#4

WEST RIDGE MINE
007/041

AMENDMENT
TO
THE MINING AND RECLAMATION PLAN

TO ALLOW FULL EXTRACTION
LONGWALL MINING OF PANEL #7

LOCATED WITHIN THE EXISTING PERMIT AREA
IN

FEDERAL LEASE UTU-068754
PENTA CREEK FEE LEASE

THIS SUBMITTAL INCLUDES THE CLEAN COPIES
FOR THE APPROVED AMENDMENT (TASK #2328)

SUBMITTED: NOVEMBER 18, 2005

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WEST RIDGE Resources, Inc. which provides full assurance that the topsoil resource in this area will be available for (and, indeed dedicated to) final reclamation of the West Ridge minesite if needed. (See Appendix 1-4)

Coal lease SL-068754-U-01215 was modified by the BLM. Refer to Appendix 1-9 for the coal lease modification.

The permit area consists of federal coal leases SL-068754-U-01215 and UTU 78562 (4297.01 acres as described in Table1-1) state coal leases ML-47711 and ML-49287 (1,682.34 acres as described in Table 1-2A), the Penta Creek fee lease (124.92 acres as described in Table 1-2B). The permit area also includes a special use state surface lease (9.6 acres as described in Table I-2A). The two areas are not contiguous however. The 9.6 acre state surface lease is for a possible topsoil borrow site if it is needed at the time of final reclamation. This permit area also includes a 0.23 acre right-of-way issued by the BLM for a water pumping station (refer to Appendix 1-12). The permit area also includes a 0.79 acre area along the Carbon County C Canyon Road down to and including the security gate (refer to Appendix 1-13). The total permit area is 6,114.89 acres. Refer to Map 1-1 for the permit area location. Refer to Table 1-4 for the legal description of the permit area.

Stipulation 17 of Federal Lease UTU-78562 states the following:

> *"17. SEISMIC STIPULATION: Mining operations shall be conducted in a manner to prevent seismic events that would cause damage to surface or subsurface structures such as: power lines or mine pillars and other structures such as Grassy Trail Reservoir and/or create hazardous conditions such as landslides.*
>
> *The Lessee shall: (1) Provide a seismic risk assessment of the Grassy Trail Reservoir to the AO prior to mining in the lease. (2) Prior to mining in the lease, the Lessee shall provide a plan to monitor the Reservoir and the steps necessary to mitigate any damage created by the lessee. These plans shall be updated by the Lessee as deemed necessary by the AO.*
>
> *The AO will either approve or may prescribe the mining methods used, the amount of coal recovered or determine the corrective measures necessary to assure protection of surface or subsurface structures and resources. The Lessee is and will remain liable for any and all damages or hazardous conditions resulting from the mining operations under the lease."*
> (Refer to Appendix 1-4)

WEST RIDGE Resources hired RB&G Engineering to prepare a study of the risk to

the Grassy Trail dam and reservoir from seismicity and subsidence associated with longwall mining in the West Ridge Mine. This study involved collection of additional data from newly-installed accelerometers, subsidence monitoring stations, and piezometers in the area around the dam. This study was conducted with input from BLM, DOGM, Division of Dam Safety, and East Carbon City.

On August 5, 2005 RB&G Engineering completed the seismicity study. (Refer to Appendix 5-11, Grassy Trail Dam & Reservoir Mining - Induced Seismicity Report.) In addition, RB&G prepared a second report which analyzed the Grassy Trail Dam so that East Carbon City can comply with the regulatory requirements of Utah Division of Dam Safety. There are a number of overlapping and interconnected issues addressed in the seismicity study and the dam safety study. Therefore the dam safety study is included as Appendix 5-12 (Grassy Trail Dam & Reservoir, Phase II Dam Safety Study, August 27, 2005.)

After a thorough review of the study the BLM approved a minor modification of the R2P2 (see Appendix 5-3B) to allow full extraction longwall mining of Panel #7. In the approval BLM concluded that *"The submitted report from RB&G concludes that it is unlikely that the anticipated mining of panel 7 would impact the performance of the dam and reservoir. The analysis of seismic impacts used a large maximum event (3.9 Richter Scale Magnitude) which is well above any recorded event in the immediate area. Using the maximum event, RB&G still anticipates a factor of safety still well above minimum Utah State Dam Safety standards. The BLM accepts the report and agrees with the recommendations. West Ridge is hereby authorized to extract longwall panel #7 per the approved R2P2, having met the conditions for approval."*

The seismicity report addressed the issues of dam stability analysis, subsidence, internal erosion potential, reservoir seepage and landslide potential. The report concluded that "it is unlikely that the anticipated mining induced seismicity will impact the performance of the dam and reservoir." The report also recommended the following inspection and monitoring program during the longwall mining of Panel #6 and Panel #7:

- *Bi-weekly site reconnaissance to observe any change of conditions in the embankment crest or slopes and landslide areas. Particular attention should be given to cracking, ground deformation or seepage.*

- *Monthly measurement of inclinometers, piezometers and ground motion monitoring devices.*

- *Annual survey of control points on the embankment and in the landslide areas.*

- *Daily monitoring of the UUSS list of recent seismic events (www.seis.utah.edu/recactivity/recent.shtml) should be performed. A daily record should be maintained of the largest recorded event within 5 miles of the site. When an event greater than 3.0 occurs within 5 miles of the site, a site reconnaissance of the embankment crest, slopes and landslide areas should be performed within 24 hours and a review of ground motion recordings should be made. If recorded ground acceleration exceeds 0.4g, instrumentation readings should be performed.*

- *Site reconnaissance and instrumentation reports should be forwarded to RB&G Engineering and the Utah State Dam Safety Engineer within 24 hours, and the daily monitoring record should be submitted on a monthly basis.*

The BLM R2P2 approval is conditioned upon WEST RIDGE Resources monitoring the inspection/monitoring program as outlined above.

Based on the conclusions of the seismicity study the Utah Division of Dam Safety has requested an additional monitoring and inspection program above and beyond that required by the R2P2. The elements of this expanded monitoring plan includes:

- *Prior to longwall mining of Panel No. 7 additional subsidence control monuments will be established across the crest of the dam on 100' centers, across the face of the dam midway down the slope on 200' centers, and along the toe of the dam on 200' centers.*

- *Prior to longwall mining the upper hillside accelerometer will be removed, recalibrated, and relocated at the dam. The dam site accelerometer will be removed, recalibrated, and relocated at a new location on the hillside approximately midway between the dam and the previous upper hillside location.*

- *Prior to longwall mining a seepage collection system will be installed at the seep area located along the east abutment of the dam. This system will be designed to collect the entire flow of the seep to a common point to allow accurate measurement of the seepage flow.*

- *Prior to longwall mining a complete set of premining baseline data will be established including:*
  -Peizometer readings.
  -Accelerometer readings.
  -Inclinometer readings.
  -Relative elevations of all subsidence monitoring monuments located on the dam. (Absolute elevations of all monuments will be surveyed before and

after extraction of longwall Panel No. 7)
-Flow rates at the east abutment seep, west abutment seep, and toe drain.
-Visual inspection of the dam, seeps, and slide area.
-Electronic photographs at predetermined designated viewpoints.

- *RB&G will be responsible for compiling and distributing the following weekly, monthly, and event-driven inspection and monitoring reports. These reports will be generated in an electronic format and emailed on a timely basis to the Division of Dam Safety, Division of Oil, Gas & Mining, Bureau of Land Management, East Carbon City, Sunnyside City, and WEST RIDGE Resources (herein after referred to as the designated parties).*

- ***Weekly basis:*** *After longwall mining has commenced in Panel No. 7 the following monitoring will be done on a weekly basis:*
  -Site reconnaissance/visual inspection (weekly inspections will be done by the same individual from WEST RIDGE Resources to ensure consistency of visual observation interpretations).
  -Electronic photographs from predetermined viewpoints.
  -Flow rates at the east seep, west seep, and toe drain. (These flow rates will be determined by actual measurements not by visual estimates.)
  -Reservoir level.
  -Electronic reports including all reading and photos will be emailed immediately after the inspection to the designated parties.

- ***Monthly basis:*** *In addition to the weekly monitoring the following monitoring will be conducted on a monthly basis:*
  -Accelerometer readings This information will be downloaded by RB&G and attached to the monthly summary.
  -Piezometer readings (to be taken by RB&G)
  -Inclinometer readings (to be taken by RB&G)
  -Relative elevations of subsidence monitoring monuments located on the dam. These surveys will be conducted by a registered professional surveyor.
  -Electronic reporting (emails) of the monthly measurements will be combined with the fourth weekly inspection report sent to the designated parties.

- ***Event-driven basis:*** *In addition to the weekly and monthly inspections the following measures will be taken on an event-driven basis:*
  -The University of Utah seismic readings will be monitored on a daily basis, if any events are recorded greater than a magnitude 3.0 within 5 miles of the dam then, within 24 hours of such readings, a full site reconnaissance and visual inspection will be conducted, and accelerometer readings will be taken. If the accelerometer readings show any value greater than 0.2g then

inclinometer readings, piezometer readings and drainflow measurements (east seep, west seep, and toe drain) will be taken at that time. The results of these measurements will be emailed immediately to all designated parties.

- *The standardized form of the inspection/monitoring reports is included in Appendix 1-17.*

- *Monitoring and reporting will continue on the prescribed weekly, monthly, and event driven basis during the mining of Panel No. 7 as long as seismic events continue to be recorded. At such time that the frequency and magnitude of the events diminishes sufficiently the agencies (Dam Safety, DOGM, BLM, East Carbon City, and Sunnyside City) will make a collective consensus determination to reduce, modify, and/or eliminate the various elements of the monitoring program.*

WEST RIDGE Resources, Inc. commits to implementing this inspection/monitoring program for full extraction of Panel #7. The complete monitoring/inspection plan, including maps, standardized forms, and notification list is included in Appendix 5-13.

114.200 Not applicable, the fee lease mineral estate is not severed from the surface estate.

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R645-301-522 COAL RECOVERY

A Resource Recovery and Protection Plan (R2P2), has been approved by the BLM. The R2P2 will assure that coal mining and reclamation operations are conducted so as to maximize the utilization and conservation of the coal, while utilizing the best technology currently available to maintain environmental integrity, so that reaffecting the land in the future through coal mining and reclamation operations is minimized. Refer to Appendix 5-3, 5-3A and 5-3B for the R2P2 which includes a discussion of coal resource utilization and conservation. The Utah School and Institutional Trust Lands Administration (SITLA), with concurrence from the BLM, has approved the mining plan for State Leases ML-47711 and ML-59287 (See Appendix 5-10).

R645-301-523 MINING METHODS

Both longwall and continuous miner methods will be employed to recover the coal resource. Longwall will be the primary production method, while continuous miners will be used mainly for mine development to support the longwall. The longwall panels shown on Map 5-4B have been laid out to maximize recovery of the primary coal reserves. Continuous miners will be utilized to develop main entries, longwall gate entries, sumps and other similar development areas.

Initial mine production has come from reserves located in the southeastern portion of the existing lease area. Panels will be developed to the north and south of the mains, progressing in an eastward direction. Longwall panel layout may change depending on conditions encountered in the underground workings.

The projected life of the West Ridge Mine is 15 years. Acquisition of additional federal coal reserves in the West Ridge area would extend the life of the mine beyond 15 years. In the unlikely event that non federal reserves cannot be acquired then the mine plan projection will be altered to maximize the economic and recovery of federal coal in the irregular blocks not amenable to mining. After the economically recoverable reserves within the lease area have been depleted, the portals would be sealed and reclamation of the surface facility area would begin unless additional leases were acquired.

The West Ridge mine is being proposed as an average size underground longwall mine by Utah industry standards, producing at an average rate of about 3 million tons per year. Mine production is subject to normal fluctuations depending on operational variables such as

geologic mining conditions, marketing, equipment availability, and/or worker productivity. The mine is expected to produce about 42 million tons of coal from the existing leases. The existing mine plan assumes that mining in the area northeast of Whitmore Canyon will be limited by heavy cover (plus 3000'). However, if conditions allow, mining activity will continue as far as possible in this direction on federal coal which would be leased in the future.

Full production could be reached by a gradual buildup during the first two years of mining. See Map 5B for mine projections and timing information for the future expanded mining area.

Major equipment for the mine will include:

Continuous Mining System:

Drum-Type Continuous Mining Machine
Shuttle Cars
Roof Bolter
Diesel Scoop Tractor
Feeder Breaker
Section Power Center
Section Auxiliary Face Ventilation Fan

Longwall Mining System:

Double Drum Shearing Machine
Armored Face Conveyor
Hydraulically Activated Shield Roof Support
Armored Stage Loader and Crusher
Longwall Power Center
High Pressure Hydraulic Pumping System

No surface coal mining (strip mining) will be done.

All mining will be done in accordance with the provisions of the approved R2P2 and the terms and stipulations of the federal and state leases within the West Ridge mining area. Stipulation 17 of federal lease UTU-78562 has been complied with. A seismic analysis report of the Grassy Trail Dam and Reservoir has been completed and BLM has determined that the seismic/subsidence effects of longwall mining on the Grassy Trail dam and reservoir have been satisfactorily addressed. The BLM has approved the R2P2 to allow full extraction longwall mining in panel #7.

Mitigation

Mitigation measures may include: grading of damage resulting from subsidence on grazable lands (where accessible), fencing to restrict access (where necessary) and restoration of adversely affected roads and trails. Graded areas will be reseeded using a seed mix designated by the BLM.

525.130 State Appropriated Waters-Quantity and Use

Refer to Appendix 7-5 for all state appropriated water right within and adjacent to the permit area, including appropriated quantities and designated usage.

525.200 Subsidence Control

WEST RIDGE Resources, Inc. will adopt measures which are technologically and economically feasible to prevent subsidence under areas to be protected and to provide for planned controlled subsidence in all other areas. WEST RIDGE Resources, Inc. will comply with all provisions of the approved subsidence control plan.

Material damage resulting from subsidence will be corrected to the extent technologically and economically feasible. Where possible, the land will be restored to a condition comparable to the use it supported prior to subsidence.

Mining will not be conducted beneath or adjacent to public buildings, churches, schools, hospitals. None of these structures exist within or adjacent to the permit area. A small portion of Grassy Trail Reservoir (less than 0.6 acres) lies within a corner of the permit area. Grassy Trail Reservoir impounds more than 20 acre feet of water. However, there will be no mining or mining related subsidence below this reservoir.

The Grassy Trail Reservoir, which impounds more than 20 acre-feet of water, is located partially within and adjacent to the permit area. There will be no mining conducted beneath the reservoir or impoundment structure. As presently planned, Panel 7 is the closest longwall panel to Grassy Trail Reservoir, located approximately 995' from the reservoir measured horizontally. This panel is also 1664' below the reservoir at this point.

WEST RIDGE Resources hired RB&G Engineering to prepare a study of the risk to the Grassy Trail dam and reservoir from seismicity and subsidence associated with longwall mining in the West Ridge Mine. This study involved collection of additional data from newly-installed accelerometers, subsidence monitoring stations, and piezometers in the area around the dam. This study was conducted with input from BLM, DOGM, Division of Dam Safety, and East Carbon City.

On August 5, 2005 RB&G Engineering completed the seismicity study. (Refer to

Appendix 5-11, Grassy Trail Dam & Reservoir Mining - Induced Seismicity Report.) In addition, RB&G prepared a second report which analyzed the Grassy Trail Dam so that East Carbon City can comply with the regulatory requirements of Utah Division of Dam Safety. There are a number of overlapping and interconnected issues addressed in the seismicity study and the dam safety study. Therefore the dam safety study is included as Appendix 5-12 (Grassy Trail Dam & Reservoir, Phase II Dam Safety Study, August 27, 2005.)

After a thorough review of the study the BLM approved a minor modification of the R2P2 (see Appendix 5-3B) to allow full extraction longwall mining of Panel #7. In the approval BLM concluded that *"The submitted report from RB&G concludes that it is unlikely that the anticipated mining of panel 7 would impact the performance of the dam and reservoir. The analysis of seismic impacts used a large maximum event (3.9 Richter Scale Magnitude) which is well above any recorded event in the immediate area. Using the maximum event, RB&G still anticipates a factor of safety still well above minimum Utah State Dam Safety standards. The BLM accepts the report and agrees with the recommendations. West Ridge is hereby authorized to extract longwall panel #7 per the approved R2P2, having met the conditions for approval."*

The seismicity report addressed the issues of dam stability analysis, subsidence, internal erosion potential, reservoir seepage and landslide potential. The report concluded that "it is unlikely that the anticipated mining induced seismicity will impact the performance of the dam and reservoir." The report also recommended the following inspection and monitoring program during the longwall mining of Panel #6 and Panel #7:

- *Bi-weekly site reconnaissance to observe any change of conditions in the embankment crest or slopes and landslide areas. Particular attention should be given to cracking, ground deformation or seepage.*

- *Monthly measurement of inclinometers, piezometers and ground motion monitoring devices.*

- *Annual survey of control points on the embankment and in the landslide areas.*

- *Daily monitoring of the UUSS list of recent seismic events (www.seis.utah.edu/recactivity/recent.shtml) should be performed. A daily record should be maintained of the largest recorded event within 5 miles of the site. When an event greater than 3.0 occurs within 5 miles of the site, a site reconnaissance of the embankment crest, slopes and landslide areas should be performed within 24 hours and a review of ground motion recordings should be made. If recorded ground acceleration exceeds 0.4g, instrumentation readings should be performed.*

- *Site reconnaissance and instrumentation reports should be forwarded to RB&G Engineering and the Utah State Dam Safety Engineer within 24 hours, and the daily monitoring record should be submitted on a monthly basis.*

The BLM R2P2 approval is conditioned upon WEST RIDGE Resources monitoring the inspection/monitoring program as outlined above. Therefore WEST RIDGE Resources, Inc. commits to implementing this inspection/monitoring program effective immediately upon Division approval for full extraction of Panel #7. This monitoring plan has been expanded to address concerns raised by Utah Division of Dam Safety (refer to Appendix 5-13).

525.300 Public Notice of Proposed Mining

No coal mining will be conducted under any buildings, facilities or impoundments (other than the recreational cabin referred to in 521.120). The BLM will be kept informed as to the dates and locations of mining activities. All owners of surface property and structures (BLM) above the underground works will receive notification at least six months prior to mining of the specific areas in which mining will take place, dates of mining and the location at which the subsidence control plan may be examined.

525.480 State Appropriated Water Replacement Mitigation

WEST RIDGE Resources, Inc. commits to mitigate the diminution or degradation of state appropriated waters within or adjacent to the permit area caused by surface affects of mine related subsidence. Mitigation measures would include such measures as sealing surface cracks with expansive clay materials (such as bentonite), trucking water, piping across fracture zones, transfer of water rights, installation of wildlife guzzlers and/or compensation to water rights owners.

525.480 Bear Canyon is situated in the northwest portion of the permit area within the SITLA lease area. This canyon is unique because it is within the right fork of this drainage that the cover over the longwall subsidence zone is the shallowest of anywhere in the entire permit area. In one part of the bottom of the (right fork) Bear Canyon drainage the cover over the longwall panes is approximately 325'. Due to the increased potential for the effects of subsidence to reach the surface in this area special attention has been focused on the hydrologic character of the Bear Canyon drainage.

Bear Canyon is typical of the canyons draining the southwest-facing front slopes of the Book Cliffs in this area. These canyons are generally shorter and drier than those drainages on the back-side of the Cliffs. Several baseline surveys of Bear Canyon right fork done in the late 1980's showed the drainage to be mostly dry and the canyon was identified as ephemeral along with other similar front-facing canyons in the permit area, such as "C" Canyon, "B" Canyon, and "A" Canyon. However, during site visits in June

and July of 2005, substantial stream-flow was observed in the drainage. This occurrence of flow, along with the observation of riparian vegetation in the lower stretches of the canyon, has led to a re-evaluation of the classification of the drainage as intermittent. Also, because the area of the Bear Canyon watershed is greater than one square mile the drainage is classified as intermittent under DOGM regulations.

Historical observation of Bear Canyon shows the streamflow in the bottom of the drainage to be a combination of surface flow and subsurface flow. In those areas where bedrock is at or close to the surface, flow is forced up to the surface. In other areas where the alluvium in the channel is thick and porous the flow is subsurface and the stream channel is often dry. The stretches of channel exhibiting surface flow as opposed to subsurface flow will vary from season to season, and year to year depending on prior precipitation trends in the watershed. There are times when the entire length of the channel could be expected to exhibit surface flow, and other times when surface flow is confined to certain segments. And, according to past monitoring observations, there are often times when there is no flow in the stream channel. In order to better define the hydrologic character of the canyon WEST RIDGE Resources will expand the monitoring program in Bear Canyon by adding two new monitoring sites and relocating a third site (see Map 7-7 and Table 7-1).

As mentioned previously, there is a point in the right fork of Bear Canyon where cover over the longwall panel will be about 325' which is the shallowest surface cover of any place within the current WEST RIDGE mine plan. This, along with the fact that there are state-appropriated surface water rights in this drainage (refer to Appendix 7-5), makes this an area of special interest. There is reason to expect that full-extraction longwall mining will not adversely affect the hydrologic resources of the canyon in this area. According to Syd S. Peng, ("Coal Mine Ground Control", 1978, Wiley, New York) a general rule-of-thumb is that subsidence-related fractures can be expected for a distance above the coal seam equal to 50 times the mining height, which works out to be 316' for the shallow point in Bear Canyon, which is slightly less than the cover in that area. Therefore due to the shallowness of cover in this area there could be subsidence fractures which reach the surface in the bottom of the canyon, and mitigation will be done to protect the resource.

The shallow overburden point coincides with the inflection point of the longwall subsidence profile. Based on a 22 degree angle of draw the tension zone will extend along the surface from the inflection point (shallow point) downstream approximately 130'. Areas upstream from the inflection point will be in compression as the longwall panel are extracted in progression from the southwest to the northeast according to the approved mining plan. Cracks are more likely to open up in the tension zone as compared to the compression zone where lateral forces are pushing toward each other rater than pulling apart. As mining progresses to the northeast, cover increases rapidly because of the gradient of the channel bottom and the dip of the coal seam, and surface

effects of subsidence should diminish in that direction. Therefore, it is expected that any cracking which might reach the surface should most likely appear in the canyon bottom in the 130' (plus/minus) tension zone down-canyon from the inflection point. Special subsidence monitoring will be focused on this area.

WEST RIDGE will establish two new hydrologic monitoring sites in the right fork of Bear Canyon. The first site (ST-11) will be located within the tension zone described above. This site was chosen because this location should be well-suited to determine if tension cracks have affected stream flow. It is also, coincidentally, one of the areas where the bedrock nature of the channel bottom forces water to the surface, thereby making streamflow measurements more accurate. The second site (ST-12) will be located about 2400' farther up-canyon in another area where, again, the bedrock nature of the channel allows for a more accurate streamflow measurement. A third monitoring site (ST-13) will be located below the forks of Bear Canyon just outside the permit area boundary. This site will replace the existing monitoring site ST-4.

During the flow season of 2005 and 2006 (that is, May 15 through September 15) site ST-11 will be monitored monthly as long as flow is present. This monthly monitoring will help better define the nature of streamflow prior to longwall extraction in the area, which is presently scheduled for May, 2007. Thereafter, monitoring will be done on the regular quarterly basis. Site ST-12 is more inaccessible, and could be dangerous to reach in the winter. Therfore this site will be monitored twice a year, once during late spring/early summer (expected peak flow) and once in late summer/early fall, when the canyons are normally much drier. Site ST-13 will be monitored quarterly.

The longwall is presently scheduled to pass under Bear Canyon in the spring of 2007. Prior to that, WEST RIDGE will complete a survey of a series of subsidence monitoring points established up the bottom of the drainage on either side of the inflection point. After the longwall has passed under the drainage these points will be re-surveyed and an accurate account undermined WEST RIDGE will visually inspect the area to determine if any effects of subsidence are apparent. Within thirty days of the inspection WEST RIDGE will submit a written report to the Division outlining the results of this inspection.

Recent site visits have determined the existence of riparian type vegetation in the lower reaches of Bear Canyon below the forks. WEST RIDGE commits to preparing a detailed vegetation survey and mapping of the canyon bottom with emphasis on the existence of riparian specie. This survey will be conducted during the growing season of 2005 or 2006. The survey will be done in consultation with Division biologists and the completed report will be added to the Mining and Reclamation Plan as an appendix.

If it is determined that mining-related subsidence has adversely impacted the hydrologic resources of Bear Canyon, including and state-appropriated water rights, WEST RIDGE will mitigate the damage. The first option would be to seal any cracks with the

application of bentonite clay. Bentonite sealing compounds are available commercially made specifically for such applications. Access to the are would be by pack animals along the remnants of an old existing drill-hole access road. If larger mechanical equipment is needed. Access could be improved as necessary because the surface is owned by the BLM and SITLA and the coal leases held by WEST RIDGE provides for such surface rights. If bentonite sealing proved ineffective, WEST RIDGE would propose the installation of piping to transport stream water across the fracture zone to continue the flow downstream. Any work done in the stream channel would most likely require the issuance of a channel alteration permit from the Utah Division of Water Rights.

Spring Canyon is located in the northern part of the permit area in SITLA lease 44771. There are no state-appropriated water rights on this lease. (Refer to Appendix 7-5 for additional details.) The surface is privately owned by Penta Creek with whom WEST RIDGE maintains coal mining rights. Longwall mining in this area is not scheduled until the year 2014. In this area the coal seam is 2500' deep under the bottom of the Canyon. Spring Canyon, as the name would imply, contains several springs. The drainage area of Spring Canyon is well in excess of one square mile. The canyon supports a number of beaver dams indicative of perennial flow. WEST RIDGE will add three additional monitoring points to collect baseline water monitoring data in Spring Canyon, namely ST-15 located upstream from the junction of Grassy Trail Creek, SP-101 located on a channel-bottom spring a short ways up Little Spring Canyon (a fork of Spring Canyon), and SP-102 located about 1000' upstream from the junction of Little Spring Canyon. This spring emanates from the west side of the canyon approximately 200' up from the canyon bottom. Refer to Map 7-7 and Table 7-1 for details. For the first two years (starting with the third quarter of 2005) these sites will be monitored on a quarterly basis for baseline data according to the field measurements and laboratory measurements outlined in Table 7-2 (Surface Monitoring) and Table 7-3 (Groundwater Monitoring). Thereafter, all sites will be monitored for flow and field parameters on a quarterly basis.

APPENDIX 5-3B

BLM R2P2
APPROVAL OF FULL EXTRACTION
LONGWALL PANEL #7

APPENDIX 5-3B

R2P2 APPROVAL OF FULL EXTRACTION OF PANEL #7

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Utah State Office
P.O. Box 45155
Salt Lake City, UT 84145-0155
http://www.blm.gov

TAKE PRIDE IN AMERICA

AUG 31 2005

IN REPLY REFER TO:
3482
SL-068754, UTU-78562
(UT-923)

Certified Mail--Return Receipt Requested

Mr. John C. Lewis
Mining Engineer
West Ridge Resources, Inc.
P. O. Box 1077
Price, Utah 84501

Re: Minor Modification, Resource Recovery and Protection Plan (R2P2), Longwall Panel # 7, West Ridge Mine

Dear Mr. Lewis:

The Bureau of Land Management (BLM) has received from West Ridge Resources, Inc., (West Ridge) a request to modify the approved R2P2 by authorizing the full extraction of longwall panel # 7 (9th Right Headgate). The approval for proposed longwall panel # 7 was conditioned on West Ridge addressing subsidence and seismic issues related to the Grassy Trails Reservoir as per lease stipulation # 17. West Ridge has submitted a final report prepared by RB&G Engineering, which addresses these issues, as justification for mining the longwall panel. The area of panel # 7 is located on Federal coal lease UTU-78562 and some private coal lands.

The submitted report from RB&G concludes that it is unlikely that the anticipated mining of panel 7 would impact the performance of the dam and reservoir. The analysis of seismic impacts used a large maximum event (3.9 Richter Scale Magnitude) which is well above any recorded event in the immediate area. Using the maximum event, RB&G still anticipates a factor of safety still well above minimum Utah State Dam Safety standards. The BLM accepts the report and agrees with the recommendations. West Ridge is hereby authorized to extract longwall panel # 7 per the approved R2P2, having met the conditions for approval. Further longwall panels down dip of panel # 7 (scheduled to be mined later) are not approved pending seismic data results.

This approval of a minor modification to an existing R2P2 is Categorically Excluded from National Environmental Policy Act (NEPA) analysis in that no new surface disturbance will occur from this action as stated in Overview of BLM's NEPA Process, February 1997, Appendix 2, page 2-7 (F)(7).

Longwall mining of panel # 7 complies with the Mineral Leasing Act of 1920, as amended, the regulations at 43 CFR 3480, the lease terms and conditions, and will achieve maximum economic recovery of the Federal coal. Approval is conditioned on maintaining the dam inspection and monitoring schedule as outlined on page 34 of the RB&G report. Also, this

approval does not release the lessee of any liability as outlined in lease stipulation # 17. A copy of the approved mine map showing authorization of panel # 7, is enclosed.

If you have any questions, please contact Stephen Falk of the Price Field Office at 435-636-3605 or Jeff McKenzie of my staff at 801-539-4038.

Sincerely,

James Kohler
Chief, Solid Minerals

Enclosure
Approved Mine Map

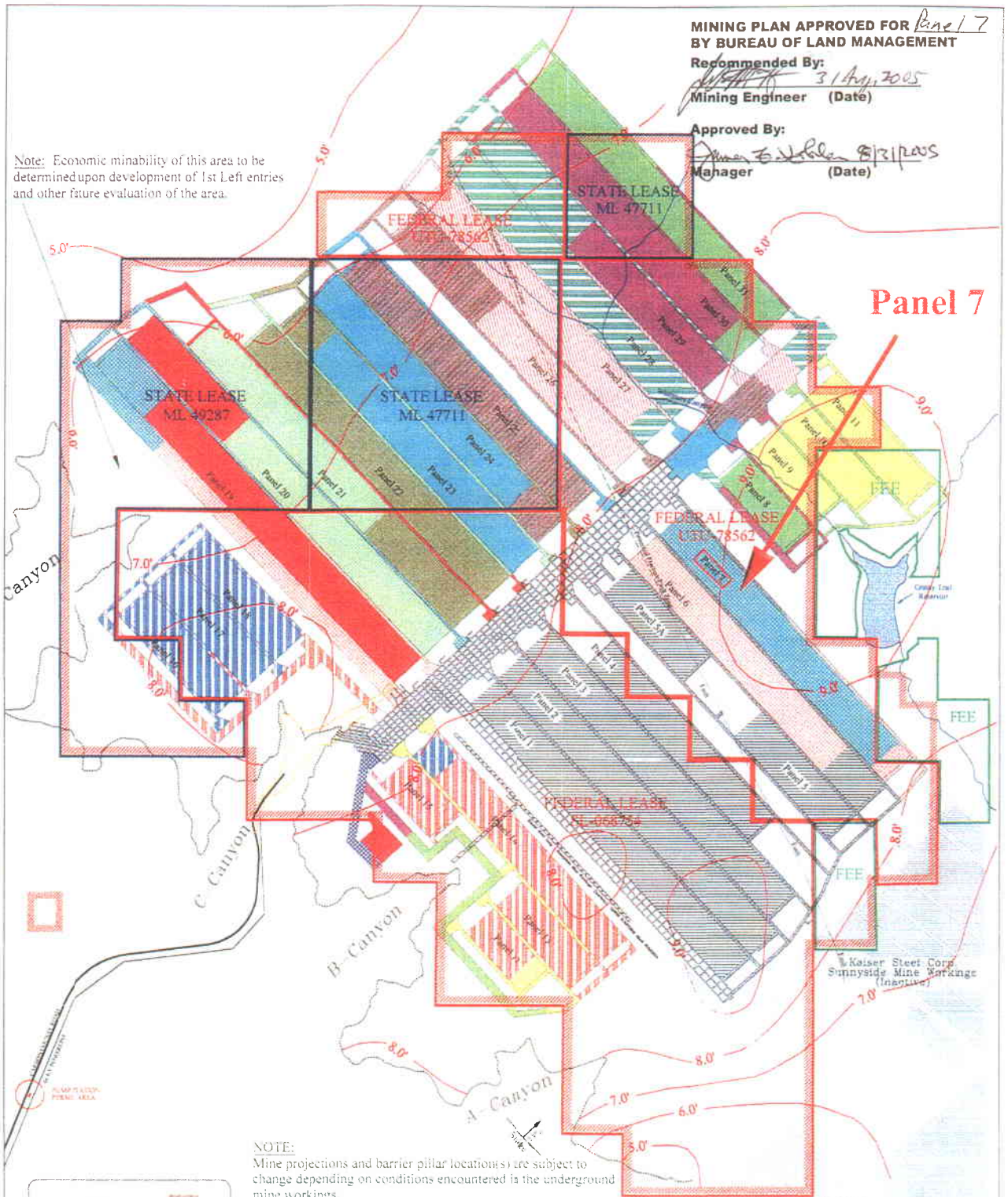
cc: Price Field Office (UT-070) (w/ encl.)
Utah Division of Oil Gas and Mining
1594 West North Temple, Suite 1210
Salt Lake City, Utah 84114-5801 (w/encl.)

MINING PLAN APPROVED FOR Panel 7
BY BUREAU OF LAND MANAGEMENT

Recommended By:
Mining Engineer (Date) 31 Aug, 2005

Approved By:
Manager (Date) 8/31/2005

Note: Economic minability of this area to be determined upon development of 1st Left entries and other future evaluation of the area.



NOTE:
Mine projections and barrier pillar location(s) are subject to change depending on conditions encountered in the underground mine workings.
Actual mine works are shown as of March 01, 2005.
Mine projections depicted in the fringe areas beyond the existing permit area are speculative and based on future reserve acquisitions. No mining will be conducted in these areas unless those reserves are acquired in the future and permitted according to federal, state, and local permitting requirements.
West Ridge Resources acknowledges that permission to mine within the permit boundary does not imply permission to mine beyond the permit boundary.
Longwall mining will not be conducted within panel 7 until stipulation 17 of Federal Lease U-78562 has been complied with and approved by the BLM.

UTAH REGISTERED #191488 PROFESSIONAL ENGINEER

WEST RIDGE MINE

Mine Plan

LEGEND:
- Permit Boundary (PENDING)
- Federal Lease
- State Lease (ML 49287)
- Penta Creek Fee
- Surface Facility Area
- Outcrop

WEST RIDGE
RESOURCES, INC.

SCALE 1"=2000'

APPENDIX 5-9

ALTERNATE HIGHWALL RECLAMATION PLAN
********TO BE ADDED LATER********

APPENDIX 5-9

ALTERNATE HIGHWALL RECLAMATION PLAN
*******TO BE ADDED LATER******

APPENDIX 5-11

GRASSY TRAIL DAM & RESERVOIR MINING-INDUCED SEISMICITY REPORT (RB&G ENGINEERING)

NOTE: THIS APPENDIX IS IN A SEPARATE BINDER

APPENDIX 5-11

GRASSY TRAIL DAM & RESERVOIR MINING-INDUCED SEISMICITY REPORT (RB&G ENGINEERING)

NOTE: THIS APPENDIX IS IN A SEPARATE BINDER

APPENDIX 5-12

GRASSY TRAIL DAM & RESERVOIR
PHASE II AM SAFETY REPORT
(RB&G ENGINEERING)

NOTE: THIS APPENDIX IS IN A SEPARATE BINDER

APPENDIX 5-12

GRASSY TRAIL DAM & RESERVOIR
PHASE II AM SAFETY REPORT
(RB&G ENGINEERING)

NOTE: THIS APPENDIX IS IN A SEPARATE BINDER

APPENDIX 5-13

GRASSY TRAIL DAM & RESERVOIR MONITORING & INSPECTION PLAN PANEL #7

APPENDIX 5-13

GRASSY TRAIL MONITORING/INSPECTION PLAN FOR PANEL #7

GRASSY TRAIL DAM MONITORING/INSPECTION PLAN, PANEL #7

- *Prior to longwall mining of Panel No. 7 additional subsidence control monuments will be established across the crest of the dam on 100' centers, across the face of the dam midway down the slope on 200' centers, and along the toe of the dam on 200' centers.*

- *Prior to longwall mining the upper hillside accelerometer will be removed, recalibrated, and relocated at the dam. The dam site accelerometer will be removed, recalibrated, and relocated at a new location on the hillside approximately midway between the dam and the previous upper hillside location.*

- *Prior to longwall mining a seepage collection system will be installed at the seep area located along the east abutment of the dam. This system will be designed to collect the entire flow of the seep to a common point to allow accurate measurement of the seepage flow.*

- *Prior to longwall mining a complete set of premining baseline data will be established including:*
  - *-Peizometer readings.*
  - *-Accelerometer readings.*
  - *-Inclinometer readings.*
  - *-Relative elevations of all subsidence monitoring monuments located on the dam. (Absolute elevations of all monuments will be surveyed before and after extraction of longwall Panel No. 7)*
  - *-Flow rates at the east abutment seep, west abutment seep, and toe drain.*
  - *-Visual inspection of the dam, seeps, and slide area.*
  - *-Electronic photographs at predetermined designated viewpoints.*

- *RB&G will be responsible for compiling and distributing the following weekly, monthly, and event-driven inspection and monitoring reports. These reports will be generated in an electronic format and emailed on a timely basis to the Division of Dam Safety, Division of Oil, Gas & Mining, Bureau of Land Management, East Carbon City, Sunnyside City, and WEST RIDGE Resources (herein after referred to as the designated parties).*

- ***Weekly basis:** After longwall mining has commenced in Panel No. 7 the following monitoring will be done on a weekly basis:*
  - *-Site reconnaissance/visual inspection (weekly inspections will be done by the same individual from WEST RIDGE Resources to ensure consistency of visual observation interpretations).*

-Electronic photographs from predetermined viewpoints.
-Flow rates at the east seep, west seep, and toe drain. (These flow rates will be determined by actual measurements not by visual estimates.)
-Reservoir level.
-Electronic reports including all reading and photos will be emailed immediately after the inspection to the designated parties.

- ***Monthly basis:*** *In addition to the weekly monitoring the following monitoring will be conducted on a monthly basis:*
  -Accelerometer readings This information will be downloaded by RB&G and attached to the monthly summary.
  -Piezometer readings (to be taken by RB&G)
  -Inclinometer readings (to be taken by RB&G)
  -Relative elevations of subsidence monitoring monuments located on the dam. These surveys will be conducted by a registered professional surveyor.
  -Electronic reporting (emails) of the monthly measurements will be combined with the fourth weekly inspection report sent to the designated parties.

- ***Event-driven basis:*** *In addition to the weekly and monthly inspections the following measures will be taken on an event-driven basis:*
  -The University of Utah seismic readings will be monitored on a daily basis, if any events are recorded greater than a magnitude 3.0 within 5 miles of the dam then, within 24 hours of such readings, a full site reconnaissance and visual inspection will be conducted, and accelerometer readings will be taken. If the accelerometer readings show any value greater than 0.2g then inclinometer readings, piezometer readings and drainflow measurements (east seep, west seep, and toe drain) will be taken at that time. The results of these measurements will be emailed immediately to all designated parties.

- *The standardized form of the inspection/monitoring reports is included in Appendix 1-17.*

- *Monitoring and reporting will continue on the prescribed weekly, monthly, and event driven basis during the mining of Panel No. 7 as long as seismic events continue to be recorded. At such time that the frequency and magnitude of the events diminishes sufficiently the agencies (Dam Safety, DOGM, BLM, East Carbon City, and Sunnyside City) will make a collective consensus determination to reduce, modify, and/or eliminate the various elements of the monitoring program.*

GRASSY TRAIL DAM
MONITORING NOTIFICATION LIST

RB&G ENGINEERING

Brad Price	bprice@rbgengineering.com	
	Bus.	801 374-5771
	Cell	801 319-0539
Mark Stilson	mkstilson@hotmail.com	
	Bus.	435 749-0577
	Cell	801 602-6939
Michael Hansen	mhansen@rbgengineering.com	
	Bus.	801 374-5771
	Cell	801 368-7317

DIVISION OF DAM SAFETY

Dave Marble	davemarble@utah.gov	
	Bus	801 538-7376
	Cell	801 580-5128
Bret Dixon	bretdixon@utah.gov	
	Bus.	801 538-7373
	Cell	801 673-5913

DIVISION OF OIL, GAS & MINING

Pam Grubaugh-Littig	pamgrubaughlittig@utah.gov	
	Bus.	801 538-5286
Wayne Hedberg	waynehedberg@utah.gov	
	Bus.	801 538-5286
Karl Houskeeper	karlhouskeeper@utah.gov	
	Bus	435 613-1146

BUREAU OF LAND MANAGEMENT

Jim Kohler	james_kohler@blm.gov Bus. 801 539-4037
Stan Perkes	stan_perkes@blm.gov Bus. 801 539-4036
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EAST CARBON CITY

Dale Andrews	ecc@emerytelcom.net Bus. 435 888-6613

SUNNYSIDE CITY

Bruce Andrews	suncity@emerytelcom.net Bus. 435 888-4444

WEST RIDGE RESOURCES

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John Lewis	jlewis@andalex.com Bus. 435 888-4016
James Sorensen	jsorensen@andalex.com Bus. 435 888-4008

GRASSY TRAIL DAM
INSPECTION REPORT

DATE: _____ WEATHER: _____ TEMP. _____/_____

INSPECTOR: _____ ORGANIZATION: _____

RESERVOIR LEVEL (Distance above or below spillway crest in inches): _____ above / below

OUTLET FLOWS (Check if flowing): ☐ Main Outlet Pipe, ☐ Stream Outlet Pipe, ☐ Spillway

		DATE
HAS MONUMENT SURVEY BEEN COMPLETED FOR MONTH?	☐ YES, ☐ NO:	_____
HAVE SEEPAGE POINTS BEEN READ THIS WEEK?	☐ YES, ☐ NO:	_____
HAVE PIEZOMETERS BEEN READ THIS MONTH?	☐ YES, ☐ NO:	_____
HAVE INCLINOMETERS BEEN READ THIS MONTH?	☐ YES, ☐ NO:	_____
HAVE ACCELEROMETERS BEEN READ THIS TIME PERIOD?	☐ YES, ☐ NO:	_____

DAM EMBANKMENT (If yes to any of the below items – describe and sketch in detail.)

CRACKING:

Old Cracks Opening ☐ YES ☐ NO Crack Location: ☐ Crest ☐ Upstream Slope ☐ Downstream Slope

New Cracks Opening ☐ YES ☐ NO

SLUMPS / BULGES:

Old Slumps Moving ☐ YES ☐ NO Old Bulges Moving ☐ YES ☐ NO Location: ☐ UPSTREAM ☐ DOWNSTREAM

New Slumps Forming ☐ YES ☐ NO New Bulges Forming ☐ YES ☐ NO

SEEPAGE / WET SPOTS:

New Seepage Points Observed ☐ YES ☐ NO Location: ☐ EAST SIDE

New Wet Spots Observed ☐ YES ☐ NO ☐ CENTER

Seepage ☐ CLEAR ☐ CLOUDY ☐ WEST SIDE

SINKHOLES OR OTHER ABNOMALITIES (Describe): _____

_____

_____

ABUTMENTS, FOUNDATION, AND RESERVOIR BASIN (If yes – describe & sketch in detail.)

LANDSLIDE (Right Abutment): Southwest & Northwest	New Movement Observed	☐ YES	☐ NO	(Sketch Locations)
	New Springs Observed	☐ YES	☐ NO	(Sketch Locations)
LANDSLIDE (Left Abutment):	New Movement Observed	☐ YES	☐ NO	(Sketch Locations)
	New Springs Observed	☐ YES	☐ NO	(Sketch Locations)

CRACKING:

Old Cracks Opening ☐ YES ☐ NO (Sketch Locations)

New Cracks Opening ☐ YES ☐ NO (Sketch Locations)

SLUMPS / BULGES:

Old Slumps Moving ☐ YES ☐ NO Old Bulges Moving ☐ YES ☐ NO (Sketch Locations)

New Slumps Forming ☐ YES ☐ NO New Bulges Forming ☐ YES ☐ NO (Sketch Locations)

SEEPAGE / WET SPOTS:

New Seepage Points Observed ☐ YES ☐ NO Seepage ☐ Clear (Sketch Locations)

New Wet Spots Observed ☐ YES ☐ NO ☐ Cloudy (Sketch Locations)

SINKHOLES OR OTHER ABNOMALITIES (Describe): _____

_____

_____

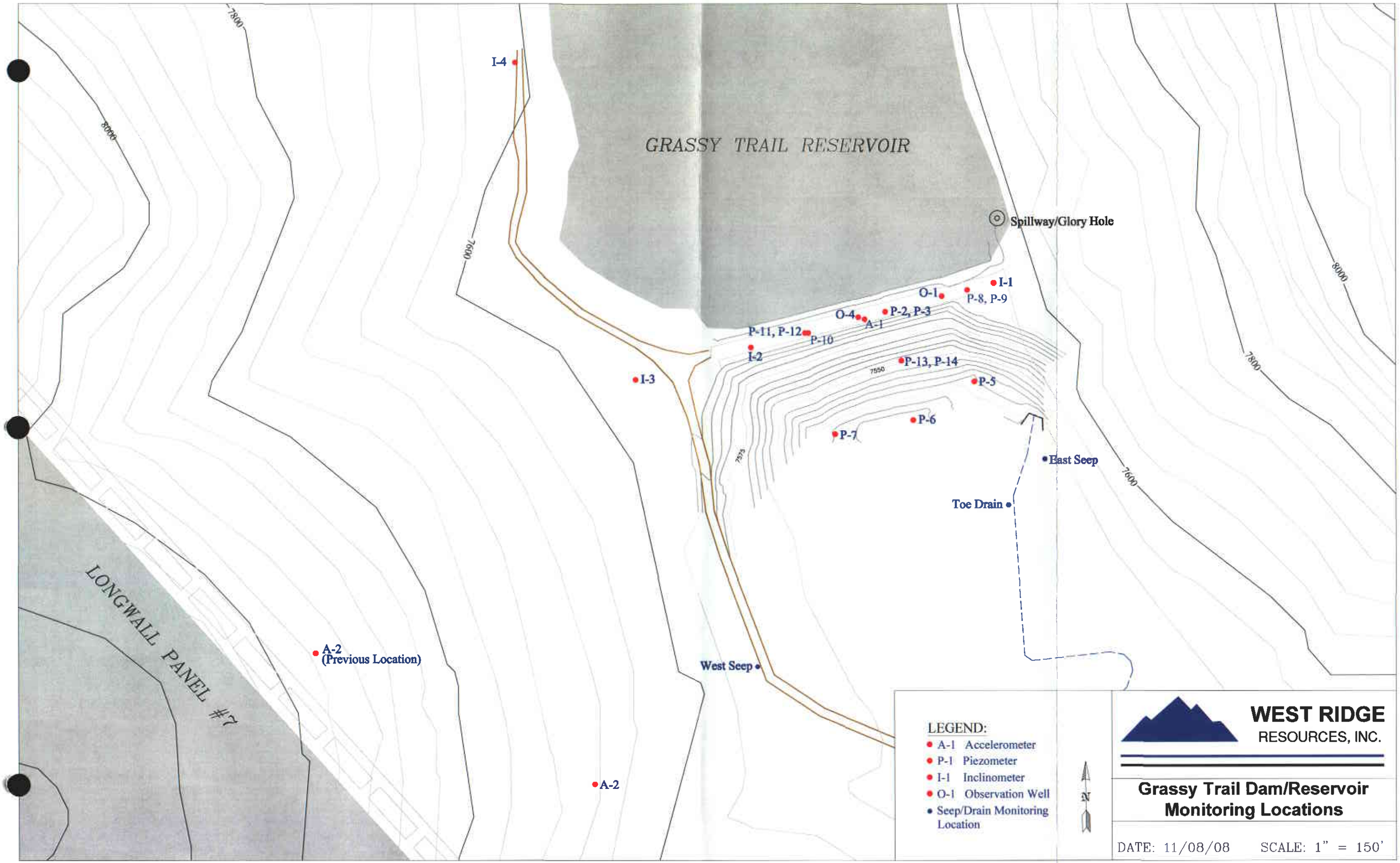
GRASSY TRAIL DAM PIEZOMETER & OBSERVATION WELL READINGS

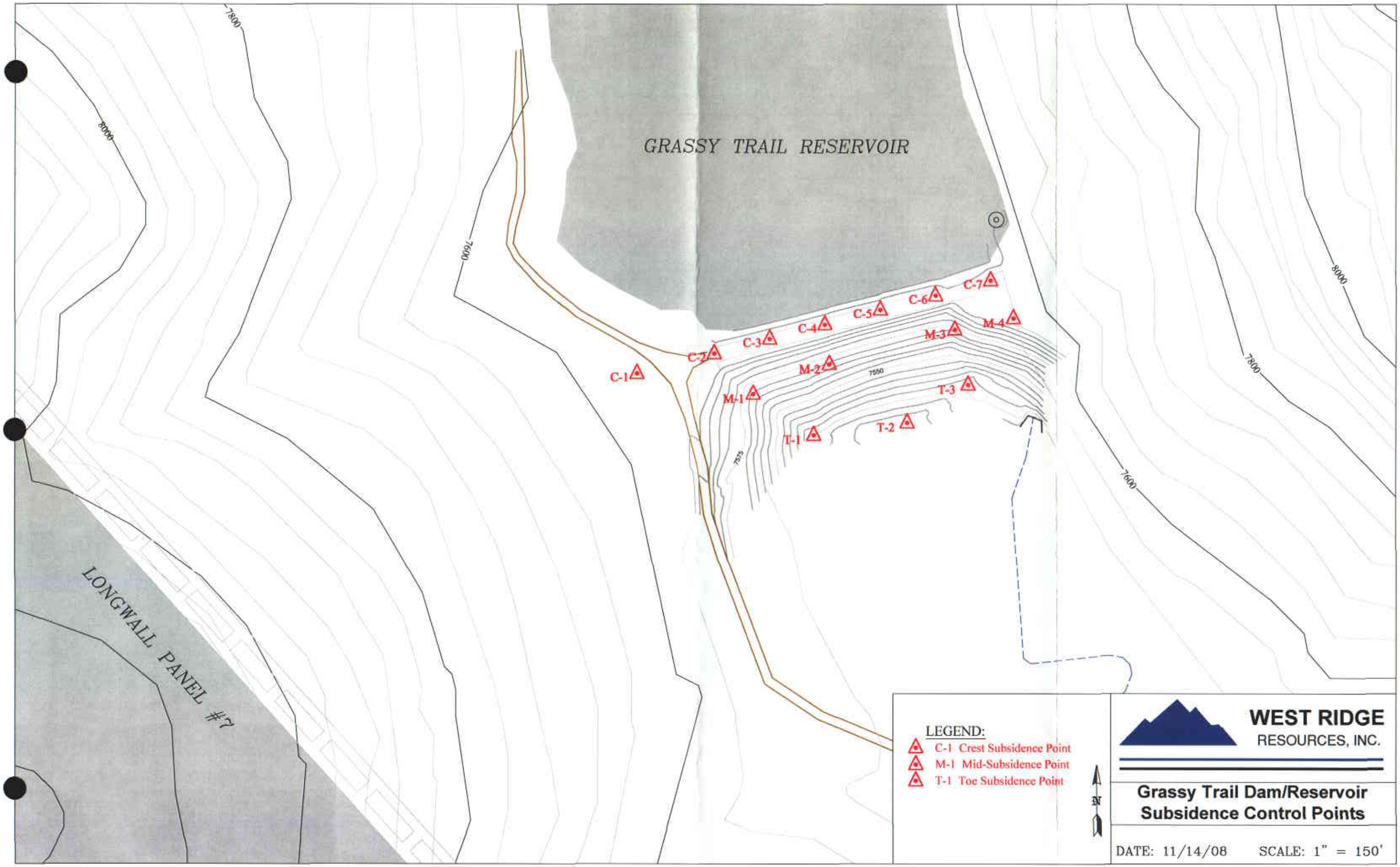
TAKE READING AT RIM ELEV																
			05-2		79-4	98-3		05-4		79-3	05-3A	05-3		98-2	98-4	98-6
			5+62		5+15	4+14		~4+14		3+63	2+77	2+71				
Dam Crest Elev. (ft)	7600.0		PIEZ.	PIEZ.	O.W.	PIEZ.		PIEZ.		O.W.	PIEZ	PIEZ	PIEZ	PIEZ	PIEZ	PIEZ
Spillway Elev. (ft)	7592.5		8	9	1	2	3	13	14	4	10	11	12	5	6	7
Rim Elev. (ft)			7601.5		7601.8	7601.7		7558.9	7558.9	7601.7	7601.8	7601.7	7601.7	7526.8	7512.0	7519.5
Tip Elev. (ft)	(actual)		7554.5	7535.1	7491.8	7525.4	7491.0	7521.0	7499.5	7491.7	7550.8	7572.0	7529.5	7501.5	7479.5	7493.0
Piezometer Location:			CREST	CREST	CREST	CREST	CREST	D.S.SLOPE	D.S.SLOPE	CREST	CREST	CREST	CREST	TOE	TOE	TOE
			EMBANK.	FOUND.	EMBANK/FOUND	EMBANK	FOUND.	EMBANK	FOUND.	EMBANK/FOUND	EMBANK	EMBANK	FOUND.	FOUND.	FOUND.	FOUND.
Date	Initials	Reservoir Elevation	45.75' (47')	65' (64.4')	110'	76.2' (76.3')	110.7'	36.5' (37.9')	58.8' (59.4')	110'	49.5' (51')	28.5' (29.7')	84.0' (72.2')	27.3'	32.5'	26.5'

GRASSY TRAIL DAM SEEPAGE READINGS

Dam Crest Elev. (ft) 7600.0
Spillway Elev. (ft) 7592.5

			SEEP 1	SEEP 2	SEEP 3						
		Seep Location:	TOE DRAIN	LEFT ABUT. (EAST SEEP)	RIGHT ABUT. (WEST SEEP)						
Date	Initials	Reservoir Elevation	(GAL/MIN)	(GAL/MIN)	(GAL/MIN)						


GRASSY TRAIL RESERVOIR
LONGWALL PANEL #7
Spillway/Glory Hole
I-4
I-1
O-1
P-8, P-9
O-4
A-1
P-2, P-3
P-11, P-12
P-10
I-2
P-13, P-14
I-3
P-5
P-6
P-7
East Seep
Toe Drain
West Seep
A-2
(Previous Location)
A-2
8000
7800
7600
7550
7575
LEGEND:
A-1 Accelerometer
P-1 Piezometer
I-1 Inclinometer
O-1 Observation Well
Seep/Drain Monitoring Location
N
WEST RIDGE
RESOURCES, INC.
Grassy Trail Dam/Reservoir
Monitoring Locations
DATE: 11/08/08
SCALE: 1" = 150'


GRASSY TRAIL RESERVOIR
LONGWALL PANEL #7
8000
7800
7600
7550
7575
C-1
C-2
C-3
C-4
C-5
C-6
C-7
M-1
M-2
M-3
M-4
T-1
T-2
T-3
LEGEND:
C-1 Crest Subsidence Point
M-1 Mid-Subsidence Point
T-1 Toe Subsidence Point
N
WEST RIDGE
RESOURCES, INC.
Grassy Trail Dam/Reservoir
Subsidence Control Points
DATE: 11/14/08
SCALE: 1" = 150'

should not pose a significant problem because the coal will be stockpiled in a relatively contained area of the mineyard and all runoff from the site will flow to the sediment pond for containment. At the time of reclamation, the coal will be removed from the site prior to the commencement of any regrading activities. Also, any waste rock generated through underground activities, such as construction of overcasts, will be permanently stored underground and therefore should not be a factor in surface reclamation activities.

623.300 Subsidence Control Plan

Map 5-7 shows the locations of the subsidence monitoring control points proposed for the initial mining area. Refer to R645-301-525 in Chapter 5 for the discussion on subsidence. The geology of the area around Grassy Trail reservoir is discussed in a seismic analysis report (see Appendix 5-11) and the Phase II dam safety report (see Appendix 5-12). These reports conclude that it is unlikely that mining induced seismicity or subsidence will impact the performance of the Grassy Trail Dam and Reservoir. Based on the conclusion of this study the BLM has approved the R2P2 to allow full extraction longwall mining of Panel #7.

R645-301-624 GEOLOGIC DESCRIPTION

624.100 Regional and Structural Geology

The proposed permit area is located in the Sunnyside coal-mining district, an area in the western Book Cliffs on the northern margin of the Colorado Plateau. The proposed permit area is bounded on the southwest by East Carbon Valley and on the northeast by Whitmore Canyon. The permit area is bounded by the existing (abandoned) Sunnyside Mines on the south. Elevations in the area range from 7,000 to 8,500 feet.

The permit area is underlain by north to northeast dipping clastic sedimentary rocks deposited during the Cretaceous and Tertiary period. The regional dip is a result of the effect of the San Rafael Swell located to the southwest.

Professional papers by Osterwald et al. (1981) and Doelling et al. (1979) have described the geology of the region. Kaiser Coal Corporation (1986) has described the geology of the proposed permit area in a previous permit application submitted to the Division of Oil, Gas and Mining during the mid 1980's. Pike Coal Company (1988) has prepared a report describing the geology and coal reserves of the general permit area (in-house report). Sunnyside Coal Company (1993) has described the geology of the coal leases located immediately to the southeast of the proposed permit area. The geologic description that follows is based on information from these sources.

Colton and North Horn Formations within the permit area may discharge as springs in Whitmore Canyon because of the northeasterly dip of the rocks. Due to abundant claystone and mudstone in these formations and the thickness of the interburden between these formations and the mining horizon, mining will not impact groundwater in these horizons.

Adjacent to the permit area, the upper slopes of the east side of West Ridge are the recharge area for Colton Formation groundwater systems that discharge as springs in Whitmore Canyon and contribute base flow to Grassy Trail Creek. These groundwater systems occur in the shallow subsurface and will not be undermined. Mining will have no impact on the recharge and discharge of these springs.

724.700 Not applicable.

R645-301-725 Baseline Cumulative Impact Area Information

Mayo and Associates (1997; Appendix 7-1, 2001; Appendix 7-1A) have analyzed geologic and hydrologic information and prepared a document describing the surface-water and groundwater systems of the permit and adjacent areas. This report contains the information to assess the probable cumulative hydrologic impacts of coal mining and reclamation operations as required by R645-301-729.

The hydrology and geology of the area around Grassy Trail reservoir is discussed in a seismic analysis report (see Appendix 5-11) and the Phase II dam safety report (see Appendix 5-12). These reports conclude that it is unlikely that mining induced seismicity or subsidence will impact the performance of the Grassy Trail Dam and Reservoir. Based on the conclusion of this study the BLM has approved the R2P2 to allow full extraction longwall mining of Panel #7.

R645-301-726 Modeling

No numerical models have been created for the permit area.

R645-301-727 Alternative Water Source Information

The determination of the probable hydrologic consequences (R645-301-728) indicates that the proposed coal mining activities will not result in the contamination, diminution, or interruption of groundwater or surface-water sources within the proposed or adjacent areas. Therefore, WEST RIDGE Resources, Inc. has not prepared information regarding alternative water sources.

would be by pack animals along the remnants of an old existing drill-hole access road. If larger mechanical equipment is needed. Access could be improved as necessary because the surface is owned by the BLM and SITLA and the coal leases held by WEST RIDGE provides for such surface rights. If bentonite sealing proved ineffective, WEST RIDGE would propose the installation of piping to transport stream water across the fracture zone to continue the flow downstream. Any work done in the stream channel would most likely require the issuance of a channel alteration permit from the Utah Division of Water Rights.

Spring Canyon is located in the northern part of the permit area in SITLA lease 44771. There are no state-appropriated water rights on this lease. (Refer to Appendix 7-5 for additional details.) The surface is privately owned by Penta Creek with whom WEST RIDGE maintains coal mining rights. Longwall mining in this area is not scheduled until the year 2014. In this area the coal seam is 2500' deep under the bottom of the Canyon. Spring Canyon, as the name would imply, contains several springs. The drainage area of Spring Canyon is well in excess of one square mile. The canyon supports a number of beaver dams indicative of perennial flow. WEST RIDGE will add three additional monitoring points to collect baseline water monitoring data in Spring Canyon, namely ST-15 located upstream from the junction of Grassy Trail Creek, SP-101 located on a channel-bottom spring a short ways up Little Spring Canyon (a fork of Spring Canyon), and SP-102 located about 1000' upstream from the junction of Little Spring Canyon. This spring emanates from the west side of the canyon approximately 200' up from the canyon bottom. Refer to Map 7-7 and Table 7-1 for details. For the first two years (starting with the third quarter of 2005) these sites will be monitored on a quarterly basis for baseline data according to the field measurements and laboratory measurements outlined in Table 7-2 (Surface Monitoring) and Table 7-3 (Groundwater Monitoring). Thereafter, all sites will be monitored for flow and field parameters on a quarterly basis.

The Grassy Trail Dam and Reservoir is located immediately outside the eastern boundary of the permit area. This dam/reservoir is owned and operated by the cities of East Carbon and Sunnyside, has a storage capacity of 916 acre-feet, and provides most of the culinary water supply to these municipalities. The dam lies approximately 1664' vertically and 995' horizontally away from the nearest point of projected underground mining (longwall panel #7). This equates to 31 degrees, which is greater than the normal angle of draw associated with longwall subsidence. WEST RIDGE Resources has hired R,B&G Engineering to prepare a detailed evaluation report of the potential effects of longwall mining on the dam and reservoir. This evaluation report was reviewed by the Division of Dam Safety, DOGM, Bureau of Land Management, and the cities of East Carbon and Sunnyside. The report analyzed the potential impacts from both subsidence and seismicity associated with full extraction mining, with specific emphasis on panel #7, the

longwall panel projected for mining nearest to the dam. The report concluded that the risk to the dam and reservoir is minimal, and that event the maximum probable seismic event or subsidence scenario would be well within the safety factor of the dam. In addition, there are no known faults that intercept the dam that could be encountered in the mining of Panel #7. The Division of Dam Safety, the BLM, and the cities of East Carbon and Sunnyside have all accepted the conclusions of the report. This report (Grassy Trail Dam and Reservoir Seismicity Report) is included in Appendix 5-11. This report also includes as an appendix an independent report prepared by Agapito Associates (Estimated Impacts to the Grassy Trail Reservoir due to Longwall Mining) which addresses the potential effects on the dam/reservoir due to longwall induced subsidence. A companion report (Grassy Trail Dam & Reservoir Phase II Dam Safety Study) is included as Appendix 5-12. WEST RIDGE has committed to an intensive program of monitoring of the dam and reservoir during the mining of Panel #7. This monitoring plan is outlined in section 301-114.100 of this Mining & Reclamation Plan and is included indetail in Appendix 5-13.

728.320 Presence of acid-forming or toxic-forming materials

Acid-forming materials in western coal mines generally consist of sulfide minerals, namely pyrite and marcasite, which, when exposed to air and water, are oxidized causing the production of H^+ ions (acid). Oxidation of pyrite will occur in the mine; however, acidic waters will not be observed in the mine. The acid is quickly consumed by dissolution of abundant, naturally occurring carbonate minerals. Iron is readily precipitated, as iron-hydroxide, and excess iron will be not observed in mine discharge water.

No other acid-forming materials or any toxic-forming materials have been identified or are suspected to exist in materials to be disturbed by mining.

728.331 Sediment yield from the disturbed area

Undisturbed drainage from C Canyon upstream from the mine yard facility area will, for the most part, be culverted underneath the mine site by means of a 4' diameter corrugated metal pipe in the right fork and a 3' diameter culvert in the left fork drainage. This culvert has been sized to meet or exceed the design storm for this drainage area. Runoff from the mine site disturbed area and whatever natural runoff which flows onto the disturbed area will be channeled to the mine site sediment pond. The drainage control system for the mine site is shown on Map 7-2.

The culvert and ditch system is designed to handle drainage from a 10 year, 24 hour event. Any storm event that exceeds this amount will flow through the mine yard

drainage structures to the sediment pond. If a storm should exceed the design event and the magnitude of the runoff exceeds the pond capacity, the over flow will be channeled through the pond cells and out the emergency spillway to the natural drainage channel below the sediment pond. This overflow will have a lower suspended solid content than the inflow to the pond or any drainage which may be flowing down the natural drainage channel. The sediment pond will detain the inflowing water and allow suspended solids to settle out in the pond cells prior to discharge. Given the ephemeral nature of the drainages and the fact that the sediment pond is designed for the complete retention of the 10 year, 24 hour storm event, it is unlikely that discharge from the sediment pond will occur very often if ever. Since the sediment pond is designed to completely contain the 10 year, 24 hour event, only a limited amount of outflow, that in excess of the design event, would be discharged. Excess water contained in the sediment pond following runoff events would be

728.334 Groundwater and surface water availability

Mining in the permit area will not significantly affect the availability of groundwater. Groundwaters in the Blackhawk Formation exist in highly compartmentalized partitions, both vertically and horizontally, and the formation does not act as a hydraulically continuous aquifer. Groundwater systems in the Blackhawk Formation are hydraulically isolated from overlying, modern groundwaters. The effects of locally dewatering the Blackhawk Formation adjacent to mine openings will not have any significant impact on groundwater availability in the region surrounding the mine.

There are no groundwater supply wells in the mine lease area or adjacent to it. The removal of water from horizons immediately above and below the mined horizon will not impact any water supplies. Rather, underground mining makes water available from the Blackhawk Formation that was previously inaccessible.

728.400

The hydrology and geology of the area around Grassy Trail reservoir is discussed in a seismic analysis report (see Appendix 5-11) and the Phase II dam safety report (see Appendix 512). These reports conclude that it is unlikely that mining induced seismicity or subsidence will impact the performance of the Grassy Trail Dam and Reservoir. Based on the conclusion of this study the BLM has approved the R2P2 to allow full extraction longwall mining of Panel #7.

R645-301-729 CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

The Division will provide an assessment of the probable cumulative hydrologic impacts of the proposed coal mining and reclamation operation and all anticipated coal mining and reclamation operations upon surface and groundwater systems in the cumulative impact area.

R645-301-730 OPERATION PLAN

R645-301-731 GENERAL REQUIREMENTS

A plan has been included to minimize disturbance to the hydrologic balance, to prevent material damage, and to support postmining land use.

731.100 Hydrologic Balance Protection

Groundwater Protection

Although testing has shown that no significant impacts from acid or toxic producing materials should occur, groundwater quality will be protected by handling runoff in a manner which minimizes the infiltration into the groundwater system. Examples of techniques that may be utilized to accomplish this would include routing disturbed area drainage to the sediment pond through properly sized ditches and culverts and diverting undisturbed drainage through a bypass pipe past the disturbed area.

Within the disturbed area, drainage will be directed to ditches by sloping the yard areas. The ditches will be appropriately sized to handle flow from the 10 year/24 hour event. Culverts within the drainage system have also been sized to meet or exceed the 10 year, 24 hour design criteria.

Surface Water Protection

Coal mining and reclamation activities will be conducted according to the following plan.

The sediment pond will be installed as soon as possible during construction of the surface facility area. The pond will be appropriately sized to handle the design storm event (10 year, 24 hour) for the mine site.

Protection of surface water will incorporate measures cited under Groundwater Protection. All surface runoff from the mine site disturbed area will be diverted to the sediment pond for treatment. The sediment pond has been designed to provide total containment for the 10 year/24 hour storm plus three years of sediment accumulation. Based on sampling of the soils in the area and the fact that waste rock material will not be stored on the surface, it is unlikely that the sediment pond will impound acid- or toxic-drainage.

It is anticipated, based on the climate of the area, that the sediment pond will remain dry most of the time. (This has been demonstrated to be true for existing coal mining operations in central Utah.) Water in the pond should evaporate rapidly following precipitation events. Infiltration into ground water zones is not expected because of the interbedded nature of the strata below the pond. Thick sequences of shale in the bedrock below the pond will greatly limit the vertical movement of water. Also, the alkaline nature of other sediment flowing to the sediment pond would serve to neutralize any low pH materials when mingled together.

To minimize disturbance to the undisturbed drainage, large diameter bypass culverts will be installed beneath the mine yard facility to allow runoff upstream above the mine site to continue downstream without coming in contact with and becoming contaminated by the mine yard area.

WEST RIDGE MINE

007/041

MINING AND RECLAMATION PLAN

APPENDIX 5-11

GRASSY TRAIL DAM & RESERVOIR
MINING-INDUCED SEISMICITY REPORT

APPENDIX 5-12

GRASSY TRAIL DAM & RESERVOIR
PHASE II DAM SAFETY REPORT

APPENDIX 5-9

GRASSY TRAIL DAM & RESERVOIR MINING-INDUCED SEISMICITY REPORT (R, B, & G ENGINEERING)

RB&G
ENGINEERING
INC.

August 5, 2005

John C. Lewis
West Ridge Resources, Inc.
P.O. Box 1077
Price, UT 84501

Subject: Grassy Trail Dam and Reservoir
Mining-Induced Seismicity

Gentlemen:

A Mining-Induced Seismicity Study has been completed for the Grassy Trail Dam and Reservoir in Carbon County, Utah. The results of the study are summarized in the report transmitted herewith. Personnel involved in preparation of this report include the following:

Bradford E. Price, Principal Geotechnical Engineer
Michael N. Hansen, Professional Geologist
S. Robert Johnson, Engineer
Marc K. Stilson, Professional Engineer

We appreciate the opportunity of providing this service for you. If there are any questions relating to the information contained herein, please call.

Sincerely,

RB&G ENGINEERING, INC.

REGISTERED PROFESSIONAL ENGINEER
NO.162291
BRADFORD E. PRICE
8/5/05
STATE OF UTAH

Bradford E. Price, P.E.

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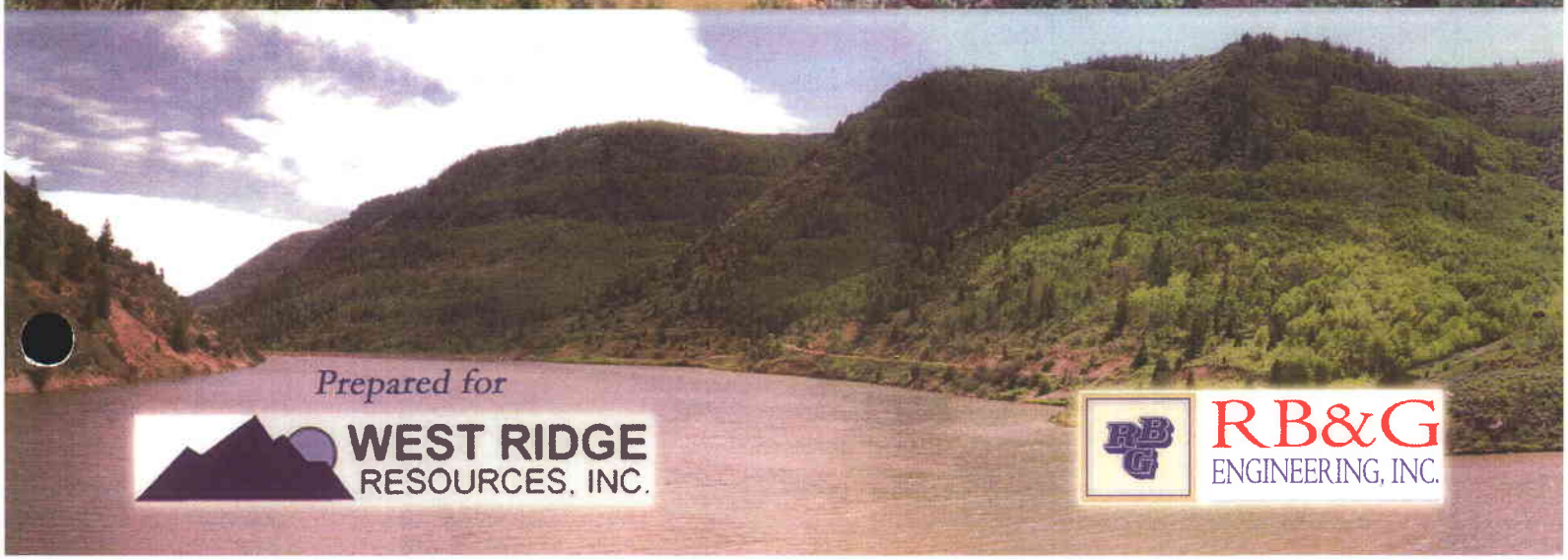
Grassy Trail Dam and Reservoir

Mining-Induced Seismicity

July 2005



Prepared for

WEST RIDGE RESOURCES, INC.

RB&G ENGINEERING, INC.

MINING-INDUCED SEISMICITY
NEAR GRASSY TRAIL DAM AND RESERVOIR
Carbon County, Utah

Evaluation and Monitoring

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SLOPE STABILITY ANALYSIS RESULTS

DEFORMATION ANALYSIS

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MINING-INDUCED SEISMICITY NEAR GRASSY TRAIL DAM AND RESERVOIR

Carbon County, Utah

Evaluation and Monitoring

I. INTRODUCTION

West Ridge Resources contracted with RB&G Engineering to provide engineering services related to the evaluation and monitoring of mining-induced seismicity (MIS) at the Grassy Trail Dam and Reservoir. RB&G Engineering performed a Dam Safety Study for the owner of the Grassy Trail Dam in 1979. In 1998, RB&G Engineering provided geotechnical engineering services relating to the Phase II Dam Safety Study for Creamer & Noble Engineers, requested by the Utah State Division of Water Resources. These services included installing instrumentation (piezometers and inclinometers) to allow monitoring of the embankment.

Agapito Associates, Inc. prepared a report for West Ridge Resources in November 2004 evaluating the estimated impacts to the Grassy Trail Reservoir due to longwall mining, which includes the anticipated ground deformation at or near the reservoir. A copy of the Agapito report is included in the appendix.

The purpose of this report is to further assess the risk to the dam and reservoir associated with the proposed longwall mining plan. The evaluation included a review of the geologic setting, reservoir construction, and previous dam safety studies. Anticipated ground motions were determined based on regional historical seismicity and site specific conditions. Using data obtained, embankment slope stability and deformation analyses were performed for the dam along

with an evaluation of the potential for (1) internal erosion of embankment materials, (2) increased seepage from the reservoir, and (3) additional landslide activity along the perimeter of the reservoir.

The project area is shown on the vicinity map in Figure 1. It will be noted that the Grassy Trail Dam and Reservoir is located in the Book Cliff Mountains in eastern Utah about seven miles north of Sunnyside, Utah. The dam is located in Section 7, Township 14 South, Range 14 East, Salt Lake Base and Meridian. The multi-zoned earth embankment structure was completed in 1952 and is 89 feet high, with a crest length of about 600 feet. The reservoir supplies culinary water to the towns of Sunnyside and East Carbon, Utah. The reservoir has a storage capacity at the spillway crest of about 916 acre feet.

Figures 2 and 2A show the location of the proposed longwall extraction area in relation to the reservoir. The sections shown in Figure 2A are presented in Figures 3A and 3B. It will be observed from Figure 3B (Cross Section B-B) that the nearest proposed mined area will be 1664 feet below and 995 feet right (1939 feet hypocentral distance) from the right abutment of the dam.

II. GEOLOGY

A. REGIONAL GEOLOGY

The dam site is within the Roan Cliffs region northeast of the Book Cliffs, which are within the Colorado Plateau Physiographic Province. These mountains were formed along the northern flank of a large structural anticline known as the San Rafael Anticline, which includes the physiographic feature known as the San Rafael Swell. There is no strong evidence for the precise age of the swell, but it is believed to have formed sometime during the late Cretaceous to mid Tertiary times, 40 to 60 million years ago. The San Rafael Swell is located about 50 miles south of the dam site. Much of the center of the anticline has been removed by erosion, which exposed the softer underlying Mancos Shale. The resistant sandstone of the Book Cliffs now forms the northern extent of the highly eroded portion of the anticline.

B. SITE GEOLOGY

Grassy Trail Reservoir is located at the junction of the left and right forks of Whitmore Canyon. The dam and reservoir are located on the Colton Formation laid down during the Tertiary Period, Eocene and Paleocene Epochs, about 38 to 56 million years ago. The formation consists of dark-reddish-brown to green beds of mudstone and shaly siltstone interbedded with yellowish to grayish-orange and grayish brown, thin, fine to medium grained quartzose sandstone, with sparse limestone beds. The formation is primarily of alluvial origin with some marginal lacustrine and deltaic deposits (Weiss and others, 1990). Bedrock appears to dip gently to the northeast at an angle of about 7 to 8 degrees. Previous studies at the dam have mentioned that the mudstones throughout the area appear to be fairly massive, while the sandstone rimrocks are broken by two sets of joints that parallel the strike and dip direction of the bedrock (RB&G, 1979).

The West Ridge Coal Mine is located within about a four square mile area just southwest of the dam. Current mining plans propose mining toward the northeast and ending within a surface distance of about 1,000 feet of the dam (Figure 2A). Mining in this area is done by

retreating longwall panels. The coal seam being mined is the Lower Sunnyside Seam, which is located in the Black Hawk Formation.

The Blackhawk Formation was deposited during the Upper Cretaceous and consists predominantly of light-brown, locally light-gray, thin- to medium-bedded, fine- to medium-grained quartzose sandstone, interlayered with shaley siltstone, shale, carbonaceous shale, and several coal seams (Weiss et al, 1990). In this area, maps show the Blackhawk Formation to be bound by the Castlegate Sandstone Formation above, with the Blue Gate Member of the Mancos Shale below (Weiss et al, 1990).

Maps of the West Ridge Mine show the coal seam within the area to vary from 7 to 9 feet thick, with 8 feet being the predominant thickness. A West Ridge map shows bedrock dipping down to the northeast at about 7-8 degrees (12 to 15%) with a strike of about North 43 degrees West. Due to this northeasterly dip, some coal seams within the Blackhawk Formation pass beneath the dam at a depth of about 1,685 feet (West Ridge Mine core log for drill hole H-31).

The Lower Sunnyside coal seam is underlain by a competent sandstone floor. Bedrock directly above the seam appears to vary from sandstone, shale/mudstone and sandstone with interbedded mudstone layers. Above the ceiling are more interbedded layers of sandstone and shale, which also include the Upper Sunnyside Seam, which is not being mined (West Ridge Mine core log for drill hole H-31).

The Agapito study shows that the predominant orientation for joints in bedrock above the coal seam averages about N 75 degrees W. This report states that the joints in the Blackhawk Formation have been observed to be nearly vertical and discontinuous and rarely penetrate more than a few beds. No major faults have been mapped in the immediate vicinity of the existing dam. A map of the West Ridge Mine shows a normal, down to the west, fault trending to the northwest about 3/4 miles southwest of the dam. This fault trends approximately N 30 degrees W. The fault is described as a scissor fault with increasing displacement toward the southeast. Within the mine the fault has displacements ranging from

0 at the northeast to about 5 feet toward the southeast. Due to the fault, mining within Panels 4 and 5 was modified to lessen the impact on the longwall operations.

The 1979 RB&G report references a map, prepared by other investigators, of the geology for Grassy Trail Reservoir. This map identifies two small faults located about 1 to 2 miles west of the dam, and appear to be near vertical with trace lengths less than two miles long.

III. SITE CONDITIONS

The characteristics of the Grassy Trail Dam are described in the 1979 Dam Safety Study. A profile along centerline and maximum section through the dam are presented in Figure 5 of the 1979 RB&G report and included in the appendix of this report. It will be noted from the cross section that the design intent was to construct a zoned embankment with the interior zone consisting of impervious material transitioning to more pervious material in the outer zones. From sketches of the foundation grouting plan and final cross sections, it appears that the cutoff trench extends to bedrock, with the foundation consisting predominantly of layers of sandy clay with gravel and clayey gravel with sand.

Also included in the appendix are the results of 5 test borings drilled along the crest of the embankment during the 1979 study, 7 piezometer and inclinometer borings drilled in the abutments, crest, and downstream toe in 1998, and 4 borings drilled in 2005. The 2005 borings included one inclinometer boring on the west rim of the reservoir, two piezometer borings on the dam crest, and one piezometer boring midway down the downstream slope. The location of the piezometer and inclinometer borings is shown in Figure 4. The borings document the relatively impervious nature of the inner zone, with materials classifying predominately as lean clay (CL) type soil. The 2005 boring placed in the outer downstream zone showed this material to be more random, consisting of layers of lean clay (CL), clayey sand (SC) and clayey gravel (GC). The results of investigations performed to date indicate that granular layers in the foundation are generally in a relatively dense condition, with pockets of loose material which do not appear to be continuous, and liquefaction during a seismic event is considered unlikely at this site.

Also shown on the site plan in Figure 4 are the location of survey points within the slide areas on the left and right abutments and above the reservoir, and the location of seismic monitoring instruments. Included in the appendix are tables showing the coordinates and elevations of each survey point taken in July 2004 and July 2005.

Reported survey elevations for the dam have varied significantly since original construction was completed in 1952. The initial plans and construction documents show the dam crest at elevation

7620 feet, with the spillway at 7616.37 feet. The Phase I Inspection Report (RB&G 1979) indicated that the dam crest appeared to have been raised in the past by about one foot over the original crest elevation, resulting in a crest elevation of 7621 feet. The 1972 USGS 15-minute topographic map of the Sunnyside Quadrangle shows the spillway elevation at 7580 feet. Surveys performed in 1999 by Creamer & Noble Engineers show the dam crest elevation at 7600 feet, with the spillway at 7592.5 feet. Cross sections provided by West Ridge Resources show the dam crest at 7591 feet with a high water elevation of 7585 feet. The Utah Division of Water Rights Dam Inventory currently lists the crest elevation as 7600 feet. In this report, the dam crest elevation is assumed to be 7600 feet, with the spillway at elevation 7592.5 feet. It should be noted that some figures and some data included in the appendix of this report were copied from previous studies, and the elevations shown on the figures correspond to the elevation datum used in each study.

Included in the appendix are the results of piezometer readings performed from March 1998 through July 2005. This information has been used in stability analyses performed during this study.

A. LANDSLIDE HAZARD

Evidence of slope instability exists over a significant area of the west or right abutment (right and left are relative to a view looking downstream). As shown on Figures 4 thru 4D, this area extends both upstream and downstream from the axis of the dam. Photos of the slides are shown in Figure 4B. Movement at this location was reported to have occurred after the dam was constructed. An access road which cuts into the slope along the right (west) abutment appears to be responsible for some of the movement in this area. In the past, slides have occurred along this roadway.

Landslides on the right abutment and west rim of the reservoir did not show signs of recent movement during our site reconnaissance in the summer of 2004 and 2005; however landslide scarps appear to be significantly larger than the earlier descriptions in the 1960's reports. Personal communications with employees of the City of East Carbon (Dale Andrews, Mayor / Mick Dickson, Water Department) that some movements may have taken place during the wet years around 1984. They indicated that since the first few years after the

reservoir filled movement along the west rim has been related to material from above sliding down onto the road. There has not been any reported movement of the road itself moving toward the reservoir. Slides have also been documented on the left abutment. Overburden was removed from the hillside above the spillway in the 1990's (personal communication with Dale Andrews) to prevent rock fall or slide debris from damaging the Morning Glory spillway. Based on field investigations during 2005, large-scale landslides on the left abutment (east) do not appear to show signs of recent movement. The most significant slide on the east side is a wet area with a small slump located along the east side of the outlet conduit downstream of the dam.

Inclinometers were installed on the crest of the dam near the left and right abutments and on the hillside immediately west of the right abutment in 1998. Keeping in mind that the normal accuracy of an inclinometer survey is ± 0.3 inches per 100 feet, readings taken through July 2005 do not show significant movement since installation. Copies of the inclinometer graphs are presented in the appendix. In addition to the inclinometers, survey points have also been placed at various locations within the potential slide areas and a review of the survey data gathered in 1999, July 2004, and July 2005 is presented in Section VI.D.

In order to further evaluate the west rim landslide, an additional inclinometer was installed in the northwestern portion of the landslide in February of 2005 at the location shown in Figure 4. This inclinometer (I-4) was installed along the road cut near the maximum section of this northwesterly landslide in an area that appears to have had some sloughing of the slope. Due to the abnormally wet winter and spring this year (2005), naturally flowing seeps and springs have been more active. An area located between 15 to 77 feet south of Inclinometer #4 as shown in Figure 4A identifies a very wet slope with several flowing springs. A close up view of this area is shown on the photos in Figures 4C and 4D. While it has not been documented with instruments, the alluvium on the steep slope in this area appears to have some eastward movement. It should be noted that these springs are about in line with another spring noted in 2004 further up slope. During field reconnaissance in June 2005 this upper spring only flowed about 20 feet before the water seeped back into some cracks in the ground. This may be the same water that resurfaces down slope just above the road. The inclinometer (I-4) located just north of this wet area shows a very slight movement toward the northeast of about 0.04 inch. As shown on the inclinometer survey profile in the appendix, the total overall movement has been very small but gradually increasing during the five months of monitoring between 2/16/05 and the most recent reading on 7/13/05. It should be noted that reading on 7/13/05 showed some back to vertical movement along the north-south axis.

The depth of movement begins at the reading at 62 feet below the top of the inclinometer casing, which is equal to a depth of about 59 feet below ground surface. The boring log for Test Hole 05-1 (I-4) shows the material at about 59 feet to consist of red and green mudstone with a soft clay layer near 59 feet. This clay layer may represent a failure surface. Although this magnitude of movement is below the instrument accuracy, due to the apparent gradual increase in movement which is occurring at a distinct depth near 62 feet, it is our opinion that this inclinometer should be monitored frequently. Analysis of potential impacts from landslide movement is discussed in Section VI.D. of this report.

IV. MINING INDUCED SEISMICITY

Peak ground accelerations at Grassy Trail Dam are based on correlations between magnitude vs distance from the site. As mining gets closer to the dam, acceleration values are expected to increase.

Numerous factors influence the seismicity associated with longwall mining including the lithology and characteristics of bedrock above and below the coal seam, the strength and thickness of the coal seam, and the depth of cover above the seam. Also, the mining methods used may influence the MIS, including extraction rates, and the width and placement of panels and pillars, etc.

A joint agency study by members of the University of Utah Seismograph Stations, U.S. Bureau of Reclamation Seismotectonics and Geophysics Group, University of Utah Department of Mining Engineering, the U.S. Geological Survey was conducted on the potential ground motion shaking hazards at Joes Valley Dam due to the MIS in the Cottonwood Coal Tract at Trail Mountain Mine. At this time the study consists of several separate and combined reports of which some final reports are currently under review. Although these studies were specifically for the Trail Mountain-Joes Valley Reservoir area, much of the information gathered was taken from an overall study of the geologic conditions and MIS in the Wasatch Plateau and Book Cliffs (WP-BC) mining region. While this overall mining region is about 50 miles wide, the general geologic conditions and bedrock formations are the same. Seismicity maps show the area as a horseshoe shaped feature due to the MIS. With this in mind, information gathered during these previous detailed studies have been directly applied to this Grassy Trail investigation, where appropriate.

A. MINING INDUCED EARTHQUAKE MAGNITUDE

In assessing the potential earthquake magnitude for this project, we have considered historical earthquake data from three principal areas within the Wasatch Plateau-Book Cliffs (WP-BC) mining region.

(1) Grassy Trail Reservoir/West Ridge Mine

For this project, the University of Utah Seismograph Stations (UUSS) sorted their earthquake catalog for the Grassy Trail Dam/West Ridge Mine area bounded by latitude 39.6438 to 39.5709 degrees North and longitude 110.4575 to 110.3655 degrees West. The sorted data revealed a total of 100 events recorded since 1962, ranging in magnitude from 1.2 to 3.2. In a memo to RB&G Engineering (included in the appendix), the UUSS researchers indicated that none of the sorted events could be positively excluded from the list as not being mining related (Arabasz and Burlacu 2004).

In August 2003, UUSS began continuous seismic recording at station BCE located above the West Ridge Mine, providing digital accelerographic recordings for mining-induced seismicity at the mine. Seismic events recorded at station BCE since August 2003 to July 2005 have not exceeded 2.0 in magnitude.

(2) Willow Creek Mine

The Willow Creek Mine is located approximately 45 km (28 miles) northwest of Grassy Trail Reservoir. A magnitude 4.2 seismic event was recorded in March 2000 near the Willow Creek Mine. While some uncertainty exists as to the source of this event, the 4.2 earthquake is currently considered the maximum mining-induced magnitude that has been documented by instruments in Utah since 1962 (Arabasz et al. 2002).

(3) Joe's Valley Reservoir/Trail Mountain Mine

The Trail Mountain Mine is located about 75 miles southwest of Grassy Trail Reservoir. This area was the subject of detailed seismic analysis by McGarr and Fletcher (2005), Arabasz et al. (2002, 2005) and others to assess potential hazards at Joe's Valley Dam induced by mining in the Cottonwood Tract.

Arabasz et al. (2002, 2005) assessed the probable maximum magnitude earthquake for mining-induced seismicity in the Joe's Valley/Trail Mountain area. With consideration of topography, depth of cover, tectonic structures, potential mining methods, and historical

mining-induced seismicity data, the authors developed an "informed consensus" probability distribution. The distribution employed upper and lower bounds of 4.6 and 2.7, respectively, with a mode of 3.1. The upper bound of 4.6 allowed for the possibility of a 4.2 event similar to the Willow Creek event, plus some necessary conservatism due to uncertainties regarding that event. For engineering analysis, the researchers proposed using the 84th percentile value of the cumulative distribution function, which corresponds to a probable maximum magnitude of 3.9.

Dr. Arabasz (Arabasz and Burlacu 2004) has suggested that a probability study for the Grassy Trail/West Ridge Mine area would likely employ the same lower and upper bounds and mode as the Joe's Valley/Trail Mountain study and would likely arrive at virtually the same conclusion. Based on these recommendations, we have selected 3.9 as the probable maximum earthquake for engineering analysis.

It should be emphasized that the probable maximum 3.9 magnitude represents the largest anticipated event based on an "informed consensus" probability distribution, and that recorded MIS events in the vicinity of Grassy Trail Reservoir have historically had much lesser magnitudes. The largest recorded magnitude in the Sunnyside mine area (records available from 1962 to 2004) was 3.2. The magnitude 3.2 event in 1981 had a source depth of about 6 km (3.7 miles) and may not have been mining related. No MIS event exceeding magnitude 2.0 has been recorded in the area since the West Ridge Mine began operations in May 2001. It should be noted that earthquake magnitudes are measured relative to energy on a base-ten logarithmic scale, meaning that each whole-number increase in magnitude indicates a ten-fold increase in energy. In other words, the energy release from a magnitude 3.0 event is 10 times the energy from a magnitude 2.0 event.

B. PEAK GROUND ACCELERATION

Assuming a probable maximum magnitude of 3.9 originating from the location of the nearest proposed mining panel (hypocentral distance of approximately 0.59 km (1,939 ft.) from the Grassy Trail Dam), the next task was to estimate the anticipated peak ground acceleration

resulting from this event. While many empirical ground motion attenuation relationships exist, most of these were developed primarily from event magnitudes greater than 4.0 and based on ground accelerations recorded at distances greater than 1 km (0.62 miles) from the seismic source. For the relatively low magnitudes and small hypocentral distances involved in the Grassy Trail study, the available relationships result in widely varying PGA values.

Noting that existing prediction equations were unsuitable for low-magnitude, near-source events, McGarr and Fletcher (2005) revised the general ground motion equation to fit mining-induced seismicity in the Joe's Valley/Trail Mountain area. The regression considered seismic data recorded near Trail Mountain, along with the magnitude 4.2 event recorded at Willow Creek.

McGarr and Fletcher noted a good correlation between their new PGA relationship and both the SEA '99 (Spudich et al. 1999) and the Joyner-Boore (1993) equations for a magnitude 4.0 event at distances less than 1 km (0.62 miles). For a consistent comparison at close distances, McGarr and Fletcher used the hypocentral distance for the distance parameter in all of the equations, acknowledging that the SEA'99 and Joyner-Boore relationships were not intended for direct use of hypocentral distances.

Based on the relatively low magnitudes, small distances, geological conditions, and mining focus entailed in the McGarr/Fletcher relationship, it is our opinion that this equation will give the best approximation of peak ground acceleration for the Grassy Trail area. Accelerations calculated from this relationship for various event magnitudes and distances are shown in Figure 5. The hypocentral distance between the right abutment of the dam and Panels 5 through 7 is noted on this figure. The figure shows that the maximum considered event of magnitude 3.9 at the minimum considered distance of 0.59 (Panel 7, as close as 1939 ft to the dam) will result in a PGA of about 1.07g at the dam.

The University of Utah initiated continuous digital accelerographic recording on August 26, 2003 at station BCE located above the West Ridge Mine. At present, twelve digital accelerographic recordings are available from this station. The records are for event

magnitudes in the order of 1.5 to 2.0 at epicentral distances of 1 to 3 km (0.62 to 1.86 miles). Values calculated from the McGarr/Fletcher relationship appear to agree relatively well with the peak horizontal ground accelerations measured from these events. It should be noted that the events were relatively minor and estimated site-to-source distances were subject to significant error. At this time, we have limited data with which to verify the applicability of the equation to the Grassy Trail site, and no data for the maximum anticipated events in the 3.5 to 4.0-magnitude range. It is our opinion that the McGarr/Fletcher equation is the most appropriate available relationship for the magnitudes, distances, source type, and geologic conditions anticipated at Grassy Trail and that the maximum PGA for engineering analysis should be in the order of 1.07g with a 3.9 magnitude. It should be noted that a mining induced event of this magnitude will produce motions having shorter duration and fewer cycles than a higher magnitude event.

C. SEISMIC MONITORING

In September 2004, two Instantel MiniMate Plus (standard triaxial geophone) seismic monitoring instruments were installed at the Grassy Trail Reservoir study area. These two monitoring units were installed so that information could be gathered on the frequency of seismic events and the peak ground acceleration values generated at various distances from the areas of longwall mining. An additional objective was to evaluate how the recorded events correlated with seismic events reported by the University of Utah Seismograph Stations (UUSS).

Unit #BE9690 was installed on the crest of the dam near the maximum section as shown in Figure 4. The second unit #BE9698 was installed on the hillside about 900 feet west of the right (west) abutment at an elevation of about 7900 feet. The location for this unit was chosen so that it would be at a similar hypocentral distance to the mining of Panel #6 as the dam would be to the proposed mining of Panel #7 in 2006. Based on the information gathered during the mining of Panel #6, it is anticipated that similar types of peak ground accelerations (PGA), frequency and durations of events will occur for Panel #7. This monitoring shows the expected seismicity that is being generated by the mine, but does not

reflect extreme events that may occur from a hypothetical 3.9 magnitude mining induced seismic event.

The two instruments were set up on September the 11, 2004. The actual monitoring of events on the hillside did not begin until after January 1, 2005 with the first mining induced event recorded on January 21, 2005. The instrument on the dam crest had setup problems and did not begin monitoring until February 22, 2005.

Between January and July 14, 2005 the hillside unit, which was located closer to the mine, recorded 398 seismic events, while the unit on the dam only recorded 25 events. In addition to the increased distance from the mine to the unit on the dam, other factors may have contributed to the reduced number of events recorded on the dam. These factors include damping caused by various types of material and saturated soils in the foundation and embankment at the dam. Copies of the MiniMate readings, along with selected printouts of the waveforms for the earthquakes documented by the UUSS and readings recorded on both units, are included in the appendix. Some of these readings have been edited to remove manmade events caused while moving around the instruments. Some waveforms for several manmade events are also included in the appendix for comparison. It should be noted that, while both units were setup with the same trigger level, the hillside unit was much more susceptible to recording manmade movements than the unit located on the dam. This may be due to the near surface bedrock interface on the hillside.

It should be noted that the clock on the MiniMate units did not keep accurate time and needed to be synchronized after each download. At one time the units were about 15 minutes slow, which accounts for variation in the times recorded on the units versus the time shown on the UUSS seismogram data.

As mentioned earlier, the monitoring unit on the dam crest only recorded 25 mining induced events along with a few manmade events. All of the actual seismic events were also recorded on the hillside unit, which helped to verify the validity of these events.

Between January and July 13, 2005, 15 seismic events/earthquakes were documented by the University of Utah Seismograph Stations (UUSS) within the general area of the West Ridge Mine. The following table summarizes these events, along with the PGA values recorded on the Hillside and Dam monitoring units. The table shows that not all events were recorded by both units. Copies of the UUSS reports and the MiniMate recordings are included in the appendix of this report.

Date	MST	Lat	Long	depth	mag	dist				Monitoring Unit PGA (g) Hillside	Dam
2/5/05	15:58:44	39.62N	110.37W	4.4	**1.6**	4.7mi	N	Of	Sunnyside	0.0149	Nr
2/7/05	14:42:19	39.61N	110.40W	0.1	**1.6**	3.9mi	NNW	Of	Sunnyside	0.0149	Nr
2/8/05	21:30:43	39.60N	110.40W	0.6	**1.6**	3.8mi	NNW	Of	Sunnyside	0.0149	Nr
2/23/05	12:28:38	39.60N	110.40W	0.6	**1.7**	3.6mi	NNW	Of	Sunnyside	0.0182	Nr
3/24/05	18:02:00	39.61N	110.40W	0.7	**1.7**	4.1mi	NNW	Of	Sunnyside	0.0199	0.00663
4/2/05	16:36:56	39.60N	110.40W	0.9	**1.8**	3.7mi	NNW	Of	Sunnyside	0.0166	0.00829
4/22/05	11:52:15	39.61N	110.395W	0.5	**1.6**	4mi	N	Of	Sunnyside	0.0166	Nr
4/25/05	9:20:06	39.62N	110.38W	0.1	**1.7**	4.5mi	N	Of	Sunnyside	0.0133	Nr
4/27/05	15:22:25	39.61N	110.40W	0.6	**1.8**	3.9mi	NNW	Of	Sunnyside	0.0166	0.00663
4/29/05	21:40:58	39.61N	110.38W	0.1	**0.9**	4.4mi	N	Of	Sunnyside	Nr	Nr
5/3/05	15:07:51	39.61N	110.40W	0.3	**1.6**	4.3mi	NNW	Of	Sunnyside	0.0249	0.00663
5/10/05	12:41:50	39.60N	110.40W	0.5	**2.0**	3.5mi	NNW	Of	Sunnyside	0.0149	0.00663
6/2/05	18:38:00	39.62N	110.4W	0	**1.3**	4.9mi	NNW	Of	Sunnyside	0.0232	0.00829
6/14/05	4:16:17	39.61N	110.39W	0.4	**1.6**	3.8mi	NNW	Of	Sunnyside	0.0199	0.00994
7/8/05	20:43:54	39.61N	110.39W	1.1	**1.6**	3.8mi	NNW	Of	Sunnyside	0.0166	Nr

Nr = not recorded

All of the events recorded are being considered as mining induced. Earthquake magnitudes ranged from 0.9 to 2.0 with seven of these events classified as magnitude 1.6. The reported depth of the events varies from 0 to 1.1 km (0.68 miles) with one event at 4.4 km (2.7 miles) deep. The average depth for most of the events is about 0.45km (0.28 miles or ~1,500 feet) which is reasonable for the depth of mining. It should be noted that horizontal and vertical depth errors are calculated for each event and generally range from about ± 0.2 to 2 miles. Based on this information we cannot exclude any of these events as not being related to longwall mining in the West Ridge Mine. Other events were also documented within the larger surrounding area but are more questionable as to whether they were related to the West Ridge Mine.

The UUSS has a seismograph station located directly above the West Ridge Mine Panel #4, about 4500 feet (horizontal distance) southwest of the dam, as shown in Figure 6. This station is referred to as the Book Cliffs East (BCE) station. All of these UUSS events were recorded on the hillside unit with the exception of the smaller 0.9 mag event. Seven events were also recorded on the Dam unit as show in table above.

It should be noted that the larger magnitude events recorded by the UUSS did not always generate the largest PGA values. The largest magnitude earthquake of 2.0 generated one of the smaller PGA values of 0.0149g. One 1.7 magnitude event had one of the higher PGA values of 0.0199g, while another had one of the lowest at 0.0133g. The largest PGA value recorded as an earthquake by the UUSS was 0.0249g during a magnitude 1.6 event on May 3, 2005 while mining was closer to the hillside unit. Of the hillside events which can be correlated with the UUSS earthquakes, PGA values range from 0.0133 to 0.0249g, as shown on the above table. PGA values for the Dam unit ranged from 0.00663 to 0.00994. It should be noted from the above table that the larger PGA values on the Hillside unit did not always correlate with the larger PGA values on the Dam.

It should also be noted the some of the larger PGA events recorded on the Hillside were not reported as earthquakes by UUSS. Three 0.0249g events were recorded on the hillside. These three events occurred between April 27 and May 7, 2005. Only one of these events was recorded on both the dam and hillside units and was also reported as an earthquake by the UUSS (magnitude 1.6). The other two events were not detected on the dam. Sixteen events were large enough to be picked up by both the dam and hillside units but were not reported as earthquakes by UUSS. The following table summarizes the range of values recorded on the dam and hillside units for peak particle velocity, acceleration and frequency.

	Peak Particle velocity (mm/s)	Peak Acceleration (g)	ZC Frequency (Hz)
Dam			
Maximum	1.17	0.0116	15.5
Average	0.068	0.0073	9.08
Minimum	0.22	0.005	3.56
Hillside			
Maximum	3.81	0.315	34.1
Average	0.64	0.011	12.88
Minimum	0.143	0.005	2.19

Shown in Figure 6 is the location of mining activity along Panel 6 on a weekly basis. This map shows that relative to the Hillside monitoring unit, mining was nearest the unit between April 18 and April 24, 2005. As shown on Figure 7, events recorded on the Hillside unit for that time period range from 1 to 7 events per day. The highest frequency of events recorded

took place between May 3 and May 7, 2005, with events per day of 12, 14, 10, 6, and 12, respectively. After May 7, 2005 the number of events dropped off again to range from 0 to 8 events per day.

Based on the premise that the portion of the panel being mined is similar to the areas surrounding it and that the nearer the mining is to the monitoring unit, the more events the unit will record; the data shows that there was about a two week lag time between the mining near the unit and the rock bursts that followed as the roof collapsed. It should also be noted that the closer the events are to the monitoring unit, the higher the anticipated PGA values. Our records confirm this with the highest PGA's recorded between April 27 and May 7, 2005. As shown on Figure 8, PGA values greater than 0.02g occurred into June. The highest PGA value was recorded on June 17th at 0.0315g. This event was recorded on both units but was not documented as an earthquake by the UUSS. It should be noted that the UUSS siesmogram recordings for that day were very noisy. It is expected that the frequency of seismic events and the acceleration values will continue to decline over time as mining moves further away from the Hillside monitoring unit.

The Sunnyside Mine stopped production in April of 1994 and the West Ridge Mine began long wall mining in May 2001. The following table shows a summary of the number of events that have been recorded within the greater Sunnyside West Ridge Mine area since monitoring started 1962. Not all of the less than 1.4 magnitude events are shown here. Figure 9 also shows various plots of these events. Only one event is shown as having a magnitude greater than 3.0. This event was recorded in 1981 with a magnitude of 3.19. While this event was recorded at a depth of about 6 km (3.7 miles), we have assumed that it may be mining related. Since production at West Ridge Mine started in May, 2001 the largest event recorded is a 2.0 magnitude event recorded in May 2005. A copy of the list of events from 1962 to 2004 is included in the appendix.

MAGNITUDE	1962 TO JULY 2005	JANUARY 2005 TO JULY 2005
	No. of Events	No. of Events
Less than 1.4	11	2
1.41 to 1.6	16	7
1.61 to 1.8	14	5
1.81 to 2.0	17	1
2.01 to 2.2	12	0
2.21 to 2.4	11	0
2.41 to 2.6	13	0
2.61 to 2.8	14	0
2.81 to 2.9	4	0
> than 3.0 @ 3.19	1	0

Based upon the information outlined above, it is apparent that MIS events which have been monitored during the mining of Panel #6 are only a fraction of the recommended probable maximum credible event (0.0315g max. versus 1.07g). The recorded peak ground accelerations are in general agreement with the estimated values using the McGarr and Fletcher equations.

V. STABILITY AND DEFORMATION ANALYSES

A. STABILITY ANALYSIS

Slope stability analyses were performed for the earth dam using the computer program STABL for Windows. Spencer's Method, which satisfies both force and moment equilibrium, was used in the analyses. The soil parameters for the embankment fill were selected based on consolidated undrained triaxial shear tests with pore pressure measurements. The triaxial shear tests were performed on samples obtained from vertical borings both at the crest of the dam and near the midpoint of the downstream slope.

It will be noted that the shear tests showed significant variation in strength characteristics. Sensitivity analyses performed using drained and undrained strength parameters estimated from the tests have suggested that the undrained condition is not markedly inferior to the drained condition for purposes of slope stability. Because this study focuses primarily on seismic slope stability, parameters were selected to approximate undrained conditions. A summary of the soil parameters used in the analysis is shown on the table below.

Layer No.	Material	Moist Weight (pcf)	Saturated Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Piezometer and observation well readings for the dam indicate that the phreatic surface may vary significantly along the length of the dam. Some readings suggest that the phreatic surface is drawn down near the foundation elevation (approx. elev. 7510 ft.) directly beneath the downstream crest. Other readings indicate the presence of water as high as about elevation 7580 feet beneath the downstream crest at some locations along the length of the dam. In the interest of conservatism, the higher phreatic surface was assumed for the stability analyses described in this report.

Analyses were performed for the static steady-state seepage case for both the upstream and downstream slopes. The sudden drawdown condition was also studied for the upstream slope, with the phreatic surface modeled near the face of the upstream slope. In accordance with guidelines published by the Bureau of Reclamation, post-earthquake stability conditions were conservatively modeled using pore pressure parameters of 0.1 and 0.2 in the clayey embankment fill and clay foundation layers, respectively (USBR, 1989).

Pseudostatic stability analyses were performed for Grassy Trail Dam to evaluate slope stability under seismic conditions. A pseudostatic coefficient was applied in the analysis to simulate seismic forces within the embankment. Hynes-Griffin and Franklin (1984) concluded that earth dams having a factor of safety greater than 1.0 under a pseudostatic force of 0.5 times the peak acceleration would not undergo "dangerously large" deformations under the peak seismic acceleration. For a pseudostatic force of 0.54g (0.5 times the PGA of 1.07g), the factor of safety for Grassy Trail Dam was determined to be well below 1.0 for both undrained and drained soil conditions.

Because the factor of safety was less than 1.0 for a pseudostatic force equal to half the maximum anticipated acceleration, a more detailed seismic deformation analysis was required. The applied pseudostatic coefficient was iteratively decreased in the analysis to achieve a factor of safety of 1.0. The resulting pseudostatic force, termed the yield acceleration, was 0.20g for the downstream slope and 0.22g for the upstream slope. A brief summary of the slope stability analysis results is shown below, and copies of the output graphics from the slope stability program are included in the appendix.

Slope	Condition	Factor of Safety	Required F.S.
Downstream Slope	Static, Steady State	1.60	1.5
	Seismic Yield (a = 0.20g)	1.0	---
	Post-Earthquake	1.39	1.2
Upstream Slope	Static, Steady State	2.33	1.5
	Static, Sudden Drawdown	1.35	1.2
	Seismic Yield (a = 0.22g)	1.0	---
	Post-Earthquake	1.83	1.2

With a minimum pseudostatic yield acceleration of 0.20g, the embankment slopes should not undergo significant deformation when subjected to a peak acceleration of about 0.40g. Figure 10 shows the relationship between peak acceleration and the factor of safety against slope deformation up to the critical acceleration value of about 0.40g.

Figure 11 shows the anticipated magnitude required to generate a peak ground acceleration of 0.40g for increasing hypocentral distances from the seismic source. The plotted values were calculated using the McGarr/Fletcher relationship. At the minimum anticipated hypocentral distance of 0.59 km (1,939 ft.), the figure shows that a magnitude in the order of 3.4 to 3.5 would likely be required to produce accelerations of 0.40g or greater. This leads to the conclusion that the embankment will not likely undergo significant slope deformation during events having magnitudes less than about 3.4.

B. METHODS OF DEFORMATION ANALYSIS

Since the anticipated PGA is greater than 0.35g, deformation analyses are required to satisfy dam safety standards. Methods of earthquake deformation analysis considered for this project include the following:

(1) Swaisgood's Method

Swaisgood (referenced in Marble 1993) proposed an empirical method that considers only peak ground acceleration, the height of the dam, and the thickness of underlying alluvium. This relationship relies heavily on peak ground acceleration, and is limited to accelerations of less than about 0.7g. The method, therefore, does apply to the extreme event considered in this project, where the anticipated PGA is about 1.07g.

(2) Jansen's Method (1988)

The method proposed by Jansen considers earthquake magnitude, embankment yield acceleration, and embankment crest acceleration. While considering more pertinent variables than the Swaisgood method, Jansen's method relies heavily on event magnitude

and predicts very minor deformations for a 3.9 event. It is our opinion that this method is not applicable for this project.

(3) Makdisi-Seed Method (1977)

The Makdisi-Seed method provides perhaps the most complete empirical estimate of seismic deformation for earth dams. Unfortunately, this method only provides correlations for magnitudes between 6.5 and 8.25 and cannot be used for a 3.9 event.

(4) Newmark Sliding Block Method (1965)

The Newmark approach requires estimates of the acceleration vs. time record at locations along the anticipated failure surface. The yield acceleration of the failure mass is subtracted from the acceleration record. The resulting acceleration record is then double-integrated to give the cumulative deformation caused by accelerations greater than the yield acceleration. Due to its theoretical nature, the Newmark method is more appropriate for this project than empirical methods based on larger-magnitude events.

C. GROUND MOTION DATA

The University of Utah Seismograph Stations have provided digital acceleration data from the two of the largest magnitude readings at Station BCE, along with data for the magnitude 4.2 Willow Creek Event. Data for these three events are tabulated below.

Station	Date	Magnitude	Epicentral Distance to Station (km)
WCS (Willow Creek)	03/07/2000	4.2	2
BCE (West Ridge Mine)	02/06/2004	2.0	1
BCE (West Ridge Mine)	02/11/2004	2.0	1

Acceleration data from the three events listed above were analyzed to evaluate potential mining-induced ground motions at Grassy Trail Reservoir. The data from station BCE give an indication of mining-induced seismicity specific to the Grassy Trail/West Ridge site, while the WCS event allows comparison to a larger-magnitude event recorded in the same general mining region.

The peak acceleration recorded at station BCE was in the order of 0.006g, while the peak acceleration recorded at station WCS in the magnitude 4.2 event was about 0.36g. These records were rescaled to the anticipated peak ground acceleration of 1.07g anticipated at the dam. Kramer (1996) cites recommendations that actual ground motion records not be scaled by factors greater than 4.0, and that several scaled records be considered in engineering analysis. The WCS record requires a scaling factor of about 3.0, indicating that the scaled ground motion is suitable for analysis. The scaling factor for the BCE records far exceeds the recommended limit; however, due to lack of stronger ground motion data specific to the West Ridge Mine vicinity, we have chosen to evaluate the scaled BCE data along with the scaled WCS data.

Acceleration response spectra were obtained for the North-South, East-West, and Vertical components of the three records using the computer program ProShake (2003). With all records scaled to a peak ground acceleration of 1.07g, the WCS Vertical Component and the 2/6/04 BCE North-South Component were found to produce the greatest spectral response. The two response spectra are shown for 5% structural damping in Figure 12. The WCE event gives the critical response for periods less than about 0.14 seconds, with the BCE event being more critical for longer periods. Based on the available information, it is our opinion that these two earthquake records scaled to the probable maximum PGA represent the best available approximation of the ground motion caused by the maximum considered earthquake at the nearest hypocentral distance.

D. APPLICATION OF NEWMARK DEFORMATION ANALYSIS

In applying the Newmark method, we have used the scaled ground motion records from station BCE and station WCS as input motions in ProShake to anticipate the motions at the likely failure surfaces within the embankment. Acceleration vs time data were developed at three locations (near crest, midpoint, and near toe) along the anticipated failure surfaces for both the upstream and downstream slopes of the dam. At each location, a softer "slip" layer was incorporated at the failure surface, as recommended by Houston et al. (1987). The shear

modulus of the slip layer was reduced to the point that the calculated peak acceleration above the layer (within the failure mass) was approximately equal to the yield acceleration. Double integration was then performed for the acceleration immediately below the slip layer at each location on the failure surface to obtain an estimate of the deformation for each slope.

Newmark deformation analyses were performed for the downstream and upstream slopes of Grassy Trail Dam. The applied yield accelerations were 0.20g for the downstream slope and 0.22g for the upstream slope. It is our opinion that the applied yield acceleration values are conservative for both the drained and undrained soil conditions.

In the analysis, the scaled North-South component of the event recorded at station BCE on February 6, 2004 was found to induce the greatest deformation. Results of the analysis are shown in the Embankment Deformation Analysis section of the appendix. The average calculated deformation was about 2.9 inches for the downstream slope and 2.5 inches for the upstream slope. Maximum computed deformations were in the order of 5.5 inches for the downstream slope and 4.2 inches for the upstream slope. Conservatively, the anticipated deformations for the two slopes can be summed to give an average total crest deformation of about 5.4 inches and a maximum total crest deformation of approximately 9.7 inches.

VI. OTHER CONSIDERATIONS

A. SUBSIDENCE

The Agapito (2004) report addresses potential subsidence associated with the mining-induced seismicity. A copy of the report is included in the appendix. Their analysis projects a maximum vertical ground subsidence of 0.5 feet at the right abutment of the dam attenuating to 0.1 feet at the left abutment using a conservative angle of draw of 45 degrees. The report recognizes that the actual angle of draw is expected to be significantly less than 45 degrees and analyses were performed varying the angle of draw at 20, 30 and 45 degrees. At 30 degrees, the predicted vertical subsidence is less than 0.1 feet at the right abutment, with negligible subsidence predicted at the left abutment.

The highest magnitude ground strains that can be expected at the dam, assuming the worst case condition with the high angle of draw of 45 degrees, are tensile strains in the order of 0.4×10^{-3} (0.04%). The Agapito report references published criteria for allowable deformation in dams and beneath bodies of water, with a minimum suggested limit for horizontal strain of 1×10^{-3} (0.1%). The predicted maximum horizontal strain using the 45 degree angle of influence is below the minimum limit by a factor of about 2.5. Predicted tensile strains are negligible when the angle of draw is less than 30 degrees.

Additional discussion has occurred between representatives of Agapito Associates and the Utah State Engineer's Office. This correspondence is documented in the appendix of this report following the reproduced Agapito subsidence report. As a part of this discussion, Agapito Associates provided figures showing the "Maximum Credible Tensile Strain Limit" (MCTSL) predicted for mining operations. It was noted that the MCTSL for 0.1% strain is more than 580 feet from the nearest point on the dam, and that the MCTSL for 0.05% strain is 290 feet from the dam. This supplemental information from Agapito further emphasizes that strains exceeding the conservative allowable strain limit of 0.1% are not anticipated at the dam site.

B. INTERNAL EROSION POTENTIAL

Ground shaking associated with seismic activity has the potential to create open fractures and cracks within the embankment crest. Based upon the expected deformation, these cracks should be shallow and terminate well above the high water level. The embankment is zoned, with the central core consisting of sandy clay with some gravel. The design drawings show that the outer zones transition to sandy gravel, with rock shells on the outer slopes. A test boring (05-4) was drilled through the outer zone midway down the downstream embankment. The embankment profile consists of layers of lean clay, clayey sand and clayey gravel with the percent silt and clay in the granular layers ranging from 28 to 49%. It appears that the soils in the outer downstream zone are not significantly different than the central zone and that piping of materials from the inner to the outer zone is unlikely. The foundation soils consist predominately of interbedded sandy clay with gravel and clayey gravel with sand. Some layers of silty sand with gravel, and silty gravel with sand were encountered in the 1979 and 1998 borings. The granular layers are in a relatively dense condition. At least 10 feet of foundation soils exists between the embankment and the bedrock on the right abutment. The near surface bedrock consists predominately of shale with some weathered sandstone. Opening of significant fractures in the abutment bedrock is unlikely due to the nature of the rock and the small tensile strains predicted due to MIS.

Based upon the information outlined above, we consider the potential for internal erosion due to mining induced seismicity to be very low at this site.

C. RESERVOIR SEEPAGE

The Agapito Report (2004) addresses the potential for increased seepage due to mining induced seismicity. Due to the depth of cover-to-mining height ratio and predicted low horizontal strains, the risk is considered low. We concur with this assessment. It should be noted that no faults have been identified traversing the reservoir footprint and that existing joints in the bedrock formation are typically discontinuous, extending through only a few beds.

D. LANDSLIDES

Slope failures have occurred in the right abutment above the dam, along the right (west) side of the reservoir basin, and above the left abutment. Inclinometers installed on the left and right abutments show no significant movement in the slides since 1998. Borings drilled during inclinometer installation showed bedrock in these areas to be relatively shallow and it appears that these slides do not extend into the bedrock. It is our opinion that additional movement of these slides will not impact the dam and reservoir, however, monitoring of the inclinometers should continue on a regular basis during mining.

(1) Stability of Landslide on West Rim of Reservoir

a. Characteristics of West Rim Landslide

Evidence of past landslides exists along the west rim of the reservoir. A "Category C Subsidence Monitoring Report" available at the Utah State Dam Safety Office lists surveyed elevations for the west rim landslides for 1969 and 1988 and suggests subsidence of up to about 3.55 feet occurred during that time interval. Landslide activity was documented near the right abutment between 1982 and 1983, and it has been assumed that most of the subsidence documented on the west reservoir rim occurred during that same time period.

Site reconnaissance and subsurface investigations performed in 2004 and 2005 have provided additional information regarding the characteristics of the landslide on the west reservoir rim. Points located in the landslide area were surveyed in July 2004 and again in July 2005 to monitor potential subsidence of these points. Several of these points were also surveyed during an earlier study in February 1999. These points are shown on Figure 4 and the surveyed elevations are listed on tables in the appendix. It will be noted that both the lateral movement and the vertical subsidence of survey points located in the west rim landslide were less than 0.6 feet since 1999, with movement less than about 0.2 feet since July, 2004.

Scarps existing on the slope were also documented and are identified on the aerial photograph in Figure 4A. The scarps show an approximate landslide area of about 500 feet long and 550 feet wide in plan view.

Boring 05-1 was drilled within the landslide area on the road that runs along the west side of the reservoir. An inclinometer casing installed in Boring 05-1 (I-4) shows distinct but very slight movement in a northeasterly direction occurring at a depth of about 60 feet in a zone with clay seams. It should be noted that the degree of motion indicated to date by inclinometer I-4 may be smaller than the accuracy limits of the instrumentation. Due to the very limited movement shown on the inclinometer readings, our estimate of the landslide failure plane elevation at this location is uncertain; however, it likely represents a conservative limit of the failure plane depth.

b. Approximate Volume of West Rim Landslide

The approximate volume of the west rim landslide mass was estimated based on the information described above. The lateral extents were assumed to be 500 feet long (west to east) and 550 feet wide (north to south) in plan view. An estimated circular failure surface was drawn through the slip point indicated by the inclinometer and extending west, up the slope to the approximate location of the highest observed scarp. It was assumed that the failure wedge section is constant across the 550-foot width of the slide area. Based on these assumptions, the estimated volume of the slide mass is about 560,000 cubic yards, which is equivalent to about 350 acre feet. The assumed section used in the analysis is shown on Figures 13 and 14.

Assuming the slide occurs along the surface indicated by the inclinometer, the distance from the toe of the estimated slide area to the original river channel is about 250 feet. It is considered unlikely that the slide mass would slide beyond this location. As a result, only a portion of the total slide mass would actually

enter the current reservoir area and displace water. Assuming the slide moved laterally a distance of about 250 feet, the estimated volume of the assumed slide mass entering the reservoir would be in the order of 210 acre feet. Storage-Elevation curves for the reservoir show that an approximate storage volume of about 220 acre feet exists between the spillway elevation and the top of the dam. Based on this data, it is considered unlikely that the estimated slide mass would displace more water than could be accommodated by the freeboard storage of the reservoir. A relatively slowly-occurring slide of the estimated extents will not likely threaten the dam; however, a sudden slide of this magnitude may create a large wave that could overtop the dam.

c. Impact of Mining-Induced Seismicity on West Rim Landslide

The maximum mining-induced seismic event at the West Ridge Mine is anticipated to have a magnitude of 3.9. It has been noted that no recorded event nearing this magnitude has been associated with the Sunnyside and West Ridge Mines, and that such an event is considered very unlikely. The Transportation Research Board provided guidelines for landslide investigation and mitigation in *Special Report 247* (TRB, 1996). In the TRB report, a graph published by Keefer (1984) is reproduced that delineates the maximum distance from earthquake epicenters to earthquake-triggered landslides as determined from 40 historic earthquakes. A copy of this plot is included in this report (see Figure 15). It will be noted from the figure that earthquakes having magnitudes less than 4.0 were not shown to trigger landslides, even at epicentral distances as close as 100 meters (328 feet). The distance-magnitude relationship shown on the figure suggests that mining-induced events of magnitude 3.9 or less will not trigger significant landslide activity.

An estimate of potential landslide deformation triggered by mining-induced seismic activity was obtained using the Newmark sliding block method, as described in the Section V.D. of this report. Because documented motion of the slide during recent mining activity has been negligible, it is reasonable to assume

that the yield acceleration of the slide mass has not been exceeded during the recent mining for which accelerometer data exists. Since accelerations as large as 0.03g have been recorded in the general area of the west rim landslide during recent mining, we assumed a minimum yield acceleration of 0.03g for deformation analysis of the slide area.

In the Newmark analysis, ground motions from the BCE event of February 6, 2004 and the WCS event of March 7, 2000 were scaled to a peak ground acceleration of 1.07g and used as ProShake input motions for the landslide profile. The motion was modeled at various points in the soil profile to evaluate motions at different points along the potential failure surface. Based on the ProShake analysis, it was determined that the scaled input BCE record was more critical than output records taken from various points in the soil profile. The BCE event was also shown to be more critical than the WCS event for the slope deformation analysis. As a result, the scaled BCE input record was selected to conservatively represent the motions occurring at the landslide failure surface.

Based on the Newmark analysis, the deformation resulting from the maximum anticipated mining-induced event (event magnitude 3.9, peak ground acceleration 1.07g) was calculated to be in the order of 12 to 18 inches. The acceleration, velocity, and displacement plots are included in the Deformation Analysis section of this report. It was noted during the analysis that the calculated deformation is limited by the short duration of the acceleration pulses and the relatively small number of cycles in the scaled earthquake records from mining-induced events. It is our opinion that the calculated magnitude of deformation is not large enough to cause a significant overtopping wave that could threaten the dam.

VII. CONCLUSIONS AND RECOMMENDATIONS

Based upon the information presented in the previous sections of this report, it is our opinion that the following conclusions and recommendations are applicable:

- The proposed mining plan projects the Panel No. 7 longwall to be 1939 feet hypocentral distance from the right abutment of Grassy Trail Dam.
- Mining-induced seismicity is expected to generate a maximum credible earthquake (MCE) event of 3.9, based on the Richter Scale. Due to the short distance from the reservoir to the nearest mining-induced seismic source, a peak ground acceleration of 1.07g is estimated for the MCE. The anticipated maximum event results in an estimated average embankment deformation of 5.4 inches, with a maximum deformation of 9.7 inches. The dam currently has 7.5 feet of free-board between high water level and top of dam. This results in a factor of safety of greater than 9 against overtopping due to seismic deformation. Utah State Dam Safety standards require a minimum factor of safety of 3. Adding 6 inches of potential ground subsidence to the right side of the embankment area reduces the factor of safety to 5.7, which is still well above the minimum. Post-event stability analyses indicate that an adequate factor of safety exists against slope failure of the embankment.
- For the maximum magnitude of vertical displacement described above, open joints and cracks in the embankment crest are not expected to propagate below the high water level.
- For seismic events having magnitudes less than 3.4, significant deformation of the embankment is not expected, even for events originating in the closest longwall panel. Mining operations should be planned and executed in such a manner as to continue to minimize the magnitude of seismic events.
- Slope failures have been documented in areas above the abutments and the reservoir. These failures appear to be shallow on the abutments, and continued movement will not likely impact the dam and reservoir, beyond minor maintenance.
- Landslide activity has been documented on the west rim of the reservoir, and the potential for further sliding exists. An inclinometer was installed near the toe of this slide area to monitor further movement. Readings of this inclinometer to date suggest that some minor movement may have occurred since the inclinometer was installed in

February. The maximum mining-induced seismic event at the West Ridge Mine is anticipated to have a magnitude of 3.9. It has been noted that no recorded event nearing this magnitude has been associated with the Sunnyside and West Ridge Mines, and that such an event is considered very unlikely. Research of historic earthquake-triggered landslides indicates that earthquakes having magnitudes less than 4.0 are not likely to trigger landslides, even at epicentral distances as close as 100 meters (328 feet). It is concluded that the potential for landslide activity triggered by anticipated mining-induced seismicity is very low.

- Based upon the analyses included in this report, it is unlikely that the anticipated mining-induced seismicity will impact the performance of the dam and reservoir. In order to verify the results of the analyses and protect against unforeseen conditions, it is recommended that an inspection and monitoring schedule be implemented when longwall mining activity occurs in Panel 6 and Panel 7. We recommend that the schedule include the following:

  - Bi-weekly site reconnaissance to observe any change of conditions in the embankment crest or slopes and landslide areas. Particular attention should be given to cracking, ground deformation or seepage.
  - Monthly measurement of inclinometers, piezometers and ground motion monitoring devices.
  - Annual survey of control points on the embankment and in the landslide areas.
  - Daily monitoring of the UUSS list of recent seismic events (www.seis.utah.edu/recactivity/recent.shtml) should be performed. A daily record should be maintained of the largest recorded event within 5 miles of the site. When an event greater than 3.0 occurs within 5 miles of the site, a site reconnaissance of the embankment crest, slopes and landslide areas should be performed within 24 hours and a review of ground motion recordings should be made. If recorded ground acceleration exceeds 0.4g, instrumentation readings should be performed.
  - Site reconnaissance and instrumentation reports should be forwarded to RB&G Engineering and the Utah State Dam Safety Engineer within 24 hours, and the daily monitoring record should be submitted on a monthly basis.

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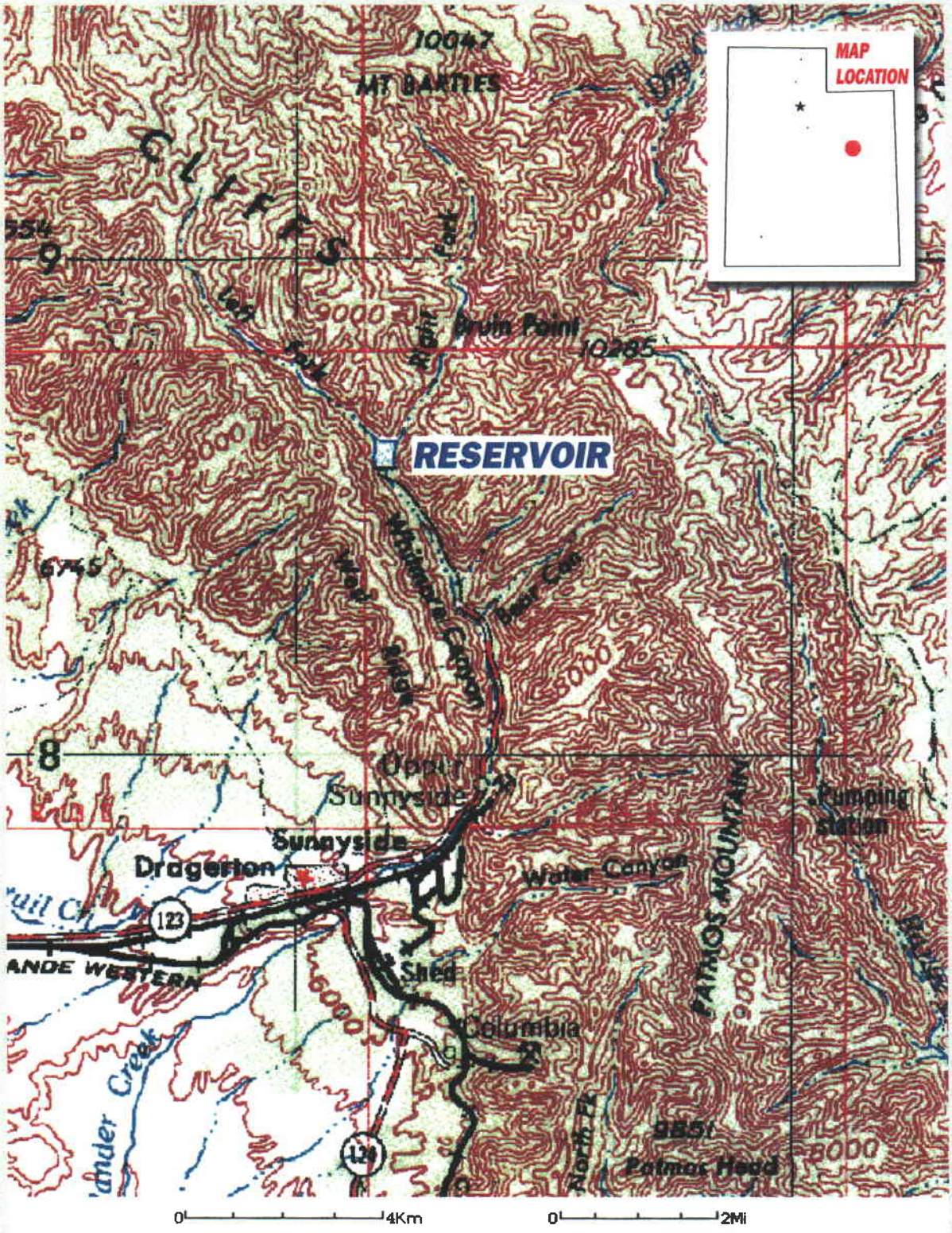
FIGURES



Source: USGS, 5 km NE of East Carbon City, Utah, July 1970.

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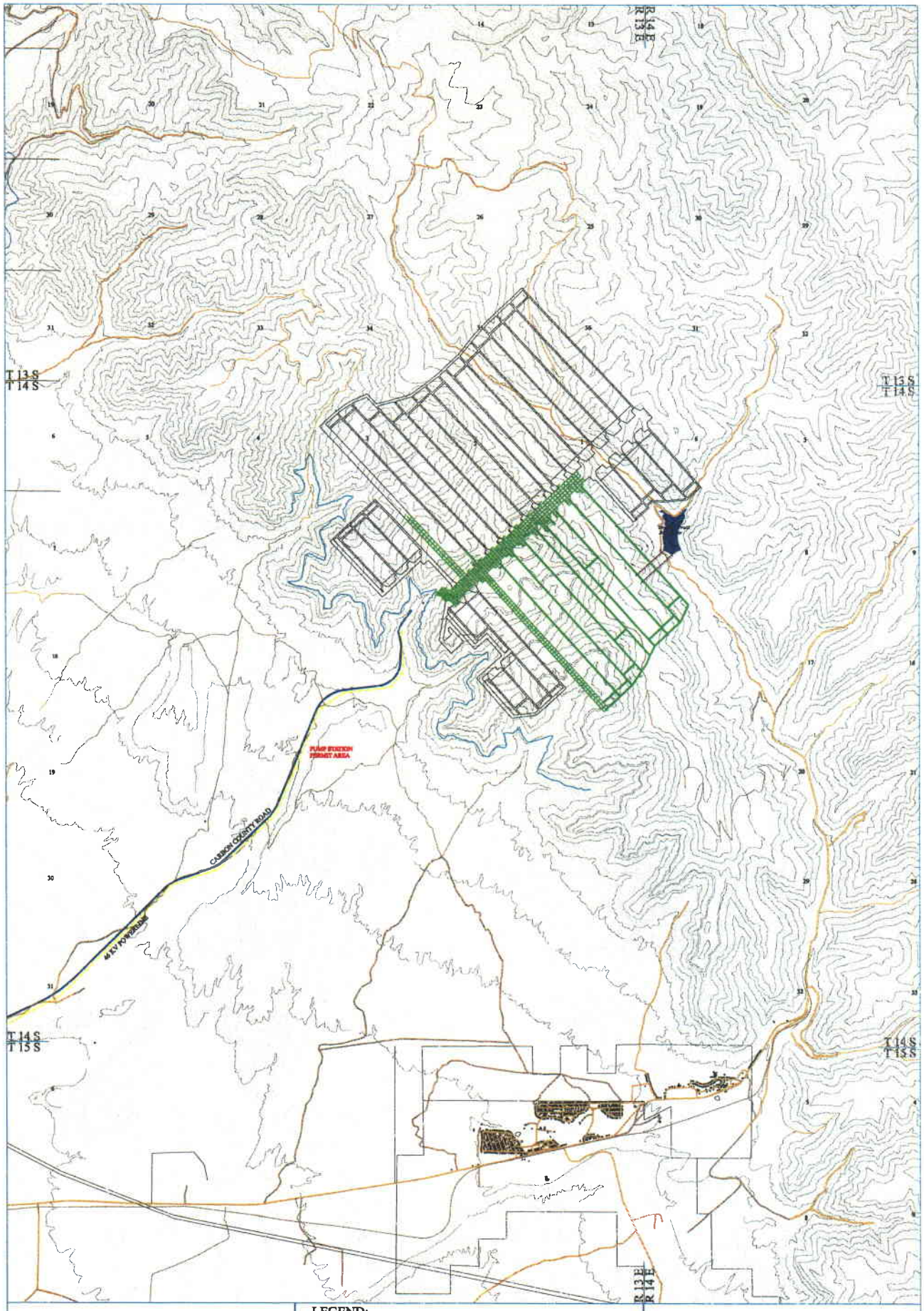
Figure 1. Vicinity Map

Mining-Induced Seismicity Near Grassy Trail Dam and Reservoir



WEST RIDGE MINE

Project Area

DATE: 06/02/05

ACAD REF: WR_INDEX

LEGEND:

- Permit Boundary
- Federal Lease
- State Lease
- Penta Creek Fee
- Surface Facility Area
- Outcrop
- Carbon County Road
- Power Line
- Existing Road

N

WEST RIDGE RESOURCES, INC.

SCALE: 1" = 4300'

FIGURE 2

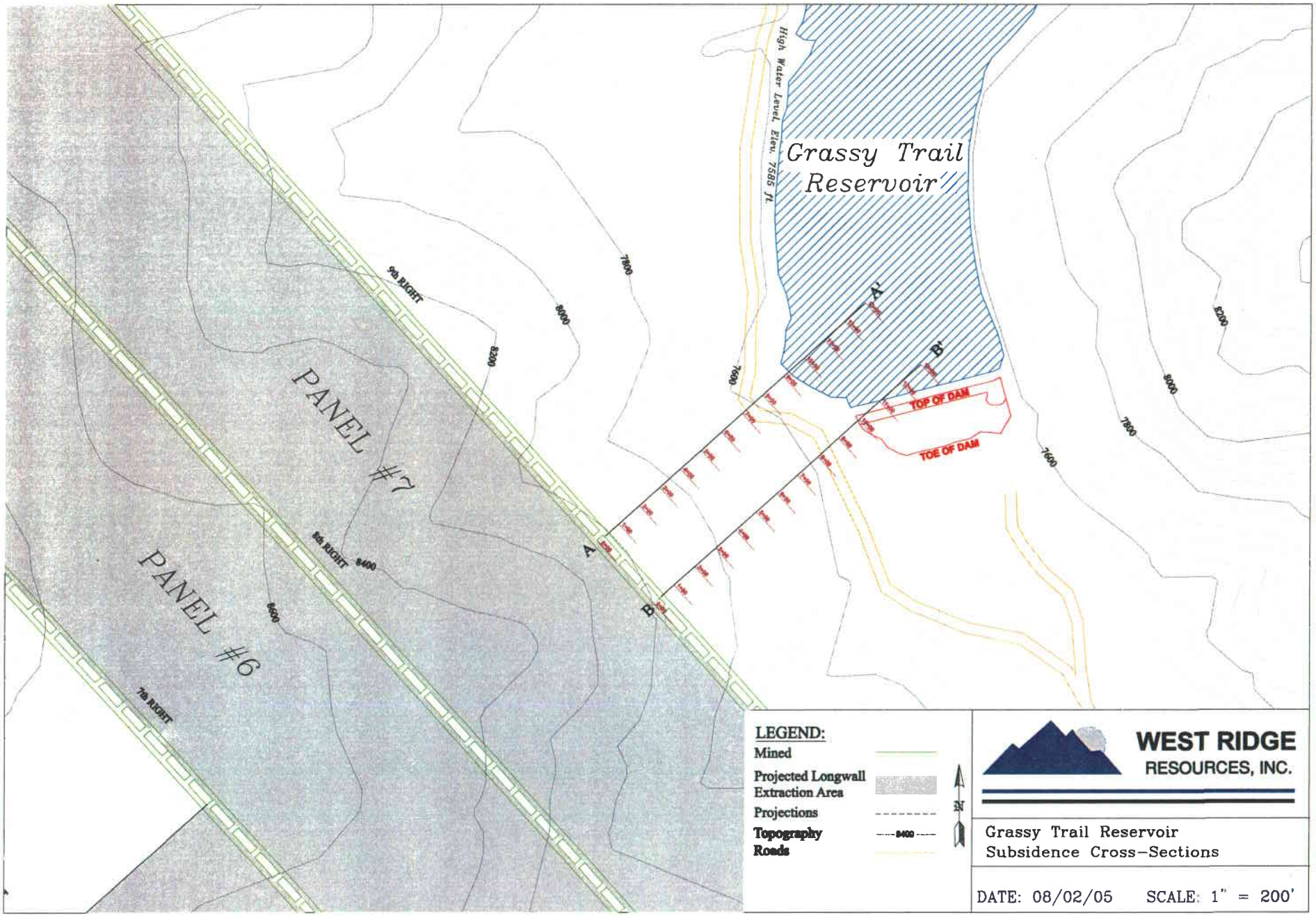
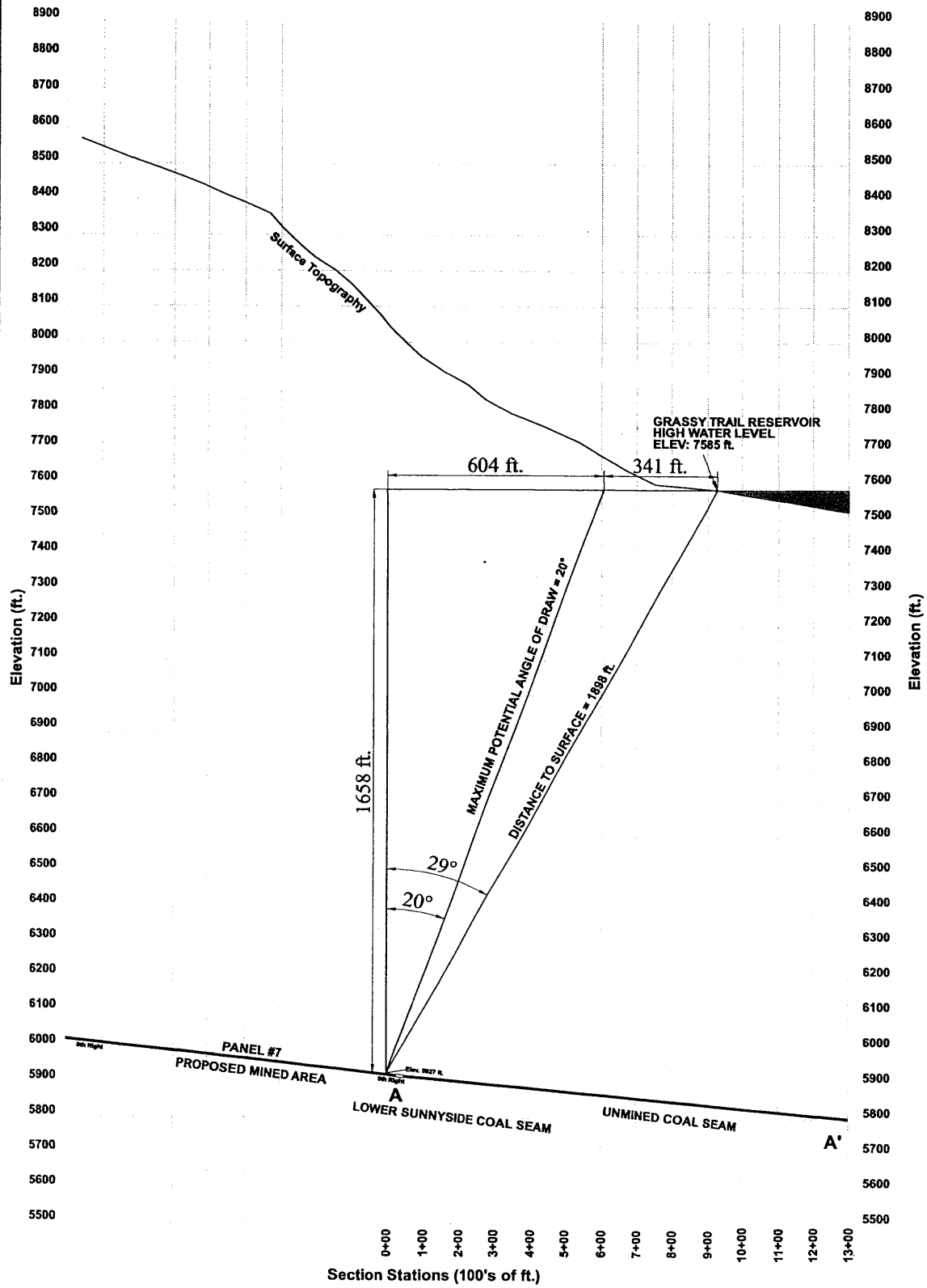

Grassy Trail Reservoir
High Water Level, Elev. 7585 ft.
PANEL #7
PANEL #6
9th RIGHT
8th RIGHT
7th RIGHT
8400
8200
8000
7800
7600
A
A'
B
B'
TOP OF DAM
TOE OF DAM
LEGEND:
Mined
Projected Longwall Extraction Area
Projections
Topography
Roads
N
WEST RIDGE RESOURCES, INC.
Grassy Trail Reservoir
Subsidence Cross-Sections
DATE: 08/02/05
SCALE: 1" = 200'

FIGURE 2A

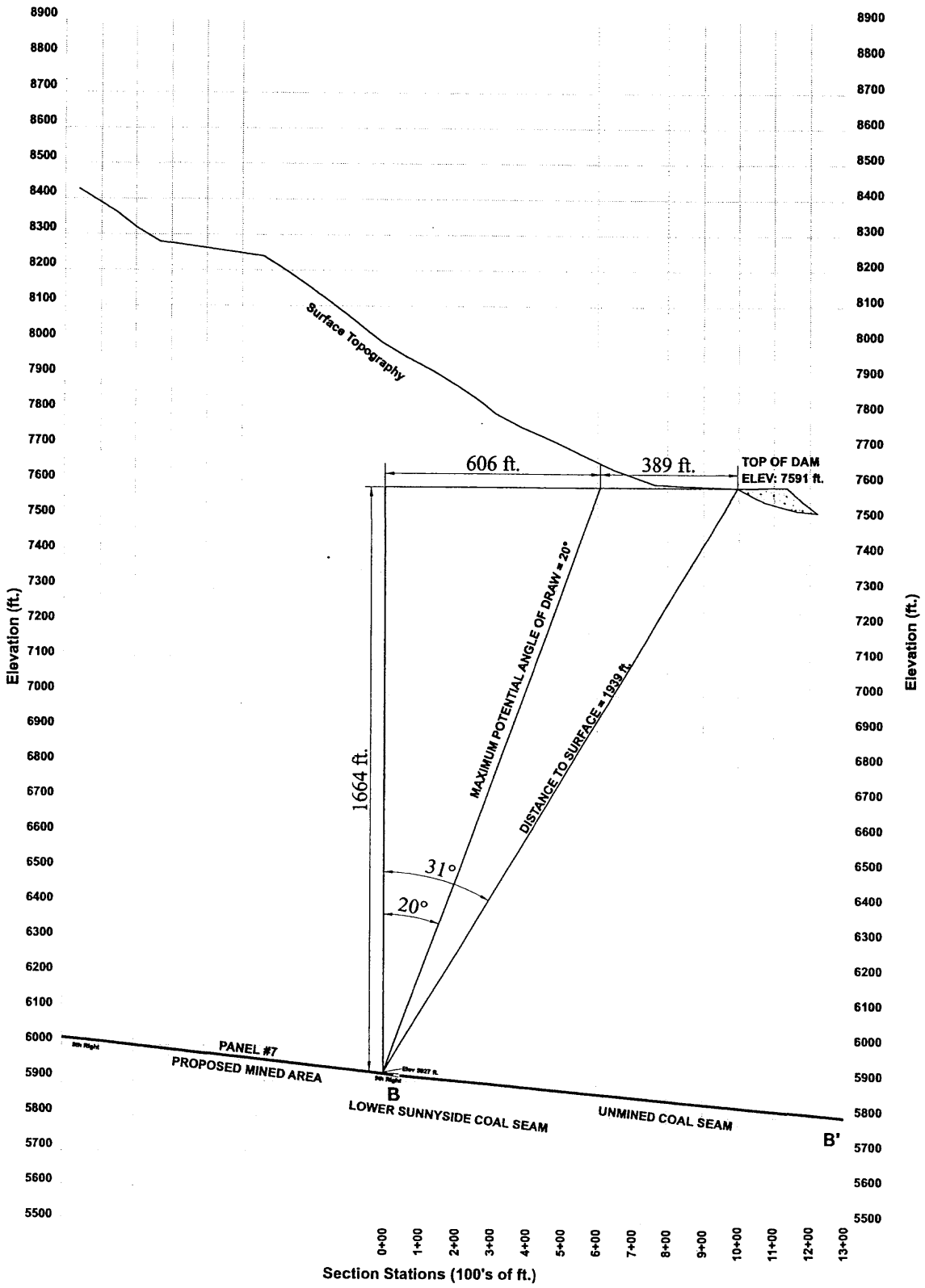


WEST RIDGE
RESOURCES, INC.

Grassy Trail Reservoir
Subsidence Cross-Section A – A'

DATE: 07/22/04

FIGURE 3A



WEST RIDGE
RESOURCES, INC.

Grassy Trail Reservoir
Subsidence Cross-Section B -B'

DATE: 07/22/04

FIGURE 3B

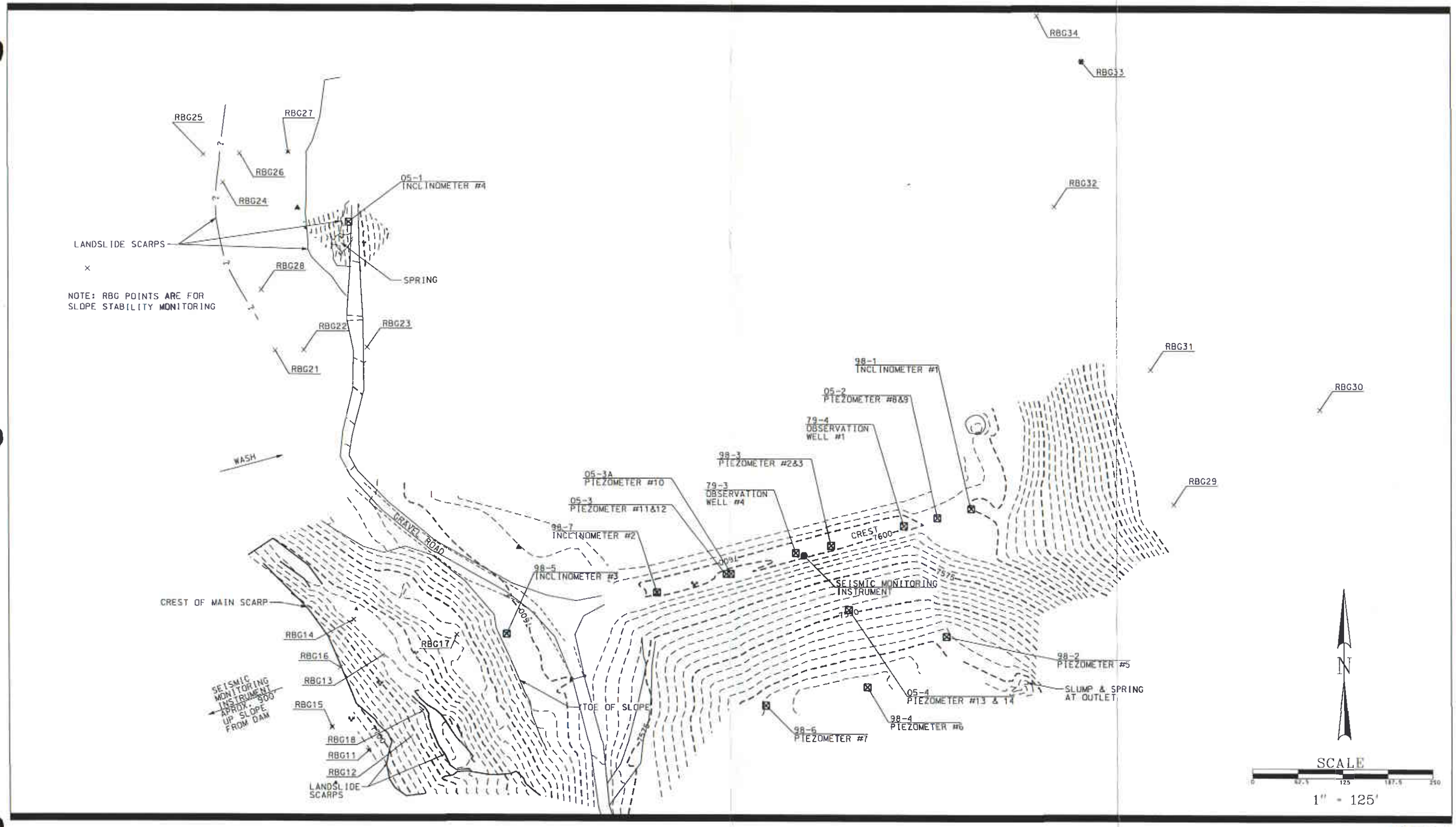


Figure 4

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Provo, Utah

GRASSY TRAIL DAM
CARBON COUNTY, UTAH

LOCATION OF INSTRUMENTATION

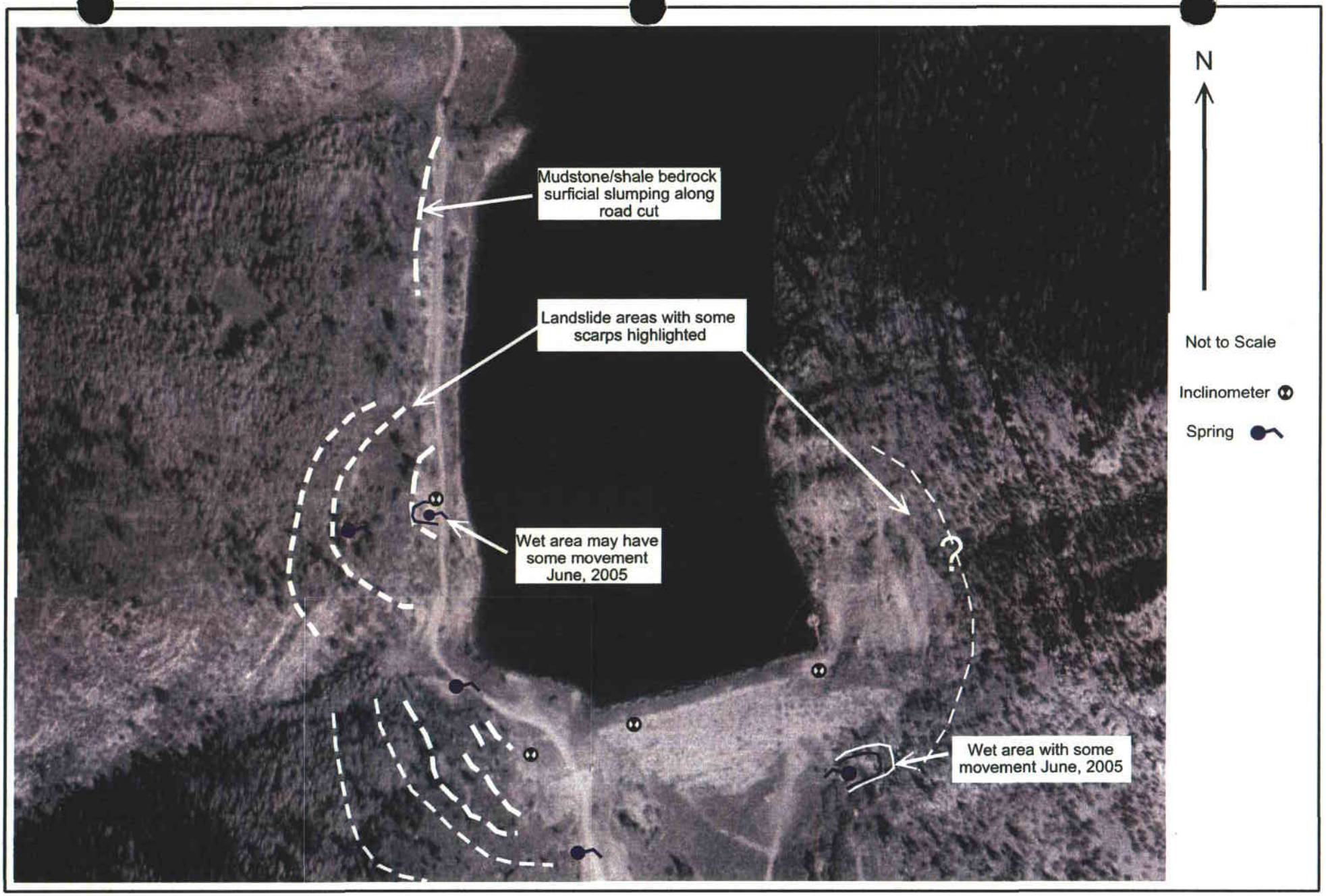

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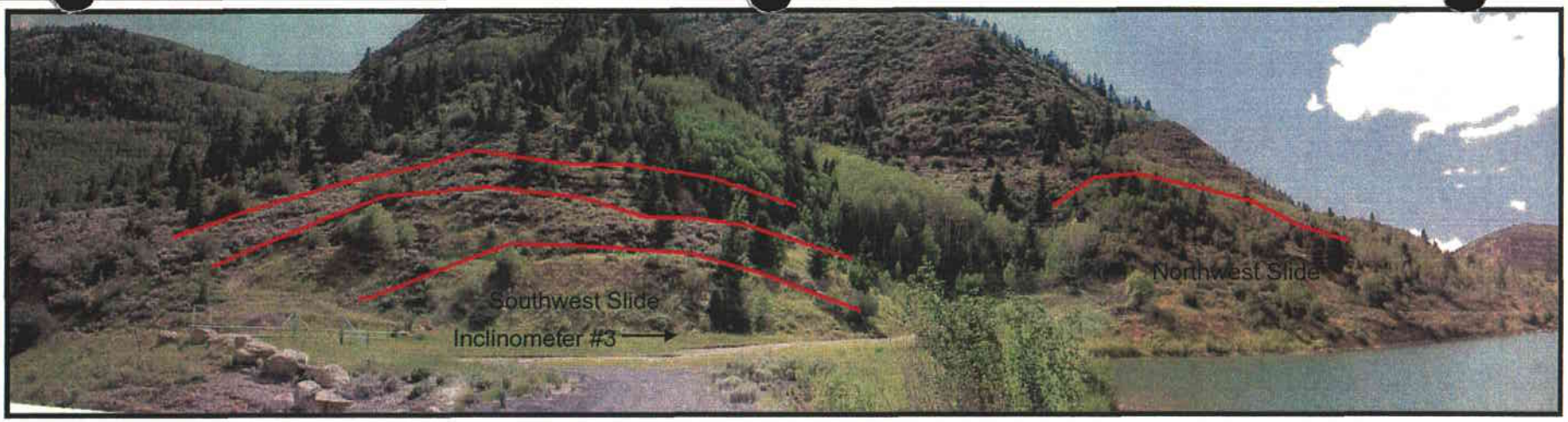
Figure 4A Aerial View Showing Potential Landside Areas
Project *Grassy Trail Dam*
Location *Near East Carbon, Sunnyside, Carbon County, Utah*



View looking west at right abutment from dam

View looking southeast toward left abutment from northwest slide area

Landslides and scarps highlighted

RB&G ENGINEERING, INC.

