction microtremor method
s-wave = 2800 f/s below ~39 ft depth
Relative depth, feet
Distance, feet

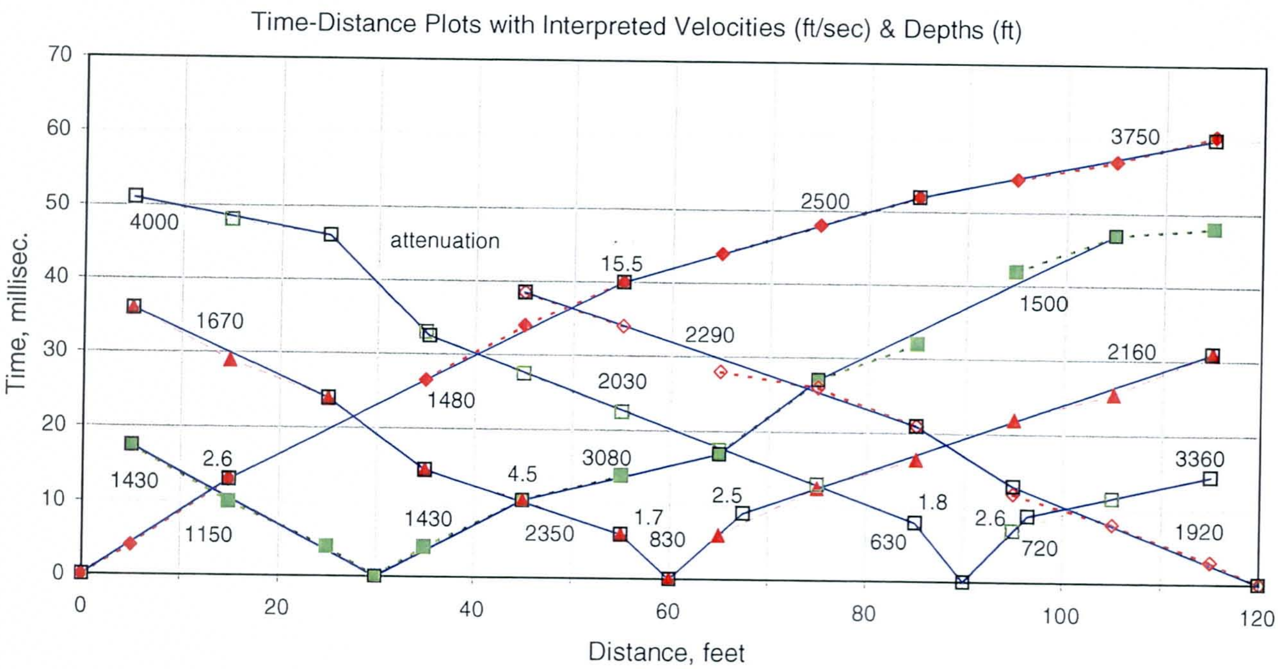

Time-Distance Plots with Interpreted Velocities (ft/sec) & Depths (ft)
attenuation
attenuation
2000
2500
3000
2670
8.7
2370
2220
1640
2800
1820
2000
4.2
1600
3.3
2500
3.0
3.4
2.6
1.3
1150
1.2
1000
1.7
1000
1000
1000
Time, millisec.
Distance, feet

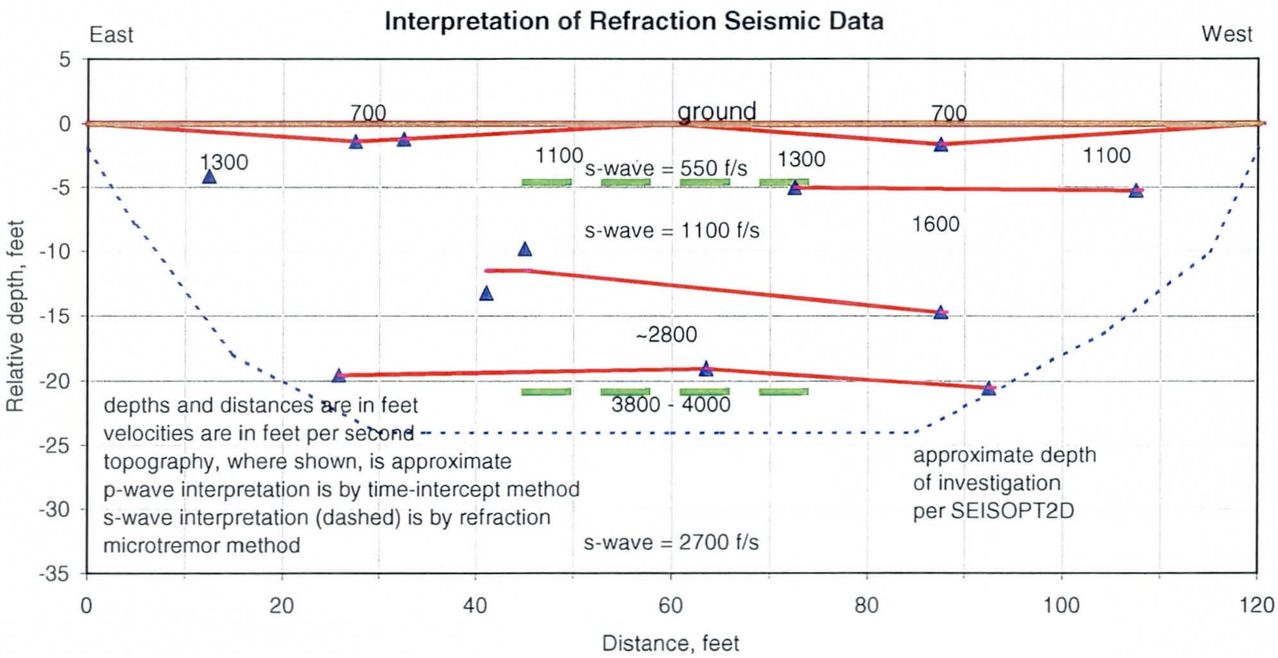
Refraction Seismic Interpretation

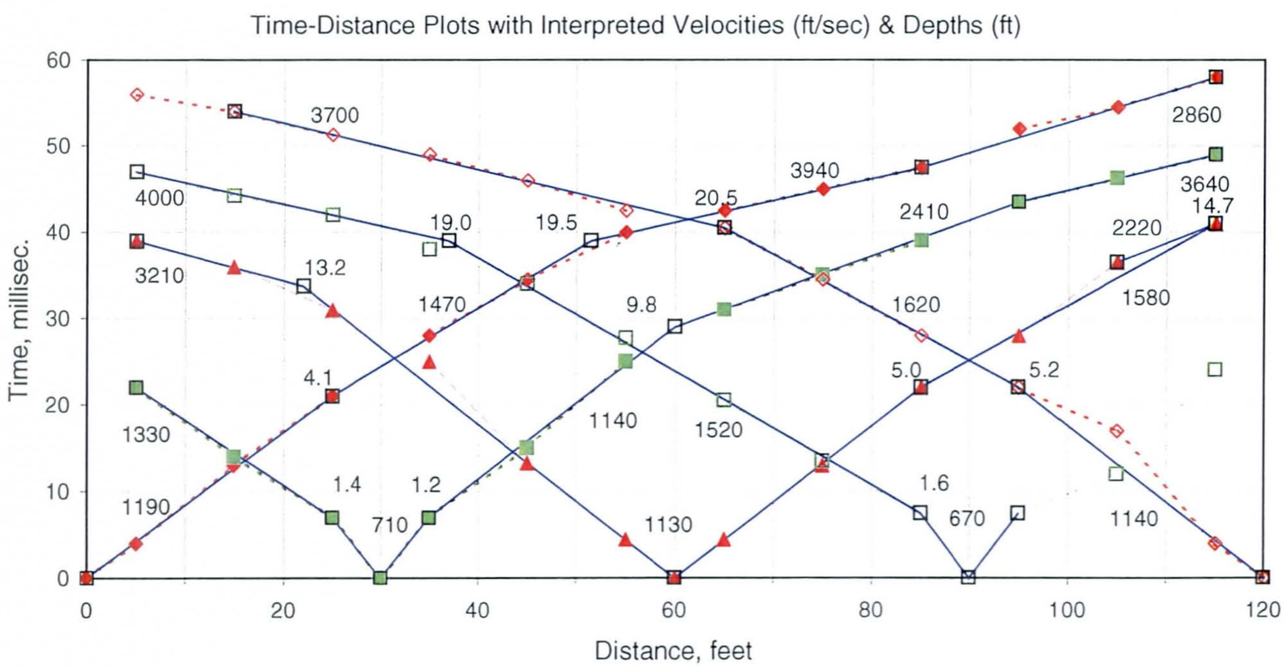
Line 6

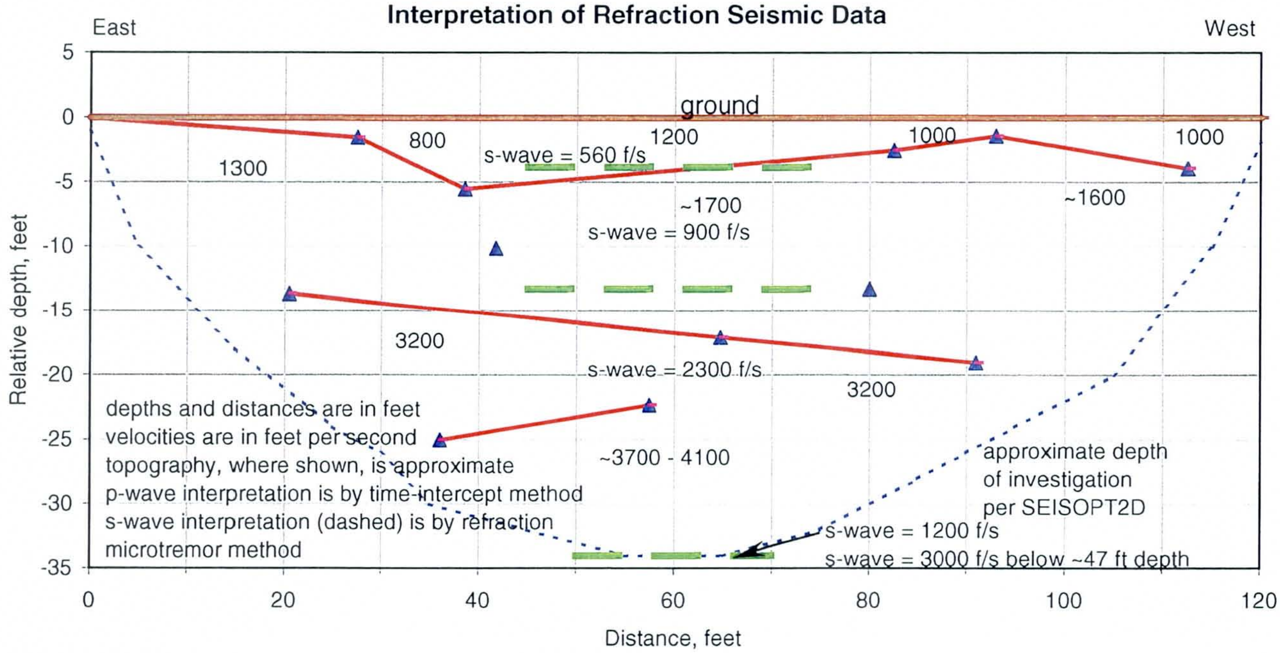
AMEC Job No. 4-117-001021

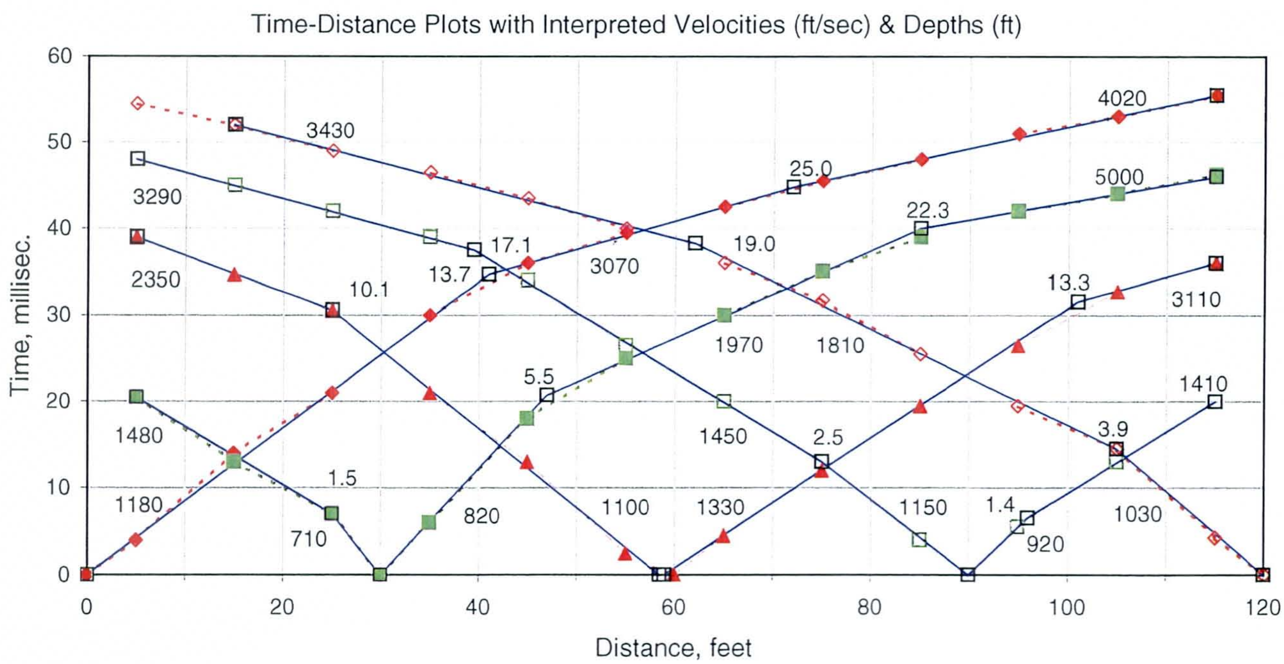





Interpretation of Refraction Seismic Data
East
West
ground
700
700
1300
1100
s-wave = 550 f/s
1300
1100
1600
s-wave = 1100 f/s
~2800
3800 - 4000
depths and distances are in feet
velocities are in feet per second
topography, where shown, is approximate
p-wave interpretation is by time-intercept method
s-wave interpretation (dashed) is by refraction microtremor method
s-wave = 2700 f/s
approximate depth of investigation per SEISOPT2D
Relative depth, feet
Distance, feet


Time-Distance Plots with Interpreted Velocities (ft/sec) & Depths (ft)
3700
2860
4000
3940
3640
20.5
14.7
19.0
19.5
2410
2220
3210
13.2
1470
9.8
1620
1580
4.1
5.0
5.2
1330
1140
1520
1.4
1.2
1.6
1190
710
1130
670
1140
Time, millisec.
Distance, feet


Interpretation of Refraction Seismic Data
East
West
ground
1300
800
1200
1000
1000
s-wave = 560 f/s
~1700
s-wave = 900 f/s
~1600
3200
s-wave = 2300 f/s
3200
~3700 - 4100
depths and distances are in feet
velocities are in feet per second
topography, where shown, is approximate
p-wave interpretation is by time-intercept method
s-wave interpretation (dashed) is by refraction microtremor method
approximate depth of investigation per SEISOPT2D
s-wave = 1200 f/s
s-wave = 3000 f/s below ~47 ft depth
Relative depth, feet
Distance, feet


Time-Distance Plots with Interpreted Velocities (ft/sec) & Depths (ft)
3430
4020
3290
25.0
5000
22.3
2350
10.1
13.7
17.1
3070
19.0
13.3
3110
1970
1810
5.5
1410
1480
1450
2.5
3.9
1.5
1180
820
1100
1330
1150
1.4
1030
710
920
Time, millisec.
Distance, feet

amec

REFRACTION MICROTREMOR (ReMi) SHEAR WAVE EQUIPMENT & PROCEDURES

Refraction microtemor or ReMi surveys are performed in general accordance with the method described by Louie (2001) to develop vertical one-dimensional shear wave (s-wave) velocity profiles. The same equipment used for ReMi is also used for refraction seismic. When appropriate, both p-wave and s-wave data can be collected with the same physical seismic line setup.

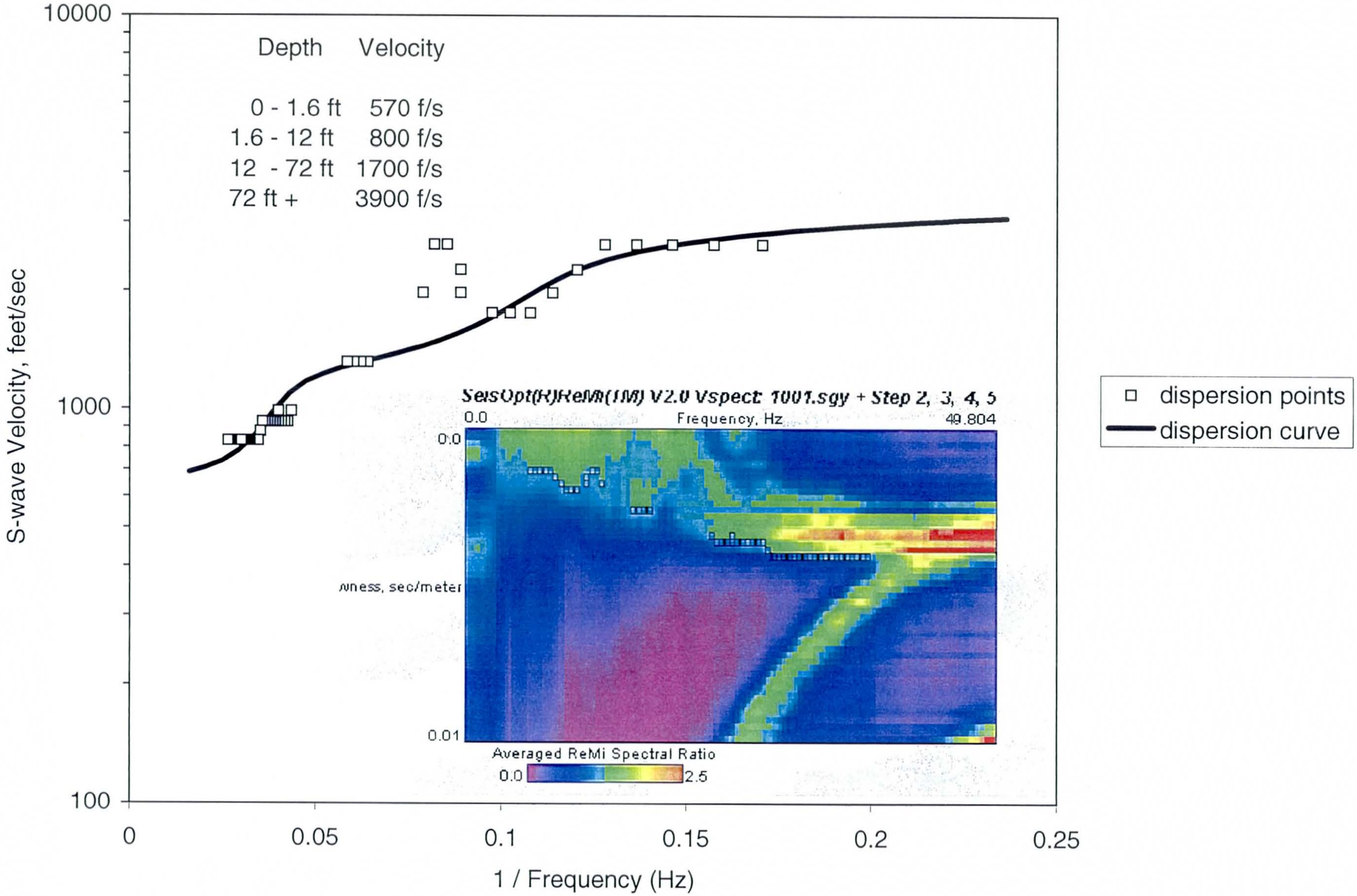
ReMi Seismic Equipment - ReMi surveys are performed using a Geometrics S-12 Smartseis signal enhancement seismograph. This instrument has the capability to digitally record and store up to 12 channels of geophone data in SEG2 format. Up to 16,384 samples can be acquired for each geophone channel at sample intervals as long as 0.25, 0.5, 1 and 2 milliseconds. Sampling events to collect ReMi field data may typically last 6, 12 or 24 seconds. Geophone cables with 12 geophone takeouts at 10-foot or 20-meter spacings are presently used. Vertical geophones with resonant frequencies of 28 Hz and 4.5 Hz are used to obtain surface wave data for s-wave vertical profile analysis. High frequency geophones are used for shorter arrays with shallower depths of investigation, and low frequency geophones are used for longer arrays with greater depths of investigation. Broad band ambient site noise may be used as a surface wave energy source. Controlled surface wave energy sources include jogging alongside shorter geophone arrays and driving a field vehicle alongside longer geophone arrays. The seismograph system is extremely portable. In areas where vehicular access is not possible, the equipment can be mobilized by various means, including backpacking, packhorse, helicopter and canoe.

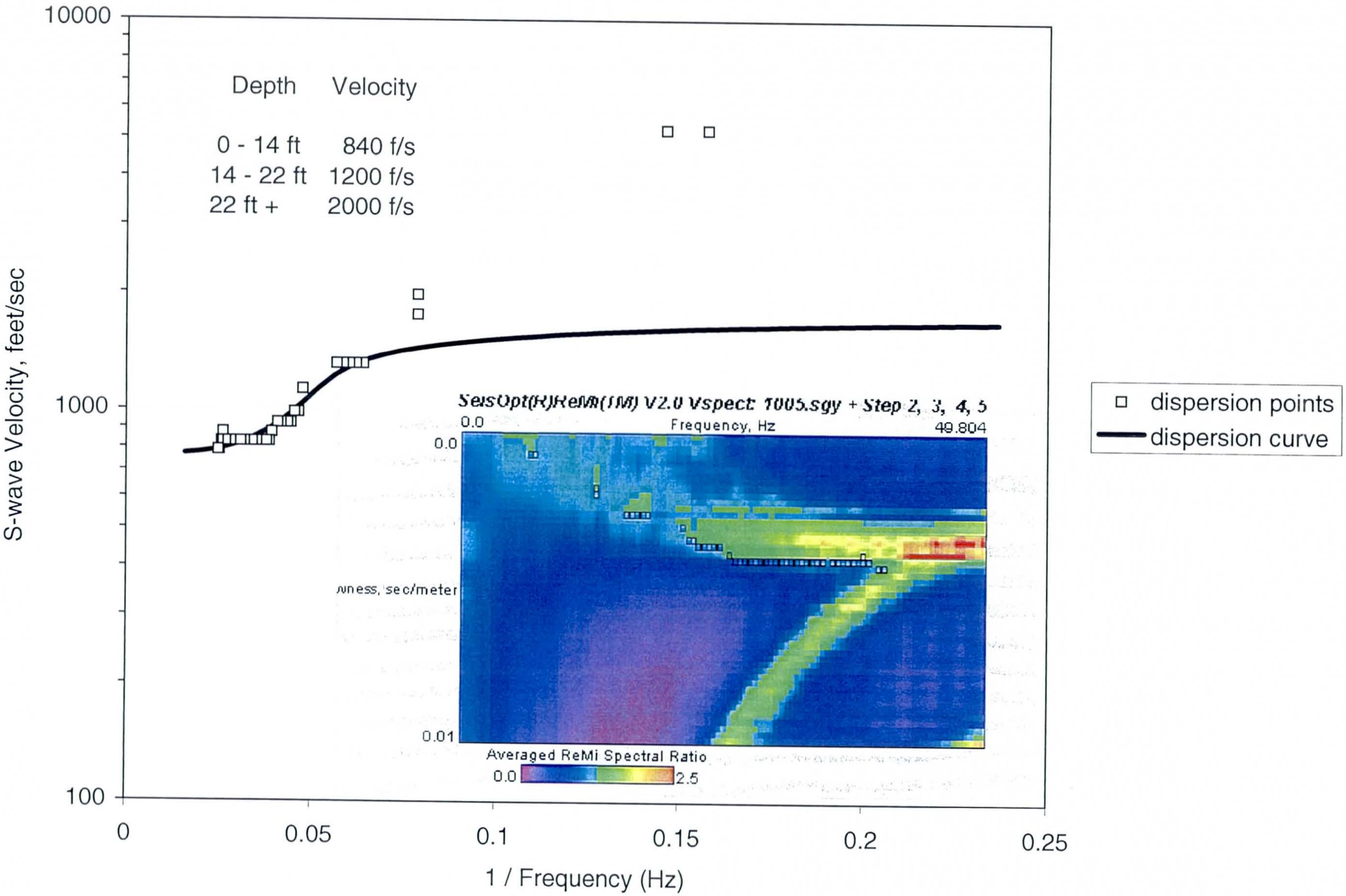
ReMi Field Procedures - - The field operations are directed by our experienced engineer or geologist, who operates the equipment, prepares the records and examines the data in the field. ReMi seismic lines are generally laid out using the standard spacings on the geophone cables. A depth of investigation of about 100 meters or more may be possible using a 240 meter array. For shorter lines with improved near-surface resolution, 10-foot spacings between geophones with a 120-foot array have a depth of investigation of about 30 to 40 feet or more. Other geophone spacings can also be used.

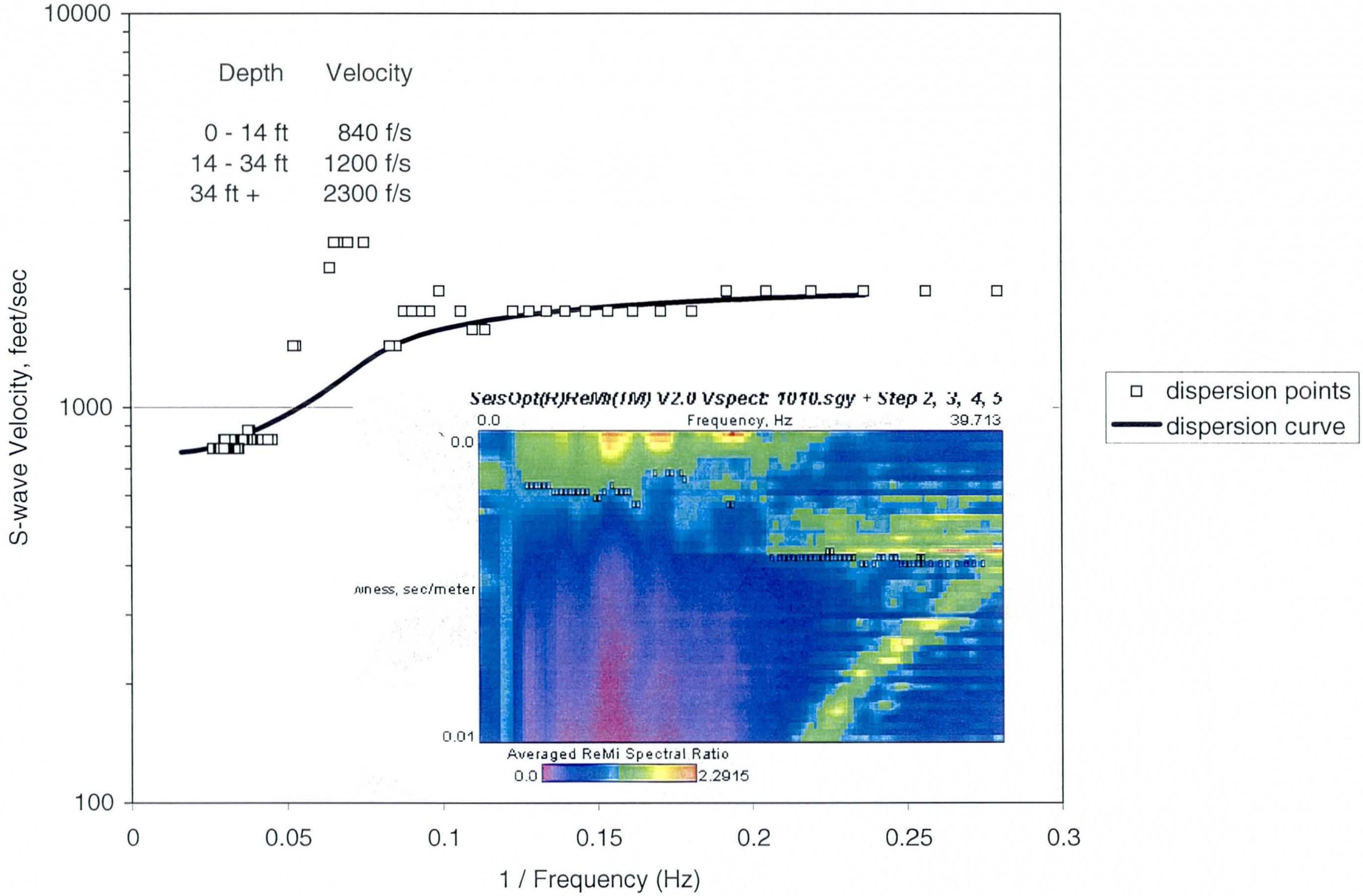
Data collection consists of the system sampling the ambient or generated surface waves (a sampling event) at the geophone array for several to many seconds. Typical sampling times and intervals for a sampling event may be 6 seconds at 0.5 milliseconds, 12 seconds at 1 millisecond and 24 seconds at 2 milliseconds for array lengths of 60 feet, 120 feet and 240 meters, respectively. Several sampling events are collected at each ReMi setup. For shorter arrays where ReMi with surface wave energy generated by jogging is conducted in concert with seismic refraction data collection, four sampling events may typically be recorded. For longer arrays where urban ambient noise or a field vehicle generates the surface wave energy, six to ten sampling events may be recorded. Field notes, including line number and orientation, topographic variations and other notes as appropriate are made on hard copy of traces. Locations and other notes are made on site maps and in notebooks as appropriate. Sample data files may be transferred by 3.5-inch floppy to the laptop computer and preliminary interpretations made for immediate data adequacy verification as part of the quality control process.

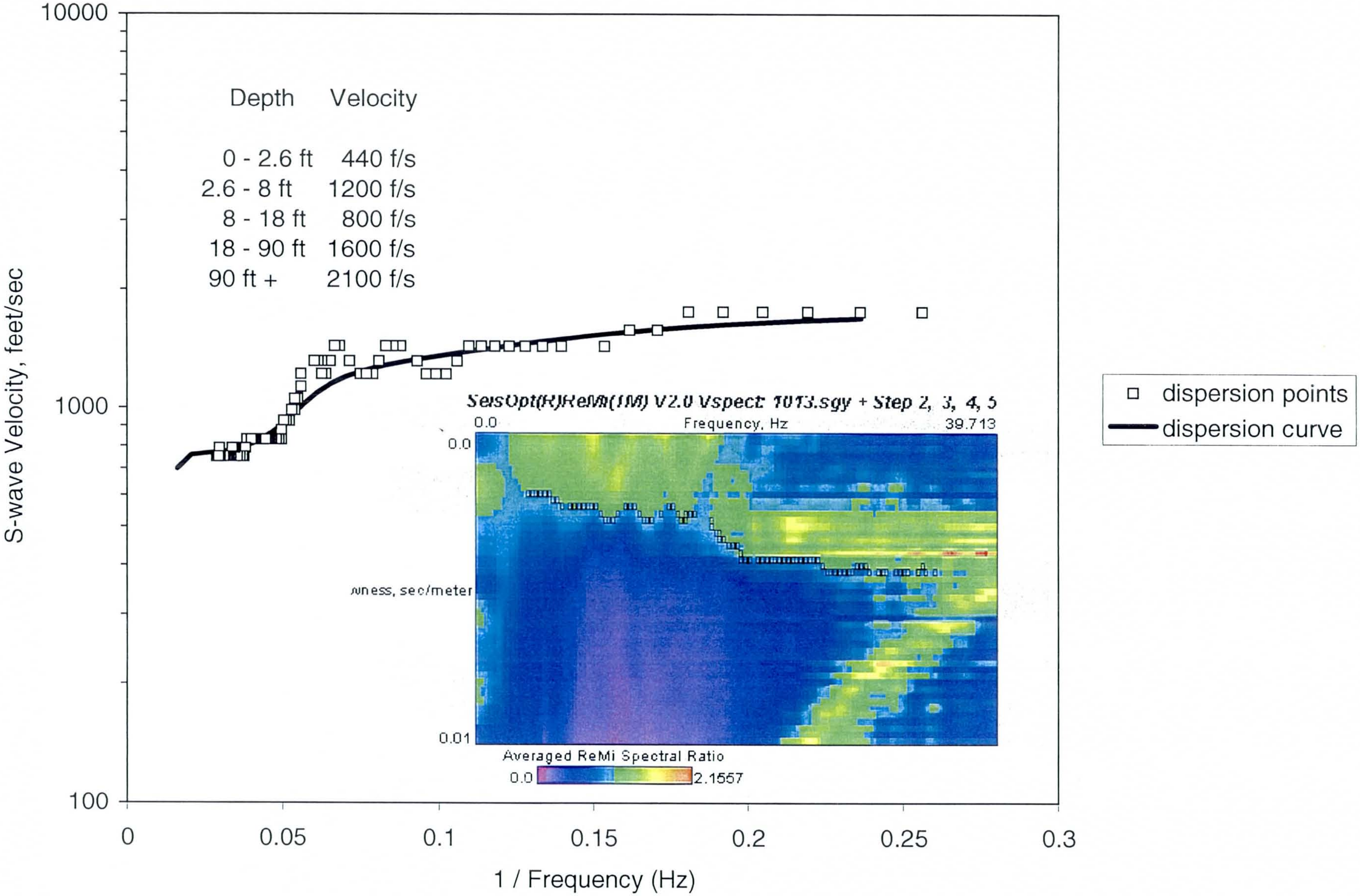
Interpretation - Although preliminary or quality control initial ReMi seismic data interpretations may sometimes be performed in the field, full interpretations are completed in the office. Data files, typically about 580kb each in size, are transferred from the seismograph to the laptop computer using 3.5-inch floppy disks. Interpretation is performed using the SeisOpt ReMi Version 1.0 (2002) software package by Optim, L.L.C., of Reno, Nevada. The software consists of two modules. The ReMiVsSpect module is used to convert the SEG2 files into a spectral energy shear wave frequency versus shear wave velocity presentation for a ReMi seismic setup. The interpreter then selects a dispersion curve consisting of the lower bound of the spectral energy shear wave velocity versus frequency trend, and that dispersion curve is saved to disk. Tracing the lower bound (slowest) of the shear wave velocity at each frequency selects the ambient energy propagating parallel to the geophone array, since energy propagating incident to the array will appear to have a faster propagating velocity. The second module, ReMiDisper, is then invoked. The interpreter models a dispersion curve with multiple layers and s-wave velocities to match the selected dispersion curve from the field data. An interpreted vertical s-wave profile is obtained through this process. It must be understood that this type of interpretation may not result in a unique solution.

Louie, J.L., 2001, Faster, Better: Shear-wave velocity to 100 meters depth from refraction microtremor arrays, Bulletin of the Seismological Society of America, Vol. 91, 347-364.

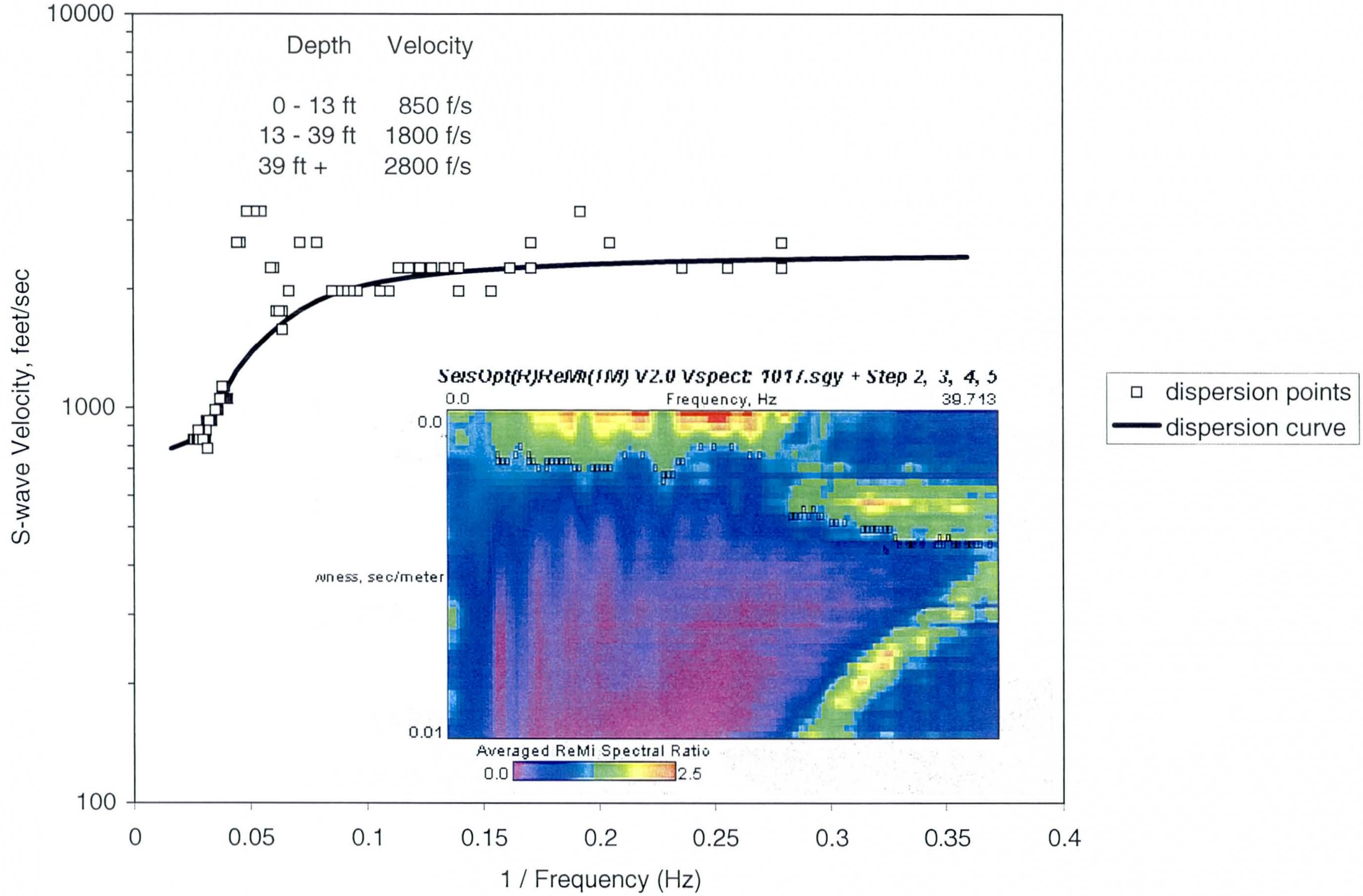

Depth Velocity
0 - 1.6 ft 570 f/s
1.6 - 12 ft 800 f/s
12 - 72 ft 1700 f/s
72 ft + 3900 f/s
10000
1000
100
S-wave Velocity, feet/sec
0
0.05
0.1
0.15
0.2
0.25
1 / Frequency (Hz)
SeisOpt(R)ReMi(TM) V2.0 Vspect: 1001.sgy + Step 2, 3, 4, 5
0.0
Frequency, Hz
49.804
0.0
wness, sec/meter
0.01
Averaged ReMi Spectral Ratio
0.0
2.5
dispersion points
dispersion curve


Depth Velocity
0 - 14 ft 840 f/s
14 - 22 ft 1200 f/s
22 ft + 2000 f/s
S-wave Velocity, feet/sec
10000
1000
100
0
0.05
0.1
0.15
0.2
0.25
1 / Frequency (Hz)
dispersion points
dispersion curve
SeisOpt(R)ReMi(TM) V2.0 Vspect: 1005.sgy + Step 2, 3, 4, 5
Frequency, Hz
0.0
49.804
0.0
0.01
wness, sec/meter
Averaged ReMi Spectral Ratio
0.0
2.5

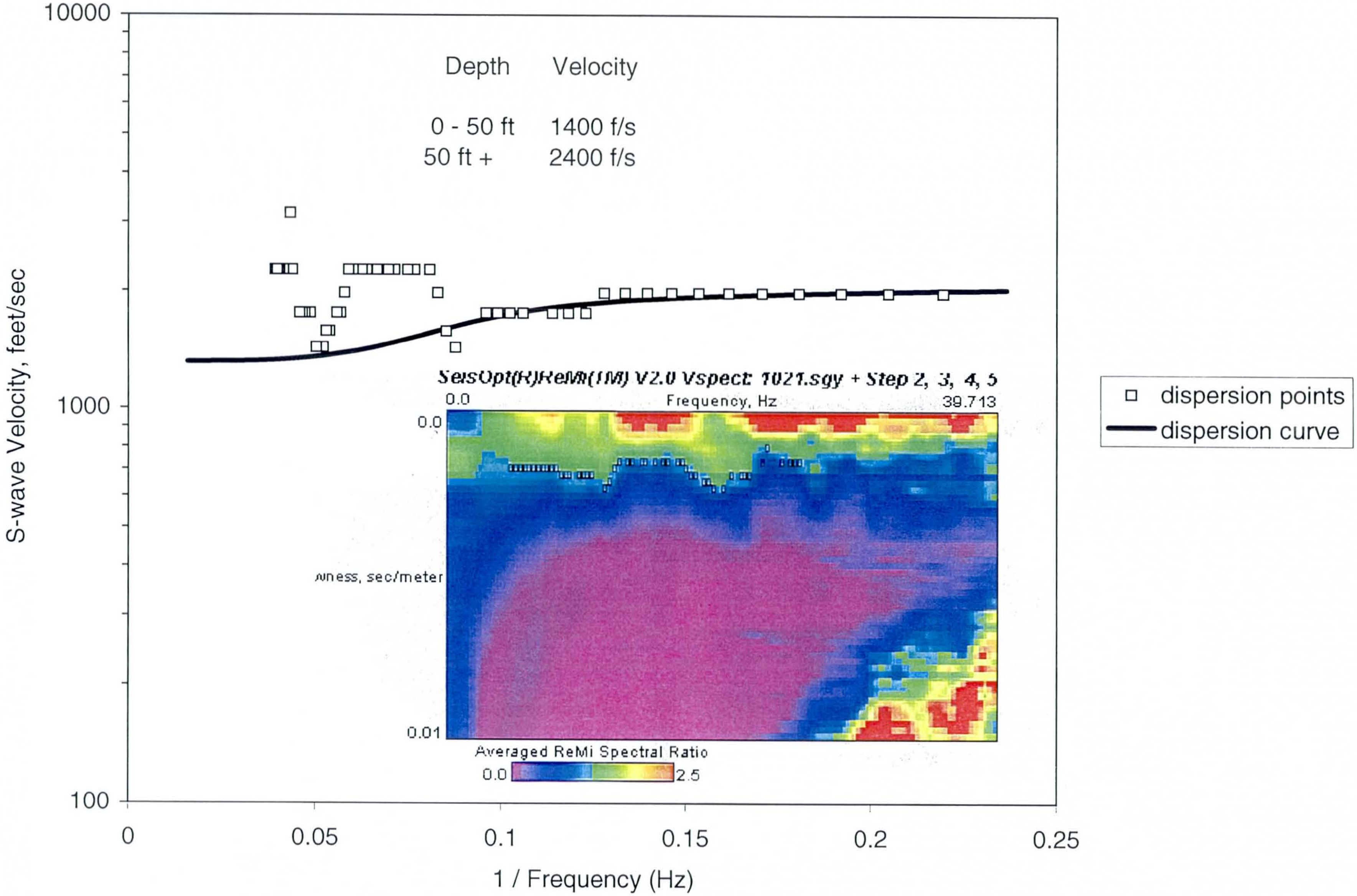

10000
1000
100
S-wave Velocity, feet/sec
Depth Velocity
0 - 14 ft 840 f/s
14 - 34 ft 1200 f/s
34 ft + 2300 f/s
0
0.05
0.1
0.15
0.2
0.25
0.3
1 / Frequency (Hz)
dispersion points
dispersion curve
Frequency, Hz
0.0
39.713
0.01
Averaged ReMi Spectral Ratio
2.2915


Depth Velocity
0 - 2.6 ft 440 f/s
2.6 - 8 ft 1200 f/s
8 - 18 ft 800 f/s
18 - 90 ft 1600 f/s
90 ft + 2100 f/s
S-wave Velocity, feet/sec
1 / Frequency (Hz)
10000
1000
100
0
0.05
0.1
0.15
0.2
0.25
0.3
dispersion points
dispersion curve
Frequency, Hz
39.713
0.01
Averaged ReMi Spectral Ratio
2.1557

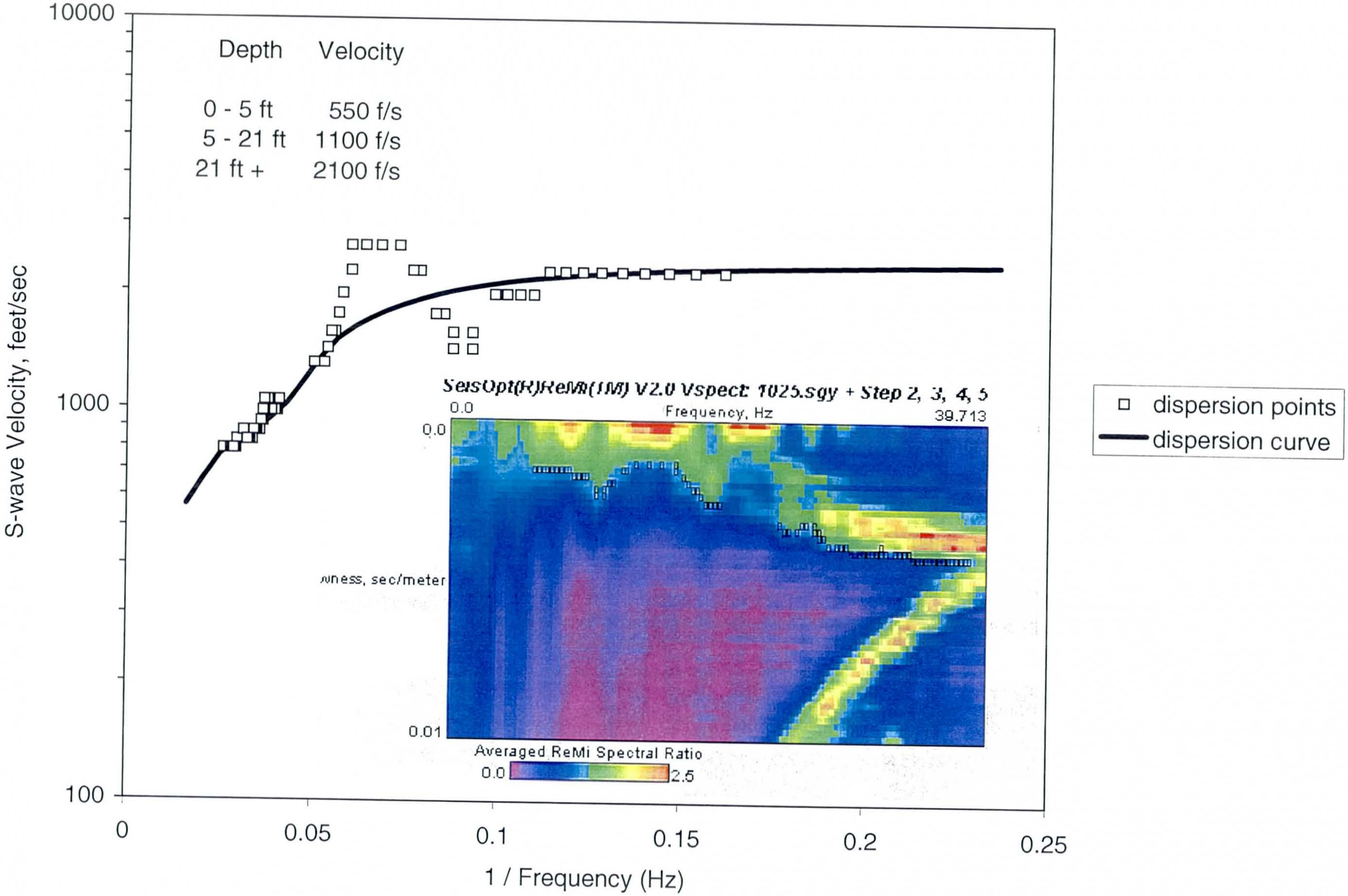
Line 5

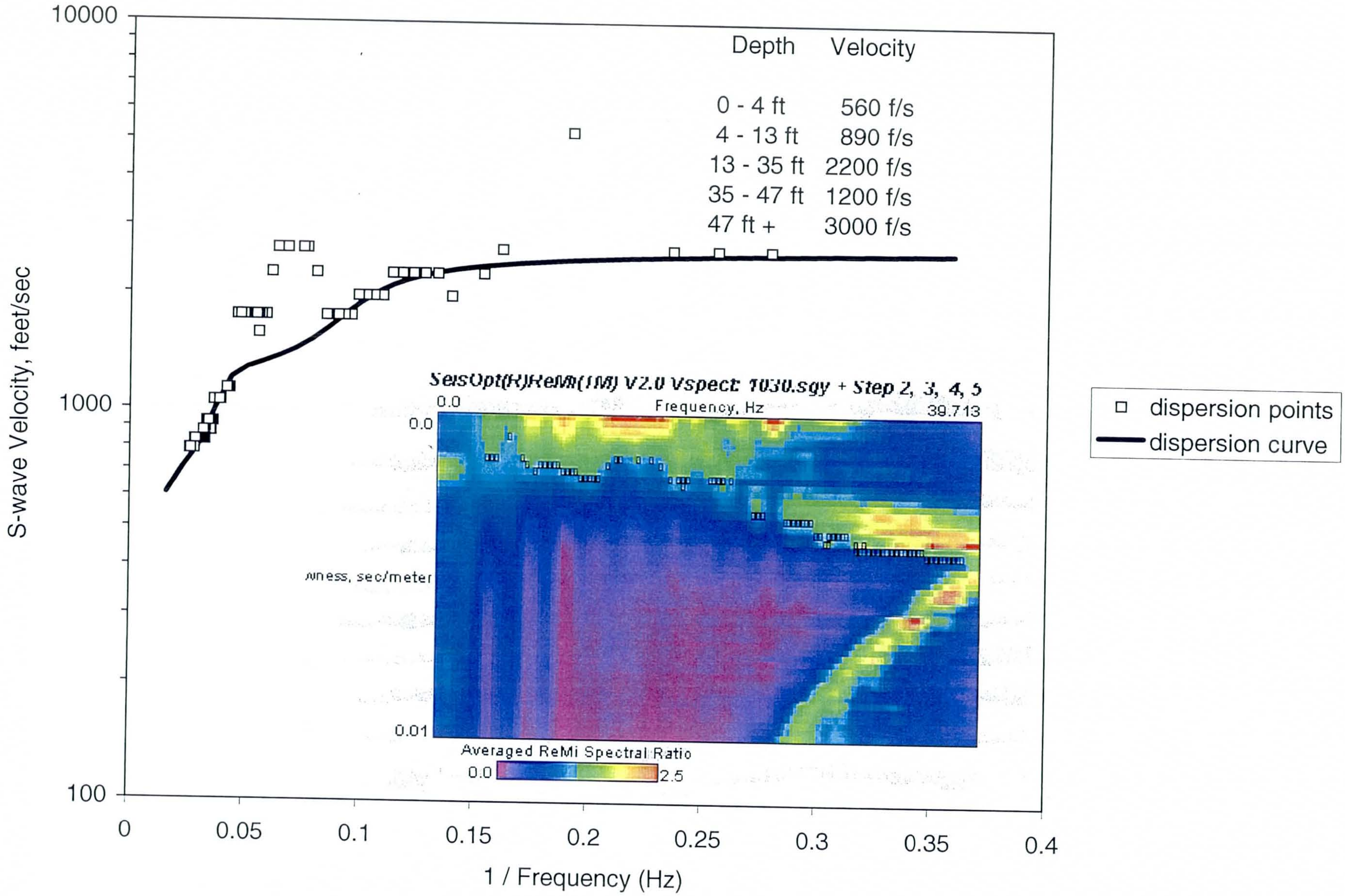


Depth Velocity
0 - 13 ft 850 f/s
13 - 39 ft 1800 f/s
39 ft + 2800 f/s
S-wave Velocity, feet/sec
1 / Frequency (Hz)
10000
1000
100
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
dispersion points
dispersion curve
Frequency, Hz
0.0
39.713
0.01
Averaged ReMi Spectral Ratio
2.5


Depth
Velocity
0 - 50 ft
1400 f/s
50 ft +
2400 f/s
S-wave Velocity, feet/sec
10000
1000
100
0
0.05
0.1
0.15
0.2
0.25
1 / Frequency (Hz)
dispersion points
dispersion curve
SeisOpt(R)ReMi(TM) V2.0 Vspect: 1021.sgy + Step 2, 3, 4, 5
0.0
Frequency, Hz
39.713
wness, sec/meter
0.01
Averaged ReMi Spectral Ratio
2.5

Line 7

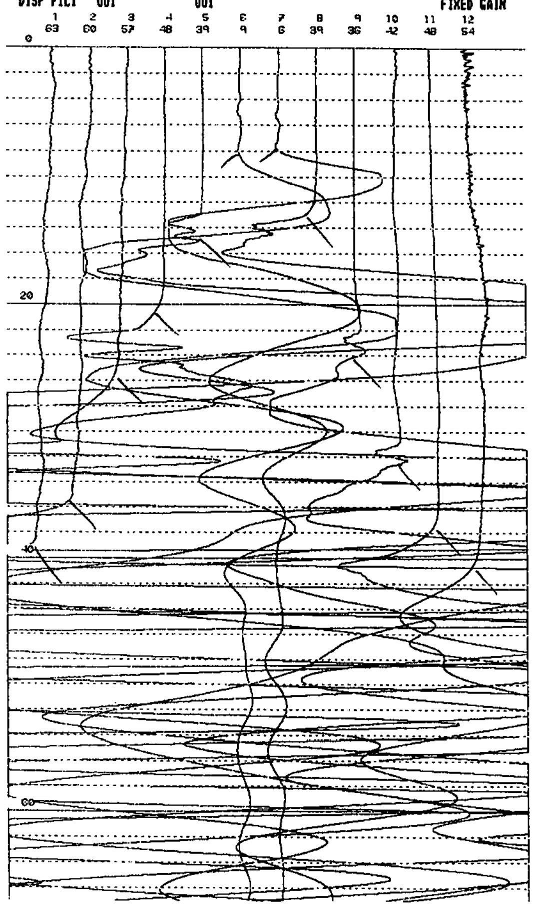

Depth Velocity
0 - 5 ft 550 f/s
5 - 21 ft 1100 f/s
21 ft + 2100 f/s
10000
1000
100
S-wave Velocity, feet/sec
0
0.05
0.1
0.15
0.2
0.25
1 / Frequency (Hz)
dispersion points
dispersion curve
SeisOpt(R)ReMi(TM) V2.0 Vspect: 1025.sgy + Step 2, 3, 4, 5
0.0
Frequency, Hz
39.713
0.0
0.01
Averaged ReMi Spectral Ratio
0.0
2.5


10000
1000
100
S-wave Velocity, feet/sec
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
1 / Frequency (Hz)
Depth
Velocity
0 - 4 ft
560 f/s
4 - 13 ft
890 f/s
13 - 35 ft
2200 f/s
35 - 47 ft
1200 f/s
47 ft +
3000 f/s
SeisOpt(R)ReMi(TM) V2.0 Vspect: 1030.sgy + Step 2, 3, 4, 5
0.0
Frequency, Hz
39.713
0.0
wness, sec/meter
0.01
Averaged ReMi Spectral Ratio
0.0
2.5
dispersion points
dispersion curve

L1
ms

GEOMETRICS StrataView

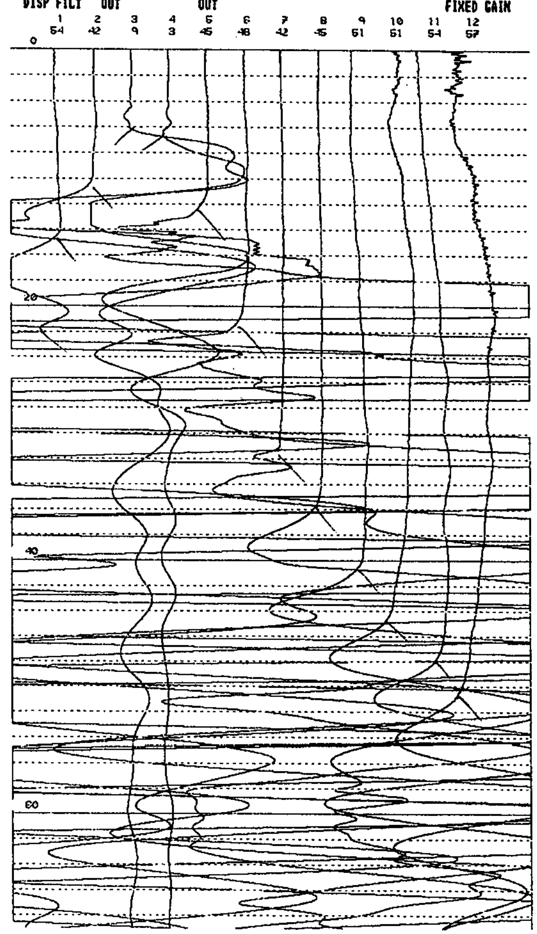
UNSAVED STACKED DATA 10:32:12 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



L1
Fms

GEOMETRICS StrataView

UNSAVED STACKED DATA 10:33:41 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



Buckeye #1

L1
FS

ReMi
1ft 550 f/s
1.4'
800
12.3'
1730,
72
3890

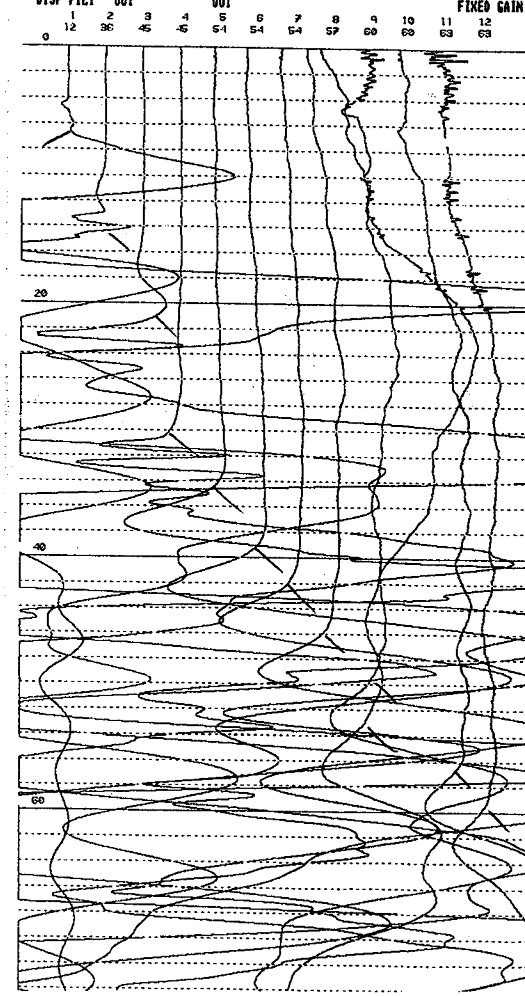
4-1021

~720+20
@ upstrm toe
E
1001-1004

W

GEOMETRICS StrataView

UNSAVED STACKED DATA 10:35:35 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN

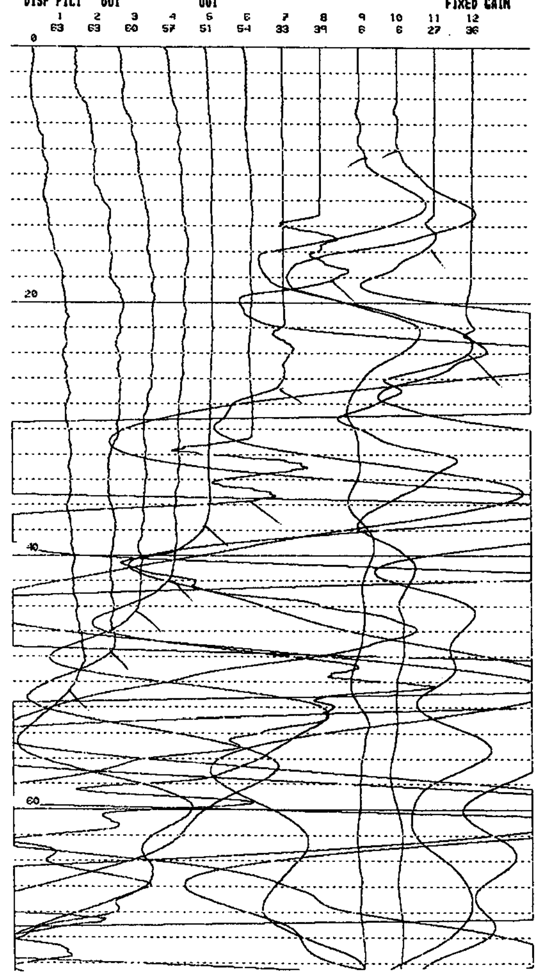


Line 1

L1
BmS

GEOMETRICS StrataView

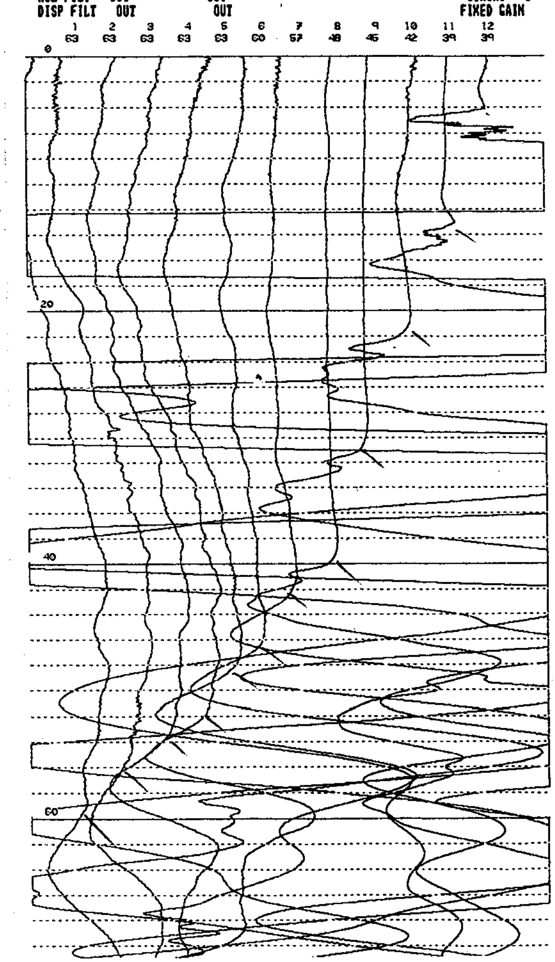
UNSAVED STACKED DATA 10:30:36 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