Figure 4B	Landslides near Abutments
Project	Grassy Trail Dam
Location	Near Sunnyside, Carbon County, Utah

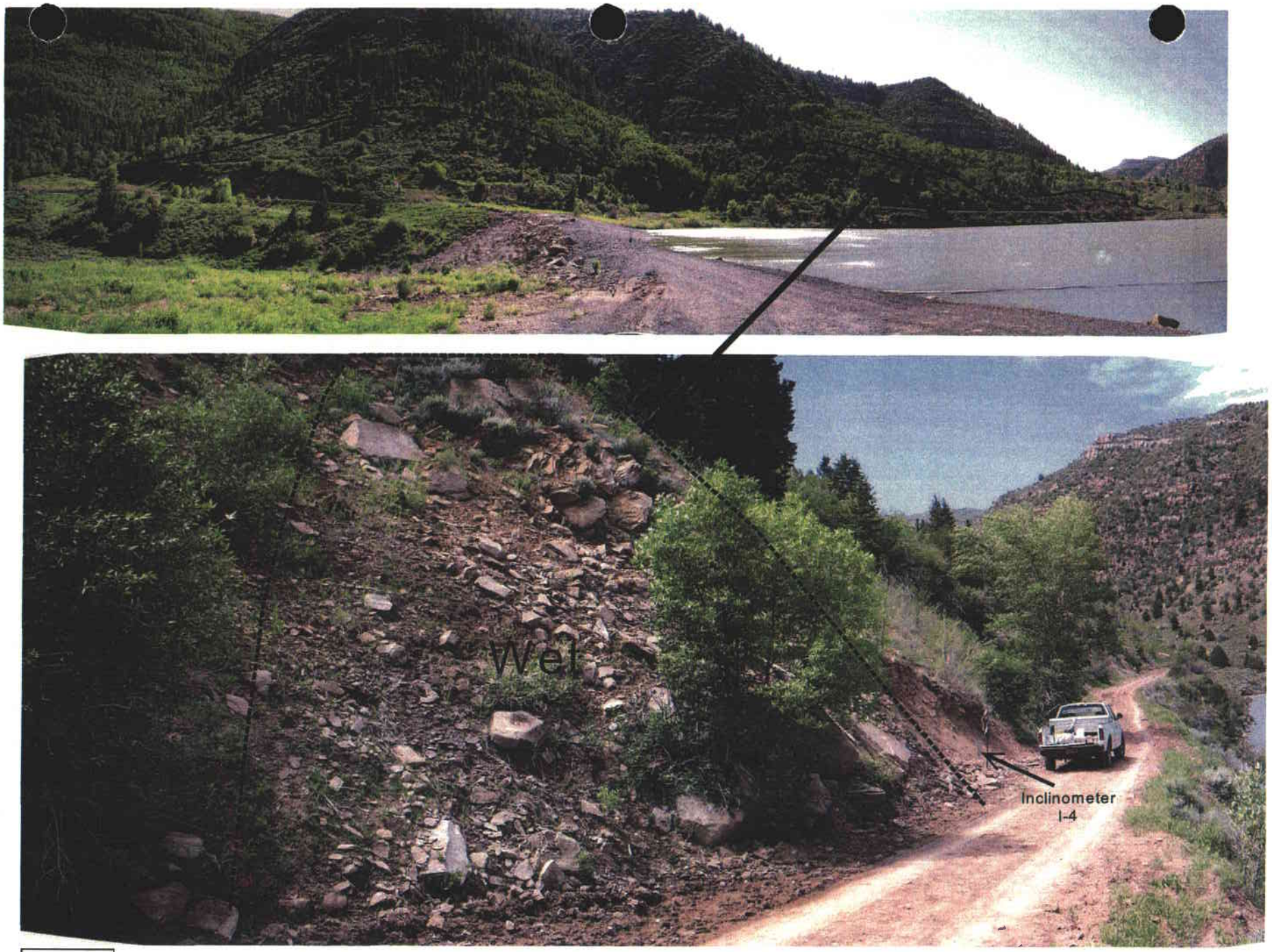


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Figure 4C Potential Landside Areas
Project *Grassy Trail Dam*
Location *Near East Carbon, Sunnyside, Carbon County, Utah*

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Provo, Utah

Figure 4D Spring in Potential Landside Areas on West Rim of Reservoir
Project *Grassy Trail Dam*
Location *Near East Carbon, Sunnyside, Carbon County, Utah*

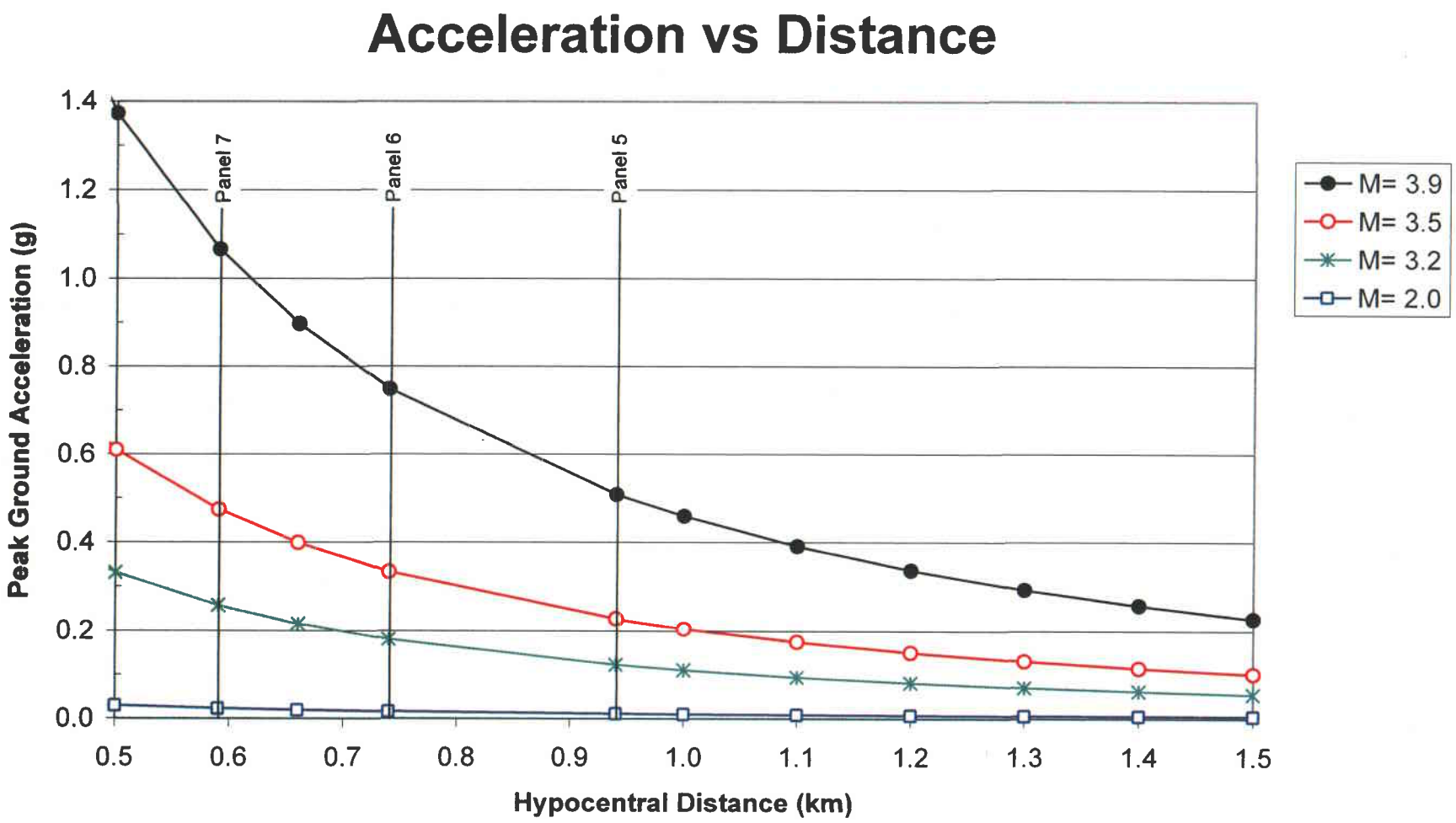

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Figure 5 Peak Ground Acceleration vs Hypocentral Distance
Based on McGarr-Fletcher relationship (2005)

Grassy Trail Dam and Reservoir

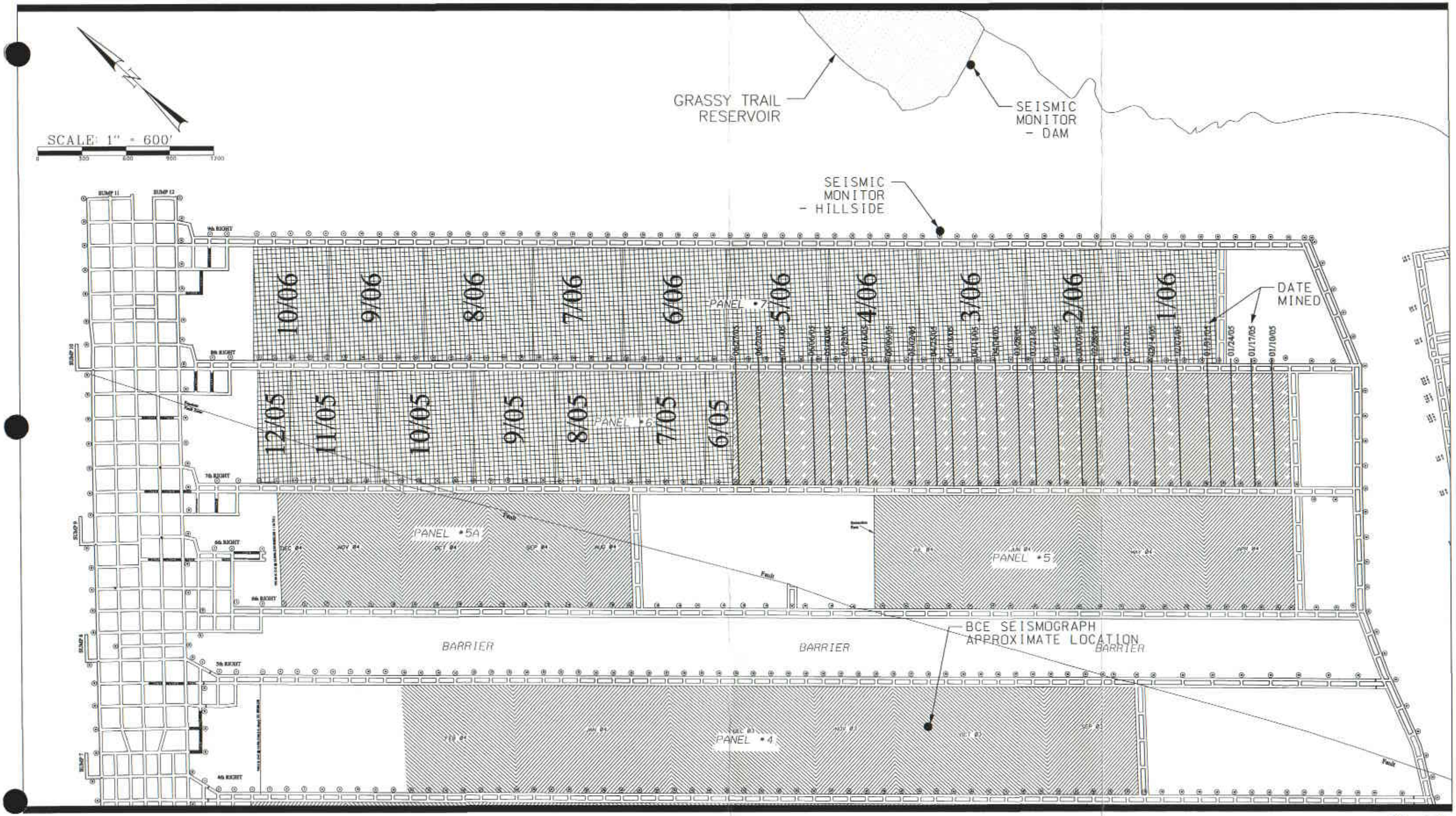

Figure 6

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GRASSY TRAIL DAM
CARBON COUNTY, UTAH

LOCATIONS OF WEEKLY MINING ACTIVITY ALONG PANEL 6

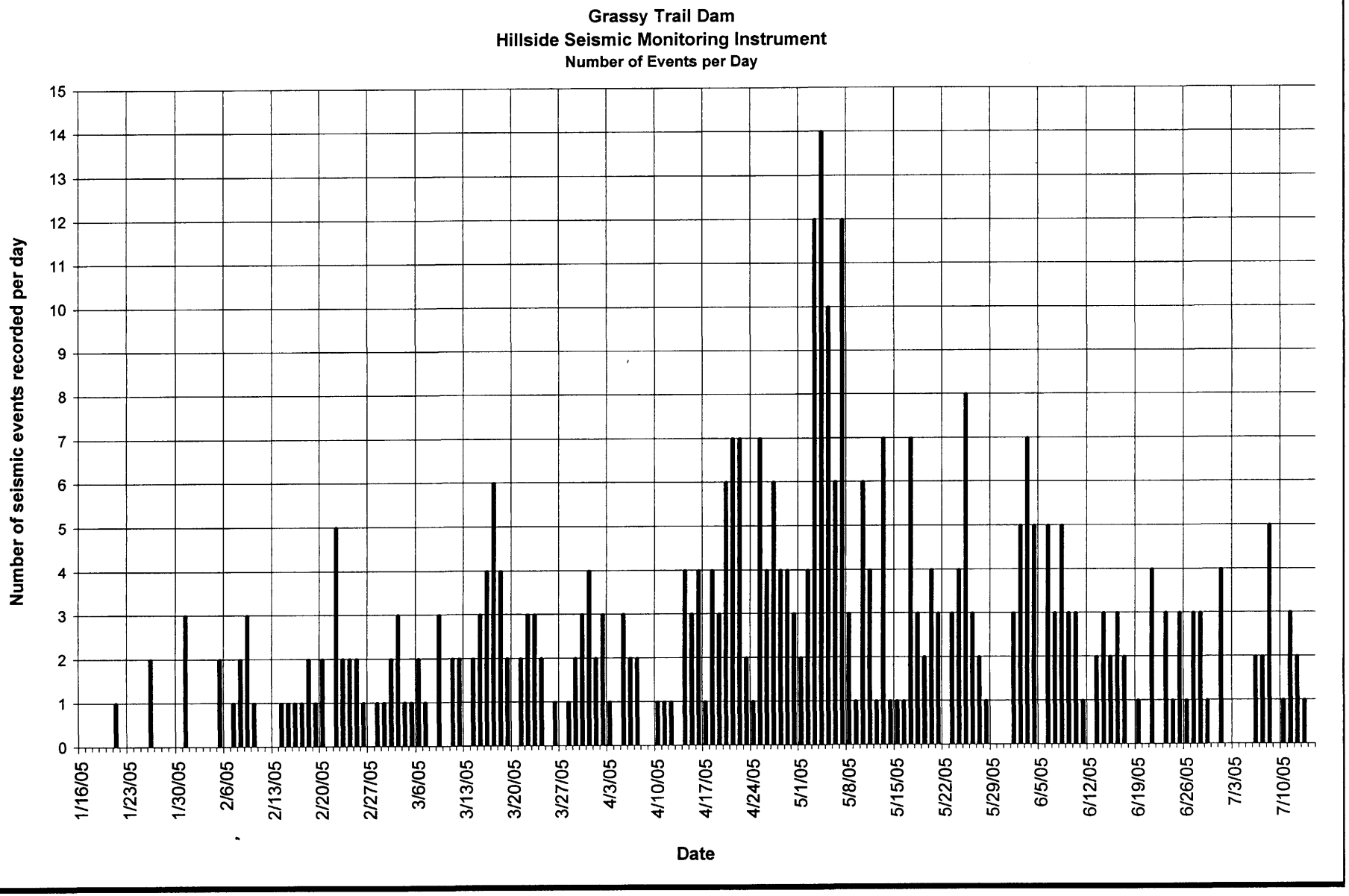

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Figure 7 Events per Day
Hillside Seismic Monitoring Instrument

Grassy Trail Dam and Reservoir

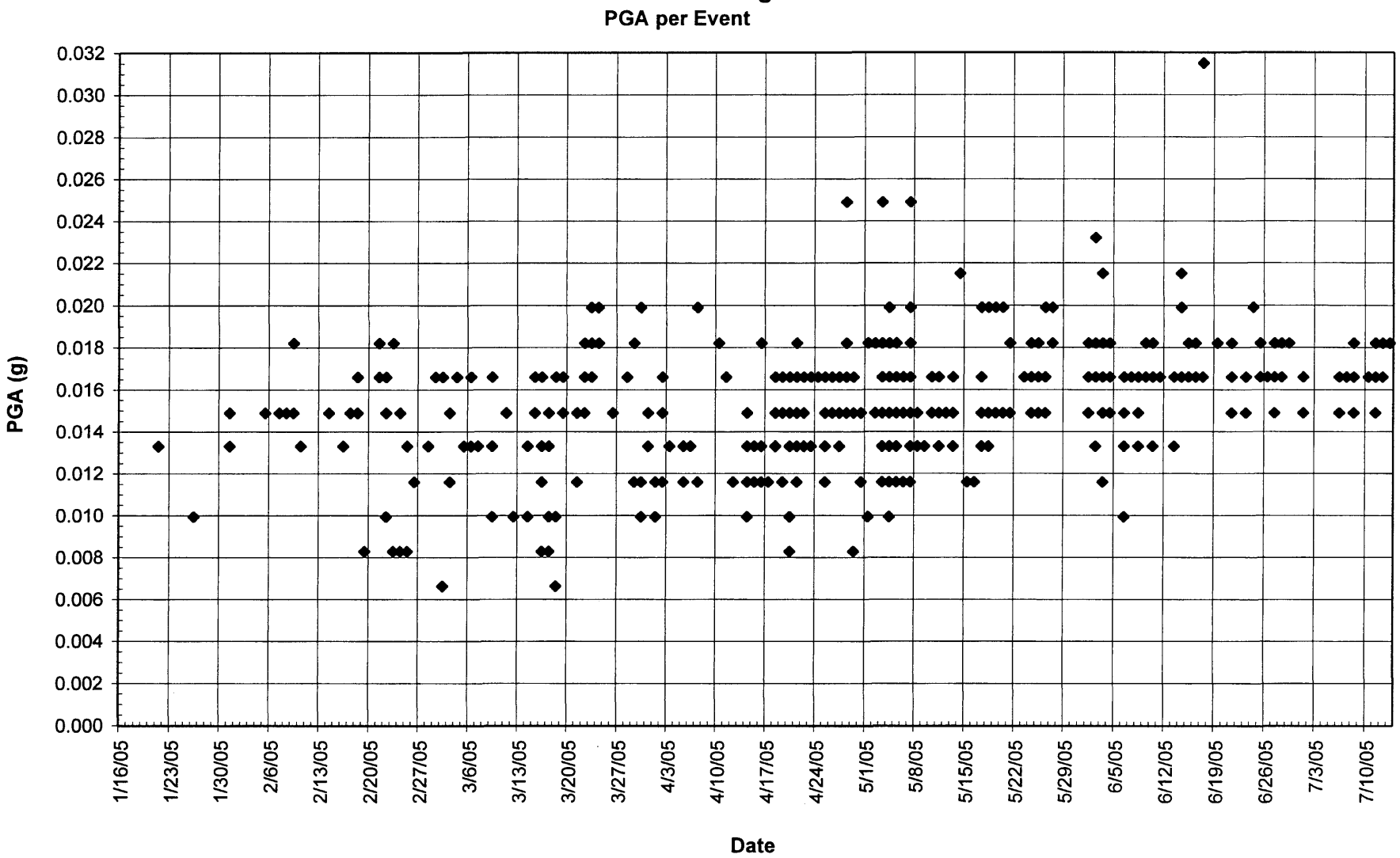

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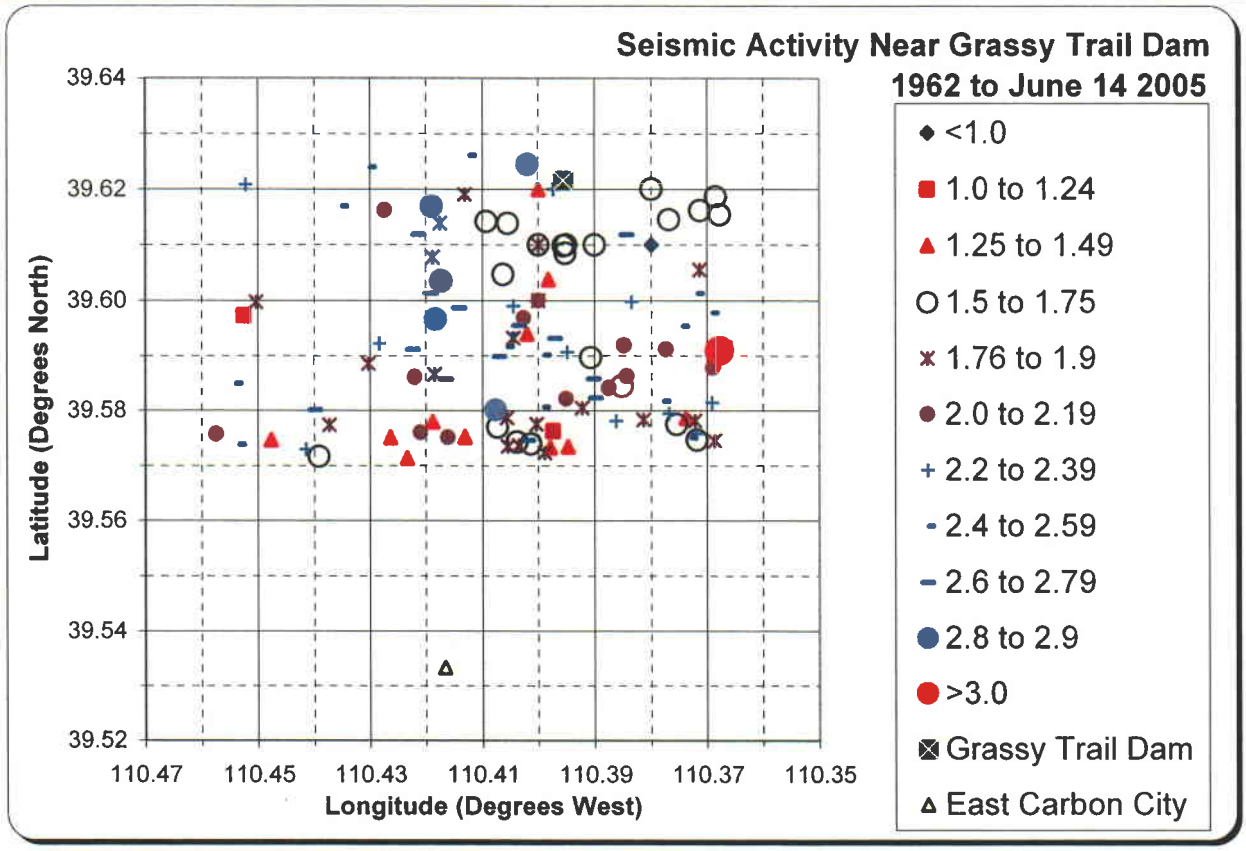
Figure 8 Recorded Peak Ground Accelerations
Hillside Seismic Monitoring Instrument

Grassy Trail Dam and Reservoir



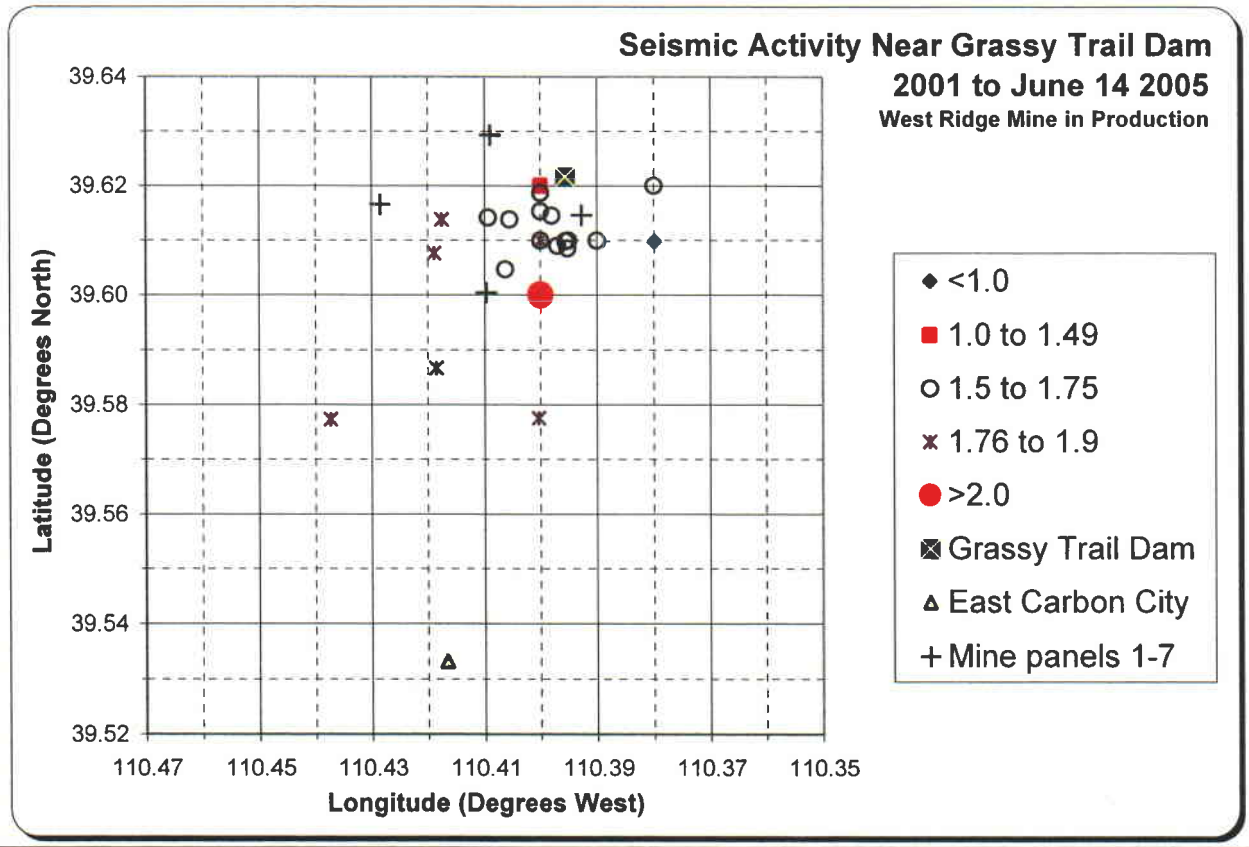


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Figure 9 Seismic Activity Near Grassy Trail Dam

Grassy Trail Dam and Reservoir

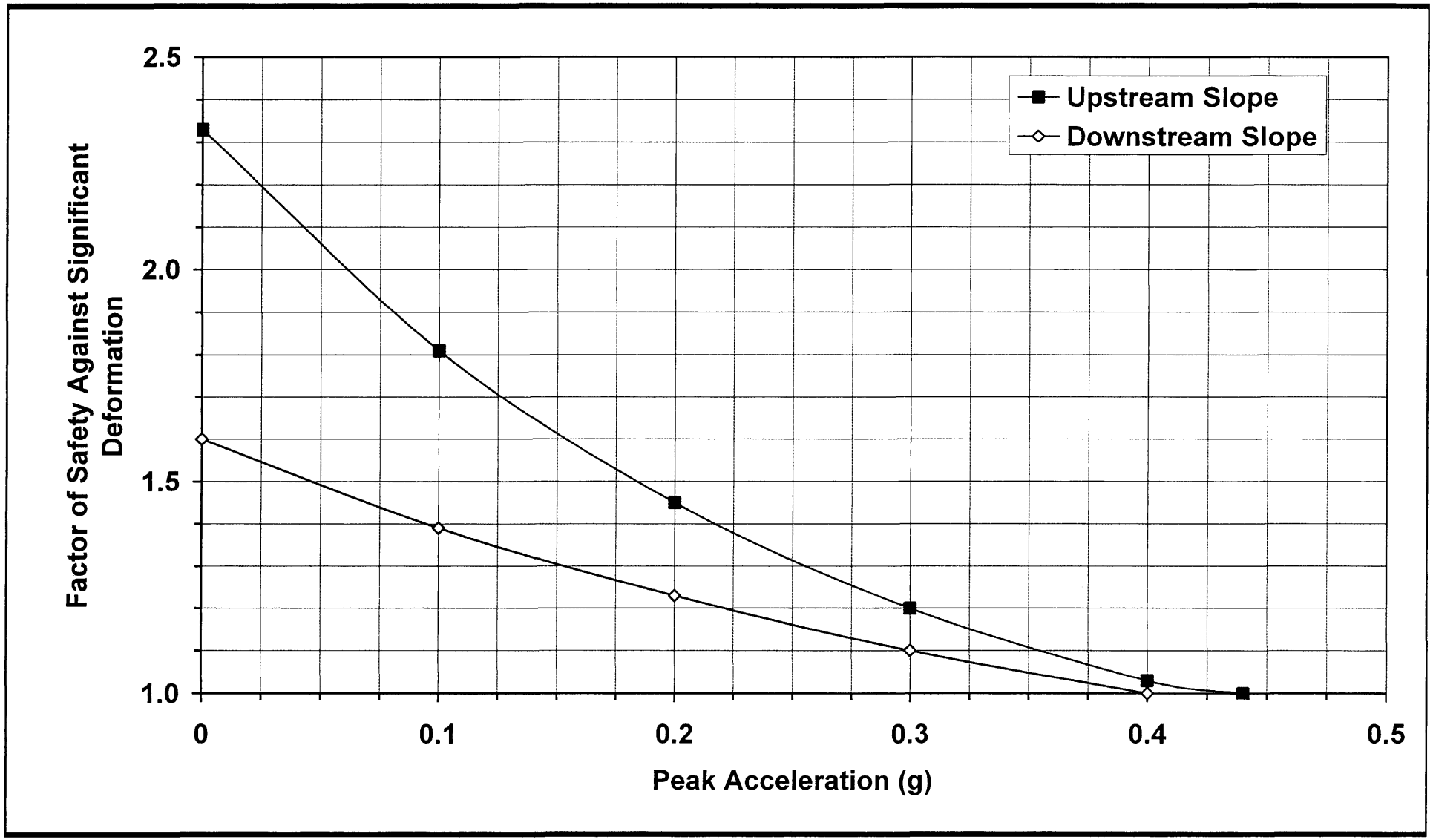

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Figure 10 Peak Acceleration and Factor of Safety Against Significant Embankment Slope Deformation

Grassy Trail Dam and Reservoir

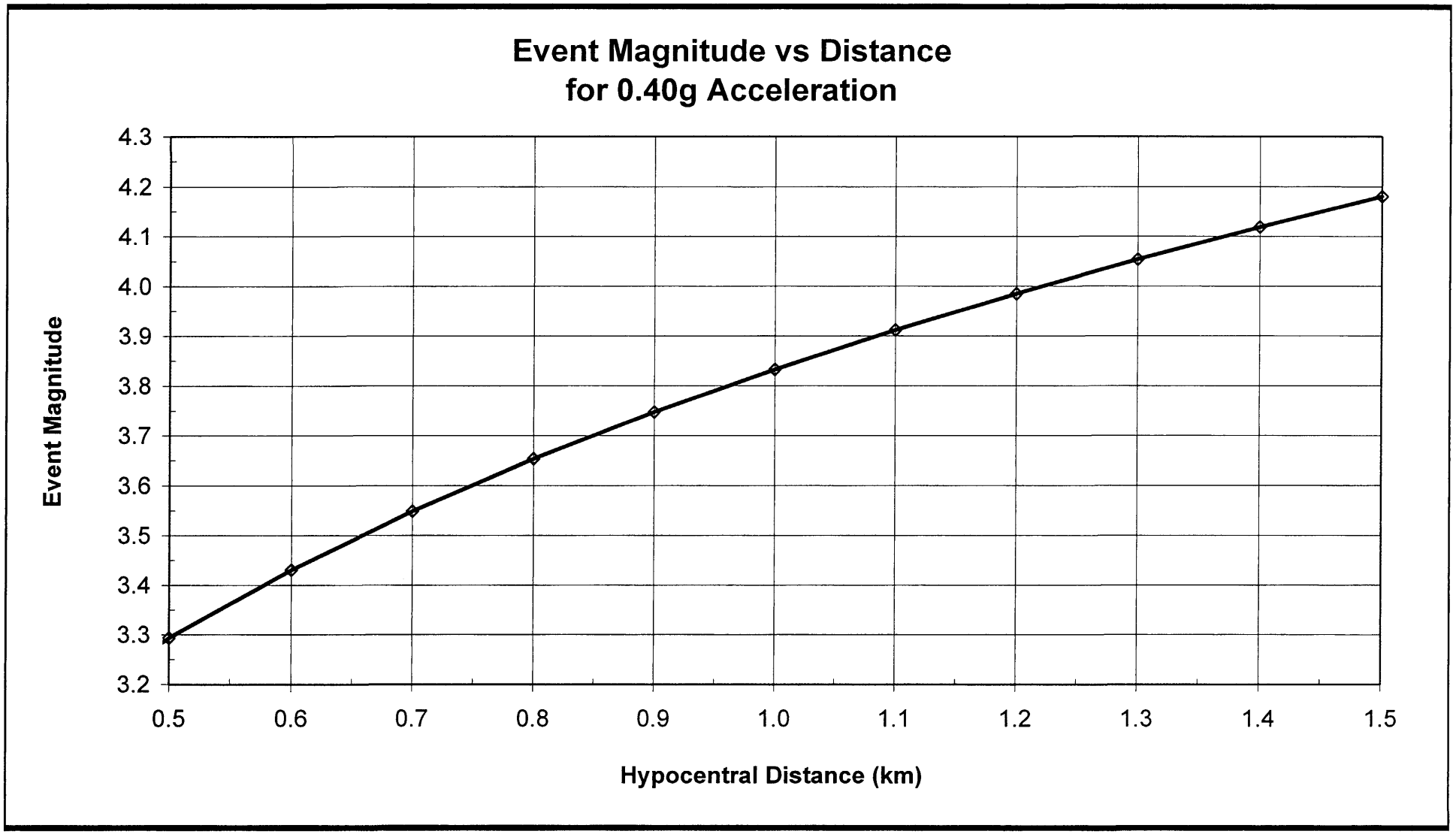

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Figure 11 Magnitude vs Distance for Peak Ground Acceleration of 0.40g
Based on McGarr-Fletcher relationship (2005)

Grassy Trail Dam and Reservoir

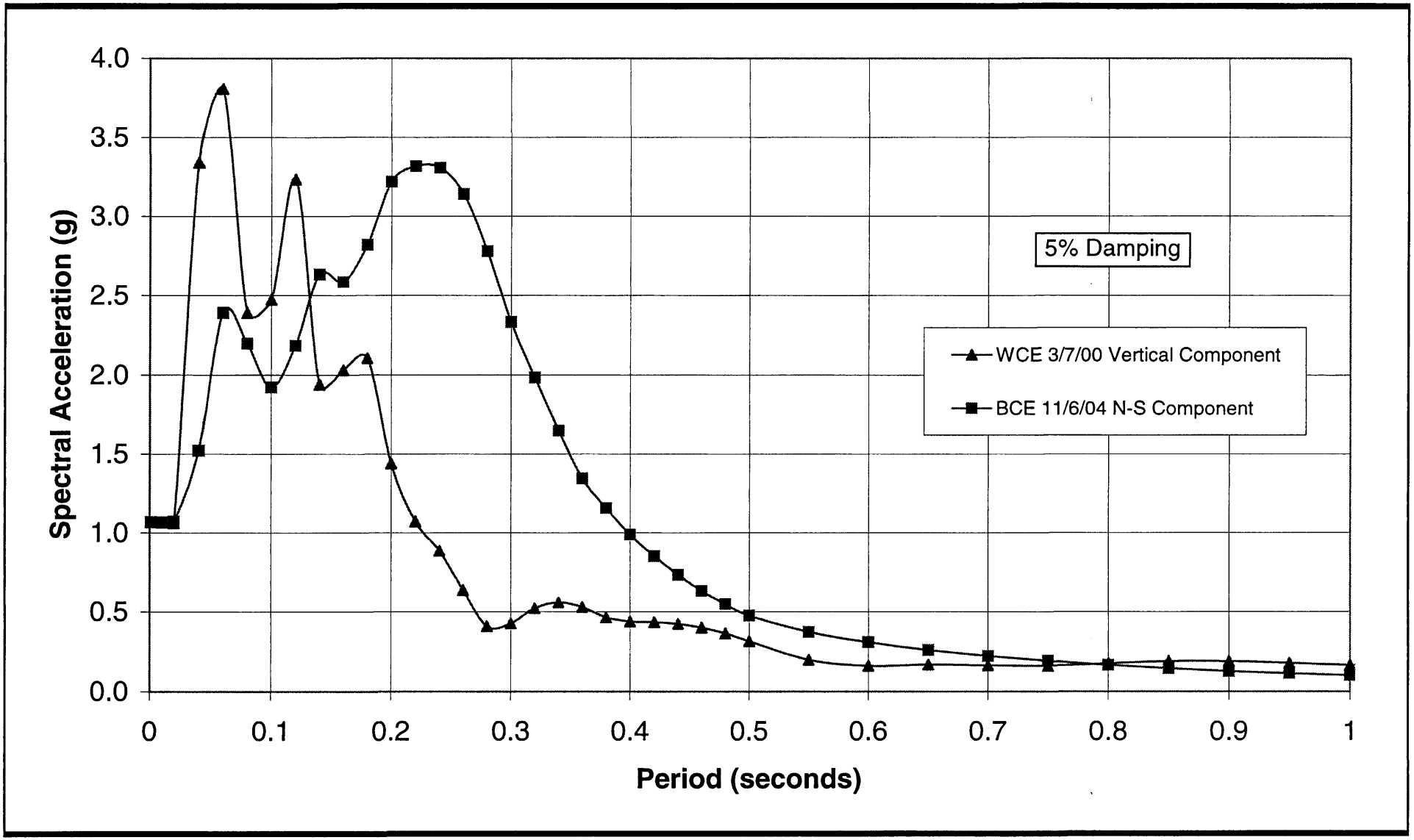

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Figure 12 Acceleration Response Spectra for Ground Motions Scaled to 1.07g

Grassy Trail Dam and Reservoir

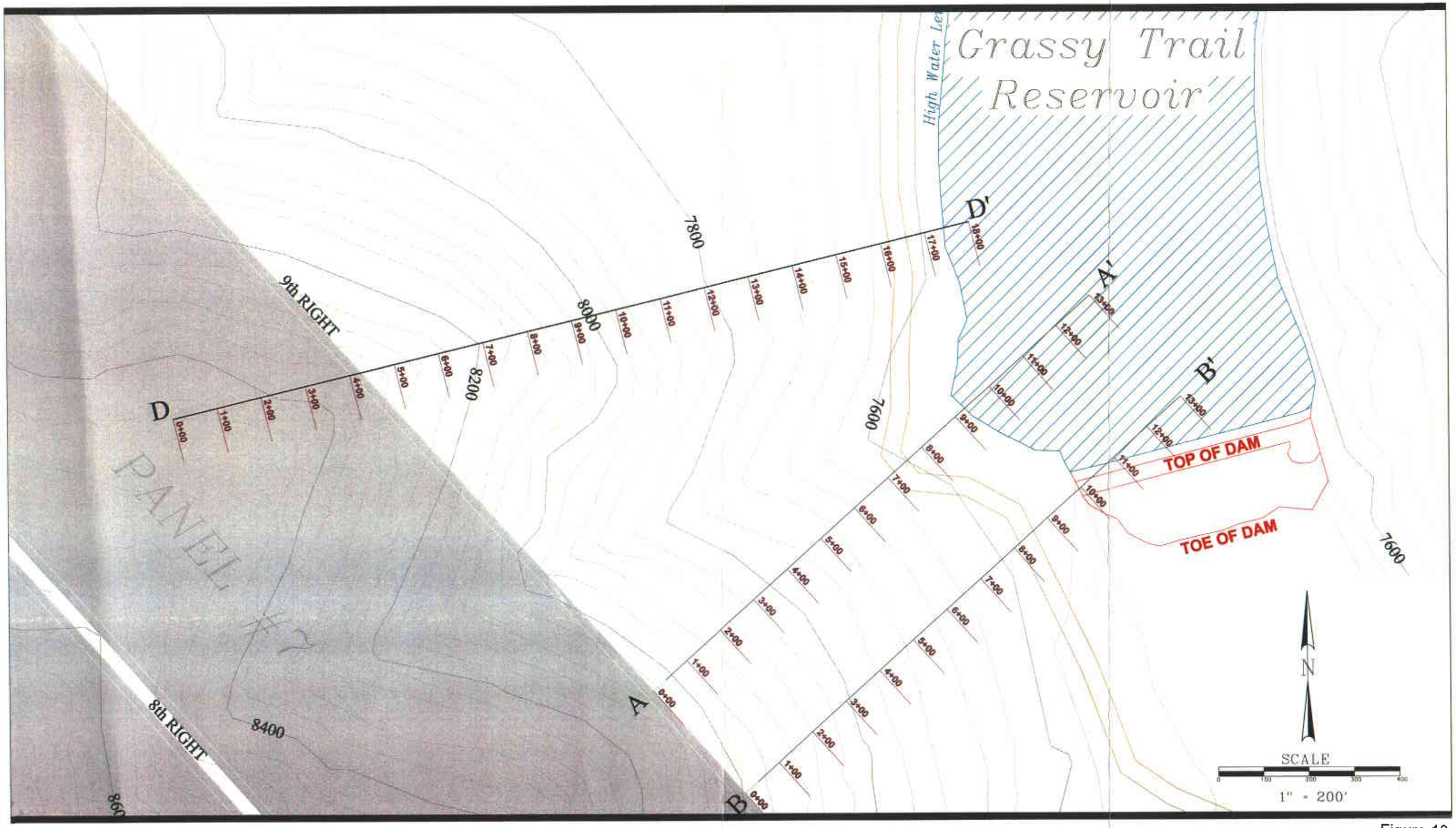

Figure 13

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GRASSY TRAIL DAM
CARBON COUNTY, UTAH

WEST RIM LANDSLIDE
SECTION D–D'

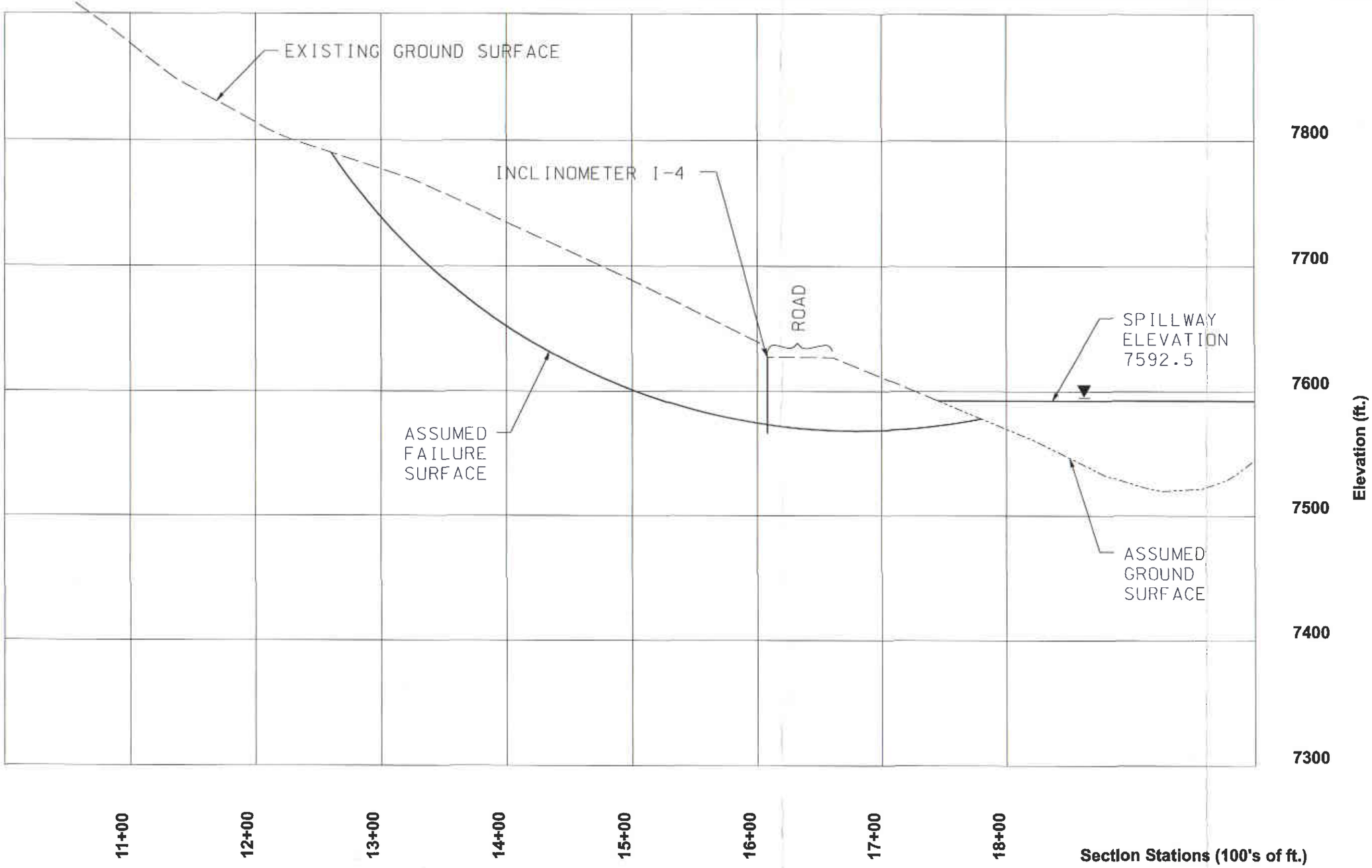

Figure 14

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GRASSY TRAIL DAM
CARBON COUNTY, UTAH

POTENTIAL FAILURE SURFACE
FOR WEST RIM LANDSIDE
SECTION D–D'

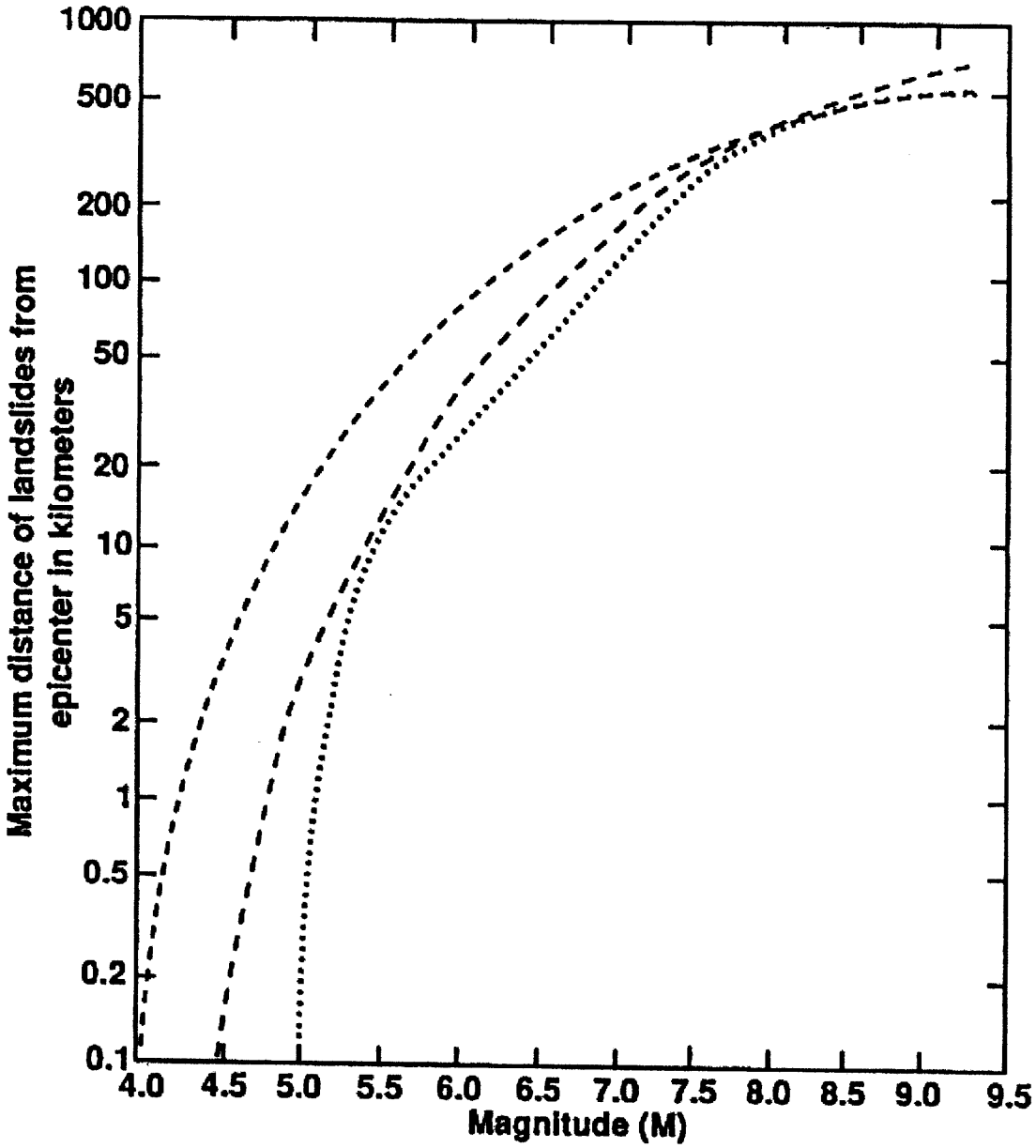

FIGURE 4-13 (*above*)
Maximum distance to landslides from epicenter for earthquakes of different magnitudes. - - - -, disrupted falls and slides; – – –, bound for coherent slides; . . . ., bound for spreads and flows (Keefer 1984).

APPENDIX

Agapito Associates, Inc. Report

460-6

Estimated Impacts
to the
Grassy Trail Reservoir
Due to
Longwall Mining
West Ridge Mine

prepared for

WEST RIDGE
RESOURCES, INC.

November 2004

AGAPITO ASSOCIATES, INC.
715 Horizon Dr., Ste. 340, Grand Junction, CO 81506
970/242-4220 • FAX 970/245-9234 • www.agapito.com

ESTIMATED IMPACTS TO THE GRASSY TRAIL RESERVOIR DUE TO LONGWALL MINING

West Ridge Mine

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ESTIMATED IMPACTS TO THE GRASSY TRAIL RESERVOIR DUE TO LONGWALL MINING
West Ridge Mine

EXECUTIVE SUMMARY

As part of an effort to minimize the possibility that mining operations will adversely impact the Grassy Trail Reservoir near its West Ridge Mine, West Ridge Resources, Inc. (WRRI) contracted Agapito Associates, Inc. (AAI) to develop a predictive subsidence model. The Grassy Trail Reservoir is impounded by an earthen dam constructed in the late 1950s, and the current mine plan is designed to mitigate impacts to the dam and reservoir.

The West Ridge Mine is longwalling the Lower Sunnyside Seam, with an average mining height of approximately 8 ft. Panels 1 through 4 have been retreated, with retreat of Panel 5 ongoing. Using available subsidence monitoring data from the surface above and adjacent to Panel 1, in conjunction with a knowledge of western U.S. subsidence data from similar geologic settings, AAI has used the influence function method to predict surface deformation (vertical subsidence, horizontal strain, slope, and radius of curvature) associated with two different longwall retreat plans for panels near the dam and reservoir.

SUMMARY OF MAJOR FINDINGS

- Based on the subsidence monitoring data from the line above Panel 1, and on western U.S. subsidence studies, AAI estimates that an appropriate subsidence factor (ratio of maximum possible subsidence to mining height) for the West Ridge Mine lies in a range from 0.45 to 0.70.
- Western U.S. experience indicates angle of draw values ranging from 0° to 30°. Due to the difficulty in measuring the angle of draw, and the resulting variability from study to study, AAI model inputs were varied to represent a range of draw angles. Model results show that higher angles of draw result in less subsidence intensity over a larger area (including the Grassy Trail Reservoir and Dam), while lower angles result in higher subsidence intensity over a smaller area (that does not include the Grassy Trail Reservoir and Dam). Therefore, for conservatism, the models representing a higher angle of draw should be used to estimate

impacts to the dam and reservoir, even though the actual angle of draw is expected to be significantly less.

- Modeling results indicate that for reasonable worst-case (upper limit) conditions with respect to the dam and reservoir (high angle of draw), the highest magnitude ground strains that can be expected at the Grassy Trail Reservoir/Dam are tensile strains on the order of 0.4×10^{-3} (0.04%). Maximum slope values are on the order of 1.5×10^{-3} (0.15%), while radius of curvature does not drop below 20 miles at the reservoir (and is in excess of 40 miles at the dam). These results are small relative to published upper-limit deformation criteria for dams and reservoirs. Implications are that the mining plans currently being considered pose a low level of risk to the Grassy Trail Dam and Reservoir.

CONCLUSIONS

The subsidence model developed in this study and the resulting ground deformations provide WRRI with an effective tool for estimating impacts to the Grassy Trail Reservoir/Dam. Based on this analysis and published subsidence criteria for dams and reservoirs, it appears that subsidence impacts associated with either of the mine plans currently being considered will be minimal. AAI recommends, to the extent practicable, that subsidence monitoring lines be established from the edges of Panels 7 and 8 towards the reservoir/dam. Prior to the development of Panel 8, periodic survey results should be compared with model results from corresponding mining geometries to further establish the validity and conservatism of the predictive model. The dam owner/engineer should also be consulted, and damage criteria more specific to the Grassy Trail Reservoir/Dam should be applied, if appropriate.

ESTIMATED IMPACTS TO THE GRASSY TRAIL RESERVOIR DUE TO LONGWALL MINING
West Ridge Mine

1.0 INTRODUCTION

As part of an effort to minimize the possibility that mining operations will adversely impact the Grassy Trail Reservoir near its West Ridge Mine, West Ridge Resources, Inc. (WRRI) contracted Agapito Associates, Inc. (AAI) to develop a predictive subsidence model. The Grassy Trail Reservoir is impounded by an earthen dam constructed in the late 1950s, and the current mine plan is designed to mitigate impacts to the dam and reservoir.

Located near Sunnyside, Utah, (Figure 1) the West Ridge Mine is longwalling the Lower Sunnyside Seam, with an average mining height of approximately 8 ft. Panels 1 through 4 have been retreated, with retreat of Panel 5 ongoing. At this point of mine planning, two options for mine development are being considered. In the first (Plan A, Figure 2), a barrier separates panels 5, 6, 7, and 8 south of the Grassy Trail Reservoir and panels 9, 10, and 11 west of the reservoir. In the second (Plan B, Figure 3), the barrier separates panels 5, 6, and 7 from panels 8, 9, 10, and 11.

Using available subsidence monitoring data from the surface above and adjacent to Panel 1, in conjunction with a knowledge of western U.S. subsidence data from similar geologic settings, AAI has used the influence function method to predict surface deformation (vertical subsidence, horizontal strain, slope, and radius of curvature) associated with the retreat of panels near the dam and reservoir. The results presented in this report provide WRRI with a sound engineering basis for judgments regarding the adequacy of current and future reservoir/dam protection measures.

2.0 MINE SETTING AND GEOLOGY

The West Ridge Mine is located within the Book Cliffs of the Colorado Plateau Geologic Province. Mining is currently carried out in the Lower Sunnyside Seam, part of the Cretaceous Blackhawk Formation. The Blackhawk Formation is comprised of interbedded quartzose sandstone, shaley siltstone, shale, carbonaceous shale, and coal (RB&G Engineering, Inc. 1999).

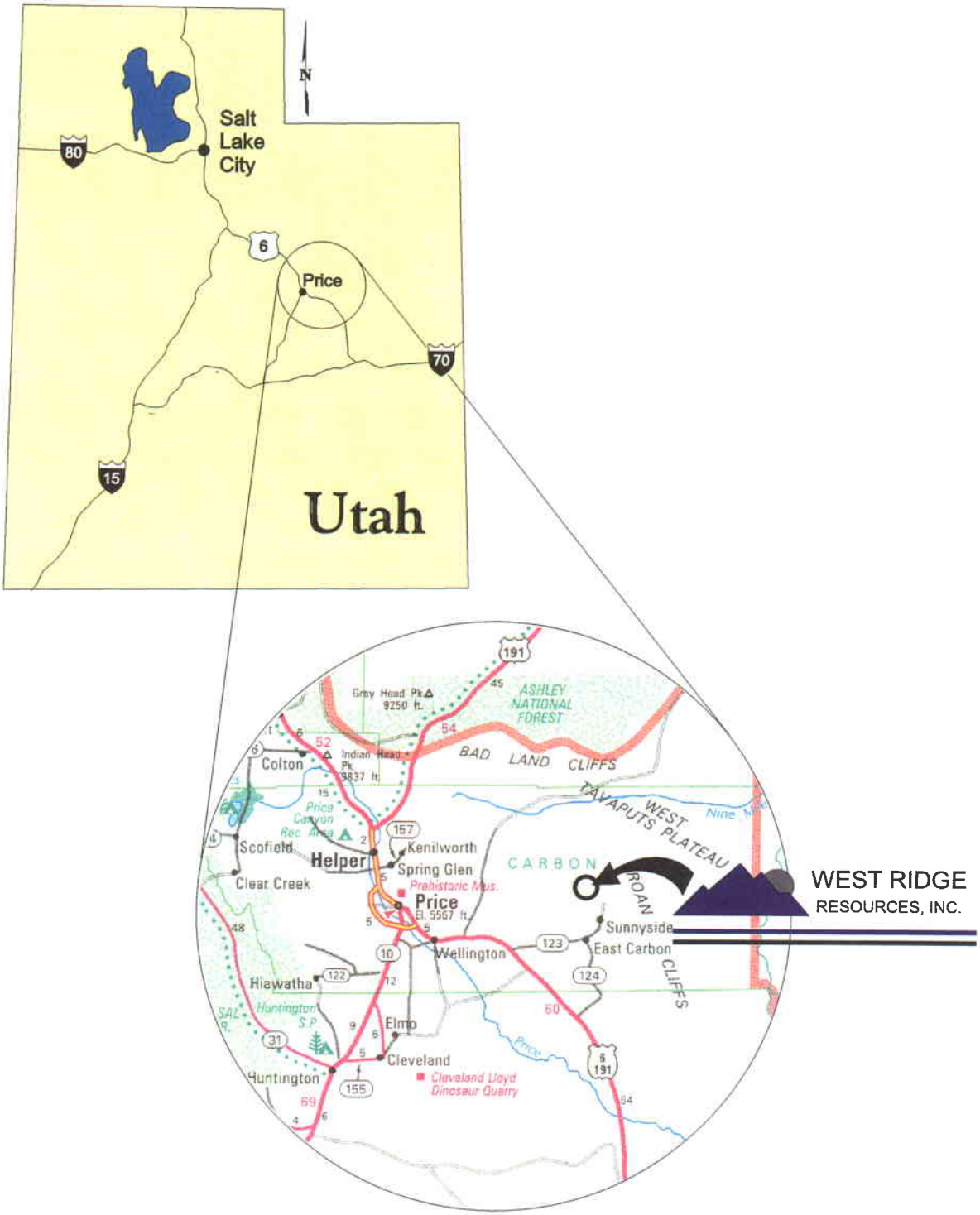
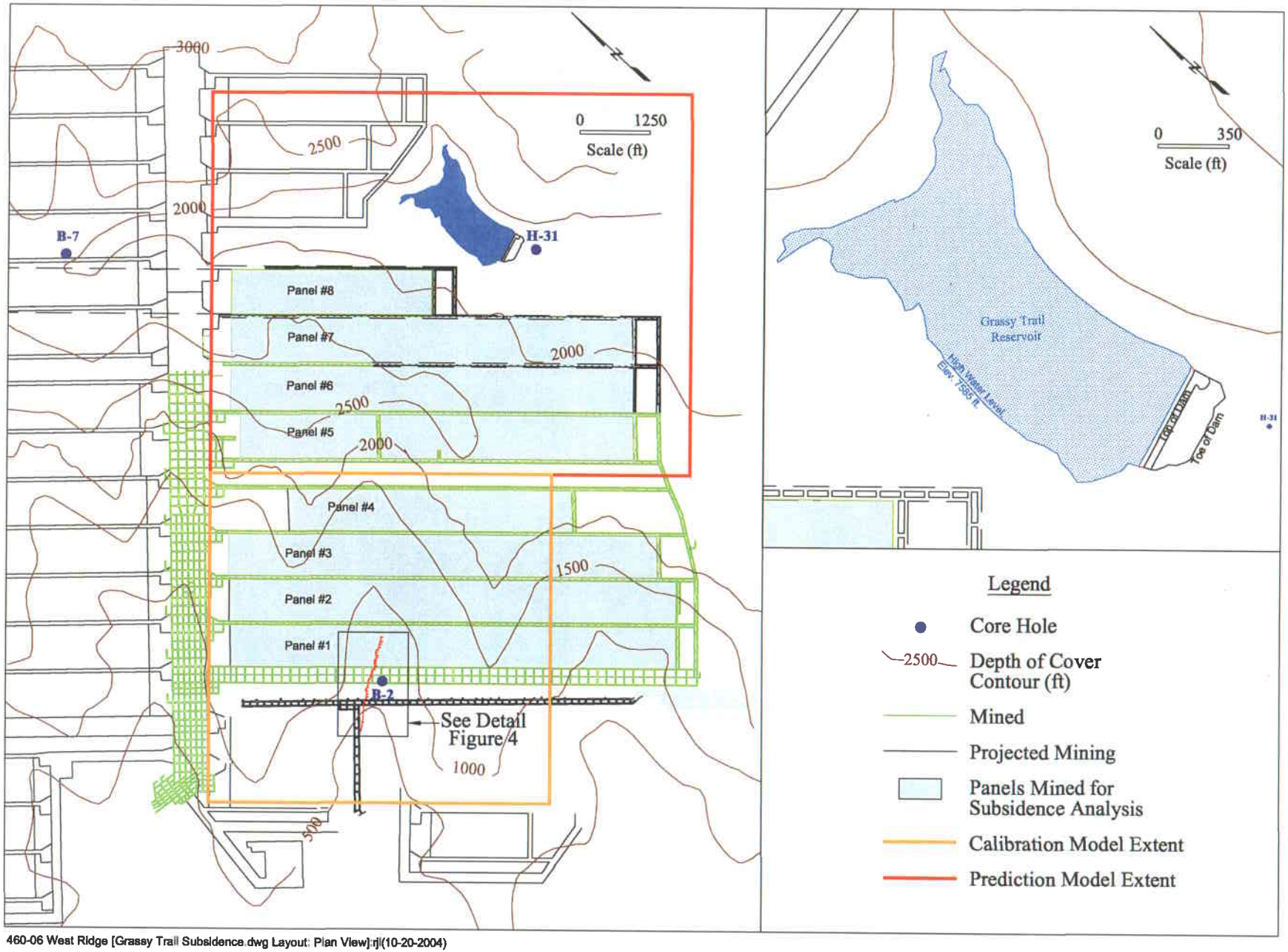
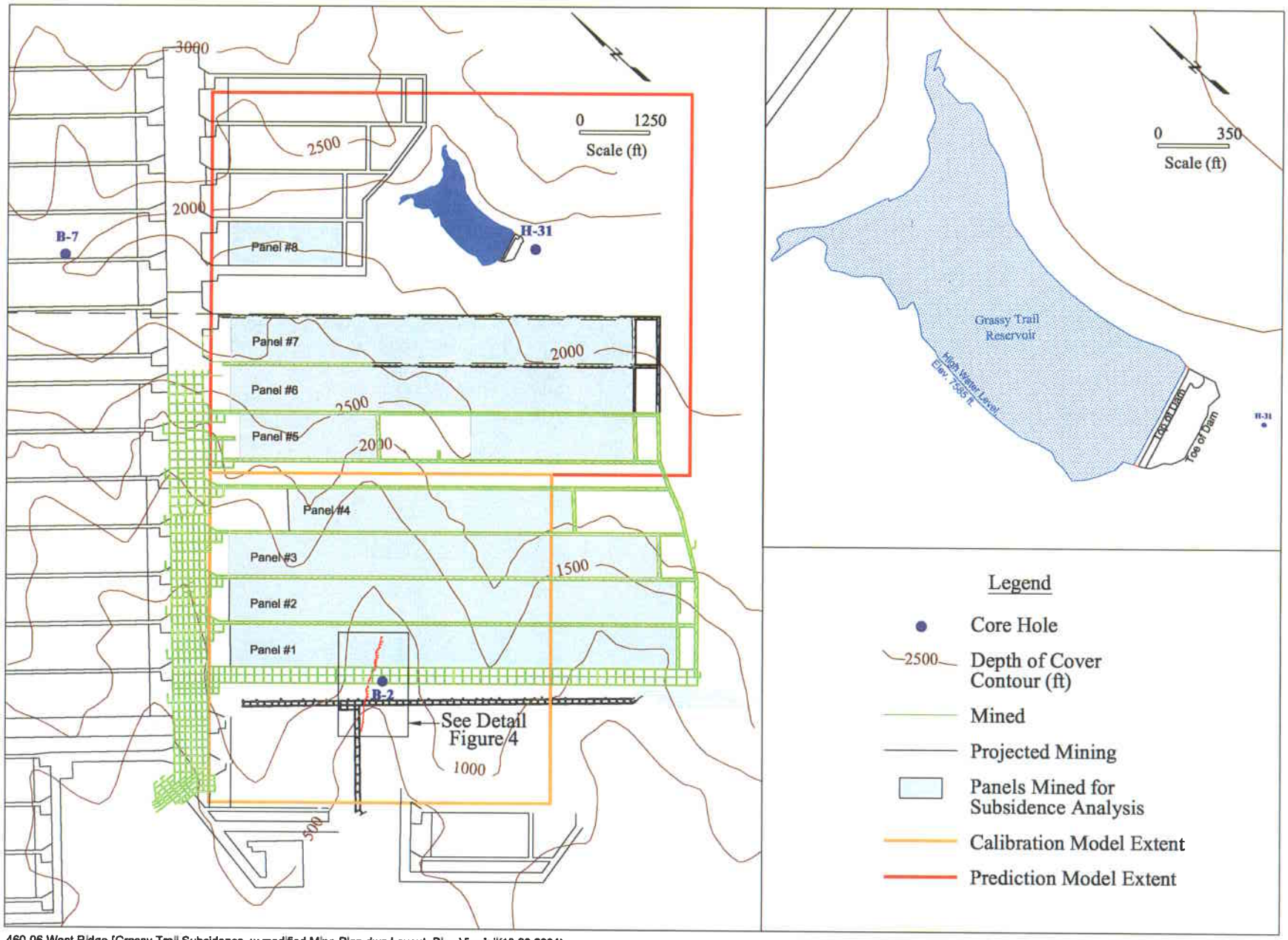


Figure 1. General Location of the West Ridge Mine



460-06 West Ridge [Grassy Trail Subsidence.dwg Layout: Plan View]:rjl(10-20-2004)

Figure 2. Map Showing Panels 1–8, Plan A, in Relation to the Grassy Trail Reservoir



460-06 West Ridge [Grassy Trail Subsidence_w modified Mine Plan.dwg Layout: Plan View]:rjl(10-28-2004)

Figure 3. Map Showing Panels 1–8, Plan B, in Relation to the Grassy Trail Reservoir

The Sunnyside coal member, consisting of the Lower Sunnyside and two splits of the Upper Sunnyside, underlies the interbedded sandstone and siltstone. Underlying the Lower Sunnyside Seam is the Lower Sunnyside Sandstone, a massive, competent quartzose sandstone.

The average strike of joints in the units overlying the Sunnyside coal is 105° (AAI 1997a, b). Joints in the Blackhawk Formation have been observed to be discontinuous, dip nearly vertical, and rarely penetrate more than a few beds. The regional strike of bedding structures is about 135°, with dips ranging from 2° to 11°, with an average dip of 7° to the northeast.

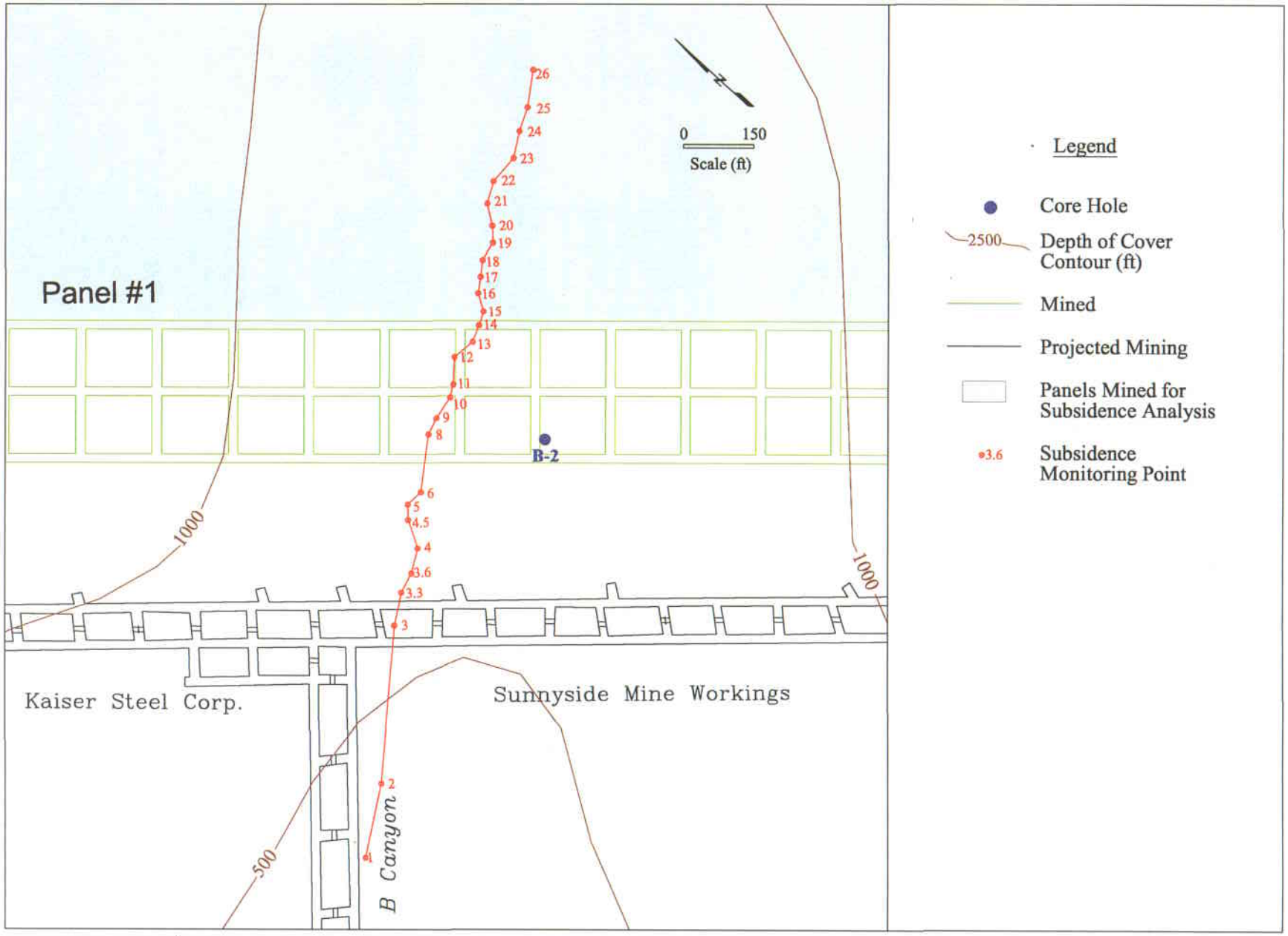
One fault zone has been encountered in the West Ridge Mine. This fault, which trends approximately N30°W, is a scissor fault, with increasing displacement to the south and east. The fault was first encountered during the mining of Panel 4, and the start room of Panel 4 was moved to the northwest to avoid it. The layout of Panel 5 was also modified to minimize the impact of the fault on longwall operations. No other significant faulting has been documented in the West Ridge Mine.

3.0 SUBSIDENCE PARAMETERS AND FACTORS AFFECTING SUBSIDENCE

AAI estimated ground deformation at and near the Grassy Trail Reservoir using the AAI proprietary influence function code BASIN version 6.0. Input for the model was based on (1) field data supplied by WRRI from a set of 28 subsidence monitoring stations in B Canyon over and adjacent to Panel 1 (Figure 4), and (2) published accounts of western U.S. subsidence experience. The combination of data sources allowed AAI to provide a range of likely ground deformations based on both site-specific and regional experience. The following sections describe the parameters required for input to BASIN, other parameters that affect measured subsidence, and an overview of western U.S. case histories.

3.1 Subsidence Parameters

Surface subsidence occurs as a result of downward strata movement caused by caving of the overburden after the coal seam is mined. Longwall mining produces "trough" type subsidence, characterized by the formation of a broad, elliptical basin without continuous fracturing between the mine and the surface. Figure 5 shows a generalized subsidence trough cross section where zones of lateral tension and compression are formed at the surface. Tension can cause an opening up of existing fractures and the formation of new ones, while compression tends to close up fractures.



460-06 West Ridge [Grassy Trail Subsidence.dwg Layout: Sub Mon]:rjl(10-20-2004)

Figure 4. Location of Subsidence Monitoring Stations Above and Adjacent to Panel 1

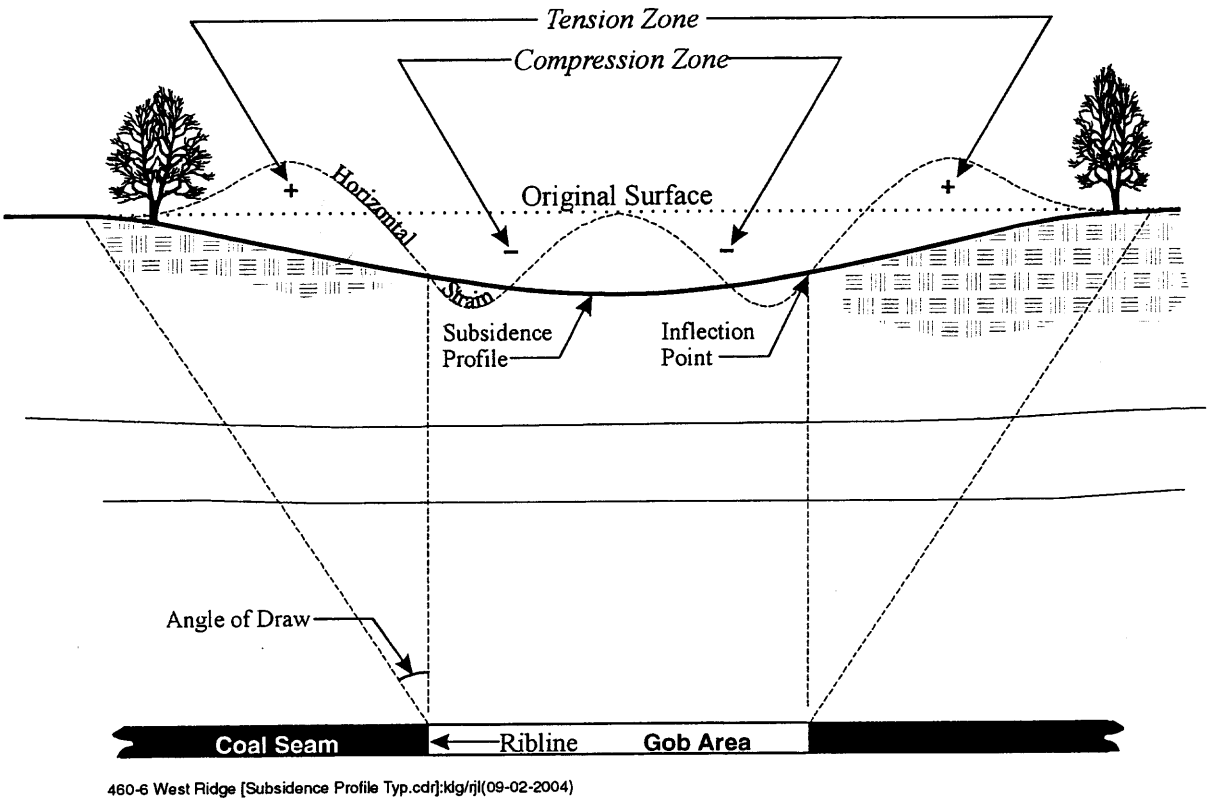


Figure 5. Schematic of Generalized Subsidence Parameters

Movements that develop at surface consist basically of vertical and horizontal displacements, tilts, and curvatures. These movements are more pronounced at the edges of the subsidence trough and can cause damage to surface features and structures. A portion of the subsidence trough moves with the longwall face. However, because the Grassy Trail Reservoir lies outside of the retreat mining area rather than over it, only the final subsidence profile, after mining is complete, needs to be considered.

Subsidence is highly dependent on geological and mining variables, including (1) angle of draw, (2) subsidence factor, (3) depth of cover, (4) mining height, and (5) horizontal displacement. These factors are directly accounted for in BASIN, as described below.

3.1.1 Angle of Draw

The angle of draw is the angle formed by the vertical line drawn from the retreated panel edge to the point of "zero" subsidence on the ground surface. Zero subsidence is often defined as 0.01 ft, but other values are used, resulting in large variations in reported angles of draw. Alternative

definitions exist which can be more meaningful, including the "angle of critical deformation" measured between the edge of mining and a point of "critical" deformation (based on a particular subsidence damage criterion) on the surface (Singh 1992). In practice, "critical" values often coincide with the minimum surveying resolution. Because it is rare to achieve 0.01-ft surveying precision, angles of critical deformation are often based on subsidence limits an order of magnitude or higher than the 0.01-ft limit defined by the National Coal Board (NCB 1975). Generally, angles of critical deformation are much smaller than angles of draw.

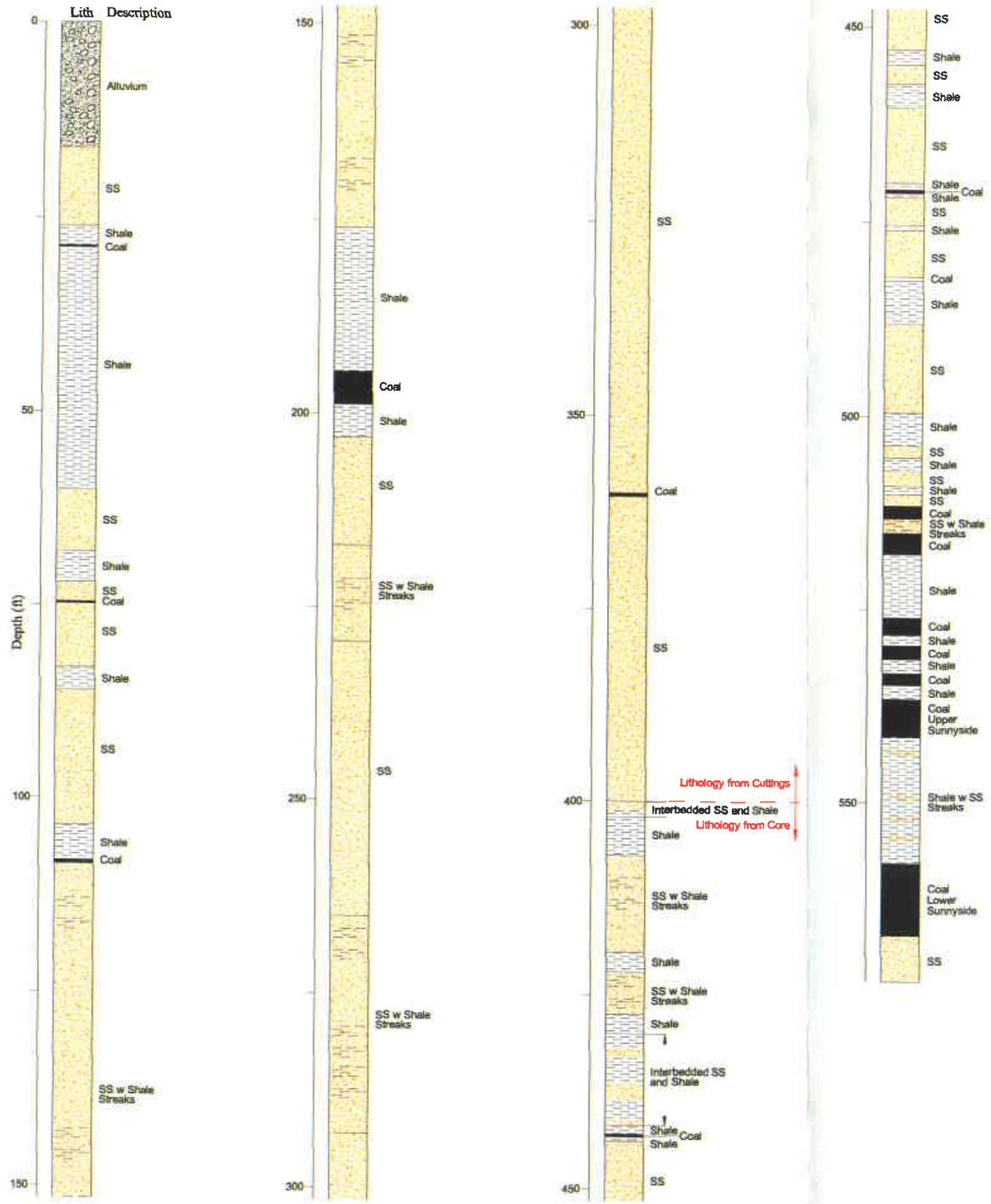
The angle of draw is a function of lithology and can be steeper in regions where massive sandstones and limestones occur in the overlying strata. This may be attributed to the tendency of these massive formations to break along vertical fracture planes rather than drawing into excavated areas as do shales and weaker strata. To assess in general the lithology near the Grassy Trails Reservoir/Dam, lithology logs (Figures 6 through 8) from three holes provided by WRRI were examined. Hole locations are shown in Figure 2 and again in Figure 3. These logs show that the overburden over the West Ridge Mine consists of sandstone, limestone, and calcareous mudstone, primarily in thick, massive beds. This overburden composition indicates that expected draw angles should be steeper (lower magnitude) than those associated with weaker, less massive strata.

The angle of draw or, alternatively, angle of critical deformation can be determined after the fact from the results of a properly conducted subsidence survey, but is difficult to predict, often varying considerably in a mining region and even on different sides of the same panel. In practice, angles can range from negative values to as large as 60°. The National Coal Board recommends an angle of draw of 35° for predicting subsidence over coal measure rocks in the United Kingdom. In some areas of both the western U.S. and Appalachia, strong sandstone members in the overburden result in much steeper angles of 20° or less.

As will be discussed further in Section 4.2, variability in the West Ridge subsidence data above Panel 1 makes calculation of the angle of draw somewhat subjective; however, it appears to be on the order of 30°.

3.1.2 Subsidence Factor

Subsidence factor is defined as the fraction of the extracted seam height that occurs at the surface as subsidence. It can only be accurately determined by measurements over supercritical



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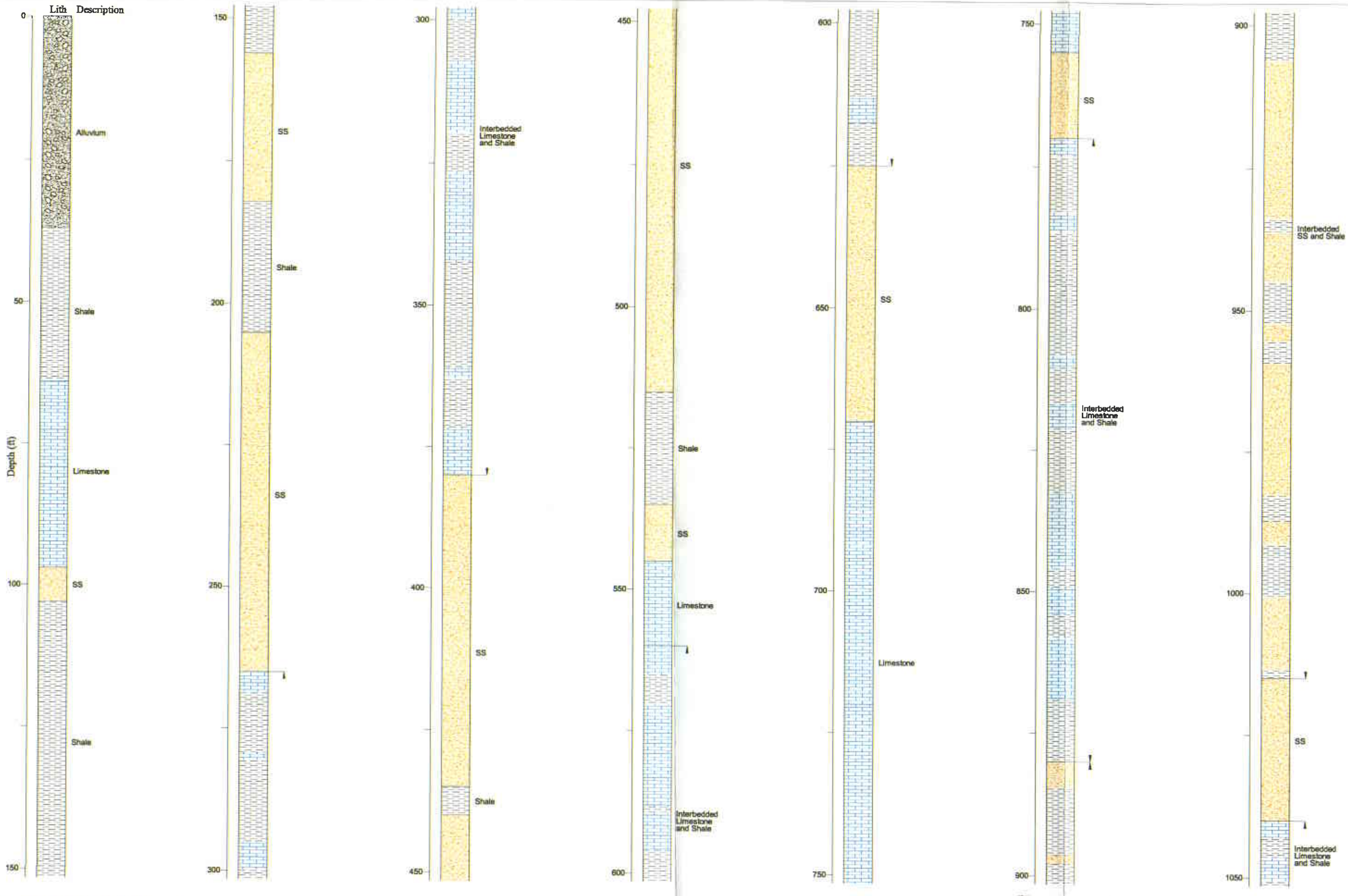
Sheet 1 of 1

Figure 6. Generalized Lithology Log for Core Hole B-2



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Sheet 1 of 2

Figure 7a. Generalized Lithology Log for Core Hole B-7

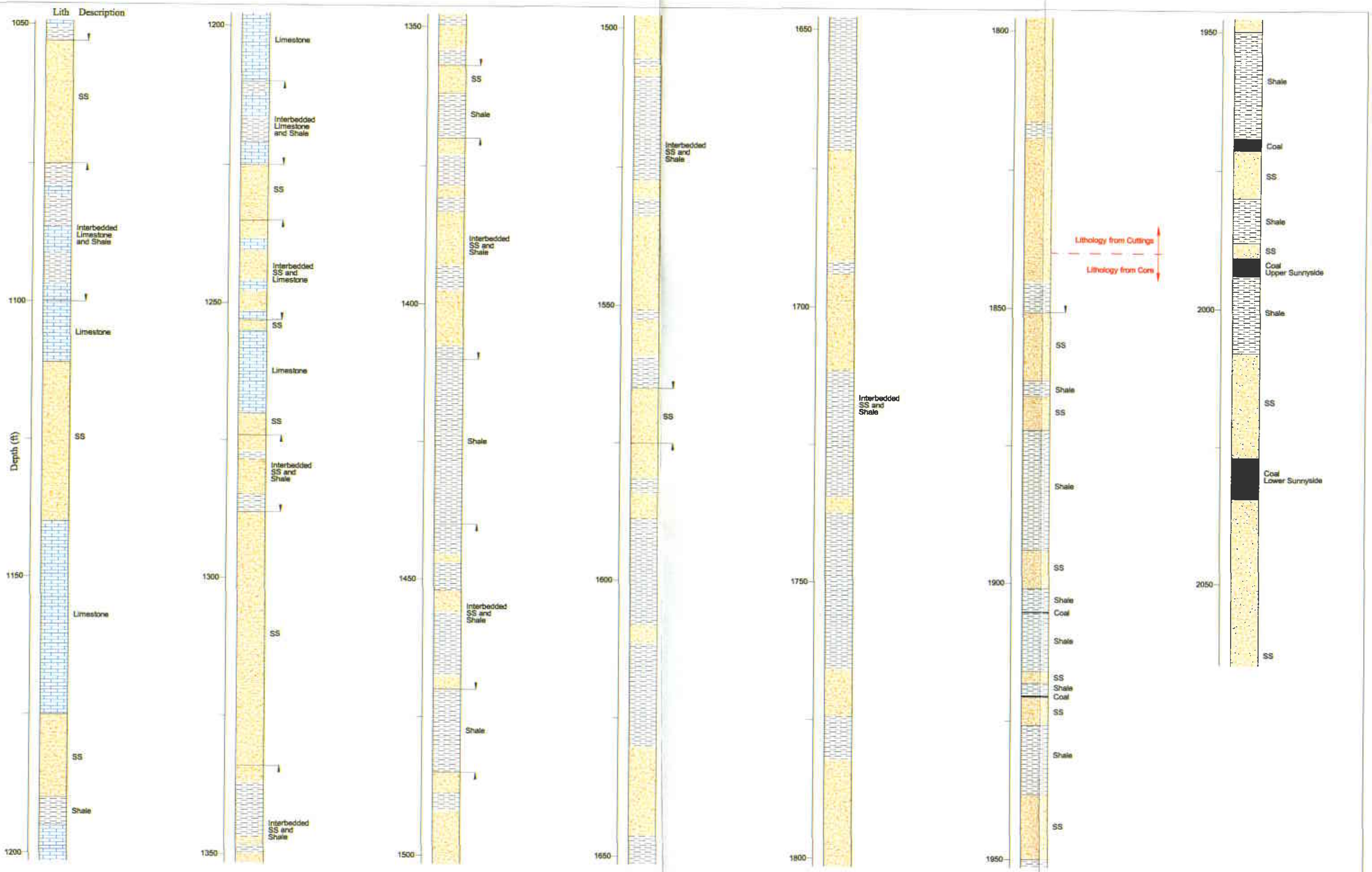

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Figure 7b. Generalized Lithology Log for Core Hole B-7

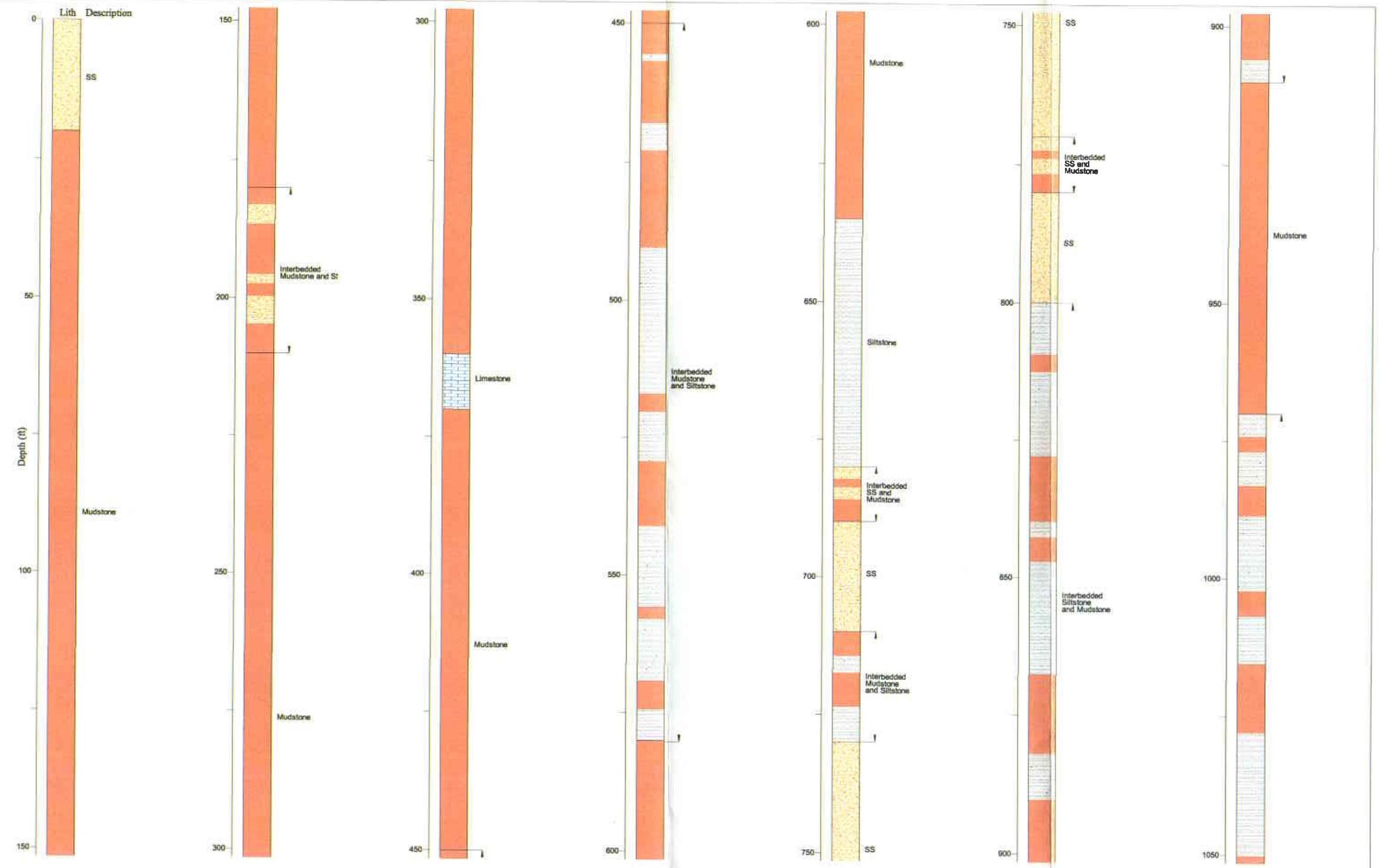

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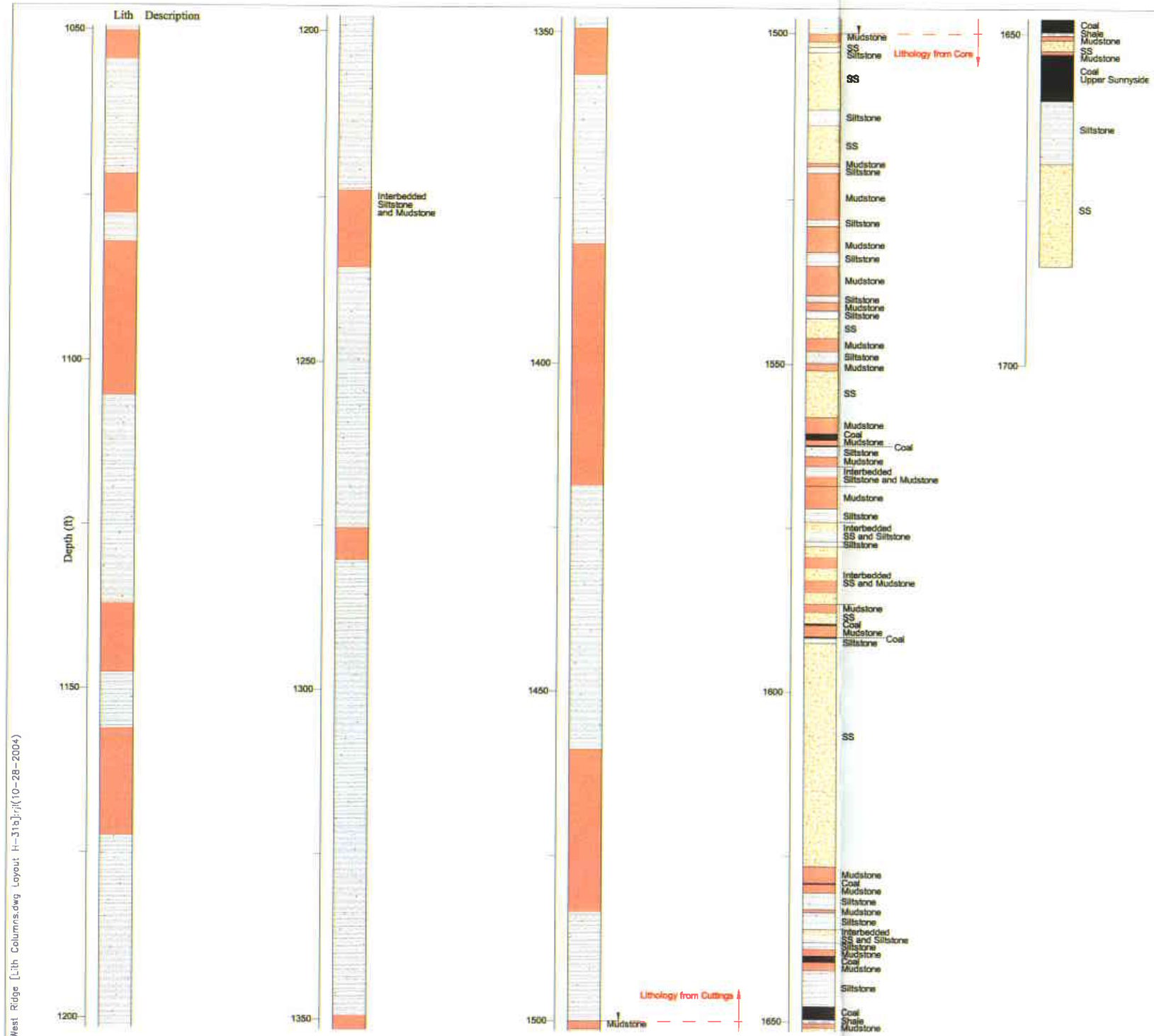
Figure 8a. Generalized Lithology Log for Core Hole H-31



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Sheet 2 of 2

Figure 8b. Generalized Lithology Log for Core Hole H-31

panel widths. The critical width is typically 1.0 to 1.4 times the cover depth. It is possible that the critical width exceeds this range where the overburden is exceptionally thick and massive. Determination of the subsidence factor may also be complicated by time effects, especially over areas of gradually deteriorating pillars. Mining wider than the critical width results in supercritical conditions, where maximum subsidence and a flat-bottomed subsidence trough are achieved.

Maximum subsidence measured above West Ridge Panel 1 was 3.6 ft. WRRI indicates that the mining height in Panel 1 averaged 8.0 to 8.5 ft, which results in a subsidence factor range from 0.42 to 0.45.

3.1.3 Cover Depth

In general, the subsidence factor decreases with cover depth. Therefore, subsidence associated with deep cover tends to be milder than that over shallow cover.

The depth of cover above Panels 1 through 8 ranges from approximately 500 ft to the southwest of Panel 1, to more than 2,500 ft over portions of Panels 5, 6, and 7 (Figures 2 and 3). The Grassy Trail Reservoir lies in a valley, with cover depth over the nearest mine workings of about 2,000 ft. Variable cover depths were included in the subsidence analysis, with cover depth averaged over a 50-ft by 50-ft area.

3.1.4 Mining Height

Mining height affects subsidence in that for a given subsidence factor, total subsidence will increase with mining height. For modeling purposes, mining height over Panels 1 through 8 was held constant; a value of 8 ft was used based on information provided by WRRI.

3.1.5 Horizontal Displacement

The horizontal displacement factor (c) is an empirically-determined constant defined as the ratio of maximum possible horizontal displacement at the surface to maximum possible surface subsidence. Values of c are reported to range between 0.12 and 0.30, based largely on Appalachian coal mining experience (Peng and Chen 1981). AAI examined x, y, and elevation data from the subsidence monitoring stations in B Canyon in an attempt to determine a site-specific horizontal displacement factor. However, this was not possible due to variability in the data, and instead, a value of 0.33 was used. Based on AAI's experience in calibrating BASIN results to field data in the west (Goodrich et al. 1999), this is a conservative value, producing larger rather than smaller

movements. Therefore, horizontal movements predicted by the model are expected to be in the upper range of actual values.

3.2 Other Factors Affecting Subsidence

In addition to the parameters mentioned above, which are included in the BASIN input, the following factors (Peng 1992) affect subsidence but are not directly accounted for in the code. The discussion of these factors is included to aid WRRI in interpreting both the results of this study, and future subsidence measurements and observations on the property.

3.2.1 Surface Topography

Although BASIN accounts for depth of cover, to which surface topography contributes, free surface effects are not addressed. Steep slopes subject to subsidence can fail and form landslides, depositing material at lower elevations. Subsidence is therefore sometimes greater at topographic highs and lower at topographic lows. The same is true for surface ground strains, which tend to be more tensile at hilltops and more compressive at slope bottoms. These effects are more often seen in the West where the topography is commonly severe.

3.2.2 Time

The relationship between face advance and subsidence, and the time that subsidence is active after mining is complete, is important in determining the impacts of subsidence. Subsidence at a given point generally begins at a distance 1.0 times the depth ahead of the face. As the face gets closer, subsidence gradually increases. When the face is even with the point, subsidence is about 7% of its final value. As the face passes, subsidence increases rapidly. When the face is 0.5 times the depth past the point, subsidence is about 73% of its final value. At 1.2 times the depth past the point, subsidence is 97% of its final value; the remainder is due to gob compaction.

The time that subsidence is active after mining is complete is typically between 4 and 12 months, although this is a function of seam depth. Deeper seams (typical of the West) have periods of active subsidence at the upper end of this range. Subsidence impacts to the Grassy Trail Reservoir/Dam, if any, could occur anytime during the period of active subsidence of adjacent panels.

3.3 Review of Western U.S. Case Histories

Included in Appendix A is a brief review of western U.S. subsidence case histories with similar geologic settings to West Ridge. These case histories illustrate trends in measured subsidence versus depth, overburden integrity, etc., and show the variability of subsidence parameters from property to property. Summaries of the case histories are shown in Table 1. The case histories can be used to establish a range of expected subsidence factors and angle of draw values, recognizing that it is difficult to predict with certainty where future West Ridge subsidence will fall in the range. In general, Table 1 shows that subsidence factors for western U.S. mines range from 0.3 to 0.7, with draw angles ranging from 0° to 30°. Subsidence factor appears to decrease as overburden competence increases. The relationship between angle of draw and overburden competence is less clear, with one case with massive sandstone (Geneva/Book Cliffs) having an angle of draw of zero, while another (Deer Creek/Wilberg) has an angle of draw of 30°.

In addition to the data summarized in Table 1, data from the Utah Division of Oil, Gas and Mining (DOGM) for the adjacent Sunnyside Mine were supplied by WRRI (2004). These data show a maximum measured subsidence over extracted longwalls of 3.15 ft, with an assumed 8-ft mining height, at a depth of 1,140 ft. The resulting subsidence factor of 0.4 falls within the range given in Table 1, and should be representative of West Ridge conditions given the proximity of the two mines. Angle of draw was calculated by AAI to be on the order of 30°, although the data that this value is based on were limited.

4.0 ANALYSIS

4.1 Methodology

The BASIN program, used to estimate ground deformation near the Grassy Trail Reservoir/Dam, is based on the grid-integration method, which translates seam closures to the surface, defining the shape of the resulting subsidence basin. Prior to running the program, it is necessary to discretize the mining region into a grid of mined and unmined elements. The calculated subsidence at any reference point on the surface is influenced by mining of elements in the seam within a "cone of influence" defined by the "angle of influence." The influence of each element is a function of radial distance from the reference point. An influence function of the form

Table 1. Summary of Western U.S. Subsidence Case Histories

Mine	Reference	Approximate Excavated Area (ft)	Depth (ft)	Strata	Measured Subsidence/ Mining Height	Angle of Draw	Comments
Geneva/Book Cliffs, UT	Dunrud 1976	Extraction widths of 1,700 ft and 2,500 ft separated by a barrier	900	Strong sandstones alternating with weak shales and mudstones	Not measured	Nearly vertical	Tension cracks in massive sandstone, cracks up to 3 ft wide observed in strong massive sandstone. Surface and groundwater flows disrupted.
Somerset, CO	Dunrud 1976	2000 by 2,000	300–1,600	Mudstone and shale with sandstone beds	0.31	20° in weak over-burden 600–900 ft deep, 15° in stronger over-burden 900 ft deep	Tension cracks, up to 1 ft wide, appeared 2–4 months after mining in mudstone-sandstone overburden 500–600 ft thick. Subsidence appeared to be complete 1.5 years after mining under 300–470 ft of cover.
Roadside, CO	Magers 1993	a) 1,200 by 1,400 b) 700 by 1,300 c) 450 by 1,600	a) 200 b) 50–200 c) 350–700	Shale, weak sandstone, and unconsolidated till	a) 0.43 b) 0.06 c) 0.32	a) 11°–14° b) n/a c) 8°–11°	Partial extraction room-and-pillar; 20-ft-wide stumps left in Areas A and C, retreat not complete in Area B. Tension cracks visible on the surface over Area A.
Castlegate No. 3	Fejes 1986	1,100 by 1,900	800–1,500	Sandstone, shale, carbonaceous shale, coal	0.37	Not given	Massive Castlegate Sandstone, 500 ft thick, 50 ft above longwall panels may have resulted in low subsidence factor.
Deer Creek/ Wilberg	Dyni 1991, Allgaier 1982 and 1988	2,200 by 3,800	1,530–1,600	Sandstone (45%), siltstone, and mudstone	Deer Creek 0.68, Wilberg 0.73	Deer Creek 30° Wilberg 30°	Castlegate Sandstone, 200 ft thick, 880 ft above study panels. Deer Creek panels mined first, then undermined by Wilberg panels 50 ft below. Undermining increased subsidence factor, but had no effect on angle of draw. No surface damage observed.
SUFCO, UT	Goodrich et al. 1999	5,000 by 14,200	600–1,000	Sandstone (60%–65%), shale, mudstone, siltstone	0.45 under Castlegate Sandstone, 0.64 under draws where Castlegate Sandstone not present	15°	Castlegate Sandstone, 200 ft thick, 775 ft above the study panels. Subsidence factor lower under Castlegate Sandstone, at greater depth (1,000 ft vs. 600 ft).

$$P = \frac{nS_{\max}}{B^2}\exp\left[-\pi n\left(\frac{r}{B}\right)^2\right] \tag{1}$$

was used to describe the relationship where

P = Subsidence at a surface grid point

S_{max} = Maximum possible subsidence

r = Radial distance from reference point

B = Radius of area of influence = depth × tan (angle of influence)

n = Shape factor

These factors are explicit input parameters in BASIN which control the shape of the simulated subsidence basin. These factors do not directly correspond to measured subsidence parameters, such as angle of draw or subsidence factor, but can be calibrated to reproduce field measurements.

The influence function used in BASIN is a normal distribution function that has been used widely to predict mine subsidence in the U.S. and elsewhere (Brauner 1973). The variable S_{max} considers both subsidence factor and mining height per element location. Values used for angle of influence, subsidence factor, depth, and mining height are discussed in Section 4.2.

Superposition by integration of these influences from neighboring excavations over the area of influence gives total subsidence at a reference point. Variable topographic relief is considered by varying the depth at each mining element. Greater mining depths result in a broader and shallower subsidence basin by this influence function.

Horizontal movements (H) on the surface were approximated by the function

$$H = \frac{2\pi n^2 S_{\max} r\, c}{B^3}\exp\left[-\pi n\left(\frac{r}{B}\right)^2\right] \tag{2}$$

where c is the horizontal-displacement factor. Horizontal strains are derived from the horizontal movements.

4.2 Model Calibration

A base numerical model was calibrated to subsidence measurements from the 28 monitoring points established by WRRI over Panel 1, as shown in Figure 4. Initial survey data from

October 2001 were used as the baseline, with the October 2001 elevations subtracted from subsequent survey data to generate subsidence profiles over time. Results are shown in Figure 9. The monitoring period includes the face approach to the monitoring line during Panel 1 retreat, continuing through to complete retreat of Panels 1 through 4, for a total extracted width of about 3,100 ft. Taking into consideration the accuracy of the survey (±0.25 ft), these results show that subsidence was largely inactive as of September 2003 (a period covering the last 3 surveys). This would indicate that the maximum subsidence measured (approximately 3.6 ft) is a good estimate of S_{max}. However, S_{max} could be larger, due to the possibility that (1) the monitoring line may not extend far enough from the panel edge to be over the flat-bottomed portion of the subsidence trough, or (2) that the extracted panel width of 3,100 ft is subcritical due to the relatively high depth of cover. Of these possibilities, AAI considers the latter to be less likely.

Figure 9 also illustrates the difficulty of calculating angle of draw due to variability of field data. For example, given the variability, an argument could be made for any point between stations 3 and 19 as representing the point of zero subsidence. Using an average depth of 700 ft, this results in a range of angle of draw from –15° (using station 19) to 43° (using station 3). Using station 6 as a best estimate of zero subsidence results in a draw angle of 28°, similar to that calculated from available Sunnyside data.

Keeping these uncertainties in mind, BASIN models were run for complete extraction of Panels 1 through 4 for various angles of influence, maximum subsidence, and shape factor. Table 2 summarizes the range of input values.

Table 2. Range of Input Values Used to Fit Influence Function to Measured Subsidence

Subsidence Parameter	Range Modeled
Angle of influence	20°–45°
Maximum subsidence (S_{max})	2.4–6.0
Shape factor (n)	0.25–2.0

Profiles of the model results were then taken to correspond with the line of the subsidence monitoring stations over Panel 1. Results are shown in Figure 10. None of the curves matched the measured subsidence with a high degree of accuracy; therefore, AAI decided to focus on two cases that represent the lower and upper bounds of subsidence factor on the property. Using the data from

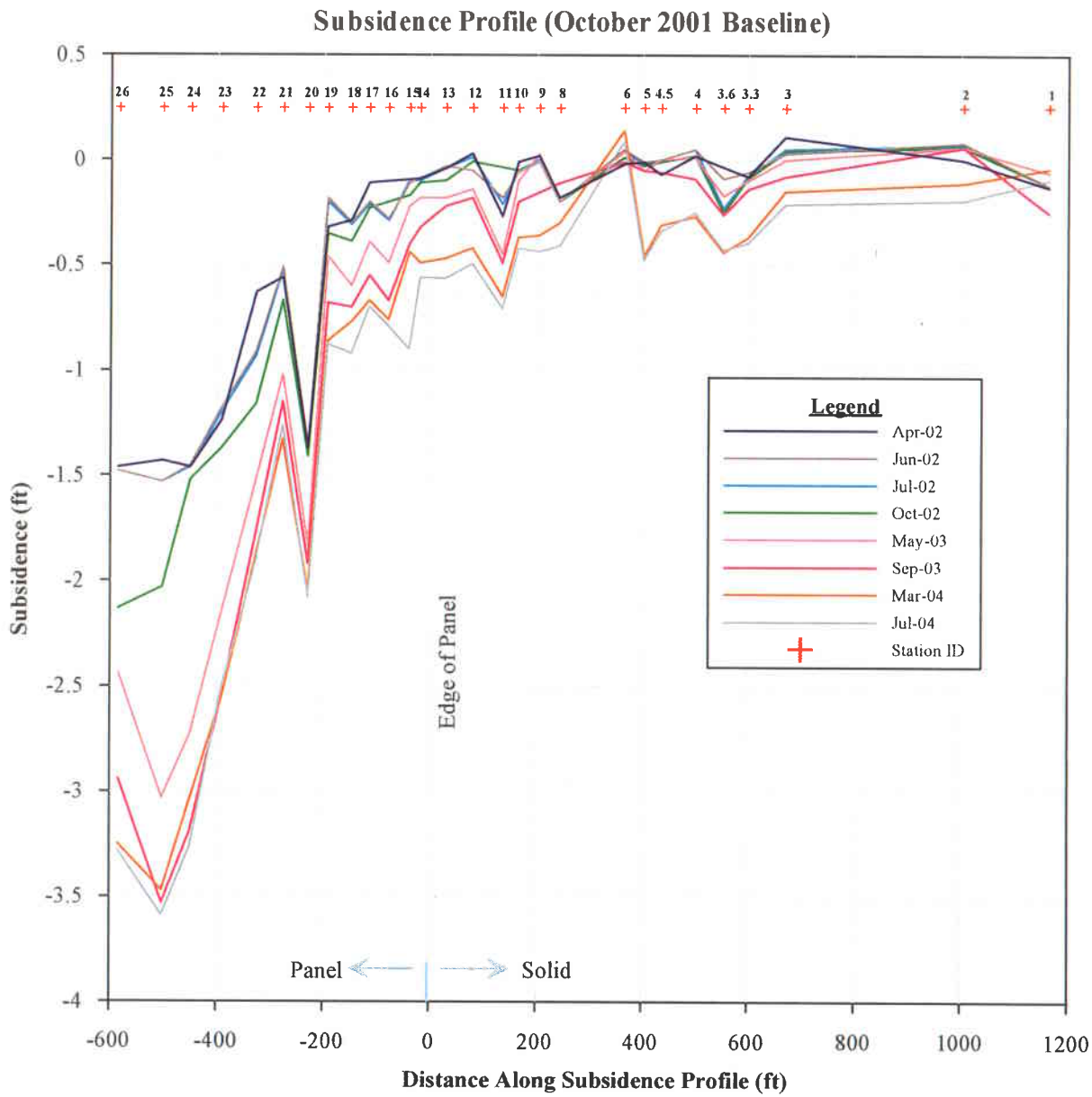


Figure 9. Subsidence Monitoring Results over Panel 1 (from April 2002 to July 2004)

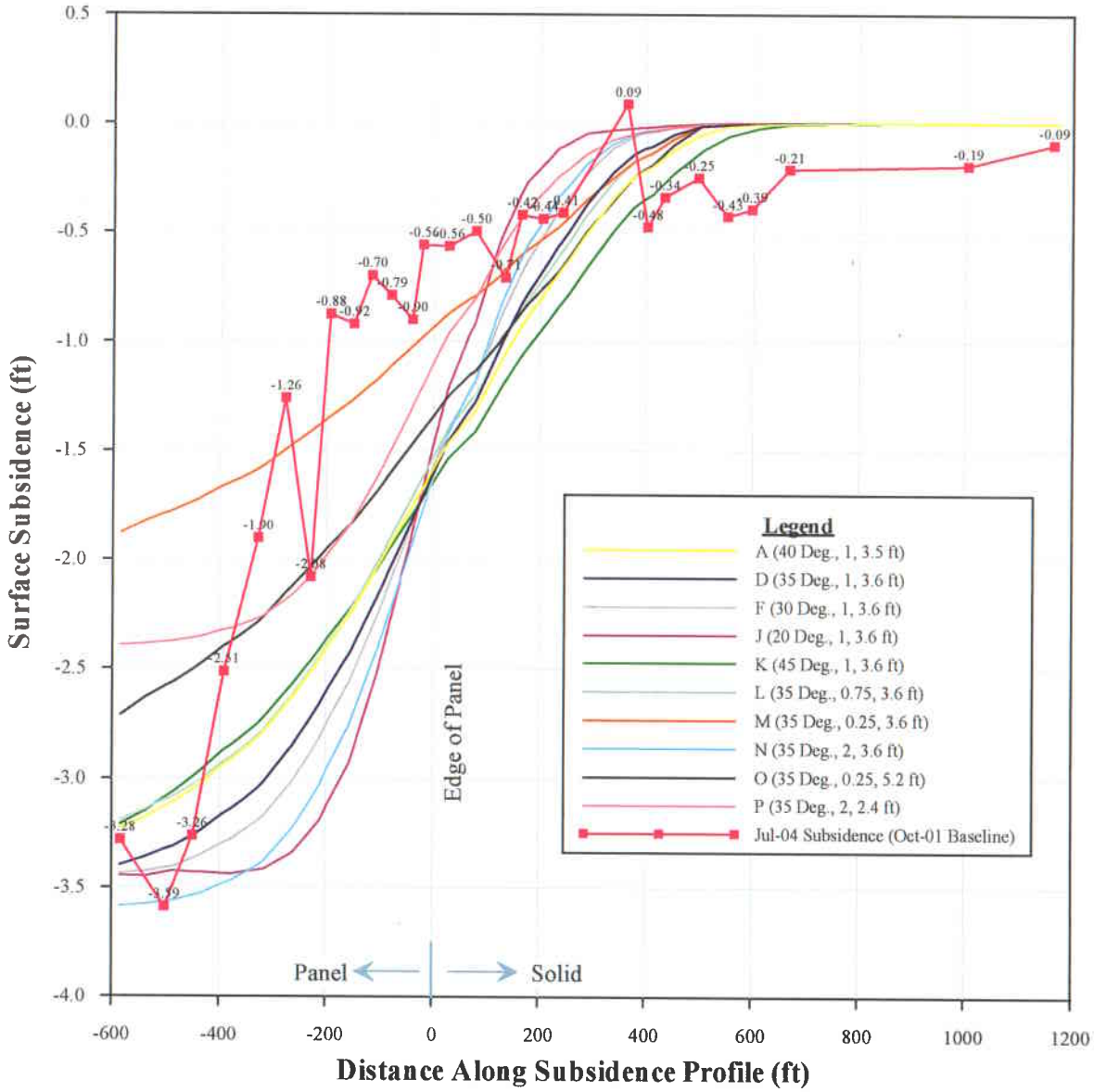


Figure 10. BASIN Calibration Results Compared to the Final Subsidence Profile from Field Monitoring

the monitoring line above Panel 1, a lower bound of subsidence factor of 0.45 was used (similar to the 0.4 value from Sunnyside). For an upper bound, the 0.7 subsidence factor from the case study review was used, giving a maximum subsidence of 5.6 ft. AAI deemed a shape factor of 1.0 appropriate, and decided to model each combination of subsidence factor with angles of influence of 20°, 30°, and 45°. The resulting range of subsidence factor and angle of influence provides a conservative estimate of potential subsidence impacts to the Grassy Trail Reservoir/Dam, and allows WRRI to make judgments regarding the appropriate barrier distance between longwall retreat and the reservoir and dam.

4.3 Grassy Trail Model Results

Using the range of S_{max} and angle of influence determined from the calibration procedure of Panels 1 through 4, and a shape factor of 1.0, models were run to predict likely ground deformation parameters for Grassy Trail Dam/Reservoir panels 5 through 8. To maximize the efficiency of the modeling effort, initial runs were performed corresponding to the geometry of Plan A (Figure 2). Once modeling parameters were established to best assess subsidence impacts, an additional model corresponding to Plan B (Figure 3) geometry was run. In all, six Plan A models (Models 1 through 6) and one Plan B (Model 7) were run. Table 3 summarizes the input parameters for each model.

Table 3. Model Parameters Used to Estimate Ground Deformation at the Grassy Trail Reservoir/Dam*

Model	Influence Angle (degree)	S_{max} (ft)
1	20	3.6
2	30	3.6
3	45	3.6
4	20	5.6
5	30	5.6
6	45	5.6
7	45	5.6

*Models 1 through 6 correspond to the geometry of Plan A, Model 7 corresponds to the geometry of Plan B.

Subsidence and horizontal strain (more precisely, maximum principal horizontal strain) results for the six Plan A models are shown in Figures 11 through 16. Vertical subsidence is contoured with labeled lines, while horizontal strain is color-coded. The figures show that for lower influence angles, ground deformations are more intense, but extend over a smaller area. For higher

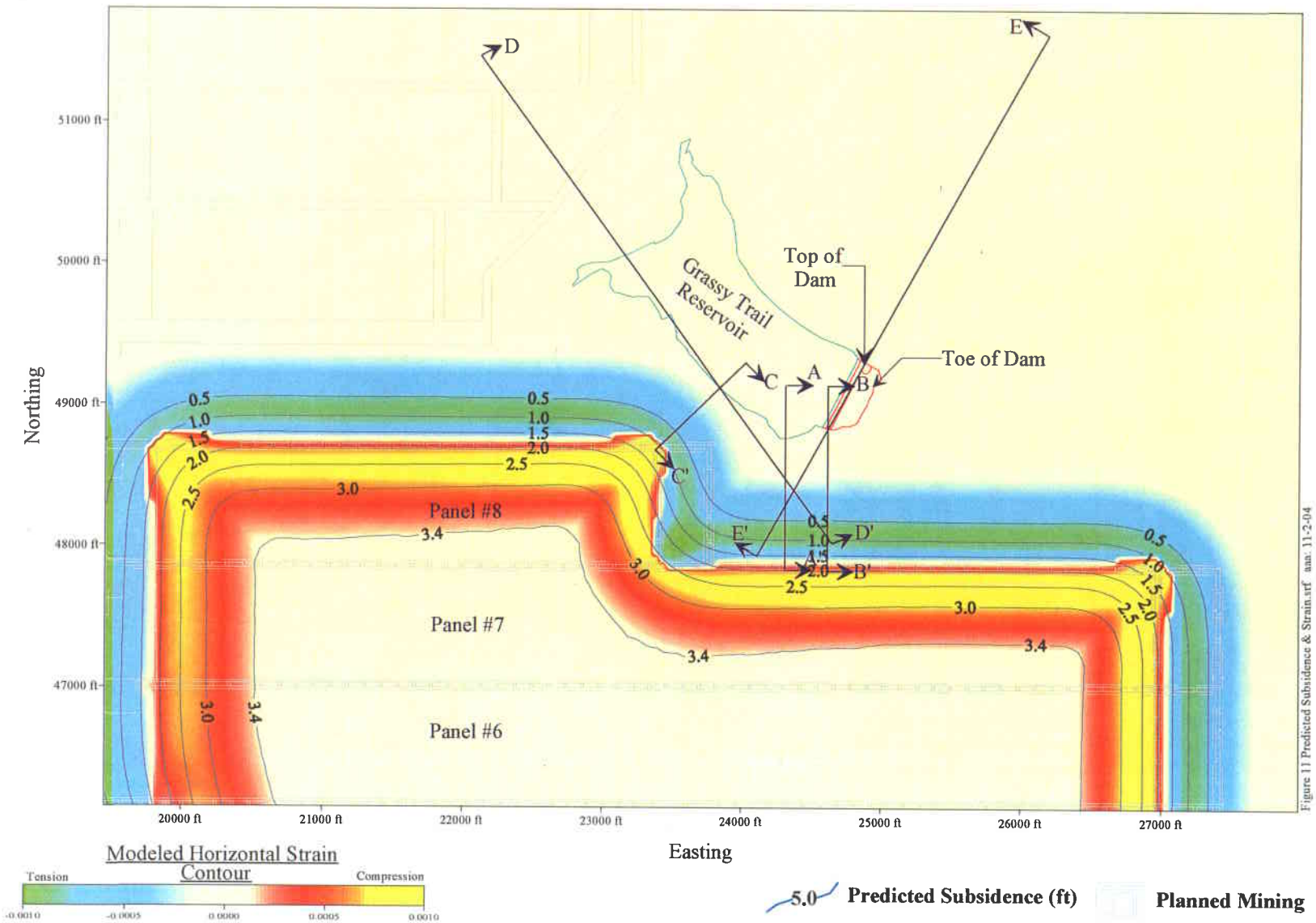


Figure 11. **Vertical Subsidence** (labeled contours) **and Horizontal Strain** (color coded) **for Model 1** (20° Angle of Influence, 3.6 ft S_{max})

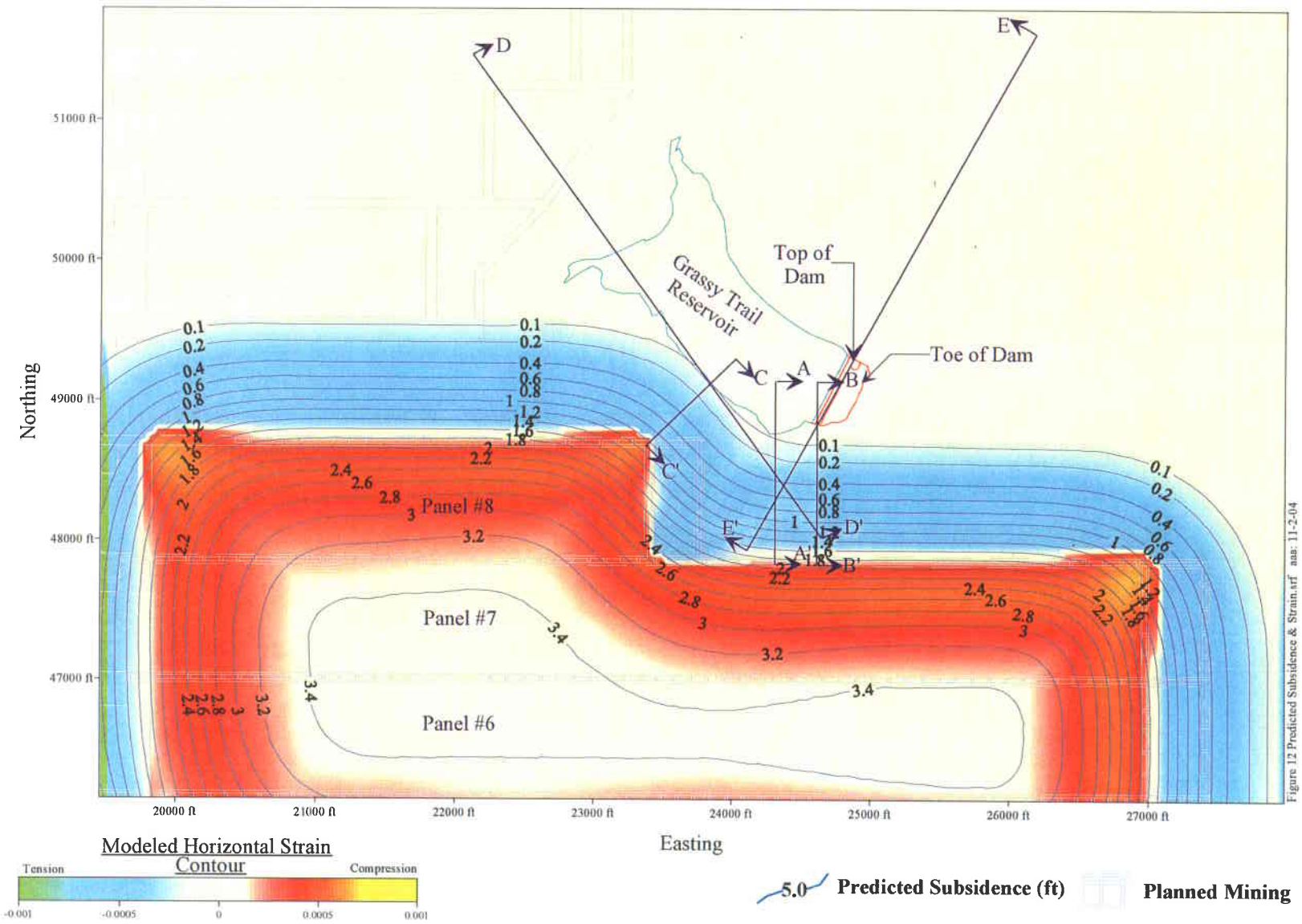


Figure 12. **Vertical Subsidence** (labeled contours) **and Horizontal Strain** (color coded) **for Model 2** (30° Angle of Influence, 3.6 ft S_{max})

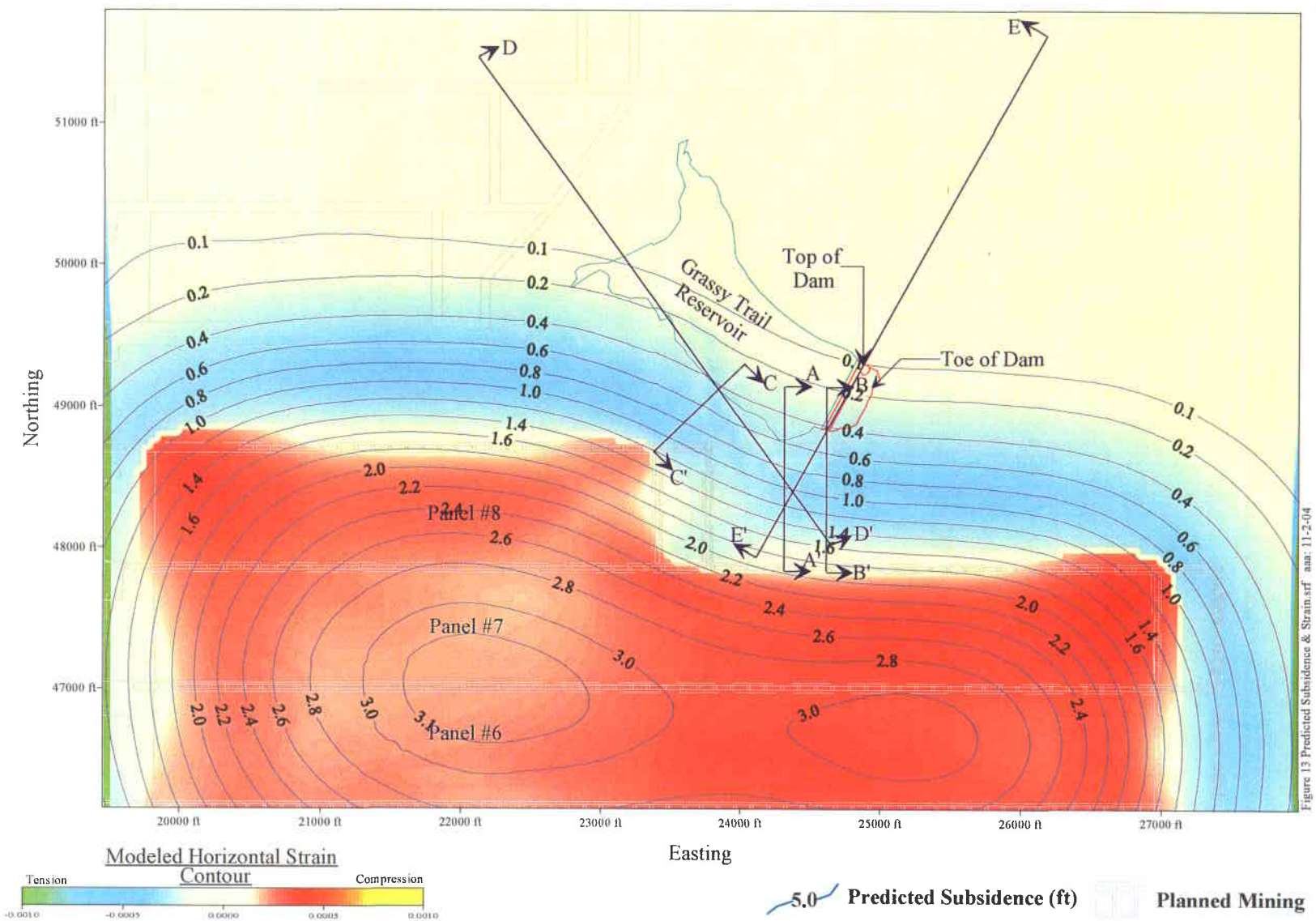


Figure 13. **Vertical Subsidence** (labeled contours) **and Horizontal Strain** (color coded) **for Model 3** (45° Angle of Influence, 3.6 ft S_{max})

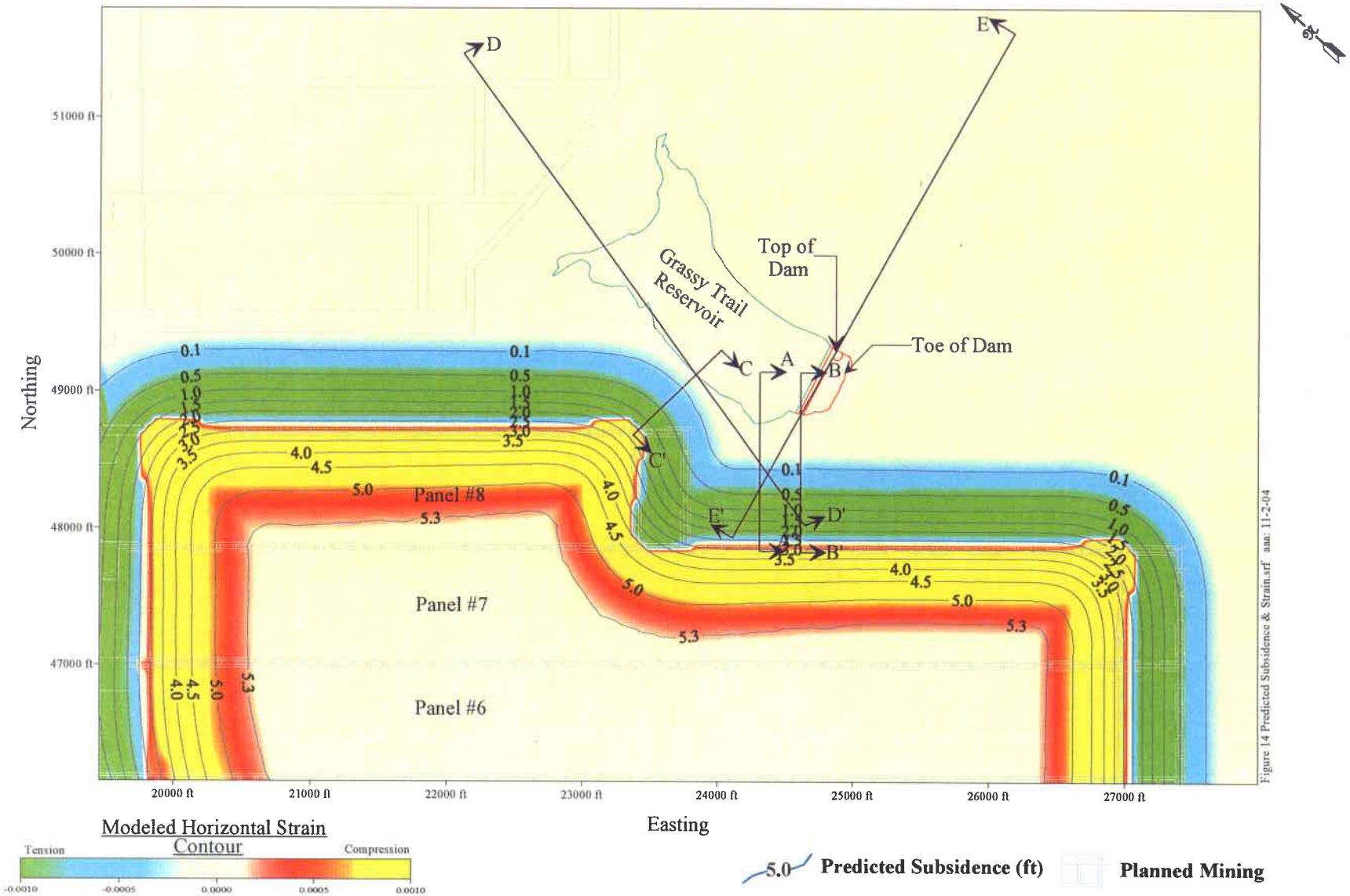


Figure 14. **Vertical Subsidence** (labeled contours) **and Horizontal Strain** (color coded) **for Model 4** (20° Angle of Influence, 5.6 ft S_{max})

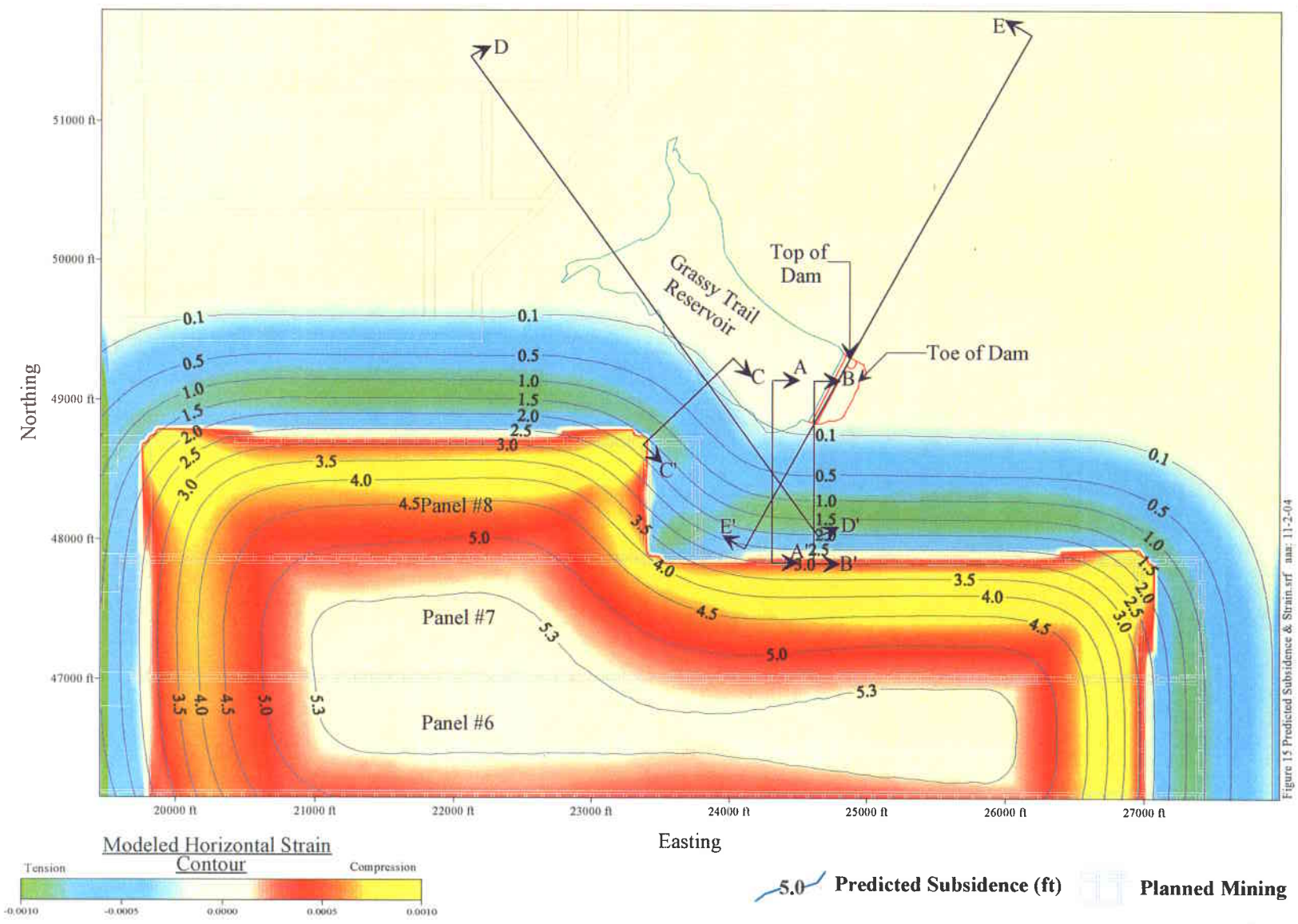
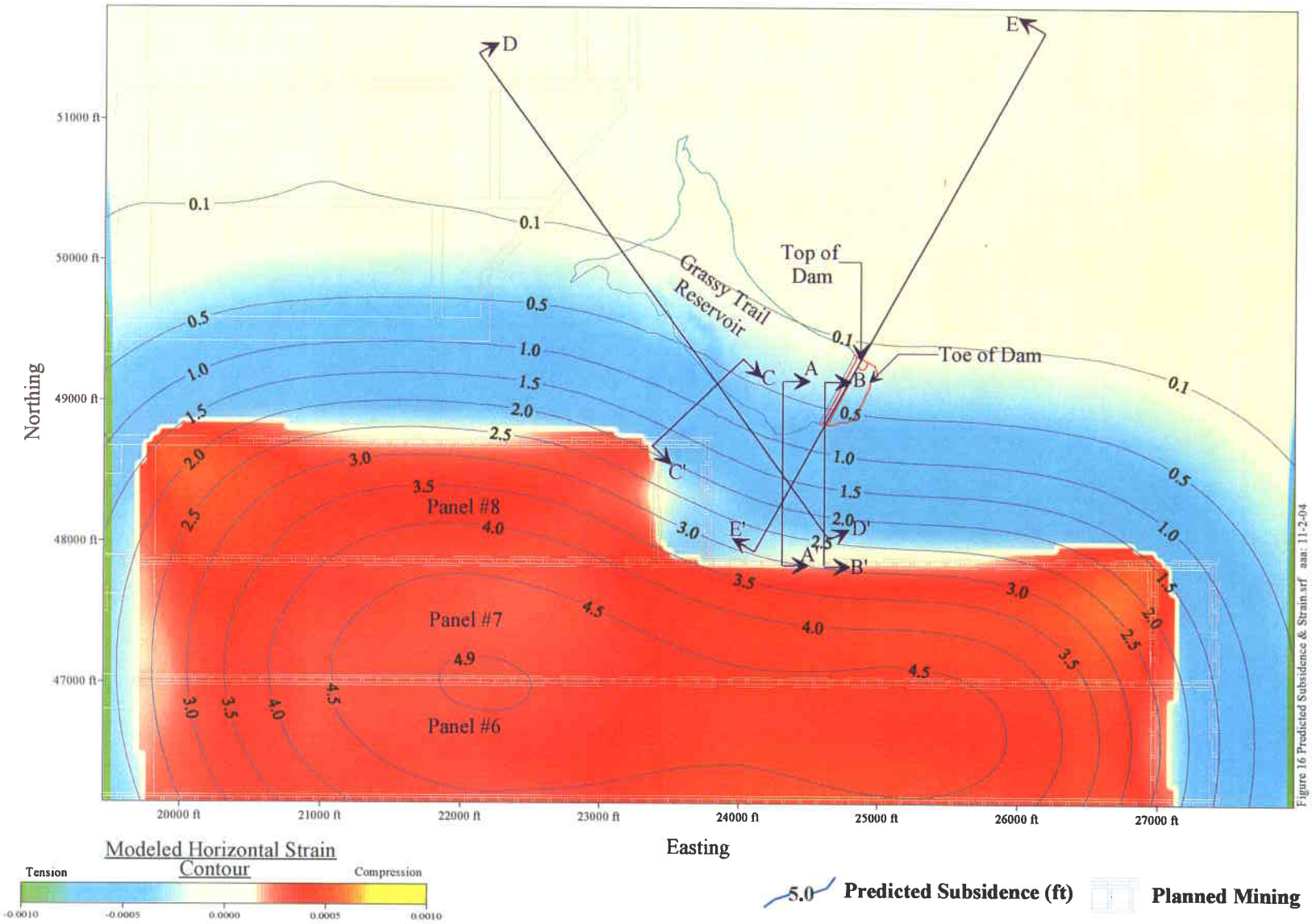


Figure 15. Vertical Subsidence (labeled contours) **and Horizontal Strain** (color coded) **for Model 5** (30° Angle of Influence, 5.6 ft S_{max})



Modeled Horizontal Strain Contour

Tension — Compression

-0.0010 -0.0005 0.0000 0.0005 0.0010

5.0 Predicted Subsidence (ft)

Planned Mining

Figure 16. Vertical Subsidence (labeled contours) **and Horizontal Strain** (color coded) **for Model 6** (45° Angle of Influence, 5.6 ft S_{max})

influence angles, ground deformations are more subdued, but extend over a wider area, including the Grassy Trail Reservoir/Dam. For a given angle of influence, the intensity of horizontal strain is greater for the 5.6 S_{max} case than for the 3.6 S_{max} case. To help quantify the horizontal strain near the reservoir/dam, horizontal strain along subsidence sections defined by WRRI (lines A-A′, B-B′, and C-C′) and two lines defined by AAI (lines D-D′ and E-E′) were examined for each of the six modeled Plan A cases. Maximum horizontal strain magnitudes within the reservoir/dam along these lines are shown in Table 4.

Table 4. Greatest Horizontal Strain Magnitudes Within the Reservoir/Dam for Each of the Six Modeled Plan A Cases (all strains are tensile)

Profile Line	Feature (Dam or Reservoir)	Largest Horizontal Strain (10^{-3})					
		M1	M2	M3	M4	M5	M6
A-A′	Reservoir	0.00	0.14	0.26	0.00	0.22	0.40
B-B′	Dam	0.00	0.10	0.24	0.00	0.17	0.37
C-C′	Reservoir	0.07	0.18	0.27	0.10	0.28	0.42
D-D′	Dam	0.16	0.19	0.27	0.10	0.30	0.42
E-E′	Reservoir	0.00	0.09	0.25	0.00	0.14	0.38

Model 6, with an influence angle of 45°and an S_{max} of 5.6 ft, produces the largest strains in the area of the Grassy Trail Reservoir/Dam, on the order of -0.4×10^{-3} (negative indicating tension). With this relationship established, a seventh model, incorporating the geometry of Plan B, was run. Subsidence and horizontal strain for Model 7 are shown in Figure 17, with maximum strains near the dam/reservoir on the order of -0.4×10^{-3}.

Although horizontal strain is considered the most critical subsidence parameter with regard to dam or reservoir damage, slope and radius of curvature are important subsidence parameters also. Slope and radius of curvature for worst-case conditions, with regard to the reservoir/dam (as represented by Model 6), are shown in Figures 18 and 19, respectively. Similarly, slope and radius of curvature for Model 7 are shown in Figures 20 and 21.

For comparison with possible future field measurements, vertical subsidence profiles from each of the seven models (along lines A-A′, B-B′, and C-C′) are presented in Appendix B.

4.4 Suggested Damage Criteria for the Reservoir/Dam

Published criteria for allowable deformation in dams and beneath bodies of water such as reservoirs are offered below.

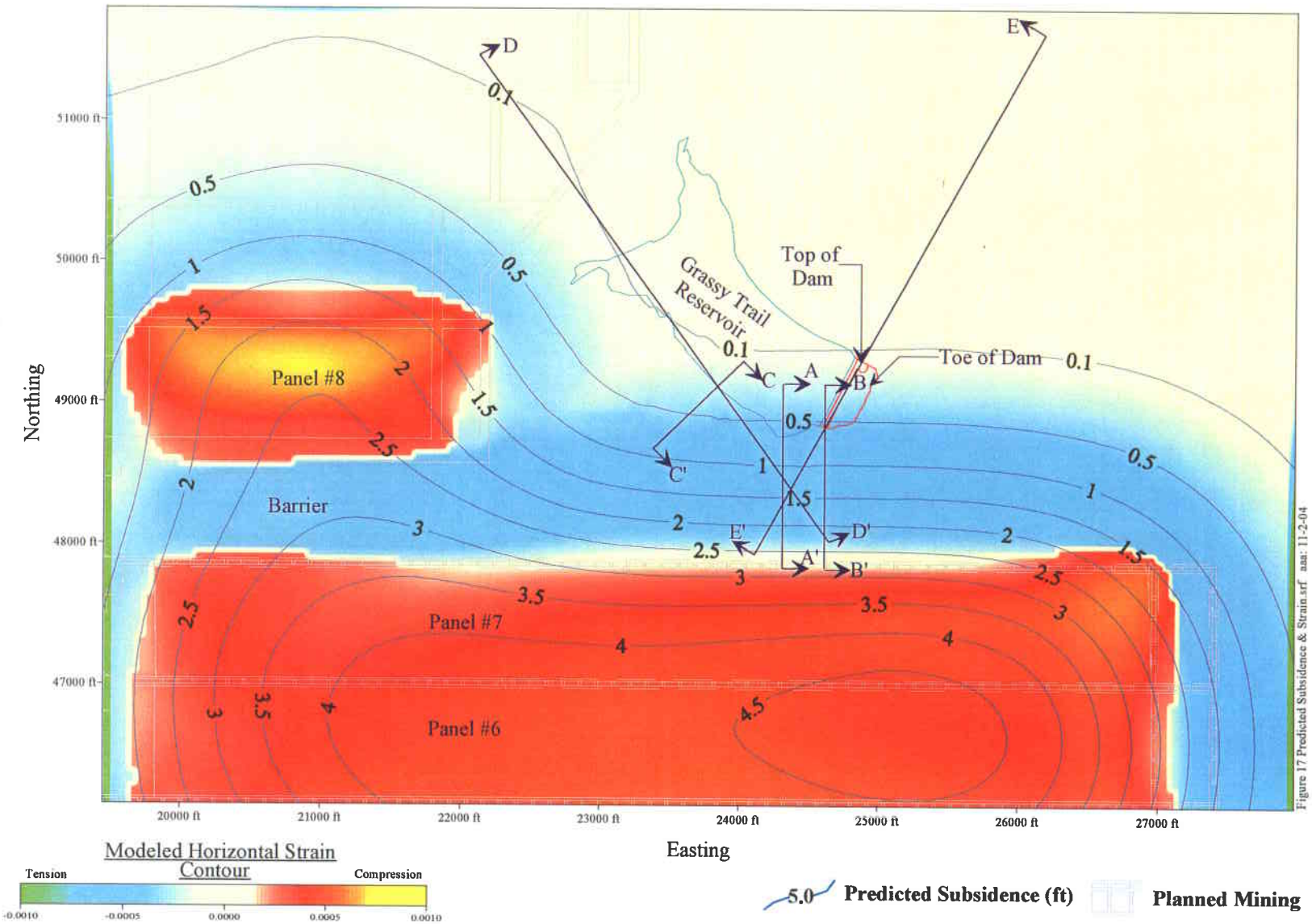
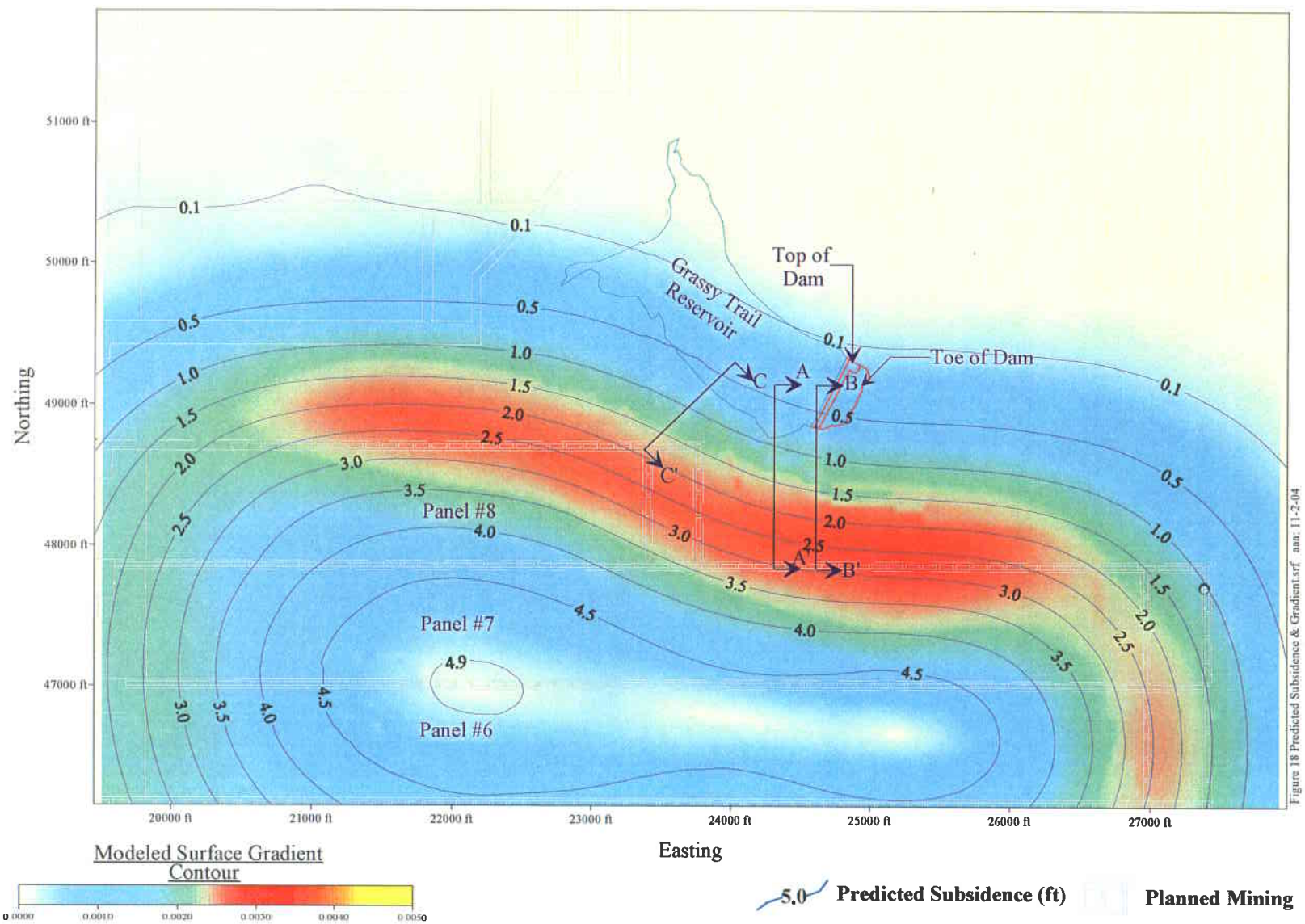


Figure 17. Vertical Subsidence (labeled contours) **and Horizontal Strain** (color coded) **for Model 7** 45° Angle of Influence, 5.6 ft S_{max})



Modeled Surface Gradient Contour

0.0000 0.0010 0.0020 0.0030 0.0040 0.0050

5.0 Predicted Subsidence (ft)

Planned Mining

Figure 18. Vertical Subsidence (labeled contours) **and Slope** (color coded) **for Model 6** (45° Angle of Influence, 5.6 ft S_{max})

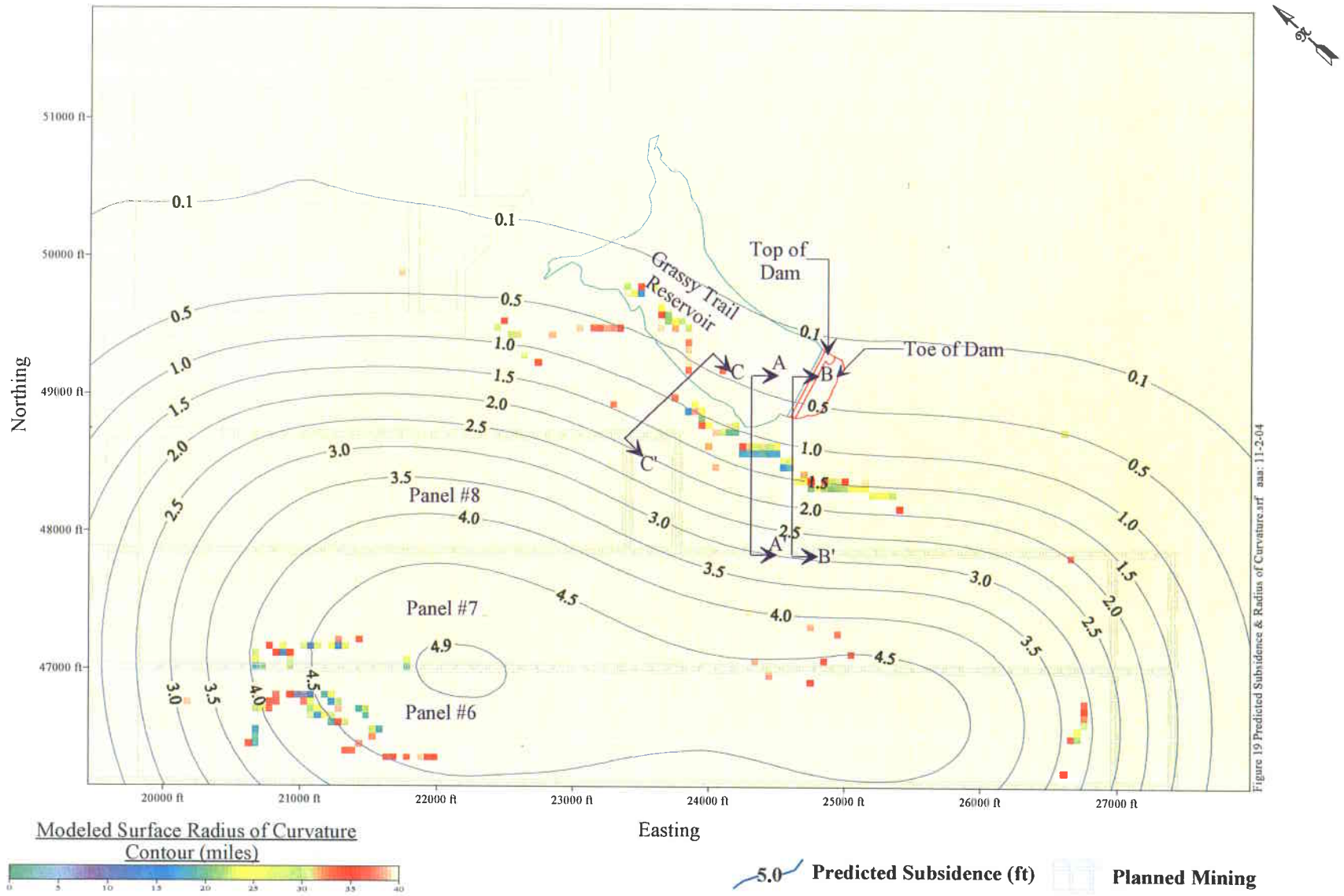
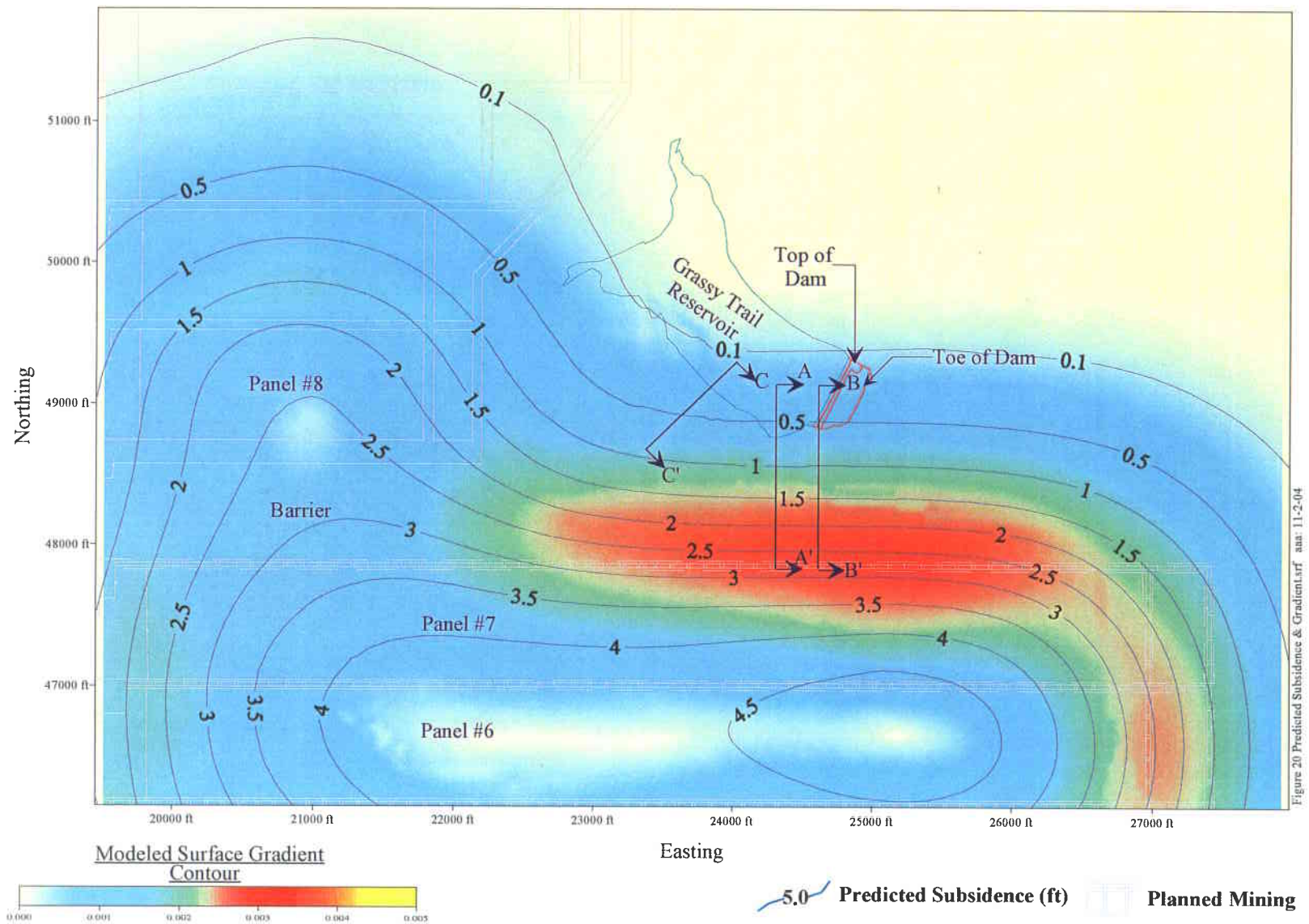


Figure 19. Vertical Subsidence (labeled contours) **and Radius of Curvature** (color coded) **for Model 6** (45° Angle of Influence, 5.6 ft S_{max})



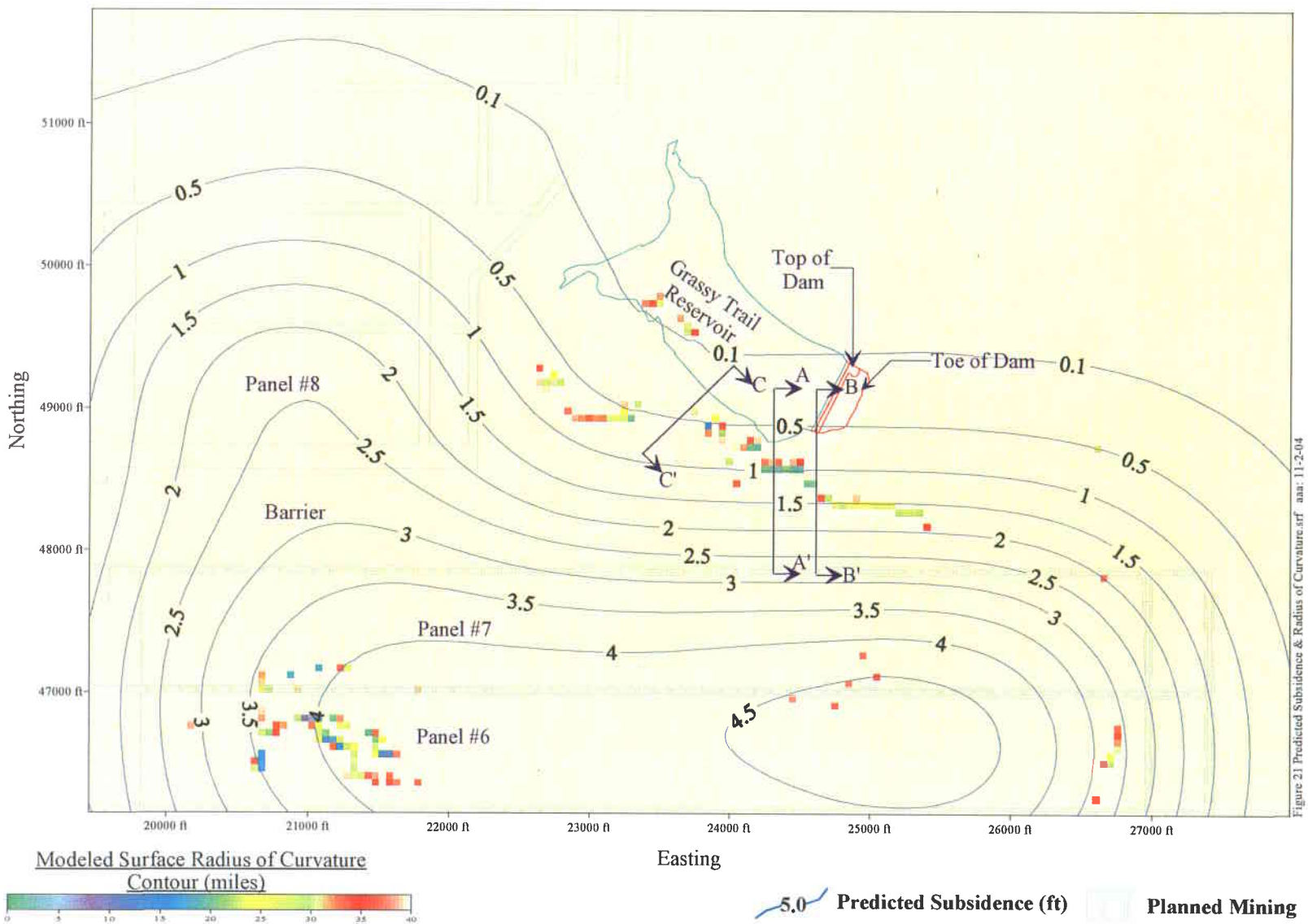
Modeled Surface Gradient Contour

0.000 0.001 0.002 0.003 0.004 0.005

5.0 Predicted Subsidence (ft)

Planned Mining

Figure 20. Vertical Subsidence (labeled contours) **and Slope** (color coded) **for Model 7** (45° Angle of Influence, 5.6 ft S_{max})



Modeled Surface Radius of Curvature Contour (miles)

0 5 10 15 20 25 30 35 40

5.0 Predicted Subsidence (ft)

Planned Mining

Figure 21. Vertical Subsidence (labeled contours) **and Radius of Curvature** (color coded) **for Model 7** (45° Angle of Influence, 5.6 ft S_{max})

Comparing the modeled strains from Table 4 and Figures 11 through 17 with the values in Table 5, predicted horizontal strain is below the minimum suggested limit by a factor of at least 2.3. These limits are in line with a previous AAI study that documented surface cracks in sandstone above a western U.S. mine at horizontal strain levels of 1 to 2 × 10^{-3} (Goodrich et al. 1999).

Table 5. Published Subsidence Criteria for Dams and Reservoirs

Reference	Structure or Feature	Type of Movement	Allowable Value	Suggested Limit
Singh 1992	Reservoir/Dam	Horizontal strain	—	1.0×10^{-3}
	Reservoir	Horizontal strain	5.0×10^{-3}	10.0×10^{-3}
Peng 1992	Stone or reinforced concrete dam	Horizontal strain	—	2.5×10^{-3}
		Radius of curvature	—	Not less than 12 km (7.5 miles)
	Earth dam with overflow	Horizontal strain	6×10^{-3}	9×10^{-3}
	Earth dam without overflow	Horizontal strain	4×10^{-3}	—

With regard to loss of water from the reservoir, the depth of cover-to-mining height ratio near Panel 8 of either mining plan approaches 250, far greater than a criterion cited by Singh (1992) requiring a ratio of 60 or greater. The risk to the Grassy Trail Reservoir should be even less, considering that this criterion is for undermining a body of water and the reservoir does not directly overlie the mining.

The radius of curvature at the dam for either mining plan is in excess of 40 miles, far above the minimum limiting 7.5 mile criterion given in Table 5. Smaller radii imply greater surface flexure and higher potential for damage. Model results indicate minimal mining-induced surface curvature.

Based on the subsidence model developed and on published subsidence damage criteria, it appears that both mining Plans A and B pose minimal risk to the Grassy Trail Dam and Reservoir. It should be noted, however, that damage criteria for dams vary with the types of materials and construction methods employed, and that these criteria should only be used in an initial assessment of impact to the reservoir/dam. AAI recommends that WRRI consult with the dam owner/engineer to determine if other criteria are more appropriate for the Grassy Trail Reservoir/Dam.

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APPENDIX A

WESTERN U.S. SUBSIDENCE CASE HISTORIES

A.1 GENEVA AND BOOK CLIFFS MINES, UTAH

Subsidence cracks were mapped above the Geneva and Book Cliffs mines of the Sunnyside Mining District, Utah (Dunrud 1976). Data from this study are largely qualitative, as subsidence measurement was not the primary objective. Utilizing room-and-pillar retreat methods, the Geneva and Book Cliffs mines were located in the Mesa Verde Group, which is composed of strong sandstones alternating with weak shales and mudstones. Approximately 1.5 years after mining was completed, large tension cracks, some of which were hundreds of feet long, were observed in cliff-forming sandstones about 900 ft above the mine workings. These cracks ranged in width from 0.06 inches to 3 ft and made up a fracture zone up to 250 ft wide. Although no surface structures were present (had there been they would have been destroyed), surface and groundwater flows were disrupted. Based on the surface expression of the cracks relative to panel edge barriers, the surmised angle of draw was nearly vertical. This study supports the observation that angles of draw steepen (decrease in magnitude) when the overburden is comprised of strong strata such as sandstone.

A.2 SOMERSET MINE, COLORADO

Subsidence was measured over several room-and-pillar retreat panels at the Somerset Mine (Dunrud 1976). The total extracted area measured about 2,000 ft by 2,000 ft, under 300–1,600 ft of cover. The overburden was comprised of mudstones, shales, and sandstones. The measured angle of draw varied from 15° in intermediate-strength strata under 900 ft of cover to 20° in weak overburden 600–900 ft deep. The maximum subsidence measured during the study was 3.1 ft over an area with a mining height of 10 ft, giving a subsidence factor of 0.31. Tension cracks, up to 1 ft in width, appeared on the surface 2–4 months after pillar retreat in mudstone-sandstone overburden 500–600 ft deep. This corresponded to an excavation width-to-depth ratio of about 1.0. In a shallower area of the mine (300–470 ft of cover), subsidence was complete after 1.5 years.

A.3 ROADSIDE MINE, COLORADO

Three different room-and-pillar retreat areas of the Roadside Mine were monitored for subsidence by the United States Bureau of Mines [USBM] (Magers 1993). The areas of extraction were relatively small (450–1,200 ft wide), but given the shallow overburden (50–700 ft), the ratios of extraction width to depth were average to high. Mining was in the Cameo B Seam of the Mount Garfield Formation, and overburden was comprised of shales, weak sandstones, and unconsolidated till. Based on the subsidence profiles presented, subsidence widths appear to be subcritical, although this may be more a function of partial pillaring than panel width (20-ft-wide pillar stumps were left in the Northwest and Third West sections, and the Southwest section was abandoned before retreat was complete). This partial pillaring is reflected in the low subsidence factors, which ranged from 0.06 for the abandoned panel to 0.43 for the Northwest section. Surface cracks were observed above the Northwest section (under 200 ft of cover), but not Third West (350–700 ft deep, 0.32 subsidence factor). Development-only mining and barrier pillars were used successfully to protect pipelines, utility lines, roads, and streams above the mine. A survey performed 6 years after mining to evaluate residual subsidence detected no additional ground movement.

A.4 CASTLEGATE NO. 3 MINE, UTAH

The Castlegate No. 3 Mine was located in the Spring Canyon Sub 3 Seam of the Book Cliffs coalfield in central Utah. The overburden associated with this longwall operation is comprised mainly of sandstone, shale, carbonaceous shale, and coal. Depth of cover associated with the panels ranged from 800 to 1,500 ft. The mining height averaged 6 ft within the panel area studied by the USBM (Fejes 1986). The massive Castlegate sandstone, up to 500 ft thick over the mine, lay just 50 ft above the panels. In addition, overmining above the Castlegate sandstone was performed about 40 years prior to the study.

Subsidence surveys were taken over adjacent longwall panels 4E and 5E. Each had face widths of about 500 ft. After the survey lines were established, each panel was only partially retreated due to mining difficulties and a gob fire. This limited panel length to about 1,900 ft. The total extracted area, therefore, (including chain pillars between panels) was about 1,100 ft wide by 1,900 ft long. Due to the shortening of the panels, a transverse survey line that had been established was not undermined, and only longitudinal surveys were performed over each panel. The maximum

subsidence measured was 2.2 ft, or 37% of the average mining height, and subsidence profiles indicate that critical panel width had not been achieved. Subsidence was first detected after the face had retreated between 1,180 and 1,450 ft, or approximately equal to the cover depth, and subsidence was active for a period of 19 months.

Although surface strains were not measured in the surveys, a surface building was damaged due to tension-induced cracking. This was the only sign of disturbance on the surface; however, the ground surface remained stable with no indications of slope failure or surface cracks, perhaps an indication that healing had been achieved in the topsoil. No discernable changes to local drainage patterns were observed.

A.5 DEER CREEK-WILBERG MULTI-SEAM LONGWALL, UTAH

The USBM conducted a long-term study of subsidence associated with multi-seam, longwall mining from 1978 to 1989 at the Wilberg and Deer Creek mines (Allgaier 1982 and 1988; Dyni 1991). The panels involved were 5 through 8 East in Deer Creek, and 6 through 8 Right and 10 through 12 Right in Wilberg. Mining at Deer Creek was in the Blind Canyon Seam, whereas Wilberg operated in the Hiawatha Seam approximately 50 ft below. Over the study area, the Deer Creek mining height was a fairly consistent 8 ft. The Wilberg panels ranged in height from 6 to 9 ft, averaging 8 ft. The surface topography over the study area was gently rolling, with a total elevation differential of 400 ft. Cover averaged 1,540 ft over Deer Creek, and about 1,600 ft over Wilberg.

The overburden in this area of the Wasatch Plateau is generally comprised of sandstone, siltstone, and mudstone, with interbeds of sandstone and siltstone. About 45% of the overburden is sandstone, with 35% of this sandstone occurring in thick beds. The effect on subsidence of the Castlegate sandstone, which lies about 880 ft above the Deer Creek panels and is about 200 ft thick, was of particular interest during the study.

The first longwall mined was the 5 East panel at the Deer Creek Mine, a panel about 500 ft wide by 2,200 ft long. Subsidence was first detected after the face had retreated between 550 and 1,050 ft. Subsidence stabilized over this panel after approximately 30 months as adjacent panels were mined to the south. Undermining by Wilberg panel 10 Right reactivated the subsidence in the area, increasing the active subsidence period another 2 years. Generally, each subsequent Deer Creek panel took a shorter time to stabilize, whereas the Wilberg panels had fairly consistent

subsidence stabilization times. This was attributed to the state of the overburden when the Deer Creek and Wilberg panels were mined. The Deer Creek panels were in virgin ground, and arching over the panels probably delayed subsidence until the arch was broken down, thus explaining why each successive panel took less time for subsidence to stabilize. When the Wilberg panels were mined below the Deer Creek panels, the overburden was already broken up, and the arching effect was not as pronounced; therefore, the Wilberg periods of active subsidence were more consistent.

The integrity of the overburden was also found to influence the subsidence factor. The maximum measured subsidence associated with the Deer Creek panels was 5.8 ft in an 8.5-ft mining height, a ratio of 0.68. When the Deer Creek panels were undermined by the Wilberg panels, the measured subsidence factor increased to 0.73. These results support the observation that the subsidence factor is inversely proportional to the integrity of the overburden. Based on the shape of the subsidence profiles, it is not believed that the critical width was achieved, probably due to the relatively short length of the panels (2,200 ft) and the presence of the Castlegate sandstone.

Angle of draw for the two mines was consistent, averaging about 30°. Subsidence near the Deer Creek fault did not decrease the angle of draw; however, the magnitude of subsidence beyond the fault was reduced.

The maximum subsidence in the study area was 11.6 ft. Despite this magnitude, no visible damage to the ground surface was detected. No apparent changes in vegetation, ground surface features, or drainage were evident, and no surface cracks were discovered. This lack of visible subsidence evidence was attributed to the unconsolidated nature of the immediate topsoil and its ability to shift and heal itself as ground movement occurred.

A.6 SUFCO MINE, UTAH

AAI (Goodrich et al. 1999) performed modeling using the BASIN code and compared results to data from subsidence monitoring lines over five longwall panels at the SUFCO Mine. In addition, data from 22 years of photogrammetric surveys were summarized and surface expressions of subsidence were documented.

The SUFCO Mine is located in the southern Wasatch Plateau, mining the Upper Hiawatha Seam, with surrounding strata of sandstone, siltstone, shale, and other coal seams. Most of the longwall mining has been at a depth of about 1,000 ft. The Castlegate sandstone is about 200 ft thick

and occurs approximately 775 ft above the longwall panels. The longwall panels that were the main focus of the study were 930 ft wide by 14,200 ft long, separated by three-entry gateroads with abutment pillars. Seam thickness averaged 15.4 ft, with a mining height ranging from 9 to 12 ft.

Subsidence-induced cracks were noted above most of the subsided areas, with cracks generally occurring at trough margins. Crack orientations ran parallel to the gateroads and longwall faces, and sub-parallel to the regional joint set. Crack apertures varied from hairline to 6 inches.

The magnitude of subsidence increased over panels with increasing face width, suggesting that even the maximum panel width (930 ft) was subcritical. Gateroad abutment pillars did not appear to crush out, so that adjacent subcritical panels did not form a supercritical width.

One interesting observation involved mining both beneath and in the absence of the Castlegate sandstone. Where mining was conducted in draws out from under the Castlegate sandstone, subsidence in excess of 7 ft was measured, while under the Castlegate sandstone, maximum subsidence was about 5 ft. A contributing factor may have been mining depth (mining depth of 600 ft under the draw, 1,000 ft under the Castlegate sandstone), but nevertheless, this observation supports the conclusion that subsidence factor is inversely proportional to strata competence.

Surface expressions of subsidence were also correlated with horizontal strains calculated from deformation data. Subsidence cracks were observed where extensional horizontal strains of 1×10^{-3} to 2×10^{-3} were attained. A natural bridge near an escarpment of the Castlegate sandstone failed at a horizontal strain of about 2.7×10^{-3}. A natural rock overhang survived horizontal strains of 2.0×10^{-3}, although some cracking of the underside of the overhang appeared to be subsidence related.

APPENDIX B

VERTICAL SUBSIDENCE PREDICTIONS ALONG SECTIONS A-A′, B-B′, AND C-C′

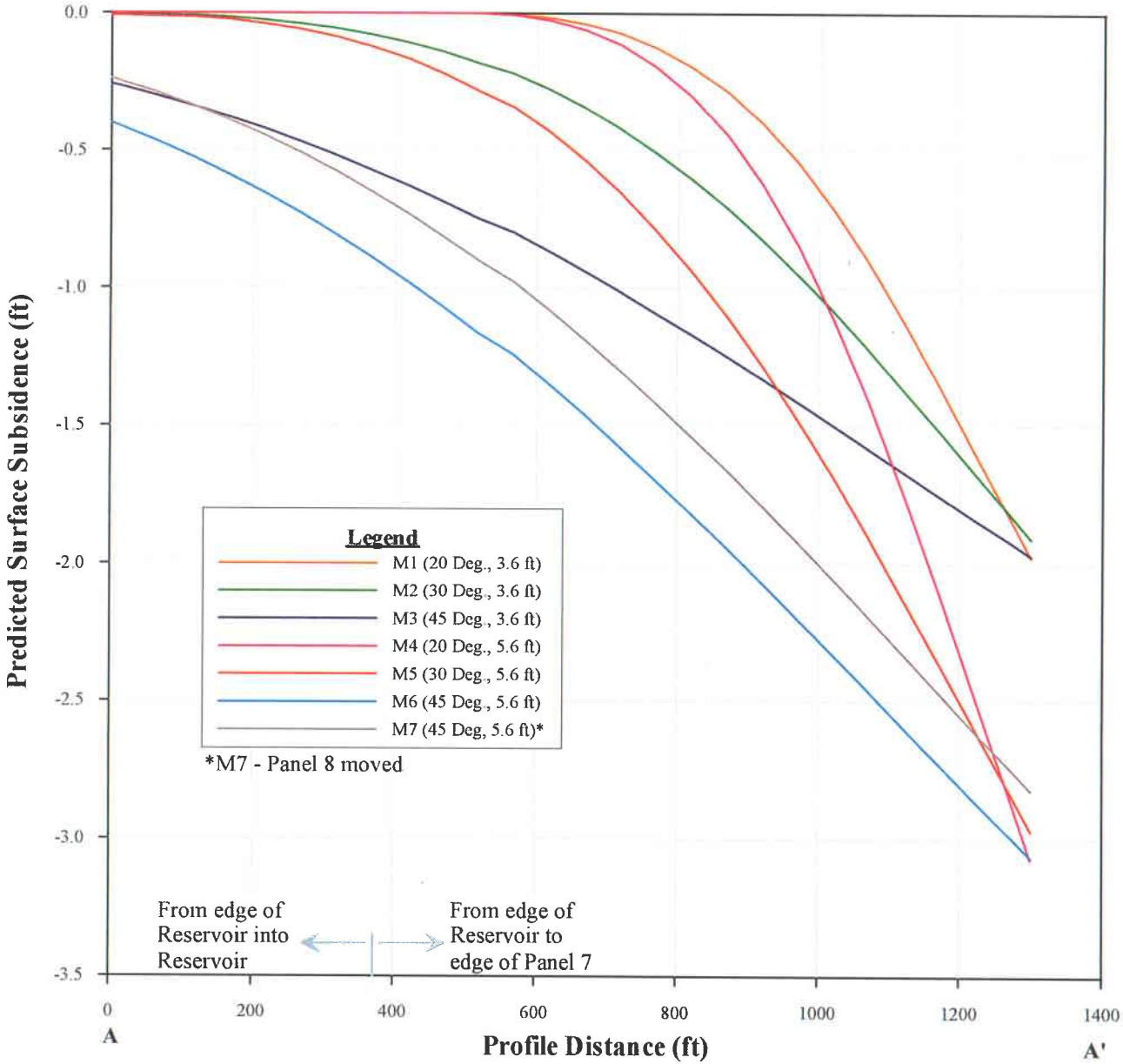

Figure B-1. Modeled Vertical Subsidence along Line A-A′

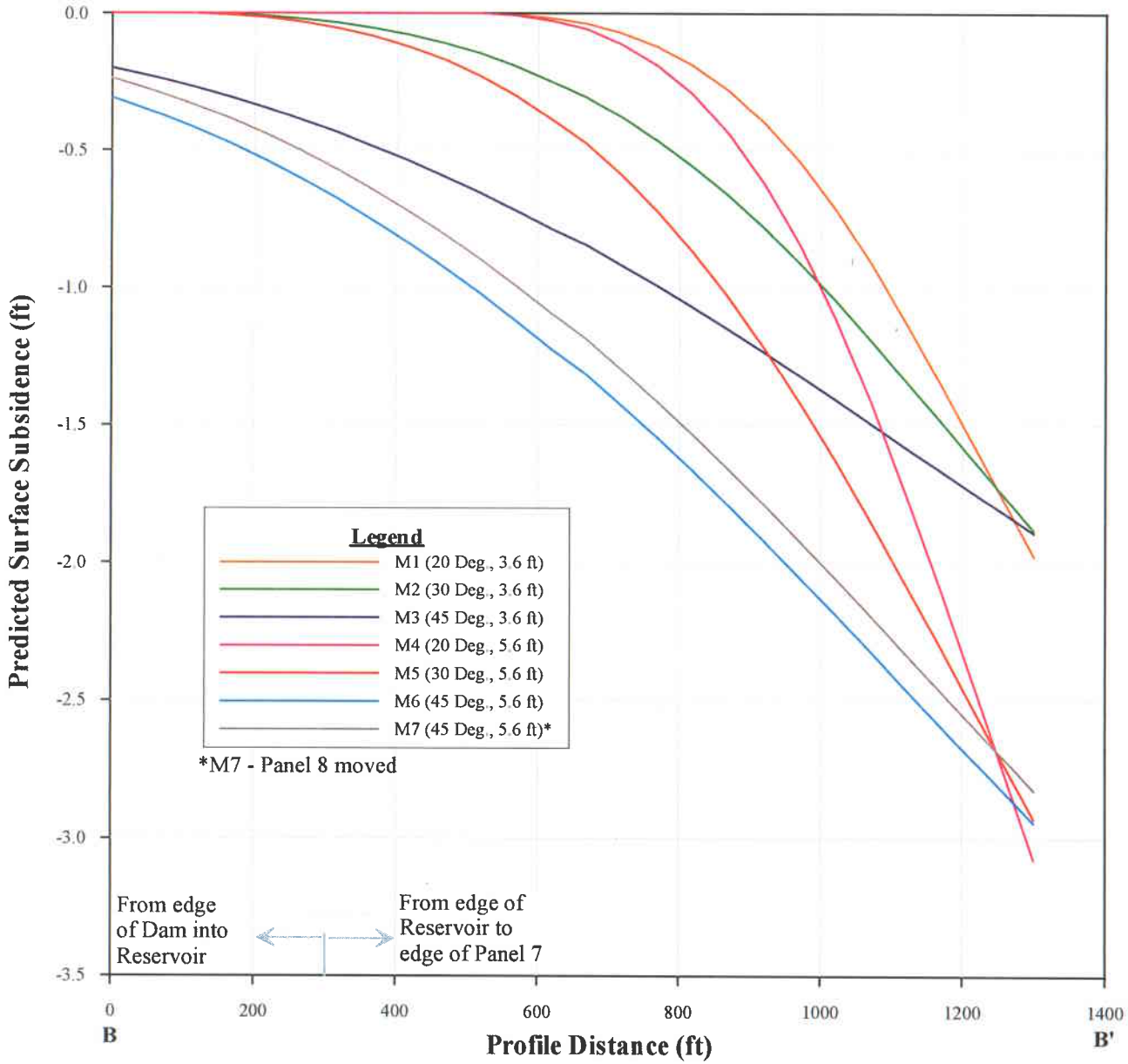

Figure B-2. Modeled Vertical Subsidence along Line B-B′

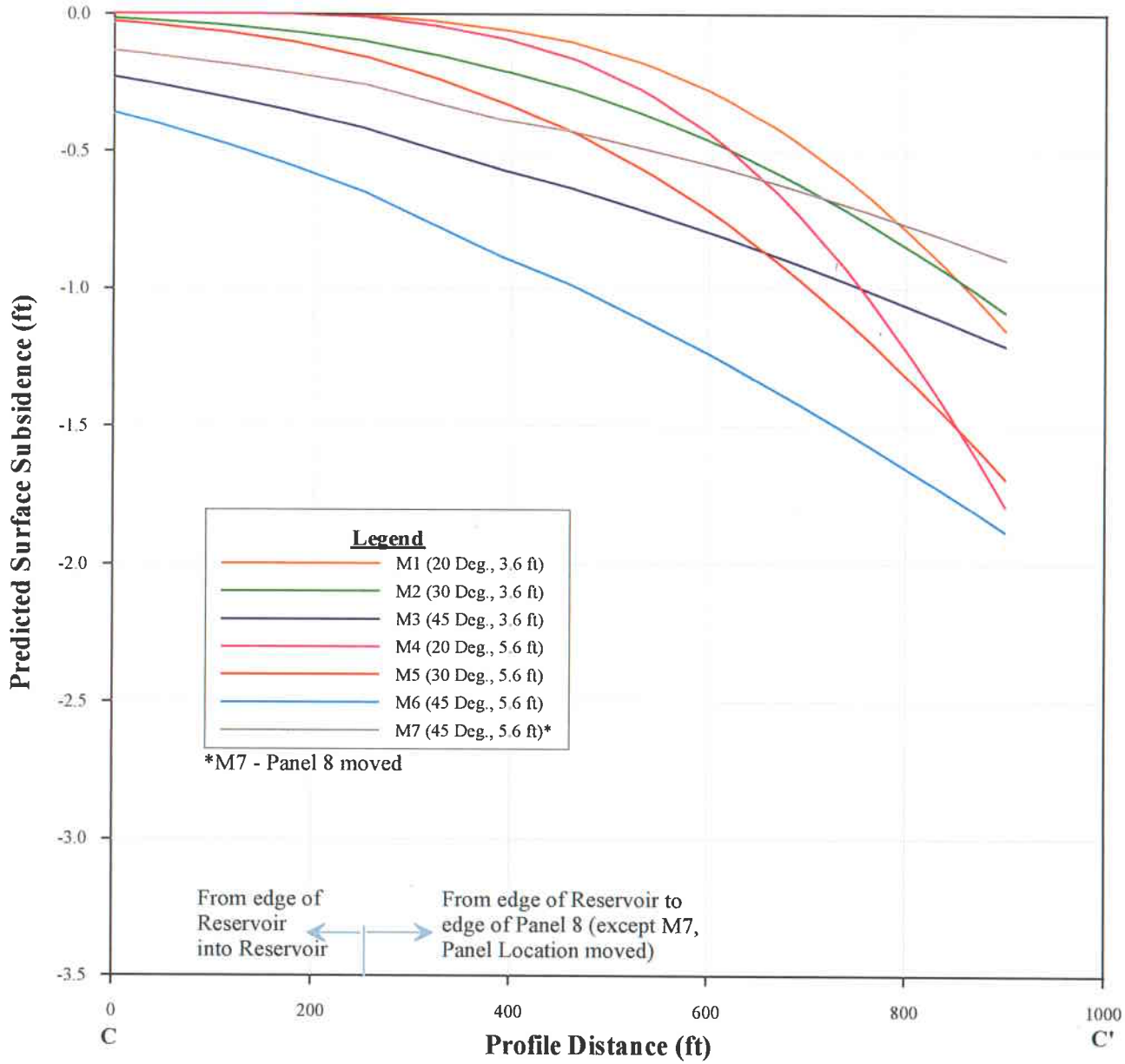

Figure B-3. Modeled Vertical Subsidence along Line C-C′

From: "Leo Gilbride" <gilbride@agapito.com>
To: <bretdixon@utah.gov>
Date: 3/7/05 5:28PM
Subject: (460-06) Grassy Trails Dam Subsidence

Dear Bret,

Pursuant to our telephone conversation this morning regarding subsidence potential of the Grassy Trails dam, I am attaching two figures (PDF) that describe the "Maximum Credible Tensile Strain Limit" (MCTSL) predicted for planned longwall mining at the West Ridge coal mine.

Figure 1 shows the MCTSL for a 0.001 (0.1%) strain threshold. The 0.001 (0.1%) strain threshold represents the most conservative published criterion for preventing the formation of open cracks, fissures, or loss of water in reservoirs/dams. Horizontal strain is the predominant damage index for dams and reservoirs cited in the literature. This 0.001 (0.1%) allowable strain limit is based on numerous case studies and is the same criterion cited in the 1985 Engineers International, Inc. report entitled "Development of Subsidence Damage Criteria," which you referenced during our conversation. The figure shows more than 580 ft of separation between the closest (right) dam abutment and the MCTSL. The outer limit of the MCTSL is defined by a nominally 10 degree angle from the edge of longwall mining (measured from vertical).

Figure 2 shows the MCTSL for a 0.0005 (0.05%) strain threshold in accordance with our conversation. While this is 50% lower than the most conservative published criterion, Figure 2 shows that 290 ft still separates the dam and MCTSL outer limit.

Although we are not fully familiar with the Grassy Trails dam's design and construction, industry experience as a whole suggests that the predicted magnitudes of strain are small relative to the deformation capacity of comparable earthen dams and their foundations. Although the strain capacity of the Grassy Trails dam is not well defined, uncertainty is partly offset by the inherent safety margin built into the suggested allowable strain limit (0.001 or 0.1%) and the conservatism of our subsidence predictions. While the MCTSL represents worst case conditions, "probable" subsidence will likely result in strain magnitudes an order-of-magnitude less than the MCTSL.

Please contact me with any questions or to discuss these issues.

Sincerely,

Leo Gilbride
Principal

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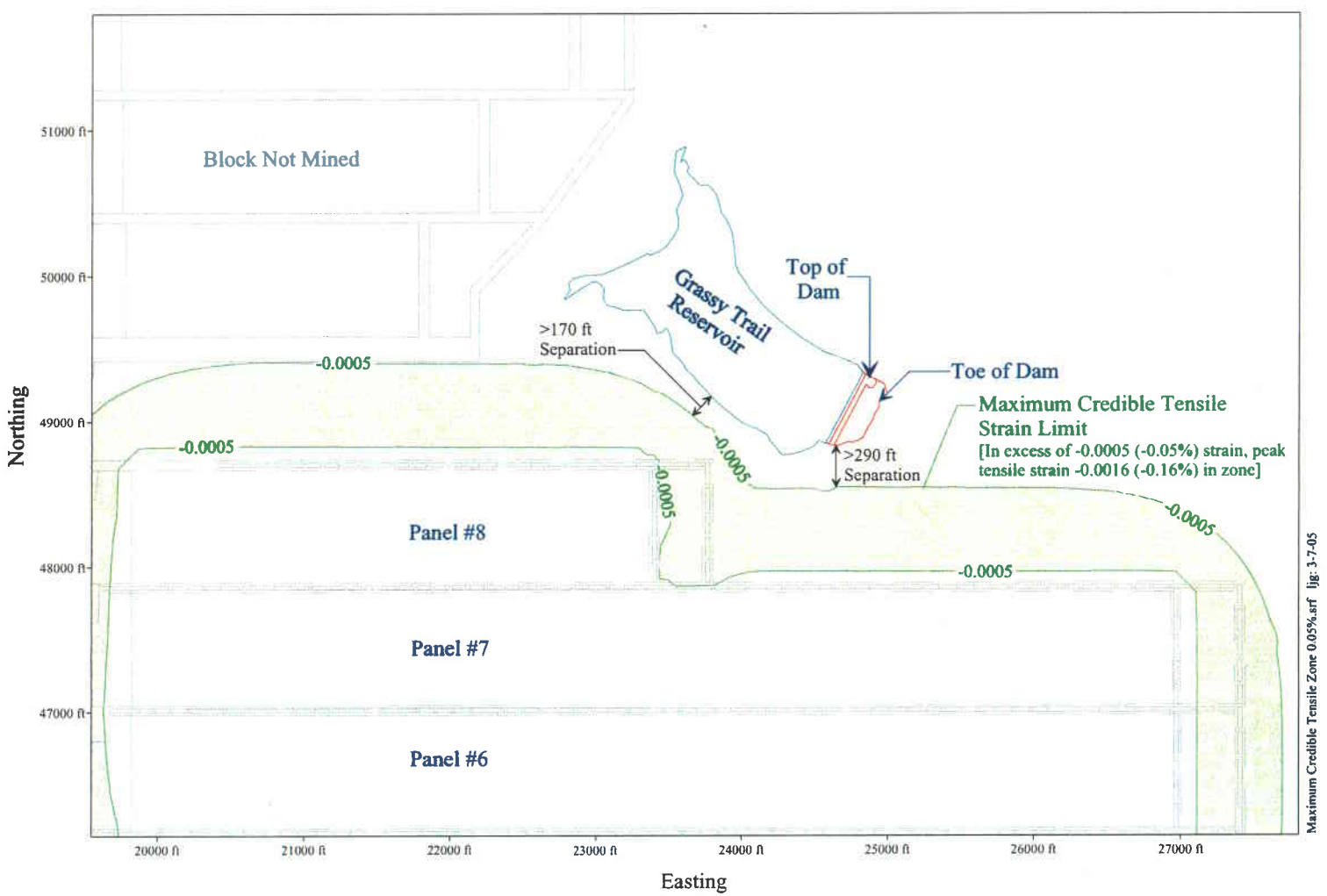
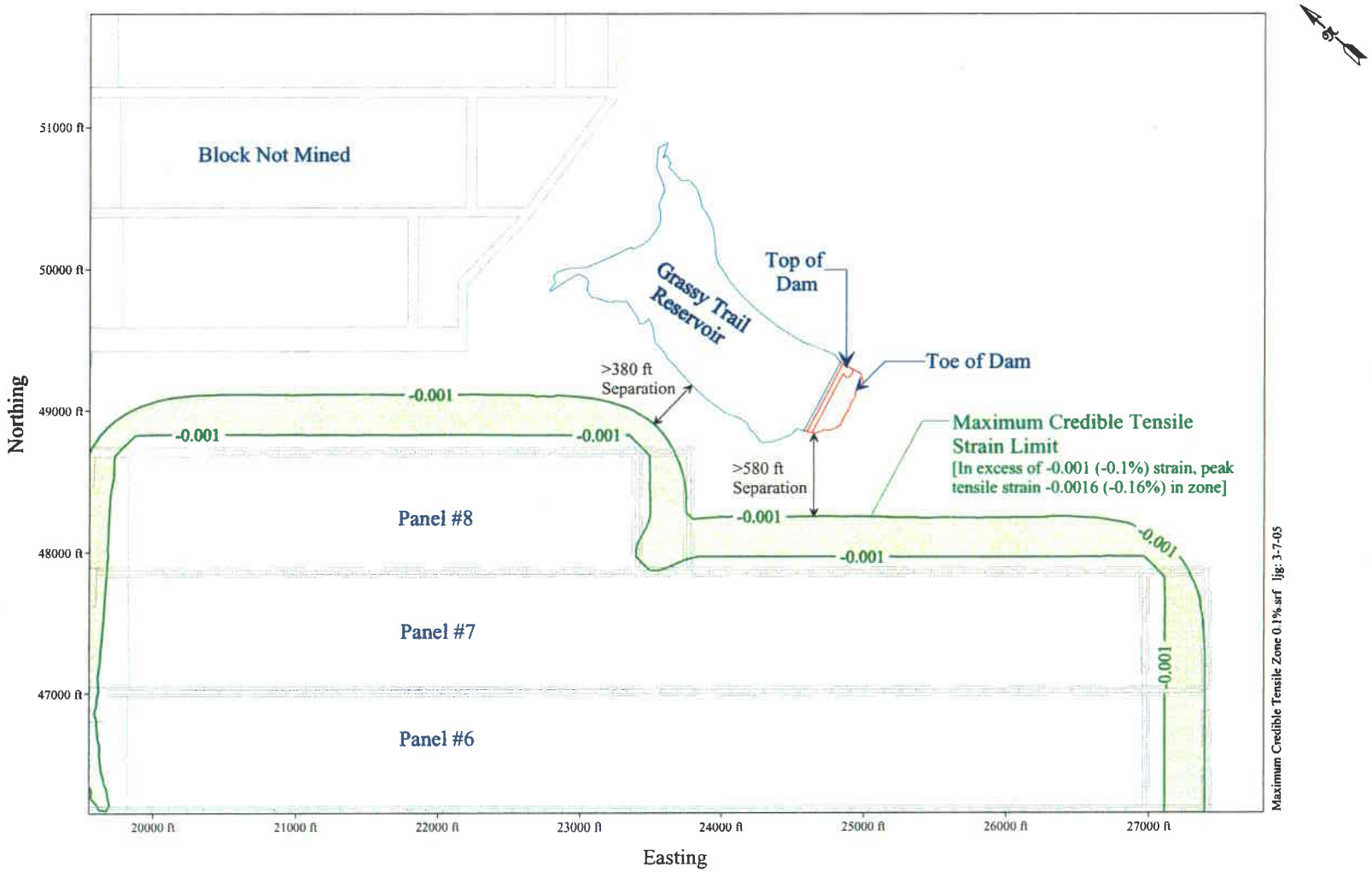


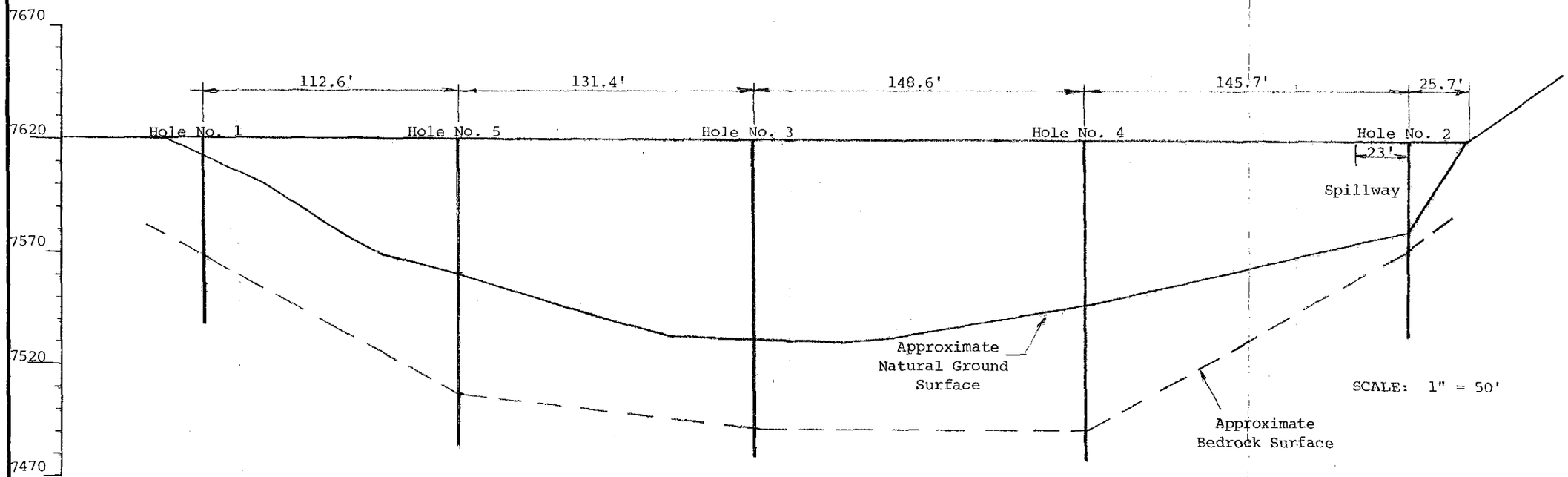
Planned Mining



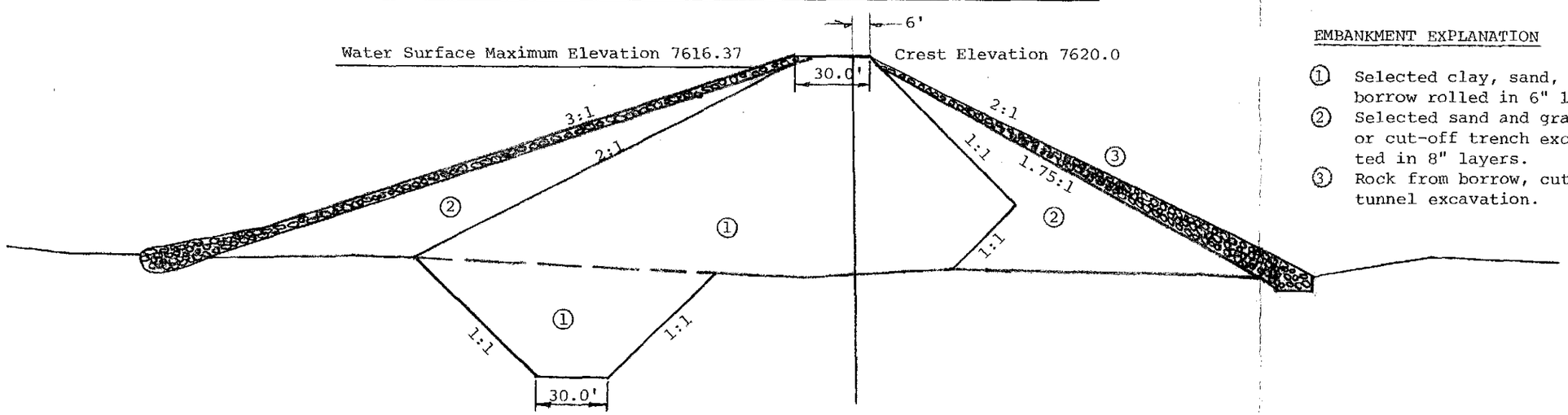
Planned Mining

SUB-SURFACE INVESTIGATIONS

Subsurface Investigations



PROFILE OF DAM ALONG CENTER LINE OF TEST BORINGS



EMBANKMENT EXPLANATION

① Selected clay, sand, and gravel from borrow rolled in 6" layers.
② Selected sand and gravel from borrow or cut-off trench excavation compacted in 8" layers.
③ Rock from borrow, cut-off trench or tunnel excavation.

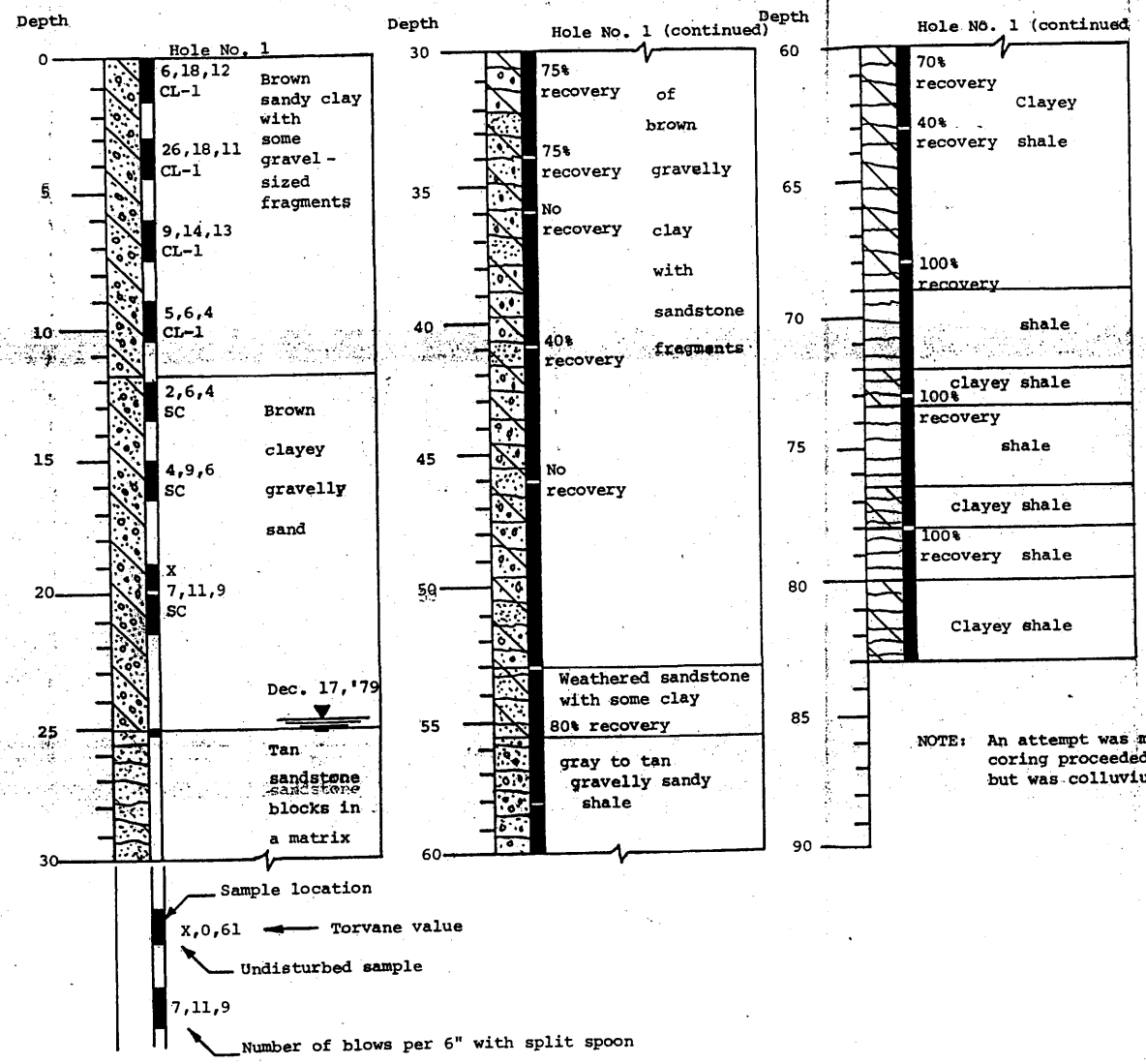
MAXIMUM SECTION

Note: Elevations on this figure are based on original construction plans

SCALE DESIGNED CHECKED DRAWN DATE APPROVED LICENSE NO.	**ROLLINS, BROWN & GUNNELL, Inc.** **CONSULTING ENGINEERS**	MAXIMUM SECTION THROUGH DAM BASED ON THE DESIGN DRAWINGS AND PROFILE ALONG AXIS OF DAM AS DETERMINED BY THE TEST BORINGS SHOWN. GRASSY TRAILS CREEK DAM AND RESERVOIR

Figure No. 5

Bruning "500"



PERMEABILITY DATA

From	To	Permeability (feet/year)
0'	10'	490
10'	20'	4900
30'	40'	1145
41'	53'	876
53'	63'	64
63'	73'	35'
73'	83'	11

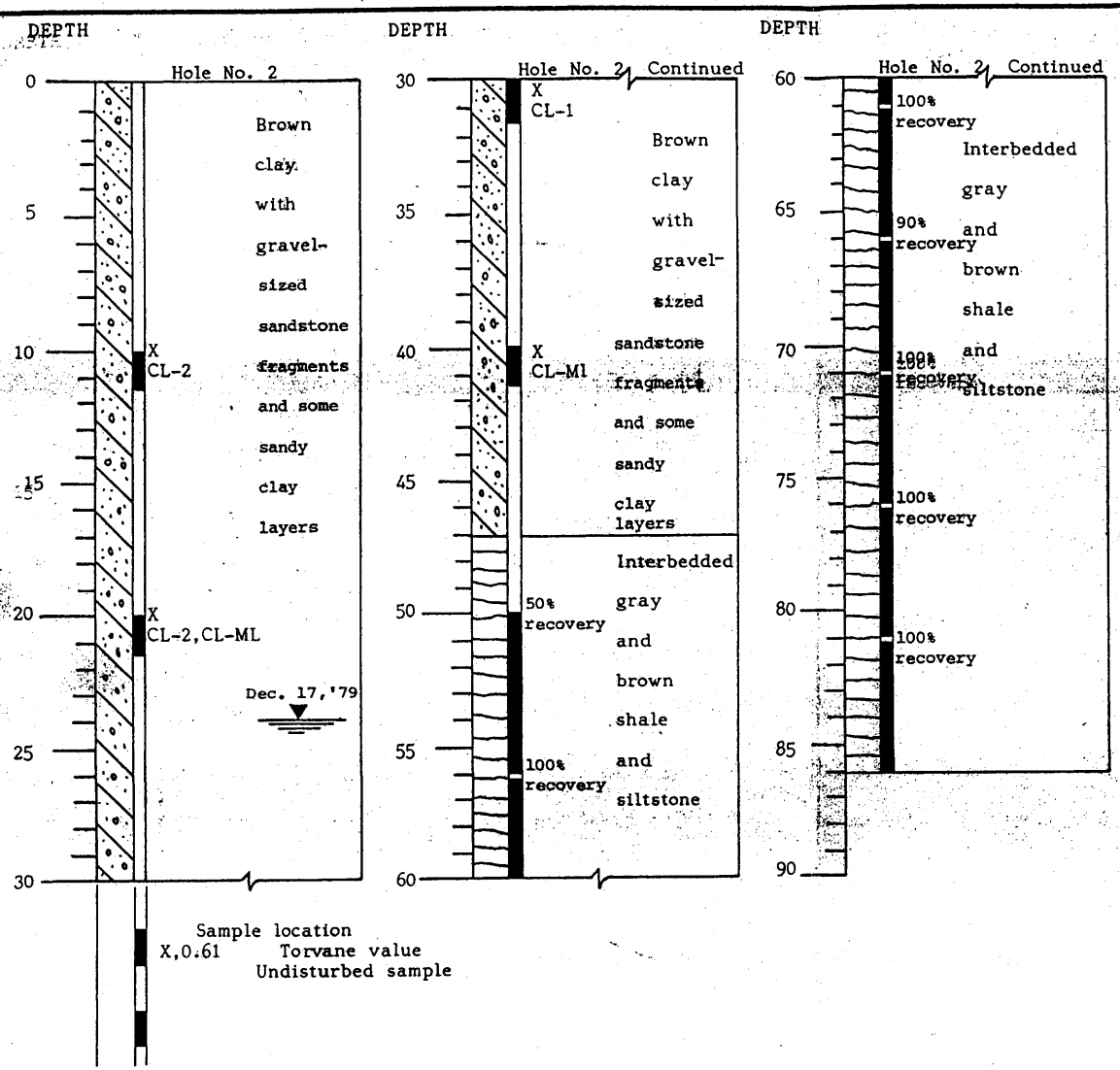
NOTE: An attempt was made to core the sandstone encountered at 25 feet. As coring proceeded it became apparent that this material was not bedrock, but was colluvium to a depth of 53 feet where the weathered bedrock exists.

SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 1 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 7



PERMEABILITY DATA

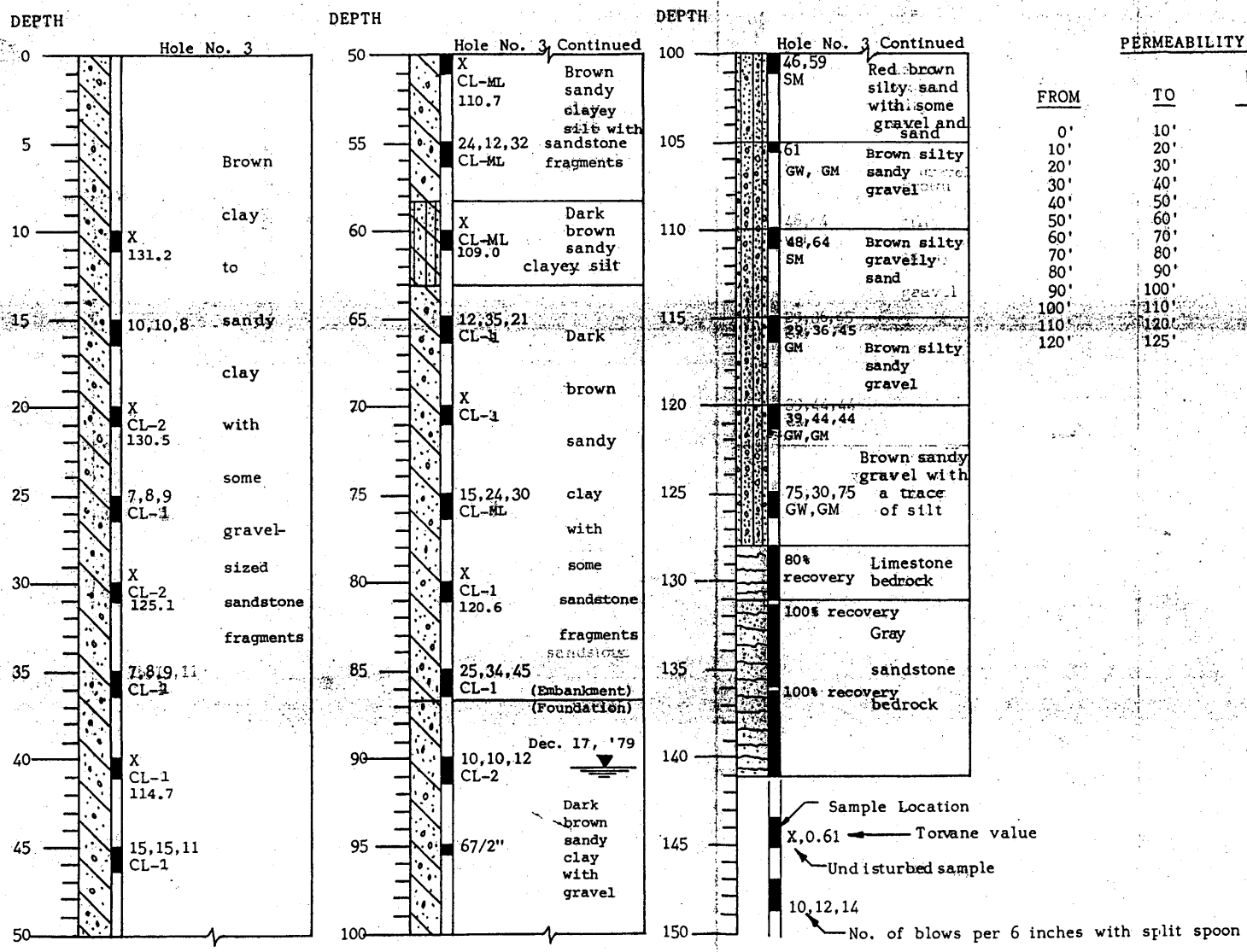
FROM	TO	PERMEABILITY (feet/year)
0'	10'	980
10'	20'	980
20'	30'	NML
30'	40'	NML
40'	50'	196
50'	61'	232
60'	71'	160
70'	81'	43
75'	86'	NML

SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 2 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 8



PERMEABILITY DATA

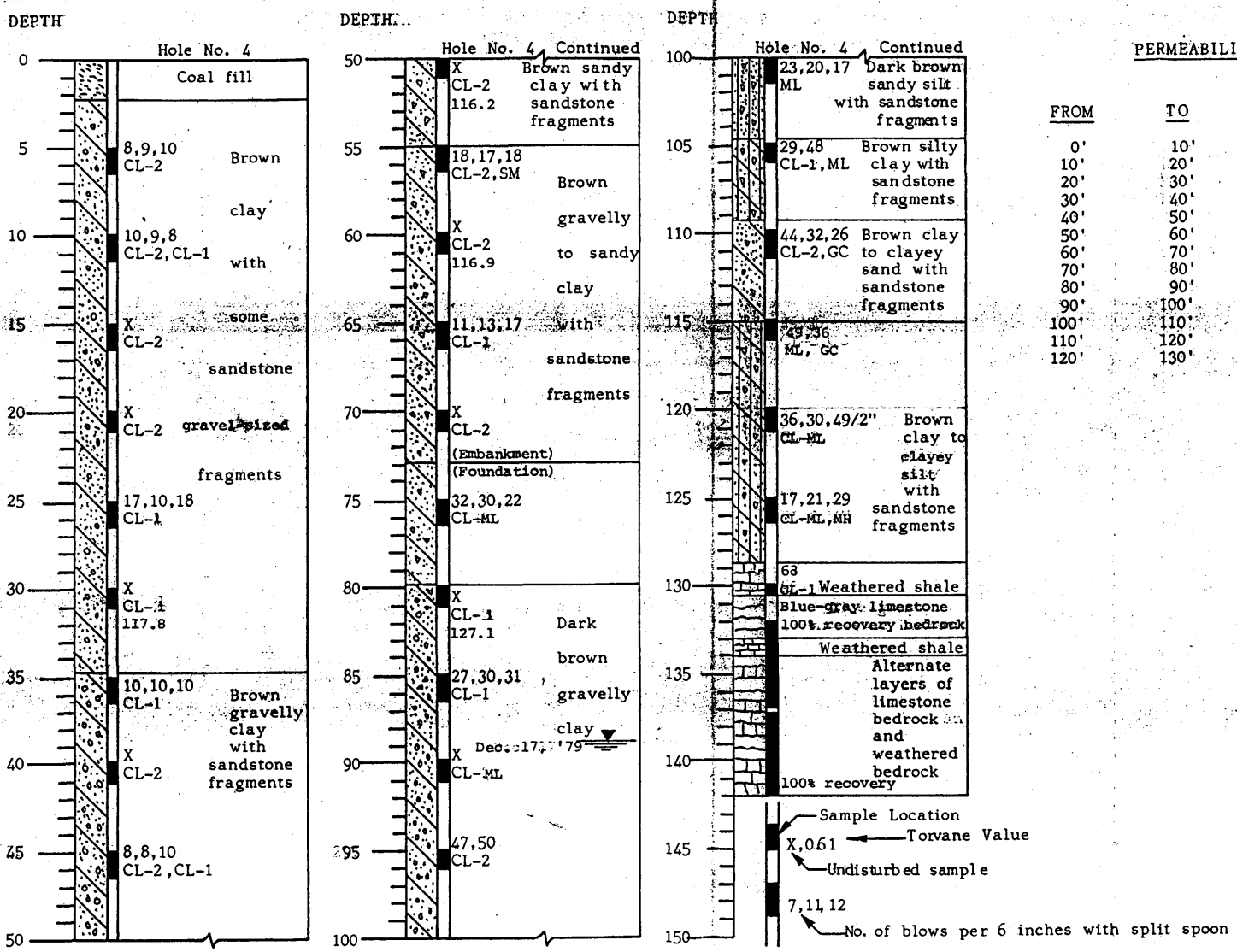
FROM	TO	PERMEABILITY (feet/year)
0'	10'	136
10'	20'	31
20'	30'	21
30'	40'	44
40'	50'	109
50'	60'	167
60'	70'	32
70'	80'	0
80'	90'	2,042
90'	100'	1,925
100'	110'	1,838
110'	120'	729
120'	125'	1,952

SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 3 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 9



PERMEABILITY DATA

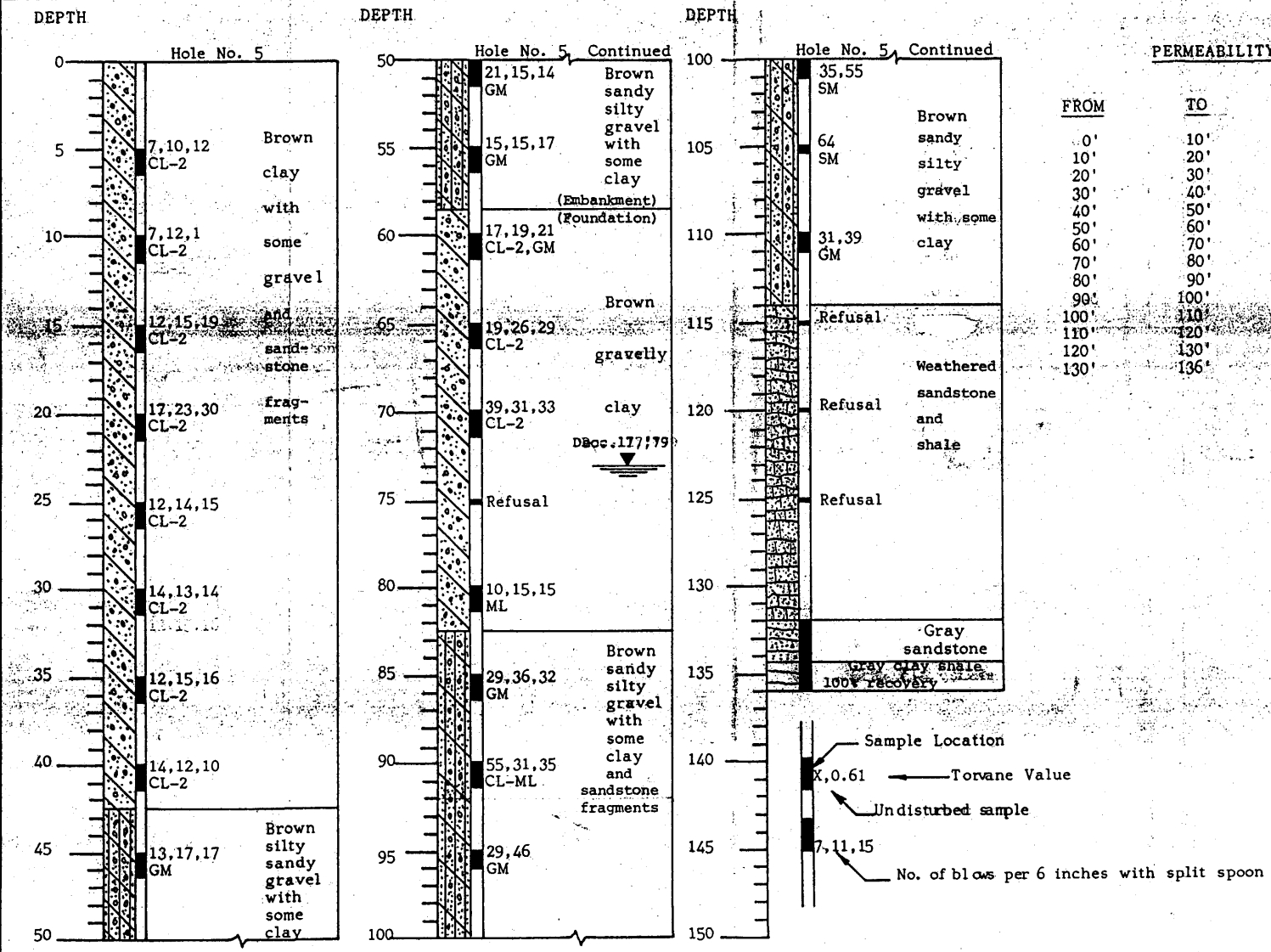
FROM	TO	PERMEABILITY (feet/year)
0'	10'	9,800
10'	20'	2,123
20'	30'	980
30'	40'	382
40'	50'	251
50'	60'	314
60'	70'	161
70'	80'	[illegible]
80'	90'	108
90'	100'	80
100'	110'	1,546
110'	120'	1,167
120'	130'	1,137

SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 4 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. E0



PERMEABILITY DATA

FROM	TO	PERMEABILITY (feet/year)
0'	10'	113
10'	20'	754
20'	30'	392
30'	40'	200
40'	50'	344
50'	60'	275
60'	70'	397
70'	80'	594
80'	90'	274
90'	100'	1,099
100'	110'	1,722
110'	120'	1,633
120'	130'	170
130'	136'	3,665

SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 5 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 11

Bruning "500"

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-1 Inclinometer No. 1 Sheet 1 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	

Boring Depth (ft.): 110	Elev: 7599.5'	Driller: B. HARTLEY	Starting Date: 3/13/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 47.5', ROTARY WASH N.W. CASING TO 99', N.Q. CORE			Ending Date: 3/16/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 1	Comments
						Coal Dust		Slope Indicator Pipe
7595	5							Low Strength Cement Grout
				CL-2	20,9,7			
7590	10							
						Reddish-Brown Sandy Clay W/Gravel (Fill)		
7585	15							
				CL-2	7,8,14			
7580	20							
7575	25							
				X	Pushed			
7570	30							
7565	35							
				CL-2	7,12,15	Reddish-Brown Gravelly Clay (Fill)		
7560	40							
7555	45							
				CL-2	7,8,11	Embankment Foundation		
7550								

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-1 Inclinometer No. 1 Sheet 2 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	
Boring Depth (ft.): 110 / Elev: 7599.5'	Driller: B. HARTLEY	Starting Date: 3/13/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 47.5', ROTARY WASH N.W. CASING TO 99', N.Q. CORE		Ending Date: 3/16/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 1	Comments
						Dark Gray Sandy Clay (Natural)		Slope Indicator Pipe
7545	55			CL-1	51,56/4.5"	Dark Brown Clayey Gravel		Low Strength Cement Grout
7540	60							
7535	65			CL-2	14,17,18			
7530	70					Gray-Brown Sandy Clay W/Gravel and Sandstone Cobbles		
7525	75			CL-2	9,17,21			
7520	80							
7515	85			CL-2	8,23,29			
7510	90							
7505	95			X	Pushed	Purplish-Brown W/Yellow and Brown Weathered Shale		
7500								

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD)
- Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-1 Inclinometer No. 1 Sheet 3 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	

Boring Depth (ft.): 110	Elev: 7599.5'	Driller: B. HARTLEY	Starting Date: 3/13/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 47.5', ROTARY WASH N.W. CASING TO 99', N.Q. CORE			Ending Date: 3/16/98

Elev. (Feet)	Depth (Feet)	Lithology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 1	Comments
					CORE 100,51	Bedrock Greenish-Gray Calcareous Mudstone to Siltstone		Slope Indicator Pipe
7495	105				CORE 100,86 CORE 100,100	Greenish-Gray Weakly Calcareous Mudstone to Siltstone W/Purplish-Brown Mudstone Layers		Low Strength Cement Grout
7490	110				CORE 100,83			Inclinometer #1
7485	115							
7480	120							
7475	125							
7470	130							
7465	135							
7460	140							
7455	145							
7450								

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-2 Piezometer No. 5 Sheet 1 of 1
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	
Boring Depth (ft.): 26.5 / Elev: 7527.0'	Driller: B. HARTLEY	Starting Date: 3/19/98
Equip./Drill Method: CME-55 / ROTARY WASH N.W. CASING		Ending Date: 3/19/98

Elev. (Feet)	Depth (Feet)	Lithology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7525						Brown Clay W/Gravel		Cement Grout
	5			SM CL-1	16,9,7	Yellow Soft Silty Sandstone Cobble		
7520						Dark Brown Sandy Clay		
	10			CL-2	4,7,7	Dark Brown Clayey Sand to Sandy Clay W/Gravel and Cobbles		Bentonite Seal
7515								
	15			SP-SM	12,19,20	Cobbles W/Silty Sand and Clay		
7510								
	20			SP-GP	13,13,6	100% Water Loss — Weathered Sandstone Cobbles W/Clay Matrix		
7505						Brown Sandy Clay W/Gravel and Sandstone Cobbles		Sand Piezometer #5
	25			CL-2	5,4,3			Sluff
7500								

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-3 Piezometer No. 2 & No. 3 Sheet 1 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, V.N.B.	

Boring Depth (ft.): 116.5	Elev: 7600.3'	Driller: B. HARTLEY	Starting Date: 3/3/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 80', ROTARY WASH N.W. CASING			Ending Date: 3/15/98

Elev. (Feet)	Depth (Feet)	Lithology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7600						Coal Fill		
7595	5					Reddish-Brown W/Greenish-Gray Sandy Lean Clay W/Gravel		
				CL-1	4,9,15			
7590	10							
7585	15							
				CL-1	9,7,4			
7580	20							
7575	25					Reddish-Brown Lean Clay W/Sand		
				CL-1	4,6,12 0.99+			
7570	30							
7565	35							Bentonite
				CL-1	1,4,8 0.99+			
7560	40					Reddish-Brown Sandy Lean Clay W/Gravel		
7555	45							
				CL-1	4,12,11			

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-3 Piezometer No. 2 & No. 3 Sheet 2 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, V.N.B.	

Boring Depth (ft.): 116.5	Elev: 7600.3'	Driller: B. HARTLEY	Starting Date: 3/3/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 80', ROTARY WASH N.W. CASING			Ending Date: 3/15/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7550								
7545	55			CL-1/ GC	16,14,19	Brown Gravelly Lean Clay W/Sand to Clayey Gravel W/Sand		
7540	60							
7535	65			CL-1	13,12,19	Dark Brown Sandy Lean Clay W/Gravel		
7530	70							Sand
								Piezometer #2
7525	75			SC/ CL-1	12,17,13	Dark Brown-Black Clayey Sand W/Gravel to Sandy Lean Clay W/Gravel		
7520	80							
7515	85			SC/ CL-1	7,11,14			
						Embankment Foundation		
7510	90					Brown Sandy Clay		Bentonite
7505	95			X	Pushed	Brown Silty Clayey Sand		
				CL-1	6,6,12			
						Clay		

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-3 Piezometer No. 2 & No. 3 Sheet 3 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, V.N.B.	
Boring Depth (ft.): 116.5 / Elev: 7600.3'	Driller: B. HARTLEY	Starting Date: 3/3/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 80', ROTARY WASH N.W. CASING		Ending Date: 3/15/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7500								
						Brown Sandy Clay		
7495	105			GC	6,28,13	Brown Clayey Gravel W/Sand		Sand Piezometer #3
7490	110			SC-SM	7,6,4			
						Brown Silty Clayey Sand		
7485	115			GM	13,14,27			
						Brown Silty Gravel W/Sand		
7480	120							
7475	125							
7470	130							
7465	135							
7460	140							
7455	145							

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-4 Piezometer No. 6 Sheet 1 of 1
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	
Boring Depth (ft.): 36.5 / Elev: 7510.4'	Driller: B. HARTLEY	Starting Date: 3/20/98
Equip./Drill Method: CME-55 / ROTARY WASH N.W. CASING		Ending Date: 3/20/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7510						Dark Brown Gravelly Clay W/Cobbles		Cement Grout
7505	5			SM-GM	17,22,16	Dark Brown Silty Gravelly Sand W/Clay and Some Cobbles		
						Clay		
7500	10			GC	10,6,7			
7495	15			GC	17,19,19	Dark Brown Clayey Sandy Gravel W/Cobbles		Bentonite
7490	20					Sandstone Boulder		
						Clayey Sandy Gravel		
				GP-GC CL-2	11,7,4	Dark Gray Clay		
						Clayey Sandy Gravel		
7485	25			CL-1	3/12",2	Dark Brown Clay W/Silty Sand Lenses		Sand
7480	30			CL-2 /SM	6,3,3	Red-Brown Sandy Clay W/Silty Sand Layers		Piezometer #6
						Sandstone Boulder		
7475	35			GP-GM	10,19,22	Brown Silty Sandy Gravel W/Clay		Sluff
7470	40							
7465	45							

LEGEND

2,3,2 — Blow Count per 6"
0.45 — Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-5 Inclinometer No. 3 Sheet 1 of 2
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	

Boring Depth (ft.): 54	Elev: 7601.4'	Driller: B. HARTLEY	Starting Date: 3/18/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 5', ROTARY WASH N.W. CASING TO 10', N.Q. CORE			Ending Date: 3/18/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 3	Comments
7600								Slope Indicator Pipe
				CL-1	5,9,14	Reddish-Brown Sandy Clay W/Gravel		
	5							
7595								Low Strength Cement Grout
						Bedrock		
	10			CL-2	37,61/5"	Interbedded Light Green and Reddish-Brown Weathered Mudstone (Shale) W/Some Interbedded Gravel		
7590					CORE 97,60			
	15							
7585					CORE 80,38			
	20							
7580					CORE 94,62	Light Green Fractured Mudstone		
	25							
7575					CORE 100,82			
	30					Blue-Gray Mudstone to Claystone W/Some Brown Layers		
7570					CORE 100,89			
	35					Very Soft Mudstone		
7565					CORE 100,72	Dark Red-Brown Shaley Mudstone		
	40							
7560					CORE 99,76	Blue-Gray Mudstone to Siltstone		
	45					Yellow-Greenish-Brown Sandstone W/Some Fractures		
7555					CORE 100,86			

LEGEND

- 2,3,2 ← Blow Count per 6"
- 0.45 ← Torvane (tsf)
- Disturbed Sample
- Core 100,60 ← Rock Quality Designation (RQD)
- Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-5 Inclinometer No. 3 Sheet 2 of 2
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	

Boring Depth (ft.): 54	Elev: 7601.4'	Driller: B. HARTLEY	Starting Date: 3/18/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 5', ROTARY WASH N.W. CASING TO 10', N.Q. CORE			Ending Date: 3/18/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 3	Comments
7550					CORE 100,70	100% Water Loss Yellow-Grayish-Brown Sandstone W/Fractures		Inclinometer #3 Low Strength Cement Grout Sluff
7545	55							
7540	60							
7535	65							
7530	70							
7525	75							
7520	80							
7515	85							
7510	90							
7505	95							

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-6 Piezometer No. 7 Sheet 1 of 1
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	
Boring Depth (ft.): 41.5 / Elev: 7518.0'	Driller: B. HARTLEY	Starting Date: 3/23/98
Equip./Drill Method: CME-55 / N.W. CASING		Ending Date: 3/23/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7515						Dark Brown Sandy Clay		Cement Grout
	5			CL-1	4,5,6			
7510								
	10			X	Pushed	Dark Brown Silty Fine Sand W/Some Clay Layers		Bentonite
				SM	4,4,3			
7505								
	15			SM	3,3,4			
7500								
	20			CL-2	1/24"	Dark Brown Sandy Clay		Sand
7495								Piezometer #7
	25			CL-1	1,1,1			
				SM		Dark Brown Silty Sand		Bentonite
7490								
	30			CL-1	0/9", 2/9"	Dark Brown Sandy Clay		
						Sandy Clay W/Gravel		
7485								
	35			GC	7,9,8	Brown Sandy Clayey Gravel		Sand
7480								
	40			GM	5,13,17	Brown Silty Sandy Gravel		
7475								
	45							
7470								

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-7 Inclinometer No. 2 Sheet 1 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, M. HANSEN, V.N.B.	

Boring Depth (ft.): 132.4	Elev: 7600.2'	Driller: B. HARTLEY	Starting Date: 3/5/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 49', N.Q. CORE TO 58', ROTARY WASH TO 120', N.Q. CORE			Ending Date: 3/11/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 2	Comments
7600								Slope Indicator Pipe
7595	5							Low Strength Cement Grout
				CL-1	7,6,4	Reddish-Brown Sandy Lean Clay W/Gravel		
7590	10							
7585	15							
				CL-1	8,9,10			
7580	20							
						Boulder		
7575	25					Reddish-Brown Sandy Lean Clay W/Gravel		
				X, CL-1	Pushed 0.75			
				SP-SM	26,13,12	Brown Sandstone		
7570	30					Brown Sandy Clay W/Gravel		
7565	35							
				CL-2	6,7,10			
7560	40							
7555	45					Tan Sandstone Sand W/Gravel and Cobbles		
				SP	21,36,39			

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD)
- Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-7 Inclinometer No. 2 Sheet 2 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, M. HANSEN, V.N.B.	

Boring Depth (ft.): 132.4	Elev: 7600.2'	Driller: B. HARTLEY	Starting Date: 3/5/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 49', N.Q. CORE TO 58', ROTARY WASH TO 120', N.Q. CORE			Ending Date: 3/11/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 2	Comments
7550					CORE 19,0	Tan and Gray Sandstone		Slope Indicator Pipe
7545	55				CORE 32,0			Low Strength Cement Grout
						Reddish-Brown Clayey Gravel W/Sand		
7540	60			CL-2	7,10,9	Brown Clay W/Sand, Gravel and Cobbles		
7535	65							
7530	70			GC	12,11,14	Brown Clayey Sandy Gravel		
7525	75							
7520	80			CL-2	6,7,11	Reddish-Brown Sandy Clay W/Gravel		
7515	85							
7510	90			CL-2	17,9,11			
7505	95					Yellow and Brown Sandy Clay W/Gravel and Cobbles		

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-7 Inclinometer No. 2 Sheet 3 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, M. HANSEN, V.N.B.	
Boring Depth (ft.): 132.4 / Elev: 7600.2'	Driller: B. HARTLEY	Starting Date: 3/5/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 49', N.Q. CORE TO 58', ROTARY WASH TO 120', N.Q. CORE		Ending Date: 3/11/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 2	Comments
7500				CL-2	16,28,26			Slope Indicator Pipe
7495	105					Boulder		Low Strength Cement Grout
7490	110			CL-2	15,14,14	Yellow and Brown Sandy Clay W/Gravel and Cobbles		
7485	115							
7480	120			GC	56/6", REF			
					CORE 64,45	Bedrock - Orange Sandstone Silty Sandstone		
7475	125				CORE 100,100	Gray Sandstone		Inclinometer #2
7470	130				CORE 86,75	Greenish-Gray Shaley Mudstone		Sluff
7465	135							
7460	140							
7455	145							

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-1, I-4

Sheet: 1 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR
PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC.
DATE: 2/2/05
LOCATION: SEE SITE PLAN: N 10513, E 9652
ELEVATION: 7626.3'
DRILLER: D. SAMPSON, J. BAILEY
LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / N.W. CASING TO 43.8' THEN N.Q. CORE
DEPTH TO WATER - INITIAL: ▽ 39.0'? AFTER 24 HOURS: ▽ 39.5' ARTESIAN?

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	See Legend	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7625				9	0,6,6	CL	brown, moist, some roots — Top 0.5' loose from constructing drill pad — SANDY LEAN CLAY W/GRAVEL — some roots, gravel is angular sandstone & mudstone										
7620	5			9	3,4,6	GC	brown, moist — CLAYEY GRAVEL W/SAND										Slope Indicator Pipe
7615	10			11	6,8,10	SC	brown, moist — CLAYEY SAND W/GRAVEL		14.5			27	46	27			
	15			8	14,9,12	GM	brown, moist — SILTY GRAVEL W/SAND — some clay layers										
7610				4	27,53, REF	SM	brown, moist — SILTY SAND W/GRAVEL										
7605	20			6	13,14,14	GM	brown, moist — SILTY GRAVEL W/SAND — some clay layers										
				9	8,17,18	SC	brown, moist — CLAYEY SAND W/GRAVEL		13.2			36	40	24			
7600	25			7	15,17,19	GM	mottled green-gray w/red-brown — SILTY GRAVEL W/SAND, CLAY & MUDSTONE FRAGMENTS — sandstone gravel										Low Strength Grout
	30			7	14,11,12	GC	brown to red-brown, moist — CLAYEY GRAVEL W/SAND										
7595				13	7,9,12 1.00+	CL-1	red-brown, moist, med. plasticity — SANDY CLAY W/SANDSTONE & MUDSTONE GRAVEL		14.9	24	9						
7590	35			11	Pushed	GC	green, moist — CLAYEY GRAVEL W/SAND — sandstone bottom — very highly weathered bedrock?										
				9	15,14,17 1.00+	CL/CH	red-brown, moist, high plasticity — CLAY TO CLAYEY MUDSTONE — w/green sandstone fragments										
▽	40			13	12,28,57 1.00+	CL/CH	brown-red, moist, high plasticity — CLAYEY MUDSTONE — very highly weathered										
7585				6 4 6	Pushed 56/4" 1.00+ Core 100,100	CL-1 CL -	red-brown & gray, moist	128.3	11.0	33	14				DS		
	45																
7580				60	Core 100,42	-	green — SANDY MUDSTONE										
	50						100% water loss at 49.8'										

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Core
100,60 ← Rock Quality Designation (RQD)
Percent Sample Recovery
Undisturbed Sample
Groundwater Elevation

DS - Direct Shear Test
UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-1, I-4

Sheet: 2 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR
PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC.
DATE: 2/2/05
LOCATION: SEE SITE PLAN: N 10513, E 9652
ELEVATION: 7626.3'
DRILLER: D. SAMPSON, J. BAILEY
LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / N.W. CASING TO 43.8' THEN N.Q. CORE
DEPTH TO WATER - INITIAL: ▽ 39.0'? AFTER 24 HOURS: ▽ 39.5' ARTESIAN?

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	See Legend	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7575				60	Core 100,54	-	SANDY MUDSTONE										
	55						red-brown MUDSTONE										Slope Indicator Pipe
							green MUDSTONE										
7570				48	Core 80,42	-	green SANDSTONE										
							green MUDSTONE										
							red-brown MUDSTONE										
							green MUDSTONE										
							green SANDSTONE										
	60						red-brown MUDSTONE										
							green SILTY MUDSTONE										Low Strength Grout
							red-brown MUDSTONE										
7565				54	Core 90,84	-	mottled red, green & yellow MUDSTONE										
							mottled red-brown & green MUDSTONE W/CLAY SEAMS ~0.25" THICK										
	65						green MUDSTONE TO SANDSTONE										
7560				59	Core 98,96	-	green SILTY SANDSTONE W/FEW MUDSTONE INCLUSIONS										
																	Sluff
	70																
7555																	
	75																
7550																	
	80																
7545																	
	85																
7540																	
	90																
7535																	
	95																
7530																	
	100																

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Core 100,60 ← Rock Quality Designation (RQD)
Percent Sample Recovery
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-2

Sheet: 1 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 2/9/05
LOCATION: SEE SITE PLAN: N 10106, E 10460 — ELEVATION: 7599.8'
DRILLER: D. SAMPSON, J. BAILEY — LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER
DEPTH TO WATER - INITIAL: ▽ 41.5' AFTER 24 HOURS: ▽ 29.6'

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7595	5			5	4,4,5	CL	black, moist										Locking Well Cover Rim Elev. 7601.5'
							SANDY LEAN CLAY W/SAND & GRAVEL (embankment fill)										PVC Pipe
7590	10																Low Strength Grout
				9	9,6,6	CL	brown, moist										
7585	15																
7580	20																Bentonite Seal
				2	6,6,7	GM	gray-brown, moist										
7575	25						SILTY GRAVEL W/SAND (embankment fill)										
																	Sluff
7570 ▽	30																
				8	4,7,8	CL	brown, moist										
7565	35																Bentonite Seal
7560	40						SANDY LEAN CLAY W/SAND & GRAVEL LAYERS (embankment fill)										
▽				3	5,8,10	CL	brown, moist										10/20 Silica Sand
7555	45																Piezomter
7550	50																Bentonite Seal

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-3

Sheet: 1 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 2/15/05
LOCATION: SEE SITE PLAN: N 10028, E 10171 — ELEVATION: 7600.3'
DRILLER: D. SAMPSON, J. DARTER — LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER
DEPTH TO WATER - INITIAL: ▽ 49.4' AFTER 24 HOURS: ▽ 34.5'

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7600																	Locking Well Cover Rim Elev. 7601.7'
			■	-	4,6,11	-											
7595	5																PVC Pipe
7590	10		■	9	6,13,5 0.68	CL	red-brown, moist to wet										
7585	15																
7580	20		⊠	0	Pushed	-											Bentonite Seal
			■	7	7,4,7 0.57	CL	med. brown & yellow-brown, moist										
7575	25		⊠	5	Pushed 0.75	CL	red-brown, moist										3' Slotted PVC Pipe; 10/20 Silica Sand
7570	30		■	14	5,6,12	-	moist										Bentonite Seal
7565	35		⊠	14	Pushed 0.68	CL	brown, red-brown & green, moist to wet, water in hole after sample taken										
7560	40		■	13	7,19,19	CL	brown, moist										Mix w/Bentonite
7555	45																
	50																

LEAN CLAY W/SAND & GRAVEL & W/SOME COBBLES (fill)

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-3

Sheet: 2 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 2/15/05
LOCATION: SEE SITE PLAN: N 10028, E 10171 — ELEVATION: 7600.3'
DRILLER: D. SAMPSON, J. DARTER — LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER
DEPTH TO WATER - INITIAL: ▽ 49.4' AFTER 24 HOURS: ▽ 34.5'

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7550				5	Pushed	-	wet										
				11	14,19,20	CL	brown, moist w/wet layers										
7545	55																
7540	60			17	7,10,19	CL	med. to lt. brown, wet to moist, dk. gray — SANDY LEAN CLAY W/GRAVEL (fill)										Mix w/Bentonite
7535	65																
7530	70			17	8,16,24 1.00+	CL	dk. gray, moist, trace roots, sligth organic odor										
7525	75			11	37,24,31	CL,SC	brown & dk. gray, moist — LEAN CLAY W/SAND & SANDY CLAY W/SANDSTONE GRAVEL										Bentonite Seal
7520	80			15	13,28,35	CL	brown, moist — SANDY LEAN CLAY W/SANDSTONE GRAVEL										10/20 Silica Sand; Piezometer
7515	85			18	6,8,13 0.71	CL	dk. gray-brown										Sluff
7510	90																
7505	95																
	100																

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-3A

Sheet: 1 of 1

PROJECT: GRASSY TRAIL DAM & RESERVOIR
PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC.
DATE: 2/20/05
LOCATION: SEE SITE PLAN: N 10029, E 10177
ELEVATION: 7600.2'
DRILLER: D. SAMPSON, J. DARTER
LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER
DEPTH TO WATER - INITIAL: ▽ 38.0' AFTER 24 HOURS: ▽ 31.0'

Elev. (Feet)	Depth (Feet)	Lithology	SAMPLE Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7600							EMBANKMENT FILL - SEE LOG FOR DRILL HOLE 05-3										Locking Well Cover Rim Elev. 7601.8'
7595	5																Cement Grout
7590	10																
7585	15																
7580	20																
7575	25			5	Pushed 0.75	CL	red-brown w/mottled green, moist										Bentonite Seal
7570	30						LEAN CLAY W/SAND & GRAVEL (embankment fill)										
7565	35			14	Pushed 0.68	CL	red-brown & green, moist to wet										
7560	40																
7555	45																10/20 Silica Sand; 5' Slotted PVC Pipe
7550	50																Sluff

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

DRILL HOLE LOG

BORING NO. 05-4

Sheet: 1 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR
PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC.
DATE: 6/14/05
LOCATION: SEE SITE PLAN: N , E
ELEVATION: 7557.4'
DRILLER: D. SAMPSON
LOGGED BY: M.S., V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER TO 51' THEN N.W. CASING
DEPTH TO WATER - INITIAL: ▽ 50.5' AFTER 24 HOURS: ▽ NOT MEASURED

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
				8	5,5,2	-											Locking Well Cover Rim Elev. 7558.9
7555																	
				7	2,1,1	-											
	5						CLAYEY GRAVEL/ GRAVELLY CLAY										
				7	0,3,2	-											
7550																	
	10			8	4,7,6,7	-											Cement Grout
							(Road Fill 0' to 11.5')										
7545				21	2,4,11,14 0.75	CL-1 SC	brown, moist, very stiff — SANDY LEAN CLAY W/GRAVEL		15.8	28	13	19	25	56			
	15			7	Pushed	CL/SC -	tan, moist; cobble — ALTERNATING LAYERS OF: SANDY CLAY, SANDY CLAY W/GRAVEL, CLAYEY SAND W/GRAVEL, CLAYEY GRAVEL W/SAND										
7540				18	5,15,13	SC	tan, moist, dense-very stiff										
				18	4,7,10	CL GC	dk. brown, moist										
	20			18	8,10,15 1.00	CL	dk. brown, moist — INTERMIXED CLAY, SAND & GRAVEL W/OCCASIONAL COBBLE										
7535																	
	25			0	Pushed	GC	sandstone cobble										
				18	5,15,13	GC-GM	brown, moist, med. dense — SILTY CLAYEY GRAVEL W/SAND		13.1	22	6	39	33	28			Bentonite Seal
7530				-	Pushed	CL	dk. brown, moist, hard										
				18	6,16,26	GC CL	crushed rock; brown										
	30			18	11,15,19	CL	brown, moist, hard — SANDY LEAN CLAY W/GRAVEL										
7525																	
				18	8,17,24	SC	dk. brown, moist, dense										10/20 Silica Sand
	35																Piezomter
				18	12,16,15	SC	blackish-brown, moist, dense-hard — CLAYEY SAND W/GRAVEL	94.8	11.2	26	11	15	42	43			
7520																	
	40			12	Pushed	SC	brown, moist			27	14	18	33	49	TS		
				18	11,16,20	CL	dk. brown, moist, hard										
7515				7	Pushed	CL	dk. brown, moist — SANDY LEAN CLAY W/GRAVEL										
				15	12,20,34	CL	dk. brown, moist, hard										Bentonite Seal
	45			18	10,22,30	GC	dk. brown-gray, moist, dense — CLAYEY GRAVEL W/SAND		15.0	27	12	36	31	33			
7510						CL	dk. brown, moist, — SANDY LEAN CLAY W/GRAVEL (Embankment Fill 11.5' to 48.5')										
				15	5,9,8	SM	SILTY SAND										
	50					ML	dk. gray — SILT										

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

TS - Triaxial Shear Test
UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-4

Sheet: 2 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 6/14/05
LOCATION: SEE SITE PLAN: N , E — ELEVATION: 7557.4'
DRILLER: D. SAMPSON — LOGGED BY: M.S., V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER TO 51' THEN N.W. CASING
DEPTH TO WATER - INITIAL: ▽ 50.5' AFTER 24 HOURS: ▼ NOT MEASURED

Elev. (Feet)	Depth (Feet)	Lith-ology	Sample Type	Sample Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description		Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
				17	18,21,34	GP-GM	brown to yellow-brown, moist, dense	POORLY GRADED GRAVEL W/SILT, SAND & CLAY LENSES		10.9		NP	52	36	12			Bentonite Seal
7505																		
	55			17	22,13,32	SM	brown to dk. brown, wet, dense	SILTY SAND W/GRAVEL & FEW CLAY LENSES										10/20 Silica Sand
7500																		Piezomter
	60			15	16,16,23	GP-GM	brown, wet, dense	POORLY GRADED GRAVEL W/SILT & SAND										
7495																		
	65																	
7490																		
	70																	
7485																		
	75																	
7480																		
	80																	
7475																		
	85																	
7470																		
	90																	
7465																		
	95																	
7460																		
	100																	

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

Instrumentation

Grassy Trail Reservoir **Landslide Monitoring Program**
Survey Points Right Abutment Slide

Point: **RBG11**

Date	Point	Northing	Easting	Elevation
7/21/2004	1051	9,785.380	9,678.527	7,710.960
7/15/2005	rbg11g	9,785.386	9,678.549	7,710.757

Point: **RBG12**

Date	Point	Northing	Easting	Elevation
7/21/2004	1102	9,803.955	9,735.965	7,681.139
7/15/2005	rbg12	9,803.990	9,735.979	7,680.833

Point: **RBG13**

Date	Point	Northing	Easting	Elevation
7/21/2004	1115	9,916.023	9,697.414	7,660.658
7/15/2005	rbg13	9,916.000	9,697.475	7,660.468

Point: **RBG14**

Date	Point	Northing	Easting	Elevation
2/4/1999	452	9,965.37	9,658.59	7,659.04
7/21/2004	1125	9,965.298	9,658.446	7,658.906
7/15/2005	rbg14	9,965.358	9,658.425	7,658.574

Point: **RBG15**

Date	Point	Northing	Easting	Elevation
2/4/1999	451	9,817.63	9,628.59	7,721.82
7/21/2004	1052	9,817.630	9,628.590	7,721.820
7/15/2005	rbg15	9,817.630	9,628.590	7,721.820

Point: **RBG16**

Date	Point	Northing	Easting	Elevation
7/21/2004	1129	9,979.465	9,662.129	7,658.056
7/15/2005	rbg16	9,979.465	9,662.129	7,658.056

Point: **RBG17**

Date	Point	Northing	Easting	Elevation
7/21/2004	1161	9,944.476	9,799.510	7,635.150
7/15/2005	rbg17	9,944.456	9,799.532	7,634.978

Point: **RBG18**

Date	Point	Northing	Easting	Elevation
2/4/1999	450	9,839.63	9,751.74	7,665.45
7/21/2004	1054	9,839.671	9,751.660	7,665.321
7/15/2005	rbg18	9,839.714	9,751.760	7,665.119

Grassy Trail Reservoir **Landslide Monitoring Program**

Survey Points Right Abutment Slide

Summary of Recorded Movement as of 7/15/05

Point: RBG11

Date	Point	Northing	Easting	Elevation
7/21/2004	1051	9,785.380	9,678.527	7,710.960
7/15/2005	rbg11g	9,785.386	9,678.549	7,710.757
since 7/04:		*0.006*	*0.022*	*-0.203*
lateral movement & direction:			*0.023 ft N 74.7° E*	

Point: RBG15

Date	Point	Northing	Easting	Elevation
2/4/1999	451	9,817.63	9,628.59	7,721.82
7/21/2004	1052	9,817.630	9,628.590	7,721.820
7/15/2005	rbg15	9,817.630	9,628.590	7,721.820
since 7/04:		*0*	*0*	*0*
lateral movement & direction:			*none*	
since 2/99:		*0*	*0*	*0*
lateral movement & direction:			*none*	

Point: RBG12

Date	Point	Northing	Easting	Elevation
7/21/2004	1102	9,803.955	9,735.965	7,681.139
7/15/2005	rbg12	9,803.990	9,735.979	7,680.833
since 7/04:		*0.035*	*0.014*	*-0.306*
lateral movement & direction:			*0.038 ft N 21.8° E*	

Point: RBG16

Date	Point	Northing	Easting	Elevation
7/21/2004	1129	9,979.465	9,662.129	7,658.056
7/15/2005	rbg16	9,979.465	9,662.129	7,658.056
since 7/04:		*0*	*0*	*0*
lateral movement & direction:			*none*	

Point: RBG13

Date	Point	Northing	Easting	Elevation
7/21/2004	1115	9,916.023	9,697.414	7,660.658
7/15/2005	rbg13	9,916.000	9,697.475	7,660.468
since 7/04:		*-0.023*	*0.061*	*-0.19*
lateral movement & direction:			*0.065 ft S 69.3° E*	

Point: RBG17

Date	Point	Northing	Easting	Elevation
7/21/2004	1161	9,944.476	9,799.510	7,635.150
7/15/2005	rbg17	9,944.456	9,799.532	7,634.978
since 7/04:		*-0.020*	*0.022*	*-0.172*
lateral movement & direction:			*0.030 ft S 47.7° E*	

Point: RBG14

Date	Point	Northing	Easting	Elevation
2/4/1999	452	9,965.37	9,658.59	7,659.04
7/21/2004	1125	9,965.298	9,658.446	7,658.906
7/15/2005	rbg14	9,965.358	9,658.425	7,658.574
since 7/04:		*0.060*	*-0.021*	*-0.332*
lateral movement & direction:			*0.064 ft N 19.3° W*	
since 2/99:		*-0.01*	*-0.17*	*-0.47*
lateral movement & direction:			*0.17 ft S 85.8° W*	

Point: RBG18

Date	Point	Northing	Easting	Elevation
2/4/1999	450	9,839.63	9,751.74	7,665.45
7/21/2004	1054	9,839.671	9,751.660	7,665.321
7/15/2005	rbg18	9,839.714	9,751.760	7,665.119
since 7/04:		*0.043*	*0.100*	*-0.202*
lateral movement & direction:			*0.109 ft N 66.7° E*	
since 2/99:		*0.08*	*0.02*	*-0.33*
lateral movement & direction:			*0.09 ft N 13.4° E*	

Grassy Trail Reservoir **Landslide Monitoring Program**

Survey Points West Reservoir Rim Slide

Point: **RBG21**

Date	Point	Northing	Easting	Elevation
7/21/2004	1242	10,335.666	9,551.444	7,686.687
7/15/2005	rbg21	10,335.710	9,551.481	7,686.698

Point: **RBG22**

Date	Point	Northing	Easting	Elevation
7/21/2004	1243	10,336.464	9,590.499	7,664.921
7/15/2005	rbg22	10,336.457	9,590.456	7,664.765

Point: **RBG23**

Date	Point	Northing	Easting	Elevation
7/21/2004	1245	10,340.529	9,677.497	7,632.089
7/15/2005	rbg23	10,340.548	9,677.541	7,632.105

Point: **RBG24**

Date	Point	Northing	Easting	Elevation
2/4/1999	461	10,566.41	9,479.56	7,707.75
7/21/2004	1250	10,566.191	9,479.371	7,707.411
7/15/2005	rbg24	10,566.356	9,479.385	7,707.204

Point: **RBG25**

Date	Point	Northing	Easting	Elevation
7/21/2004	1249	10,604.610	9,453.468	7,728.636
7/15/2005	rbg25	10,604.785	9,453.516	7,728.592

Point: **RBG26**

Date	Point	Northing	Easting	Elevation
7/21/2004	1251	10,606.120	9,502.784	7,701.777
7/15/2005	rbg26	10,606.302	9,502.837	7,701.562

Point: **RBG27**

Date	Point	Northing	Easting	Elevation
7/21/2004	1252	10,608.006	9,569.479	7,677.601
7/15/2005	rbg27	10,608.075	9,569.577	7,677.667

Point: **RBG28**

Date	Point	Northing	Easting	Elevation
2/4/1999	459	10,419.20	9,532.18	7,693.46
7/21/2004	1244	10,418.983	9,532.087	7,692.992
7/15/2005	rbg28	10,419.029	9,532.159	7,692.918

Grassy Trail Reservoir **Landslide Monitoring Program**

Survey Points West Reservoir Rim Slide

Summary of Recorded Movement as of 7/15/05

Point: RBG21

Date	Point	Northing	Easting	Elevation
7/21/2004	1242	10,335.666	9,551.444	7,686.687
7/15/2005	rbg21	10,335.710	9,551.481	7,686.698
since 7/04:		*0.044*	*0.037*	*0.011*
lateral movement & direction:			*0.057 ft N 40.1° E*	

Point: RBG25

Date	Point	Northing	Easting	Elevation
7/21/2004	1249	10,604.610	9,453.468	7,728.636
7/15/2005	rbg25	10,604.785	9,453.516	7,728.592
since 7/04:		*0.175*	*0.048*	*-0.044*
lateral movement & direction:			*0.181 ft N 15.3° E*	

Point: RBG22

Date	Point	Northing	Easting	Elevation
7/21/2004	1243	10,336.464	9,590.499	7,664.921
7/15/2005	rbg22	10,336.457	9,590.456	7,664.765
since 7/04:		*-0.007*	*-0.043*	*-0.156*
lateral movement & direction:			*0.044 ft S 80.7° W*	

Point: RBG26

Date	Point	Northing	Easting	Elevation
7/21/2004	1251	10,606.120	9,502.784	7,701.777
7/15/2005	rbg26	10,606.302	9,502.837	7,701.562
since 7/04:		*0.182*	*0.053*	*-0.215*
lateral movement & direction:			*0.190 ft N 16.2° E*	

Point: RBG23

Date	Point	Northing	Easting	Elevation
7/21/2004	1245	10,340.529	9,677.497	7,632.089
7/15/2005	rbg23	10,340.548	9,677.541	7,632.105
since 7/04:		*0.019*	*0.044*	*0.016*
lateral movement & direction:			*0.048 ft N 66.6° E*	

Point: RBG27

Date	Point	Northing	Easting	Elevation
7/21/2004	1252	10,608.006	9,569.479	7,677.601
7/15/2005	rbg27	10,608.075	9,569.577	7,677.667
since 7/04:		*0.069*	*0.098*	*0.066*
lateral movement & direction:			*0.120 ft N 54.9° E*	

Point: RBG24

Date	Point	Northing	Easting	Elevation
2/4/1999	461	10,566.41	9,479.56	7,707.75
7/21/2004	1250	10,566.191	9,479.371	7,707.411
7/15/2005	rbg24	10,566.356	9,479.385	7,707.204
since 7/04:		*0.165*	*0.014*	*-0.207*
lateral movement & direction:			*0.166 ft N 4.8° E*	
since 2/99:		*-0.05*	*-0.17*	*-0.55*
lateral movement & direction:			*0.18 ft S 72.9° W*	

Point: RBG28

Date	Point	Northing	Easting	Elevation
2/4/1999	459	10,419.20	9,532.18	7,693.46
7/21/2004	1244	10,418.983	9,532.087	7,692.992
7/15/2005	rbg28	10,419.029	9,532.159	7,692.918
since 7/04:		*0.046*	*0.072*	*-0.074*
lateral movement & direction:			*0.085 ft N 57.4° E*	
since 2/99:		*-0.17*	*-0.02*	*-0.54*
lateral movement & direction:			*0.17 ft S 7.0° W*	

Grassy Trail Reservoir **Landslide Monitoring Program**

Survey Points East Reservoir Rim and Abutment Slide

Point: RBG29

Date	Point	Northing	Easting	Elevation
2/4/1999	453	10,124.51	10,788.66	7,716.70
7/21/2004	1253	10,124.638	10,788.679	7,716.384
7/15/2005	rbg29	10,124.439	10,788.425	7,716.391

Point: RBG32

Date	Point	Northing	Easting	Elevation
2/4/1999	455	10,534.59	10,622.87	7,716.89
7/21/2004	1255	10,534.565	10,622.890	7,716.519
7/15/2005	rbg32	10,534.392	10,623.044	7,716.128

Point: RBG30

Date	Point	Northing	Easting	Elevation
2/4/1999	458	10,255.86	10,991.17	7,871.55
7/21/2004	1258	10,256.055	10,991.285	7,871.016
7/15/2005	not surveyed		---	---

Point: RBG33

Date	Point	Northing	Easting	Elevation
2/4/1999	456	10,733.08	10,660.59	7,761.26
7/21/2004	1256	10,732.996	10,660.423	7,761.011
7/15/2005	rbg33	10,732.810	10,660.562	7,760.805

Point: RBG31

Date	Point	Northing	Easting	Elevation
2/4/1999	454	10,310.63	10,756.70	7,716.67
7/21/2004	1254	10,310.659	10,756.622	7,716.380
7/15/2005	rbg31	10,310.438	10,756.881	7,715.878

Point: RBG34

Date	Point	Northing	Easting	Elevation
2/4/1999	457	10,794.73	10,599.32	7,720.72
7/21/2004	1257	10,794.666	10,599.097	7,720.323
7/15/2005	rbg34	10,794.475	10,599.157	7,720.259

Grassy Trail Reservoir **Landslide Monitoring Program**

Survey Points East Reservoir Rim and Abutment Slide

Summary of Recorded Movement as of 7/15/05

Point: RBG29

Date	Point	Northing	Easting	Elevation
2/4/1999	453	10,124.51	10,788.66	7,716.70
7/21/2004	1253	10,124.638	10,788.679	7,716.384
7/15/2005	rbg29	10,124.439	10,788.425	7,716.391
since 7/04:		*-0.199*	*-0.254*	*0.007*
lateral movement & direction:			*0.323 ft S 51.9° W*	
since 2/99:		*-0.07*	*-0.24*	*-0.31*
lateral movement & direction:			*0.25 ft S 73.2° W*	

Point: RBG32

Date	Point	Northing	Easting	Elevation
2/4/1999	455	10,534.59	10,622.87	7,716.89
7/21/2004	1255	10,534.565	10,622.890	7,716.519
7/15/2005	rbg32	10,534.392	10,623.044	7,716.128
since 7/04:		*-0.173*	*0.154*	*-0.391*
lateral movement & direction:			*0.232 ft S 41.7° E*	
since 2/99:		*-0.20*	*0.17*	*-0.76*
lateral movement & direction:			*0.26 ft S 41.3° E*	

Point: RBG30

Date	Point	Northing	Easting	Elevation
2/4/1999	458	10,255.86	10,991.17	7,871.55
7/21/2004	1258	10,256.055	10,991.285	7,871.016
7/15/2005	not surveyed		---	---
from 2/99 to 7/04:		*0.19*	*0.11*	*-0.53*
lateral movement & direction:			*0.23 ft N 30.5° E*	

Point: RBG33

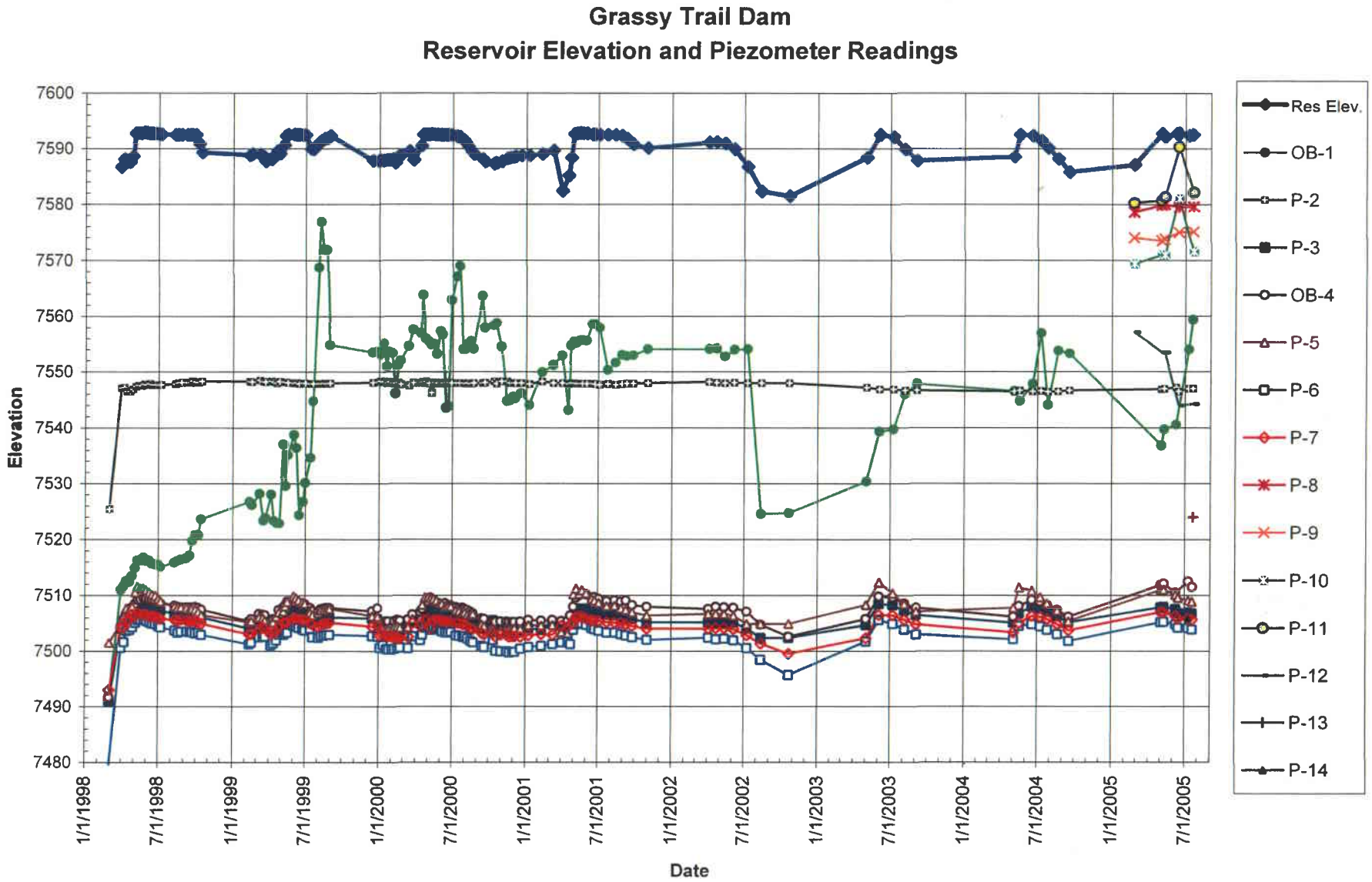
Date	Point	Northing	Easting	Elevation
2/4/1999	456	10,733.08	10,660.59	7,761.26
7/21/2004	1256	10,732.996	10,660.423	7,761.011
7/15/2005	rbg33	10,732.810	10,660.562	7,760.805
since 7/04:		*-0.186*	*0.139*	*-0.206*
lateral movement & direction:			*0.232 ft S 36.8° E*	
since 2/99:		*-0.27*	*-0.03*	*-0.45*
lateral movement & direction:			*0.27 ft S 5.9° W*	

Point: RBG31

Date	Point	Northing	Easting	Elevation
2/4/1999	454	10,310.63	10,756.70	7,716.67
7/21/2004	1254	10,310.659	10,756.622	7,716.380
7/15/2005	rbg31	10,310.438	10,756.881	7,715.878
since 7/04:		*-0.221*	*0.259*	*-0.502*
lateral movement & direction:			*0.340 ft S 49.5° E*	
since 2/99:		*-0.19*	*0.18*	*-0.79*
lateral movement & direction:			*0.26 ft S 43.3° E*	

Point: RBG34

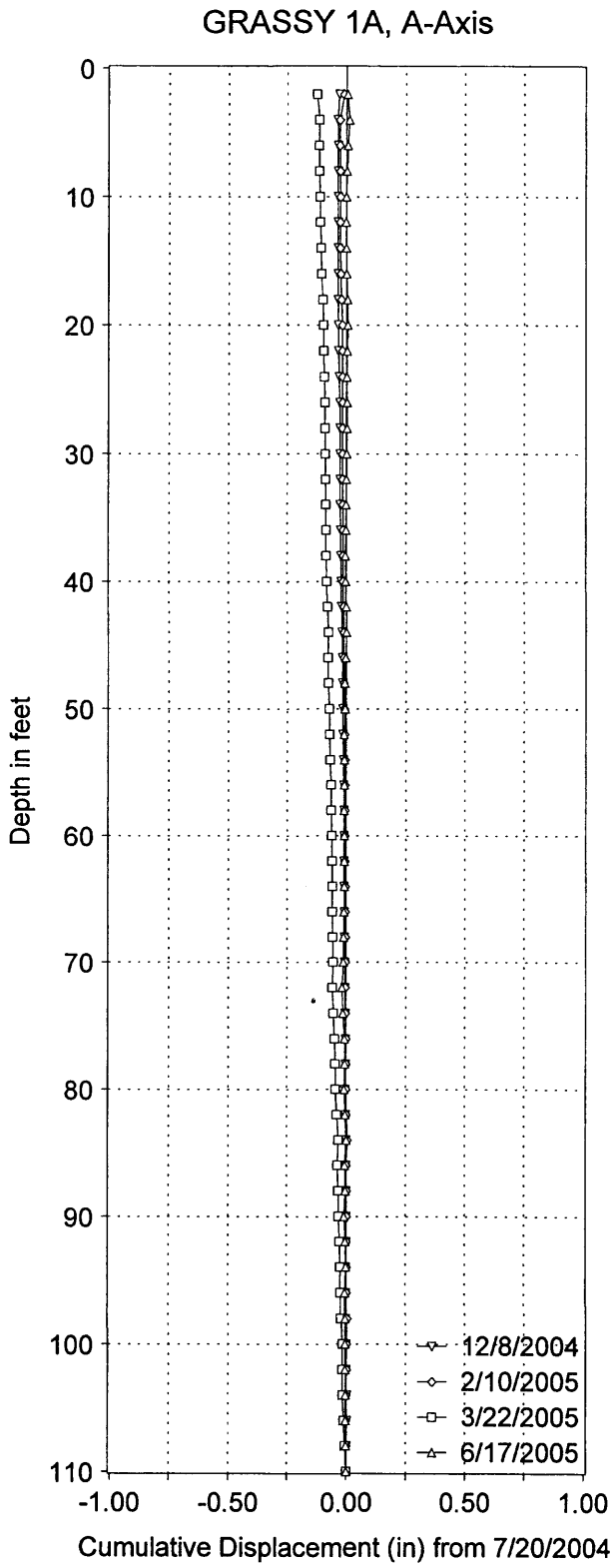
Date	Point	Northing	Easting	Elevation
2/4/1999	457	10,794.73	10,599.32	7,720.72
7/21/2004	1257	10,794.666	10,599.097	7,720.323
7/15/2005	rbg34	10,794.475	10,599.157	7,720.259
since 7/04:		*-0.191*	*0.060*	*-0.064*
lateral movement & direction:			*0.200 ft S 17.4° E*	
since 2/99:		*-0.25*	*-0.16*	*-0.46*
lateral movement & direction:			*0.30 ft S 43.3° W*	

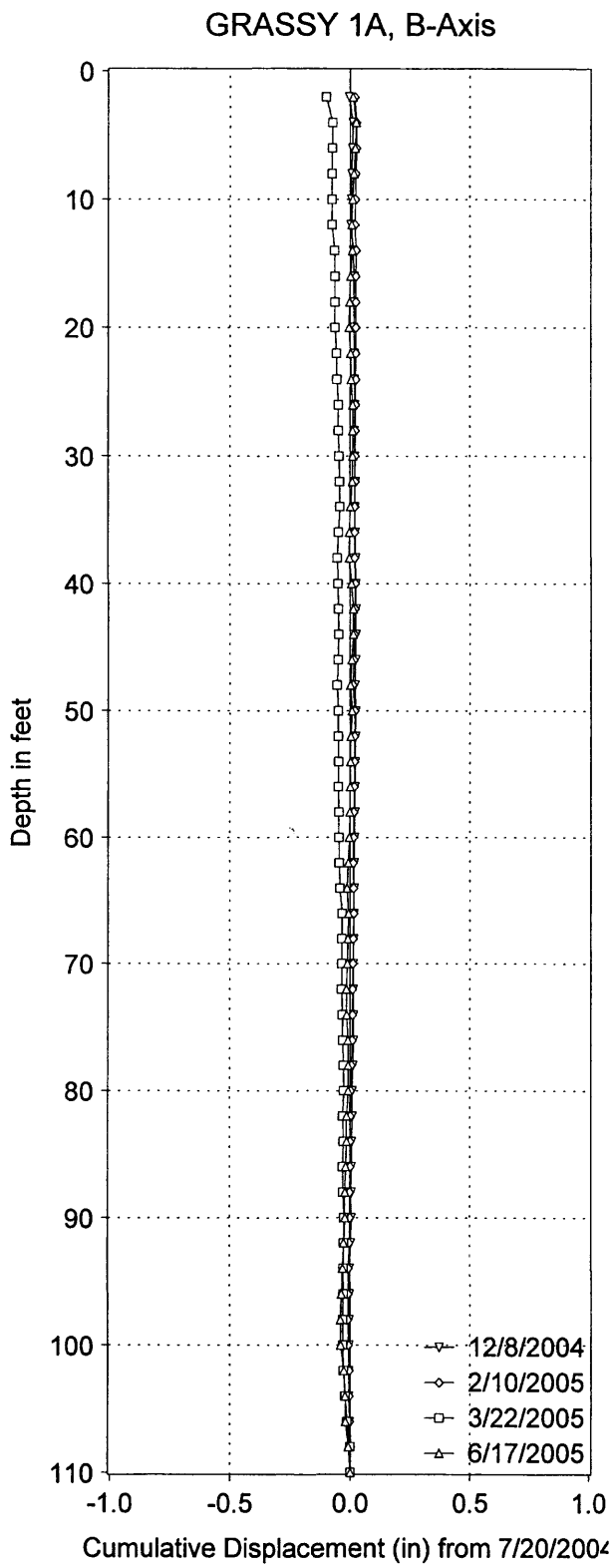


RB&G ENGINEERING INC.
Provo, Utah

Figure Reservoir Elevation and Piezometer Readings
March 1998 to July 2005

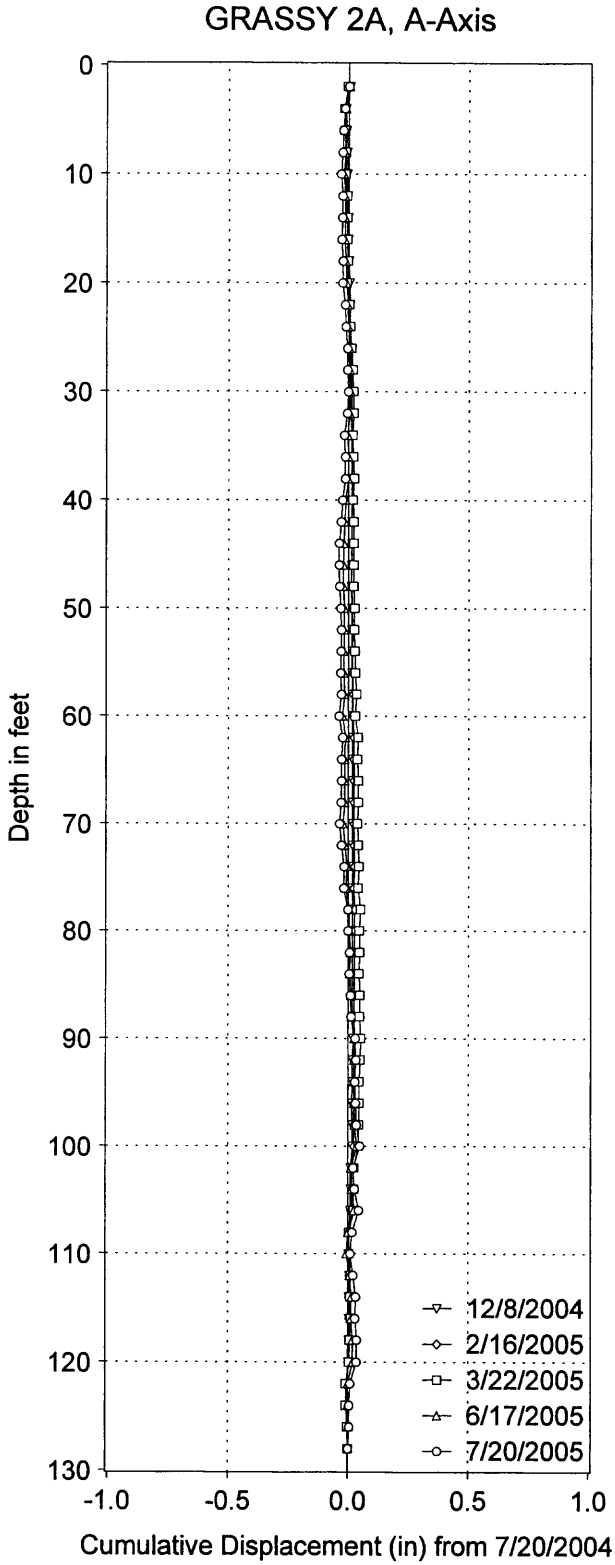
Grassy Trail Dam and Reservoir

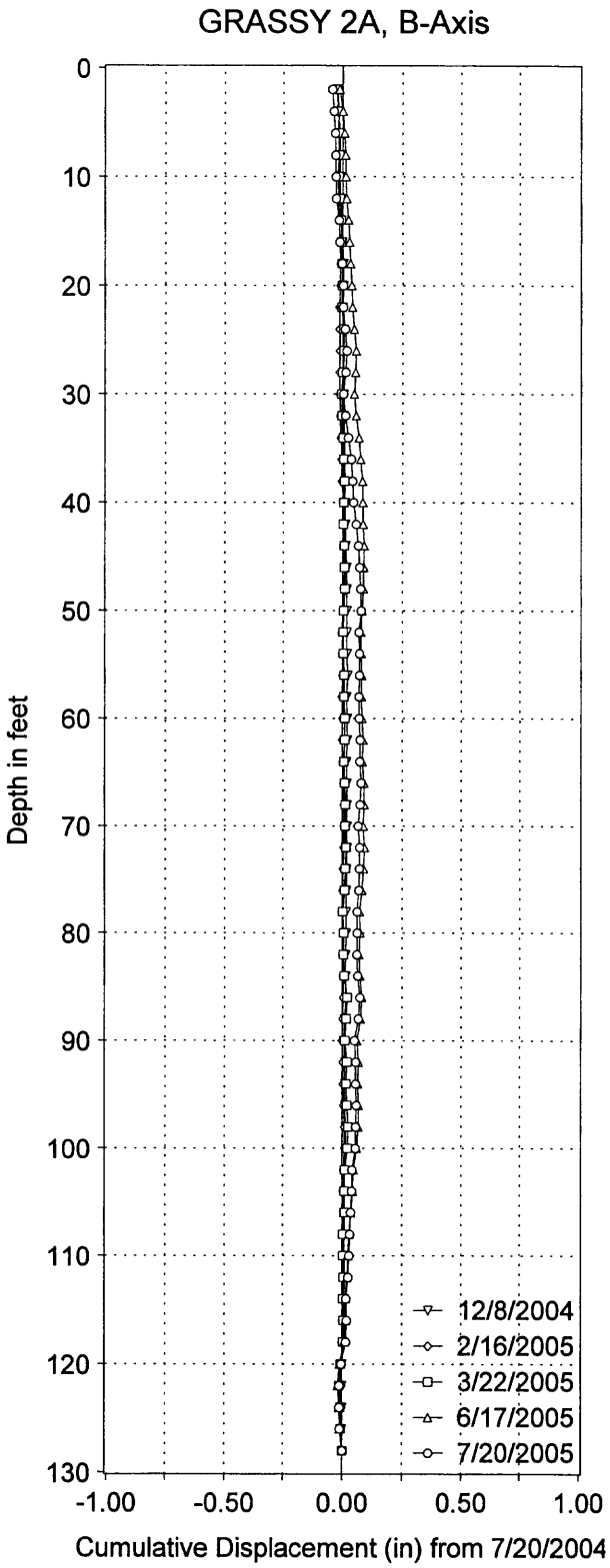




A - axis is to the Southeast

Corrected for rotation error
7/21/05 pem





Gassy Trail Dam Inclinometers

Corrected Cum. Displacements 2A

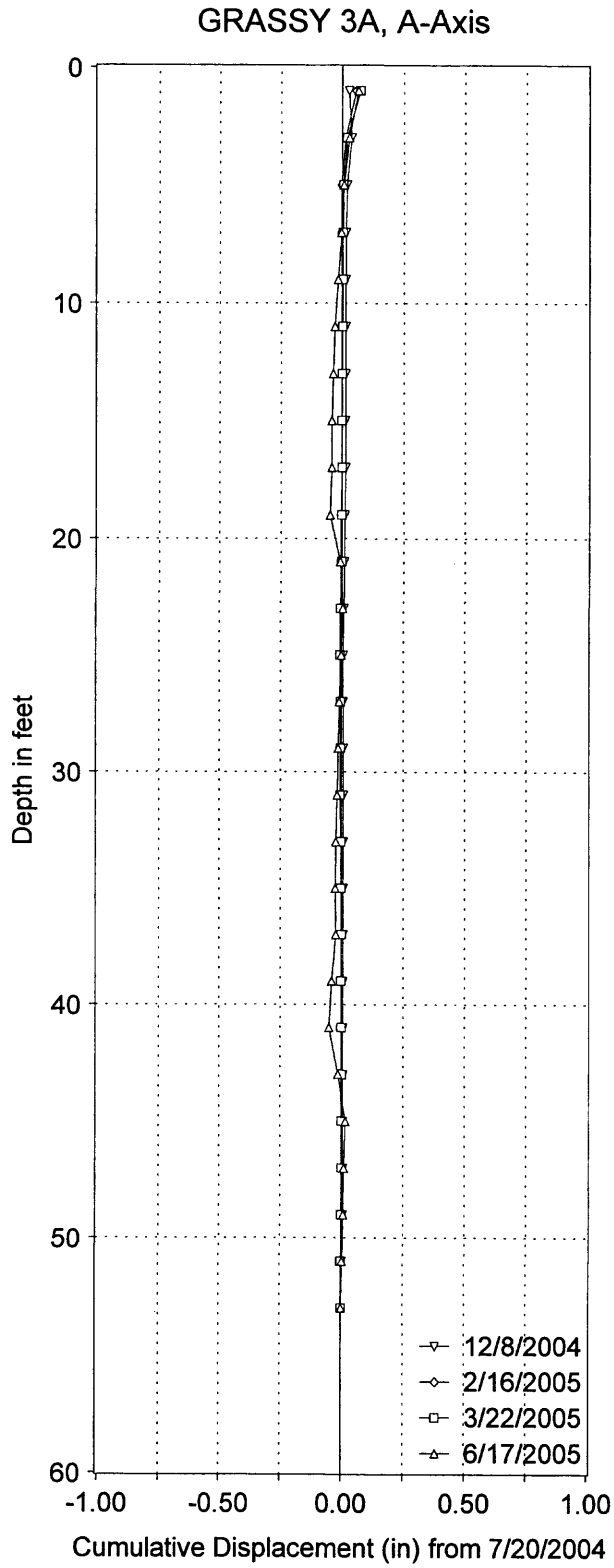
by pem 7/21/05

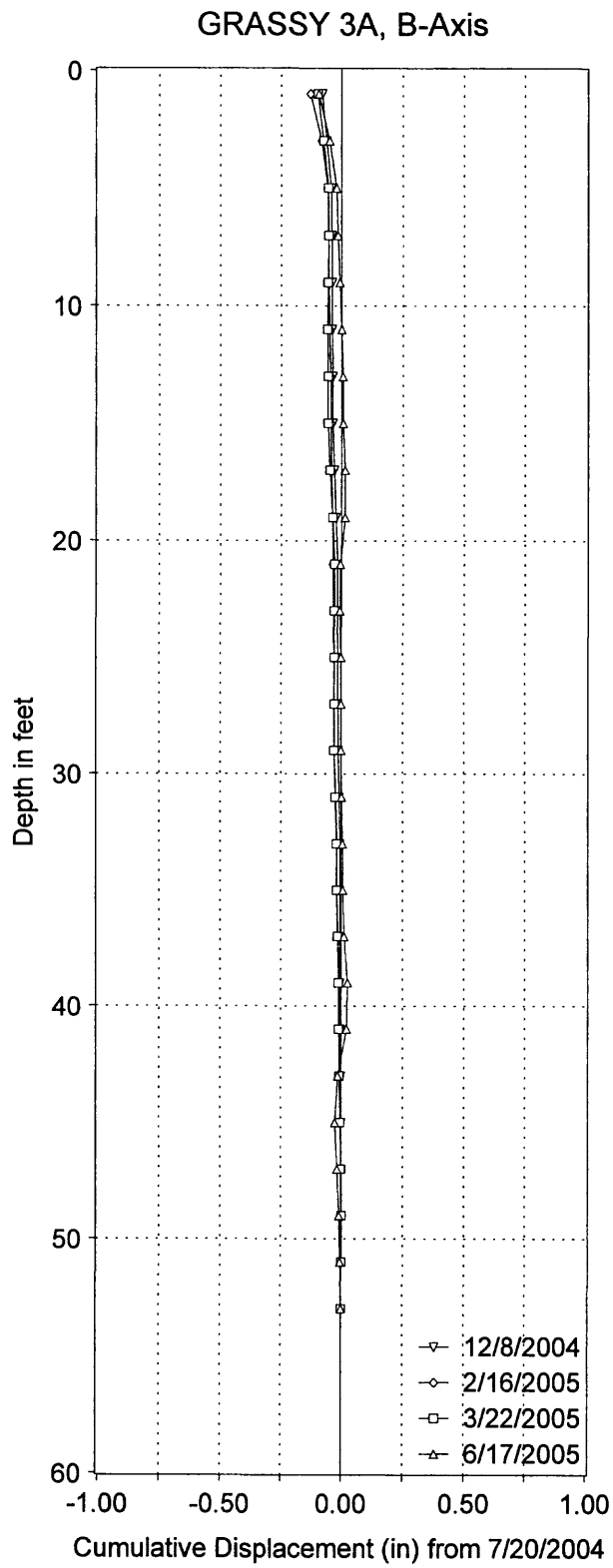
GeoMetron Inc PS

Data by RB&G Engineering Inc

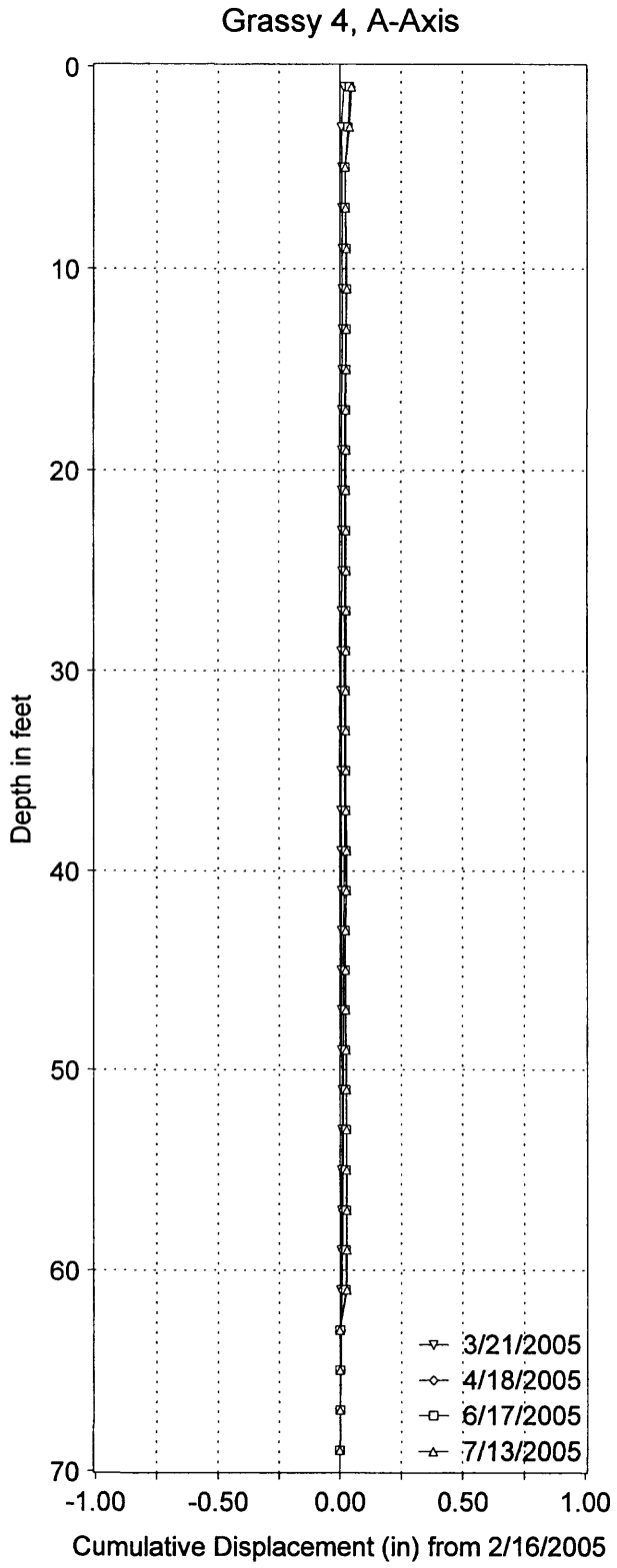
A - axis is to the west

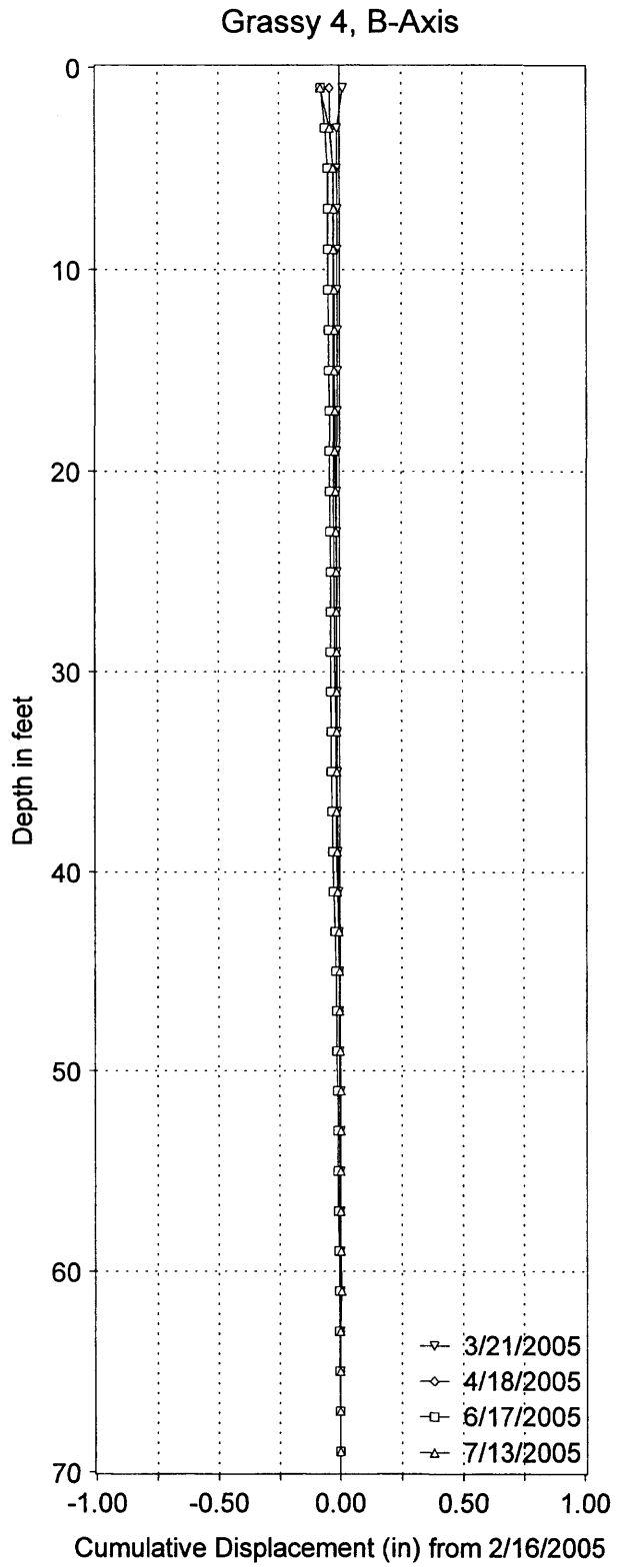
Data corrected for rotation errors



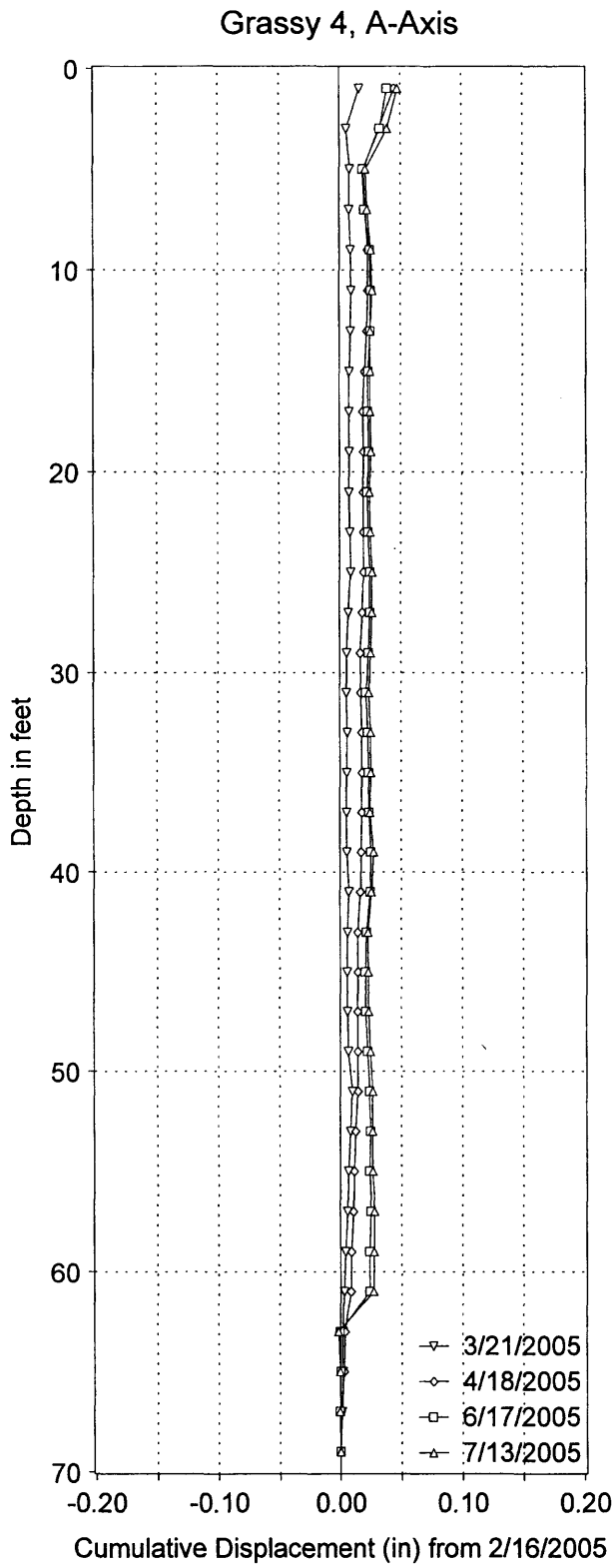


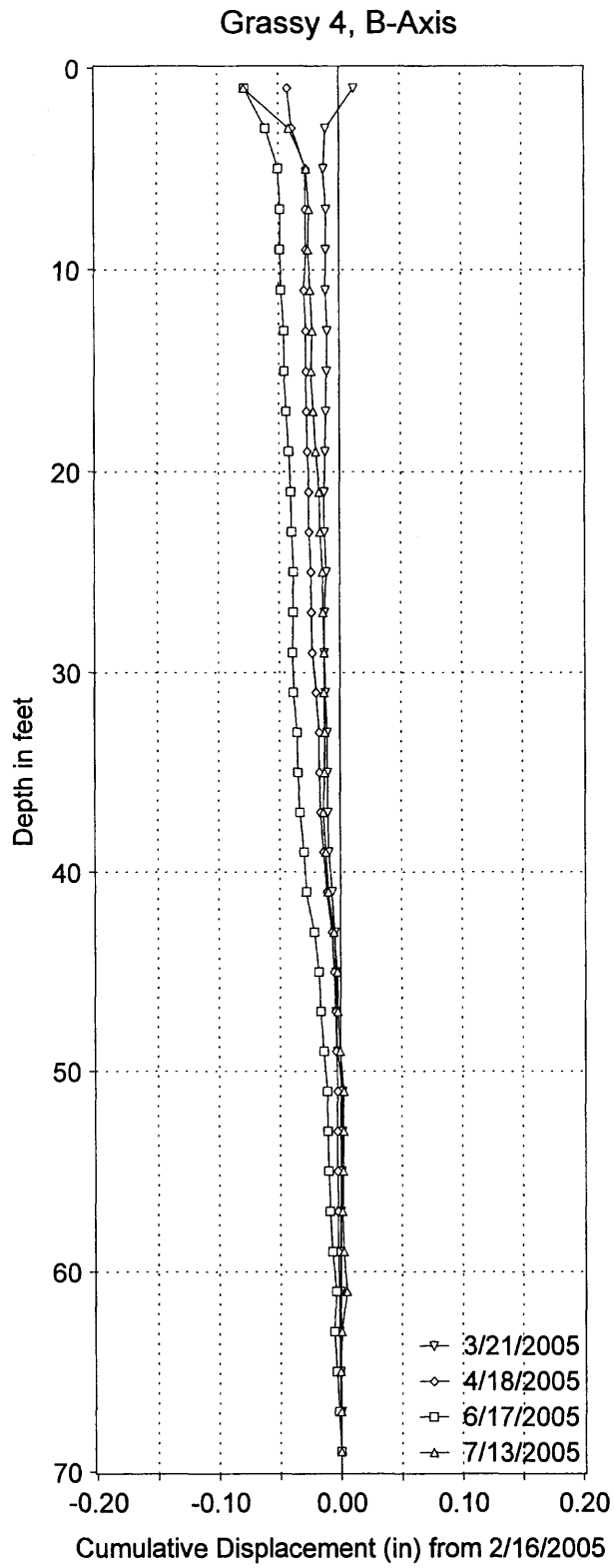
A-axis is to the West





A- axis face East in about the direction of the slide
shows slight movement to the east
B- axis is to the South





A- axis face East in about the direction of the slide
shows slight movement to the east
B- axis is to the South
edited by pem 7/21/05, but no corrections. Displ. indicated 61' to 63' interval

SEISMIC MONITORING

Seismic Monitoring

Seismic Monitoring

THE UNIVERSITY OF UTAH

Seismograph Stations – Department of Geology and Geophysics
135 S. 1460 E. Rm 705 Salt Lake City, Utah 84112-0111 (801) 581-6274

MEMORANDUM

TO: Michael Hanson, RBG Engineering

FROM: Walter J. Arabasz and Relu Burlacu

DATE: September 23, 2004

SUBJECT: Your Request for Additional Seismic Information

This memo is a response to your "request for additional seismic information" sent to us by e-mail on September 7, 2004, relating to mining-induced seismicity (MIS) in the eastern Book Cliffs area.

Your request involved three parts::

1. *A sorting and review of mining-induced seismic events from 1962 to present in a rectangular area surrounding the West Ridge Mine and bounded between latitude 39.6438º and 39.5709º N and longitude 110.4575º and 110.3655º W.*

We have sorted our earthquake catalog data for the requested time period and geographic area and found a total of 100 seismic events ranging in magnitude from 1.2 to 3.2. The data, together with an explanation of the format, are included in Attachment A.

Note: For the period July 1, 1962–December 31, 1980, the data are from our online catalog; for January 1, 1981–September 20, 2004, the data are from a recently completed refined catalog, which includes improved estimates of magnitude (whether Richter local magnitude, M_L, or coda magnitude, M_C (a calibrated estimator of M_L for smaller shocks less than about magnitude 3).

The largest shock in the sorted data sample is a shock of magnitude (M_C) 3.2 that occurred on September 22, 1981. We have no reliable basis for excluding any of the seismic events included in the data sample as not mining-induced. In other words, although we cannot establish this assertion with absolute certainty, our best judgment is that all the events indeed are caused by local mining.

2. *A detailed evaluation of events for which digital accelerographic data were recorded at our station BCE, located above the West Ridge Mine.*

The University of Utah Seismograph Stations began continuous, digital accelerographic recording at station BCE on August 26, 2003. Prior to this date, we have no ground-motion data close to the West Ridge Mine that provide measures of peak ground acceleration (PGA)

that you are seeking. Of the 100 events in the geographic sort area, digital accelerographic recordings were successfully made at station BCE for only three events. A detailed evaluation was made for each of these three events, and corresponding summaries are attached.

3. *"The 'probable maximum magnitude' which could be generated from long wall mining at the West Ridge Mine based on geologic conditions and various site parameters and mining practices.*

We regret to reply that we are not in a position to provide a full expert evaluation of the Probable Maximum Magnitude (PMM) for potential MIS at the West Ridge Mine, similar to what was done for the Trail Mountain Mine through the collaboration of seismologists and engineers from the University of Utah, the U.S. Geological Survey, and the U.S. Bureau of Reclamation (e.g., http://www.seis.utah.edu/Reports/sitla2002b/index.shtml). Such an undertaking inherently requires multiple expert opinion and careful consideration of many seismological and mining factors.

Nevertheless, if one examines the information that entered into the probability distribution constructed by Arabasz and others in the cited study for Trail Mountain, one likely would be led to virtually the same result for the West Ridge Mine. That is, the triangular distribution used to construct the consensus probability density function for maximum magnitude would likely incorporate the same lower and upper bounds and mode—chiefly constrained by historical observations of MIS in the Wasatch Plateau–Book Cliffs mining region. Because the PMM comes from a probability distribution, take care to understand that it is an estimate of the largest size event that is expected to occur within some specified probability—which is not necessarily the same as the largest event most likely to occur (the mode of the probability distribution function).

In order to complete this data request in a timely way, we are sending this memo and accompanying attachments to you by mail. We invite you to make an appointment to visit us for more complete explanation of the data, to ask any questions, and to get a copy of the catalog data in digital form.

In a spirit of cooperation with the operators of West Ridge Mine, there will be no charge for our response to this data request. For additional data requests, however, we may have to consider charging a fee, depending on the nature of your request(s).