L1
BS
4-1021

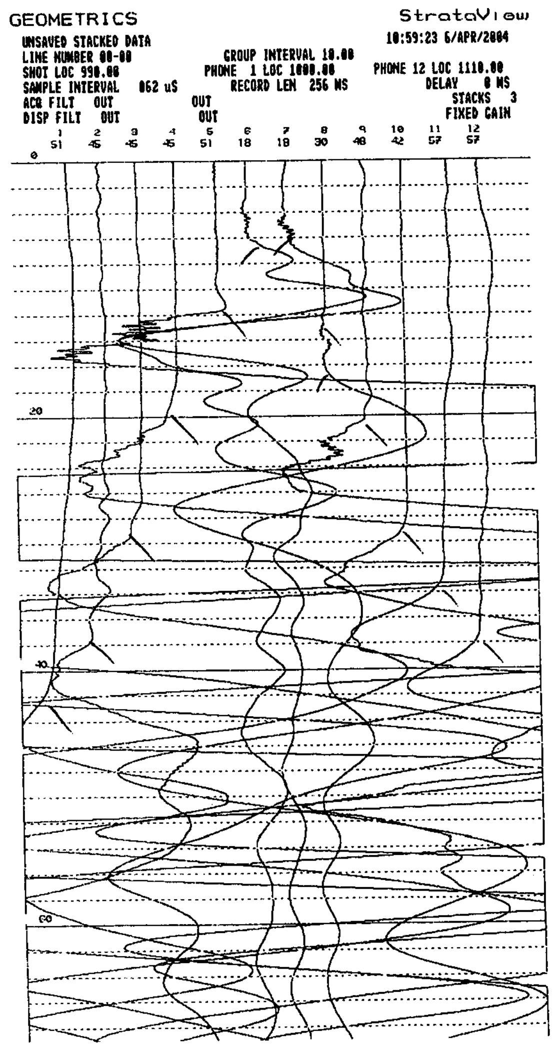
GEOMETRICS StrataView

UNSAVED STACKED DATA 10:28:25 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN

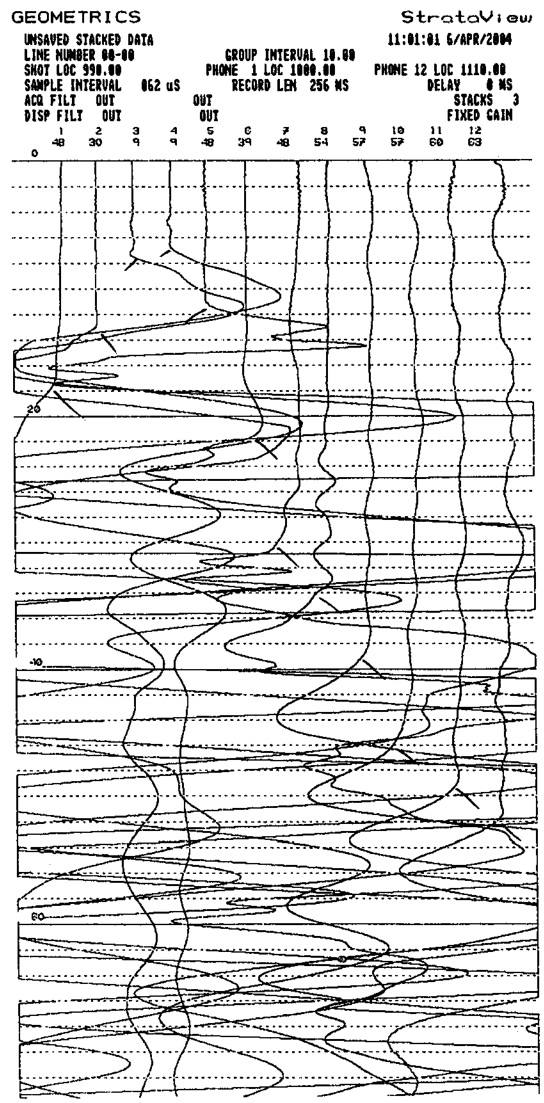


4-1021

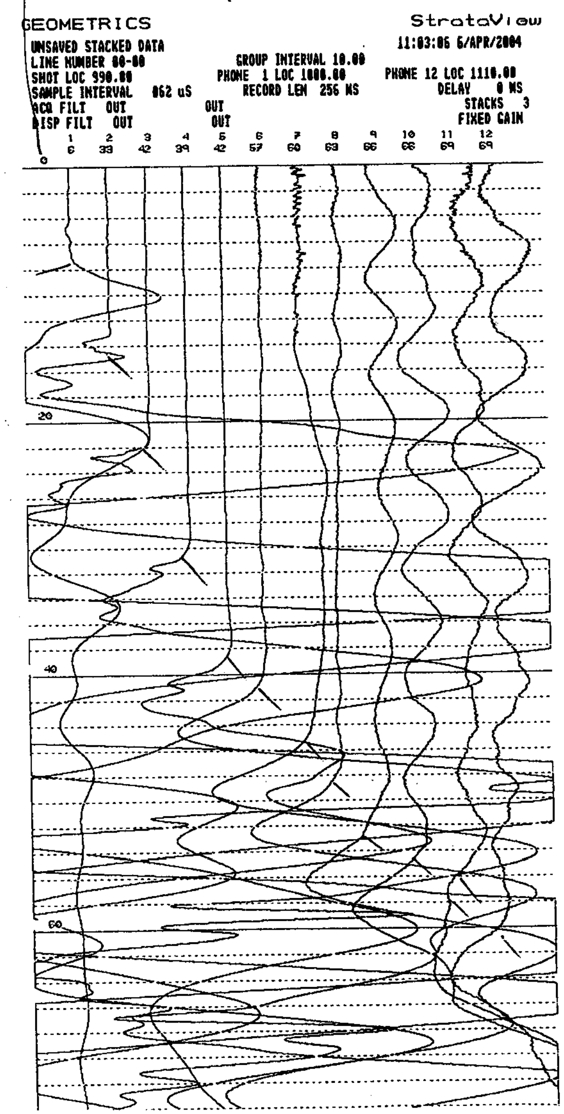
LZ
MS



LZ
FMS



L1 p8
@ toe (upstrm)
LZ
FS
E
1005-1008
W



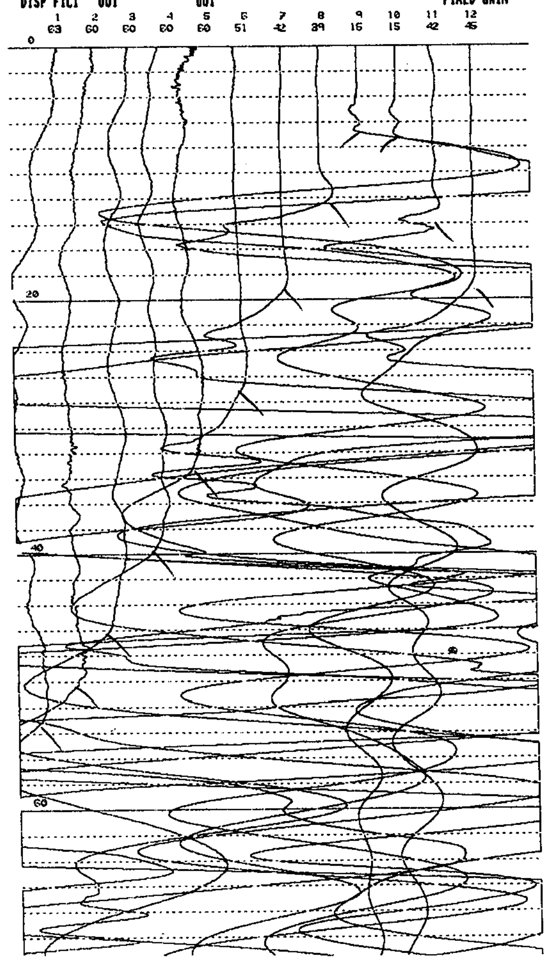
Line 2

4-1021

L2
BMS

GEOMETRICS StrataView

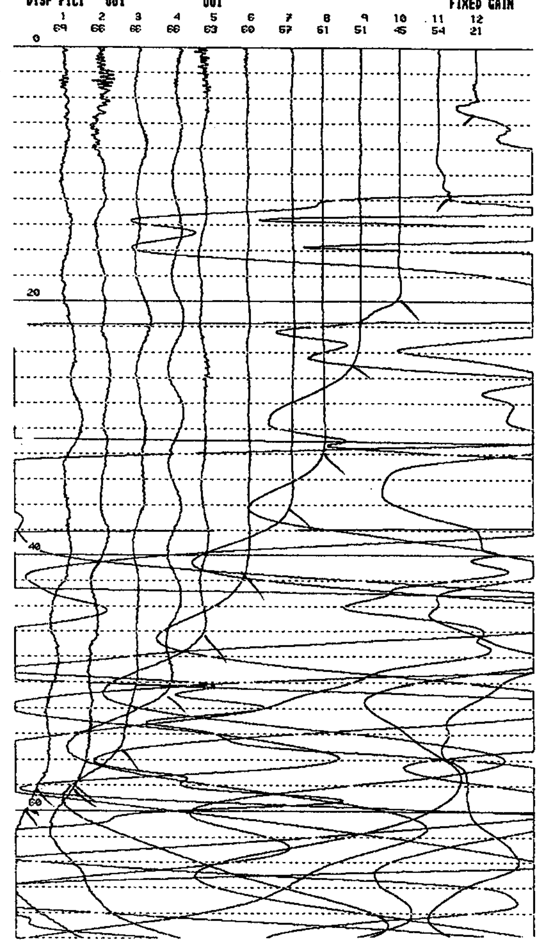
UNSAVED STACKED DATA 10:57:50 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



L2
BS

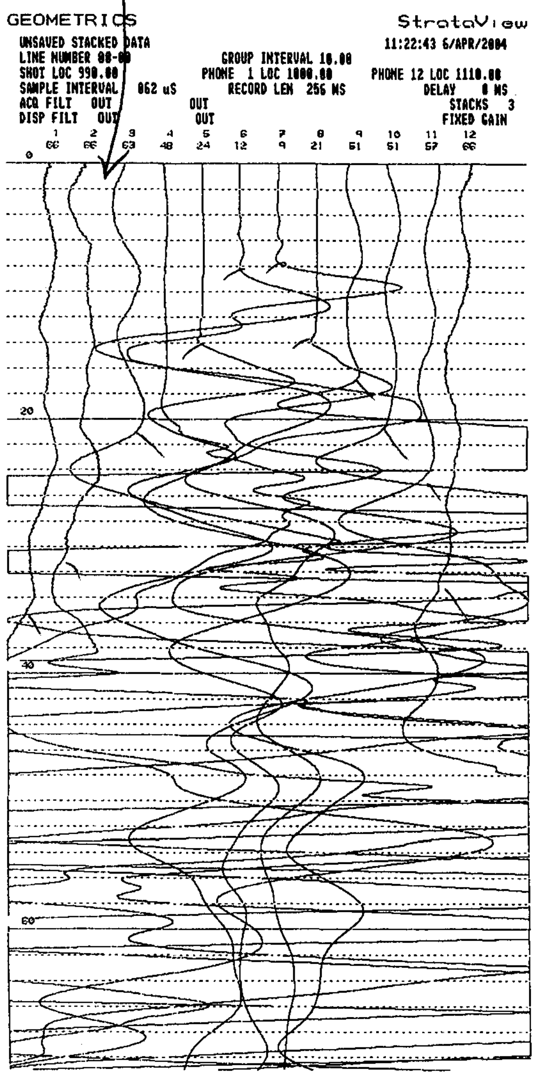
GEOMETRICS StrataView

UNSAVED STACKED DATA 10:55:56 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



L3 ms

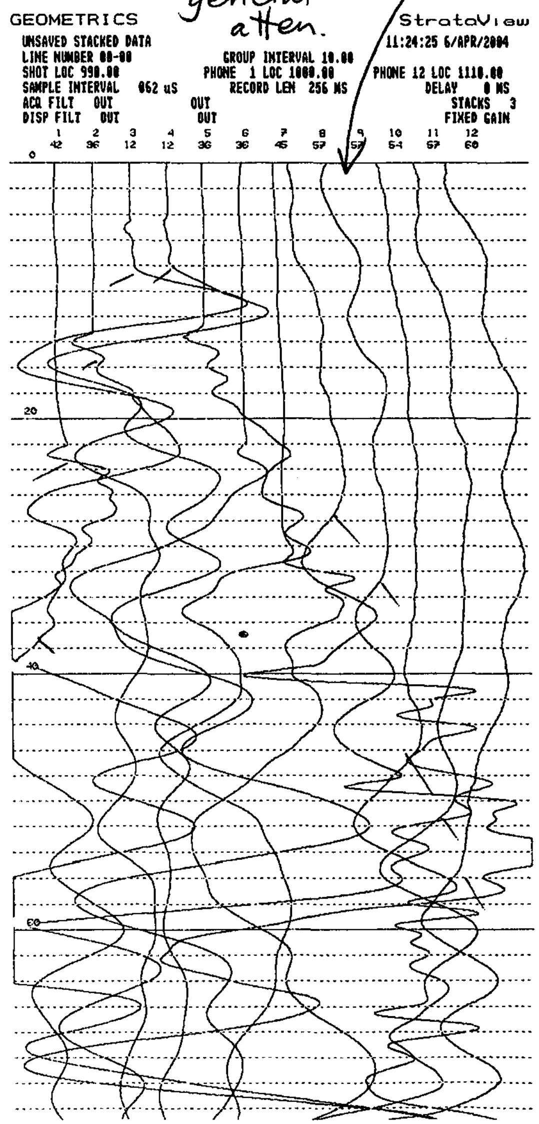
time



L3 Fms

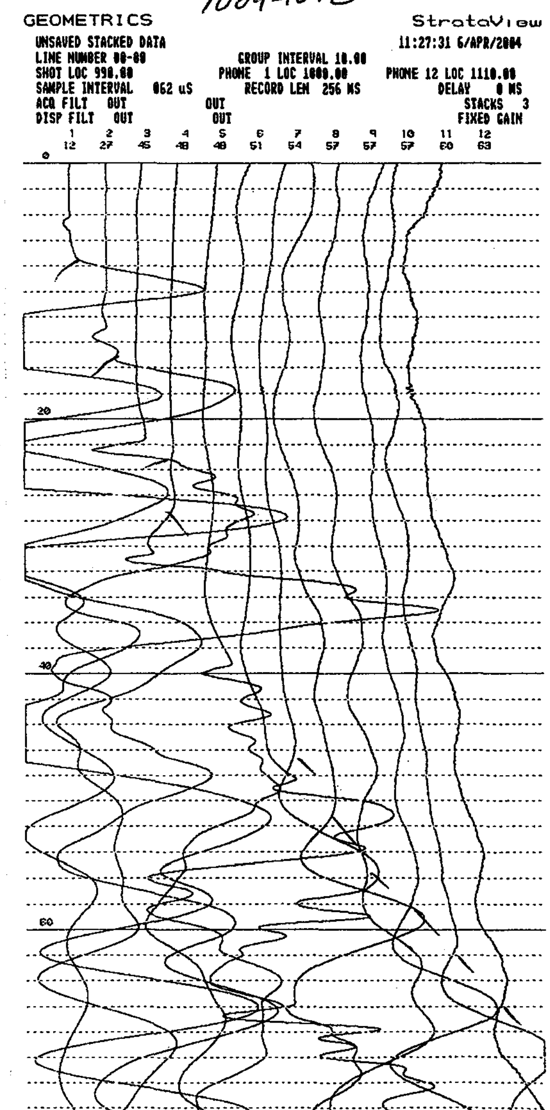
general atten.

time

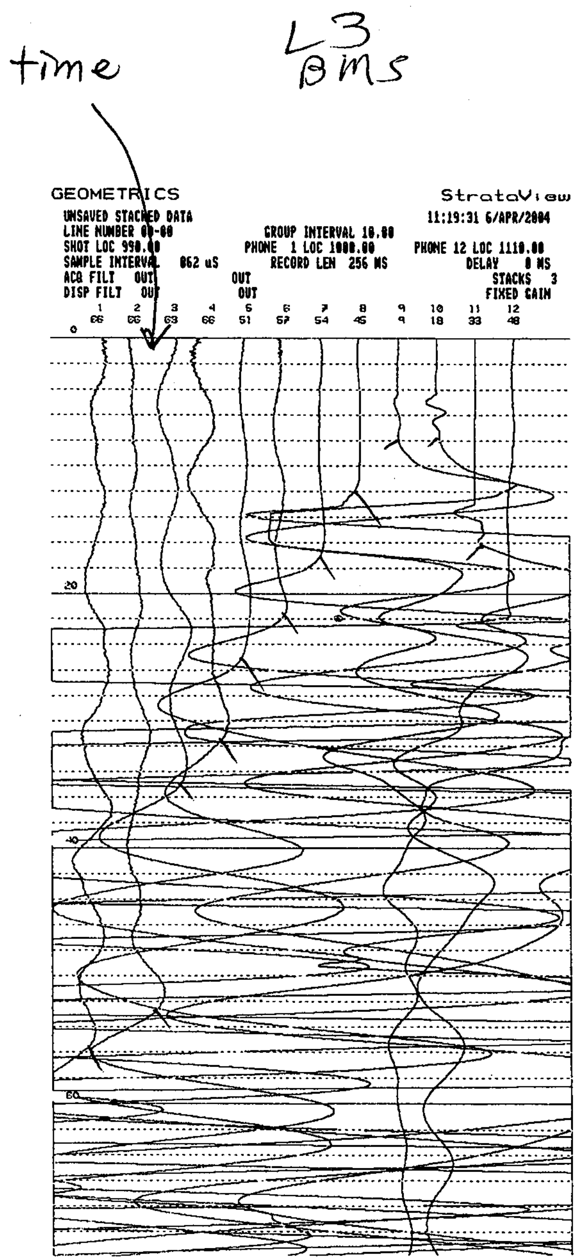


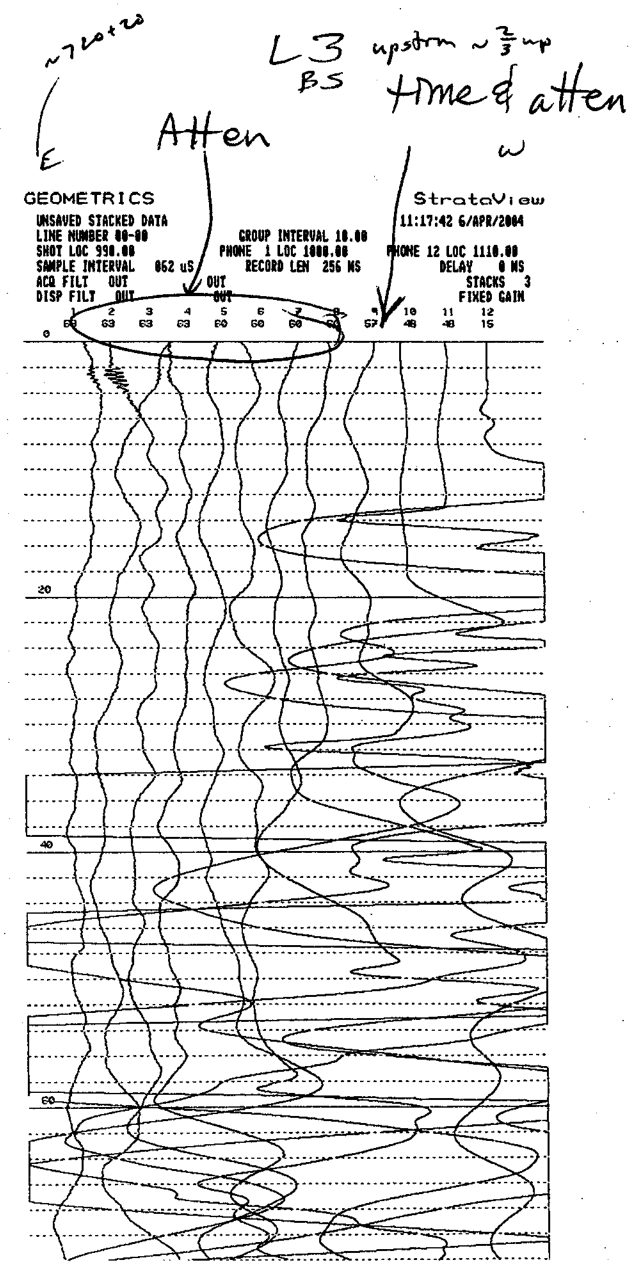
L3 FS

1009-1012



Line 3 - considerable general attenuation

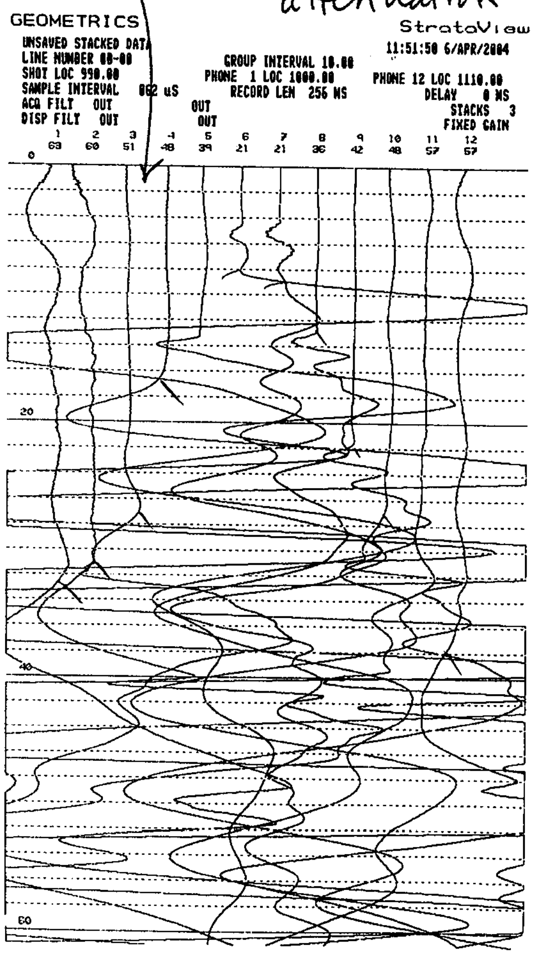

time
L3
BMS
GEOMETRICS
StrataView
UNSAVED STACKED DATA
11:19:31 6/APR/2004
LINE NUMBER 00-00
GROUP INTERVAL 10.00
SHOT LOC 990.00
PHONE 1 LOC 1000.00
PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS
RECORD LEN 256 MS
DELAY 0 MS
ACQ FILT OUT
OUT
STACKS 3
DISP FILT OUT
OUT
FIXED GAIN
1 2 3 4 5 6 7 8 9 10 11 12
66 66 63 66 51 57 54 45 9 18 33 48
0
20
40
60


~720+20
E
L3
BS
upstrm ~2/3 up
time & atten.
Atten
ω
GEOMETRICS
StrataView
UNSAVED STACKED DATA
11:17:42 6/APR/2004
LINE NUMBER 00-00
GROUP INTERVAL 10.00
SHOT LOC 990.00
PHONE 1 LOC 1000.00
PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS
RECORD LEN 256 MS
DELAY 0 MS
ACQ FILT OUT
OUT
STACKS 3
DISP FILT OUT
OUT
FIXED GAIN
1 2 3 4 5 6 7 8 9 10 11 12
63 63 63 63 60 60 60 60 57 48 48 15
0
20
40
60

time

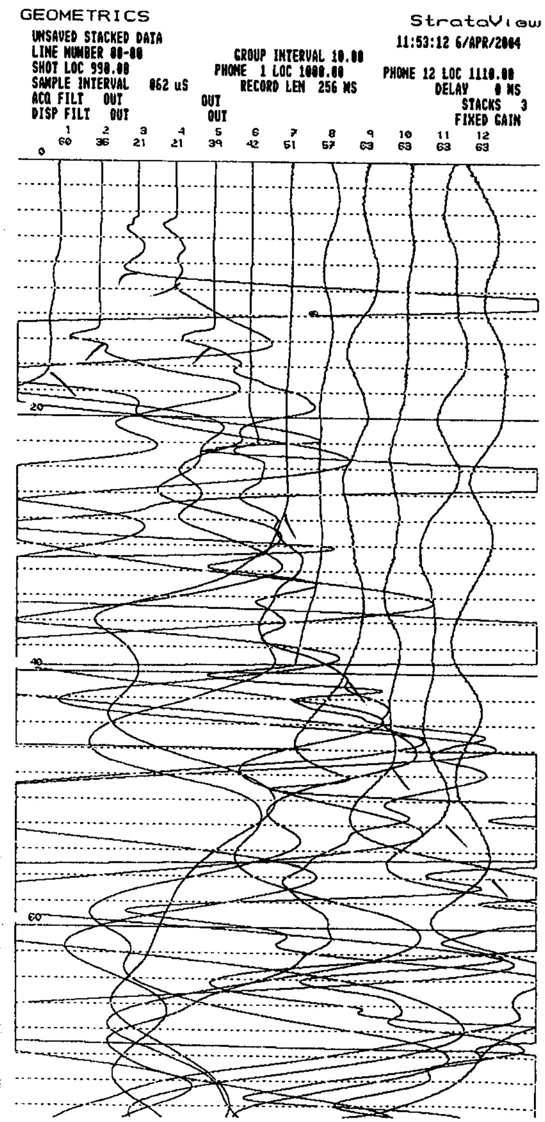
L~~3~~4

MS general attenuation



L4

FMS



L3 PB

L4

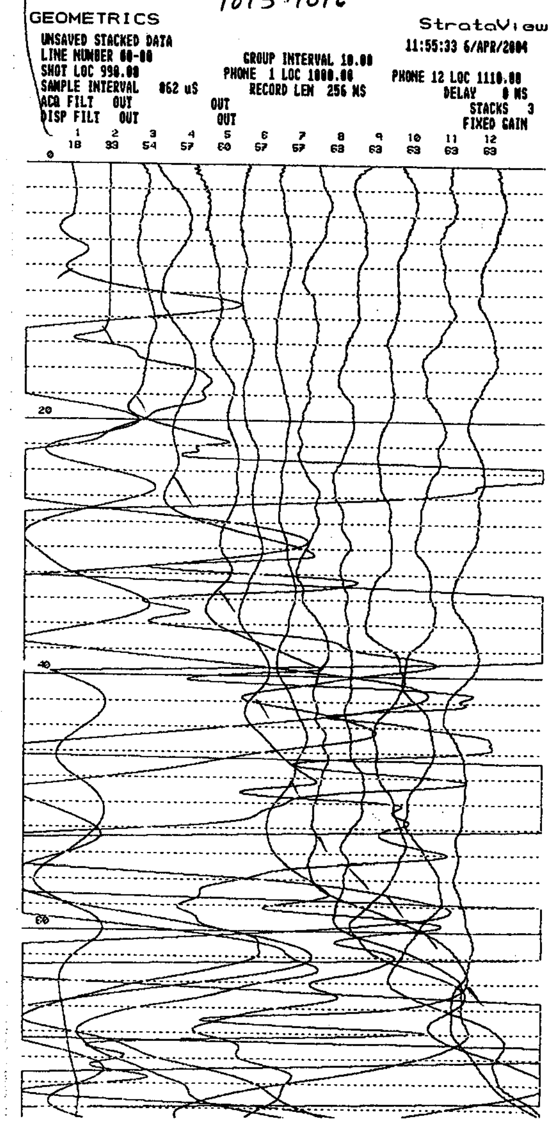
FS

4-1021

E

1013-1016

W

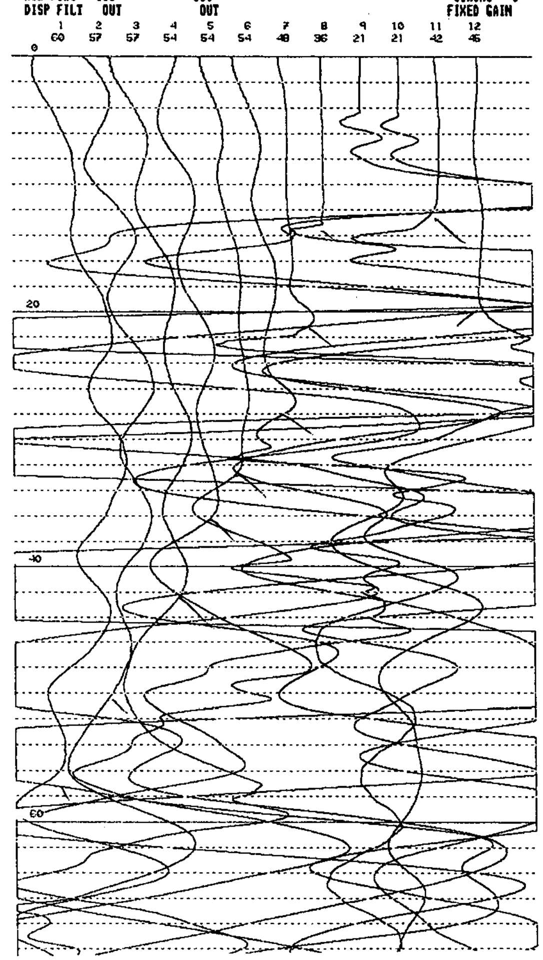


Line 4 - lots of general attenuation

L ~~3~~4
BMS

GEOMETRICS StrataView

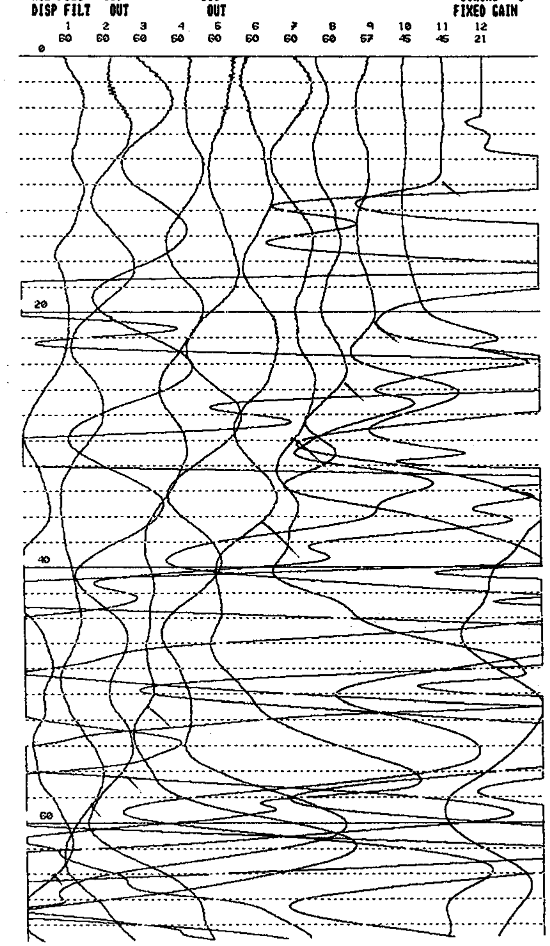
UNSAVED STACKED DATA 11:50:18 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



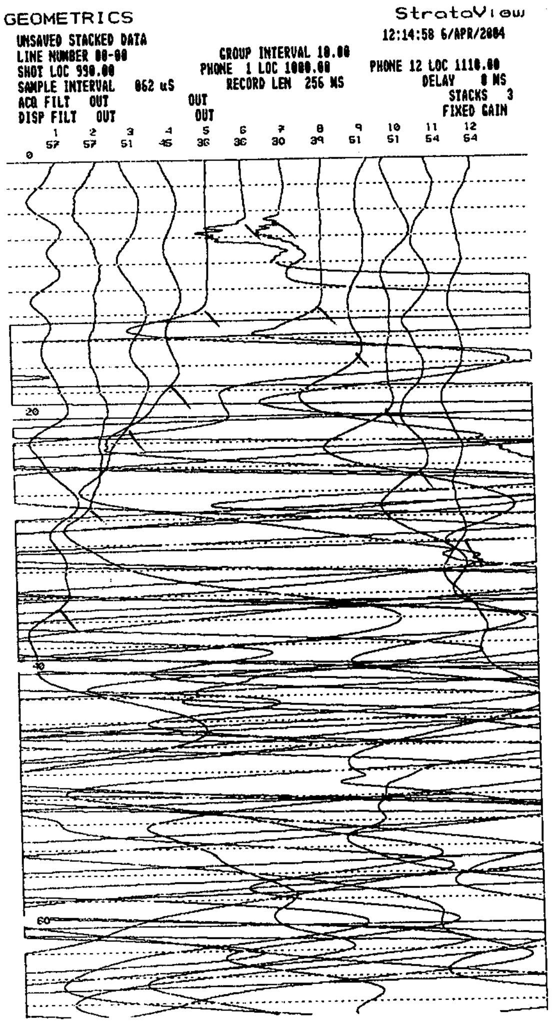
L 4
BS

GEOMETRICS StrataView

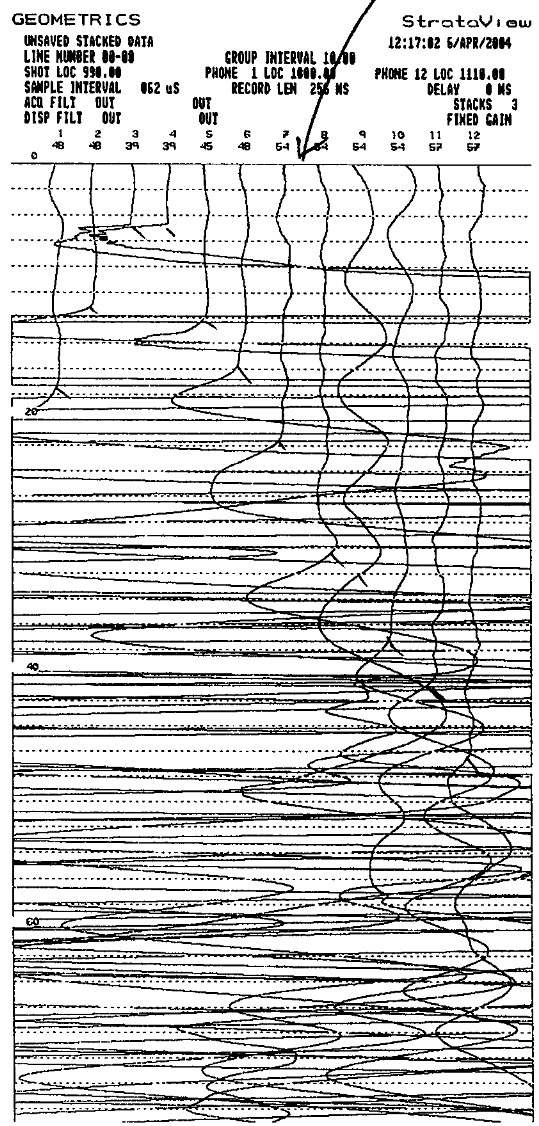
UNSAVED STACKED DATA 11:48:44 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



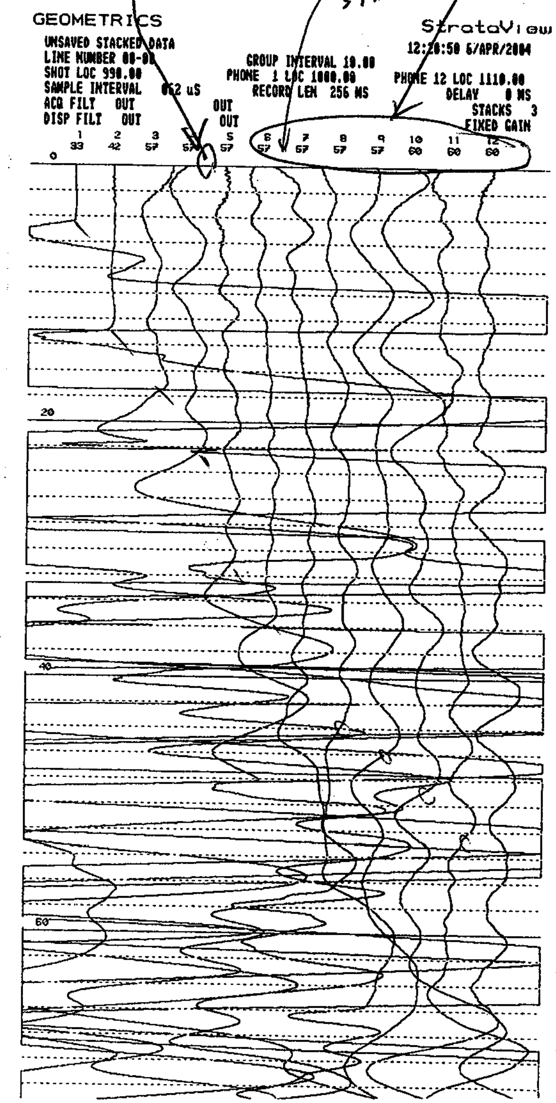
L5
MS



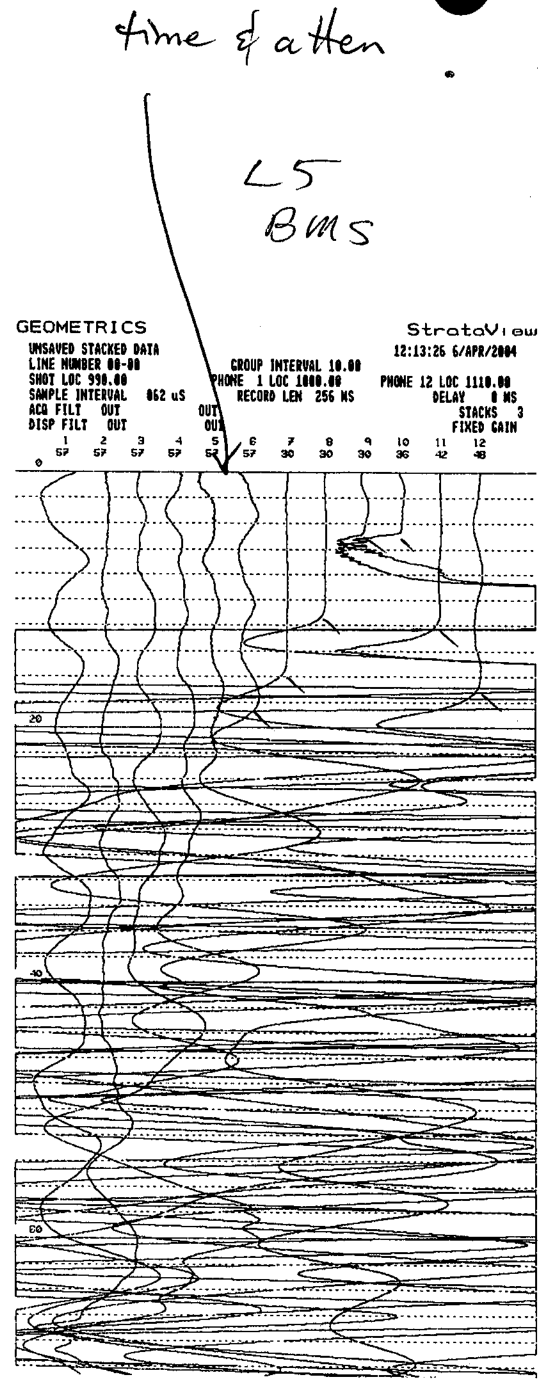
L5
FMS
time?
E
W

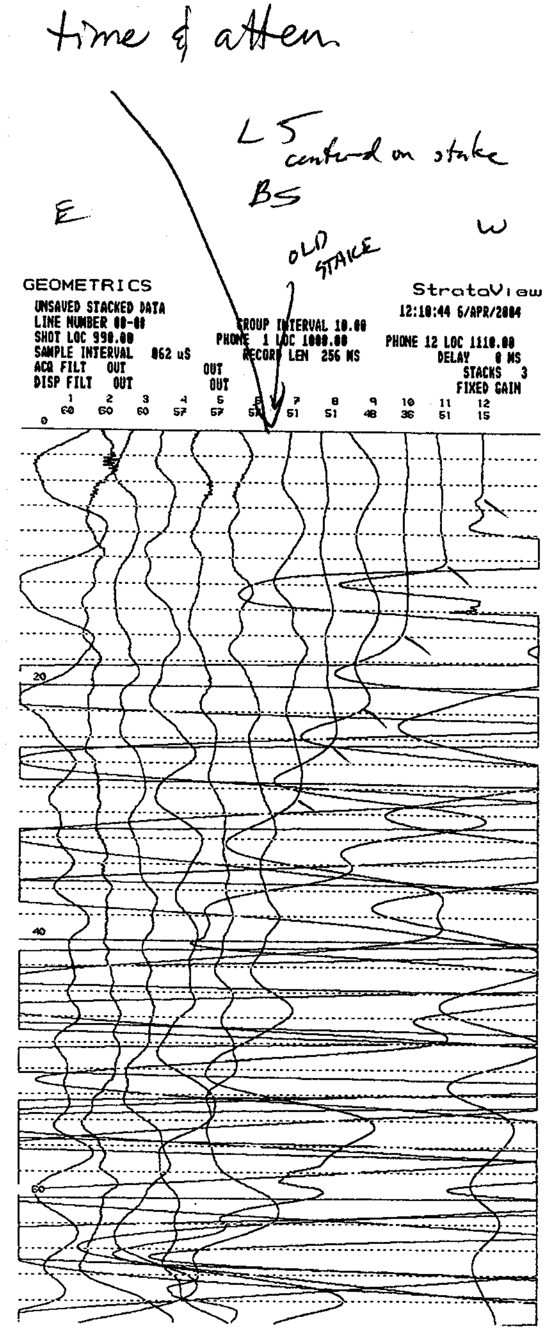


time
L5
FS
general attenuation
E
W
1017-1020
OLD STAKE



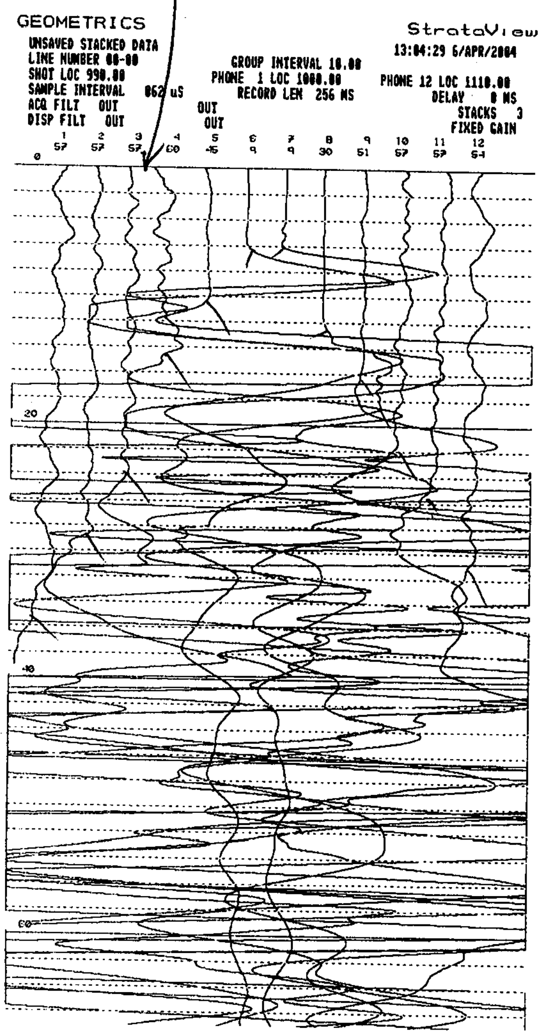
Line 5 - considerable general attenuation


time & atten
L5
BMS
GEOMETRICS
StrataView
UNSAVED STACKED DATA
12:13:26 6/APR/2004
LINE NUMBER 00-00
GROUP INTERVAL 10.00
SHOT LOC 990.00
PHONE 1 LOC 1000.00
PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS
RECORD LEN 256 MS
DELAY 0 MS
ACQ FILT OUT OUT
STACKS 3
DISP FILT OUT OUT
FIXED GAIN
1 2 3 4 5 6 7 8 9 10 11 12
57 57 57 57 57 57 30 30 30 36 42 48
0
20
40
60


time & atten
L5 centered on stake
BS
E
W
OLD STAKE
GEOMETRICS
StrataView
UNSAVED STACKED DATA
12:10:44 6/APR/2004
LINE NUMBER 00-00
GROUP INTERVAL 10.00
SHOT LOC 990.00
PHONE 1 LOC 1000.00
PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS
RECORD LEN 256 MS
DELAY 0 MS
ACQ FILT OUT OUT
STACKS 3
DISP FILT OUT OUT
FIXED GAIN
1 2 3 4 5 6 7 8 9 10 11 12
60 60 60 57 57 57 51 51 48 36 51 15
0
20
40
60

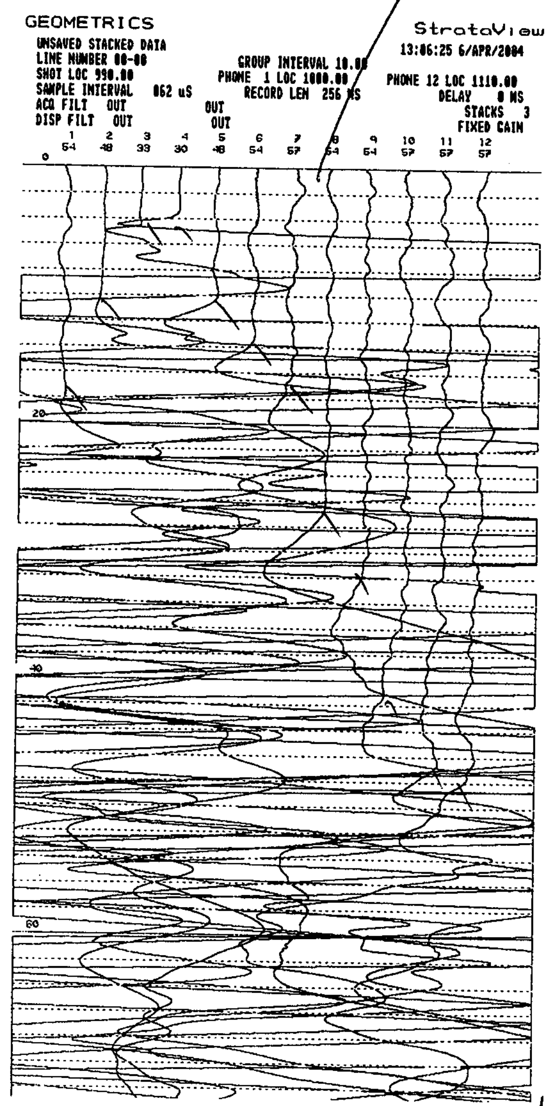
time

L6
MS



L6
FMS

time &
atten.



?

E

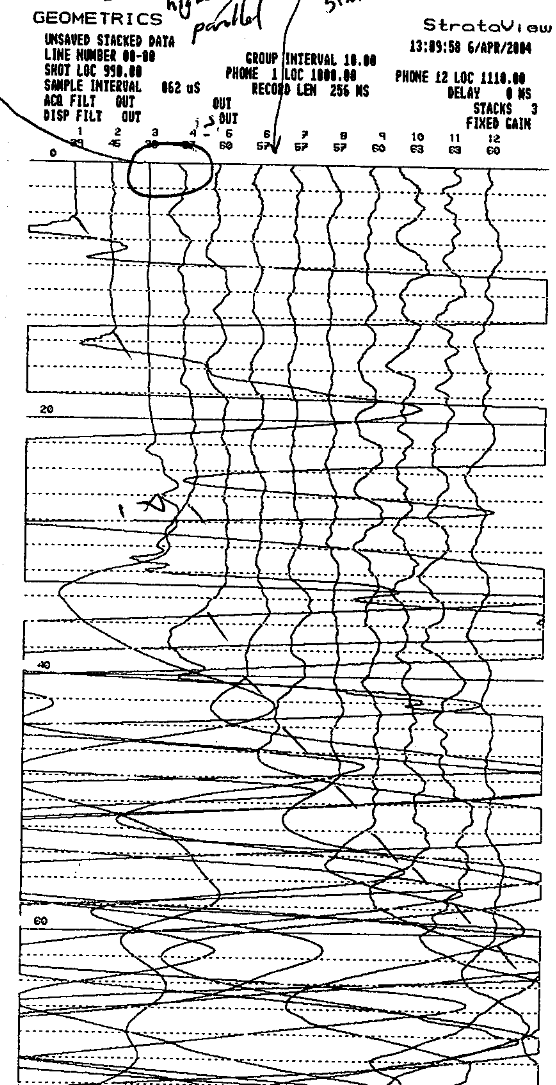
1021-1024
ambient only
bad angle?
highway
parallel

below old
strike

L6
FS

dnstrm slope

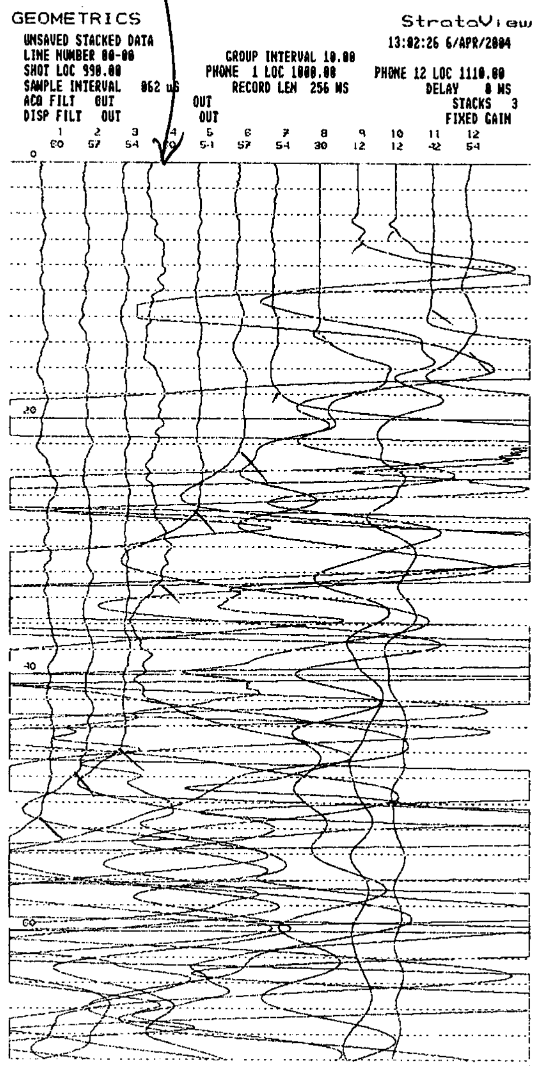
W



Line 6 - considerable general attenuation

time

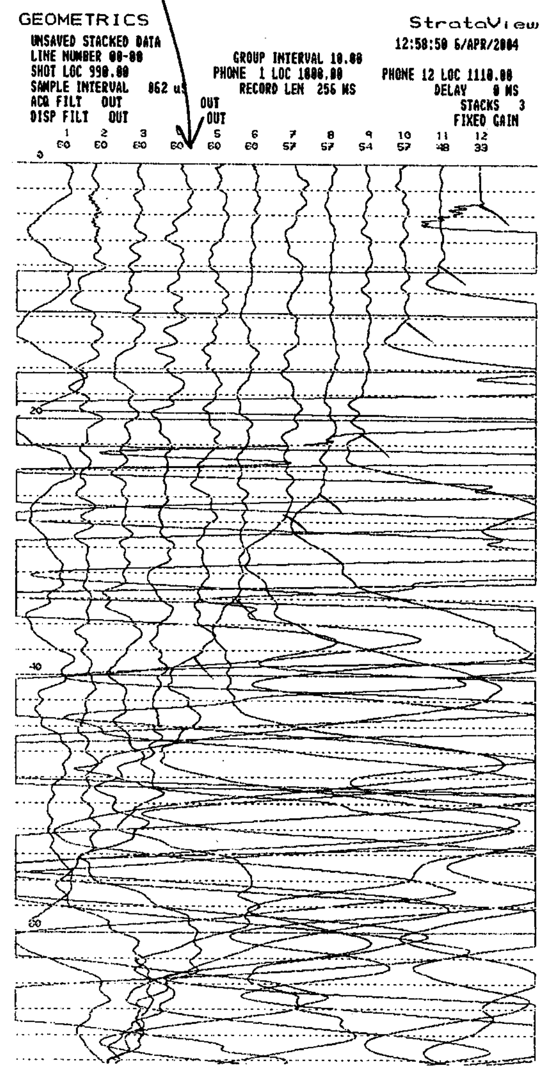
L6
Bins



time

mudgt downstrm

L6
BS

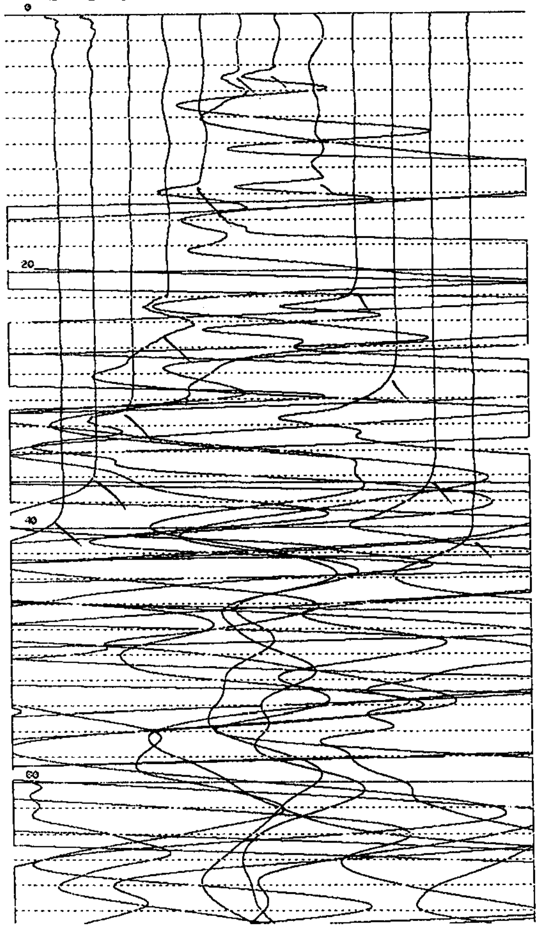


L7
MS

GEOMETRICS StrataView

UNSAVED STACKED DATA 13:38:36 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN

1	2	3	4	5	6	7	8	9	10	11	12
48	42	39	36	36	21	21	42	39	42	39	45

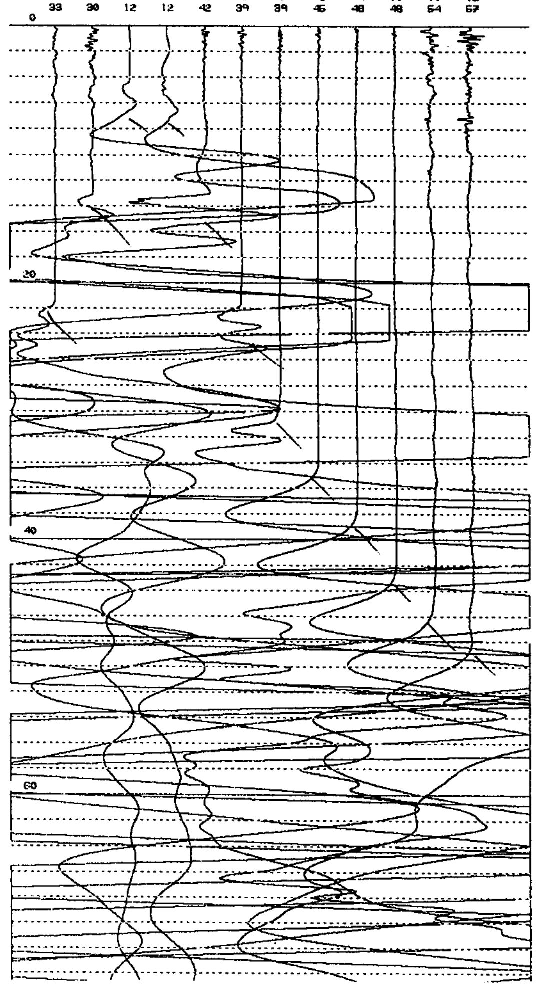


L7
FMS

GEOMETRICS StrataView

UNSAVED STACKED DATA 13:40:01 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN

1	2	3	4	5	6	7	8	9	10	11	12
33	30	12	12	42	39	39	45	48	48	54	57



on ONSTRM side equal to L1

L7
FS

E
720+20

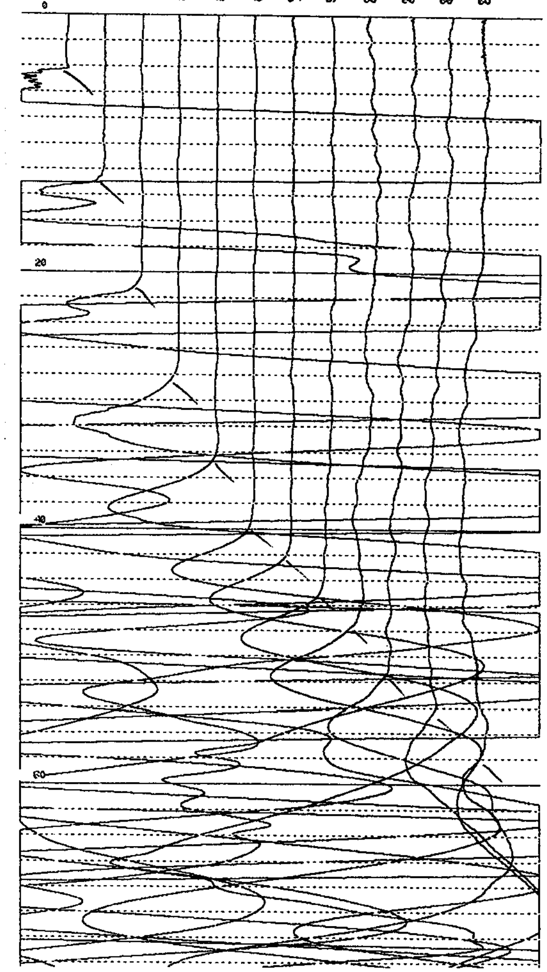
W

1025-1028

GEOMETRICS StrataView

UNSAVED STACKED DATA 13:41:41 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN

1	2	3	4	5	6	7	8	9	10	11	12
33	42	45	45	48	48	54	57	60	60	60	60



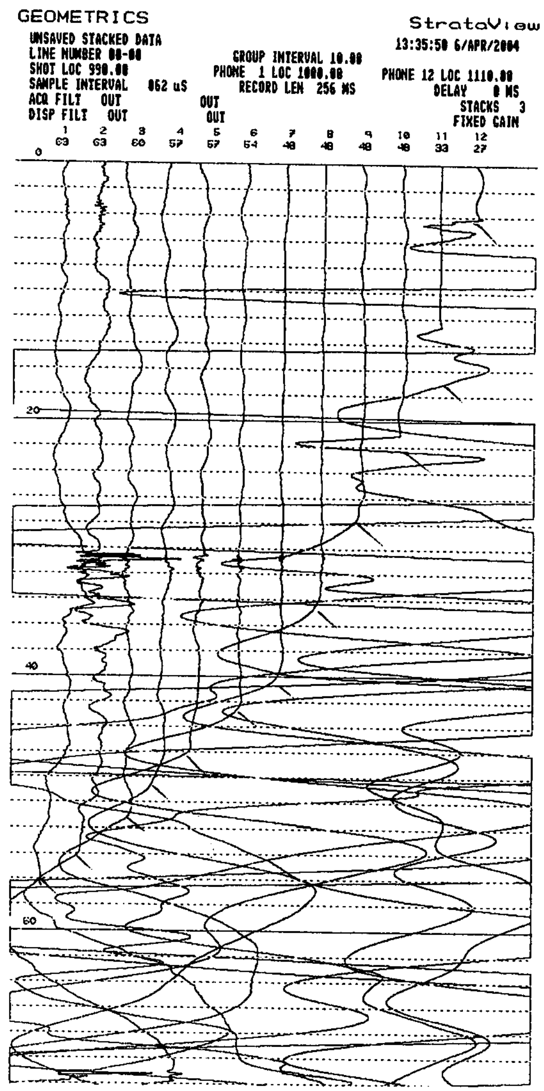
Line 7

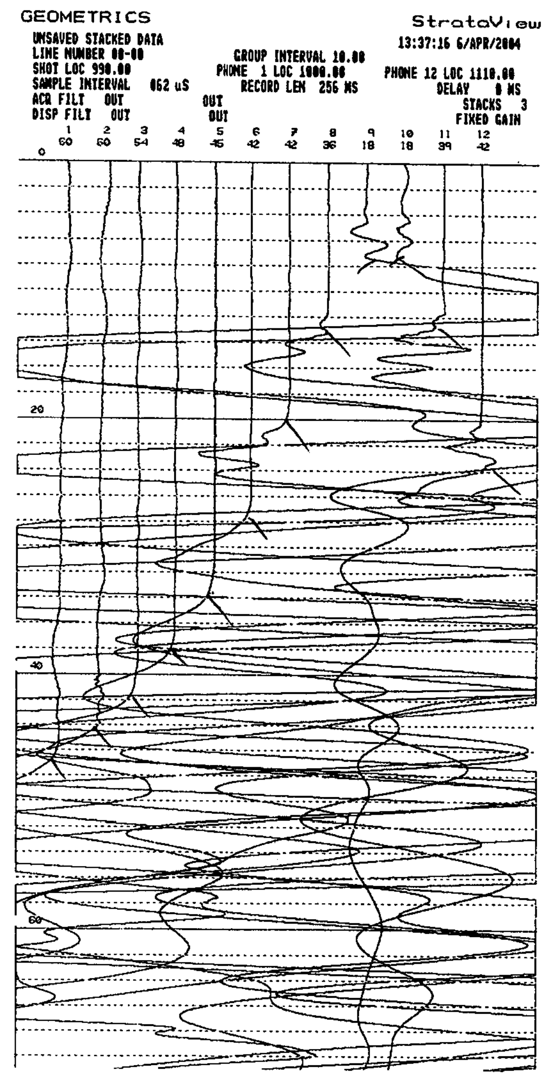
720+20

downstrm toe

E L7 BS W

L7 BMS

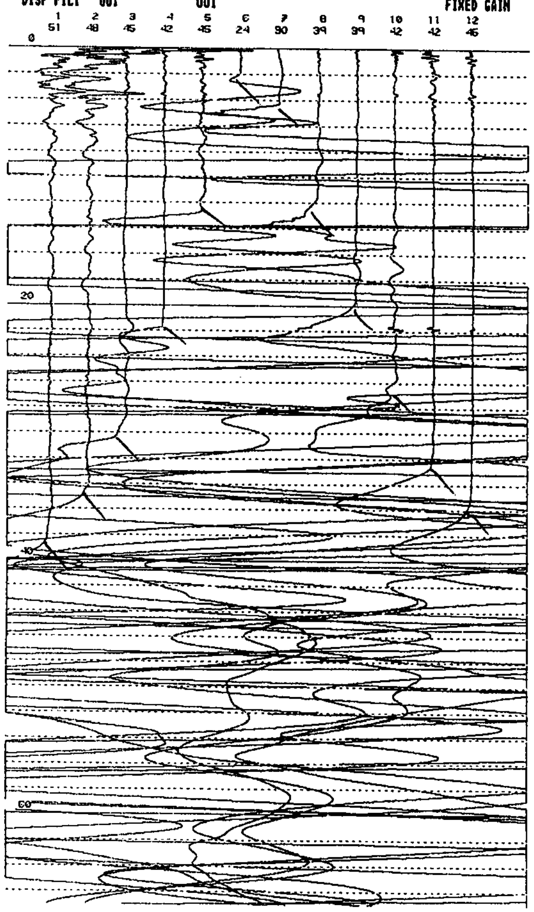




L8
MS

GEOMETRICS StrataView

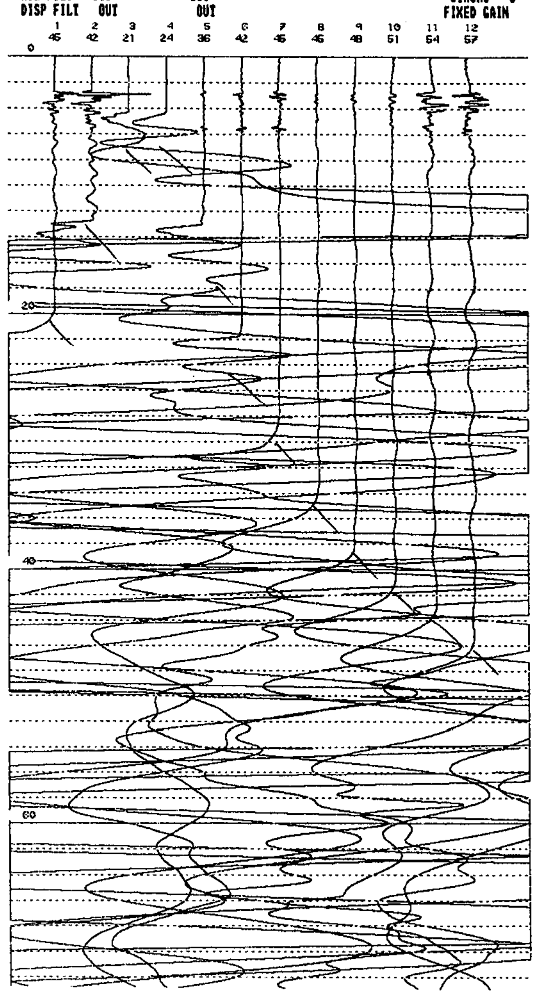
UNSAVED STACKED DATA 14:03:52 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