Attachment A

The data catalog is in "hypo71" sumfile format:

Column	Format	Description
1-2	I2	Year
3-6	I4	Date (UTC)
8-11	I4	Origin time hour and minute (UTC)
13-17	F5.2	Origin time seconds
19-20	I2	Latitude, degrees
22-26	F5.2	Latitude, minutes
28-30	I3	Longitude, degrees
32-36	F5.2	Longitude, minutes
39-43	F5.2	Depth, km
44	A1	"*" for fixed or poor quality depth
45	A1	"W" for Wood-Anderson magnitude
46-50	F5.2	Magnitude
52-53	I2	NO (number of arrivals used)
55-57	I3	GAP (maximum station gap, degrees)
58-62	F5.1	DMN (minimum station distance, km)
63-67	F5.2	RMS, sec
68-72	F5.1	ERH (horizontal error estimate, km)
73-77	F5.1	ERZ (vertical error estimate, km)

Date	Time						Depth	Mag							
630902	1740	12.85	39	37.47	110	24.11	7.00*	2.90	9	157	34.7	0.70	1.6	1.3	
641213	1806	17.24	39	35.47	110	22.65	7.00*	2.10	5	160	36.8	0.62	1.9	1.8	
641226	2058	16.38	39	36.71	110	23.06	2.00*	2.70	7	158	36.1	0.70	1.1	1.6	
6[illegible]10	1157	17.15	39	37.57	110	24.75	7.00*	2.40	6	156	33.8	0.80	1.7	1.6	
6[illegible]06	1834	33.41	39	34.93	110	23.70	7.00*	2.00	6	159	35.3	0.82	1.8	1.8	
6[illegible]309	0530	14.54	39	37.20	110	23.84	7.00*	2.20	5	225	35.0	0.90	5.7	2.1	
680421	0204	49.06	39	35.44	110	23.69	7.00*	2.20	5	232	35.3	0.31	5.5	2.0	
700122	1249	23.53	39	34.81	110	24.46	7.00*	2.80	10	95	3.7	0.81	0.9	0.9	
710223	1844	03.57	39	37.44	110	25.81	7.00*	2.40	5	223	32.3	0.26	6.4	2.1	
761116	1612	32.32	39	37.25	110	27.13	7.00*	2.30	13	264	111.5	0.45	2.4	1.9	
781230	1052	26.29	39	35.98	110	27.02	7.00*	1.90	6	300	30.5	0.65	2.7	2.0	
790905	1107	09.97	39	34.89	110	22.15	7.00*	2.20	5	275	50.4	0.30	2.7	1.8	
791017	0646	06.22	39	34.81	110	26.39	7.00*	2.60	8	236	48.0	0.37	1.4	1.6	
791025	0307	42.14	39	34.38	110	26.49	7.00*	2.30	9	236	47.2	0.43	1.2	1.2	
791101	0119	57.70	39	34.77	110	22.61	7.00*	2.30	9	251	49.9	0.39	1.5	1.1	
800904	2343	13.52	39	34.69	110	23.17	7.00*	2.30	6	251	49.4	0.48	3.9	1.8	
810922	0503	59.17	39	35.45	110	22.07	6.11	3.19	11	236	51.4	1.53	12.8	8.4	*
850405	0101	21.19	39	36.08	110	25.15	0.82	2.76	25	221	51.9	0.60	3.0	4.6	
850421	1934	55.62	39	35.53	110	25.70	7.67	2.25	11	237	49.6	0.40	3.2	1.8	
850424	1924	58.29	39	37.14	110	24.79	10.76	1.87	12	239	52.9	0.44	6.4	4.6	
850426	2323	05.43	39	35.99	110	23.01	10.36	2.25	12	242	51.8	0.36	3.4	1.5	
850505	0530	57.10	39	36.08	110	22.31	6.37	2.43	15	243	52.4	0.45	2.9	1.7	
850507	2158	48.92	39	34.43	110	27.21	8.61	2.41	13	235	47.0	0.36	2.8	1.4	
850508	0324	46.94	39	35.63	110	24.30	6.93	2.43	16	239	50.5	0.42	2.6	1.5	
850514	2244	21.05	39	35.94	110	24.27	5.80	2.32	14	240	51.0	0.40	2.7	1.7	
850521	0657	51.02	39	35.87	110	22.15	6.76	2.53	14	243	52.0	0.46	3.2	1.8	
850531	0052	01.63	39	35.91	110	24.85	0.40	2.69	17	238	50.7	0.45	2.0	2.0	
850615	0534	04.88	39	36.97	110	25.64	0.22	2.05	13	236	50.7	0.44	2.6	3.4	
8[illegible]627	1850	22.70	39	36.21	110	25.04	0.30	2.87	18	230	51.1	0.36	1.3	1.7	
8[illegible]629	1758	46.25	39	35.50	110	24.34	6.83	2.58	17	231	50.2	0.47	2.6	1.8	
8[illegible]717	1848	50.69	39	37.01	110	25.14	0.03	2.83	26	179	51.3	0.55	2.6	4.8	
850721	0139	00.64	39	35.59	110	23.82	6.15	2.64	18	232	50.7	0.46	2.6	1.8	
850806	1010	24.96	39	35.39	110	24.42	6.70	2.61	17	231	50.0	0.40	2.1	1.4	
850831	1424	25.05	39	35.58	110	22.10	6.42	2.42	17	244	51.6	0.48	3.2	1.8	
850905	2217	31.80	39	35.73	110	24.21	7.43	2.67	17	239	50.7	0.44	2.5	1.5	
850906	0143	40.18	39	35.79	110	25.10	0.50	2.88	18	238	50.3	0.39	1.7	1.7	
850912	2208	14.51	39	35.15	110	24.99	8.40	2.65	13	239	49.2	0.47	3.3	1.9	
850924	1811	02.36	39	35.47	110	25.34	0.97	2.62	14	164	114.5	0.44	1.8	11.9	
850929	0510	36.79	39	36.71	110	25.28	0.01	2.76	13	237	51.9	0.42	3.4	4.6	
851011	0518	56.65	39	37.01	110	26.12	0.06	2.52	16	203	50.0	0.53	3.0	5.5	
851026	1137	17.25	39	35.41	110	23.94	5.98	2.51	15	240	50.2	0.50	3.7	2.1	
860727	0611	25.22	39	35.10	110	27.24	1.42	2.40	15	238	49.7	0.42	2.6	1.2	
871031	0611	01.55	39	34.48	110	22.31	10.15	1.52	8	244	46.4	0.31	3.8	1.7	
900818	1607	24.09	39	34.51	110	22.38	8.96	2.43	9	180	46.2	0.25	2.5	1.4	
900823	2159	33.31	39	34.34	110	23.93	0.59	1.95	8	191	44.7	0.23	1.8	1.3	
900902	1718	32.74	39	34.40	110	23.87	1.15	1.47	5	247	102.0	0.42	7.1	25.9	
900908	1653	09.75	39	35.07	110	23.11	10.65	1.72	8	193	44.8	0.14	1.7	0.8	
901004	0114	17.05	39	35.15	110	23.41	5.53	2.69	9	193	44.4	0.37	2.7	3.2	
901023	0418	58.49	39	34.91	110	22.68	11.22	2.42	9	193	45.5	0.16	1.3	0.7	
910704	1622	02.86	39	35.17	110	25.32	0.12	2.05	11	175	42.1	0.30	1.8	2.5	
910905	2347	30.03	39	35.18	110	23.06	7.28	2.03	6	194	44.7	0.12	1.4	12.1	
910910	1219	55.93	39	35.27	110	22.14	5.25	2.00	6	196	45.8	0.18	1.7	15.3	
920407	1956	10.81	39	34.30	110	26.35	6.87	1.60	6	187	42.0	0.18	1.6	13.6	
[illegible]0501	2336	28.21	39	35.05	110	23.25	6.02	2.06	6	232	44.7	0.20	2.5	1.8	
[illegible]501	2342	51.51	39	34.94	110	23.39	7.39	2.79	9	231	44.6	0.19	1.5	1.1	
[illegible]610	0638	24.69	39	34.44	110	24.08	7.87	1.52	7	230	44.4	0.17	0.8	1.3	
920610	2056	52.77	39	34.55	110	22.32	11.96	2.37	12	177	46.2	0.32	2.2	1.0	
920618	1458	48.55	39	35.51	110	23.09	5.52	2.01	7	194	44.4	0.33	3.7	2.7	
920625	0602	05.33	39	34.58	110	23.84	3.34	1.22	7	195	44.5	0.25	1.9	2.9	
920805	1919	40.97	39	35.54	110	22.02	9.33	2.73	11	234	45.6	0.39	4.0	1.6	

Date	Time						Depth		Mag							
920811	1941	21.24	39	34.48	110	24.11	8.33		2.74	11	230	44.2	0.22	2.2	1.0	
920814	1540	00.77	39	34.41	110	23.68	9.78		1.47	8	194	44.9	0.18	2.2	1.0	
920815	1654	19.16	39	34.65	110	22.53	11.69		1.68	11	177	53.5	0.27	1.1	1.6	
9[illegible]15	2247	06.40	39	34.42	110	24.21	7.07		1.90	9	190	44.2	0.19	2.3	1.2	
9[illegible]819	0157	59.86	39	35.64	110	24.12	5.10		1.34	9	236	54.8	0.36	2.6	3.6	
920827	0227	12.18	39	34.69	110	22.33	12.67		1.80	7	249	46.1	0.21	5.0	1.3	
920829	0030	24.72	39	34.46	110	24.23	8.22		1.54	10	244	44.2	0.33	2.5	1.3	
920928	1857	04.63	39	34.84	110	23.95	5.55		2.42	11	195	44.0	0.38	2.5	2.0	
920929	0241	32.63	39	34.72	110	22.43	10.05		1.40	11	196	46.0	0.24	1.9	1.1	
921001	0248	08.12	39	34.51	110	24.79	7.34		1.27	7	242	43.5	0.12	1.4	1.1	
921006	1347	18.62	39	34.70	110	22.88	10.12		1.91	11	193	45.5	0.18	1.0	0.8	
921009	1757	33.15	39	34.56	110	25.26	6.65		2.00	11	189	42.9	0.33	2.0	1.3	
921010	1430	07.28	39	35.59	110	24.27	7.22		1.86	6	245	54.6	0.25	2.1	20.2	
921014	0112	47.62	39	34.47	110	22.12	8.14		1.85	11	193	46.6	0.19	0.9	1.0	
921109	1042	10.15	39	34.41	110	24.33	0.00		1.76	7	226	44.1	0.13	1.2	1.6	
921116	2114	17.75	39	34.72	110	24.34	11.53		1.89	10	191	43.8	0.37	1.5	2.0	
930502	0730	56.90	39	34.51	110	24.97	3.24		2.05	9	171	43.2	0.09	0.8	1.1	
930515	0227	37.48	39	34.48	110	26.86	4.06		1.42	9	170	41.2	0.13	0.9	1.3	
930527	1800	21.06	39	36.23	110	23.89	6.35		1.36	5	248	42.7	0.15	2.6	17.6	
930622	0133	22.17	39	34.54	110	27.45	4.85		2.09	9	169	40.5	0.18	1.5	1.1	
930623	1913	14.39	39	35.72	110	22.48	7.60		2.43	9	196	44.9	0.24	2.0	1.1	
930626	0458	45.53	39	34.62	110	24.44	7.98		1.57	10	172	43.8	0.33	2.4	1.7	
930627	0219	40.63	39	36.33	110	22.28	1.25		1.98	7	175	44.5	0.34	1.9	4.7	
930716	1901	59.23	39	34.83	110	23.53	1.71		1.80	13	173	44.5	0.24	1.3	1.7	
930810	1639	57.54	39	34.68	110	25.13	7.45		1.35	7	189	42.9	0.15	1.2	1.8	
931216	1930	06.42	39	34.28	110	25.40	5.15		1.35	8	172	43.0	0.17	1.2	1.6	
940131	1337	12.74	39	34.50	110	25.58	8.38		1.32	8	188	42.6	0.13	1.0	0.8	
950226	1713	03.61	39	35.83	110	27.15	1.25		1.24	8	172	54.4	0.46	3.1	39.5	
[illegible]625	0521	23.75	39	35.38	110	23.44	1.11		1.55	10	173	54.5	0.80	3.4	33.1	
[illegible]906	1737	08.85	39	35.81	110	24.16	1.28		2.04	10	194	42.8	0.35	2.3	40.9	
[illegible]929	1644	28.78	39	35.31	110	25.82	8.47		1.85	11	190	41.4	0.22	2.0	0.9	
010927	1217	07.80	39	34.65	110	24.02	8.33		1.76	11	227	44.2	0.32	2.2	1.5	
031017	0536	43.00	39	34.64	110	26.24	8.81	W	1.90	10	217	41.7	0.26	1.9	1.3	
031022	1346	50.02	39	35.20	110	25.11	11.63		1.81	6	243	42.4	0.09	1.7	1.0	
031028	0311	26.23	39	36.51	110	23.71	0.46		1.71	7	250	1.2	0.38	3.2	1.3	
031107	0159	38.56	39	36.28	110	24.38	0.08		1.55	9	200	0.9	0.22	1.9	1.5	
031229	1600	03.93	39	36.85	110	24.56	0.11		1.67	5	199	0.1	0.11	2.6	0.9	
040206	0457	55.63	39	36.83	110	24.33	0.02	W	1.50	9	248	0.2	0.12	1.2	0.8	*
040206	1848	32.49	39	36.46	110	25.13	0.21	W	1.88	11	134	1.1	0.26	1.6	2.1	*
040211	0139	31.96	39	36.83	110	25.05	0.09	W	1.78	11	150	0.8	0.20	1.4	1.7	*

M_L 1.5 Earthquake on February 5, 2004 at 09:57 PM MST

This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements.
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.
3. Figure of the Webicorder recording from the day of the earthquake.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.76 km, which implies that the focal depth of 0.19 km is subject to an uncertainty at least as large as ±0.76 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_L) of 1.5 is based on amplitude measurements from 2 stations.
7. The clear S-P observation at BCE of 0.31 seconds implies a source-to-station distance of ~1.3 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

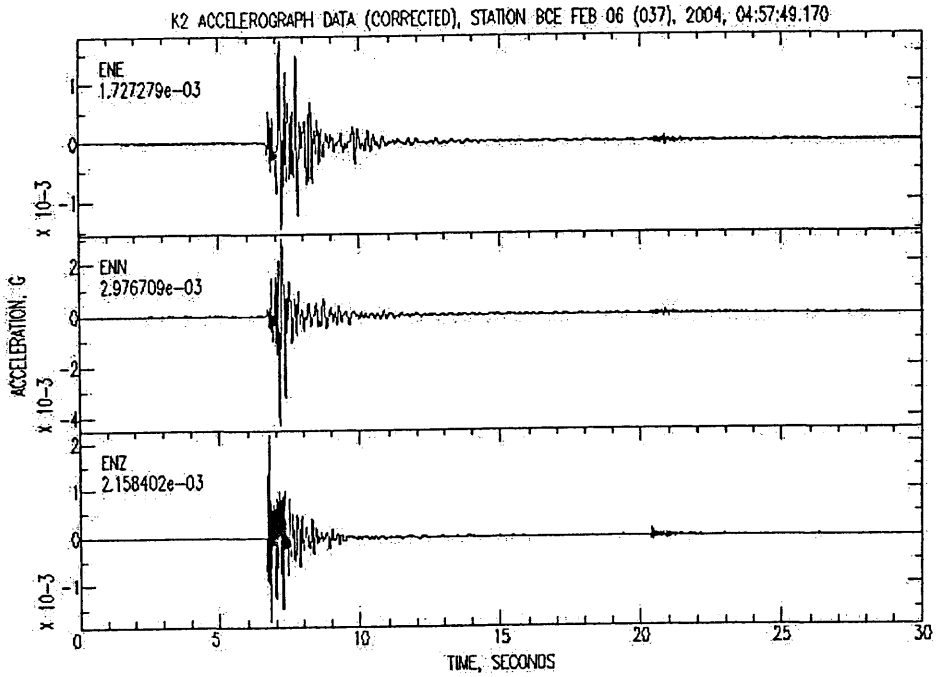
Prepared by: Paul Roberson — Date: 9-22-04

Michelle Howell — Date: 9-22-04

Reviewed by: Relu Burlacu — Date: 09/22/04

M_L 1.5 Earthquake on February 6, 2004 at 04:57 UTC

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
February 6, 2004 04:57	04020604575	M_C 2.0 M_L 1.5	39° 36.95′ 110° 22.45′ 0.19	3.0



Instrument Corrected Peak Accelerations from station BCE

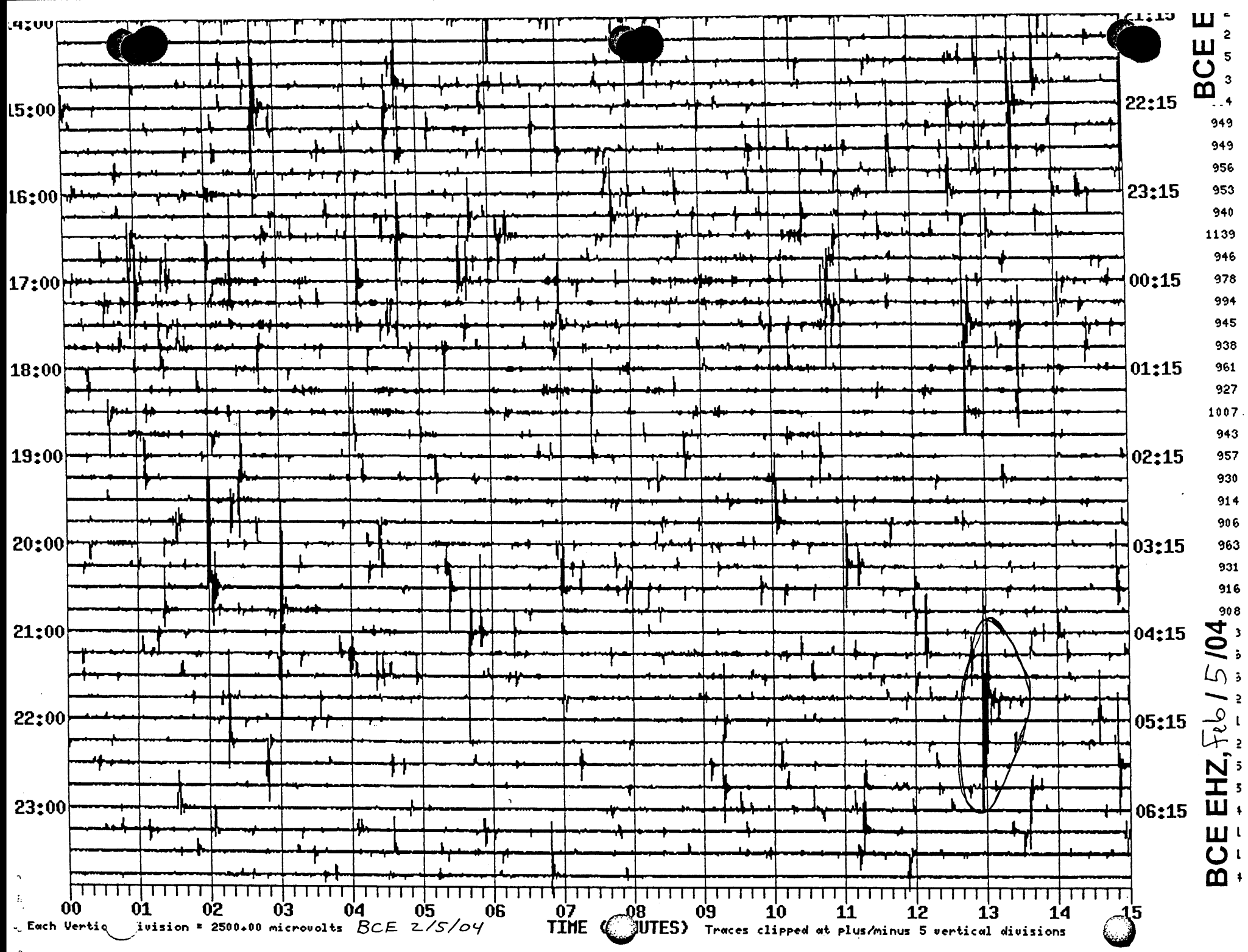
	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	0.77	0.01
East/West:	1.70	0.07
North/South:	4.20	0.10

PRT File

yr mo da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
4- 2- 6	457 54.98	39 36.95	110 22.45	0.19	0.25	0.97	0.76	253		2.0

rmswt	dmin	itr	nfm	nwr	nws	remk	cond	no
0.25	3.0	9	2	10	3		14.8	

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	3.0	265	91	Pd		457	55.82	0.00	0.85	0.75	0.00	0.00	0.10	1.43		1.87	0.634
				S	2	457	56.13	0.00	1.16	1.47	0.00	0.00	-0.32	0.71			0.586
dcmz	20.0	296	40	P	1	457	59.20	0.00	4.23	4.52	0.00	0.03	-0.32	1.07		2.71	0.360
bcwz	34.0	292	40	P	2	458	1.67	0.00	6.69	6.77	0.00	0.04	-0.12	0.71		1.29	0.142
EMUZ	43.7	300	40	P	1	458	3.45	0.00	8.47	8.34	0.00	-0.03	0.15	1.07		1.71	0.404
sruz	57.6	193	34	Pd		458	5.57	0.00	10.59	10.58	0.00	-0.11	0.12	1.43			0.675
				S	2	458	12.86	0.00	17.88	18.76	0.00	-0.24	-0.64	0.71			0.400
DBD	70.2	241	40	P	1	458	7.56	0.00	12.58	12.61	0.00	-0.03	-0.01	1.07		2.15	0.117
tm2z	80.0	244	34	P	1	458	9.21	0.00	14.23	14.19	0.00	0.06	-0.03	1.07		2.55	0.114
				S	2	458	20.82	0.00	25.84	25.04	0.00	0.13	0.66	0.71			0.561


BCE EHZ, Feb 15/04
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
21:15
22:15
23:15
00:15
01:15
02:15
03:15
04:15
05:15
06:15
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
TIME (MINUTES)
Each Vertical Division = 2500.00 microvolts
BCE 2/5/04
Traces clipped at plus/minus 5 vertical divisions

M_L 1.9 Earthquake on February 6, 2004 at 11:48 AM MST

This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements.
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.
3. Figure of the Webicorder recording from the day of the earthquake.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.34 km, which implies that the focal depth of 1.32 km is subject to an uncertainty at least as large as ±0.34 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_L) of 1.9 is based on amplitude measurements from 2 stations.
7. Observed first motions include both dilatational (down) and compressional (up) pulses. This implies a shear-slip source.
8. The clear S-P observation at BCE of 0.46 seconds implies a source-to-station distance of ~2.0 km.
9. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

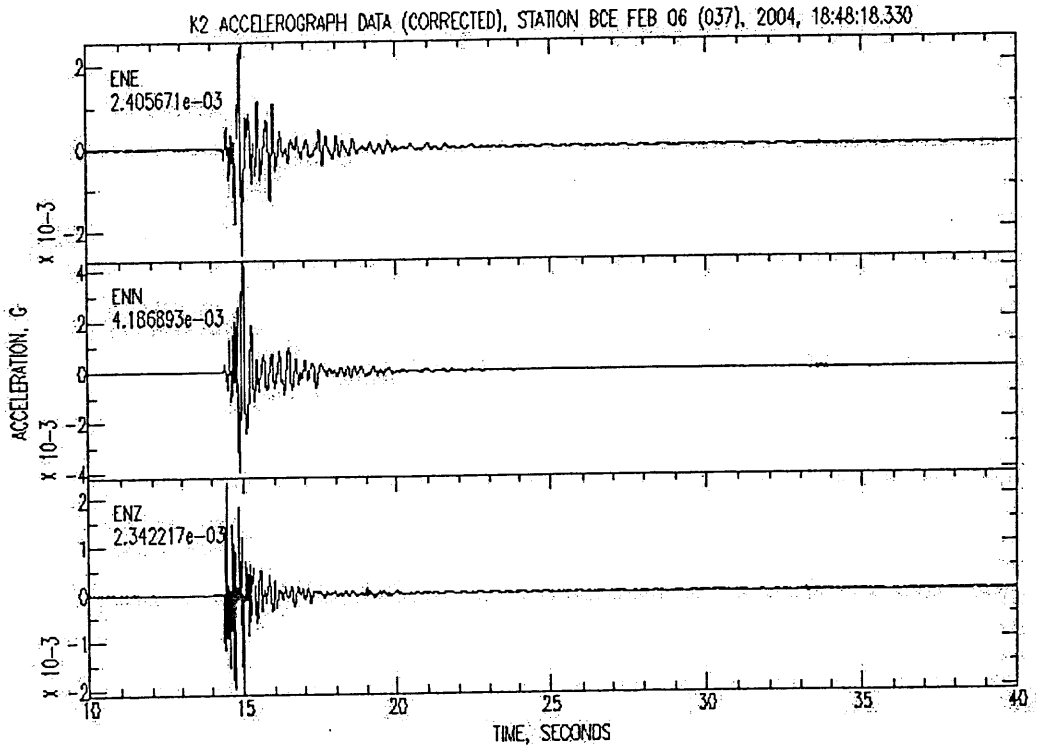
Prepared by: Paul Roberson — 9-22-04 Date

Michelle Howell — 9-22-04 Date

Reviewed by: Relu Burlacu — 09/22/04 Date

M_L 1.9 Earthquake on February 6, 2004 at 18:48 UTC

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
February 6, 2004 18:48	04020618482	M_C 2.0 M_L 1.9	39° 37.04′ 110° 23.88′ 1.32	1.0



Instrument Corrected Peak Accelerations from station BCE

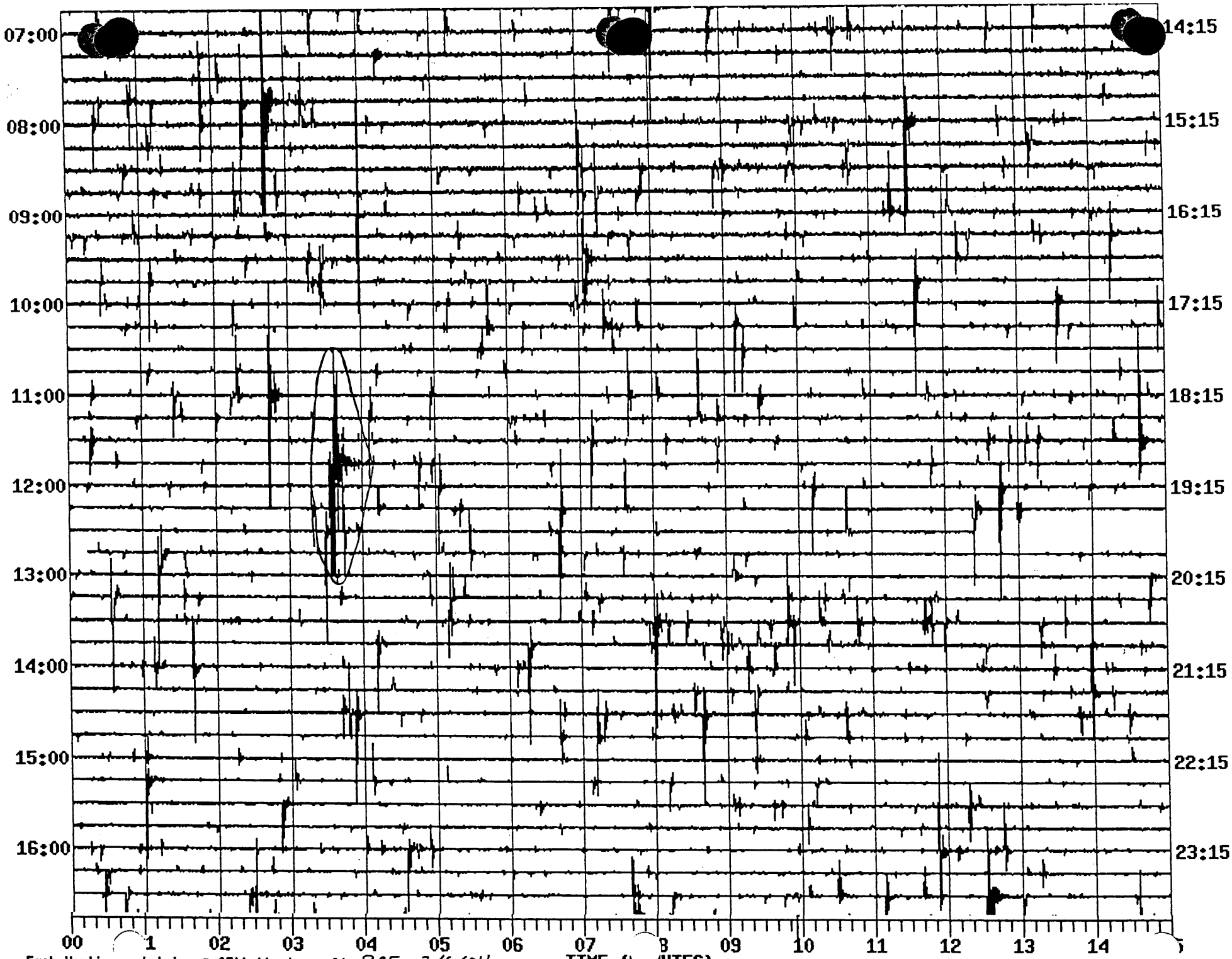
	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	2.30	0.04
East/West:	2.48	0.11
North/South:	4.11	0.16

PRT File

yr	mo	da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
4-	2-	6	1848 32.23	39 37.04	110 23.88	1.32	0.17	1.52	0.34	249		2.0

rmswt	dmin	itr	nfm	nwr	nws	remk	cond no
0.17	1.0	7	3	12	3		28.0

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.0	244	141	Pd		1848	32.68	0.00	0.45	0.40	0.00	0.05	0.00	1.33			0.657
				S	2	1848	33.14	0.00	0.91	0.79	0.00	0.11	0.02	0.67			0.575
dcmz	18.1	299	43	P		1848	36.03	0.00	3.80	4.01	0.00	0.03	-0.23	1.33		1.77	0.365
bcwz	32.0	293	43	P	1	1848	38.48	0.00	6.25	6.26	0.00	0.04	-0.05	1.00		1.64	0.160
EMUZ	41.9	302	37	Pc	1	1848	40.36	0.00	8.13	7.84	0.00	-0.03	0.32	1.00		2.07	0.236
				S	2	1848	46.15	0.00	13.92	13.91	0.00	-0.05	0.07	0.67			0.328
sruz	57.4	191	37	Pd		1848	42.46	0.00	10.23	10.34	0.00	-0.11	0.01	1.33			0.664
				S	2	1848	50.28	0.00	18.05	18.26	0.00	-0.24	0.03	0.67			0.404
DBD	68.5	241	43	P	1	1848	44.37	0.00	12.14	12.14	0.00	-0.03	0.03	1.00		2.31	0.156
ELU	69.1	272	43	P	1	1848	44.83	0.00	12.60	12.23	0.00	0.11	0.26	1.00		2.15	0.122
tm2z	78.2	243	43	P	1	1848	46.04	0.00	13.81	13.70	0.00	0.06	0.05	1.00		2.25	0.155
SNO	103.3	251	46	P	1	1848	50.45	0.00	18.22	18.52	0.00	0.02	-0.32	1.00			0.175


07:00
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23:15
00 1 02 03 04 05 06 07 8 09 10 11 12 13 14
TIME (MINUTES)
Each Vertical division = 2500.00 microvolts BCE 2/6/04
Traces clipped at plus/minus 5 vertical divisions
BCE EHZ, Feb 16 /04

M_L 1.8 Earthquake on February 10, 2004 at 6:39 PM MST

This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements.
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.
3. Figure of the Webicorder recording from the day of the earthquake.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.35 km, which implies that the focal depth of 1.53 km is subject to an uncertainty at least as large as ±0.35 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_L) of 1.8 is based on amplitude measurements from 2 stations.
7. The clear S-P observation at BCE of 0.47 seconds implies a source-to-station distance of ~2.0 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

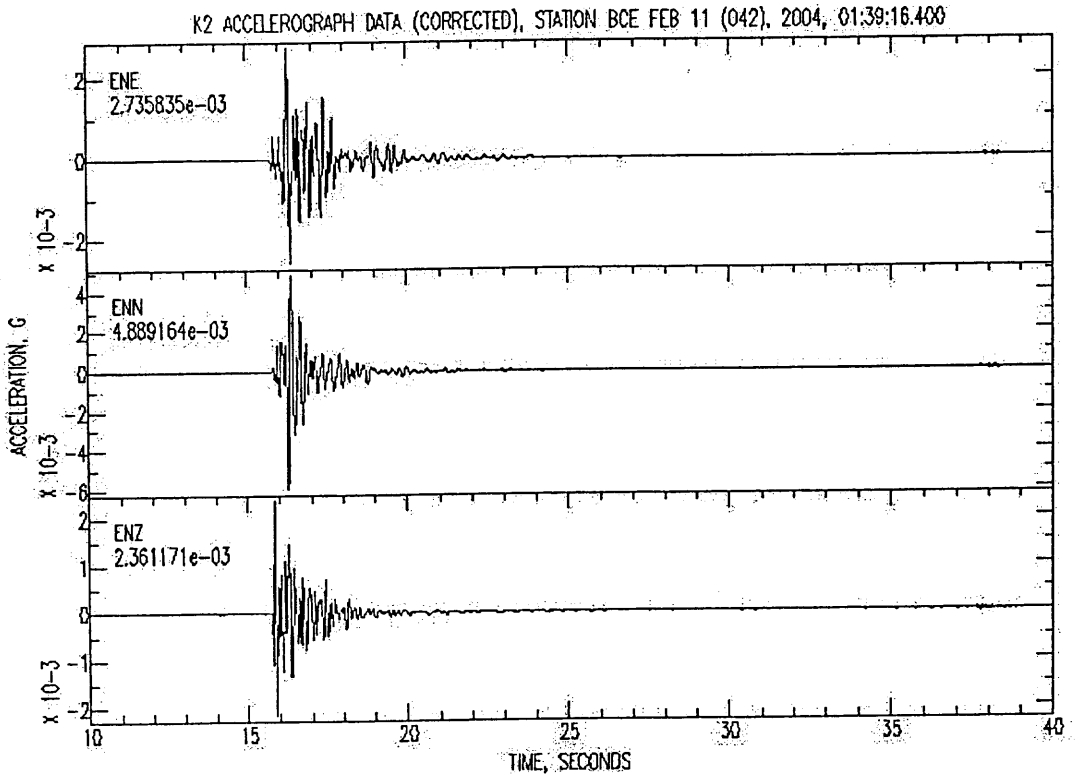
Prepared by: Paul Roberson — 9-22-04 Date

Michelle Howell — 9-22-04 Date

Reviewed by: Relu Burlacu — 09/22/04 Date

M_L 1.8 Earthquake on February 11, 2004 at 01:39 UTC

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
February 11, 2004 01:39	04021101392	M_C 2.0 M_L 1.8	39° 36.96′ 110° 23.84′ 1.53	1.0



Instrument Corrected Peak Accelerations from station BCE

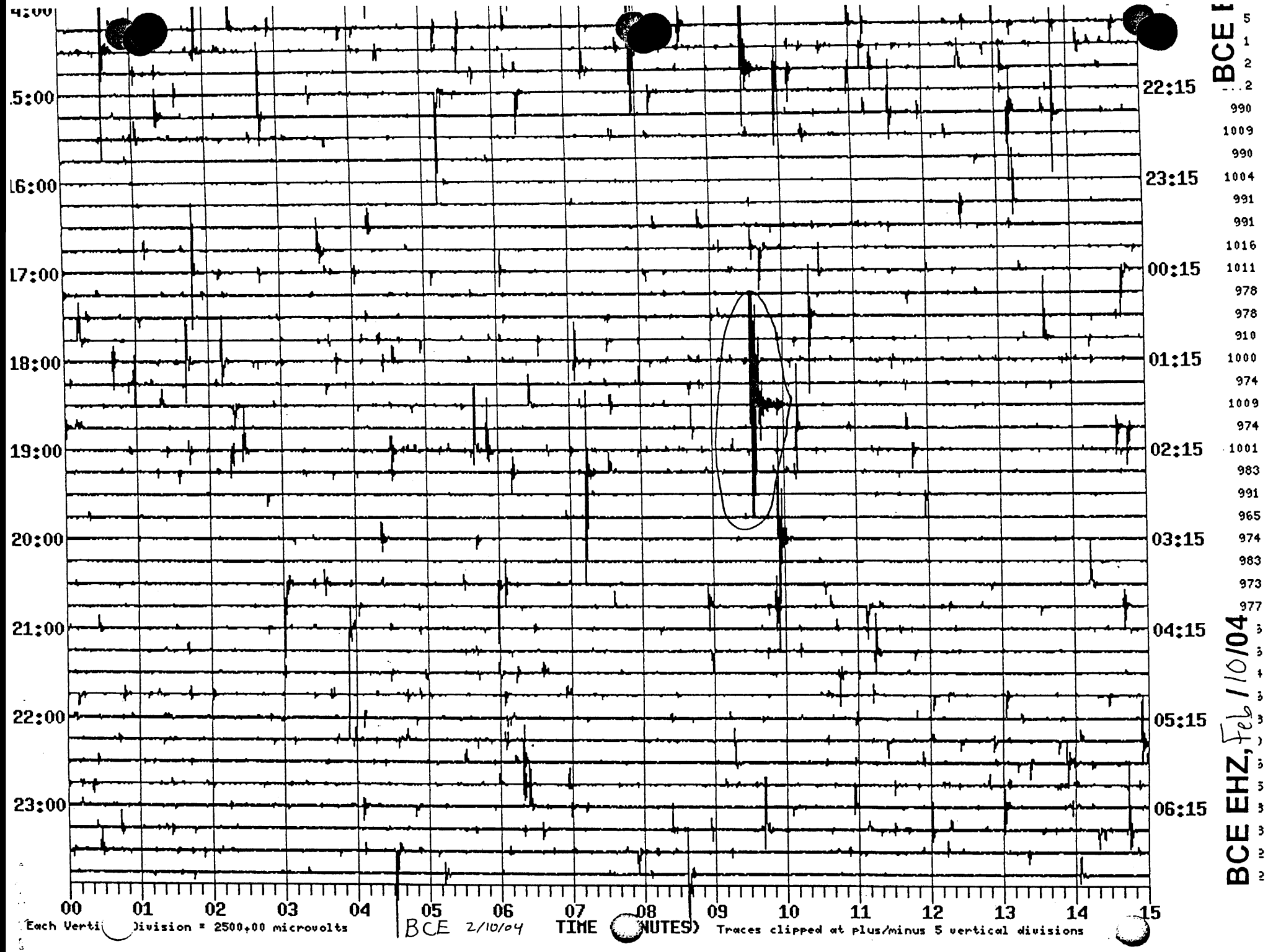
	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	2.32	0.05
East/West:	2.68	0.10
North/South:	5.79	0.20

PRT File

yr	mo	da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
4-	2-	11	139 31.66	39 36.96	110 23.84	1.53	0.21	1.35	0.35	249		2.0

rmswt	dmin	itr	nfm	nwr	nws	remk	cond no
0.21	1.0	7	3	13	3		22.4

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.0	253	145	Pd		139	32.15	0.00	0.49	0.44	0.00	0.06	0.00	1.45		2.10	0.631
				S	2	139	32.62	0.00	0.96	0.86	0.00	0.11	-0.01	0.73			0.527
dcmz	18.2	299	43	Pd	1	139	35.49	0.00	3.83	3.99	0.00	0.03	-0.18	1.09		1.73	0.349
bcwz	32.2	293	43	P	1	139	37.98	0.00	6.32	6.24	0.00	0.04	0.04	1.09		1.90	0.286
EMUZ	42.0	302	43	P	2	139	39.62	0.00	7.96	7.83	0.00	-0.03	0.16	0.73		1.83	0.171
sruz	57.2	191	37	Pd		139	41.93	0.00	10.27	10.28	0.00	-0.11	0.11	1.45			0.680
				S	2	139	49.26	0.00	17.60	18.15	0.00	-0.24	-0.31	0.73			0.322
DBD	68.5	241	43	P	1	139	43.85	0.00	12.19	12.10	0.00	-0.03	0.12	1.09		2.20	0.110
ELU	69.2	272	43	P	2	139	44.35	0.00	12.69	12.21	0.00	0.11	0.37	0.73		2.15	0.070
tm2z	78.2	243	37	P		139	45.48	0.00	13.82	13.66	0.00	0.06	0.10	1.45		2.21	0.197
				S	2	139	56.12	0.00	24.46	24.03	0.00	0.13	0.30	0.73			0.487
SNO	103.4	251	46	P	2	139	49.85	0.00	18.19	18.50	0.00	0.02	-0.33	0.72			0.056
SGU	117.6	246	46	P	1	139	52.03	0.00	20.37	20.90	0.00	-0.01	-0.52	1.01		2.13	0.107


BCE EHZ, Feb 10/04
BCE
4:00
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23:15
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02:15
03:15
04:15
05:15
06:15
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
TIME (MINUTES)
Each Vertical Division = 2500+00 microvolts
BCE 2/10/04
Traces clipped at plus/minus 5 vertical divisions

M_C 1.7 Earthquake on February 23, 2005 at 12:28 PM MST

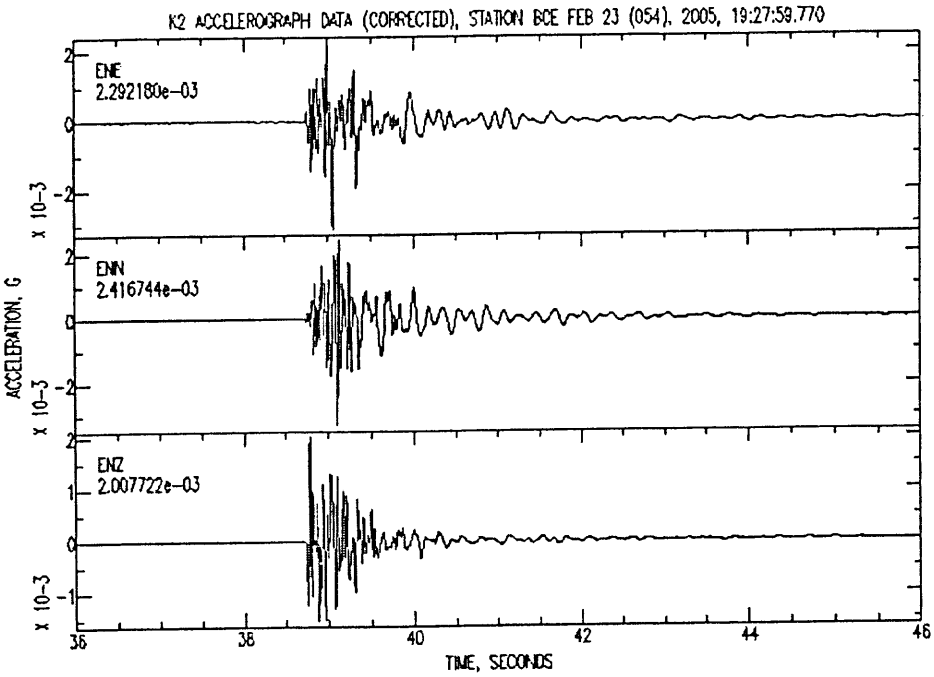
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.87 km, which implies that the focal depth of 0.56 km is subject to an uncertainty at least as large as ±0.87 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_C) of 1.7 is based on coda duration measurements from 3 stations.
7. The clear S-P observation at BCE of 0.44 seconds implies a source-to-station distance of ~1.90 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

M_C 1.7 Earthquake on February 23, 2005 at 19:28 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
Feburary 23, 2005 19:28	05022319283	M_C 1.7	39° 36.14′ 110° 23.91′ 0.56	1.5

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	1.97	0.02
East/West:	3.04	0.04
North/South:	3.24	0.04

PRT File

yr	mo	da	origin		lat n		lon w		depth	rms	erh	erz	gap	xmag	fmag
5-	2-	23	1928	38.01	39	36.14	110	23.91	0.56	0.14	0.78	0.87	167		1.7

rmswt	dmin	itr	nfm	nwr	nws	remk	cond	no
0.14	1.5	11	1	6	2		17.7	

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.5	325	108	P	1	1928	38.38	0.00	0.37	0.40	0.00	0.02	-0.05	1.06		1.90	0.578
				S	2	1928	38.82	0.00	0.81	0.80	0.00	0.04	-0.03	0.71			0.556
ROA	7.2	24	68	Pd		1928	39.75	0.00	1.74	1.74	0.00	0.05	-0.05	1.41		1.77	0.948
ARGU	27.5	333	40	P	1	1928	43.85	0.00	5.84	5.65	0.00	0.08	0.11	1.06		1.45	0.718
sruz	55.7	191	34	P	1	1928	48.28	0.00	10.27	10.20	0.00	-0.11	0.19	1.06			0.678
				S	2	1928	55.50	0.00	17.49	18.08	0.00	-0.24	-0.35	0.71			0.519

M_L 1.7 Earthquake on March 24, 2005 at 6:02 PM MST

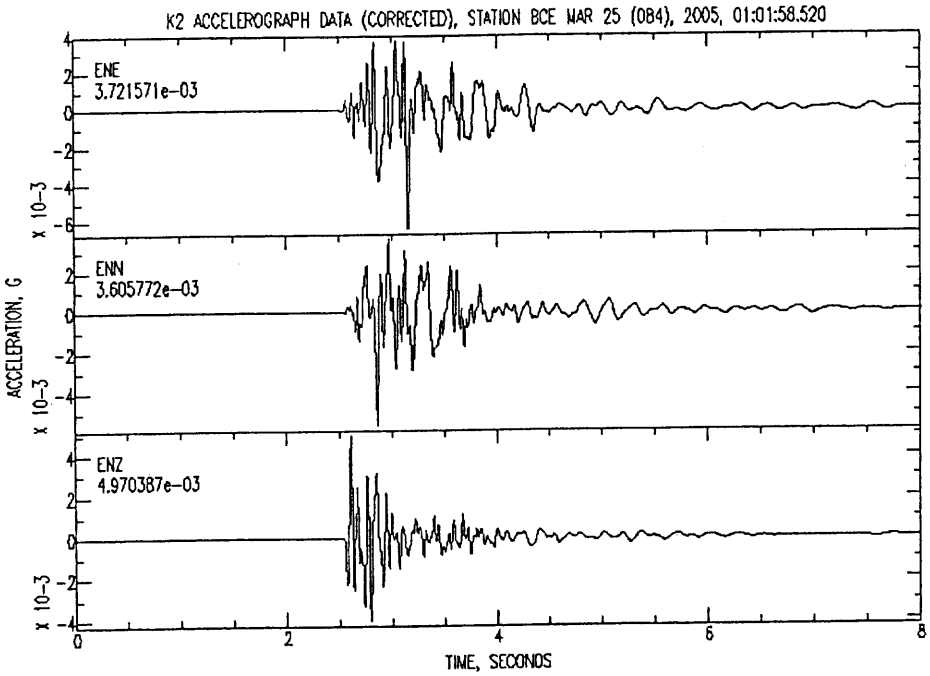
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.62 km, which implies that the focal depth of 0.77 km is subject to an uncertainty at least as large as ±0.62 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_L) of 1.7 is based on amplitude measurements from 2 stations.
7. The clear S-P observation at BCE of 0.19 seconds implies a source-to-station distance of ~0.82 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

M_L 1.7 Earthquake on March 25, 2005 at 01:02 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
March 25, 2005 01:02	05032501014	M_C 1.9 M_L 1.7	39° 36.43′ 110° 23.81′ 0.77	1.2

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	4.87	0.08
East/West:	6.23	0.11
North/South:	5.48	0.11

PRT File

yr mo da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
5- 3-25	1 2 0.64	39 36.43	110 23.81	0.77	0.19	0.61	0.62	167		1.9

rmswt	dmin	itr	nfm	nwr	nws	remk	cond no
0.19	1.2	8	3	13	2		15.2

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.2	304	115	Pd		102	1.03	0.00	0.39	0.35	0.00	0.04	0.00	1.30		1.63	0.590
				S	2	102	1.22	0.00	0.58	0.70	0.00	0.07	-0.19	0.65			0.393
ROA	6.7	24	91	Pd		102	2.29	0.00	1.65	1.61	0.00	0.05	-0.01	1.30		1.89	0.874
dcmz	18.8	301	43	P	1	102	4.65	0.00	4.01	4.21	0.00	0.03	-0.23	0.97		1.32	0.186
ARGU	27.1	332	43	P	1	102	6.32	0.00	5.68	5.55	0.00	0.08	0.05	0.97		2.05	0.275
bcwz	32.6	295	43	P	1	102	7.19	0.00	6.55	6.44	0.00	0.04	0.07	0.97		1.93	0.171
EMUZ	42.5	303	43	P	1	102	8.58	0.00	7.94	8.05	0.00	-0.03	-0.09	0.97		1.83	0.191
sruz	56.2	191	37	Pd		102	10.83	0.00	10.19	10.26	0.00	-0.11	0.04	1.30			0.582
				S	2	102	18.09	0.00	17.45	18.15	0.00	-0.24	-0.46	0.65			0.230
DBD	68.1	241	43	P	1	102	12.91	0.00	12.27	12.16	0.00	-0.03	0.13	0.97		2.11	0.128
ELU	69.2	273	43	P	1	102	13.57	0.00	12.93	12.35	0.00	0.11	0.47	0.97			0.127
tm2z	77.8	244	43	P	1	102	14.55	0.00	13.91	13.72	0.00	0.06	0.12	0.97		2.37	0.124
SNO	103.1	252	46	P	1	102	18.96	0.00	18.32	18.57	0.00	0.02	-0.27	0.97			0.123

M_C 1.8 Earthquake on April 2, 2005 at 4:36 PM MST

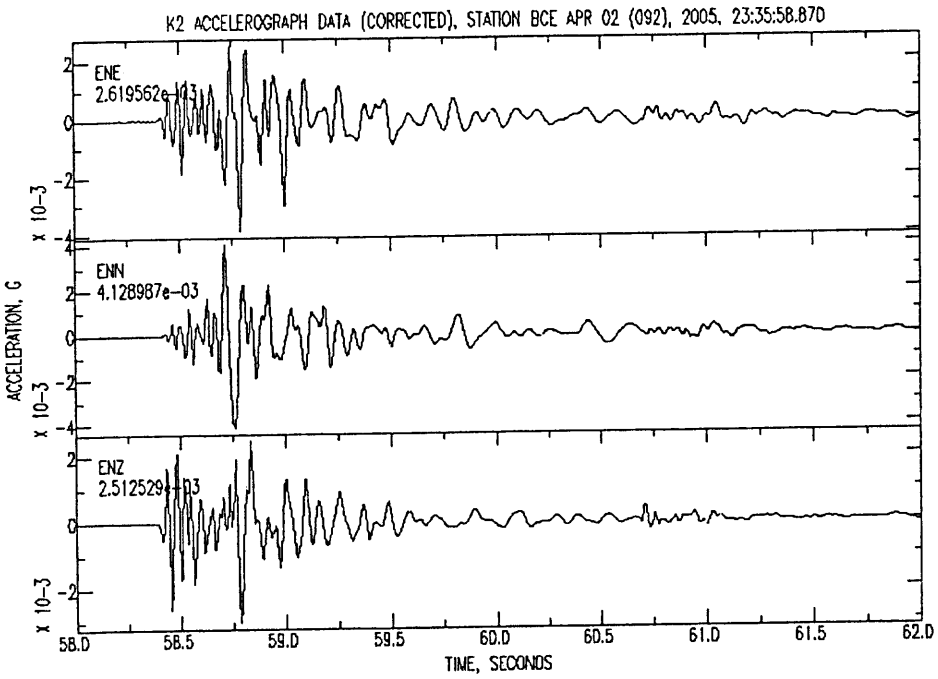
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.55 km, which implies that the focal depth of 0.78 km is subject to an uncertainty at least as large as ±0.55 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_C) of 1.8 is based on coda duration measurements from 4 stations.
7. The clear S-P observation at BCE of 0.23 seconds implies a source-to-station distance of ~0.99 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

M_C 1.8 Earthquake on April 2, 2005 at 23:36 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
April 2, 2005 23:36	05040223364	M_C 1.8	39° 36.28′ 110° 23.96′ 0.78	1.2

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	2.98	0.04
East/West:	4.09	0.05
North/South:	3.82	0.08

PRT File

yr	mo	da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
5-	4-	2	2336 56.85	39 36.28	110 23.96	0.78	0.12	0.56	0.55	166		1.8

rmswt	dmin	itr	nfm	nwr	nws	remk	cond no
0.12	1.2	9	3	7	2		13.9

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.2	320	115	Pd		2336	57.26	0.00	0.42	0.37	0.00	0.04	0.01	1.27		1.79	0.644
				S	2	2336	57.49	0.00	0.65	0.72	0.00	0.07	-0.14	0.64			0.412
ROA	7.0	25	91	Pd		2336	58.52	0.00	1.68	1.69	0.00	0.05	-0.06	1.27		1.91	0.930
dcmz	18.7	302	43	P	1	2337	1.00	0.00	4.15	4.20	0.00	0.03	-0.08	0.95		1.77	0.344
ARGU	27.2	333	43	Pd		2337	2.61	0.00	5.76	5.58	0.00	0.08	0.10	1.27		1.60	0.656
sruz	56.0	191	37	P	1	2337	7.10	0.00	10.25	10.21	0.00	-0.11	0.15	0.95			0.598
				S	2	2337	14.34	0.00	17.49	18.07	0.00	-0.24	-0.34	0.64			0.414

M_C 1.8 Earthquake on April 25, 2005 at 10:20 AM MDT

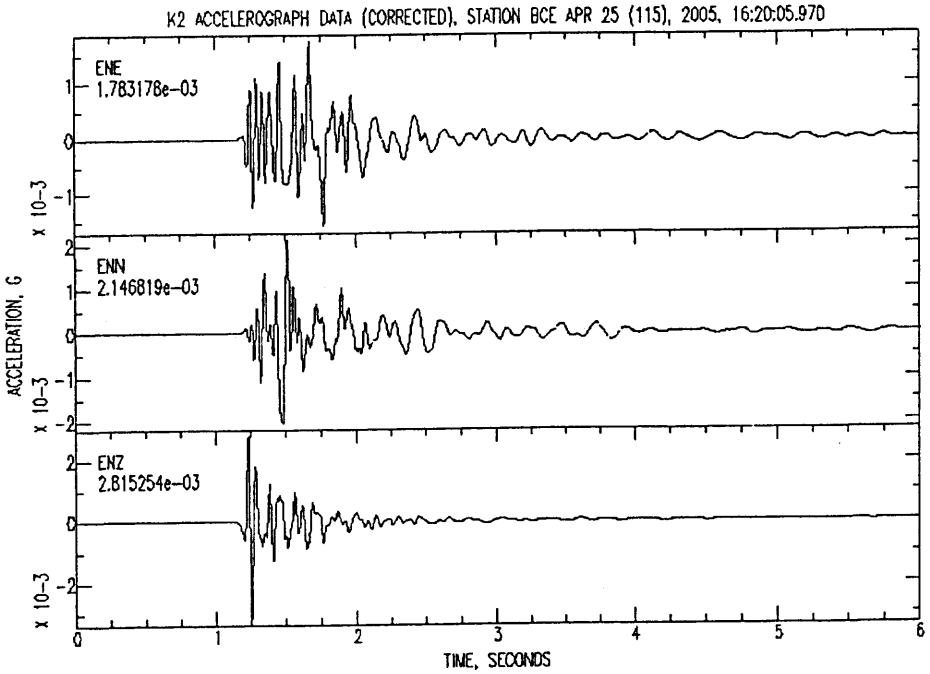
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.81 km, which implies that the focal depth of 0.82 km is subject to an uncertainty at least as large as ±0.81 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_C) of 1.7 is based on coda duration measurements from 3 stations.
7. The clear S-P observation at BCE of 0.21 seconds implies a source-to-station distance of ~0.91 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

M_C 1.7 Earthquake on April 25, 2005 at 16:20 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
April 25, 2005 16:20	05042516195	M_C 1.7	39° 36.31′ 110° 23.87′ 0.82	1.3

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	3.10	0.03
East/West:	1.75	0.03
North/South:	2.11	0.05

PRT File

yr	mo	da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
5-	4-	25	1620	6.71 39	36.31 110	23.87	0.82	0.14	0.76	0.81	167	1.7

rmswt	dmin	itr	nfm	nwr	nws	remk	cond no
0.14	1.3	8	3	6	2		16.8

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.3	315	116	Pd		1620	7.13	0.00	0.42	0.38	0.00	0.04	0.00	1.26		2.36	0.625
				S	2	1620	7.34	0.00	0.63	0.75	0.00	0.07	-0.19	0.63			0.448
ROA	6.9	24	92	Pd		1620	8.36	0.00	1.65	1.67	0.00	0.05	-0.07	1.26		1.40	0.943
ARGU	27.2	333	43	P	1	1620	12.48	0.00	5.77	5.57	0.00	0.08	0.12	0.95		1.34	0.872
sruz	56.0	191	37	Pd		1620	16.91	0.00	10.20	10.21	0.00	-0.11	0.10	1.26			0.728
				S	2	1620	24.13	0.00	17.42	18.07	0.00	-0.24	-0.41	0.63			0.382

M_C 1.8 Earthquake on April 27, 2005 at 4:22 PM MDT

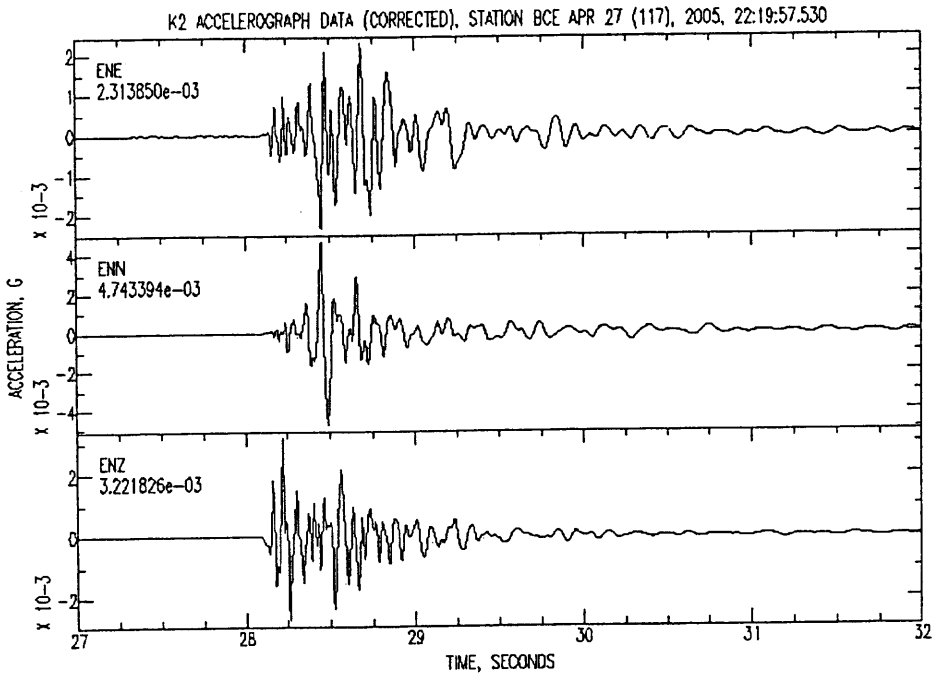
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.67 km, which implies that the focal depth of 0.73 km is subject to an uncertainty at least as large as ±0.67 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_C) of 1.8 is based on coda duration measurements from 5 stations.
7. The clear S-P observation at BCE of 0.16 seconds implies a source-to-station distance of ~0.69 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

M_C 1.8 Earthquake on April 27, 2005 at 22:20 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
April 27, 2005 22:20	05042722201	M_C 1.8	39° 36.22′ 110° 23.90′ 0.73	1.4

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	3.16	0.03
East/West:	2.30	0.04
North/South:	4.71	0.07

PRT File

yr	mo	da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
5-	4-	27	2220 25.16	39 36.22	110 23.90	0.73	0.13	0.55	0.67	167		1.8

rmswt	dmin	itr	nfm	nwr	nws	remk	cond	no
0.13	1.4	11	3	8	2		15.9	

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.4	321	109	Pd		2220	25.61	0.00	0.45	0.39	0.00	0.03	0.03	1.45		2.05	0.657
				S	2	2220	25.77	0.00	0.61	0.78	0.00	0.06	-0.23	0.73			0.416
ROA	7.1	24	91	Pd		2220	26.87	0.00	1.71	1.70	0.00	0.05	-0.04	1.45		2.00	0.937
dcmz	18.9	303	43	P	2	2220	29.27	0.00	4.11	4.23	0.00	0.03	-0.15	0.73		2.17	0.202
ARGU	27.4	333	43	Pd	1	2220	30.94	0.00	5.78	5.61	0.00	0.08	0.09	1.09		1.60	0.551
bcwz	32.7	296	43	P	2	2220	31.92	0.00	6.76	6.46	0.00	0.04	0.26	0.73		1.03	0.194
sruz	55.9	191	37	P	1	2220	35.34	0.00	10.18	10.20	0.00	-0.11	0.09	1.09			0.618
				S	2	2220	42.67	0.00	17.51	18.05	0.00	-0.24	-0.30	0.73			0.421

M_C 1.5 Earthquake on May 3, 2005 at 4:07 PM MDT

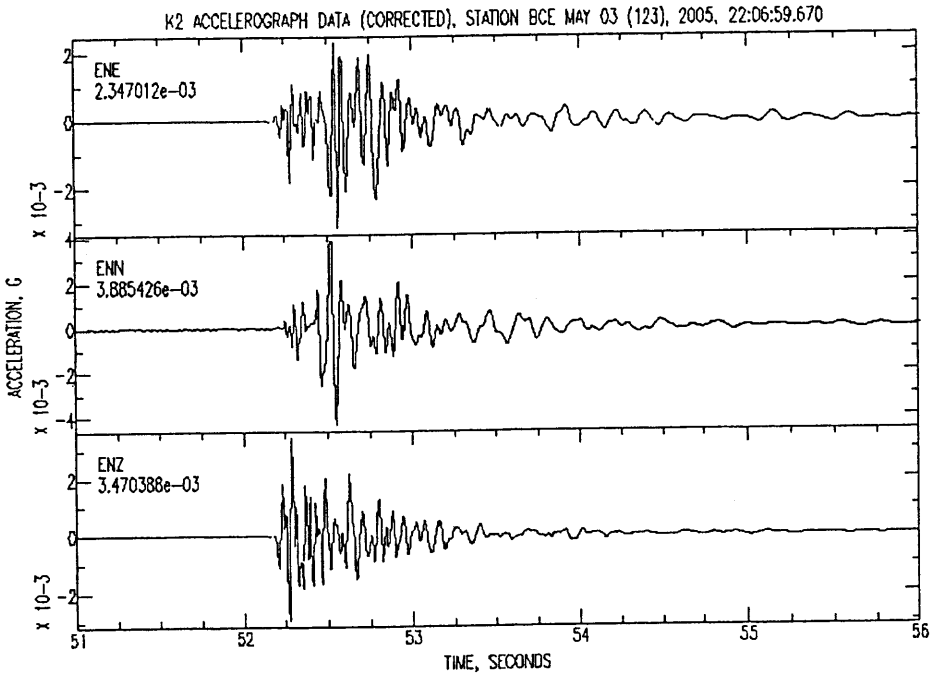
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.60 km, which implies that the focal depth of 0.10 km is subject to an uncertainty at least as large as ±0.60 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_C) of 1.5 is based on coda duration measurements from 5 stations.
7. The clear S-P observation at BCE of 0.20 seconds implies a source-to-station distance of ~0.86 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

M_C 1.5 Earthquake on May 3, 2005 at 22:07 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
May 3, 2005 22:07	05050322074	M_C 1.5	39° 36.63′ 110° 23.75′ 0.10	1.1

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	3.40	0.03
East/West:	3.12	0.04
North/South:	4.25	0.05

PRT File

yr	mo	da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
5-	5-	3	22 7 51.46	39 36.63	110 23.75	0.10	0.10	0.43	0.60	166		1.5

rmswt	dmin	itr	nfm	nwr	nws	remk	cond no
0.10	1.1	8	2	9	2		16.7

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.1	286	90	P		2207	51.82	0.00	0.36	0.30	0.00	0.00	0.06	1.33		1.61	0.710
				S	2	2207	52.02	0.00	0.56	0.59	0.00	0.00	-0.03	0.67			0.416
ROA	6.2	25	68	Pd		2207	53.09	0.00	1.63	1.56	0.00	0.05	0.02	1.33		1.78	0.835
dcmz	18.6	300	40	P	1	2207	55.59	0.00	4.13	4.31	0.00	0.03	-0.21	1.00		1.61	0.198
ARGU	26.8	332	40	Pd		2207	57.16	0.00	5.70	5.63	0.00	0.08	-0.01	1.33		1.39	0.427
bcwz	32.5	294	40	P	2	2207	58.17	0.00	6.71	6.56	0.00	0.04	0.11	0.67			0.084
EMUZ	42.4	302	40	P	1	2207	59.70	0.00	8.24	8.15	0.00	-0.03	0.11	1.00		1.13	0.200
sruz	56.7	191	34	P	1	2208	1.67	0.00	10.21	10.44	0.00	-0.11	-0.12	1.00			0.618
				S	2	2208	9.93	0.00	18.47	18.53	0.00	-0.24	0.18	0.67			0.508

M_C 2.0 Earthquake on May 10, 2005 at 1:41 PM MDT

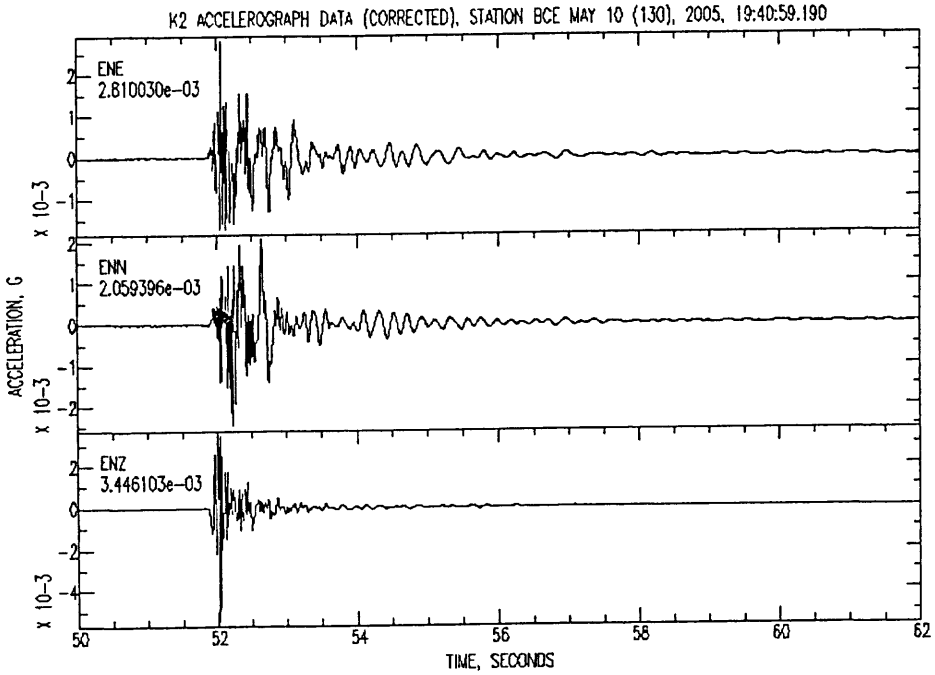
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station BCE together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.77 km, which implies that the focal depth of 0.46 km is subject to an uncertainty at least as large as ±0.77 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_C) of 2.0. is based on coda duration measurements from 3 stations.
7. The clear S-P observation at BCE of 0.06 seconds implies a source-to-station distance of ~0.26 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2666 meters above sea level.

M_C 2.0 Earthquake on May 10, 2005 at 19:41 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
May 10, 2005 19:41	05051019413	M_C 2.0	39° 36.19′ 110° 24.07′ 0.46	1.3

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	5.32	0.04
East/West:	2.76	0.06
North/South:	2.40	0.06

PRT File

yr	mo	da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
5-	5-	10	1941 50.67	39 36.19	110 24.07	0.46	0.15	0.73	0.77	166		2.0

rmswt	dmin	itr	nfm	nwr	nws	remk	cond	no
0.15	1.3	12	3	7	2		16.4	

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.3	330	107	Pd		1941	51.04	0.00	0.38	0.35	0.00	0.02	0.02	1.33		2.09	0.705
				S	2	1941	51.10	0.00	0.44	0.69	0.00	0.04	-0.28	0.67			0.410
ROA	7.2	25	68	Pd		1941	52.42	0.00	1.76	1.75	0.00	0.05	-0.04	1.33		2.09	0.920
ARGU	27.3	333	40	Pd		1941	56.46	0.00	5.80	5.64	0.00	0.08	0.08	1.33		1.75	0.721
sruz	55.8	191	34	P	1	1942	0.90	0.00	10.23	10.23	0.00	-0.11	0.12	1.00			0.629
				S	2	1942	8.09	0.00	17.42	18.13	0.00	-0.24	-0.47	0.67			0.408
ELU	68.9	273	40	P	2	1942	3.34	0.00	12.67	12.35	0.00	0.11	0.22	0.67			0.203

M_C 1.5 Earthquake on June 2, 2005 at 7:38 PM MDT

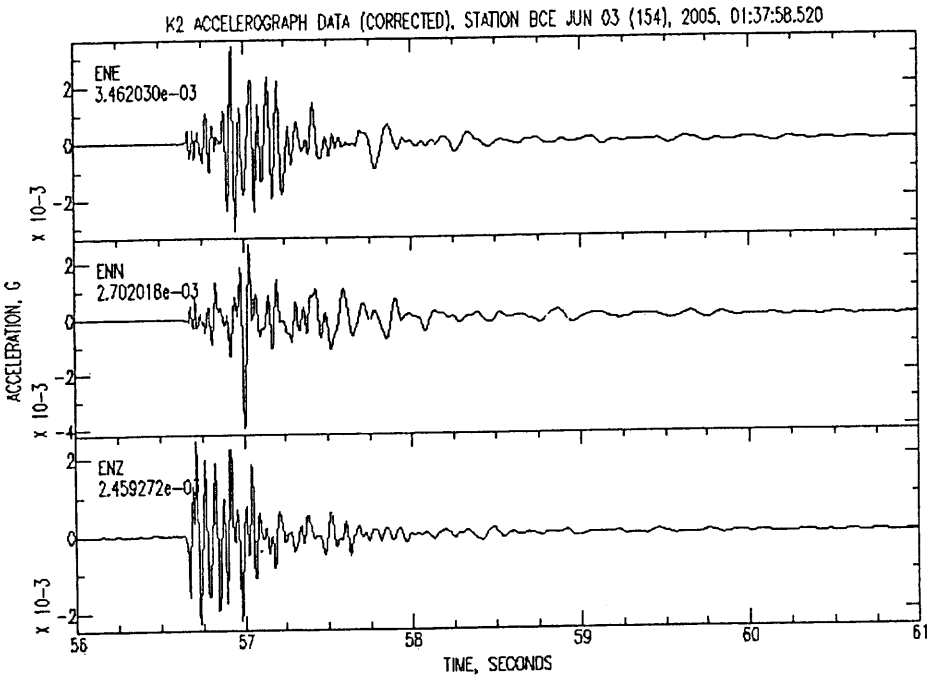
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 1.99 km, which implies that the focal depth of 0.50 km is subject to an uncertainty at least as large as ±1.99 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_C) of 1.5 is based on coda duration measurements from 4 stations.
7. The clear S-P observation at BCE of 0.19 seconds implies a source-to-station distance of ~0.82 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

M_C 1.5 Earthquake on June 3, 2005 at 1:38 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
June 3, 2005 1:38	05060301384	M_C 1.5	39° 36.99′ 110° 25.39′ 0.50	1.3

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	2.41	0.03
East/West:	3.40	0.04
North/South:	3.39	0.05

PRT File

yr	mo	da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
5-	6-	3	138 54.75	39 36.99	110 25.39	0.50	0.20	1.45	1.99	132		1.5

rmswt	dmin	itr	nfm	nwr	nws	remk	cond	no
0.20	1.3	14	2	6	1		27.5	

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.3	106	108	Pd		138	55.15	0.00	0.41	0.35	0.00	0.02	0.04	1.26		1.39	0.840
				S	2	138	55.34	0.00	0.60	0.70	0.00	0.04	-0.14	0.63			0.409
ROA	7.1	45	68	Pd		138	56.41	0.00	1.67	1.71	0.00	0.05	-0.09	1.26		1.46	0.885
ARGU	25.1	336	40	P	1	139	0.51	0.00	5.76	5.29	0.00	0.08	0.39	0.95		1.17	0.351
SRU	56.9	189	40	P	1	139	4.99	0.00	10.24	10.41	0.00	-0.11	-0.05	0.95		2.10	0.979
DAU	113.5	321	42	P	1	139	14.85	0.00	20.10	20.37	0.00	0.07	-0.33	0.95			0.534

M_L 1.6 Earthquake on June 14, 2005 at 5:16 AM MDT

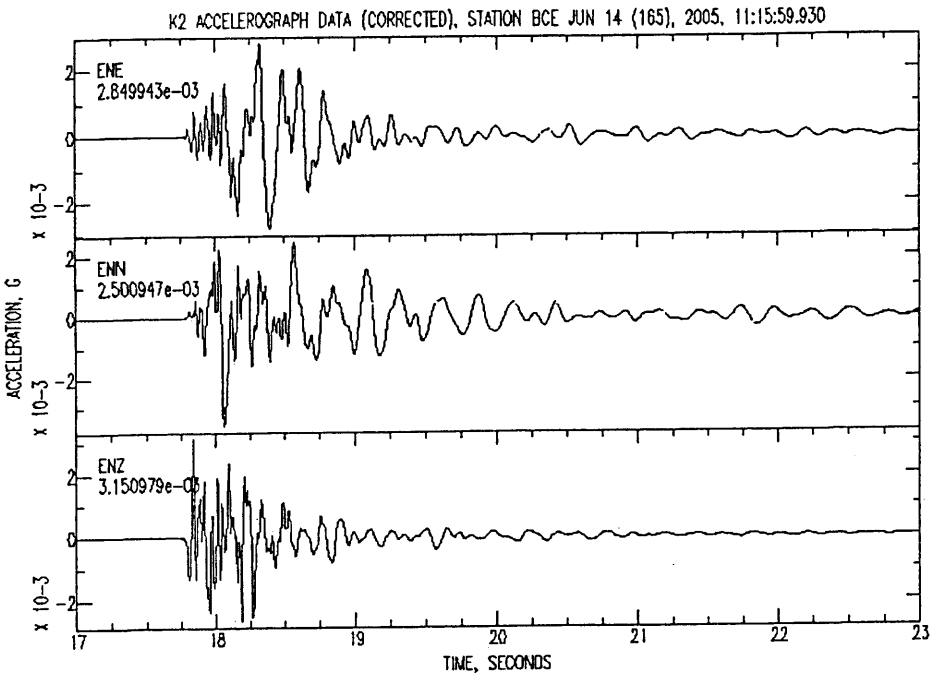
This document contains information regarding the above event. Subsequent pages include:

1. Figure showing the accelerometer recordings from the above-mine station (BCE) together with location and magnitude information, epicentral (map) distance to BCE, and three-component peak acceleration and peak velocity measurements
2. Detailed output from the location program (PRT file) indicating the stations used to locate the seismic event. The solution parameters "erh" and "erz" indicate the standard errors (in km) in horizontal location and vertical location, respectively.

Additional notes regarding this earthquake:

1. The revised location in this report differs from the location reported on the UUSS Website. The revised location was found using a velocity model customized for the Book Cliffs. Additional S-wave arrival-time picks were also added to better constrain the depth of the earthquake.
2. The S-wave arrival time picks used in the revised location were identified on horizontal-component rotated seismograms.
3. The reported depth is given with respect to a datum of 2,400 meters above sea level.
4. The standard error in computing focal depth (erz in PRT file) is 0.61km, which implies that the focal depth of 0.40 km is subject to an uncertainty at least as large as ±0.61 km.
5. The time on the plot of accelerometer data can be determined by adding the number of seconds from the x-axis to the time in the title.
6. The reported magnitude (M_L) of 1.6 is based on amplitude measurements from 2 stations.
7. The clear S-P observation at BCE of 0.48 seconds implies a source-to-station distance of ~2.07 km.
8. The coordinates of BCE are 39° 36.79' N, 110° 24.51' W, and 2,666 meters above sea level.

M_L 1.6 Earthquake on June 14, 2005 at 11:16 UTC



Instrument Corrected Peak Accelerations from station BCE

Earthquake Date & Time (UTC)	Event ID No.	Magnitude	Revised Location and Depth (km)	Epicentral Distance to BCE (km)
June 14, 2005 11:16	05061411160	M_L 1.6 M_C 1.7	39° 36.21′ 110° 23.84′ 0.40	1.5

	Peak Acceleration (cm/sec^2)	Peak Velocity (cm/sec)
Vertical:	3.09	0.05
East/West:	2.79	0.09
North/South:	3.51	0.09

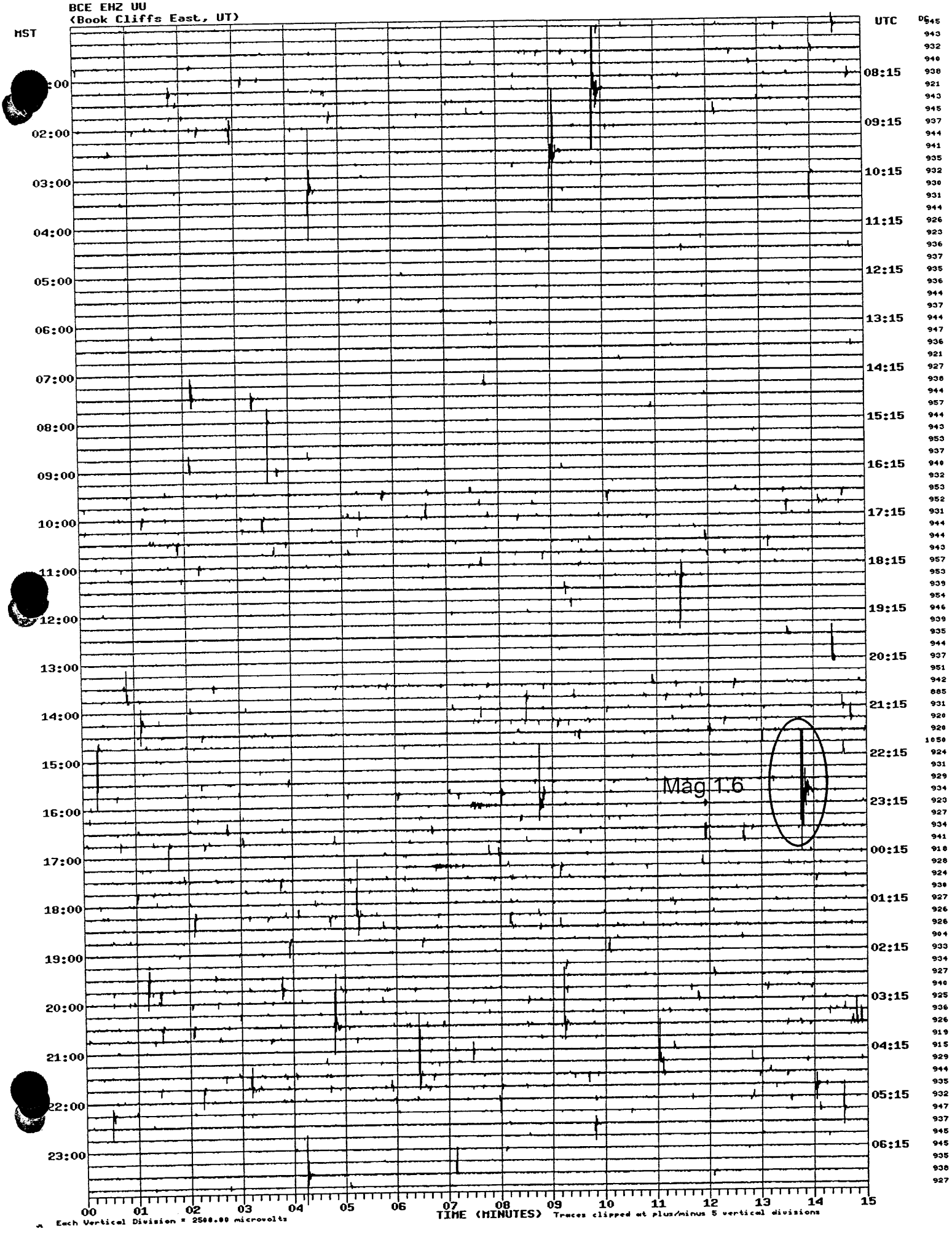
PRT File

yr	mo da	origin	lat n	lon w	depth	rms	erh	erz	gap	xmag	fmag
5-	6-14	1116 17.26	39 36.21	110 23.84	0.40	0.22	0.59	0.61	168		1.7

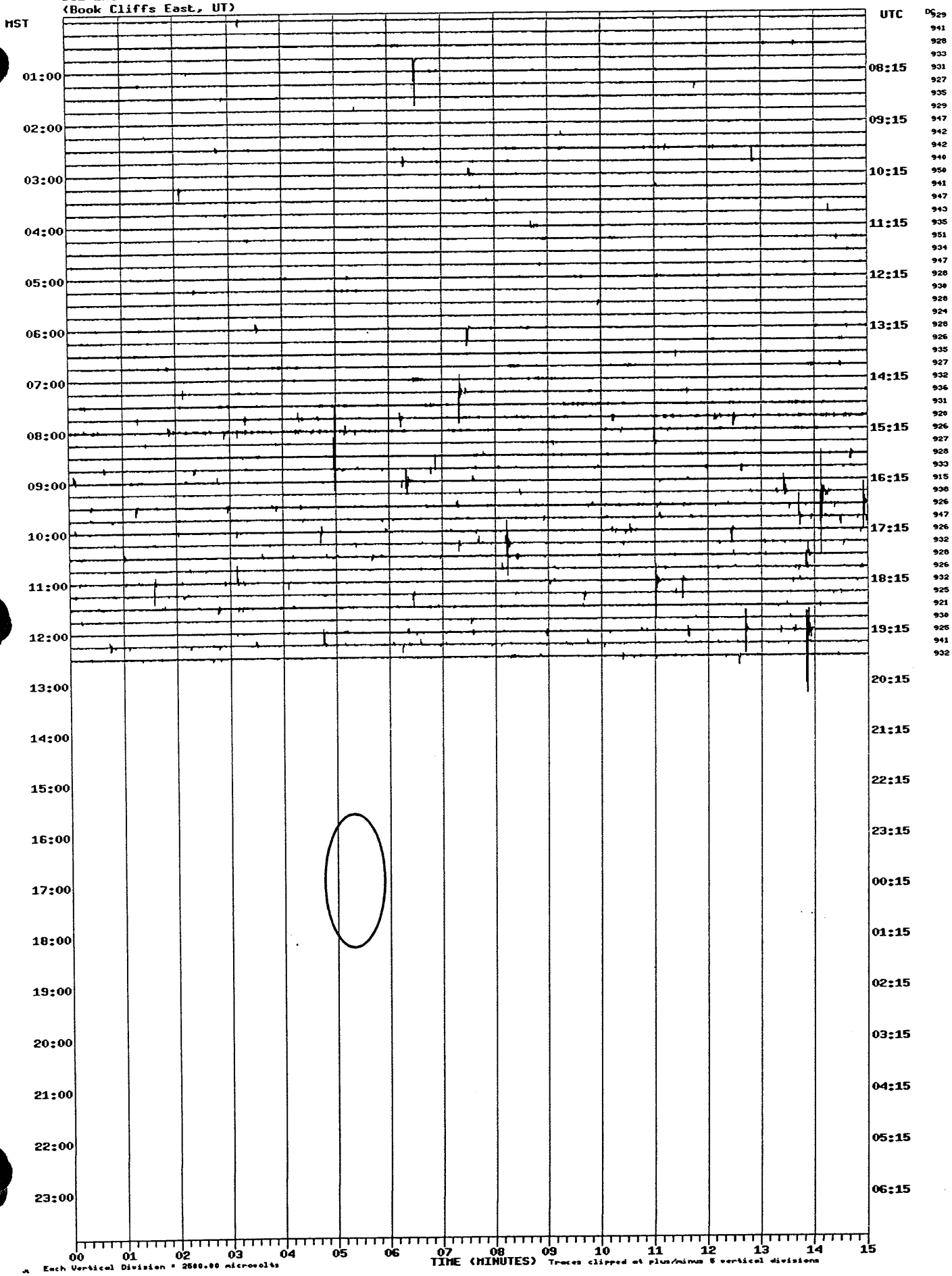
rmswt	dmin	itr	nfm	nwr	nws	remk	cond no
0.22	1.5	7	3	12	4		11.8

sta	dist	azm	an	p/s	w	hrmn	sec	+ccor	(tobs	-tcal	-dly	-eldy	=res)	wt	xmg	fmg	impor
bcez	1.5	318	102	P	1	1116	17.49	0.00	0.23	0.38	0.00	0.01	-0.16	1.16		1.93	0.466
				S	2	1116	17.97	0.00	0.71	0.75	0.00	0.03	-0.07	0.77			0.475
ROA	7.1	23	68	Pd		1116	18.96	0.00	1.70	1.72	0.00	0.05	-0.07	1.55		2.05	0.792
ARGU	27.5	333	40	Pd		1116	22.99	0.00	5.73	5.68	0.00	0.08	-0.03	1.55		1.85	0.318
EMUZ	42.8	303	34	P	2	1116	25.38	0.00	8.12	8.15	0.00	-0.03	0.00	0.77		1.46	0.063
				S	2	1116	32.11	0.00	14.85	14.50	0.00	-0.05	0.40	0.77			0.478
sruz	55.9	191	34	Pd		1116	27.53	0.00	10.27	10.26	0.00	-0.11	0.13	1.55			0.613
				S	2	1116	34.86	0.00	17.60	18.18	0.00	-0.24	-0.34	0.77			0.249
DBD	67.8	242	40	P	2	1116	29.61	0.00	12.35	12.19	0.00	-0.03	0.19	0.77		1.15	0.092
ELU	69.2	273	40	P	2	1116	30.20	0.00	12.94	12.41	0.00	0.11	0.42	0.77		1.89	0.070
tm2z	77.6	244	34	P	2	1116	31.21	0.00	13.95	13.76	0.00	0.06	0.13	0.77		1.74	0.091
				S	2	1116	41.04	0.00	23.78	24.28	0.00	0.13	-0.63	0.77			0.286

Feb 5,2005
BCE EHZ UU
(Book Cliffs East, UT)



Feb 7,2005
BCE EHZ UU
(Book Cliffs East, UT)



USGS Earthquake Hazards Program

Recent Earthquake Activity in the USA

Magnitude 1.7 - UTAH
2005 February 23 19:28:38 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 19:28:38 (UTC) on Wednesday, February 23, 2005. The magnitude 1.7 event has been located in UTAH. The hypocentral depth was poorly constrained. (This event has been reviewed by a seismologist.)

Magnitude	**1.7**
Date-Time	**Wednesday, February 23, 2005 at 19:28:38 (UTC)** = Coordinated Universal Time **Wednesday, February 23, 2005 at 12:28:38 PM** = local time at epicenter
Location	39.602°N, 110.398°W
Depth	0.6 km (~0.4 mile) (poorly constrained)
Region	**UTAH**
Distances	6 km (4 miles) N (2°) from **Sunnyside, UT** 7 km (4 miles) NNE (15°) from **East Carbon, UT** 29 km (18 miles) ENE (76°) from **Wellington, UT** 35 km (22 miles) E (89°) from **Price, UT** 129 km (80 miles) ESE (123°) from **Provo, UT** 180 km (112 miles) SE (135°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 0.8 km (0.5 miles); depth +/- 0.9 km (0.6 miles)
Parameters	Nph= 6, Dmin=1.5 km, Rmss=0.14 sec, Gp=166°, M-type=duration magnitude (Md), Version=2
Source	University of Utah Seismograph Stations
Event ID	uu02231928

Location Maps:
2-degree

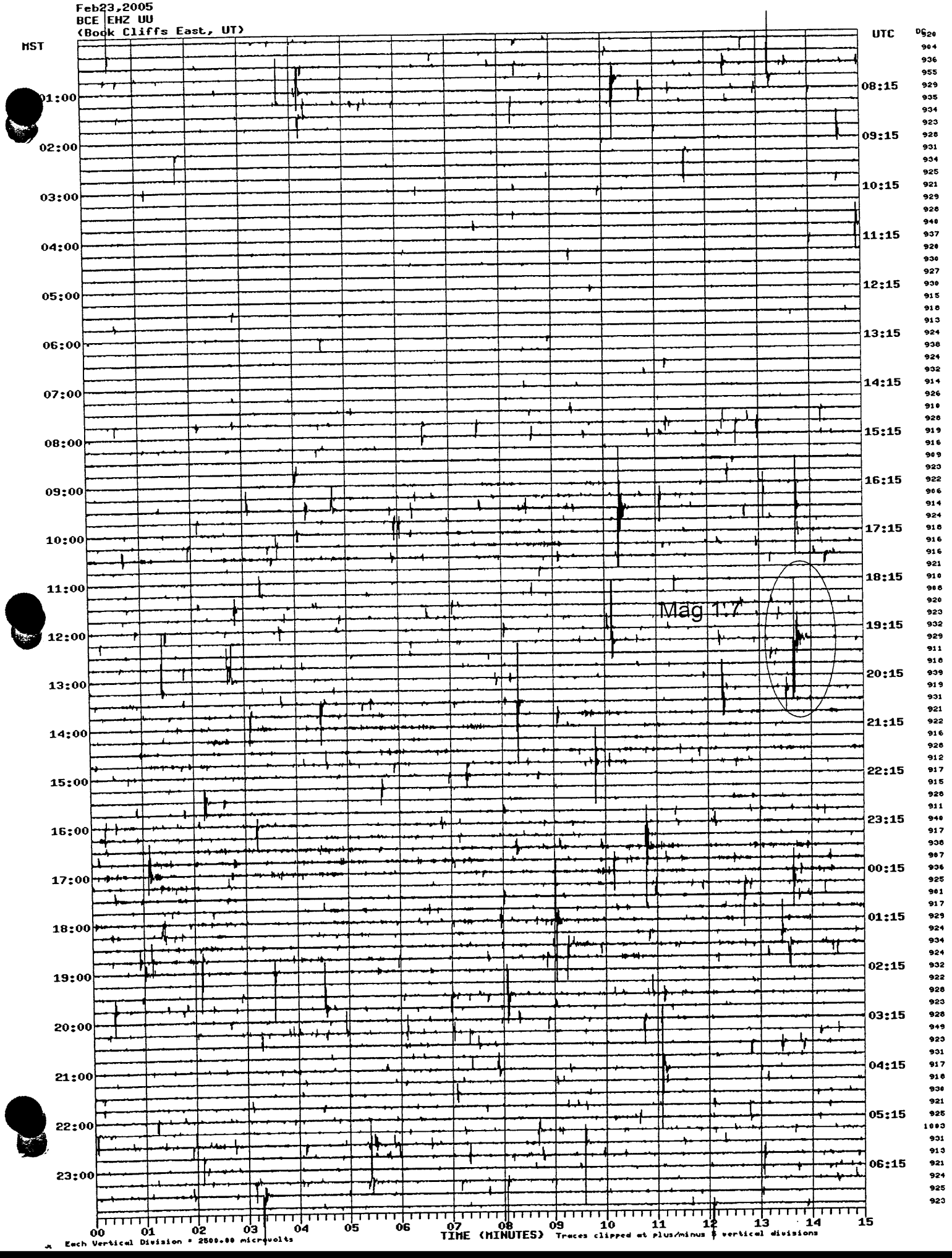
Topo map centered at earthquake
(This link takes you offsite. Not all regions have topo maps available.)

Did you feel it?
Report shaking and damage at your location. You can also view a map displaying accumulated data from your report and others.

Archive of newsworthy events

Printer friendly version

Feb23,2005
BCE EHZ UU
(Book Cliffs East, UT)



USGS Earthquake Hazards Program

1st event recorded on Both Sam and [illegible]

Recent Earthquake Activity in the USA

Magnitude 1.7 - UTAH
2005 March 25 01:02:00 UTC

= March 24 in [illegible]

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 01:02:00 (UTC) on Friday, March 25, 2005. The magnitude 1.7 event has been located in UTAH. The hypocentral depth was estimated to be 1 km (0.4 mile). (This event has been reviewed by a seismologist.)

Magnitude	**1.7**
Date-Time	**Friday, March 25, 2005 at 01:02:00 (UTC)** = Coordinated Universal Time **Thursday, March 24, 2005 at 6:02:00 PM** MST = local time at epicenter 18:02
Location	39.609°N, 110.397°W
Depth	0.7 km (~0.4 mile)
Region	**UTAH**
Distances	6 km (4 miles) N (3°) from **Sunnyside, UT** 8 km (5 miles) NNE (14°) from **East Carbon, UT** 30 km (18 miles) ENE (75°) from **Wellington, UT** 35 km (22 miles) E (88°) from **Price, UT** 129 km (80 miles) ESE (123°) from **Provo, UT** 180 km (112 miles) SE (135°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 0.6 km (0.4 miles); depth +/- 0.6 km (0.4 miles)
Parameters	Nph= 11, Dmin=1.1 km, Rmss=0.17 sec, Gp=166°, M-type=local magnitude (ML), Version=2
Source	University of Utah Seismograph Stations
Event ID	uu03250102

Location Maps:
2-degree
NEIC Maps

Topo map centered at earthquake
(This link takes you offsite. Not all regions have topo maps available.)

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Historical Moment Tensor Solutions

Seismic Hazard Map

Historical Seismicity

topozone

Trailhead Base Camp

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45° 22.31' -110° 16.94'

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Map/Photo Info
Topo Download
Photo Download

USGS Topo Maps
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- ( ) 1:100K Series
- ( ) 1:250K Series

Map Size
- ( ) Small
- (•) Medium
- ( ) Large

View Scale
1 : 100,000

Update Map

Coordinate Format
DD.DDD

Coordinate Datum
NAD27

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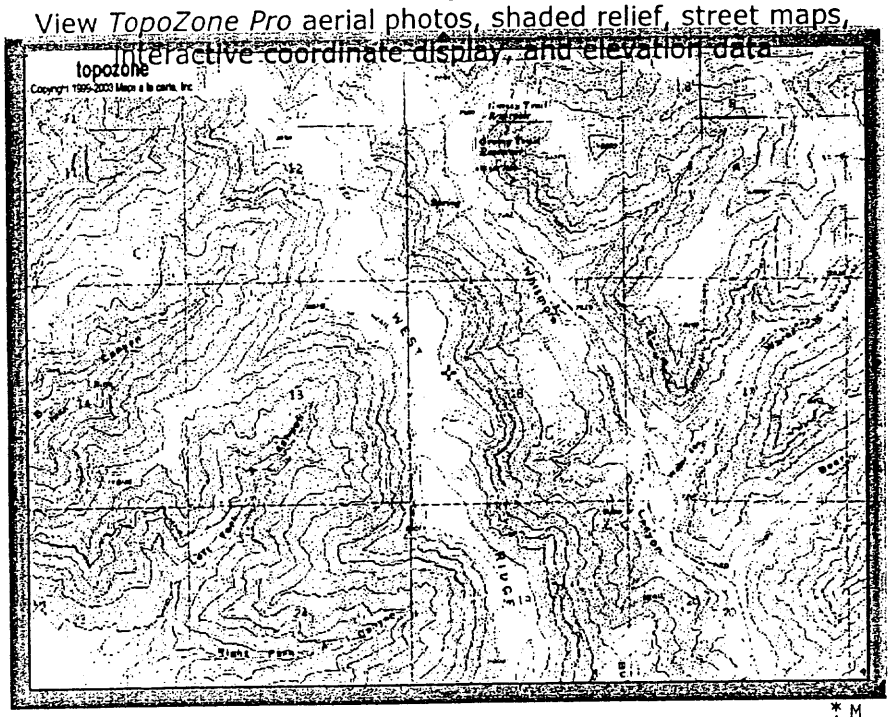
39.6090°N, 110.3968°W (NAD27)

USGS **Sunnyside** Quad

View *TopoZone Pro* aerial photos, shaded relief, street maps, interactive coordinate display, and elevation data



0 1 2 3 4 5 km

0 0.6 1.2 1.8 2.4 3 mi

M
G

M=12.498
G=0.384
What's This?

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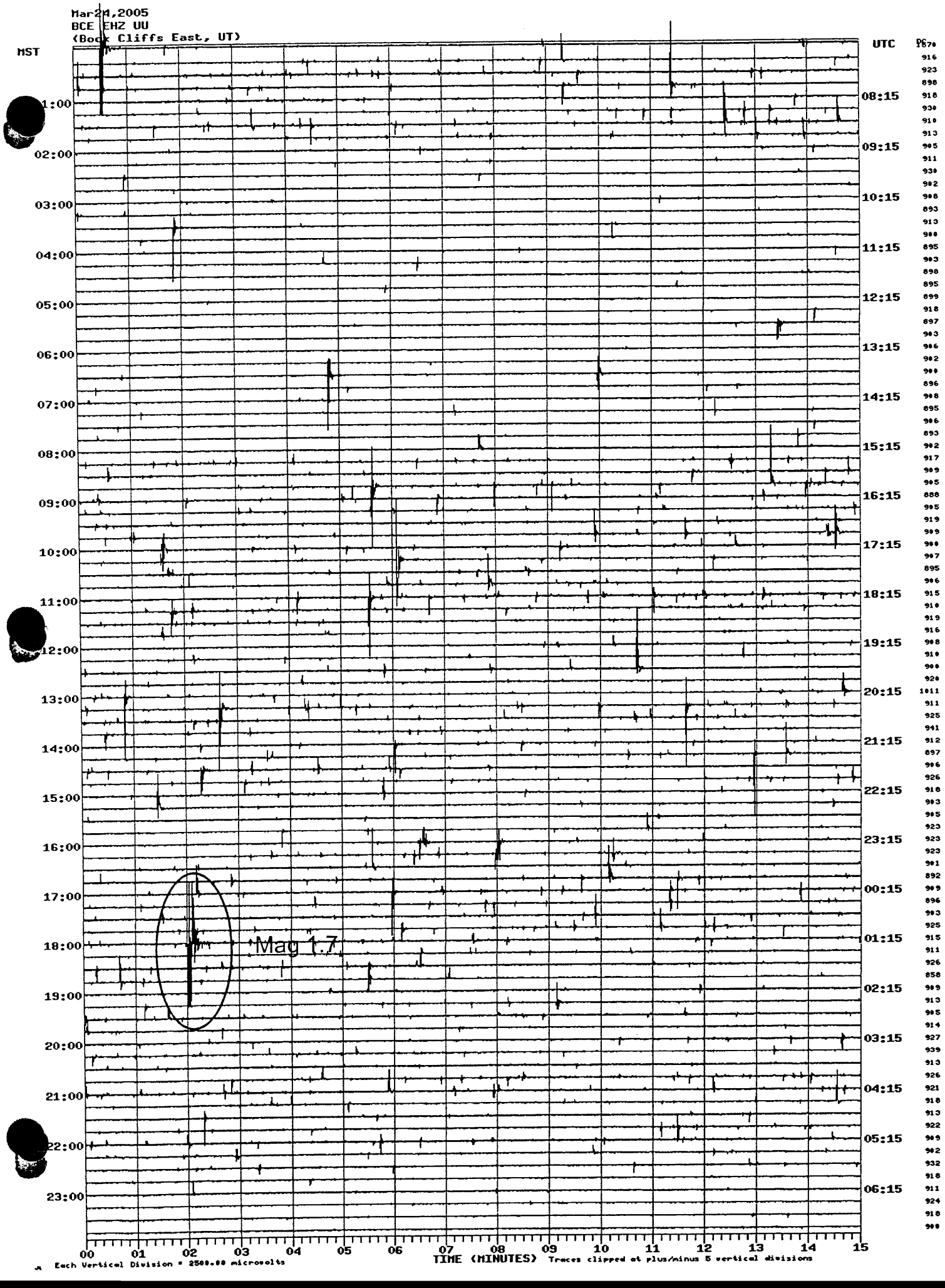

Mar24,2005
BCE EHZ UU
(Book Cliffs East, UT)
MST
UTC
Mag 1.7
TIME (MINUTES)
Each Vertical Division = 2500.00 microvolts
Traces clipped at plus/minus 5 vertical divisions

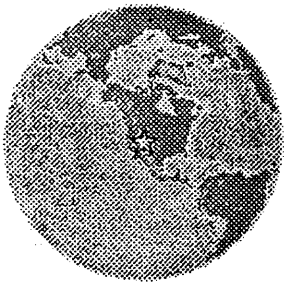
USGS
Earthquake Hazards Program

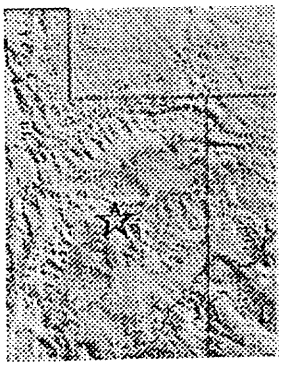
Recent Earthquake Activity in the USA

Magnitude 1.8 - UTAH
2005 April 2 23:36:56 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 23:36:56 (UTC) on Saturday, April 2, 2005. The magnitude 1.8 event has been located in UTAH. The hypocentral depth was estimated to be 1 km (1 mile). (This event has been reviewed by a seismologist.)





Magnitude	**1.8**
Date-Time	**Saturday, April 2, 2005 at 23:36:56 (UTC)** = Coordinated Universal Time **Saturday, April 2, 2005 at 4:36:56 PM** = local time at epicenter
Location	39.604°N, 110.397°W
Depth	0.9 km (~0.6 mile)
Region	**UTAH**
Distances	6 km (4 miles) N (4°) from **Sunnyside, UT** 7 km (4 miles) NNE (16°) from **East Carbon, UT** 29 km (18 miles) ENE (76°) from **Wellington, UT** 35 km (22 miles) E (89°) from **Price, UT** 129 km (80 miles) ESE (123°) from **Provo, UT** 180 km (112 miles) SE (135°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 0.6 km (0.4 miles); depth +/- 0.5 km (0.3 miles)
Parameters	Nph= 6, Dmin=1.5 km, Rmss=0.11 sec, Gp=169°, M-type=duration magnitude (Md), Version=2
Source	University of Utah Seismograph Stations
Event ID	uu04022336

Location Maps:
2-degree

Map/Photo Info
Topo Download
Photo Download
USGS Topo Maps
1:24K/25K Series
1:100K Series
1:250K Series
Map Size
Small
Medium
Large
View Scale
1 : 100,000
Update Map

Coordinate Format
DD.DDD
Coordinate Datum
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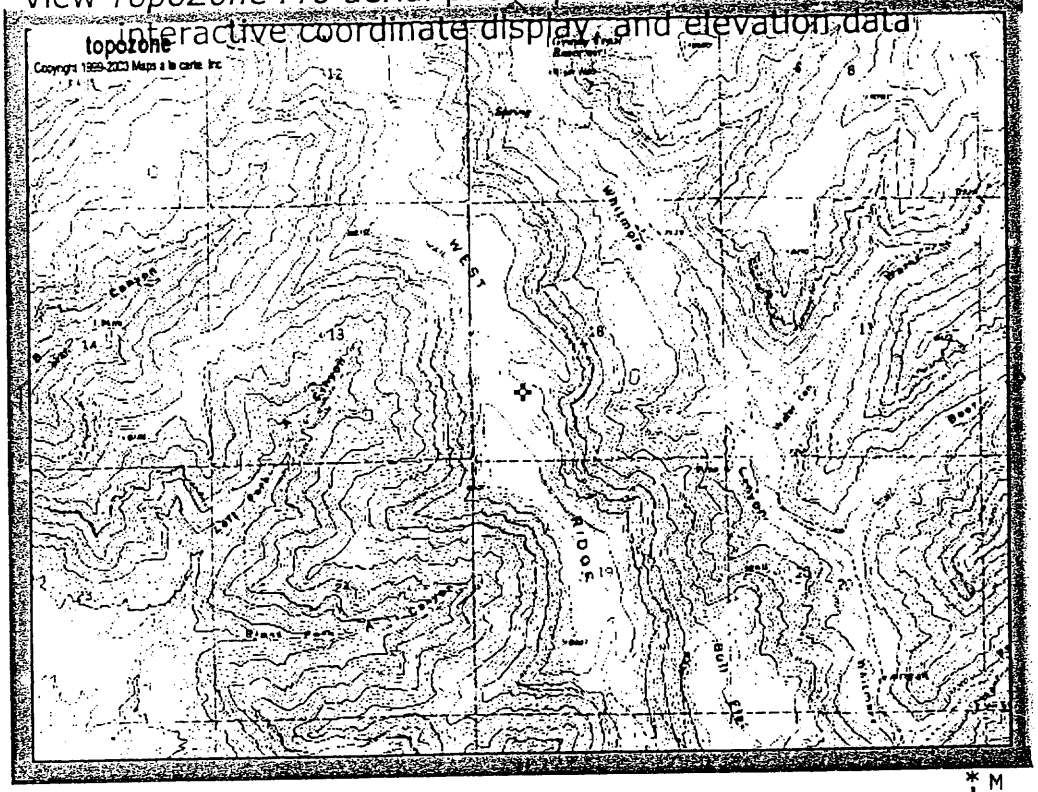
39.6042°N, 110.3965°W (NAD27)

USGS **Sunnyside** Quad

View *TopoZone Pro* aerial photos, shaded relief, street maps, interactive coordinate display, and elevation data



0 1 2 3 4 5 km
0 0.6 1.2 1.8 2.4 3 mi

M
G
M=12.497
G=0.384
What's This?

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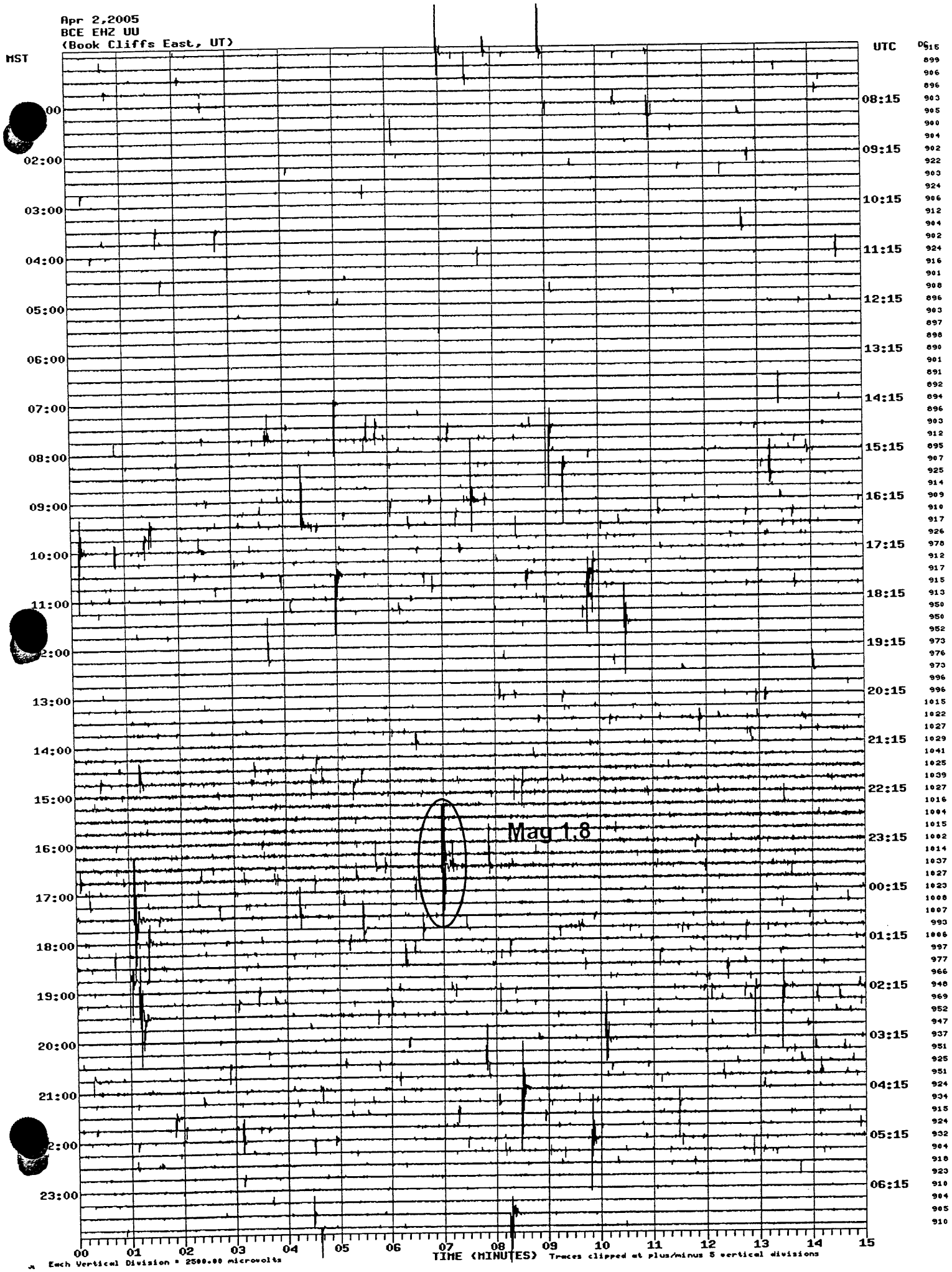

Apr 2,2005
BCE EHZ UU
(Book Cliffs East, UT)
MST
UTC
DG
Mag 1.8
TIME (MINUTES)
Each Vertical Division = 2500.00 microvolts
Traces clipped at plus/minus 5 vertical divisions

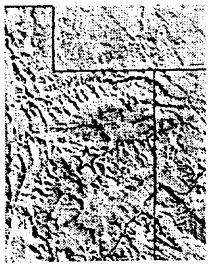
USGS
Earthquake Hazards Program

Recent Earthquake Activity in the USA

Magnitude 1.6 - UTAH
2005 April 22 18:52:15 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 18:52:15 (UTC) on Friday, April 22, 2005. The magnitude 1.6 event has been located in UTAH. The hypocentral depth was poorly constrained. (This event has been reviewed by a seismologist.)



Magnitude	**1.6**
Date-Time	**Friday, April 22, 2005 at 18:52:15 (UTC)** = Coordinated Universal Time **Friday, April 22, 2005 at 12:52:15 PM** = local time at epicenter
Location	39.610°N, 110.395°W
Depth	0.5 km (~0.3 mile) (poorly constrained)
Region	**UTAH**
Distances	6 km (4 miles) N (4°) from **Sunnyside, UT** 8 km (5 miles) NNE (15°) from **East Carbon, UT** 30 km (18 miles) ENE (75°) from **Wellington, UT** 35 km (22 miles) E (88°) from **Price, UT** 129 km (80 miles) ESE (123°) from **Provo, UT** 180 km (112 miles) SE (135°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 0.6 km (0.4 miles); depth +/- 0.6 km (0.4 miles)
Parameters	Nph= 4, Dmin=1.2 km, Rmss=0 sec, Gp=166°, M-type=duration magnitude (Md), Version=2
Source	University of Utah Seismograph Stations
Event ID	uu04221852

Location Maps:
2-degree
NEIC Maps

Topo map centered at earthquake
(This link takes you offsite. Not all regions have topo maps available.)

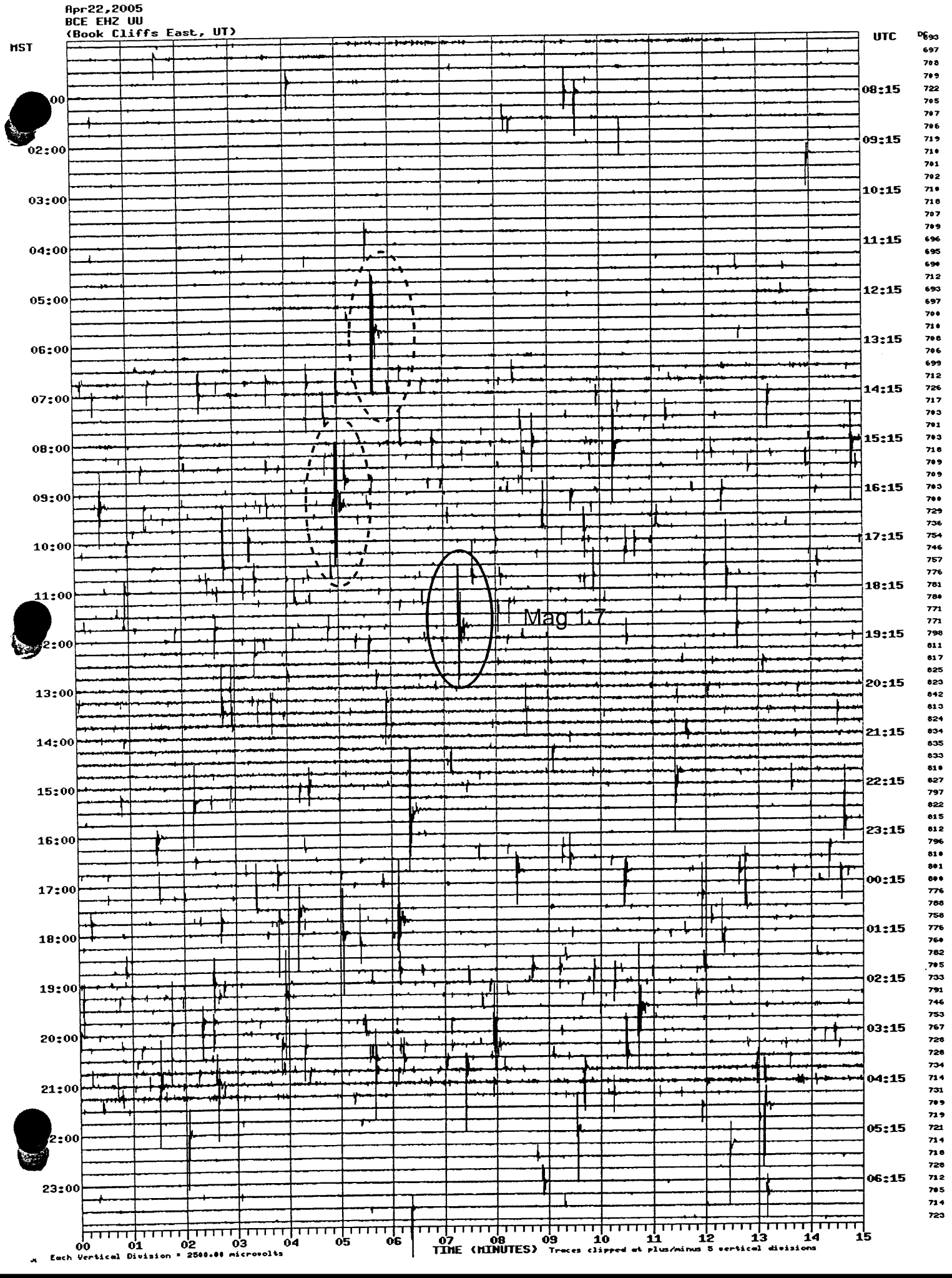
Did you feel it?
Report shaking and damage at your location. You can also view a map displaying accumulated data from your report and others.

Historical Moment Tensor Solutions

Seismic Hazard Map

Historical Seismicity

Theoretical P-Wave Travel Times


Apr22,2005
BCE EHZ UU
(Book Cliffs East, UT)
MST
UTC
DC
Mag 1.7
TIME (MINUTES)
Each Vertical Division = 2500.00 microvolts
Traces clipped at plus/minus 5 vertical divisions

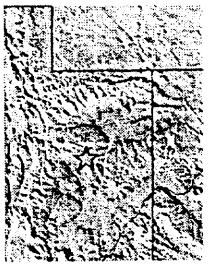
USGS
Earthquake Hazards Program

Recent Earthquake Activity in the USA

Magnitude 1.7 - UTAH
2005 April 25 16:20:06 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 16:20:06 (UTC) on Monday, April 25, 2005. The magnitude 1.7 event has been located in UTAH. The hypocentral depth was poorly constrained. (This event has been reviewed by a seismologist.)



Magnitude	**1.7**
Date-Time	**Monday, April 25, 2005 at 16:20:06 (UTC)** = Coordinated Universal Time **Monday, April 25, 2005 at 10:20:06 AM** 9:20 MST = local time at epicenter
Location	39.615°N, 110.382°W
Depth	0.1 km (~0.1 mile) (poorly constrained)
Region	**UTAH**
Distances	7 km (4 miles) NNE (13°) from **Sunnyside, UT** 9 km (5 miles) NNE (22°) from **East Carbon, UT** 31 km (19 miles) ENE (74°) from **Wellington, UT** 36 km (23 miles) E (87°) from **Price, UT** 130 km (80 miles) ESE (122°) from **Provo, UT** 180 km (112 miles) SE (134°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 1.7 km (1.1 miles); depth +/- 1.9 km (1.2 miles)
Parameters	Nph= 6, Dmin=2.3 km, Rmss=0.28 sec, Gp=176°, M-type=duration magnitude (Md), Version=2
Source	University of Utah Seismograph Stations
Event ID	uu04251620

Location Maps:
2-degree
NEIC Maps

Topo map centered at earthquake
(This link takes you offsite. Not all regions have topo maps available.)

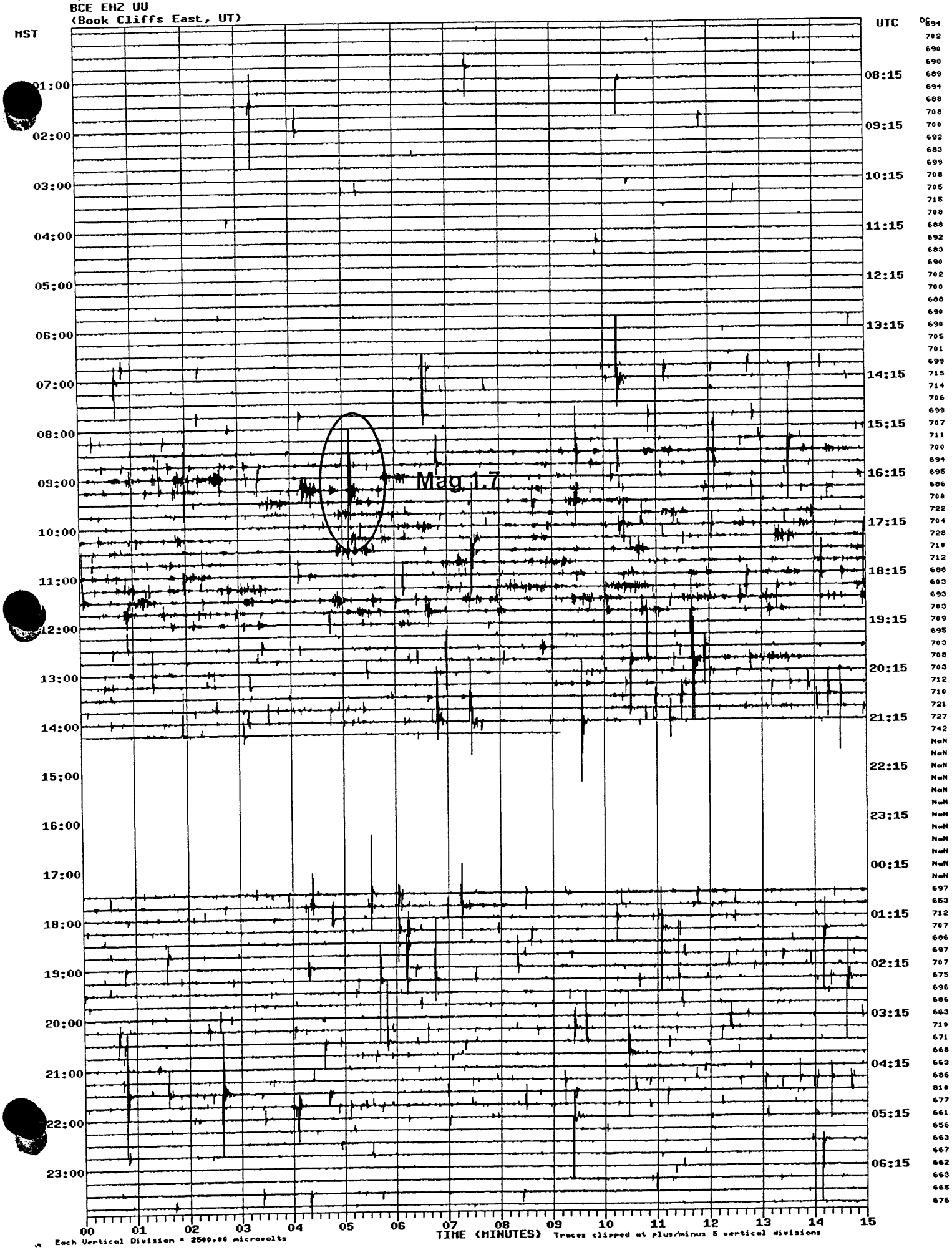
Did you feel it?
Report shaking and damage at your location. You can also view a map displaying accumulated data from your report and others.

Historical Moment Tensor Solutions

Seismic Hazard Map

Historical Seismicity

Apr25,2005
BCE EHZ UU
(Book Cliffs East, UT)



USGS
Earthquake Hazards Program

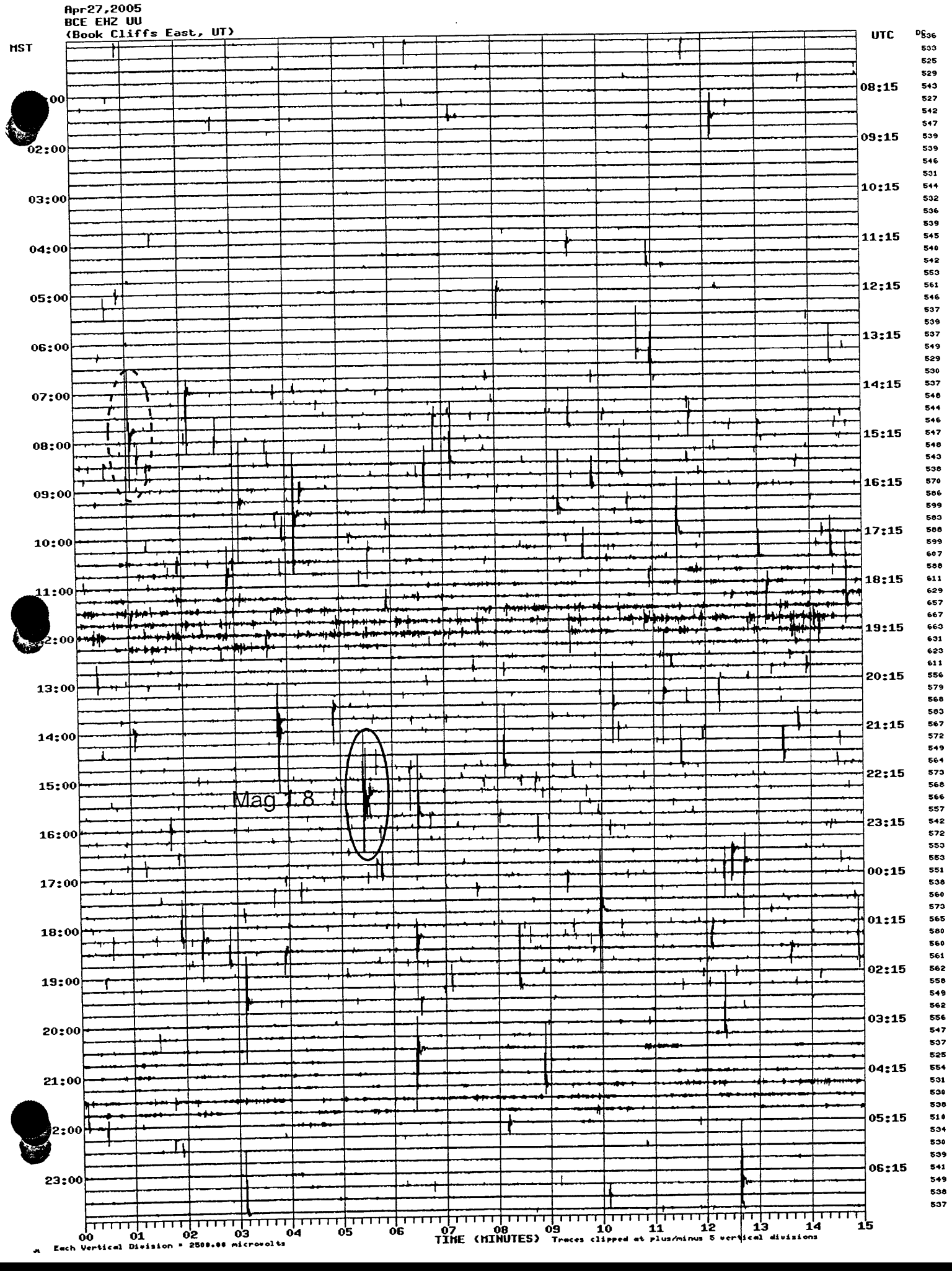
Recent Earthquake Activity in the USA

Magnitude 1.8 - UTAH
2005 April 27 22:20:25 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 22:20:25 (UTC) on Wednesday, April 27, 2005. The magnitude 1.8 event has been located in UTAH. The hypocentral depth was estimated to be 1 km (0.4 mile). (This event has been reviewed by a seismologist.)

Magnitude	**1.8**
Date-Time	**Wednesday, April 27, 2005 at 22:20:25 (UTC)** = Coordinated Universal Time **Wednesday, April 27, 2005 at 4:20:25 PM** = local time at epicenter
Location	39.607°N, 110.396°W
Depth	0.6 km (~0.4 mile)
Region	**UTAH**
Distances	6 km (4 miles) N (4°) from **Sunnyside, UT** 7 km (5 miles) NNE (15°) from **East Carbon, UT** 30 km (18 miles) ENE (75°) from **Wellington, UT** 35 km (22 miles) E (89°) from **Price, UT** 129 km (80 miles) ESE (123°) from **Provo, UT** 180 km (112 miles) SE (135°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 0.6 km (0.4 miles); depth +/- 0.5 km (0.3 miles)
Parameters	Nph= 6, Dmin=1.3 km, Rmss=0.08 sec, Gp=169°, M-type=duration magnitude (Md), Version=2
Source	University of Utah Seismograph Stations


Apr27,2005
BCE EHZ UU
(Book Cliffs East, UT)
MST
UTC
Mag 1.8
TIME (MINUTES)
Each Vertical Division = 2500.00 microvolts
Traces clipped at plus/minus 5 vertical divisions

Recent Earthquakes in the Intermountain West

== PRELIMINARY EARTHQUAKE REPORT==

University of Utah Seismograph Stations, Salt Lake City, Utah

Version #2: This report supersedes any earlier reports of this earthquake.

This event has been reviewed by a data analyst.

A micro earthquake occurred on Friday, 29 April 2005 at 10:40:58PM (MDT).
The magnitude 0.9 event occurred 7 km (4 miles) N of Sunnyside, UT.
The hypocentral depth is 0.1 km (0.1 miles).

Magnitude 0.9 - coda duration magnitude (Mcd)

Time Friday, 29 April 2005 at 10:40:58PM (MDT) = 9:40 = 21:40 PST
Saturday, 30 April 2005 at 4:40:58 (UTC)

Location from **Sunnyside, UT** - 7 km (4 miles) N (4 degrees)
from **E. Carbon City, UT** - 8 km (5 miles) NNE (21 degrees)
from **Wellington, UT** - 31 km (19 miles) ENE (75 degrees)
from **Price, UT** - 37 km (23 miles) E (87 degrees)

Coordinates 39 deg. 36.9 min. N (39.615N), 110 deg. 22.8 min. W (110.381W)

Depth 0.1 km (0.1 miles)

Quality Fair

Parameters Nph= 6, Dmin=2.4 km, Rmss=0.29 sec, Erho=1.4 km, Erzz=1.2 km, Gp=176.4 degrees (parameter info)

Event ID# uu04300440

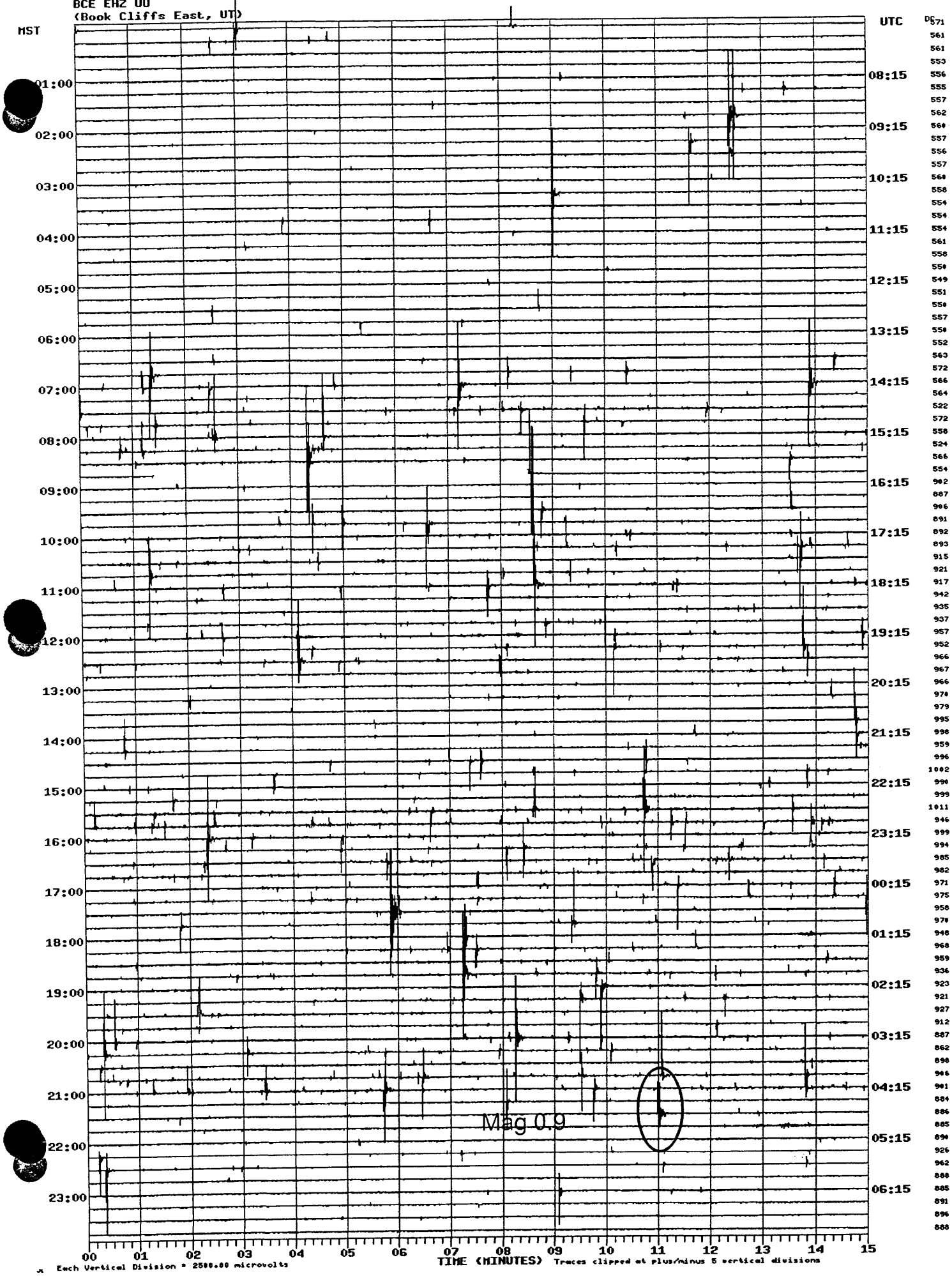
Additional Information map

[Index map || big earthquake list || all earthquake list || glossary of terms || top of page]

Data Sources:

Utah Region + Yellowstone National Park Region = University of Utah Seismograph Stations
a member of the Advanced National Seismic System (ANSS)

Apr29,2005
BCE EHZ UU
(Book Cliffs East, UT)



USGS
Earthquake Hazards Program

Recent Earthquake Activity in the USA

Magnitude 1.6 - UTAH
2005 May 3 22:07:51 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 22:07:51 (UTC) on Tuesday, May 3, 2005. The magnitude 1.6 event has been located in UTAH. The hypocentral depth was estimated to be 0.4 km (0.2 mile). (This event has been reviewed by a seismologist.)

Magnitude **1.6**

Date-Time **Tuesday, May 3, 2005 at 22:07:51 (UTC)**
= Coordinated Universal Time
Tuesday, May 3, 2005 at 4:07:51 PM = 3:07:51 MST 15:07
= local time at epicenter

Location 39.612°N, 110.397°W

Depth 0.4 km (~0.2 mile)

Region **UTAH**

Distances 7 km (4 miles) N (3°) from **Sunnyside, UT**
8 km (5 miles) NNE (14°) from **East Carbon, UT**
30 km (18 miles) ENE (74°) from **Wellington, UT**
35 km (22 miles) E (88°) from **Price, UT**
129 km (80 miles) ESE (123°) from **Provo, UT**
180 km (112 miles) SE (135°) from **Salt Lake City, UT**

Location Uncertainty horizontal +/- 0.6 km (0.4 miles); depth +/- 0.4 km (0.2 miles)

Parameters Nph= 7, Dmin=1 km, Rmss=0.1 sec, Gp=166°,
M-type=duration magnitude (Md), Version=2

Source University of Utah Seismograph Stations

Event ID uu05032207

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- ( ) 1:100K Series
- ( ) 1:250K Series

Map Size
- (●) Small
- ( ) Medium
- ( ) Large

View Scale
1 : 100,000

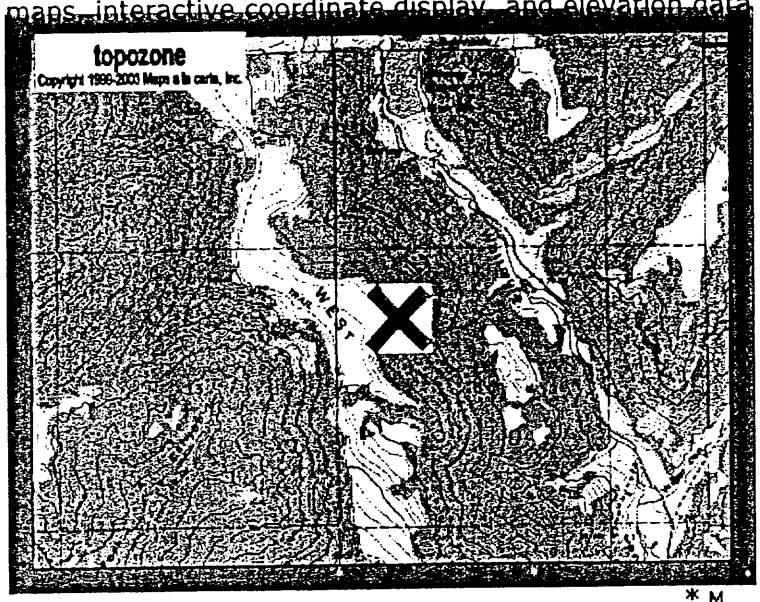
Update Map

Coordinate Format
DD.DDD

Coordinate Datum
NAD27

☑ Show target
Email this map
Bookmark this map
Print this map

39.6120°N, 110.3970°W (NAD27)
USGS **Sunnyside** Quad
View *TopoZone Pro* aerial photos, shaded relief, street maps, interactive coordinate display, and elevation data



0 0.6 1.2 1.8 2.4 3 km
0 0.4 0.8 1.2 1.6 2 mi

* M
G

M=12.499
G=0.384
What's This?

1.6
May 3
22:07:51 UTC

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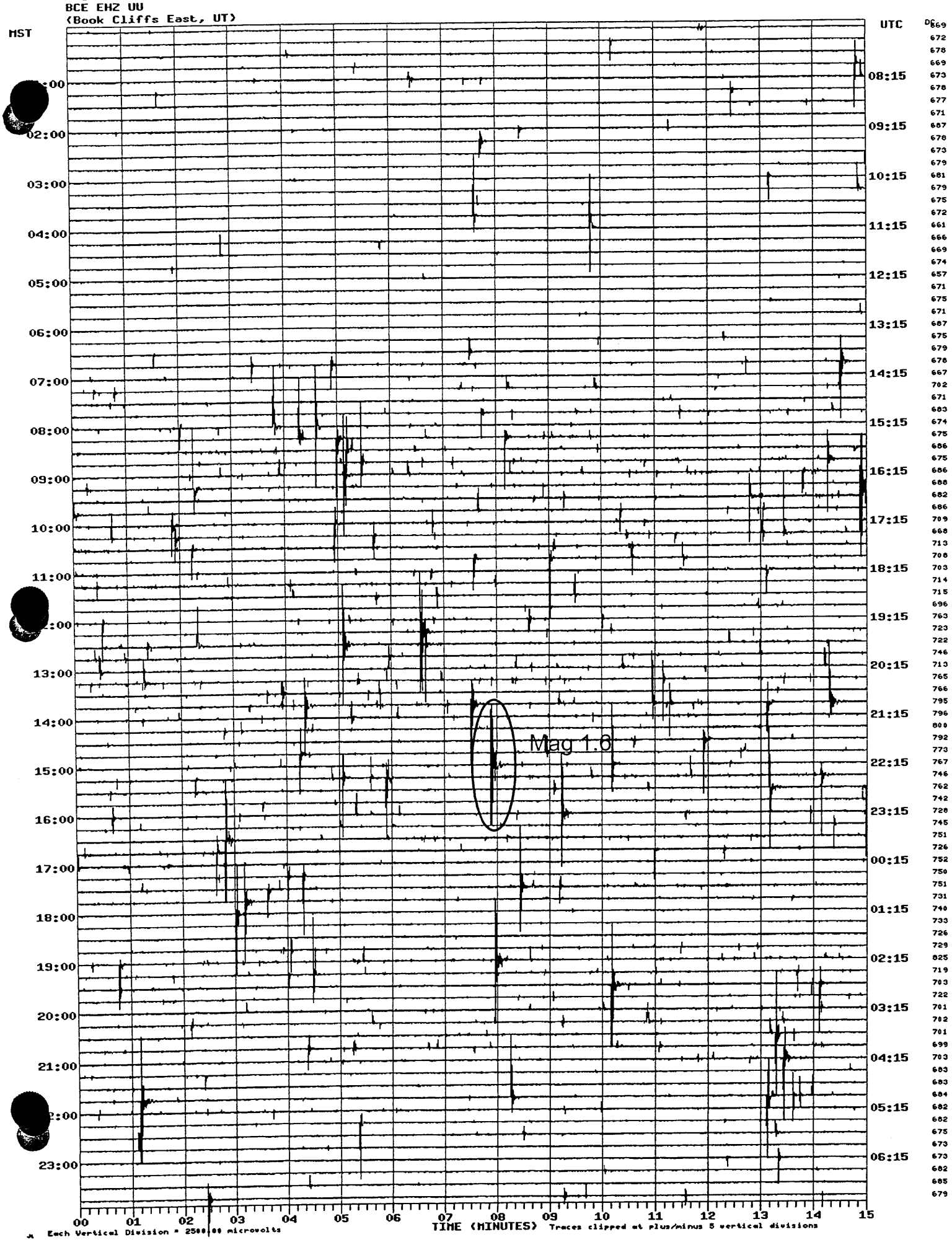
May 3,2005
BCE EHZ UU
(Book Cliffs East, UT)



USGS
Earthquake Hazards Program

Recent Earthquake Activity in the USA

Magnitude 2.0 - UTAH
2005 May 10 19:41:50 UTC

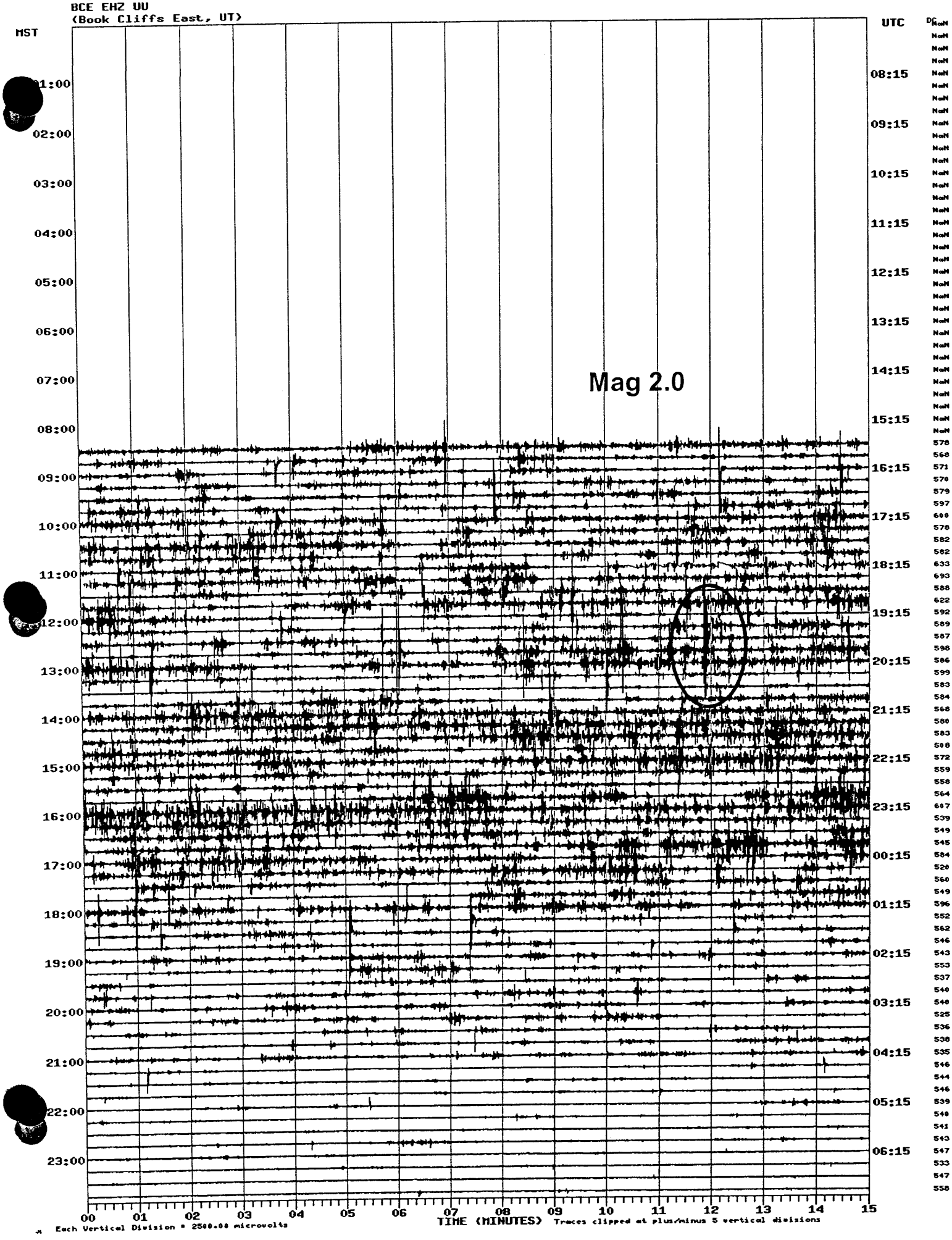
Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 19:41:50 (UTC) on Tuesday, May 10, 2005. The magnitude 2.0 event has been located in UTAH. The hypocentral depth was poorly constrained. (This event has been reviewed by a seismologist.)

Magnitude	**2.0**
Date-Time	**Tuesday, May 10, 2005 at 19:41:50 (UTC)** = Coordinated Universal Time **Tuesday, May 10, 2005 at 1:41:50 PM** = 12:41 MST = local time at epicenter
Location	39.601°N, 110.397°W
Depth	0.5 km (~0.3 mile) (poorly constrained)
Region	**UTAH**
Distances	5 km (3 miles) N (4°) from **Sunnyside, UT** 7 km (4 miles) NNE (16°) from **East Carbon, UT** 29 km (18 miles) ENE (76°) from **Wellington, UT** 35 km (22 miles) E (90°) from **Price, UT** 129 km (80 miles) ESE (123°) from **Provo, UT** 181 km (112 miles) SE (135°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 0.8 km (0.5 miles); depth +/- 0.7 km (0.4 miles)
Parameters	Nph= 6, Dmin=1.7 km, Rmss=0.13 sec, Gp=169°, M-type=duration magnitude (Md), Version=2
Source	University of Utah Seismograph Stations
Event ID	uu05101941

Location Maps:
2-degree

May10,2005
BCE EHZ UU
(Book Cliffs East, UT)



USGS
Earthquake Hazards Program

Recent Earthquake Activity in the USA

Magnitude 1.3 - UTAH
2005 June 3 01:38:54 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 01:38:54 (UTC) on Friday, June 3, 2005. The magnitude 1.3 event has been located in UTAH. The hypocentral depth was poorly constrained. (This event has been reviewed by a seismologist.)

Magnitude	**1.3**
Date-Time	**Friday, June 3, 2005 at 01:38:54 (UTC)** = Coordinated Universal Time **Thursday, June 2, 2005 at 7:38:54 PM** = local time at epicenter 18:38 MST
Location	39.621°N, 110.398°W
Depth	0 km (~0 mile) (poorly constrained)
Region	**UTAH**
Distances	8 km (5 miles) N (2°) from **Sunnyside, UT** 9 km (6 miles) N (11°) from **East Carbon, UT** 30 km (18 miles) ENE (72°) from **Wellington, UT** 35 km (22 miles) E (86°) from **Price, UT** 128 km (80 miles) ESE (122°) from **Provo, UT** 179 km (111 miles) SE (134°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 1.6 km (1.0 miles); depth +/- 0.9 km (0.6 miles)
Parameters	Nph= 5, Dmin=1.2 km, Rmss=0.23 sec, Gp=158°, M-type=duration magnitude (Md), Version=2
Source	University of Utah Seismograph Stations
Event ID	uu06030138

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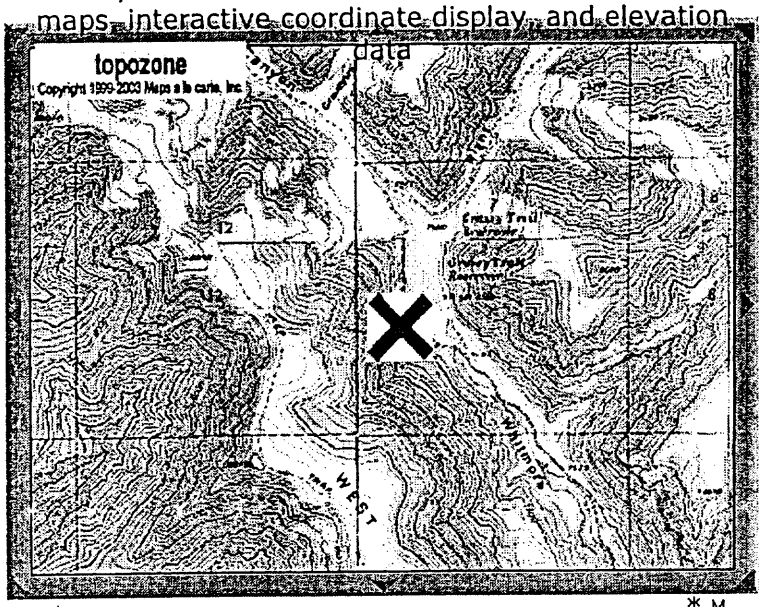
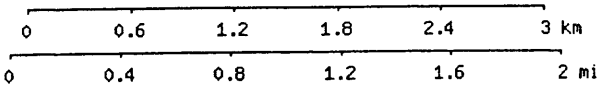
39.6213°N, 110.3983°W (NAD27)
USGS **Sunnyside** Quad
View *TopoZone Pro* aerial photos, shaded relief, street maps, interactive coordinate display, and elevation data

Mag 1.3
June 3
1:38:54 UTC





M=12.501
G=0.383
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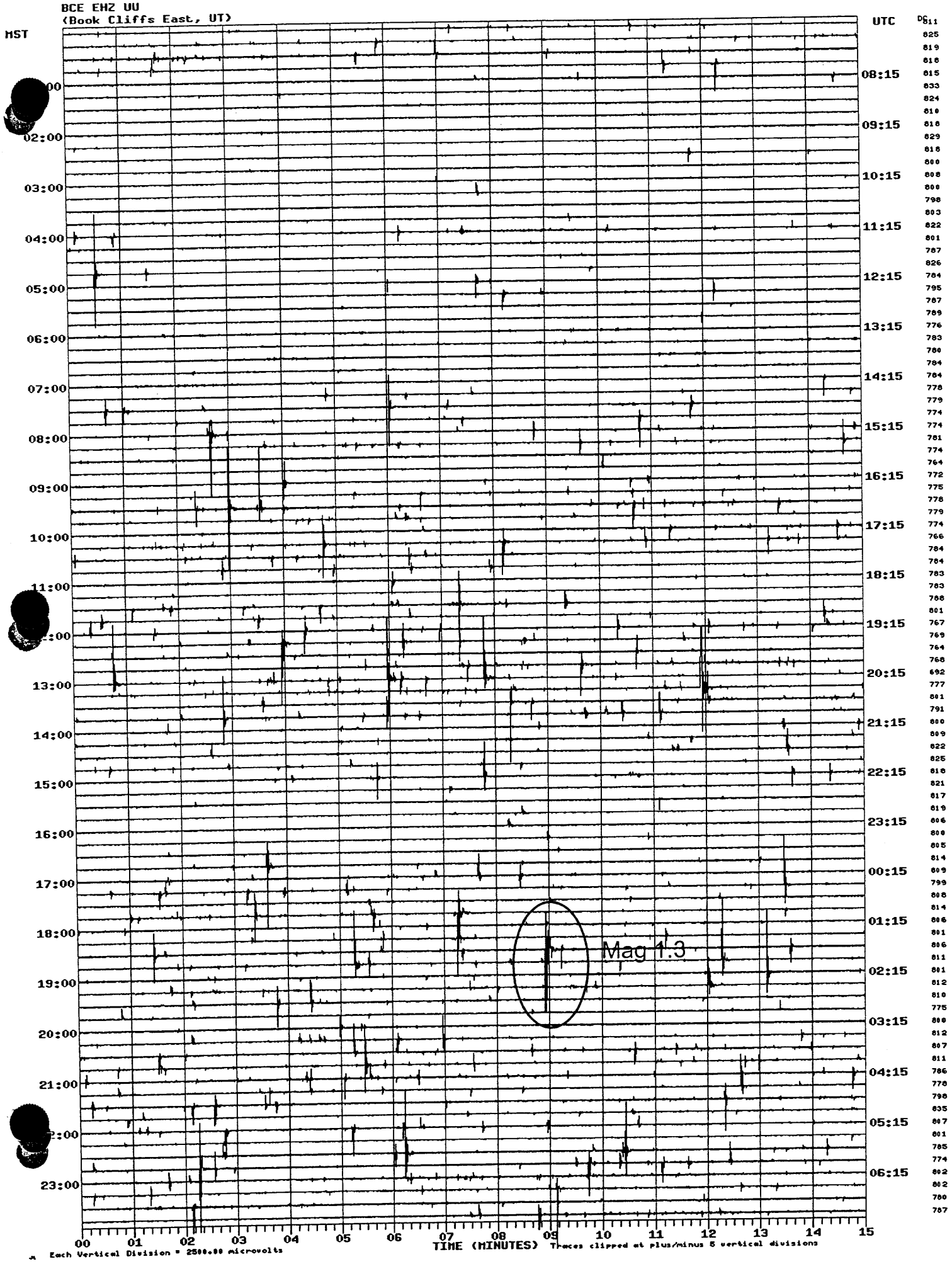
Jun 2,2005
BCE EHZ UU
(Book Cliffs East, UT)



Each Vertical Division = 2500.00 microvolts

Traces clipped at plus/minus 5 vertical divisions

USGS
Earthquake Hazards Program

Recent Earthquake Activity in the USA

Magnitude 1.6 - UTAH
2005 June 14 11:16:17 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 11:16:17 (UTC) on Tuesday, June 14, 2005. The magnitude 1.6 event has been located in UTAH. The hypocentral depth was poorly constrained. (This event has been reviewed by a seismologist.)

Magnitude **1.6** Hill and Dan 4:13

Date-Time **Tuesday, June 14, 2005 at 11:16:17 (UTC)**
= Coordinated Universal Time
Tuesday, June 14, 2005 at 5:16:17 AM = 4:16 MST
= local time at epicenter

Location 39.606°N, 110.395°W

Depth 0.4 km (~0.2 mile) (poorly constrained)

Region **UTAH**

Distances 6 km (4 miles) N (5°) from **Sunnyside, UT**
7 km (4 miles) NNE (16°) from **East Carbon, UT**
30 km (18 miles) ENE (76°) from **Wellington, UT**
35 km (22 miles) E (89°) from **Price, UT**
129 km (80 miles) ESE (123°) from **Provo, UT**
180 km (112 miles) SE (135°) from **Salt Lake City, UT**

Location Uncertainty horizontal +/- 0.6 km (0.4 miles); depth +/- 0.7 km (0.4 miles)

Parameters Nph= 9, Dmin=1.5 km, Rmss=0.15 sec, Gp=169°,
M-type=local magnitude (ML), Version=2

Source University of Utah Seismograph Stations

Event ID uu06141116

Location Maps:
2-degree

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39.6057°N, 110.3948°W (NAD27)

USGS **Sunnyside** Quad

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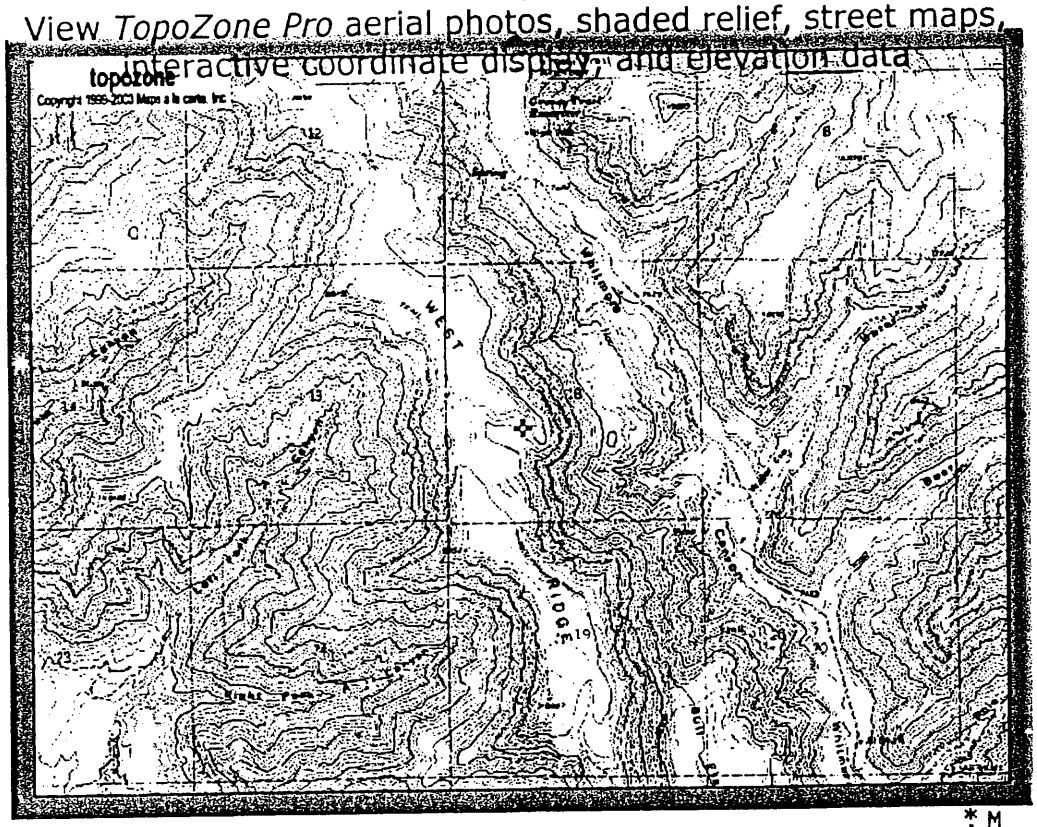

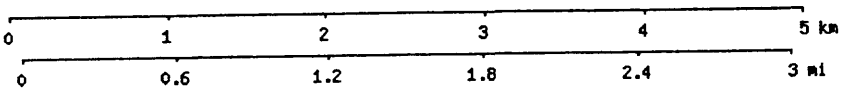

M=12.497
G=0.385
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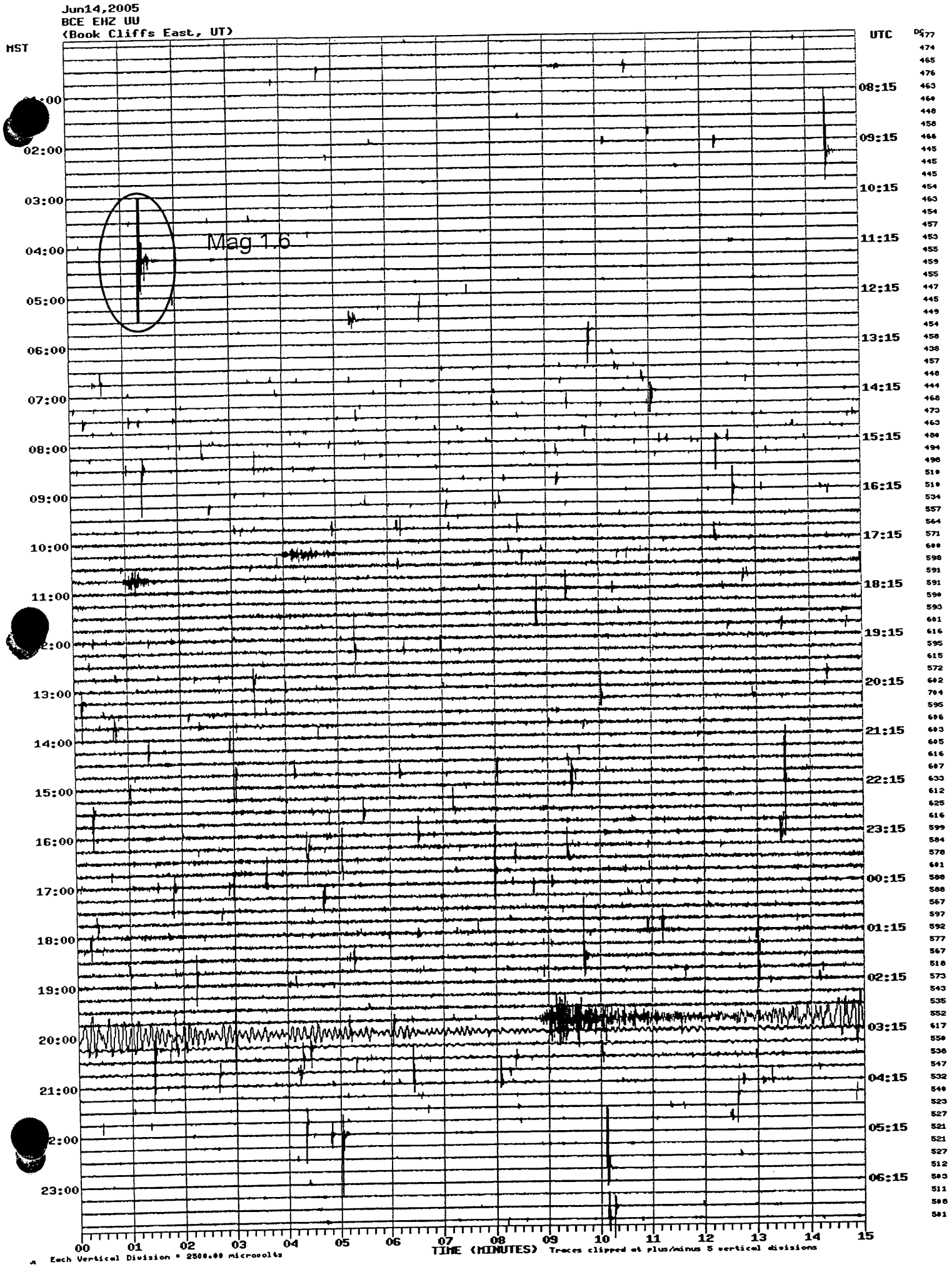
Jun14,2005
BCE EHZ UU
(Book Cliffs East, UT)
MST
UTC
Mag 1.6
TIME (MINUTES)
Each Vertical Division = 2500.00 microvolts
Traces clipped at plus/minus 5 vertical divisions

USGS
Earthquake Hazards Program

Recent Earthquake Activity in the USA

Magnitude 1.6 - UTAH
2005 July 9 03:43:54 UTC

Preliminary Earthquake Report
University of Utah Seismograph Stations

A micro earthquake occurred at 03:43:54 (UTC) on Saturday, July 9, 2005. The magnitude 1.6 event has been located in UTAH. The hypocentral depth was estimated to be 1 km (1 mile). (This event has been reviewed by a seismologist.)