L8
FMS

GEOMETRICS StrataView

UNSAVED STACKED DATA 14:04:53 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN



Line 8

E
L7
p8

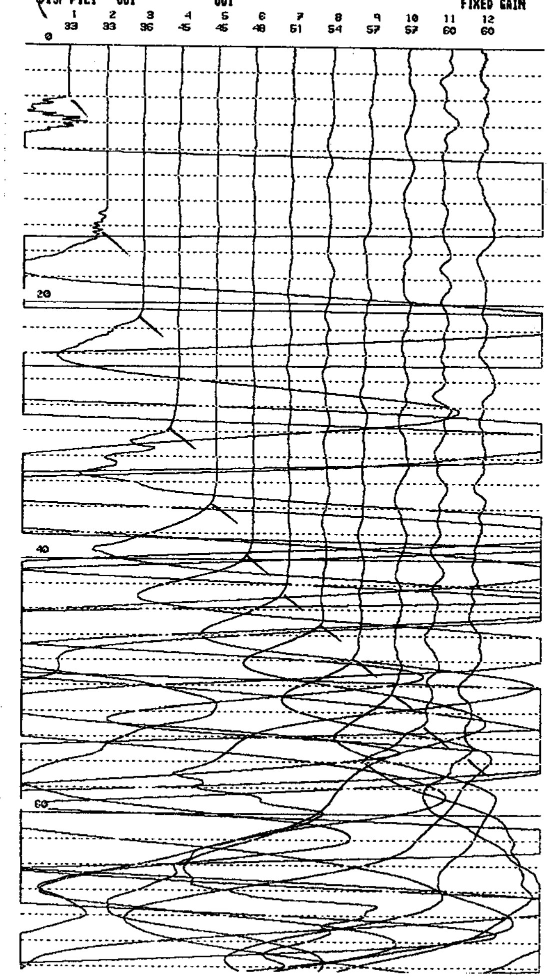
L8
FS dnstrm toe

parallel to L2
on upstrm toe
W

1029-1032

GEOMETRICS StrataView

UNSAVED STACKED DATA 14:07:07 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN

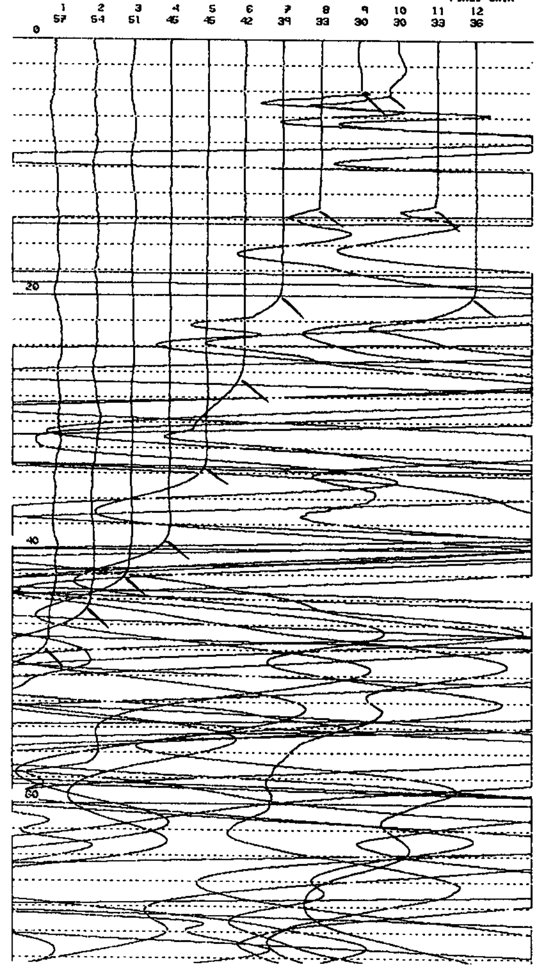


L8
BMS

GEOMETRICS StrataView

UNSAVED STACKED DATA 14:01:41 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN

1	2	3	4	5	6	7	8	9	10	11	12
57	54	51	45	45	42	39	33	30	30	33	36

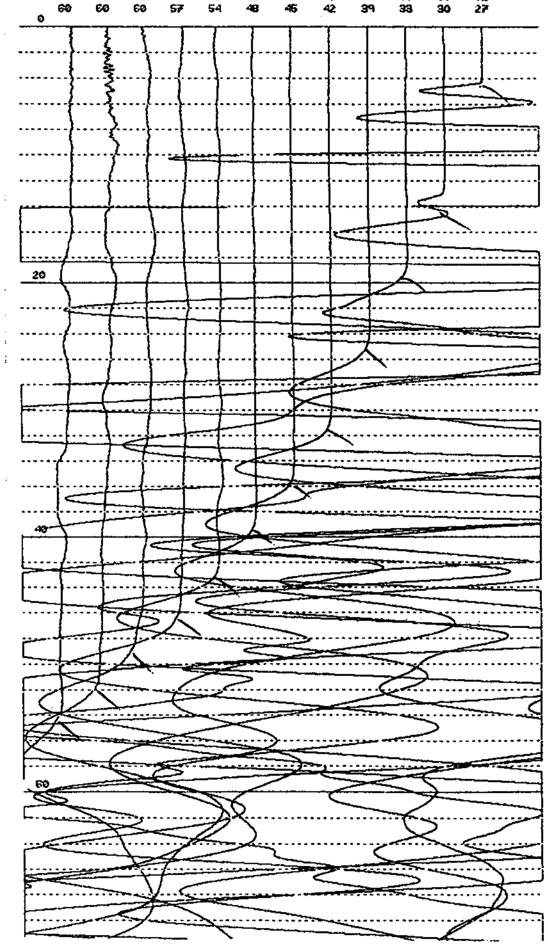


L8
BS

GEOMETRICS StrataView

UNSAVED STACKED DATA 14:00:27 6/APR/2004
LINE NUMBER 00-00 GROUP INTERVAL 10.00
SHOT LOC 990.00 PHONE 1 LOC 1000.00 PHONE 12 LOC 1110.00
SAMPLE INTERVAL 062 uS RECORD LEN 256 MS DELAY 0 MS
ACQ FILT OUT OUT STACKS 3
DISP FILT OUT OUT FIXED GAIN

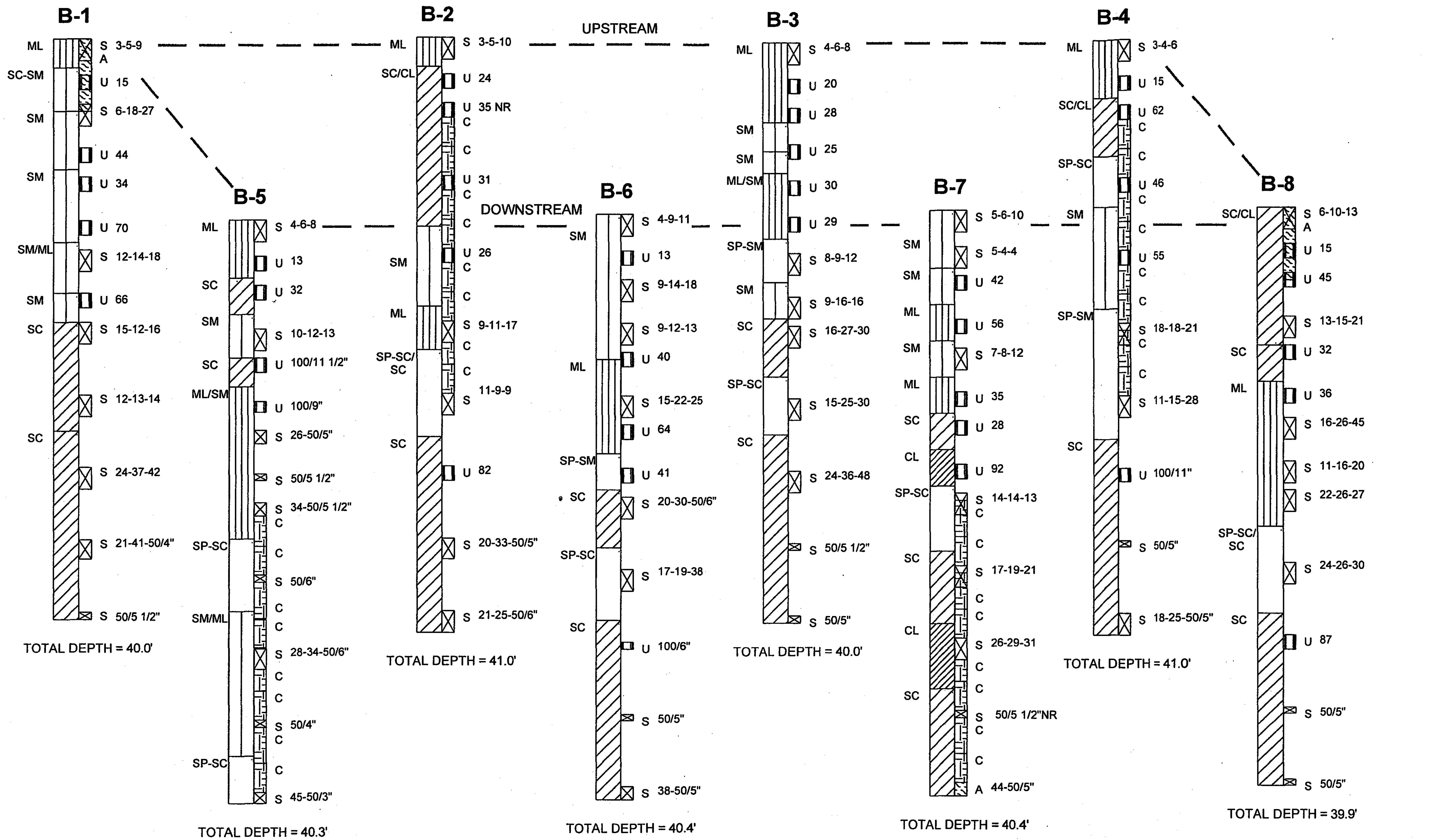
1	2	3	4	5	6	7	8	9	10	11	12
60	60	60	57	54	48	45	42	39	33	30	27



amec

APPENDIX D

HOLLOW-STEM AUGER DRILLING



SAMPLE TYPE

S - 2" O.D., 1.38" I.D. TUBE SAMPLE
U - 3" O.D., 2.42" I.D. TUBE SAMPLE
C - 3" O.D. CME TUBE SAMPLE

NOTE: 1) SEE FIGURE 2 FOR BORING LOCATIONS
2) SAMPLE TYPE DESIGNATION ACCOMPANIED BY UNIFIED SOIL CLASSIFICATION AND BLOWCOUNTS FOR 6-INCH PENETRATION UNING 140 LB. DROP HAMMER/30-INCH FALL.

JOB NO.	4-117-001021
DESIGN:	REW
DRAWN:	GWH
DATE:	6/2004
SCALE:	N.T.S.

FENCE DIAGRAM OF BORING DATA

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE D-1

amec

amec

TEST DRILLING EQUIPMENT & PROCEDURES

Description of Subsurface Exploration Methods

Auger Boring Drilling through overburden soils is performed with 6 5/8-inch O.D., 3 1/4-inch I.D. hollow stem auger or 4 1/2-inch solid stem continuous flight auger. Carbide insert teeth are normally used on bits so they can penetrate soft rock or very strongly cemented soils. A CME-75 truck-mounted drill rig is used to advance the auger. The drill rigs are powered with six-cylinder Cummins diesel engines capable of delivering about 11.4 kN-m torque to the drill spindle. The spindle is advanced with twin hydraulic rams capable of exerting 90 kN (20,000 pounds) downward force.

Generally, refusal to penetration of the auger is adopted as top of the SGC or "river-run" material or harder bedrock, which require other techniques for penetration. Grab samples or auger cuttings may be taken as necessary. Standard penetration tests or 2.42-inch diameter ring samples are taken in conjunction with the auger borings as needed, with the sampling interval and type being indicated on the boring logs.

Hammer Drill Drilling with the Hammer drill is accomplished with a Drill Systems AP-1000 drill rig advancing a double-walled drive casing with a link-belt 180 diesel pile driving hammer, having a rated energy of 8,100 foot-pounds per blow. Where noted on the boring log, the hammer is equipped with a supercharger which can boost the energy to approximately 12,000 foot-pounds per blow. The supercharger is used only in portions of the boring where blow counts are relatively high. Cuttings are removed with compressed air by a reverse circulation process, and are collected in a cyclone from which grab samples are obtained. The drive casing is either 9-inch O.D. by 6-inch I.D. or 6 5/8-inch O.D. by 4-inch I.D. and employs an expendable bit of slightly larger diameter than the O.D. of the casing. Hammer blows required to advance the drive casing are recorded in 1-foot increments, as noted on the boring logs. Standard penetration tests or 2.42-inch diameter ring samples taken are noted on the boring logs.

Core Boring Rock core samples are retrieved using a CME-75 drill rig, SAITECH GH 3 rig or Burley 2500, 4500 or 4000. The GH 3 is a portable hydraulic core drill. The GH 3 is powered by a Kohler two-cylinder 25-horsepower engine. The hydraulics motor which feeds a two-speed transmission and powers the BW spindle. This unit has a 3-foot stroke and is hand-fed with a 2,000 pound push-pull capability. The GH 3 has the capability of drilling with either B- or N-size core steel using standard or wireline systems. N-size core is the preferred size and it has a nominal O.D. of about 2 inches. The Burley 2500 and 4500 series are portable hydraulic core drills. The 4500 series is capable of a track-mounted or skid-type chassis. The Burley 2500 and 4500 series are powered by 44 and 75 HP power units, respectively, provide up to 2,000 foot-pounds (ft.-lbs.) of torque and in excess of 1,000 revolutions per minute (RPM) of spindle speed. Both rigs are capable of retrieving either N- or H-sized core using wireline systems. The N-size core has a nominal O.D. of about 2 inches and the H-size of about 2.4 inches. The Burley 4000 is a track-mounted core drill.

The CME-75 utilizes a wireline core drilling system that takes N-size cores. Using the NQ wireline system, core is recovered quickly by retrieving the core-laden inner tube through the drill string.

TEST DRILLING EQUIPMENT & PROCEDURES (Cont.)

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 test procedure. In many cases, 2-inch O.D., 1 3/8-inch I.D. samples are used to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3-inch O.D. samples lined with 2.42-inch I.D. brass rings. The driving energy is generally recorded as the number of blows of a 140-pound, 30-inch free fall drop hammer required to advance the samples in 6-inch increments. However, in stratified soils, driving resistance is sometimes recorded in 2- or 3-inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. These values are expressed in blows per 6 inches on the boring logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587), pitcher samplers, Denison samplers or continuous CME samplers. Where samples of rock are required, they are obtained by NQ diamond core drilling (ASTM D2113). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings. Also, representative samples are obtained from the cuttings from the hammer and Schramm drill rig.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares the boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487), with appropriate group symbols being shown on the boring logs.

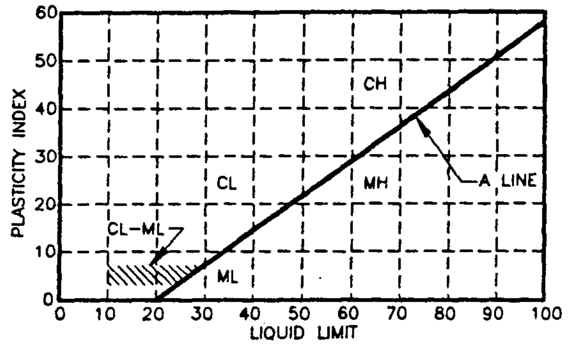
UNIFIED CLASSIFICATION SYSTEM FOR SOILS

Soils are visually classified by the Unified Soil Classification System on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" ASTM Designation: D2487.

MAJOR DIVISION				GRAPH SYMBOL	GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sand mixtures or sand-gravel-cobble mixtures.
					GP	poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS Limits plot below "A" line & hatch zone on plasticity chart	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)			MH	Inorganic silts of high plasticity, silty soils, elastic silts.
	CLAYS Limits plot above "A" line & hatch zone on plasticity chart	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)			CH	Inorganic clays of high plasticity, fat clays, silty and sandy clays of high plasticity.

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

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Boulders	Above 300mm (12in.)
Cobbles	300mm to 75mm (12in. to 3in.)
Gravel	75mm (3in.) to No. 4 sieve
Coarse gravel	75mm to 19mm (3in. to 3/4in.)
Fine gravel	19mm (3/4in.) to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

amec

TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY, CONSISTENCY OR FIRMNESS OF SOILS

The terminology used on the boring logs to describe the relative density, consistency or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by the ASTM D1586 procedure using 2" O.D., 1 3/8" I.D. samplers.

1. Relative Density. Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

N	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

2. Relative Consistency. Terms for description of clays which are saturated or near saturation.

N	Relative Consistency	Remarks
0-2	Very soft	Easily penetrated several inches with fist.
3-4	Soft	Easily penetrated several inches with thumb.
5-8	Medium stiff	Can be penetrated several inches with thumb with moderate effort.
9-15	Stiff	Readily indented with thumb, but penetrated only with great effort.
16-30	Very stiff	Readily indented with thumbnail.
30+	Hard	Indented only with difficulty by thumbnail.

3. Relative Firmness. Terms for description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays, cemented granular materials, silts and silty and clayey granular soils.

N	Relative Firmness
0-4	Very soft
5-8	Soft
9-15	Moderately firm
16-30	Firm
31-50	Very firm
50+	Hard

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/12/04

amec

LOCATION N889886 E4[illegible]

RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S, A	3-5-9			ML	slightly moist; moderately firm	**SANDY SILT,** predominantly fine to medium grained sand, considerable calcium carbonate, low plasticity, light brown
				U	15	106	3	SC-SM	slightly moist; moderately firm	**SILTY SAND TO CLAYEY SAND,** predominantly fine to medium grained sand, weakly lime cemented, low plasticity, light bown
				S	6-18-27					
5								SM	slightly moist; very firm	**SILTY SAND,** trace of clay, occasional gravel, predominantly fine to medium grained sand, weakly to moderately lime cemented, low plasticity, light brown
				U	44					
								SM	slightly moist; very firm	**SILTY SAND,** trace of clay, trace of gravel, weakly lime cemented, low to medium plasticity, light brown
10				U	34	100	6			
				U	70					
								SM/ML	slightly moist to moist; very firm	**SILTY SAND TO SANDY SILT,** trace of clay, predominantly fine grained sand, weakly lime cemented, low plasticity, light brown
15				S	12-14-18		6			
				U	66			SM	slightly moist to moist; very firm	**SILTY SAND,** considerable gravel, predominantly fine to medium grained sand, weakly lime cemented, low plasticity, light brown
20				S	15-12-16		6	SC	moist; firm	**CLAYEY SAND,** trace of gravel, predominantly fine to medium grained sand, medium plasticity, light reddish-brown
				S	12-13-14		4			
25										

GROUNDWATER

D[illegible] (ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-1

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

amec

JOB NO. 4-117-001021 DATE 4/12/04

LOCATION N889886 E463734

RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25			X					SC	moist firm	**CLAYEY SAND,** continued
								SC	moist firm	**CLAYEY SAND,** considerable silt, predominantly fine to medium grained sand, weakly lime cemented, Stage III, medium plasticity, light reddish-brown
30			X	S	24-37-42		10			
35			X	S	21-41-50/4"		10			
40			X	S	50/5 1/2"					Stopped Auger at 39'6" Sampler refused at 40'
45										
50										

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-1

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/12/04

amec

LOCATION N889870 E4[illegible]2
RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	3-5-10			ML	slightly moist moderately firm	**SANDY SILT,** considerable calcium carbonate, low plasticity, light brown
								SC/CL	slightly moist firm	**CLAYEY SAND TO SANDY CLAY,** some silt, trace of gravel, predominantly fine to medium grained sand, weakly lime cemented, medium plasticity, light brown
				U	24					
5				U	35 NR	103	5			
				C		117	6			
				C			6			
10				U	31					
				C		110	6			
				C		119	4			
								SM	slightly moist firm	**SILTY SAND,** considerable gravel, predominanlty fine to medium grained sand, some calcium carbonate, low plasticity, light brown
15				U	26	118	6			
				C						
				C		110	5			
								ML	slightly moist firm	**SANDY SILT,** weakly to moderately lime cemented, low to medium plasticity, light brown
20				S	9-11-17		5			
				C		111	4			
								SP-SC/SC	moist firm	**CLAYEY SAND,** trace to some gravel, some silt, predominantly fine to medium grained sand, some silt, predominantly fine to medium grained sand, medium plasticity, light brown
				C		106	7			
25				S	11-9-9					

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-2

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/12/04

amec

LOCATION N889870 E463792

RIG TYPE CME-95

BORING TYPE 8 5/8" O.D. Hollow Stem Auger

SURFACE ELEV.

DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25			X					SP-SC/ SC	moist firm	**CLAYEY SAND,** continued
								SC	moist hard	**CLAYEY SAND,** trace to considerable gravel, predominantly fine to medium grained sand, medium plasticity, light reddish-brown
30				U	82					
35			X	S	20-33-50/5"					
40			X	S	21-25-50/6"					
										Stopped Auger at 39'6" Sampler refused at 41'
45										
50										

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
∇		none	
▼			
∇			
∇			

SAMPLE TYPE

A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-2

amec

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/12/04

LOCATION N889861 E4[illegible]
RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	4-6-8			ML	slightly moist moderately firm	**SANDY SILT,** considerable calcium carbonate, low plasticity, light brown note: occasional lense of silty sand (predominantly fine to medium grained) note: weakly lime cemented below 2'
				U	20					
5				U	28					
				U	25	105	6	SM	slightly moist firm	**CLAYEY SAND,** some silt, some to considerable gravel, predominantly fine to medium grained sand, considerable calcium carbonate, medium plasticity, light brown
								SM	slightly moist firm	**SILTY SAND,** predominantly fine to medium grained sand, weakly lime cemented, low to medium plasticity, light grayish-brown
10				U	30			ML/SM	slightly moist firm	**SANDY SILT TO SILTY SAND,** weakly lime cemented, low plasticity, light grayish-brown
				U	29	96	6			
15				S	8-9-12			SP-SM	slightly moist medium dense	**SAND TO SILTY SAND,** trace of clay, trace of gravel, predominantly fine to medium grained sand, some calcium carbonate, nonplastic to low plasticity, light reddish-brown
				S	9-16-16			SM	slightly moist to moist very firm	**SILTY SAND,** trace of clay, predominantly fine to medium grained sand, considerable calcium carbonate, low plasticity, light brown
20				S	16-27-30			SC	slightly moist to moist hard	**CLAYEY SAND,** trace to some sand, predominantly fine to medium grained sand, medium plasticity, light reddish-brown
25				S	15-25-30			SP-SC	slightly moist very dense	**CLAYEY SAND,** trace of gravel, trace of silt, predominantly fine to medium grained sand, nonplastic to low plasticity, light brown

GROUNDWATER

DEPTH (ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-3

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/12/04

amec

LOCATION N889861 E4[illegible]

RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25			X					SP-SC	slightly moist very dense	**CLAYEY SAND,** continued
								SC	slightly moist hard	**CLAYEY SAND,** predominantly fine to medium grained sand, moderately to strongly lime cemented, Stage III to III+, medium plasticity, light brown
30			X	S	24-36-48		6			
35			X	S	50/ 5 1/2"					
			X	S	50/5"					
40										Stopped Auger at 39'6" Sampler refused at 40'
45										
50										

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-3

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/12/04

amec

LOCATION	N889843 E463883
RIG TYPE	CME-95
BORING TYPE	8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.	
DATUM	AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	3-4-6			ML	slightly moist moderately firm	**SANDY SILT,** considerable calcium carbonate, low plasticity, light brown
				U	15					
5								SC/CL	slightly moist very firm to hard	**CLAYEY SAND TO SANDY CLAY,** some silt, trace of gravel, predominantly fine to medium grained sand, weakly to moderately lime cemented, Stage III, medium plasticity, light grayish-brown
				U	62		6			
				C						
				C		117	4			
								SP-SC	slightly moist firm to very firm	**CLAYEY SAND & GRAVEL,** trace of silt, predominantly fine to medium grained sand, predominantly fine grained gravel, weakly lime cemented, medium plasticity, light brown
10				U	46					
				C						
								SM	slightly moist very firm	**SILTY SAND,** trace of clay, trace of gravel, predominantly fine to medium grained sand, weakly to moderately lime cemented, medium plasticity, light brown
				C		119	3			
15				U	55	99	6			
				C						
				C		116	4			
								SP-SM	slightly moist dense	**SAND TO SILTY SAND,** trace to some gravel, predominantly fine to medium grained sand, some calcium carbonate, nonplastic, light brown
20				S	18-18-21		3			
				C		110	7			
				C						
				S	11-15-28		2			
25										

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-4

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/12/04

amec

LOCATION N889843 E463883

RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25								SP-SM	slightly moist dense	**SAND TO SILTY SAND,** continued
								SC	slightly moist hard	**CLAYEY SAND,** trace of gravel, trace of silt, predominantly fine to medium grained sand, moderately to strongly lime cemented, Stage III+, medium plasticity, light reddish-brown
30				U	100/11"					
35				S	50/5"					
40				S	18-25-50/5"					
										Stopped Auger at 39'6" Sampler refused at 41'
45										
50										

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-4

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 DATE 4/13/04

amec

LOCATION N889741 E463673

RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	4-6-8			ML	slightly moist moderately firm	**SILTY SAND,** predominantly fine to medium grained sand, considerable calcium carbonate, low plasticity, light brown
				U	13					
5				U	32		5	SC	slightly moist firm	**CLAYEY SAND,** trace of silt, weakly lime cemented, Stage II+ to III, medium plasticity, light grayish-brown
				S	10-12-13		4	SM	slightly moist firm	**SILTY SAND,** some gravel, predominantly fine to medium grained sand, considerable calcium carbonate, medium plasticity, light brown
10				U	100/ 11 1/2"		4	SC	slightly moist hard	**CLAYEY SAND,** trace of gravel, predominantly fine to medium grained sand, moderately lime cemented, Stage II+ to III, medium plasticity, light reddish-brown
				U	100/9"		7	ML/SM	slightly moist hard	**SANDY SILT TO SILTY SAND,** trace of clay, moderately lime cemented, Stage II+ to III, nonplastic to low plasticity, light grayish-brown
15				S	26-50/5"		5			
				S	50/ 5 1/2"					
20				S	34-50/ 5 1/2"		6			
				C						
				C				SP-SC	slightly moist very dense	**SAND TO CLAYEY SAND,** trace of silt, trace to some gravel, predominantly fine to medium grained sand, trace of calcium carbonate, nonplastic to low plasticity, light brown
25				S	50/6"					

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-5

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/13/04

amec

LOCATION N889741 E4[illegible]73
RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25				C				SP-SC	slightly moist very dense	**SAND TO CLAYEY SAND,** continued
				C				SM/ML	slightly moist hard	**SANDY SILT TO SILTY SAND,** some clay, predominantly fine to medium grained sand, moderately lime cemented, Stage III, nonplastic to low plasticity, light grayish-brown
30				S	28-34-50/6"					
				C						
				C						
35				S	50/4"					
				C						
				C				SP-SC	slightly moist to moist very dense	**SAND TO CLAYEY SAND,** trace of gravel, predominantly fine to medium grained sand, nonplastic to low plasticity, light reddish-brown
40				S	45-50/3"					
										Stopped Auger at 39'6" Sampler refused at 40'3"
45										
50										

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
∇		none	
▼			
∇			
∇			

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-5

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/13/04

amec

LOCATION N889720 E4[illegible]
RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	4-9-11			SM	slightly moist moderately firm to firm	**SILTY SAND,** trace of gravel, predominantly fine to medium grained sand, considerable calcium carbonate, nonplastic to low plasticity, light brown note: weakly lime cemented below 4' (Stage II+ to III)
				U	13	117	2			
5				S	9-14-18					
				S	9-12-13					
				U	40					
10								ML	slightly moist very firm	**SANDY SILT,** weakly lime cemented, Stage II+ to III, low plasticity, light grayish-brown
				S	15-22-25					
15				U	64					
								SP-SM	slightly moist dense	**SAND TO SILTY SAND,** trace of clay, trace of gravel, predominantly fine to medium grained sand, weakly lime cemented, nonplastic to low plasticity, light brown note: clay increases with depth
				U	41					
								SC	slightly moist hard	**CLAYEY SAND,** trace of gravel, trace of silt, predominantly fine to medium grained sand, medium plasticity, light reddish-brown
20				S	20-30-50/6"					
								SP-SC	slightly moist to moist very dense	**SAND TO CLAYEY SAND,** trace of gravel, trace of silt, predominantly fine to medium grained sand, nonplastic to low plasticity, light reddish-brown
25				S	17-19-38					

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-6

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 DATE 4/13/04

amec

LOCATION N889720 E463748
RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25			X					SP-SC	slightly moist to moist very dense	**SAND TO CLAYEY SAND,** continued
								SC	slightly moist hard	**CLAYEY SAND,** trace of gravel, some silt, predominantly fine to medium grained sand, moderately lime cemented, Stage II+, medium plasticity, light reddish-brown
30				U	100/6"					
35			X	S	50/5"					
40			X	S	38-50/5"					
										Stopped Auger at 39'6" Sampler refused at 40'5"
45										
50										

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-6

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 **DATE** 4/13/04

amec

LOCATION N889703 E46[illegible]

RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	5-6-10			SM	slightly moist to moist moderately firm to firm	**SILTY SAND,** trace of gravel, predominantly fine to meduim grained sand, considerable calcium carbonate, low plasticity, light brown
				S	5-4-4					
5				U	42			SM	slightly moist very firm	**SILTY SAND,** trace of gravel, predominantly fine to medium grained sand, weakly to moderately lime cemented, Stage II+ to III, low plasticity, light brownish-gray
				U	56			ML	slightly moist very firm	**SANDY SILT,** weakly lime cemented, Stage II+, low plasticity, light grayish-brown
10				S	7-8-12			SM	slightly moist firm	**SILTY SAND,** trace of clay, trace of gravel, predominantly fine to medium grained sand, weakly lime cemented, low plasticity, light brown
				U	35			ML	slightly moist firm	**SANDY SILT,** weakly lime cemented, Stage II+, low plasticity, light grayish-brown
15				U	28	113	4	SC	slightly moist firm	**CLAYEY SAND,** predominantly medium to fine grained sand, weakly lime cemented, medium plasticity, light grayish-brown
				U	92			CL	slightly moist hard	**SILTY CLAY,** trace of sand, weakly lime cemented, Stage III, low to medium plasticity, light grayish-brown
20				S C	14-14-13			SP-SC	slightly moist to moist dense	**SAND TO CLAYEY SAND,** trace of gravel, trace of silt, some calcium carbonate, nonplastic to low plasticity, light reddish-brown
				C						
25				S	17-19-21			SC	slightly moist very firm	**CLAYEY SAND,** trace of silt, predominantly fine to medium grained sand, weakly lime cemented, Stage I+, medium plasticity, light brown

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
▽		none	
▼			
▽			
▼			

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-7

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 DATE 4/13/04

amec

LOCATION	N889703 E463808
RIG TYPE	CME-95
BORING TYPE	8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.	
DATUM	AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25				C				SC	slightly moist very firm to hard	**CLAYEY SAND,** continued
				C						
								CL	slightly moist hard	**SANDY CLAY,** some silt, weakly lime cemented, Stage I+, medium plasticity, light brown
30				S	26-29-31					
				C						
				C						
								SC	slightly moist hard	**CLAYEY SAND,** some gravel, predominantly fine to medium grained sand, medium plasticity, light brown
35				S	50/ 5 1/2" NR					
				C						
				C						
40				A	44-50/5"					
										Stopped Auger at 39'6" Sampler refused at 40'5"
45										
50										

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-7

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 DATE 4/13/04

LOCATION N889692 E463855
RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S A	6-10-13			SC/CL	slightly moist firm to very firm	**SANDY CLAY TO CLAYEY SAND,** some silt, trace of gravel, considerable calcium carbonate, medium plasticity, light brown
				U	15					
										note: weakly lime cemented (Stage II+ to III) below 4'
5				U	45					
				S	13-15-21					
10				U	32			SC	slightly moist firm	**CLAYEY SAND,** trace of gravel, some silt, weakly lime cemented, medium plasticity, light reddish-brown
				U	36			ML	slightly moist firm to hard	**SANDY SILT,** trace of gravel, weakly lime cemented, Stage II+, low plasticity, light brown
15				S	16-26-45					
				S	11-16-20					
20				S	22-26-27					
								SP-SC/SC	slightly moist very dense	**SAND TO CLAYEY SAND,** trace of gravel, trace of silt, predominantly fine to medium grained sand, nonplastic to low plasticity, light reddish-brown
25				S	24-26-30					

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE
A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-8

PROJECT Supplemental Investigation of Transverse Cracks
Buckeye FRS No. 1
Contract FCD 2003C014, Work Assignment No. 2

JOB NO. 4-117-001021 DATE 4/13/04

LOCATION N889692 E463855

RIG TYPE CME-95
BORING TYPE 8 5/8" O.D. Hollow Stem Auger
SURFACE ELEV.
DATUM AMEC

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count Per 6-inches	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25			X					SP-SC/SC	slightly moist very dense	**SAND TO CLAYEY SAND,** continued
								SC	slightly moist	**CLAYEY SAND,** some silt, predominantly fine to medium grained sand, weakly to moderately lime cemented, Stage II+, medium plasticity, light brown
30				U	87				hard	
35			X	S	50/5"					
40			X	S	50/5"					
										Stopped Auger at 39'6" Sampler refused at 39'11"
45										
50										

GROUNDWATER

DEPTH (ft)	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
C - 3" O.D. CME tube sample
NR - No Recovery
PR - Poor Recovery

LOG OF TEST BORING NO. B-8

amec

APPENDIX E

EXCAVATIONS OF UPSTREAM SLOPE

amec

Notes for Figure E-1

Zone 1

1. Crack aperture is ~ ¼ to 1/8" wide. Photos Note1_1 and Note1_2.
2. Crack aperture is ~ 0.2" wide. Photos Note2_1 and Note2_2.
3. Crack aperture is 0.2 to 0.4" wide. Photos Note3_1 and Note3_2.
4. Filled crack up to 8" wide. Photos Note4_1 and Note4_2.

Zone 2

5. Crack aperture is 0.05 to 0.2" wide. Photos Note5_1 and Note5_2.
6. Crack aperture is 0.05 to 0.2" wide. Photos Note6_1 and Note6_2.
7. Filled crack up to 8" wide. Photo Note7_1.
8. Filled crack up to 12" wide. Photos Note8_1 and Note8_2.

Zone 3

9. Cracks are not organized and continuous (before additional cleaning). Photo Note9_1.

Zone 1

10. Open crack with 0.3 to 2" aperture. Photo Note10_1.
11. Open crack with 0.4" aperture. Photo Note11_1.
12. Open crack with 0.2 to 0.5" aperture. Photo Note 12_1.
13. Partially filled crack and filled zone 4 to 6" wide. Photo Note13_1.
14. Open crack with 0.2" aperture. Photo Note14_1.
15. Open crack with 0.3" aperture. Photo Note15_1.
16. Partially filled crack with 0.2 to 0.4" aperture. Photo Note16_1.
17. Filled crack 2 to 4" wide. Photo Note17_1.
18. ~ parallel filled cracks 2 to 3 inches wide. Photo Note18_1.
19. ~ parallel filled cracks 2 to 4" wide. Photo Note19_1.
20. Filled crack 3 to 4" wide. Photo Note20_1.

Zone 2

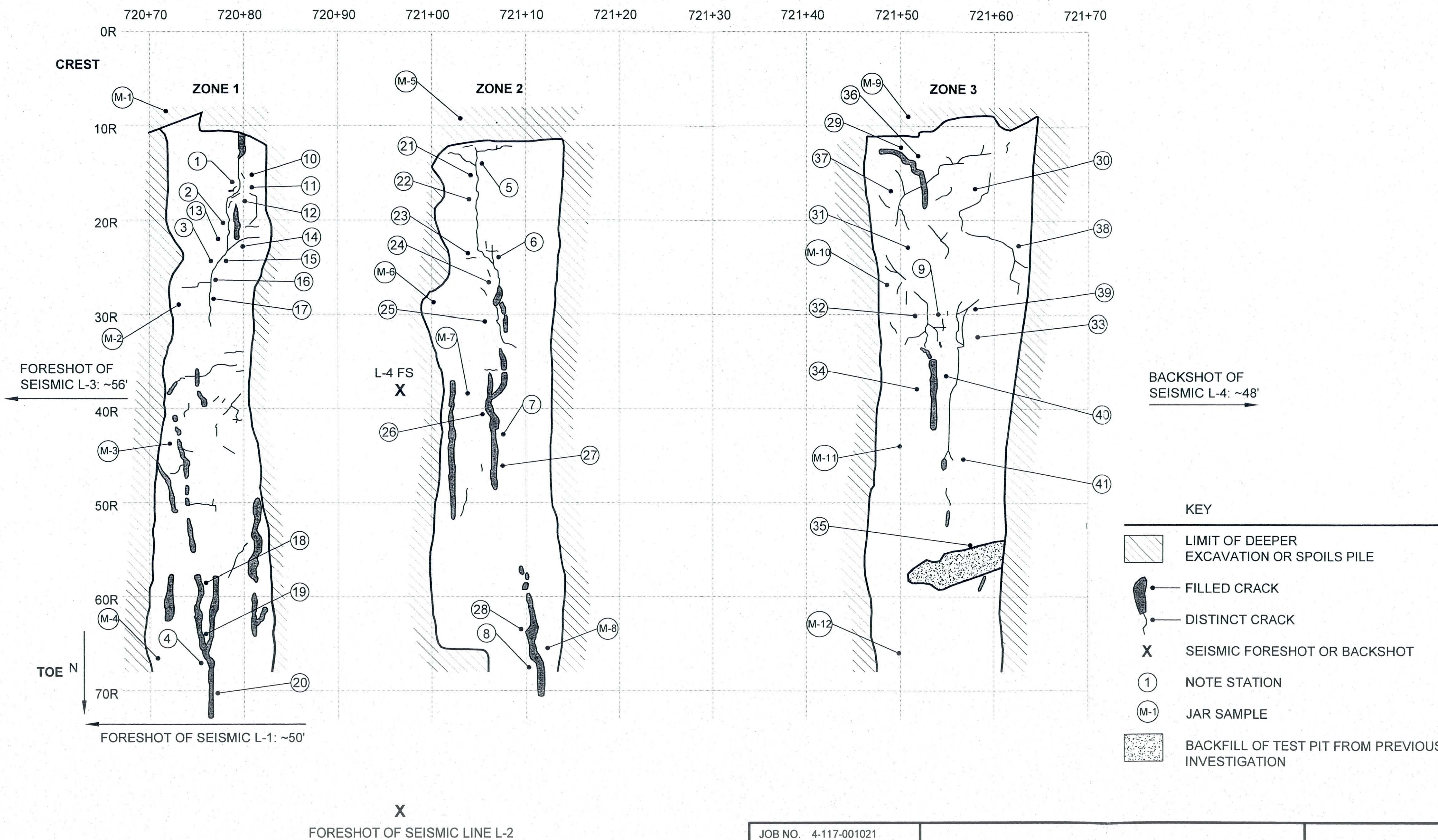
21. Open cracks with 0.03 to 0.2" aperture. Photo Note21_1.
22. Partially filled crack with ~ 0.2" aperture. Photo Note22_1.
23. Partially filled crack with up to 0.1" aperture. Photo Note23_1.
24. Open crack with 0.2 to 0.5" aperture. Photo Note24_1.
25. Partially filled to filled crack up to 3" wide. Photo Note25_1.
26. Filled crack 2 to 6" wide. Photo Note26_1.
27. Filled crack 2 to 3" wide. Photo Note27_1.
28. Filled crack 2 to 12" wide. Photo Note28_1.

Zone 3

29. Photo Note29_1.
30. Photo Note30_1.
31. Photo Note31_1.

32. Photo Note32_1.
33. Photo Note33_1.
34. Photo Note34_1.
35. Photo Note35_1.
36. Filled crack 0.6 to 2.0" wide. Photo Note36_1.
37. Partially filled crack 0.2 to 1.0" wide. Photo Note37_1.
38. Open crack with 0.1 to 0.5" aperture. Photo Note38_1.
39. Open cracks 0.1 to 0.2" aperture. Photo Note39_1.
40. Filled crack (left) up to 12" wide and partially filled crack (right) with up to 2.0" aperture. Photo Note40_1.
41. Partially filled crack up to 1.5" wide. Photo Note41_1.

Note: the use of pressurized air for surficial cleaning may result in overestimation of the above measured apertures.



NOTE: GRID VIEW IS PERPENDICULAR TO OVERALL 3:1 SLOPE

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	1" = 10'

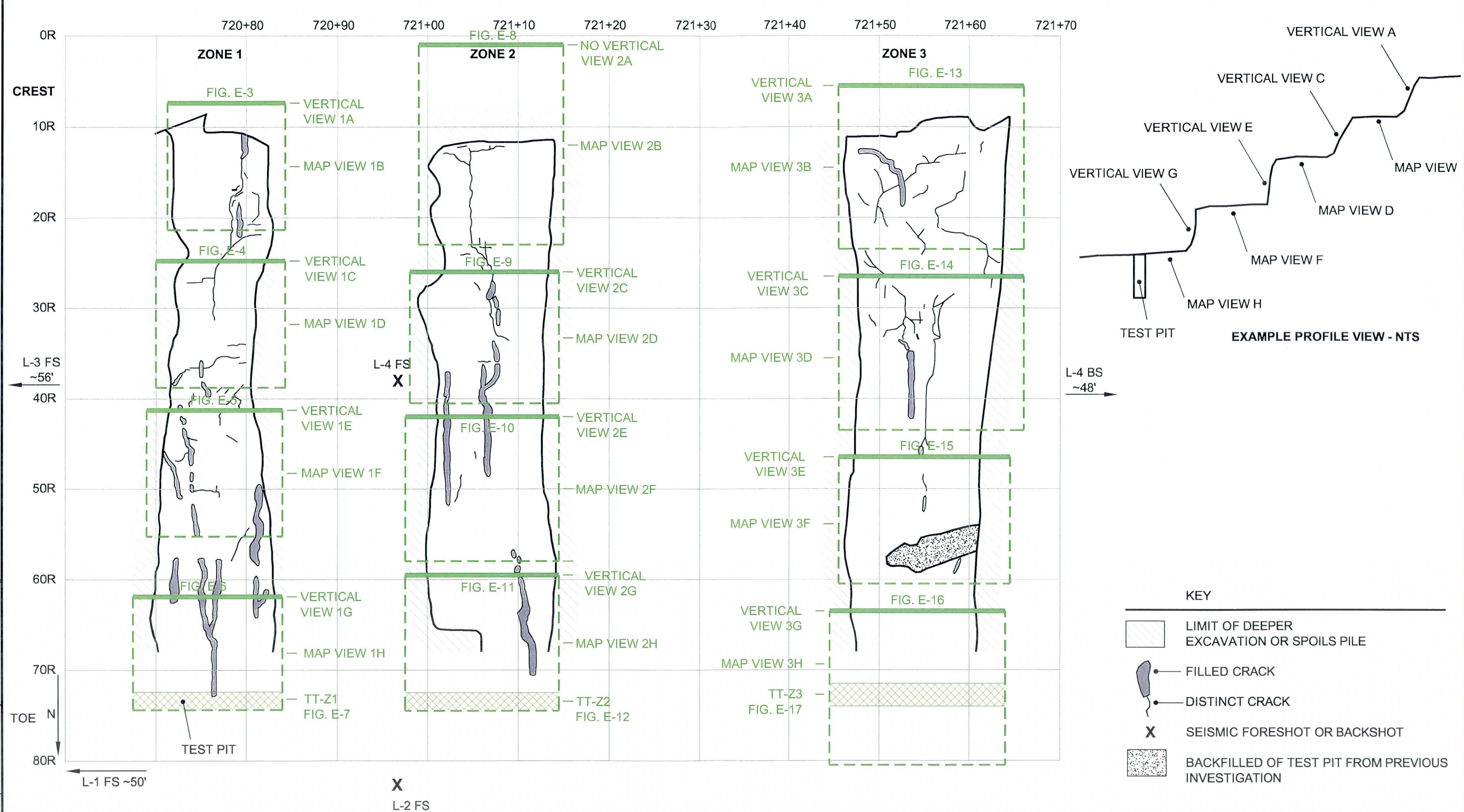
SURFICIAL CRACK MAPPING

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO.2

FIGURE E-1

amec

G:\Engineering Dep...\2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\Zns1_2_3_-X-Section.dwg



NOTE: GRID VIEW IS PERPENDICULAR TO SLOPE

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	1" = 10'

LOCATIONS OF UPSTREAM SLOPE LOGS

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO.2

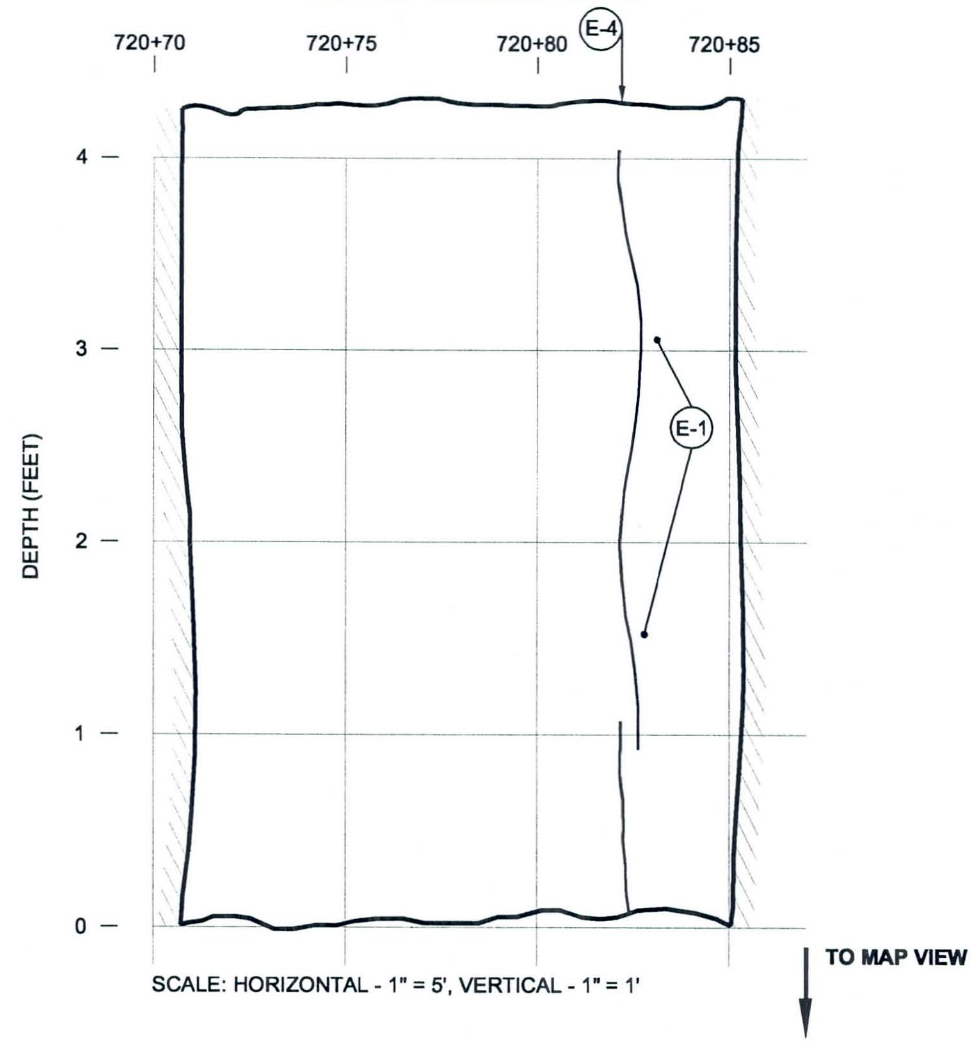
FIGURE E-2

amec

G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\Zns-X-Section.dwg

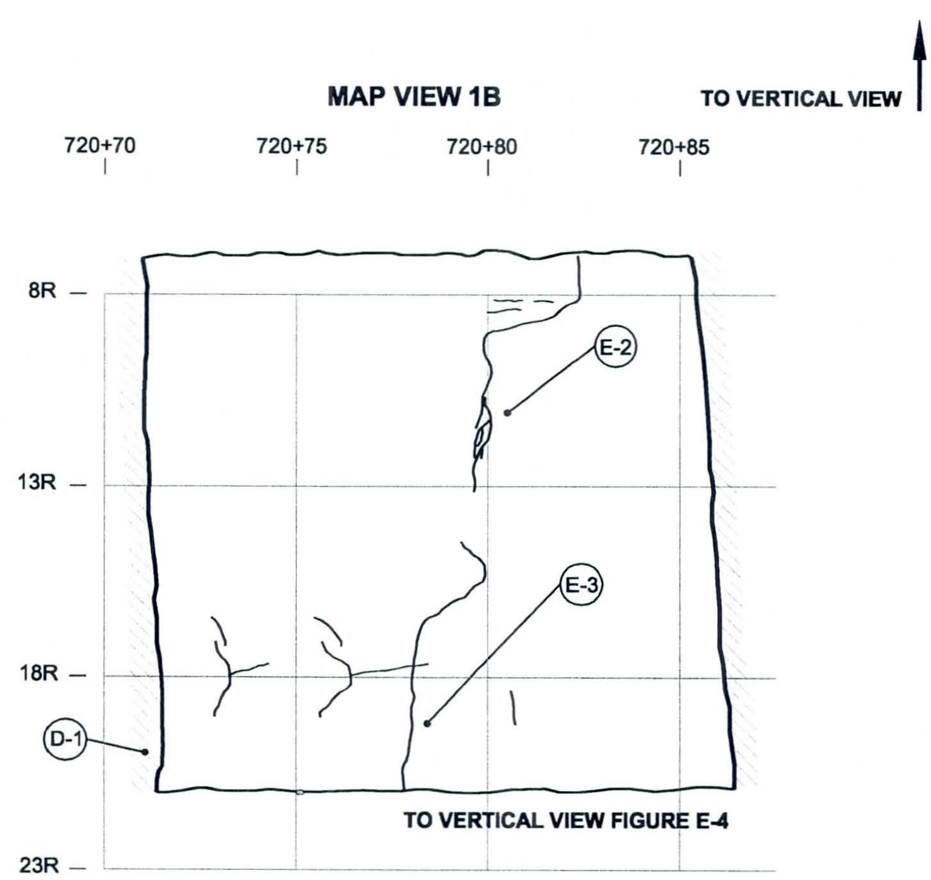
ZONE 1

VIEW OF VERTICAL WALL



SCALE: HORIZONTAL - 1" = 5', VERTICAL - 1" = 1'

MAP VIEW 1B



SCALE: 1" = 5'

KEY

- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- FILLED CRACK
- DISTINCT CRACK
- (D-1) BULK SAMPLE LOCATION

- (E-1) PARTIALLY FILLED TO FILLED CRACK TYPICAL <0.1" WIDE OCCASIONAL ZONE WITH 1/16" APERTURE, 2 PHOTOS
- (E-2) PARTIALLY FILLED TO OPEN CRACK <0.1" APERTURE, 2 PHOTOS
- (E-3) OPEN CRACK ~0.2" APERTURE, 1 PHOTO
- (E-4) CRACK FILLED <1/16" WIDE (DOES NOT PENETRATE DRAIN), 1 PHOTO

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 1
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

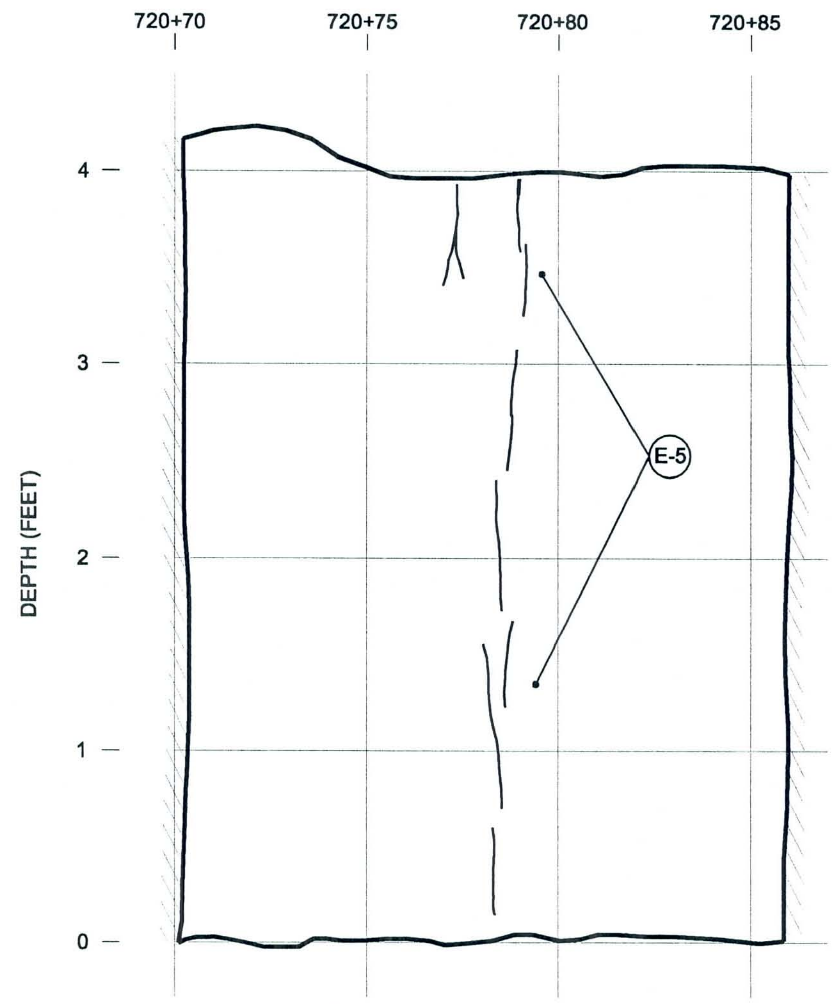
FIGURE
E-3

amec

ZONE 1

VERTICAL VIEW 1C

TO MAP VIEW PAGE 1

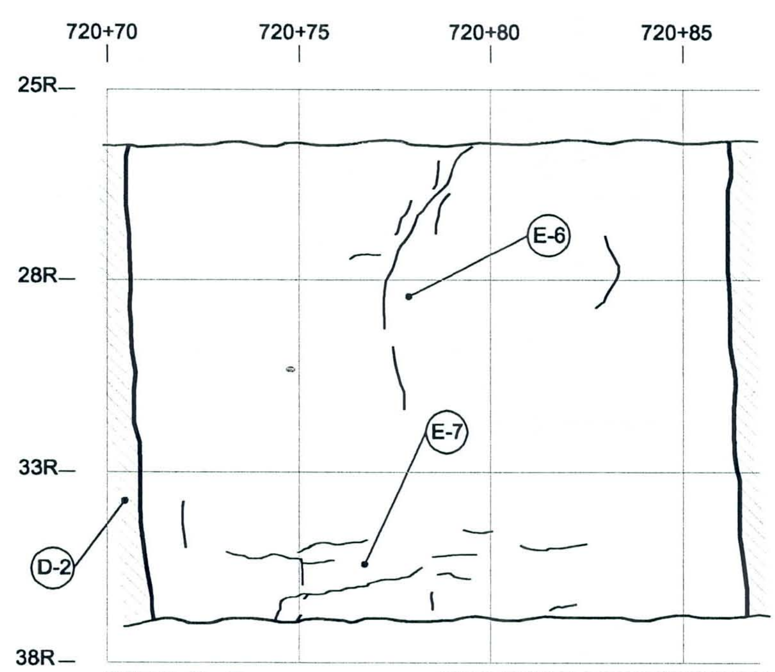


SCALE: HORIZONTAL - 1" = 5', VERTICAL - 1" = 1'

TO MAP VIEW

MAP VIEW 1D

TO VERTICAL VIEW



SCALE: 1" = 5'

TO VERTICAL VIEW FIGURE E-5

KEY

(hatched box)	LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
(filled symbol)	FILLED CRACK
(line symbol)	DISTINCT CRACK
D-2	BULK SAMPLE LOCATION
E-5	PARTIALLY FILLED CRACK HAIRLINE TO 0.05", 2 PHOTOS
E-6	PARTIALLY FILLED CRACK 0.1 TO 0.2", 1 PHOTOS
E-7	OPEN CRACK UP TO 0.5" OPEN APPEARS TO BE DUE TO TRENCH AFFECTS, 2 PHOTOS

JOB NO. 4-117-001021
DESIGN: KCF
DRAWN: GWH
DATE: 6/2004
SCALE: AS SHOWN

ZONE 1
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

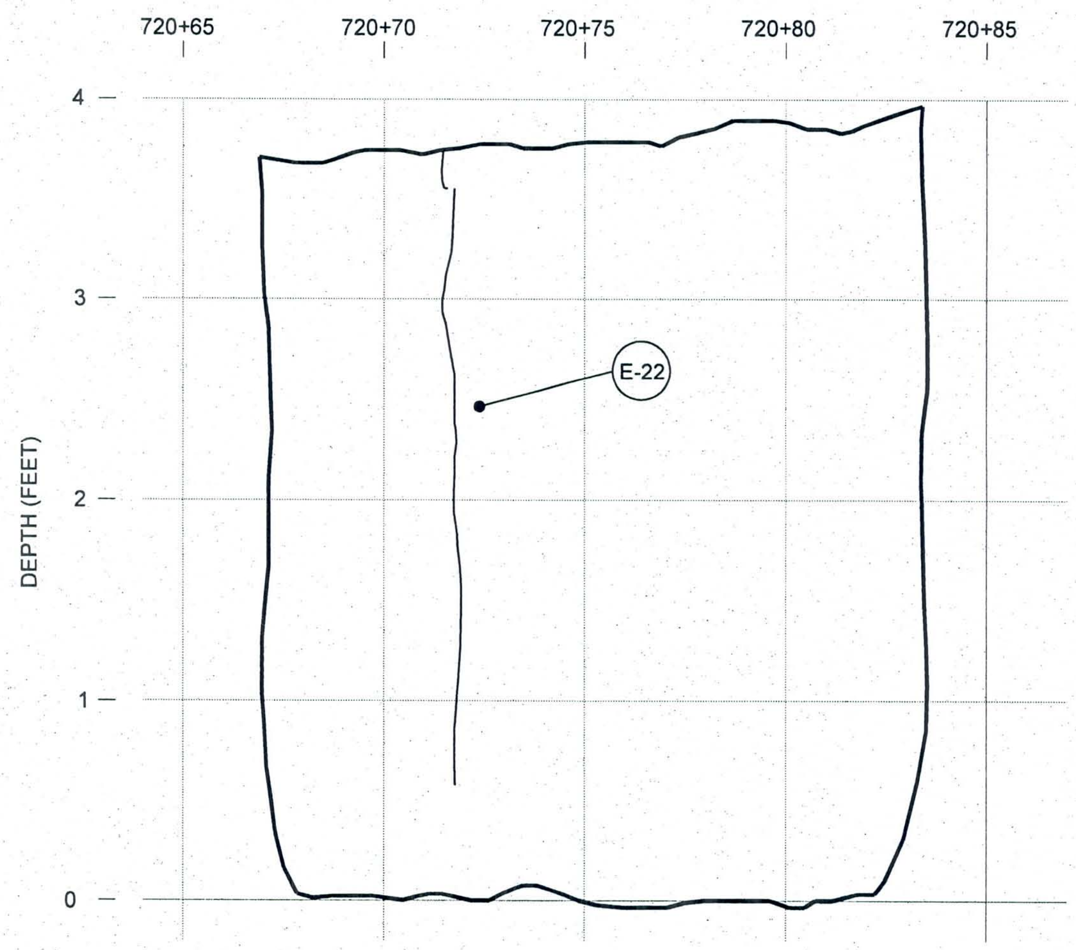
FIGURE E-4

amec

ZONE 1

VERTICAL VIEW 1E

TO MAP VIEW PAGE 3

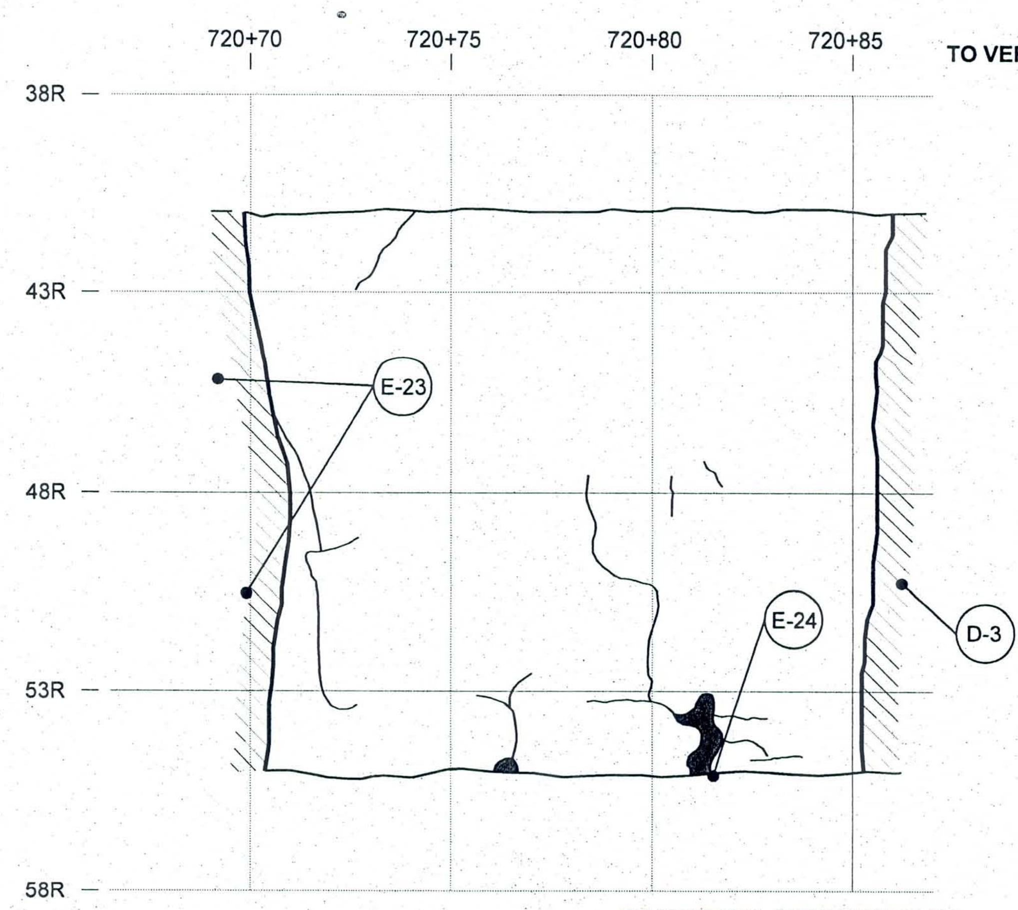


SCALE: HORIZONTAL - 1" = 5', VERTICAL - 1" = 1'

TO MAP VIEW

MAP VIEW 1F

TO VERTICAL VIEW



TO VERTICAL VIEW FIGURE E-6

KEY

- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- FILLED CRACK
- DISTINCT CRACK
- (E-22) SMALL CRACK <1/16" OPEN, NO PHOTO
- (E-23) SMALL PARTIALLY FILLED TO FILLED CRACK TYP. ~0.05" WIDE UP TO 0.2", NO PHOTO
- (E-24) PHOTO
- (D-3) BULK SAMPLE LOCATION

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 1
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

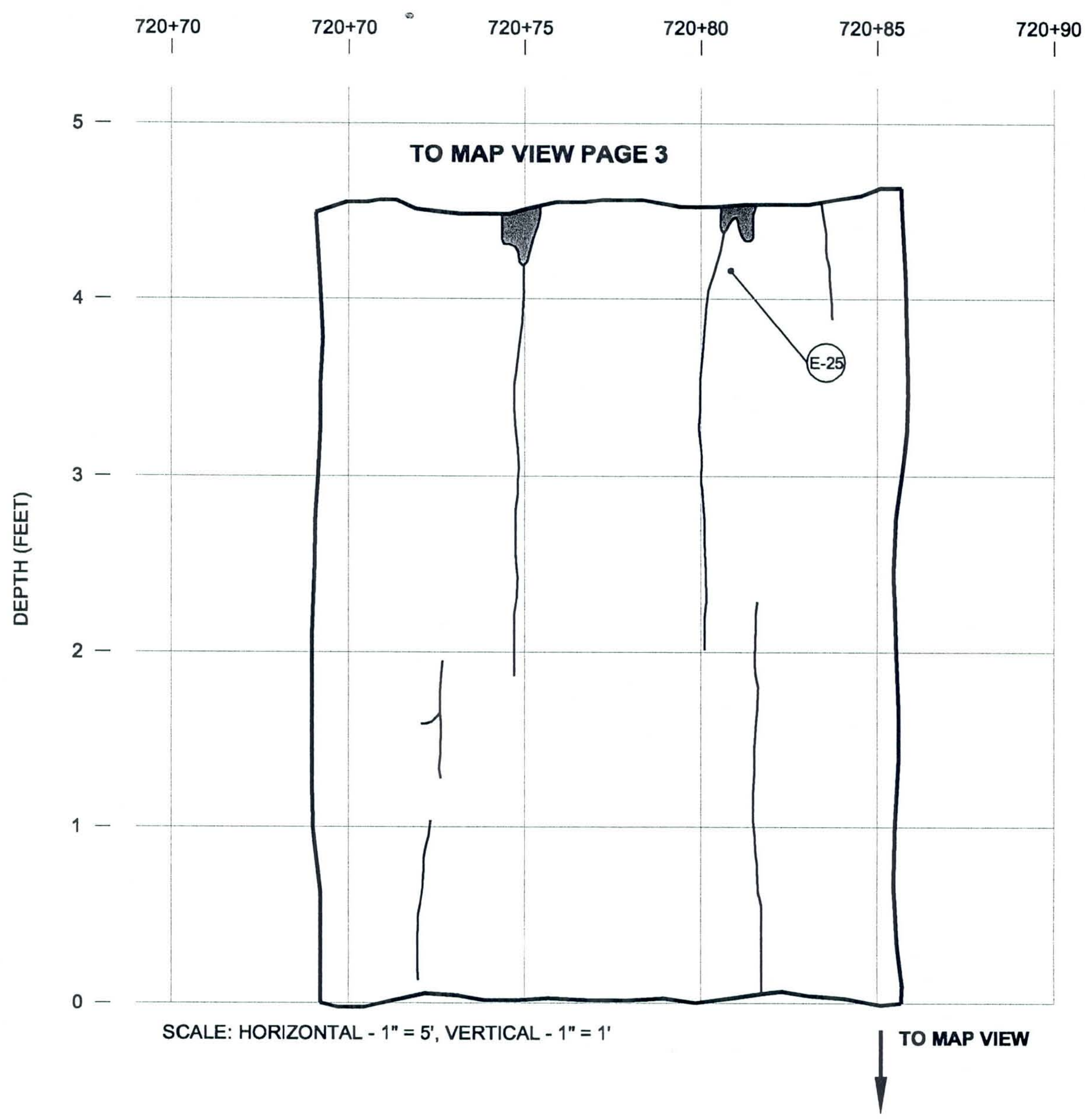
FIGURE E-5

amec

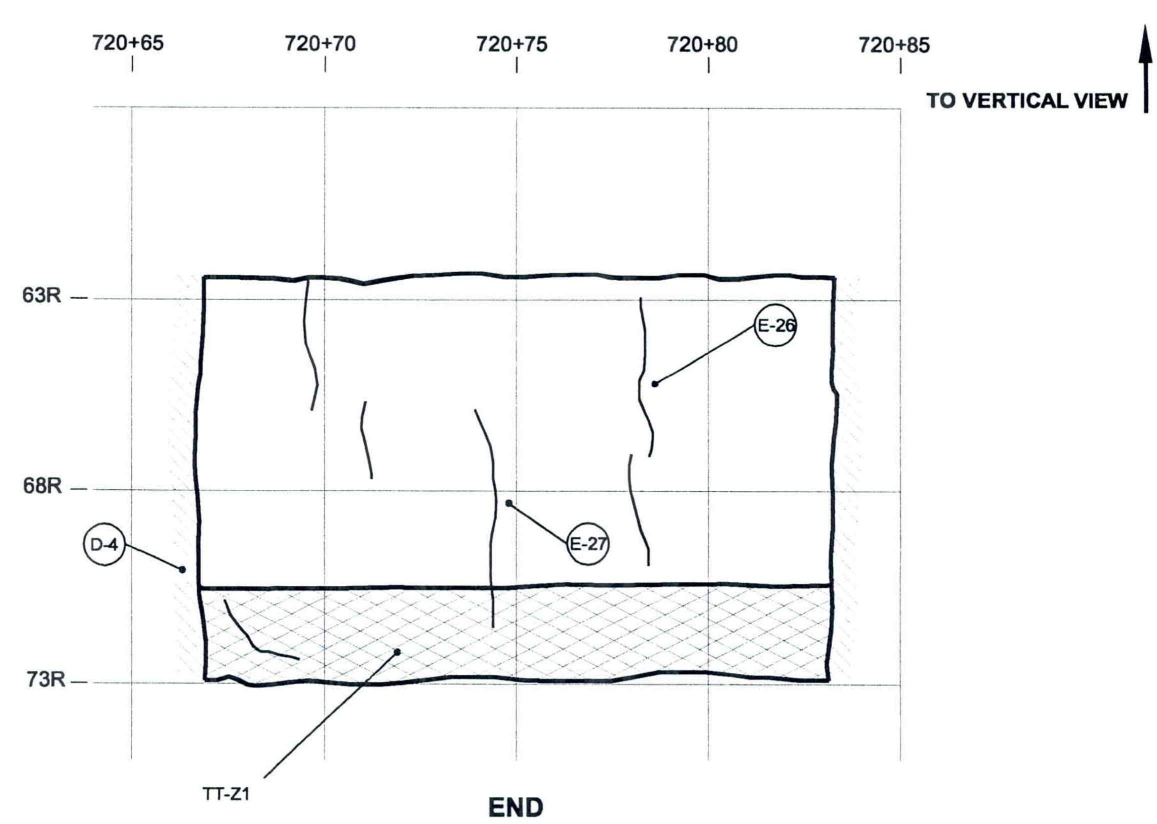
G:\Engineering Departm... Projects\4-117-001021 Buckeye FRS No. 1 \Cad\More - Vert_Hor_Views.dwg

ZONE 1

VERTICAL VIEW 1G



MAP VIEW 1H



KEY

- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- TEST TRENCH
- FILLED CRACK
- DISTINCT CRACK
- (E-25) PHOTO
- (E-26) PARTIALLY FILLED CRACK UP TO 0.2" OPEN, PHOTO
- (E-27) PARTIALLY FILLED CRACK UP TO 0.1" OPEN, PHOTO
- (D-4) BULK SAMPLE LOCATION

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

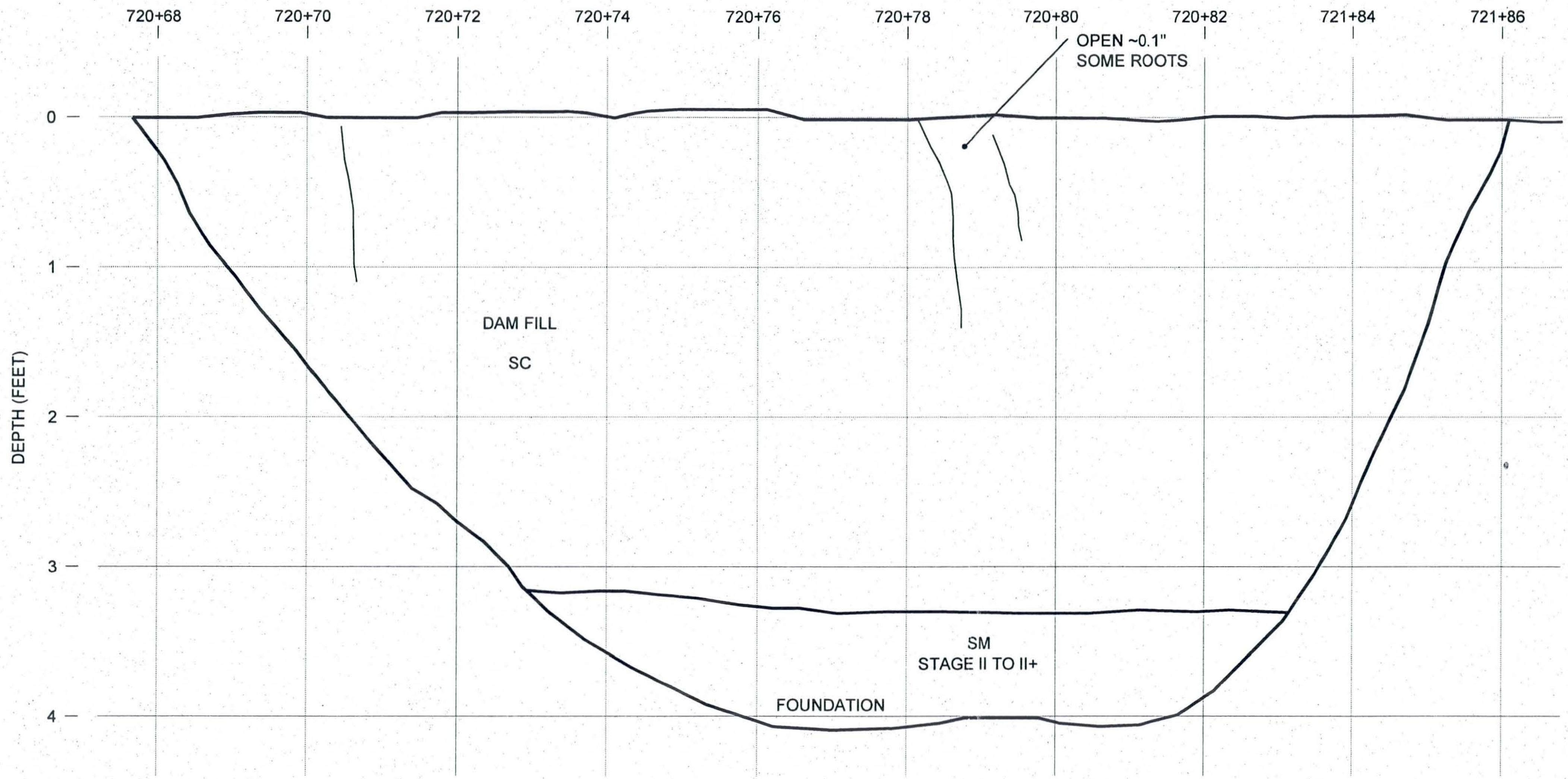
ZONE 1
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
E-6

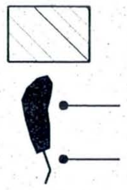
amec

TEST TRENCH-Z1
FACING SOUTH



SCALE: HORIZONTAL - 1" = 2', VERTICAL - 1" = 1'

KEY



G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\North-South Wall_Vert-Hor-Views.dwg

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

TT-Z1 - FACING SOUTH

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

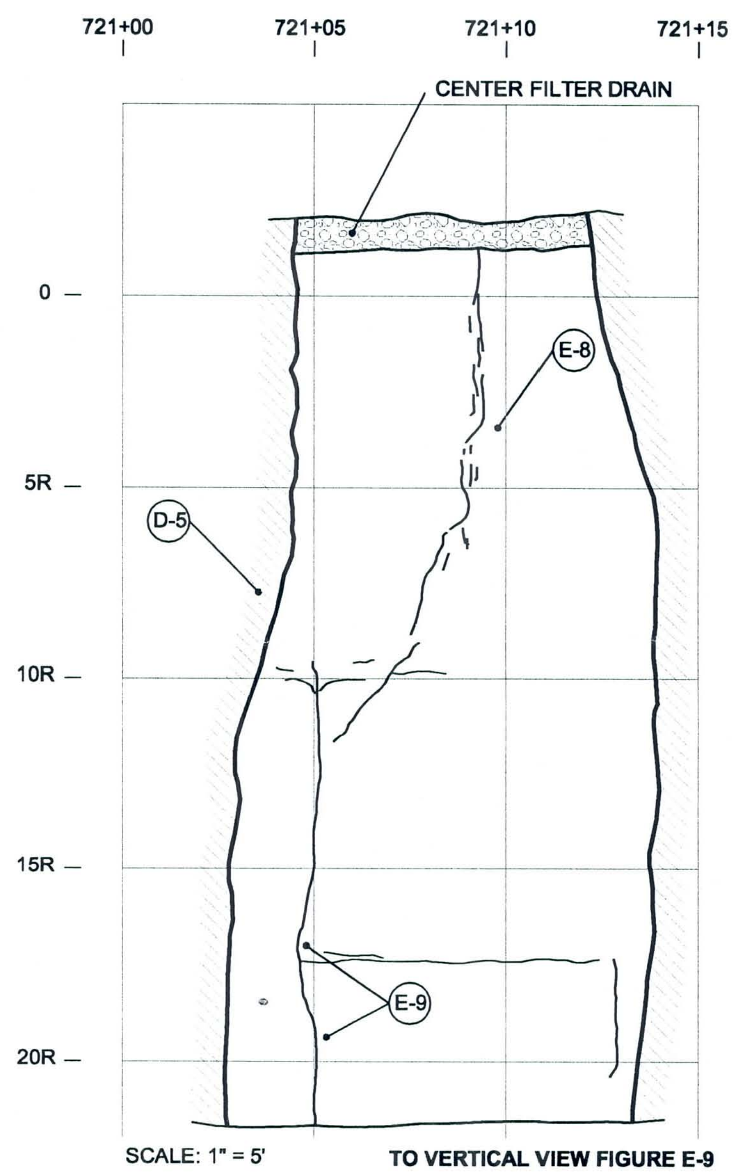
FIGURE
E-7

amec

ZONE 2

TO MAP VIEW PAGE 1

NO VERTICAL VIEW 2A



KEY

LIMIT OF DEEPER EXCAVATION OR SPOILS PILE

FILLED CRACK

DISTINCT CRACK

(D-5) BULK SAMPLE LOCATION

(E-8) ZONE OF PARTIALLY FILLED CRACKING NOT OPEN, 1 PHOTO

(E-9) OPEN CRACK 0.2 TO 0.3", 2 PHOTOS

JOB NO. 4-117-001021
DESIGN: KCF
DRAWN: GWH
DATE: 6/2004
SCALE: AS SHOWN

ZONE 2
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

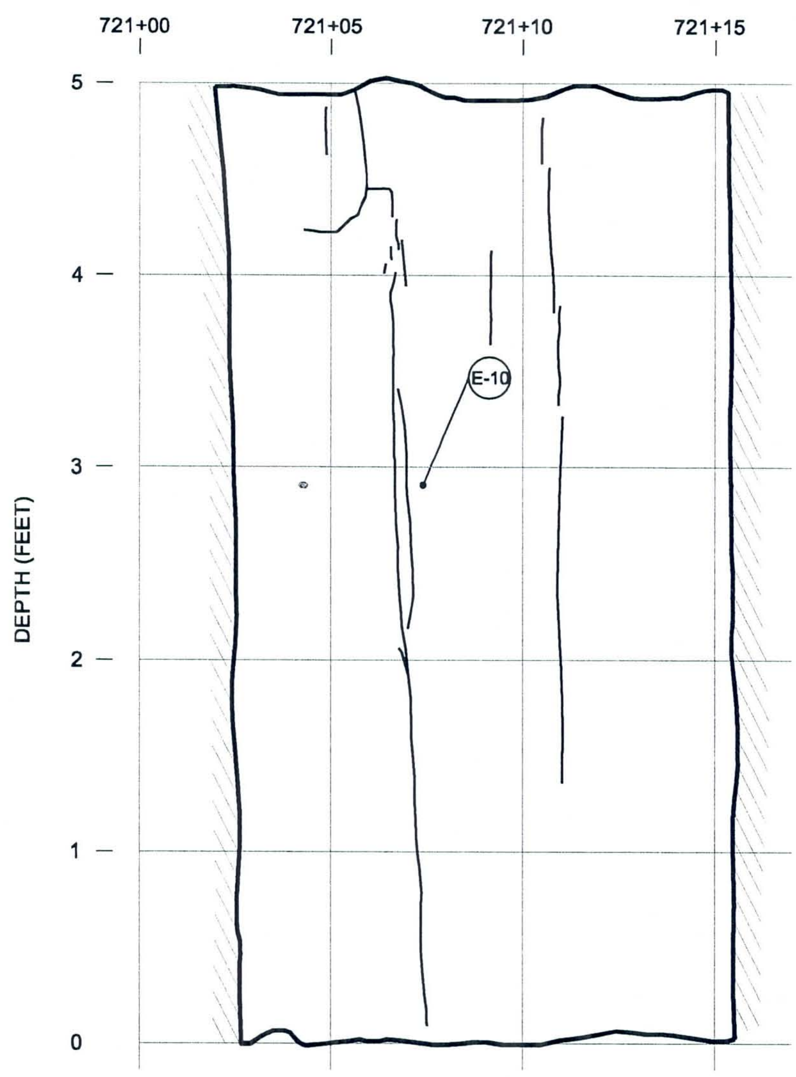
FIGURE
E-8

amec

ZONE 2

VERTICAL VIEW 2C

TO MAP VIEW PAGE 1



SCALE: HORIZONTAL - 1" = 5', VERTICAL - 1" = 1'

TO MAP VIEW

MAP VIEW 2D

TO VERTICAL VIEW

SCALE: 1" = 5'

TO VERTICAL VIEW FIGURE E-10

KEY

- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- FILLED CRACK
- DISTINCT CRACK
- (D-6) BULK SAMPLE LOCATION
- (E-10) OPEN ZONE OF CRACK OPEN UP TO 0.2" NEAR 5°; TYPICALLY <0.05", 2 PHOTOS
- (E-11) ZONE OF PARTIALLY OPEN CRACKS TYPICALLY <0.5", 1 PHOTO
- (E-12) OPEN CRACK ~0.05" OPEN, 1 PHOTO

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 2
NEAR VERTICAL VIEW & MAP VIEW

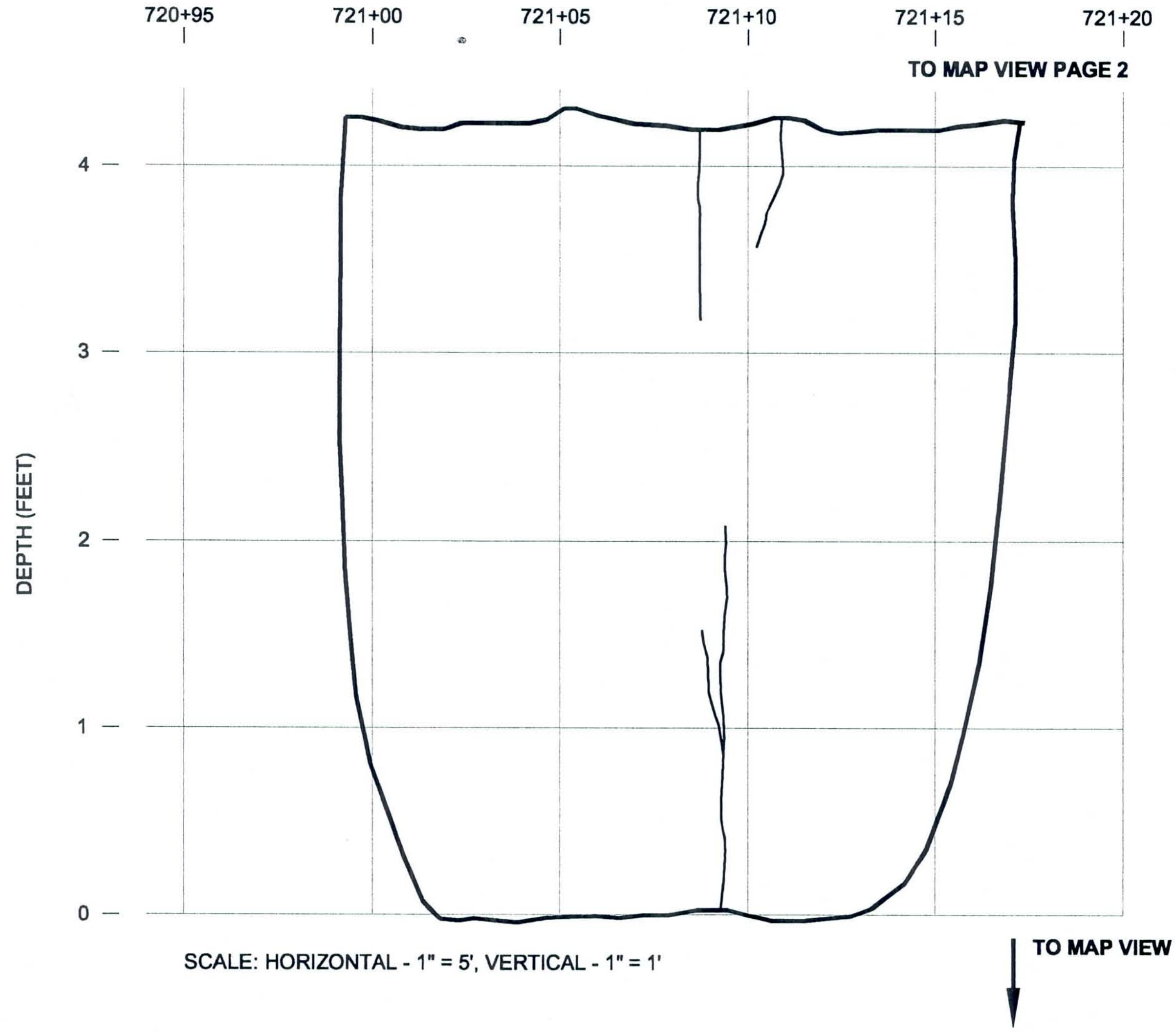
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
E-9

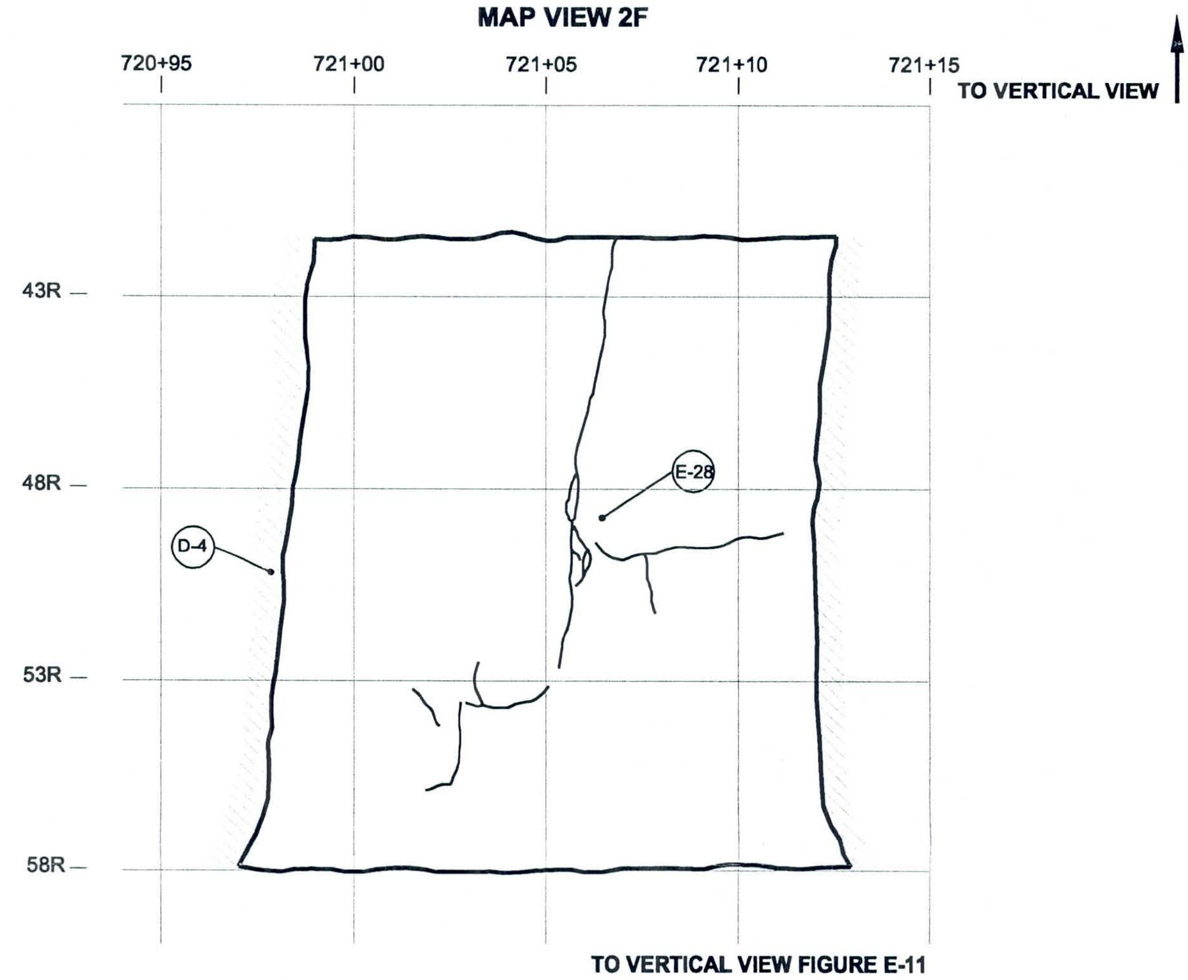
amec

G:\Engineering Departm Projects\4-117-001021 Buckeye FRS No. 1\Cad\More - Vert_Hor_Views.dwg

VERTICAL VIEW 2E



MAP VIEW 2F



KEY

- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- FILLED CRACK
- DISTINCT CRACK
- (E-28) PARTIALLY FILLED TO FILLED CRACK OPEN UP TO 0.2", FILLED UP TO 2" WIDE, PHOTO
- (D-7) BULK SAMPLE LOCATION

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 1
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

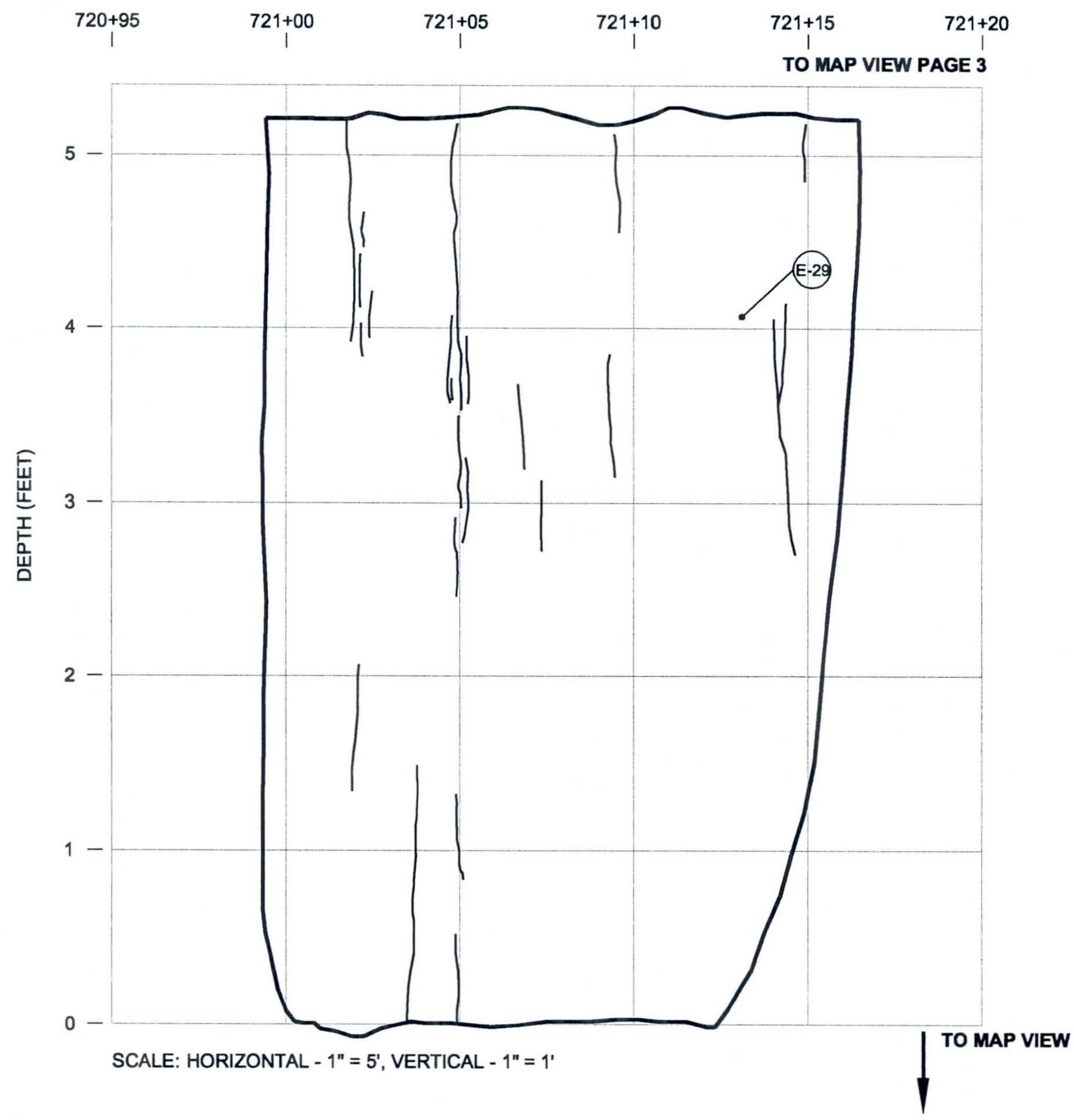
FIGURE
E-10

amec

G:\Engineering Departm... Projects\4-117-001021 Buckeye FRS No. 1 \Cad\More - Vert_Hor_Views.dwg

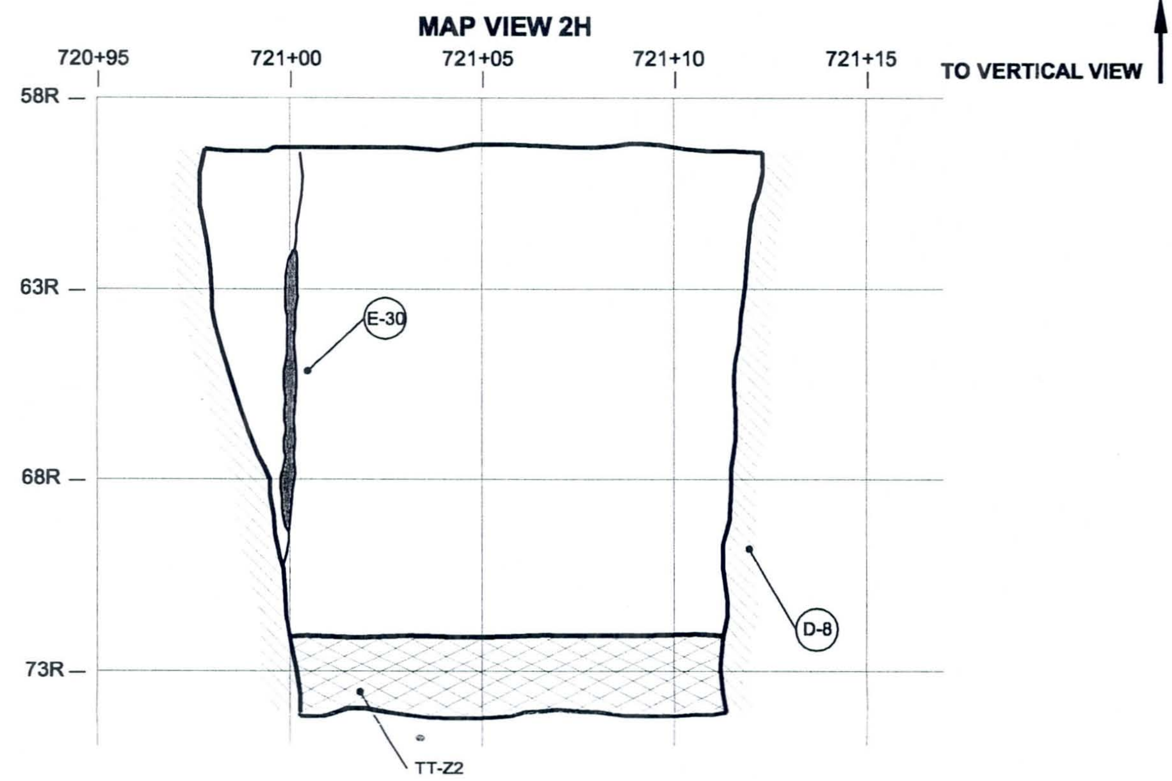
ZONE 2

VERTICAL VIEW 2G



SCALE: HORIZONTAL - 1" = 5', VERTICAL - 1" = 1'

MAP VIEW 2H



KEY

- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- TEST TRENCH
- FILLED CRACK
- DISTINCT CRACK
- (E-29) SMALL CRACKS <0.05" OPEN
- (E-30) PARTIALLY FILLED TO FILLED CRACK
- (D-8) BULK SAMPLE LOCATION

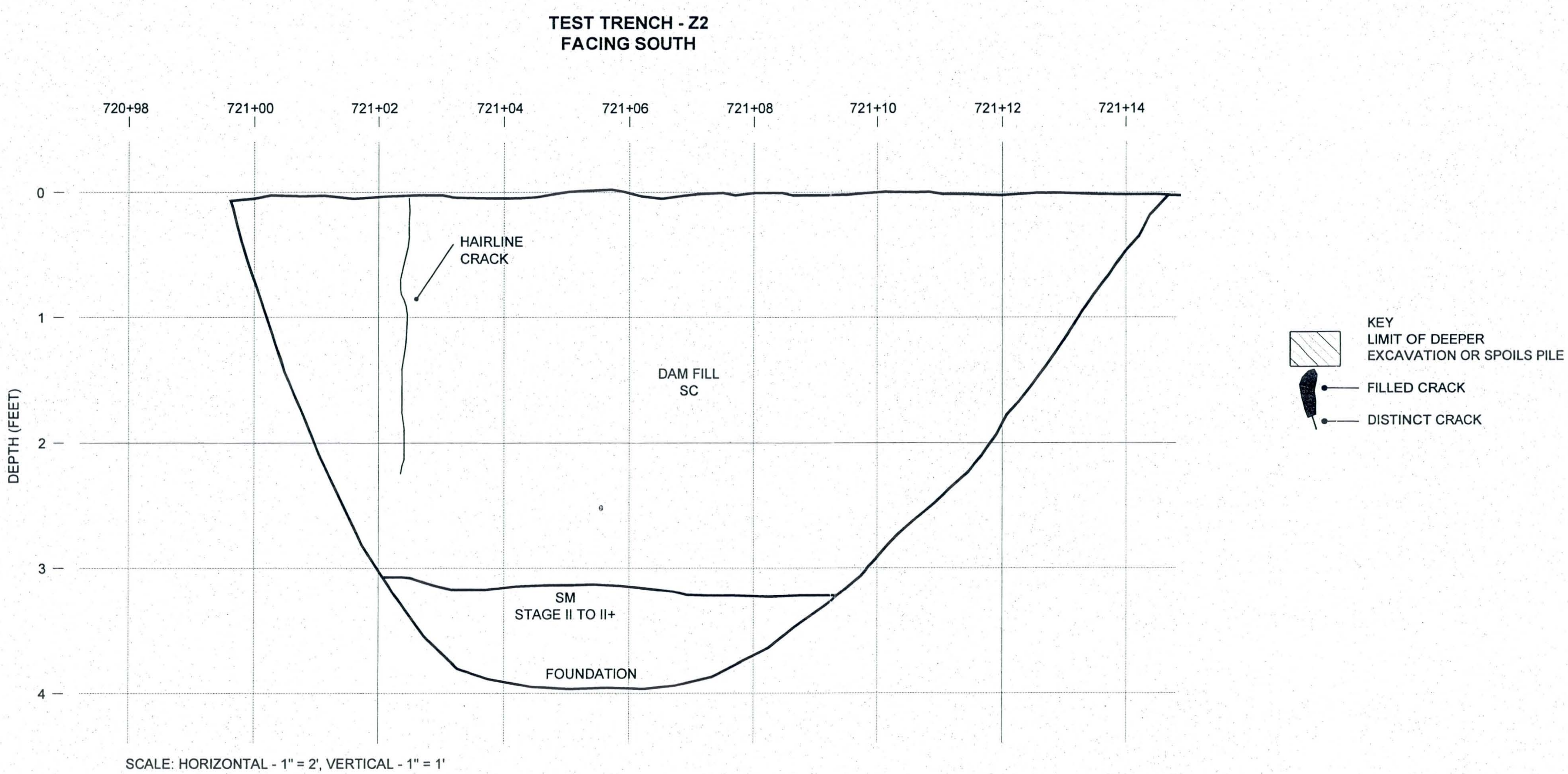
JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 2
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE E-11

amec



G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\North-South Wall_Vert-Hor-Views.dwg

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

TT-Z2 - FACING SOUTH

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

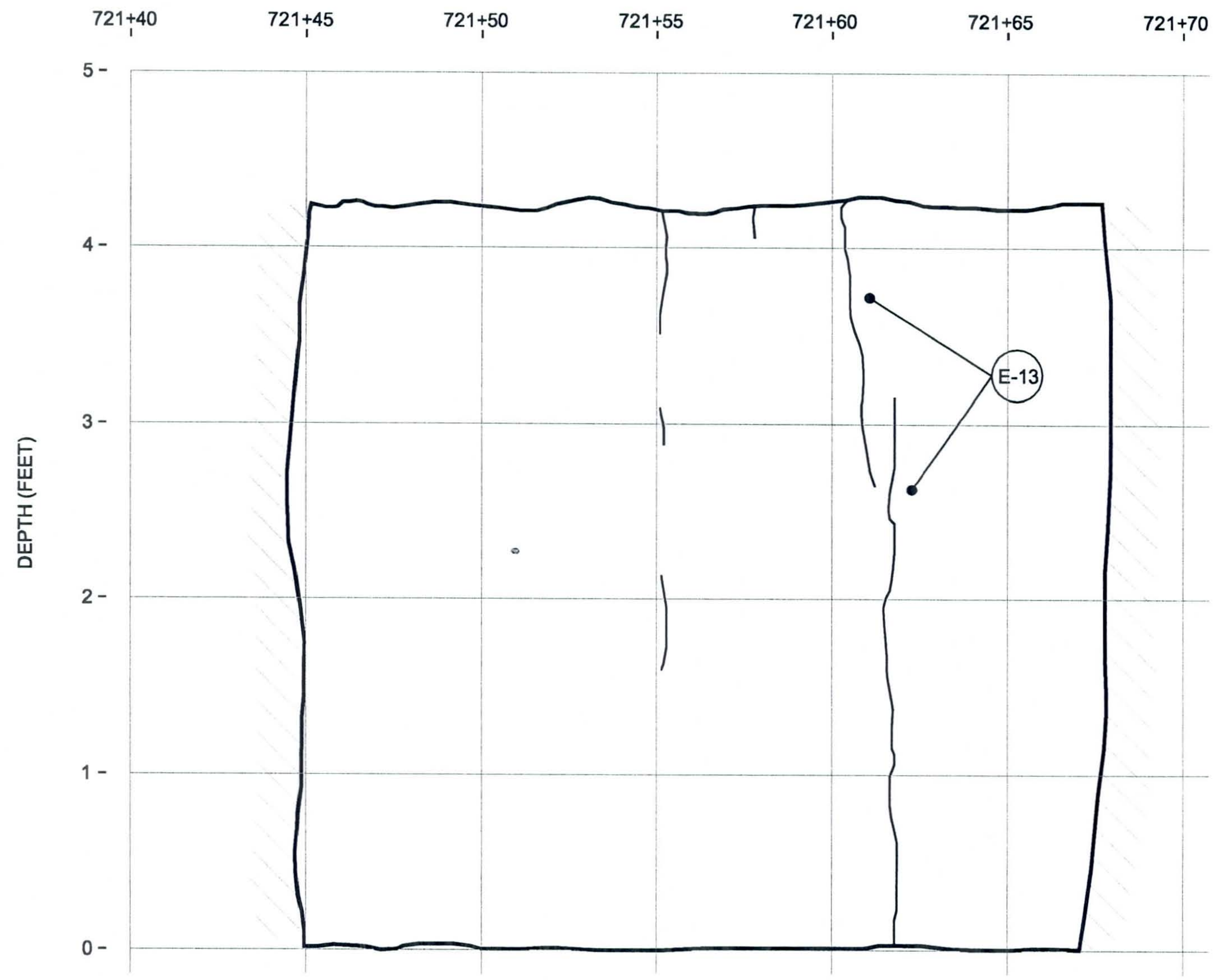
FIGURE E-12

amec

G:\Engineering Departm... Projects\4-117-001021 Buckeye FRS No. 1\Cad\Zns1_2_3_-Vert_Hor_Views.dwg

ZONE 3

VERTICAL VIEW 3A

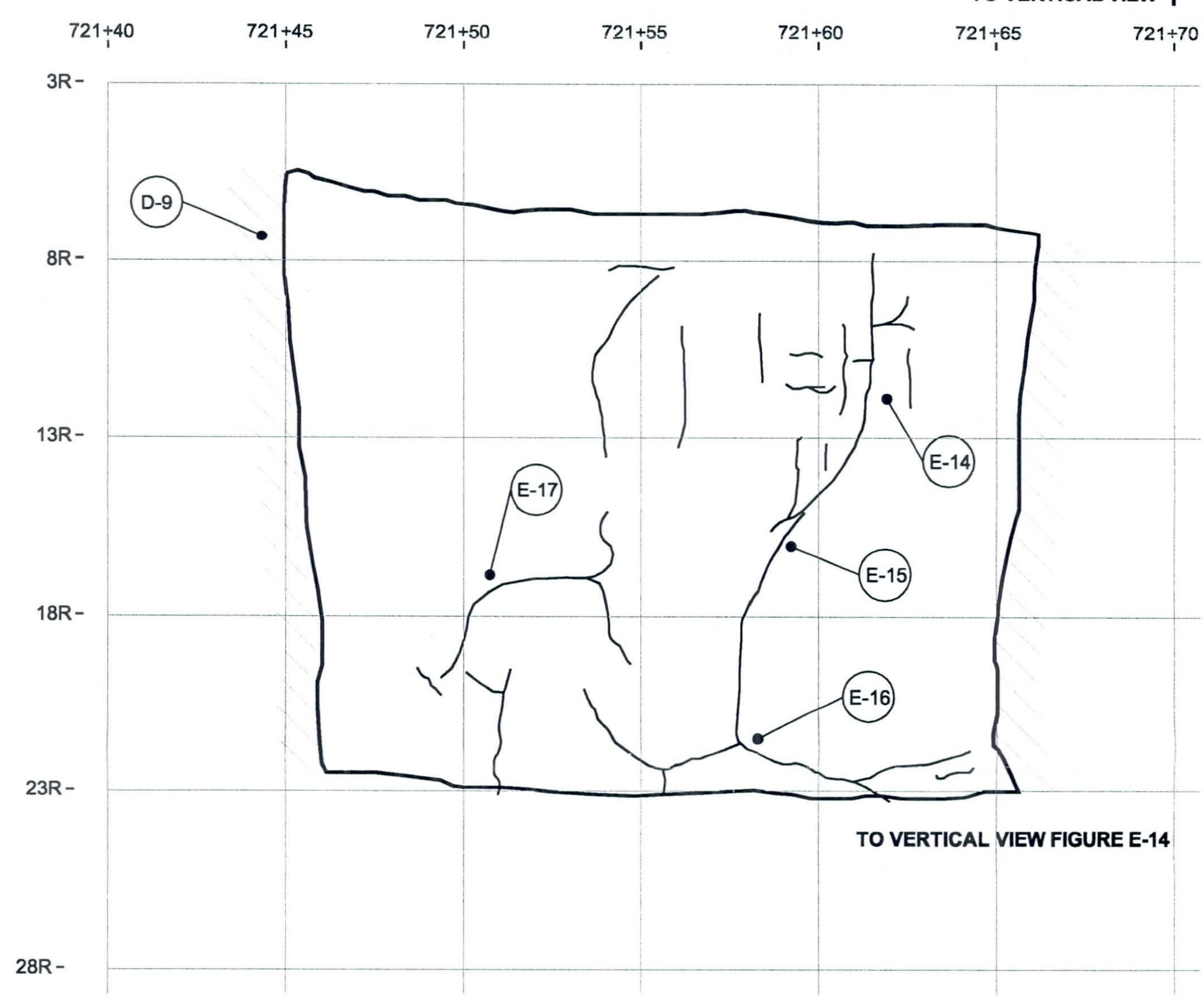


SCALE: HORIZONTAL - 1" = 5', VERTICAL - 1" = 1'

TO MAP VIEW

MAP VIEW 3B

TO VERTICAL VIEW



TO VERTICAL VIEW FIGURE E-14

SCALE: 1" = 5'

KEY

- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- FILLED CRACK
- DISTINCT CRACK
- (D-1) BULK SAMPLE LOCATION
- (E-13) OPEN TO PARTIALLY FILLED CRACK 0.1 TO 0.4" OPEN, 2 PHOTOS
- (E-14) OPEN CRACKS 0.1 TO 0.3", 1 PHOTO
- (E-15) OPEN CRACK 0.2", 1 PHOTO
- (E-16) PARTIALLY FILLED CRACKS 0.1 TO 0.3" OPEN, 1 PHOTO
- (E-17) PARTIALLY FILLED CRACK 0.2" OPEN, 1 PHOTO

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 3
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
E-13

amec

G:\Engineering Departm Projects\4-117-001021 Buckeye FRS No. 1\Cad\Zns1_2_3_-Vert_Hor_Views.dwg

ZONE 3

VERTICAL VIEW 3C

TO MAP VIEW PAGE 1

SCALE: HORIZONTAL - 1" = 5', VERTICAL - 1" = 1'

TO MAP VIEW

MAP VIEW 3D

TO VERTICAL VIEW

SCALE: 1" = 5'

TO VERTICAL VIEW FIGURE E-15

KEY

LIMIT OF DEEPER EXCAVATION OR SPOILS PILE

FILLED CRACK

DISTINCT CRACK

(E-18) CRACK <1/16" OPEN, 1 PHOTO

(E-19) CRACK <1/16" OPEN, 1 PHOTO

(E-20) OPEN CRACK UP TO 0.5" OPEN, 1 PHOTO

(E-21) OPEN CRACK TO PARTIALLY FILLED UP TO 1.0" OPEN, 2 PHOTOS

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 3
NEAR VERTICAL VIEW & MAP VIEW

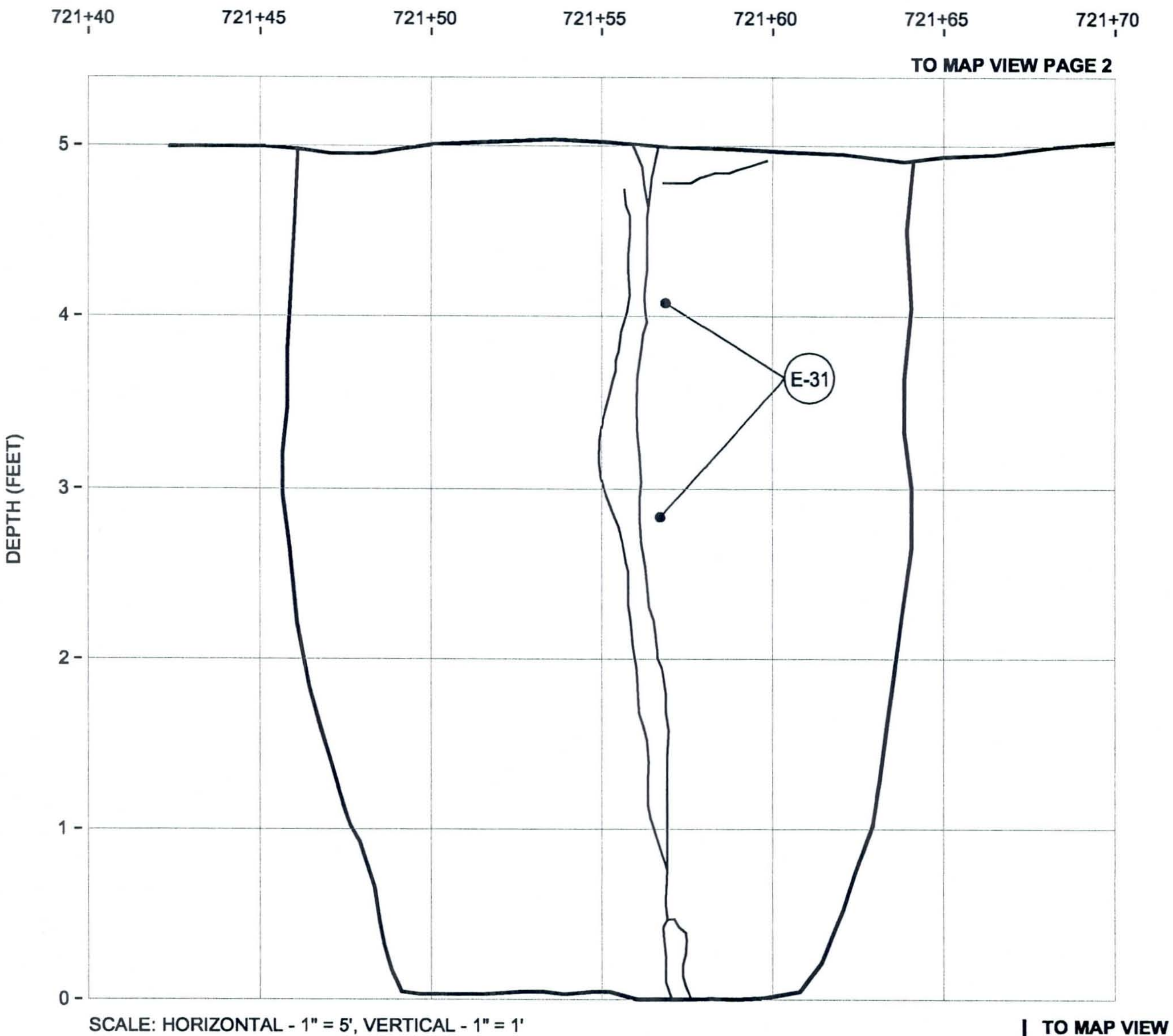
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
E-14

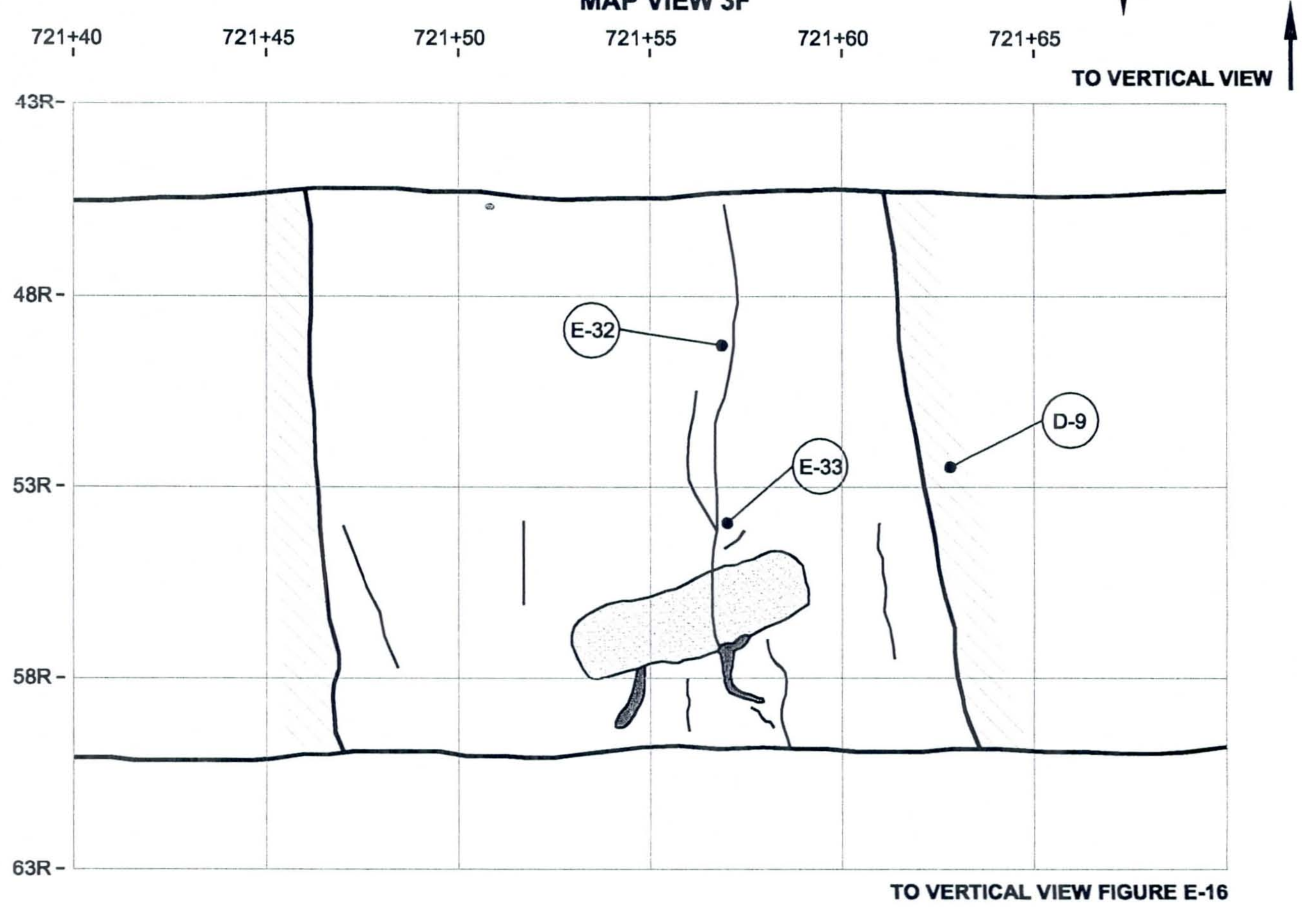
amec

ZONE 3

VERTICAL VIEW 3E



MAP VIEW 3F



KEY

- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- FILLED CRACK
- DISTINCT CRACK
- (D-11) BULK SAMPLE LOCATION
- C-33 BACKFILL IN PREVIOUS TEST PIT
- (E-31) MAJOR CRACK TYP. OPEN 0.2" TO 0.5" UP TO 2"+ OPEN, 2 PHOTOS
- (E-32) MAJOR PARTIALLY FILLED CRACK UP TO 2" WIDE, 1 PHOTO
- (E-33) MAJOR PARTIALLY FILLED CRACK AND SAND FROM PREVIOUS INVESTIGATION, 4 PHOTOS

JOB NO. 4-117-001021
DESIGN: KCF
DRAWN: GWH
DATE: 6/2004
SCALE: AS SHOWN

ZONE 3
NEAR VERTICAL VIEW & MAP VIEW

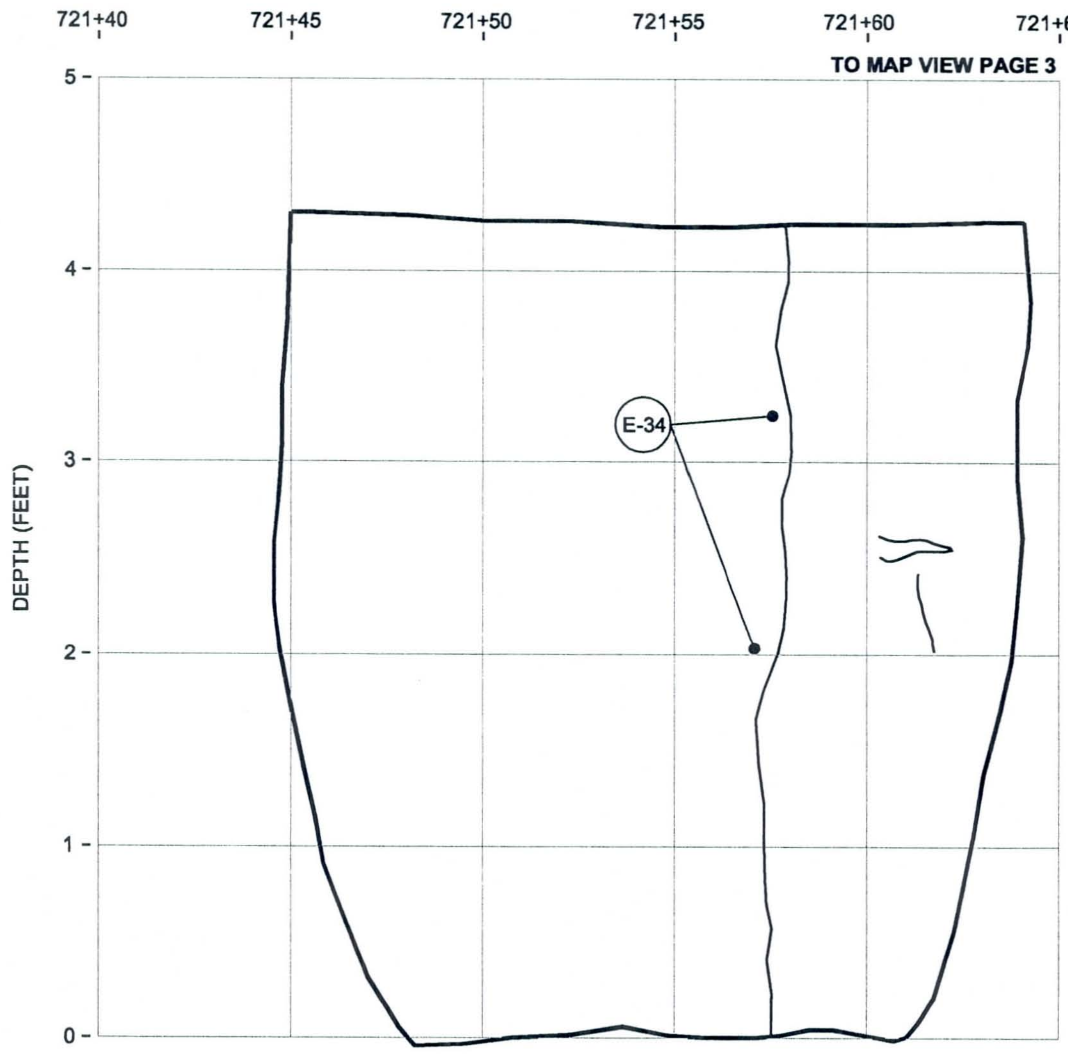
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
E-15

amec

ZONE 3

VERTICAL VIEW 3G

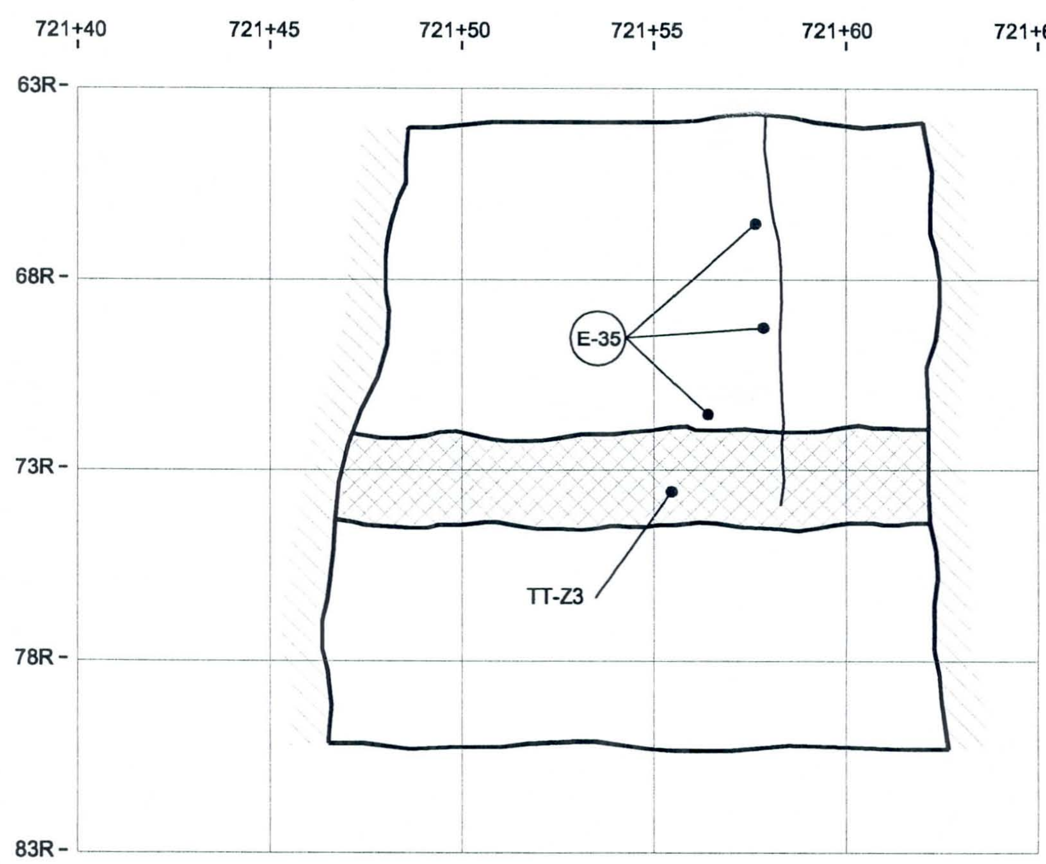


SCALE: HORIZONTAL - 1" = 5', VERTICAL - 1" = 1'

TO MAP VIEW

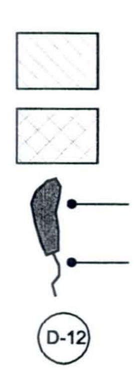
MAP VIEW 3H

TO VERTICAL VIEW



END

KEY



- LIMIT OF DEEPER EXCAVATION OR SPOILS PILE
- TEST TRENCH
- FILLED CRACK
- DISTINCT CRACK
- (D-12) BULK SAMPLE LOCATION
- (E-34) MAJOR PARTIALLY FILLED CRACK UP TO 1" WIDE, 2 PHOTOS
- (E-35) MAJOR PARTIALLY FILLED CRACK UP TO 1" WIDE TYP. 0.2" TO 0.4", 4 PHOTOS

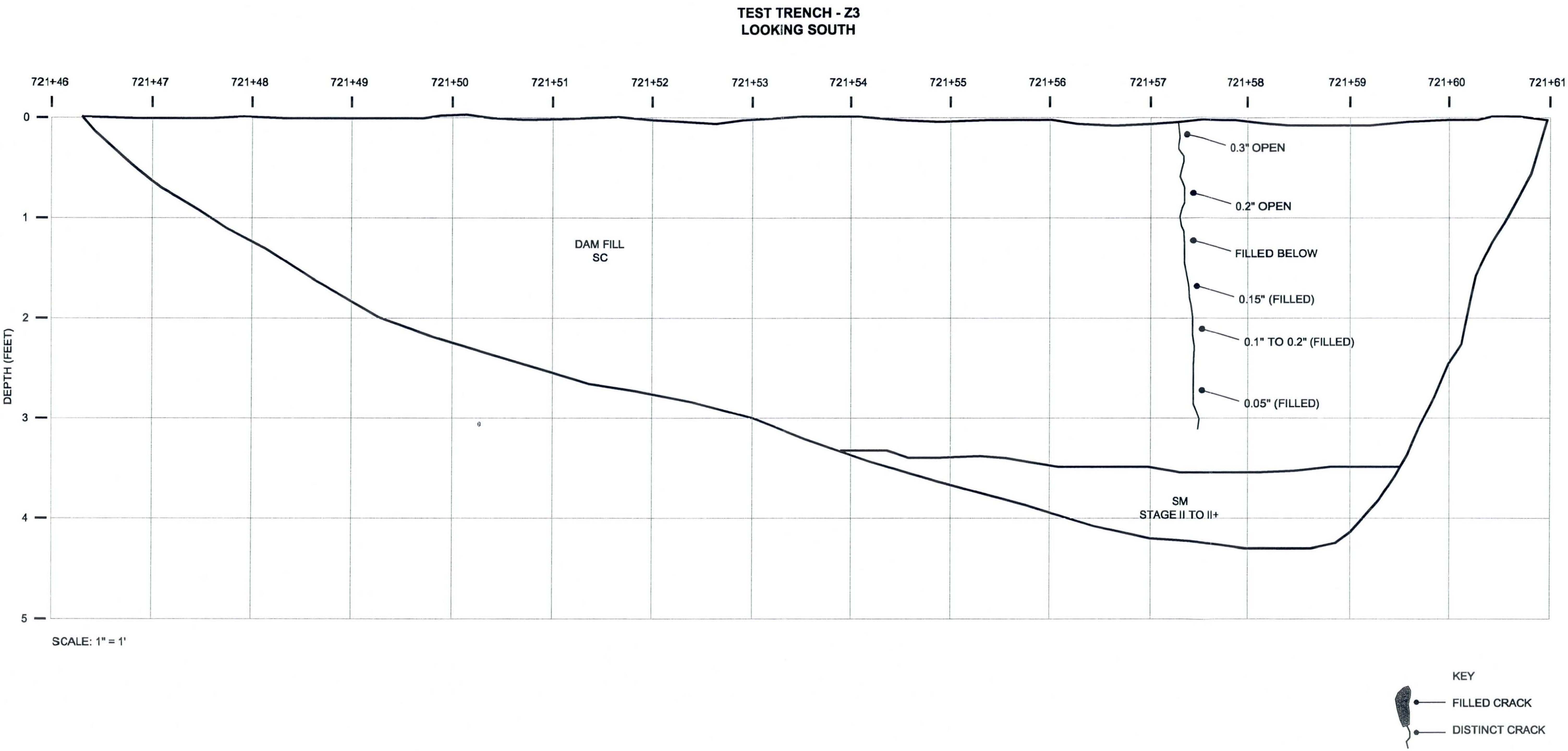
JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 3
NEAR VERTICAL VIEW & MAP VIEW

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
E-16

amec



G:\Engineering Departm... Projects\4-117-001021 Buckeye FRS No. 1\Cad\More - Vert_Hor_Views.dwg

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

TEST TRENCH Z3

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
E-17

amec

VIEW OF ZONE 1.