Magnitude	**1.6**
Date-Time	**Saturday, July 9, 2005 at 03:43:54 (UTC)** = Coordinated Universal Time **Friday, July 8, 2005 at 9:43:54 PM** = local time at epicenter
Location	39.605°N, 110.392°W
Depth	1.1 km (~0.7 mile)
Region	**UTAH**
Distances	6 km (4 miles) N (7°) from **Sunnyside, UT** 7 km (5 miles) NNE (18°) from **East Carbon, UT** 30 km (19 miles) ENE (76°) from **Wellington, UT** 36 km (22 miles) E (89°) from **Price, UT** 129 km (80 miles) ESE (123°) from **Provo, UT** 180 km (112 miles) SE (135°) from **Salt Lake City, UT**
Location Uncertainty	horizontal +/- 0.6 km (0.4 miles); depth +/- 0.5 km (0.3 miles)
Parameters	Nph= 6, Dmin=1.6 km, Rmss=0.1 sec, Gp=173°, M-type=duration magnitude (Md), Version=2
Source	University of Utah Seismograph Stations
Event ID	uu07090343

Location Maps:
2-degree
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39.6055°N, 110.3920°W (NAD27)
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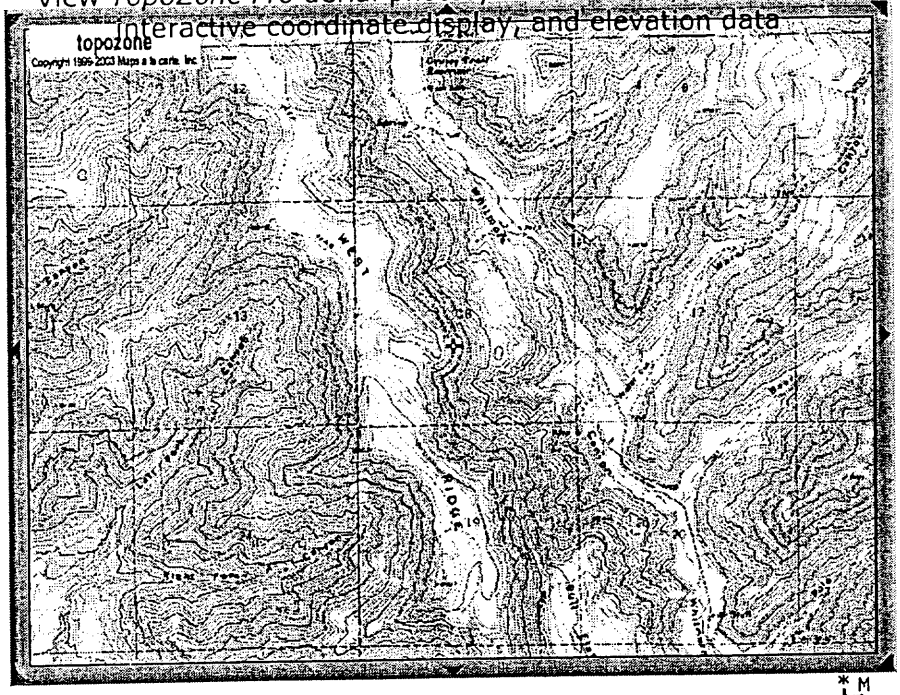

0 1 2 3 4 5 km
0 0.6 1.2 1.8 2.4 3 mi

M
G
M=12.496
G=0.387
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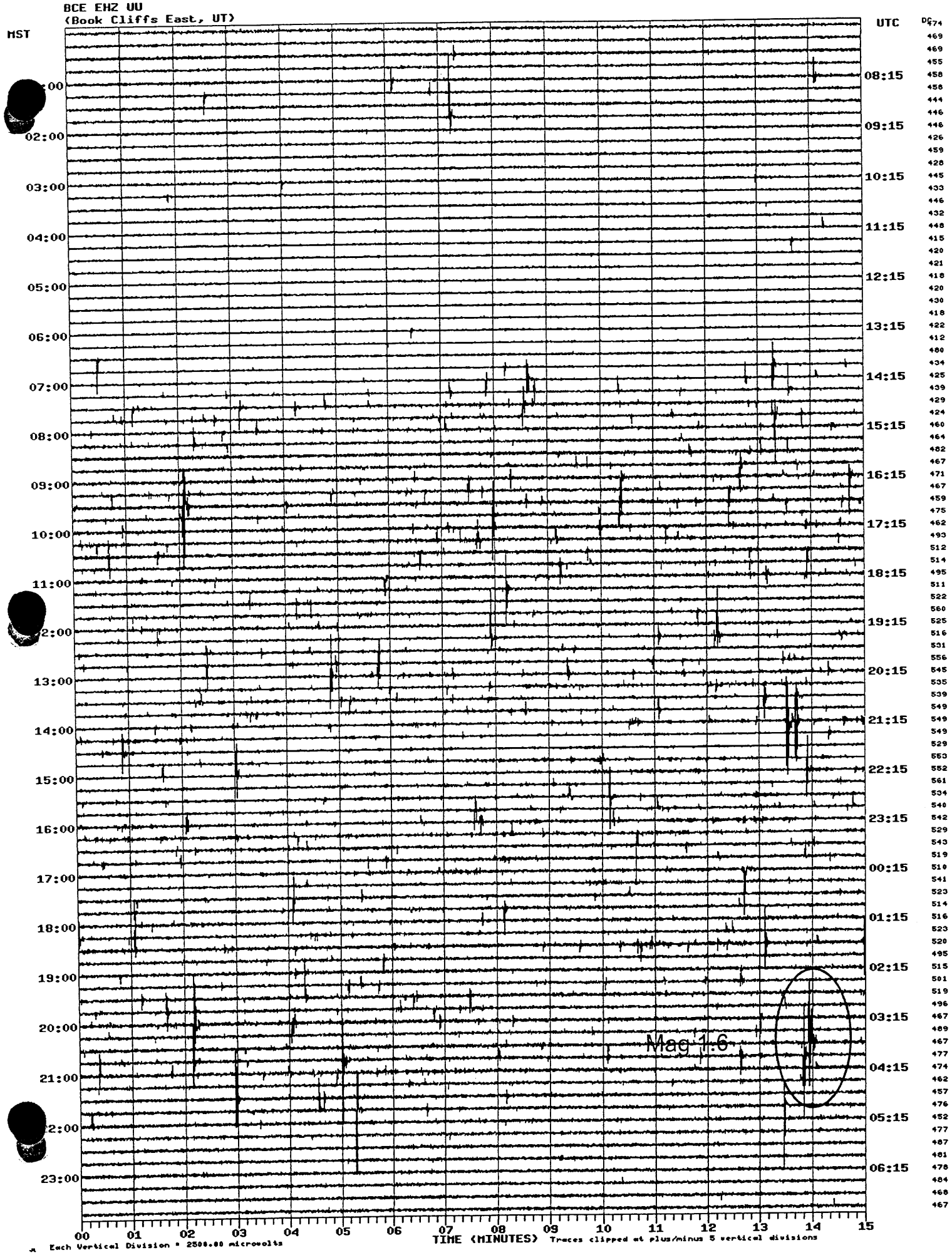


Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\1s11_m22

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
LOG	BE9690	Sep 11 /04 10:25:12	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	Sep 11 /04 12:31:27	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Sep 11 /04 12:31:48	1.27	0.397	1.14	1.34	Long	0.0862	0.0331	0.0547		Man made event
W	BE9690	Sep 17 /04 08:41:54	0.730	0.333	0.397	0.863	Tran	0.0514	0.0298	0.0331		Man made event
W	BE9690	Sep 18 /04 17:34:18	0.302	0.429	0.683	0.809	Long	0.0315	0.0232	0.0464		Man made event
LOG	BE9690	Sep 18 /04 17:39:32	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Sep 18 /04 17:41:32	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9690	Oct 22 /04 09:40:51	0.317	0.413	0.698	0.734	Long	0.0166	0.0182	0.0282		Man made event
LOG	BE9690	Nov 18 /04 15:01:56	***	***	***	***	***	***	***	***	Remote Stop	No events recorded. (Remote Exit)
LOG	BE9690	Nov 18 /04 15:02:41	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Remote Exit)
LOG	BE9690	Nov 18 /04 15:03:26	***	***	***	***	***	***	***	***	Remote Stop	No events recorded. (Remote Exit)
LOG	BE9690	Nov 18 /04 15:04:34	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Remote Exit)
LOG	BE9690	Nov 18 /04 15:06:17	***	***	***	***	***	***	***	***	Remote Stop	No events recorded. (Remote Exit)
LOG	BE9690	Nov 18 /04 15:07:24	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Remote Exit)
LOG	BE9690	Nov 18 /04 15:17:12	***	***	***	***	***	***	***	***	Remote Stop	No events recorded. (Remote Exit)
LOG	BE9690	Nov 18 /04 15:18:00	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9690	Nov 18 /04 15:34:59	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Nov 18 /04 15:37:55	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9690	Nov 22 /04 15:50:22	***	***	***	***	***	***	***	***	Stop Monitoring	Start Monitoring
LOG	BE9690	Nov 22 /04 16:34:25	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9690	Nov 23 /04 14:35:00	***	***	***	***	***	***	***	***	Stop Monitoring	Event recorded. (Keyboard Exit)
LOG	BE9690	Nov 23 /04 14:38:06	***	***	***	***	***	***	***	***	Start Monitoring	Event recorded. (Keyboard Exit)
LOG	BE9690	Nov 23 /04 14:38:13	***	***	***	***	***	***	***	***	Stop Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9690	Jan 8 /05 14:04:15	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
W	BE9689	Jan 21 /05 17:53:34	0.603	0.222	0.317	0.635	Tran	0.00663	0.00663	0.0133		First MIS Event
W	BE9689	Jan 26 /05 21:44:51	1.03	0.381	0.476	1.10	Tran	0.00994	0.00663	0.00829		
W	BE9689	Jan 31 /05 10:29:24	0.635	0.286	0.349	0.689	Tran	0.00829	0.00663	0.0149		
W	BE9689	Jan 31 /05 15:19:02	0.619	0.254	0.302	0.681	Tran	0.00663	0.00663	0.0133		
W	BE9689	Jan 31 /05 17:35:42	0.714	0.349	0.397	0.777	Tran	0.00994	0.00663	0.0133		
LOG	BE9690	Feb 4 /05 09:45:14	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Feb 4 /05 09:52:16	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9690	Feb 4 /05 10:06:07	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Feb 4 /05 10:07:10	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9690	Feb 4 /05 10:11:39	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Feb 4 /05 10:12:25	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
W	BE9689	Feb 5 /05 01:10:23	0.873	0.381	0.444	0.889	Tran	0.00663	0.00663	0.0149		
W	BE9689	Feb 5 /05 15:44:16	0.968	0.524	0.714	1.01	Long	0.00829	0.00663	0.0149		Earthquake mag 1.6 UTC 22:58:44
W	BE9689	Feb 7 /05 14:27:39	0.905	0.587	0.556	0.912	Tran	0.00829	0.00829	0.0149		mag 1.6 UTC 21:42:19
LOG	BE9690	Feb 8 /05 13:00:00	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Feb 8 /05 13:12:47	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9690	Feb 8 /05 13:13:05	0.222	0.794	0.175	0.797	Vert	0.0133	0.0315	0.00829		
LOG	BE9690	Feb 8 /05 13:14:06	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Feb 8 /05 13:14:50	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)

Printed: July 21, 2005 (V 4.37 - 4.37)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\1s11_m22

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
LOG	BE9690	Feb 8 /05 13:16:07	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
W	BE9689	Feb 8 /05 18:37:29	0.619	0.286	0.413	0.681	Tran	0.00663	0.00663	0.0149		
W	BE9689	Feb 8 /05 21:15:55	1.40	0.683	1.02	1.49	Tran	0.00994	0.00829	0.0149		mag 1.6 UTC 4:30:43 on 2/9/05
W	BE9689	Feb 9 /05 11:03:06	0.667	0.302	0.413	0.714	Tran	0.00663	0.00663	0.0149		
W	BE9689	Feb 9 /05 13:21:04	0.603	0.254	0.460	0.658	Tran	0.00663	0.00663	0.0149		
W	BE9689	Feb 9 /05 15:00:12	0.937	0.444	0.571	1.04	Tran	0.00663	0.00663	0.0182		
W	BE9689	Feb 10 /05 01:55:17	0.651	0.302	0.492	0.711	Tran	0.00663	0.00663	0.0133		
W	BE9689	Feb 14 /05 14:34:07	1.29	0.540	1.05	1.38	Tran	0.00994	0.00829	0.0149		
W	BE9689	Feb 15 /05 14:03:57	1.76	1.98	0.778	2.08	Tran	0.229	0.202	0.0911		
LOG	BE9689	Feb 15 /05 14:04:56	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Feb 15 /05 15:25:47	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	Feb 15 /05 15:25:47	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	Feb 15 /05 15:25:47	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	Feb 15 /05 15:25:47	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Feb 15 /05 15:36:16	0.397	0.746	0.317	0.757	Vert	0.0414	0.0895	0.0282		
W	BE9689	Feb 15 /05 15:38:31	1.22	1.16	0.635	1.41	Vert	0.123	0.0994	0.101		
W	BE9689	Feb 16 /05 19:24:22	0.683	0.270	0.460	0.721	Tran	0.00663	0.00663	0.0133		
LOG	BE9690	Feb 17 /05 12:06:17	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
W	BE9689	Feb 17 /05 14:45:20	1.00	0.444	0.698	1.09	Long	0.00994	0.00829	0.0149		
W	BE9689	Feb 18 /05 09:56:53	0.952	0.349	0.857	1.03	Long	0.00994	0.00497	0.0149		
W	BE9689	Feb 18 /05 13:52:06	0.746	0.302	0.476	0.767	Tran	0.00994	0.00663	0.0166		
W	BE9689	Feb 19 /05 16:44:46	0.651	0.286	0.524	0.691	Tran	0.00663	0.00663	0.00829		
W	BE9689	Feb 21 /05 21:44:13	1.08	0.349	0.746	1.17	Long	0.00994	0.00663	0.0182		
W	BE9689	Feb 21 /05 21:51:20	0.619	0.206	0.492	0.648	Tran	0.00663	0.00663	0.0166		
W	BE9689	Feb 22 /05 07:54:54	0.794	0.317	0.810	0.965	Long	0.00829	0.00663	0.0149		
LOG	BE9690	Feb 22 /05 12:57:26	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Feb 22 /05 12:57:43	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Feb 22 /05 13:33:59	0.841	0.302	0.889	1.08	Long	0.0116	0.00663	0.0149		
W	BE9689	Feb 22 /05 15:04:25	0.683	0.302	0.667	0.810	Long	0.00663	0.00663	0.00994		
W	BE9689	Feb 22 /05 18:19:08	0.683	0.222	0.619	0.748	Long	0.00829	0.00663	0.0166		
W	BE9689	Feb 22 /05 19:58:37	0.762	0.286	0.492	0.803	Tran	0.00663	0.00663	0.0149		
W	BE9689	Feb 23 /05 09:39:29	0.952	0.333	0.857	1.08	Long	0.00663	0.00663	0.00829		
W	BE9689	Feb 23 /05 12:27:50	1.19	0.397	0.937	1.26	Long	0.00994	0.00663	0.0182		mag 1.7 UTC 19:28:38
W	BE9689	Feb 24 /05 09:40:37	0.714	0.254	0.651	0.780	Long	0.00663	0.00663	0.0149		
W	BE9689	Feb 24 /05 13:23:34	0.667	0.286	0.571	0.727	Tran	0.00663	0.00663	0.00829		
W	BE9689	Feb 25 /05 14:55:59	0.857	0.429	0.730	0.958	Long	0.00829	0.00663	0.00829		
W	BE9689	Feb 25 /05 19:45:53	0.571	0.270	0.635	0.736	Long	0.00663	0.00663	0.0133		
W	BE9689	Feb 26 /05 11:44:44	0.968	0.349	0.889	1.03	Long	0.00829	0.00663	0.0116		
W	BE9689	Feb 28 /05 15:54:45	0.889	0.349	0.778	0.956	Long	0.00829	0.00663	0.0133		
W	BE9690	Mar 1 /05 06:26:47	0.238	0.730	0.476	0.865	Vert	0.0282	0.0746	0.0580		appears man made
W	BE9689	Mar 1 /05 12:07:42	0.984	0.365	0.968	1.20	Long	0.00994	0.00663	0.0166		
W	BE9689	Mar 2 /05 09:27:04	1.35	0.476	1.16	1.45	Long	0.0116	0.00829	0.0166		
W	BE9689	Mar 2 /05 21:14:37	0.841	0.349	0.635	0.890	Tran	0.00663	0.00497	0.00663		

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\1s11_m22

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
W	BE9689	Mar 3 /05 01:28:53	0.730	0.365	0.698	0.847	Long	0.00829	0.00663	0.0116		
W	BE9689	Mar 3 /05 18:31:45	0.635	0.254	0.667	0.776	Long	0.00663	0.00663	0.0149		
W	BE9689	Mar 3 /05 22:03:11	0.508	0.238	0.603	0.700	Long	0.00663	0.00663	0.0116		
W	BE9689	Mar 3 /05 22:21:45	0.556	0.222	0.603	0.708	Long	0.00663	0.00663	0.0149		
W	BE9689	Mar 4 /05 13:35:43	1.29	0.587	1.14	1.45	Tran	0.00994	0.00829	0.0166		
W	BE9689	Mar 5 /05 21:40:37	0.508	0.270	0.667	0.740	Long	0.00663	0.00663	0.0133		
W	BE9689	Mar 6 /05 13:07:43	0.667	0.381	0.762	0.764	Tran	0.00663	0.00663	0.0166		
W	BE9689	Mar 6 /05 20:39:58	0.841	0.365	0.810	0.966	Long	0.00829	0.00663	0.0133		
W	BE9689	Mar 7 /05 21:13:31	1.17	0.429	1.19	1.40	Long	0.0116	0.00829	0.0133		
W	BE9689	Mar 9 /05 02:51:18	0.714	0.270	0.603	0.756	Long	0.00663	0.00663	0.0166		
W	BE9689	Mar 9 /05 13:21:26	0.794	0.365	0.730	0.893	Long	0.00829	0.00663	0.0133		
W	BE9689	Mar 9 /05 21:16:04	0.714	0.508	0.794	0.970	Long	0.00663	0.00829	0.00994		
W	BE9689	Mar 11 /05 17:56:19	1.03	0.413	0.921	1.11	Long	0.00994	0.00663	0.0149		
W	BE9689	Mar 11 /05 19:19:02	0.651	0.429	0.540	0.749	Tran	0.00829	0.00663	0.0149		
W	BE9689	Mar 12 /05 09:44:07	0.524	0.333	0.603	0.702	Long	0.00663	0.00663	0.00994		
W	BE9689	Mar 14 /05 08:39:07	0.619	0.270	0.683	0.735	Tran	0.00829	0.00663	0.0133		
W	BE9689	Mar 14 /05 17:50:07	0.651	0.254	0.635	0.753	Long	0.00663	0.00663	0.00994		
W	BE9689	Mar 15 /05 17:02:39	0.698	0.524	0.698	0.858	Tran	0.00994	0.00994	0.0166		
W	BE9689	Mar 15 /05 20:47:45	1.13	0.714	1.37	1.66	Vert	0.0116	0.00994	0.0166		
W	BE9689	Mar 15 /05 20:58:48	0.730	0.333	0.810	0.927	Long	0.00829	0.00663	0.0149		
W	BE9689	Mar 16 /05 09:26:33	0.571	0.254	0.603	0.682	Long	0.00663	0.00663	0.0166		
W	BE9689	Mar 16 /05 11:53:10	0.603	0.286	0.651	0.755	Long	0.00497	0.00663	0.00829		
W	BE9689	Mar 16 /05 13:34:39	0.683	0.413	0.794	0.996	Tran	0.00994	0.00829	0.0133		
W	BE9689	Mar 16 /05 17:00:06	0.794	0.683	0.381	0.828	Vert	0.00829	0.0116	0.00829		
W	BE9689	Mar 17 /05 00:10:55	0.778	0.397	1.11	1.18	Long	0.00994	0.00829	0.00994		
W	BE9689	Mar 17 /05 00:53:04	0.524	0.302	0.730	0.817	Long	0.00663	0.00663	0.0149		
W	BE9689	Mar 17 /05 05:30:29	0.873	0.476	0.762	0.951	Long	0.00829	0.00663	0.0149		
W	BE9689	Mar 17 /05 17:00:34	0.508	0.302	0.667	0.712	Long	0.00497	0.00829	0.0133		
W	BE9689	Mar 17 /05 18:36:51	0.746	0.286	0.778	0.845	Long	0.00663	0.00829	0.0133		
W	BE9689	Mar 17 /05 22:12:06	0.508	0.286	0.619	0.700	Long	0.00663	0.00663	0.00829		
W	BE9689	Mar 18 /05 00:31:33	0.698	0.317	0.730	0.865	Long	0.00663	0.00663	0.0166		
W	BE9689	Mar 18 /05 11:05:57	0.460	0.302	0.635	0.686	Long	0.00663	0.00663	0.0166		
W	BE9689	Mar 18 /05 12:21:27	1.02	0.476	1.05	1.22	Long	0.00994	0.00829	0.0166		
W	BE9689	Mar 18 /05 21:30:50	0.651	0.302	0.619	0.713	Long	0.00663	0.00663	0.00994		
W	BE9689	Mar 18 /05 22:49:31	0.508	0.238	0.651	0.683	Long	0.00663	0.00663	0.00663		
W	BE9689	Mar 19 /05 09:55:36	0.905	0.413	0.937	1.17	Long	0.00829	0.00663	0.0166		
W	BE9689	Mar 19 /05 17:25:57	0.587	0.333	0.937	0.951	Long	0.00663	0.00663	0.0149		
W	BE9689	Mar 21 /05 02:39:04	0.714	0.619	0.476	0.739	Vert	0.00829	0.00994	0.0149		
W	BE9689	Mar 21 /05 09:27:23	0.524	0.429	0.857	0.948	Long	0.00829	0.00829	0.0116		
LOG	BE9689	Mar 21 /05 15:37:20	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:37:20	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:37:20	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:37:20	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\1s11_m22

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
LOG	BE9689	Mar 21 /05 15:45:08	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:45:08	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:45:08	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:45:08	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:48:50	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:48:50	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:48:50	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:48:50	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 21 /05 15:50:45	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	Mar 21 /05 15:50:45	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	Mar 21 /05 15:50:45	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	Mar 21 /05 15:50:45	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Mar 21 /05 15:54:30	1.10	0.778	1.08	1.53	Tran	0.159	0.0696	0.0679		appears man made
LOG	BE9690	Mar 21 /05 16:19:17	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Mar 21 /05 16:21:50	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
W	BE9689	Mar 22 /05 04:19:01	1.13	0.492	1.30	1.58	Tran	0.00994	0.00663	0.0149		
W	BE9689	Mar 22 /05 10:24:39	0.556	0.302	0.746	0.754	Long	0.00829	0.00829	0.0182		
LOG	BE9690	Mar 22 /05 12:27:10	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
W	BE9689	Mar 22 /05 14:02:45	0.349	0.492	0.619	0.846	Long	0.0116	0.0133	0.0149		appears man made
W	BE9689	Mar 22 /05 14:04:34	2.95	2.05	1.73	3.66	Vert	0.275	0.202	0.252		appears man made
LOG	BE9689	Mar 22 /05 14:05:30	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 22 /05 14:05:30	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 22 /05 14:05:30	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 22 /05 14:05:30	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\2m22_a27

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
LOG	BE9690	Mar 22 /05 13:03:43	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9689	Mar 22 /05 14:59:54	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	Mar 22 /05 14:59:54	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9690	Mar 22 /05 18:14:47	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Mar 22 /05 18:36:15	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
W	BE9689	Mar 22 /05 19:08:42	0.698	0.730	0.937	1.07	Vert	0.0116	0.00994	0.0166		
W	BE9689	Mar 23 /05 08:34:44	0.587	0.317	0.921	1.03	Long	0.00663	0.00663	0.0133		
LOG	BE9690	Mar 23 /05 09:58:39	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Mar 23 /05 10:00:11	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Mar 23 /05 19:39:45	0.952	0.429	1.29	1.48	Long	0.00994	0.00994	0.0182		
W	BE9689	Mar 23 /05 19:49:04	0.635	0.603	0.873	0.992	Long	0.00994	0.0116	0.0166		
W	BE9689	Mar 24 /05 00:00:28	1.41	0.476	1.41	1.58	Tran	0.00994	0.00994	0.0182		
W	BE9690	Mar 24 /05 18:01:54	0.873	0.810	0.873	1.25	Vert	0.00663	0.00663	0.00663		Both, EQ mag 1.7 UTC 1:02:00 3/25/05
W	BE9689	Mar 24 /05 18:01:55	2.22	0.841	2.29	2.71	Vert	0.0166	0.0116	0.0199		Both, EQ mag 1.7 UTC 1:02:00 3/25/05
W	BE9689	Mar 26 /05 14:05:50	0.571	0.397	0.746	0.832	Long	0.00829	0.00829	0.0149		
W	BE9689	Mar 28 /05 18:05:55	0.937	0.444	1.29	1.46	Long	0.00829	0.00829	0.0166		
W	BE9689	Mar 29 /05 18:47:32	0.540	0.365	0.778	0.855	Long	0.00663	0.00663	0.0116		
W	BE9689	Mar 29 /05 19:51:29	1.02	0.619	1.51	1.73	Tran	0.0116	0.0116	0.0182		
W	BE9689	Mar 30 /05 09:48:26	0.905	0.524	0.873	0.987	Long	0.00829	0.00994	0.0116		
W	BE9689	Mar 30 /05 12:29:55	0.444	0.603	0.349	0.608	Vert	0.00829	0.00994	0.00994		
W	BE9689	Mar 30 /05 21:30:09	1.30	0.651	1.46	1.64	Vert	0.0116	0.0116	0.0199		
W	BE9689	Mar 31 /05 07:57:55	0.540	0.222	0.619	0.683	Long	0.00663	0.00497	0.0133		
W	BE9689	Mar 31 /05 14:58:12	0.413	0.429	1.02	1.07	Long	0.00829	0.00994	0.0133		
W	BE9689	Mar 31 /05 20:04:41	0.698	0.476	1.32	1.50	Long	0.00663	0.00829	0.0133		
W	BE9689	Mar 31 /05 21:20:05	0.524	0.476	1.14	1.26	Long	0.00663	0.00829	0.0149		
W	BE9689	Apr 1 /05 14:42:46	0.349	0.667	0.413	0.668	Vert	0.00663	0.00994	0.00829		
W	BE9689	Apr 1 /05 14:46:02	0.444	0.476	1.10	1.15	Long	0.00829	0.00663	0.0116		
W	BE9690	Apr 2 /05 16:35:56	0.683	0.365	0.365	0.705	Tran	0.00497	0.00829	0.00663		Both, EQ mag 1.8 UTC 23:36:56
W	BE9689	Apr 2 /05 16:35:58	0.683	0.635	1.30	1.32	Vert	0.00994	0.0133	0.0166		Both, EQ mag 1.8 UTC 23:36:56
W	BE9689	Apr 2 /05 17:30:06	0.603	0.952	0.619	1.02	Vert	0.00829	0.0133	0.0149		
W	BE9689	Apr 2 /05 21:07:28	0.540	0.492	0.683	0.704	Long	0.00829	0.00663	0.0116		
W	BE9689	Apr 3 /05 19:59:48	1.13	0.651	1.03	1.16	Vert	0.0133	0.00994	0.00994		
W	BE9689	Apr 5 /05 06:57:02	0.333	0.619	0.444	0.634	Vert	0.00663	0.0116	0.0166		
W	BE9689	Apr 5 /05 17:43:06	0.683	0.603	0.730	0.879	Vert	0.00994	0.0116	0.0133		
W	BE9689	Apr 5 /05 23:35:13	0.540	0.190	0.667	0.732	Long	0.00829	0.00663	0.0133		
W	BE9689	Apr 6 /05 00:39:15	0.667	0.619	0.762	0.829	Vert	0.00829	0.00829	0.0133		
W	BE9689	Apr 6 /05 20:23:20	0.524	0.190	0.603	0.649	Long	0.00663	0.00663	0.0133		
W	BE9689	Apr 7 /05 20:20:34	0.556	0.349	0.810	0.865	Long	0.00663	0.00663	0.0116		
W	BE9690	Apr 7 /05 23:51:38	0.571	0.667	0.889	0.923	Vert	0.00663	0.00663	0.00994		Event recorded on both units
W	BE9689	Apr 7 /05 23:51:40	0.794	1.35	1.05	1.35	Vert	0.0116	0.0199	0.0149		Event recorded on both units
W	BE9689	Apr 9 /05 14:40:49	0.619	0.857	0.651	1.10	Tran	0.0464	0.0597	0.0464		appears man made
W	BE9689	Apr 9 /05 14:41:28	0.603	0.730	0.619	0.969	Tran	0.0696	0.0530	0.0447		appears man made
W	BE9689	Apr 9 /05 14:42:54	1.38	2.79	1.52	2.80	Tran	0.133	0.192	0.124		appears man made

Printed: July 20, 2005 (V 4.37 - 4.37)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\2m22_a27

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
LOG	BE9689	Apr 9 /05 14:44:13	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Apr 9 /05 14:44:13	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Apr 9 /05 15:14:15	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Apr 9 /05 15:18:39	1.24	2.11	0.952	2.14	Vert	0.143	0.182	0.0696		
LOG	BE9690	Apr 9 /05 15:50:19	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Apr 9 /05 16:08:46	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9690	Apr 9 /05 16:08:58	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Apr 9 /05 16:12:38	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Apr 10 /05 09:32:38	0.857	1.43	0.952	1.43	Vert	0.0133	0.0182	0.0166		Both
W	BE9690	Apr 10 /05 09:32:40	0.730	0.857	0.937	1.06	Vert	0.00829	0.00829	0.0116		Both
W	BE9689	Apr 11 /05 11:53:03	0.778	0.238	0.746	0.860	Long	0.00829	0.00663	0.0166		
W	BE9689	Apr 12 /05 10:47:08	0.619	0.397	0.905	0.911	Long	0.00829	0.00663	0.0116		
W	BE9689	Apr 14 /05 10:49:54	0.286	0.286	0.603	0.611	Long	0.00829	0.00829	0.0149		
W	BE9689	Apr 14 /05 17:07:22	0.508	0.349	0.889	0.929	Long	0.00663	0.00663	0.0133		
W	BE9689	Apr 14 /05 20:10:12	0.508	0.254	0.873	0.879	Long	0.00663	0.00663	0.0116		
W	BE9689	Apr 14 /05 21:30:46	0.667	0.270	0.905	1.02	Long	0.00829	0.00663	0.00994		
W	BE9689	Apr 15 /05 09:35:14	0.508	0.302	0.825	0.842	Long	0.00663	0.00663	0.0116		
W	BE9689	Apr 15 /05 12:21:18	0.873	0.540	1.37	1.38	Long	0.00829	0.00829	0.0133		
W	BE9689	Apr 15 /05 21:15:19	0.460	0.302	0.778	0.828	Long	0.00663	0.00829	0.0133		
W	BE9689	Apr 16 /05 11:36:34	0.730	0.556	1.38	1.40	Long	0.00994	0.00994	0.0182		
W	BE9689	Apr 16 /05 15:41:05	0.667	0.349	1.17	1.22	Long	0.00663	0.00663	0.0133		
W	BE9689	Apr 16 /05 15:57:56	0.540	0.143	0.651	0.686	Long	0.00829	0.00663	0.0133		
W	BE9689	Apr 16 /05 18:59:32	0.556	0.476	0.984	1.04	Long	0.00829	0.00829	0.0133		
W	BE9689	Apr 16 /05 22:12:50	0.603	0.190	0.667	0.747	Long	0.00829	0.00829	0.0116		
W	BE9689	Apr 17 /05 08:41:23	0.587	0.381	0.635	0.746	Long	0.00663	0.00663	0.0116		
W	BE9689	Apr 18 /05 10:10:17	0.571	0.270	0.841	0.880	Long	0.00663	0.00663	0.0149		
W	BE9689	Apr 18 /05 12:17:54	0.508	0.413	0.984	0.990	Long	0.00829	0.00829	0.0166		
W	BE9689	Apr 18 /05 13:24:36	2.64	0.905	1.57	2.68	Long	0.118	0.0646	0.0978		man made from reading intstrument
LOG	BE9689	Apr 18 /05 13:28:15	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	Apr 18 /05 13:34:23	***	***	***	***	***	***	***	***	Start Monitoring	No events recorded. (Keyboard Exit)
LOG	BE9689	Apr 18 /05 13:34:53	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
W	BE9689	Apr 18 /05 13:53:36	3.08	2.48	2.43	3.41	Long	0.143	0.103	0.157		man made after starting unit
LOG	BE9690	Apr 18 /05 14:32:59	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
W	BE9689	Apr 18 /05 16:37:19	0.587	0.365	0.984	1.03	Long	0.00663	0.00663	0.0166		
W	BE9689	Apr 18 /05 18:16:00	0.460	0.222	0.619	0.635	Long	0.00663	0.00663	0.0133		
W	BE9689	Apr 19 /05 18:34:36	0.397	0.254	0.698	0.725	Long	0.00663	0.00663	0.0149		
W	BE9689	Apr 19 /05 21:16:02	0.444	0.254	0.889	0.951	Long	0.00663	0.00663	0.0116		
W	BE9689	Apr 19 /05 22:55:36	0.540	0.222	0.778	0.835	Long	0.00663	0.00663	0.0166		
W	BE9689	Apr 20 /05 07:07:05	0.286	0.206	0.603	0.630	Long	0.00663	0.00663	0.0149		
W	BE9689	Apr 20 /05 10:22:24	0.333	0.238	0.762	0.798	Long	0.00663	0.00663	0.00829		
W	BE9689	Apr 20 /05 12:04:24	0.349	0.206	0.667	0.704	Long	0.00663	0.00663	0.00829		
W	BE9689	Apr 20 /05 16:08:56	0.651	0.254	0.937	0.966	Long	0.00829	0.00663	0.0133		
W	BE9689	Apr 20 /05 20:43:36	0.587	0.286	1.14	1.19	Long	0.00663	0.00663	0.0166		

Printed: July 20, 2005 (V 4.37 - 4.37)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\2m22_a27

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
W	BE9689	Apr 20 /05 22:02:31	0.429	0.333	0.984	1.02	Long	0.00829	0.00663	0.00994		
W	BE9689	Apr 21 /05 00:21:37	0.762	0.190	0.857	0.899	Long	0.00663	0.00663	0.0133		
W	BE9689	Apr 21 /05 08:52:50	0.683	0.413	1.03	1.13	Long	0.00829	0.00829	0.0149		
W	BE9689	Apr 21 /05 13:11:14	0.619	0.238	0.587	0.655	Tran	0.00829	0.00663	0.0133		
W	BE9689	Apr 21 /05 13:45:16	0.381	0.270	0.667	0.676	Long	0.00663	0.00663	0.0116		
W	BE9689	Apr 21 /05 16:18:42	0.460	0.286	0.810	0.848	Long	0.00663	0.00663	0.0116		
W	BE9689	Apr 21 /05 20:31:42	0.810	1.03	1.14	1.16	Vert	0.0133	0.0133	0.0166		Both
W	BE9690	Apr 21 /05 20:31:42	0.587	0.698	0.873	0.940	Vert	0.00663	0.00829	0.00829		Both
W	BE9689	Apr 21 /05 21:43:10	0.825	0.508	1.49	1.59	Long	0.00994	0.00829	0.0182		
W	BE9689	Apr 22 /05 05:50:33	0.762	0.683	0.984	1.11	Vert	0.0116	0.0149	0.0166		Both
W	BE9690	Apr 22 /05 05:50:33	0.651	0.349	0.460	0.686	Tran	0.00829	0.00663	0.00663		Both
W	BE9689	Apr 22 /05 09:19:48	1.17	0.365	1.33	1.38	Tran	0.0116	0.00663	0.0166		
W	BE9689	Apr 22 /05 11:52:08	0.873	0.476	1.33	1.40	Long	0.0116	0.00829	0.0166		mag 1.6 UTC 18:52:15
W	BE9689	Apr 22 /05 14:56:16	0.397	0.254	0.635	0.670	Long	0.00663	0.00663	0.0166		
W	BE9689	Apr 22 /05 15:36:10	0.794	0.317	0.952	1.02	Long	0.00829	0.00663	0.0149		
W	BE9689	Apr 22 /05 17:50:57	0.397	0.222	0.651	0.699	Long	0.00663	0.00663	0.0133		
W	BE9689	Apr 22 /05 20:22:45	0.460	0.333	0.968	1.03	Long	0.00663	0.00663	0.0149		
W	BE9689	Apr 23 /05 02:30:15	1.08	0.381	1.59	1.61	Long	0.00994	0.00663	0.0166		Both
W	BE9690	Apr 23 /05 02:30:15	0.603	0.397	0.460	0.706	Tran	0.00663	0.00663	0.00663		Both
W	BE9689	Apr 23 /05 18:47:18	0.841	0.254	0.762	0.871	Long	0.00829	0.00663	0.0133		
W	BE9689	Apr 24 /05 04:56:53	1.05	0.571	1.21	1.24	Tran	0.0116	0.00994	0.0166		
W	BE9689	Apr 25 /05 07:09:52	0.444	0.302	0.873	0.927	Long	0.00829	0.00663	0.0116		
W	BE9689	Apr 25 /05 09:19:43	0.492	0.270	0.937	0.982	Long	0.00663	0.00663	0.0133		mag 1.7 UTC 16:20:06
W	BE9689	Apr 25 /05 10:22:03	0.460	0.270	0.889	0.938	Long	0.00829	0.00663	0.0149		
W	BE9689	Apr 25 /05 12:56:17	0.460	0.270	0.810	0.849	Long	0.00663	0.00663	0.0149		
W	BE9689	Apr 25 /05 14:07:01	0.429	0.190	0.619	0.648	Long	0.00663	0.00663	0.0133		
W	BE9689	Apr 25 /05 15:15:21	0.413	0.270	0.873	0.913	Long	0.00663	0.00663	0.0149		
W	BE9689	Apr 25 /05 21:32:12	0.317	0.238	0.651	0.683	Long	0.00829	0.00663	0.0166		
W	BE9689	Apr 26 /05 10:02:32	0.667	0.714	0.810	0.829	Vert	0.00994	0.00994	0.0166		
W	BE9689	Apr 26 /05 15:53:47	1.24	0.460	1.33	1.51	Tran	0.0149	0.00994	0.0166		Both
W	BE9690	Apr 26 /05 15:53:47	0.635	0.381	0.524	0.640	Tran	0.00663	0.00497	0.00829		Both
W	BE9689	Apr 26 /05 16:14:45	0.492	0.540	0.651	0.654	Long	0.00994	0.00829	0.0149		
W	BE9689	Apr 26 /05 19:03:29	0.286	0.190	0.619	0.644	Long	0.00663	0.00829	0.0166		
W	BE9689	Apr 27 /05 07:45:28	0.603	0.317	0.714	0.725	Tran	0.00994	0.00829	0.0149		
W	BE9689	Apr 27 /05 10:49:22	4.71	1.86	3.24	5.15	Long	0.280	0.119	0.174		

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\3a27_m23

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
LOG	BE9689	Apr 27 /05 11:13:52	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9690	Apr 27 /05 11:59:38	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Apr 27 /05 15:19:50	1.27	0.619	1.46	1.57	Tran	0.0149	0.0116	0.0166		Both EQ mag 1.8 UTC 22:20:25
W	BE9690	Apr 27 /05 15:19:50	0.841	0.492	0.508	0.850	Tran	0.00663	0.00497	0.00663		Both EQ mag 1.8 UTC 22:20:25
W	BE9689	Apr 27 /05 17:54:21	0.667	0.254	0.651	0.790	Long	0.00663	0.00663	0.0133		
W	BE9690	Apr 27 /05 23:26:59	0.413	0.540	0.714	0.729	Long	0.00663	0.00663	0.00829		picked up on both units
W	BE9689	Apr 27 /05 23:27:00	0.794	0.873	1.00	1.03	Vert	0.00994	0.0116	0.0166		picked up on both units
W	BE9689	Apr 28 /05 08:04:06	0.746	0.508	0.698	0.861	Long	0.00663	0.00663	0.0149		
W	BE9689	Apr 28 /05 17:51:09	1.13	1.02	1.38	1.81	Long	0.0199	0.0199	0.0249		0.0249 g, not recorded on Dam Unit, or as an earthquake UUSS
W	BE9689	Apr 28 /05 20:00:54	1.14	0.873	1.27	1.32	Vert	0.0116	0.0133	0.0166		
W	BE9689	Apr 28 /05 20:51:48	0.317	0.270	0.952	0.982	Long	0.00663	0.00663	0.0182		
W	BE9689	Apr 29 /05 03:23:17	0.524	0.254	0.603	0.668	Long	0.00663	0.00663	0.0166		
W	BE9689	Apr 29 /05 08:18:34	0.556	0.254	0.873	0.924	Long	0.00663	0.00663	0.0149		
W	BE9689	Apr 29 /05 17:35:04	0.683	0.365	0.746	0.810	Long	0.00829	0.00829	0.0149		
W	BE9689	Apr 29 /05 18:51:28	0.698	0.254	0.762	0.852	Long	0.00663	0.00663	0.00829		
W	BE9690	Apr 30 /05 05:21:36	1.00	0.714	1.00	1.25	Vert	0.00994	0.00829	0.00663		picked up on both units
W	BE9689	Apr 30 /05 05:21:38	1.54	0.889	1.41	1.60	Vert	0.0149	0.00994	0.0116		picked up on both units
W	BE9689	Apr 30 /05 07:00:46	0.698	0.349	1.19	1.20	Tran	0.00663	0.00663	0.0116		
W	BE9689	Apr 30 /05 20:18:46	0.635	0.254	0.476	0.668	Tran	0.00829	0.00663	0.0149		
W	BE9689	May 1 /05 03:03:55	0.841	0.270	1.02	1.10	Long	0.00829	0.00663	0.00994		
W	BE9690	May 1 /05 06:59:07	0.508	0.762	0.952	0.959	Vert	0.00497	0.00829	0.00994		picked up on both units
W	BE9689	May 1 /05 06:59:08	1.21	1.40	1.76	1.76	Vert	0.0182	0.0182	0.0182		picked up on both units
W	BE9689	May 2 /05 08:12:13	0.429	0.254	0.714	0.745	Long	0.00663	0.00663	0.0149		
LOG	BE9690	May 2 /05 08:13:36	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	May 2 /05 08:25:21	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	May 2 /05 09:06:28	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	May 2 /05 09:15:37	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	May 2 /05 09:50:21	1.03	0.524	1.46	1.55	Long	0.00994	0.00829	0.0149		
W	BE9689	May 2 /05 12:36:53	0.460	0.302	0.746	0.787	Long	0.00829	0.00663	0.0149		
W	BE9689	May 2 /05 16:19:21	0.857	0.365	0.905	0.984	Tran	0.00829	0.00829	0.0182		
W	BE9689	May 3 /05 09:44:54	0.825	0.444	1.32	1.44	Long	0.00829	0.00663	0.0182		
W	BE9689	May 3 /05 12:21:33	0.667	0.286	0.857	1.00	Long	0.00663	0.00663	0.0133		
W	BE9689	May 3 /05 12:35:05	0.302	0.175	0.730	0.744	Long	0.00663	0.00663	0.0149		
W	BE9689	May 3 /05 13:52:30	0.714	0.206	0.825	0.918	Long	0.00829	0.00663	0.0149		
W	BE9689	May 3 /05 15:07:52	1.62	1.00	1.60	1.74	Vert	0.0215	0.0199	0.0249		Both, mag 1.6, 0.0249 g UTC 22:07:51
W	BE9690	May 3 /05 15:07:53	0.746	0.349	0.714	0.810	Long	0.00663	0.00663	0.00663		Both, mag 1.6 UTC 22:07:51
W	BE9689	May 3 /05 16:32:49	0.508	0.302	0.968	0.999	Long	0.00994	0.00663	0.0116		
W	BE9689	May 3 /05 17:48:10	0.778	0.873	0.873	0.925	Vert	0.0116	0.0133	0.0149		
W	BE9689	May 3 /05 19:07:57	0.429	0.222	0.635	0.663	Long	0.00663	0.00663	0.0149		
W	BE9689	May 3 /05 19:40:10	0.381	0.222	0.603	0.634	Long	0.00663	0.00663	0.0149		
W	BE9689	May 3 /05 21:13:24	0.333	0.190	0.619	0.642	Long	0.00829	0.00663	0.0166		
W	BE9689	May 3 /05 21:46:08	0.397	0.254	0.794	0.837	Long	0.00663	0.00663	0.0116		
W	BE9689	May 3 /05 21:58:06	0.571	0.222	0.762	0.798	Long	0.00663	0.00663	0.0166		

Printed: July 20, 2005 (V 4.37 - 4.37)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\3a27_m23

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
W	BE9689	May 4 /05 08:09:26	0.841	0.413	1.38	1.49	Long	0.00663	0.00663	0.0149		
W	BE9689	May 4 /05 09:22:59	0.619	0.302	1.02	1.07	Long	0.00663	0.00663	0.0116		
W	BE9689	May 4 /05 10:48:28	0.492	0.238	0.810	0.828	Long	0.00663	0.00663	0.0166		
W	BE9689	May 4 /05 10:53:50	0.397	0.222	0.635	0.700	Long	0.00663	0.00663	0.0133		
W	BE9689	May 4 /05 11:13:02	0.349	0.222	0.635	0.642	Long	0.00663	0.00663	0.0149		
W	BE9689	May 4 /05 12:35:16	0.889	0.508	1.27	1.39	Long	0.00994	0.00829	0.00994		
W	BE9689	May 4 /05 13:46:31	0.413	0.302	0.857	0.882	Long	0.00829	0.00829	0.0149		
W	BE9689	May 4 /05 13:55:13	0.317	0.190	0.667	0.685	Long	0.00663	0.00663	0.0133		
W	BE9689	May 4 /05 14:07:15	0.365	0.238	0.730	0.745	Long	0.00663	0.00663	0.0182		
W	BE9689	May 4 /05 14:11:00	0.873	0.413	1.16	1.21	Long	0.00829	0.00829	0.0199		
W	BE9689	May 4 /05 17:56:58	0.603	0.349	0.968	0.994	Long	0.00829	0.00829	0.0149		
W	BE9689	May 4 /05 18:34:15	0.492	0.476	0.635	0.648	Long	0.00994	0.00829	0.0149		
W	BE9689	May 4 /05 19:17:17	0.556	0.365	0.841	0.928	Long	0.00829	0.00663	0.0182		
W	BE9689	May 4 /05 20:33:13	0.444	0.286	0.698	0.724	Long	0.00829	0.00829	0.0166		
W	BE9689	May 5 /05 00:28:57	0.905	0.302	0.857	1.03	Long	0.00994	0.00829	0.0166		
W	BE9689	May 5 /05 02:38:48	0.619	0.365	0.873	0.935	Long	0.00994	0.00663	0.0149		
W	BE9689	May 5 /05 03:52:47	0.444	0.286	0.651	0.711	Long	0.00663	0.00829	0.0166		
W	BE9689	May 5 /05 07:59:15	0.524	0.270	0.778	0.865	Long	0.00663	0.00663	0.0133		
W	BE9689	May 5 /05 10:19:04	0.397	0.238	0.698	0.724	Long	0.00663	0.00663	0.0149		
W	BE9689	May 5 /05 12:25:04	0.762	0.349	0.556	0.832	Tran	0.00994	0.00829	0.0166		
W	BE9689	May 5 /05 14:41:25	0.683	0.286	0.873	0.896	Long	0.00829	0.00663	0.0149		
W	BE9689	May 5 /05 16:35:03	0.889	0.635	1.05	1.08	Vert	0.00829	0.00829	0.0116		
W	BE9689	May 5 /05 19:11:04	0.619	0.254	0.730	0.850	Long	0.00829	0.00829	0.0133		
W	BE9689	May 5 /05 23:09:43	0.492	0.254	0.714	0.812	Long	0.00663	0.00663	0.0182		
W	BE9689	May 6 /05 00:34:10	0.571	0.238	0.698	0.786	Long	0.00663	0.00663	0.0149		
W	BE9689	May 6 /05 06:58:40	0.476	0.254	0.603	0.633	Long	0.0116	0.00663	0.00829		
W	BE9689	May 6 /05 08:40:41	0.381	0.270	0.619	0.655	Long	0.00663	0.00663	0.0166		
W	BE9689	May 6 /05 12:00:17	0.397	0.254	0.889	0.908	Long	0.00829	0.00663	0.0149		
W	BE9689	May 6 /05 14:16:10	0.778	0.444	1.24	1.26	Long	0.00829	0.00663	0.0166		
W	BE9689	May 6 /05 22:21:49	0.762	0.508	0.683	0.806	Long	0.0116	0.00663	0.0166		
W	BE9689	May 7 /05 08:22:53	0.619	0.286	0.921	1.00	Long	0.00663	0.00663	0.0249		0.0249 g, not recorded on Dam Unit, or as an earthquake UUSS
W	BE9689	May 7 /05 08:44:09	0.524	0.286	0.810	0.911	Long	0.00663	0.00829	0.0116		
W	BE9689	May 7 /05 08:49:10	0.270	0.159	0.603	0.623	Long	0.00663	0.00663	0.0166		
W	BE9689	May 7 /05 09:01:10	0.651	0.317	0.905	1.03	Long	0.00829	0.00663	0.0133		
W	BE9689	May 7 /05 11:22:49	0.270	0.175	0.635	0.655	Long	0.00663	0.00829	0.0166		
W	BE9689	May 7 /05 11:30:56	0.810	0.333	1.11	1.18	Long	0.00829	0.00829	0.0149		
W	BE9689	May 7 /05 14:29:44	0.476	0.206	0.667	0.699	Long	0.00663	0.00663	0.0182		
W	BE9689	May 7 /05 17:07:29	0.492	0.254	0.651	0.731	Long	0.00663	0.00663	0.0149		
W	BE9689	May 7 /05 18:55:58	0.603	0.302	0.762	0.884	Long	0.00663	0.00663	0.0149		
W	BE9689	May 7 /05 19:17:51	0.476	0.270	0.714	0.815	Long	0.00663	0.00663	0.0133		
W	BE9689	May 7 /05 20:02:31	0.587	0.286	0.762	0.852	Long	0.00663	0.00663	0.0116		
W	BE9689	May 7 /05 21:47:39	0.667	0.238	1.00	1.11	Long	0.00829	0.00663	0.0199		
W	BE9689	May 8 /05 09:32:38	0.794	0.444	1.19	1.21	Long	0.00829	0.00663	0.0133		

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\3a27_m23

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
W	BE9689	May 8 /05 12:12:15	0.698	0.603	0.651	0.919	Vert	0.0116	0.00994	0.0149		
W	BE9689	May 8 /05 23:14:55	0.476	0.206	0.619	0.664	Long	0.00829	0.00663	0.0133		
LOG	BE9690	May 9 /05 08:11:17	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	May 9 /05 08:22:45	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	May 9 /05 10:53:04	0.619	0.175	0.556	0.658	Tran	0.00497	0.00663	0.0149		
LOG	BE9689	May 9 /05 12:45:32	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	May 9 /05 13:06:07	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	May 10 /05 00:29:28	0.698	0.444	1.14	1.17	Long	0.00829	0.00829	0.0149		
W	BE9689	May 10 /05 00:46:46	0.698	0.270	0.889	1.01	Long	0.00829	0.00663	0.0149		
W	BE9689	May 10 /05 12:41:16	1.32	0.571	1.75	1.78	Long	0.0133	0.00829	0.0149		Both, mag 2.0 UTC 19:41:50
W	BE9690	May 10 /05 12:41:16	0.810	0.873	0.746	1.16	Vert	0.00663	0.00663	0.00663		Both, mag 2.0 UTC 19:41:50
W	BE9689	May 10 /05 12:50:27	0.397	0.286	0.619	0.668	Long	0.00663	0.00663	0.0166		
W	BE9689	May 10 /05 14:08:19	0.540	0.317	0.841	0.889	Long	0.00663	0.00663	0.0149		
W	BE9689	May 10 /05 18:34:27	0.587	0.222	0.746	0.825	Long	0.00663	0.00663	0.0166		
W	BE9689	May 11 /05 08:24:35	0.460	0.254	0.619	0.699	Long	0.00663	0.00663	0.0133		
W	BE9689	May 11 /05 11:05:55	0.492	0.317	0.714	0.726	Long	0.00663	0.00663	0.0149		
W	BE9689	May 11 /05 14:53:41	0.365	0.206	0.603	0.641	Long	0.00663	0.00663	0.0166		
W	BE9689	May 11 /05 19:15:09	0.492	0.190	0.635	0.686	Long	0.00663	0.00663	0.0149		
W	BE9689	May 12 /05 09:35:36	0.667	0.286	0.762	0.861	Long	0.00663	0.00663	0.0166		
W	BE9689	May 13 /05 04:02:51	1.52	0.873	2.08	2.13	Vert	0.0149	0.0133	0.0166		picked up on both units
W	BE9690	May 13 /05 04:02:51	0.698	0.714	0.921	1.11	Long	0.00663	0.00663	0.00663		Both
W	BE9689	May 13 /05 07:02:36	1.08	0.571	1.41	1.45	Long	0.00994	0.00994	0.0149		
LOG	BE9690	May 13 /05 07:22:38	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	May 13 /05 07:30:21	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9689	May 13 /05 07:58:21	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9689	May 13 /05 08:10:34	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	May 13 /05 09:37:06	0.524	0.317	0.714	0.793	Long	0.00663	0.00663	0.0149		
W	BE9689	May 13 /05 11:14:51	0.587	0.317	0.857	0.949	Long	0.00829	0.00663	0.0133		
W	BE9689	May 13 /05 15:27:25	0.619	0.349	0.635	0.669	Long	0.00829	0.00663	0.0149		
W	BE9689	May 13 /05 19:27:17	0.571	0.254	0.651	0.713	Long	0.00663	0.00663	0.0166		
W	BE9689	May 13 /05 21:23:51	2.14	1.22	2.84	2.91	Vert	0.0215	0.0149	0.0166		picked up on both units
W	BE9690	May 13 /05 21:23:52	1.06	0.603	1.21	1.47	Vert	0.00829	0.00663	0.00829		picked up on both units
W	BE9689	May 14 /05 15:23:36	0.651	0.270	0.762	0.827	Long	0.00663	0.00663	0.0116		
W	BE9689	May 15 /05 13:59:59	0.746	0.651	0.889	0.958	Vert	0.0116	0.0116	0.0116		
W	BE9689	May 16 /05 19:11:51	1.13	0.714	1.22	1.55	Long	0.0116	0.00663	0.0199		picked up on both units
W	BE9690	May 16 /05 19:11:51	0.444	0.381	0.730	0.733	Long	0.00663	0.00663	0.00663		Both
W	BE9689	May 17 /05 04:44:14	0.571	0.286	0.841	0.880	Long	0.00829	0.00663	0.0149		
W	BE9689	May 17 /05 13:20:12	0.492	0.556	0.714	0.723	Long	0.00994	0.00994	0.0149		
W	BE9689	May 17 /05 14:06:37	0.571	0.333	0.921	1.02	Long	0.00663	0.00663	0.0166		
W	BE9689	May 17 /05 15:58:33	0.873	0.413	1.17	1.19	Long	0.00829	0.00663	0.0166		
W	BE9689	May 17 /05 18:11:04	1.10	0.540	1.44	1.49	Long	0.00829	0.00829	0.0133		
W	BE9689	May 17 /05 18:12:21	0.540	0.286	0.714	0.790	Long	0.00663	0.00829	0.0149		
W	BE9689	May 17 /05 22:06:24	0.460	0.238	0.714	0.764	Long	0.00663	0.00497	0.0199		

Printed: July 20, 2005 (V 4.37 - 4.37)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\3a27_m23

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
W	BE9689	May 18 /05 11:32:32	0.492	0.365	0.905	0.939	Long	0.00663	0.00663	0.0133		
W	BE9689	May 18 /05 22:16:10	0.571	0.365	0.603	0.723	Long	0.00829	0.00663	0.0149		
W	BE9689	May 18 /05 23:54:46	1.22	0.635	1.75	1.77	Vert	0.00829	0.00829	0.0149		picked up on both units
W	BE9690	May 18 /05 23:54:46	0.444	0.429	0.667	0.792	Long	0.00663	0.00663	0.00663		Both
W	BE9689	May 19 /05 07:46:57	0.730	0.397	1.02	1.02	Long	0.00663	0.00663	0.0199		
W	BE9689	May 19 /05 20:51:54	0.444	0.238	0.619	0.700	Long	0.00663	0.00663	0.0149		
W	BE9689	May 20 /05 11:16:02	0.619	0.270	0.635	0.739	Long	0.00663	0.00663	0.0149		
W	BE9689	May 20 /05 12:15:10	0.540	0.381	0.603	0.811	Long	0.00829	0.00663	0.0199		
W	BE9689	May 20 /05 15:06:10	0.556	0.571	0.635	0.812	Long	0.00994	0.00994	0.0149		
W	BE9689	May 20 /05 15:06:24	0.397	0.190	0.635	0.683	Long	0.00663	0.00829	0.0149		
W	BE9689	May 21 /05 06:59:47	0.381	0.222	0.635	0.690	Long	0.00663	0.00663	0.0149		
W	BE9689	May 21 /05 16:56:08	0.460	0.333	0.730	0.741	Long	0.00663	0.00663	0.0182		
W	BE9689	May 21 /05 19:29:49	0.429	0.270	0.619	0.659	Long	0.00829	0.00663	0.0166		
W	BE9690	May 23 /05 07:23:53	1.32	2.14	1.25	2.20	Vert	0.0663	0.0514	0.0381		Man made, CAT passing inst. to make road
W	BE9689	May 23 /05 10:24:09	0.524	0.286	0.683	0.785	Long	0.00663	0.00663	0.0166		
W	BE9689	May 23 /05 12:32:51	0.603	0.444	0.619	0.855	Tran	0.00829	0.00829	0.0166		
LOG	BE9689	May 23 /05 20:39:37	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	May 23 /05 21:18:51	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\event

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
LOG	BE9689	May 23 /05 20:49:22	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
LOG	BE9690	May 23 /05 21:26:44	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9690	May 24 /05 11:57:23	3.14	3.35	2.37	4.16	Long	0.0862	0.104	0.0679		Man made, Cat leaving the site
W	BE9689	May 24 /05 15:44:07	0.619	0.333	0.778	0.939	Long	0.00663	0.00663	0.0166		
W	BE9689	May 24 /05 17:13:40	0.571	0.381	0.873	0.995	Long	0.00663	0.00663	0.0149		
W	BE9689	May 24 /05 17:26:44	0.524	0.302	0.667	0.766	Long	0.00663	0.00829	0.0182		
W	BE9689	May 24 /05 18:26:25	0.476	0.429	0.714	0.786	Long	0.00829	0.00663	0.0149		
W	BE9689	May 25 /05 05:37:28	0.603	0.444	0.540	0.821	Tran	0.00994	0.00663	0.0149		
W	BE9690	May 25 /05 08:16:19	0.635	0.571	1.14	1.30	Long	0.00829	0.00829	0.00829		recorded on both units
W	BE9689	May 25 /05 08:16:20	1.92	0.921	2.98	3.10	Vert	0.0133	0.0116	0.0166		recorded on both units
W	BE9690	May 25 /05 08:17:59	0.556	0.492	0.794	0.943	Long	0.00663	0.00663	0.00663		recorded on both units
W	BE9689	May 25 /05 08:18:00	0.984	0.794	1.62	1.67	Vert	0.00829	0.0116	0.0182		recorded on both units
W	BE9689	May 25 /05 16:37:03	0.444	0.333	0.762	0.842	Long	0.00663	0.00663	0.0149		
W	BE9689	May 25 /05 16:56:06	0.349	0.381	0.619	0.629	Long	0.00829	0.00663	0.0149		
W	BE9689	May 25 /05 20:51:14	0.778	0.444	0.587	0.966	Tran	0.00994	0.00829	0.0149		
W	BE9689	May 25 /05 22:25:19	0.333	0.222	0.683	0.738	Long	0.00663	0.00663	0.0149		
W	BE9689	May 25 /05 23:49:55	0.857	0.397	0.540	0.997	Tran	0.00994	0.00663	0.0149		
W	BE9689	May 26 /05 09:36:37	0.571	0.270	0.825	0.936	Long	0.00663	0.00663	0.0166		
W	BE9689	May 26 /05 11:20:28	0.413	0.270	0.746	0.794	Long	0.00663	0.00663	0.0199		
W	BE9689	May 26 /05 18:36:45	0.619	0.476	1.25	1.42	Long	0.00829	0.00829	0.0199		
W	BE9689	May 27 /05 09:41:18	0.381	0.270	0.619	0.737	Long	0.00663	0.00829	0.0182		
W	BE9690	May 27 /05 09:51:27	0.270	0.556	0.762	0.771	Long	0.00663	0.00663	0.00829		recorded on both units
W	BE9689	May 27 /05 09:51:30	1.16	0.825	1.16	1.61	Vert	0.0149	0.0133	0.0182		recorded on both units
W	BE9689	May 28 /05 18:39:23	0.667	0.365	0.571	0.764	Tran	0.0116	0.00829	0.0149		
W	BE9689	Jun 1 /05 17:54:40	0.635	0.317	0.540	0.813	Tran	0.00829	0.00663	0.0182		
W	BE9689	Jun 1 /05 19:02:18	0.698	0.571	0.667	0.934	Long	0.00994	0.00994	0.0166		
W	BE9689	Jun 1 /05 22:33:43	0.603	0.333	0.413	0.689	Tran	0.00829	0.00663	0.0133		
W	BE9689	Jun 2 /05 04:43:47	0.603	0.333	0.444	0.742	Tran	0.00994	0.00663	0.0166		
W	BE9689	Jun 2 /05 12:17:10	0.794	0.381	0.603	0.998	Tran	0.0116	0.00663	0.0182		
W	BE9689	Jun 2 /05 13:25:09	0.651	0.397	1.00	1.14	Long	0.00829	0.00829	0.0166		
W	BE9690	Jun 2 /05 18:37:05	0.619	0.413	0.619	0.783	Tran	0.00663	0.00663	0.00829		Both, mag 1.3 UTC 1:38:54, June 3
W	BE9689	Jun 2 /05 18:37:08	1.06	0.651	1.35	1.38	Vert	0.0133	0.00994	0.0232		Both, mag 1.3 UTC 1:38:54, June 3
W	BE9689	Jun 2 /05 18:48:29	0.714	0.381	0.587	0.925	Tran	0.00994	0.00829	0.0182		
W	BE9689	Jun 3 /05 03:09:00	0.603	0.270	0.492	0.783	Tran	0.00994	0.00663	0.0182		
W	BE9689	Jun 3 /05 15:37:20	1.43	0.651	0.841	1.47	Vert	0.0215	0.0116	0.0149		
W	BE9689	Jun 3 /05 16:29:21	0.714	0.302	0.508	0.880	Tran	0.0116	0.00663	0.0116		
W	BE9689	Jun 3 /05 17:30:10	0.444	0.254	0.635	0.709	Long	0.00663	0.00663	0.0166		
W	BE9689	Jun 3 /05 19:13:28	0.968	0.413	0.778	1.24	Tran	0.0133	0.00829	0.0149		
W	BE9689	Jun 3 /05 19:16:26	0.667	0.254	0.413	0.785	Tran	0.00829	0.00663	0.0166		
W	BE9689	Jun 3 /05 23:18:15	0.603	0.238	0.333	0.650	Tran	0.00663	0.00663	0.0166		
W	BE9689	Jun 4 /05 02:06:14	0.698	0.302	0.683	0.824	Tran	0.00663	0.00663	0.0149		
W	BE9689	Jun 4 /05 10:03:22	0.778	0.397	1.11	1.16	Long	0.00829	0.00829	0.0149		
W	BE9689	Jun 4 /05 14:27:00	0.460	0.254	0.603	0.644	Long	0.00663	0.00663	0.0166		

Printed: July 20, 2005 (V 4.37 - 4.37)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\event

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
W	BE9689	Jun 4 /05 15:10:28	0.476	0.317	0.746	0.779	Long	0.00663	0.00663	0.0182		
W	BE9689	Jun 4 /05 15:54:48	0.667	0.286	0.667	0.808	Tran	0.00994	0.00663	0.0149		
W	BE9689	Jun 6 /05 08:56:07	0.667	0.349	0.619	0.750	Tran	0.00829	0.00829	0.0166		
W	BE9689	Jun 6 /05 15:14:52	0.635	0.254	0.508	0.729	Tran	0.00829	0.00663	0.0166		
W	BE9689	Jun 6 /05 18:41:50	0.968	0.556	0.762	1.23	Tran	0.0133	0.00829	0.0133		
W	BE9689	Jun 6 /05 19:33:43	0.619	0.254	0.444	0.754	Tran	0.00994	0.00663	0.00994		
W	BE9689	Jun 6 /05 21:25:47	0.587	0.381	0.810	0.856	Long	0.00663	0.00663	0.0166		
W	BE9689	Jun 7 /05 01:00:32	0.984	0.698	1.16	1.33	Vert	0.0133	0.0116	0.0166		
W	BE9689	Jun 7 /05 07:06:01	0.587	0.349	0.603	0.644	Long	0.00663	0.00663	0.0166		
W	BE9689	Jun 7 /05 14:17:58	0.651	0.286	0.444	0.768	Tran	0.00829	0.00663	0.0133		
W	BE9689	Jun 8 /05 05:34:45	0.841	0.349	0.571	1.00	Tran	0.0149	0.00663	0.0166		
W	BE9689	Jun 8 /05 13:50:24	0.698	0.444	0.587	0.915	Tran	0.00829	0.00829	0.0149		
W	BE9689	Jun 8 /05 13:55:21	0.603	0.206	0.365	0.682	Tran	0.00829	0.00663	0.0166		
W	BE9689	Jun 8 /05 15:01:43	0.635	0.190	0.333	0.717	Tran	0.00829	0.00829	0.0149		
W	BE9689	Jun 8 /05 15:06:11	0.571	0.730	0.556	0.920	Vert	0.0249	0.0282	0.0348		appears man made/animal?
W	BE9689	Jun 8 /05 15:06:17	0.778	1.08	0.889	1.60	Tran	0.0547	0.0464	0.0547		appears man made/animal?
W	BE9689	Jun 8 /05 15:07:27	0.603	0.857	0.873	1.00	Vert	0.0298	0.0398	0.0381		appears man made/animal?
W	BE9689	Jun 8 /05 18:59:35	1.64	0.778	1.17	1.93	Vert	0.0166	0.0116	0.0133		
W	BE9689	Jun 9 /05 08:18:05	0.825	0.270	0.492	0.946	Tran	0.0116	0.00663	0.0166		
W	BE9689	Jun 9 /05 09:50:00	0.429	0.349	0.635	0.654	Long	0.00663	0.00663	0.0182		
W	BE9689	Jun 9 /05 12:38:50	1.97	1.22	1.87	2.08	Vert	0.0182	0.0182	0.0149		
W	BE9689	Jun 10 /05 03:48:58	0.603	0.238	0.365	0.706	Tran	0.00994	0.00829	0.0166		
W	BE9689	Jun 10 /05 11:43:16	0.968	0.381	0.619	1.15	Tran	0.0133	0.00829	0.0116		
W	BE9689	Jun 10 /05 17:19:39	0.619	0.222	0.317	0.670	Tran	0.00994	0.00663	0.0166		
W	BE9689	Jun 11 /05 20:56:50	0.730	0.238	0.365	0.784	Tran	0.00994	0.00663	0.0133		
W	BE9689	Jun 13 /05 15:35:35	1.19	0.429	0.698	1.33	Tran	0.0166	0.00829	0.0166		
W	BE9690	Jun 13 /05 17:19:11	0.524	0.635	0.429	0.816	Vert	0.0398	0.0431	0.0215		appears man made
W	BE9689	Jun 13 /05 23:52:26	0.603	0.349	0.698	0.719	Long	0.00663	0.00663	0.0166		
W	BE9690	Jun 14 /05 02:26:31	0.222	0.492	0.698	0.702	Long	0.00663	0.00663	0.00829		recorded on both units
W	BE9689	Jun 14 /05 02:26:37	2.03	0.619	1.17	2.17	Vert	0.0215	0.00994	0.0166		recorded on both units
W	BE9690	Jun 14 /05 04:13:27	1.05	1.14	1.71	2.00	Long	0.00829	0.00829	0.00994		Both, mag 1.6 UTC 11:16:17
W	BE9689	Jun 14 /05 04:13:33	2.29	0.968	3.81	3.87	Vert	0.0182	0.0116	0.0199		Both, mag 1.6 UTC 11:16:17
LOG	BE9689	Jun 14 /05 06:05:46	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
W	BE9690	Jun 17 /05 15:45:37	0.302	0.651	0.810	0.827	Vert	0.00829	0.00994	0.00994		Both, Hillside had 0.0315g
W	BE9690	Jun 17 /05 16:24:43	0.524	0.984	0.508	1.23	Vert	0.0580	0.108	0.0580		man made
LOG	BE9690	Jun 17 /05 16:25:35	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\grassy~1.05

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
LOG	BE9689	Jun 14 /05 06:23:03	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Jun 14 /05 18:38:43	0.857	0.238	0.587	0.915	Tran	0.00994	0.00663	0.0166		
W	BE9689	Jun 15 /05 15:55:34	0.698	0.206	0.365	0.750	Tran	0.00994	0.00663	0.0166		
W	BE9689	Jun 15 /05 18:02:33	0.603	0.444	0.683	0.729	Long	0.00829	0.00829	0.0182		
W	BE9689	Jun 16 /05 04:45:02	0.508	0.333	0.667	0.719	Long	0.00829	0.00663	0.0182		
W	BE9689	Jun 16 /05 11:42:44	0.349	0.286	0.651	0.667	Long	0.00663	0.00829	0.0182		
W	BE9689	Jun 16 /05 16:46:13	1.30	0.365	0.651	1.39	Tran	0.0149	0.00663	0.0166		
W	BE9689	Jun 17 /05 15:47:36	2.59	0.889	1.52	2.85	Vert	0.0315	0.0133	0.0182		Both 0.0315g
LOG	BE9690	Jun 17 /05 16:38:18	***	***	***	***	***	***	***	***	Start Monitoring	Start Monitoring
W	BE9689	Jun 17 /05 20:05:20	0.651	0.540	1.00	1.01	Long	0.00663	0.00994	0.0166		
W	BE9689	Jun 19 /05 15:54:54	0.540	0.444	0.730	0.750	Long	0.00829	0.00994	0.0182		
W	BE9689	Jun 21 /05 10:22:24	1.06	0.556	0.984	1.16	Long	0.0116	0.00829	0.0149		
W	BE9689	Jun 21 /05 16:12:56	1.54	0.492	0.873	1.59	Long	0.0182	0.00829	0.0149		
W	BE9689	Jun 21 /05 20:41:01	0.889	0.286	0.540	0.916	Tran	0.0133	0.00829	0.0166		
W	BE9689	Jun 21 /05 21:27:52	0.873	0.302	0.492	0.936	Tran	0.0116	0.00829	0.0182		
W	BE9689	Jun 23 /05 16:10:26	0.492	0.302	0.730	0.751	Long	0.00829	0.00663	0.0149		
W	BE9689	Jun 23 /05 18:00:46	0.889	0.254	0.492	0.927	Tran	0.00994	0.00663	0.0166		
W	BE9689	Jun 23 /05 22:14:06	0.667	0.190	0.349	0.689	Tran	0.00829	0.00829	0.0166		
W	BE9689	Jun 24 /05 15:07:16	0.429	0.365	0.794	0.820	Long	0.00663	0.00829	0.0199		
W	BE9689	Jun 25 /05 12:47:34	0.397	0.238	0.683	0.714	Long	0.00829	0.00663	0.0166		
W	BE9689	Jun 25 /05 12:51:47	0.619	0.222	0.317	0.640	Tran	0.00663	0.00663	0.0182		
W	BE9689	Jun 25 /05 18:56:43	1.19	0.413	0.667	1.32	Tran	0.0116	0.00829	0.0166		
W	BE9689	Jun 26 /05 04:37:14	0.714	0.222	0.381	0.737	Tran	0.00994	0.00663	0.0166		
W	BE9689	Jun 27 /05 15:16:20	0.429	0.286	0.667	0.707	Long	0.00663	0.00829	0.0182		
W	BE9689	Jun 27 /05 15:56:47	0.905	0.413	1.22	1.24	Long	0.00829	0.00663	0.0149		
W	BE9689	Jun 27 /05 17:12:36	0.460	0.317	0.635	0.647	Long	0.00663	0.00663	0.0166		
W	BE9689	Jun 28 /05 10:55:35	0.651	0.222	0.413	0.678	Tran	0.00663	0.00663	0.0166		
W	BE9689	Jun 28 /05 12:50:43	0.540	0.238	0.746	0.784	Long	0.00663	0.00663	0.0182		
W	BE9689	Jun 28 /05 21:24:29	1.46	0.476	0.905	1.49	Tran	0.0166	0.00663	0.0166		
W	BE9689	Jun 29 /05 20:36:15	0.587	0.413	0.683	0.727	Long	0.00829	0.00829	0.0182		
W	BE9689	Jul 1 /05 11:17:25	0.603	0.206	0.444	0.605	Tran	0.00829	0.00663	0.0166		
W	BE9689	Jul 1 /05 15:41:49	0.857	0.349	0.524	0.920	Tran	0.00994	0.00829	0.0149		
W	BE9689	Jul 1 /05 18:02:44	0.683	0.222	0.413	0.702	Tran	0.00994	0.00663	0.0166		
W	BE9689	Jul 1 /05 19:58:34	0.746	0.349	0.603	0.837	Tran	0.0133	0.00829	0.0166		
W	BE9689	Jul 6 /05 00:00:30	0.905	0.302	0.508	0.917	Tran	0.0116	0.00829	0.0166		
W	BE9689	Jul 6 /05 18:39:27	0.603	0.190	0.381	0.650	Tran	0.00994	0.00829	0.0149		
W	BE9689	Jul 7 /05 10:38:58	0.603	0.508	0.857	0.914	Long	0.00829	0.00829	0.0166		
W	BE9689	Jul 7 /05 13:33:57	0.413	0.302	0.619	0.671	Long	0.00829	0.00829	0.0166		
W	BE9689	Jul 8 /05 09:29:15	0.556	0.270	1.06	1.17	Long	0.00829	0.00663	0.0149		
W	BE9689	Jul 8 /05 14:10:41	0.635	0.286	0.794	0.800	Long	0.00663	0.00829	0.0149		
W	BE9689	Jul 8 /05 19:59:18	0.635	0.238	0.413	0.669	Tran	0.00994	0.00663	0.0149		
W	BE9689	Jul 8 /05 20:41:03	1.10	0.556	0.937	1.20	Tran	0.00829	0.00663	0.0166		Mag 1.6 not recorded on Dam
W	BE9689	Jul 8 /05 21:47:25	0.651	0.381	0.794	0.993	Long	0.00994	0.00994	0.0182		

Printed: July 20, 2005 (V 4.37 - 4.37)

Grassy Trail Dam, Carbon County, Utah
Hillside unit #9689 Dam #9690

Event Report: Event List - c:\blast\grassy~1.05

Type	Serial No.	Date/Time	Tran Peak (mm/s)	Vert Peak (mm/s)	Long Peak (mm/s)	PVS1 (mm/s)	Trigger	Tran Accel (g)	Vert Accel (g)	Long Accel (g)	Description	Post Event Note first line
W	BE9689	Jul 10 /05 14:05:57	0.540	0.238	0.635	0.655	Long	0.00829	0.00663	0.0166		
W	BE9689	Jul 11 /05 01:30:47	0.571	0.397	0.825	0.863	Long	0.00829	0.00663	0.0149		
W	BE9689	Jul 11 /05 12:58:53	0.540	0.270	0.794	0.820	Long	0.00829	0.00663	0.0182		
W	BE9689	Jul 11 /05 21:19:51	0.603	0.222	0.476	0.626	Tran	0.00663	0.00663	0.0166		
W	BE9689	Jul 12 /05 03:37:02	0.619	0.524	0.857	0.879	Long	0.00829	0.00829	0.0166		
W	BE9689	Jul 12 /05 22:35:37	0.698	0.365	0.651	0.762	Tran	0.00994	0.00829	0.0182		
W	BE9689	Jul 13 /05 04:36:13	0.540	0.444	0.921	0.939	Long	0.00994	0.00663	0.0182		
LOG	BE9689	Jul 13 /05 14:08:24	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)
LOG	BE9690	Jul 13 /05 14:41:48	***	***	***	***	***	***	***	***	Keyboard Stop	No events recorded. (Keyboard Exit)

Instantel®

Event Report

Date/Time	Long at 15:44:16 February 5, 2005
Trigger Source	Geo: 0.600 mm/s
Range	Geo :31.7 mm/s
Record Time	6.25 sec (Auto=6Sec) at 1024 sps
Job Number:	1

Serial Number	BE9689 V 7.1-4.32 MiniMate Plus
Battery Level	6.6 Volts
Calibration	August 13, 2004 by Instantel Inc.
File Name	K689AHLT.1S0

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Earthquake mag 1.6 UTC 22:58:44

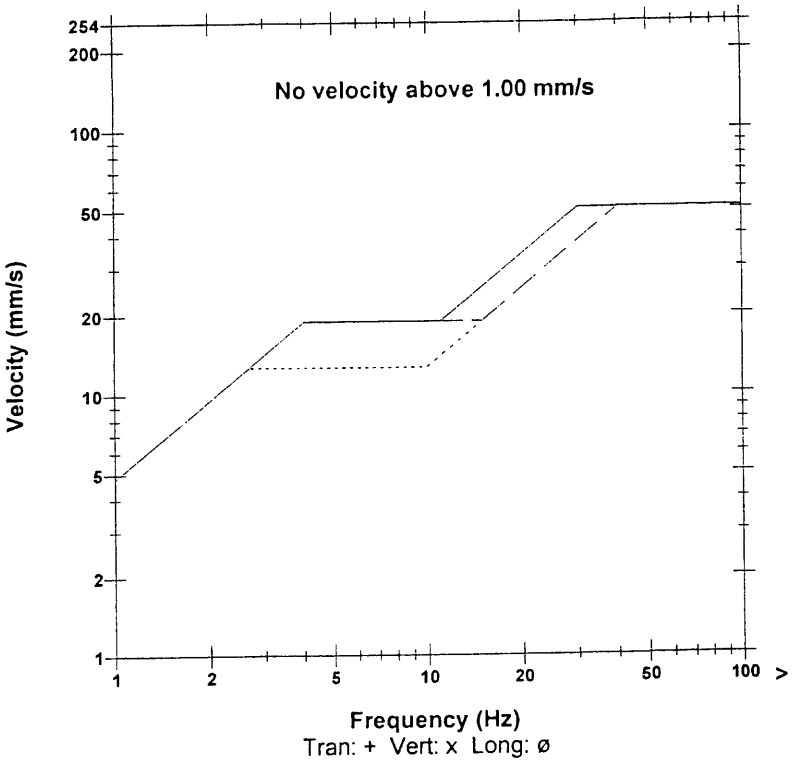
Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

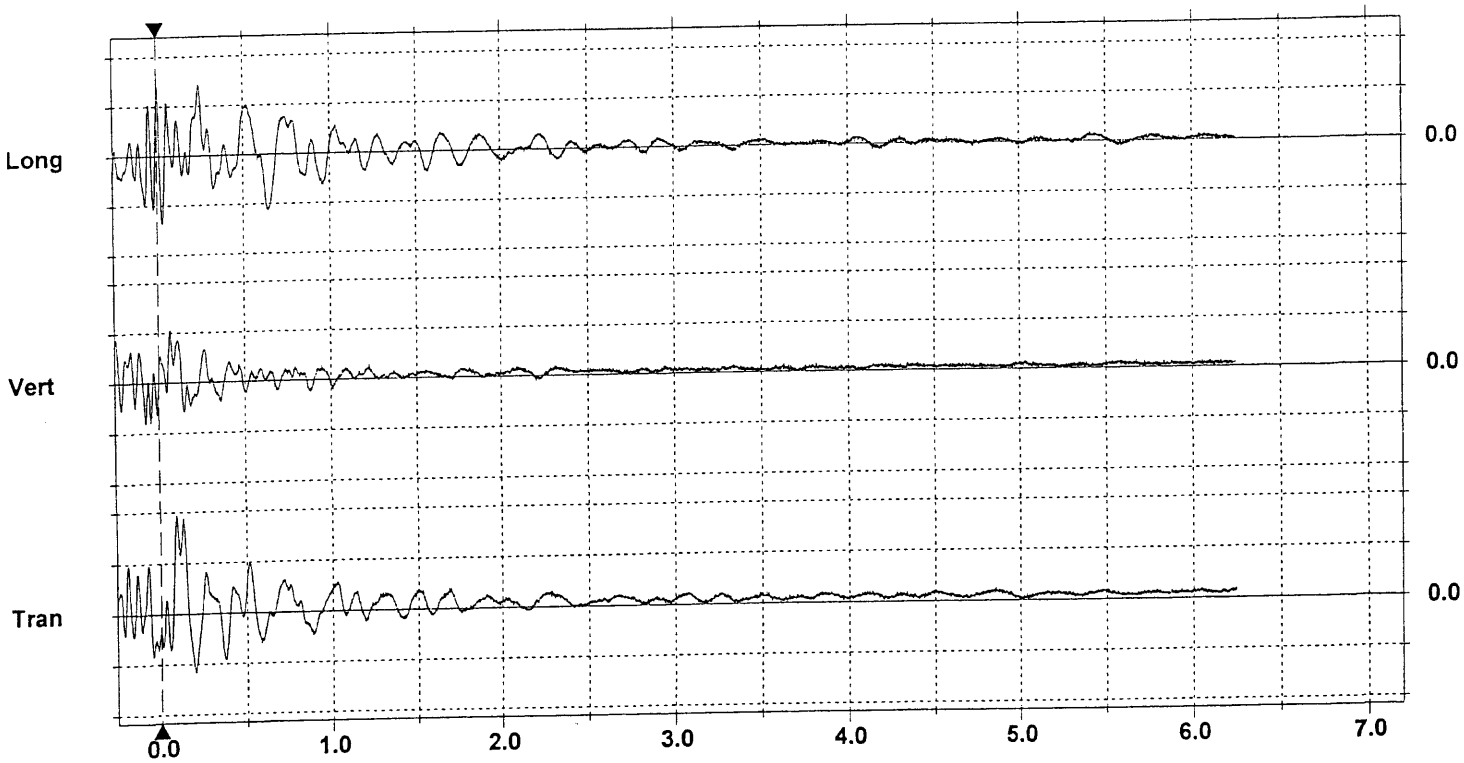
	Tran	Vert	Long	
PPV	0.968	0.524	0.714	mm/s
ZC Freq	5.6	6.4	4.3	Hz
Time (Rel. to Trig)	0.092	0.068	0.244	sec
Peak Acceleration	0.00829	0.00663	0.0149	g
Peak Displacement	0.0280	0.0124	0.0188	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.01 mm/s at 0.094 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger =

Printed: July 19, 2005 (V 4.37 - 4.37)

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Event Report

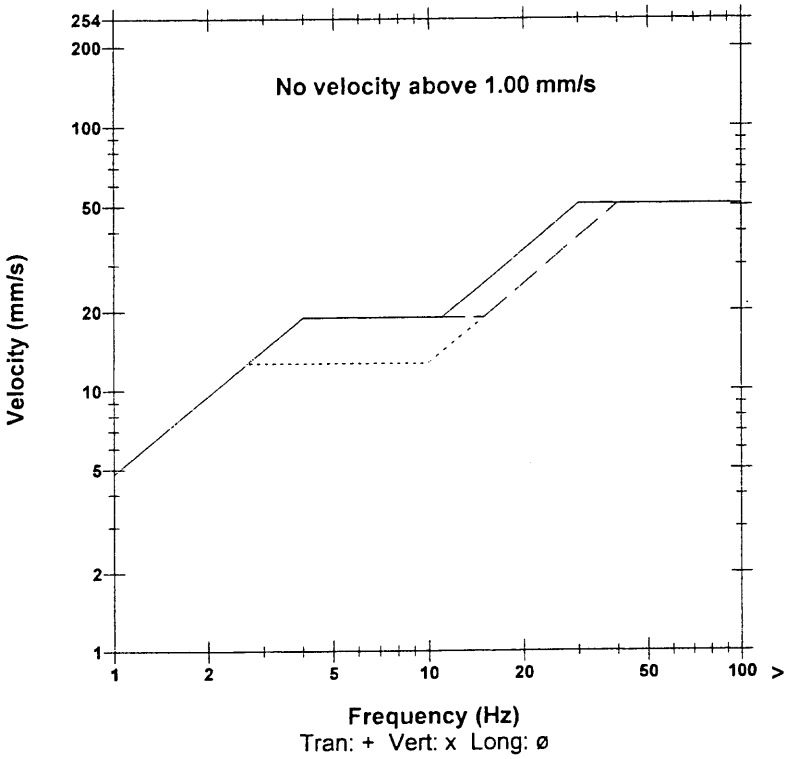
Date/Time	Tran at 14:27:39 February 7, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.9 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AHPE.U30
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
mag 1.6 UTC 21:42:19

USBM RI8507 And OSMRE

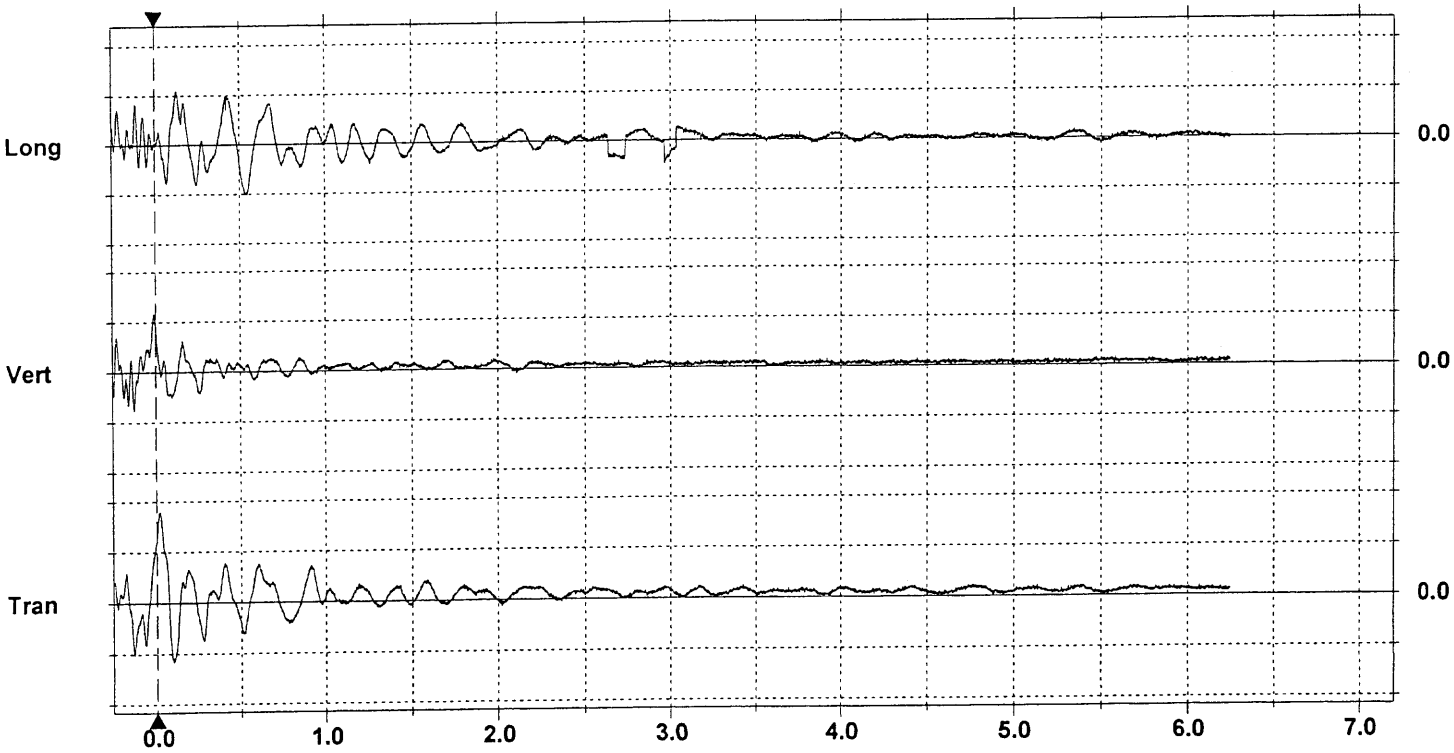


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.905	0.587	0.556	mm/s
ZC Freq	4.4	5.2	4.5	Hz
Time (Rel. to Trig)	0.020	-0.008	0.128	sec
Peak Acceleration	0.00829	0.00829	0.0149	g
Peak Displacement	0.0280	0.0124	0.0171	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.912 mm/s at 0.020 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger =

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Tran at 21:15:55 February 8, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.3 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AHRS.EJ0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
mag 1.6 UTC 4:30:43 on 2/9/05

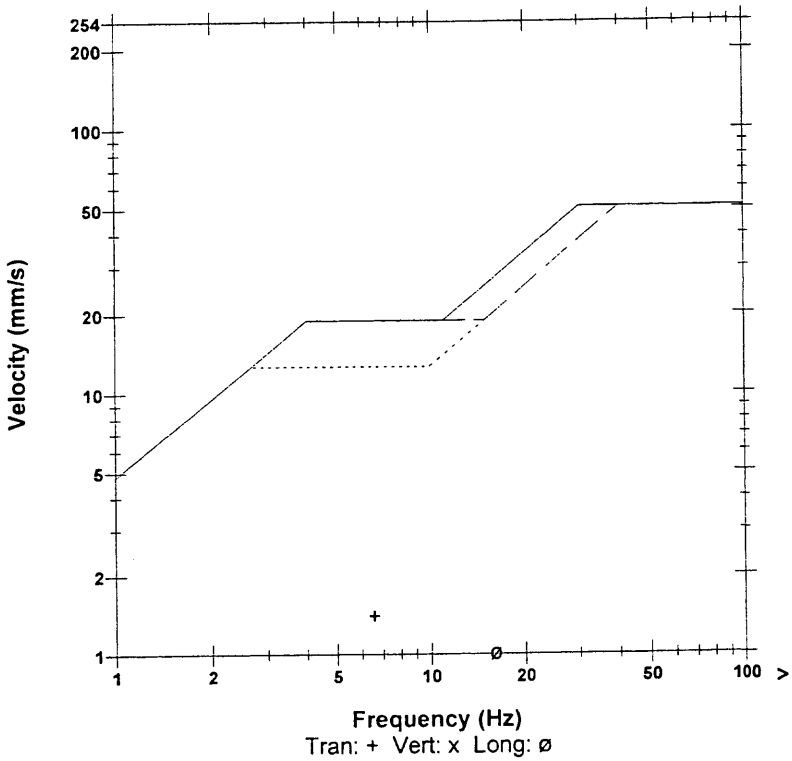
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

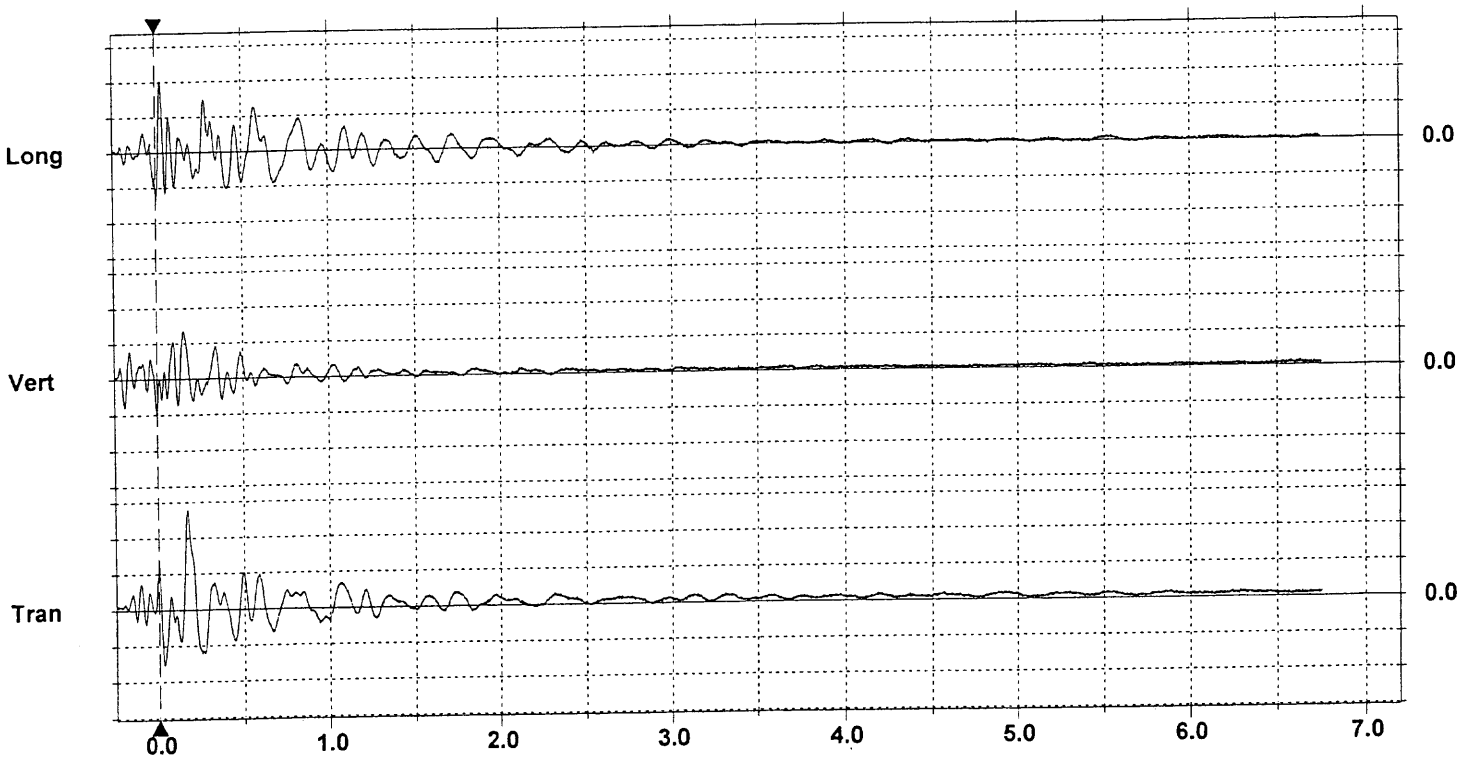
	Tran	Vert	Long	
PPV	1.40	0.683	1.02	mm/s
ZC Freq	6.6	9.0	16	Hz
Time (Rel. to Trig)	0.168	0.152	0.030	sec
Peak Acceleration	0.00994	0.00829	0.0149	g
Peak Displacement	0.0305	0.0116	0.0170	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.49 mm/s at 0.166 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.50 sec/div **Amplitude Scale:** Geo: 0.500 mm/s/div
Trigger =

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

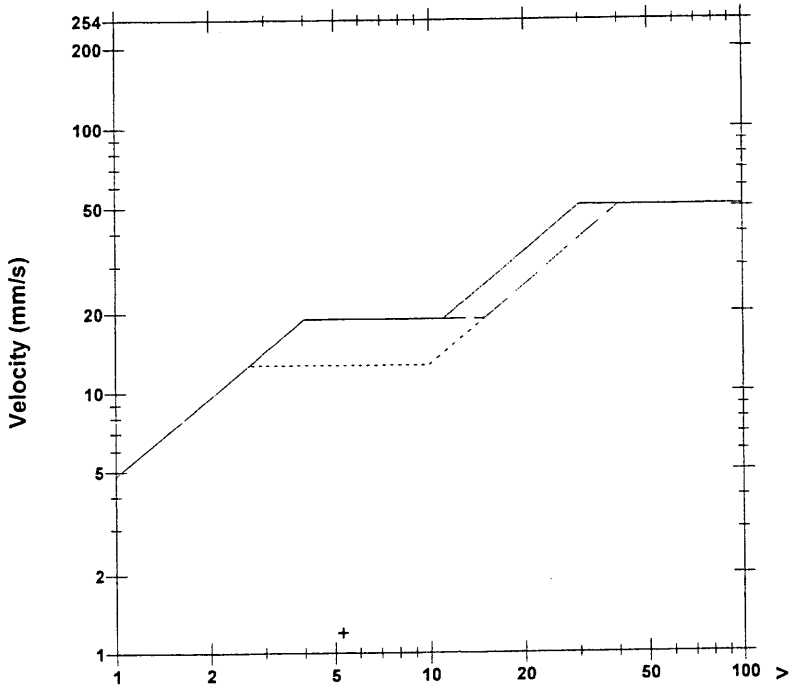
Date/Time	Long at 12:27:50 February 23, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.9 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AIIV.YE0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
mag 1.7 UTC 19:28:38

USBM RI8507 And OSMRE



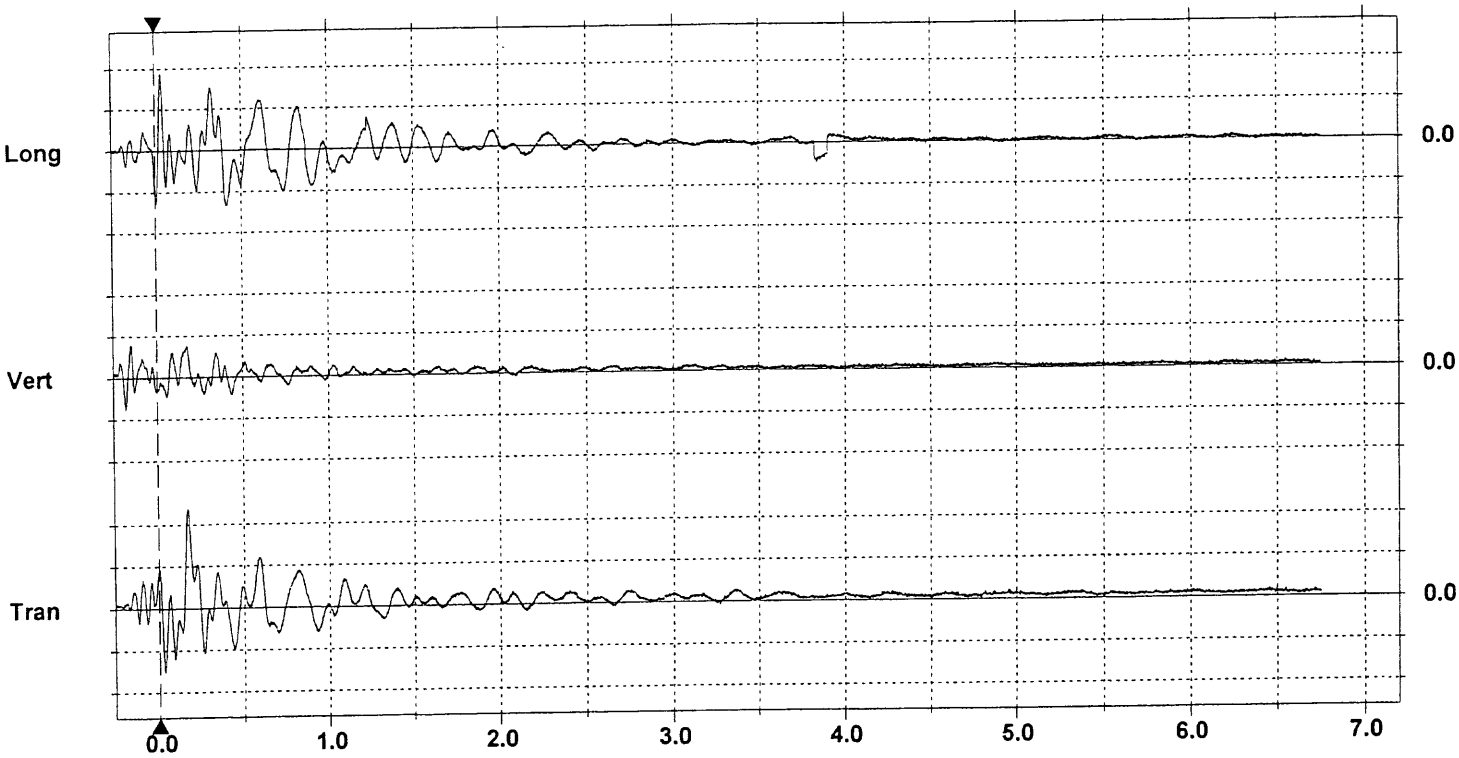
Tran: + Vert: x Long: ø

Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	1.19	0.397	0.937	mm/s
ZC Freq	5.3	16	15	Hz
Time (Rel. to Trig)	0.166	-0.150	0.033	sec
Peak Acceleration	0.00994	0.00663	0.0182	g
Peak Displacement	0.0276	0.00792	0.0223	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.26 mm/s at 0.170 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — —◀

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Event Report

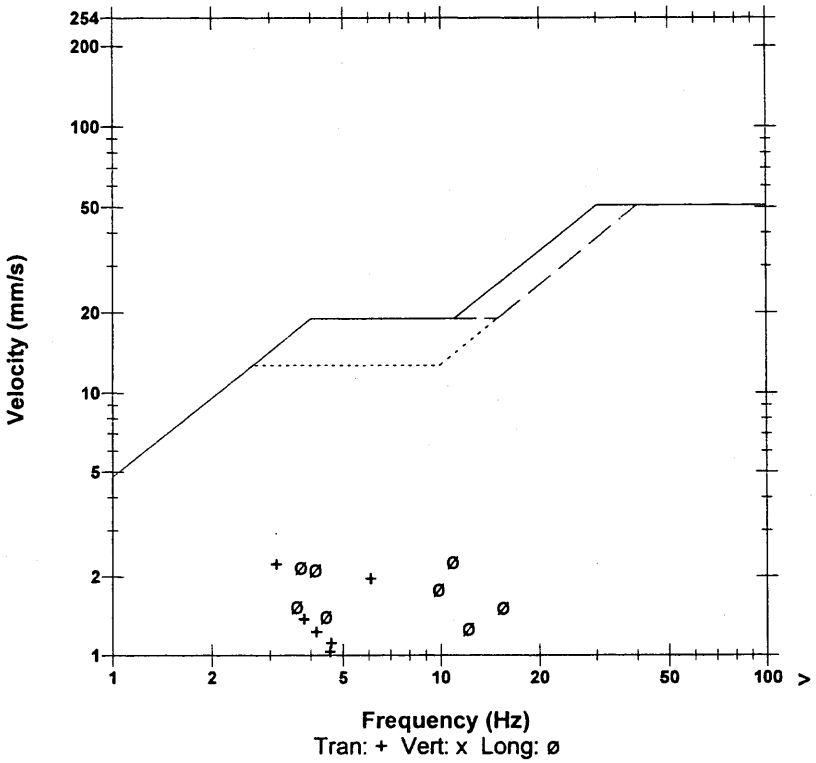
Date/Time	Vert at 18:01:55 March 24, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.4 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AK10.R70
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, EQ mag 1.7 UTC 1:02:00 3/25/05

USBM RI8507 And OSMRE

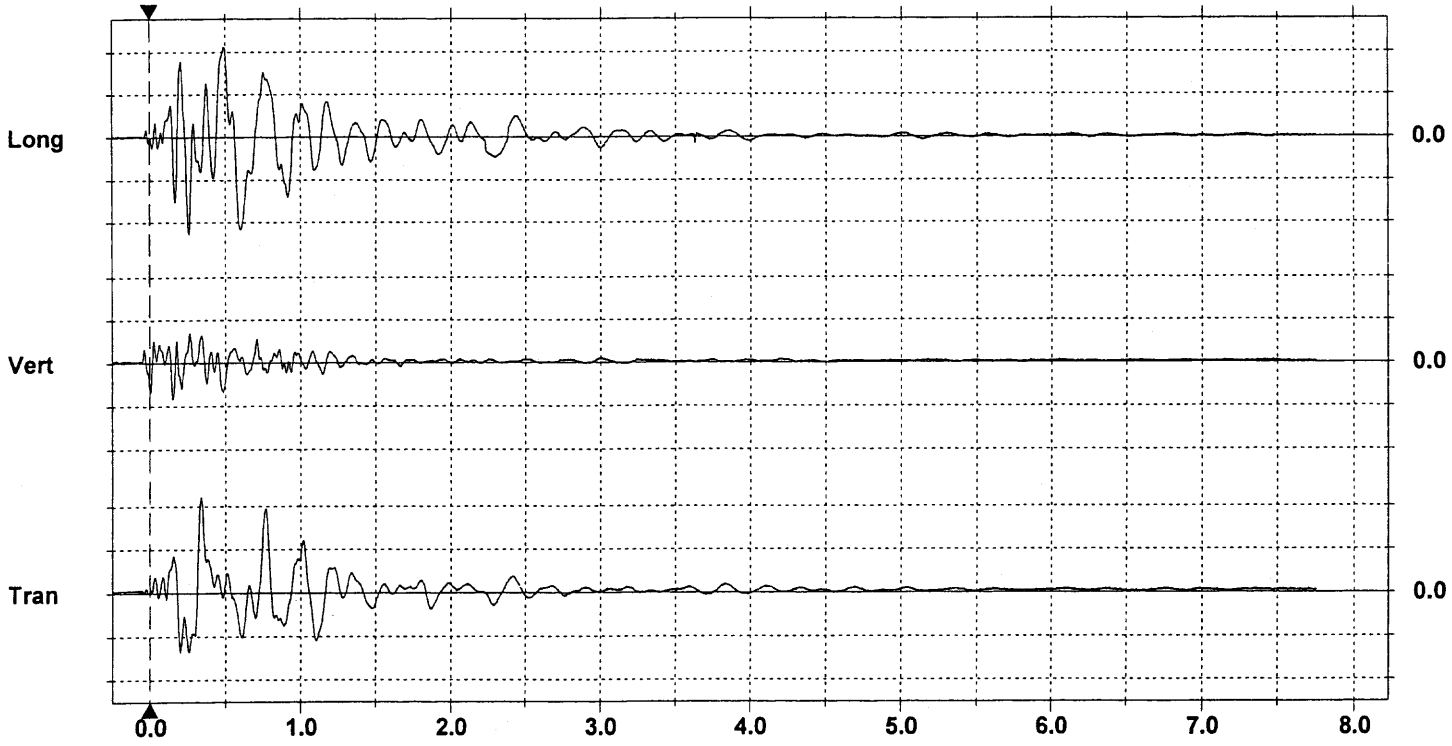


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	2.22	0.841	2.29	mm/s
ZC Freq	3.1	17	11	Hz
Time (Rel. to Trig)	0.341	0.152	0.260	sec
Peak Acceleration	0.0166	0.0116	0.0199	g
Peak Displacement	0.0636	0.0116	0.0819	mm
Sensorcheck	Check	Check	Check	

Peak Vector Sum 2.71 mm/s at 0.260 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 1.000 mm/s/div
Trigger = ▶— — —◀

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Event Report

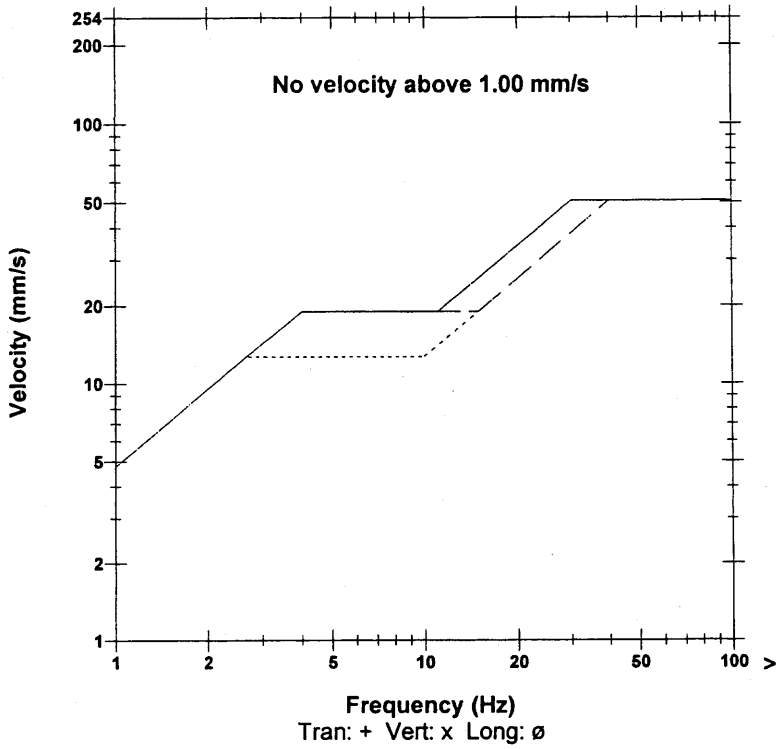
Date/Time	Vert at 18:01:54 March 24, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.4 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AK10.R60
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, EQ mag 1.7 UTC 1:02:00 3/25/05

USBM RI8507 And OSMRE

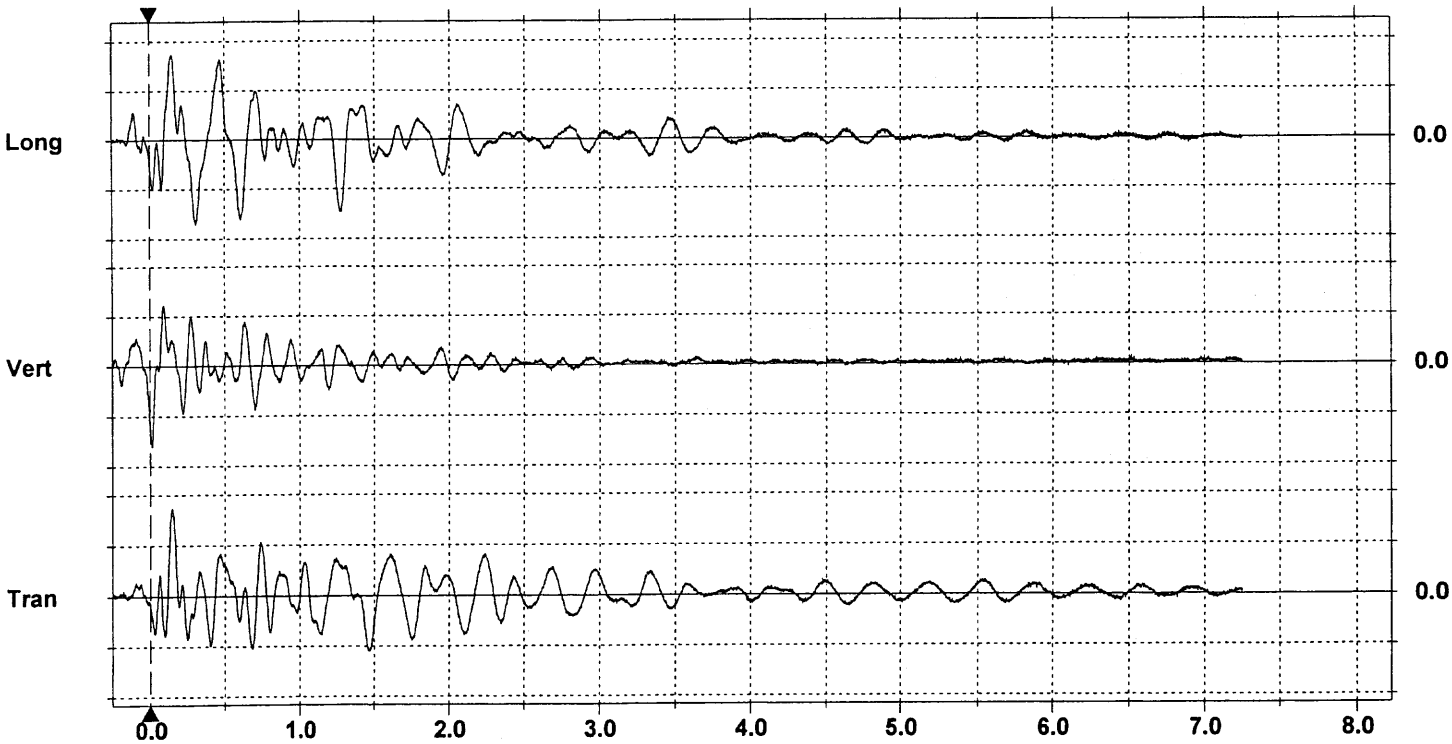


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.873	0.810	0.873	mm/s
ZC Freq	7.9	7.1	3.6	Hz
Time (Rel. to Trig)	0.143	0.011	0.145	sec
Peak Acceleration	0.00663	0.00663	0.00663	g
Peak Displacement	0.0200	0.0146	0.0284	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.25 mm/s at 0.143 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

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Event Report

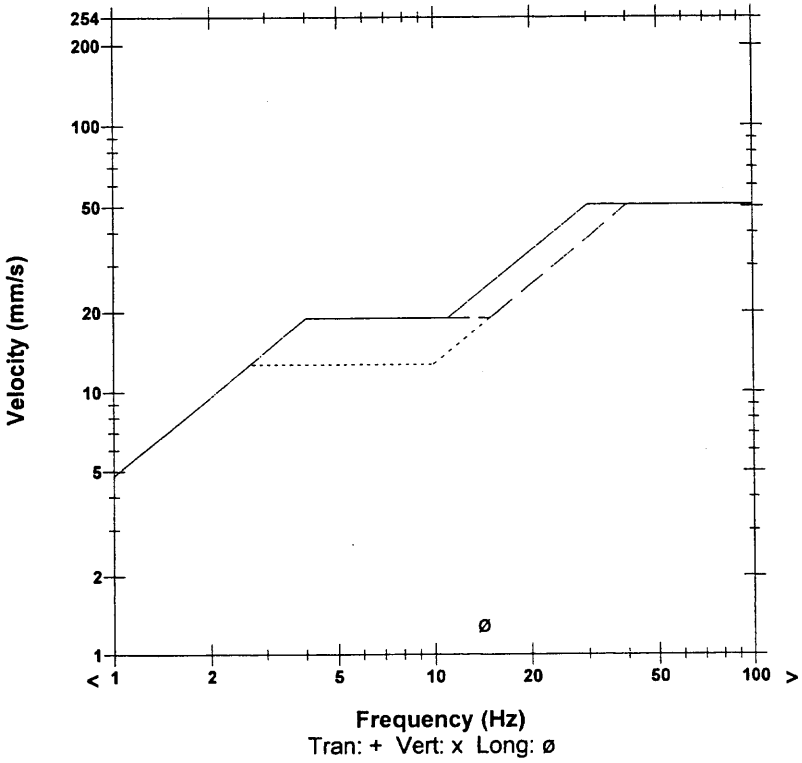
Date/Time	Vert at 16:35:58 April 2, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.9 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AKHK.RY0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, EQ mag 1.8 UTC 23:36:56

USBM RI8507 And OSMRE

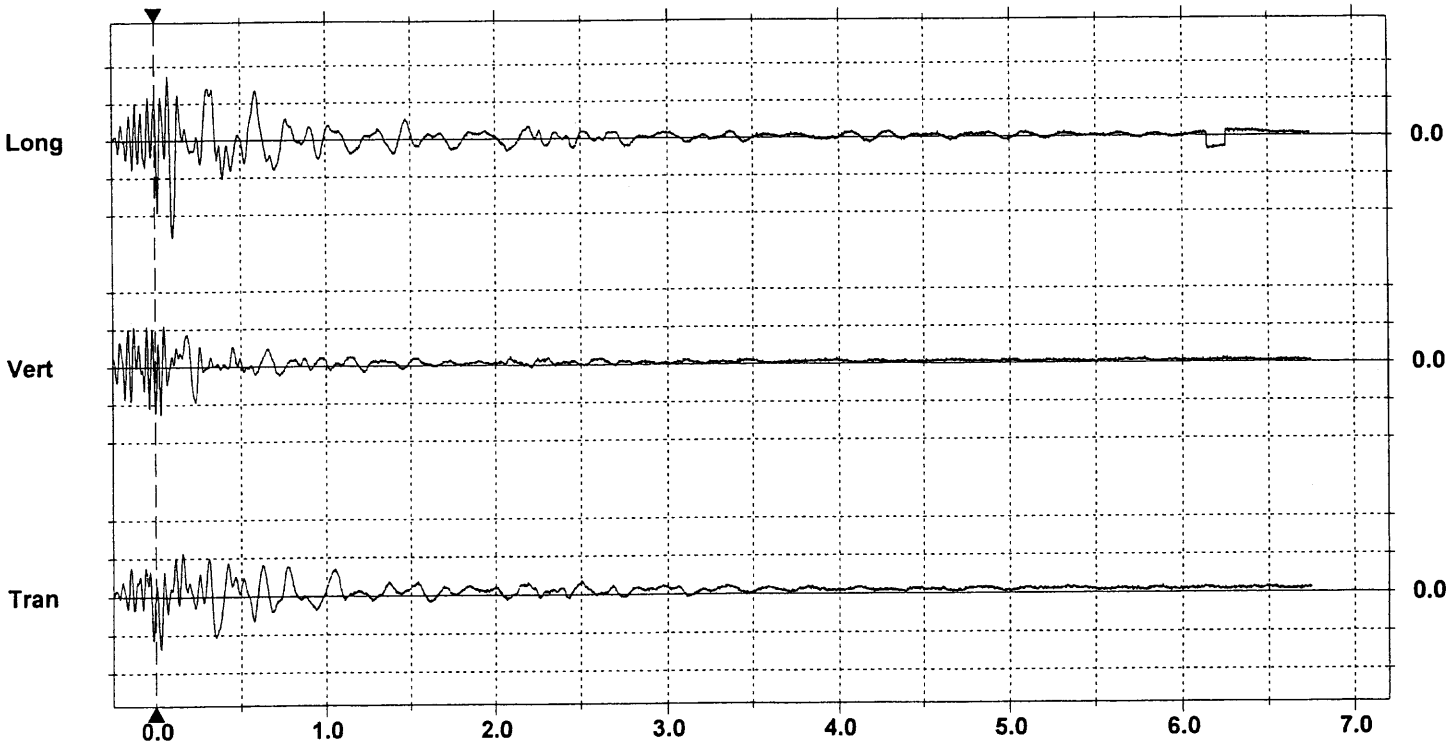


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.683	0.635	1.30	mm/s
ZC Freq	17	28	14	Hz
Time (Rel. to Trig)	0.027	0.031	0.102	sec
Peak Acceleration	0.00994	0.0133	0.0166	g
Peak Displacement	0.0152	0.0124	0.0188	mm
Sensorcheck	Check	Check	Check	

Peak Vector Sum 1.32 mm/s at 0.102 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

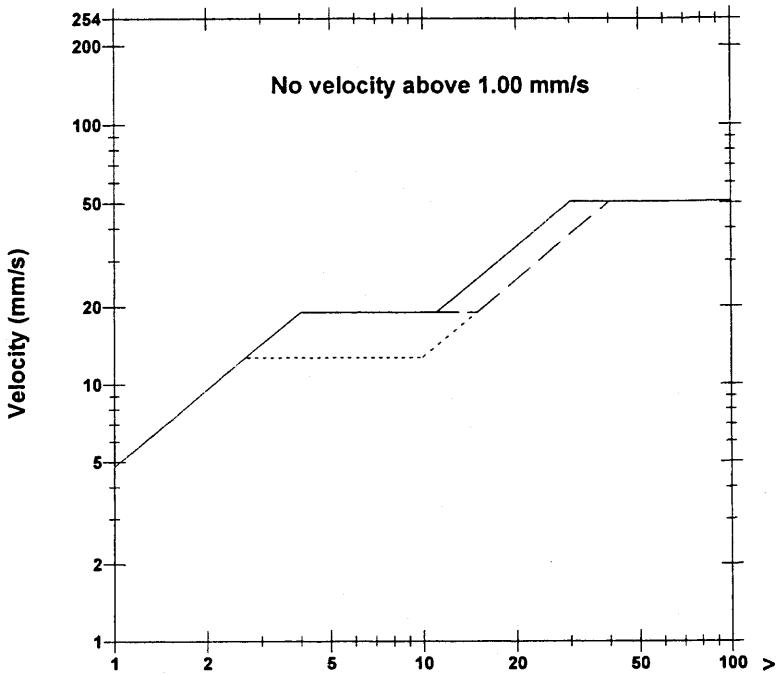
Date/Time	Tran at 16:35:56 April 2, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.8 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AKHK.RW0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, EQ mag 1.8 UTC 23:36:56

USBM RI8507 And OSMRE

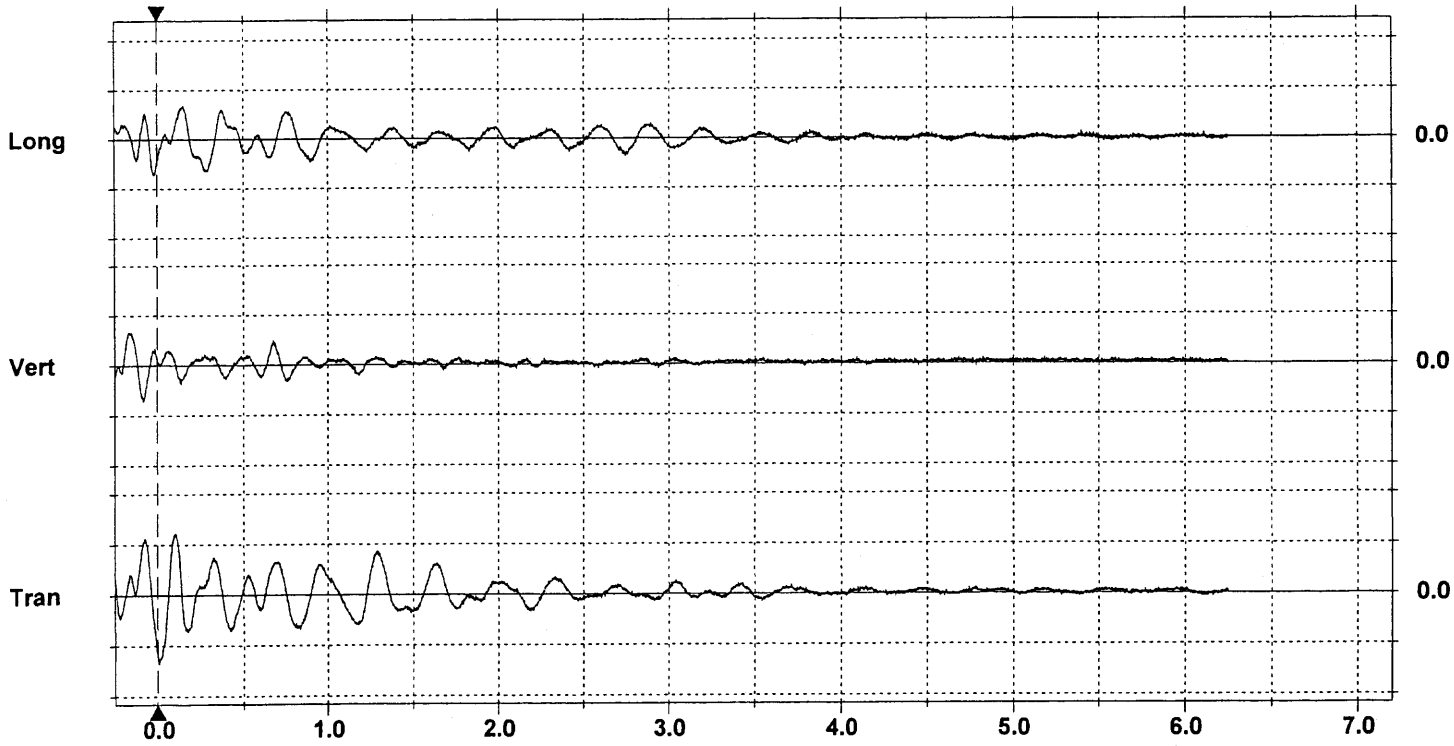


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.683	0.365	0.365	mm/s
ZC Freq	5.2	7.3	6.7	Hz
Time (Rel. to Trig)	0.006	-0.083	-0.021	sec
Peak Acceleration	0.00497	0.00829	0.00663	g
Peak Displacement	0.0200	0.00885	0.0141	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.705 mm/s at 0.006 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

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Event Report

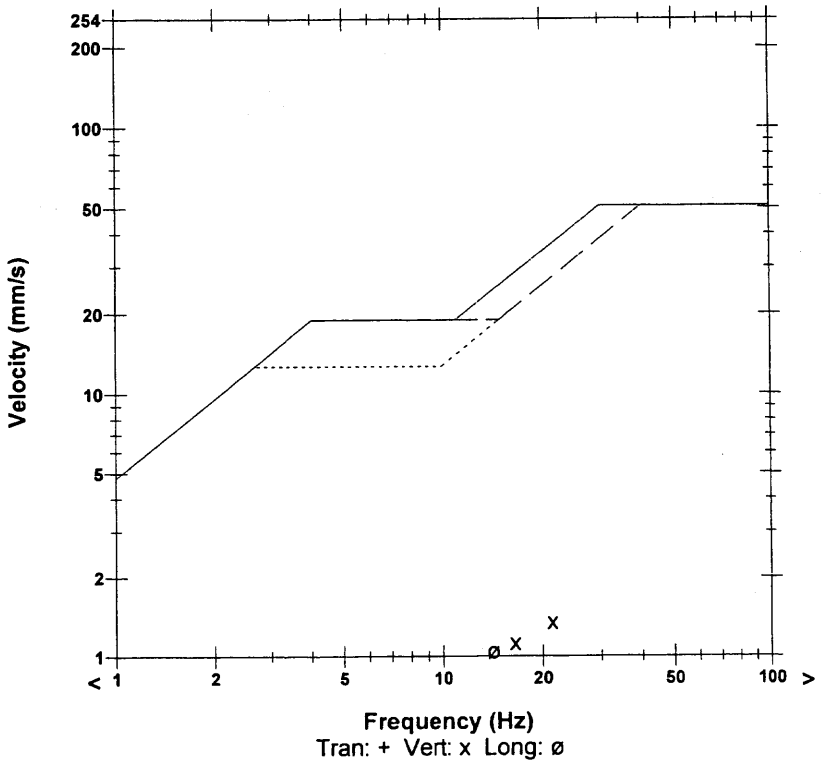
Date/Time	Vert at 23:51:40 April 7, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AKRE.A40
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Event recorded on both units

USBM RI8507 And OSMRE

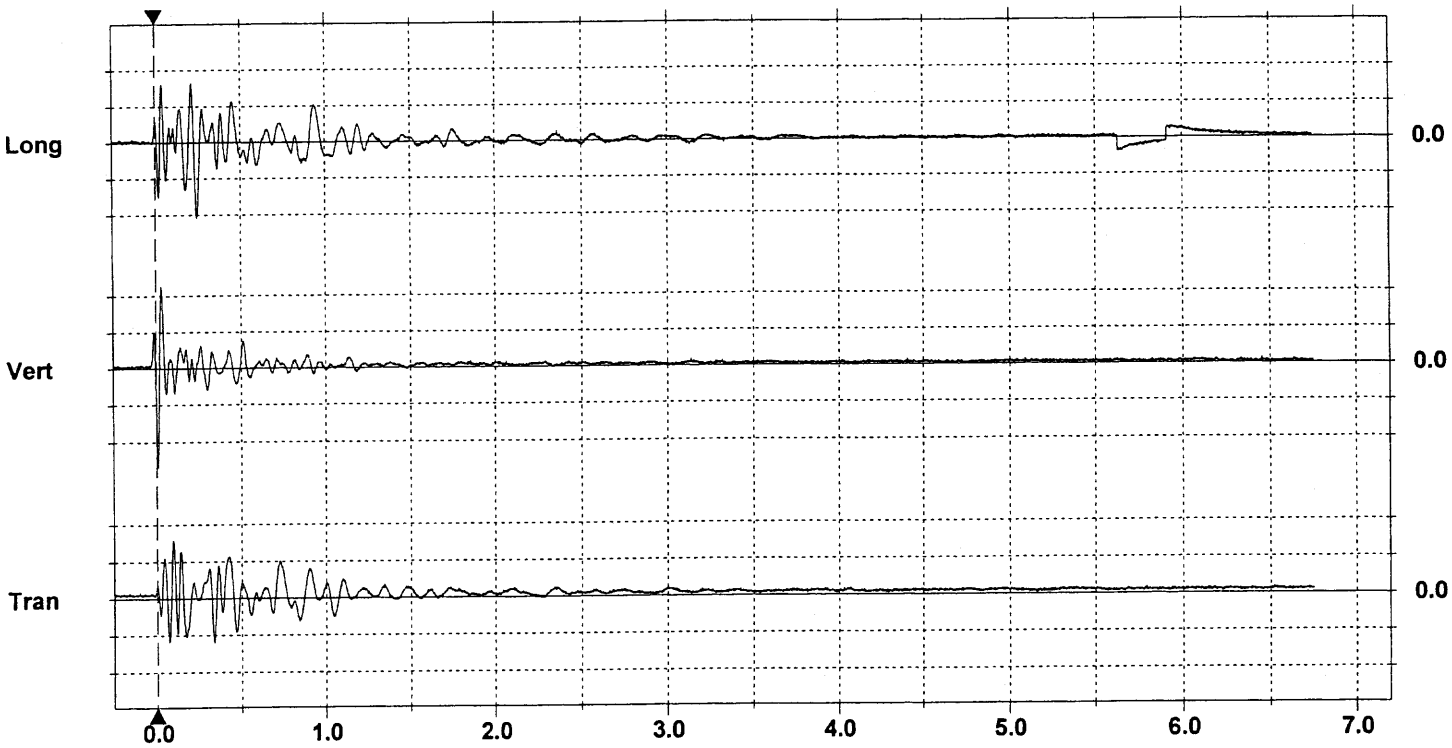


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.794	1.35	1.05	mm/s
ZC Freq	19	21	14	Hz
Time (Rel. to Trig)	0.097	0.009	0.244	sec
Peak Acceleration	0.0116	0.0199	0.0149	g
Peak Displacement	0.0209	0.0104	0.0167	mm
Sensorcheck	Check	Check	Check	

Peak Vector Sum 1.35 mm/s at 0.009 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

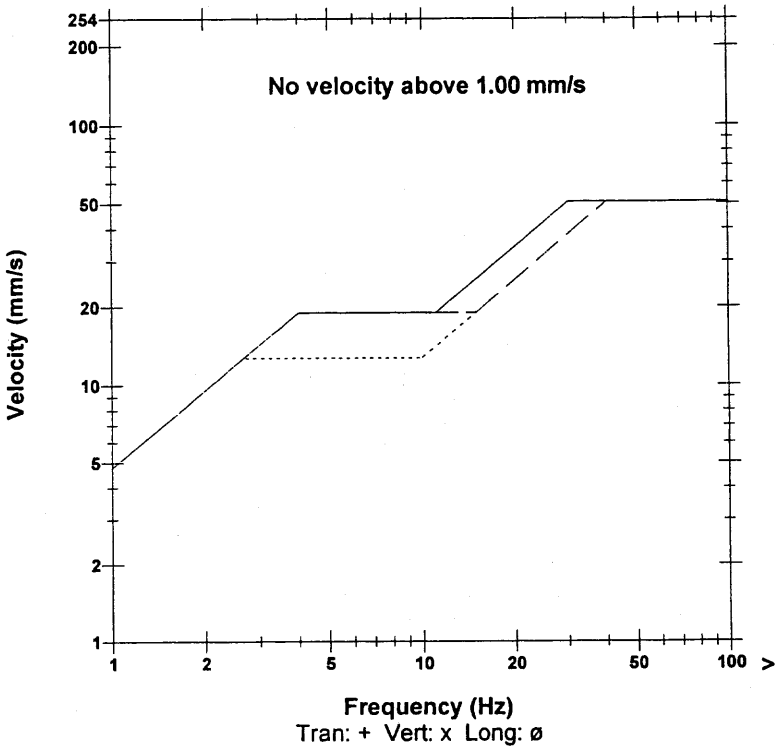
Date/Time	Vert at 23:51:38 April 7, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.3 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AKRE.A20
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Event recorded on both units

USBM RI8507 And OSMRE

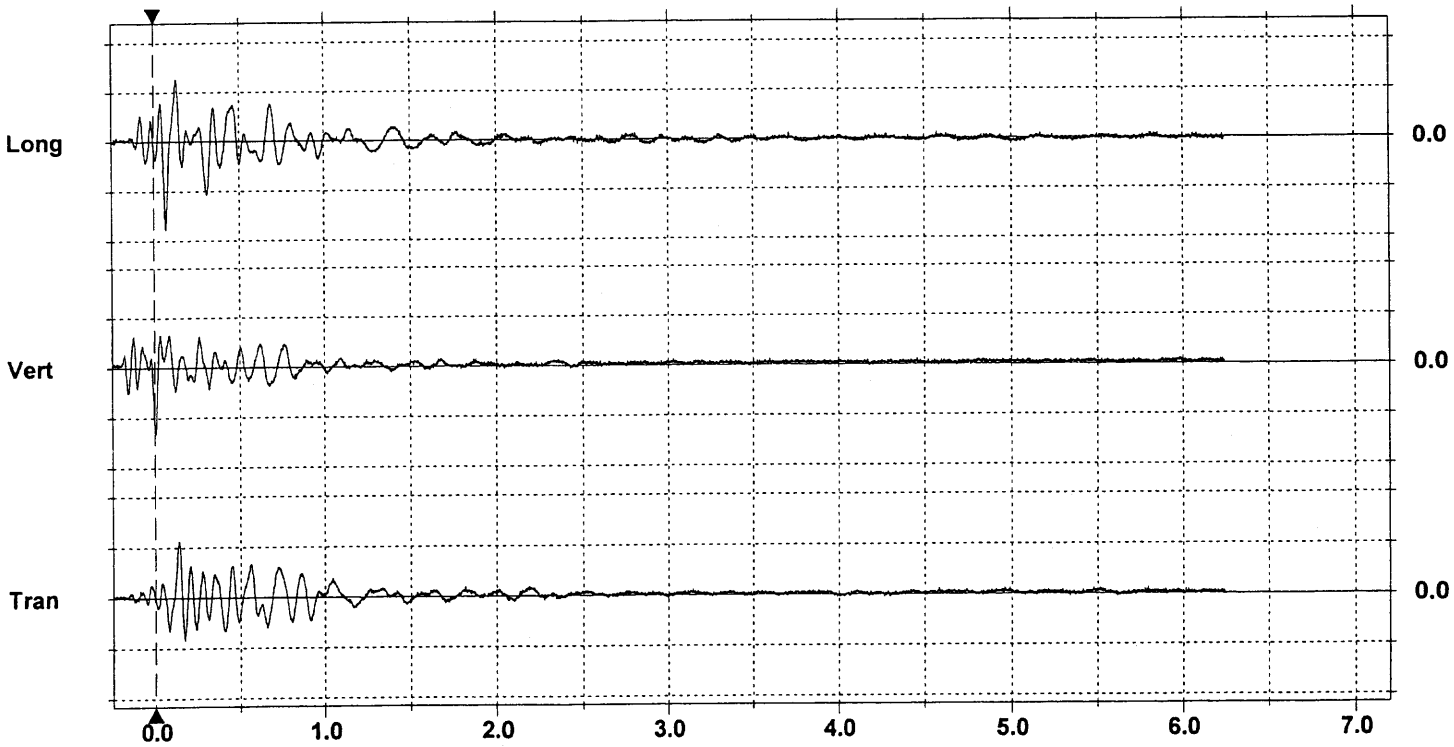


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.571	0.667	0.889	mm/s
ZC Freq	11	14	12	Hz
Time (Rel. to Trig)	0.140	0.005	0.070	sec
Peak Acceleration	0.00663	0.00663	0.00994	g
Peak Displacement	0.00807	0.00817	0.00977	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.923 mm/s at 0.070 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Vert at 09:32:38 April 10, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.9 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AKVU.IE0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

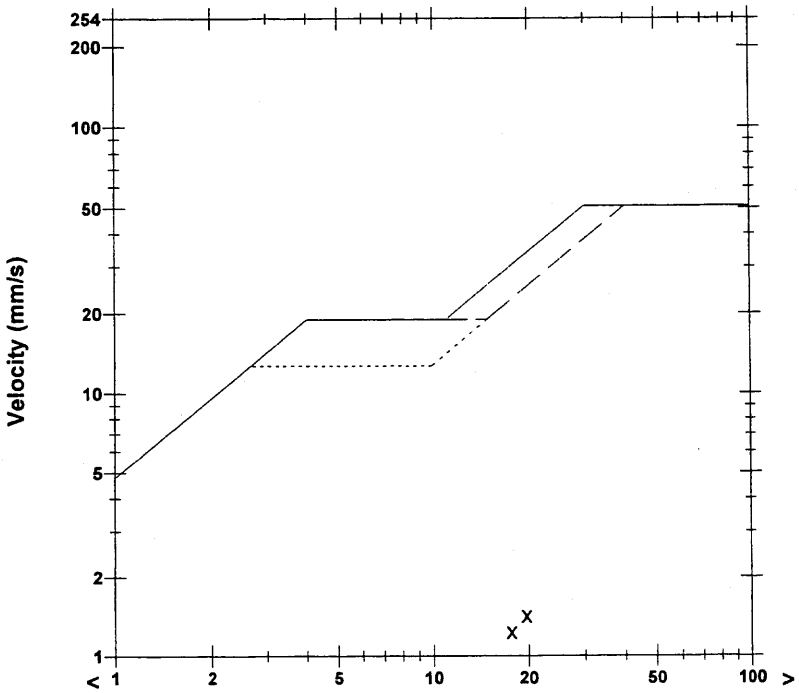
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

	Tran	Vert	Long	
PPV	0.857	1.43	0.952	mm/s
ZC Freq	11	20	13	Hz
Time (Rel. to Trig)	0.198	0.021	0.260	sec
Peak Acceleration	0.0133	0.0182	0.0166	g
Peak Displacement	0.0186	0.0113	0.0184	mm
Sensorcheck	Passed	Passed	Passed	

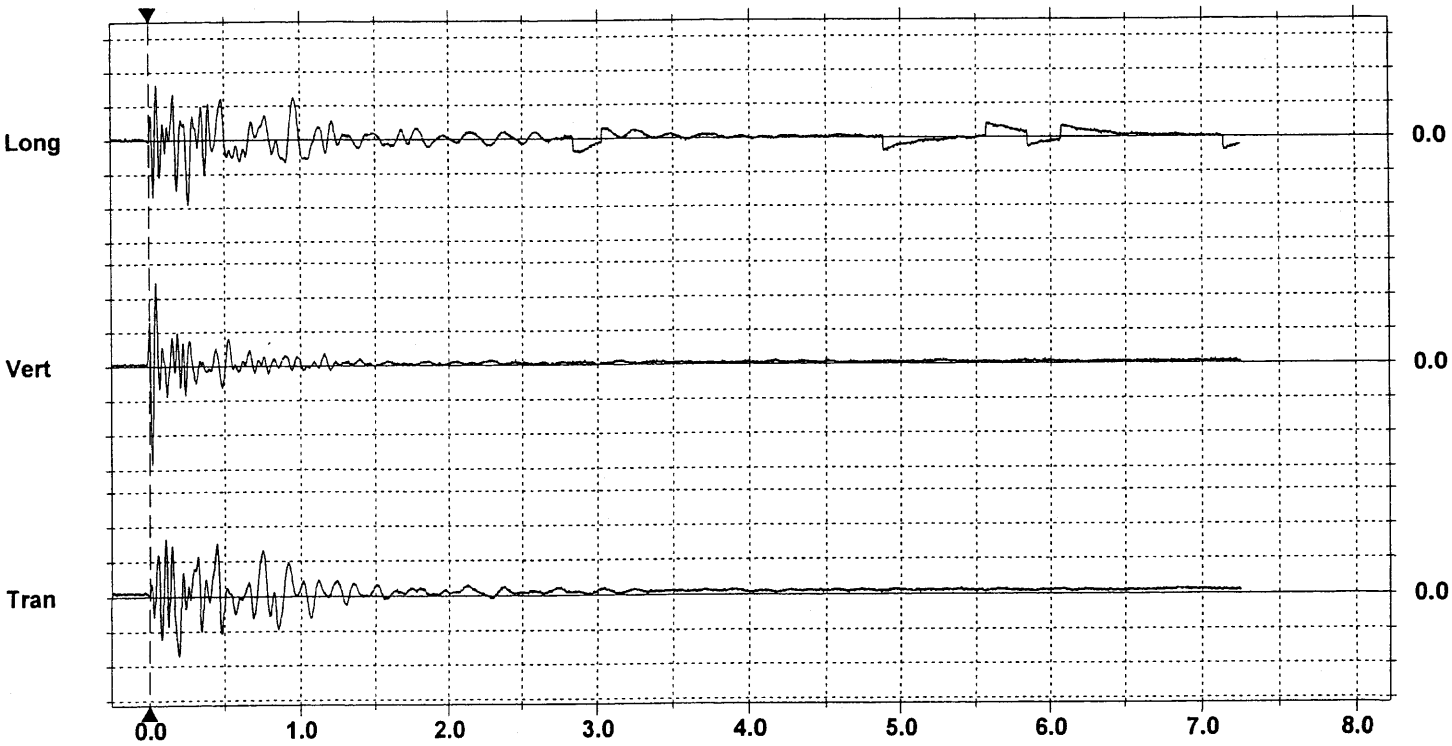
Peak Vector Sum 1.43 mm/s at 0.021 sec

N/A: Not Applicable

USBM RI8507 And OSMRE



Tran: + Vert: x Long: ø



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Printed: June 23, 2005 (V 4.37 - 4.37)

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

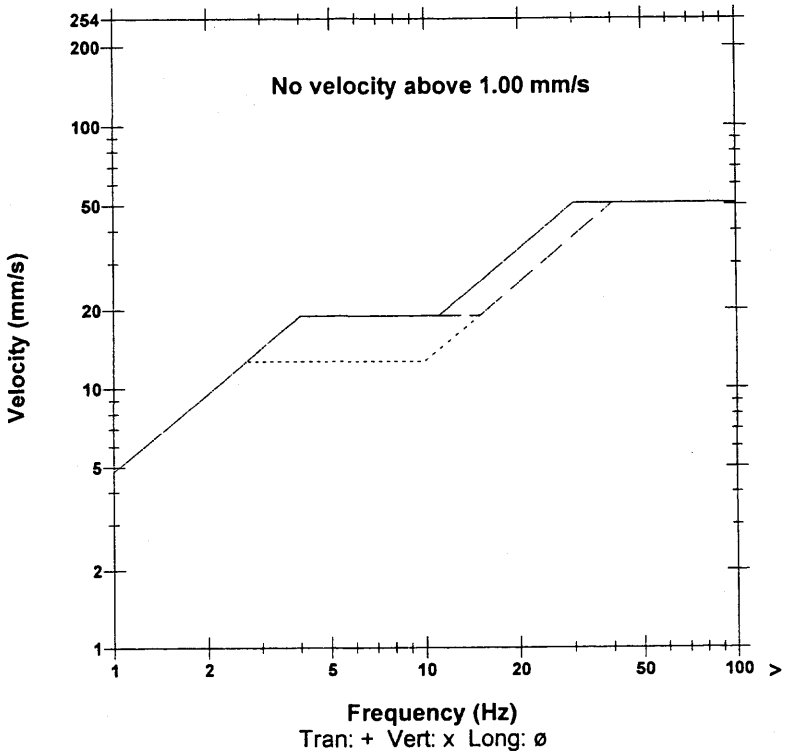
Date/Time	Vert at 09:32:40 April 10, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.9 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AKVU.IG0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

USBM RI8507 And OSMRE

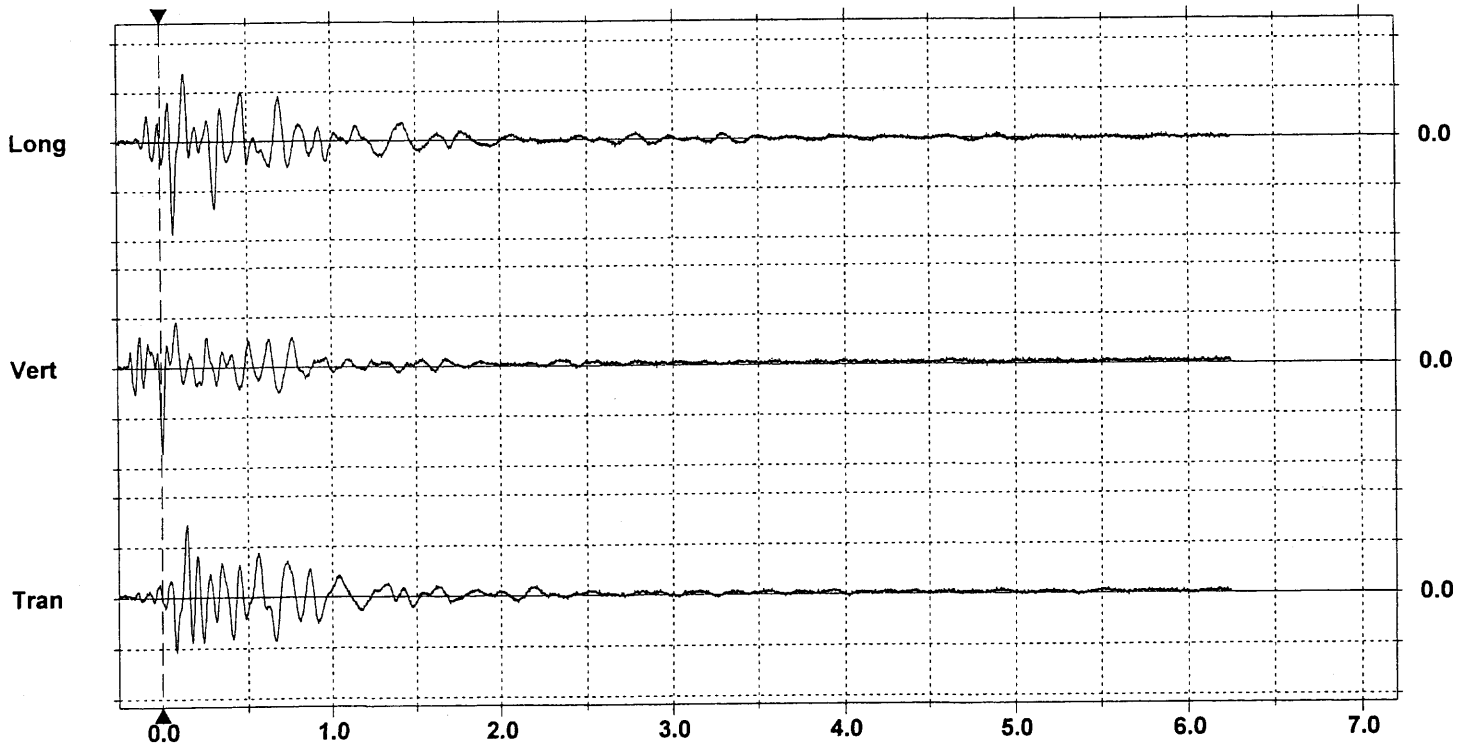


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.730	0.857	0.937	mm/s
ZC Freq	12	13	10	Hz
Time (Rel. to Trig)	0.145	0.008	0.072	sec
Peak Acceleration	0.00829	0.00829	0.0116	g
Peak Displacement	0.0102	0.00908	0.0110	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.06 mm/s at 0.074 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Vert at 20:31:42 April 21, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.3 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALH2.CU0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

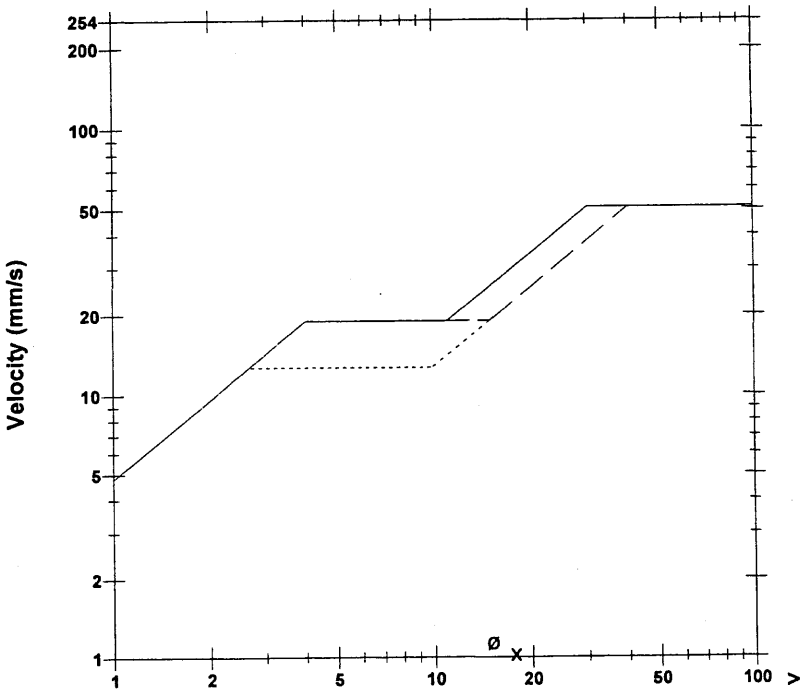
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

	Tran	Vert	Long	
PPV	0.810	1.03	1.14	mm/s
ZC Freq	20	18	15	Hz
Time (Rel. to Trig)	0.099	0.007	0.248	sec
Peak Acceleration	0.0133	0.0133	0.0166	g
Peak Displacement	0.0130	0.00874	0.0194	mm
Sensorcheck	Check	Check	Check	

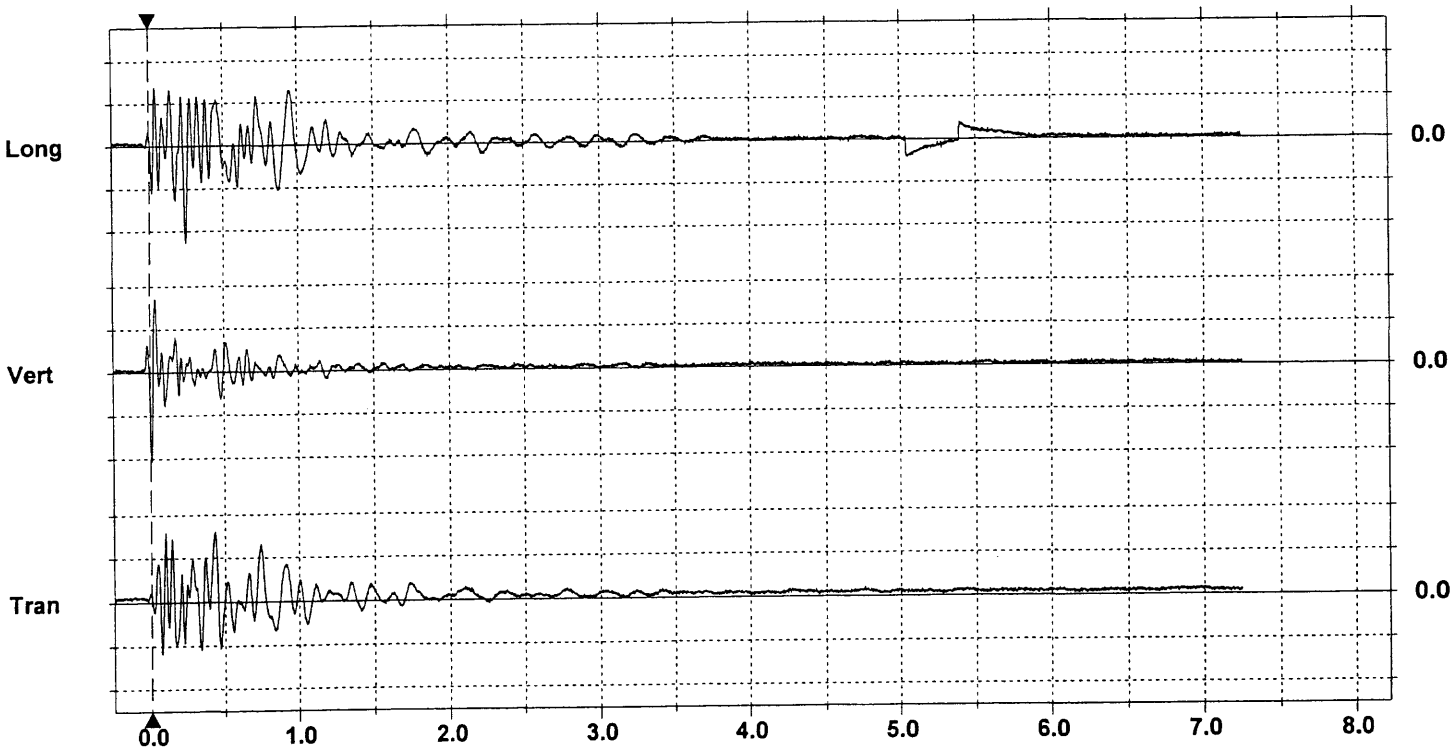
Peak Vector Sum 1.16 mm/s at 0.248 sec

N/A: Not Applicable

USBM RI8507 And OSMRE



Tran: + Vert: x Long: ø



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

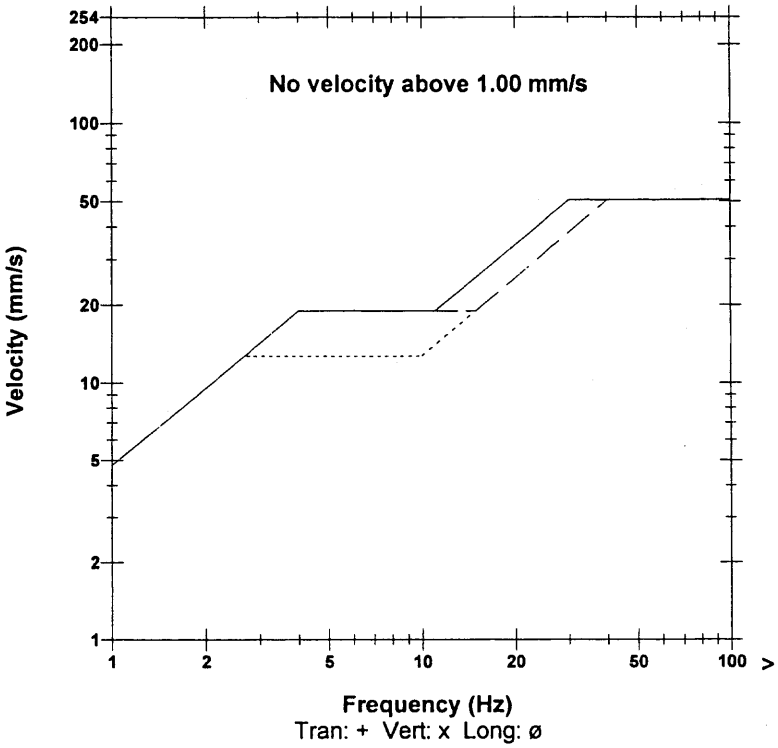
Date/Time	Vert at 20:31:42 April 21, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.3 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ALH2.CU0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

USBM RI8507 And OSMRE

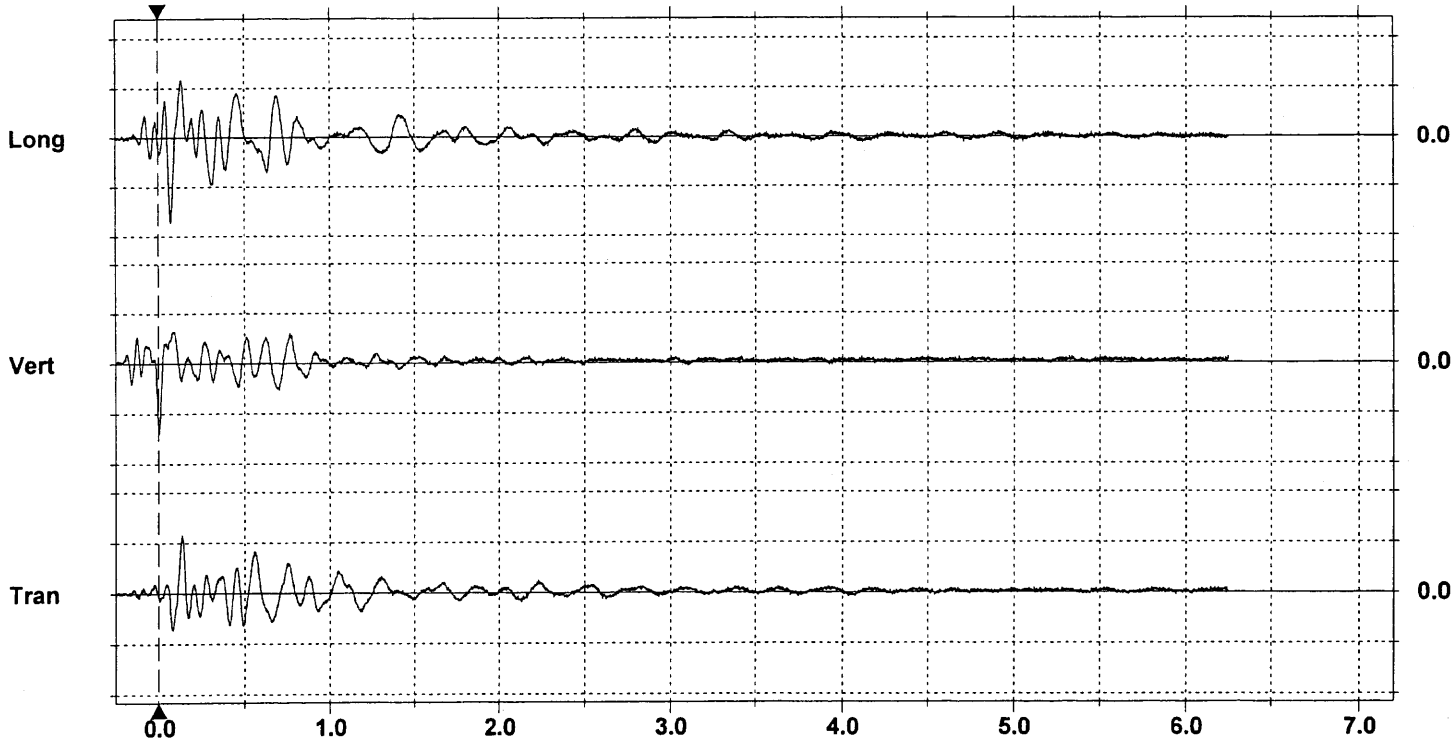


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.587	0.698	0.873	mm/s
ZC Freq	10	12	12	Hz
Time (Rel. to Trig)	0.138	0.004	0.073	sec
Peak Acceleration	0.00663	0.00829	0.00829	g
Peak Displacement	0.00924	0.00946	0.0121	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.940 mm/s at 0.073 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

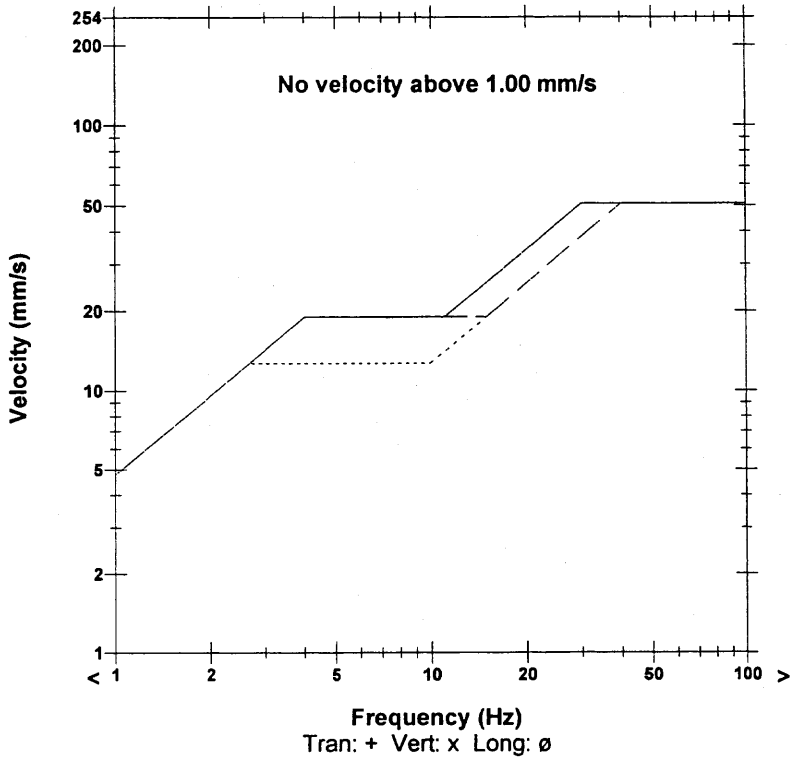
Date/Time	Vert at 05:50:33 April 22, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALHS.890
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

USBM RI8507 And OSMRE

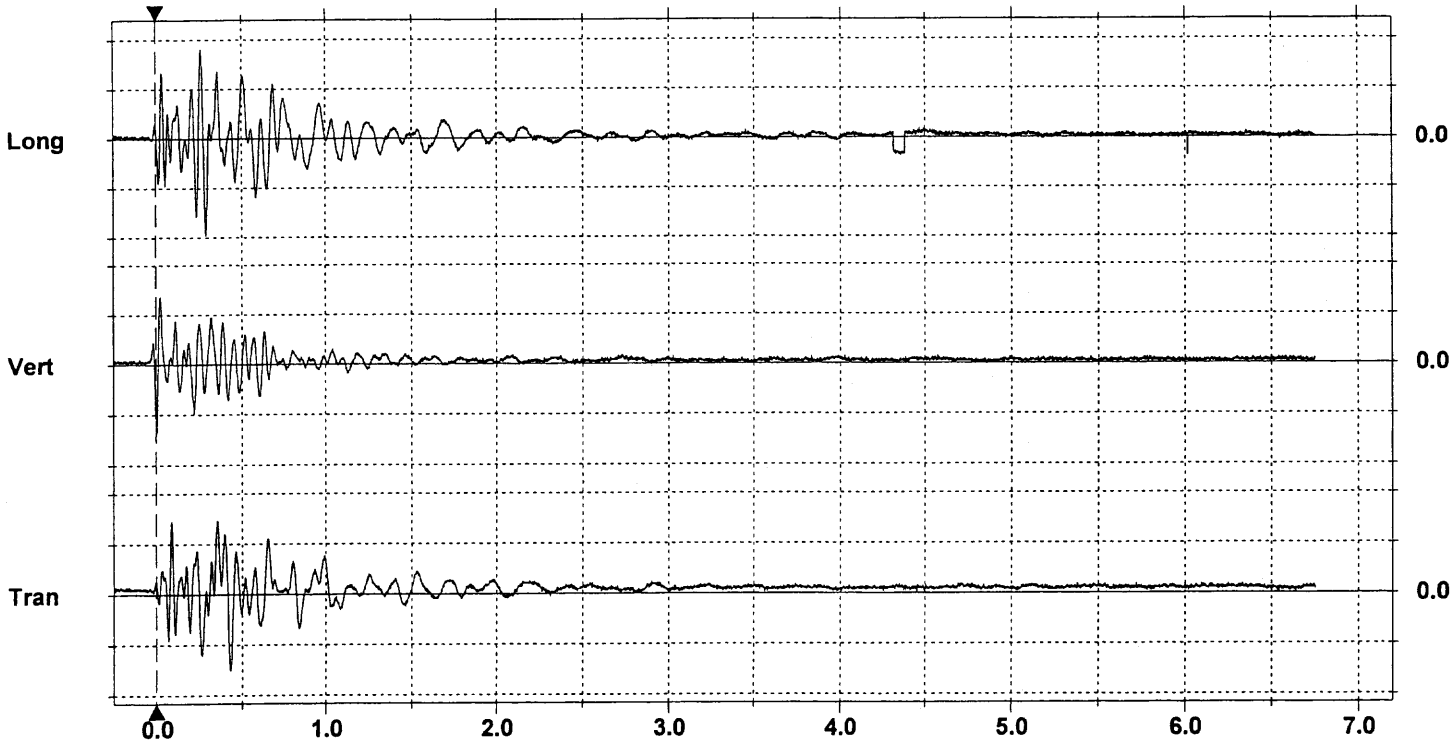


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.762	0.683	0.984	mm/s
ZC Freq	14	23	18	Hz
Time (Rel. to Trig)	0.430	0.004	0.289	sec
Peak Acceleration	0.0116	0.0149	0.0166	g
Peak Displacement	0.0201	0.00666	0.00933	mm
Sensorcheck	Check	Check	Check	

Peak Vector Sum 1.11 mm/s at 0.262 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