VIEW OF FILLED CRACKS IN ZONE 1 AT NOTE 19.

VIEW OF CRACK AS IT APPROACHES THE CENTER DRAIN. (PENCIL MARKS THE CRACK LOCATION AND CRACK DOES NOT PROPAGATE INTO THE DRAIN).

JOB NO. 4-117-001021	SELECT PHOTOGRAPHS OF ZONE 1		amec
DESIGN: REW			
DRAWN: GWH			
DATE: 6/2004	SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS BUCKEYE FRS NO.1 CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2	FIGURE E-18	
SCALE: N.T.S.			

VIEW OF ZONE 2.

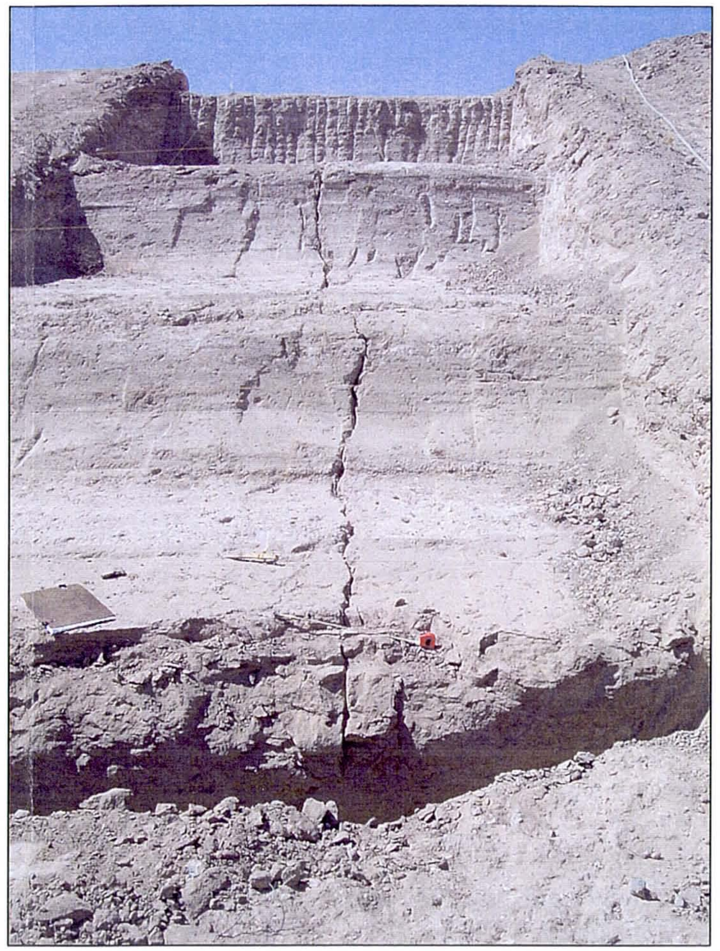
VIEW OF CRACK AT NOTE 23.

VIEW OF CRACK (INDICATED BY PEN) AS IT APPROACHES THE CENTER DRAIN (CRACK IS NOT PRESENT IN DRAIN MATERIAL).

JOB NO. 4-117-001021	PHOTOGRAPH LOG OF ZONE 2		amec
DESIGN: REW			
DRAWN: GWH	SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS BUCKEYE FRS NO.1 CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2	FIGURE E-19	
DATE: 6/2004			
SCALE: N.T.S.			

G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\Photograph Log.dwg

VIEW OF ZONE 3.



VIEW OF TT-Z3 AND CRACK IN ZONE 3 (CRACK DOES NOT PRPOGATE INTO FOUNDATION).

VIEW OF CRACK IN ZONE 3 AS IT APPROACHES THE CENTER DRAIN (CRACK IS NOT PRESENT IN DRAIN MATERIAL).

G:\Engineering Department\4 Projects\4-117-001021 Buckeye FRS No. 1\Cad\Photograph Log.dwg

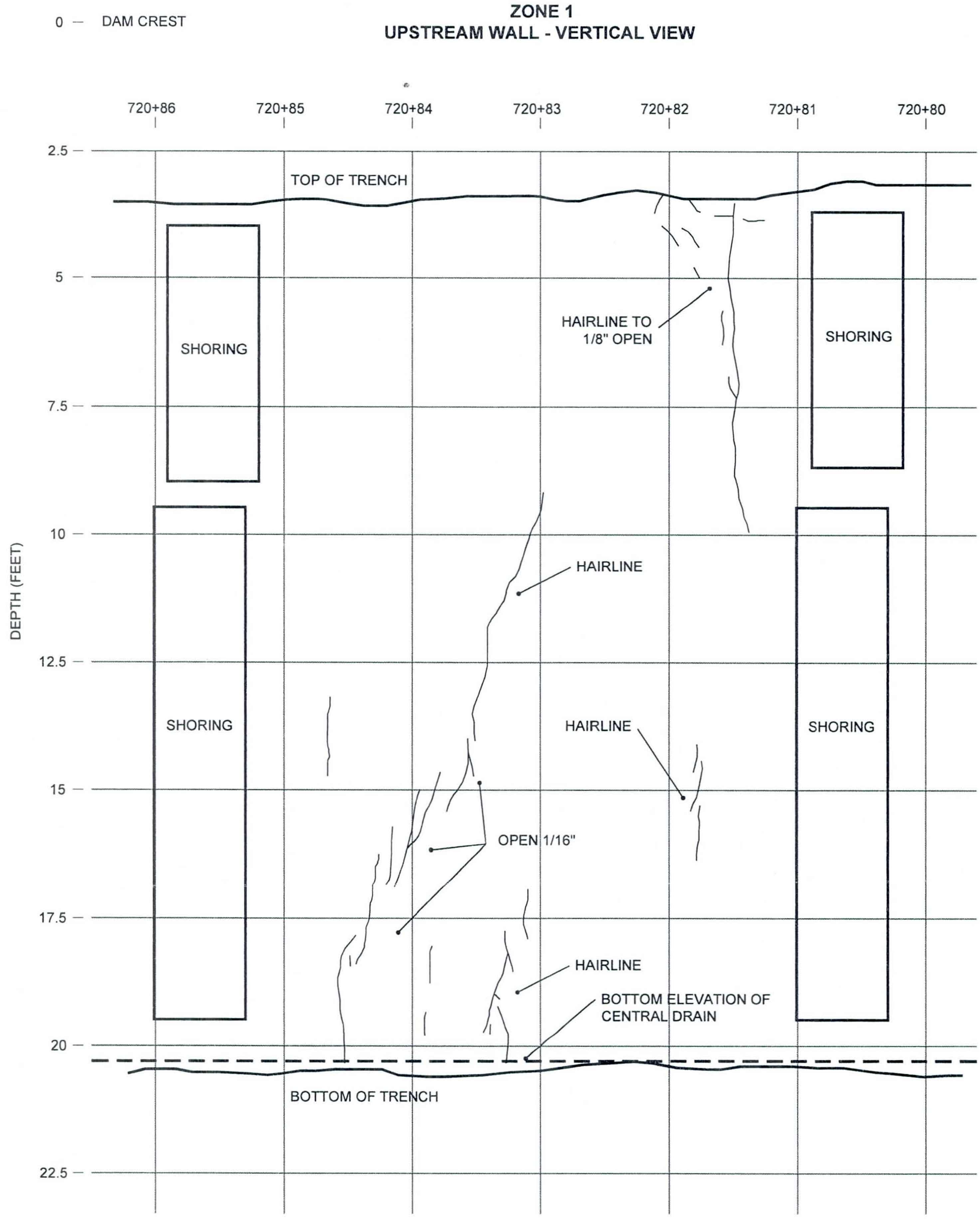
JOB NO. 4-117-001021	SELECT PHOTOGRAPHS OF ZONE 3		amec
DESIGN: REW			
DRAWN: GWH	SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS BUCKEYE FRS NO.1 CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2	FIGURE E-20	
DATE: 6/2004			
SCALE: N.T.S.			

amec

APPENDIX F

TRENCHING OF CENTER DRAIN

ZONE 1
UPSTREAM WALL - VERTICAL VIEW



SCALE: HORIZONTAL - 1" = 1', VERTICAL - 1" = 2.5'

KEY

NOTE: BOTTOM ELEVATION OF CENTRAL DRAIN WAS NOT OBSERVED DURING THE CURRENT INVESTIGATION. IT IS BASED ON AS-BUILT REPORT ERTEC (1981)

JOB NO. 4-117-001021
DESIGN: KCF
DRAWN: GWH
DATE: 6/2004
SCALE: AS SHOWN

ZONE 1
UPSTREAM WALL OF LONGITUDINAL TRENCH

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

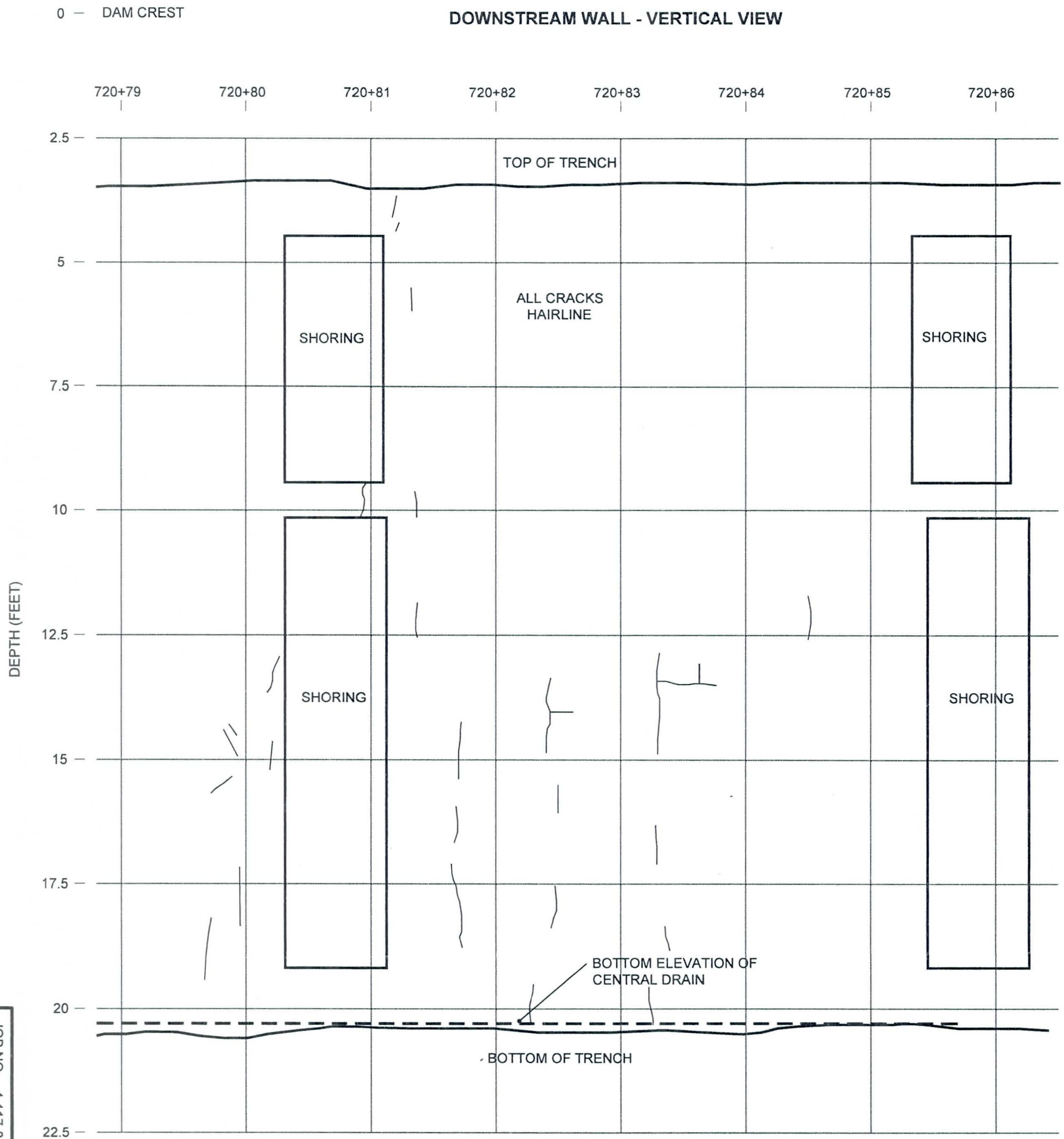
FIGURE F-1

amec

G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\North-South Wall_Vert-Hor-Views.dwg

ZONE 1

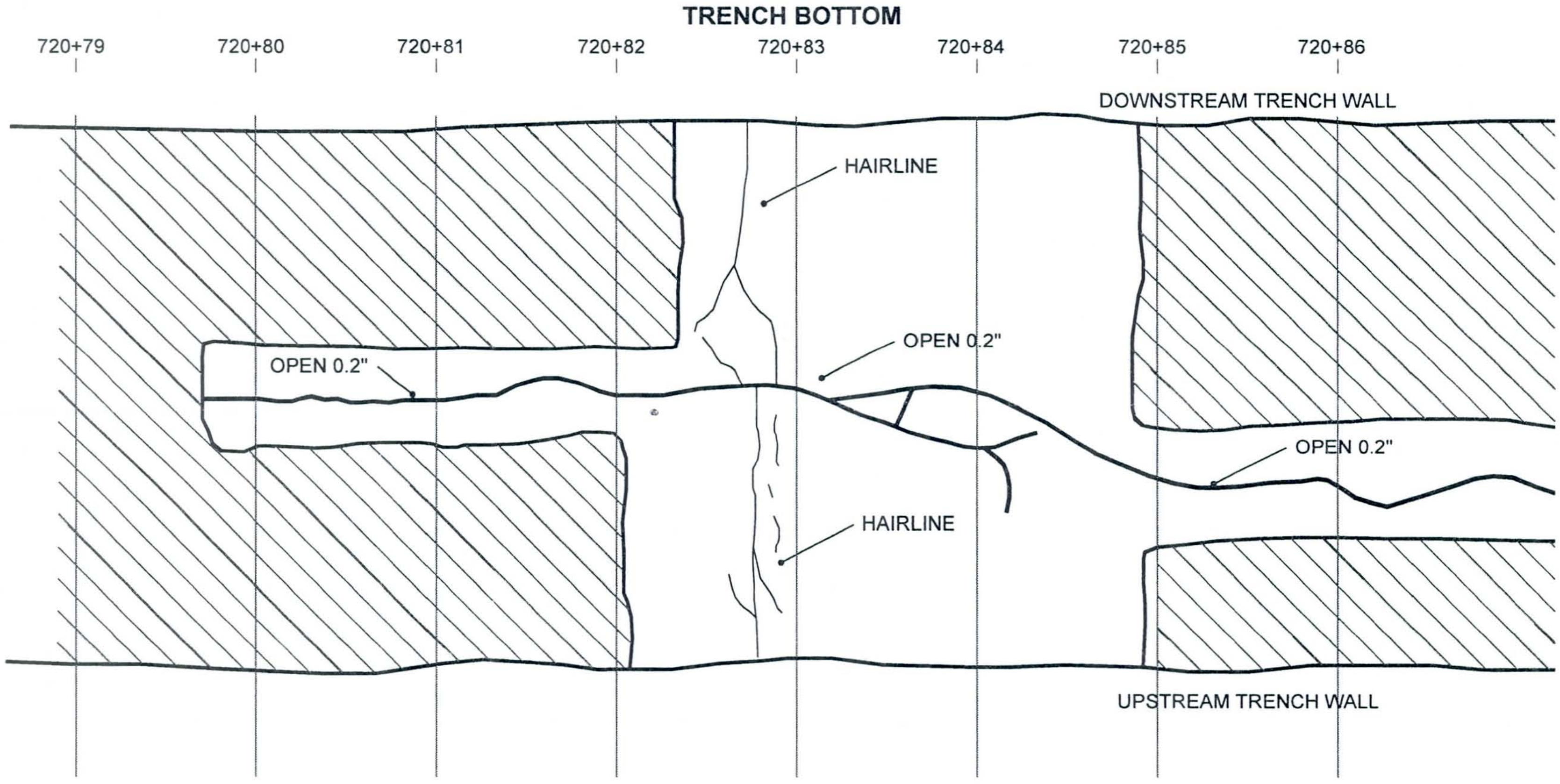
DOWNSTREAM WALL - VERTICAL VIEW



SCALE: HORIZONTAL - 1" = 1', VERTICAL - 1" = 2.5'

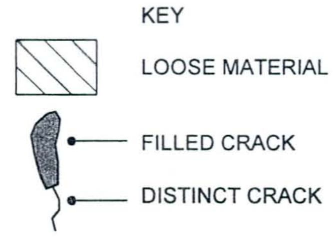
NOTE: BOTTOM ELEVATION OF CENTRAL DRAIN WAS NOT OBSERVED DURING THE CURRENT INVESTIGATION. IT IS BASED ON AS-BUILT REPORT ERTEC (1981)

MAP VIEW TRENCH BOTTOM



SCALE: 1" = 1'

KEY



JOB NO. 4-117-001021
DESIGN: KCF
DRAWN: GWH
DATE: 6/2004
SCALE: AS SHOWN

ZONE 1
DOWNSTREAM WALL AND BOTTOM OF LONGITUDINAL TRENCH

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE F-2

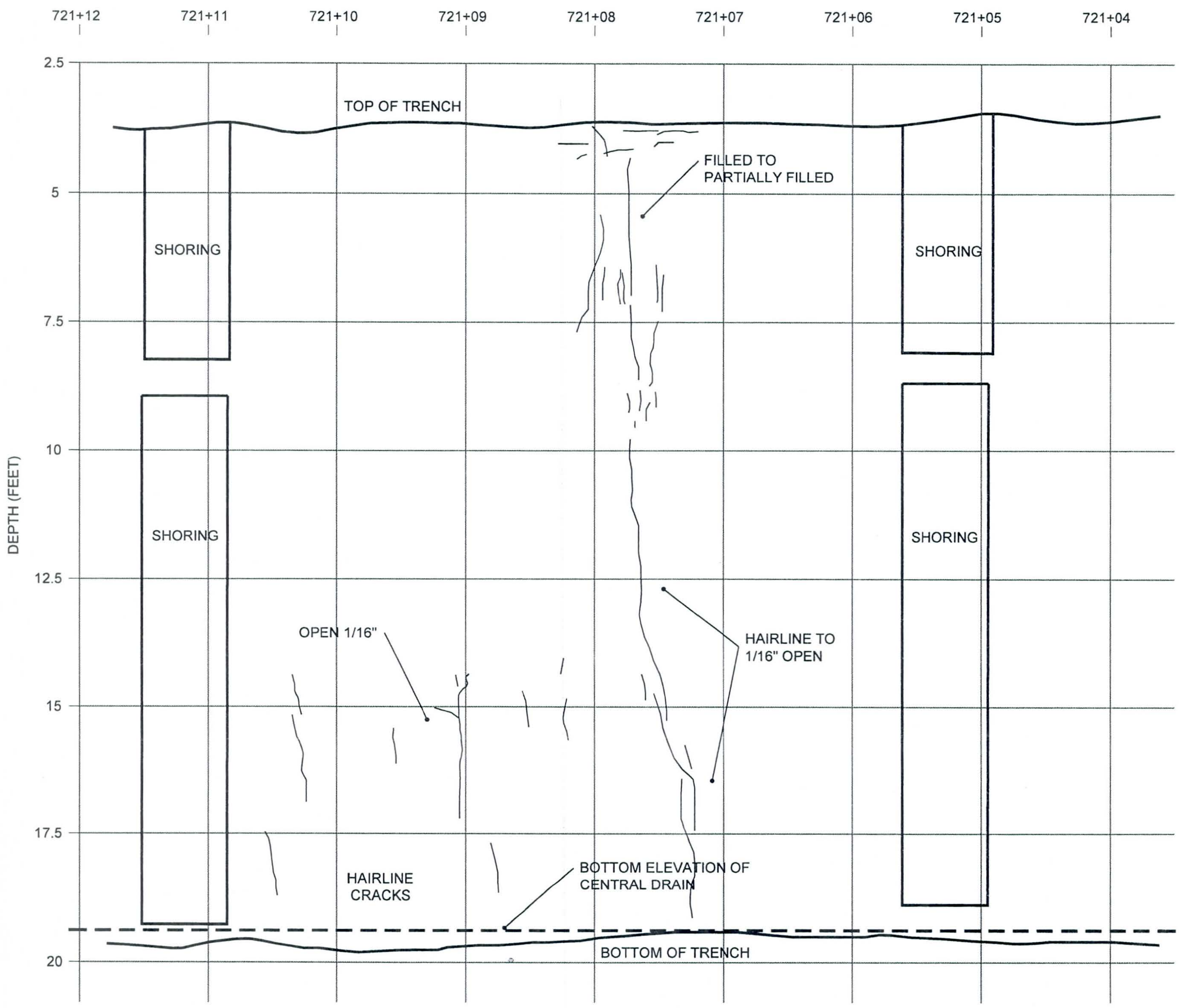
amec

G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\North-South Wall_Vert-Hor-Views.dwg

0 — DAM CREST

ZONE 2

UPSTREAM WALL - VERTICAL VIEW



SCALE: HORIZONTAL - 1" = 1', VERTICAL - 1" = 2.5'

NOTE: BOTTOM ELEVATION OF CENTRAL DRAIN WAS NOT OBSERVED DURING THE CURRENT INVESTIGATION. IT IS BASED ON AS-BUILT REPORT ERTEC (1981)

JOB NO. 4-117-001021
DESIGN: KCF
DRAWN: GWH
DATE: 6/2004
SCALE: AS SHOWN

ZONE 2
UPSTREAM WALL OF LONGITUDINAL TRENCH

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

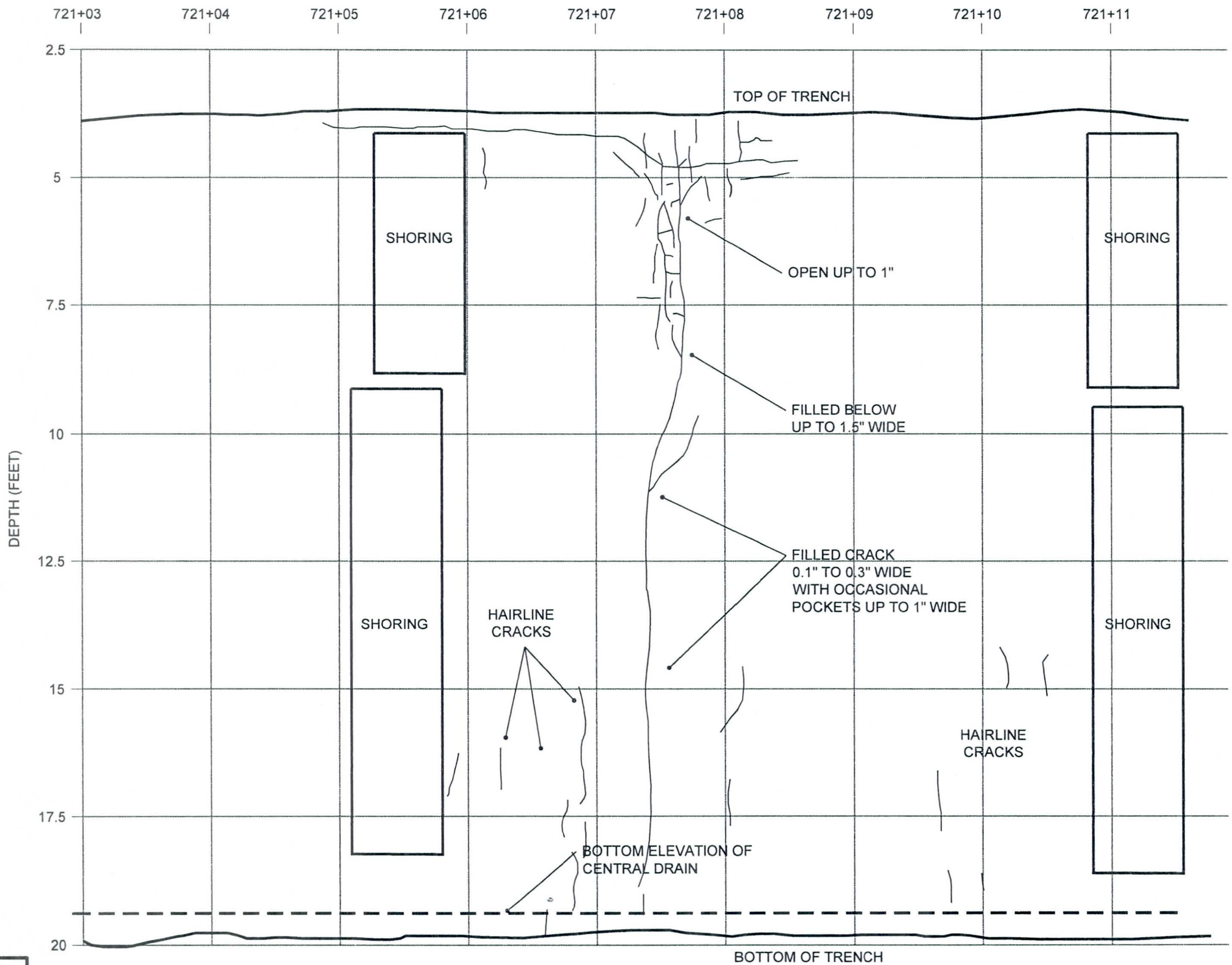
FIGURE F-3

amec

G:\Engineering Department\2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\North-South Wall_Vert-Hor-Views.dwg

ZONE 2

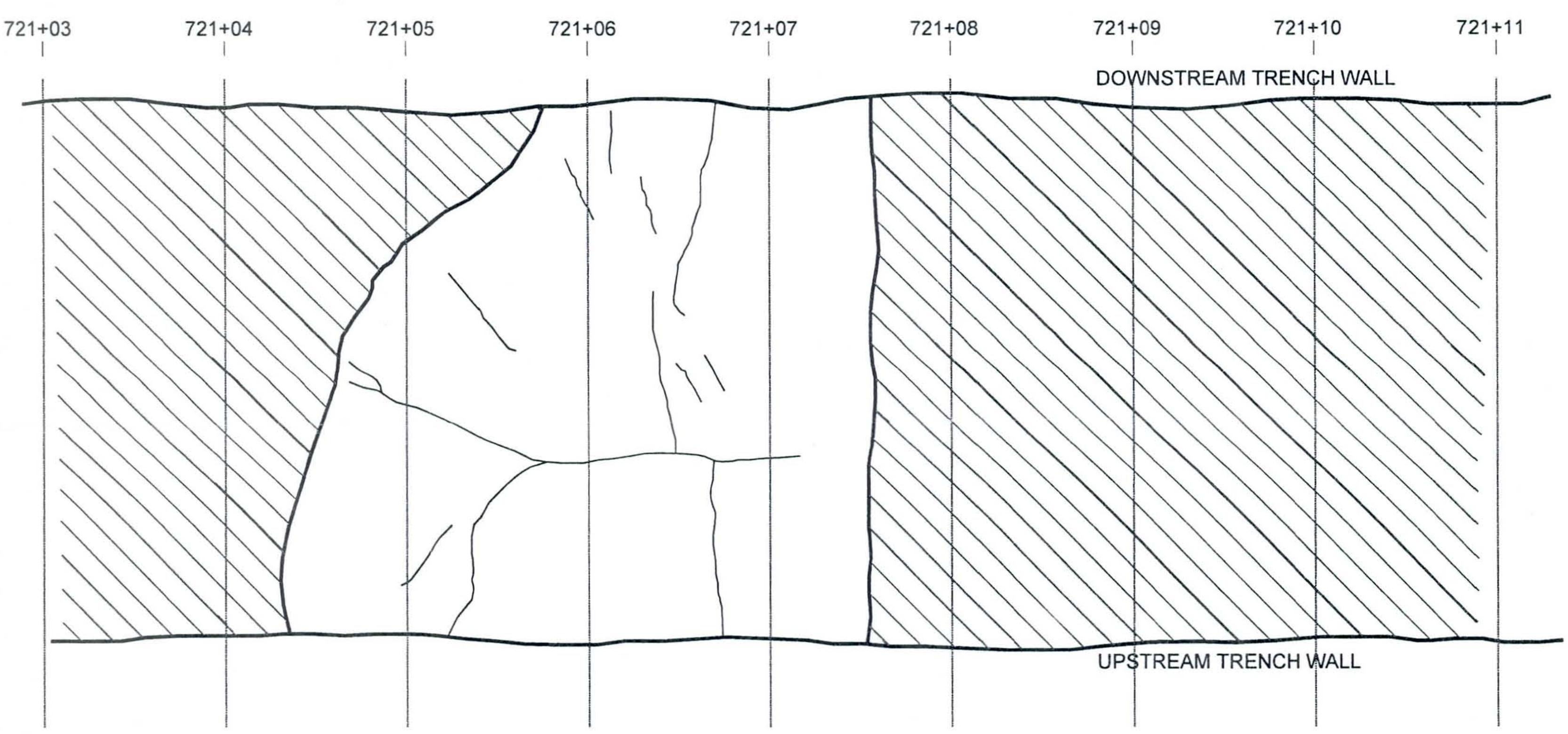
DOWNSTREAM WALL - VERTICAL VIEW



SCALE: HORIZONTAL - 1" = 1', VERTICAL - 1" = 2.5'

NOTE: BOTTOM ELEVATION OF CENTRAL DRAIN WAS NOT OBSERVED DURING THE CURRENT INVESTIGATION. IT IS BASED ON AS-BUILT REPORT ERTEC (1981)

MAP VIEW
TRENCH BOTTOM



SCALE: 1" = 1'

KEY

LOOSE MATERIAL

FILLED CRACK

DISTINCT CRACK

JOB NO. 4-117-001021
DESIGN: KCF
DRAWN: GWH
DATE: 6/2004
SCALE: AS SHOWN

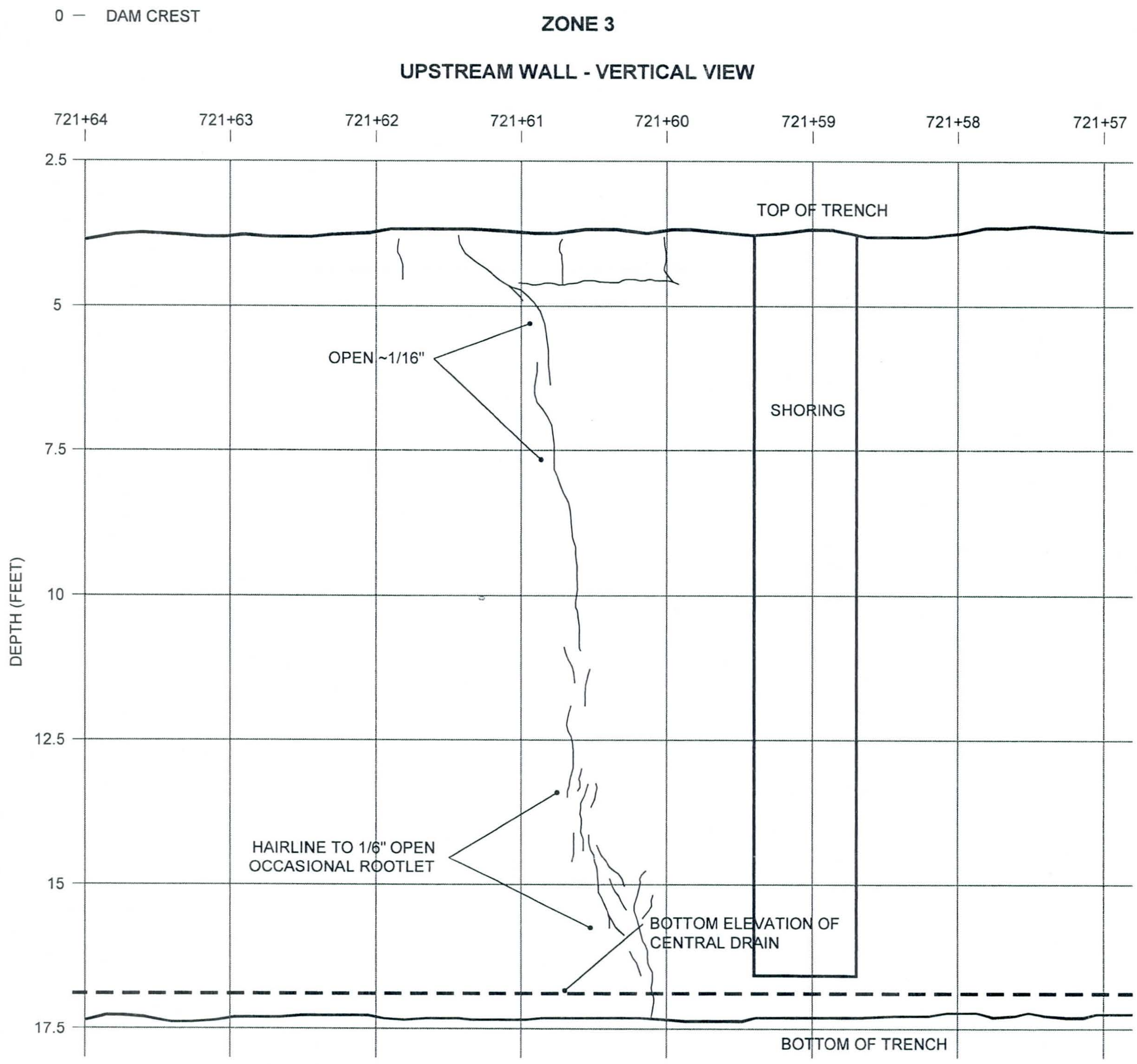
ZONE 2
DOWNSTREAM WALL AND LONGITUDINAL TRENCH BOTTOM
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
F-4

amec

ZONE 3

UPSTREAM WALL - VERTICAL VIEW



SCALE: HORIZONTAL - 1" = 1', VERTICAL - 1" = 2.5'

NOTE: BOTTOM ELEVATION OF CENTRAL DRAIN WAS NOT OBSERVED DURING THE CURRENT INVESTIGATION. IT IS BASED ON AS-BUILT REPORT ERTEC (1981)

JOB NO.	4-117-001021
DESIGN:	KCF
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

ZONE 3
UPSTREAM WALL OF LONGITUDINAL TRENCH

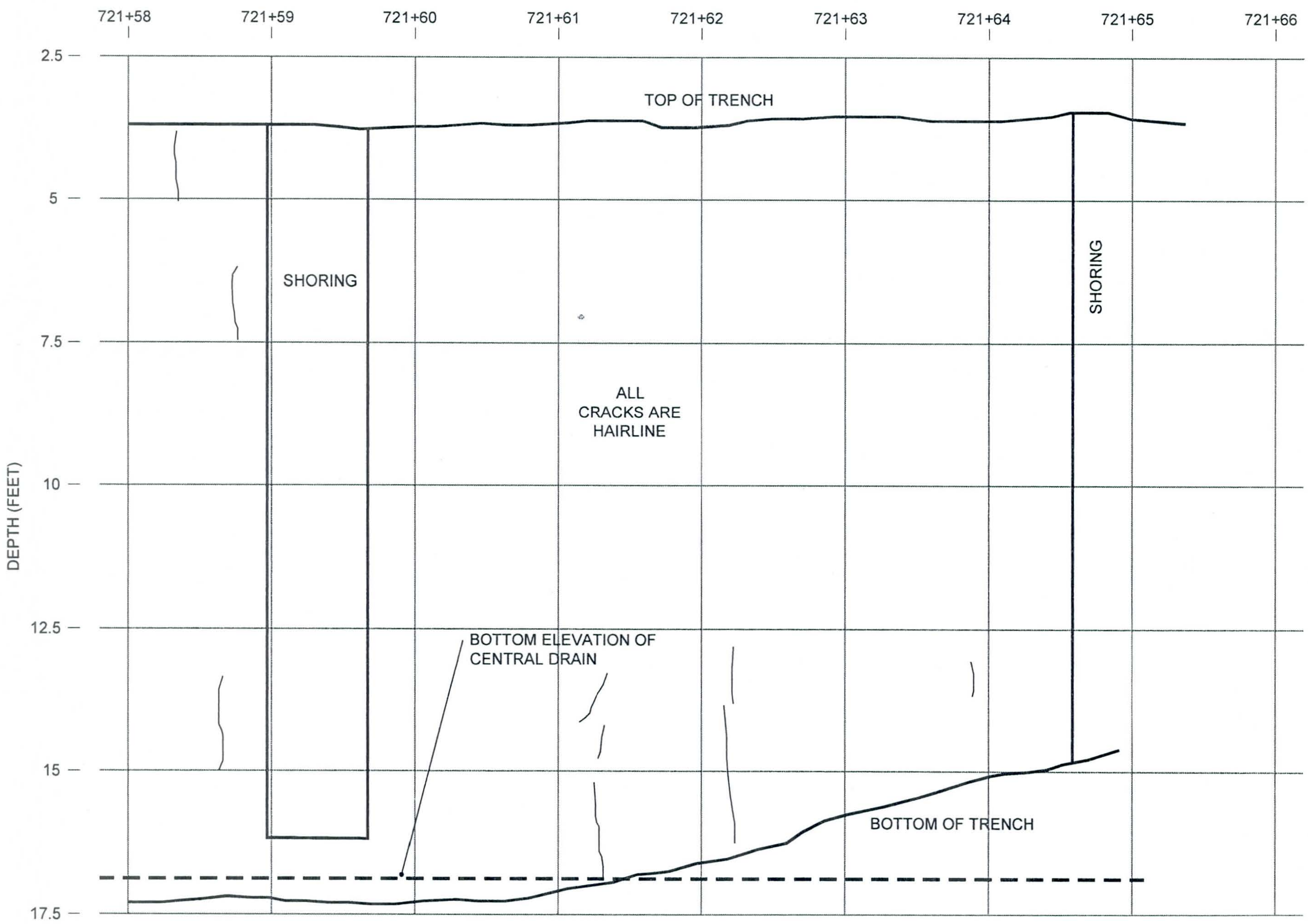
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
F-5

amec

ZONE 3

DOWNSTREAM WALL - VERTICAL VIEW



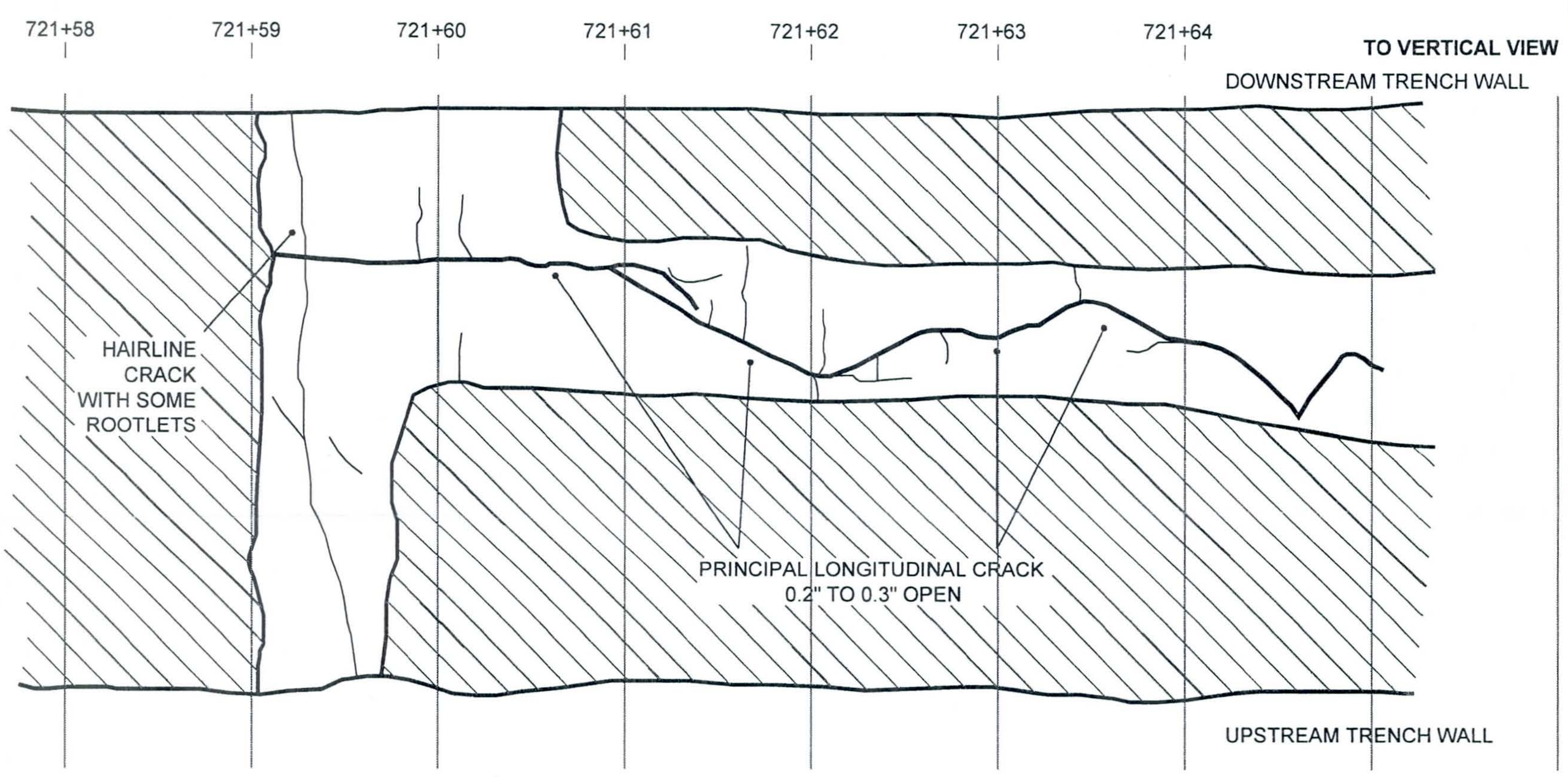
SCALE: HORIZONTAL - 1" = 1', VERTICAL - 1" = 2.5'

TO MAP VIEW

NOTE: BOTTOM ELEVATION OF CENTRAL DRAIN WAS NOT OBSERVED DURING THE CURRENT INVESTIGATION. IT IS BASED ON AS-BUILT REPORT ERTEC (1981)

MAP VIEW
TRENCH BOTTOM

TO VERTICAL VIEW



SCALE: 1" = 1'

KEY

LOOSE MATERIAL

FILLED CRACK

DISTINCT CRACK

JOB NO. 4-117-001021
DESIGN: KCF
DRAWN: GWH
DATE: 6/2004
SCALE: AS SHOWN

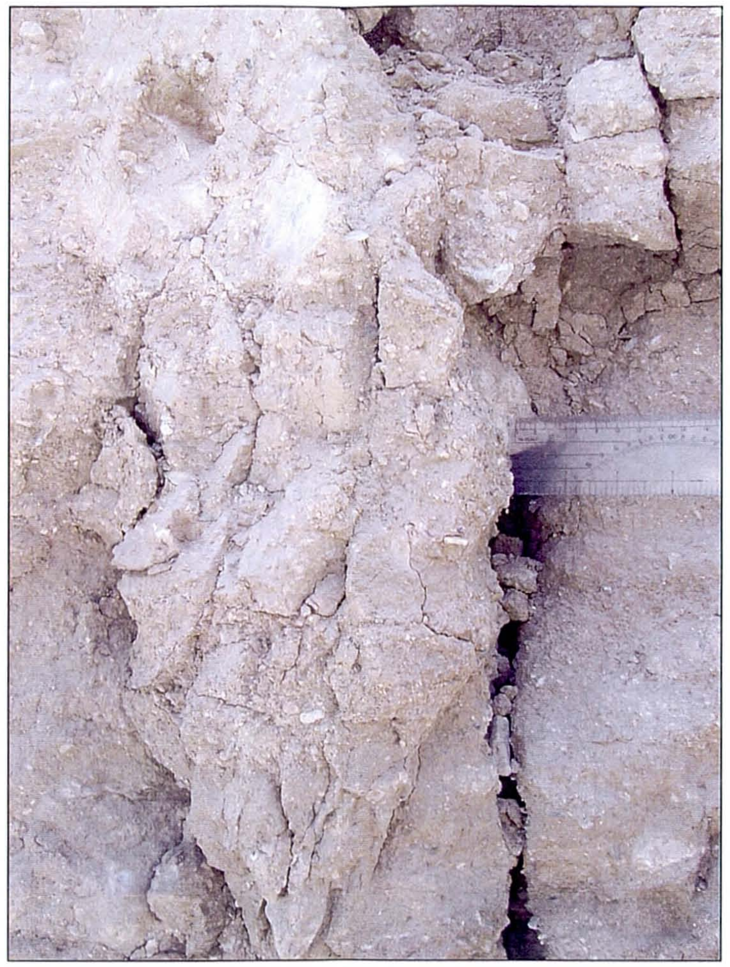
ZONE 3
DOWNSTREAM WALL AND TRENCH BOTTOM

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE F-6

amec

VIEW (FACING WEST) OF LONGITUDINAL TRENCH.



VIEW OF CRACK IN DOWNSTREAM WALL IN ZONE 2. THE DEPTH IS ABOUT 5-FEET BELOW THE CREST OF THE DAM

VIEW OF CRACK IN UPSTREAM WALL IN ZONE 3. THE DEPTH IS ABOUT 7-FEET BELOW THE CREST OF THE DAM

JOB NO.	4-117-001021
DESIGN:	REW
DRAWN:	GWH
DATE:	6/2004
SCALE:	N.T.S.

SELECT PHOTOGRAPHS OF LONGITUDINAL TRENCH

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE F-7

amec

G:\Engineering Depa... 2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\Photograph Log.dwg

VIEW OF TRENCH BOTTOM (UPSTREAM WALL AT TOP OF PHOTO) AT ZONE 3. NOTE LARGE LONGITUDINAL CRACK AND INTERSECTING TRANSVERSE CRACKS.

VIEW OF LONGITUDINAL CRACK IN VICINITY OF STATION 721+20 (UPSTREAM WALL IS AT TOP OF PHOTO). NOTE INTERSECTING TRANSVERSE CRACKS.

CLOSE-UP VIEW OF LONGITUDINAL CRACK IN THE VICINITY OF ZONE 1.

JOB NO.	4-117-001021
DESIGN:	REW
DRAWN:	GWH
DATE:	6/2004
SCALE:	N.T.S.

SELECT PHOTOGRAPHS OF LONGITUDINAL TRENCH

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE F-8

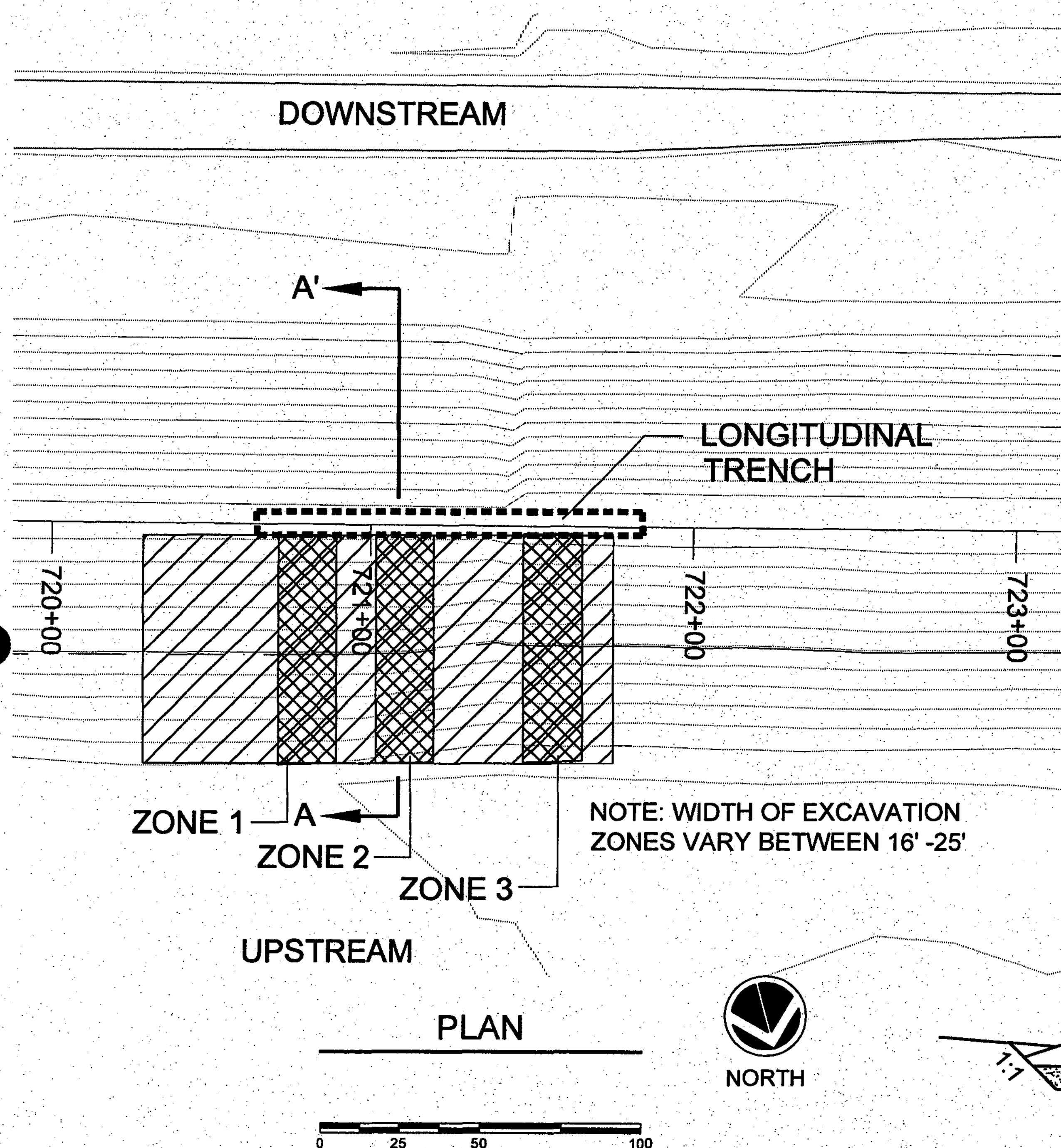
amec

G:\Engineering Depa... 2004 Projects\4-117-001021 Buckeye FRS No. 1\Cad\Photograph Log.dwg

amec

APPENDIX G

EXCAVATION BACKFILL & DAM REPAIR



PLAN

FILTER MATERIAL A

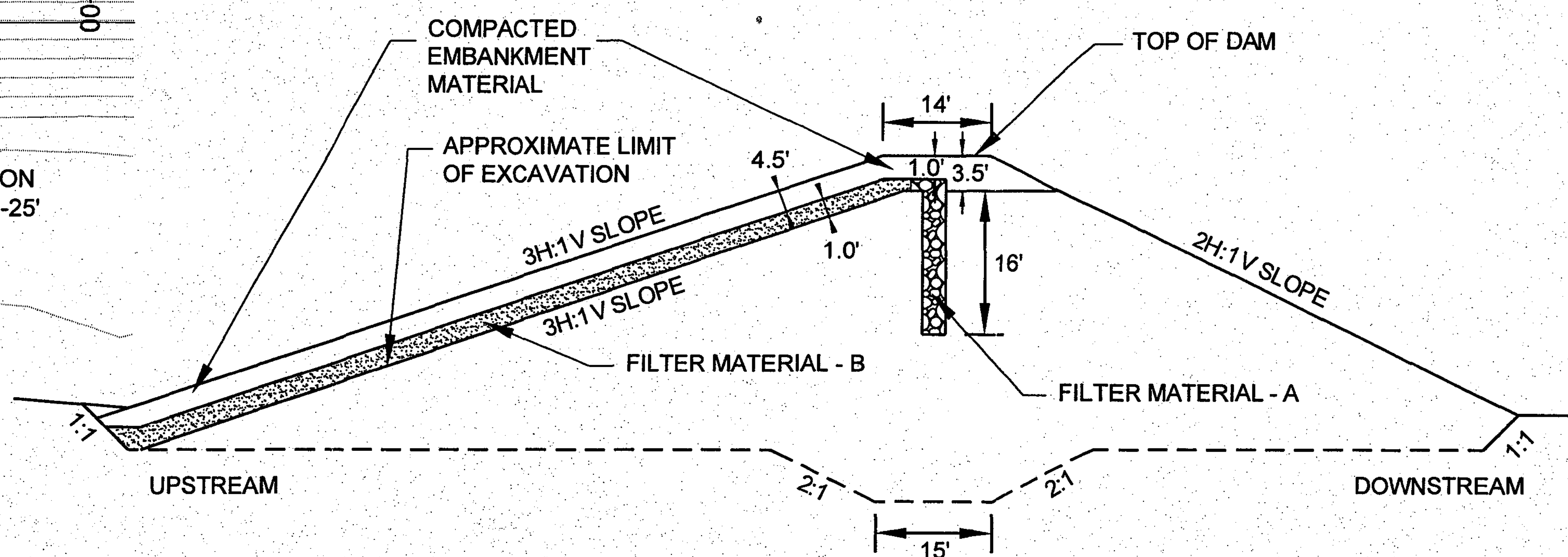
SIEVE SIZE	% PASSING
1 IN.	100
3/4 IN.	100
1/2 IN.	100
3/8 IN.	99
1/4 IN.	89
#4	81
#8	62
#10	58
#16	47
#30	28
#40	16
#50	10
#100	4
#200	1.6

FILTER MATERIAL B

SIEVE SIZE	% PASSING
1 IN.	100
3/4 IN.	100
1/2 IN.	100
3/8 IN.	100
1/4 IN.	100
#4	98
#8	82
#10	78
#16	66
#30	45
#40	31
#50	21
#100	8
#200	2.4

NOTE: FILTER MATERIAL A WAS PLACED DRY AND UNCOMPACTED.
FILTER MATERIAL B WAS PLACED MOIST AND UNCOMPACTED.

NOTE: THE EMBANKMENT SOIL IS COMPACTED TO A MINIMUM OF 95 PERCENT OF THE ASTM D698 MAXIMUM DRY DENSITY, WITH THE MOISTURE CONTENT AS CLOSE AS POSSIBLE TO OPTIMUM MOISTURE CONTENT, BUT WITHIN THE RANGE OF 1 PERCENT ABOVE TO 3 PERCENT BELOW OPTIMUM MOISTURE CONTENT.



TYPICAL CROSS-SECTION ALONG A-A'

LEGEND

- APPROXIMATE AREA OF INITIAL SURFICIAL CLEANING
- EMBANKMENT TRENCHING
- LONGITUDINAL DRAIN TRENCH

JOB NO.	4-117-001021
DESIGN:	BBP
DRAWN:	GWH
DATE:	6/2004
SCALE:	AS SHOWN

AS BUILT OF EMBANKMENT REPAIR

BUCKEYE FRS NO. 1
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
CONTRACT FCD 2003C014 - WORK ASSIGNMENT NO. 2

FIGURE G-1

amec

\Engineering-Development\2000Projects\0-117-001122 Structures Assessment-Ph II\Task 3 - Buckeye FRS #1\CAD\Backfill of Test Tr...dwg

Supplemental Investigation of Cracks
Buckeye FRS No.1
Contract FCD 2003C014, Work Assignment No.2

Figure G-2
Proposed Filter Design

AMEC Job No. 4-117-001021

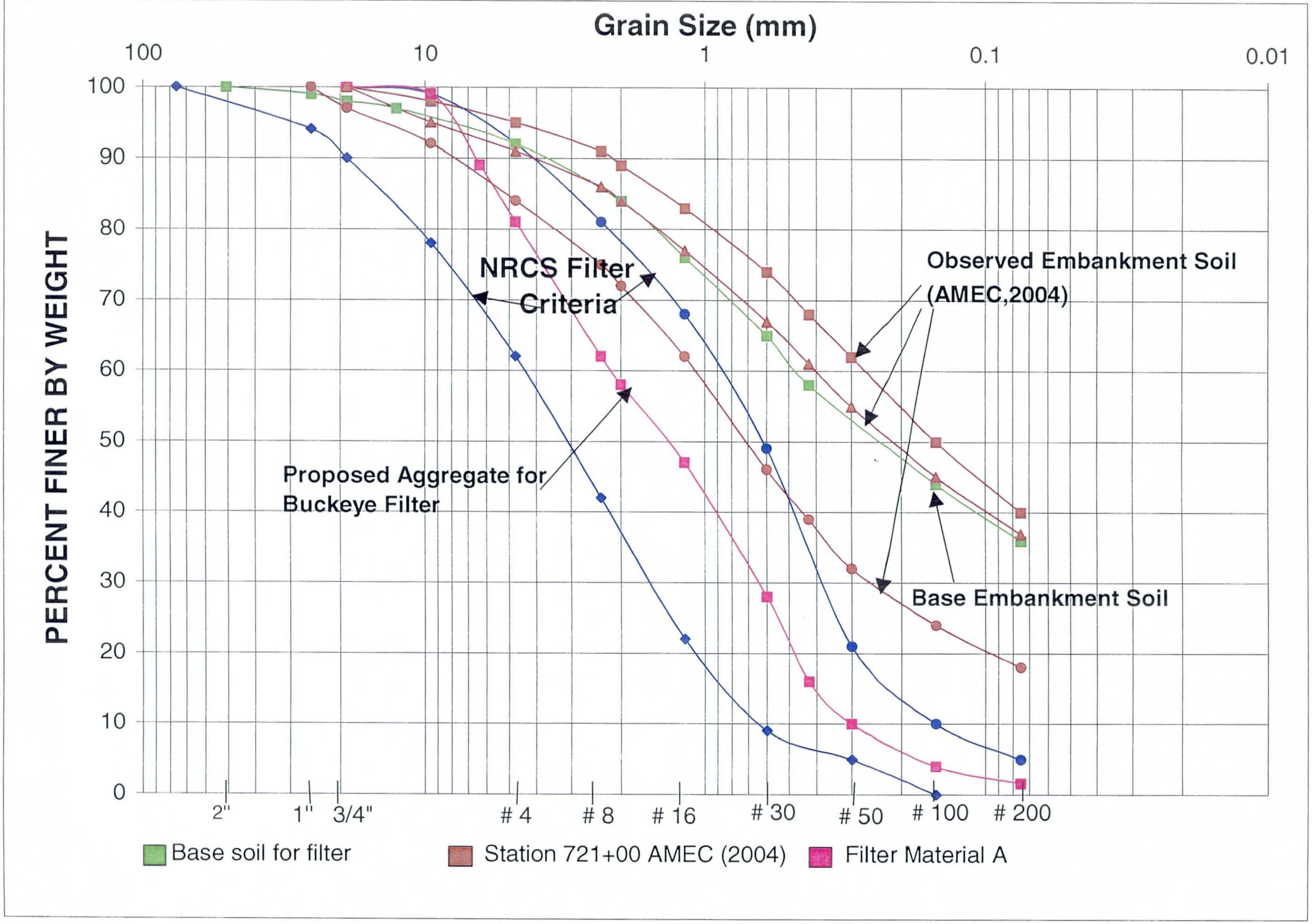
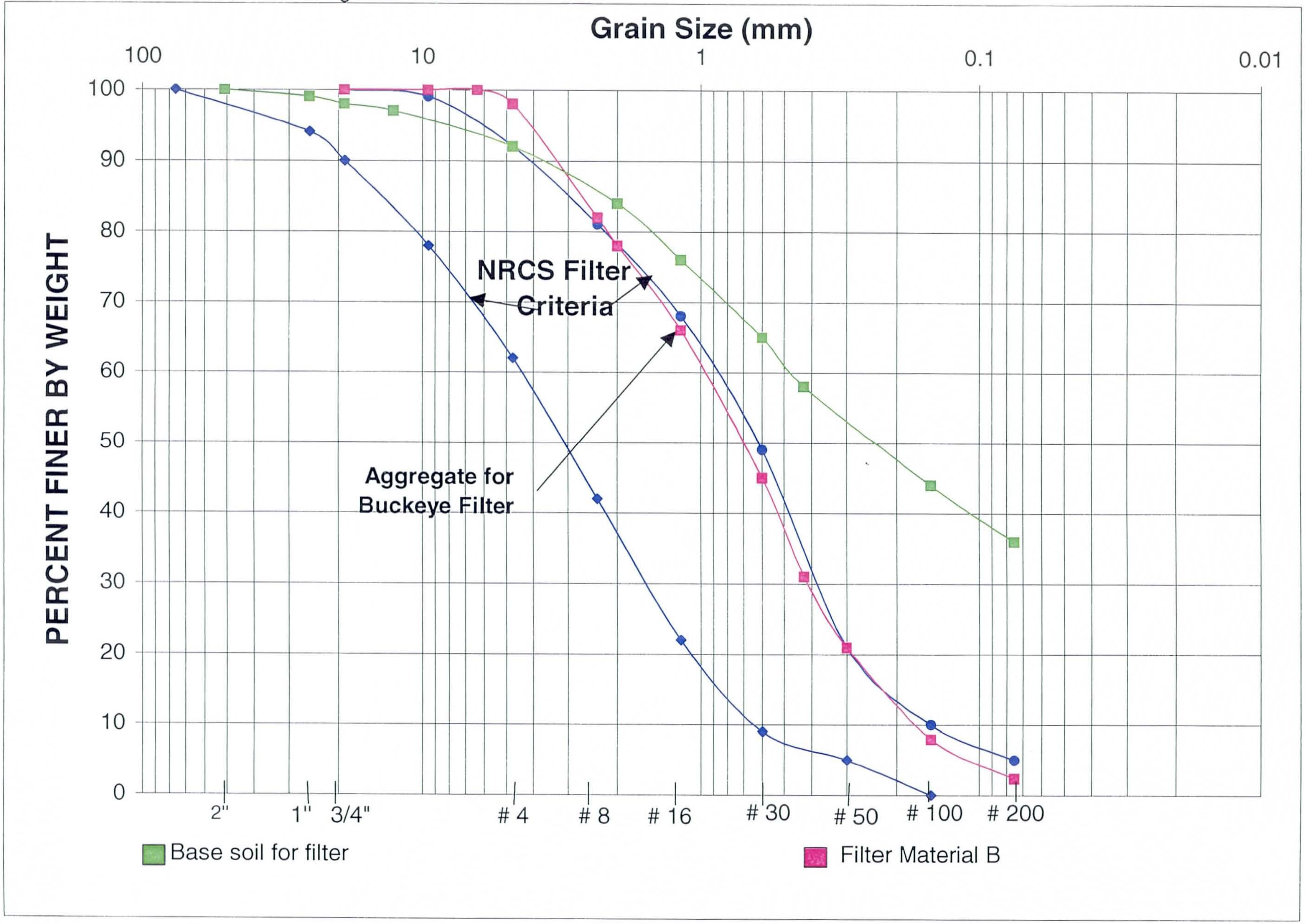


Figure G-3
Filter Material B



VIEW OF AGGREGATE BACKFILL OF THE LONGITUDINAL TRENCH.

VIEW OF EMBANKMENT REPAIR.

VIEW OF CONFIRMATION FIELD DENSITY TESTING OF EMBANKMENT REPAIR.

JOB NO.	4-117-001021
DESIGN:	REW
DRAWN:	GWH
DATE:	6/2004
SCALE:	N.T.S.

SELECT PHOTOGRAPHS OF EMBANKMENT REPAIR

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE G-4

amec

G:\Engineering Departm... Projects\4-17-001021 Buckeye FRS No. 1\Cad\Photograph Log.dwg

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**1**
Project Name	**Buckeye FRS No. 1**	Date: **05/12/04**	Time: **9:00am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Trench Backfill**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests		Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp	x	# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; No compaction specifications. Material to be placed carefully to avoid segregation.

STRUCTURE: Longitudinal central test trench in dam.

PRODUCT: Filter material.

SCOPE: Observed backfill of central trench with filter material. After material was placed it was remixed by backhoe operator to prevent segregation.

RESULTS: Trench was filled to 3.5' below top of crest.

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**2**
Project Name	**Buckeye FRS No. 1**	Date: **05/13/04**	Time: **6:30am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Trench Backfill**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests		Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp	x	# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; No compaction specifications. Material to be placed carefully to avoid segregation.

STRUCTURE: Longitudinal central test trench in dam.

PRODUCT: Filter material.

SCOPE: Project delayed due to damage (theft & vandalism) to loader and backhoe.
Crew began working at approximately 9:30am. Cleared area for future stockpile of filter material. Cleaned up crest excavation and stockpiled filter material at crest excavation.

RESULTS:

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**3**
Project Name	**Buckeye FRS No. 1**	Date: **05/17/04**	Time: **7:00am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Trench Backfill**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests		Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp	x	# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; Stockpile dam excavation spoils; moisture specification -3 to +1 percent of optimum moisture content.

STRUCTURE: Backfill material for crest of slope.

PRODUCT: Filter material.

SCOPE: Monitored delivery of filter materials from Mesa Sun Plant aggregate. Three end-dumps, operated by Double A Transport, delivered 292 tons of washed concrete sand (290 tons ordered) to site. A total of 12 loads (see attached tickets).

American Fence arrived on site to pick up 8 panels contracted by county. Panels not on site. Called Ken Furgeson (AMEC) to investigate if GSI picked up panels by mistake.

RESULTS: Crew of 3 processing stockpile with moisture for backfill of crest of slope.

NOTIFICATION:

Notes/Comments: American Fence arrived on site to pick up 8 panels contracted by county. Panels not on site. Called Ken Furgeson (AMEC) to investigate if GSI picked up panels by mistake.

AMEC Representative: Brian Banks

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**4**
Project Name	**Buckeye FRS No. 1**	Date: **05/18/04**	Time: **6:30am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Observation and Testing**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests	8	Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Backfill material for crest of slope.

PRODUCT: Embankment soils, Curve P2 - 118.9 pcf at 11.5% moisture.

SCOPE: Material from dam excavation spoils was processed and placed in 6" lifts as backfill of crest of slope from elevation of 3.5' to 0.0' below top of crest.

Material was placed and rolled with Cat 950G loader and Motor Grader 140G.

Performed 8 nuclear density tests.

RESULTS: Tests indicated passing results.

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

ect Buckeye FRS No. 1
Location Parallel to WB I-10, West of Exit 109

Job Number 4-117-001021
Date 05/18/04
Report Number 4

DENSITY OF SOIL IN PLACE BY THE SAND CONE METHOD (ASTM D1556, AAHSTO T217 & T224)
DENSITY OF SOIL IN PLACE BY THE NUCLEAR METHOD (ASTM D2922 & D3017)

CURVES:

	DESCRIPTION:	DENS (pcf)	MOIST (%)
P2	Embankment Soils	118.9	11.5

SAND CONE TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve

NUCLEAR TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve
1	Slope Crest Sta. 720+75	05/18/04	-2.5'	14	122.7	9.2	123.1	8.1	**100**	**95**	P2
2	Slope Crest Sta. 721+36	"	-2.5'	16	120.8	9.5	123.7	8.1	**98**	**95**	P2
3	Slope Crest Sta. 720+88	"	-1.5'	22	124.5	8.1	125.5	6.5	**99**	**95**	P2
4	Slope Crest Sta. 721+50	"	-1.5'	17	120.0	9.7	124.0	8.2	**97**	**95**	P2
5	Slope Crest Sta. 720+55	"	-0.5'	25	125.3	9.3	126.4	7.2	**99**	**95**	P2
6	Slope Crest Sta. 721+07	"	-0.5'	20	125.8	8.1	124.9	6.7	**100+**	**95**	P2
7	Slope Crest Sta. 720+82	"	-0.0'	25	123.4	9.9	126.4	7.7	**98**	**95**	P2
8	Slope Crest Sta. 721+40	"	-0.0'	19	121.2	10.2	124.6	8.5	**97**	**95**	P2

* DEPTH OF REFERENCE POINT: Top of Crest

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**5**
Project Name	**Buckeye FRS No. 1**	Date: **05/19/04**	Time: **7:00am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Observation**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests		Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Backfill material for crest of slope.

PRODUCT: Filter material.

SCOPE: Crew excavated trench in backfill of crest through to filter material in longitudinal trench for the length of that trench. Filter material was extended up through crest to 1.0' below finished grade. A 1.0' cap of soil (stockpile of material from dam excavation) was placed in trench for final 1.0' below finished grade.

RESULTS:

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**6**
Project Name	**Buckeye FRS No. 1**	Date: **05/20/04**	Time: **7:00am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Observation & Testing**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests	1	Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Upstream slope - dam.

PRODUCT: Embankment soils, Curve P2 - 118.9 pcf at 11.5% moisture.

SCOPE: Crew leveling benches cut into upstream slope. Excavations with backhoe creating slopes that match adjacent surface slopes in preparation for backfill of excavations. Crew processing material excavated from benches with moisture.

Conducted 1 nuclear density test on backfill of 1.0' soil cap of longitudinal drain.

RESULTS: Density test met criteria for compaction and moisture.

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

Project	Buckeye FRS No. 1	Job Number	4-117-001021
Location	Parallel to WB I-10, West of Exit 109	Date	05/20/04
		Report Number	6

DENSITY OF SOIL IN PLACE BY THE SAND CONE METHOD (ASTM D1556, AAHSTO T217 & T224)
DENSITY OF SOIL IN PLACE BY THE NUCLEAR METHOD (ASTM D2922 & D3017)

CURVES:

	DESCRIPTION:	DENS (pcf)	MOIST (%)
P2	Embankment Soils	118.9	11.5

SAND CONE TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve

NUCLEAR TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve
1	Crest of Slope Sta. 721+02	05/20/04	-0.0'	15	119.4	8.2	123.4	7.1	97	95	P2

* DEPTH OF REFERENCE POINT: Below Top of Crest

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**7**
Project Name	**Buckeye FRS No. 1**	Date: **05/24/04**	Time: **7:30am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Observation**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC	CONCRETE	ASPHALT	MASONRY
Sandcone tests	Concr, volume	AC placement (tons)	# of grout prisms
Nuclear tests	Sets of cyl.	Nuclear tests	# of mortar specimens
Spec. Insp	# of cylinders	# of samples	# of masonry prisms
Testing Only	# of cores	# of cores	Special Inspection
Footing Insp	Spec. Insp.	Observation & testing	Testing only
Caisson Insp.	Testing only	Testing only	Sample pickup
Sample pickup	Monitor slump	Other	
	Sample pickup		

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Upstream slope - dam.

PRODUCT: Filter material.

SCOPE: Crew continues leveling benches cut into upstream slope excavation using blade and loader at approximate Sta. 721+53. Planned backfill of excavations postponed due to equipment breakdown.

RESULTS:

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**8**
Project Name	**Buckeye FRS No. 1**	Date: **05/25/04**	Time: **6:30am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Observation**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC	CONCRETE	ASPHALT	MASONRY
Sandcone tests	Concr, volume	AC placement (tons)	# of grout prisms
Nuclear tests	Sets of cyl.	Nuclear tests	# of mortar specimens
Spec. Insp	# of cylinders	# of samples	# of masonry prisms
Testing Only	# of cores	# of cores	Special Inspection
Footing Insp	Spec. Insp.	Observation & testing	Testing only
Caisson Insp.	Testing only	Testing only	Sample pickup
Sample pickup	Monitor slump	Other	
	Sample pickup		

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Upstream slope - dam.

PRODUCT: Filter material.

SCOPE: Crew completes cleaning up excavation of benches. Progress of backfill of filter material on slope suspended to determine whether material delivered by Mesa Materials is suitable for filter material. Crew proceeds to process excavation spoils with moisture.

RESULTS:

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**9**
Project Name	**Buckeye FRS No. 1**	Date: **05/26/04**	Time: **6:30am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Observation/Testing**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests	3	Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Upstream slope - dam.

PRODUCT: Embankment soils, Curve P2 - 118.9 pcf at 11.5% moisture.

SCOPE: Crew roughed in filter material 12" deep in slope excavation, preceded by excavating toe at base of excavation at Sta. 721+53. Remaining sand placed at that excavation.

Performed 3 nuclear density tests from top of excavation to top of filter material in excavation: 4.4' (top of excavation), 4.6' (middle) and 4.6' (bottom).

Crew proceeding with backfill of excavation.

RESULTS: Density tests met criteria for compaction and moisture content.

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

ect	Buckeye FRS No. 1	Job Number	4-117-001021
Location	Parallel to WB I-10, West of Exit 109	Date	05/26/04
		Report Number	9

DENSITY OF SOIL IN PLACE BY THE SAND CONE METHOD (ASTM D1556, AAHSTO T217 & T224)
DENSITY OF SOIL IN PLACE BY THE NUCLEAR METHOD (ASTM D2922 & D3017)

CURVES:

	DESCRIPTION:	DENS (pcf)	MOIST (%)
P2	Embankment Soils	118.9	11.5

SAND CONE TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve

NUCLEAR TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve
1	Upstream Slope Sta. 721+53 8' from Toe	05/26/04	-3.5'	12	119.8	7.9	122.5	7.1	98	95	P2
2	Upstream Slope Sta. 721+53 11' from Toe	"	-0.0'	8	119.6	9.4	121.3	8.7	99	95	P2
3	Upstream Slope Sta. 721+53 17' from Toe	"	-2.5'	15	121.1	8.4	123.4	7.3	98	95	P2

* DEPTH OF REFERENCE POINT: Finished Grade

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**10**
Project Name	**Buckeye FRS No. 1**	Date: **05/27/04**	Time: **6:30am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Observation/Testing**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests	6	Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Upstream slope - dam.

PRODUCT: Embankment soils, Curve P2 - 118.9 pcf at 11.5% moisture.

SCOPE: Crew continues to backfill slope excavation at Sta. 721+53 and excavates toe at base of excavation, Sta. 721+06.

Performed 6 nuclear density tests (1 retest).

RESULTS: Density tests met criteria for compaction and moisture content.

NOTIFICATION:

Notes/Comments:

AMEC Representative: Brian Banks

Project	Buckeye FRS No. 1	Job Number	4-117-001021
Location	Parallel to WB I-10, West of Exit 109	Date	05/27/04
		Report Number	10

DENSITY OF SOIL IN PLACE BY THE SAND CONE METHOD (ASTM D1556, AAHSTO T217 & T224)
DENSITY OF SOIL IN PLACE BY THE NUCLEAR METHOD (ASTM D2922 & D3017)

CURVES:

	DESCRIPTION:	DENS (pcf)	MOIST (%)
P2	Embankment Soils	118.9	11.5

SAND CONE TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve

NUCLEAR TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve
1	Upstream Slope Sta. 721+53 22' from Toe	05/27/04	-1.5'	10	117.9	10.8	121.9	9.8	**97**	**95**	P2
2	Upstream Slope Sta. 721+53 34' from Toe	"	-3.0'	14	118.8	9.7	123.1	8.5	**97**	**95**	P2
3	Upstream Slope Sta. 721+53 37' from Toe	"	-1.0'	12	116.1	9.7	122.5	8.7	**95**	**95**	P2
4	Upstream Slope Sta. 721+53 45' from Toe	"	-0.0'	15	117.0	8.0	123.4	7.0	**95**	**95**	P2
5	Upstream Slope Sta. 721+53 52' from Toe	"	-2.0'	15	115.4	10.2	123.4	8.8	**94**	**95**	P2
6	Retest of Test No. 5	"	-2.0'	15	121.3	9.1	123.4	7.9	**98**	**95**	P2

* DEPTH OF REFERENCE POINT: Finished Grade

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	4-117-001021	**Report No.**	11
Project Name	Buckeye FRS No. 1	Date: 06/01/04	Time: 7:00am
Project Location	Parallel to WB I-10, West of Exit 109		
Services Requested	Observation	By:	Brett Howey, P.E.

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests		Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Upstream slope - dam.

PRODUCT: Filter material.

SCOPE: One-man crew completes excavation of toes at upstream slope and line toes with filter material 12" deep.

Two water trucks broken down. Crew dresses up finished grade on slopes while waiting for repairs.

Measured distance from top of filter material in slope excavations to original slope elevation: Excavation at Sta. 721+03, top 4.4', middle 4.5'; bottom 4.3'. Excavation at Sta. 720+80; top 4.8'; middle 4.8'; bottom 4.4'.

RESULTS:

NOTIFICATION:

Notes/Comments: Two water trucks repaired mid-afternoon. Water trucks, blade and loader scarifying and processing native material with moisture.

AMEC Representative: Brian Banks

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**	**Report No.**	**12**
Project Name	**Buckeye FRS No. 1**	Date: **06/03/04**	Time: **7:00am**
Project Location	**Parallel to WB I-10, West of Exit 109**		
Services Requested	**Observation/Testing**	By:	**Brett Howey, P.E.**

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests	4	Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Upstream slope - dam.

PRODUCT: Embankment soils, Curve P3 - 112.0 pcf at 14.5% moisture.

SCOPE: Two water trucks and blade continue to process backfill material (native) for upstream slope excavations. Loader places and compacts processed material at excavations located at Sta. 720+80 and 721+06.

Performed 4 nuclear density tests.

RESULTS: Density tests met criteria for compaction and moisture content. Crew finished backfill operation at 11:45am. I left site, but was called back to site by crew supervisor, Dan Michael, who said backfill would re-start. Arrived on site but work cancelled; crew done for the day.

NOTIFICATION:

Notes/Comments:

A[illegible] Representative: Brian Banks

Project	Buckeye FRS No. 1	Job Number	4-117-001021
Location	Parallel to WB I-10, West of Exit 109	Date	06/03/04
		Report Number	12

DENSITY OF SOIL IN PLACE BY THE SAND CONE METHOD (ASTM D1556, AAHSTO T217 & T224)
DENSITY OF SOIL IN PLACE BY THE NUCLEAR METHOD (ASTM D2922 & D3017)

CURVES:

	DESCRIPTION:	DENS (pcf)	MOIST (%)
P2	Embankment Soils	118.9	11.5
P3	Embankment Soils	112.0	14.5

SAND CONE TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve

NUCLEAR TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve
1	Upstream Slope Sta. 721+06 10' up from Toe	06/03/04	-3.5'	0	110.4	13.4	112.0	13.4	**99**	**95**	P3
2	Upstream Slope Sta. 721+06 12' up from Toe	"	-2.0'	14	114.1	11.4	117.2	9.9	**97**	**95**	P3
3	Upstream Slope Sta. 720+80 6' up from Toe	"	-3.5'	0	110.0	11.7	112.0	11.7	**98**	**95**	P3
4	Upstream Slope Sta. 720+80 11' up from Toe	"	-1.5'	0	109.4	13.8	112.0	13.8	**98**	**95**	P3

* DEPTH OF REFERENCE POINT: Finished Grade

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	**4-117-001021**		**Report No.**		**13**
Project Name	**Buckeye FRS No. 1**	Date:	**06/07/04**	Time:	**10:30am**
Project Location	**Parallel to WB I-10, West of Exit 109**				
Services Requested	**Observation/Testing**	By:	**Brett Howey, P.E.**		

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests	6	Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

STRUCTURE: Upstream slope - dam.

PRODUCT: Embankment soils, Curve P3 - 112.0 pcf at 14.5% moisture.

SCOPE: Observed upstream slope excavation at Sta. 720+80 and performed 6 nuclear density tests.

RESULTS: Tests met criteria for compaction.

NOTIFICATION:

Notes/Comments:

C Representative: Brian Banks

Project	Buckeye FRS No. 1	Job Number	4-117-001021
Location	Parallel to WB I-10, West of Exit 109	Date	06/07/04
		Report Number	13

DENSITY OF SOIL IN PLACE BY THE SAND CONE METHOD (ASTM D1556, AAHSTO T217 & T224)
DENSITY OF SOIL IN PLACE BY THE NUCLEAR METHOD (ASTM D2922 & D3017)

CURVES:

	DESCRIPTION:	DENS (pcf)	MOIST (%)
P2	Embankment Soils	118.9	11.5
P3	Embankment Soils	112.0	14.5

SAND CONE TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve

NUCLEAR TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve
1	Upstream Slope Sta. 720+80 30' up from Toe	06/07/04	-0.0'	0	111.2	13.4	112.0	13.4	**99**	**95**	P3
2	Upstream Slope Sta. 720+80 42' up from Toe	"	-3.0'	0	107.3	15.3	112.0	15.3	**96**	**95**	P3
3	Upstream Slope Sta. 720+80 38' up from Toe	"	-1.5'	12	117.0	9.8	116.4	8.7	**100+**	**95**	P3
4	Upstream Slope Sta. 720+80 52' up from Toe	"	-3.5'	0	110.4	12.5	112.0	12.5	**99**	**95**	P3
5	Upstream Slope Sta. 720+80 58' up from Toe	"	-2.0'	0	108.8	11.9	112.0	11.9	**97**	**95**	P3
6	Upstream Slope Sta. 720+80 67' up from Toe	"	-0.0'	17	115.9	10.6	118.3	9.0	**98**	**95**	P3

* DEPTH OF REFERENCE POINT: Finished Grade

SPECIAL INSPECTION / DAILY PROGRESS REPORT

SERVICES SCHEDULED

Project Number	4-117-001021		Report No.		14
Project Name	Buckeye FRS No. 1	Date:	06/08/04	Time:	10:00am
Project Location	Parallel to WB I-10, West of Exit 109				
Services Requested	Observation/Testing	By:	Brett Howey, P.E.		

SERVICES PERFORMED

SOIL/ABC		CONCRETE		ASPHALT		MASONRY	
Sandcone tests		Concr, volume		AC placement (tons)		# of grout prisms	
Nuclear tests	6	Sets of cyl.		Nuclear tests		# of mortar specimens	
Spec. Insp		# of cylinders		# of samples		# of masonry prisms	
Testing Only		# of cores		# of cores		Special Inspection	
Footing Insp		Spec. Insp.		Observation & testing		Testing only	
Caisson Insp.		Testing only		Testing only		Sample pickup	
Sample pickup		Monitor slump		Other			
		Sample pickup					

SPECIFICATIONS; 95% minimum compaction with -3 to +1 percent of optimum moisture content.

UCTURE: Upstream slope of dam, Sta. 721+06.

PRODUCT: Embankment soils, Curve P3 - 112.0 pcf at 14.5% moisture.

SCOPE: Observed upstream slope excavation at Sta. 721+06 and performed 6 nuclear density tests.

RESULTS: Completed testing of backfill of upstream slope excavation, Sta. 721+06.
Test performed met criteria for density and moisture.

NOTIFICATION:

Notes/Comments:

A C Representative: Brian Banks

Project	Buckeye FRS No. 1	Job Number	4-117-001021
Location	Parallel to WB I-10, West of Exit 109	Date	06/08/04
		Report Number	14

DENSITY OF SOIL IN PLACE BY THE SAND CONE METHOD (ASTM D1556, AAHSTO T217 & T224)
DENSITY OF SOIL IN PLACE BY THE NUCLEAR METHOD (ASTM D2922 & D3017)

CURVES:

	DESCRIPTION:	DENS (pcf)	MOIST (%)
P2	Embankment Soils	118.9	11.5
P3	Embankment Soils	112.0	14.5

SAND CONE TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve

NUCLEAR TESTS:

Test #	Location	Date	Elevation*	Rock (%)	Dry Density (pcf)	Moisture (%)	Maximum Density	Corrected Moisture (%)	Compaction (%)	Required Compaction	Curve
1	Upstream Slope Sta. 721+06 20' up from Toe	06/08/04	-3'	12	110.3	10.9	116.4	9.7	**95**	**95**	P3
2	Upstream Slope Sta. 721+06 25' up from Toe	"	=1'	10	111.5	13.6	115.7	12.3	**96**	**95**	P3
3	Upstream Slope Sta. 721+06 37" up from Toe	"	-0'	16	115.1	11.9	117.9	10.2	**98**	**95**	P3
4	Upstream Slope Sta. 721+06 45' up from Toe	"	-3.5'	0	108.2	13.5	112.0	13.5	**97**	**95**	P3
5	Upstream Slope Sta. 721+06 62' up from Toe	"	-1.5'	0	110.2	12.7	112.0	12.7	**98**	**95**	P3
6	Upstream Slope Sta. 721+06 56' up from Toe	"	-0'	0	107.9	14.8	112.0	14.8	**96**	**95**	P3

* DEPTH OF REFERENCE POINT: Finished Grade

APPENDIX H

LABORATORY TEST DATA

Supplemental Investigation of Tranverse Cracks
Buckeye FRS No. 1
Flood Control District of Maricopa County
Contract FCD2003C014
Work Assignment No. 2
AMEC Job No. 4-117-001021

TABLE H-1 - SUMMARY OF LABORATORY TEST RESULTS

Boring/Test Trench/Sample Number	Location or Depth (ft)	USCS/Group Symbol	Plasticity Index	Moisture Content (ASTM D2216) (%)	Dry Density (ASTM D2937)(pcf)	Consolidation (ASTM D2435) (%)	Unconfined Compression (ASTM D2166) (psi)	Calcium Carbonate Content (ADOT 732) (%)	Maximum Dry Density (pcf) (ASTM D698A)	Optimum Moisture Content (%)	Bulk Density - Clod Method (pcf)	Hydraulic Conductivity (ASTM 5084-90) (cm/sec)	pH (AZ 236)	Crumb Test (USBR 5400-89)	Pinhole Test (ASTM D4647)	Soundness of Aggregate by Use of Sodium Sulfate (ASTM C88)	Sand Equivalent Value (ASTM D2419)	Exchangeable Sodium (ARIZ 729a) (ppm)	Aggregate Sieve Analysis (ASTM C136/C117)
B-1	2.5-3.5	SC-SM	4	3.1	106.2														
B-1	4.5-6.0			5															
B-1	9.5-10.5	SM	12	6.4	100														
B-1	14.5-16.0			6.4															
B-1	19.5-21.0			6.4															
B-1	24.5-26.0			3.9															
B-1	29.5-31.0			10.4															
B-1	34.5-36	SC	20	10.3				5.2											
B-2	4.5-5.5	SC	17	5.4	103.4														
B-2	5.0-7.5	CL	15	5.7							117.3								
B-2	7.5-10.0			6.1															
B-2	10.0-12.5			6.1							110								
B-2	12.5-15.0			4.3							118.5								
B-2	14.5-16.5			6.1							118.2								
B-2	17.5-20.0			5.1							110.1								
B-2	20.0-22.5	SC	14	5.4							111.3								
B-2	22.5-25.0			6.8							106.2								
B-3	7.5-8.5	SC	18	5.6	105.1														
B-3	12.5-13.5	SM	8	6.4	95.8														
B-3	29.5-31.0	SC	17	6				2											
B-4	2.5-3.5			5.3	95.5	16.0													
B-4	4.5-5.5	CL	12	5.7			9.0												
B-4	7.5-10.0										117.4								
B-4	9.5-10.5	SC	15				8.0												
B-4	14.5-15.5	SM	18		98.9														
B-4	15.0-17.5	SM	12				53.0				118.9								
B-4	17.5-20.0										116.1								
B-4	19.5-21.0			3.1															
B-4	20.0-22.5										109.6								
B-4	24.5-26.0			1.9															
B-4	34.5-35.0			6.9															
B-4	39.5-41.0			5.0															
B-5	4.5-5.5	SC	16	5.5	94.4	24.0													
B-5	7.5-9.0			4.3				12.0											
B-5	9.5-10.5			3.6															
B-5	12.5-13.5			6.6															
B-5	14.5-16.0	SM	NP	5.4				7.9											
B-5	19.5-20.5			5.7															
B-5	27.5-30.0	SM	NP					5.2											
B-6	2.5-3.5	SP-SM	NP	1.8	117.6														
B-6	9.5-10.5	SP-SC	14	4.9	98.6	13.0													
B-6	14.5-15.5	SM	NP	2.1	95.7	17.5													
B-7	7.5-8.5	SM	NP																
B-7	14.5-15.5	SC	9	3.9	112.6														
B-8	4.5-5.5	SC	14	6.0	91.8	23.0													
D-1	1.0-2.0														Nondispersive ND2				
D-2	1.0-2.0								124	11.6									
D-3	1.0-2.0											3.46E-08	8.4						
D-5	2.0-4.0														Nondispersive ND1				
D-7	1.0-2.0								119	12.6									
D-9	1.0-3.0														Nondispersive ND2				
D-9	3.0-4.0								116.4	11.6									

TABLE H-1 - SUMMARY OF LABORATORY TEST RESULTS

Boring/Test Trench/Sample Number	Location or Depth (ft)	USCS/Group Symbol	Plasticity Index	Moisture Content (ASTM D2216) (%)	Dry Densiy (ASTM D2937)(pcf)	Consolidation (ASTM D2435) (%)	Unconfined Compression (ASTM D2166) (psi)	Calcium Carbonate Content (ADOT 732) (%)	Maximum Dry Density (pcf) (ASTM D698A)	Optimum Moisture Content (%)	Bulk Density - Clod Method (pcf)	Hydraulic Conductivity (ASTM 5084-90) (cm/sec)	pH (AZ 236)	Crumb Test (USBR 5400-89)	Pinhole Test (ASTM D4647)	Soundness of Aggregate by Use of Sodium Sulfate (ASTM C88)	Sand Equivalent Value (ASTM D2419)	Exchangeable Sodium (ARIZ 729a) (ppm)	Aggregate Sieve Analysis (ASTM C136/C117)
D-10	1.0-2.0								121.7	11.3		3.15E-06	8.5						
D-11	2.0-4.0														Nondispersive ND2				
D-12	1.0-3.0								123	11.2									
P-1	Borrow Source	SC	13.0						118.3	12.2									
P-2	Borrow Source	SC	13.0						118.9	11.5									
P-3	Borrow Source	SC	28.0						112	14.5									
M-1	2.0-3.0			7.8															
M-2	2.0-3.0	SC	14	4.4															
M-3	2.0-3.0			5.1															
M-4	2.0-3.0			6.1															
M-5	2.0-3.0			7.2															
M-6	2.0-3.0			4.3															
M-7	2.0-3.0			3.7															
M-8	2.0-3.0	SM	2	4.2															
M-9	2.0-3.0	SC	8	3.3															
M-10	2.0-3.0			4.2															
M-11	2.0-3.0			4.0															
M-12	2.0-3.0			4.9															
F-1A	1.50															X			X
F-1B	1.5													Intermediate					
F-2A	5																	48	
F-4A	15																		X
F-4B	15													Nondispersive					
F-5B	10.5													Intermediate					
F-6A	4																29		
F-6B	4													Nondispersive					
F-7	Filter A																		X
F-8	Filter A																		X
S-1	Filter B																		X
S-2	Filter B																		X
Mesa Materials	Mesa Materials																		X

amec

PROCEDURE FOR FILTER TEST

Step 1: Prepare specimen in mold (see Figure H-1). First filter material (drain material) was placed. Then a ring of modeling clay was placed around the inside of the cylinder wall. Then a final layer of filter material was placed. Then a long strip of metal 0.5 inch wide and 0.06 inch thick was wrapped in a plastic membrane and placed in the center of the filter. Then base material (embankment material) was placed in layers to a density about 95 percent of the maximum density in accordance with ASTM D698. Finally the strip and the plastic wrapper were withdrawn to form the slot for initial leakage.

Step 2: Water valve was opened allowing the water to flow under pressure of 50-60 psi through the slot in the base specimen and discharge into the filter.

Step 3: Collect all water passing through the specimen and inspect it .

Step 4: Determine the velocity of the water passing through the filter.

FILTER TEST OBSERVATIONS

The flow rate within the every 30 seconds was recorded for 10 minutes. Then the flow rate was recorded for every ten minutes for 30 minutes. The color of the water was observed. The quantity of fine soils was also observed. The slot area after the test was measured and the condition of slut within the sample after the test was examined

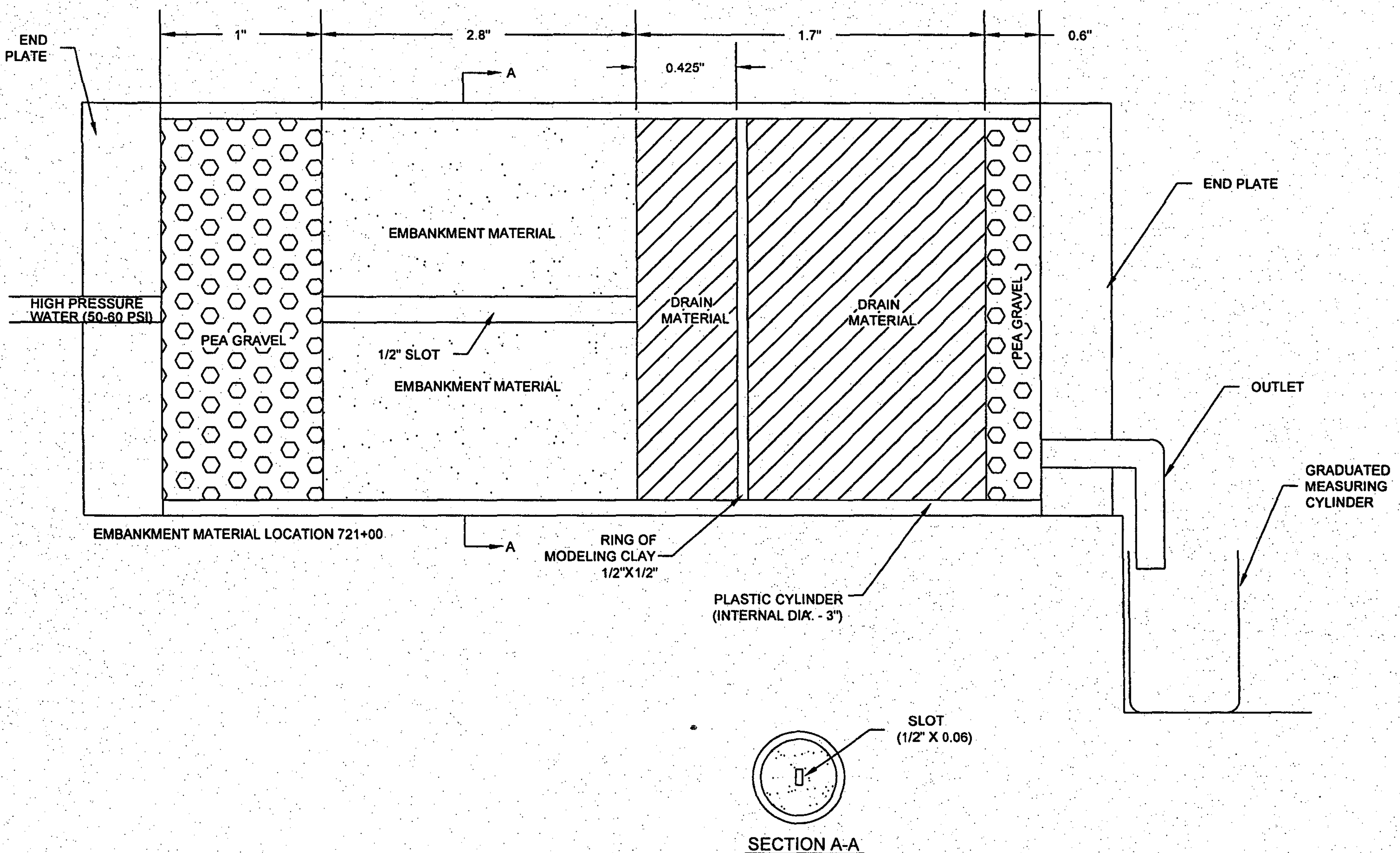
CONCLUSIONS

For tests with successful filters, the flow rate rapidly decreases and water becomes progressively clearer, finally sealing completely or stabilizing at a very small constant flow of clear water.

REFERENCES

Sherard, J.L., L.P. Dunnigan, J.R. Talbot, 1983. “Basic properties of sand and gravel filters,” ASCE Journal of Geotechnical Engineering, vol.110, No.6, pp. 684-700.

Sherard, J.L., L.P. Dunnigan, J.R. Talbot, 1983. “Filters for silts and clays,” ASCE Journal of Geotechnical Engineering, vol.110, No.6, pp. 701-718.



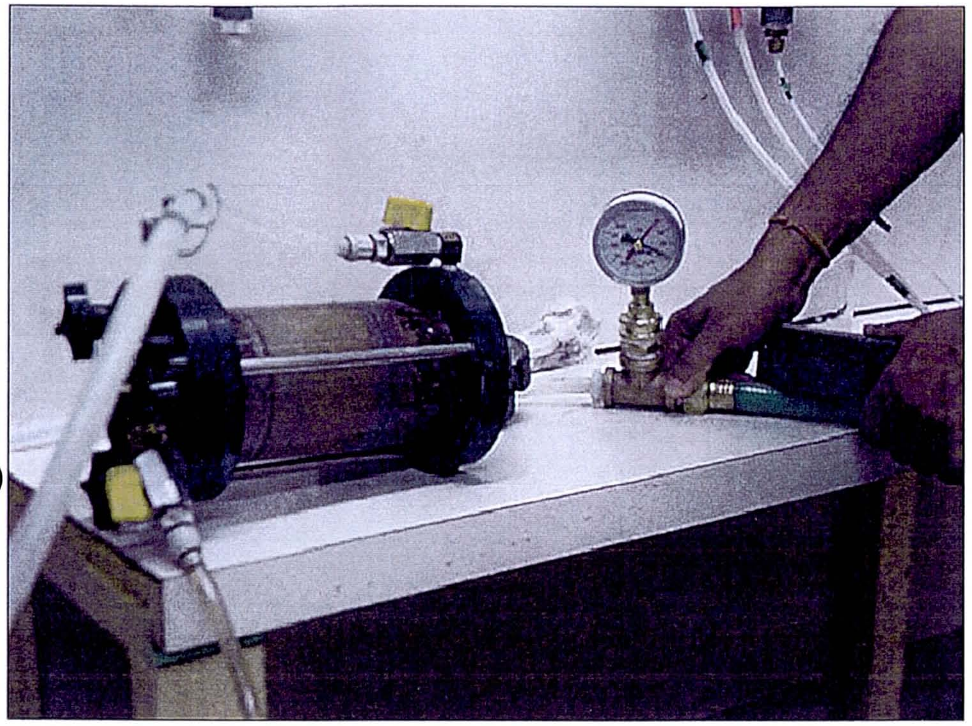
JOB NO.	4-117-001021
DESIGN:	BBP
DRAWN:	GWH
DATE:	6/2004
SCALE:	N.T.S.

FILTER TEST
MOLD DIMENSIONS AND
SPECIMEN DETAILS

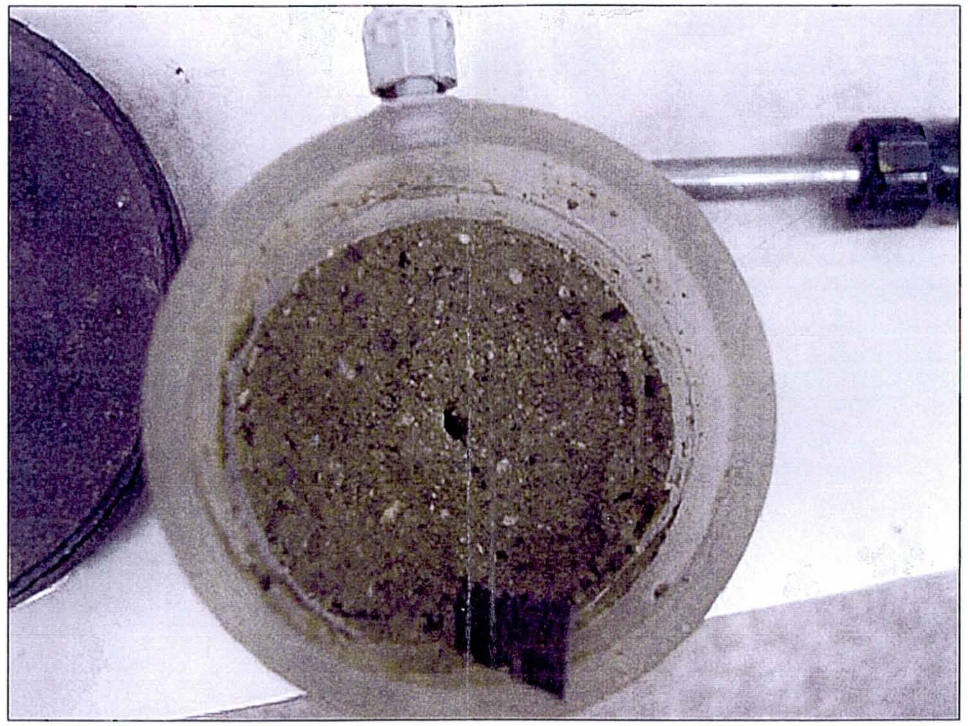
SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE
H-1

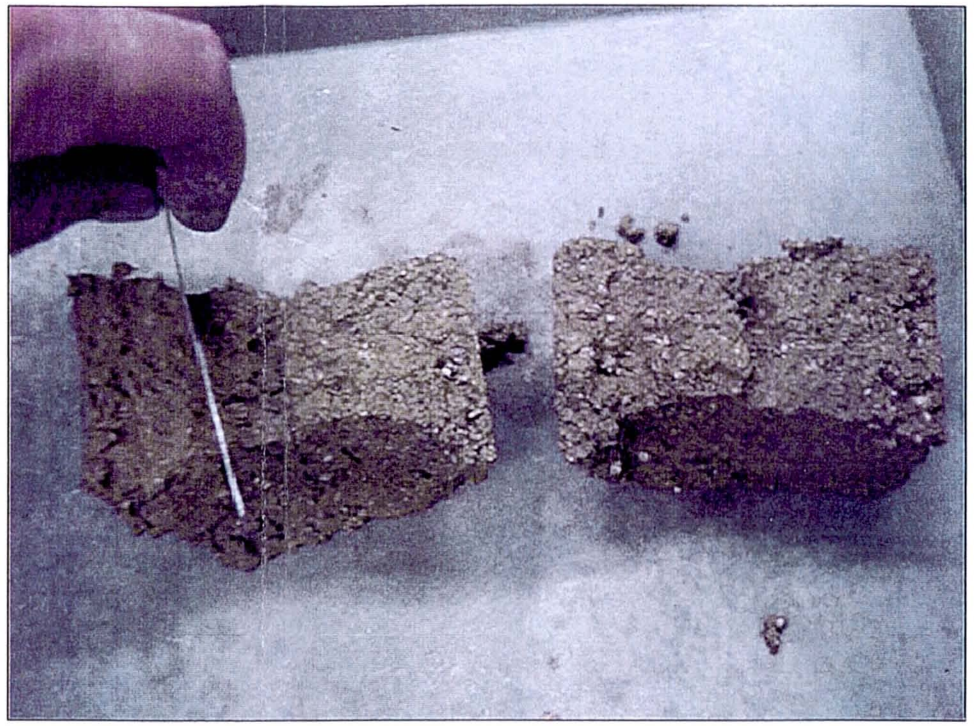
amec



FILTER TEST EXPERIMENT UNDER HIGH WATER PRESSURE.



SLOT OPENING (ENLARGED) AT INLET POSITION AFTER THE FILTER TEST.



PHOTOGRAPH OF SLOT THROUGH SOIL SAMPLE AFTER THE TEST.

JOB NO.	4-117-001021
DESIGN:	REW
DRAWN:	GWH
DATE:	6/2004
SCALE:	N.T.S.

SELECT PHOTOGRAPHS OF FILTER TEST

SUPPLEMENTAL INVESTIGATION OF TRANSVERSE CRACKS
BUCKEYE FRS NO.1
CONTRACT FCD 2003C014, WORK ASSIGNMENT NO. 2

FIGURE H-2

amec

G:\Engineering Departm... 04 Projects\4-117-001021 Buckeye FRS No. 1\Cad\Photograph Log.dwg

amec

LABORATORY TESTING PROCEDURES

Consolidation Tests Soiltest or Clockhouse apparatus of the "floating-ring" type are employed for the one-dimensional consolidation tests. They are designed to receive 1-inch high 2.5-inch O.D. brass liner rings with soil specimens as secured in the field. Procedures for the tests generally are those outlined in ASTM D2435. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. For soils which are essentially saturated, each increment of load is maintained until the deformation versus log of time curve indicates completion of primary consolidation. For partially saturated soils, each increment of load is maintained until the rate of deformation is equal or less than 1/10,000 inch per hour. Applied loads are such that each new increment is equal to the total previously applied loading. Porous stones are placed in contact with the top and bottom of the specimens to permit free addition or expulsion of water. For partially saturated soils, the tests are normally performed at in situ moisture conditions until consolidation is complete under stresses approximately equal to those which will be imposed by the combined overburden and foundation loads. The samples are then submerged to show the effect of moisture increase and the tests continued under higher loadings. Generally, the tests are continued to about twice the anticipated curve due to overburden and structural loads with a rebound curve then being established by releasing loads.

Expansion Tests The same type of consolidometer apparatus described above is used in expansion testing. Undisturbed samples contained in brass liner rings are placed in the consolidometers, subjected to appropriate surcharge loads and submerged. The loads are maintained until the expansion versus log of time curve indicates the completion of "primary swell".

Direct Shear Tests Direct shear tests are run using a Clockhouse or Soiltest apparatus of the strain-control of approximately 0.05 inch per minute. The machine is designed to receive one of the 1-inch high 2.42-inch diameter specimens obtained by tube sampling. Generally, each sample is sheared under a normal load equivalent to the effective overburden pressure at the point of sampling. In some instances, samples are sheared at several normal loads to obtain the cohesion and angle of internal friction. When necessary, samples are saturated and/or consolidated before shearing in order to approximate the anticipated controlling field loading conditions.

PROJECT: BUCKEYE FRS NO. 1
LOCATION: MARICOPA COUNTY, ARIZONA
SAMPLE SOURCE: SEE BELOW

JOB NO: 4-117-001021
WORK ORDER NO: 1
DATE SAMPLED: 4/23/04

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (ASTM D-2487)

				Silt or Clay	SAND								GRAVEL									COBBLES	
					Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	USCS	LL	PI	#200	#100	#50	#40	#30	#16	#10	#8	#4	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	3"	6"	Lab #
PERCENT PASSING BY WEIGHT																							
B-1 @ 2.5-3.5'	SC-SM	23	4	35	47	59	65	69	79	87	90	96	97	98	98	100	100	100	100	100	100	100	3
B-1 @ 9.5-10.5'	SM	39	12	40	49	61	68	74	85	92	95	98	99	100	100	100	100	100	100	100	100	100	6
B-1 @ 34.5-36.0'	SC	43	20	40	54	68	75	81	90	93	94	97	98	99	100	100	100	100	100	100	100	100	13
B-2 @ 4.5-5.5'	SC	42	17	28	38	49	55	60	70	78	81	89	91	93	94	94	100	100	100	100	100	100	17
B-2 @ 5.0-10.0'	CL	40	15	51	60	67	72	76	94	89	91	97	98	100	100	100	100	100	100	100	100	100	25
B-2 @ 20.0-22.5'	SC	35	14	38	51	64	70	76	85	91	93	97	98	100	100	100	100	100	100	100	100	100	30
B-3 @ 7.5-8.5'	SC	42	18	36	44	53	58	63	72	77	79	90	96	100	100	100	100	100	100	100	100	100	35
B-3 @ 12.5-13.5'	SM	38	8	28	41	55	62	69	81	89	92	99	100	100	100	100	100	100	100	100	100	100	37
B-3 @ 29.5-31.0'	SC	36	17	44	57	70	76	81	89	93	95	98	99	100	100	100	100	100	100	100	100	100	42
B-4 @ 4.5-5.5'	CL	35	12	59	66	72	76	80	88	92	93	97	98	99	100	100	100	100	100	100	100	100	47
B-4 @ 9.5-10.5'	SC	38	15	31	37	44	50	55	68	78	82	94	96	100	100	100	100	100	100	100	100	100	48
B-4 @ 14.5-15.5'	SM	45	18	20	36	53	62	69	79	85	87	95	97	100	100	100	100	100	100	100	100	100	49

AASHTO R18

REVIEWED BY ________

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	1
SAMPLE SOURCE:	SEE BELOW	**DATE SAMPLED:**	4/23/04

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (ASTM D-2487)

PERCENT PASSING BY WEIGHT

				Silt or Clay	SAND								GRAVEL									COBBLES	
					Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	USCS	LL	PI	#200	#100	#50	#40	#30	#16	#10	#8	#4	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	3"	6"	Lab #
B-4 @ 15.0-17.5'	SM	42	12	44	56	70	76	82	89	94	95	98	98	99	100	100	100	100	100	100	100	100	59
B-5 @ 4.5-5.5'	SC	40	16	34	49	63	71	78	88	93	95	99	100	100	100	100	100	100	100	100	100	100	65
B-5 @ 14.5-16.0'	SM	NV	NP	36	53	69	77	83	93	97	98	100	100	100	100	100	100	100	100	100	100	100	69
B-5 @ 27.5-30.0'	SM	NV	NP	50	63	73	79	84	92	96	97	99	100	100	100	100	100	100	100	100	100	100	79
B-6 @ 2.5-3.5'	SP-SM	NV	NP	10	18	28	35	41	54	62	69	92	96	100	100	100	100	100	100	100	100	100	85
B-6 @ 9.5-10.5'	SP-SC	37	14	9.4	18	28	35	43	56	64	68	90	94	100	100	100	100	100	100	100	100	100	88
B-6 @ 14.5-15.5'	SM	NV	NP	30	48	65	72	78	87	91	93	96	98	100	100	100	100	100	100	100	100	100	90
B-7 @ 7.5-8.5'	SM	NV	NP	24	37	51	58	66	78	85	87	96	97	100	100	100	100	100	100	100	100	100	100
B-7 @ 14.5-15.5'	SC	28	9	36	46	57	63	69	78	83	85	88	89	89	90	90	90	100	100	100	100	100	103
B-8 @ 4.5-5.5'	SC	34	14	37	51	65	72	78	88	94	95	99	100	100	100	100	100	100	100	100	100	100	120

AASHTO R18

REVIEWED BY [signature]

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	2
SAMPLE SOURCE:	SEE BELOW	**DATE SAMPLED:**	4/23/04

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (ASTM D-2487)

				Silt or Clay	SAND								GRAVEL									COBBLES	
					Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	**USCS**	**LL**	**PI**	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**	**#8**	**#4**	**1/4"**	**3/8"**	**1/2"**	**3/4"**	**1"**	**1 1/4"**	**1 1/2"**	**2"**	**3"**	**6"**	**Lab #**

PERCENT PASSING BY WEIGHT

M-2	SC	34	14	37	45	55	61	67	77	84	86	91	93	95	97	100	100	100	100	100	100	100	133
M-8	SM	22	2	40	50	62	68	74	83	89	91	95	96	98	99	100	100	100	100	100	100	100	139
M-9	SC	28	8	18	24	32	39	46	62	72	75	84	86	92	96	97	100	100	100	100	100	100	140

AAP AASHTO R18

REVIEWED BY [signature]

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	3
MATERIAL:	DRAIN FILL-80% 1/4" MINUS/20% 3/8" WASHED ROCK	**LAB NO:**	144
SAMPLE SOURCE:	MESA MATERIALS	**DATE SAMPLED:**	4/26/04

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MECHANICAL ANALYSIS

SIEVE SIZE	% PASSING	SPECS
6in.	100	
4in.	100	
3in.	100	
2in.	100	
1 1/2in.	100	100
1 1/4in.	100	
1in.	100	92-100
3/4in.	100	
1/2in.	100	
3/8in.	99	85-100
1/4in.	89	
#4	81	62-92
#8	62	42-81
#10	58	
#16	47	22-68
#30	28	9-49
#40	16	
#50	10	5-21
#100	4	0-10
#200	1.6	0-5

REVIEWED BY ________________

AMEC Earth & Environmental, Inc.
3232 West Virginia Avenue
Phoenix, Arizona 85009-1502
Tel +1 (602) 272-6848
Fax +1 (602) 272-7239

www.amec.com

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	6
MATERIAL:	SOIL	**LAB NO:**	150
SAMPLE SOURCE:	S-1	**DATE SAMPLED:**	5/25/04

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MECHANICAL ANALYSIS

SIEVE SIZE	% PASSING
6in.	100
4in.	100
3in.	100
2in.	100
1 1/2in.	100
1 1/4in.	100
1in.	100
3/4in.	100
1/2in.	100
3/8in.	100
1/4in.	100
#4	98
#8	82
#10	78
#16	66
#30	45
#40	31
#50	21
#100	8
#200	2.4

REVIEWED BY CY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	6
MATERIAL:	SOIL	**LAB NO:**	151
SAMPLE SOURCE:	S-2	**DATE SAMPLED:**	5/25/04

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MECHANICAL ANALYSIS

SIEVE SIZE	% PASSING
6in.	100
4in.	100
3in.	100
2in.	100
1 1/2in.	100
1 1/4in.	100
1in.	100
3/4in.	100
1/2in.	100
3/8in.	100
1/4in.	100
#4	99
#8	84
#10	80
#16	68
#30	47
#40	33
#50	21
#100	9
#200	3.5

REVIEWED BY CJ

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	8
MATERIAL:	SOIL	**LAB NO:**	164
SAMPLE SOURCE:	F-1A	**DATE SAMPLED:**	5/25/04

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MECHANICAL ANALYSIS

SIEVE SIZE	% PASSING
6in.	100
4in.	100
3in.	100
2in.	100
1 1/2in.	99
1 1/4in.	98
1in.	89
3/4in.	77
1/2in.	59
3/8in.	51
1/4in.	43
#4	39
#8	31
#10	29
#16	23
#30	16
#40	13
#50	11
#100	7
#200	5.1

REVIEWED BY Cy ______________________

amec

PROJECT:	BUCKEYE FRS. NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	8
MATERIAL:	SOIL	**LAB NO:**	166
SAMPLE SOURCE:	F-2A	**DATE SAMPLED:**	5/25/04

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MECHANICAL ANALYSIS

SIEVE SIZE	% PASSING
6in.	100
4in.	100
3in.	100
2in.	100
1 1/2in.	100
1 1/4in.	99
1in.	93
3/4in.	84
1/2in.	70
3/8in.	60
1/4in.	50
#4	46
#8	38
#10	36
#16	29
#30	20
#40	16
#50	12
#100	8
#200	4.6

REVIEWED BY ________________

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	8
MATERIAL:	SOIL	**LAB NO:**	170
SAMPLE SOURCE:	F-4A	**DATE SAMPLED:**	5/25/04

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MECHANICAL ANALYSIS

SIEVE SIZE	% PASSING
6in.	100
4in.	100
3in.	100
2in.	100
1 1/2in.	100
1 1/4in.	98
1in.	87
3/4in.	79
1/2in.	60
3/8in.	50
1/4in.	40
#4	36
#8	26
#10	23
#16	17
#30	12
#40	10
#50	8
#100	6
#200	4.3

REVIEWED BY *(signature)*

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	9
MATERIAL:	SOIL	**LAB NO:**	176
SAMPLE SOURCE:	F-7 (SOURCE PILE)	**DATE SAMPLED:**	5/25/04

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MECHANICAL ANALYSIS

SIEVE SIZE	% PASSING
6in.	100
4in.	100
3in.	100
2in.	100
1 1/2in.	100
1 1/4in.	100
1in.	100
3/4in.	100
1/2in.	100
3/8in.	100
1/4in.	95
#4	89
#8	69
#10	64
#16	52
#30	31
#40	19
#50	11
#100	4
#200	1.7

REVIEWED BY CMG

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	9
MATERIAL:	SOIL	**LAB NO:**	177
SAMPLE SOURCE:	F-8 (DRAIN)	**DATE SAMPLED:**	5/25/04

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MECHANICAL ANALYSIS

SIEVE SIZE	% PASSING
6in.	100
4in.	100
3in.	100
2in.	100
1 1/2in.	100
1 1/4in.	100
1in.	100
3/4in.	100
1/2in.	100
3/8in.	100
1/4in.	95
#4	90
#8	72
#10	67
#16	53
#30	32
#40	20
#50	12
#100	4
#200	1.7