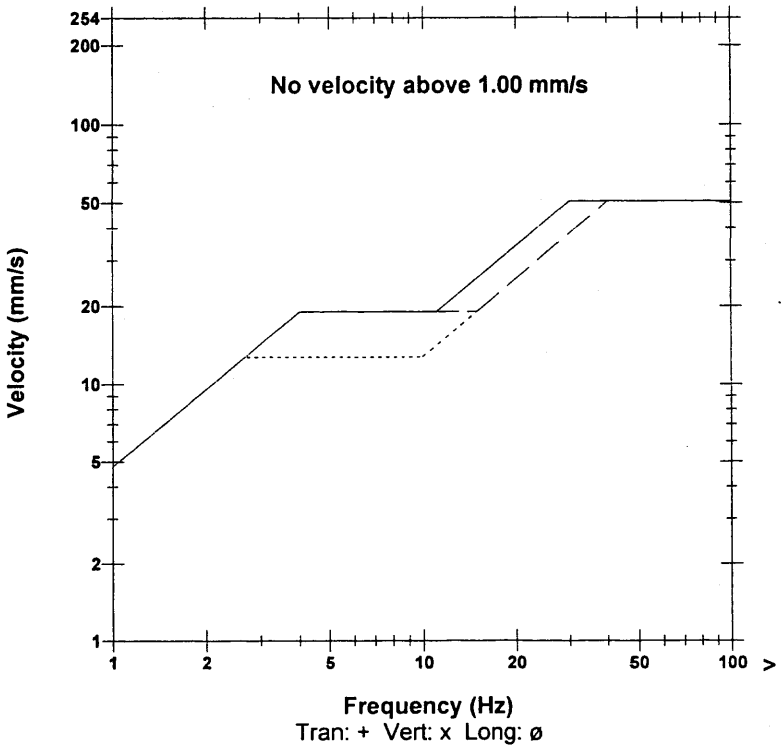
Date/Time	Tran at 05:50:33 April 22, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.1 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ALHS.890
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

USBM RI8507 And OSMRE

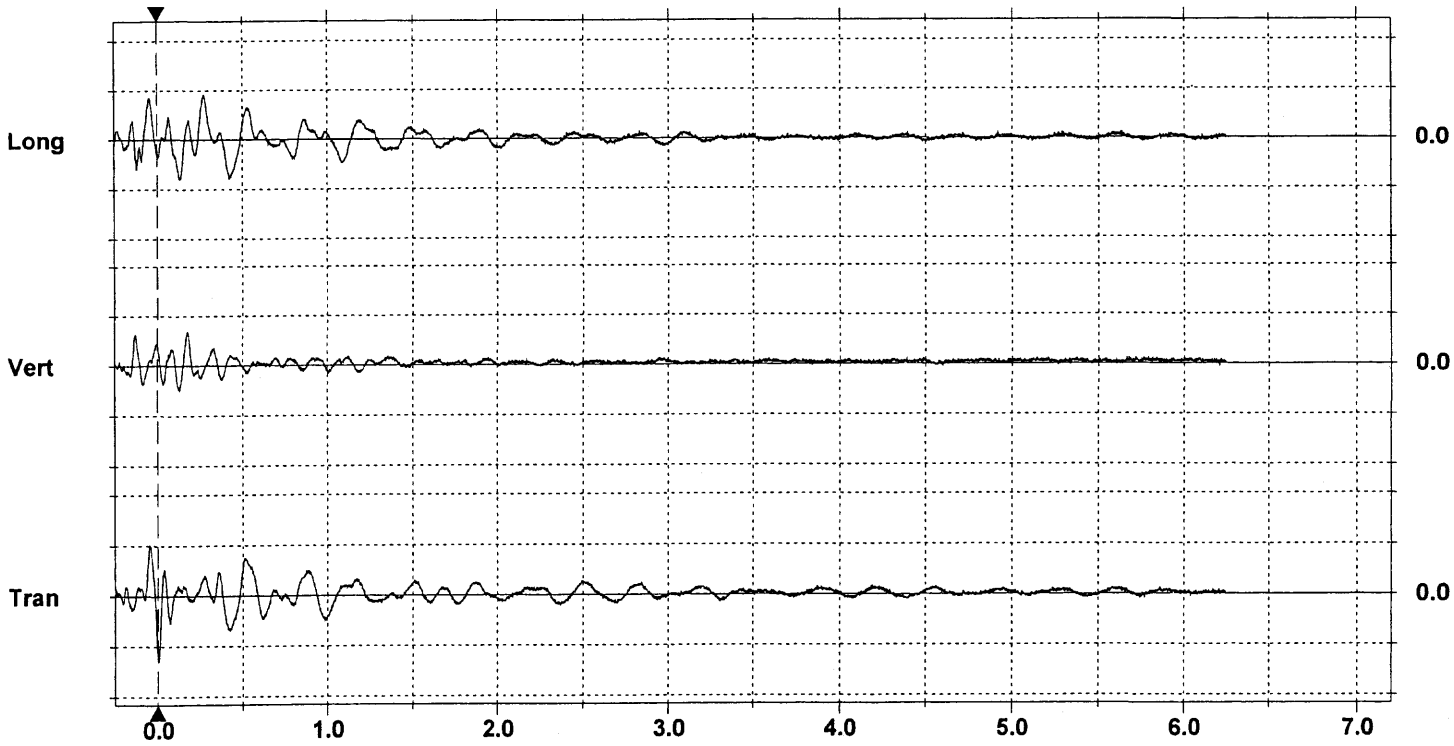


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.651	0.349	0.460	mm/s
ZC Freq	12	11	6.5	Hz
Time (Rel. to Trig)	0.005	0.182	0.276	sec
Peak Acceleration	0.00829	0.00663	0.00663	g
Peak Displacement	0.0128	0.00494	0.0114	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.686 mm/s at 0.005 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

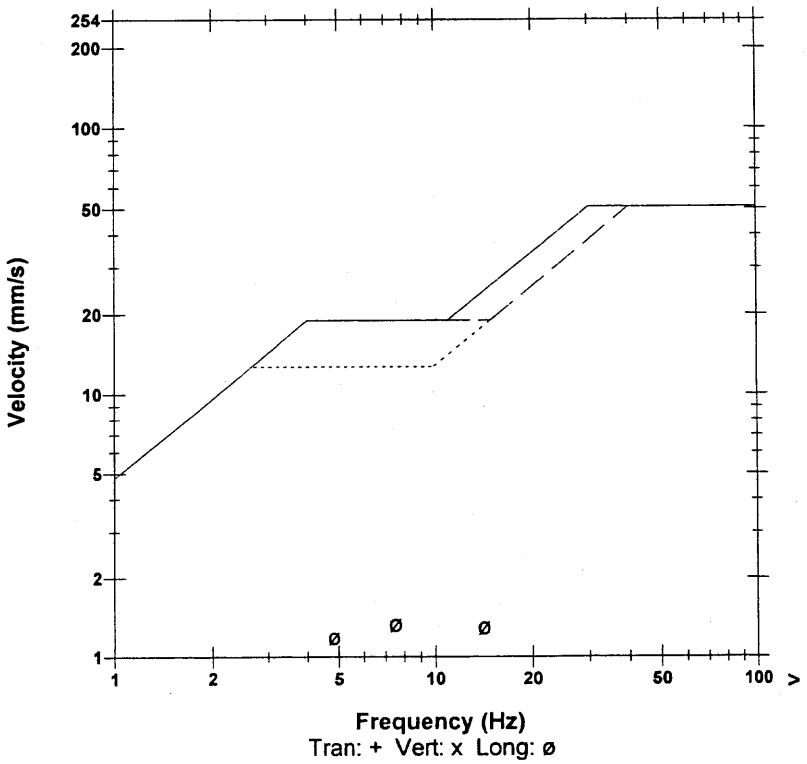
Date/Time	Long at 11:52:08 April 22, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.7 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALI8.YW0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
mag 1.6 UTC 18:52:15

USBM RI8507 And OSMRE

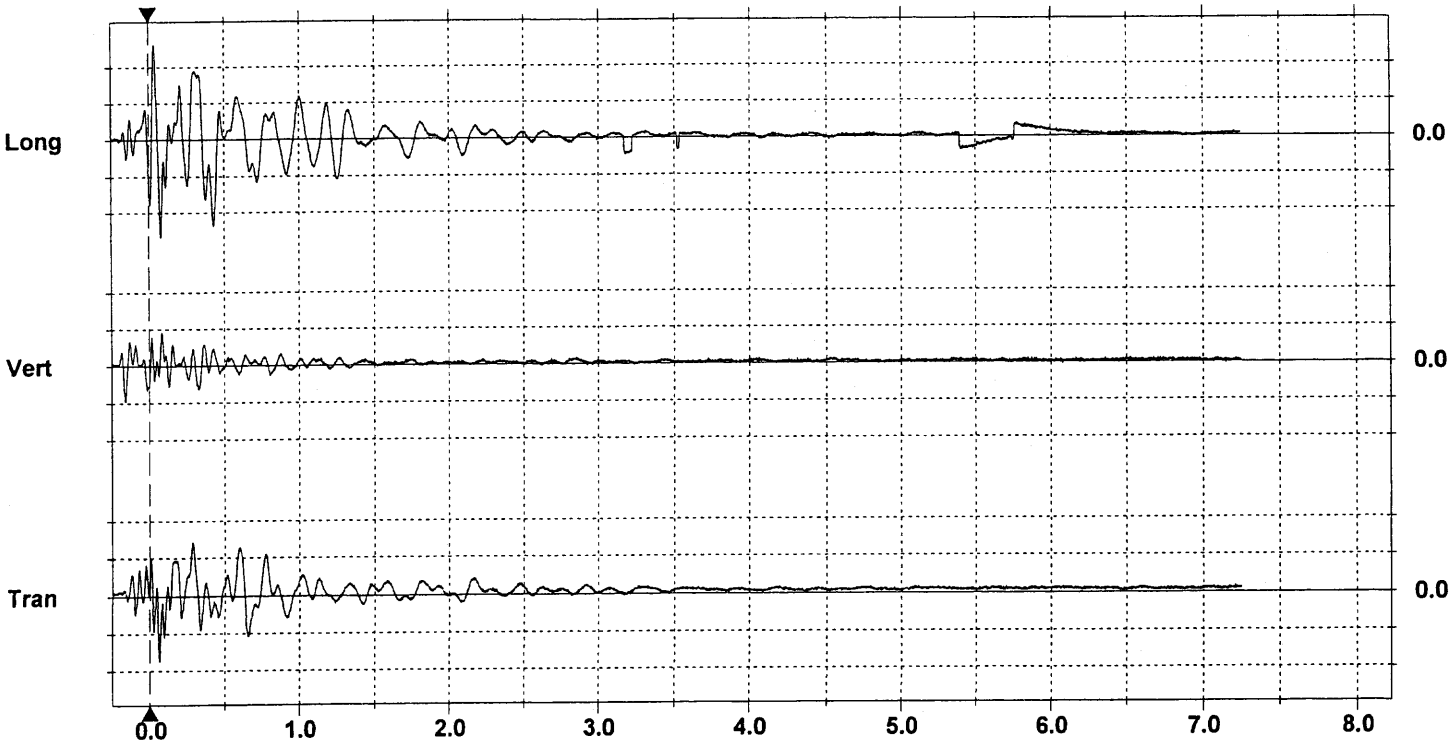


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.873	0.476	1.33	mm/s
ZC Freq	8.4	17	7.5	Hz
Time (Rel. to Trig)	0.063	-0.162	0.077	sec
Peak Acceleration	0.0116	0.00829	0.0166	g
Peak Displacement	0.0153	0.00596	0.0341	mm
Sensorcheck	Check	Check	Check	

Peak Vector Sum 1.40 mm/s at 0.079 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

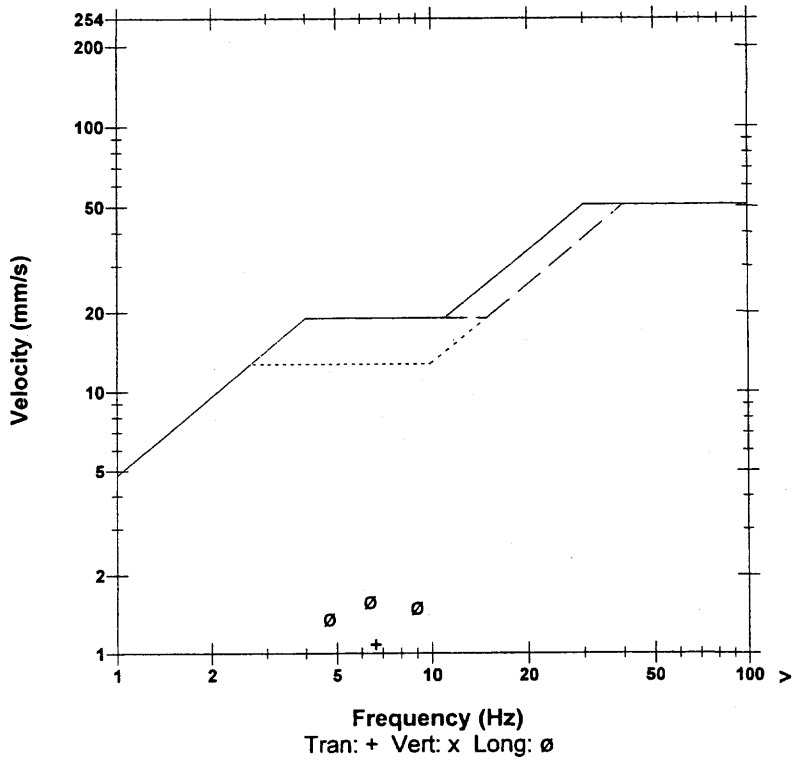
Date/Time	Long at 02:30:15 April 23, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALJD.MF0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

USBM RI8507 And OSMRE

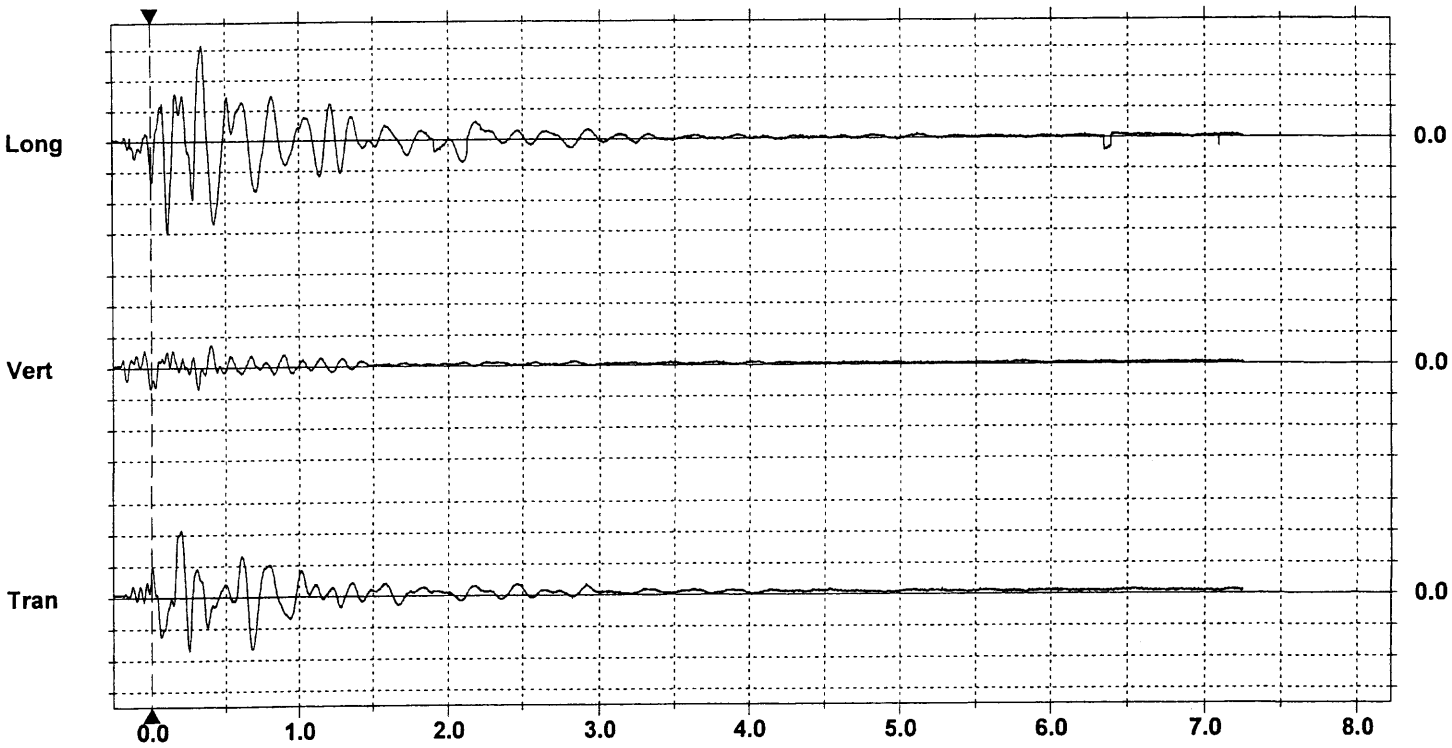


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	1.08	0.381	1.59	mm/s
ZC Freq	6.6	9.0	6.4	Hz
Time (Rel. to Trig)	0.195	0.401	0.339	sec
Peak Acceleration	0.00994	0.00663	0.0166	g
Peak Displacement	0.0278	0.00730	0.0421	mm
Sensorcheck	Check	Check	Check	

Peak Vector Sum 1.61 mm/s at 0.339 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

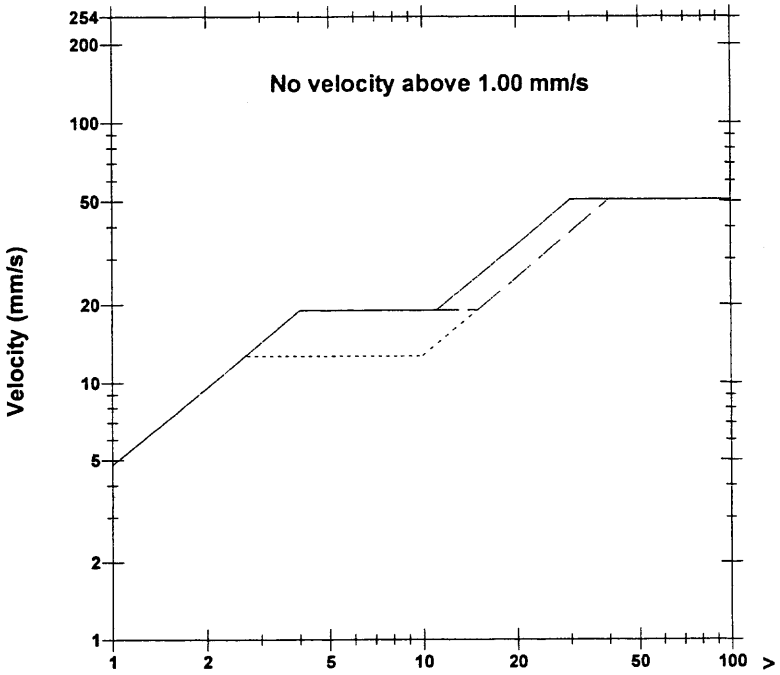
Date/Time	Tran at 02:30:15 April 23, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ALJD.MF0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

USBM RI8507 And OSMRE



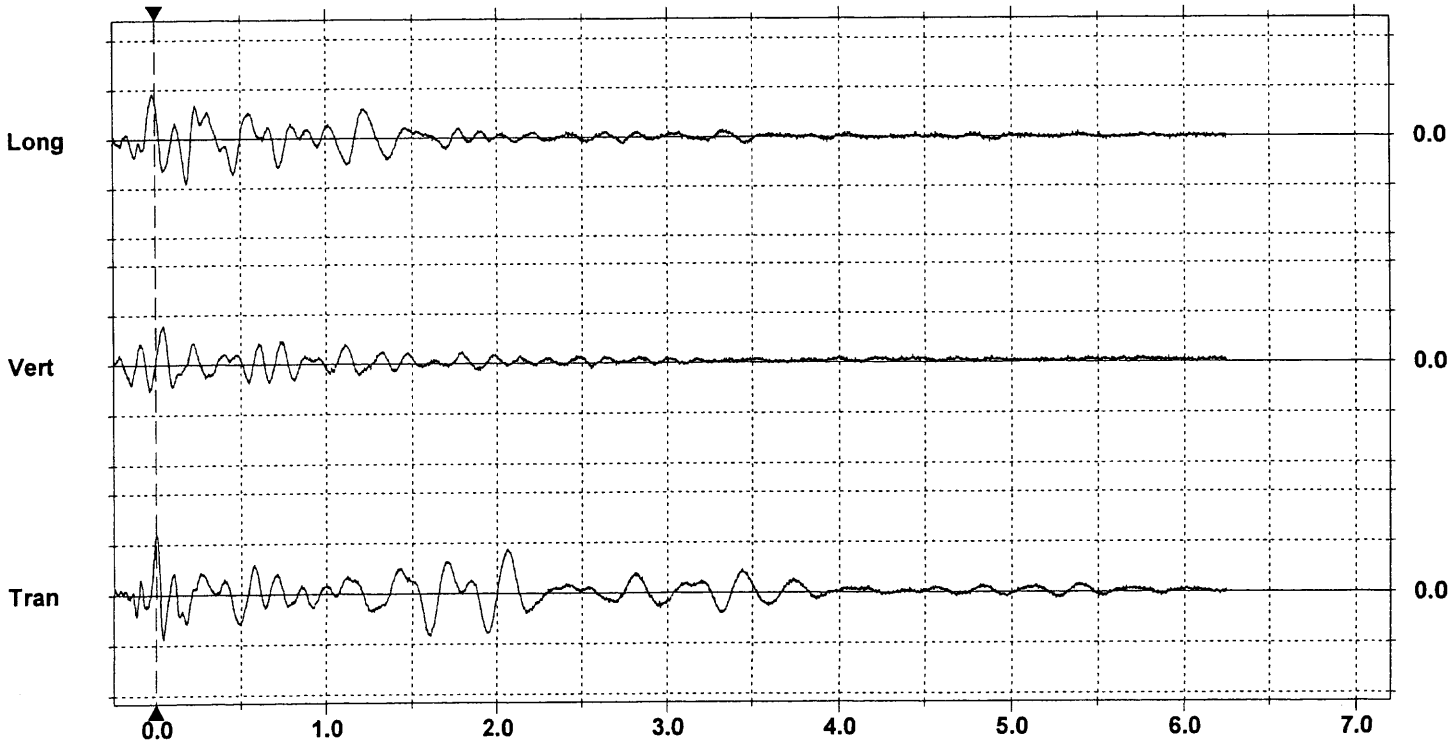
Frequency (Hz)
Tran: + Vert: x Long: ø

Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.603	0.397	0.460	mm/s
ZC Freq	8.5	6.2	6.3	Hz
Time (Rel. to Trig)	0.000	0.043	-0.021	sec
Peak Acceleration	0.00663	0.00663	0.00663	g
Peak Displacement	0.0172	0.00943	0.0138	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.706 mm/s at 0.000 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

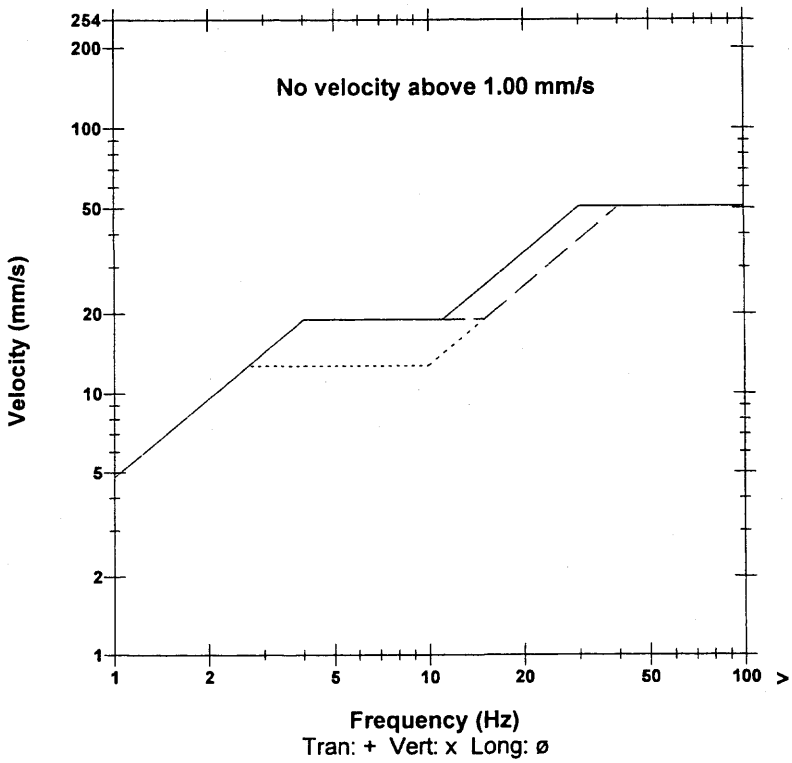
Date/Time	Long at 09:19:43 April 25, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.8 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALNL.WV0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
mag 1.7 UTC 16:20:06

USBM RI8507 And OSMRE

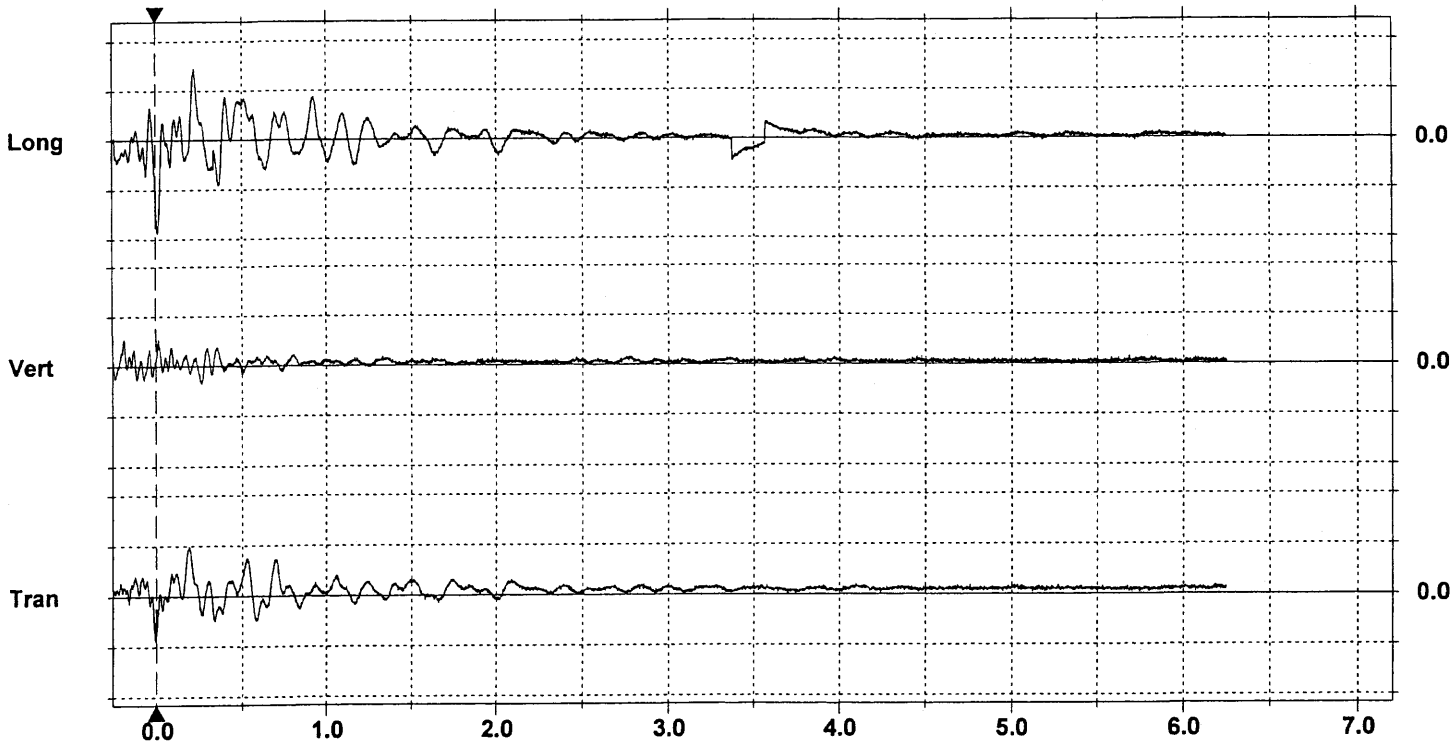


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.492	0.270	0.937	mm/s
ZC Freq	5.7	14	11	Hz
Time (Rel. to Trig)	0.187	-0.187	0.010	sec
Peak Acceleration	0.00663	0.00663	0.0133	g
Peak Displacement	0.0126	0.00265	0.0202	mm
Sensorcheck	Check	Check	Check	

Peak Vector Sum 0.982 mm/s at 0.011 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Tran at 15:53:47 April 26, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.7 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALPY.TN0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

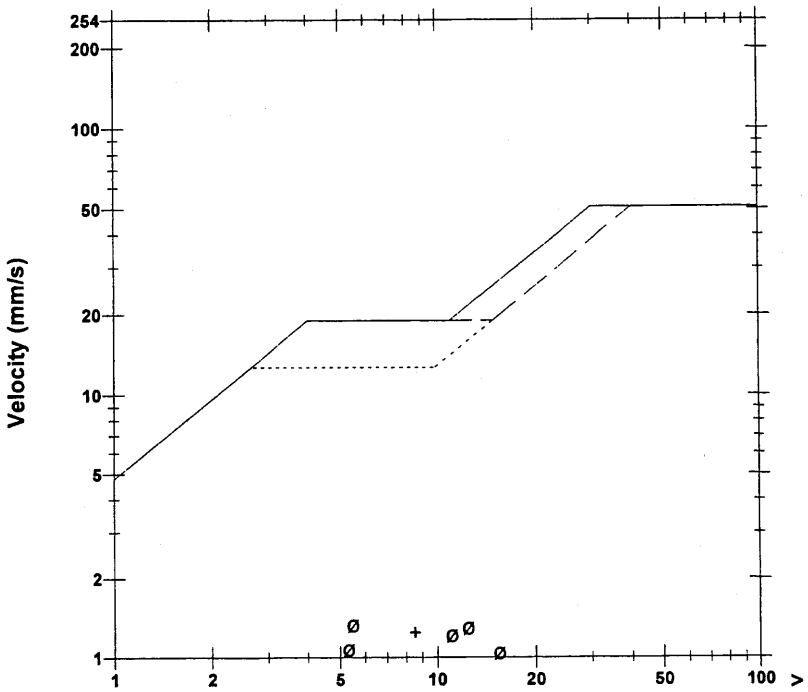
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

	Tran	Vert	Long	
PPV	1.24	0.460	1.33	mm/s
ZC Freq	8.5	24	5.5	Hz
Time (Rel. to Trig)	0.012	0.025	0.382	sec
Peak Acceleration	0.0149	0.00994	0.0166	g
Peak Displacement	0.0194	0.00484	0.0305	mm
Sensorcheck	Check	Check	Check	

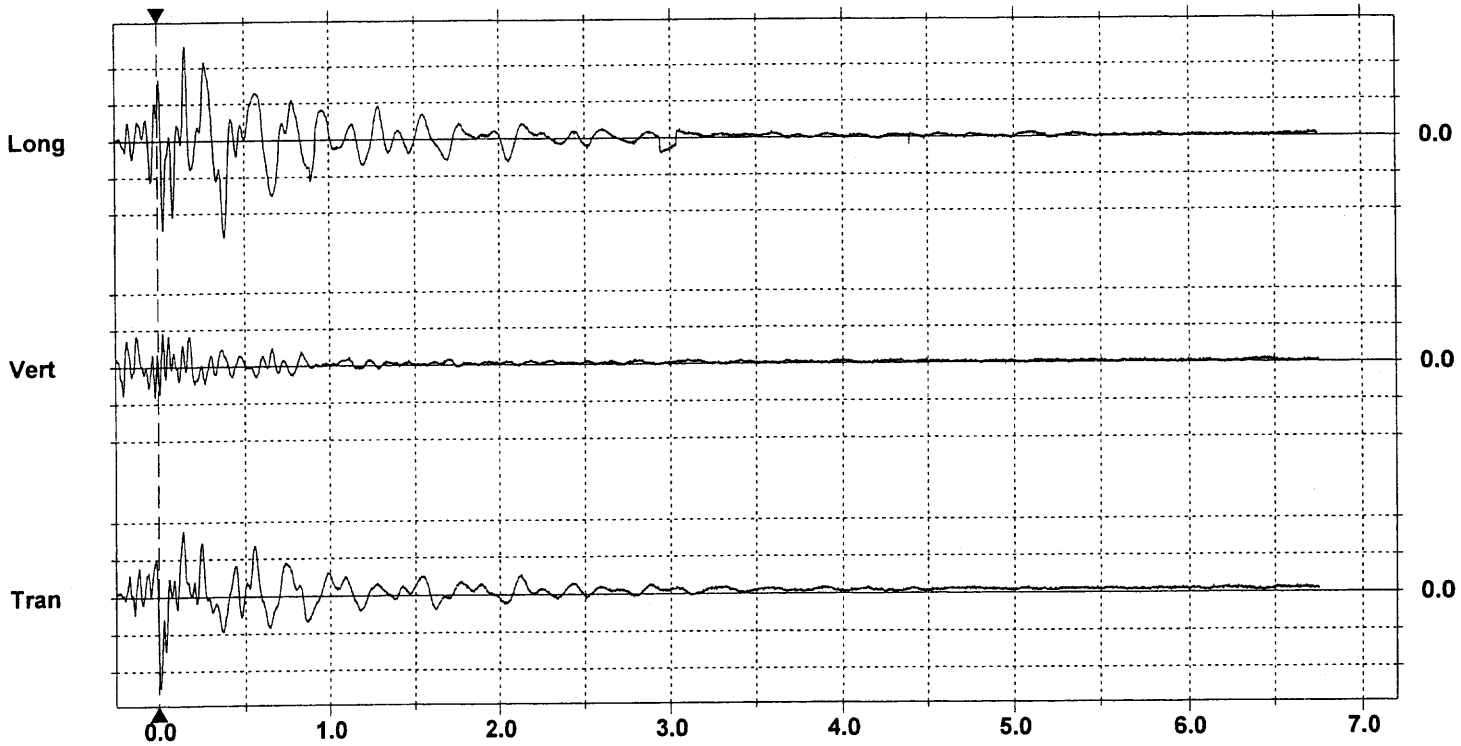
Peak Vector Sum 1.51 mm/s at 0.009 sec

N/A: Not Applicable

USBM RI8507 And OSMRE



Tran: + Vert: x Long: ø



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

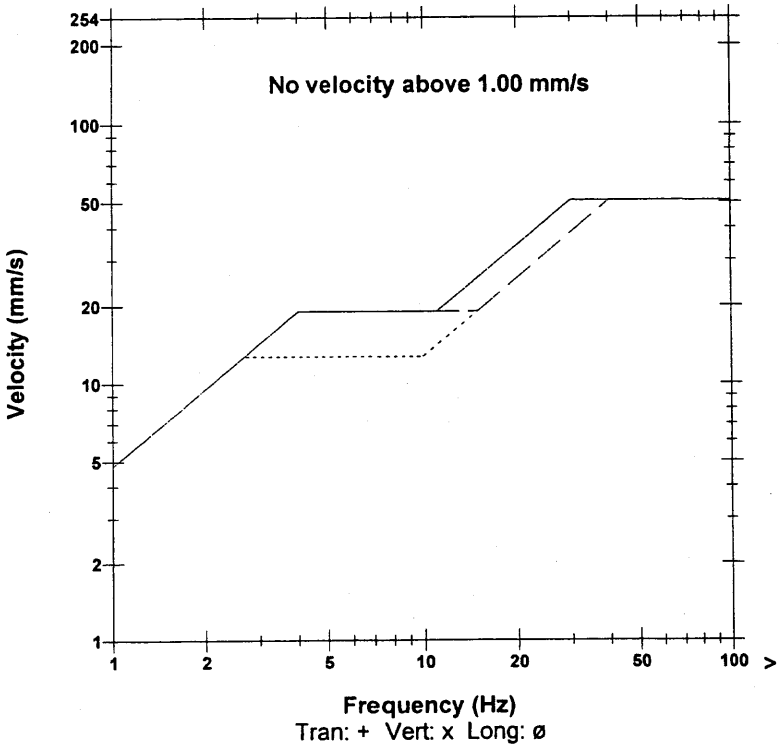
Date/Time	Tran at 15:53:47 April 26, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.7 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ALPY.TN0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

USBM RI8507 And OSMRE

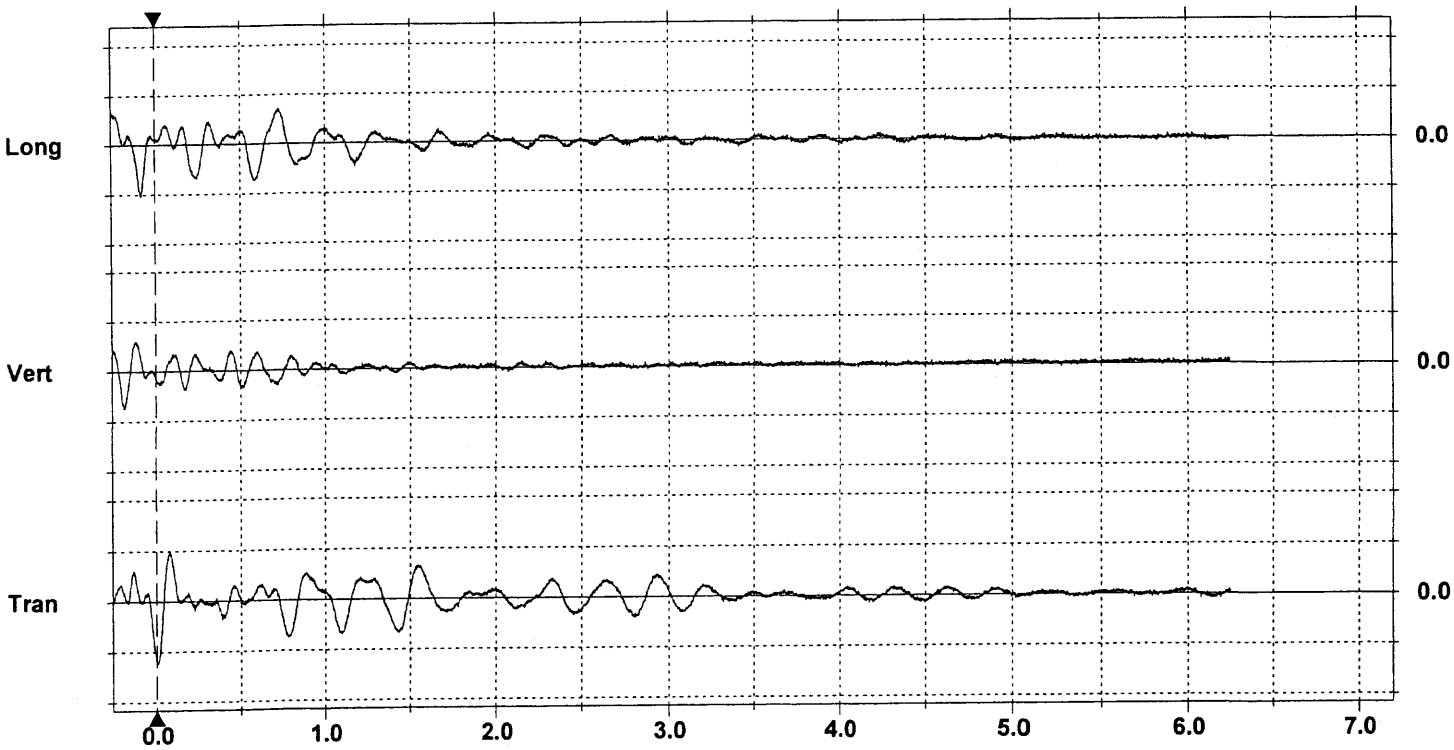


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.635	0.381	0.524	mm/s
ZC Freq	6.2	7.8	6.4	Hz
Time (Rel. to Trig)	0.002	-0.184	-0.081	sec
Peak Acceleration	0.00663	0.00497	0.00829	g
Peak Displacement	0.0159	0.00695	0.0134	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.640 mm/s at 0.002 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger =

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

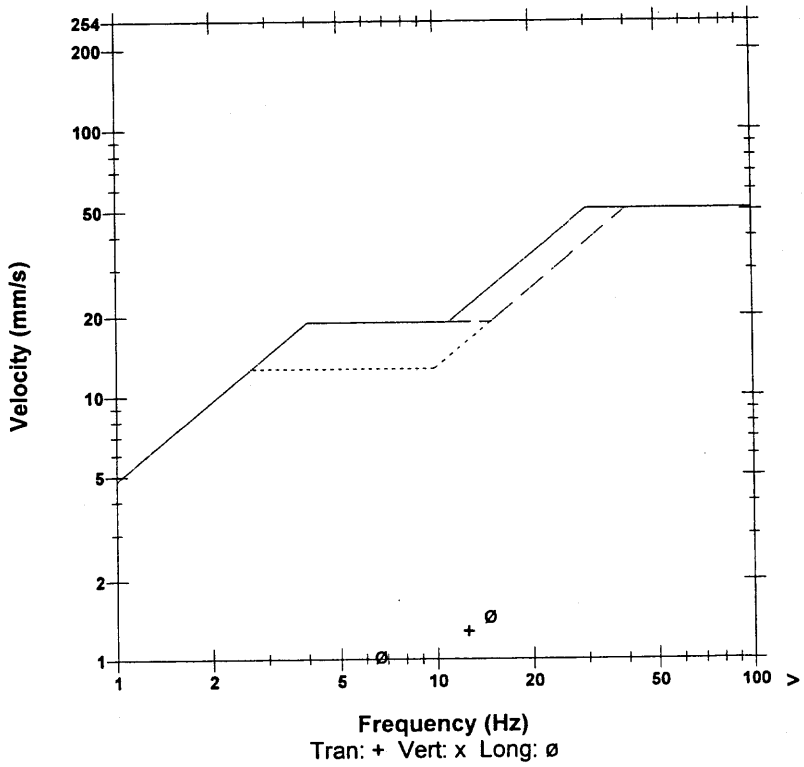
Date/Time	Tran at 15:19:50 April 27, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.8 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALRR.X20
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both EQ mag 1.8 UTC 22:20:25

USBM RI8507 And OSMRE

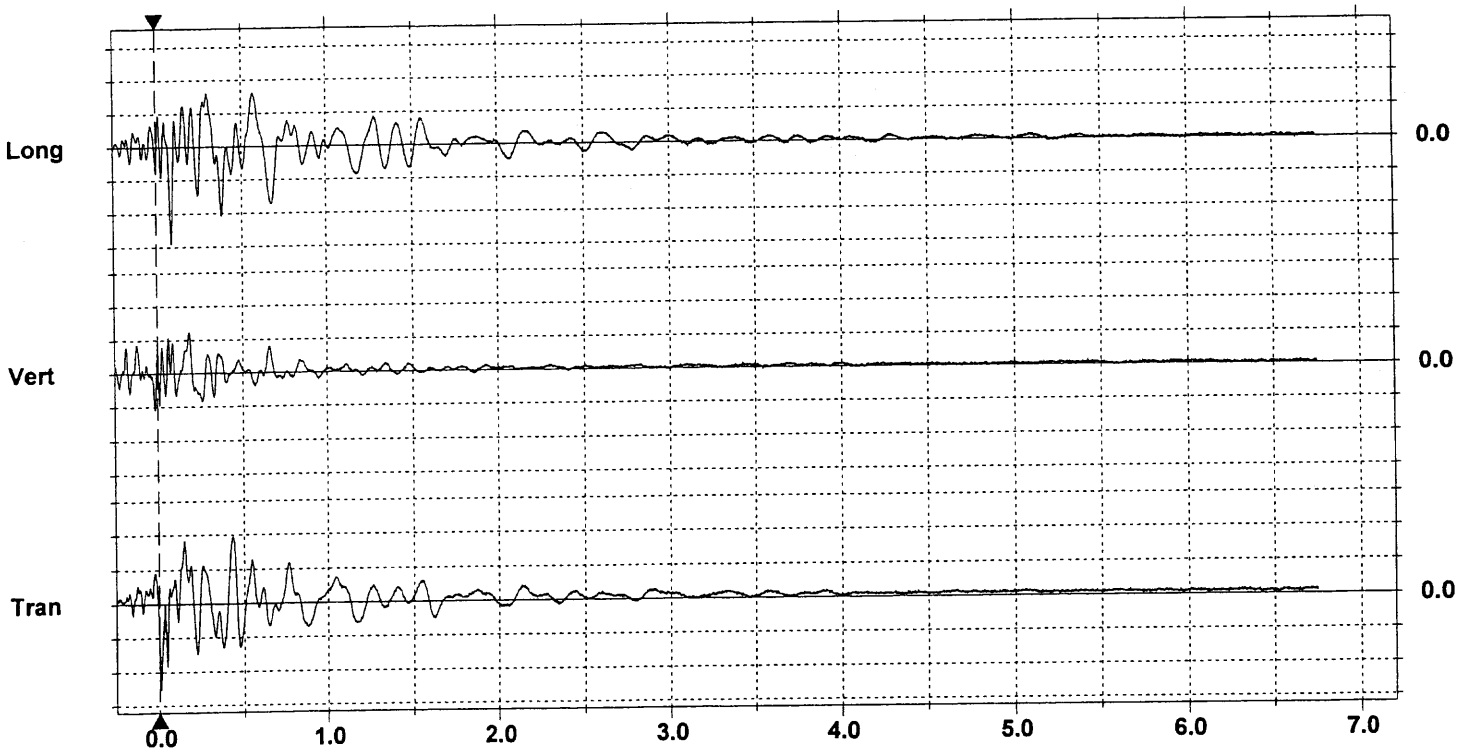


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	1.27	0.619	1.46	mm/s
ZC Freq	12	7.1	15	Hz
Time (Rel. to Trig)	0.007	0.185	0.089	sec
Peak Acceleration	0.0149	0.0116	0.0166	g
Peak Displacement	0.0212	0.0106	0.0214	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.57 mm/s at 0.089 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

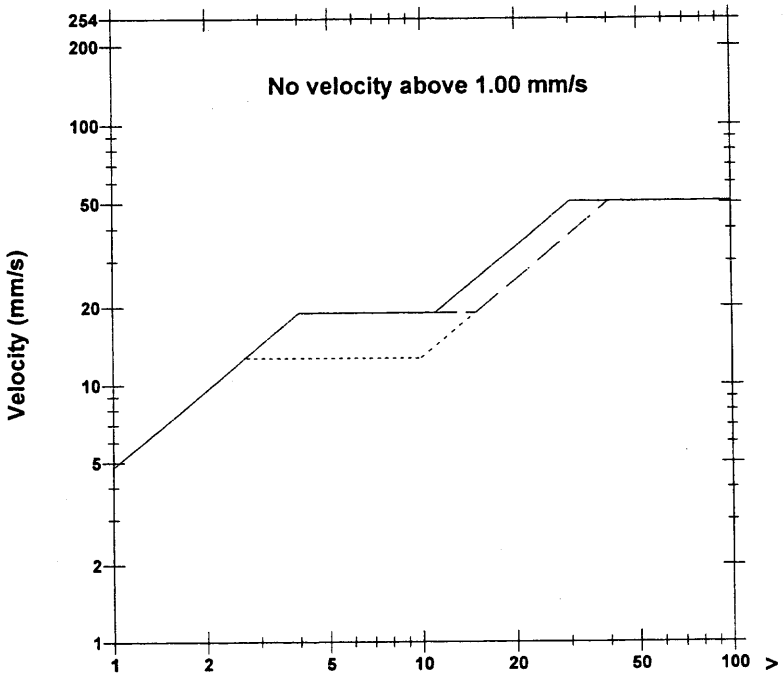
Date/Time	Tran at 15:19:50 April 27, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.8 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ALRR.X20
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both EQ mag 1.8 UTC 22:20:25

USBM RI8507 And OSMRE



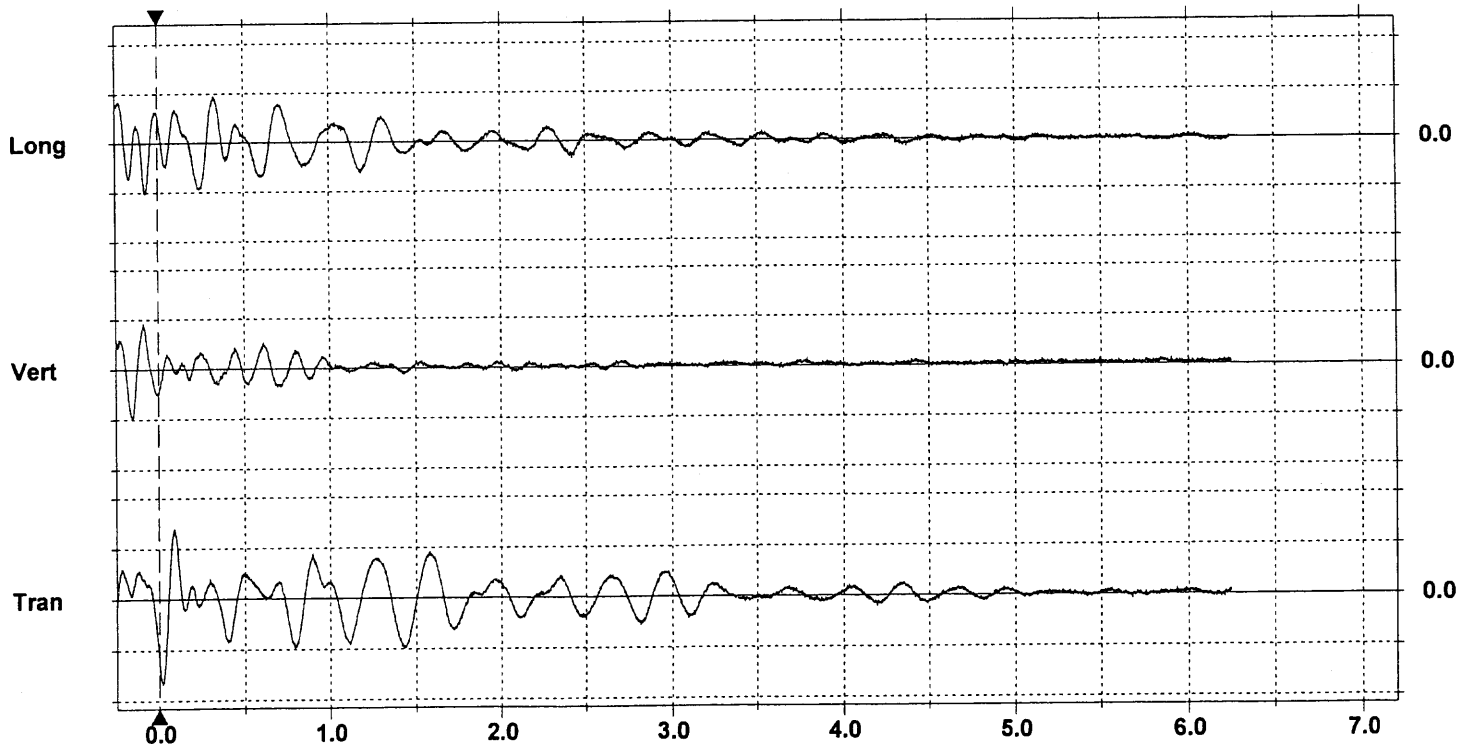
Frequency (Hz)
Tran: + Vert: x Long: ø

Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.841	0.492	0.508	mm/s
ZC Freq	5.6	7.5	8.7	Hz
Time (Rel. to Trig)	0.019	-0.155	-0.078	sec
Peak Acceleration	0.00663	0.00497	0.00663	g
Peak Displacement	0.0223	0.0101	0.0149	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.850 mm/s at 0.019 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

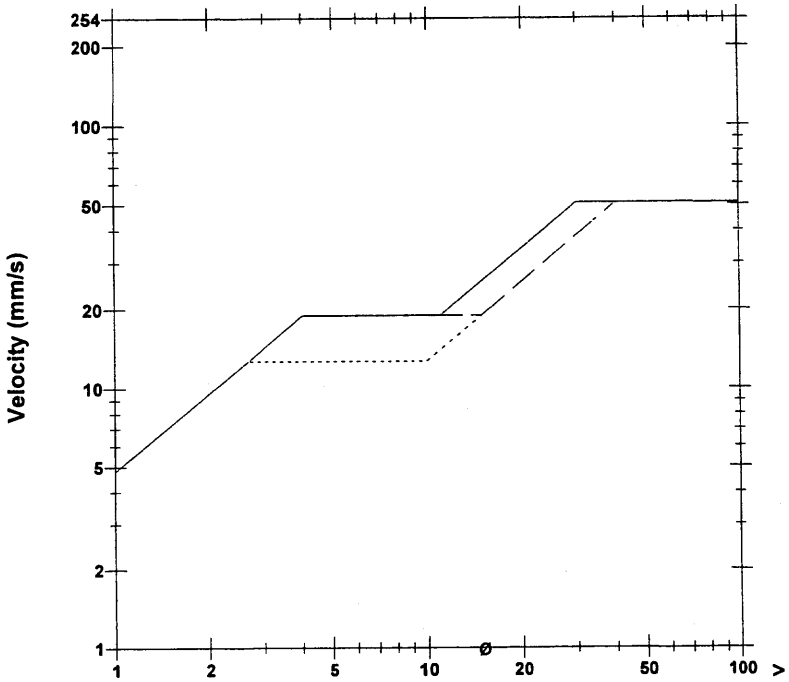
Date/Time	Vert at 23:27:00 April 27, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALSE.H00
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
picked up on both units

USBM RI8507 And OSMRE



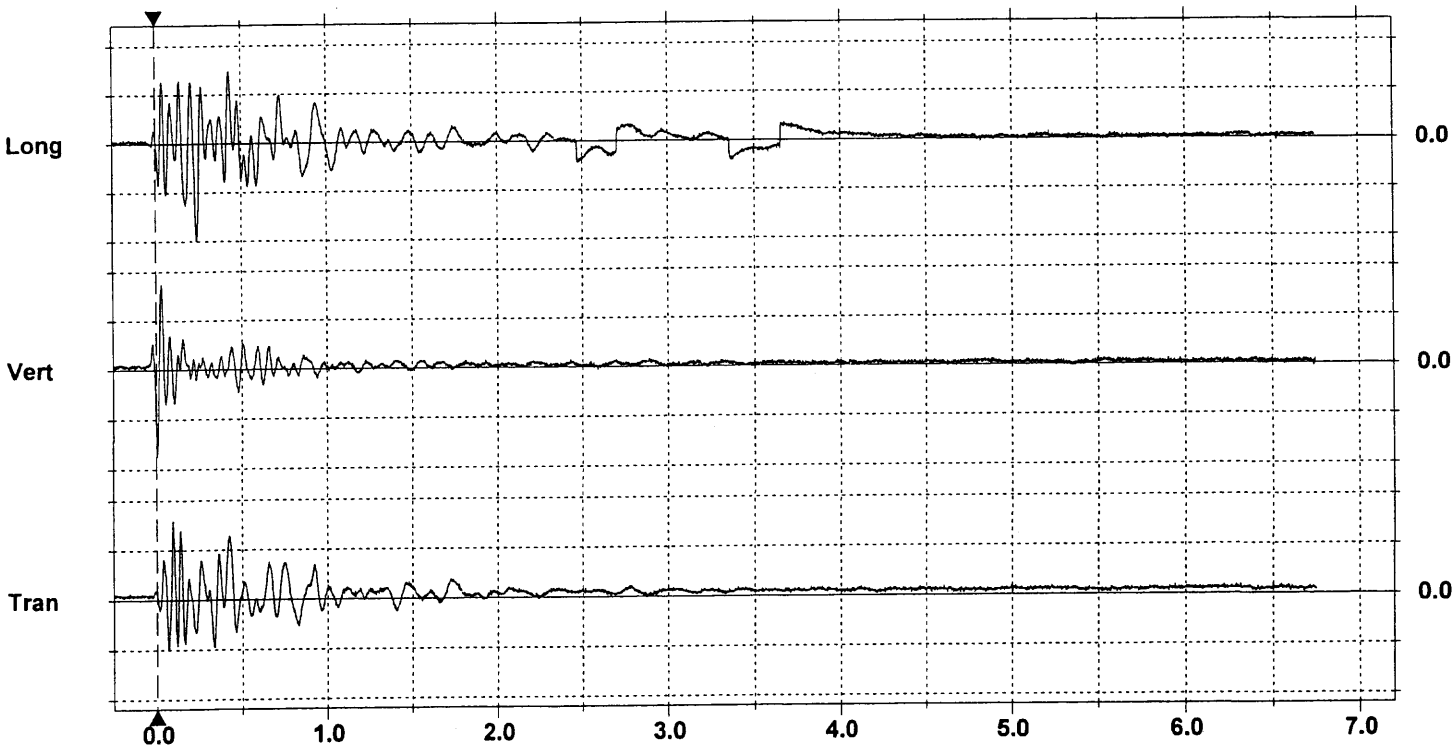
Frequency (Hz)
Tran: + Vert: x Long: ø

Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.794	0.873	1.00	mm/s
ZC Freq	20	18	15	Hz
Time (Rel. to Trig)	0.095	0.005	0.240	sec
Peak Acceleration	0.00994	0.0116	0.0166	g
Peak Displacement	0.0136	0.00797	0.0195	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.03 mm/s at 0.034 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

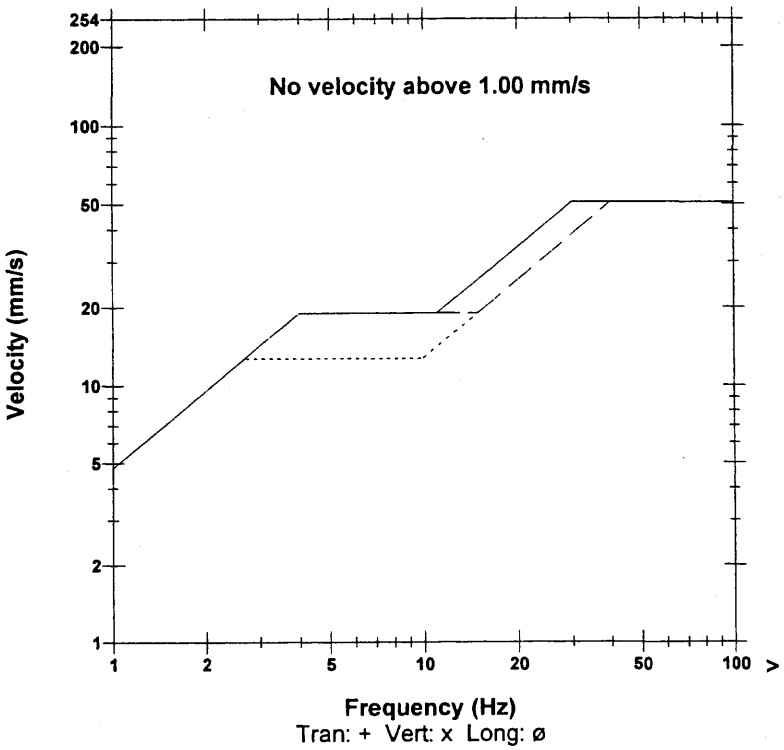
Date/Time	Long at 23:26:59 April 27, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.3 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ALSE.GZ0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
picked up on both units

USBM RI8507 And OSMRE

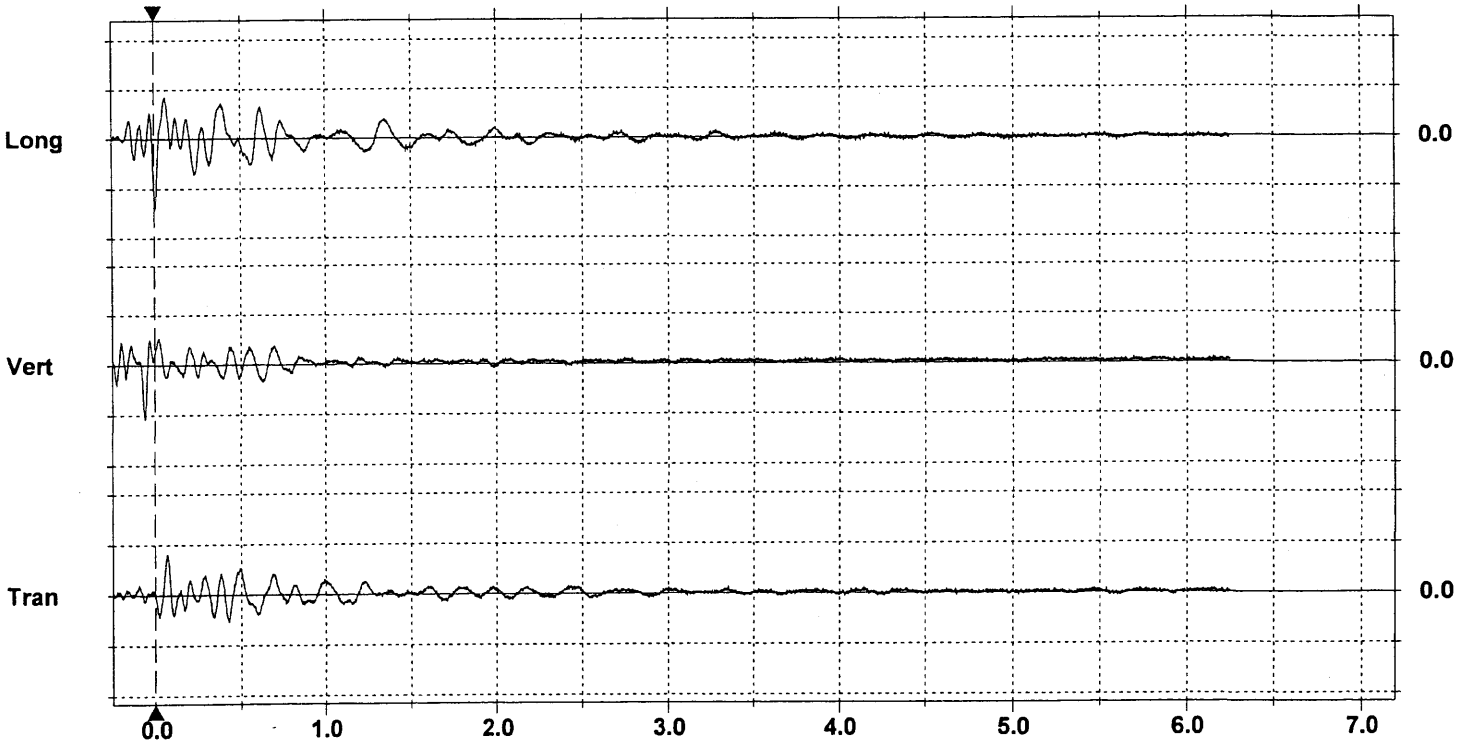


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.413	0.540	0.714	mm/s
ZC Freq	11	13	13	Hz
Time (Rel. to Trig)	0.070	-0.063	0.004	sec
Peak Acceleration	0.00663	0.00663	0.00829	g
Peak Displacement	0.00593	0.00717	0.00991	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.729 mm/s at 0.004 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

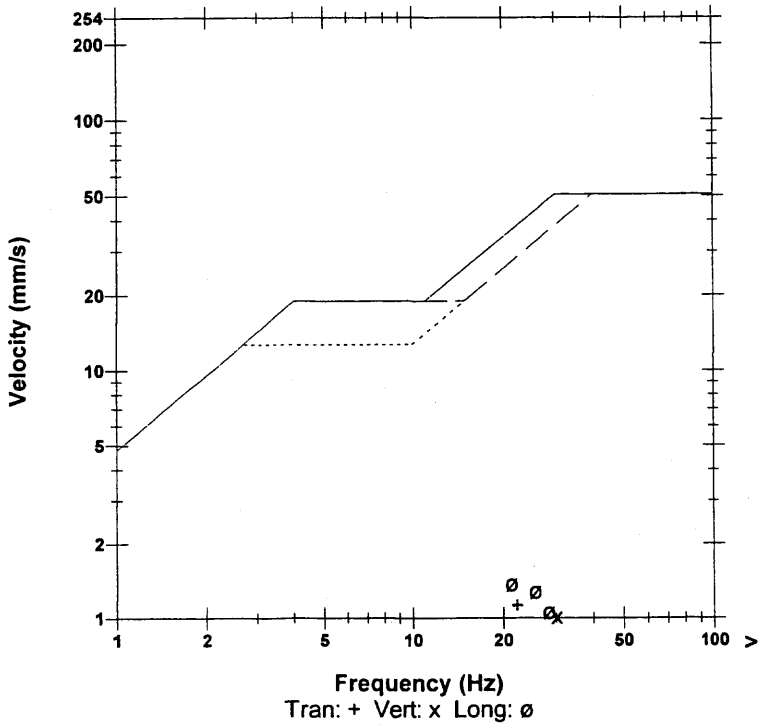
Date/Time	Long at 17:51:09 April 28, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.6 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	8.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALTT.L90
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
0.0249 g, not recorded on Dam Unit, or as an earthquake UUSS

USBM RI8507 And OSMRE

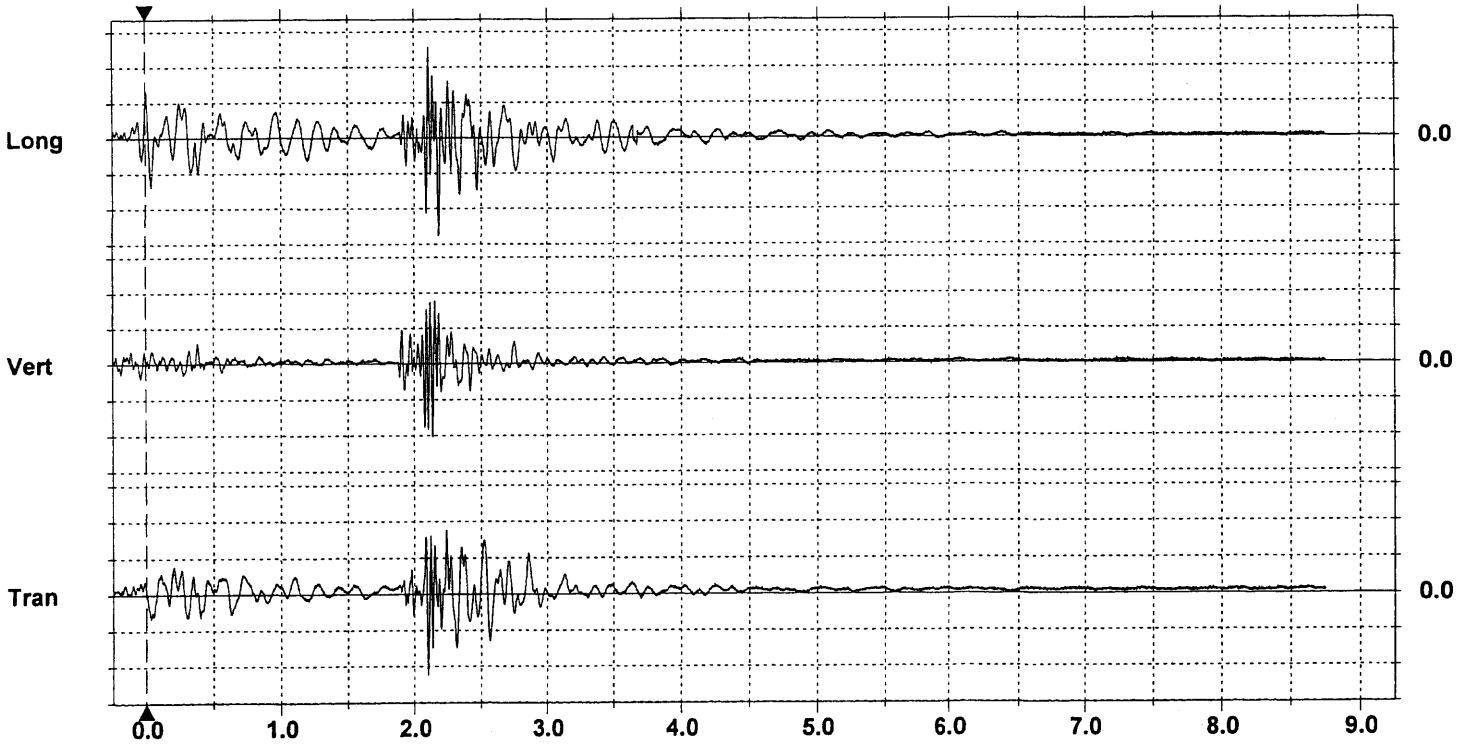


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	1.13	1.02	1.38	mm/s
ZC Freq	22	30	21	Hz
Time (Rel. to Trig)	2.100	2.136	2.180	sec
Peak Acceleration	0.0199	0.0199	0.0249	g
Peak Displacement	0.0132	0.00763	0.0152	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.81 mm/s at 2.104 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger =

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Vert at 05:21:38 April 30, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.1 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALWK.820
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
picked up on both units

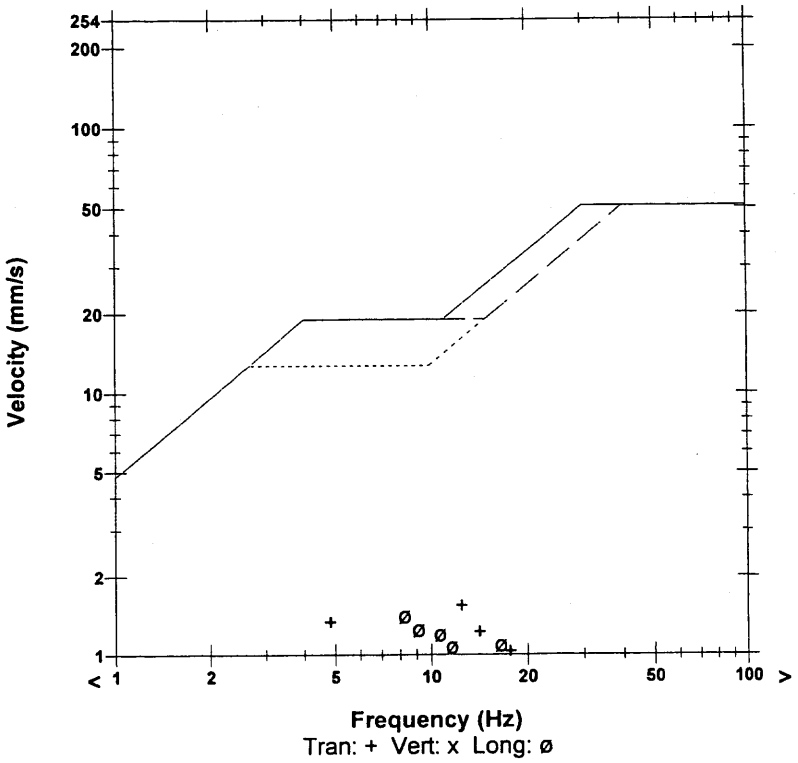
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

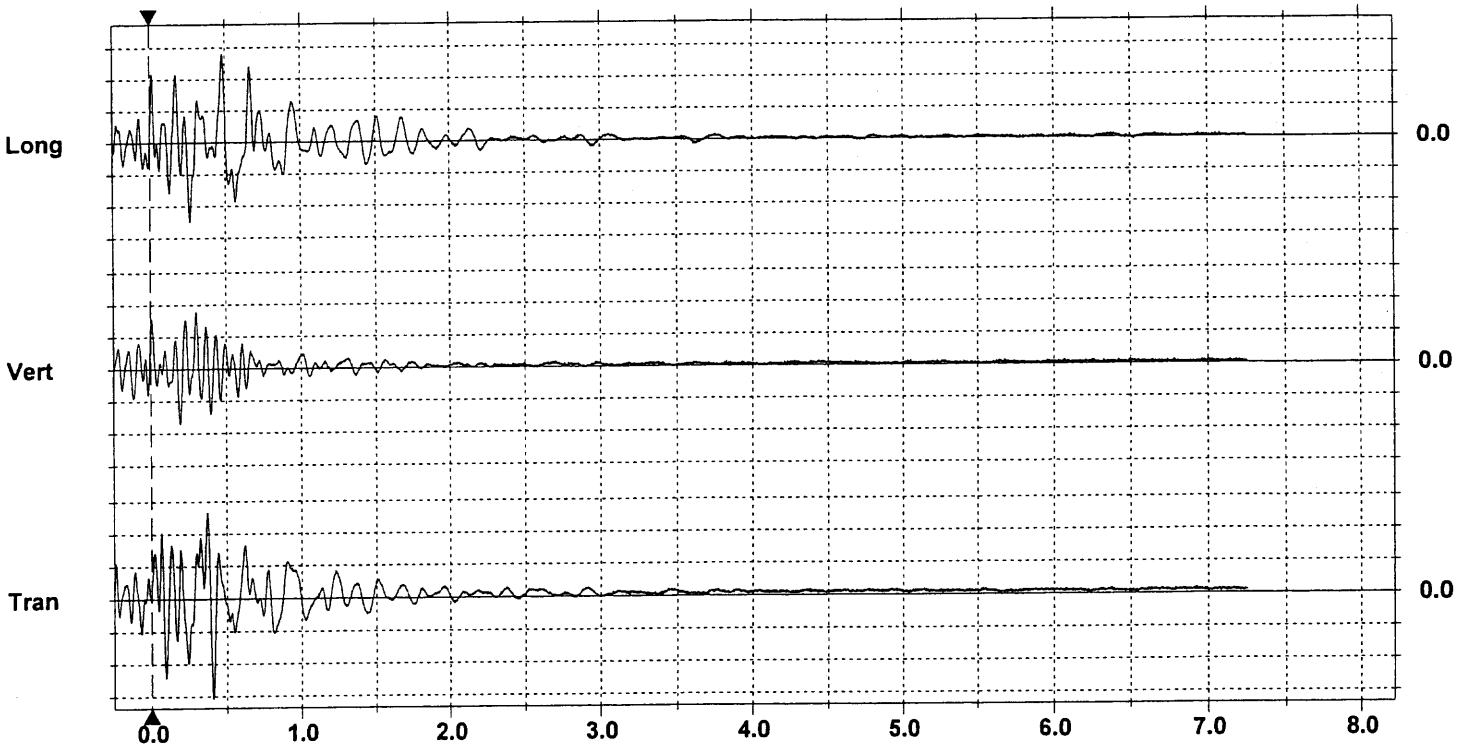
	Tran	Vert	Long	
PPV	1.54	0.889	1.41	mm/s
ZC Freq	12	13	8.3	Hz
Time (Rel. to Trig)	0.404	0.299	0.480	sec
Peak Acceleration	0.0149	0.00994	0.0116	g
Peak Displacement	0.0351	0.00940	0.0326	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.60 mm/s at 0.404 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

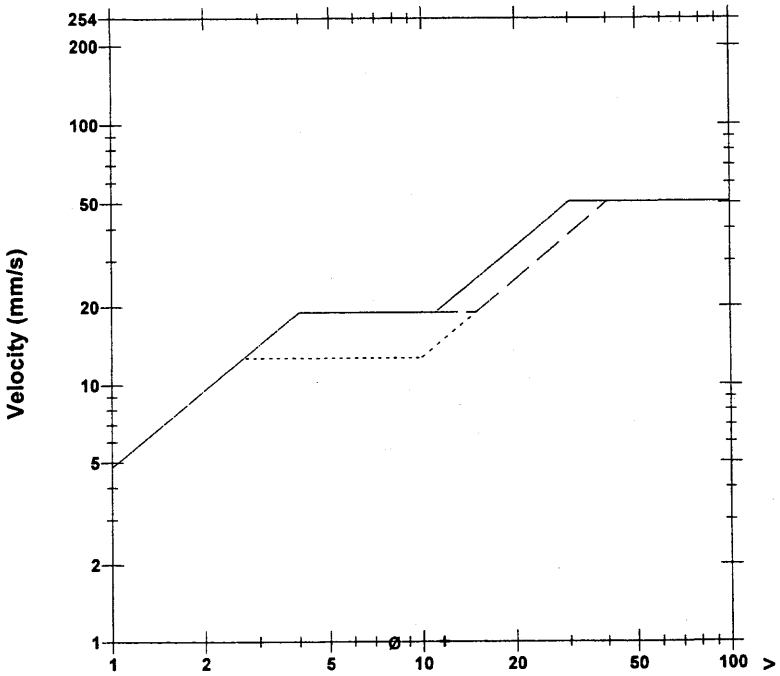
Date/Time	Vert at 05:21:36 April 30, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ALWK.800
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
picked up on both units

USBM RI8507 And OSMRE



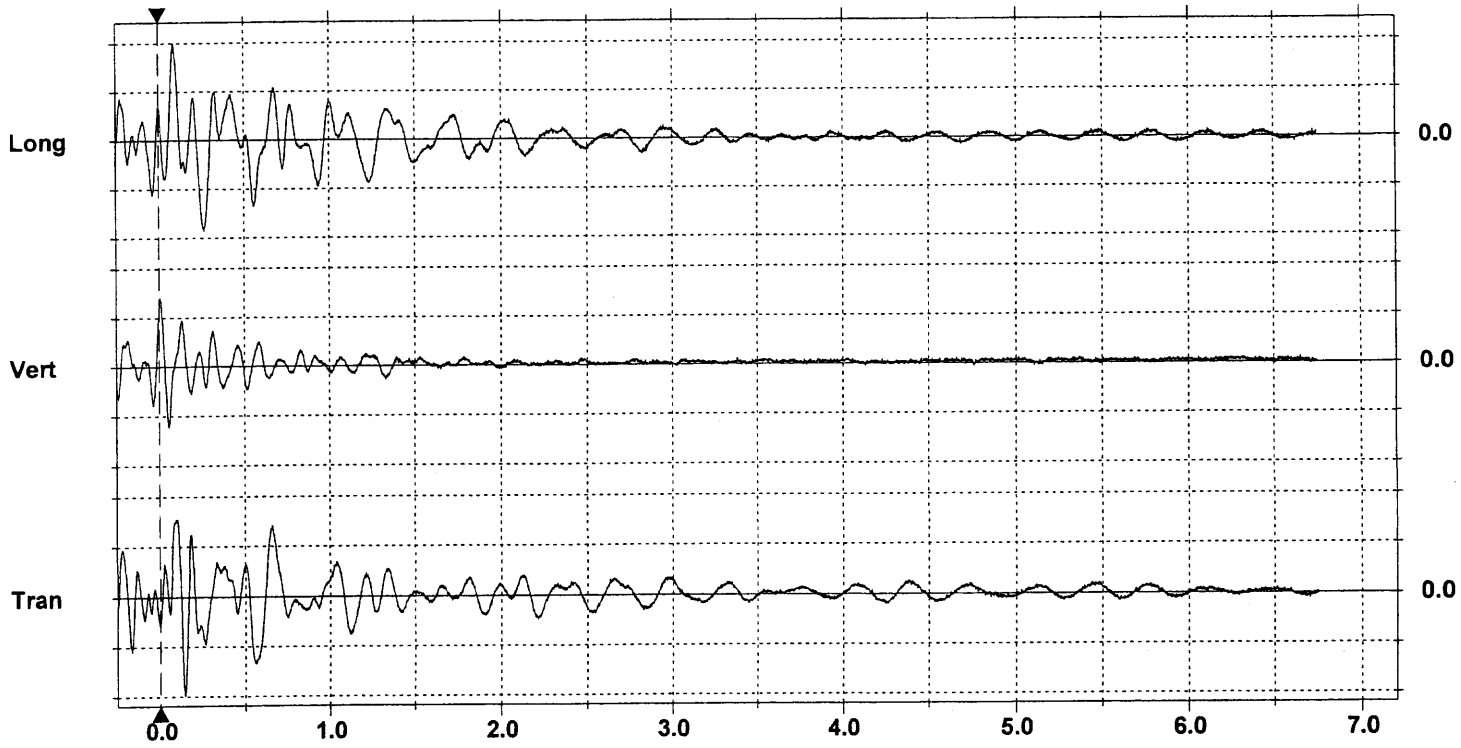
Tran: + Vert: x Long: ø

Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	1.00	0.714	1.00	mm/s
ZC Freq	12	10	8.0	Hz
Time (Rel. to Trig)	0.143	0.006	0.088	sec
Peak Acceleration	0.00994	0.00829	0.00663	g
Peak Displacement	0.0208	0.0104	0.0223	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.25 mm/s at 0.088 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

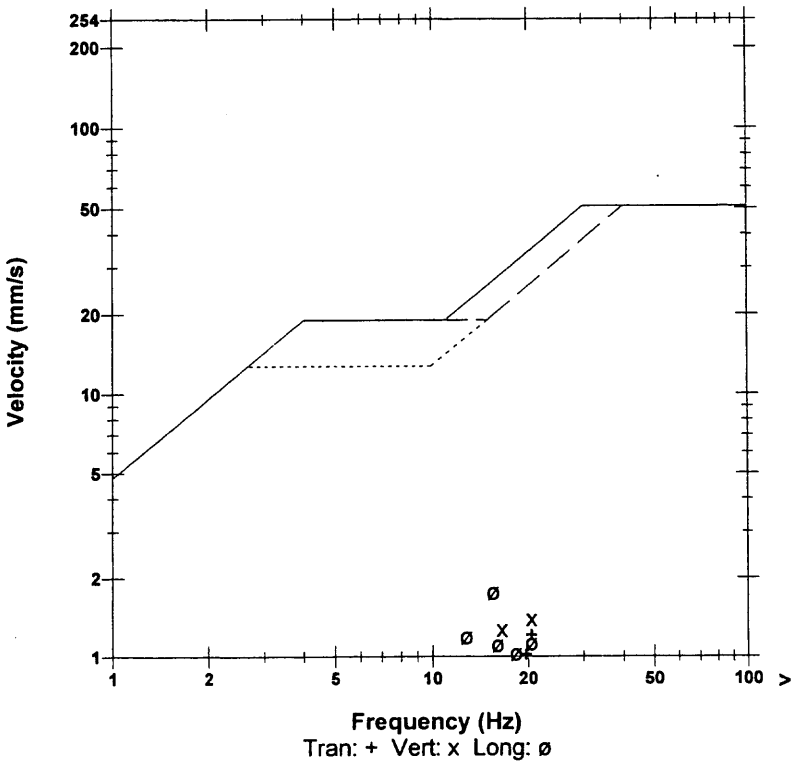
Date/Time	Vert at 06:59:08 May 1, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.6 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ALYJ.EK0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
picked up on both units

USBM RI8507 And OSMRE

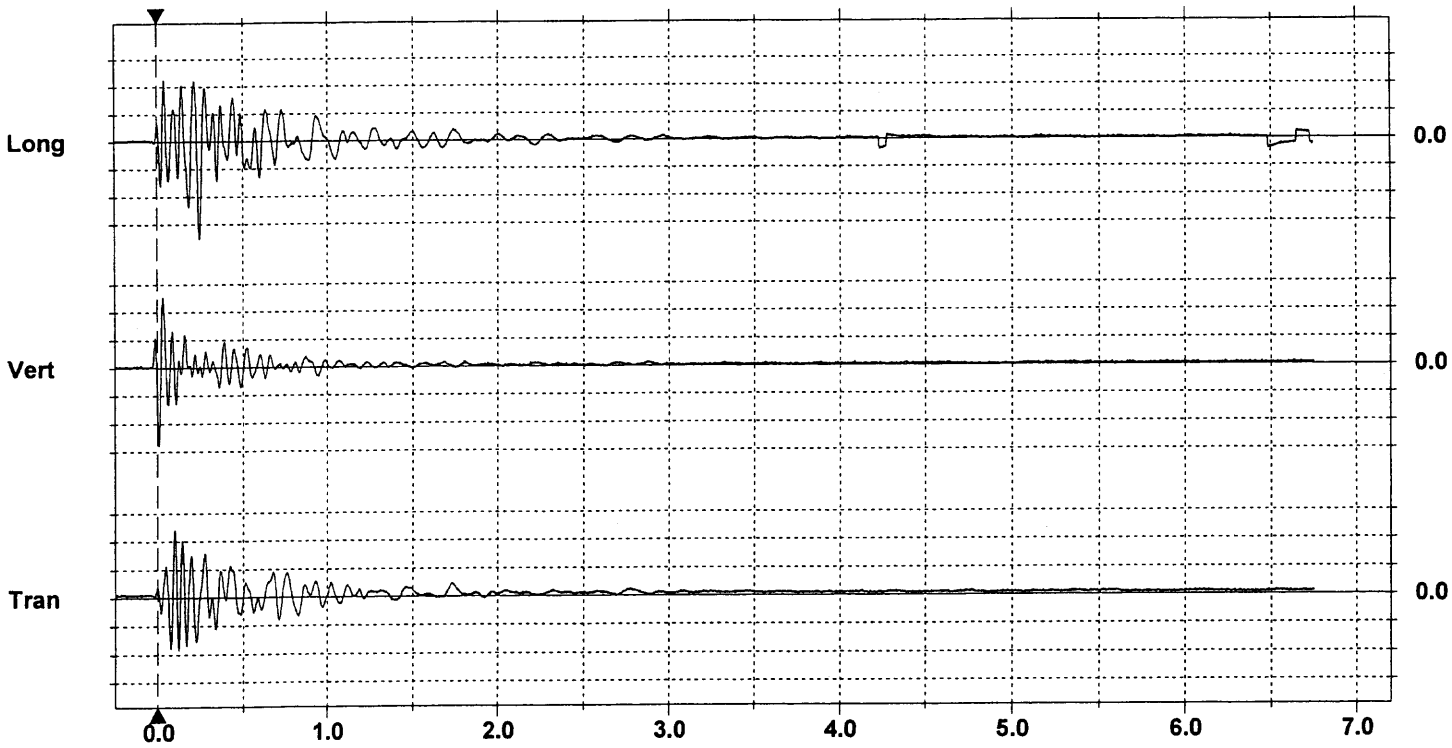


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	1.21	1.40	1.76	mm/s
ZC Freq	20	20	16	Hz
Time (Rel. to Trig)	0.099	0.008	0.244	sec
Peak Acceleration	0.0182	0.0182	0.0182	g
Peak Displacement	0.0111	0.0122	0.0172	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.76 mm/s at 0.246 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

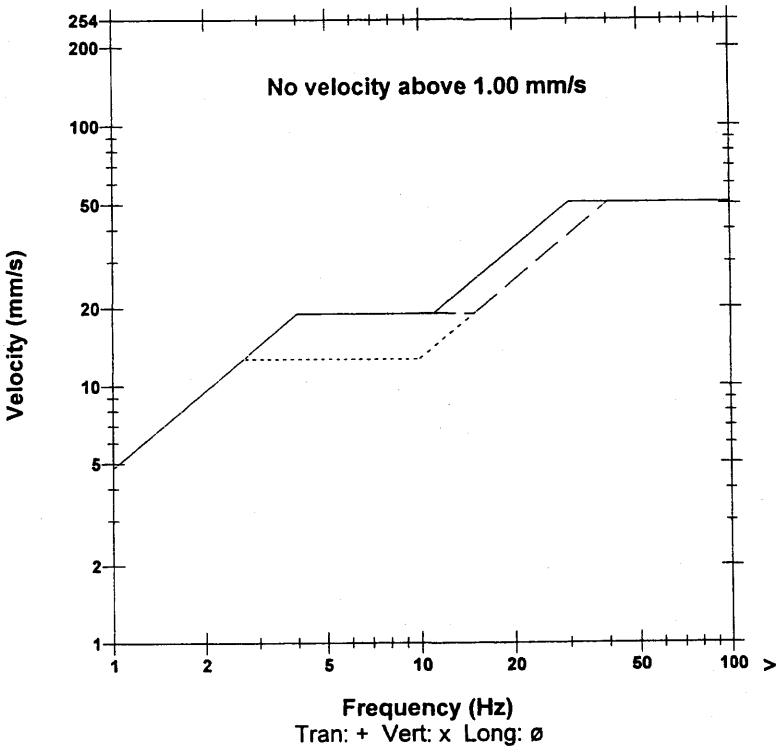
Date/Time	Vert at 06:59:07 May 1, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.6 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ALYJ.EJ0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
picked up on both units

USBM RI8507 And OSMRE

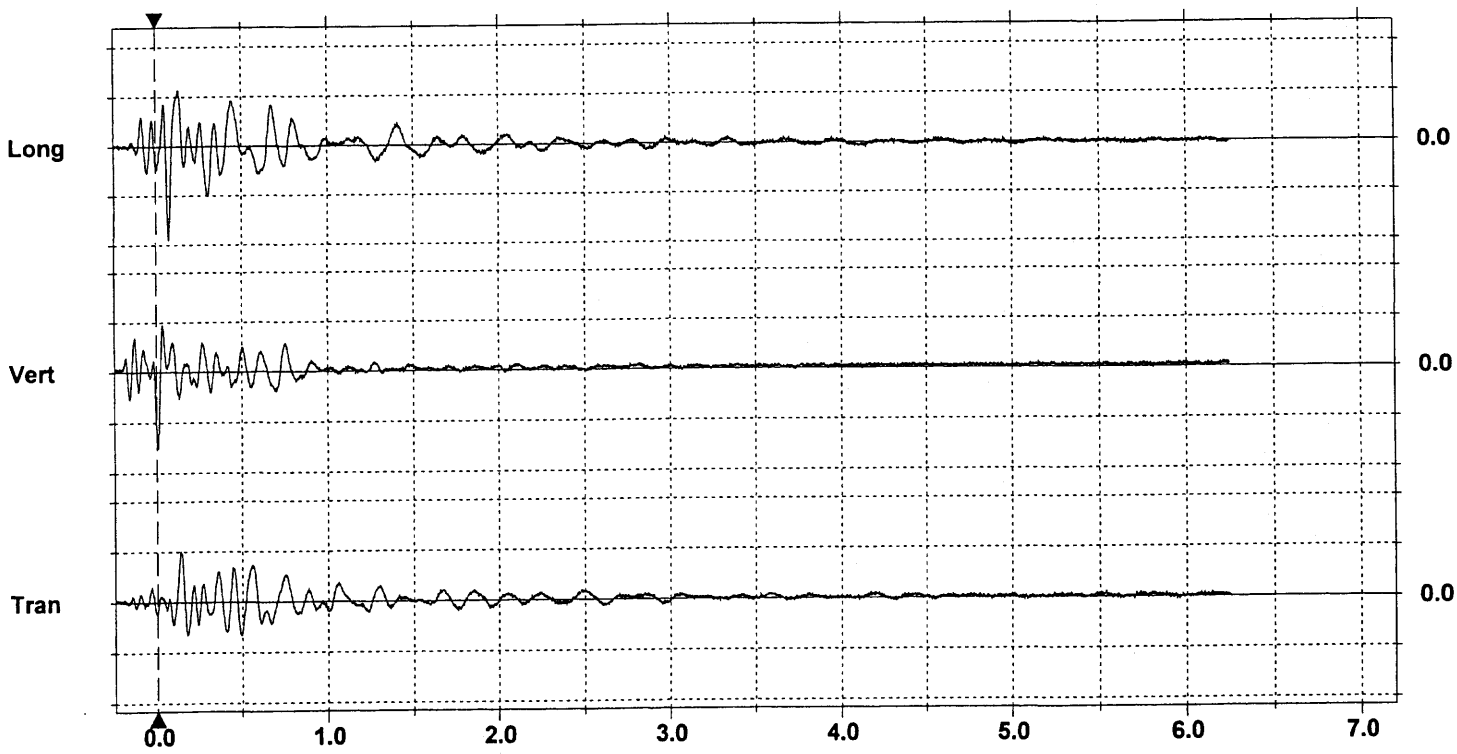


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.508	0.762	0.952	mm/s
ZC Freq	11	15	13	Hz
Time (Rel. to Trig)	0.138	0.008	0.074	sec
Peak Acceleration	0.00497	0.00829	0.00994	g
Peak Displacement	0.00833	0.00952	0.0113	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.959 mm/s at 0.074 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

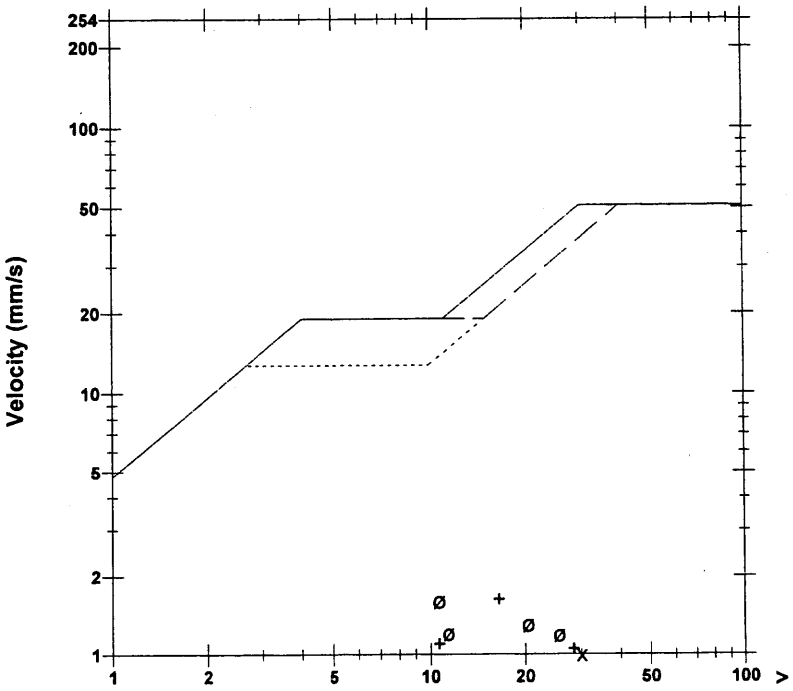
Date/Time	Vert at 15:07:52 May 3, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.8 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AM2V.D40
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, mag 1.6, 0.0249 g UTC 22:07:51

USBM RI8507 And OSMRE



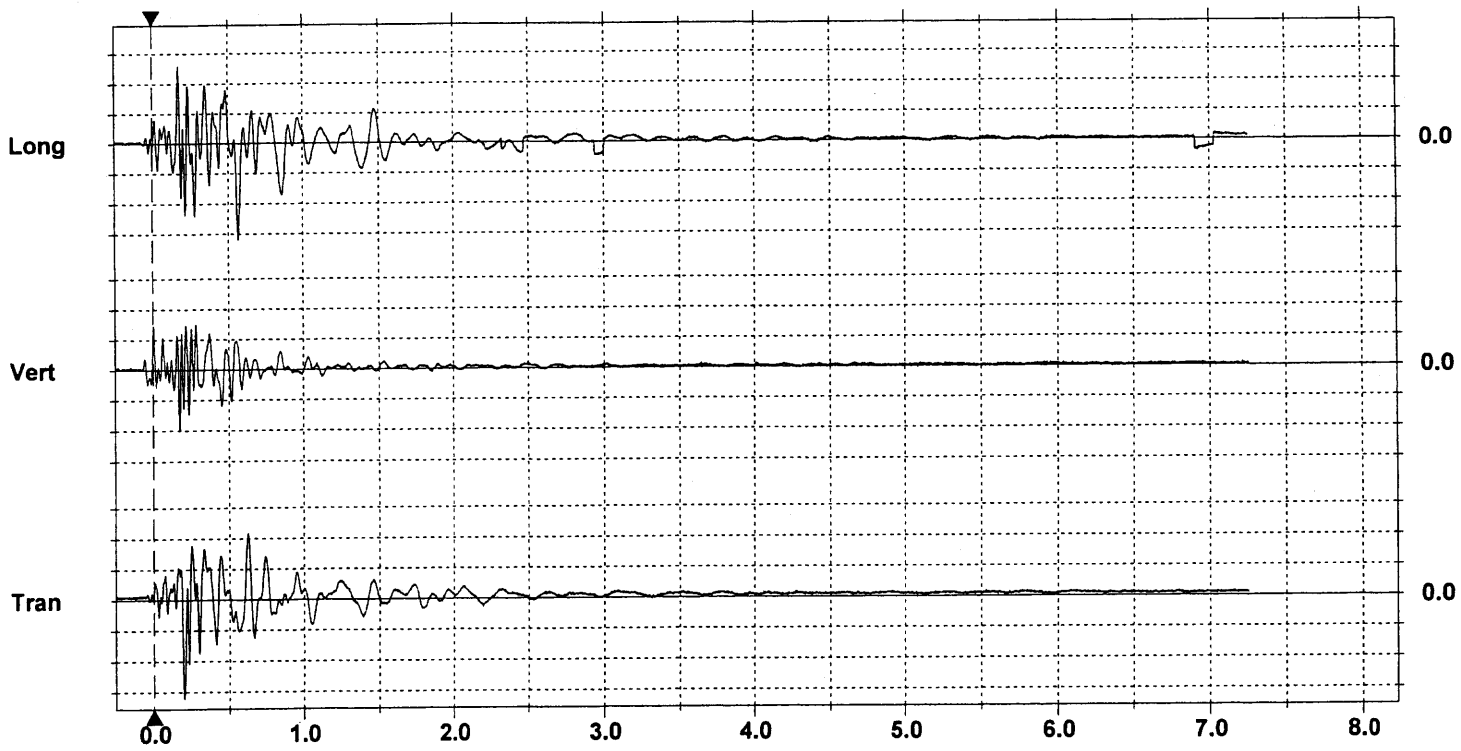
Tran: + Vert: x Long: ø

Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	1.62	1.00	1.60	mm/s
ZC Freq	17	30	11	Hz
Time (Rel. to Trig)	0.199	0.173	0.565	sec
Peak Acceleration	0.0215	0.0199	0.0249	g
Peak Displacement	0.0195	0.00914	0.0198	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.74 mm/s at 0.201 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

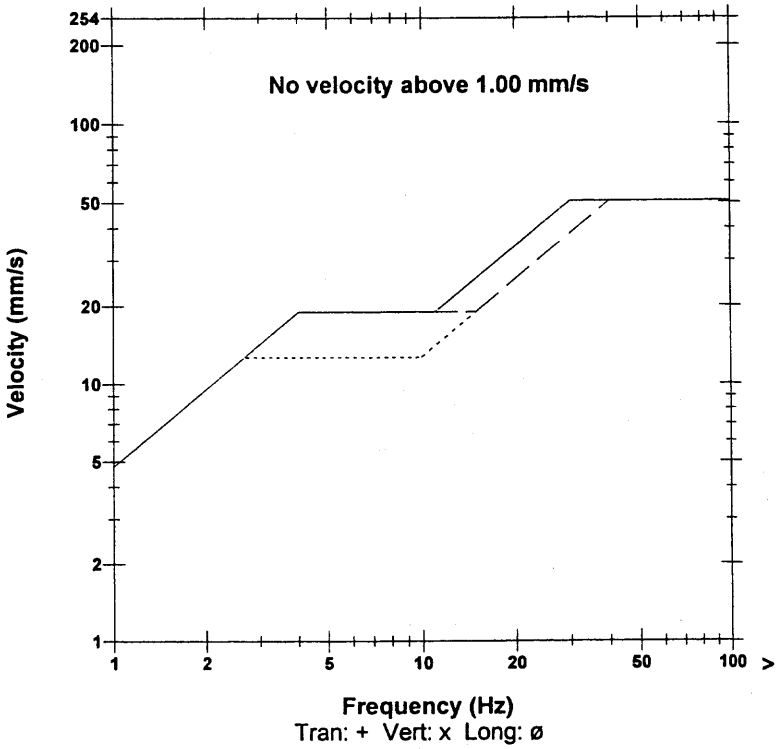
Date/Time	Long at 15:07:53 May 3, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.8 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AM2V.D50
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, mag 1.6 UTC 22:07:51

USBM RI8507 And OSMRE

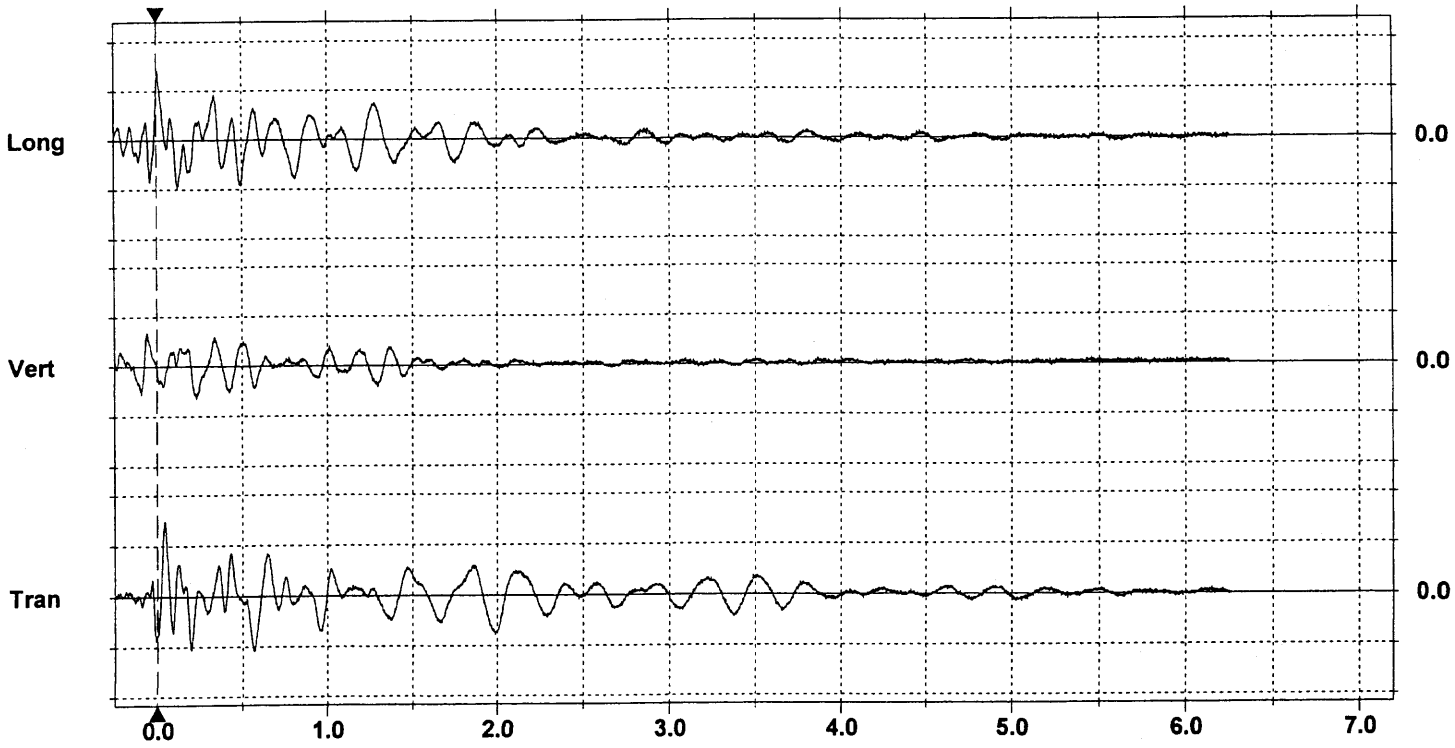


Microphone	Disabled		
PSPL	N/A		
ZC Freq	N/A		
Channel Test	N/A		

	Tran	Vert	Long	
PPV	0.746	0.349	0.714	mm/s
ZC Freq	9.8	7.1	8.3	Hz
Time (Rel. to Trig)	0.045	-0.059	0.007	sec
Peak Acceleration	0.00663	0.00663	0.00663	g
Peak Displacement	0.0153	0.00770	0.0143	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.810 mm/s at 0.007 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

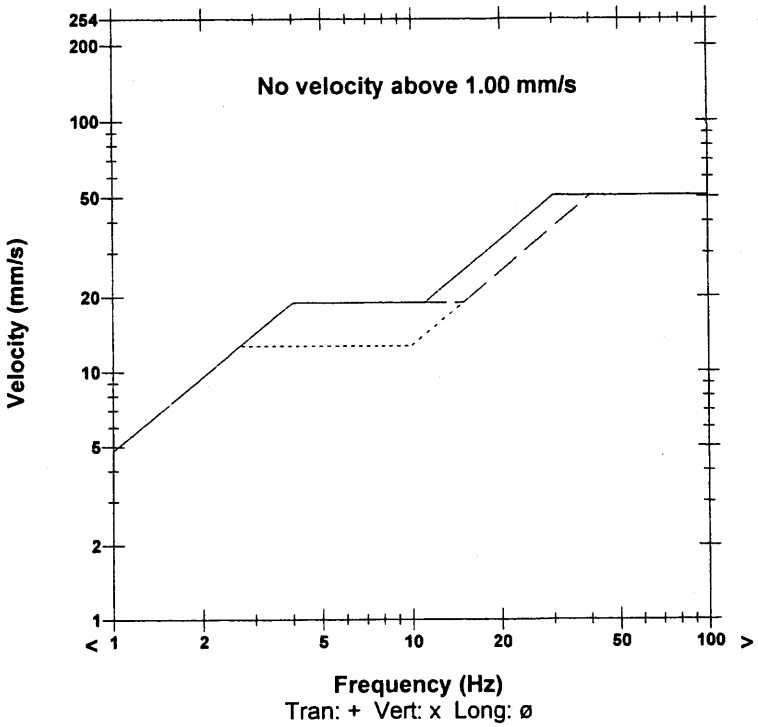
Date/Time	Long at 08:22:53 May 7, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AM9R.A50
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
0.0249 g, not recorded on Dam Unit, or as an earthquake UUSS

USBM RI8507 And OSMRE

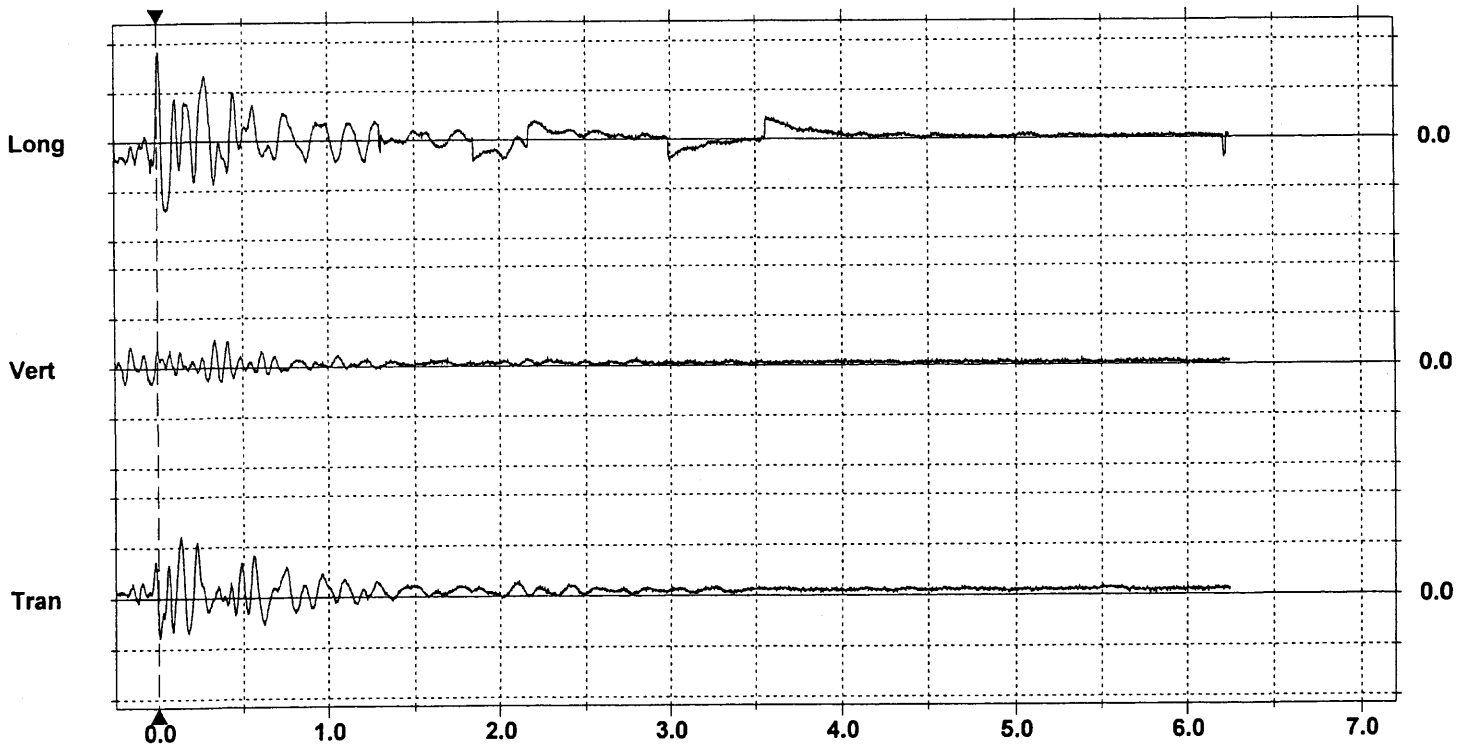


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.619	0.286	0.921	mm/s
ZC Freq	9.1	12	13	Hz
Time (Rel. to Trig)	0.134	0.331	0.008	sec
Peak Acceleration	0.00663	0.00663	0.0249	g
Peak Displacement	0.0160	0.00360	0.0238	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.00 mm/s at 0.008 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Long at 12:41:16 May 10, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.8 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AMFN.8S0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, mag 2.0 UTC 19:41:50

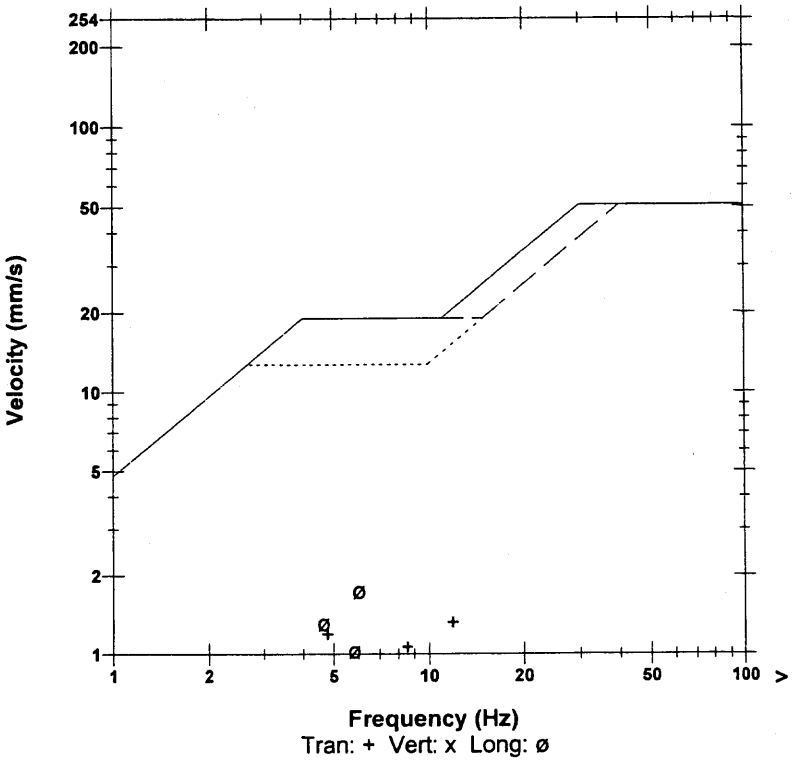
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

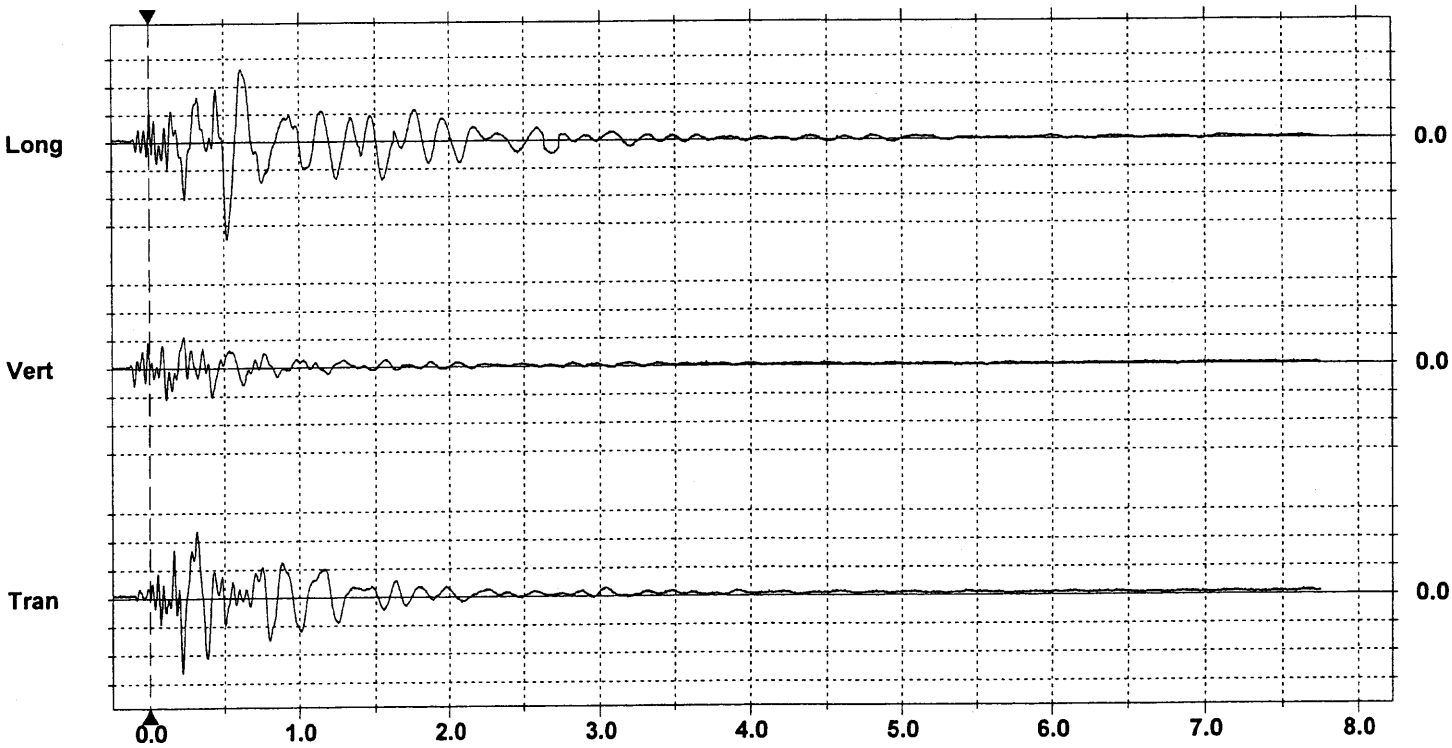
	Tran	Vert	Long	
PPV	1.32	0.571	1.75	mm/s
ZC Freq	12	9.5	6.0	Hz
Time (Rel. to Trig)	0.214	0.224	0.518	sec
Peak Acceleration	0.0133	0.00829	0.0149	g
Peak Displacement	0.0324	0.0119	0.0451	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.78 mm/s at 0.518 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

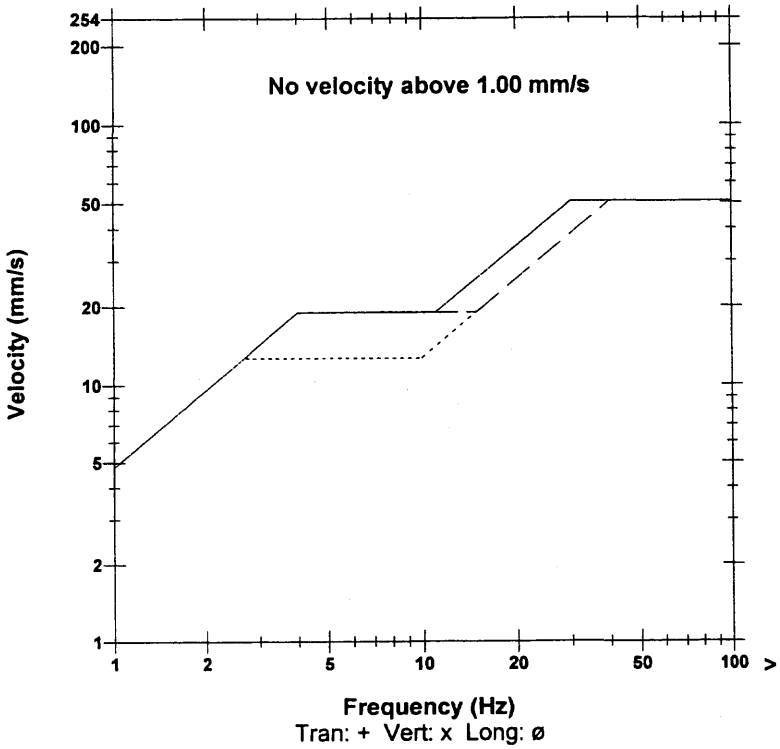
Date/Time	Vert at 12:41:16 May 10, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.8 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	8.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AMFN.8S0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, mag 2.0 UTC 19:41:50

USBM RI8507 And OSMRE

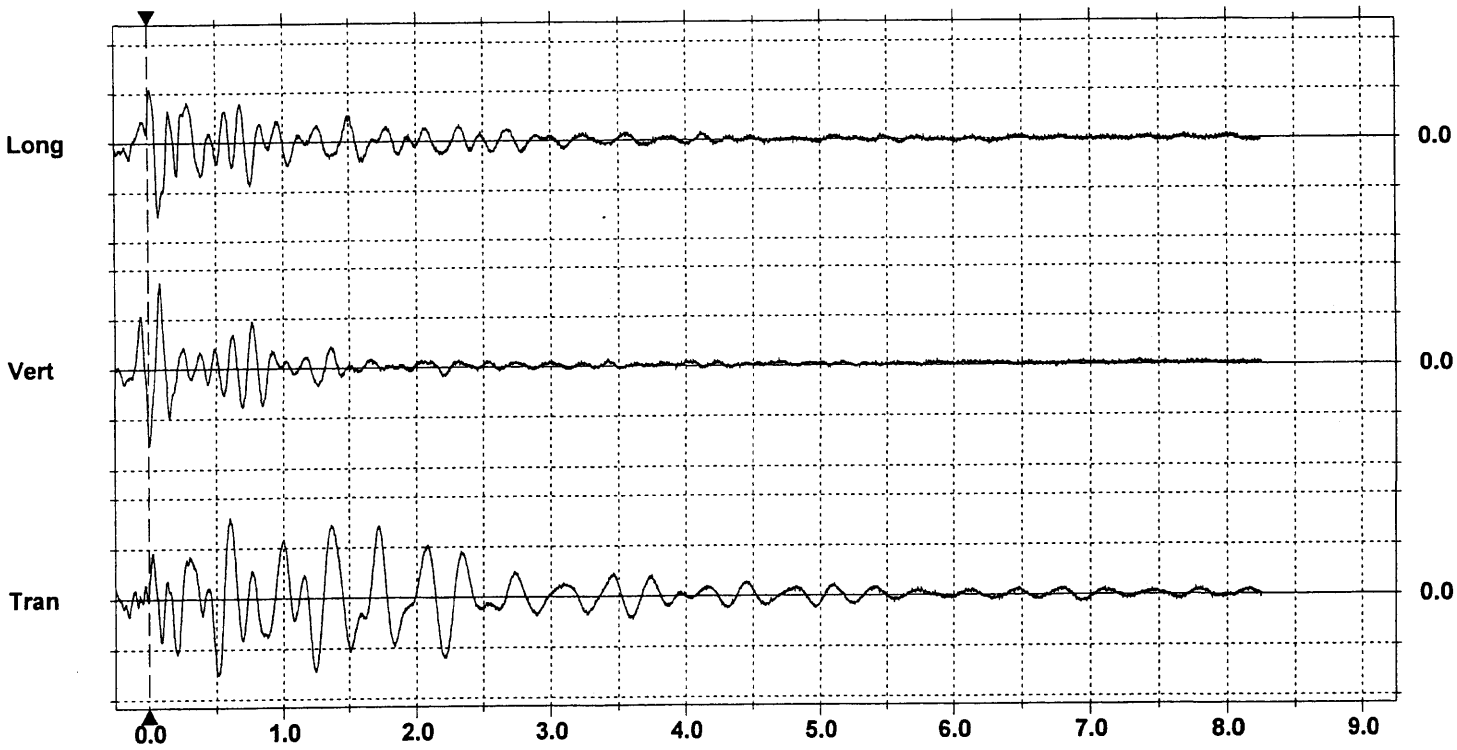


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.810	0.873	0.746	mm/s
ZC Freq	5.0	6.5	5.7	Hz
Time (Rel. to Trig)	0.603	0.083	0.077	sec
Peak Acceleration	0.00663	0.00663	0.00663	g
Peak Displacement	0.0331	0.0181	0.0208	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.16 mm/s at 0.086 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger =

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Vert at 04:02:51 May 13, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AMKJ.8R0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
picked up on both units

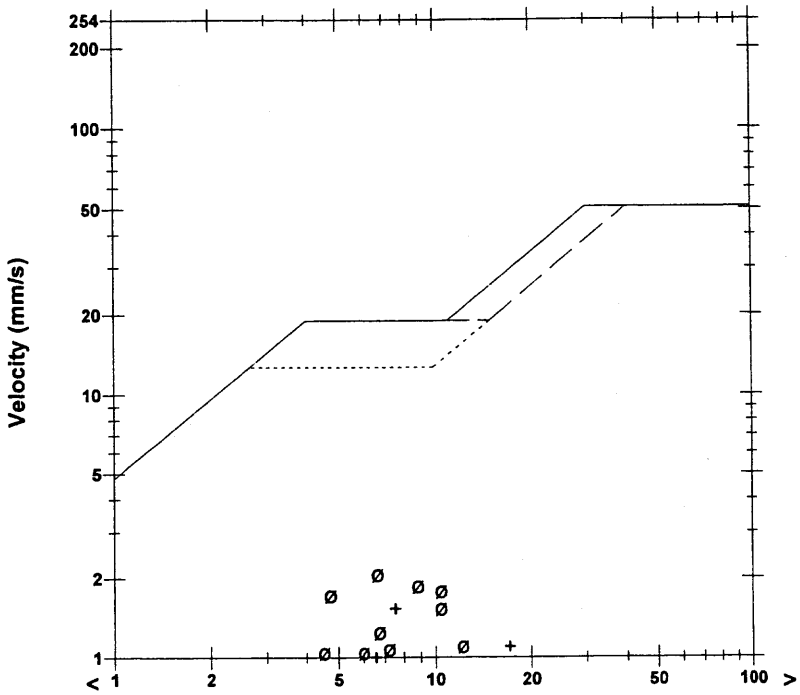
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

	Tran	Vert	Long	
PPV	1.52	0.873	2.08	mm/s
ZC Freq	7.5	18	6.6	Hz
Time (Rel. to Trig)	0.325	0.005	0.486	sec
Peak Acceleration	0.0149	0.0133	0.0166	g
Peak Displacement	0.0277	0.0124	0.0609	mm
Sensorcheck	Passed	Passed	Passed	

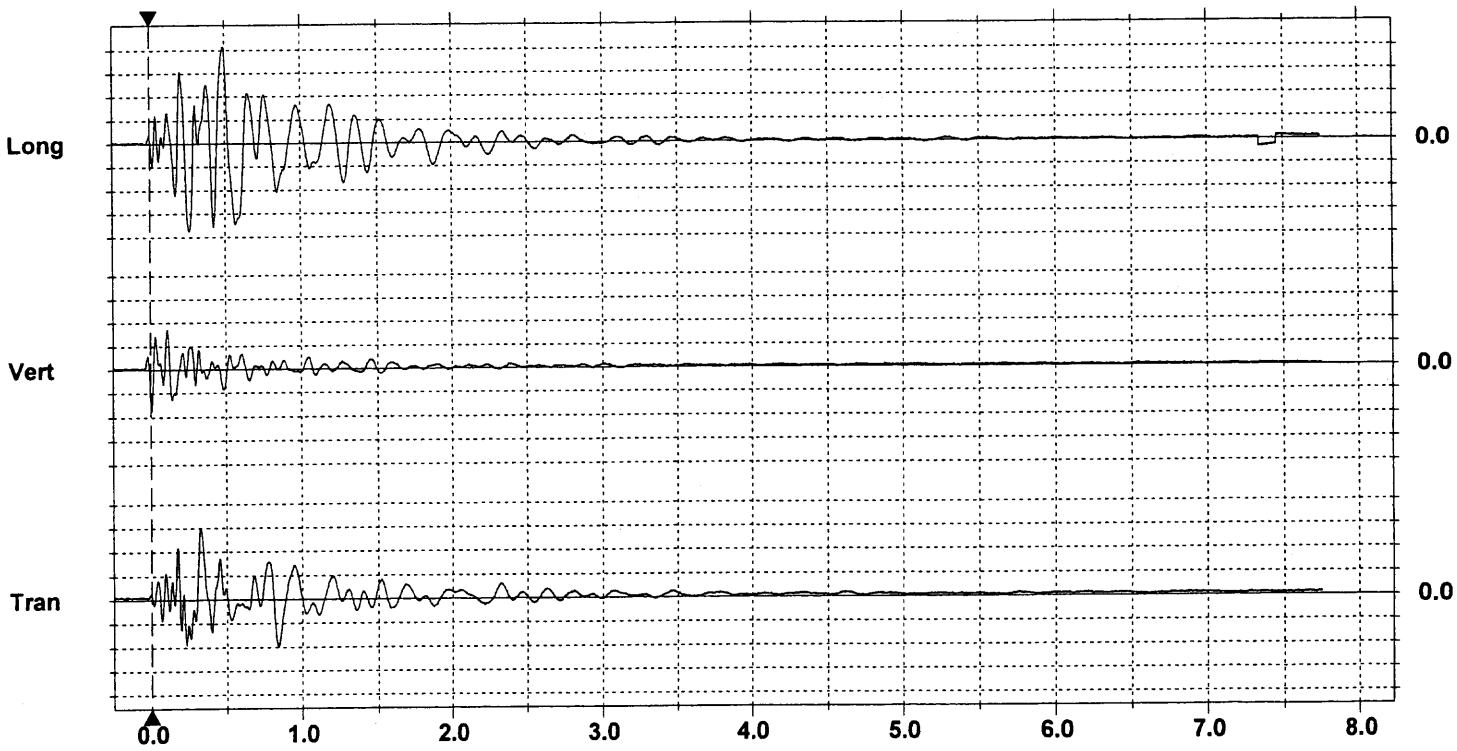
Peak Vector Sum 2.13 mm/s at 0.487 sec

N/A: Not Applicable

USBM RI8507 And OSMRE



Tran: + Vert: x Long: ø



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

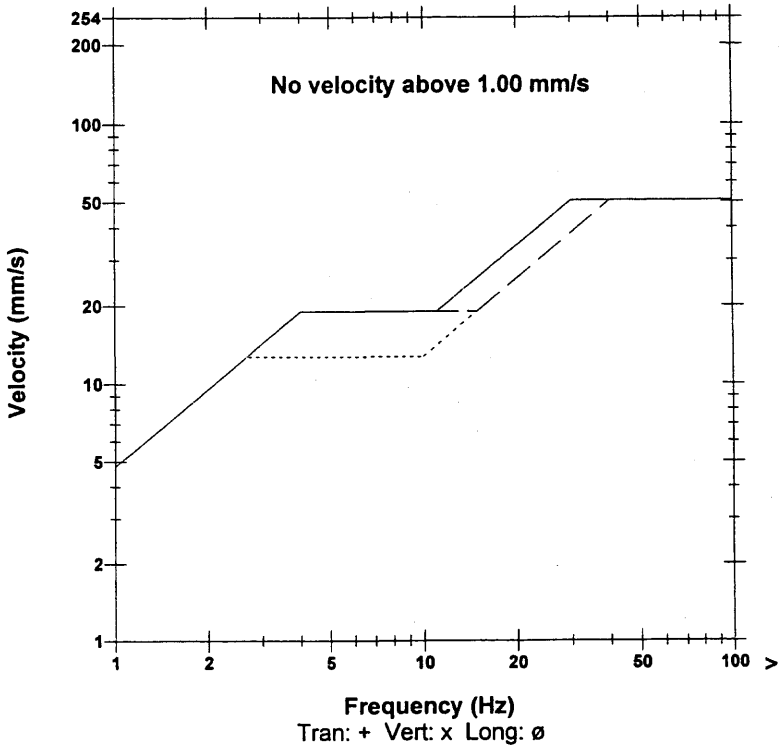
Date/Time	Long at 04:02:51 May 13, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AMKJ.8R0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

USBM RI8507 And OSMRE

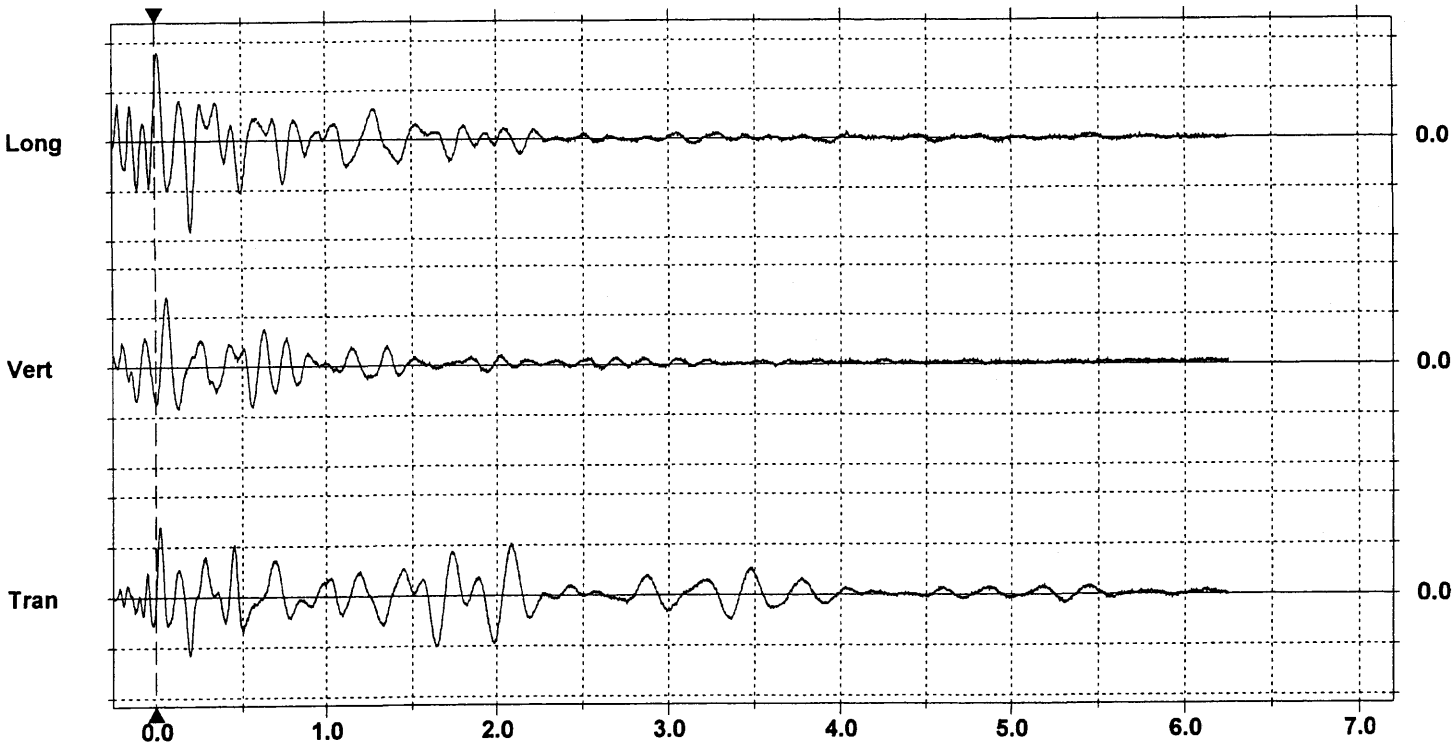


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.698	0.714	0.921	mm/s
ZC Freq	10	7.5	8.0	Hz
Time (Rel. to Trig)	0.021	0.062	0.205	sec
Peak Acceleration	0.00663	0.00663	0.00663	g
Peak Displacement	0.0176	0.0144	0.0173	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.11 mm/s at 0.018 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Vert at 23:54:46 May 18, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.3 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AMVB.RA0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
picked up on both units

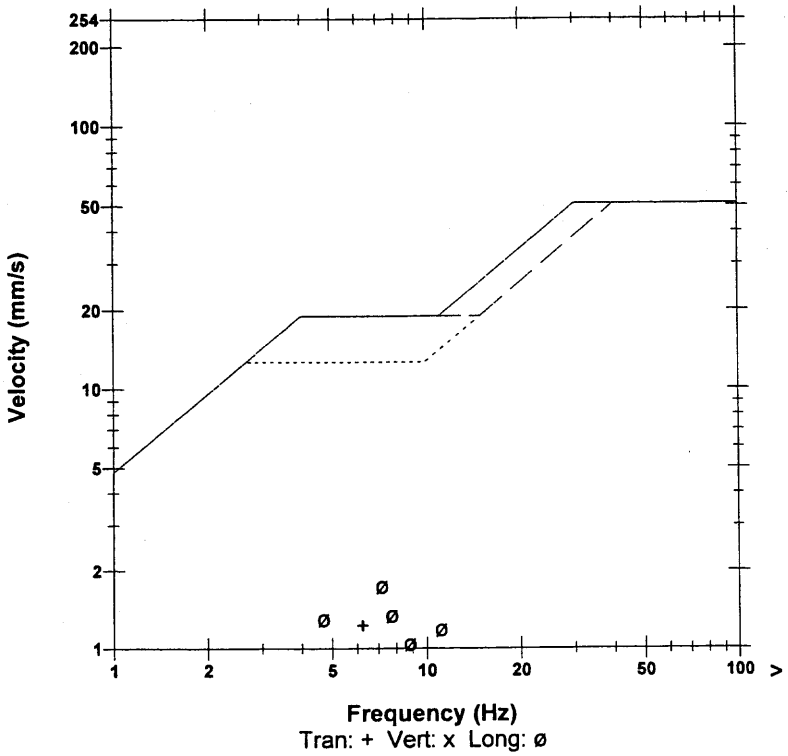
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

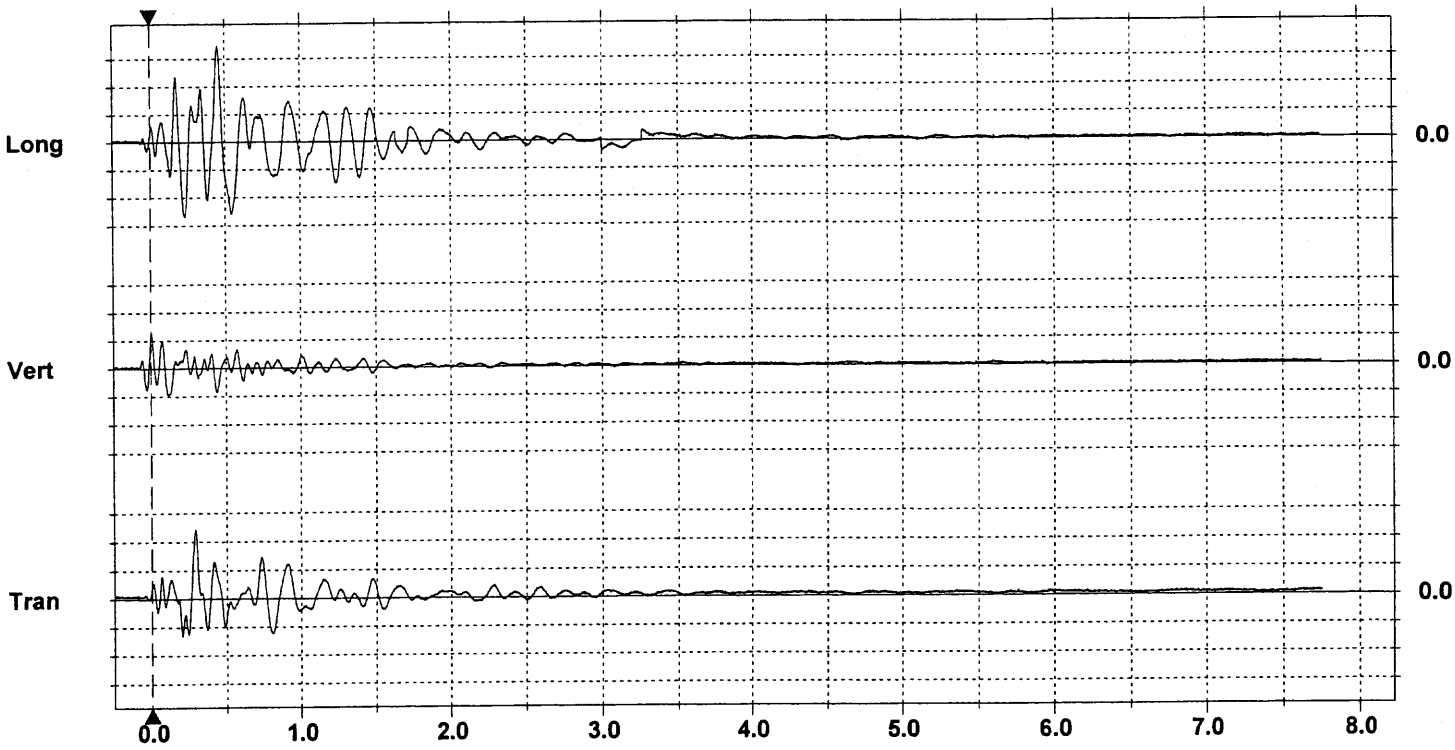
	Tran	Vert	Long	
PPV	1.22	0.635	1.75	mm/s
ZC Freq	6.2	14	7.2	Hz
Time (Rel. to Trig)	0.288	0.001	0.451	sec
Peak Acceleration	0.00829	0.00829	0.0149	g
Peak Displacement	0.0217	0.00901	0.0426	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.77 mm/s at 0.451 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Long at 23:54:46 May 18, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.3 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AMVB.RA0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both

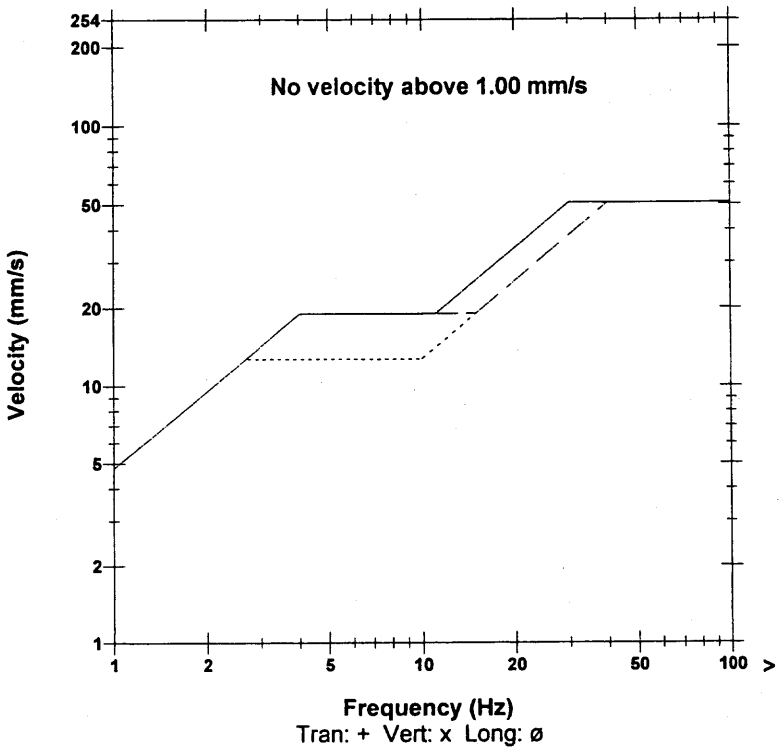
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

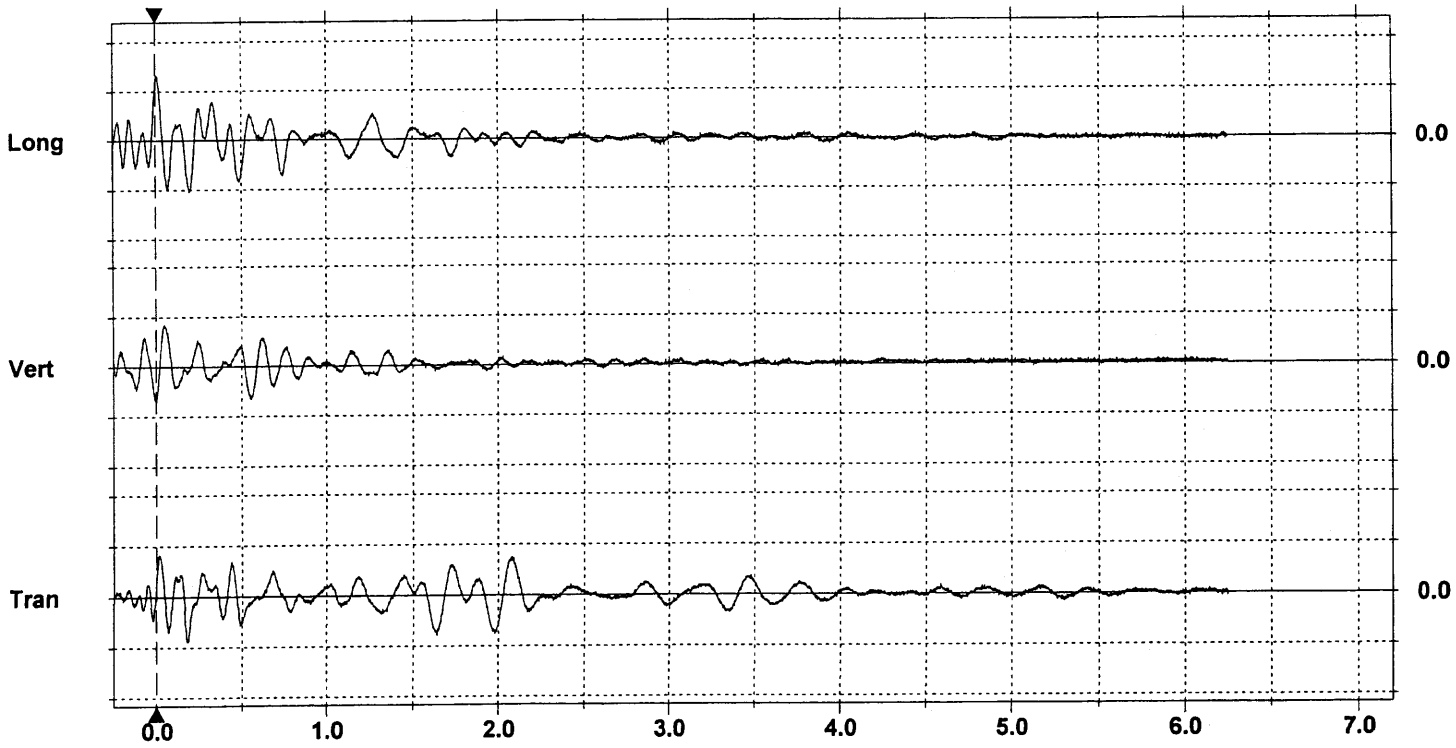
	Tran	Vert	Long	
PPV	0.444	0.429	0.667	mm/s
ZC Freq	6.4	7.1	8.0	Hz
Time (Rel. to Trig)	0.182	0.050	0.007	sec
Peak Acceleration	0.00663	0.00663	0.00663	g
Peak Displacement	0.0123	0.00943	0.0126	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.792 mm/s at 0.007 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

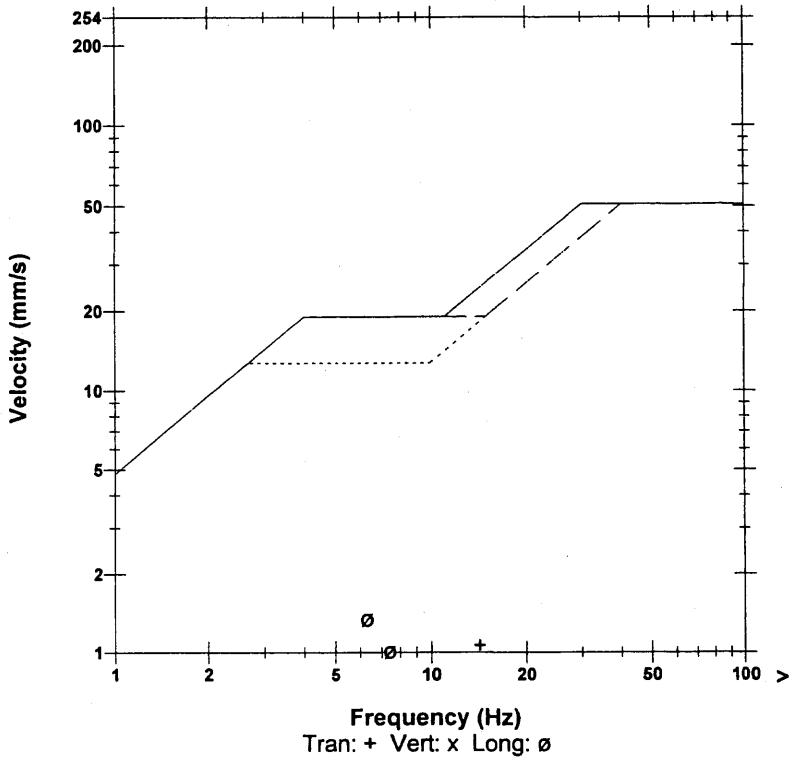
Date/Time	Vert at 18:37:08 June 2, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.7 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	7.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689ANMP.1W0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, mag 1.3 UTC 1:38:54, June 3

USBM RI8507 And OSMRE

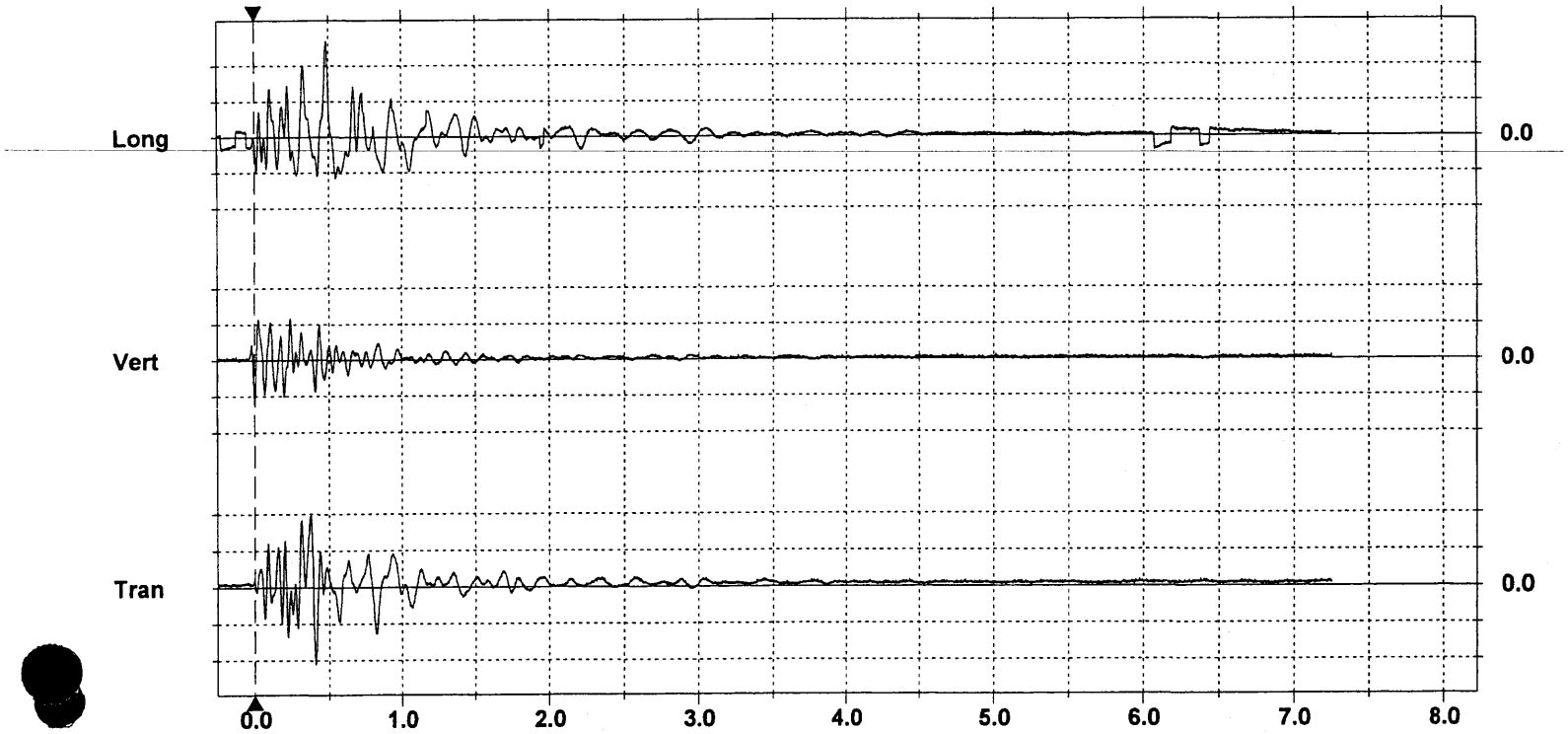


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	1.06	0.651	1.35	mm/s
ZC Freq	14	20	6.3	Hz
Time (Rel. to Trig)	0.404	0.001	0.481	sec
Peak Acceleration	0.0133	0.00994	0.0232	g
Peak Displacement	0.0149	0.00681	0.0224	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 1.38 mm/s at 0.481 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

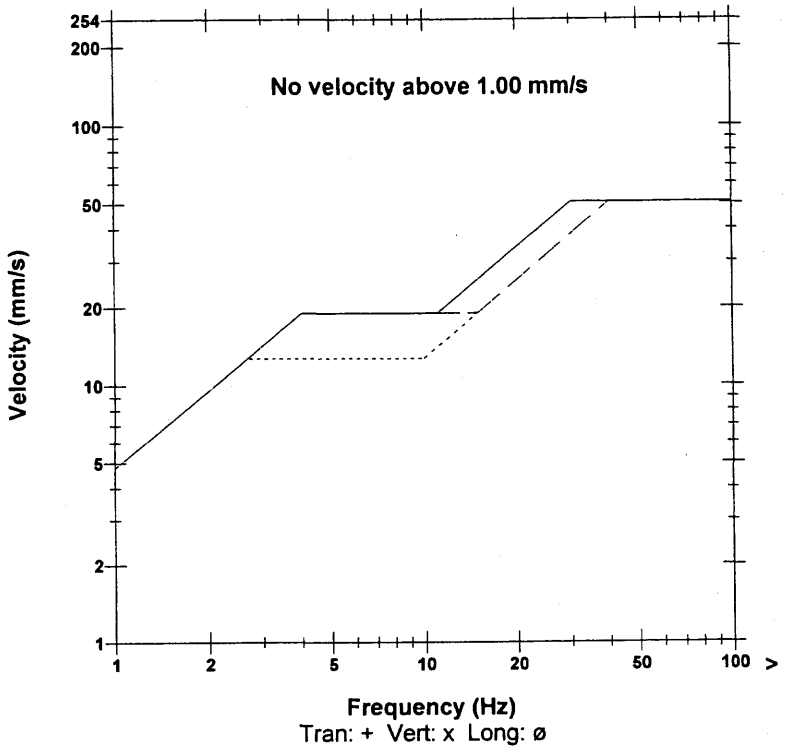
Date/Time	Tran at 18:37:05 June 2, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	5.4 Volts (Battery Very Low)
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	6.75 sec (Auto=6Sec) at 1024 sps	**File Name**	K690ANMP.1T0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, mag 1.3 UTC 1:38:54, June 3

USBM RI8507 And OSMRE

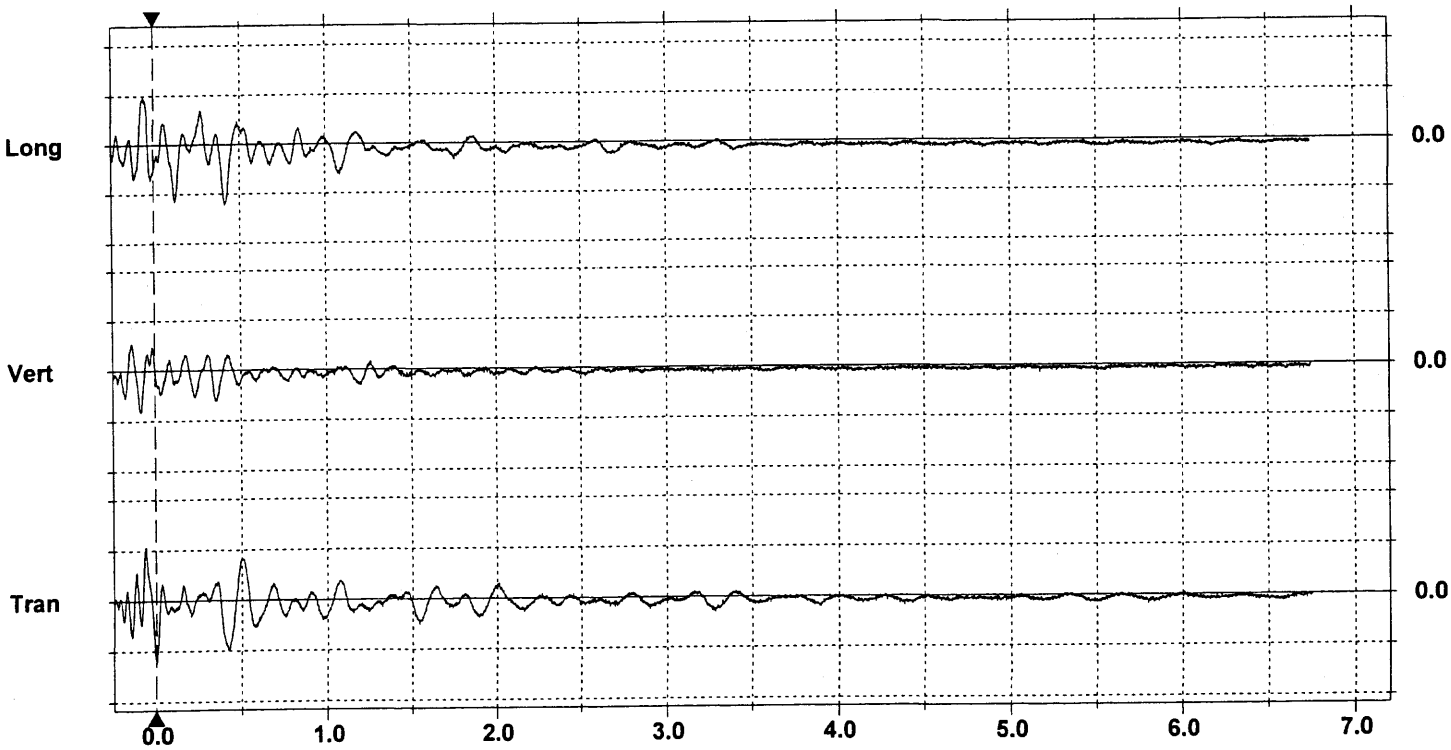


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	0.619	0.413	0.619	mm/s
ZC Freq	10	9.5	6.7	Hz
Time (Rel. to Trig)	0.003	-0.085	0.412	sec
Peak Acceleration	0.00663	0.00663	0.00829	g
Peak Displacement	0.0143	0.00626	0.0131	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 0.783 mm/s at 0.421 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

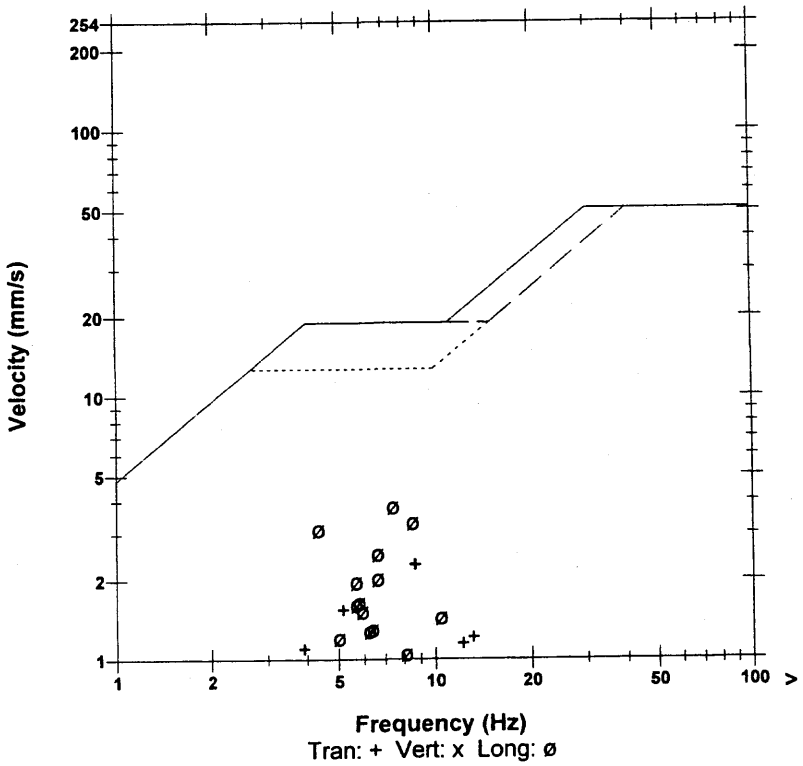
Date/Time	Vert at 04:13:33 June 14, 2005	**Serial Number**	BE9689 V 7.1-4.32 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	8.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K689AO7T.2L0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, mag 1.6 UTC 11:16:17

USBM RI8507 And OSMRE

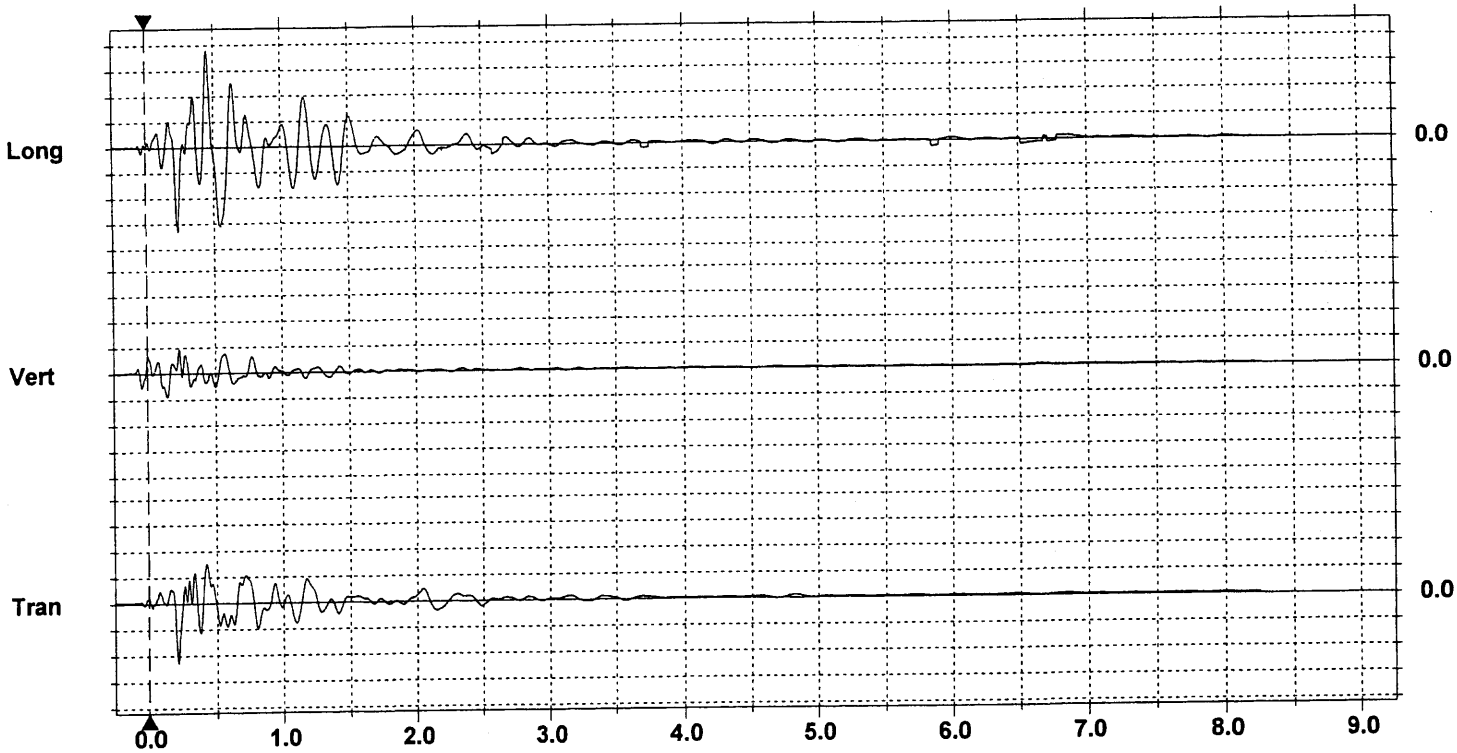


Microphone	Disabled
PSPL	N/A
ZC Freq	N/A
Channel Test	N/A

	Tran	Vert	Long	
PPV	2.29	0.968	3.81	mm/s
ZC Freq	8.7	6.2	7.4	Hz
Time (Rel. to Trig)	0.211	0.232	0.451	sec
Peak Acceleration	0.0182	0.0116	0.0199	g
Peak Displacement	0.0478	0.0198	0.106	mm
Sensorcheck	Passed	Passed	Passed	

Peak Vector Sum 3.87 mm/s at 0.451 sec

N/A: Not Applicable



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 1.000 mm/s/div
Trigger = ▶— — — —◀

Format Copyrighted 1996-2003 Instantel Inc.