REVIEWED BY C.M.K. (signature)

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BELOW	**DATE SAMPLED:**	4/19/04

MOISTURE CONTENT OF SOIL (ASTM D2216)

LAB #	BORING	DEPTH	WET WT. (gram)	DRY WT. (gram)	MOISTURE CONTENT
3	B-1	2.5-3.5'	387.2	375.4	3.1%
4	B-1	4.5-6.0'	516.7	492.3	5.0%
6	B-1	9.5-10.5'	393.8	370.2	6.4%
8	B-1	14.5-16.0'	495.2	465.4	6.4%
10	B-1	19.5-21.0'	626.1	588.2	6.4%
11	B-1	24.5-26.0'	598.7	576.5	3.9%
12	B-1	29.5-31.0'	551.8	499.8	10.4%
13	B-1	34.5-36.0'	236.5	214.5	10.3%
17	B-2	4.5-5.5'	361.7	343.1	5.4%
25	B-2	7.5-10.0'	510.3	480.9	6.1%
30	B-2	20.0-22.5'	526.5	501.1	5.1%
35	B-3	7.5-8.5'	405.1	383.8	5.6%
37	B-3	12.5-13.5'	381.5	358.7	6.4%
42	B-3	29.5-31.0	127.6	120.4	6.0%
49	B-4	4.5-5.5'	370.2	350.2	5.7%
50	B-4	19.5-21.0'	524.4	508.4	3.1%
51	B-4	24.5-26.0'	614.3	602.9	1.9%
53	B-4	34.5-35.0'	221.2	207.0	6.9%
54	B-4	39.5-41.0'	485.2	462.3	5.0%
65	B-5	4.5-5.5'	322.7	306.2	5.4%
66	B-5	7.5-9.0'	408.0	391.3	4.3%
67	B-5	9.5-10.5'	904.9	873.6	3.6%
68	B-5	12.5-13.5'	717.3	673.1	6.6%
69	B-5	14.5-16.0'	202.0	191.7	5.4%
71	B-5	19.5-20.5'	326.8	309.2	5.7%
85	B-6	2.5-3.5'	429.4	421.8	1.8%
103	B-7	14.5-15.5'	431.4	415.2	3.9%

AASHTO R18

REVIEWED BY CY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	2
MATERIAL:	SOIL	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BELOW	**DATE SAMPLED:**	4/23/04

MOISTURE CONTENT OF SOIL (ASTM D2216)

LAB #	BORING	WET WT. (gram)	DRY WT. (gram)	MOISTURE CONTENT
132	M-1	624.6	579.5	7.8%
133	M-2	320.9	307.5	4.4%
134	M-3	619.0	589.1	5.1%
135	M-4	595.0	560.6	6.1%
136	M-5	643.8	600.8	7.2%
137	M-6	689.3	660.6	4.3%
138	M-7	603.3	581.9	3.7%
139	M-8	306.9	294.4	4.2%
140	M-9	297.8	288.2	3.3%
141	M-10	665.5	638.4	4.2%
142	M-11	598.6	575.6	4.0%
143	M-12	592.8	564.9	4.9%

AAP
AASHTO R18

REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	8
MATERIAL:	SOIL	**LAB NO:**	174
SAMPLE SOURCE:	F-6A	**DATE SAMPLED:**	5/25/04

SAND EQUIVALENT VALUE FOR SOILS AND FINE AGGREGATE(ASTM D2419)

CLAY READING:	11.3	11.9	11.3
SAND READING:	3.3	3.3	3.1
SAND EQUIVALENT:	29.2	27.7	27.4
SAND EQ. RECORDED:	30.0	28.0	28.0
SAND EQ. AVERAGE:	29		
SAND EQUIVALENT:	29		
SPECIFICATION:			

AASHTO R18

REVIEWED BY CG

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	8
MATERIAL:	SOIL	**LAB NO:**	164
SAMPLE SOURCE:	F-1A	**DATE SAMPLED:**	05/25/04

SOUNDNESS OF AGGREGATE BY USE OF SODIUM SULFATE OR MAGNESIUM SULFATE (ASTM C88)

SODIUM SULFATE SOUNDNESS FOR COARSE AGGREGATE

Passing	Retained	Grading on original sample	Weight before testing (g)	Weight after testing (g)	Percent loss	Corrected percent loss
1 1/2"	3/4"	36.6%	510.1	502.9	1.4%	0.5%
3/4"	3/8"	44.3%	1000.9	995.5	0.5%	0.2%
3/8"	#4	19.1%	300.5	297.0	1.2%	0.2%
	Total:	100.0%			Total Loss:	1%

SODIUM SULFATE SOUNDNESS FOR FINE AGGREGATES

#4	#8	7.2%	100.0	96.0	4.0%	0.3%
#8	#16	23.4%	100.0	97.5	2.5%	0.6%
#16	#30	20.6%	100.1	95.5	4.6%	0.9%
#30	#50	48.8%	92.6	90.8	1.9%	0.9%
		100.0%			Total Loss:	3%

AAP
AASHTO R18

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	8
MATERIAL:	SOIL	**LAB NO:**	170
SAMPLE SOURCE:	F-4A	**DATE SAMPLED:**	05/25/04

SOUNDNESS OF AGGREGATE BY USE OF SODIUM SULFATE OR MAGNESIUM SULFATE (ASTM C88)

MAGNESIUM SULFATE SOUNDNESS FOR COARSE AGGREGATE

Passing	Retained	Grading on original sample	Weight before testing (g)	Weight after testing (g)	Percent loss	Corrected percent loss
1 1/2"	3/4"	31.1%	1016.2	966.2	4.9%	1.5%
3/4"	3/8"	46.5%	1001.0	950.6	5.0%	2.3%
3/8"	#4	22.4%	300.3	281.9	6.1%	1.4%
	Total:	100.0%			Total Loss:	5%

AAP AASHTO R18

REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SEE BELOW	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BELOW	**DATE SAMPLED:**	05/25/04

pH & RESISTIVITY (AZ 236)

LAB NO	SAMPLE SOURCE	MATERIAL	pH
154	D-3 1-2	SOIL	8.4
161	D-10 1-2	SOIL	8.5

REVIEWED BY ____________

amec

PROJECT: BUCKEYE FRS NO. 1
LOCATION: MARICOPA COUNTY, ARIZONA
MATERIAL: SOIL
SAMPLE SOURCE: SEE BORING

JOB NO: 4-117-001021
WORK ORDER NO: 1
LAB NO: SEE BELOW
DATE SAMPLED: 4/19/04

DENSITY OF SOIL IN PLACE BY THE DRIVE-CYLINDER METHOD(ASTM D2937)

LAB #	BORING	MOISTURE WET WT. (g)	MOISTURE DRY WT. (g)	MOISTURE CONTENT	NUMBER OF RINGS	WET WGT. + RINGS (g)	WEIGHT OF RINGS (g)	DRY DENSITY (pcf)	SPECIFIC GRAVITY	POROSITY
3	B-1 @ 2.5-3.5'	387.2	375.4	3.1%	5.0	891.0	229.4	106.2	2.65	0.36
6	B-1 @ 9.5-10.5'	393.7	370.2	6.4%	6.0	1,041.8	270.8	100.0	2.65	0.40
17	B-2 @ 4.5-5.5'	361.7	343.1	5.4%	5.0	882.8	224.6	103.4	2.65	0.37
35	B-3 @ 7.5-8.5'	405.1	383.8	5.6%	5.0	897.0	226.9	105.1	2.65	0.36
37	B-3 @ 12.5-13.5'	381.5	358.7	6.4%	5.0	839.7	224.6	95.8	2.65	0.42
49	B-4 @ 14.5-15.5'	370.2	350.2	5.7%	6.0	1,028.8	270.8	98.9	2.65	0.40
85	B-6 @ 2.5-3.5'	429.4	421.8	1.8%	5.0	951.8	228.7	117.6	2.65	0.29
103	B-7 @ 14.5-15.5'	431.4	415.2	3.9%	5.0	936.5	229.8	112.6	2.65	0.32

REVIEWED BY Cf

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, AZ	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BELOW	**DATE SAMPLED:**	04/19/04

DEPARTMENT OF SUSTAINABLE NATURAL RESOURCES
SOIL SURVEY STANDARD TEST METHOD
BULK DENSITY OF A SOIL: CLOD METHOD

LAB #	SAMPLE SOURCE	Wet Wgt. (g)	Dry Wgt (g)	Moisture Content (%)	Mass of Specimen (g)	Mass of Coated Specimen (g)	Mass of Coated Specimen Underwater (g)	Bulk Specific Gravity	Bulk Density (pcf)
19	B-2 @ 14.5-16.5'	510.3	480.9	6.1	38.7	40.3	18.1	1.895	118.2
25	B-2 @ 5.0-10.0'0	517.5	489.7	5.7	223.7	227.4	104.3	1.880	117.3
26	B-2 @ 10.0-12.5'	516.5	486.6	6.1	71.2	73.2	30.6	1.763	110.0
27	B-2 @ 12.5-15.0'	507.3	486.2	4.3	48.5	50.0	22.8	1.899	118.5
29	B-2 @ 17.5-20.0'	526.5	501.1	5.1	261.2	266.1	112.6	1.764	110.1
30	B-2 @ 20.0-22.5'	501.4	481.7	4.1	430.1	437.7	188.2	1.784	111.3
31	B-2 @ 22.5-25.0'	590.0	552.4	6.8	76.0	78.3	31.1	1.702	106.2
56	B-4 @ 7.5-10.0'	511.6	493.6	3.6	761.8	771.4	355.8	1.881	117.4
58	B-4 @ 12.5-15.0'	516.5	503.7	2.5	102.7	103.7	48.7	1.906	118.9
60	B-4 @ 17.5-20.0'	366.4	353.7	3.6	28.0	28.4	12.9	1.860	116.1
61	B-4 @ 20.0-25.0'	543.1	506.6	7.2	106.4	111.1	45.3	1.756	109.6

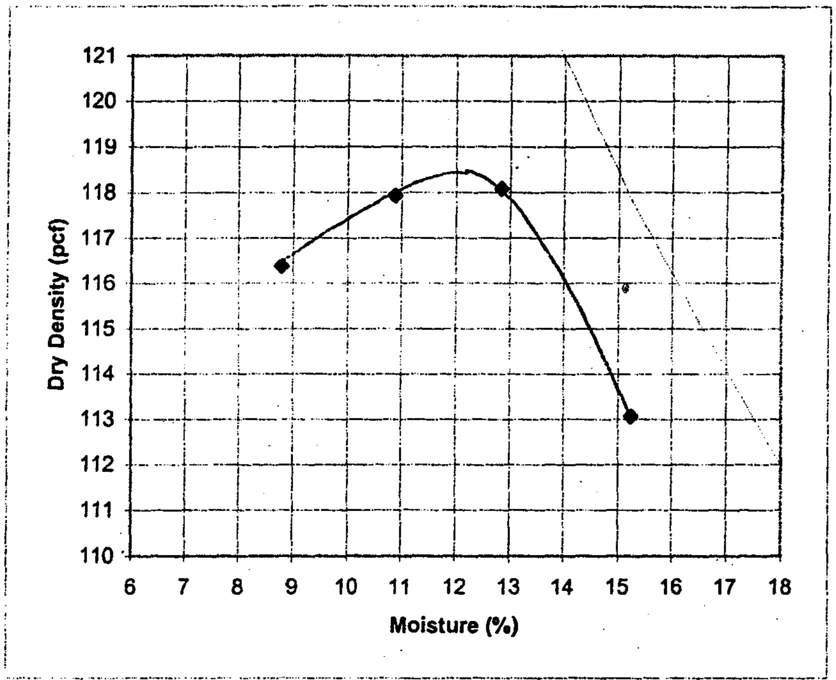
REVIEWED BY Cf

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	5
MATERIAL:	SOIL	**LAB NO:**	147
SAMPLE SOURCE:	P-1	**SAMPLE DATE:**	5/7/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ARIZ 225A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
DETERMINING PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS (AASHTO T89 & T90)

MAXIMUM DRY DENSITY (pcf): 118.3
OPTIMUM MOISTURE (%): 12.2



SIEVE SIZE	PERCENT PASSING
6"	100
4"	100
3"	100
2"	100
1 1/2"	100
1 1/4"	100
1"	100
3/4"	100
1/2"	99
3/8"	97
1/4"	94
#4	92
#8	84
#10	82
#16	75
#30	65
#40	59
#50	54
#100	45
#200	36

ATTERBERG LIMITS

LL:	32
PL:	19
PI:	13
USCS:	SC

NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.651 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

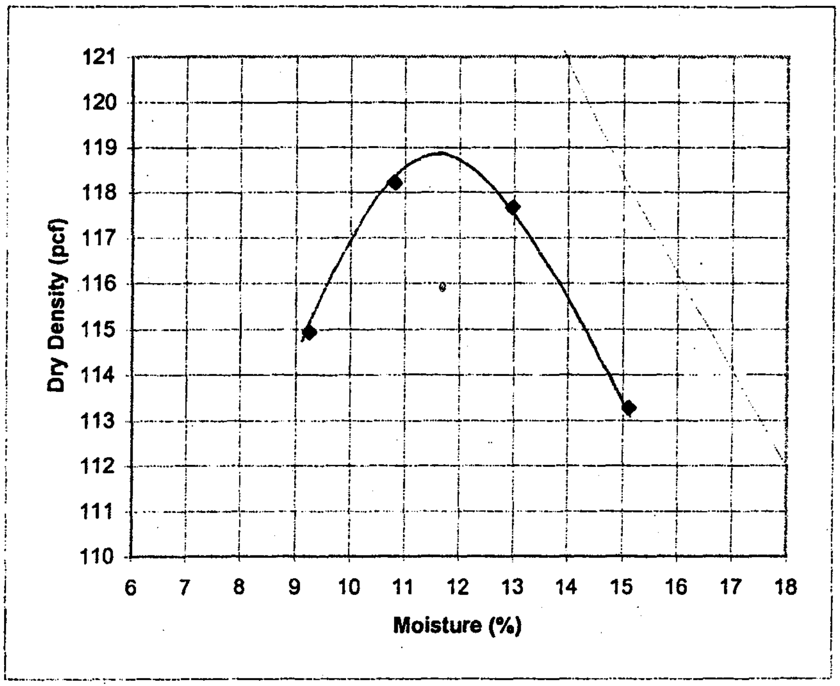
REVIEWED BY [signature]

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	5
MATERIAL:	SOIL	**LAB NO:**	148
SAMPLE SOURCE:	P-2	**SAMPLE DATE:**	5/7/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ARIZ 225A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
DETERMINING PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS (AASHTO T89 & T90)

MAXIMUM DRY DENSITY (pcf):	118.9
OPTIMUM MOISTURE (%):	11.5



SIEVE SIZE	PERCENT PASSING
6"	100
4"	100
3"	100
2"	100
1 1/2"	100
1 1/4"	100
1"	100
3/4"	99
1/2"	98
3/8"	97
1/4"	76
#4	75
#8	70
#10	68
#16	62
#30	54
#40	49
#50	44
#100	37
#200	30

ATTERBERG LIMITS

LL:	33
PL:	20
PI:	13
USCS:	SC

NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.651 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

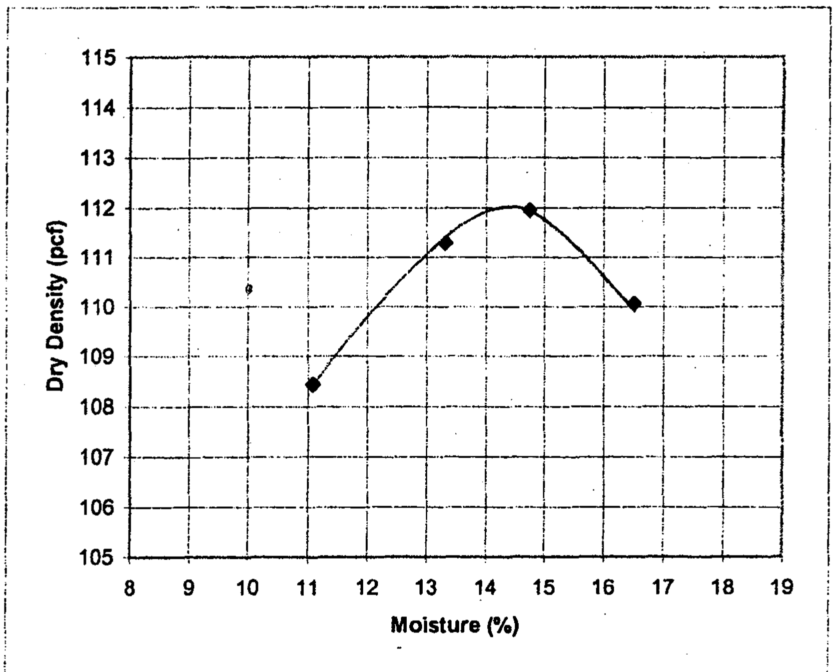
REVIEWED BY [signature]

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	5
MATERIAL:	SOIL	**LAB NO:**	149
SAMPLE SOURCE:	P-3	**SAMPLE DATE:**	5/7/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ARIZ 225A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
DETERMINING PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS (AASHTO T89 & T90)

MAXIMUM DRY DENSITY (pcf):	112.0
OPTIMUM MOISTURE (%):	14.5



SIEVE SIZE	PERCENT PASSING
6"	100
4"	100
3"	100
2"	100
1 1/2"	100
1 1/4"	100
1"	100
3/4"	99
1/2"	97
3/8"	96
1/4"	93
#4	92
#8	85
#10	83
#16	78
#30	71
#40	67
#50	63
#100	55
#200	46

ATTERBERG LIMITS

LL:	50
PL:	22
PI:	28
USCS:	SC

NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

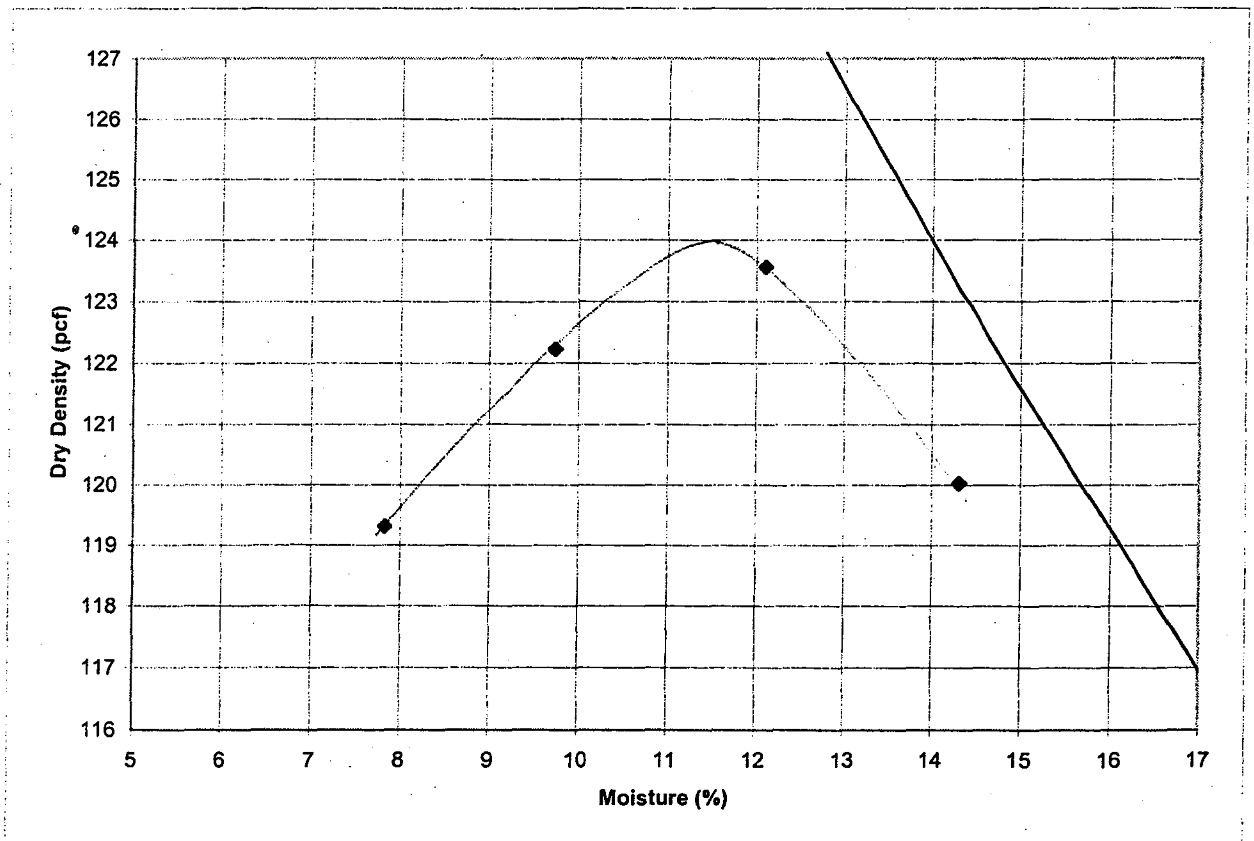
REVIEWED BY ________

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	153
SAMPLE SOURCE:	D-2 1-2	**SAMPLE DATE:**	5/25/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ASTMD698A)

MAXIMUM DRY DENSITY (pcf):	124.0
OPTIMUM MOISTURE (%):	11.6



NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.751 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, A... -1016
Tel +1 ...
Fax +1 (480) 785-0970

www.amec.com

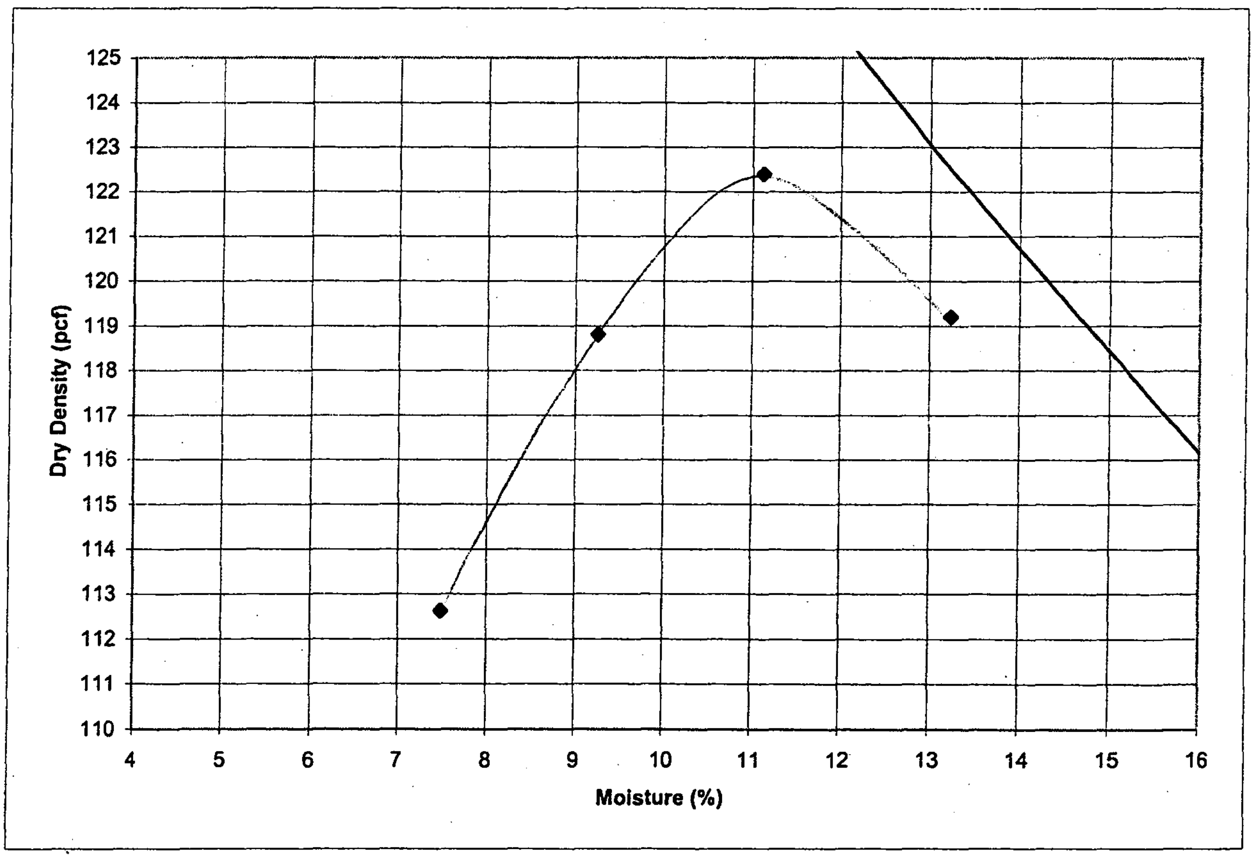
REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	154
SAMPLE SOURCE:	D-3 1-2	**SAMPLE DATE:**	5/25/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ASTMD698A)

MAXIMUM DRY DENSITY (pcf):	122.4
OPTIMUM MOISTURE (%):	11.1



NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.651 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

REVIEWED BY

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, A[illegible]-1016
Tel +1 [illegible]
Fax +1 (48[illegible]) 785-0970

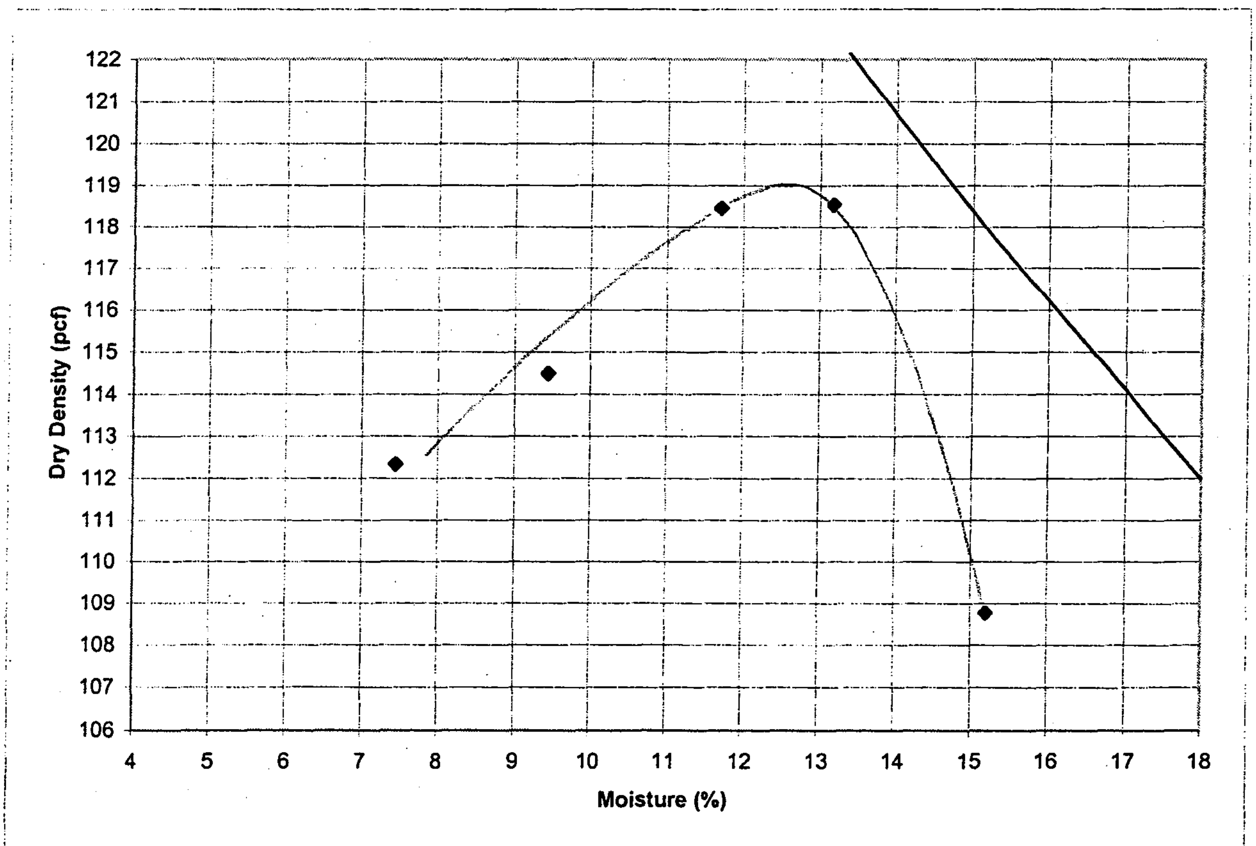
www.amec.com

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	158
SAMPLE SOURCE:	D-7 1-2	**SAMPLE DATE:**	5/25/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ASTMD698A)

MAXIMUM DRY DENSITY (pcf):	119.0
OPTIMUM MOISTURE (%):	12.6



NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.651 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

AMEC Earth & [illegible]
1405 West Auto Drive
Tempe, [illegible] 4-1016
Tel +1 [illegible]
Fax +1 (4[illegible]) 785-0970

www.amec.com

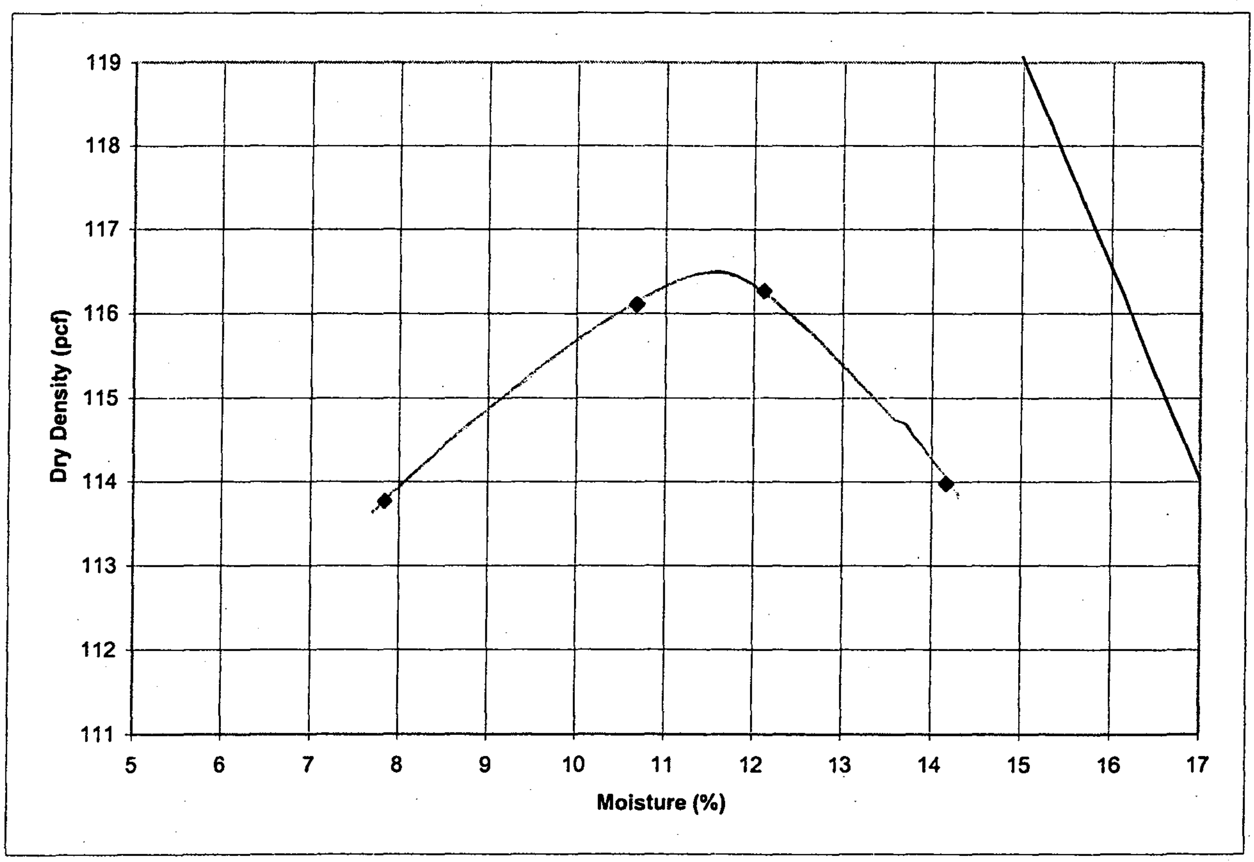
REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	160
SAMPLE SOURCE:	D-9 3-4	**SAMPLE DATE:**	5/25/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ASTMD698A)

MAXIMUM DRY DENSITY (pcf):	116.4
OPTIMUM MOISTURE (%):	11.6



NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.651 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, [illegible] -1016
Tel +1 [illegible]
Fax +1 (480) 785-0970

www.amec.com

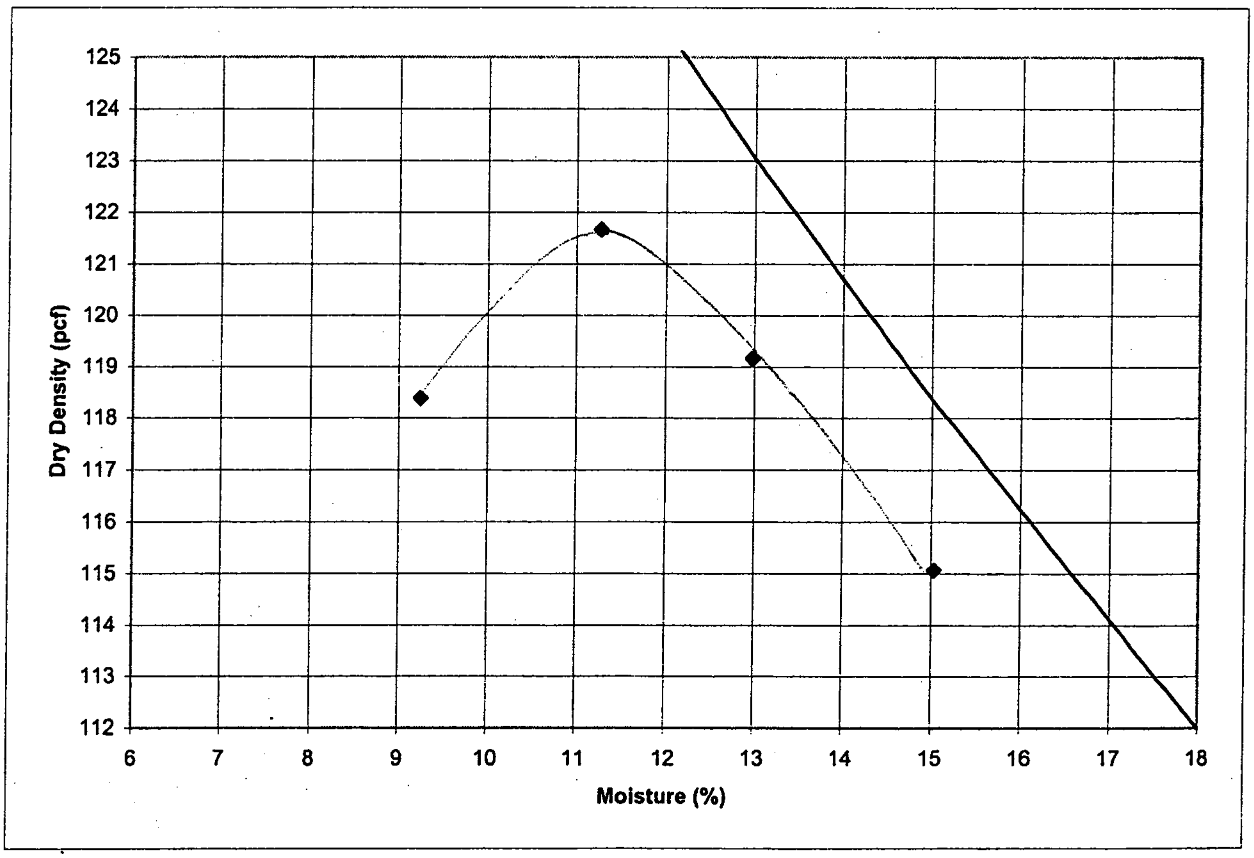
REVIEWED BY [signature]

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	161
SAMPLE SOURCE:	D-10 1-2	**SAMPLE DATE:**	5/25/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ASTMD698A)

MAXIMUM DRY DENSITY (pcf):	121.7
OPTIMUM MOISTURE (%):	11.3



NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.651 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, A[illegible]-1016
Tel +1 [illegible]
Fax +1 (480) [illegible]5-0970

www.amec.com

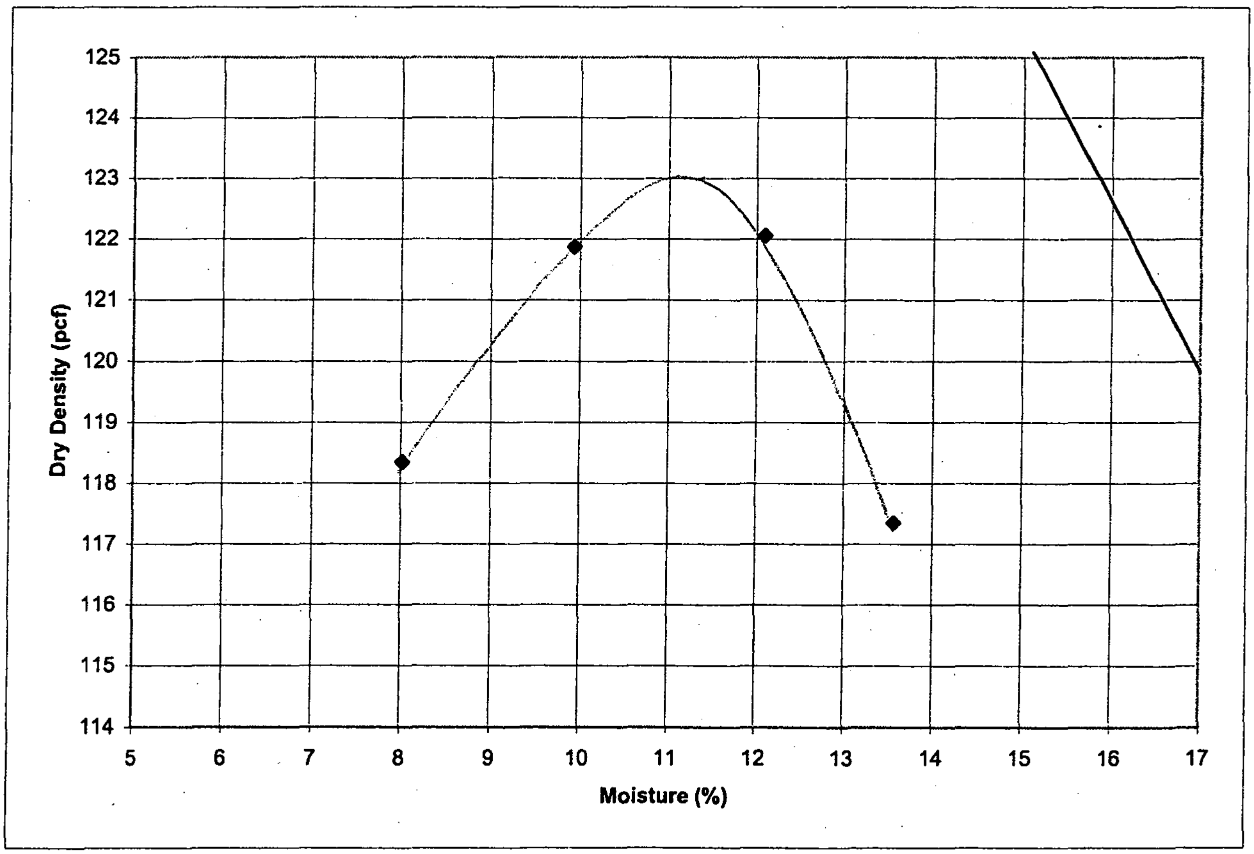
REVIEWED BY CY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	163
SAMPLE SOURCE:	D-12 1-3	**SAMPLE DATE:**	5/25/04

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ASTMD698A)

MAXIMUM DRY DENSITY (pcf):	123.0
OPTIMUM MOISTURE (%):	11.2



NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.851 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, A... -1016
Tel +1 ... 0
Fax +1 (480) 785-0970

www.amec.com

REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	161
SAMPLE SOURCE:	D-10 1-2	**DATE SAMPLED:**	5/25/04
SAMPLE PREP:	REMOLDED TO 95% MAX DRY DENSITY AND OPT. MOISTURE		
TARGET:	MAX DRY DENSITY D698A 121.6 pcf @ 11.3% OPT. MOISTURE		

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER (ASTM 5084-90)
"CV" METHOD C

AVERAGE PERMEABILITY		3.15E-08 cm/sec	
INITIAL LENGTH OF SPECIMEN		7.15 cm	
INITIAL DIAMETER OF SPECIMEN		7.15 cm	
INITIAL WATER CONTENT		10.2 %	
INITIAL DRY UNIT WEIGHT		116.3 pcf	
INITIAL VOLUME		17.52 cu.in	
PERMEANT LIQUID		BOTTLED WATER	
MAGNITUDE OF TOTAL BACK PRESSURE		65.8 psi	
EFFECTIVE CONSOLIDATION STRESS		5 psi	
RANGE OF HYDRAULIC GRADIENT USED	16.2	to	12.4
FINAL LENGTH OF SPECIMEN		6.46 cm	
FINAL DIAMETER OF SPECIMEN		7.12 cm	
FINAL WATER CONTENT		11.6 %	
FINAL DRY UNIT WEIGHT		129.8 pcf	
FINAL VOLUME		15.70 cu.in	
DEGREE OF SATURATION (BEFORE AND AFTER TEST)	60%	and	102%
SPECIFIC GRAVITY USED IN CALCULATIONS OF SATURATION		2.725	

TIME INTERVAL sec	K cm/sec	K ft/yr.
1889	2.99E-08	0.03
2094	3.12E-08	0.03
2304	3.09E-08	0.03
2498	3.41E-08	0.04

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel +1 (480) 940-2320
Fax +1 (480) 785-0970

www.amec.com

REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	154
SAMPLE SOURCE:	D-3 1-2	**DATE SAMPLED:**	5/25/04
SAMPLE PREP:	REMOLDED TO 95% MAX DRY DENSITY AND OPT. MOISTURE		
TARGET:	MAX DRY DENSITY D698A 122.4 pcf @ 11.1% OPT. MOISTURE		

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER (ASTM 5084-90) "CV" METHOD C

AVERAGE PERMEABILITY		3.46E-08 cm/sec	
INITIAL LENGTH OF SPECIMEN		7.15 cm	
INITIAL DIAMETER OF SPECIMEN		7.15 cm	
INITIAL WATER CONTENT		11.6 %	
INITIAL DRY UNIT WEIGHT		115.8 pcf	
INITIAL VOLUME		17.52 cu.in	
PERMEANT LIQUID		BOTTLED WATER	
MAGNITUDE OF TOTAL BACK PRESSURE		63.9 psi	
EFFECTIVE CONSOLIDATION STRESS		5 psi	
RANGE OF HYDRAULIC GRADIENT USED	15.4	to	13.2
FINAL LENGTH OF SPECIMEN		7.13 cm	
FINAL DIAMETER OF SPECIMEN		7.18 cm	
FINAL WATER CONTENT		12.7 %	
FINAL DRY UNIT WEIGHT		115.1 pcf	
FINAL VOLUME		17.62 cu.in	
DEGREE OF SATURATION (BEFORE AND AFTER TEST)	96%	and	102%
SPECIFIC GRAVITY USED IN CALCULATIONS OF SATURATION		2.395	

TIME INTERVAL sec	K cm/sec	K ft/yr.
697	3.48E-08	0.04
870	3.43E-08	0.04
1043	3.48E-08	0.04
1220	3.45E-08	0.04

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel +1 (480) 940-2320
Fax +1 (480) 785-0970

www.amec.com

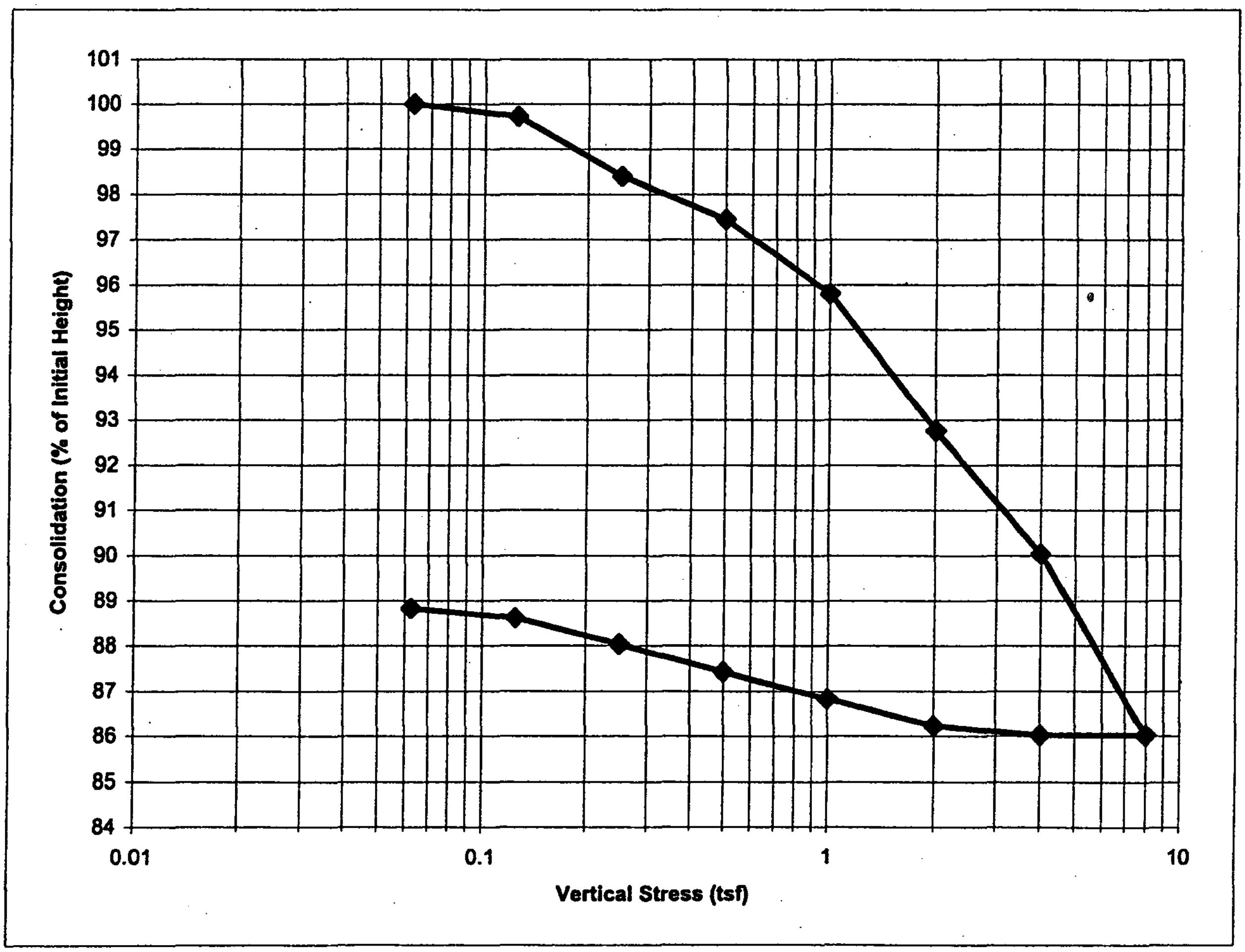
REVIEWED BY ________

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, AZ	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	88
SAMPLE SOURCE:	B-6 @ 9.5-10.5'	**DATE SAMPLED:**	4/19/04
SAMPLE PREP:	INSITU		

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	3.96
INITIAL MOISTURE CONTENT	4.9%	FINAL MOISTURE CONTENT	20.9%
INITIAL DRY DENSITY(pcf)	98.6	FINAL DRY DENSITY(pcf)	114.1
INITIAL DEGREE OF SATURATION	17%	FINAL DEGREE OF SATURATION	104%
INITIAL VOID RATIO	0.84	FINAL VOID RATIO	0.58
ESTIMATED SPECIFIC GRAVITY	2.895	SATURATED AT	2 tsf



AASHTO R18

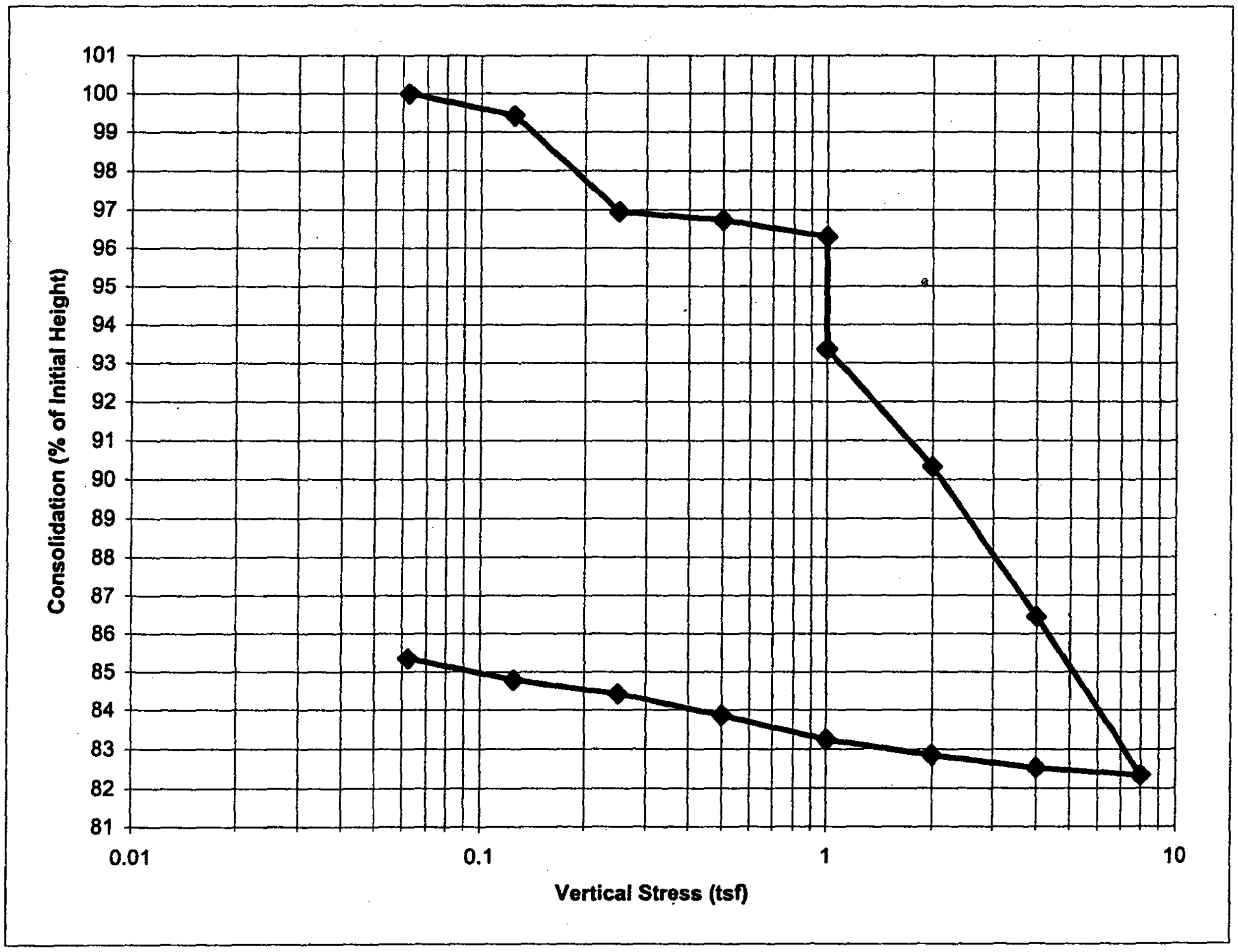
REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, AZ	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	90
SAMPLE SOURCE:	B-6 @ 14.5-15.5'	**DATE SAMPLED:**	4/19/04
SAMPLE PREP:	INSITU		

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	3.79
INITIAL MOISTURE CONTENT	2.1%	FINAL MOISTURE CONTENT	20.9%
INITIAL DRY DENSITY(pcf)	95.7	FINAL DRY DENSITY(pcf)	115.8
INITIAL DEGREE OF SATURATION	7%	FINAL DEGREE OF SATURATION	105%
INITIAL VOID RATIO	0.93	FINAL VOID RATIO	0.59
ESTIMATED SPECIFIC GRAVITY	2.951	SATURATED AT	1 tsf



AAP AASHTO R18

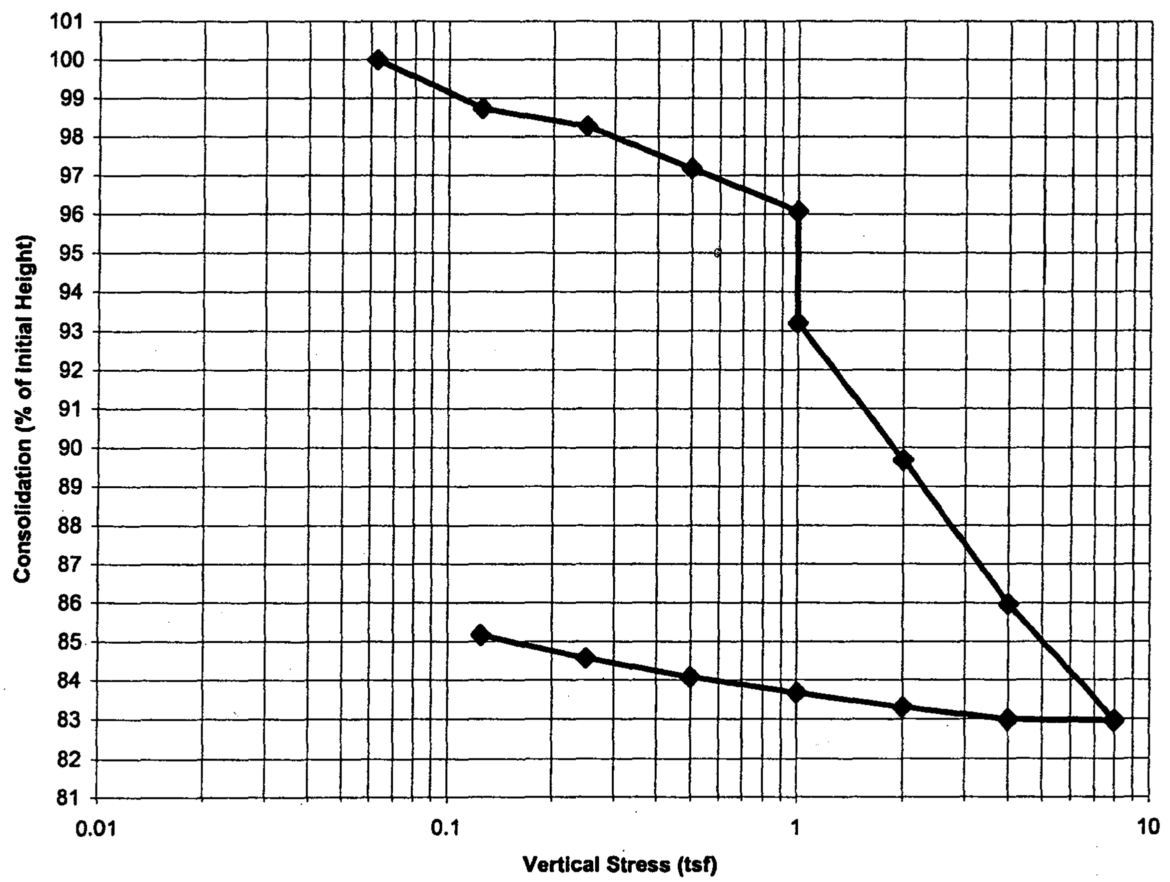
REVIEWED BY

PROJECT: BUCKEYE FRS NO. 1
LOCATION: MARICOPA COUNTY, AZ
MATERIAL: SOIL
SAMPLE SOURCE: B-4 @ 2.5-3.5'
SAMPLE PREP: INSITU

JOB NO: 4-117-001021
WORK ORDER NO: 1
LAB NO: 46
DATE SAMPLED: 4/19/04

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	3.82
INITIAL MOISTURE CONTENT	5.3%	FINAL MOISTURE CONTENT	21.0%
INITIAL DRY DENSITY(pcf)	95.5	FINAL DRY DENSITY(pcf)	114.7
INITIAL DEGREE OF SATURATION	17%	FINAL DEGREE OF SATURATION	105%
INITIAL VOID RATIO	0.90	FINAL VOID RATIO	0.58
ESTIMATED SPECIFIC GRAVITY	2.901	SATURATED AT	1 tsf



AASHTO R18

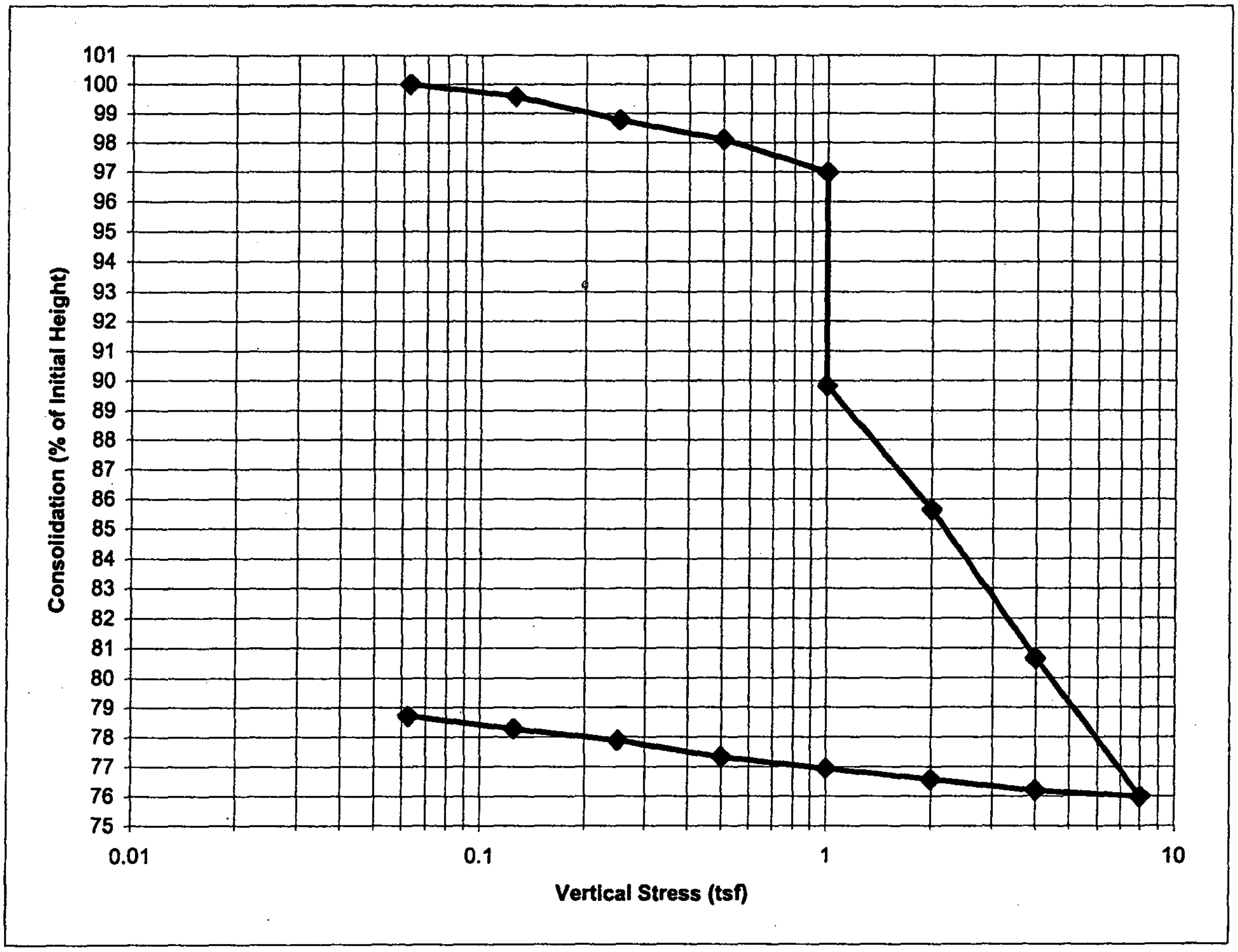
REVIEWED BY Cf

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, AZ	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	65
SAMPLE SOURCE:	B-5 @ 4.5-5.5'	**DATE SAMPLED:**	4/19/04
SAMPLE PREP:	INSITU		

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	3.49
INITIAL MOISTURE CONTENT	5.5%	FINAL MOISTURE CONTENT	19.3%
INITIAL DRY DENSITY(pcf)	94.4	FINAL DRY DENSITY(pcf)	123.8
INITIAL DEGREE OF SATURATION	16%	FINAL DEGREE OF SATURATION	105%
INITIAL VOID RATIO	1.07	FINAL VOID RATIO	0.57
ESTIMATED SPECIFIC GRAVITY	3.125	SATURATED AT	1 tsf