Event Report

Date/Time	Long at 04:13:27 June 14, 2005	**Serial Number**	BE9690 V 7.1-4.35 MiniMate Plus
Trigger Source	Geo: 0.600 mm/s	**Battery Level**	6.2 Volts
Range	Geo :31.7 mm/s	**Calibration**	August 13, 2004 by Instantel Inc.
Record Time	8.25 sec (Auto=6Sec) at 1024 sps	**File Name**	K690AO7T.2F0
Job Number:	1		

Notes
Location:
Client:
User Name:
General:

Extended Notes

Post Event Notes
Both, mag 1.6 UTC 11:16:17

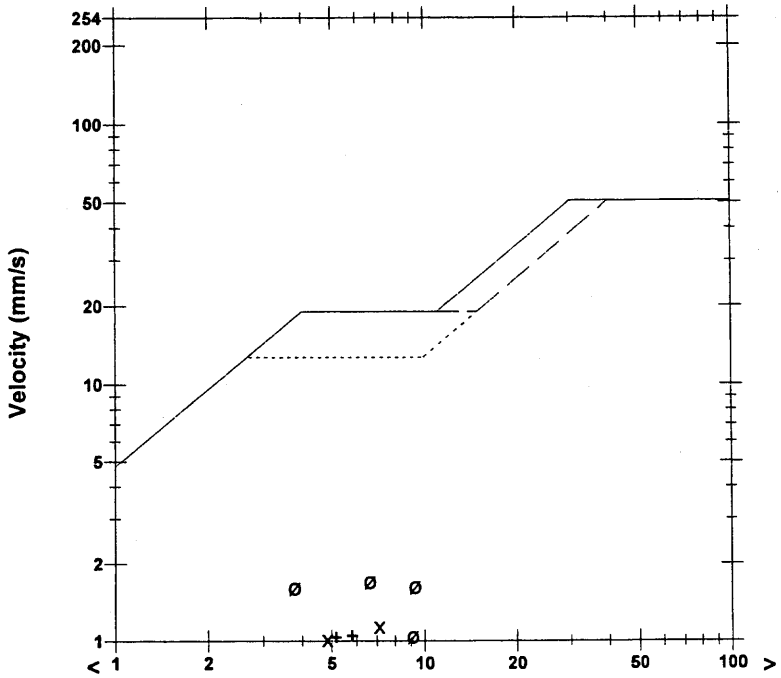
Microphone Disabled
PSPL N/A
ZC Freq N/A
Channel Test N/A

	Tran	Vert	Long	
PPV	1.05	1.14	1.71	mm/s
ZC Freq	5.8	7.1	6.6	Hz
Time (Rel. to Trig)	0.323	0.174	0.317	sec
Peak Acceleration	0.00829	0.00829	0.00994	g
Peak Displacement	0.0300	0.0257	0.0421	mm
Sensorcheck	Passed	Passed	Passed	

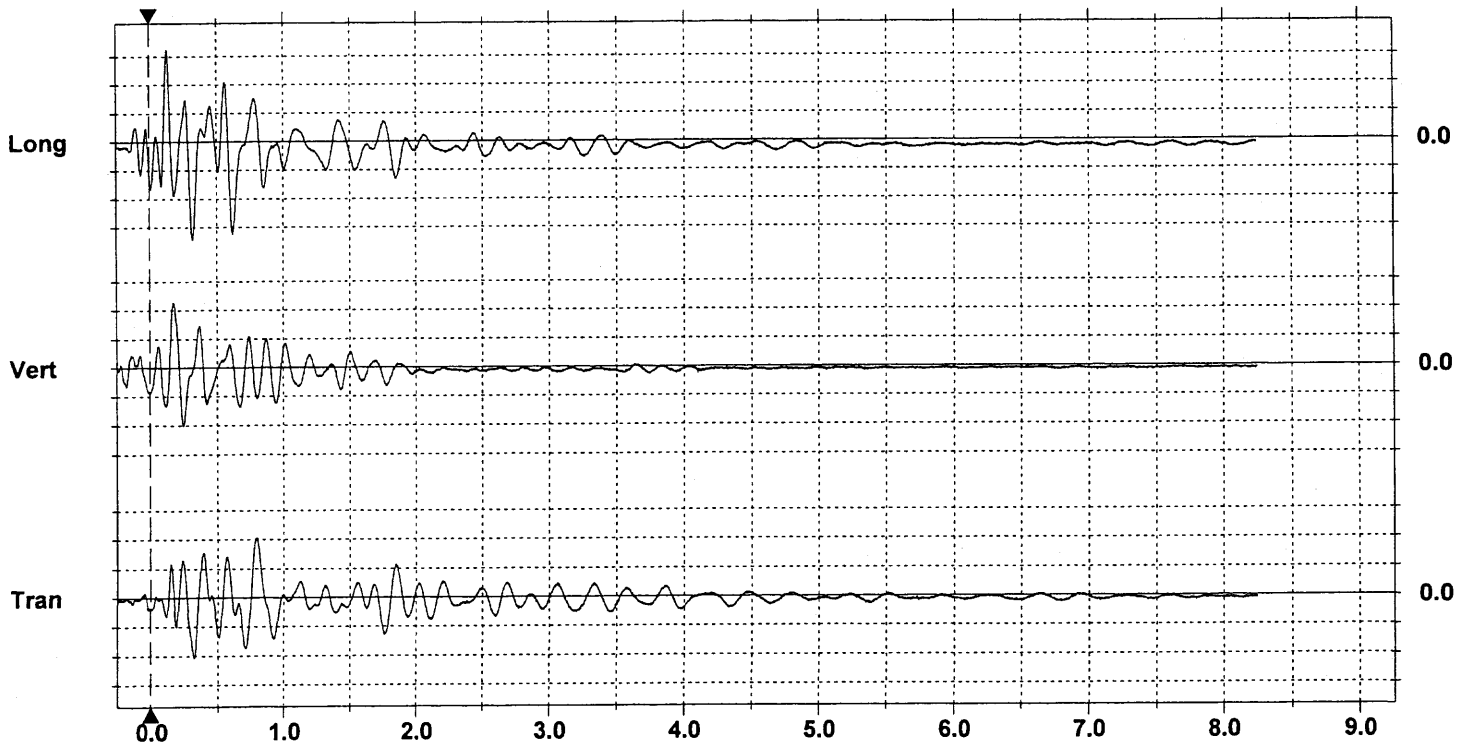
Peak Vector Sum 2.00 mm/s at 0.320 sec

N/A: Not Applicable

USBM RI8507 And OSMRE



Frequency (Hz)
Tran: + Vert: x Long: ø



Time Scale:0.50 sec/div **Amplitude Scale:**Geo: 0.500 mm/s/div
Trigger = ▶— — — —◀

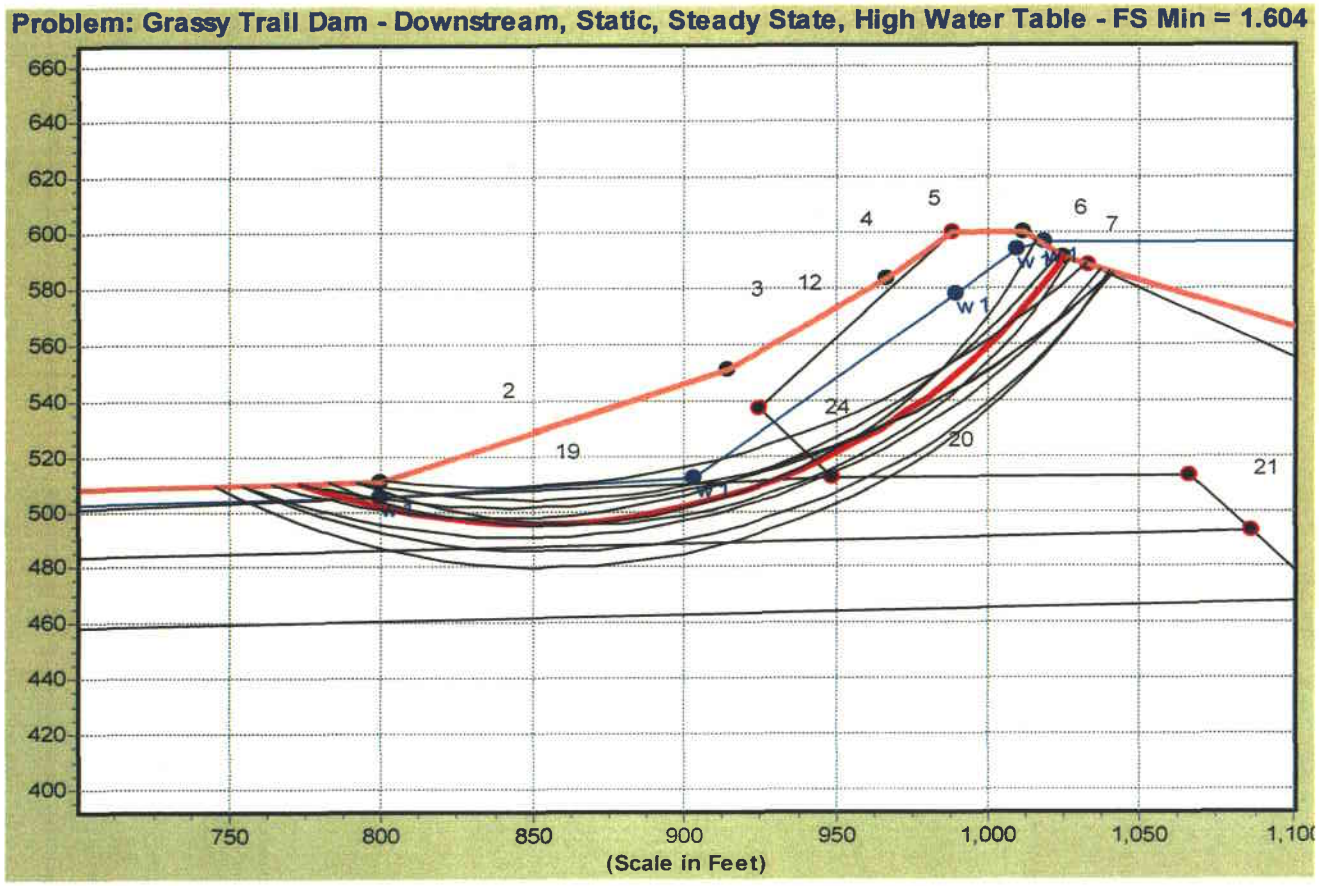
Format Copyrighted 1996-2003 Instantel Inc.

Slope Stability Analysis Results

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



RB&G ENGINEERING INC.

Provo, Utah

Slope Stability Analysis Results

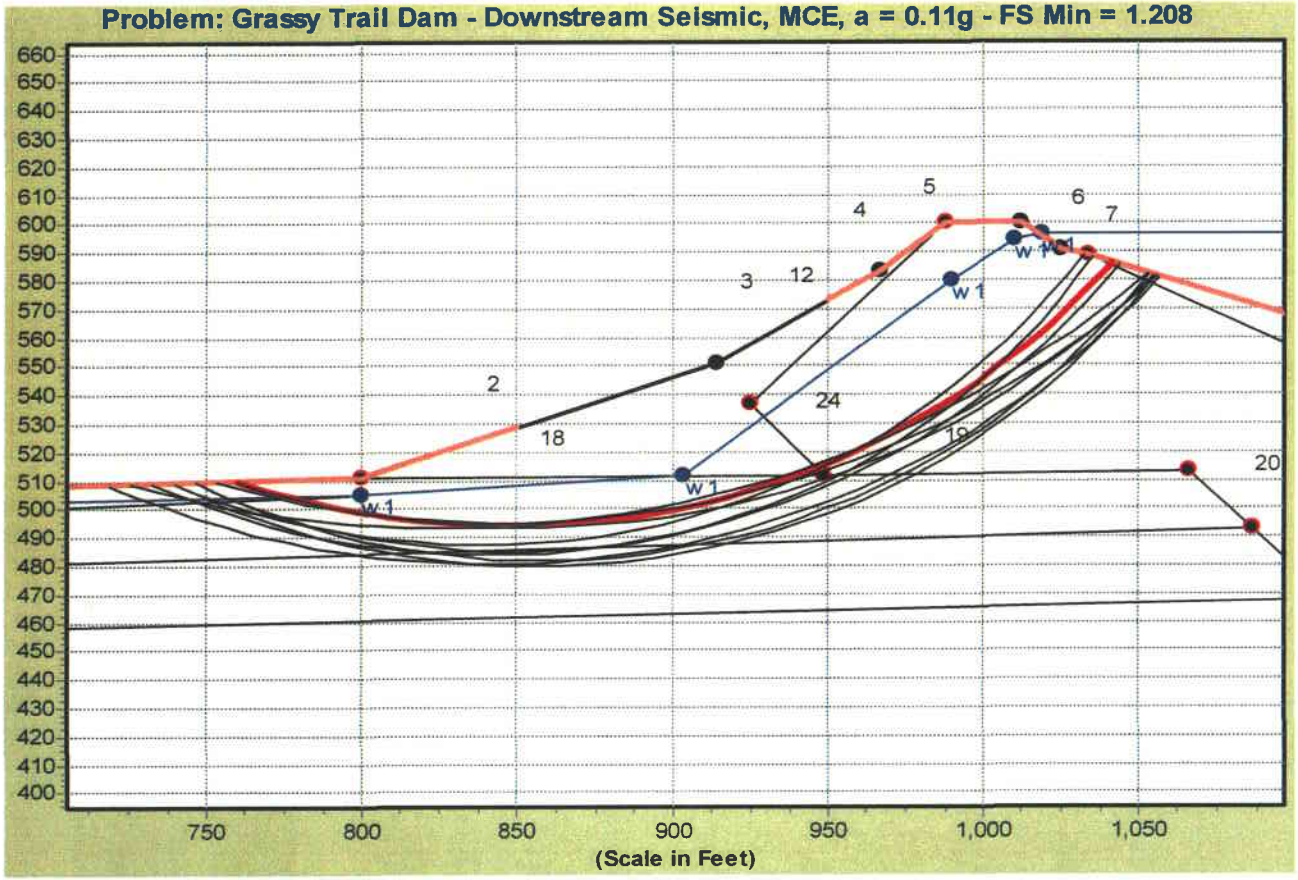
Downstream Slope - Static Steady State Seepage Condition

Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



RB&G ENGINEERING INC.

Provo, Utah

Slope Stability Analysis Results

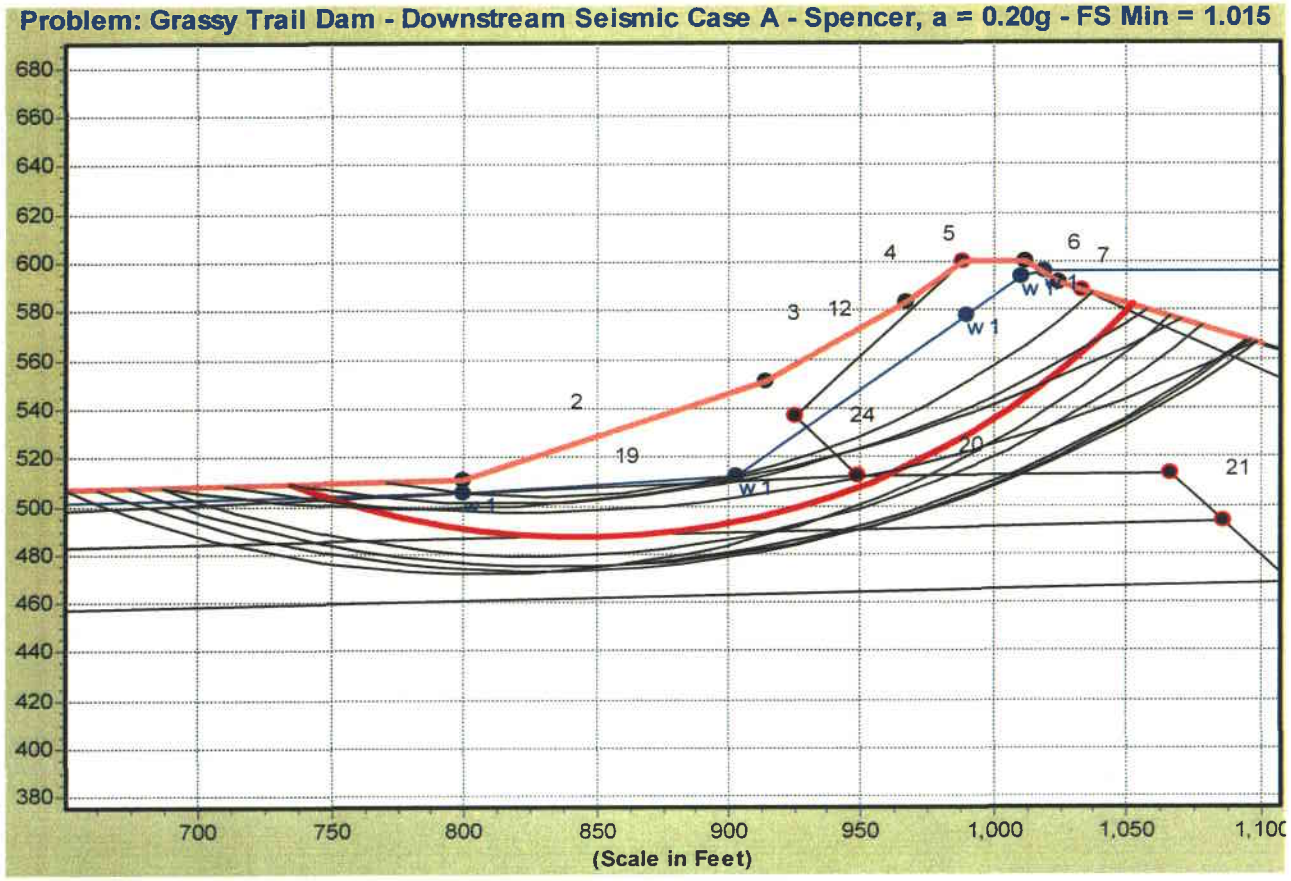
Downstream Slope - Maximum Credible Earthquake (non-mining)

Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



RB&G ENGINEERING INC.

Provo, Utah

Slope Stability Analysis Results

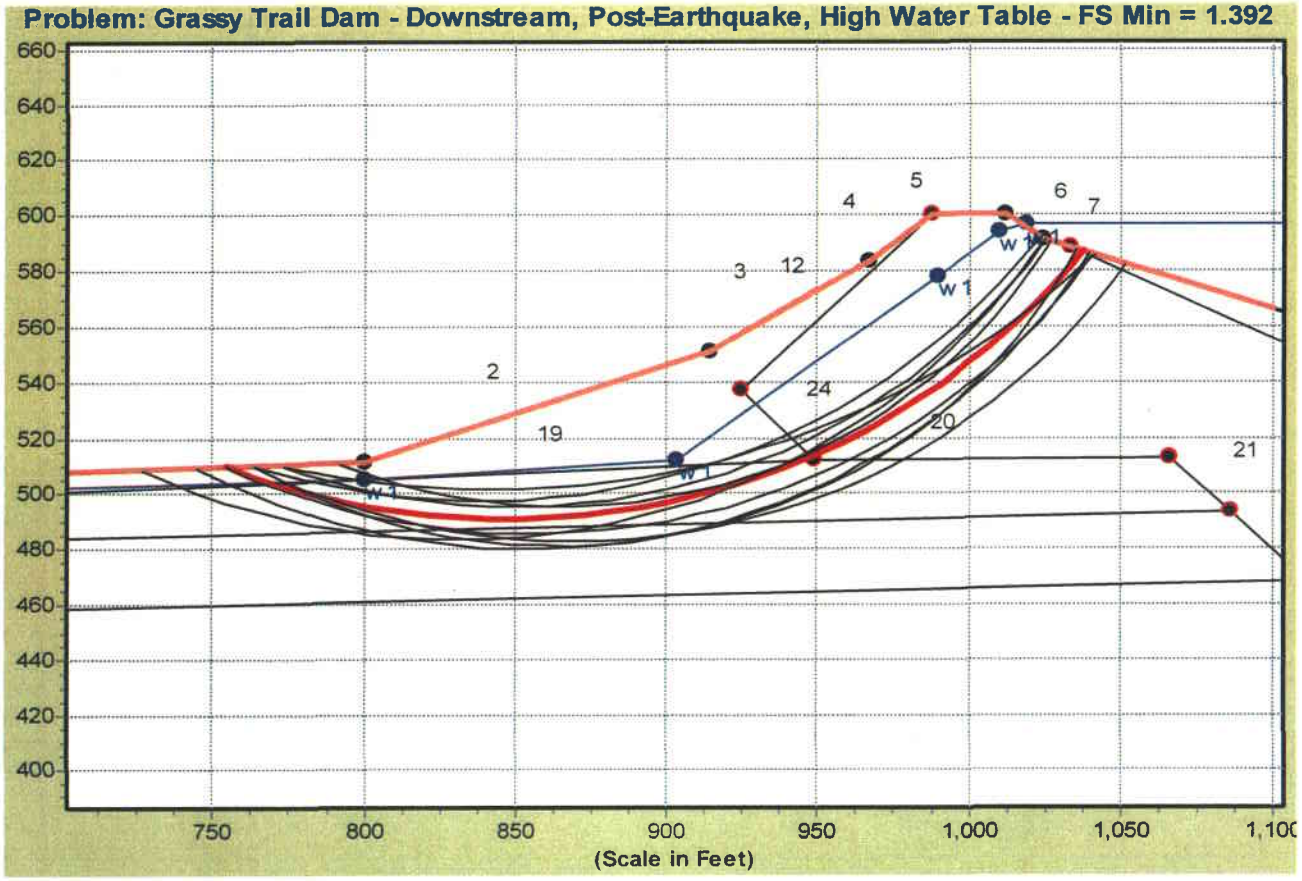
Downstream Slope - Seismic Yield Acceleration = 0.20g

Grassy Trail Dam and Reservoir

Spencer's Method

Pore pressure parameter = 0.1 in Layers 1 and 2
Pore pressure parameter = 0.2 in Layer 3
Ten most critical failure surfaces shown

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0



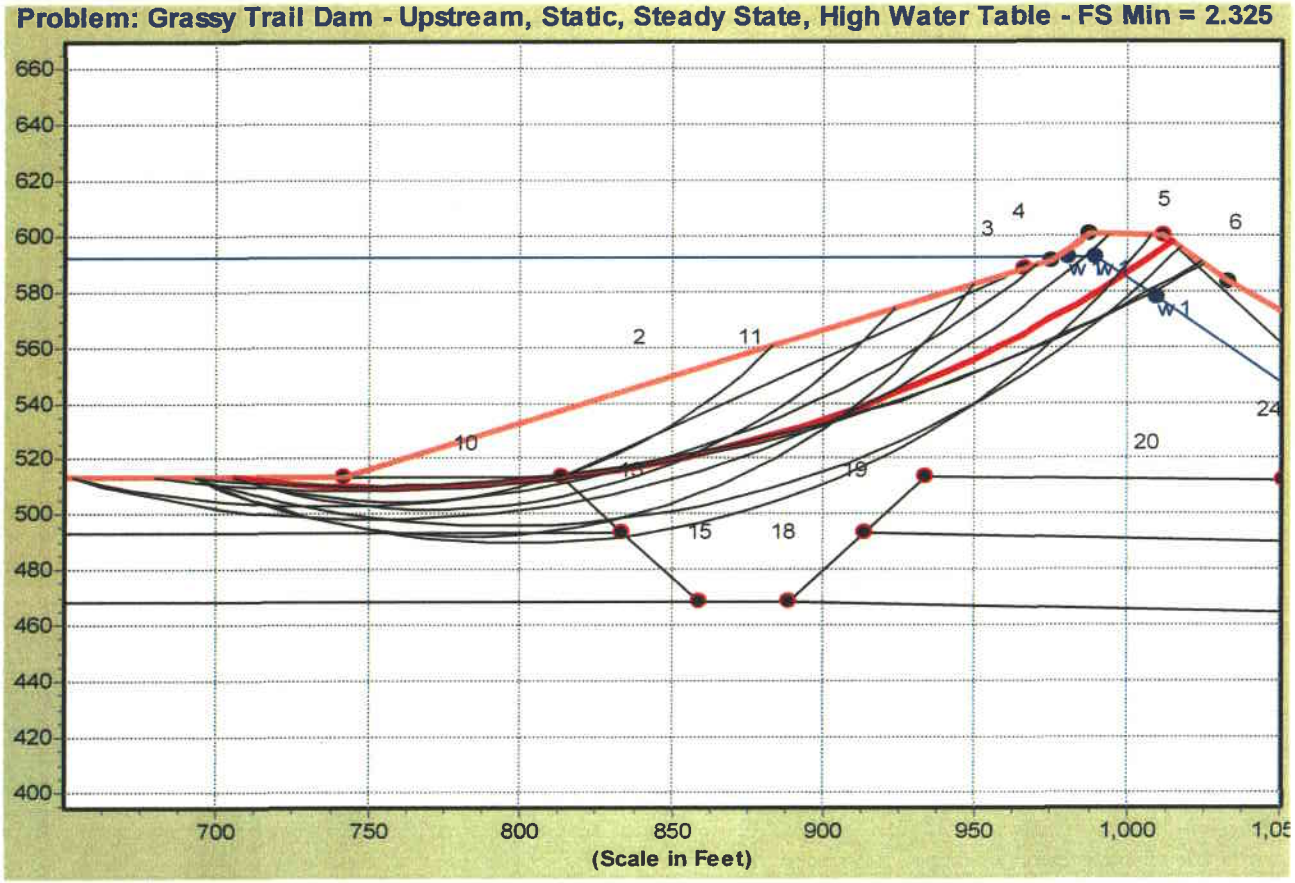
RB&G ENGINEERING INC.
Provo, Utah

Slope Stability Analysis Results
Downstream Slope - Post-Earthquake Condition
Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



RB&G ENGINEERING INC.

Provo, Utah

Slope Stability Analysis Results

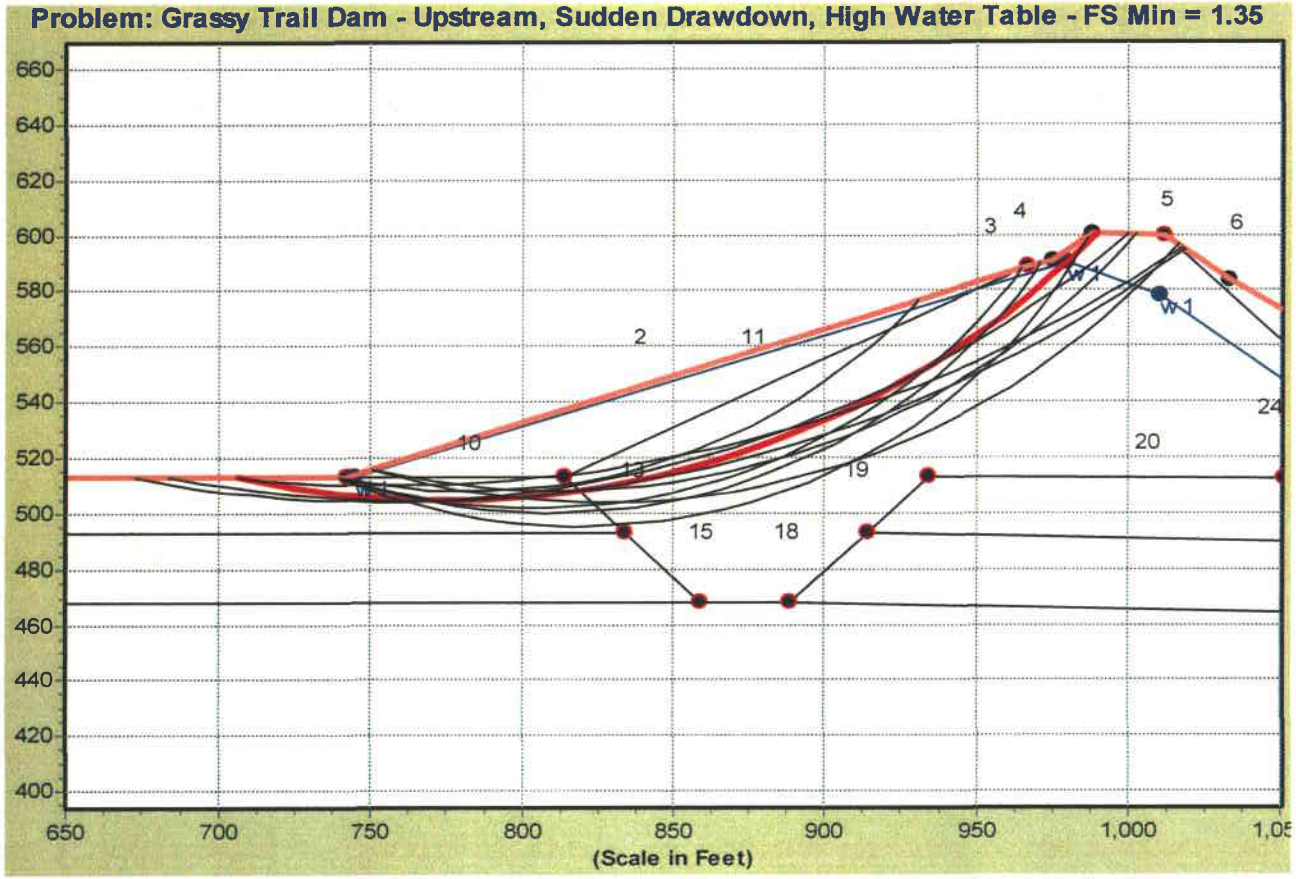
Upstream Slope - Static Steady State Seepage Condition

Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



RB&G ENGINEERING INC.

Provo, Utah

Slope Stability Analysis Results

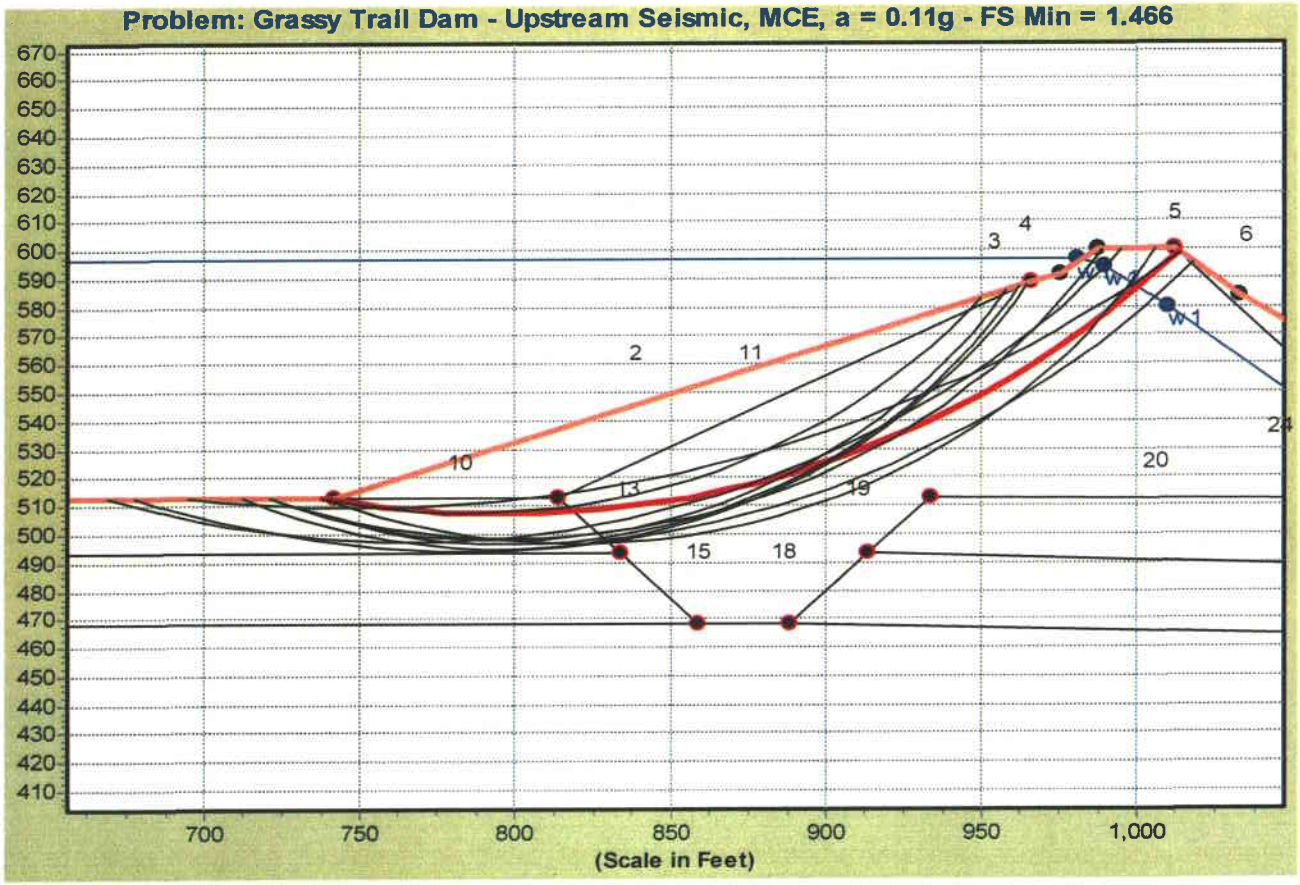
Upstream Slope - Static Sudden Drawdown Condition

Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



RB&G ENGINEERING INC.

Provo, Utah

Slope Stability Analysis Results

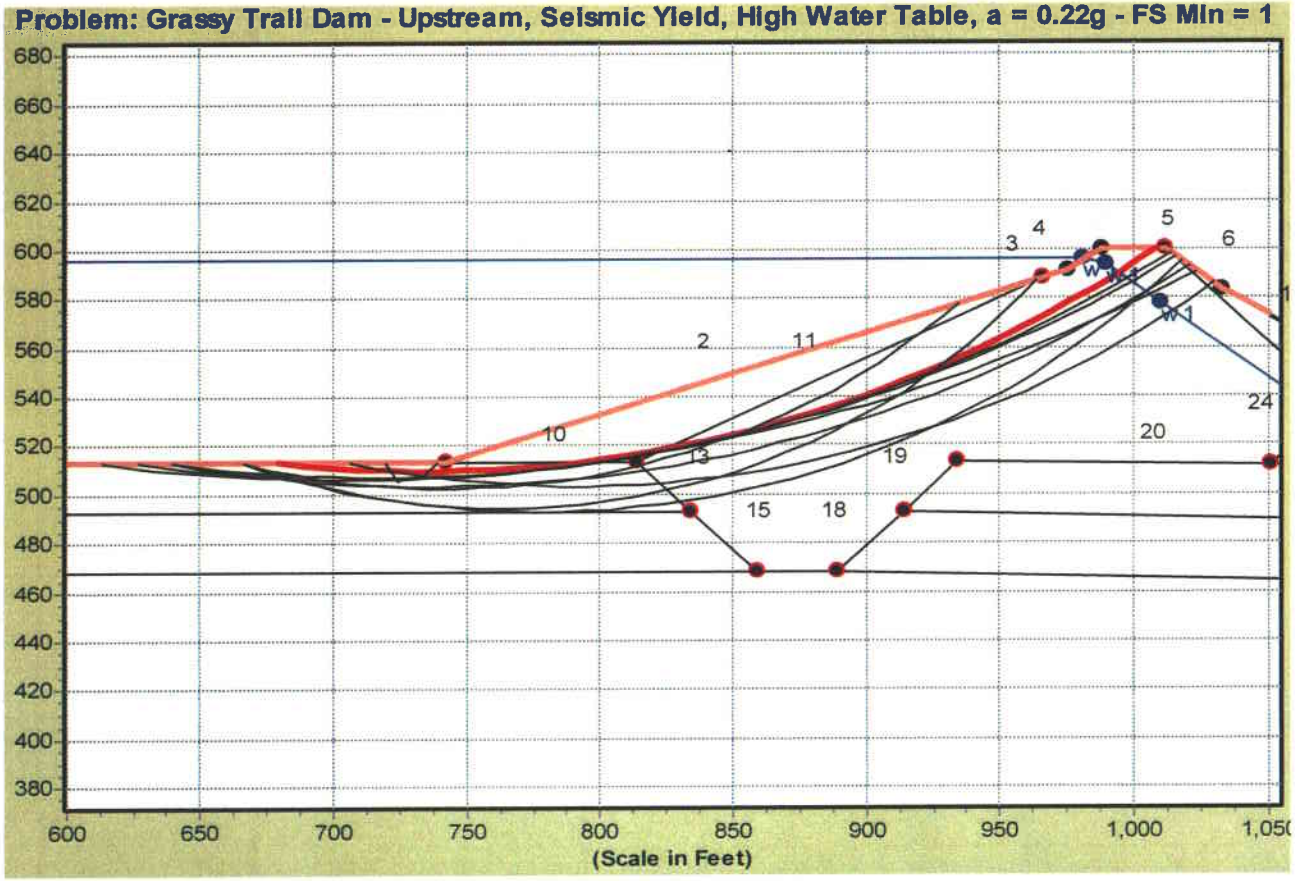
Upstream Slope - Maximum Credible Earthquake (non-mining)

Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



RB&G ENGINEERING INC.

Provo, Utah

Slope Stability Analysis Results

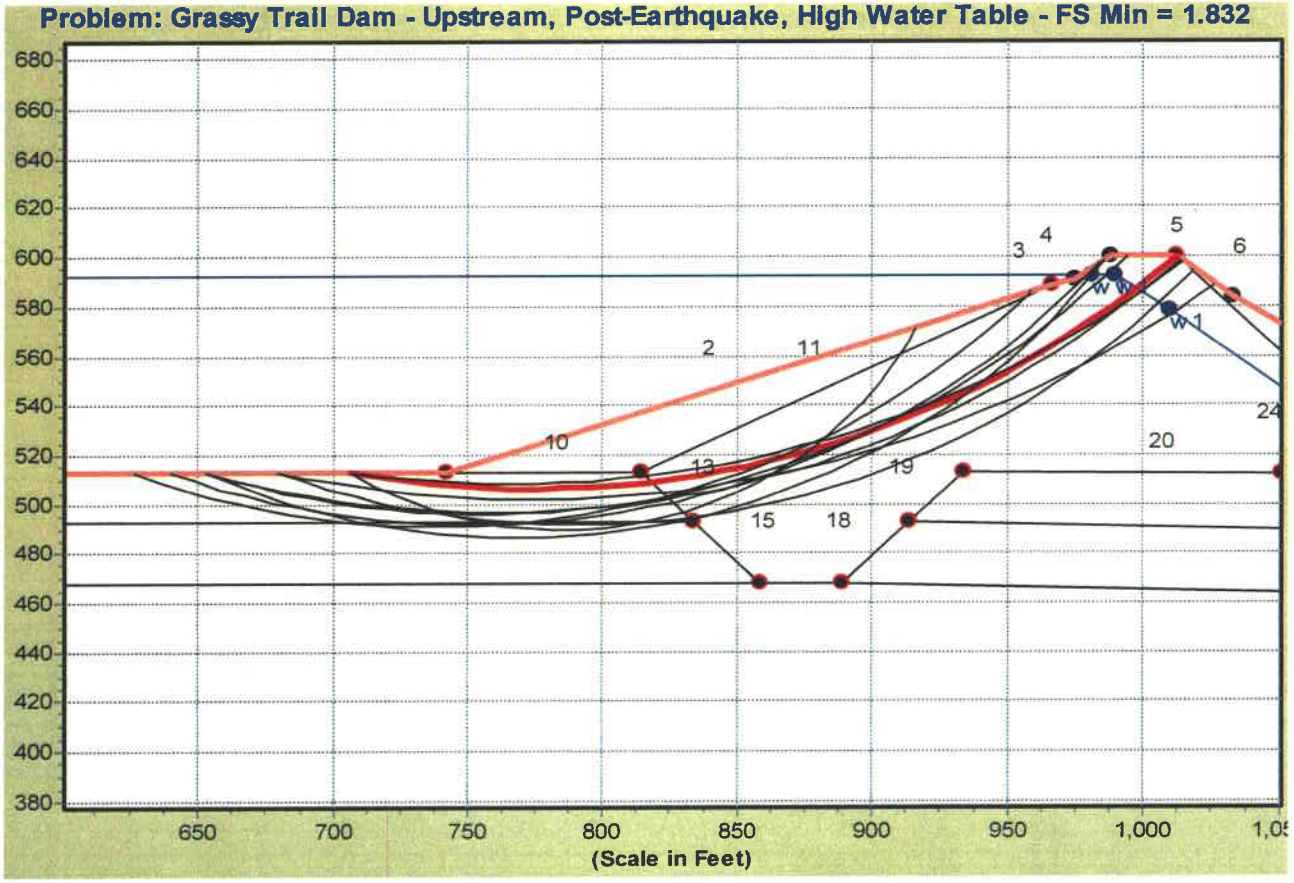
Upstream Slope - Seismic Yield Acceleration = 0.22g

Grassy Trail Dam and Reservoir

Spencer's Method

Pore pressure parameter = 0.1 in Layers 1 and 2
Pore pressure parameter = 0.2 in Layer 3
Ten most critical failure surfaces shown

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0



RB&G ENGINEERING INC.
Provo, Utah

Slope Stability Analysis Results
Upstream Slope - Post-Earthquake Condition
Grassy Trail Dam and Reservoir

Deformation Analysis

Seismic Deformation Estimate - Newmark Sliding Block Method

Project: Grassy Trail Dam - Mining-Induced Seismicity

Date: 7/20/2005

By: srj

Yield Accelerations:

beginning of earthquake

upstream:	0.22 g
downstream:	0.20 g

end of earthquake

upstream:	0.22 g
downstream:	0.20 g

Input Earthquake Record:

Earthquake:	BCE1
Date:	2/6/2004
Magnitude:	2.0
PGA:	0.0042 g
Modifications:	North-South Component, 10 to 15 seconds Scaled to PGA = 1.07g

Seismic Deformation:

positive record downstream	
top:	0.07 ft
middle:	0.19 ft
bottom:	0.46 ft
AVERAGE:	*0.24 ft*

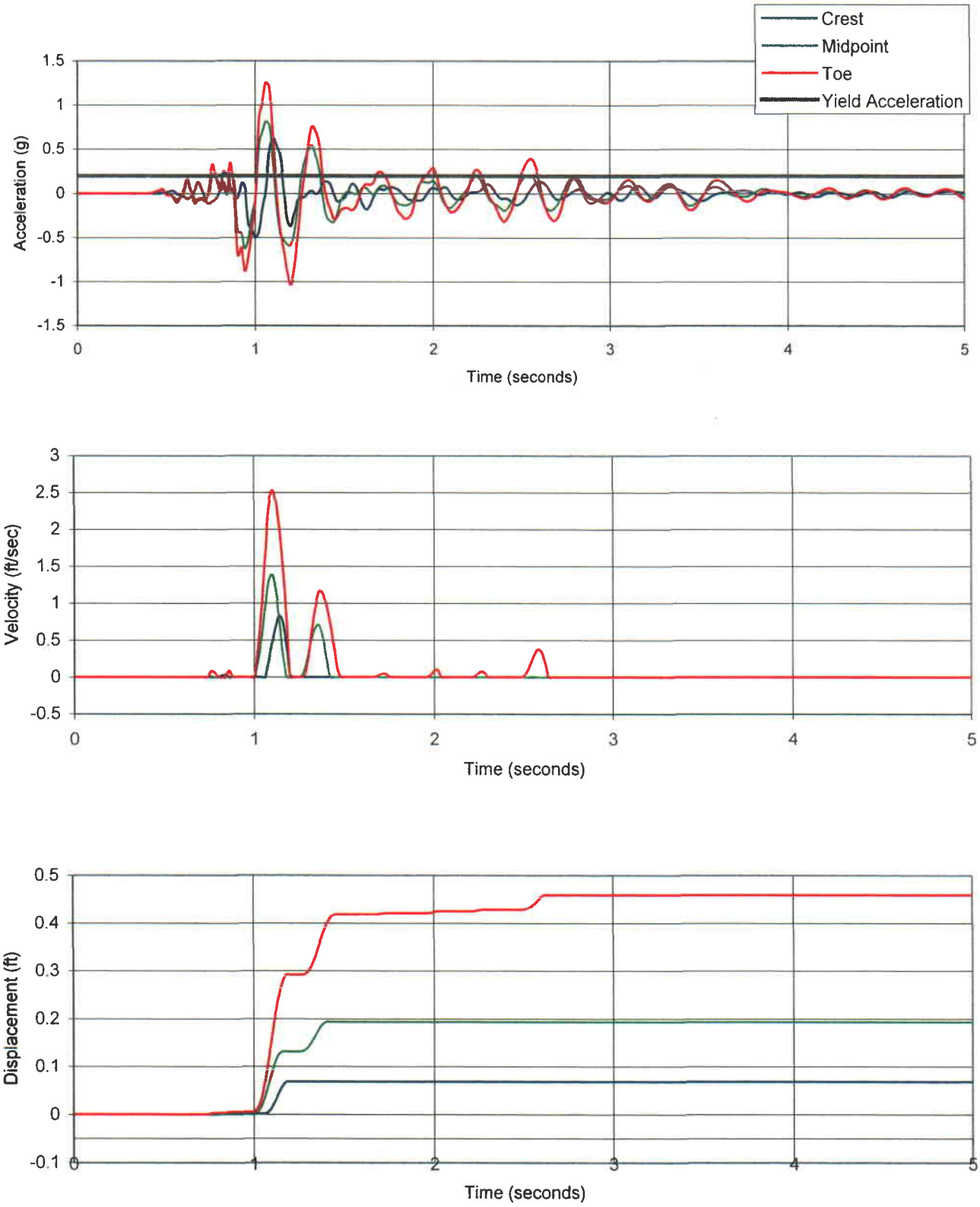
negative record downstream	
top:	0.06 ft
middle:	0.16 ft
bottom:	0.38 ft
AVERAGE:	*0.20 ft*

negative record upstream	
top:	0.10 ft
middle:	0.14 ft
bottom:	0.31 ft
AVERAGE:	*0.18 ft*

positive record upstream	
top:	0.11 ft
middle:	0.16 ft
bottom:	0.35 ft
AVERAGE:	*0.21 ft*

Acceleration Time Histories obtained using three ProShake columns for each slope with a soft "slip" layer inserted at the approximate failure surface. The slip layer was softened until the layers above the slip surface had peak acceleration approximately equal to the yield acceleration, then the acceleration was taken from the layer immediately below the slip surface.

See paper by Sandra Houston, 1985

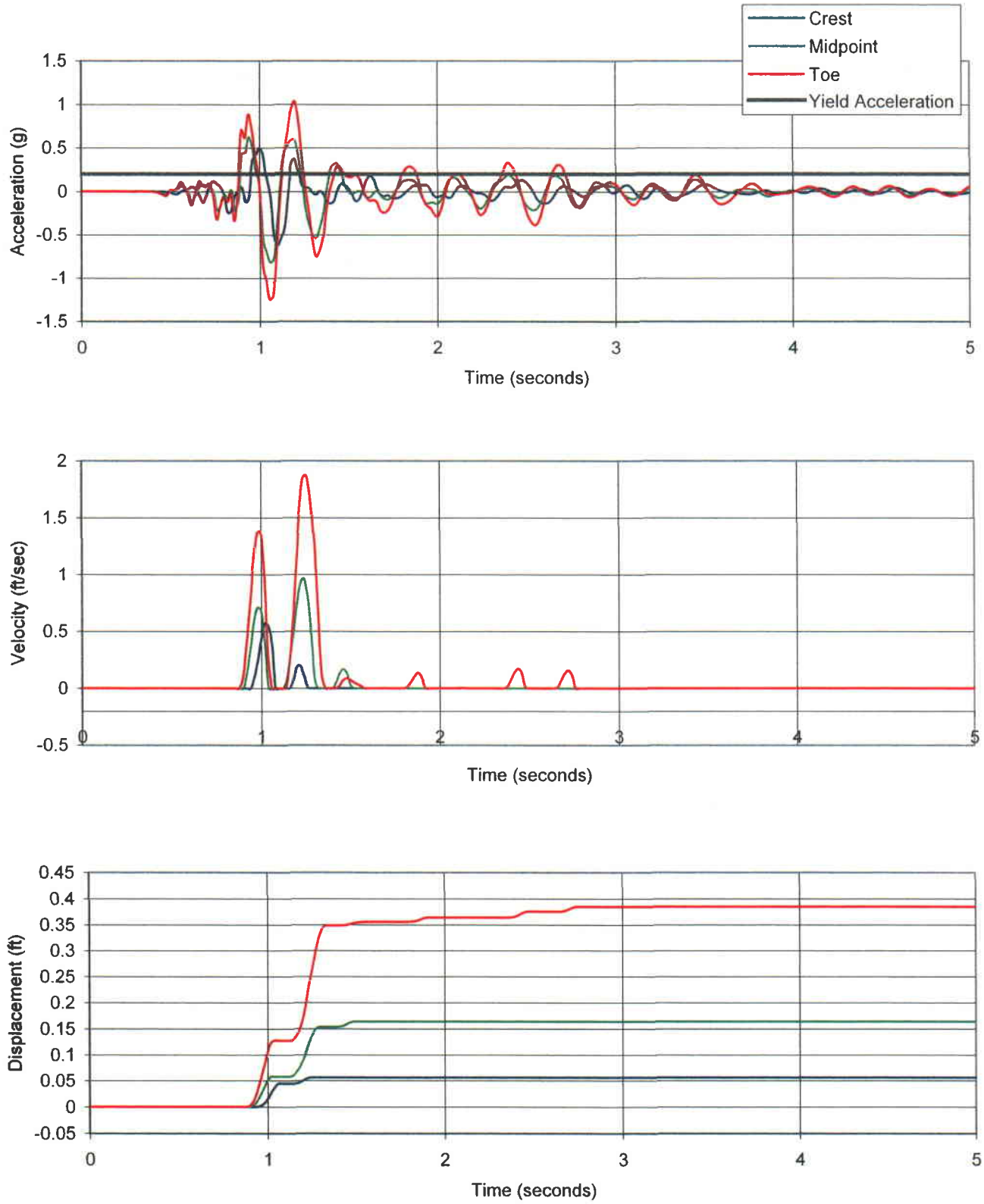


Anticipated embankment response to motion recorded at station BCE, 02/06/2004, North-South Component scaled to PGA = 1.07g

RB&G ENGINEERING INC.
Provo, Utah

Embankment Deformation
Downstream Slope, Positive Acceleration

Grassy Trail Dam and Reservoir



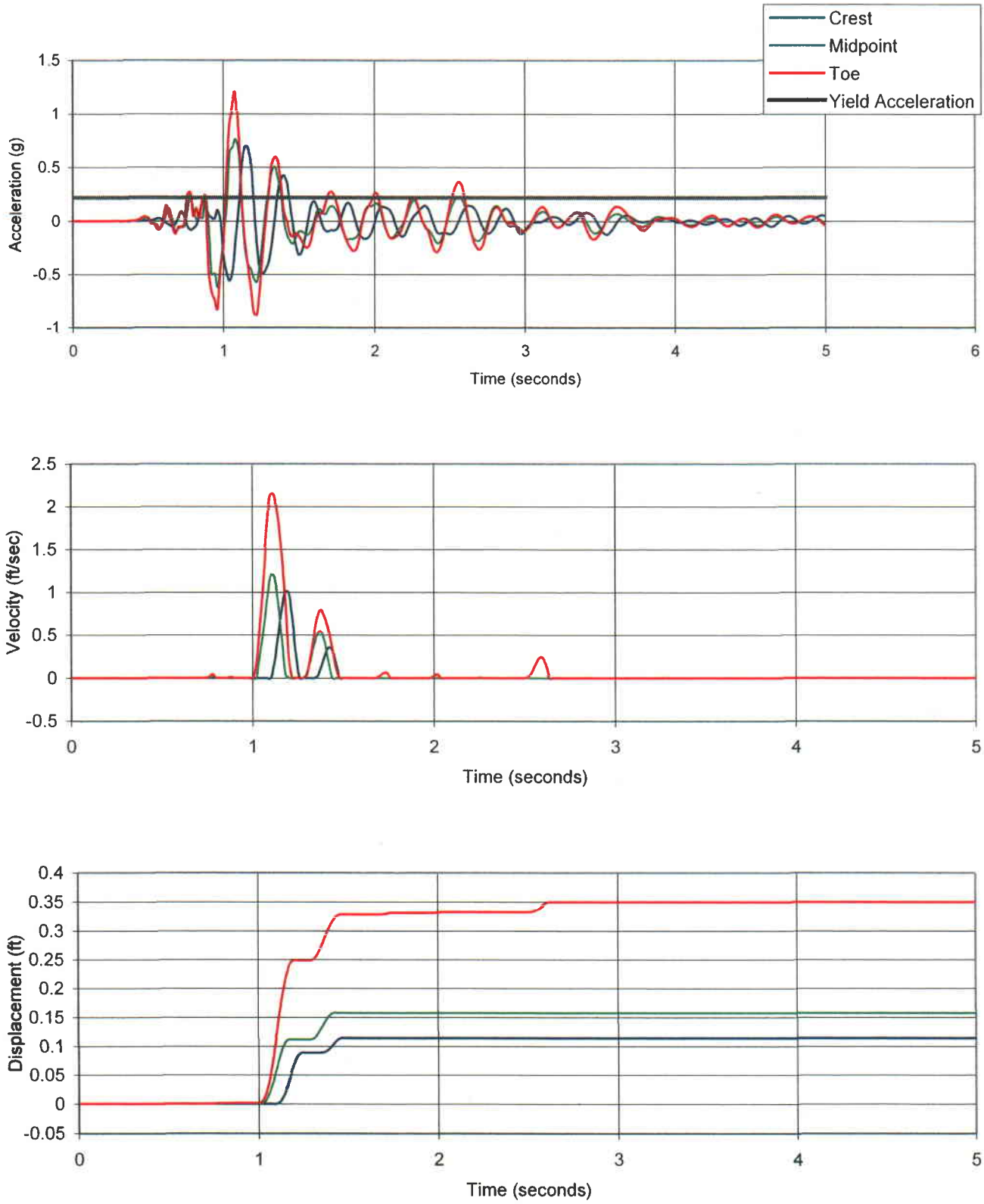
Anticipated embankment response to motion recorded at station BCE, 02/06/2004, North-South Component scaled to PGA = 1.07g

RB&G ENGINEERING INC.

Provo, Utah

Embankment Deformation
Downstream Slope, Negative Acceleratioin

Grassy Trail Dam and Reservoir



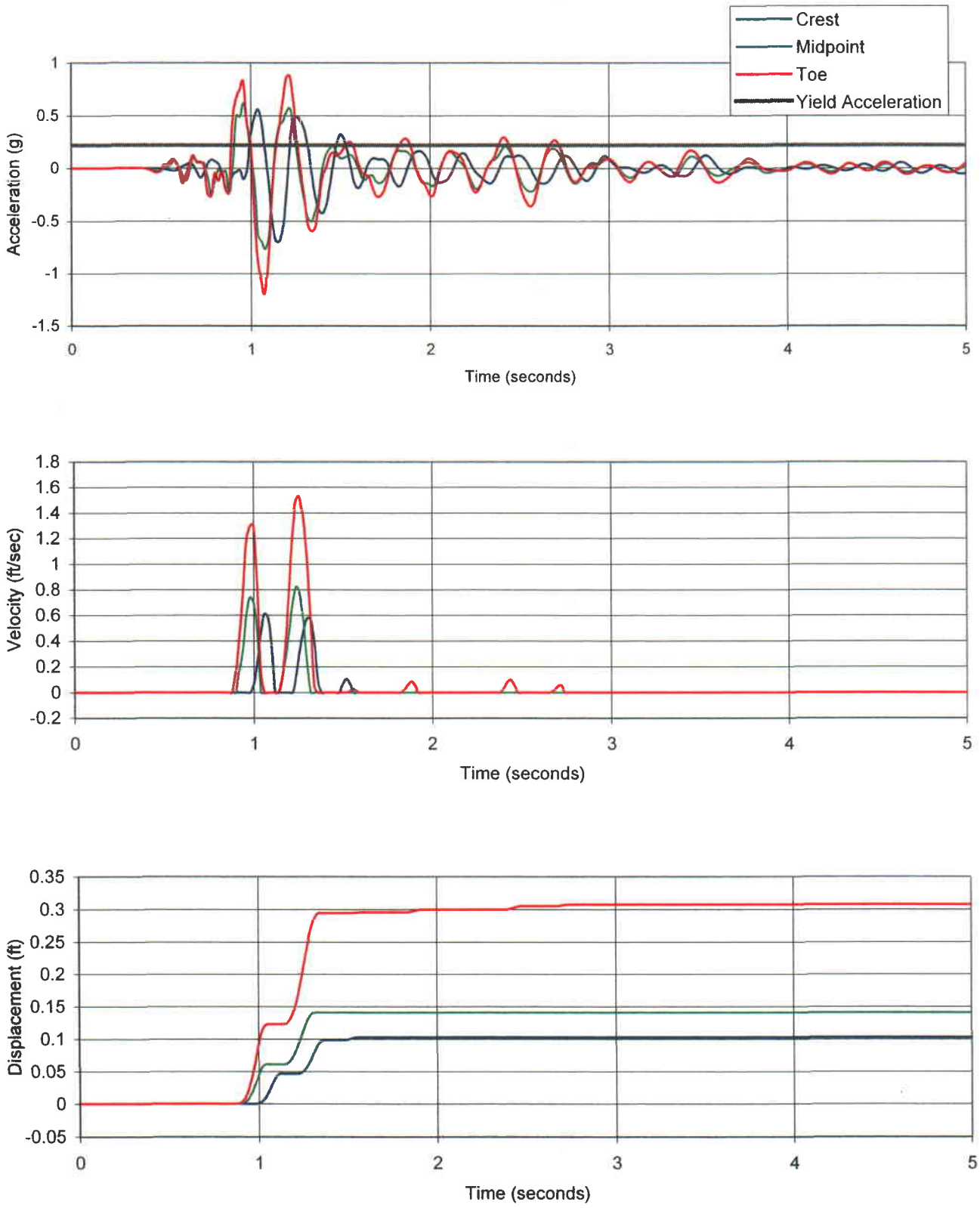
Anticipated embankment response to motion recorded at station BCE, 02/06/2004, North-South Component scaled to PGA = 1.07g

RB&G ENGINEERING INC.

Provo, Utah

Embankment Deformation
Upstream Slope, Positive Acceleration

Grassy Trail Dam and Reservoir



Anticipated embankment response to motion recorded at station BCE, 02/06/2004, North-South Component scaled to PGA = 1.07g

RB&G ENGINEERING INC.

Provo, Utah

Embankment Deformation
Upstream Slope, Negative Acceleration

Grassy Trail Dam and Reservoir

Seismic Deformation Estimate - Newmark Sliding Block Method
Project: Grassy Trail Dam - Mining-Induced Seismicity
Date: 7/18/2005
By: srj

Yield Accelerations: **For Landslide on West Reservoir Rim**

beginning of earthquake

Slope	0.03 g

end of earthquake

Slope	0.03 g

Input Earthquake Record:

Earthquake:	**BCE1**
Date:	2/6/2004
Magnitude:	2.0
PGA:	0.0042 g
Modifications:	North-South Component, 10 to 17 seconds
	Scaled to PGA = 1.07g

Seismic Deformation:

negative record	
bedrock motion:	1.19 ft
40-ft overburden:	0.99 ft
60-ft overburden:	0.87 ft

total

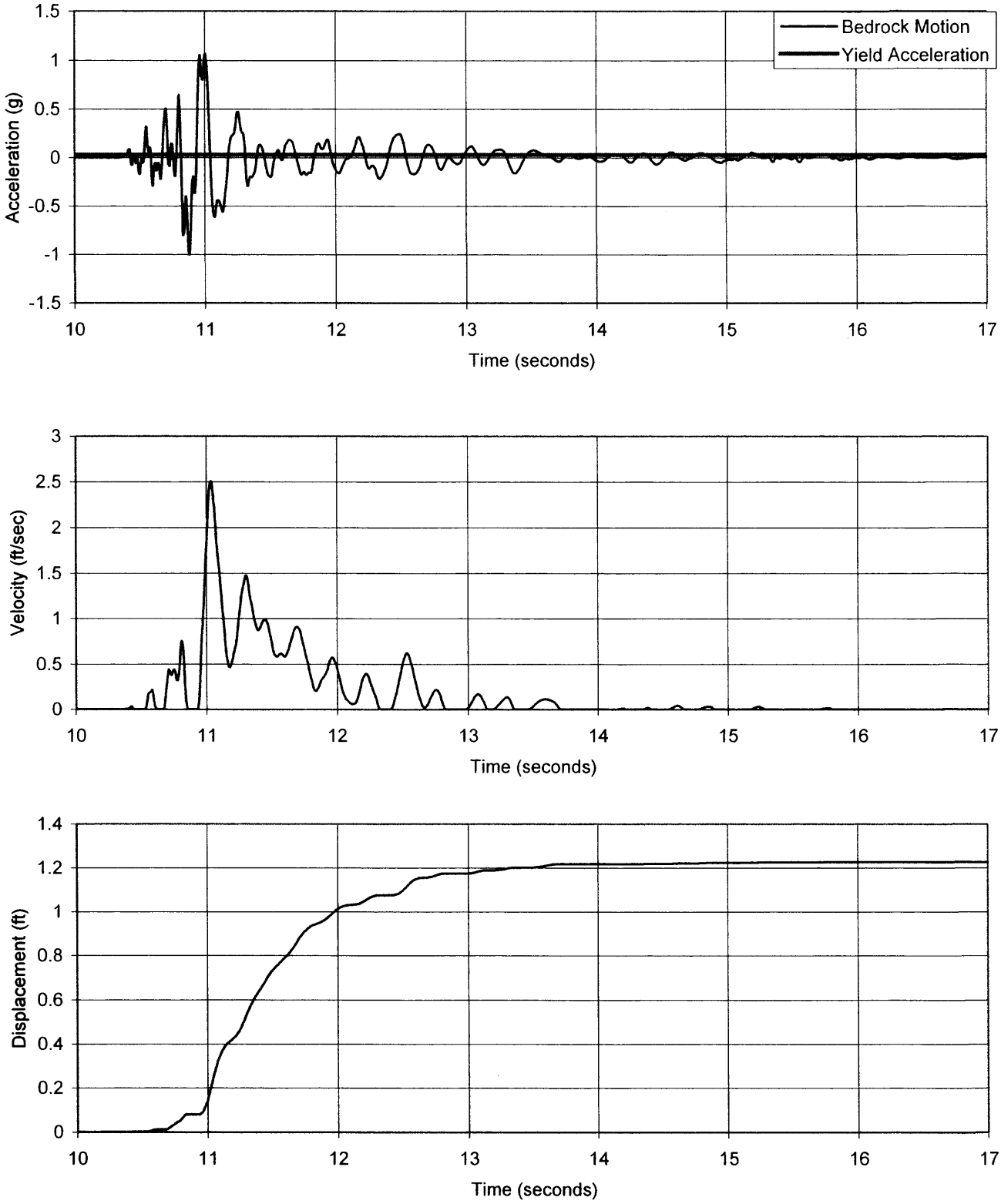
maximum:	1.19 ft
average:	1.02 ft

positive record	
bedrock motion:	1.23 ft
40-ft overburden:	1.08 ft
60-ft overburden:	0.82 ft

total

maximum:	1.23 ft
average:	1.04 ft

Acceleration Time Histories obtained using three ProShake columns for each slope with a soft "slip" layer inserted at the approximate failure surface. The slip layer was softened until the layers above the slip surface had peak acceleration approximately equal to the yield acceleration, then the acceleration was taken from the layer immediately below the slip surface.
See paper by Sandra Houston, 1985



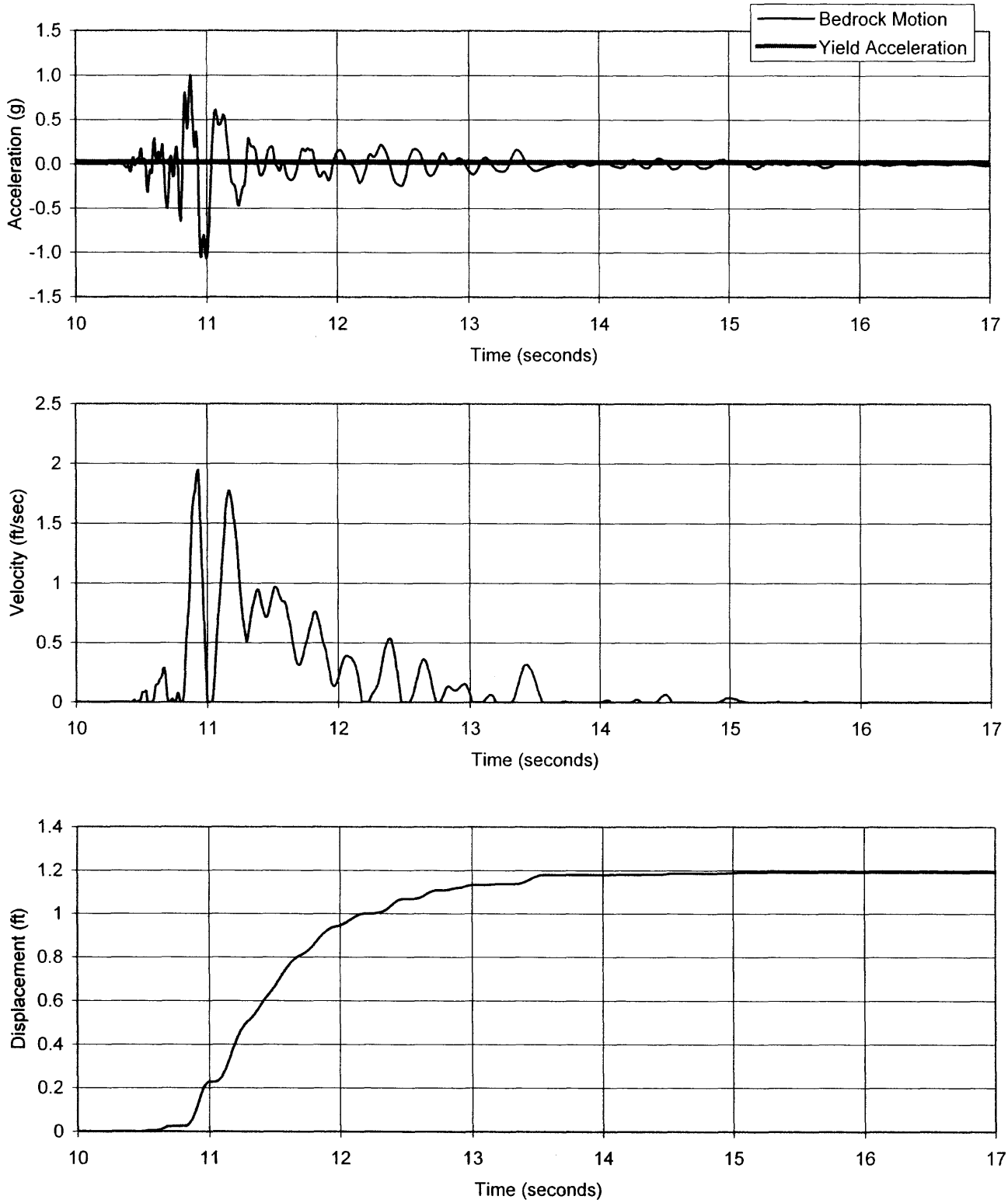
Anticipated embankment response to motion recorded at station BCE, 02/06/2004, North-South Component scaled to PGA = 1.07g

RB&G ENGINEERING INC.

Provo, Utah

Slope Deformation
West Reservoir Rim, Positive Acceleration

Grassy Trail Dam and Reservoir



Anticipated embankment response to motion recorded at station BCE, 02/06/2004, North-South Component scaled to PGA = 1.07g

RB&G ENGINEERING INC.

Provo, Utah

Slope Deformation
West Reservoir Rim, Negative Acceleration

Grassy Trail Dam and Reservoir

APPENDIX 5-9A

GRASSY TRAIL DAM & RESERVOIR
PHASE II DAM SAFETY STUDY
(R, B, & G ENGINEERING)

RB&G ENGINEERING INC.

August 27, 2005

John C. Lewis
West Ridge Resources, Inc.
P.O. Box 1077
Price, UT 84501

Subject: Grassy Trail Dam and Reservoir
Phase II Dam Safety Study

Gentlemen:

A Phase II Dam Safety Study has been completed for the Grassy Trail Dam and Reservoir in Carbon County, Utah. The results of the study are summarized in the report transmitted herewith. Personnel involved in preparation of this report include the following:

Bradford E. Price, Principal Geotechnical Engineer
Michael N. Hansen, Professional Geologist
Marc K. Stilson, Professional Engineer
S. Robert Johnson, Engineer

We appreciate the opportunity of providing this service for you. If there are any questions relating to the information contained herein, please call.

Sincerely,

RB&G ENGINEERING, INC.

REGISTERED PROFESSIONAL ENGINEER
NO.162291
BRADFORD E. PRICE
8/27/05
STATE OF UTAH

Bradford E. Price, P.E.

bep/jag

INCORPORATED
NOV 10 2005
DIV OF OIL GAS & MINING

1435 WEST 820 NORTH
PROVO, UTAH 84601-1343

PROVO 801-374-5771
SALT LAKE CITY 801-521-5771

GRASSY TRAIL DAM AND RESERVOIR

PHASE II DAM SAFETY STUDY

July 2005

Prepared for

WEST RIDGE RESOURCES, INC.

RB&G ENGINEERING, INC.

GRASSY TRAIL DAM

East Carbon City & West Ridge Resources, Inc.

Phase II Dam Safety Study

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- Table 1, Summary of Test Data
- Soil Moisture Density Relationship Curves
- Shear Test Results

1998 PHASE II INSTRUMENTATION
- Location of Instrumentation
- Boring, Inclinometer, and Piezometer Logs

2005 PHASE II DAM SAFETY STUDY
- Location of Instrumentation
- Boring and Inclinometer Logs
- Table 1, Summary of Test Data
- Sieve Analysis (Gradation)
- Direct Shear Tests

INCLINOMETER READINGS
SLOPE STABILITY ANALYSES

GRASSY TRAIL DAM

East Carbon City & West Ridge Resources, Inc.

Phase II Dam Safety Study

RB&G ENGINEERING INC.
1435 WEST 820 NORTH
PROVO, UT 84601-1343
801 374-5771 Provo
801 521-5771 SLC

I. INTRODUCTION

A. PURPOSE AND SCOPE

At the request of West Ridge Resources, Inc., RB&G Engineering has performed an evaluation and analysis of Grassy Trail Dam. On June 7, 1994 the Utah Division of Water Rights, (DWR) Dam Safety Section, conducted a "Minimum Standards" inspection of Grassy Trail Dam (UT00126) pursuant to Section 73-5a-502, Utah Code. On October 12, 1994 a letter was sent by DWR to the City of East Carbon addressing the inspection and deficiencies of the dam to current dam safety rules. A copy of this letter is included in the appendix. Deficiencies were noted in the following areas: geology/seismic studies, hydrologic design, seismic design and embankment requirements, and instrumentation. In 1998 Creamer and Noble Engineer's contracted with RB&G Engineering to install instrumentation in the dam, foundation and abutments as part of the Phase II study being performed for the owner. The Phase II study was not completed at that time.

West Ridge Resources, Inc. contracted with RB&G Engineering, Inc. in February 2005 to perform engineering studies required by DWR to complete the Phase II study and provide recommendations for remedial action to correct deficiencies. The work performed is discussed under the following headings:

- Geologic and Seismic Studies
- Hydrologic Analysis
- Subsurface Investigations
- Embankment Evaluation
- Preliminary Cost Estimate
- Conclusions and Recommendations

B. PROJECT DESCRIPTION

Grassy Trail Dam and Reservoir is part of a water system owned by the City of East Carbon to supply irrigation, municipal and stock water to agricultural and municipal users in Carbon County. The dam and reservoir are located on Whitmore Canyon Creek, about 7 miles north of Sunnyside, Carbon County, Utah. The reservoir is located in the USGS Sunnyside quadrangle Township 14 South, Range 14 East (SLBM) with a latitude of 39°37.30' N and longitude of 110°23.74' W. Figure 1 is a portion of the USGS quadrangle map for this area, showing the reservoir site in relation to the surrounding area.

The dam was constructed in 1951/1952 as a zoned earthfill embankment with a structural height of about 89 feet high with a crest length of 600 feet. The crest width is about 26 feet. The dam is currently classified as an Intermediate Size, High Hazard structure. A copy of construction drawings on file at the Utah State Division of Water Rights Dam Safety Section is included in the appendix. The reservoir was designed with a storage capacity of about 916 acre feet at the spillway level and covers an area of approximately 29 acres. A Morning Glory type spillway connects to a concrete outlet tunnel in the left abutment. The outlet works is also located in the left abutment, consisting of a 16" cast iron pipe, transitioning to steel pipe in the outlet tunnel.

Reported survey elevations for the dam have varied significantly since original construction was completed in 1952. The initial plans and construction documents show the dam crest at elevation 7620 feet, with the spillway at 7616.37 feet. The Phase I Inspection Report (1979) indicated that the dam crest appeared to have been raised in the past by about one foot over the original crest elevation, resulting in a crest elevation of 7601 feet. The 1972 USGS 15-minute topographic map of the Sunnyside Quadrangle shows the spillway elevation at 7580 feet. Surveys performed in 1999 by Creamer & Noble Engineers show the dam crest elevation at 7600 feet, with the spillway at 7592.5 feet. Cross sections provided by West Ridge Resources show the dam crest at 7591 feet with a high water elevation of 7585 feet. The Utah Division of Water Rights Dam Inventory currently lists the crest elevation as 7600 feet. In this report, the dam crest elevation is assumed to be 7600 feet, with the spillway at elevation 7592.5 feet. It should be noted that some figures and some data included in the appendix of this report were copied from previous studies, and the elevations shown on the figures correspond to the elevation datum used in each study.

C. PREVIOUS STUDIES

The following studies were reviewed for this report:

- *Flood Hazard Analyses, April 1977*, USDA, Soil Conservation Service
- *Dam Safety Report, 1979*, RB&G Engineering, Inc.
- *Phase I Inspection Report, Nov. 1979*, U.S. Army Corps of Engineers
- *Dam Breach Report, 1980*, RB&G Engineering
- *Estimated Impacts to the Grassy Trail Reservoir Due to Longwall Mining West Ridge Mine, Nov. 2004*, Agapito Associates, Inc.
- *Mining-Induced Seismicity, July 2005*, RB&G Engineering, Inc.
- *Seismic Monitoring Report Category C, 1988, (obtained from Utah Dam Safety Office)*
- *Contents of Specifications, Sunnyside-Dragerton-Columbia Water Project (obtained from Utah Dam Safety Office)*

II. GEOLOGIC AND SEISMIC STUDIES

A. REGIONAL GEOLOGY

The reservoir and dam are located within the Roan Cliffs region northeast of the Book Cliffs, within the Colorado Plateau Physiographic Province. These mountains were formed along the northern flank of a large structural anticline known as the San Rafael Anticline, which includes the physiographic feature known as the San Rafael Swell. There is no strong evidence for the precise age of the swell, but it is believed to have formed sometime during the late Cretaceous to mid Tertiary times, 40 to 60 million years ago. The San Rafael Swell is located about 50 miles south of the dam site. Much of the center of the anticline has been removed by erosion, which exposed the softer underlying Mancos Shale. The resistant sandstone of the Book Cliffs now forms the northern extent of the highly eroded portion of the anticline.

B. SITE GEOLOGY

Grassy Trail Reservoir is located at the junction of the left and right forks of Whitmore Canyon. As shown on the geologic map in Figure 2, the dam and reservoir are located on the Coulton Formation laid down during the Tertiary Period, Eocene and Paleocene Epochs, about 38 to 56 million years ago. The formation consists of dark-reddish-brown to green beds of mudstone and shaley siltstone interbedded with yellowish to grayish-orange and grayish brown, thin, fine to medium grained quartzose sandstone, with sparse limestone beds. The formation is primarily of alluvial origin with some marginal lacustrine and deltaic deposits (Weiss and others, 1990). Bedrock appears to dip gently to the northeast at an angle of about 7 to 8 degrees. Previous studies at the dam have mentioned that the mudstones throughout the area appear to be fairly massive, while the sandstone rimrocks are broken by two sets of joints that parallel the strike and dip direction of the bedrock (RB&G, 1979).

The West Ridge Coal Mine is located within about a four square mile area just southwest of the dam. Current mining plans propose mining toward the northeast and ending within a surface distance of about 1,000 feet of the dam. Mining in this area is done by advancing longwall panels. The coal seam being mined is the Lower Sunnyside Seam, which is located in the Black Hawk Formation.

Maps of the West Ridge Mine show the coal seam within the area to vary from 7 to 9 feet thick, with 8 feet being the predominant thickness. A West Ridge map shows bedrock dipping down to the northeast at about 7-8 degrees (12 to 15%) with a strike of about North 43 degrees West. Due to this northeasterly dip, some coal seams within the Blackhawk

Formation pass beneath the dam at a depth of about 1,685 feet (West Ridge Mine core log for drill hole H-31).

The 1979 RB&G report references a map, prepared by other investigators, of the geology for Grassy Trail Reservoir indicating that two faults are located 1 to 2 miles west of the dam. These faults appear to be near vertical and have trace lengths less than two miles. The geological map also shows other faults about 8 miles south of the dam site near Sunnyside and East Carbon. None of these faults have been identified as being potentially active.

C. SEISMOTECTONIC SETTING AND EARTHQUAKE HAZARDS

Seismic hazards include ground shaking from a very large seismic event. Additional hazards may include activation of landslides and seiche or wave action during a seismic event. A geologic study and map showing potentially active Quaternary age faults in Utah was compiled by Bill Black and others for the Utah Geological Survey (UGS) in 2003. This map shows the nearest (mapped) potentially active faults as the Price River area faults about 26 km to the south. The Duchesne-Pleasant Valley Fault System is located about 55 km north, and the Pleasant Valley Fault Zone with unnamed faults is located about 64 km to the west. The Joes Valley Fault Zone consisting of the East, West and Intragraben faults are located about 72 km west. Of these surrounding faults, the Joes Valley Fault Zone appears to have the greatest potential for seismic activity and may generate a 7.2 to 7.5 magnitude earthquake. A map showing the location of the faults in relation to the site is presented in Figure 3. The following is a description of the surrounding faults as taken from the 2003 UGS report.

1. Surrounding Faults

a. Duchesne - Pleasant Valleys fault system

The Duchesne - Pleasant Valleys fault system is a poorly understood suspected Quaternary fault system. The fault zone consists of a series of east-west trending normal faults in Duchesne and Pleasant Valleys in the southern Uinta Basin. Although the extensional stress regime for normal faults in Utah typically generate north-south tending faults, these faults trend east-west. Along with the lack of scarps on late Quaternary (>250 ka?) deposits brings into question the tectonic potential of this fault system. Some contributors to the UGS report state "that the fault system should not be considered a potential source for large-magnitude earthquakes. A relation between variations in escarpment height and drainage incision led some to conclude that the escarpments are fault-line features, resulting from base-level lowering and erosion rather than Quaternary faulting. However, the geomorphic position of the faults suggested to others ... the possibility of late Quaternary faulting,

and judging from scarp morphology... faulting may have occurred less than a thousand years ago"(Black and others, 2003). The fault zone is about 45 km long with an unknown slip rate that has been estimated to be less than 0.2 mm/year.

b. Price River area faults

The Price River area faults are also poorly understood and are of questionable Quaternary age faults along the Price River west of the Book Cliffs. The faults generally strike east-west along the Price River west of the Book Cliffs. The UGS reports state that "the faults are in a long, sinuous area along the base of the Book Cliffs termed the Mancos Shale Lowlands, characterized by sloping pediments, rugged badlands, and narrow flat-bottomed alluvial valleys in Cretaceous rock.

The UGS report states that "some faults within the zone displace pre-Wisconsin-age pediments less than 2 meters. Structural relations indicate that the fault zone forms the crest of a broad, collapsed anticline. The fault zone is similar in trend, pattern, and length to faults along the crest of the Moab-Spanish Valley anticline, although it is not as strongly developed. The faults are inferred to be related to a salt anticline at the northern margin of the Paradox basin. Early to middle Pleistocene pediments north of the fault zone steepen sharply at the base of the Book Cliffs, and may be warped due to elastic rebound of the Mancos Shale during erosional unloading and/or monoclinal folding. The ancestral course of Whitmore Canyon (near Sunnyside) also appears to be warped".

The fault zone is about 51km long with an unknown slip rate that has been estimated to be less than 0.2 mm/year"(Black and others, 2003).

c. Pleasant Valley fault zone unnamed faults

The unnamed faults of the Pleasant Valley fault zone are the eastern portion of a larger Pleasant Valley Fault Zone. The UGS report state that the Pleasant Valley Fault Zone consists of a series of unnamed north-trending normal faults bounding the eastern and western sides of the Pleasant Valley Fault Zone. These faults are poorly understood and have questionable Quaternary activity.

The faults are less prominent than faults bounding the Pleasant Valley and Dry Valley grabens; often having little or no topographic expression and displacements less than 100 meters. Other faults are associated with bedrock scarps and linear drainages, and have displacement similar to Pleasant and Dry Valley Faults; however, Quaternary deposits are non-existent to evaluate the age of last movement on the faults.

The faults have a length of about 31km with an unknown slip rate that has been estimated to be less than 0.2 mm/year"(Black and others, 2003).

d. Joes Valley Fault Zone East Fault

The Joes Valley Fault Zone has been divided into several sections consisting of the East, West, Intragraben, and Southern sections. For the eastern section, which is close to the site, the UGS report states the East Fault is a normal fault bounding the east side of the northern Joes Valley graben. Both East and West Faults show evidence of Holocene movement.

North-trending fault bounding the east side of the northern Joes Valley graben. Bedrock displacement along the fault is greatest at its center and diminishes toward the north and south. Joes Valley is long, straight, north-trending graben that splits the Wasatch Plateau, which is capped mainly by Tertiary Flagstaff Limestone.

The youngest measured displacement (2.5 meters) is apparently due to monoclinal folding and may be the result of several small events. The estimated maximum credible earthquake on the East Joes Valley fault is 7.5 (Ms). However, this estimate assumes the existence of a rupture pathway (presently unidentified) to the base of the seismogenic crust. Other sections of the fault zone also have the potential to create similar magnitude earthquakes.

Foley and others (1986) excavated a trench on the southeast side of Scad Valley at the north end of the Straight Canyon section, approximately 18 kilometers north of the area studied for the West Fault and Intragraben Faults. Stratigraphic and structural relations indicate at least four surface-faulting events since 150-300 ka, which is the interpreted age (based on amino acid racemization of snail shells) of the oldest unit exposed in the trench. The four events appear to have involved both brittle rupture and monoclinal folding.

The timing of most recent event occurred between 1.5 ka and 14-30 ka. Four or more events are thought to have occurred since 150-300 ka; two of these events predate a soil interpreted to date from >130 ka. The faulted deposits are Holocene in age. The fault has a recurrence interval of less than 60,000 years, with a slip rate of about 0.2-1 mm/years, and a length of about 57 km (Black and others, 2003).

While the Joes Valley Faults appear to be the most active, we cannot rule out the possibility of movement on the other more questionable faults.

2. *Mining Induced Seismicity*

In addition to the naturally occurring earthquakes on faults, seismicity at the dam may also be affected by Mining Induced Seismicity (MIS). Due to longwall coal mining at the West Ridge Mine, west of the reservoir, there is potential for ground accelerations due to rock bursts in the mined area. A separate report has been prepared which addresses MIS at Grassy Trail Dam. The MIS report should be reviewed for more detailed information. The MIS study found that the largest documented MIS event in the Wasatch Plateau coal area was a magnitude 4.2 event at the Willow Creek Mine during March, 2000. Studies by Arabaz and others (2005) determined that while the 4.2 event could happen again at other mines in the area, a magnitude 3.9 event could be used as the probable maximum earthquake. While their study was not specific to the West Ridge Mine, it is their opinion that a 3.9 event would also be appropriate for the West Ridge Mine area.

Mining projections show that longwall mining will come within about 0.59km (1936 ft) hypocentral distance of the west end of the dam in the spring of 2006 during mining of Panel No. 7. New attenuation equations were developed by McGarr and Fletcher (2005) to better evaluate PGA values for lower magnitude MIS events. Based on their equations, a 3.9 magnitude event at a distance of 0.59 km could generate a Peak Ground Acceleration (PGA) value of about 1.07 g. It should be noted that while this acceleration value is relatively high, a small 3.9 magnitude event would have a relatively low duration. An event of this magnitude within a mine may be only one impulse, which is over very quickly.

Since longwall mining started in the West Ridge Mine in 2001, the largest event documented is a magnitude 2.0 in May, 2005. Instrumentation was installed at the dam site in September 2004, with continuous monitoring from February 2005 through July 2005 during mining of Longwall Panel No. 6 (nearest hypocentral distance of 0.74 km (2,420 ft.) to the west end of the dam. The greatest recorded peak ground acceleration has been 0.0315g on the hillside about 900 feet west of the right abutment. The greatest recorded peak ground acceleration on the dam during this time has been 0.0116g.

Based on the information outlined above, it is our opinion that an acceleration of 1.07g with a 3.9 magnitude event should be used to evaluate performance of the dam for MIS.

3. *Maximum Credible Earthquake*

The dam site is located east of the Intermountain Seismic Belt (IBS). Since some of the faults west of the site are located within the IBS, the IBS seismic model is used to evaluate the study area. In the IBS, earthquakes are usually generated at depths less than 15 km, with larger magnitude quakes being generated at the deeper depths and lower

magnitude quakes at shallower depths (Arabasz & Julander, 1986). For the MCE event, we have assumed a depth of 15 km, which would produce the larger magnitude earthquake and the greater surface rupture.

Wells and Coppersmith, (1994) use several different aspects of fault geometry to calculate the moment magnitude (M_w) of an earthquake. These include surface rupture length, rupture area, and maximum displacement. Each fault is calculated for a maximum credible seismic event or Maximum Credible Earthquake (MCE) for that fault. The MCE for the dam will then be taken as the earthquake from the fault that could potentially cause the most damage at the dam. This takes into account the MCE for the faults and the peak accelerations (gravity) they could create at the site.

Moment Magnitude (Wells and Coppersmith, 1994)

Surface rupture length (SRL) = km

$M_w = a + b * \log(SRL)$ for a normal slip fault a = 4.86 & b = 1.32

$M_w = 4.86 + 1.32 * \log(SRL)$

Rupture area (RA) = km^2

With the average width of the zone being ~20 km (Machette et al, 1991)

RA= SRL * 20 km

$M_w = a + b * \log(RA)$ for a normal slip fault a = 3.93 & b = 1.02

$M_w = 3.93 + 1.02 * \log(RA)$

Max displacement (MD) = meters

$M_w = a + b* \log(MD)$ for a normal slip fault a = 6.61 & b = 0.71

$M_w = 6.61+0.71 * \log(MD)$

The maximum displacement of the faults for this report was not known.

Table 1 below identifies Quaternary faults located within approximately a 72 km radius of the dam site.

TABLE 1 MAXIMUM CREDIBLE EARTHQUAKE FOR FAULTS

Fault	SLR Km	Area km^2	MD (m) m	SLR Mw Mw	Area Mw
Price River	51	1020	na	7.1	7.0
Duchesne	45	900	na	7.0	6.9
Pleasant Valley	31	620	na	6.8	6.8
Joes Valley E	57	1140	na	7.2	7.0

Based on fault geometry, a maximum credible earthquake having a magnitude of 7.1 for the Price River area faults was determined to be appropriate for this site.

4. Ground Motion Attenuation Relationships

In calculating ground motion attenuation relationships (acceleration), we have used three different equation sources for comparison. Abrahamson & Silva with Becker, normal fault component (1997), SEA99 (1999), and Campbell (1997). Tables showing these calculations are included in the appendix with a summary of the results in the following table.

The accelerations were calculated using the MCE based on the moment magnitudes (M_w) calculated in table above.

TABLE 2 BEDROCK GROUND MOTION - ACCELERATION

Faults	Mw	R (km)	A & S	SEA 99	Campbell	Avg
Price River	**7.1**	**26**	0.180	0.162	**0.221**	**0.188**
Duchesne	7	55	0.071	0.059	0.076	0.069
Pleasant Valley	6.8	64	0.055	0.044	0.052	0.050
Joes Valley E	7.2	72	0.060	0.047	0.060	0.056

The PGA values from Frankel's 5,000 year background map, prepared for Dam Safety, show the site to have a potential PGA value of about 0.212g. This value correlates closely with the 0.221g value calculated using Campbell's equation for a 7.1 magnitude event on the Price River area faults. It should be noted that this fault zone is of questionable Quaternary age. The average PGA value calculated for this fault zone was 0.188g. Based upon this evaluation, we recommend the 5,000 year background PGA value of 0.212g be used for design, deformation and stability analysis, as related to naturally occurring earthquakes. The MIS PGA values should also be used where appropriate and are likely the controlling seismic event.

D. LANDSLIDE HAZARDS

Evidence of slope instability exists over a significant area of the right abutment. As shown on Figures 4 thru 4D, this area extends both upstream and downstream from the axis of the dam. Photos of the slides are shown in Figure 4B. Movement at this location was reported to have occurred after the dam was constructed. An access road which cuts into the slope along the right (west) abutment appears to be responsible for some of the movement in this area. In the past, slides have occurred along this roadway.

Landslides on the right abutment and west rim of the reservoir did not show signs of recent movement during our site reconnaissance in the summer of 2004 and 2005; however landslide scarps appear to be significantly larger than the earlier descriptions in the 1960's reports. Sunnyside Mine performed subsidence monitoring intermittently between 1969 and

1988. The 1988 Seismic Monitoring Report states that a slide area occurred on the east side of the dam structure between 1982 and 1983. The report also states that slumping occurred along the west side during the 1982 to 1983 time period. Personal communications with employees of the City of East Carbon (Dale Andrews, Mayor / Micky Dixon, Water Department) indicate that some movements may have taken place during the wet years around 1984. They indicated that since the first few years after the reservoir filled movement along the west rim has been related to material from above sliding down onto the road. There has not been any reported movement of the road itself moving toward the reservoir. Slides have also been documented on the left abutment. Overburden was removed from the hillside above the spillway in the 1990's (personal communication with Dale Andrews) to prevent rock fall or slide debris from damaging the Morning Glory spillway. Based on field investigations during 2005, large-scale landslides on the left abutment (east) do not appear to show signs of recent movement. The most significant slide on the east side is a wet area with a small slump located along the east side of the outlet conduit downstream of the dam.

Inclinometers were installed on the crest of the dam near the left and right abutments and on the hillside immediately west of the right abutment in 1998 at locations shown in Figure 4. Readings taken through July 2005 do not show significant movement since installation. Copies of the inclinometer graphs are presented in the appendix. In addition to the inclinometers, survey points have also been placed at various locations within the potential slide areas. Survey data gathered in 1999, July 2004, and July 2005 does not show significant movement.

In order to further evaluate the west rim landslide, an additional inclinometer was installed in the northwestern portion of the landslide in February of 2005 at the location shown in Figure 4. This inclinometer was installed along the road cut near the maximum section of this northwesterly landslide in an area that appears to have had some sloughing of the slope. Due to the abnormally wet winter and spring this year (2005), naturally flowing seeps and springs have been more active. An area located between 15 to 77 feet south of Inclinometer #4 as shown in Figure 4A identifies a very wet slope with several flowing springs. A close up view of this area is shown on the photos in Figures 4C and 4D. While it has not been documented with instruments, the alluvium on the steep slope in this area appears to have some eastward movement. It should be noted that these springs are about in line with another spring noted in 2004 further up slope.

During field reconnaissance in June 2005 this upper spring only flowed about 20 feet before the water seeped back into some cracks in the ground. This may be the same water that resurfaces down slope just above the road. Inclinometer #4 located just north of this wet area shows a very slight movement toward the northeast of about 0.04 inch. As shown on the

inclinometer survey profile in the appendix, the total overall movement has been very small but gradually increasing during the five months of monitoring between 2/16/05 and the most recent reading on 7/13/05. It should be noted that reading on 7/13/05 showed some back to vertical movement along the north-south axis. Although this magnitude of movement is below the instrument accuracy of ±0.3 inches per 100 feet of inclinometer casing, it is our opinion that further consideration is warranted due to the apparent gradual increase in movement which is occurring.

The depth of movement begins at the reading at 62 feet below the top of the inclinometer casing, which is equal to a depth of about 59 feet below ground surface. The boring log for Test Hole 05-1 (Inclinometer #4) shows the material at about 59 feet to consist of red and green mudstone with a soft clay layer near 59 feet. This clay layer may represent a failure surface.

III. HYDROLOGIC ANALYSIS

The 1979 Dam Safety Study performed by RB&G Engineering, Inc. included runoff and flood analyses for the Grassy Trail drainage basin and reservoir. At that time, the Probable Maximum Flood (PMF) inflow volume was in the order of 5,500 acre-feet, with a peak inflow of approximately 26,000 cfs. The analysis assumed a runoff curve number of 85 to represent saturated conditions. The length of the longest watercourse was determined to be about 6.55 miles, with an elevation drop of about 2375 feet. The hydraulic characteristics of the morning glory drop inlet spillway were analyzed to develop a spillway rating curve, which is reproduced in the appendix of this report. It was noted that the existing spillway was only capable of passing about 7 percent of the PMF event and that the PMF flows would overtop the embankment by about 5.7 feet.

The Phase I Inspection Report dated November 1979 also included a hydrologic analysis of the Grassy Trail watershed and reservoir. Based on an analysis of the watershed soil groups, it was concluded that curve numbers of 62 and 79 were appropriate for Antecedent Moisture Conditions (AMC) II and III, respectively. In the Phase I Report, it was noted that the PMF would result in peak flows in the order of 25,300 cfs, and that the reservoir/spillway system was only capable of passing about 8% of this event without overtopping the dam.

The State of Utah Department of Water Rights established new requirements for Hydrologic Design (R655-11-4) and Inflow Design Hydrograph Determination (R-655-11-4A) in 2003. The new requirements require that the following flood events be calculated and routed through the reservoir to determine the critical event for hydrologic and hydraulic design of dams:

- Spillway Evaluation Flood (SEF) for 72-hour general storm based on the NOAA Hydrometeorological Report No. 49 (HMR-49) and "2002 Update for Probable Maximum Precipitation, Utah 72 Hour Estimates to 5,000 sq. mi." (Jensen 2003).
- Spillway Evaluation Flood (SEF) for 6-hour local storm based on HMR-49 and "Probable Maximum Precipitation Estimates for Short Duration, Small Area Storms in Utah" (Jensen 1995).
- Flood generated by 100-year, 6-hour local storm on saturated watershed.
- Flood generated by 100-year, 24-hour general storm on saturated watershed.

According to the state rules, the critical 100-year flood should be compared to the critical SEF. If the 100-year event, including required freeboard, is more critical than the SEF, then the 100-year event should be used as the Inflow Design Flood (IDF).

Each of the required precipitation events was routed through the reservoir in accordance with state rules and the referenced documents. The 18.6 square mile watershed was assumed to be saturated (AMC III) and a curve number of 79 was used to represent this condition. A lag time of 1.6 hours, which in our opinion represents a conservative representation of the watershed slopes and runoff conditions, was used to develop the flood hydrographs. Results of the routing analyses through the existing reservoir are summarized on the table below.

Event	General SEF	Local SEF	General 100-year	Local 100-year
Duration	72 hours	6 hours	24 hours	6 hours
Rainfall Depth	10.6 in.	2.99 in.	3.18 in.	2.27 in.
Distribution	Jensen 2003	Jensen 1995	SCS 24-hr Type II	SCS – 6 hr
Peak Inflow	5556 cfs	5325 cfs	3368 cfs	1912 cfs
Max. Stage Elev.	7601.0 ft	7601.4 ft	7600.9 ft	7599.9 ft

It will be noted from the table that the General and Local SEF events result in similar peak flows through the reservoir. Based on this information, it is concluded that the SEF inflow hydrograph for this project will have a peak flow of about 5560 cfs. At present, it is estimated that the existing spillway can pass about 25% of the critical SEF. It is anticipated that the SEF event will overtop the dam by about 1.0 to 1.5 feet.

In addition to the analyses described above, floods calculated for the general and local 100-year precipitation events on an unsaturated watershed (AMC II condition) were routed through the reservoir model. The local 6-hour event was found to create a peak flow of 403 cfs (about 7% of the critical SEF flow) and a maximum stage elevation of 7594.6 ft. The general 24-hour event developed peak flows of 872 cfs (about 16% of the critical SEF) with a maximum stage elevation of 7596.4 ft.

For the dam to meet state standards, the reservoir/spillway system should pass 100% of the SEF event without overtopping. The system should also be capable of passing the critical 100-year storm flow of about 3370 cfs (about 61% of the critical SEF) while maintaining minimum embankment freeboard of 3 feet.

In order to meet the state dam criteria, we propose that an emergency spillway be constructed on the right dam abutment. It is anticipated that the spillway will be at least 150 feet wide. It is recommended that the spillway crest be located at about elevation 7596.5 feet so that events as large as the 100-year AMC II events (16% of the critical SEF) will be stored in the reservoir and routed through the existing spillway without requiring use of the emergency spillway. If the spillway is constructed in this manner, the dam crest should be raised by approximately 2 feet in order to contain the critical SEF event and allow minimum freeboard for the critical 100-year AMC III event. Alternatively, the emergency spillway crest could be located several feet lower

with the understanding that it will be used more frequently. In this case, it would not be necessary to raise the dam crest. A third option would be to construct a fuse plug in the emergency spillway in such a manner that the 100-year AMC II events would be stored by the fuse plug, but that more severe events would wash out the plug and flow through a deeper spillway.

IV. SUBSURFACE INVESTIGATIONS

Subsurface investigations of the dam embankment and foundation were performed during the 1979 RB&G Dam Safety Study. Five borings were drilled to depths varying from 83 to 143 feet on the crest of the dam and in the abutments at that time. The locations of the borings are shown on the profile view along the axis in Figure 5 of the 1979 report. A copy of the Figure 5 along with the boring logs is included in the 1979 Dam Safety Study section of the Appendix.

In 1998, 7 additional borings were drilled by RB&G for Creamer and Noble Engineers to install instrumentation. The location of these borings is shown on Figure 4, and the boring logs are included in the 1998 Phase II Instrumentation section of the appendix. It will be noted that one inclinometer was installed on the left abutment and two inclinometers on the right abutment. Piezometers were installed in the embankment and foundation in two borings on the crest and in the foundation in three borings along the downstream toe.

In 2005, additional piezometers were installed in the embankment and foundation in two borings drilled at the downstream crest to evaluate irregular water level readings near the left and right abutments and one boring was drilled midway down the downstream slope to evaluate the characteristics of the outer zone of embankment material. Piezometers were also installed in this boring. A boring was drilled upstream of the right abutment near the roadway on the west rim of the reservoir in a slide area to evaluate the subsurface materials. An inclinometer was installed in this boring. The location of all borings with instrumentation are shown in Figure 4, and a copy of the 2005 boring logs are included in the 2005 Phase II Dam Safety Study section of the appendix.

In order to obtain a reasonable indication of the characteristics of the embankment and foundation material, sampling was performed at three to five-foot intervals in unconsolidated material and continuous coring was performed in bedrock. Disturbed samples were obtained by driving a 2-inch split spoon sampling tube through a distance of 18 inches using a 140-pound weight dropped from a distance of 30 inches. The number of blows to drive the sampling spoon through each 6 inches of penetration is shown on the boring logs. The sum of the last two blow counts, which represents the number of blows to drive the sampling spoon through 12 inches, is defined as the standard penetration value. The standard penetration value provides a good indication of the in-place density of sandy material; however, it only provides an indication of the relative stiffness of the cohesive material, since the penetration resistance of materials of this type is a function of the moisture content. Considerable care must be exercised in interpreting the standard penetration value in gravelly-type soils, particularly where the size of the granular particle exceeds the inside diameter of the sampling spoon. If the spoon can be driven through the full 18 inches with a reasonable core recovery, the standard penetration value provides a

good indication of the in-place density of gravelly-type material. Where the sampling tube could not be driven through the full 18 inches, the number of blows to drive the spoon through a given depth of penetration is shown on the boring logs.

Undisturbed samples of the cohesive material were obtained by pushing a thin walled shelby tube into the profile using the hydraulic pressure of the drill rig. The location at which undisturbed samples were obtained is also shown on the boring logs.

Constant head field permeability tests were performed at about 5 foot intervals in the 1979 test borings using procedures outline in the Bureau of Reclamation's Earth Manual. The results of the permeability tests are shown on the boring logs in feet per year.

Each sample obtained in the field was classified in the laboratory according to the Modified Unified Soil Classification System. The symbol designating the soil type according to this system is presented on the logs. A description of the Modified Unified Soil Classification System is included in the appendix, and the meaning of the various symbols shown on the subsurface logs can be obtained from this figure.

Laboratory tests performed to define the characteristics of the embankment and foundation materials included mechanical analysis, Atterberg Limits, in-place dry unit weight and moisture content, soil moisture-density relationships, triaxial shear and direct shear tests. The results of all tests are included in the 1979, 1998, and 2005 sections of the Appendix.

V. SUBSURFACE SOIL CONDITIONS

A typical section of the embankment taken from the 1951-52 construction drawings is shown as Figure 5 included in the 1979 section of the appendix. It will be noted that the embankment is divided into 3 zones. The Construction Specifications state that:

> "The materials entering the embankment shall be segregated by loads so that the finished compacted fill is relatively impervious in the central selected clay, sand, and gravel core portion, relatively pervious in the portion downstream from the selected clay, sand and gravel core, and of an intermediate gradation in the portion upstream from the selected clay, sand and gravel core, the three types of material grading or blending one into another."

The characteristics of each of these zones are discussed below.

A. ZONE I CORE - DAM EMBANKMENT

It will be observed from the test hole logs that the Zone I core embankment material consists predominately of sandy lean clay with gravel, classifying as CL type soil.

1. Standard Penetration (SPT) Testing

Standard Penetration Test (SPT) values indicate that the cohesive material is in a stiff to hard condition. Tabulated below is a summary of the range and average $N_{1(60)}$ values corrected for hammer energy, rod length, and overburden stresses.

Hole No.	$N_{1(60)}$ Range	$N_{1(60)}$ Average
79-1	11-41	32
79-3	14-41	25
79-4	12-26	18
79-5	15-42	27
98-1	18-29	24
98-3	12-35	22
98-7	14-24	19
05-2	14-18	16
05-3	13-34	26
Average Embankment $N_{1(60)}$		23

2. Mechanical Analyses

Mechanical analyses were completed on 5 samples obtained from Boring 05-3 located at the downstream crest. The results of these tests are shown graphically in the Laboratory Testing section of the Appendix and summarized on Table 1 in the Appendix. It will be noted that the samples obtained from a depth of 30, 40, and 85 feet classify as lean clay

(CL-1) with 1 to 22% gravel, 19 to 39% sand, and 59 to 63% clay. The sample obtained at a depth of 60 feet classifies as silty sand (SM) with 27% gravel, 46% sand and 27% non-plastic silt. The sample at 70 feet classifies as clayey sand (SC) with 22% gravel, 32% sand and 46% clay.

The D_{85} of the samples tested ranged from about 0.2 to 35 mm, with an average of about 4 mm. The D_{15} ranged from 0.001 to 0.013 mm, with 4 of the 5 samples tested having a D_{15} of about 0.011 mm.

3. *Atterberg Limits*

Atterberg Limit tests were performed on the minus No. 40 fraction of the samples obtained from Borings 3 and 4 during the 1979 investigation, and the results are summarized in Table 1 of the 1979 section of the Appendix. It will be noted that the samples classified predominantly as lean clay, with the liquid limit ranging from 20 to 30 and the plasticity index varying from 3 to 16.

Atterberg Limits were also performed on the samples from Boring 05-3 during the 2005 investigation, and the results are summarized in Table 1 of the 2005 section of the Appendix. The liquid limit of the samples tested ranged from 26 to 29, with the plasticity index varying from 12 to 15.

4. *In-place Dry Unit Weights and Moisture Contents*

In-place dry unit weights were obtained on 11 samples of the embankment from 1979 Borings 3 and 4, and four samples from the 2005 Boring 05-3. The results are included in the Summary of Test Data tables for 1979 and 2005 and it will be noted that the in-place unit weight varied from 103.9 to 132.9 pcf, with an average of 120.1 pcf. The moisture content varied from 5.6 to 17.6%, with an average of 12.8%.

5. *Soil Moisture Density Relationships (Proctors)*

Two proctors were performed in accordance with ASTM D 698 on combined samples from the 1979 borings. The results are shown graphically in the 1979 appendix, and it will be observed that a maximum density of 116.6 and 115.9 pcf was obtained with an optimum moisture content of 14.3 and 14.5%.

6. *Direct Shear Tests*

Consolidated drained direct shear tests were performed on undisturbed samples of the lean clay at depths of 30 to 50 feet, 50 to 70 feet, and 70 to 90 feet in Boring 3 during the 1979 study. It will be noted from the 1979 appendix that the friction angle varied from 36 to 39.5 degrees, with the cohesion ranging from 2 to 25 psi. The 1979 report stated that

granular fragments in the clay may have resulted in an over-estimate of the shearing strength determined by the direct shear tests.

7. *Triaxial Shear Tests*

Consolidated undrained triaxial shear tests with pore pressure measurements were performed on 3 undisturbed samples of the lean clay obtained from 0 to 20 feet, 20 to 50 feet and 70 to 90 feet. The results are presented graphically in terms of effective stress in the 1979 appendix, and it will be observed that the friction angle ranged from 28.2 to 36.5 degrees, with the cohesion ranging from 5 to 20 psi.

B. ZONE II OUTER SHELL – DAM EMBANKMENT

The Zone II outer shell material was evaluated in 2005 by drilling Boring 05-4 midway down the downstream slope at the approximate location shown in Figure 4. The 1951/1952 construction drawings show this zone to consist of selected sand and gravel from borrow or cutoff trench excavation. It will be observed from the boring log in the 2005 section of the appendix that the embankment consists of interbedded lean clay, clayey sand and clayey gravel.

1. *Standard Penetration (SPT) Testing*

Standard Penetration Test (SPT) values indicate that the cohesive material is in a stiff to hard condition, and that the granular material is in a dense state. The $N_{1(60)}$ values ranged from 21 to 44, with an average of 33, corrected for hammer energy, rod length, and overburden stresses.

2. *Mechanical Analyses and Atterberg Limits*

Mechanical analyses were completed on 5 samples obtained from Boring 05-4. The results of these tests are shown graphically on Table 1 in the 2005 appendix. It will be noted that the samples obtained from a depth of 12 feet classifies as lean clay (CL-1) with 1% gravel, 25% sand, and 56% clay. The sample obtained at a depth of 25 feet classifies as clayey gravel with sand to silty gravel with sand (GC-GM) with 39% gravel, 33% sand and 28% silt and clay and silt with a liquid limit of 22 and a plasticity index of 6. The samples at 36 and 39 feet classify as clayey sand (SC) with 15 to 18% gravel, 33 to 42% sand, and 43 to 49% clay having a liquid limit of 26 to 27 and a plasticity index of 11 to 14. The sample obtained at a depth of 45 feet classifies as clayey gravel with sand (GC) having 36% gravel, 31% sand and 33% clay, with a liquid limit of 27 and a plasticity index of 15. The sample obtained at a depth of 51 feet classifies as silty gravel (GP-GM) with sand having 52% gravel, 36% sand and 12% non-plastic silt.

The D_{85} of the samples tested ranged from 4.5 to 30 mm, with an average of about 12 mm. The D_{15} ranged from 0.0015 to 0.11 mm, with 4 of the 5 samples tested having a D_{15} less than 0.017 mm.

3. In-place Dry Unit Weights and Moisture Contents

In-place dry unit weights were obtained on 1 sample of the embankment from the 2005 Boring 05-4. The results are included in the Summary of Test Data table for 2005 and it will be noted that the in-place unit weight for the sample at 36 feet was 94.8 pcf. The moisture content for the six samples between 12 and 51 feet varied from 10.9 to 15.8%, with an average of 13.5%.

4. Triaxial Shear Tests

A consolidated undrained triaxial shear test with pore pressure measurements was performed on an undisturbed sample of the clayey sand obtained at a depth of 39 feet in Boring 05-4. The results are presented graphically in terms of effective and total stress in the 2005 appendix, and it will be observed that a friction angle of 33.2° and 2 psi cohesion was obtained for the effective stress, and 31.7° and 2 psi cohesion was obtained for the total stress.

C. ZONE III – ROCK RIPRAP AND THIN OUTER SHELL ZONE

The embankment is enveloped with sandstone rockfill both upstream and downstream as shown in Figure 5 of the 1979 appendix. The rock appears to be in fair condition. No testing was performed on the rockfill.

D. DAM FOUNDATION

The 1979, 1998, and 2005 test borings all extended through the embankment and into the foundation materials downstream of the cutoff trench. It will be noted from the boring logs that the foundation soil consists of interbedded gravelly clay, sandy clay, clayey gravel and silty gravel with sand. Bedrock consists of interbedded mudstone, sandstone and siltstone. The approximate bedrock surface is identified on the profile view on Figure 5 of the 1979 appendix.

1. Standard Penetration (SPT) Testing

Standard Penetration Test (SPT) values indicate that the cohesive material ranges from soft to hard and that the granular soils are typically in a medium dense condition. Tabulated below is a summary of the range and average $N_{1(60)}$ values corrected for hammer energy, rod length, and overburden stresses.

Hole No.	$N_{1(60)}$ Range	$N_{1(60)}$ Average
79-1	13-21	17
79-3	11-53	38
79-4	23-48	32
79-5	16-55	35
98-1	29-93	48
98-2	8-53	26
98-3	7-28	19
98-4	7-61	33
98-6	1-30	12
98-7	11-59	22
05-2	23-36	30
05-3	15-46	34
05-4	13-42	29
Average Foundation $N_{1(60)}$		29

2. *Mechanical Analyses and Atterberg Limits*

Mechanical analyses were completed on 7 samples obtained from 1979 Borings 3 and 4, and on 2 samples obtained from 2005 Borings 05-3 and 05-4. The results of these tests are summarized on the tables in the appendix. It will be noted that the granular soils had between 25 and 80% in the gravel size, 13 and 52% sand, and 6 and 23% in the silt and clay size range, classifying as SM and GM-type soils.

The cohesive material encountered in the foundation had a liquid limit ranging from 20 to 30 and a plasticity index varying from 4 to 13, classifying as lean clay.

3. *Direct Shear Tests*

The consolidated drained direct shear tests from 70 to 90 feet in Boring 3 from the 1979 study includes foundation soil, and it will be noted that a friction angle of 38° with a cohesion of about 25 psi was obtained.

4. *Triaxial Shear Tests*

The consolidated undrained triaxial shear tests with pore pressure measurements from 70 to 90 feet from the 1979 study includes foundation soil. Thê results are presented graphically in terms of effective stress in the 1979 appendix, and it will be observed that a friction angle of 36.5°, with a cohesion of 5 to 20 psi was obtained.

VI. EMBANKMENT EVALUATION

A. SEEPAGE

Several areas of seepage have been observed on both the right and left abutments of the dam. On the left abutment, two prominent seepage exit points have been identified adjacent to or near the spillway outlet tunnel. A seep adjacent to the west side of the tunnel appears to be originating near the top of the tunnel structure. A visual estimate of the flow rate from this seep was made on May 9, 2005 with the water level in the reservoir 3.5 inches above the spillway crest. An estimated 5-10 gallons per minute of clear water was observed flowing from this seep. Heavy vegetation obscured the exact exit point. It may be that seepage is flowing along the rock/concrete interface of the tunnel. A review of the historical documents relating to the dam indicates that no filtering of internal seepage was designed into the dam structure at any point along the spillway tunnel interface. Records do however indicate that all voids behind the concrete tunnel lining were to be filled with grout. If excavation methods such as blasting were used during construction of the tunnel, the potential exists for embankment material to pipe out of the dam; however, internal erosion (piping) of embankment material through the mudstone and siltstone bedrock to this seepage exit point is unlikely due to the distance between the embankment foundation and the tunnel in the bedrock of the left abutment and the discontinuous nature of fractures in the bedrock. Currently, this seep is uncontrolled with no means for measurement.

The second seep observed on the left abutment is located just to the east of the spillway tunnel outlet structure in the area of a small slide or slump. Evidently, a collection pipe was installed to capture and monitor the flow rate from this seep. Currently the majority of seepage is by-passing this pipe. A visual estimate of the flow rate from this seep was made on May 9, 2005 with the water level in the reservoir 3.5 inches above the spillway crest. An estimated 30-40 gallons per minute of clear water was observed flowing from this seep. Several exit points along the mid-point and base of the slump were observed emitting water; additionally, the surface soils around the slump were moist. Piping of embankment material through this seep may be possible but is unlikely. Additional movement of the slump may occur in relation to the seepage exiting at this point. The location of this slump is such that significant movement may produce blockage of the spillway outlet tunnel.

Several other springs were observed in the vicinity of the dam. These springs include a seep located on the right abutment downstream of the dam and immediately adjacent to the upslope side of the main access road. Another major spring is located upstream of the right abutment in the area of one of the major slides on the right side of the reservoir basin.

Inclinometer No. 4 was placed adjacent to the west side of the road in this area to monitor movement of the slide mass. Flow from these springs is not being measured at this time.

The locations of piezometers and observation wells are shown in plan view on Figure 4. Piezometer readings correlated with the reservoir water level are summarized on the tables in Figures 5 and 6. Figure 5 summarizes all readings from March 1998 through July 2005, while Figure 6 includes readings from January 2003 through July 2005. It will be observed from Figure 5 that the water level in Observation Well 1 near the left abutment has been erratic; however, it appears that the fluctuations correspond with fluctuations of the reservoir level. Piezometers 8 and 9 were installed about 50 feet further toward the left abutment to better define the water surface profile in this area. It will be noted from Figure 6 that the water level in embankment Piezometer P-8 and foundation Piezometer P-9 is higher than that recorded in Observation Well 1. It appears that the water level in the embankment and foundation in this area may be influenced by seepage through the abutment.

Piezometers 10 and 11 were installed in the embankment and Piezometer 12 was installed in the foundation near the right abutment in 2005. It will be noted from Figure 6 that the water level in Piezometers 10 and 11 has been relatively high, at about elevation 7572 and 7582 feet, respectively, with the reservoir level at about elevation 7593 feet. It was suspected that P-12 was measuring drill water from January through the middle of May 2005, at which time the piezometers were bailed, and it will be noted that the water level has stabilized at about elevation 7544 feet.

It will be noted from Figure 4 that Piezometers 13 and 14 are located midway down the downstream slope near the maximum section. The water level in P-13 (embankment) has been between elevation 7522 and 7524 feet since installation, while the water level in P-14 (foundation) has been at about elevation 7505 feet since installation.

B. STATIC SLOPE STABILITY ANALYSIS

Slope stability analyses were performed for the earth dam using the computer program STABL for Windows. Spencer's Method, which satisfies both force and moment equilibrium, was used in the analyses. The soil parameters for the embankment fill were selected based on consolidated undrained triaxial shear tests with pore pressure measurements. The triaxial shear tests were performed on samples obtained from vertical borings both at the crest of the dam and near the midpoint of the downstream slope.

It will be noted that the shear tests showed significant variation in strength characteristics. Sensitivity analyses performed using drained and undrained strength parameters estimated

from the tests have suggested that the undrained condition is not markedly inferior to the drained condition for purposes of slope stability. A summary of the soil parameters used in the analysis is shown on the table below. It is our opinion that these parameters represent a conservative estimate of the actual conditions present in the earthfill embankment.

Layer No.	Material	Moist Weight (pcf)	Saturated Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

The strength parameters shown for Layer 3 on the table above are identical to the parameters assumed for the stability analysis described in the 1979 RB&G Dam Safety Study. To evaluate the sensitivity of the slope stability to these parameters, additional analyses were completed with the friction angle varying from 34 to 28 degrees and the cohesion value ranging from 0 to 200 psf for Layer 3. It was determined from the sensitivity analysis of static, steady-state stability that a friction angle of 28 degrees and a cohesion value of about 150 psf for Layer 3 resulted in essentially the same factors of safety as a friction angle of 34 degrees with zero cohesion. Due to the predominantly clayey composition of the upper foundation materials encountered in most of the borings, it is our opinion that Layer 3 is better modeled with a friction angle of 28 degrees and a cohesion value of about 200 psf or greater. As suggested by the sensitivity analysis described above, adequate factors of safety against slope failure exist for these parameters.

Piezometer and observation well readings for the dam indicate that the phreatic surface may vary significantly along the length of the dam. Some readings suggest that the phreatic surface is drawn down near the foundation elevation (approx. elev. 7510 ft.) directly beneath the downstream crest. Other readings indicate the presence of water as high as about elevation 7580 feet beneath the downstream crest at some locations along the length of the dam. In the interest of conservatism, the higher phreatic surface was assumed for the stability analyses described in this report.

Analyses were performed for the static steady-state seepage case for both the upstream and downstream slopes. The sudden drawdown condition was also studied for the upstream slope, with the phreatic surface modeled near the face of the upstream slope. In accordance with guidelines published by the Bureau of Reclamation, post-earthquake stability conditions were conservatively modeled using pore pressure parameters of 0.1 and 0.2 in the clayey embankment fill and clay foundation layers, respectively (USBR, 1989).

Pseudostatic stability analyses were performed for Grassy Trail Dam to evaluate slope stability under seismic conditions. A pseudostatic coefficient was applied in the analysis to simulate seismic forces within the embankment. Hynes-Griffin and Franklin (1984) concluded that earth dams having a factor of safety greater than 1.0 under a pseudostatic force of 0.5 times the peak acceleration would not undergo "dangerously large" deformations under the peak seismic acceleration. As described in Section II.C.4. of this report, the peak ground acceleration for the Maximum Considered Earthquake (MCE) at this site is about 0.212g, corresponding to a magnitude 7.1 event occurring on the Price River fault approximately 26 km (16.2 miles) from the reservoir. State Dam Safety rules allow the use of pseudostatic analysis for Grassy Trail Dam since the design peak ground acceleration for the site is less than 0.35g and the dam consists of a clay embankment on a primarily clay and bedrock foundation. For a pseudostatic force of 0.11g (0.5 times the Maximum Considered Earthqake PGA of 0.212g), the factor of safety for Grassy Trail Dam was determined to be acceptable for both undrained and drained soil conditions.

A brief summary of the slope stability analysis results is shown below, and copies of the output graphics from the slope stability program are included in the appendix.

Slope	Condition	Factor of Safety	Required F.S.
Downstream Slope	Static, Steady State	1.60	1.5
	Seismic (non-mining MCE) a = 0.11g	1.21	1.0
	Post-Earthquake	1.39	1.2
Upstream Slope	Static, Steady State	2.33	1.5
	Static, Sudden Drawdown	1.35	1.2
	Seismic (non-mining MCE) a = 0.11g	1.47	1.0
	Post-Earthquake	1.83	1.2

It should be noted that mining operations in the vicinity of the dam often create seismic type ground motions. Mining-induced seismic events have been documented in relatively close proximity to Grassy Trail Reservoir. Such events often occur at lesser distances than anticipated natural seismic events; however, the magnitudes of mining-induced events are typically much smaller than natural events originating from active faults. A detailed analysis of Mining-Induced Seismicity and its possible effects on Grassy Trail Dam and Reservoir was recently completed and is documented in a separate report by RB&G Engineering, Inc. (July 2005).

C. LIQUEFACTION CONSIDERATIONS

Each of the test hole logs was reviewed individually for possible liquefaction of the subsurface materials. The boring logs do not reveal any pockets of loose sand, which are below the water table, in the dam and dike embankments and foundation. Based on a review

of the boring logs, problems associated with liquefaction during a seismic event are unlikely at this site.

VII. OUTLET & SPILLWAY OBSERVATIONS

The reservoir was spilling over the morning glory spillway during the site visits in the Spring and Summer of 2005, preventing inspection of the tunnel. The following description of the outlet works and spillway is taken from the 1952 construction drawings.

The outlet intake structure is located on the left side of the reservoir basin approximately 100 feet upstream of the dam toe and consists of a concrete intake tower that feeds a 16 inch outlet pipe tunneled into rock going around the left abutment. The outlet pipe is cast iron class 150 pipe from the intake tower to point where the tunnel for the outlet pipe intersects the tunnel for the spillway discharge. An emergency 16" gate valve is located at this point and the pipe changes to a 16" steel pipe encased in concrete from this valve to the outlet control vault downstream of the dam toe. The pipe runs inside of the spillway tunnel from the 16" gate valve to a point just inside the exit of the spillway discharge tunnel. From here it is run underground to the outlet control vault. At the outlet control house, a 12" gate valve feeds an emergency release pipe that flows back into the downstream discharge channel. The 16" steel pipe has a reducer section with a 10" gate valve that feeds a 14" cast iron class 150 pipe that runs to the East Carbon / Sunnyside water treatment plant.

The intake structure does not have an upstream control gate; however, a gate is located where the conduit enters the tunnel upstream of the embankment footprint. The current minimum standard for dams is to have an upstream control gate. Because the outlet pipe is encased in concrete and does not pass beneath the dam embankment, failure of the pipe does not pose a threat to the dam. If one is required for this structure, we recommend a hydraulically controlled slide gate be installed at the intake control tower.

The spillway for this reservoir consists of a reinforced concrete morning glory spillway with an eight foot diameter drop inlet section that feeds into a six foot wide by seven foot tall concrete lined tunnel. Both the tunnel and two-thirds of the drop inlet were excavated down into the bedrock of the left abutment. The remaining one-third of the spillway drop inlet has been backfilled to the base of the glory hole. The construction drawings detail that backfill immediately adjacent to the drop inlet was to be "Rock Filled with Sluiced Fines" (Sheet 4 of the drawings in the appendix). The rock strata through which the drop inlet and tunnel are constructed consist of sandstone and shale with varying combinations of the two.

The slide area on the left abutment above the structure was occurring at the contact between the overburden and bedrock. The overburden was removed with the excavation extending to bedrock and does not presently pose a threat to the structure. Since the structure is embedded in the bedrock and is not free-standing, damage to the structure during a seismic event is unlikely.

State regulations require that the outlet must be capable of emptying 90 percent of the maximum normal reservoir storage, neglecting reservoir inflows, in a period of 30 days. This capability was checked by routing the full reservoir capacity through the existing outlet using the outlet rating curve provided in the appendix of the Phase I Inspection Report. The routing analysis showed that the reservoir will empty to the intake structure elevation in about 25 days, evacuating approximately 95% of the existing capacity below the spillway crest elevation. It is therefore concluded that the existing outlet meets the minimum standard for reservoir evacuation capability.

VIII. CORRECTIVE ACTIONS

Based upon the results of this study, it is our opinion that the following actions should be undertaken to upgrade the dam to meet minimum state dam safety standards:

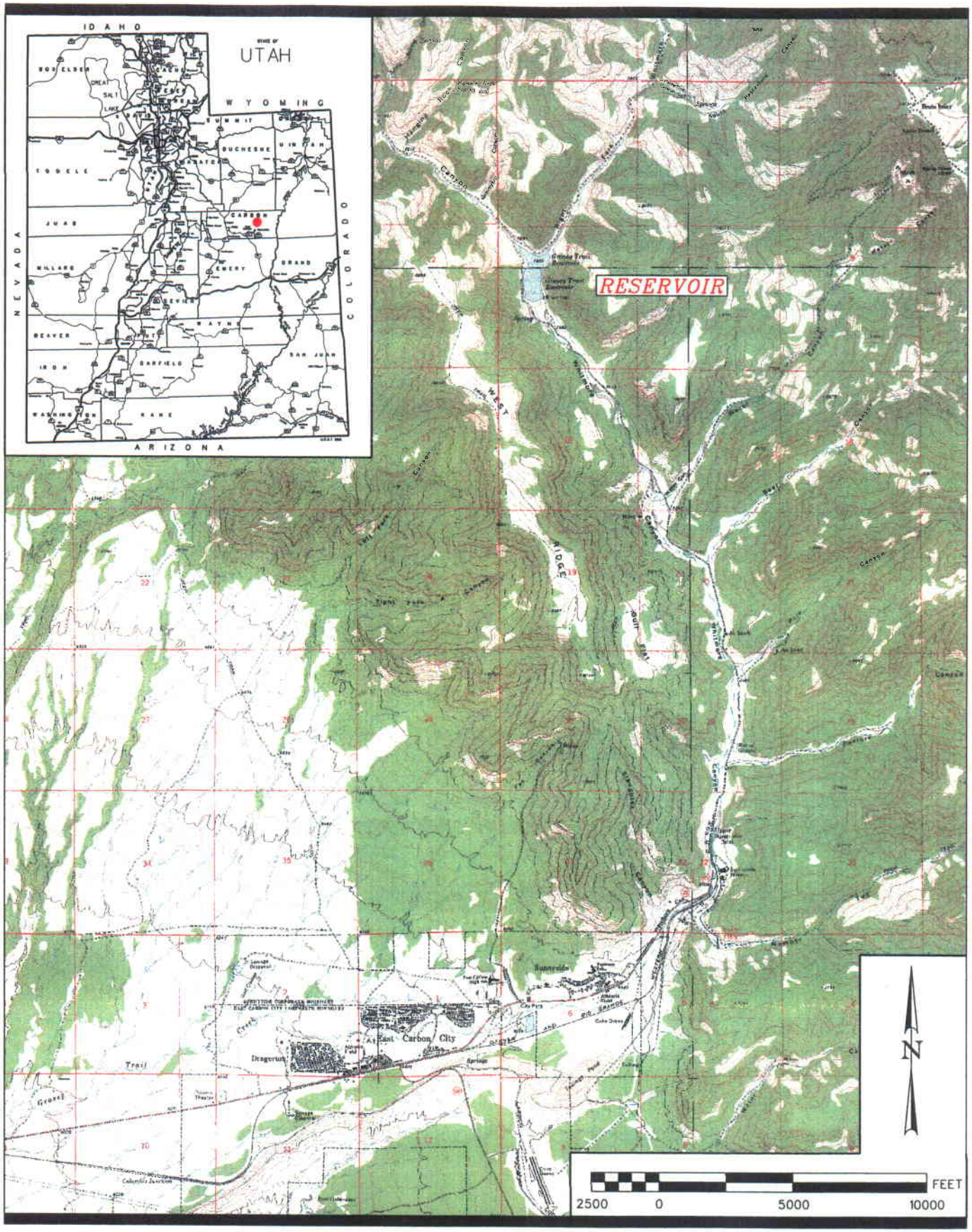
- The structure can only pass about 25% of the spillway evaluation flood (SEF) without overtopping the dam. Options are discussed in Section III of this report. It is recommended that an emergency spillway be constructed around the right abutment and that the dam crest be raised as necessary to pass the critical SEF without dam overtopping and maintain minimum freeboard when routing the critical 100-year flood event.
- We recommend that the seeps on the right and left abutments be controlled and monitored. The seepage exiting at these points should be collected in a pipe or channeled to a measuring device so that routine monitoring can detect changes in flow volume or seepage clarity. Measurements should be taken at the same time piezometer readings are taken on the dam. Additionally, we recommend that the seeps on the left abutment be filtered to prevent movement of embankment fines through these exit points. The slump on the left abutment near the outlet tunnel discharge channel should also be stabilized and drained to prevent future earth movement that may block the outlet channel.
- An upstream guard gate is required to meet current Dam Safety standards. The standards also require that outlet conduits be 24 inches in diameter or greater, unless exempted in writing by the State Engineer. The existing outlet conduit consists of a 16 inch Class 150 ductile iron pipe encased in concrete extending from the intake structure to the spillway tunnel (approx. 305 feet). The outlet conduit enters the spillway tunnel upstream of the embankment in the bedrock of the left abutment. A gate is located where the pipeline enters the tunnel. Downstream of the gate, the outlet conduit is a 16 inch steel pipe encased in concrete. Due to the location of the outlet conduit, it is our opinion that failure of the conduit would not pose a threat to the embankment. It is recommended that the owner request a variance to the upstream guard gate requirement for this structure.
- Since the 16 inch conduit will accommodate evacuating the storage within the 30 day timeframe required by the standards, it is recommended that the owner request an exemption, allowing for the outlet conduit to be smaller than the 24 inch diameter minimum requirement.

IX. OPINION OF PROBABLE COST

Tabulated below is the estimated quantities and opinion of probable cost to complete the corrective actions outlined above in Section VIII.

ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
Spillway Concrete	583	Cu yd	$500.00	$ 291,500.00
Embankment Fill	1200	Cu yd	$10.00	$ 12,000.00
Upstream Guard Gate	1	Lump Sum		$ 10,000.00
Downstream Left Abutment Slide Stabilization, Seepage Collection & Measurement	1	Lump Sum		$ 10,000.00
Engineering Design & Construction @ 15%	1	Lump Sum		$ 48,525.00
Contingencies @ 10%	1	Lump Sum		$ 32,350.00
TOTAL				**$ 404,375.00**

Figures

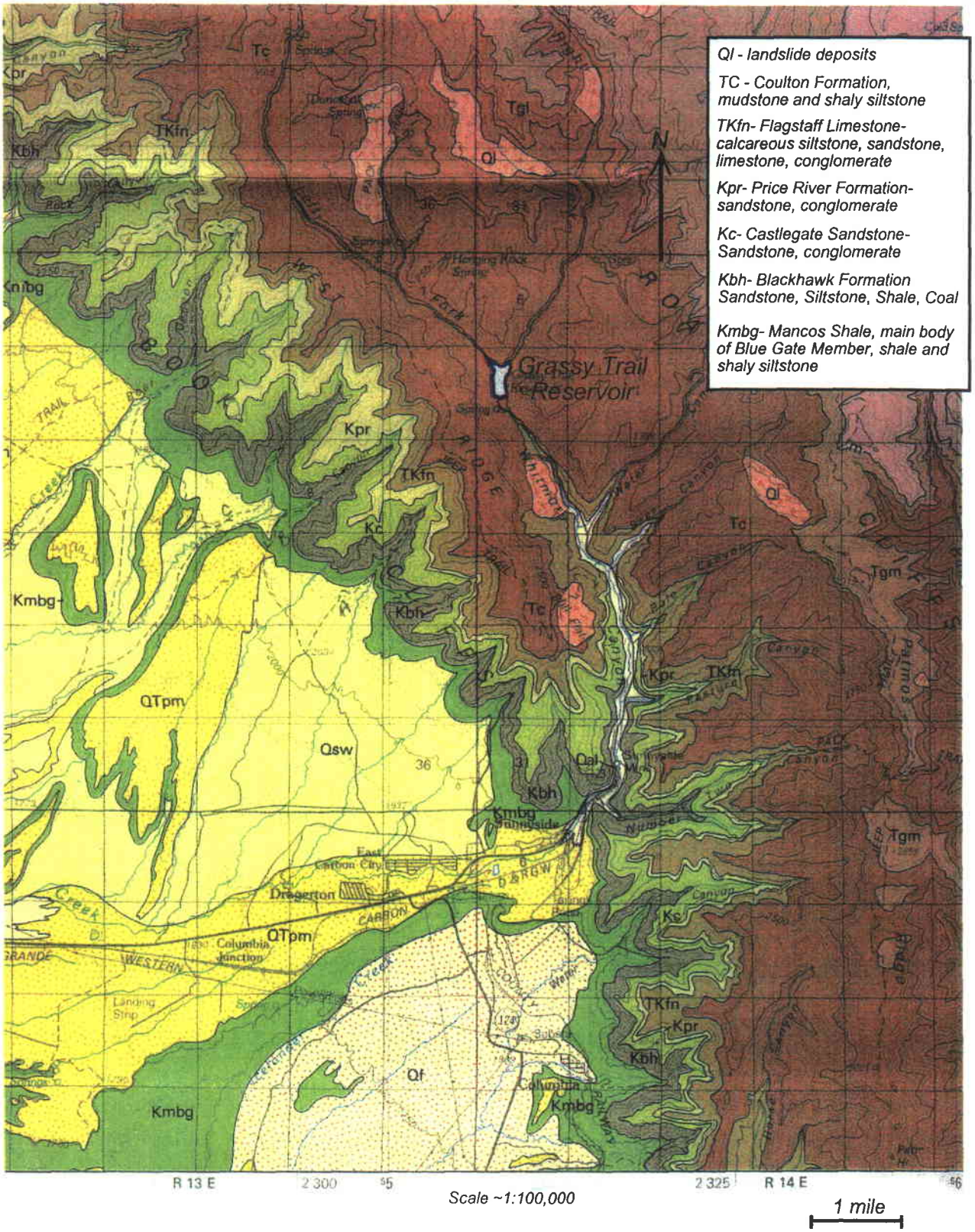


RB&G ENGINEERING INC.
Provo, Utah

Figure 1. VICINITY MAP

Phase II Dam Safety Study

Grassy Trail Dam and Reservoir



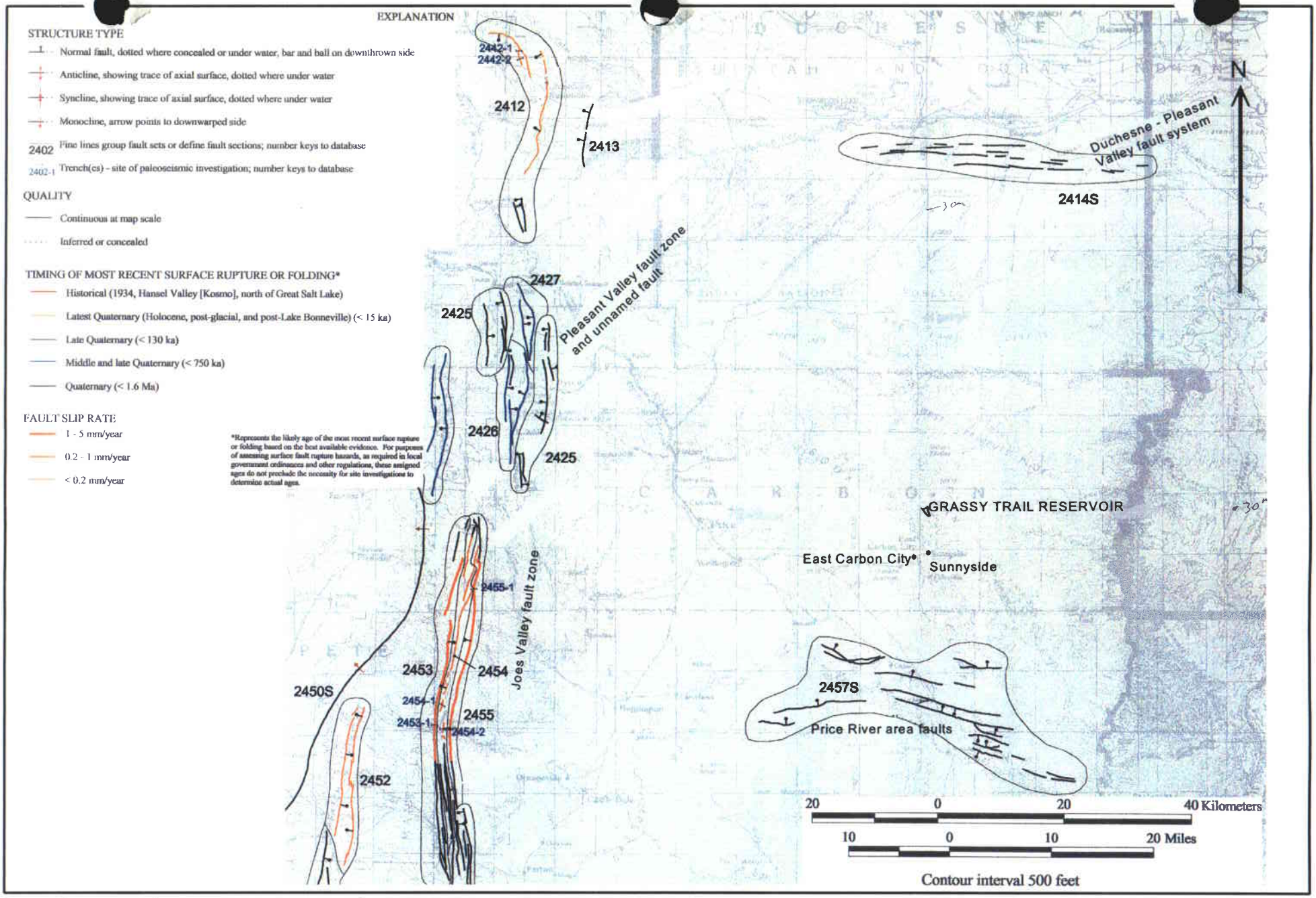
Scale ~1:100,000

1 mile

Geologic Map of the Price 30'x60' Quadrangle, Carbon, Duchesne, Uintah, Utah, and Wasatch Counties, Utah
taken and modified from Weiss and others ,1990

RB&G ENGINEERING INC.
Provo, Utah

Figure 2 Geologic Map
Project *Grassy Trail Dam, Phase II Study*
Location *Near East Carbon, Sunnyside, Carbon County, Utah*



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Provo, Utah

Figure 3 Quaternary Faults Surrounding Grassy Trail Dam
Project *Grassy Trail Dam*
Location *Near East Carbon, Sunnyside, Carbon County, Utah*

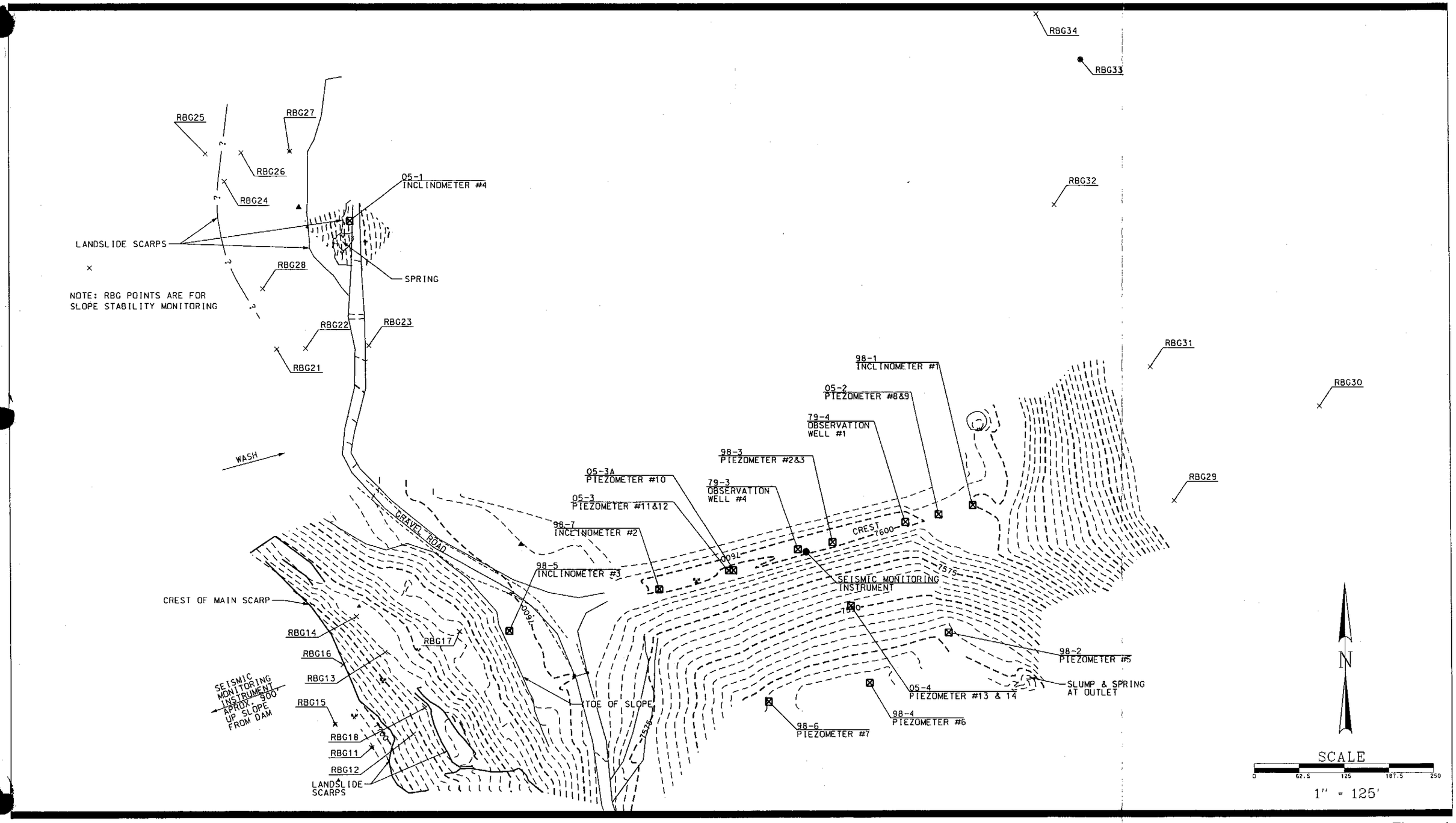

Figure 4

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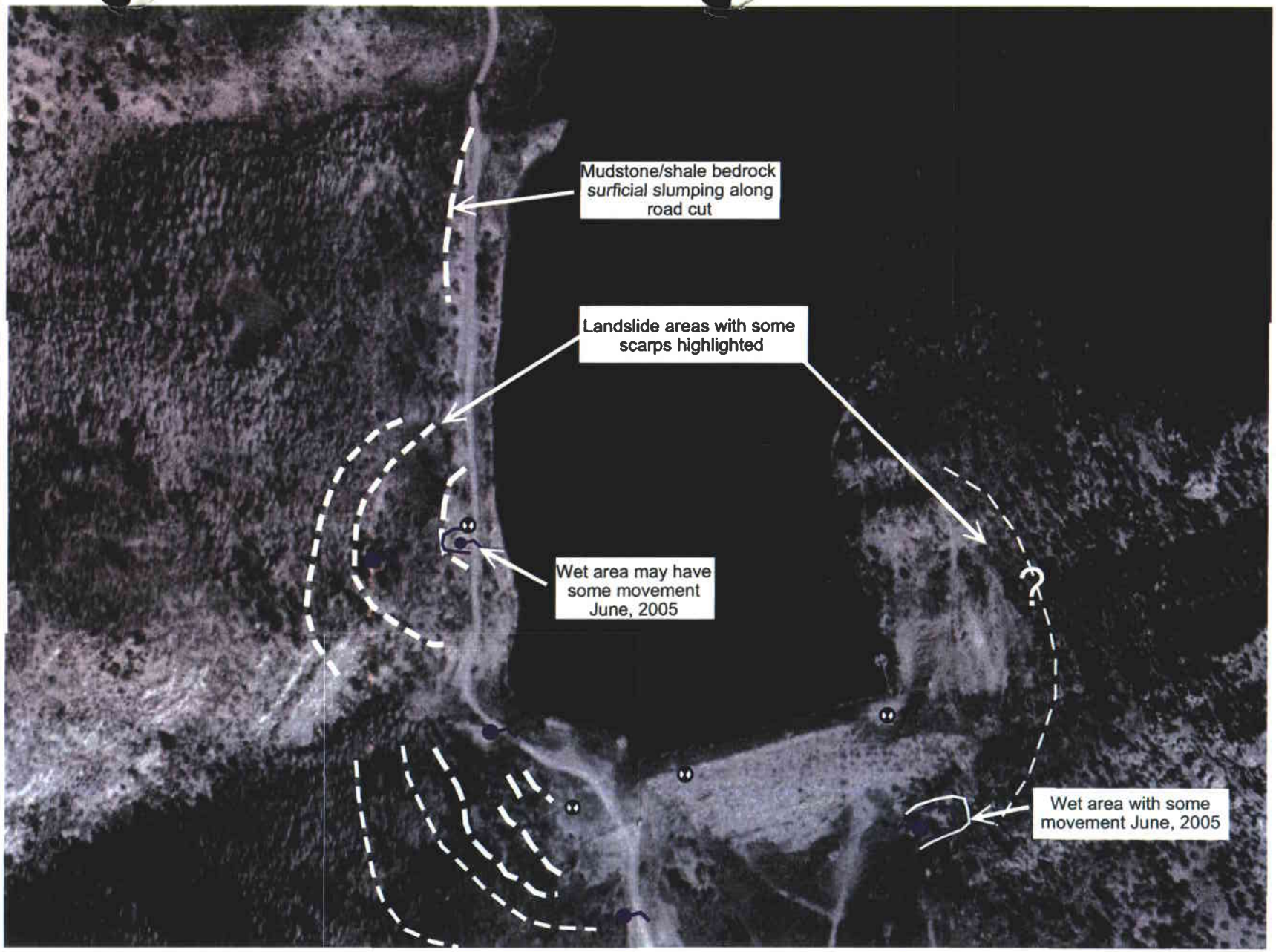
Provo, Utah

GRASSY TRAIL DAM
CARBON COUNTY, UTAH

LOCATION OF INSTRUMENTATION



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Provo, Utah

Figure 4A Aerial View Showing Potential Landslide Areas
Project *Grassy Trail Dam*
Location *Near East Carbon, Sunnyside, Carbon County, Utah*

View looking west at right abutment from dam

View looking southeast toward left abutment from northwest slide area

Landslides and scarps highlighted

RB&G ENGINEERING, INC.

Figure 4B	Landslides near Abutments
Project	Grassy Trail Dam
Location	Near Sunnyside, Carbon County, Utah

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Provo, Utah

Figure 4C Potential Landslide Areas
Project *Grassy Trail Dam*
Location *Near East Carbon, Sunnyside, Carbon County, Utah*

Spring in Potential Landslide Areas on West Rim of Reservoir near I-4

Spring and Slump on east side of outlet works

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Figure 4D Springs and Potential Landslide Areas
Project *Grassy Trail Dam*
Location *Near East Carbon, Sunnyside, Carbon County, Utah*

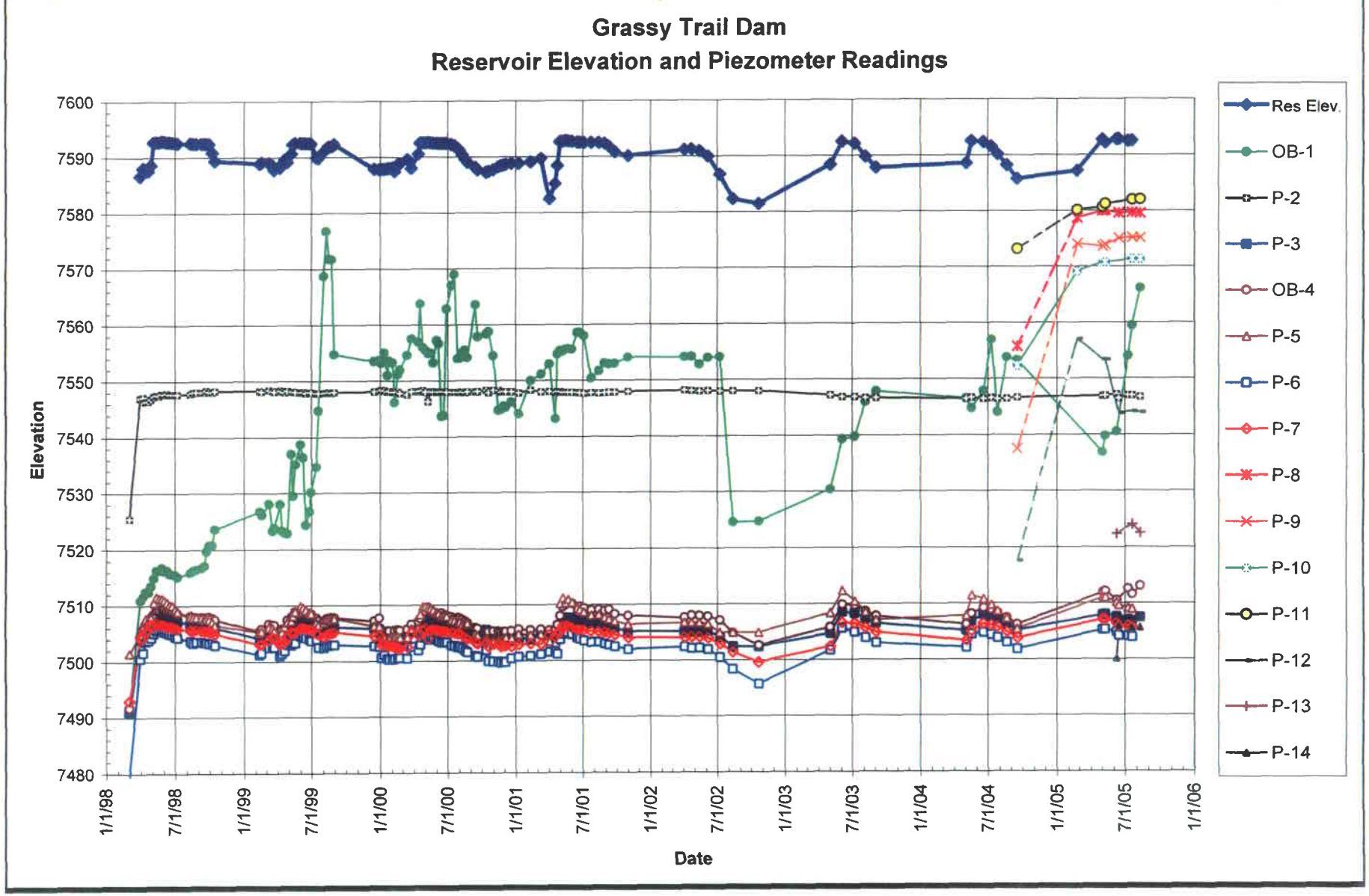

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Figure 5 Reservoir Elevation and Piezometer Readings
March 1998 to August 2005

Grassy Trail Dam and Reservoir

Appendix

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER RIGHTS

Michael O. Leavitt
Governor
Ted Stewart
Executive Director
Robert L. Morgan
State Engineer

1636 West North Temple, Suite 220
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801-538-7240
801-538-7467 (Fax)

October 12, 1994

STAN ADAMS
801- 673-8484

Mayor Paul Clark
City of East Carbon
200 Park Place
P. O. Box 70
East Carbon, UT 84520

RE: Inspection of Grassy Trail Dam/UT00126 pursuant to Section 73-5a-502 of the Utah Code Annotated 1953, as amended.

As you are aware, an inspection of Grassy Trail Dam was undertaken on June 7, 1994, with the following in attendance:

NAME	Representing
Nick Houser	East Carbon City
Dean Anderson	East Carbon City
Grant McDonald	Sunnyside City
Tom Anderson	Sunnyside City
Richard Hall	Division of Water Rights/Dam Safety Section
Mark Page	Division of Water Rights/Price

The purpose of the inspection was to conduct a visual evaluation of the dam to identify any problems. In conjunction with the visual inspection, we have also reviewed available records to determine if the facility meets the minimum standards for existing dams adopted by the State Engineer in June, 1993. The following information is a summary of our investigations, to date, as outlined in our letter to you of December 2, 1993.

VISUAL INSPECTION

The visual inspection revealed the following items regarding the operation, maintenance, and overall condition of the project.

1) Continue efforts to eradicate all woody vegetation on the dam.

2) Continue to monitor movement of slides on the abutments.

3) A level circuit of the crest should be undertaken.

4) The survey monument casings should be raised to the elevation of the top of the dam.

5) An inspection of the outlet pipe and tunnel needs to be undertaken.

MINIMUM STANDARDS

Section 73-5a-502 charges the State Engineer with the responsibility of setting minimum standards for existing dams and further describes how compliance with the standards is to be implemented. Grassy Trail Dam is designated as a High Hazard (R655-10-5A) Intermediate Size (R655-10-5B) structure. Studies have been undertaken by this office as per R655-12-5A of all High Hazard structures in Utah and Grassy Trail Dam has been determined to be in the top 25 on the priority list for 1994.

Minimum Standards for existing dams required by Section 73-5a-502 are further clarified by R655-12-5. This section refers to the specific design standards which must be imposed on existing dams as follows:

RULE NUMBER	TITLE	PAGE
R655-11-4	Hydrologic Design	24
R655-11-5	Seismic Design	27
R655-11-6	Embankment Requirements	30
R655-11-10	Instrumentation	35

R655-12-5 further states that the remaining sections of R655-11 shall apply if the State Engineer feels compliance with these rules is necessary for the safety of the structure. These rules are as follows:

RULE NUMBER	TITLE	PAGE
R655-11-7	Outlet Requirements	32
R655-11-8	Spillway Requirements	34
R655-11-9	Other Design Requirements	34

The following paragraphs will discuss Grassy Trail Dam's present compliance with each rule and summarize the State Engineer's opinion of the adequacy or the need for further investigation:

HYDROLOGIC DESIGN

Our most recent hydrology analysis shows the Probable Maximum Precipitation (PMP) to be 7.61 inches. Using a curve number of 79 to simulate saturated watershed conditions, the resulting Probable Maximum Flood has a peak inflow of 21,774 cfs. Routing the PMF through the reservoir shows that less than 10% of the PMF can be handled. Using more realistic watershed conditions, a curve number of 62 is obtained resulting in a peak Inflow Design Flood (IDF) of 13,155 cfs. Routing this flood through the reservoir shows that less than 15% of the IDF can be handled. Our analysis shows that the flood routing capabilities of the project do not meet minimum standards and additional studies will be required to develop alternatives to meet the minimum standards. However, at this point in time, the State Engineer is having statewide PMP studies conducted and this office will update the analysis when these numbers become available.