AASHTO R18

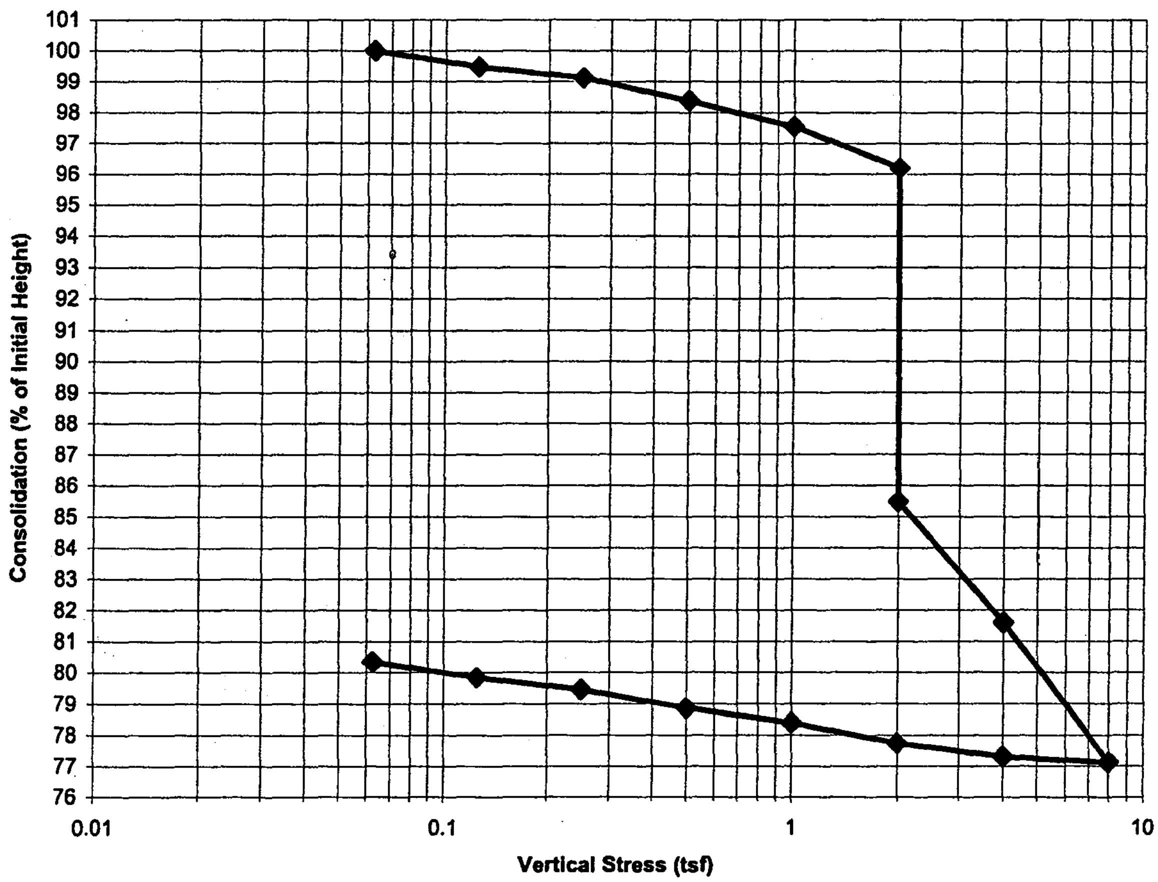
REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, AZ	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	120
SAMPLE SOURCE:	B-8 @ 4.5-5.5'	**DATE SAMPLED:**	4/19/04
SAMPLE PREP:	INSITU		

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	3.55
INITIAL MOISTURE CONTENT	6.0%	FINAL MOISTURE CONTENT	20.3%
INITIAL DRY DENSITY(pcf)	91.8	FINAL DRY DENSITY(pcf)	118.6
INITIAL DEGREE OF SATURATION	17%	FINAL DEGREE OF SATURATION	105%
INITIAL VOID RATIO	1.04	FINAL VOID RATIO	0.58
ESTIMATED SPECIFIC GRAVITY	2.995	SATURATED AT	2 tsf



AASHTO R18

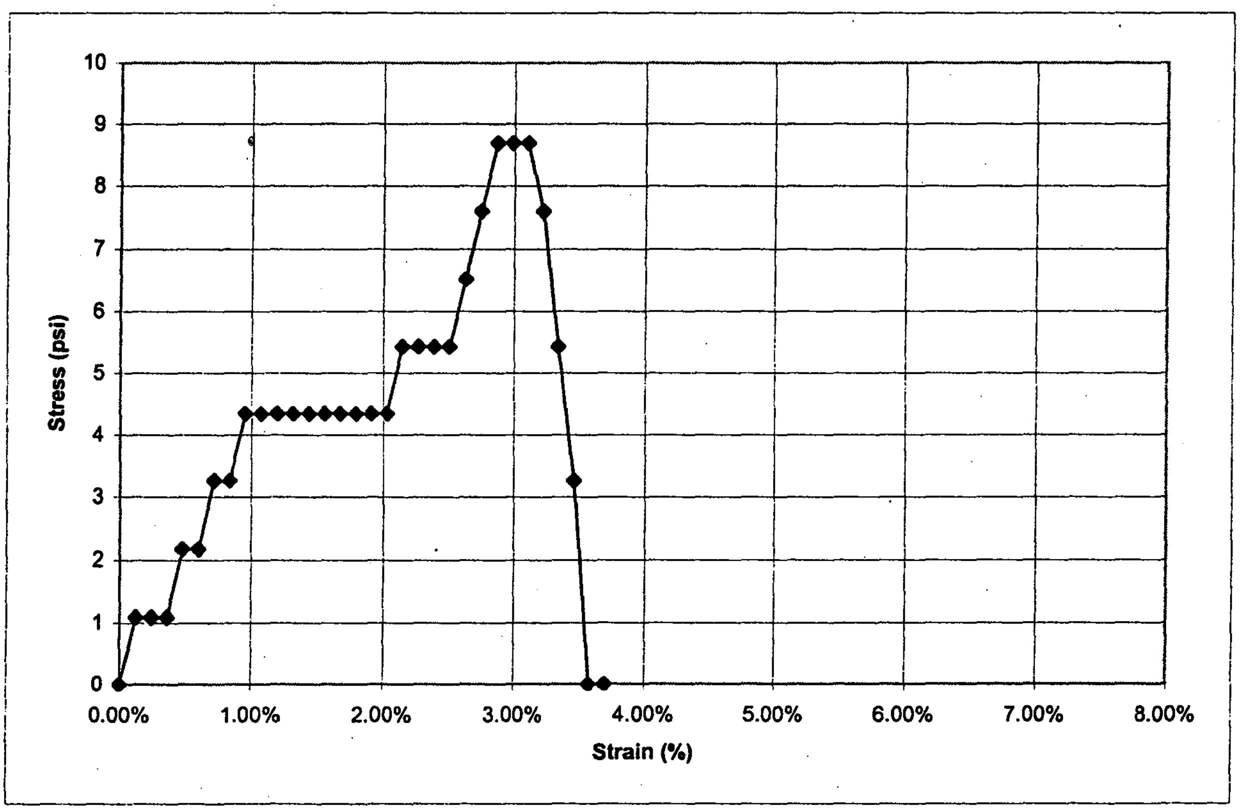
REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, AZ	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	47
SAMPLE SOURCE:	B-4 @ 4.5-5.5'	**DATE SAMPLED:**	04/19/04
SAMPLE PREP:	INSITU		

UNCONFINED COMPRESSION STRENGTH OF COHESIVE SOIL
APPLICABLE PORTIONS OF (ASTM D2166)

DIAMETER:	2.42 in	MAXIMUM STRESS:	9 psi
HEIGHT:	4.19 in	AT STRAIN:	2.86%
STRAIN RATE:	.007 inches/min.		
DRY DENSITY:	99.2 lb/cu.ft		



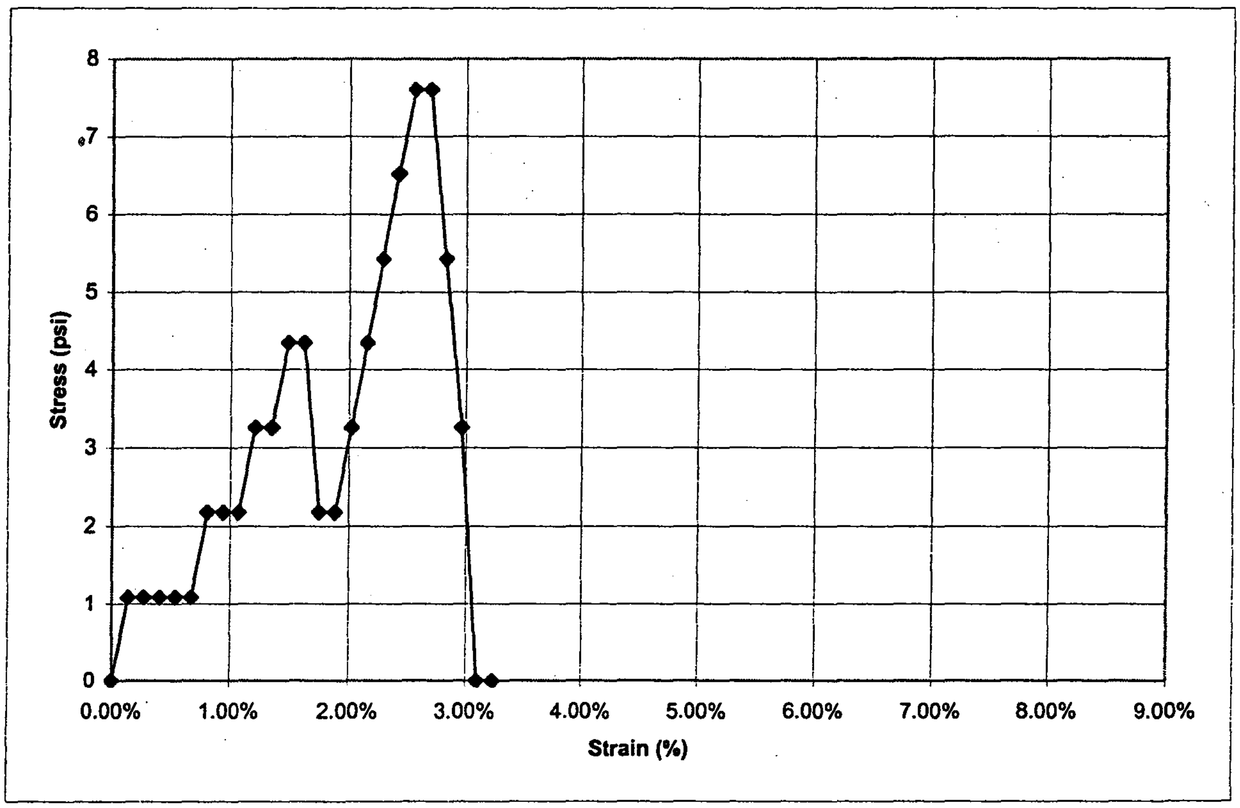
REVIEWED BY ____________

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, AZ	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	48
SAMPLE SOURCE:	B-4 @ 9.5-10.5'	**DATE SAMPLED:**	04/19/04
SAMPLE PREP:	INSITU		

UNCONFINED COMPRESSION STRENGTH OF COHESIVE SOIL
APPLICABLE PORTIONS OF (ASTM D2166)

DIAMETER:	2.42 in	MAXIMUM STRESS:	8 psi
HEIGHT:	3.71 in	AT STRAIN:	2.56%
STRAIN RATE:	.006 inches/min.		
DRY DENSITY:	100.1 lb/cu.ft		



AAP

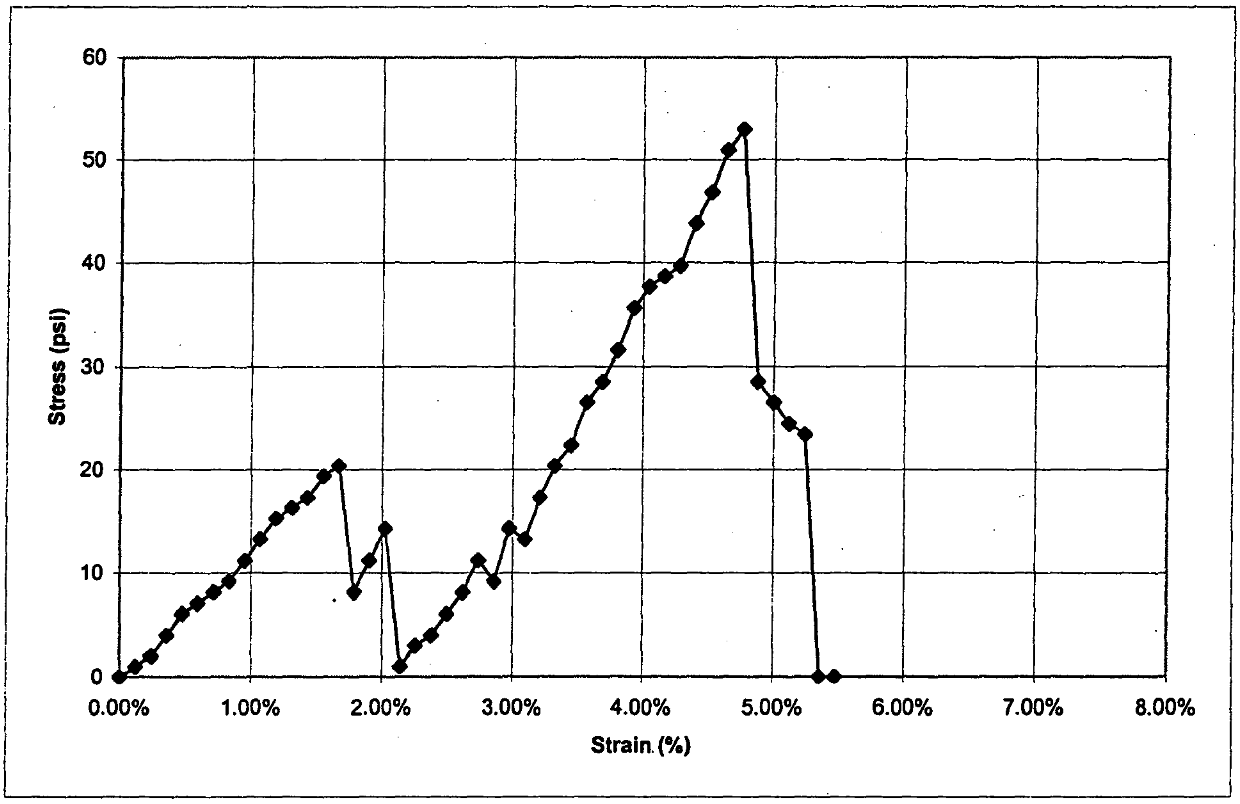
REVIEWED BY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, AZ	**WORK ORDER NO:**	1
MATERIAL:	SOIL	**LAB NO:**	59
SAMPLE SOURCE:	B-4 @ 15.0-17.5'	**DATE SAMPLED:**	04/19/04
SAMPLE PREP:	INSITU		

UNCONFINED COMPRESSION STRENGTH OF COHESIVE SOIL
APPLICABLE PORTIONS OF (ASTM D2166)

DIAMETER:	2.50 in	MAXIMUM STRESS:	53 psi
HEIGHT:	4.20 in	AT STRAIN:	4.76%
STRAIN RATE:	.032 inches/min.		
DRY DENSITY:	100.3 lb/cu.ft		



AAP

REVIEWED BY ________

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	162
SAMPLE SOURCE:	D-11 2-4	**SAMPLE DATE:**	05/25/04
PREPARATION:	REMOLDED WITH THE HARVARD COMPACTOR AT INSITU MOISTURE		

IDENTIFICATION AND CLASSIFICATION OF DISPERSIVE CLAY SOILS BY THE PINHOLE TEST(ASTM D4647)

HEAD	FLOW RATE			COLOR	FALLING PARTICLES
	(mls.)	(sec.)	(ml/sec)		
2"	15	30	0.50	Completely clear	NONE
	16	30	0.53	Completely clear	NONE
	16	30	0.53	Completely clear	NONE
7"	27	30	0.90	Completely clear	NONE
	27	30	0.90	Completely clear	NONE
	27	30	0.90	Completely clear	NONE
15"	50	30	1.67	Completely clear	NONE
	50	30	1.67	Completely clear	NONE
	50	30	1.67	Completely clear	NONE
40"	115	30	3.83	Completely clear	NONE

CLASSIFICATION: NON DISPERSIVE ND2

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel +1 (480) 940-2320
Fax +1 (480) 785-0970

www.amec.com REVIEWED BY ____

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	159
SAMPLE SOURCE:	D-8 1-3	**SAMPLE DATE:**	05/25/04
PREPARATION:	REMOLDED WITH THE HARVARD COMPACTOR AT INSITU M	**WATER CONTENT:**	

IDENTIFICATION AND CLASSIFICATION OF DISPERSIVE CLAY SOILS BY THE PINHOLE TEST(ASTM D4647)

HEAD	FLOW RATE (mls.)	(sec.)	(ml/sec)	COLOR	FALLING PARTICLES
2"	13	30	0.43	Completely clear	NONE
	13	30	0.43	Completely clear	NONE
	14	30	0.47	Completely clear	NONE
7"	35	30	1.17	Completely clear	NONE
	35	30	1.17	Completely clear	NONE
	35	30	1.17	Completely clear	NONE
15"	40	30	1.33	Completely clear	NONE
	40	30	1.33	Completely clear	NONE
	40	30	1.33	Completely clear	NONE
40"	95	30	3.17	Dark	HEAVY

CLASSIFICATION: NON DISPERSIVE ND2

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel +1 (480) 940-2320
Fax +1 (480) 785-0970

www.amec.com REVIEWED BY [signature]

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	156
SAMPLE SOURCE:	D-5 2-4	**SAMPLE DATE:**	05/25/04
PREPARATION:	REMOLDED WITH THE HARVARD COMPACTOR AT INSITU MOISTURE		

IDENTIFICATION AND CLASSIFICATION OF DISPERSIVE CLAY SOILS BY THE PINHOLE TEST(ASTM D4647)

HEAD	FLOW RATE			COLOR	FALLING PARTICLES
	(mls.)	(sec.)	(ml/sec)		
2"	11	30	0.37	Completely clear	NONE
	11	30	0.37	Completely clear	NONE
7"	30	30	1.00	Completely clear	NONE
	30	30	1.00	Completely clear	NONE
	28	30	0.93	Completely clear	NONE
15"	44	30	1.47	Completely clear	NONE
	45	30	1.50	Completely clear	NONE
	45	30	1.50	Completely clear	NONE
40"	80	30	2.67	Completely clear	NONE
	80	30	2.67	Completely clear	NONE
	81	30	2.70	Completely clear	NONE

CLASSIFICATION: NON DISPERSIVE ND1

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel +1 (480) 940-2320
Fax +1 (480) 785-0970

www.amec.com REVIEWED BY CY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	152
SAMPLE SOURCE:	D-1 1-2	**SAMPLE DATE:**	05/25/04
PREPARATION:	REMOLDED WITH THE HARVARD COMPACTOR AT INSITU MOISTURE		

IDENTIFICATION AND CLASSIFICATION OF DISPERSIVE CLAY SOILS BY THE PINHOLE TEST(ASTM D4647)

HEAD	FLOW RATE (mls.)	(sec.)	(ml/sec)	COLOR	FALLING PARTICLES
2"	13	30	0.43	Completely clear	NONE
	14	30	0.47	Completely clear	NONE
	14	30	0.47	Completely clear	NONE
7"	30	30	1.00	Completely clear	NONE
	30	30	1.00	Completely clear	NONE
	30	30	1.00	Completely clear	NONE
15"	48	30	1.60	Completely clear	NONE
	48	30	1.60	Completely clear	NONE
	48	30	1.60	Completely clear	NONE
40"	93	30	3.10	Completely clear	NONE

CLASSIFICATION: NON DISPERSIVE ND2

AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel +1 (480) 940-2320
Fax +1 (480) 785-0970

www.amec.com REVIEWED BY CJ

amec

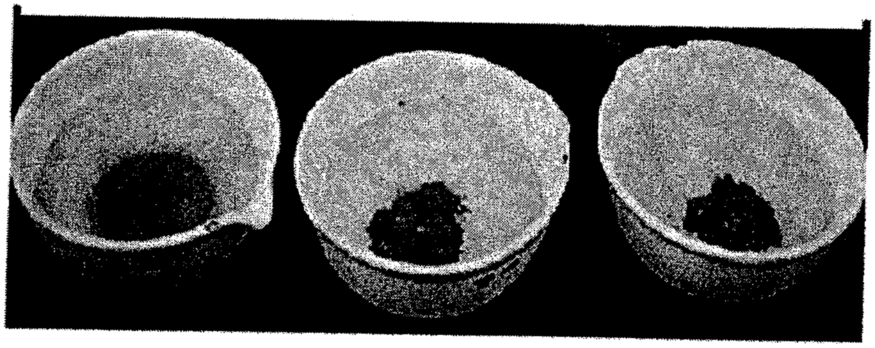
PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	7
MATERIAL:	SOIL	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BELOW	**DATE SAMPLED:**	04/23/04

DETERMINING DISPERSIBILITY OF CLAYEY SOILS BY THE CRUMB TEST METHOD (USBR 5400-89)

LAB #S	SAMPLE SOURCE	DISH #S	2 MIN.		15 MIN.		1 HOUR		24 HOURS	
			GRADE	°C	GRADE	°C	GRADE	°C	GRADE	°C
165	F-1B	13-6-11	2	21.0°	2	21.0°	2	21.0°	2	21.0°
171	F-4B	10-1-7	1	21.0°	1	21.0°	1	21.0°	1	21.0°
173	F-5B	18-14-2	2	21.0°	2	21.0°	2	21.0°	2	21.0°
175	F-6B	12-17-6	1	21.0°	1	21.0°	1	21.0°	1	21.0°

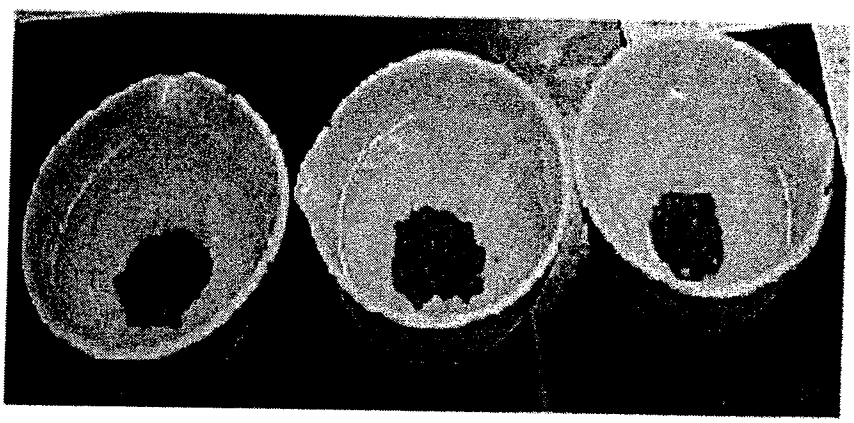
AMEC Earth & Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016
Tel +1 (480) 940-2320
Fax +1 (480) 785-0970

4-117-001021 W.O. #7



Lab 165
F-1B

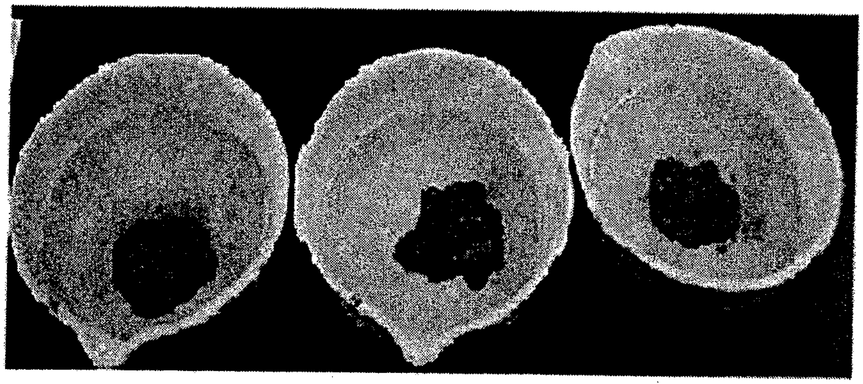
Soil Crumb Specimen after 24 hours
Grade 2 - Intermediate



Lab 171
F-4B

Soil Crumb Specimen after 24 hours
Grade 1 - Nondispersive

4-117-001021 W.O. #7



Lab 173
F-5B

Soil Crumb Specimen after 24 hours
Grade 2 - Intermediate

Lab 175
F-6B

Soil Crumb Specimen after 24 hours
Grade 1 - Nondispersive

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	4
MATERIAL:	SOIL	**LAB NO:**	145+146
SAMPLE SOURCE:	COMPOSITE GRAVEL AND EMBANKMENT SOIL	**SAMPLE DATE:**	05/25/04

FILTER TEST FOR NEW FILTER MATERIAL (FILTER MATERIAL A)

PSI	VOLUME IN mls	TIME	COLOR
50	167	30 sec.	Cloudy
42	367	1 min. 30 sec.	Cloudy
40	539	2 min.	Cloudy
38	694	2 min. 30 sec.	Cloudy
62	1038	3 min.	Cloudy
64	1245	3 min. 30 sec.	Cloudy
64	1376	4 min.	Slightly Cloudy
61	1534	4 min. 30 sec.	Slightly Cloudy
58	1723	5 min.	Slightly Cloudy
52	1835	5 min. 30 sec.	Slightly Cloudy
50	1997	6 min.	Slightly Cloudy
50	2142	6 min. 30 sec.	Slightly Cloudy
50	2400	7 min.	Slightly Cloudy
50	2567	7 min. 30 sec.	Clear
47	2696	8 min.	Clear
48	2832	8 min. 30 sec.	Clear
48	2950	9 min.	Clear
48	3080	9 min. 30 sec.	Clear
49	5558	20 min.	Clear
49	7881	30 min.	Clear

NOTE: Hole opening was 1/4" wide all the way through. The end of the hole had no blow out.

REVIEWED BY CY

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	8
MATERIAL:	SOIL	**LAB NO:**	145+146
SAMPLE SOURCE:	COMPOSITE GRAVEL AND EMBANKMENT SOIL	**SAMPLE DATE:**	05/25/04

FILTER TEST FOR NEW FILTER MATERIAL (FILTER MATERIAL A)

PSI	VOLUME IN mls	TIME	COLOR
50	167	30 sec.	Cloudy
42	367	1 min. 30 sec.	Cloudy
40	539	2 min.	Cloudy
38	694	2 min. 30 sec.	Cloudy
62	1038	3 min.	Cloudy
64	1245	3 min. 30 sec.	Cloudy
64	1376	4 min.	Slightly Cloudy
61	1534	4 min. 30 sec.	Slightly Cloudy
58	1723	5 min.	Slightly Cloudy
52	1835	5 min. 30 sec.	Slightly Cloudy
50	1997	6 min.	Slightly Cloudy
50	2142	6 min. 30 sec.	Slightly Cloudy
50	2400	7 min.	Slightly Cloudy
50	2567	7 min. 30 sec.	Clear
47	2696	8 min.	Clear
48	2832	8 min. 30 sec.	Clear
48	2950	9 min.	Clear
48	3080	9 min. 30 sec.	Clear
49	5558	20 min.	Clear
49	7881	30 min.	Clear

NOTE: Hole opening was 1/4" wide all the way through. The end of the hole had no blow out.

REVIEWED BY [signature]

amec

PROJECT: BUCKEYE FRS NO. 1
LOCATION: MARICOPA COUNTY, ARIZONA
MATERIAL: SOIL
SAMPLE SOURCE: 721+00 COMPOSITE GRAVEL AND EMBANKMENT SOIL

JOB NO: 4-117-001021
WORK ORDER NO: 8
SAMPLE DATE: 05/25/04

FILTER TEST FOR THE EXISTING FILTER DRAIN

PSI	VOLUME IN mls	TIME	COLOR
40	222	30 sec.	Cloudy
40	370	1 min.	Cloudy
40	540	1 min. 30 sec.	Cloudy
60	724	2 min.	Cloudy
50	865	2 min. 30 sec.	Cloudy
52	987	3 min.	Slightly Cloudy
56	1130	3 min. 30 sec.	Slightly Cloudy
54	1269	4 min.	Slightly Cloudy
52	1410	4 min. 30 sec.	Clear
52	1549	5 min.	Clear
52	1685	5 min. 30 sec.	Clear
54	1815	6 min.	Clear
54	1956	6 min. 30 sec.	Clear
54	2085	7 min.	Clear
54	2212	7 min. 30 sec.	Clear
52	2340	8 min.	Clear
58	2463	8 min. 30 sec.	Clear
50	2609	9 min.	Clear
50	2730	9 min. 30 sec.	Clear
50	2849	10	Clear
50	5099	20 min.	Clear
50	7245	30 min.	Clear

NOTE: Slot was slightly larger at the in-flow end, the slot was closed at the out-flow end. Slot closed about half inch from end.

REVIEWED BY ____________

Soil Analysis Report

AMEC
Mr. Cliff Metz
3232 W Virginia Ave
Phoenix, AZ 85009-1502

Project: 4-117-001021
Sampler:
Date Received: 4/27/2004
Date Reported: 5/4/2004

PO Number: 3119-1633

Lab Number: 4070-01 **13 B-1@34.5-36'**

ADOT Nutrient Requirements	Method	Result	Units
Calcium Carbonate, CaCO3	ADOT 732	5.2	%

Lab Number: 4070-02 **43 B-3 @ 29.5-31'**

ADOT Nutrient Requirements	Method	Result	Units
Calcium Carbonate, CaCO3	ADOT 732	2.0	%

Lab Number: 4070-03 **66 B-5@7.5-9'**

ADOT Nutrient Requirements	Method	Result	Units
Calcium Carbonate, CaCO3	ADOT 732	12	%

Lab Number: 4070-04 **69 B-5@ 14.5-16'**

ADOT Nutrient Requirements	Method	Result	Units
Calcium Carbonate, CaCO3	ADOT 732	7.9	%

Lab Number: 4070-05 **79 B-5@27.5-30'**

ADOT Nutrient Requirements	Method	Result	Units
Calcium Carbonate, CaCO3	ADOT 732	5.2	%

MOTZZ LABORATORY, INC.

Soil Analysis Report

AMEC
Mr. Cliff Metz
3232 W Virginia Ave
Phoenix, AZ 85009-1502

Project:	4-117-001021
Sampler:	
Date Received:	4/27/2004
Date Reported:	5/4/2004
PO Number:	3119-1633

Approved By: ______________________

2109 S. 48th Street, Suite 101 Tempe, AZ 85282 602-454-2376 (Phone) 602-454-9243 (Fax)

MOTZZ LABORATORY, INC.

Soil Analysis Report

AMEC
Mr. Cliff Metz
1405 West Auto Drive
Tempe , AZ 85284-1016

Project: 4-117-001021
Sampler:
Date Received: 6/3/2004
Date Reported: 6/10/2004

PO Number: 3119-1660

Lab Number: 4172-01 **166 F2A**

ADOT Nutrient Requirements	Method	Result	Units
Exchangeable Sodium, Exch Na	ARIZ 729a	48	ppm

Approved By: ______________________

2109 S. 48th Street, Suite 101 Tempe, AZ 85282 602-454-2376 (Phone) 602-454-9243 (Fax)

amec

PROJECT:	BUCKEYE FRS NO. 1	**JOB NO:**	4-117-001021
LOCATION:	MARICOPA COUNTY, ARIZONA	**WORK ORDER NO:**	8
MATERIAL:	SOIL	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BELOW	**DATE SAMPLED:**	04/23/04

DETERMINING DISPERSIBILITY OF CLAYEY SOILS BY THE CRUMB TEST METHOD
(USBR 5400-89)

LAB #S	SAMPLE SOURCE	DISH #S	2 MIN.		15 MIN.		1 HOUR		24 HOURS	
			GRADE	°C	GRADE	°C	GRADE	°C	GRADE	°C
165	F-1B	13-6-11	2	21.0°	2	21.0°	2	21.0°	2	21.0°
171	F-4B	10-1-7	1	21.0°	1	21.0°	1	21.0°	1	21.0°
173	F-5B	18-14-2	2	21.0°	2	21.0°	2	21.0°	2	21.0°
175	F-6B	12-17-6	1	21.0°	1	21.0°	1	21.0°	1	21.0°

amec

APPENDIX I

SEEPAGE & STABILITY ANALYSES

FIGURE I-1

Buckeye FRS No.1 Transient State Seepage under Maximum Pool Condition

(-10- time in days)

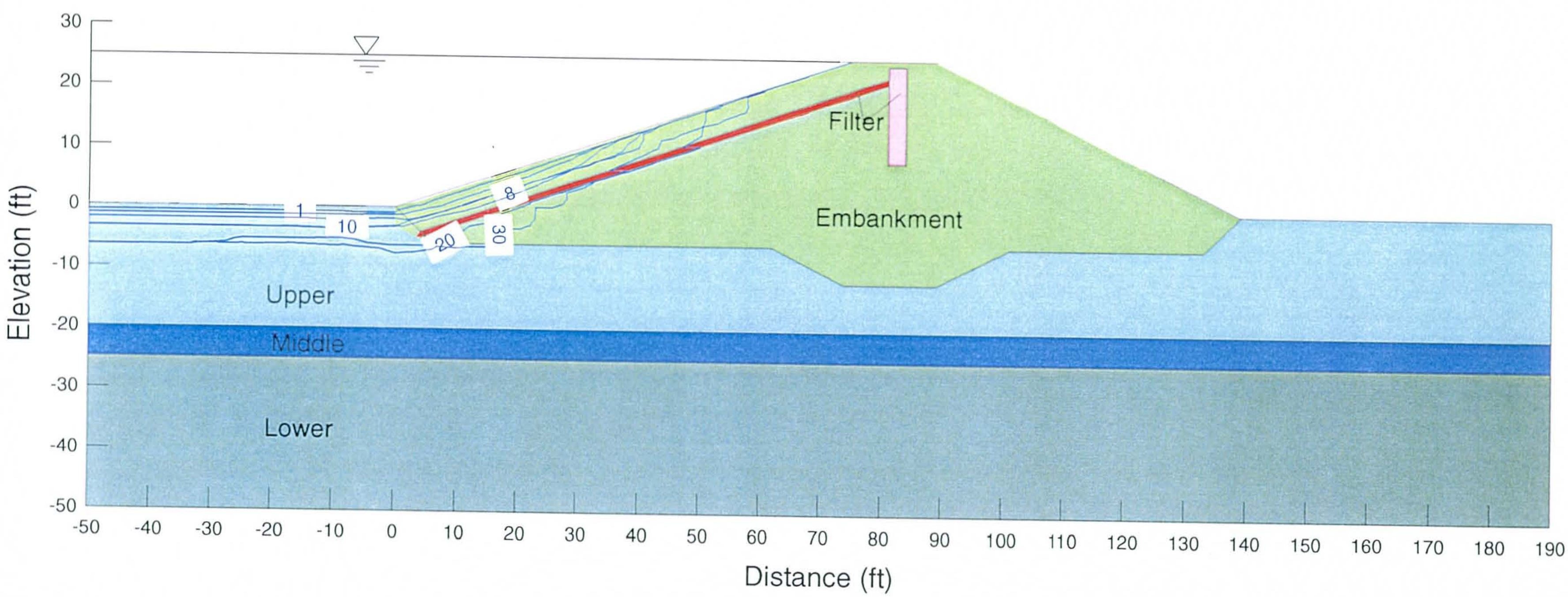
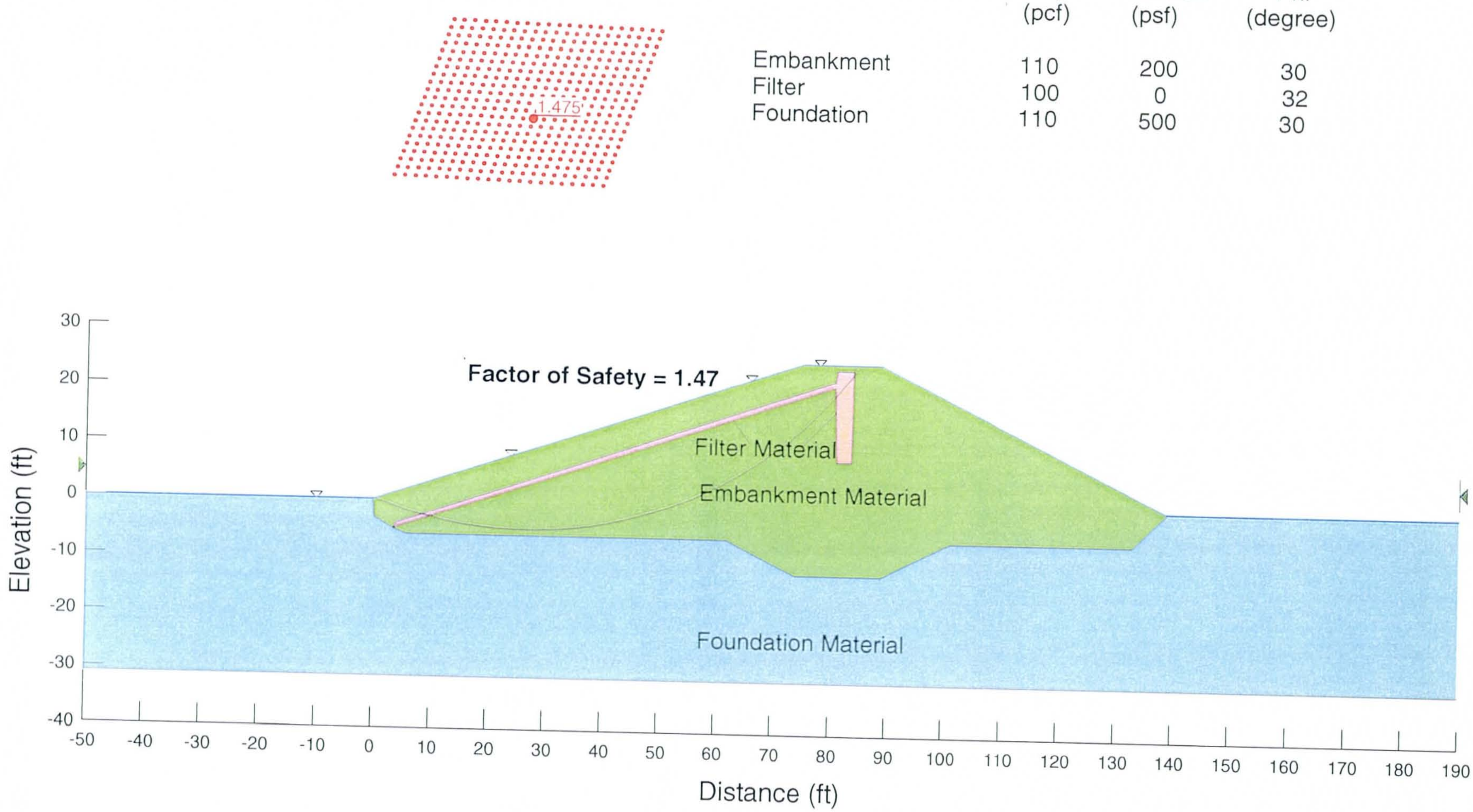


FIGURE I-2

Buckeye FRS No.1 Static Stability Analysis Under Rapid Drawdown From Maximum Pool Condition

Material Type	Unit Weight (pcf)	Cohesion (psf)	Phi (degree)
Embankment	110	200	30
Filter	100	0	32
Foundation	110	500	30



amec

APPENDIX J

FLOOD RETENTION OF FEBRUARY 2003

FCDMC ALERT System Streamflow Data Display

Note: Depth (feet) shown is arbitrary and may or may not represent the actual depth of water at the gage.

However, the Discharge (cfs) is the true total flow with depth / datum differences taken into account.

5203 Buckeye FRS #1 Pressure Transducer

Date	Time	feet	cfs
12/15/2003	23:58:07	0.26	53
12/15/2003	23:57:38	0.06	47
12/15/2003	23:52:58	0.26	53
12/15/2003	23:51:18	0.36	57
12/15/2003	23:50:18	0.06	47
2/15/2003	23:48:58	0.21	52
2/15/2003	23:43:27	0.31	55
2/15/2003	23:42:58	0.11	48
2/15/2003	23:41:38	0.36	57
2/15/2003	23:38:47	0.11	48
2/15/2003	23:38:18	0.36	57
2/15/2003	23:37:38	0.16	50
2/15/2003	23:34:38	0.36	57
2/15/2003	23:32:18	0.26	53
2/15/2003	23:31:47	0.06	47
2/15/2003	23:29:18	0.31	55
2/15/2003	23:23:18	0.31	55
2/15/2003	23:21:18	0.11	48
2/15/2003	22:31:38	0.31	55
2/1[illegible]003	22:30:38	0.51	62
2/1[illegible]2003	22:11:58	0.31	55
2/15/2003	22:10:38	0.51	62
2/15/2003	22:09:58	0.31	55
2/15/2003	22:07:38	0.51	62
2/15/2003	22:06:27	0.46	60
2/15/2003	22:05:58	0.26	53
2/15/2003	22:02:18	0.46	60
2/15/2003	21:57:38	0.26	53
2/15/2003	21:55:38	0.26	53
2/15/2003	21:54:58	0.46	60
2/15/2003	21:52:38	0.26	53
2/15/2003	21:46:38	0.46	60
2/15/2003	21:45:58	0.26	53
2/15/2003	21:38:58	0.26	53
2/15/2003	21:36:18	0.46	60
2/15/2003	21:35:38	0.26	53
2/15/2003	21:25:27	0.46	60
2/15/2003	21:24:58	0.26	53
2/15/2003	20:55:47	0.46	60
2/15/2003	20:55:18	0.26	53
2/15/2003	20:36:58	0.46	60
2/15/2003	20:36:27	0.31	55
2/15/2003	20:35:58	0.61	66
2/15/2003	20:18:08	0.41	59
/15/2003	20:17:38	0.66	68
/15/2003	20:03:18	0.46	60
/1[illegible]03	20:02:18	0.66	68
/1[illegible]003	19:56:38	0.46	60
/15/2003	19:55:18	0.66	68
/15/2003	19:53:58	0.46	60
/15/2003	19:50:18	0.66	68
/15/2003	19:46:38	0.46	60
/15/2003	19:42:58	0.66	68

02/15/2003	19:42:18	0.46	60
02/15/2003	19:29:08	0.66	68
02/15/2003	19:28:38	0.46	60
02/15/2003	19:26:38	0.66	68
02/15/2003	19:25:38	0.46	60
02/15/2003	19:22:58	0.66	68
02/15/2003	19:22:18	0.46	60
02/15/2003	19:18:18	0.66	68
02/15/2003	19:16:58	0.46	60
02/15/2003	19:09:48	0.66	68
02/15/2003	19:09:18	0.46	60
02/15/2003	18:47:18	0.71	70
02/15/2003	18:42:58	0.51	62
02/15/2003	18:33:48	0.76	72
02/15/2003	18:33:18	0.56	64
02/15/2003	17:10:58	0.76	72
02/15/2003	15:34:59	0.96	80
02/15/2003	15:33:19	1.16	88
02/15/2003	15:31:59	0.96	80
02/15/2003	15:12:39	1.16	88
02/15/2003	15:08:59	0.96	80
02/15/2003	14:01:19	1.16	88
02/15/2003	13:55:39	1.36	97
02/15/2003	13:52:19	1.16	88
02/15/2003	13:31:00	1.36	97
02/15/2003	13:15:19	1.26	92
02/15/2003	13:12:39	1.46	101
02/15/2003	13:10:39	1.26	92
02/15/2003	13:08:59	1.46	101
02/15/2003	13:01:19	1.26	92
02/15/2003	11:44:59	1.46	101
02/15/2003	11:40:39	1.66	110
02/15/2003	11:37:39	1.66	110
02/15/2003	11:36:19	1.46	101
02/15/2003	11:33:39	1.66	110
02/15/2003	11:24:19	1.46	101
02/15/2003	11:21:59	1.66	110
02/15/2003	11:16:39	1.46	101
02/15/2003	09:26:19	1.71	113
02/15/2003	08:15:40	1.91	122
02/15/2003	07:31:00	2.11	130
02/15/2003	07:28:00	2.01	126
02/15/2003	07:22:41	2.21	134
02/15/2003	07:17:09	2.21	134
02/15/2003	07:16:40	2.01	126
02/15/2003	07:07:40	2.21	134
02/15/2003	07:04:40	2.01	126
02/15/2003	07:03:20	2.26	136
02/15/2003	06:56:20	2.06	128
02/15/2003	06:55:40	2.26	136
02/15/2003	06:51:40	2.26	136
02/15/2003	06:50:20	2.06	128
02/15/2003	05:28:00	2.26	136
02/15/2003	05:26:20	2.46	144
02/15/2003	05:25:20	2.26	136
02/15/2003	05:24:20	2.46	144
02/15/2003	05:21:00	2.26	136
02/15/2003	05:15:20	2.46	144
02/15/2003	05:11:00	2.26	136
02/15/2003	05:06:00	2.46	144
02/15/2003	05:02:20	2.46	144
02/15/2003	05:01:40	2.26	136
02/15/2003	03:48:00	2.46	144
02/15/2003	03:47:20	2.66	152
02/15/2003	03:41:00	2.46	144
02/15/2003	03:38:20	2.66	152
02/15/2003	03:37:40	2.46	144

02/15/2003	03:31:40	2.66	152
02/15/2003	03:31:00	2.46	144
02/15/2003	03:21:40	2.66	152
02/15/2003	03:18:20	2.46	144
02/15/2003	02:32:20	2.66	152
02/15/2003	02:31:40	2.86	160
02/[illegible]2003	02:29:20	2.61	150
02/[illegible]2003	02:27:00	2.81	158
02/15/2003	02:25:20	2.61	150
02/15/2003	02:24:20	2.81	158
02/15/2003	02:23:20	2.61	150
02/15/2003	02:21:10	2.66	152
02/15/2003	02:20:40	2.86	160
02/15/2003	02:14:00	2.66	152
02/15/2003	02:12:40	2.86	160
02/15/2003	02:10:00	2.66	152
02/15/2003	02:02:20	2.86	160
02/15/2003	02:01:20	2.66	152
2/15/2003	01:59:50	2.86	160
2/15/2003	01:58:40	2.91	162
2/15/2003	01:58:00	2.66	152
2/15/2003	01:42:00	2.86	160
2/15/2003	01:40:40	2.66	152
2/15/2003	01:38:50	2.86	160
2/15/2003	01:38:20	2.66	152
2/15/2003	01:31:01	2.86	160
2/15/2003	01:18:10	2.91	162
2/15/2003	01:17:40	2.66	152
2/15/2003	00:57:30	2.96	164
2/15/2003	00:57:00	2.76	156
2/15/2003	00:01:41	2.96	164
2/15/2003	00:00:21	3.16	172
2/14/2003	23:55:30	2.96	164
2/[illegible]003	23:55:01	3.16	172
2/1[illegible]2003	23:52:11	2.96	164
2/14/2003	23:51:41	3.16	172
2/14/2003	23:48:01	2.96	164
2/14/2003	23:47:01	3.16	172
2/14/2003	23:41:01	2.96	164
2/14/2003	23:36:01	3.16	172
2/14/2003	23:35:21	2.96	164
2/14/2003	23:31:10	2.96	164
2/14/2003	23:28:12	3.06	168
2/14/2003	23:27:41	3.26	177
2/14/2003	23:05:21	3.06	168
2/14/2003	23:00:01	3.26	177
2/14/2003	22:58:21	3.06	168
2/14/2003	22:51:41	3.26	177
2/14/2003	22:45:30	3.06	168
2/14/2003	22:45:01	3.36	181
2/14/2003	22:35:21	3.16	172
2/14/2003	22:34:41	3.36	181
/14/2003	22:11:21	3.16	172
/14/2003	22:00:41	3.36	181
/14/2003	21:59:41	3.16	172
/14/2003	20:44:01	3.56	188
/14/2003	20:43:21	3.36	181
/14/2003	20:42:01	3.56	188
/14/2003	20:41:21	3.26	177
/14/2003	20:36:41	3.51	187
/1[illegible]03	20:35:41	3.31	179
/14[illegible]003	20:35:02	3.61	190
/14/2003	20:17:01	3.41	183
/14/2003	19:37:31	3.61	190
/14/2003	19:37:01	3.41	183
/14/2003	19:31:01	3.61	190
/14/2003	18:40:41	3.76	196

02/14/2003	18:38:31	3.56	188
02/14/2003	18:38:01	3.76	196
02/14/2003	18:33:21	3.56	188
02/14/2003	17:11:01	3.76	196
02/14/2003	17:10:22	3.96	204
02/14/2003	16:47:21	3.96	204
02/[illegible]/2003	16:46:21	3.76	196
02[illegible]2003	15:11:22	3.96	204
02/14/2003	15:07:02	4.16	212
02/14/2003	15:01:02	3.96	204
02/14/2003	13:31:03	4.16	212
02/14/2003	13:21:42	4.16	212
02/14/2003	13:20:31	4.36	220
02/14/2003	13:09:02	4.36	220
02/14/2003	13:06:42	4.16	212
02/14/2003	12:56:02	4.36	220
02/14/2003	12:54:02	4.16	212
02/14/2003	12:42:22	4.36	220
02/14/2003	12:41:42	4.16	212
02/14/2003	11:16:42	4.36	220
02/14/2003	11:01:12	4.56	228
02/14/2003	10:55:23	4.56	228
02/14/2003	10:52:22	4.36	220
02/14/2003	09:50:42	4.56	228
02/14/2003	09:41:42	4.56	228
02/14/2003	09:39:02	4.76	236
02/14/2003	09:33:03	4.56	228
02/14/2003	08:20:02	4.76	236
02/14/2003	08:07:23	4.76	236
02/14/2003	08:06:02	4.86	240
02/14/2003	08:05:32	4.76	236
02/14/2003	08:05:03	4.96	243
02/14/2003	07:57:03	4.76	236
02/[illegible]2003	07:55:23	4.96	243
02/[illegible]2003	07:54:03	4.76	236
02/14/2003	07:52:23	4.96	243
02/14/2003	07:46:23	4.96	243
02/14/2003	07:45:43	4.76	236
02/14/2003	07:32:03	4.96	243
2/14/2003	07:31:03	4.76	236
2/14/2003	06:36:13	4.96	243
2/14/2003	06:35:43	4.76	236
2/14/2003	06:05:13	4.96	243
2/14/2003	06:04:43	4.76	236
2/14/2003	05:59:03	4.76	236
2/14/2003	05:57:43	4.96	243
2/14/2003	05:33:43	4.76	236
2/14/2003	05:30:03	4.56	228
2/14/2003	05:27:43	4.76	236
2/14/2003	05:25:03	4.56	228
2/14/2003	05:24:32	4.76	236
2/14/2003	05:23:33	4.71	234
2/14/2003	05:23:03	4.51	226
2/14/2003	05:22:03	4.76	236
2/14/2003	05:09:23	4.56	228
2/14/2003	05:06:43	4.36	220
2/14/2003	05:05:23	4.56	228
2/14/2003	05:03:23	4.36	220
2/14/2003	05:02:43	4.56	228
2/14/2003	04:47:23	4.31	218
2/1[illegible]003	04:20:23	3.91	202
2/1[illegible]003	04:16:23	3.66	192
2/14/2003	04:14:43	3.86	200
2/14/2003	03:58:03	3.66	192
2/14/2003	03:30:44	3.26	177
2/14/2003	03:19:43	3.06	168
2/14/2003	03:07:03	2.86	160

02/14/2003	03:04:43	2.86	160
02/14/2003	02:53:03	2.66	152
02/14/2003	02:35:23	2.46	144
02/14/2003	02:31:43	2.26	136
02/14/2003	02:29:43	2.46	144
02/14/2003	02:18:23	2.26	136
02/[illegible]/2003	02:13:14	2.06	128
02/[illegible]2003	02:12:43	2.26	136
02/14/2003	02:07:13	2.06	128
02/14/2003	02:06:43	1.86	120
02/14/2003	02:05:23	1.86	120
02/14/2003	02:04:53	2.06	128
02/14/2003	02:00:44	2.06	128
02/14/2003	01:59:03	1.86	120
02/14/2003	01:58:33	2.11	130
02/14/2003	01:56:23	2.06	128
02/14/2003	01:55:46	1.86	120
02/14/2003	01:54:44	2.06	128
02/14/2003	01:39:43	1.86	120
02/14/2003	01:38:33	1.66	110
02/14/2003	01:38:03	1.86	120
02/14/2003	01:22:03	1.61	108
02/14/2003	01:21:23	1.36	97
02/14/2003	01:18:43	1.41	99
02/14/2003	00:56:23	1.21	90
02/14/2003	00:55:24	1.01	82
02/14/2003	00:44:03	1.01	82
02/14/2003	00:29:03	0.81	74
02/14/2003	00:27:25	0.56	64
02/14/2003	00:26:43	0.81	74
02/14/2003	00:26:13	0.56	64
02/14/2003	00:24:23	0.76	72
02/14/2003	00:21:43	0.46	60
02/[illegible]2003	00:21:03	0.66	68
02/[illegible]2003	00:18:43	0.56	64
02/14/2003	00:18:13	0.36	57
02/14/2003	00:14:43	0.56	64
02/14/2003	00:02:03	0.36	57
02/14/2003	00:01:23	0.16	50
02/13/2003	23:53:44	0.36	57
02/13/2003	23:34:04	0.11	48
02/13/2003	23:18:04	-0.09	42
02/13/2003	23:09:34	-0.29	35
02/13/2003	23:09:04	-0.09	42
02/13/2003	23:08:04	-0.54	27
02/13/2003	23:06:13	-0.34	33
02/13/2003	23:04:04	-0.34	33
02/13/2003	23:02:44	-0.54	27
02/13/2003	23:02:13	-0.34	33
02/13/2003	23:01:04	-0.49	28
02/13/2003	22:48:53	-0.94	16
02/13/2003	22:48:24	-0.74	21
02/13/2003	22:43:24	-0.94	16
02/13/2003	22:37:33	-1.14	13
02/13/2003	22:37:04	-1.34	11
02/13/2003	22:36:24	-1.14	13
02/13/2003	22:34:04	-1.34	11
02/13/2003	22:31:44	-1.54	9
02/13/2003	22:29:24	-1.74	6
02/13/2003	22:27:25	-1.94	4
02/1[illegible]003	19:31:05	-2.49	0
02/1[illegible]003	13:31:06	-2.49	0
02/13/2003	07:31:06	-2.49	0
02/13/2003	01:31:07	-2.49	0
02/12/2003	19:30:40	-2.49	0
02/12/2003	13:30:41	-2.49	0
02/12/2003	07:30:41	-2.49	0

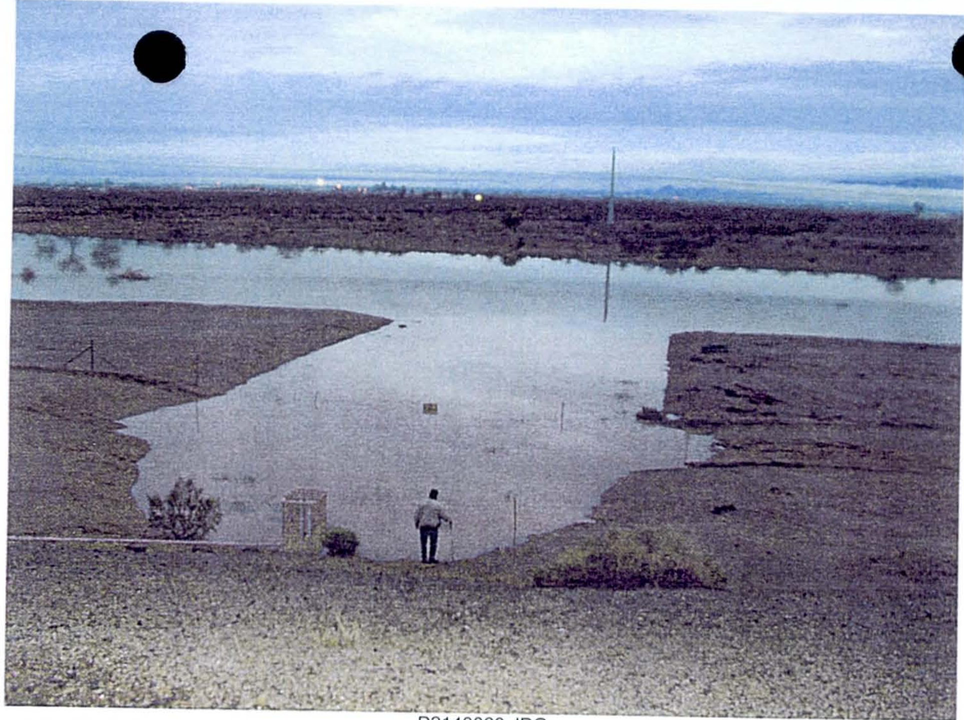
02/11/2003	19:30:43	-2.49	0
02/11/2003	13:30:46	-2.49	0
02/11/2003	07:30:44	-2.49	0
02/11/2003	01:30:45	-2.49	0
02/10/2003	19:30:46	-2.49	0
02/10/2003	13:30:47	-2.49	0
02/[illegible]/2003	07:30:47	-2.49	0
02/[illegible]/2003	01:30:48	-2.49	0

FCDMC ALERT System Data Display

5200 Buckeye FRS #1
Precipitation Gage

Date	Time	inches
02/15/2003	19:30:58	3.15
02/15/2003	13:31:00	3.15
02/15/2003	07:31:00	3.15
02/15/2003	01:31:01	3.15
02/14/2003	19:31:01	3.15
02/14/2003	13:31:03	3.15
02/14/2003	07:31:03	3.15
02/14/2003	01:58:06	3.15
2/14/2003	00:49:26	3.11
2/14/2003	00:29:34	3.07
2/14/2003	00:28:27	3.03
2/14/2003	00:27:53	2.99
2/14/2003	00:25:46	2.95
2/14/2003	00:23:34	2.91
2/14/2003	00:17:51	2.87
2/14/2003	00:14:15	2.80
2/13/2003	23:21:13	2.76
2/13/2003	22:25:54	2.68
2/13/2003	21:26:33	2.64
2/13/2003	20:57:33	2.60
2/13/2003	20:26:19	2.56
2/13/2003	20:14:40	2.52
2/13/2003	20:08:11	2.48
2/1[illegible]2003	20:03:02	2.44
2/[illegible]003	19:57:45	2.40
2/13/2003	19:31:05	2.36
2/13/2003	18:59:45	2.36
2/13/2003	18:26:03	2.24
2/13/2003	18:09:46	2.20
2/13/2003	18:03:26	2.17
2/13/2003	17:59:53	2.13
2/13/2003	17:56:47	2.09
2/13/2003	17:48:39	2.05
2/13/2003	17:33:05	2.01
2/13/2003	17:10:53	1.97
2/13/2003	16:36:42	1.93
2/13/2003	13:50:25	1.85
2/13/2003	13:31:06	1.81
2/13/2003	13:12:55	1.81
2/13/2003	12:49:14	1.77
2/13/2003	07:51:45	1.73
2/13/2003	07:33:35	1.69
2/13/2003	07:31:06	1.65
2/13/2003	07:21:41	1.65
2/13/2003	07:13:27	1.61
2/13/2003	07:05:38	1.57
2/13/2003	06:49:58	1.54
2/13/2003	06:44:57	1.50
2/13/2003	06:18:39	1.42
2/13/2003	06:09:08	1.38
2/13[illegible]003	05:59:48	1.34
2/1[illegible]03	05:44:42	1.30
2/13/2003	05:16:01	1.26
2/13/2003	05:01:35	1.22
2/13/2003	04:55:34	1.18
2/13/2003	04:43:54	1.14
2/13/2003	03:53:36	1.10
2/13/2003	02:32:26	1.06

02/13/2003	02:11:15	1.02
02/13/2003	01:31:07	0.98
02/12/2003	22:19:30	0.94
02/12/2003	21:37:13	0.91
02/12/2003	19:30:40	0.87
02/12/2003	13:30:41	0.83
02/[illegible]2003	07:30:41	0.83
02/[illegible]/2003	01:30:42	0.83
02/11/2003	19:30:43	0.83
02/11/2003	07:30:44	0.83
02/11/2003	01:30:45	0.83
02/10/2003	19:30:46	0.83
02/10/2003	13:30:47	0.83
02/10/2003	07:30:47	0.83
02/10/2003	01:30:48	0.83



P2140060.JPG
View of the inlet channel at Sta. 710+00. Note ponding adjacent to the embankment.

P2140061.JPG
Looking west at ponding adjacent to the embankment from Sta. 710+00.

P2140062.JPG

P2140063.JPG

P2140064.JPG
Looking west at ponding along the upstream toe from Sta.`730+00.

P2140068.JPG
View of ponding at the NE intersection of Johnson Camp Road and Buckeye FRS #1.

P2140070.JPG

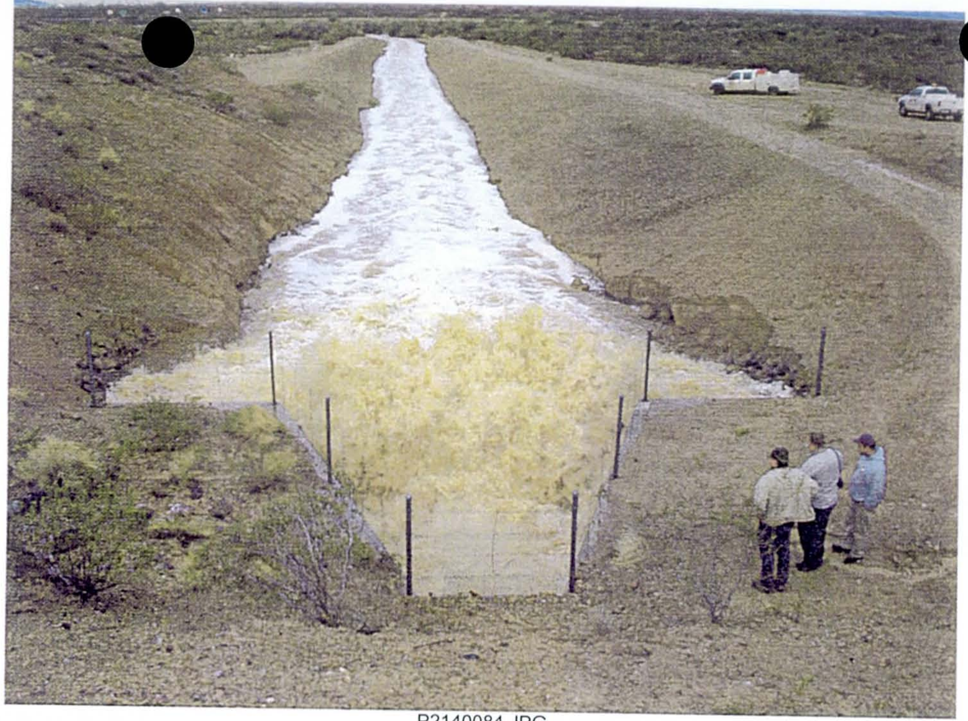
P2140078.JPG

P2140079.JPG
View of the principal outlet inlet. Note lack of debris on the trash rack.

P2140080.JPG
Looking west at the principal outlet approach channel.

P2140081.JPG

P2140082.JPG



P2140084.JPG
Looking west at the principal outlet channel. Note erosion to the sides of the channel.

P2140086.JPG
View of erosion to the left bank of the principal outlet channel. Note the high bank above the erosion.

P2140087.JPG

P2140089.JPG
Looking south at the principal outlet channel. Note erosion at the toe of the left high bank.

P2140092.JPG
Looking southeast at the principal outlet channel. Note erosion at the toe of the left high bank.

P2140094.JPG

FCDMC ALERT System Graphical Water-Level Summaries