GEOLOGIC/SEISMIC STUDIES

In order to undertake a satisfactory seismic analysis and to determine the factors of safety for the dam, it will be necessary to complete geologic and seismic investigations of the site as follows:

1) An engineering geology site map should be prepared. In order to depict necessary site features, the map should be at a scale comparable to the reservoir basin plans prepared in 1951. This map should incorporate the: results of the subsurface investigations described under embankment requirements, literature reviews of pertinent geologic studies, and in-depth field examinations of the site. This map should depict all geologic features significant to engineering, such as:

   A) All potential geologic hazards, such as, the landslides that have occurred historically in the reservoir basin and particularly the slides that occurred in the immediate vicinity of the embankment in 1969. The locations of any seeps and springs in the embankment vicinity should also be depicted.
   B) Lithology of the reservoir basin and surrounding slopes.
   C) Any deformation zones or notable shears or joints, particularly those which may be related to historical seepage.

2) A report should be prepared which includes a discussion of all potential geologic hazards pertinent to the safety of the dam and reservoir basin. Particular attention should be paid to the potential ground motions experienced at the dam and reservoir site due to seismic activity occurring on the Joe's Valley Fault Zone, "rock bursts", or subsidence associated with the local mining activity. The report should contain a conclusion summarizing all geologic issues pertinent to the dam and reservoir basin. An adequate bibliography should be included. The report should be signed by the responsible engineering geologist.

SEISMIC DESIGN

Grassy Trail Dam has not been evaluated for seismic performance. The dam is located in UBC Seismic Zone 1, which generally justifies a reduced seismic evaluation effort. In this case, however, numerous seismic events have occurred in the immediate vicinity with some events in the range of magnitude 4.0 to 4.9. Under these conditions, a full seismic evaluation of the dam is considered necessary. This will include the identification of the Maximum Credible Earthquake (MCE) and the Operating Basis Earthquake (OBE). A subsurface investigation is considered necessary to provide additional information about the engineering properties of the embankment, foundation, and abutment materials. The specific analysis techniques will be dependent on site conditions observed in the investigation and on the level of seismic motion predicted by the design earthquakes.

EMBANKMENT REQUIREMENTS

1) The stability of the embankment under long-term steady state seepage conditions should be analyzed. In addition, the upstream slope needs to be analyzed for reservoir drawdown conditions. The subsurface investigation referenced in the Seismic Design Section above will also need to obtain the required data necessary to complete this analysis.

2) Material types within the various zones of the dam, foundation, and abutments should be identified and evaluated for compatibility. Special attention should be paid to filtering capability between the zone 1 core, the downstream foundation alluvial deposits, and the downstream toe drain.

3) Pore pressure and seepage conditions in the right abutment where the cutoff trench extended into an alluvial fan should be investigated.

4) Since construction of the dam, slope failures have occurred in both the left and right abutments. The investigations of these slides have yet to fully identify the causes, slide configuration, and the potential impact on the safety of the dam. The stability of these abutments need to be fully investigated.

5) Areas of seepage along the downstream toe and abutments, especially at the base of the slides, should be evaluated.

INSTRUMENTATION

1) The dam needs to be properly instrumented. Consideration should be given to existing instrumentation which should be supplemented as needed. The installation of piezometers during the subsurface investigation is considered necessary.

2) The adequacy of the instrumentation of the slide areas should be reviewed. Depending on the results of the investigation, the installation of inclinometers may be required.

CONCLUSIONS

Grassy Trail Dam does not currently meet all of the standards for existing dams. Studies will be required to generate missing data to allow for an accurate evaluation of the Dam's compliance with the minimum standards. It will be necessary to acquire the services of an experienced dam engineer, licensed in the State of Utah, to conduct necessary investigations, perform required analyses, and develop alternatives that would bring the dam into compliance with the minimum standards.

A typical program would include the following steps:

1) A detailed research of all existing data.

2) A program to acquire missing information.

3) Analyses to determine the current safety capabilities of the dam and appurtenant structures.

4) A feasibility study of remedies to correct deficiencies and a selection of the most acceptable alternative.

5) Preparation of cost estimates associated with implementation of the selected alternative.

The State Engineer will not require any remedial construction to meet the requirements of R655-11-4 (Hydrologic Design) and R655-11-5 (Seismic Design) prior to 1996 unless the investigations show an immediate and obvious threat to the integrity of the dam.

This letter will serve as official notice of our evaluation of the deficiencies of Grassy Trail Dam as per R655-12-5B. You have 90 days to respond, in writing, as to what steps you are taking to resolve the deficiencies and the anticipated time required to complete the required investigations. This letter is a continuation of the informal adjudicative proceeding commenced in our letter of December 2, 1993.

If you have any questions or need further clarification, feel free to contact Richard Hall of our Dam Safety Section.

Sincerely,

Robert L. Morgan

Robert L. Morgan, P.E.
State Engineer

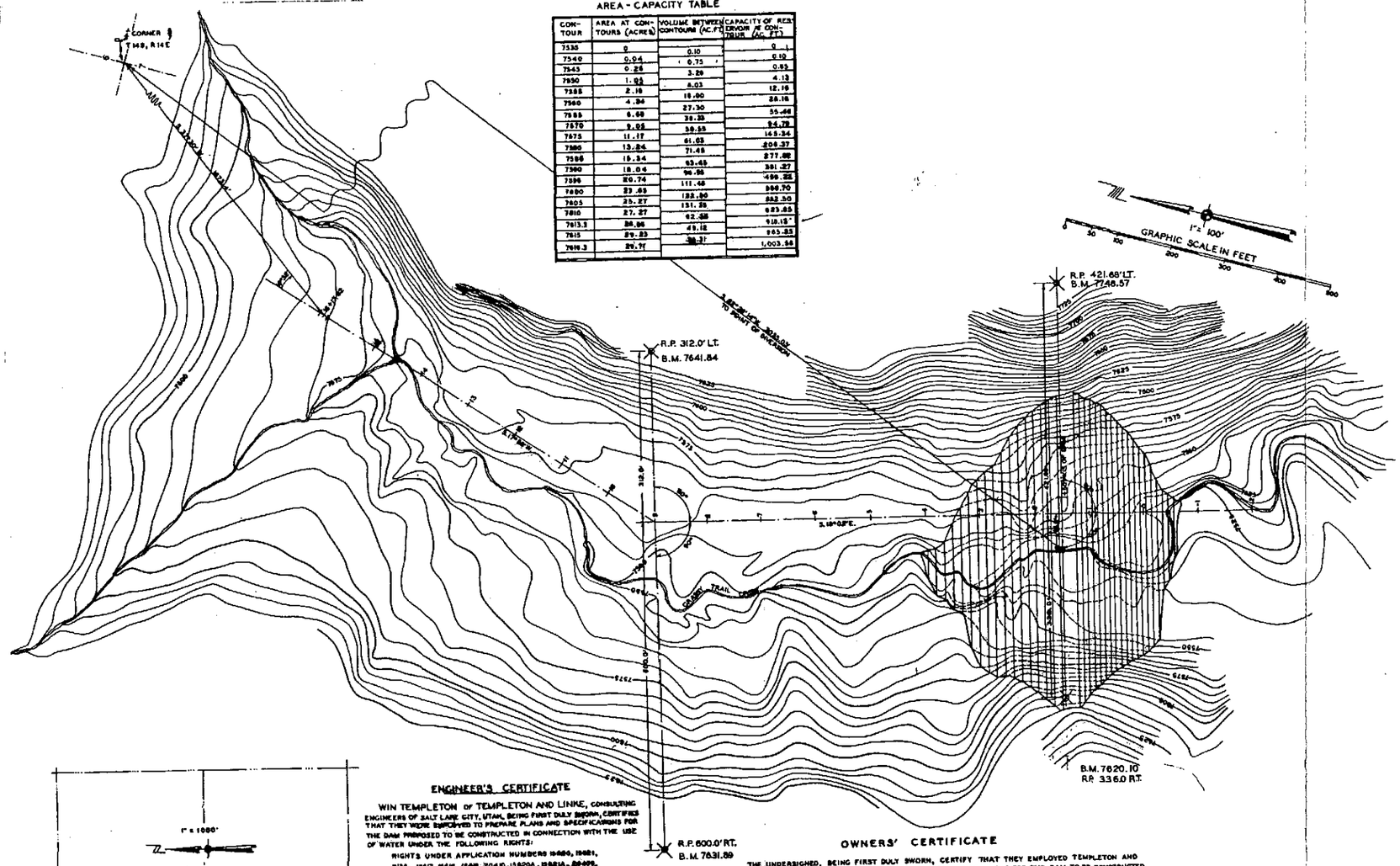
RLM/rbh

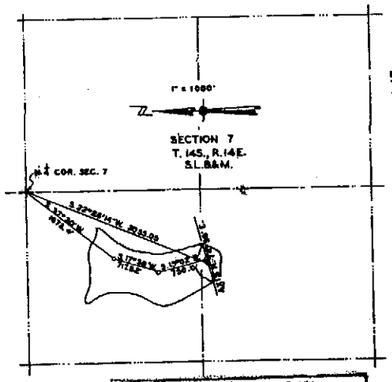
pc: Mark Page - Regional Engineer
Peter Heff - Sunnyside Coal Company

Construction Drawings

AREA - CAPACITY TABLE

CONTOUR	AREA AT CONTOURS (ACRES)	VOLUME BETWEEN CONTOURS (AC.FT)	CAPACITY OF RESERVOIR AT CONTOUR (AC. FT.)
7535	0		0
7540	0.04	0.10	0.10
7545	0.24	0.75	0.85
7550	1.03	3.28	4.13
7555	2.16	8.03	12.16
7560	4.34	15.00	28.16
7565	6.68	27.30	55.46
7570	9.05	38.33	93.79
7575	11.17	51.03	145.34
7580	13.24	71.48	206.37
7585	15.34	93.45	277.82
7590	18.04	98.98	381.27
7595	20.74	111.46	499.25
7600	23.65	122.50	566.70
7605	25.27	131.39	642.50
7610	27.27	92.58	823.85
7613.3	28.86	49.18	918.13
7615	29.23	38.31	965.83
7619.3	29.71		1,003.54





Received Sept. 24, 1951
Referred to
Approved June 24, 1951
State Engineer

ENGINEER'S CERTIFICATE

WIN TEMPLETON OF TEMPLETON AND LINKE, CONSULTING ENGINEERS OF SALT LAKE CITY, UTAH, BEING FIRST DULY SWORN, CERTIFIES THAT THEY WERE EMPLOYED TO PREPARE PLANS AND SPECIFICATIONS FOR THE DAM PROPOSED TO BE CONSTRUCTED IN CONNECTION WITH THE USE OF WATER UNDER THE FOLLOWING RIGHTS:

RIGHTS UNDER APPLICATION NUMBERS 15820, 15821, 8138, 15817, 15818, 15819, 20410, 15820A, 15821A, 20409. RIGHTS UNDER CERTIFICATE NUMBERS 808, 2047, 2024. RIGHTS UNDER DECREE OF DISTRICT COURT OF CARBON COUNTY. CASE NO. 327, WHITMORE V. SHARP, ET AL: WHITMORE RIGHT - 3 C.F.S.; M. PETERSON RIGHT - 0.875 C.F.S.

APPROPRIATE CHANGE APPLICATIONS WILL BE FILED TO PERMIT STORAGE UNDER THESE RIGHTS IN PROPOSED RESERVOIR.

THAT THESE PLANS CONSISTING OF THREE SHEETS, NUMBER 1 TO 3, INCLUSIVE, INDICATE THE INFORMATION TO BE SUBMITTED FOR APPROVAL OF SAID PLANS, AND THE SURVEY OF THE SITE WAS MADE BY THEM BETWEEN THE 1ST DAY OF APRIL, 1948, AND THE 31ST DAY OF AUGUST, 1951.

Win Templeton

SUBSCRIBED AND SWORN TO BEFORE ME THIS 21 DAY OF SEPTEMBER, 1951.

David A. West
NOTARY PUBLIC

OWNERS' CERTIFICATE

THE UNDERSIGNED, BEING FIRST DULY SWORN, CERTIFY THAT THEY EMPLOYED TEMPLETON AND LINKE OF SALT LAKE CITY, UTAH, TO PREPARE THE ACCOMPANYING PLANS FOR THE DAM TO BE CONSTRUCTED IN CONNECTION WITH THE USE OF WATER UNDER THE FOLLOWING RIGHTS:

RIGHTS UNDER APPLICATION NUMBERS 15820, 15821, 19338, 15817, 15818, 15819, 20410, 15820A, 15821A, 20409. RIGHTS UNDER CERTIFICATE NUMBERS 808, 2047, 2024. RIGHTS UNDER DECREE OF DISTRICT COURT OF CARBON COUNTY. CASE NO. 327, WHITMORE V. SHARP, ET AL: WHITMORE RIGHT - 3 C.F.S.; M. PETERSON RIGHT - 0.875 C.F.S.

APPROPRIATE CHANGE APPLICATIONS WILL BE FILED TO PERMIT STORAGE UNDER THESE RIGHTS IN PROPOSED RESERVOIR.

AND THAT THEY HEREBY ACCEPT THESE PLANS.

GENEVA STEEL COMPANY
BY: L. W. Ashby
L. W. ASHBY, VICE PRESIDENT AND MANAGER OF OPERATIONS

SUBSCRIBED AND SWORN TO BEFORE ME THIS 19th DAY OF SEPTEMBER, 1951
Carol F. Stocker
NOTARY PUBLIC

KAISER STEEL CORPORATION
BY: J. L. Ashby
J. L. ASHBY, VICE PRESIDENT AND MANAGER

SUBSCRIBED AND SWORN TO BEFORE ME THIS 19th DAY OF SEPTEMBER, 1951
Marie E. Schwab
NOTARY PUBLIC

DATE	REVISION	BY
9/14/51		E.R.A.
11/26/52	Rev. Location Rt. Point	R.E.

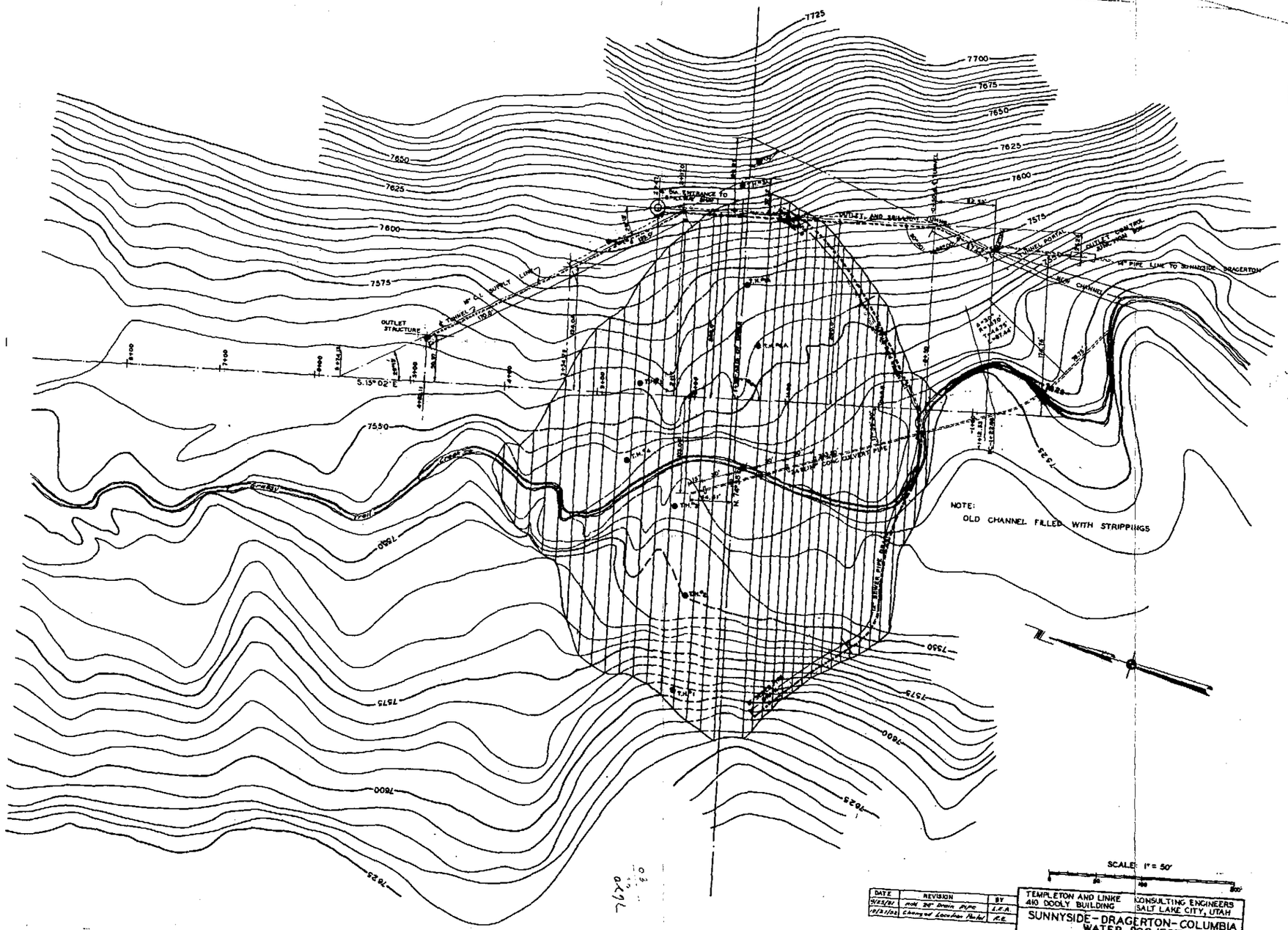
TEMPLETON AND LINKE CONSULTING ENGINEERS
410 DOOLY BUILDING SALT LAKE CITY, UTAH

SUNNYSIDE-DRAGERTON-COLUMBIA WATER PROJECT
GRASSY TRAIL RESERVOIR DAM
GENEVA STEEL CO. - KAISER STEEL CORP.
CARBON COUNTY, UTAH

SCALE: 1" = 100' | SEPTEMBER 6, 1951
CONTOUR INTERVAL - 5 FEET | SHEET 1 OF 3 SHEETS

Grassy Trail Res.

H-34-Dams
42
UT 126



DATE	REVISION	BY
9/25/81	add 24" Drain Pipe	L.F.A.
10/21/82	Change of Location Marker	R.E.

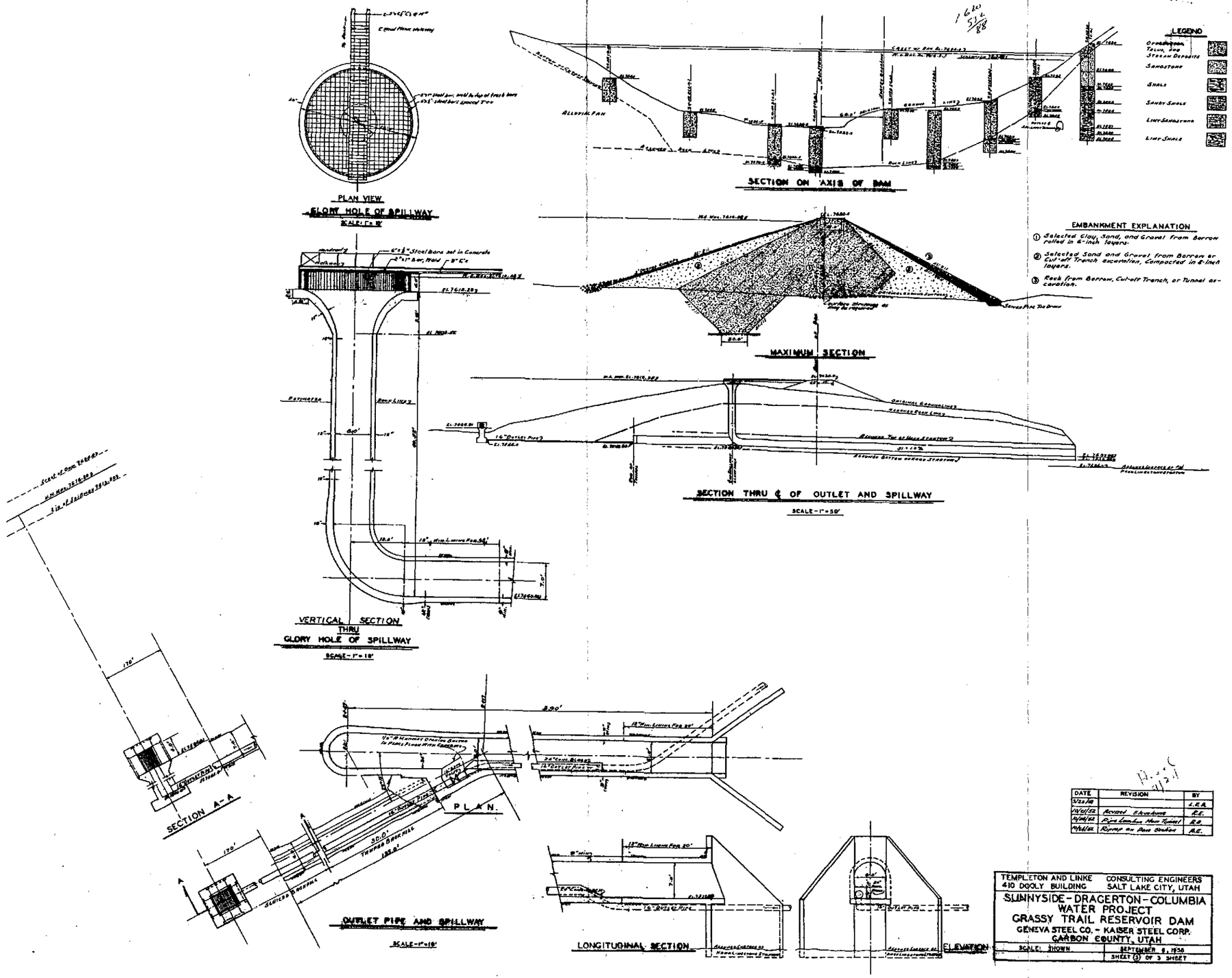
TEMPLETON AND LINKE
410 DOOLY BUILDING

CONSULTING ENGINEERS
SALT LAKE CITY, UTAH

SUNNYSIDE-DRAGERTON-COLUMBIA
WATER PROJECT
GRASSY TRAIL RESERVOIR DAM
GENEVA STEEL CO. - KAISER STEEL CORP.
CARBON COUNTY, UTAH

SCALE: 1" = 50'
CONTOUR INTERVAL - 5 FEET

SEPTEMBER 8, 1980
SHEET 1 OF 3 SHEETS



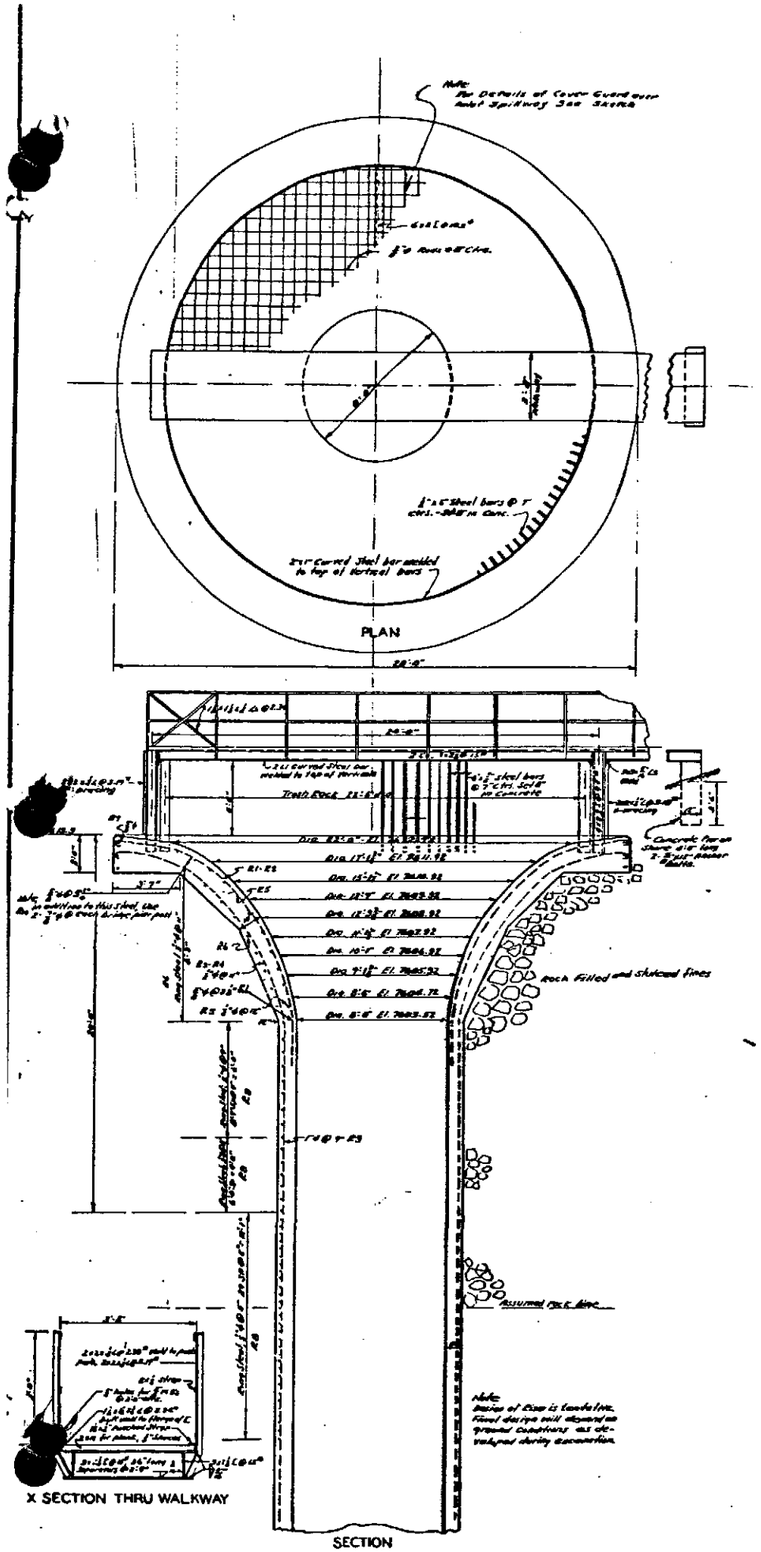
DATE	REVISION	BY
3/26/40		L.E.A.
10/21/52	Revised Elevations	R.E.
4/24/62	Pipe Lowered Near Tunnel	R.E.
4/26/62	Riprap on Face Shaded	R.E.

TEMPLETON AND LINKE — CONSULTING ENGINEERS
410 DOOLY BUILDING — SALT LAKE CITY, UTAH

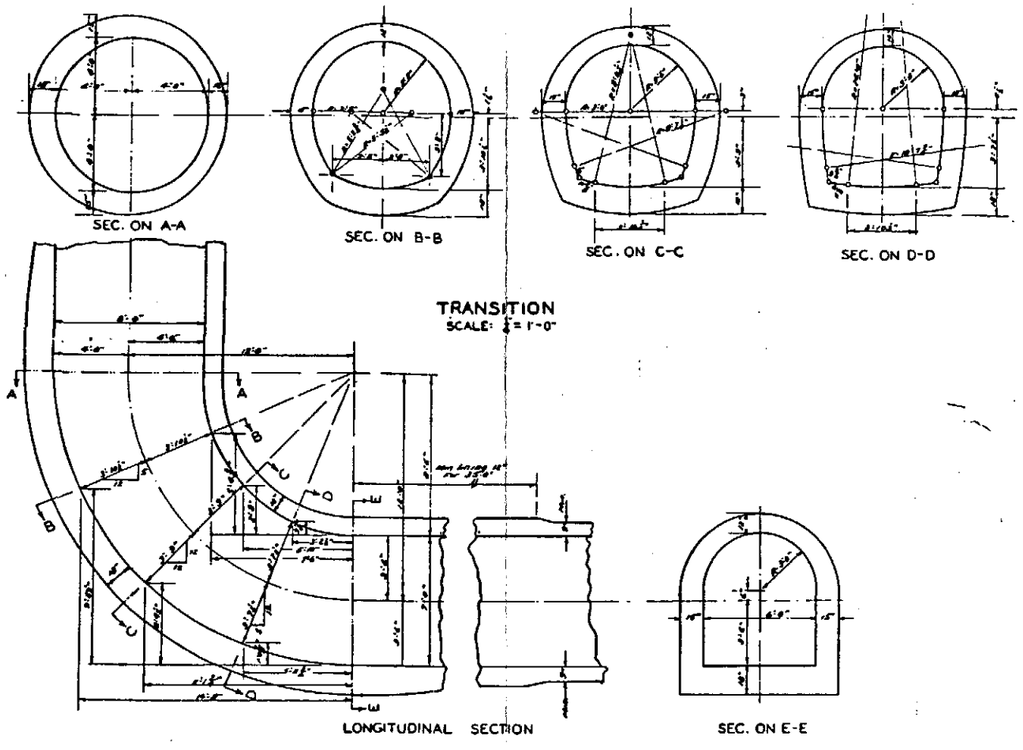
SUNNYSIDE-DRAGERTON-COLUMBIA WATER PROJECT
GRASSY TRAIL RESERVOIR DAM
GENEVA STEEL CO. - KAISER STEEL CORP.
CARBON COUNTY, UTAH

SCALE: SHOWN — SEPTEMBER 8, 1938
SHEET (3) OF 3 SHEET

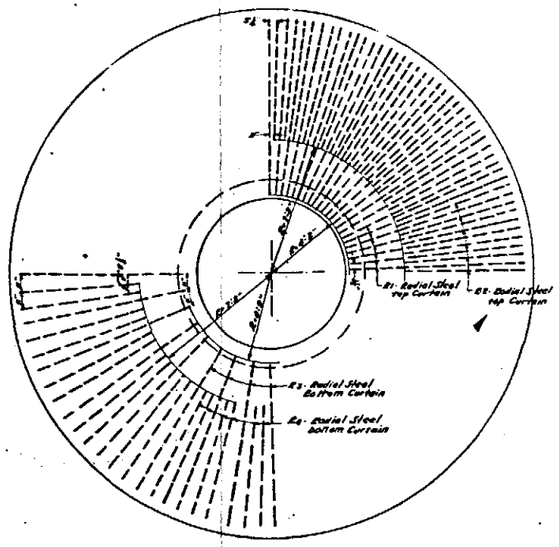
H-34-Dams



DROP INLET SPILLWAY
SCALE: $\frac{3}{4}$" = 1'-0"

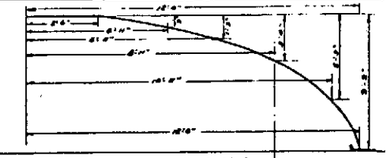


TRANSITION
SCALE: $\frac{1}{8}$" = 1'-0"



DETAIL SHOWING PLACEMENT OF RADIAL STEEL IN GLORY HOLE

REINFORCING SCHEDULE

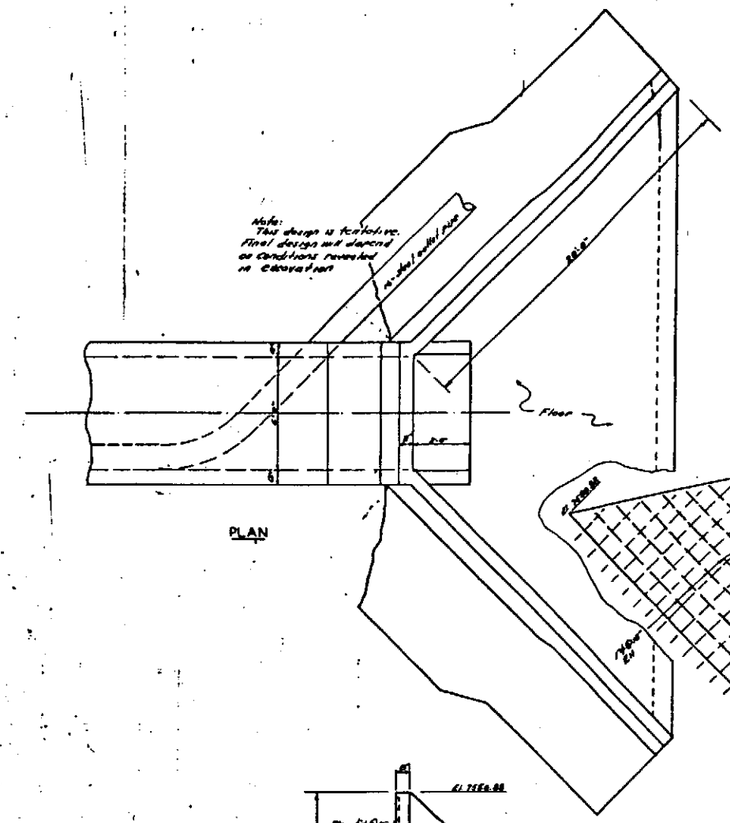
MARK	SIZE	No. REQ'D	LENGTH	DESCRIPTION
R1	$\frac{5}{8}$"φ	90	18'-8"	
R2	$\frac{5}{8}$"φ	90	9'-8"	Ditto R1 Right of this point
R3	$\frac{5}{8}$"φ	33	18'-2"	Ditto R1
R4	$\frac{5}{8}$"φ	66	9'-2"	Ditto R2
R5	$\frac{5}{8}$"φ	16	Varies	Inner Curtain: 30"-lap each Splice; 30 lin. d = 8'-4"; 100 lin. d = 12'-3"; 100 lin. d = 18'-10"; 100 lin. d = 8'-10"; 100 lin. d = 13'-6"; 100 lin. d = 21'-4"; 100 lin. d = 9'-7"; 100 lin. d = 14'-4"; 100 lin. d = 22'-8"; 100 lin. d = 10'-6"; 100 lin. d = 15'-6"; 100 lin. d = 23'-8"; 100 lin. d = 11'-4"; 100 lin. d = 17'-6"
R6	$\frac{5}{8}$"φ	18	Varies	Outer Curtain: 30"-lap each Splice; 100 lin. d = 9'-8"; 100 lin. d = 15'-0"; 100 lin. d = 20'-6"; 100 lin. d = 10'-0"; 100 lin. d = 15'-8"; 100 lin. d = 22'-6"; 100 lin. d = 11'-0"; 100 lin. d = 16'-3"; 100 lin. d = 24'-6"; 100 lin. d = 11'-8"; 100 lin. d = 17'-6"; 100 lin. d = 12'-8"; 100 lin. d = 19'-0"
R7	$\frac{5}{8}$"φ	3	66'-5" + Splices	30"-lap each Splice; D = 27'-6"
R8	$\frac{5}{8}$"φ	60	29'-10" + Splices	30"-lap each Splice; D = 9'-6"
R9	1"φ	40	37'	Straight
R10	$\frac{3}{4}$"φ	8	4'-10"	Straight

DATE	REVISION	BY
8/21/51	Add Bend Schedule	L.E.A.
3/26/52	Add Spillway Gate	H.E.

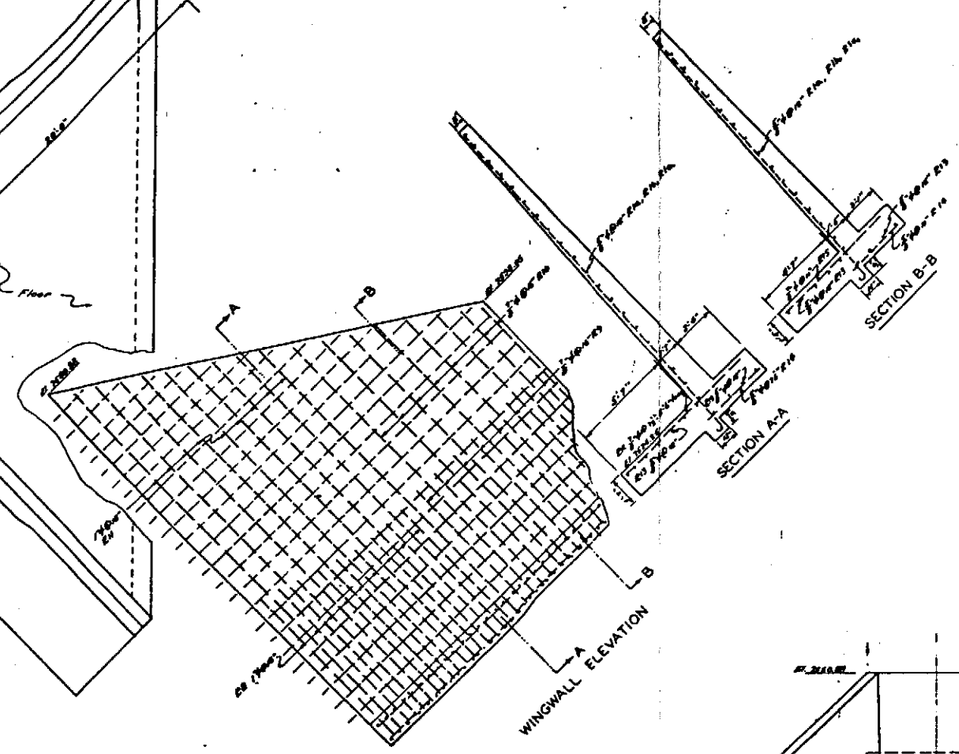
TEMPLETON AND LINKE, CONSULTING ENGINEERS
410 DOOLY BUILDING, SALT LAKE CITY, UTAH

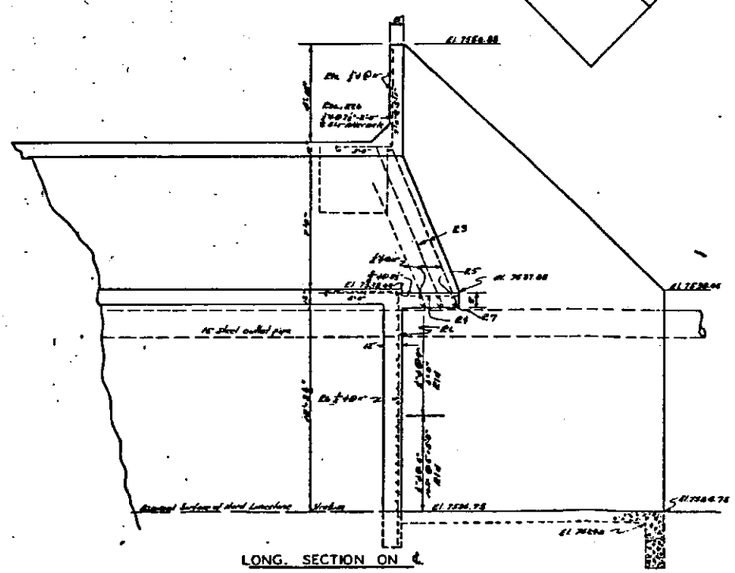
SUNNYSIDE-DRAGERTON-COLUMBIA WATER PROJECT
GRASSY TRAIL RESERVOIR DAM
GENEVA STEEL CO.-KAISER STEEL CORP.

DRAWN H.A.L.	SCALE $\frac{3}{4}$" = 1'-0"	DWG. NO. 4
CHECKED W.T.		
TRACED L.E.A.	DATE	FILE NO.
TRACING CHECKED H.A.L.		

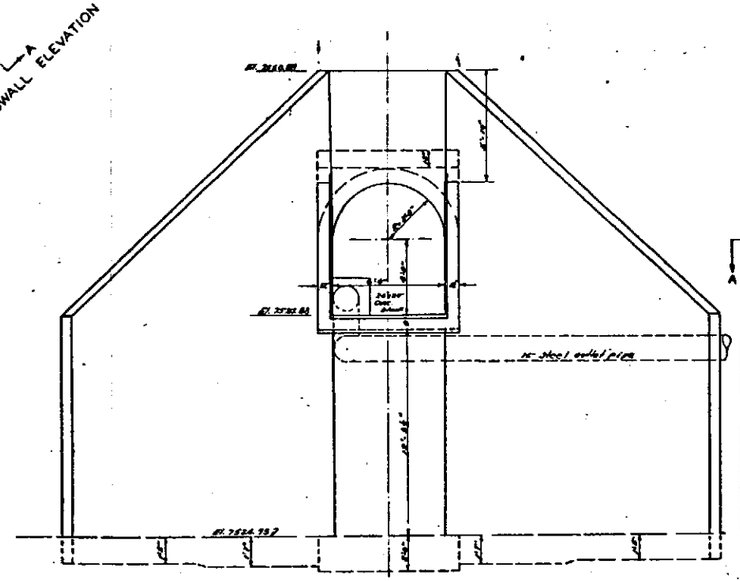


PLAN





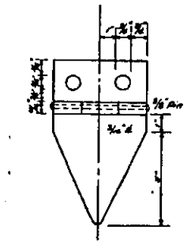
LONG. SECTION ON ℄



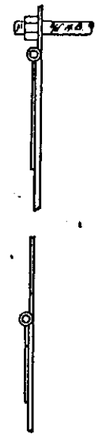
PORTAL ELEVATION

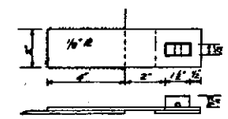
DETAILS AT TUNNEL PORTAL

SCALE: 1/4" = 1'-0"



HINGE DETAIL

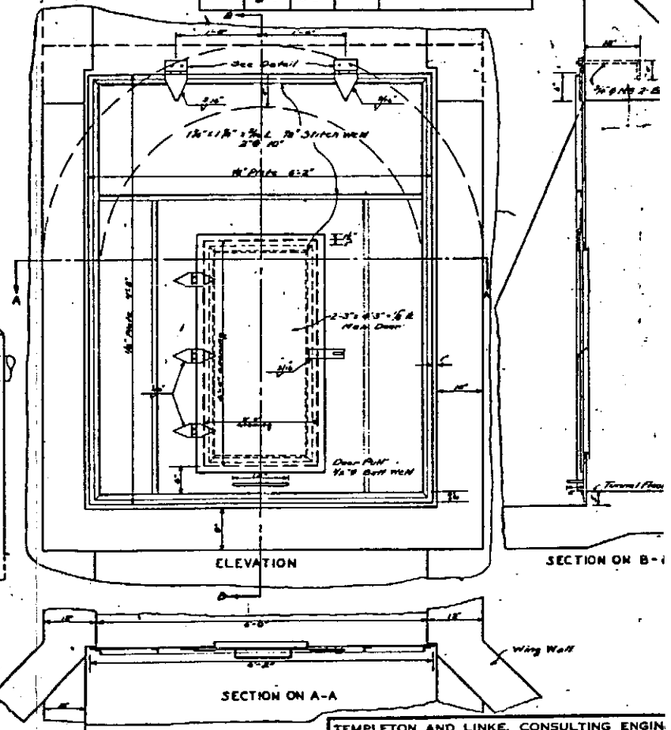




HASP

REINFORCING SCHEDULE

MARK	SIZE	No. REQ'D	LENGTH	DESCRIPTION
R1a	5/8"φ	6	Varies	8'-6"
R1b	5/8"φ	15	Varies	Varies 3'-10" to 13'-10"
R1c	5/8"φ	84	26'-10"	20'-10"
R1d	1/2"φ	32	7'-0"	6'-6"
R2a	1/2"φ	6	8'-1"	5'-11" 2'-6"
R2b	1/2"φ	5	6'-0"	3'-10" 2'-10"
R3	5/8"φ	6	9'-7"	8'-0"
R4	5/8"φ	10	8'-0"	Straight
R5	5/8"φ	8	2'-6"	1'-6" 1'-6"
R6	1/2"φ	10	10'-6"	9'-0" 6" 1
R7	5/8"φ	2	4'-6"	1'-6" 2'-6"
R8	1"φ	18	Varies	Varies 8'-6" to 8'-8"
R9	7/8"φ	10	9'-6"	8'-6"
R10	7/8"φ	14	Varies	Varies 12'-10" to 18'-3"
R11	1"φ	18	Varies	Varies 18'-6" to 22'-6"
R12	7/8"φ	32	8'-6"	Straight
R13	5/8"φ	22	20'-6"	"
R14	5/8"φ	54	4'-6"	"
R15	7/8"φ	22	7'-7"	"



ELEVATION

SECTION ON B-B

SECTION ON A-A

DOOR FOR TUNNEL PORTAL

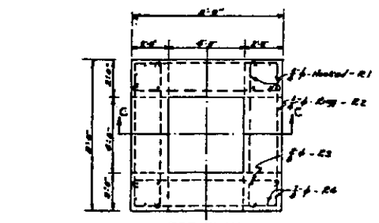
SCALE: 3/4" = 1'-0"

DATE	REVISION	BY
9/27/11	Add Reinf. Schedule	L.E.A.
3/30/12	Add Portal Door	R.C.
7/31/12	Rev. Elevations	R.C.
11/6/12	Pipe Location Main Tunnel	R.C.

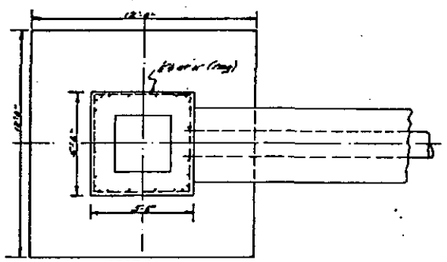
TEMPLETON AND LINKE, CONSULTING ENGIN
410 DOOLY BUILDING, SALT LAKE CITY, UTA

SUNNYSIDE-DRAGERTON-COLUMB
WATER PROJECT
GRASSY TRAIL RESERVOIR DAM
GENEVA STEEL CO.-KAISER STEEL COR

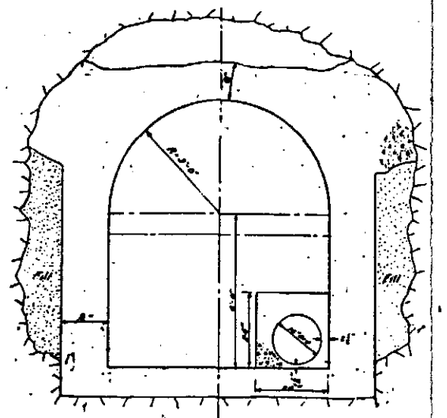
DRAWN	H.A.L.	SCALE 1/4" = 1'-0"	DWG. N 5
CHECKED	W.T.		
TRACED	L.E.A.	DATE	FILE N



TOP PLAN
$\frac{1}{4}$" = 1'-0"

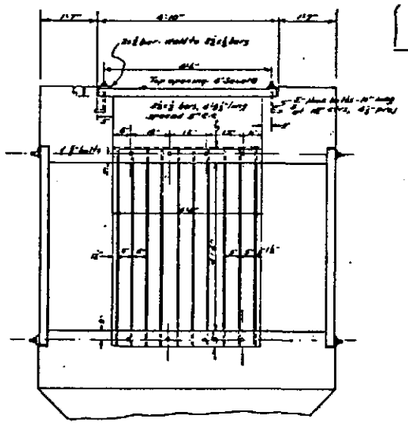


SECTION A-A
$\frac{1}{4}$" = 1'-0"

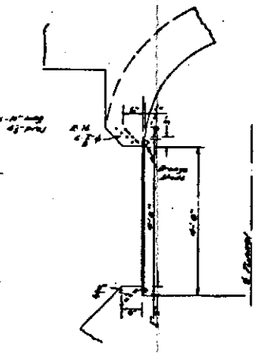


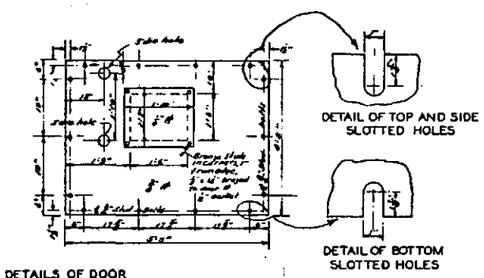
TYPICAL TUNNEL LINING
CONSTRUCTION WHERE OVER-BREAK
WILL NOT BE FULLY CONCRETED
(LOOKING SOUTH)

Note: All voids back of lining filled with grout.



SECTION C-C
$\frac{1}{4}$" = 1'-0"

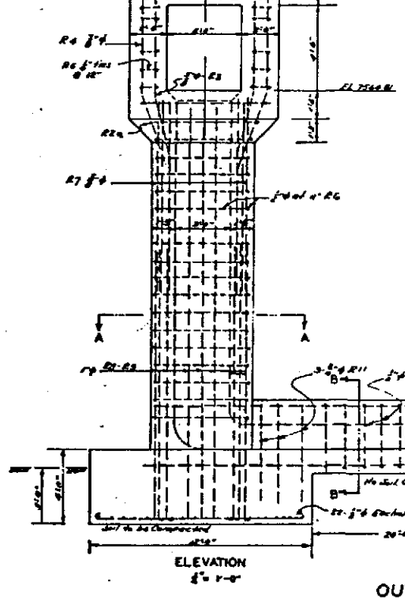




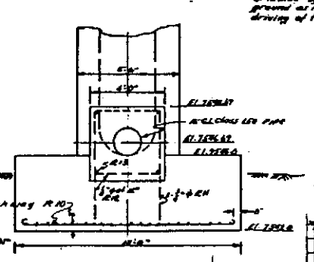
DETAIL OF TOP AND SIDE SLOTTED HOLES

DETAIL OF BOTTOM SLOTTED HOLES

DETAILS OF DOOR
$\frac{1}{4}$" = 1'-0"

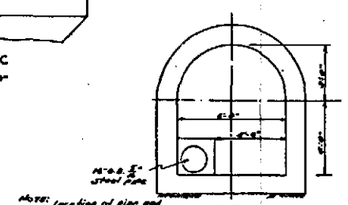


ELEVATION
$\frac{1}{4}$" = 1'-0"

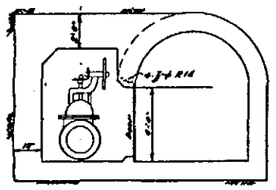


SECTION B-B
$\frac{1}{4}$" = 1'-0"

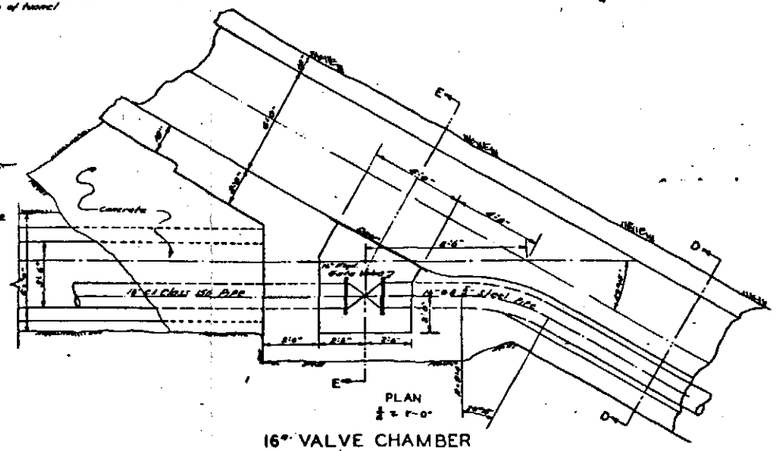
OUTLET DETAILS



SECTION D-D
$\frac{1}{4}$" = 1'-0"

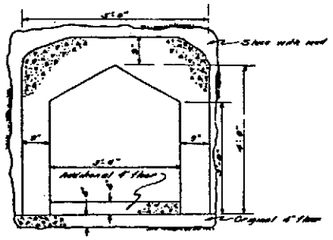


SECTION E-E
$\frac{1}{4}$" = 1'-0"



PLAN
$\frac{1}{4}$" = 1'-0"

16" VALVE CHAMBER



SECTION CONCRETE LINING
USED IN DIVERSION TUNNEL
1/2" = 1'-0"

REINFORCING SCHEDULE

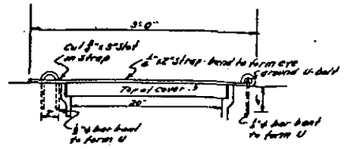
MARK	SIZE	No. REQD	LENGTH	DESCRIPTION
R1	$\frac{3}{8}$"φ	6	9'-4"	Hook 7'-6"
R2	$\frac{3}{8}$"φ	8	35'-0"	2'-6" lap 2'-6"
R2a	$\frac{3}{8}$"φ	1	26'-6"	Ditto R2 except 35'-0"
R3	$\frac{3}{8}$"φ	4	6'-0"	6'-0"
R4	$\frac{3}{8}$"φ	16	11'-6"	6'-0" 46
R5	$\frac{1}{2}$"φ	24	7'-0"	1'-6"
R6	$\frac{1}{2}$"φ	17	28'-6"	2'-6" 20" lap
R7	$\frac{5}{8}$"φ	24	16'-0"	Straight
R8	1"φ	24	15'-7"	16'-6"
R9	1"φ	12	25'-0"	21'-10"
R10	$\frac{3}{8}$"φ	44	12'-6"	11'-6"
R11	$\frac{3}{8}$"φ	3	15'-6"	3'-6" 2'-0"
R12	$\frac{3}{8}$"φ	20	15'-6"	3'-6" 2'-0" 20" lap
R13	1"φ	4	28'-6"	Straight
R14	$\frac{3}{8}$"φ	4	8'-2"	7'-0"

DATE	REVISION	BY
3/25/51	Add Reinf. Schedule	L.E.A.
4/11/52	Add Diversion Tunnel Lining	R.E.
4/8/53	Revised R.R. Junction Tunnel	R.E.

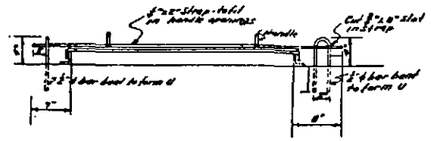
TEMPLETON AND LINKE, CONSULTING ENGINEERS
410 DOOLY BUILDING, SALT LAKE CITY, UTAH

SUNNYSIDE-DRAGERTON-COLUMBIA
WATER PROJECT
GRASSY TRAIL RESERVOIR DAM
GENEVA STEEL CO.- KAISER STEEL CORP.

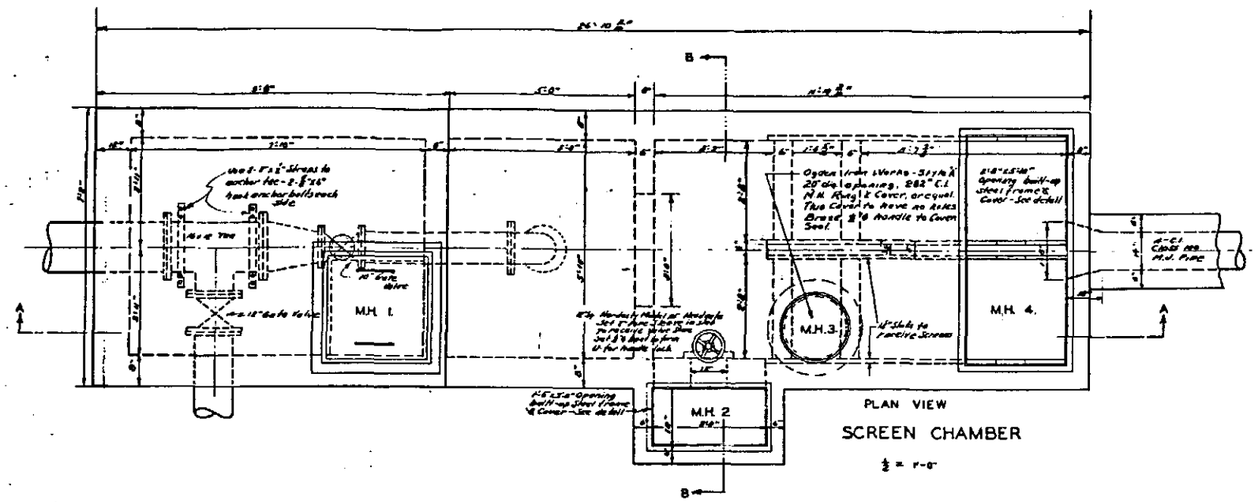
DRAWN H.A.L.	SCALE	DWG. NO.
CHECKED W.T.	AS SHOWN	6
TRACED L.E.A.	DATE	FILE NO.
TRACING CHECKED H.A.L.	SEPT. 17, 1951	



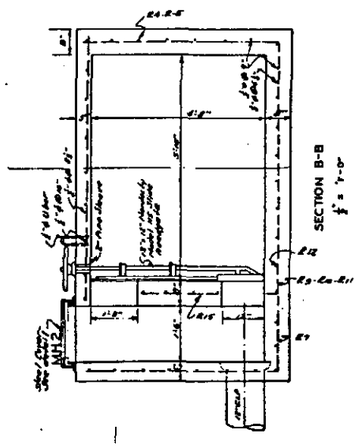
LOCKING DEVICE FOR
C.I. MANHOLE COVER-3.
1" = 1'-0"



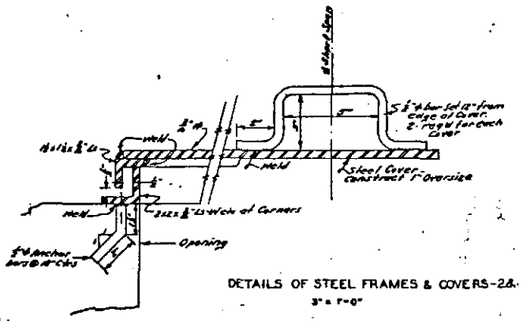
LOCKING DEVICE FOR
STEEL MANHOLE COVERS-2 & 4
1" = 1'-0"



PLAN VIEW
SCREEN CHAMBER
1/2" = 1'-0"



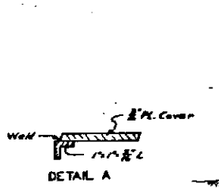
SECTION B-B
1/2" = 1'-0"



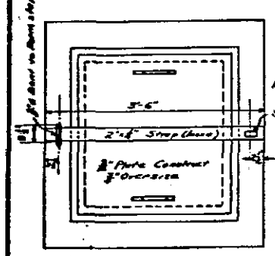
DETAILS OF STEEL FRAMES & COVERS-2&4
3" = 1'-0"

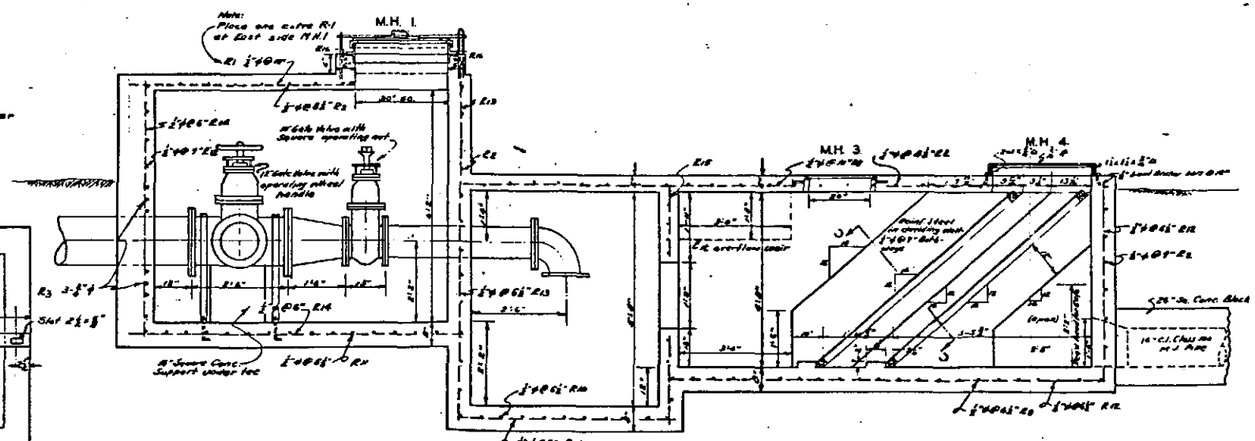
REINFORCING SCHEDULE

Mark	Size	No. Req'd	Length	Description
R1	3/4" ϕ	17	9'-2"	Straight
R2	"	53	6'-10"	"
R3	3/4" ϕ	6	6'-10"	"
R4	3/4" ϕ	14	26'-6"	"
R5	"	17	5'-7"	"
R6	"	7	5'-8"	"
R7	"	14	9'-4"	"
R8	"	9	14'-4"	"
R9	"	33	17'-0"	5'-8" / 6'-6"
R10	"	12	19'-4"	6'-6" / 6'-10"
R11	"	15	20'-4"	6'-6" / 6'-10"
R12	"	13	17'-5"	1'-9" / 11'-10" / 6'-10"
R13	"	13	18'-2"	3'-4" / 5'-6" / 1'-8" / 1'-8"
R14	"	13	17'-2"	4'-10" / 8'-7" / 1'-8"
R15	"	8	2'-6"	Straight
R16	"	1	13'-0"	2'-0" / 6'-0" / 2'-0"

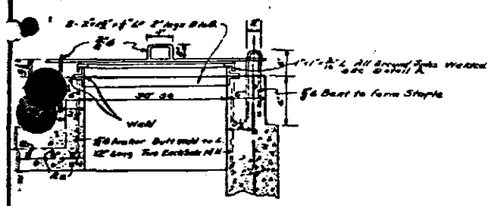


DETAIL A

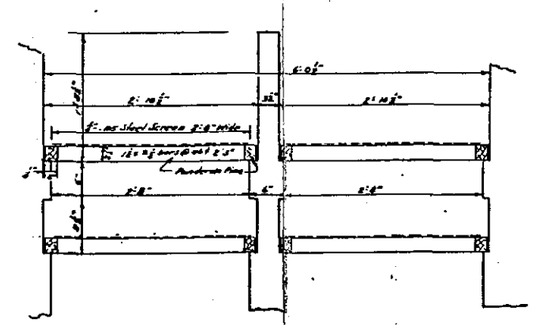




SECTION A-A
1/2" = 1'-0"



DETAIL OF STEEL FRAME AND COVER - M.H.-1



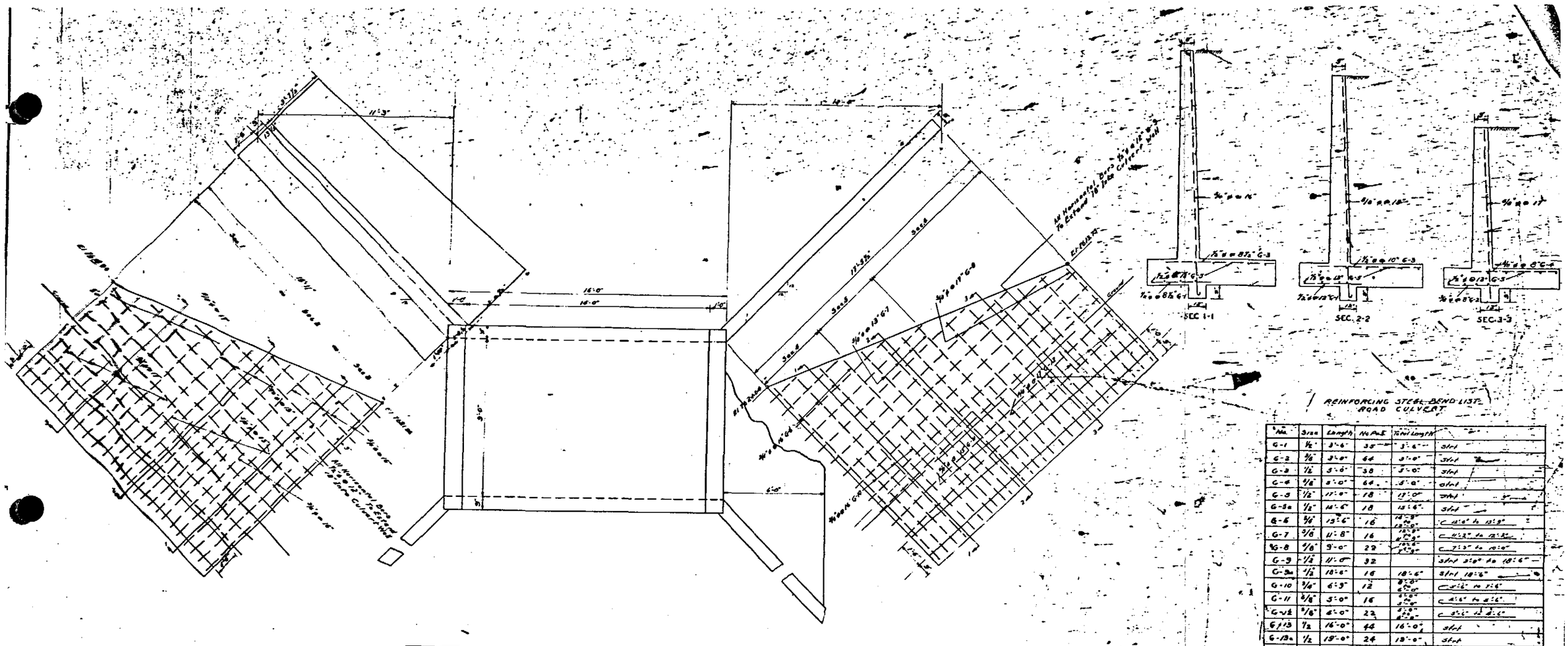
SECTION C-C
1" = 1'-0"

DATE	REVISION	BY
9/27/50	Add Bend Schedule	L.E.A.
6/27/53	Revised M.H. Location	R.E.

TEMPLETON AND LINKE. CONSULTING ENGINEERS
410 DOOLY BUILDING. SALT LAKE CITY, UTAH

SUNNYSIDE-DRAGERTON-COLUMBIA
WATER PROJECT
GRASSY TRAIL RESERVOIR DAM
GENEVA STEEL CO.-KAISER STEEL CORP.

DRAWN H.A.L.	SCALE AS SHOWN	DWG. NO. 7
CHECKED W.T.		
TRACED L.E.A.	DATE SEPT. 21, 1951	FILE NO.
TRACING CHECKED H.A.L.		
APPROVED W.T.		



REINFORCING STEEL BEND LIST
ROAD CULVERT

No.	Size	Length	No. Req.	Total Length	
G-1	1/2"	3'-6"	35	3'-6"	Strt
G-2	5/8	3'-0"	64	3'-0"	Strt
G-3	1/2"	3'-6"	38	3'-0"	Strt
G-4	5/8"	3'-0"	64	3'-0"	Strt
G-5	1/2"	17'-0"	18	17'-0"	Strt
G-5a	1/2"	14'-6"	18	15'-6"	Strt
G-6	5/8"	13'-6"	16	14'-9" 14'-9" 13'-9"	15'-0" to 13'-9"
G-7	5/8	11'-8"	16	12'-9" 12'-9" 11'-9"	11'-3" to 12'-9"
G-8	5/8"	9'-0"	22	10'-6" 10'-6" 9'-6"	7'-3" to 10'-0"
G-9	1/2	11'-0"	32		Strt 2'-0" to 18'-6"
G-9a	1/2	18'-6"	16	18'-6"	Strt 18'-6"
G-10	5/8"	6'-9"	12	8'-0" 6'-0"	4'-6" to 7'-6"
G-11	5/8"	5'-0"	16	4'-0" 3'-0"	4'-6" to 6'-6"
G-11a	5/8"	4'-0"	22	3'-0" 2'-0"	3'-6" to 6'-6"
G-13	1/2	16'-0"	44	16'-0"	Strt
G-13a	1/2	18'-0"	24	18'-0"	Strt
G-13b	1/2	8'-0"	22	8'-0"	Strt
G-14	3/4"	7'-0"	17	7'-0"	4'-6" 6'-6"
G-14a	3/4"		18	4'-6" 3'-0" 3'-0"	7'-0" to 4'-6" 3'-6"
G-14b	3/4"	2'-6"	34	2'-6"	Strt
G-15	3/4"	6'-0"	17	6'-0"	6'-0" 6'-6"
G-17	5/8"	22'-6"	5	22'-6"	Strt
G-18	5/8"	10'-0"	10	10'-0"	Strt
G-19	1/2"		32	6'-6"	3'-8" 3'-8"
G-20	3/4"	10'-0"		10'-0"	Strt
G-21	5/8"		208	12'-6"	6'-3" 6'-3"

Note:
This design not used. 48" Dia CMP 30 Feet long used in lieu of.

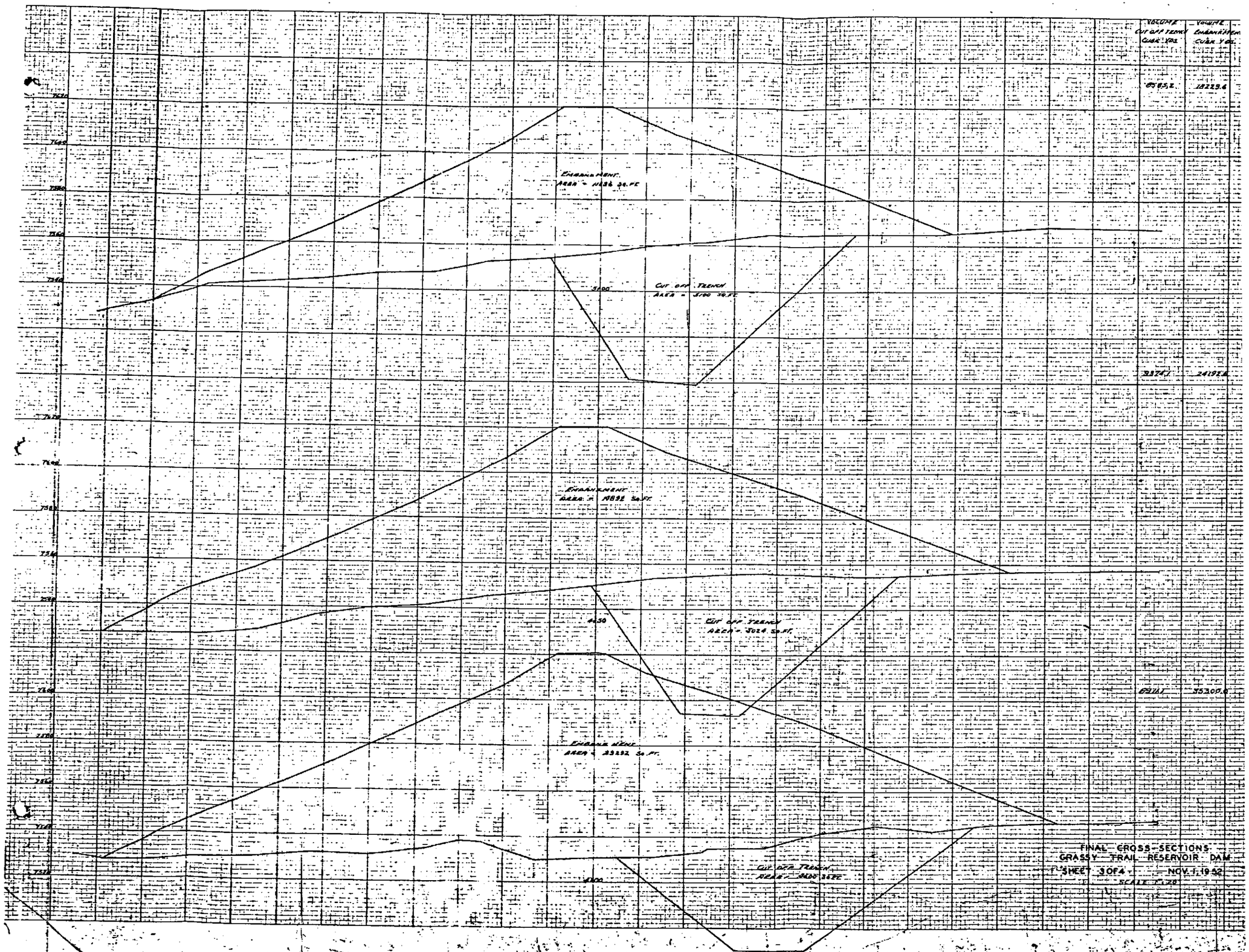
TEMPLETON AND LINKE, CONSULTING ENGINEERS
410 DOOLY BUILDING, SALT LAKE CITY, UTAH

GRASSY TRAIL RESERVOIR

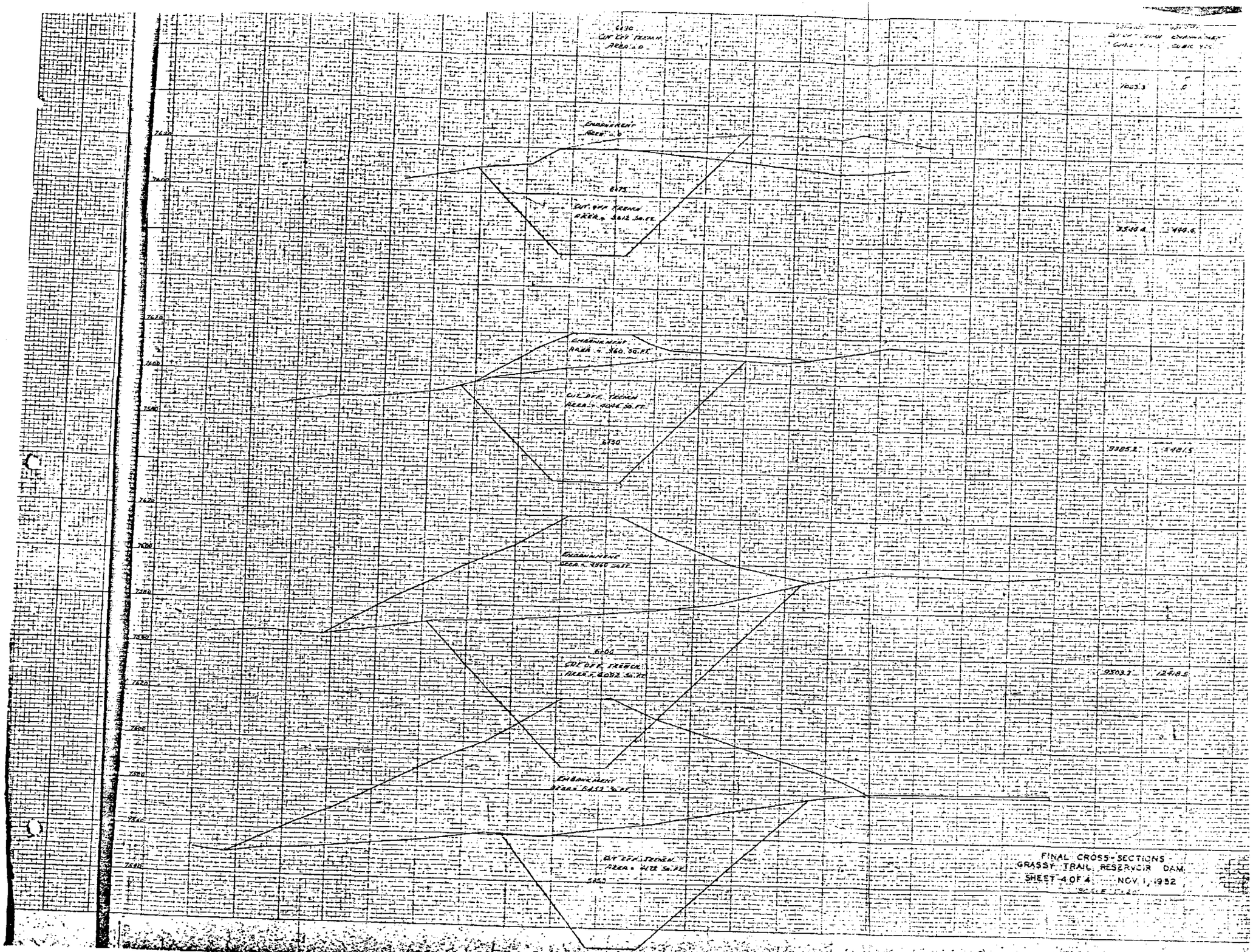
ROAD CULVERT OVER LEFT FORK

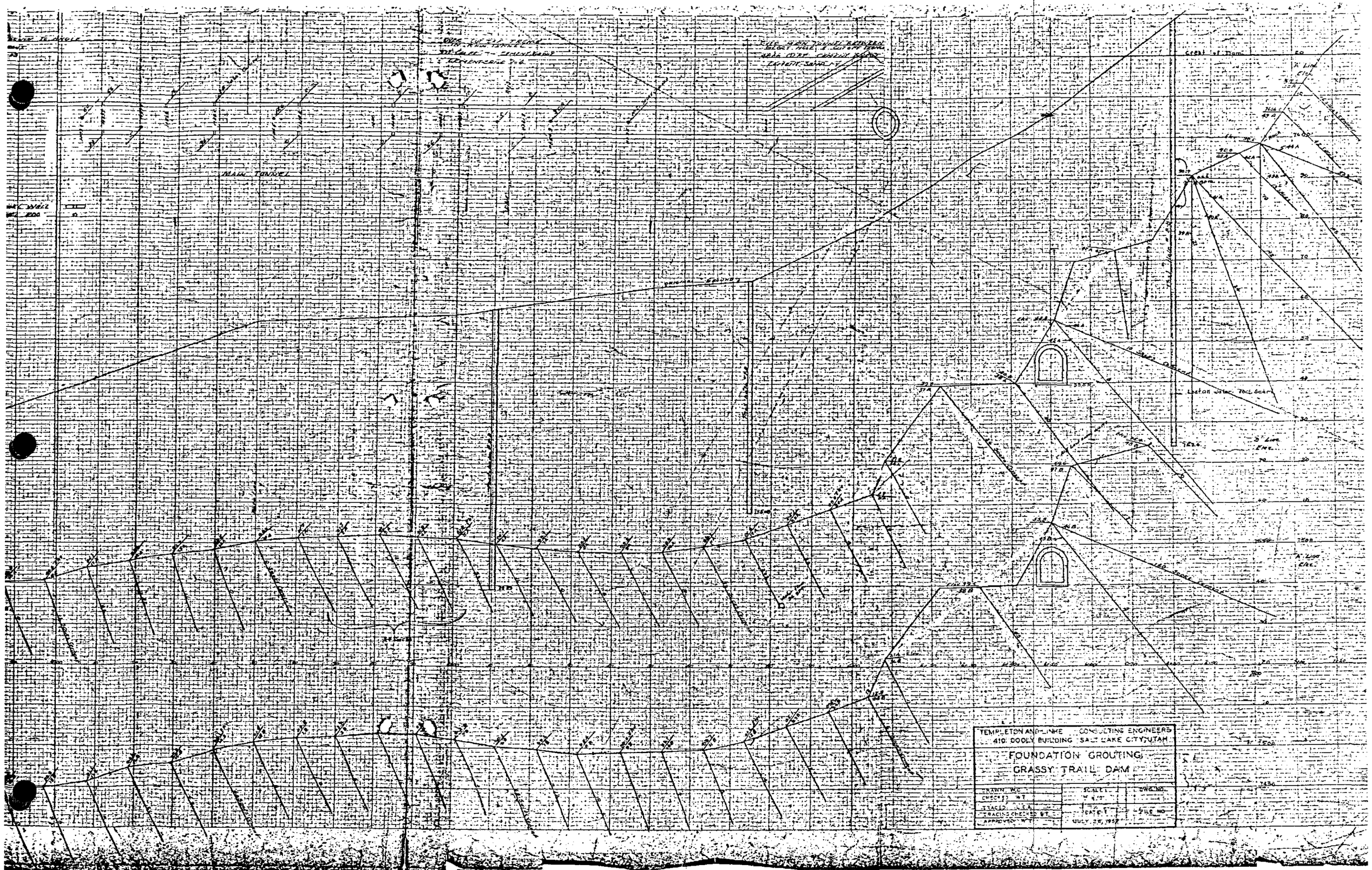
DRAWN	H.A.L.	SCALE 3/8" = 1'-0"	DWG. NO. 8
CHECKED	L.E.A. R.E.		
TRACED	R.E.	DATE	FILE NO.
TRACING CHECKED			

FINAL CROSS-SECTIONS
GRASSY TRAIL RESERVOIR DAM
SHEET 2 OF 4 NOV. 1 19



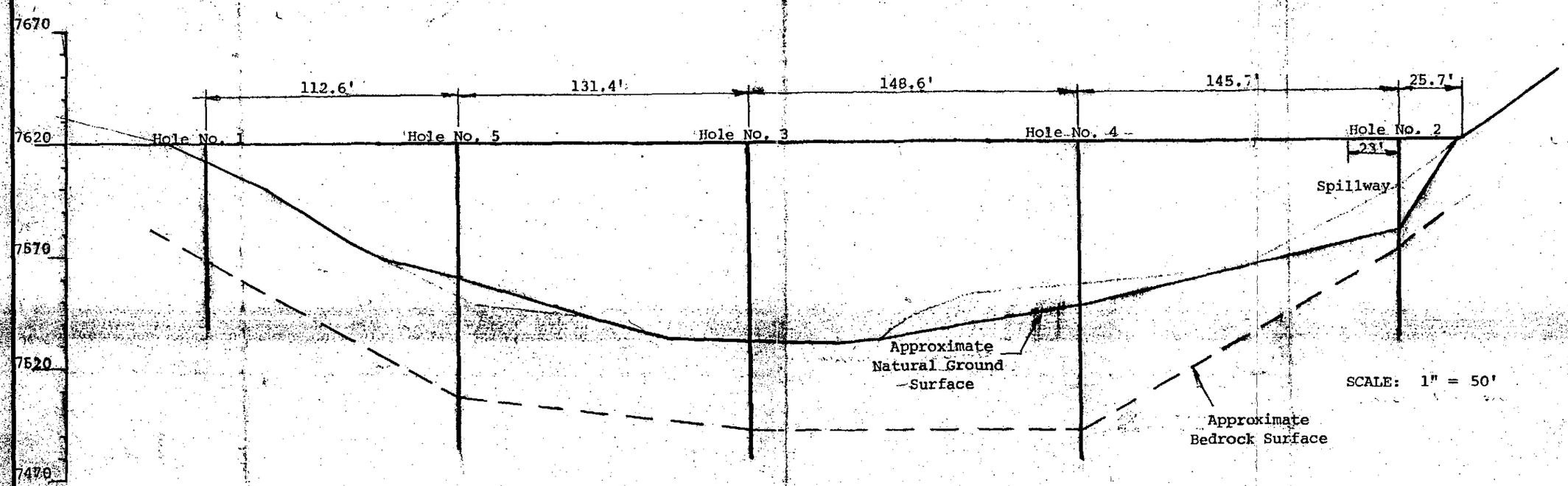
FINAL CROSS-SECTIONS
GRASSY TRAIL RESERVOIR DAM
SHEET 3 OF 4 NOV. 1, 1942
SCALE 1"=20'


6130
CUT OFF TRENCH
AREA = 0
1023.3
0
EMBANKMENT
AREA = 0
7640
6175
CUT OFF TRENCH
AREA = 3612 SQ. FT.
3540.4
490.6
7620
EMBANKMENT
AREA = 360 SQ. FT.
7600
CUT OFF TRENCH
AREA = 6046 SQ. FT.
7580
6130
3385.2
5481.5
7560
EMBANKMENT
AREA = 4960 SQ. FT.
7540
6100
CUT OFF TRENCH
AREA = 6092 SQ. FT.
3503.7
1248.5
7520
7500
EMBANKMENT
AREA = 5452 SQ. FT.
7480
CUT OFF TRENCH
AREA = 4128 SQ. FT.
7460
FINAL CROSS-SECTIONS
GRASSY TRAIL RESERVOIR DAM
SHEET 4 OF 4
NOV. 1, 1952

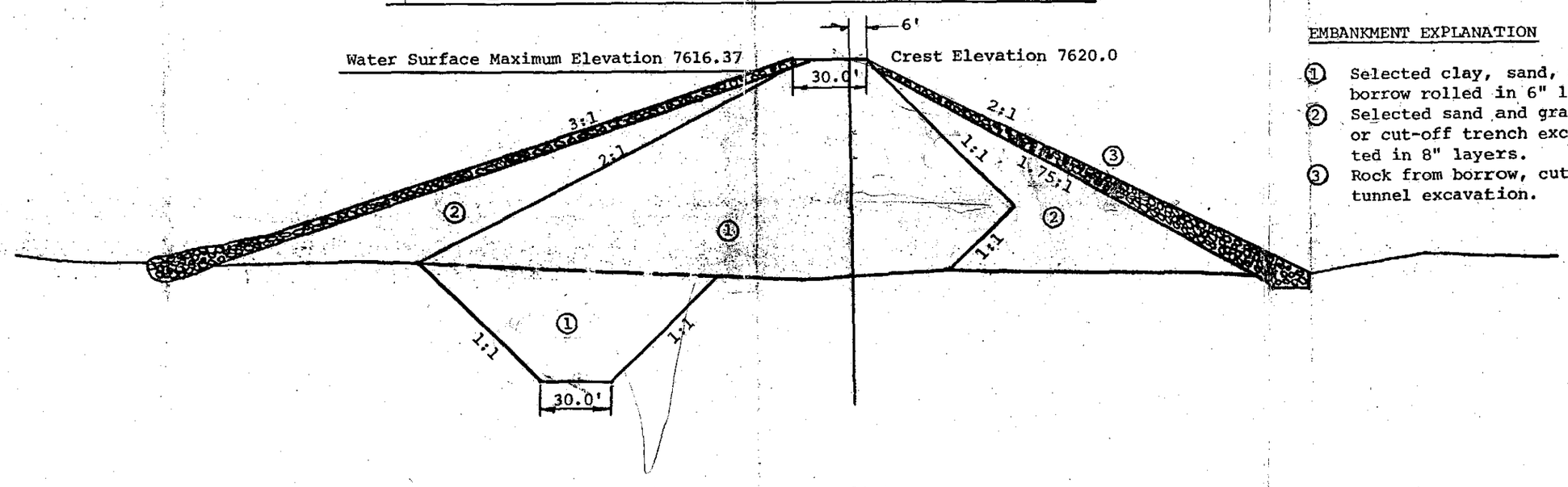

MAIN TUNNEL
Crest of Dam
TEMPLETON AND LINKE CONSULTING ENGINEERS
410 DOOLY BUILDING SALT LAKE CITY UTAH
FOUNDATION GROUTING
GRASSY TRAIL DAM
DRAWN W.C.
CHECKED W.T.
TRACED
TRACING CHECKED W.T.
APPROVED W.T.
SCALE
DATE
JULY 25, 1952
DWG. NO.
FILE NO.

MAIN TUNNEL
LEGEND
GROUT HOLE THROUGH TUNNEL WALL
GROUT HOLE THROUGH TUNNEL ROD

1979 Dam Safety Study



PROFILE OF DAM ALONG CENTER LINE OF TEST BORINGS



MAXIMUM SECTION

EMBANKMENT EXPLANATION

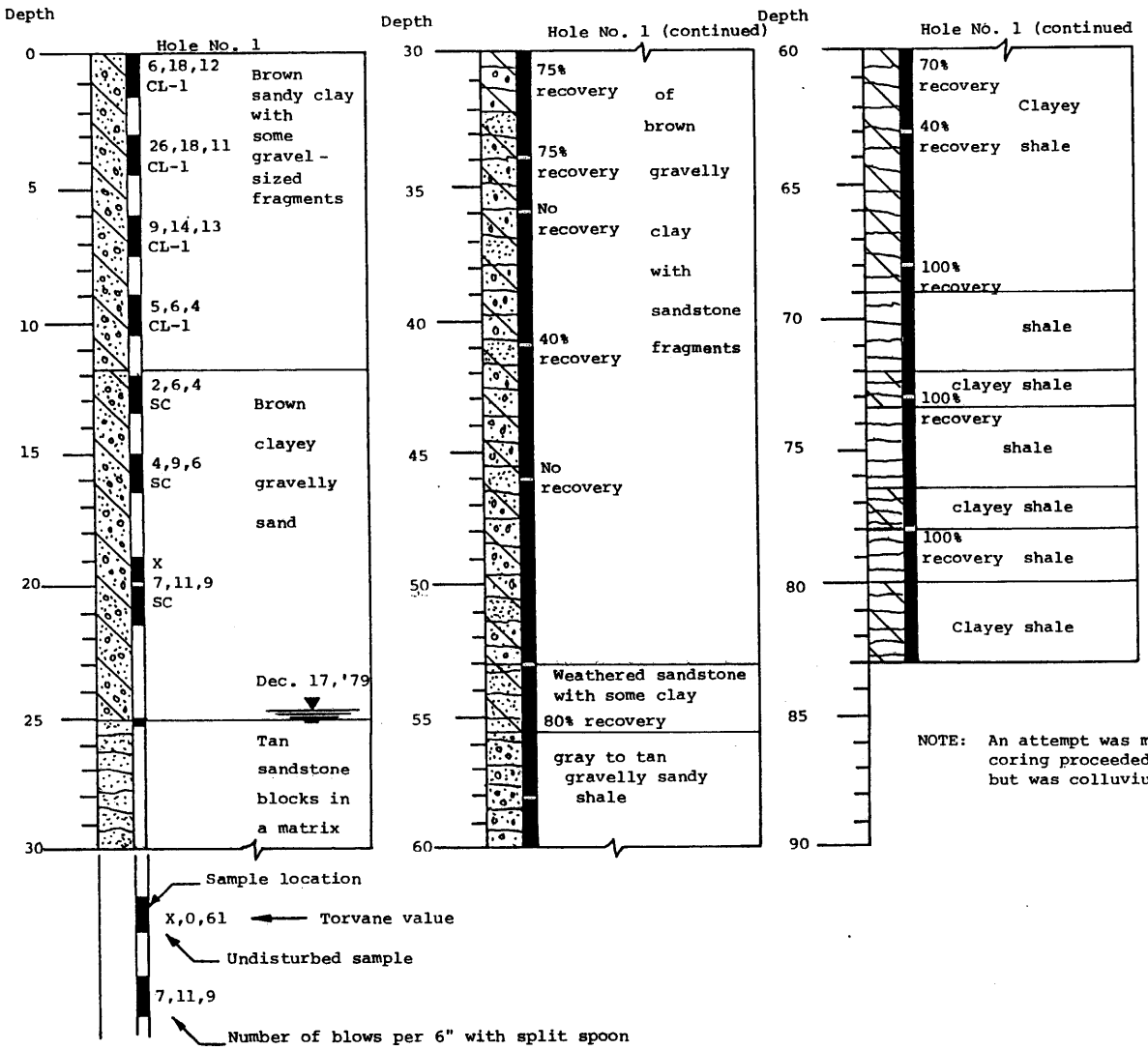
① Selected clay, sand, and gravel from borrow rolled in 6" layers.
② Selected sand and gravel from borrow or cut-off trench excavation compacted in 8" layers.
③ Rock from borrow, cut-off trench or tunnel excavation.

SCALE		
DESIGNED	CHECKED	
DRAWN	DATE	
APPROVED	LICENSE NO.	

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

MAXIMUM SECTION THROUGH DAM BASED ON THE DESIGN DRAWINGS AND PROFILE ALONG AXIS OF DAM AS DETERMINED BY THE TEST BORINGS SHOWN. GRASSY TRAILS CREEK DAM AND RESERVOIR

Figure No. 5



PERMEABILITY DATA

From	To	Permeability (feet/year)
0'	10'	490
10'	20'	4900
30'	40'	1145
41'	53'	876
53'	63'	64
63'	73'	35
73'	83'	11

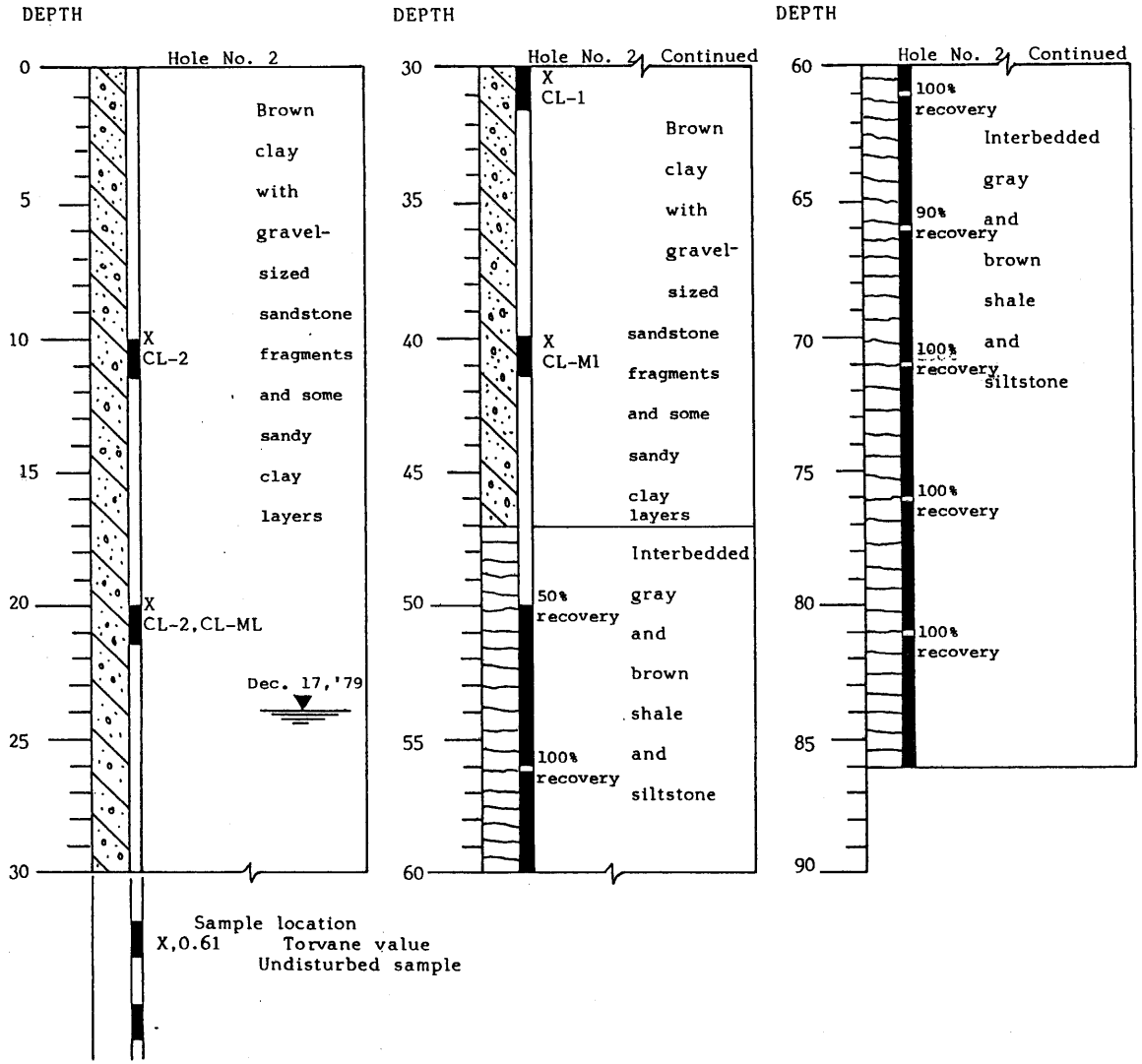
NOTE: An attempt was made to core the sandstone encountered at 25 feet. As coring proceeded it became apparent that this material was not bedrock, but was colluvium to a depth of 53 feet where the weathered bedrock exists.

SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 1 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 7



PERMEABILITY DATA

FROM	TO	PERMEABILITY (feet/year)
0'	10'	980
10'	20'	980
20'	30'	NML
30'	40'	NML
40'	50'	196
50'	61'	232
60'	71'	160
70'	81'	43
75'	86'	NML

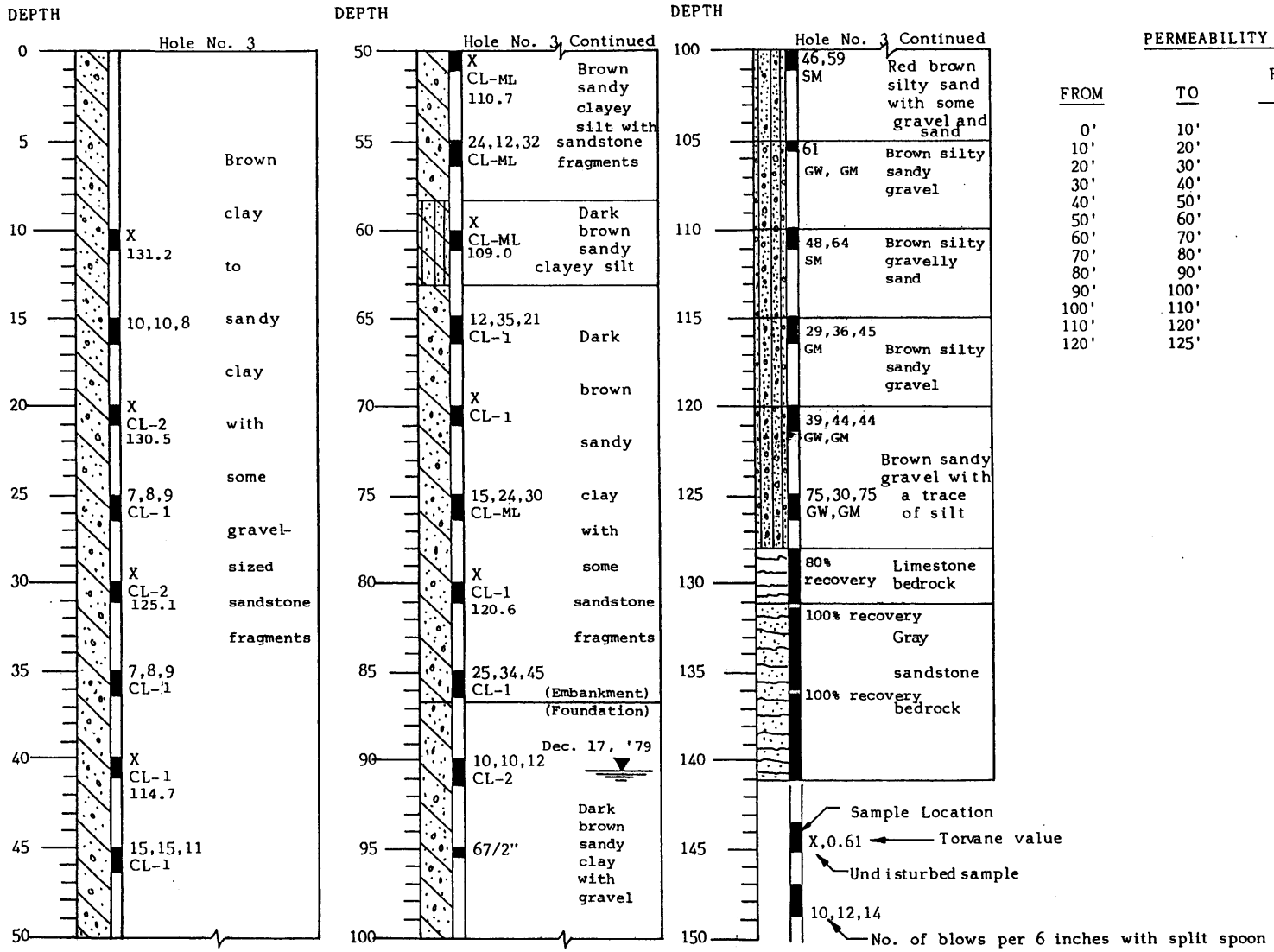
SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 2 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 8

Bruning "500"



PERMEABILITY DATA

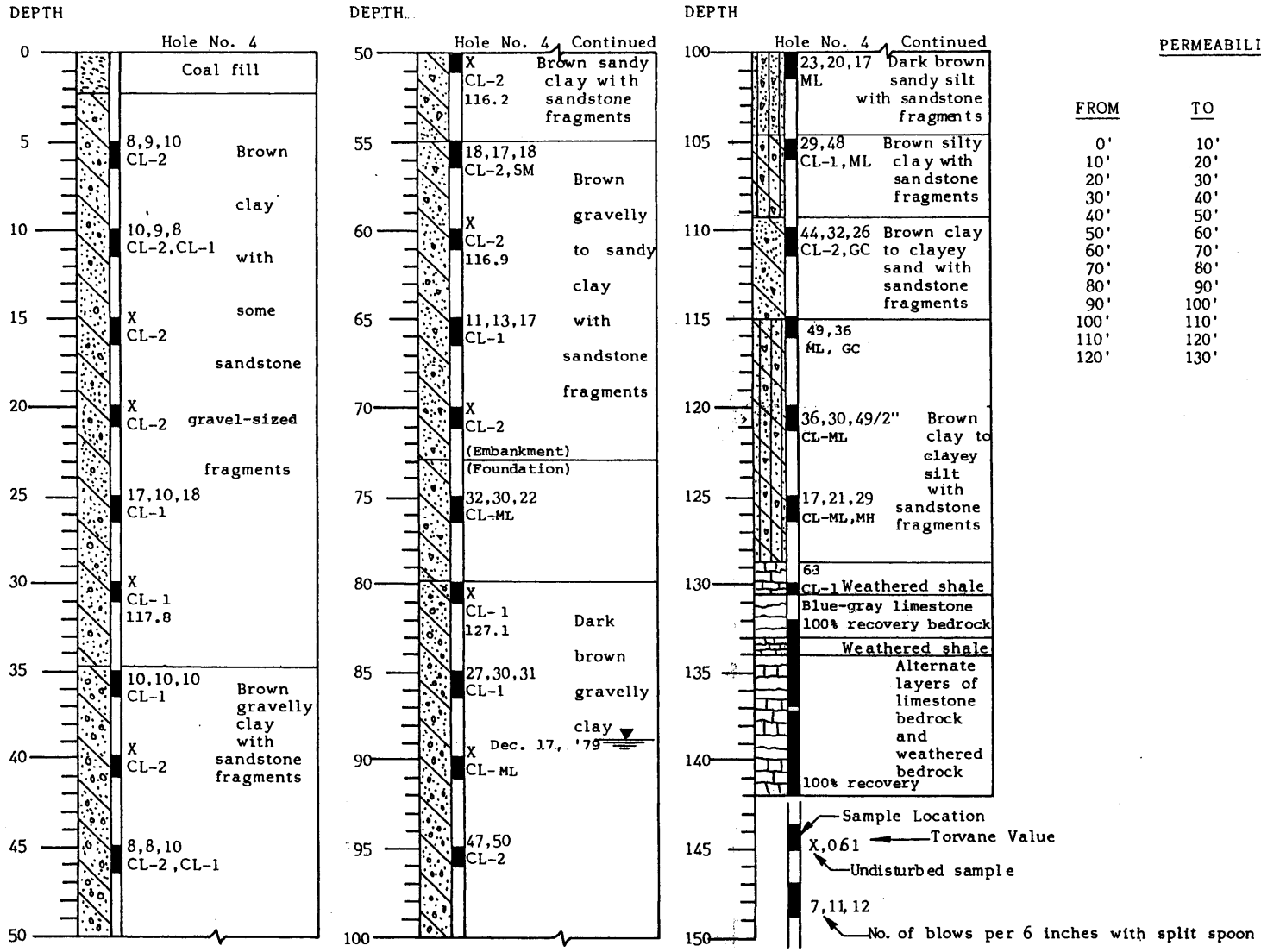
FROM	TO	PERMEABILITY (feet/year)
0'	10'	136
10'	20'	31
20'	30'	21
30'	40'	44
40'	50'	109
50'	60'	167
60'	70'	32
70'	80'	0
80'	90'	2,042
90'	100'	1,925
100'	110'	1,838
110'	120'	729
120'	125'	1,952

SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 3 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 9



PERMEABILITY DATA

FROM	TO	PERMEABILITY (feet/year)
0'	10'	9,800
10'	20'	2,123
20'	30'	980
30'	40'	382
40'	50'	251
50'	60'	314
60'	70'	161
70'	80'	
80'	90'	108
90'	100'	80
100'	110'	1,546
110'	120'	1,167
120'	130'	1,137

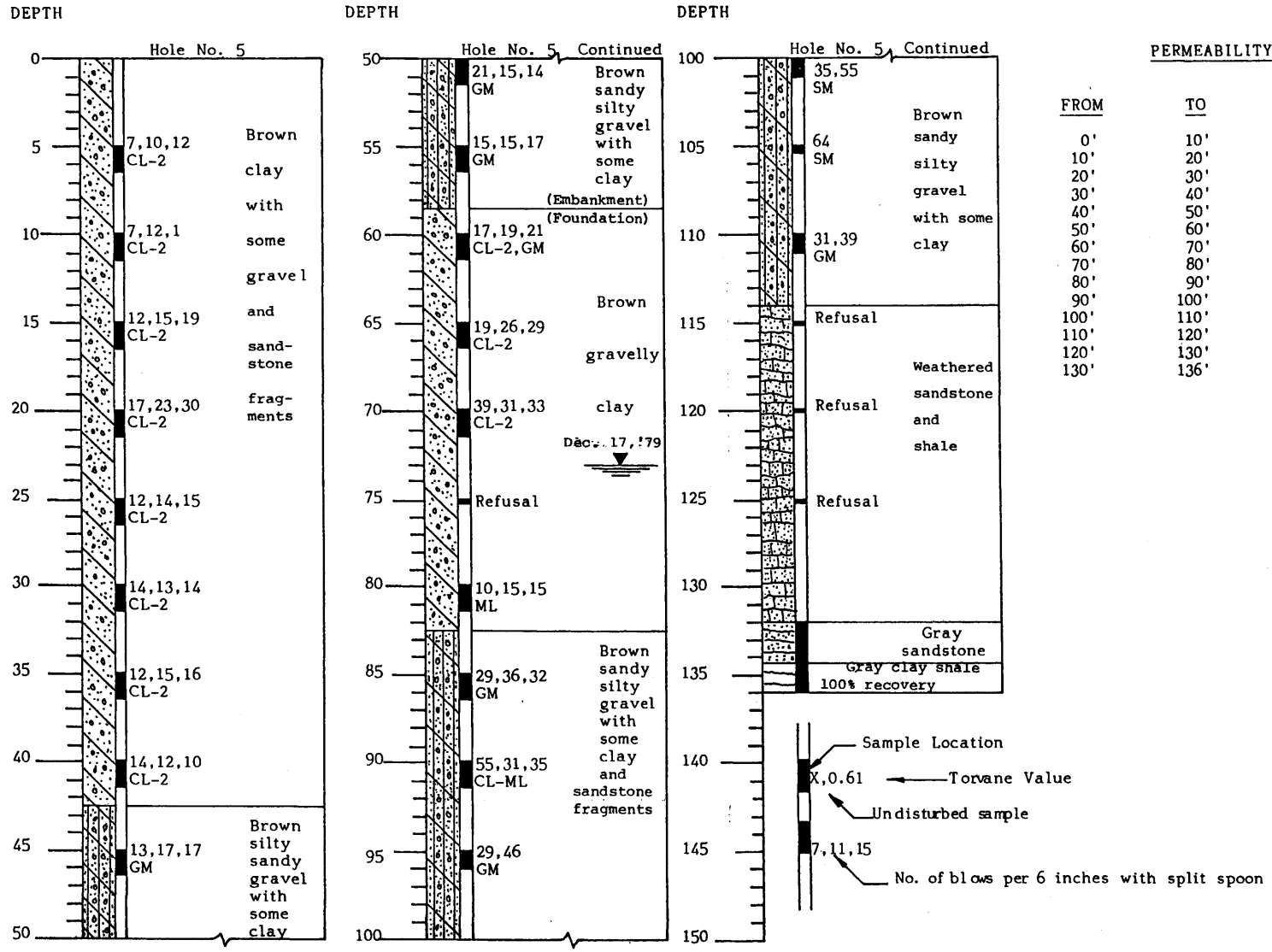
SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 4 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 10

Bruning "500"



PERMEABILITY DATA

FROM	TO	PERMEABILITY (feet/year)
0'	10'	113
10'	20'	754
20'	30'	392
30'	40'	200
40'	50'	344
50'	60'	275
60'	70'	397
70'	80'	594
80'	90'	274
90'	100'	1,099
100'	110'	1,722
110'	120'	1,633
120'	130'	170
130'	136'	3,665

SCALE
DESIGNED CHECKED
DRAWN DATE
APPROVED LICENSE NO.

ROLLINS, BROWN & GUNNELL, Inc.
CONSULTING ENGINEERS

BORING LOGS FOR TEST HOLE NO. 5 - GRASSY TRAIL CREEK DAM AND RESERVOIR

Figure No. 11

Bruning "500"

TABLE I SUMMARY OF TEST DATA

PROJECT Grassy Trails FEATURE _____ LOCATION _____

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRA. BLOWS PER FT.	IN-PLACE			UNCONFINED COMPRESSIVE STRENGTH LB/FT²	FRICTION ANGLE φ	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			SOIL CLASSIFICATION UNIFIED SYSTEM
			UNIT WEIGHT LB/FT³	MOISTURE PERCENT	VOID RATIO			L.L. %	P.L. %	P.I. %	% GRAVEL	% SAND	% SILT & CLAY	
3	10-11	Shelby	131.2	11.4				28.4	17.8	10.6				CL-1
	20-21	Shelby	130.5	14.0				31.8	15.3	16.5				Triaxial Set 3 # 1 CL-2
	21-21	Shelby						27.1	14.7	12.4				CL-1
	25-26.5	17						24.1	14.8	9.3				CL-1
	30-31	Shelby	125.1	12.1				32.7	16.9	15.8				CL-2
	35-36.5	17						25.1	14.8	10.2				CL-1
	40-41	Shelby	114.7	12.4				29.8	18.8	11.0				CL-1
	45-46.5	26						30.5	16.5	14.0				CL-1
	50-51	Shelby	110.7	15.6				23.6	17.7	5.9				CL-ML
	55-56.5	53						20.3	16.9	3.4				ML
	60-61.5	Shelby	109.0	10.0				22.4	17.2	5.2				CL-ML
	65-66.5	61						23.7	15.9	7.8				CL-1

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

TABLE I SUMMARY OF TEST DATA (continued)

PROJECT Grassy Trails FEATURE _____ LOCATION _____

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRA. BLOWS PER FT.	IN-PLACE			UNCONFINED COMPRESSIVE STRENGTH LB/FT²	FRICTION ANGLE φ	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			SOIL CLASSIFICATION UNIFIED SYSTEM
			UNIT WEIGHT LB/FT³	MOISTURE PERCENT	VOID RATIO			L.L. %	P.L. %	P.I. %	% GRAVEL	% SAND	% SILT & CLAY	
3	70-71	Shelby						24.6	14.8	9.8				CL-1
	75-76.5	54						22.5	16.7	5.8				CL-ML
	80-81	Shelby	120.6	13.9				25.0	16.4	8.6				CL-1
	90-91.5	22						28.8	19.4	9.4				CL-1
	100-101	105									25.5	51.7	22.8	SM
	105-105.5	61/5"									80.0	13.9	6.1	GW-GM
	110-111	112									33.6	51.9	14.5	SM
	115-116.5	81									49.7	33.8	16.5	GM
	120-125	88									54.3	34.2	11.5	GW-GM
	125-125.75	75/5"									63.7	28.6	7.7	GW-GM
4	5-6.5	19						28.4	15.9	12.5				CL-1
4	10-11.5	Shelby						28.1	16.4	11.7				CL-1

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

TABLE II SUMMARY OF TEST DATA (continued)

PROJECT Grassy Trails FEATURE _____ LOCATION _____

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRA. BLOWS PER FT.	IN-PLACE			UNCONFINED COMPRESSIVE STRENGTH LB/FT²	FRICTION ANGLE φ	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			SOIL CLASSIFICATION UNIFIED SYSTEM
			UNIT WEIGHT LB/FT³	MOISTURE PERCENT	VOID RATIO			L.L. %	P.L. %	P.I. %	% GRAVEL	% SAND	% SILT & CLAY	
	25-26.5	28						22.1	15.0	7.1				CL-1
	30-31	Shelby	117.8	16.9				27.5	16.2	11.3				CL-1
	35-36.5	20						22.7	15.1	7.6				CL-1
	45-46.5	18						28.8	16.3	12.5				CL-1
	50-51	Shelby	116.2	5.6				21.9	20.2	1.7				ML
	55-56.5	35						19.9	17.2	2.7				ML
	60-61	Shelby	116.9	10.7				21.2	18.9	2.3				ML
	65-66.5	30						25.2	16.1	9.1				CL-1
	75-76.5	42						21.9	16.9	5.0				CL-ML
	80-81	Shelby	127.1	11.8				27.4	18.4	9.0				CL-1
	90-91.5	Shelby						24.3	19.0	5.3				CL-ML
	95-96	97						44.8	19.3	25.5				CL-2

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

TABLE. I SUMMARY OF TEST DATA (continued)

PROJECT Grassy Trails FEATURE _____ LOCATION _____

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRA. BLOWS PER FT.	IN-PLACE			UNCONFINED COMPRESSIVE STRENGTH LB/FT²	FRICTION ANGLE φ	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			SOIL CLASSIFICATION UNIFIED SYSTEM
			UNIT WEIGHT LB/FT³	MOISTURE PERCENT	VOID RATIO			L.L. %	P.L. %	P.I. %	% GRAVEL	% SAND	% SILT & CLAY	
4	105-106.5	77						25.9	16.2	9.7				CL-1
	110-111.8	58									56.2	27.8	16.0	GC
	115-116	85						20.2	16.3	3.9				ML
	120-121.2	109						22.0	16.3	5.7				CL-ML
	125-126	50						22.6	15.2	7.4				CL-ML
	130-130.5	65/6						30.6	17.2	13.4				CL-1

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

FIGURE 13 SOIL MOISTURE DENSITY RELATIONSHIP
ASTM D 698 - 70-C
MAXIMUM DENSITY 116.6 LBS. PER CU.FT.
OPTIMUM MOISTURE 14.3 %
PROJECT: Grassy Trails Creek Dam and Reservoir
LOCATION: Sunnyside, Utah

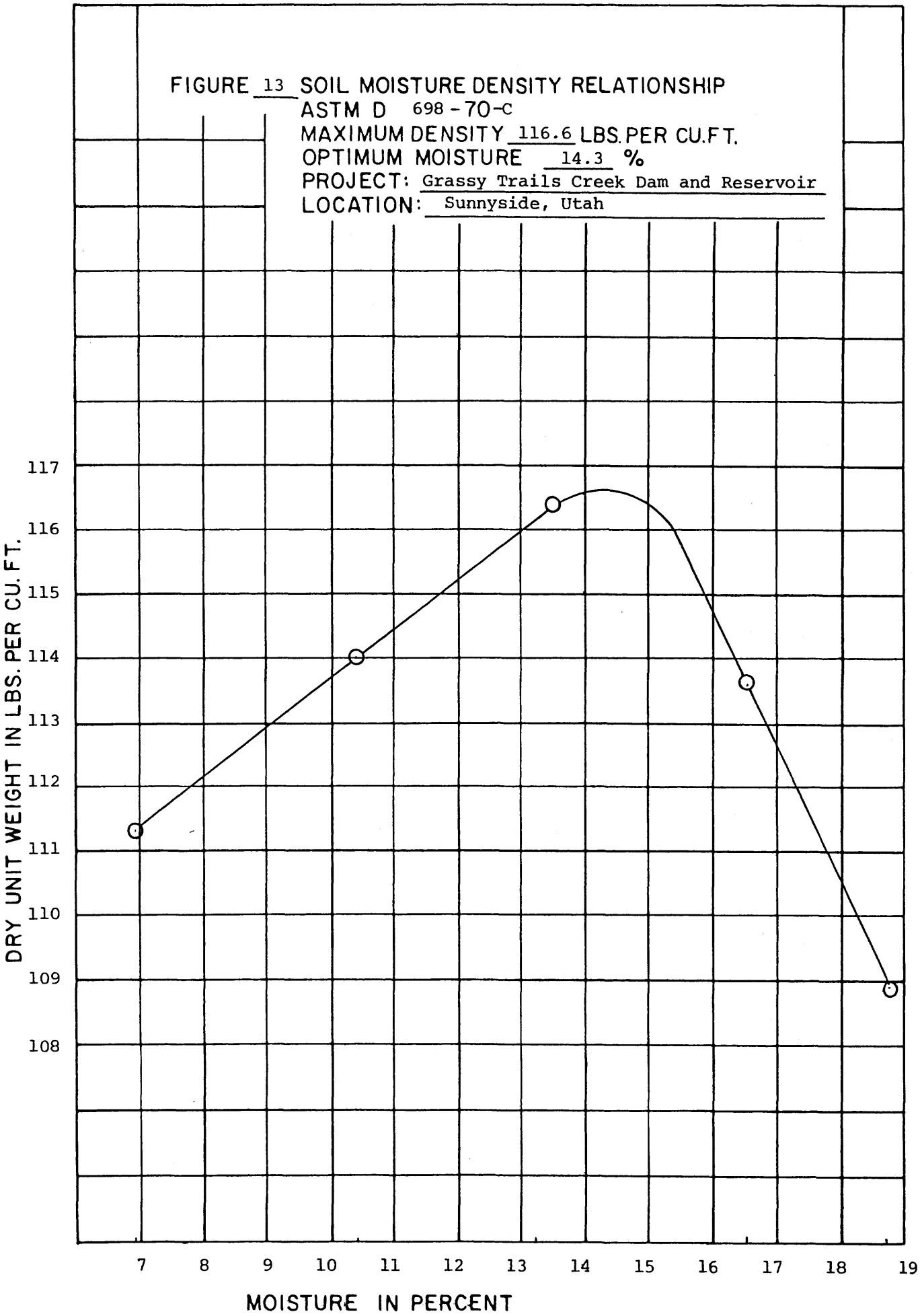
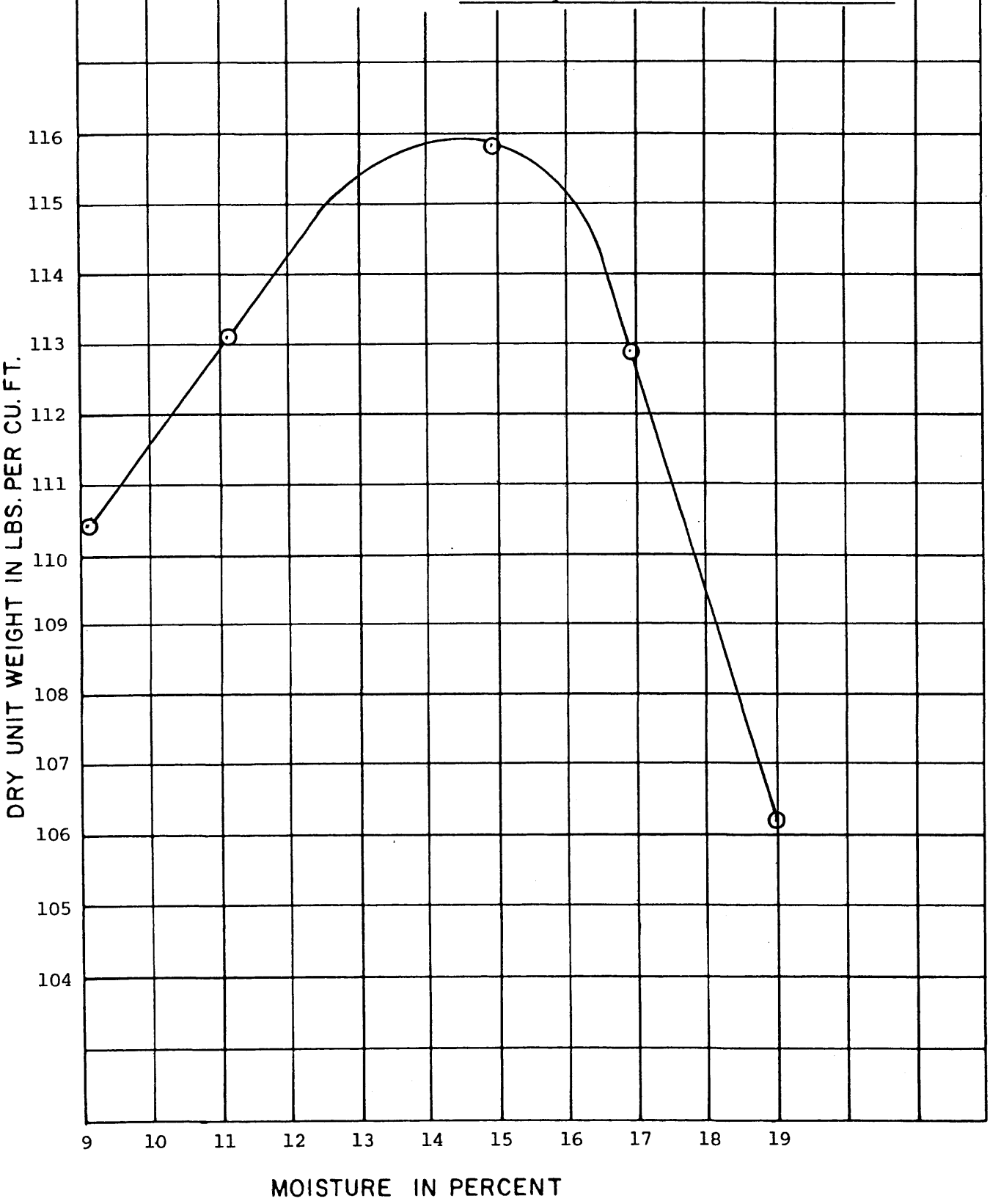


FIGURE 14 SOIL MOISTURE DENSITY RELATIONSHIP
ASTM D 698-70-C
MAXIMUM DENSITY 115.9 LBS. PER CU.FT.
OPTIMUM MOISTURE 14.5 %
PROJECT: Grassy Trails Creek Dam and Reservoir
LOCATION: Sunnyside, Utah



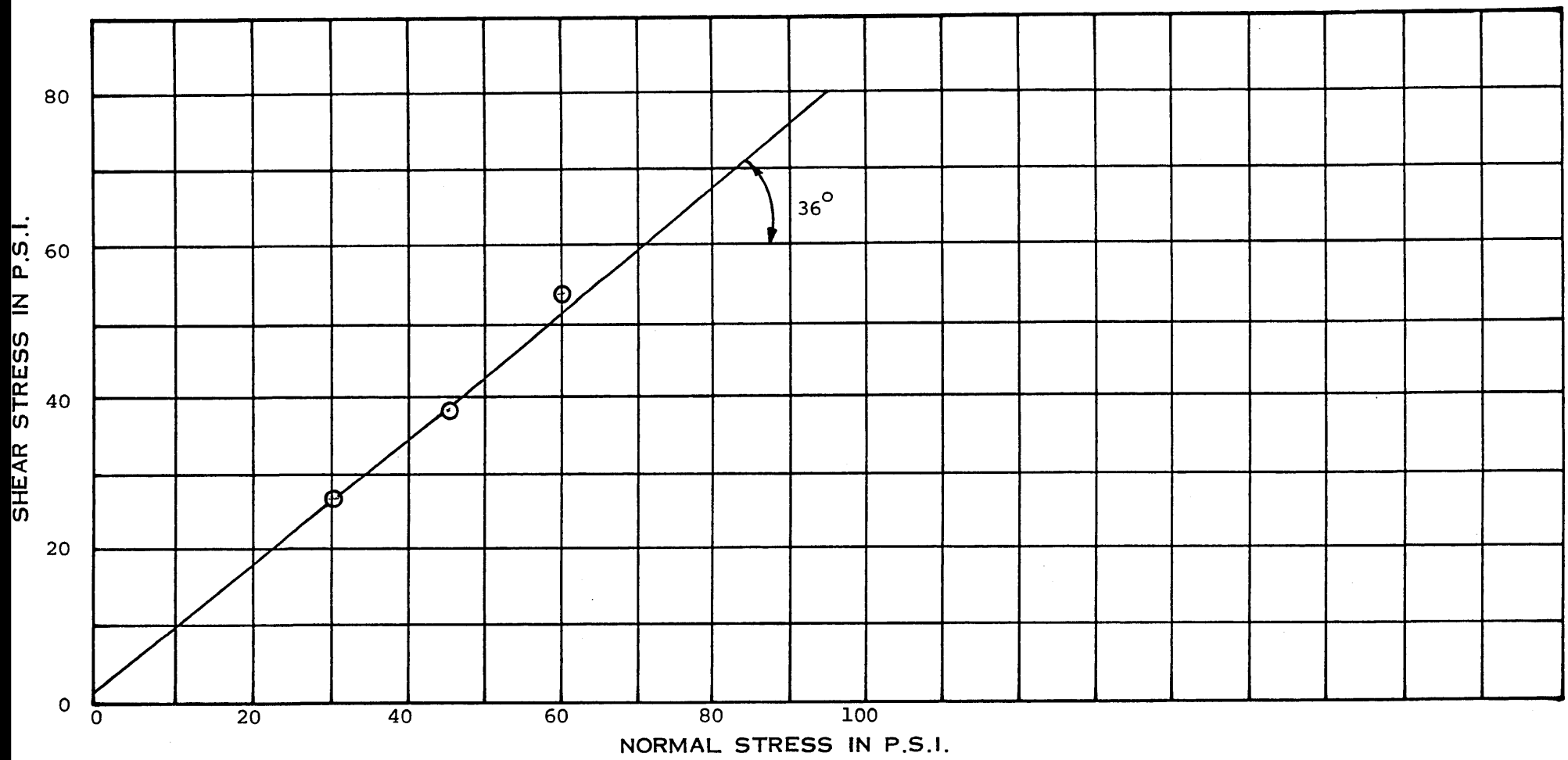


FIGURE 15 SHEAR TEST RESULTS

TYPE OF TEST Consolidated Drained - Direct Shear

Hole No. 3 DEPTH 30 - 50

Sample Density: 30' γ_{dry} = 125.1 pcf w = 12.1%

40' γ_{dry} = 114.7 pcf w = 12.4%

50' γ_{dry} = 110.7 pcf w = 13.6%

PROJECT Grassy Trails Creek Dam and Reservoir

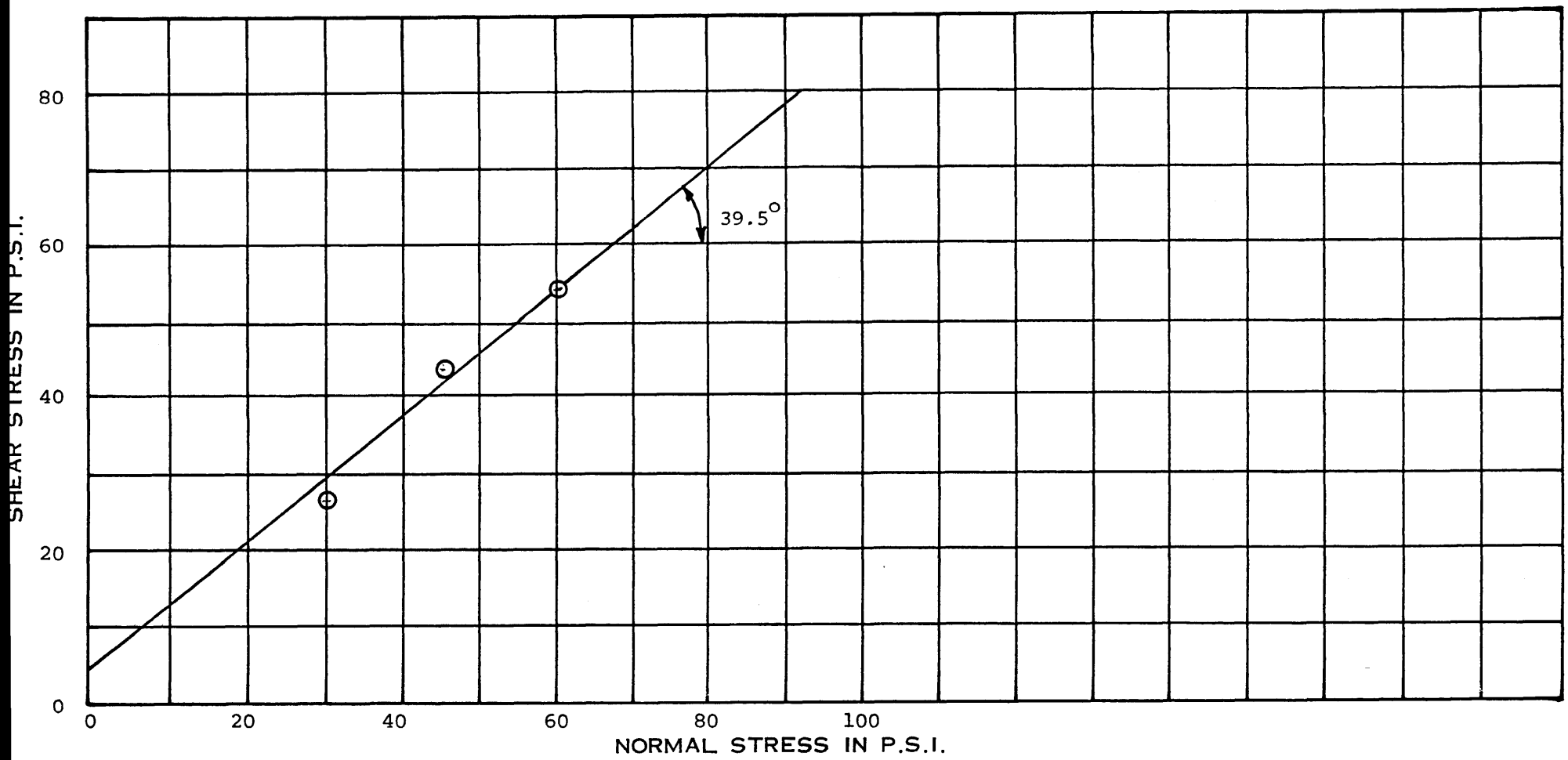


FIGURE 16 SHEAR TEST RESULTS

TYPE OF TEST Consolidated Drained - Direct Shear

Hole No. 3 DEPTH 50' - 70'

Sample Density: 50' γ_{dry} = 110.7 pcf w = 15.6%

60' γ_{dry} = 109.0 pcf w = 10.0%

PROJECT Grassy Trails Creek Dam and Reservoir

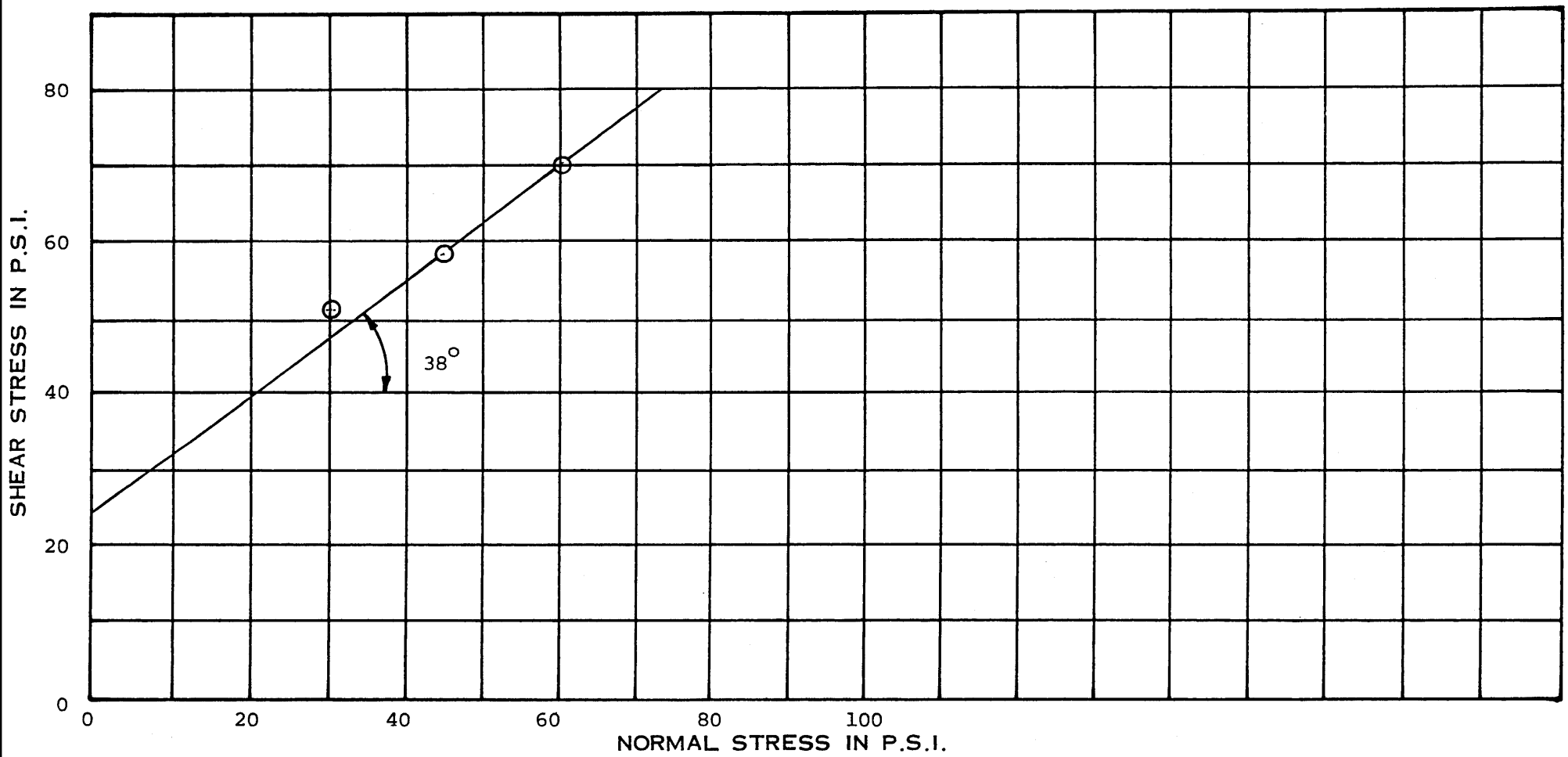


FIGURE 17 SHEAR TEST RESULTS

TYPE OF TEST Consolidated Drained - Direct Shear

Hole No. 3 DEPTH 70' - 90'

Sample Density: 80' γ_{dry} = 120.6 pcf w = 13.9%

PROJECT Grassy Trails Creek Dam and Reservoir

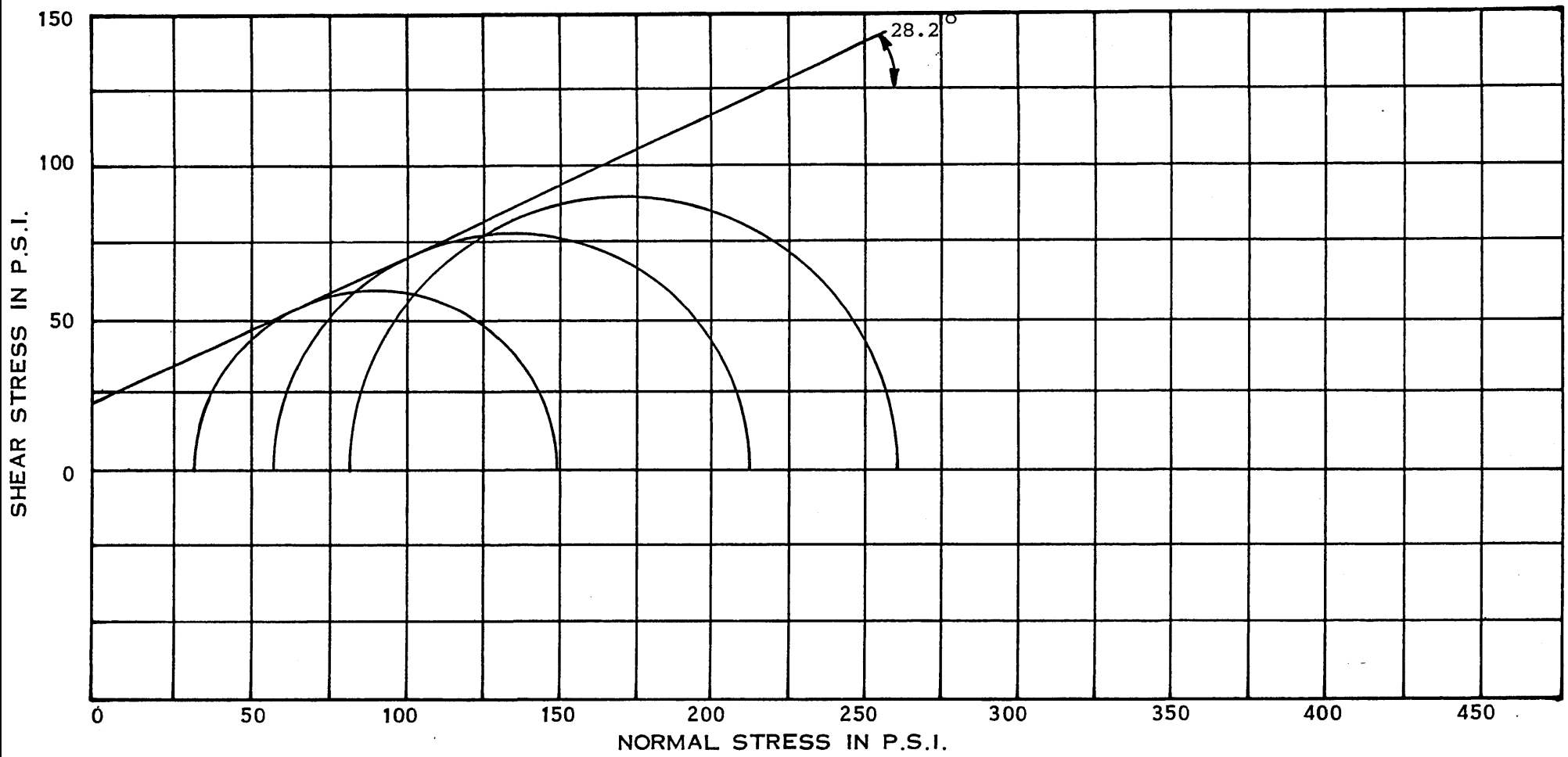


FIGURE 18 SHEAR TEST RESULTS

TYPE OF TEST Consolidated Undrained - Triaxial

Hole No. 3 DEPTH 0' - 20'

Sample Density: 10' γ_{dry} = 131.2 pcf w = 11.4%

20' γ_{dry} = 130.5 pcf w = 14.0%

PROJECT Grassy Trails Creek Dam and Reservoir

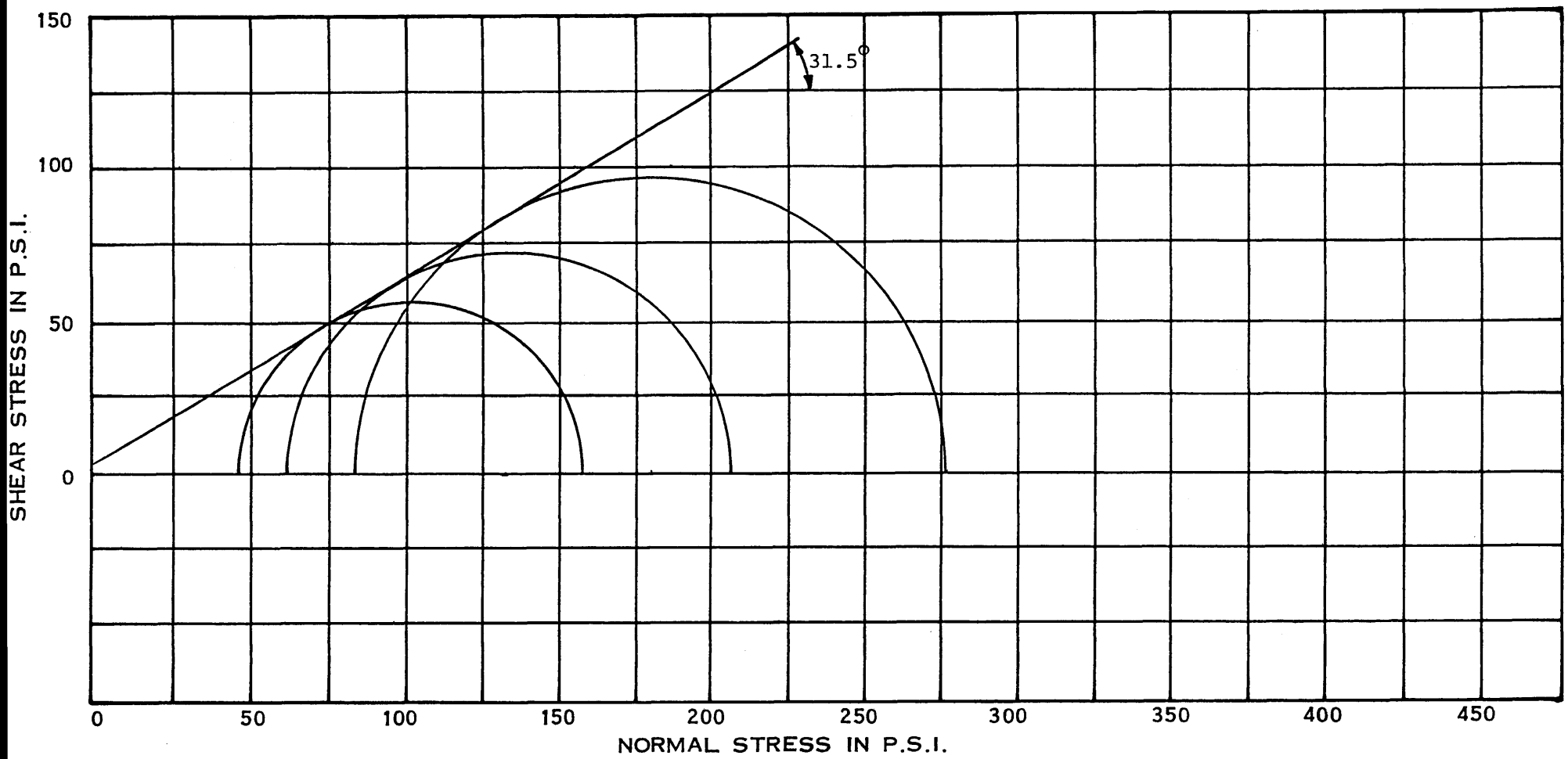


FIGURE 19 SHEAR TEST RESULTS

TYPE OF TEST Consolidated Undrained - Triaxial

Hole No. 3 DEPTH 30' - 50'

Sample Density: 30' γ_{dry} = 125.0 pcf w = 12.1%

40' γ_{dry} = 114.7 pcf w = 12.4%

50' γ_{dry} = 110.7 pcf w = 15.6%

PROJECT Grassy Trails Creek Dam and Reservoir

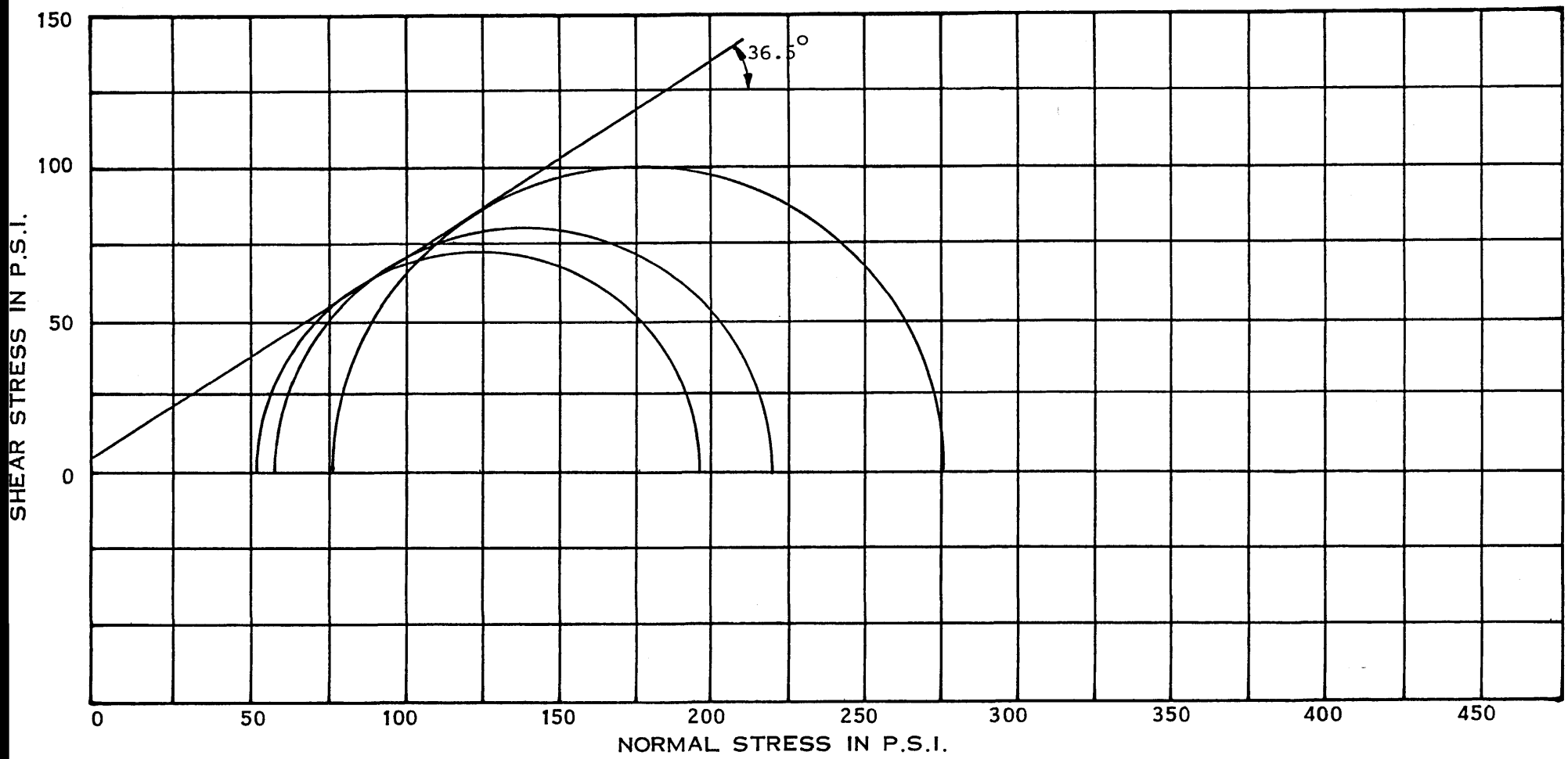


FIGURE 20 SHEAR TEST RESULTS

TYPE OF TEST Consolidated Undrained - Triaxial

Hole No. 4 DEPTH 70' - 90'

Sample Density: 80' γ_{dry} = 127.1 pcf w = 11.8%

PROJECT Grassy Trails Creek Dam and Reservoir

1998 Phase II Instrumentation

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-1 Inclinometer No. 1 Sheet 1 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	
Boring Depth (ft.): 110 / Elev: 7599.5'	Driller: B. HARTLEY	Starting Date: 3/13/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 47.5', ROTARY WASH N.W. CASING TO 99', N.Q. CORE		Ending Date: 3/16/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 1	Comments
						Coal Dust		Slope Indicator Pipe
7595	5							Low Strength Cement Grout
				CL-2	20,9,7			
7590	10							
7585	15					Reddish-Brown Sandy Clay W/Gravel (Fill)		
				CL-2	7,8,14			
7580	20							
7575	25							
				X	Pushed			
7570	30							
7565	35							
				CL-2	7,12,15	Reddish-Brown Gravelly Clay (Fill)		
7560	40							
7555	45							
				CL-2	7,8,11	Embankment Foundation		
7550								

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-1 Inclinometer No. 1 Sheet 2 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	

Boring Depth (ft.): 110	Elev: 7599.5'	Driller: B. HARTLEY	Starting Date: 3/13/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 47.5', ROTARY WASH N.W. CASING TO 99', N.Q. CORE			Ending Date: 3/16/98

Elev. (Feet)	Depth (Feet)	Lithology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 1	Comments
						Dark Gray Sandy Clay (Natural)		Slope Indicator Pipe
7545	55			CL-1	51,56/4.5"	Dark Brown Clayey Gravel		Low Strength Cement Grout
7540	60							
7535	65			CL-2	14,17,18			
7530	70					Gray-Brown Sandy Clay W/Gravel and Sandstone Cobbles		
7525	75			CL-2	9,17,21			
7520	80							
7515	85			CL-2	8,23,29			
7510	90							
7505	95			X	Pushed	Purplish-Brown W/Yellow and Brown Weathered Shale		
7500								

LEGEND

- 2,3,2 ← Blow Count per 6"
- 0.45 ← Torvane (tsf)
- Disturbed Sample
- Core 100,60 ← Rock Quality Designation (RQD)
- Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-1 Inclinometer No. 1 Sheet 3 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	

Boring Depth (ft.): 110	Elev: 7599.5'	Driller: B. HARTLEY	Starting Date: 3/13/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 47.5', ROTARY WASH N.W. CASING TO 99', N.Q. CORE			Ending Date: 3/16/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 1	Comments
					CORE 100,51	Bedrock		Slope Indicator Pipe
						Greenish-Gray Calcareous Mudstone to Siltstone		
7495	105				CORE 100,86	Greenish-Gray Weakly Calcareous Mudstone to Siltstone W/Purplish-Brown Mudstone Layers		Low Strength Cement Grout
					CORE 100,100			Inclinometer #1
7490	110				CORE 100,83			
7485	115							
7480	120							
7475	125							
7470	130							
7465	135							
7460	140							
7455	145							
7450								

LEGEND

- 2,3,2 ← Blow Count per 6"
- 0.45 ← Torvane (tsf)
- Disturbed Sample
- Core 100,60 ← Rock Quality Designation (RQD)
- Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-2 Piezometer No. 5 Sheet 1 of 1
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	
Boring Depth (ft.): 26.5 / Elev: 7527.0'	Driller: B. HARTLEY	Starting Date: 3/19/98
Equip./Drill Method: CME-55 / ROTARY WASH N.W. CASING		Ending Date: 3/19/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7525						Brown Clay W/Gravel		Cement Grout
	5			SM CL-1	16,9,7	Yellow Soft Silty Sandstone Cobble		
7520						Dark Brown Sandy Clay		
	10			CL-2	4,7,7	Dark Brown Clayey Sand to Sandy Clay W/Gravel and Cobbles		Bentonite Seal
7515								
	15			SP-SM	12,19,20	Cobbles W/Silty Sand and Clay		
7510								
	20			SP-GP	13,13,6	100% Water Loss — Weathered Sandstone Cobbles W/Clay Matrix		
7505								Sand
	25			CL-2	5,4,3	Brown Sandy Clay W/Gravel and Sandstone Cobbles		Piezometer #5 Sluff
7500								

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-3 Piezometer No. 2 & No. 3 Sheet 1 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, V.N.B.	
Boring Depth (ft.): 116.5 / Elev: 7600.3'	Driller: B. HARTLEY	Starting Date: 3/3/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 80', ROTARY WASH N.W. CASING		Ending Date: 3/15/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7600						Coal Fill		
7595	5					Reddish-Brown W/Greenish-Gray Sandy Lean Clay W/Gravel		
				CL-1	4,9,15			
7590	10							
7585	15							
				CL-1	9,7,4			
7580	20							
7575	25					Reddish-Brown Lean Clay W/Sand		
				CL-1	4,6,12 0.99+			
7570	30							
7565	35							Bentonite
				CL-1	1,4,8 0.99+			
7560	40							
7555	45					Reddish-Brown Sandy Lean Clay W/Gravel		
				CL-1	4,12,11			

LEGEND

- 2,3,2 ← Blow Count per 6"
- 0.45 ← Torvane (tsf)
- Disturbed Sample
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-3 Piezometer No. 2 & No. 3 Sheet 2 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, V.N.B.	
Boring Depth (ft.): 116.5 / Elev: 7600.3'	Driller: B. HARTLEY	Starting Date: 3/3/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 80', ROTARY WASH N.W. CASING		Ending Date: 3/15/98

Elev. (Feet)	Depth (Feet)	Lithology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7550								
7545	55		CL-1/ GC		16,14,19	Brown Gravelly Lean Clay W/Sand to Clayey Gravel W/Sand		
7540	60							
7535	65		CL-1		13,12,19	Dark Brown Sandy Lean Clay W/Gravel		
7530	70							Sand
7525	75		SC/ CL-1		12,17,13	Dark Brown-Black Clayey Sand W/Gravel to Sandy Lean Clay W/Gravel		Piezometer #2
7520	80							
7515	85		SC/ CL-1		7,11,14			
						Embankment Foundation		
7510	90					Brown Sandy Clay		Bentonite
7505	95		X CL-1		Pushed 6,6,12	Brown Silty Clayey Sand		
						Clay		

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-3 Piezometer No. 2 & No. 3 Sheet 3 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, V.N.B.	
Boring Depth (ft.): 116.5 / Elev: 7600.3'	Driller: B. HARTLEY	Starting Date: 3/3/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 80', ROTARY WASH N.W. CASING		Ending Date: 3/15/98

Elev. (Feet)	Depth (Feet)	Lithology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7500								
						Brown Sandy Clay		
7495	105			GC	6,28,13			
						Brown Clayey Gravel W/Sand		Sand Piezometer #3
7490	110			SC-SM	7,6,4			
						Brown Silty Clayey Sand		
7485	115			GM	13,14,27			
						Brown Silty Gravel W/Sand		
7480	120							
7475	125							
7470	130							
7465	135							
7460	140							
7455	145							

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM		Project Number: 9712.000	Boring No.: 98-4 Piezometer No. 6 Sheet 1 of 1
Client: CREAMER & NOBLE ENGINEERS		Logged By: M. HANSEN, V.N.B.	
Boring Depth (ft.): 36.5	Elev: 7510.4'	Driller: B. HARTLEY	Starting Date: 3/20/98
Equip./Drill Method: CME-55 / ROTARY WASH N.W. CASING			Ending Date: 3/20/98

Elev. (Feet)	Depth (Feet)	Lithology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7510						Dark Brown Gravelly Clay W/Cobbles		Cement Grout
7505	5			SM-GM	17,22,16	Dark Brown Silty Gravelly Sand W/Clay and Some Cobbles		
						Clay		
7500	10			GC	10,6,7			
7495	15			GC	17,19,19	Dark Brown Clayey Sandy Gravel W/Cobbles		Bentonite
7490	20			GP-GC CL-2	11,7,4	Sandstone Boulder Clayey Sandy Gravel Dark Gray Clay Clayey Sandy Gravel		
7485	25			CL-1	3/12",2	Dark Brown Clay W/Silty Sand Lenses		Sand
7480	30			CL-2 /SM	6,3,3	Red-Brown Sandy Clay W/Silty Sand Layers		Piezometer #6
						Sandstone Boulder		
7475	35			GP-GM	10,19,22	Brown Silty Sandy Gravel W/Clay		Sluff
7470	40							
7465	45							

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-5 Inclinometer No. 3 Sheet 1 of 2
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	

Boring Depth (ft.): 54	Elev: 7601.4'	Driller: B. HARTLEY	Starting Date: 3/18/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 5', ROTARY WASH N.W. CASING TO 10', N.Q. CORE			Ending Date: 3/18/98

Elev. (Feet)	Depth (Feet)	Lithology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 3	Comments
7600						Reddish-Brown Sandy Clay W/Gravel		Slope Indicator Pipe
				CL-1	5,9,14			
	5							Low Strength Cement Grout
7595						Bedrock		
	10			CL-2	37,61/5"	Interbedded Light Green and Reddish-Brown Weathered Mudstone (Shale) W/Some Interbedded Gravel		
7590					CORE 97,60			
	15							
7585					CORE 80,38			
	20							
7580					CORE 94,62	Light Green Fractured Mudstone		
	25							
7575					CORE 100,82			
	30					Blue-Gray Mudstone to Claystone W/Some Brown Layers		
7570					CORE 100,89			
	35					Very Soft Mudstone		
7565					CORE 100,72	Dark Red-Brown Shaley Mudstone		
	40							
7560					CORE 99,76	Blue-Gray Mudstone to Siltstone		
	45					Yellow-Greenish-Brown Sandstone W/Some Fractures		
7555					CORE 100,86			

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-5 Inclinometer No. 3 Sheet 2 of 2
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	

Boring Depth (ft.): 54	Elev: 7601.4'	Driller: B. HARTLEY	Starting Date: 3/18/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 5', ROTARY WASH N.W. CASING TO 10', N.Q. CORE			Ending Date: 3/18/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 3	Comments
7550					CORE 100,70	100% Water Loss Yellow-Grayish-Brown Sandstone W/Fractures		Inclinometer #3 Low Strength Cement Grout Sluff
7545	55							
7540	60							
7535	65							
7530	70							
7525	75							
7520	80							
7515	85							
7510	90							
7505	95							

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-6 Piezometer No. 7 Sheet 1 of 1
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. HANSEN, V.N.B.	
Boring Depth (ft.): 41.5 / Elev: 7518.0'	Driller: B. HARTLEY	Starting Date: 3/23/98
Equip./Drill Method: CME-55 / N.W. CASING		Ending Date: 3/23/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Well Detail	Comments
7515						Dark Brown Sandy Clay		Cement Grout
	5			CL-1	4,5,6			
7510								
	10			X	Pushed	Dark Brown Silty Fine Sand W/Some Clay Layers		Bentonite
				SM	4,4,3			
7505								
	15			SM	3,3,4			
7500								
	20			CL-2	1/24"	Dark Brown Sandy Clay		Sand
7495								Piezometer #7
	25			CL-1	1,1,1			
				SM		Dark Brown Silty Sand		Bentonite
7490								
	30			CL-1	0/9", 2/9"	Dark Brown Sandy Clay		
						Sandy Clay W/Gravel		
7485								
	35			GC	7,9,8	Brown Sandy Clayey Gravel		Sand
7480						Brown Silty Sandy Gravel		
	40			GM	5,13,17			
7475								
	45							
7470								

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-7 Inclinometer No. 2 Sheet 1 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, M. HANSEN, V.N.B.	
Boring Depth (ft.): 132.4 / Elev: 7600.2'	Driller: B. HARTLEY	Starting Date: 3/5/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 49', N.Q. CORE TO 58', ROTARY WASH TO 120', N.Q. CORE		Ending Date: 3/11/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 2	Comments
7600								Slope Indicator Pipe
7595	5							Low Strength Cement Grout
				CL-1	7,6,4	Reddish-Brown Sandy Lean Clay W/Gravel		
7590	10							
7585	15							
				CL-1	8,9,10			
7580	20							
						Boulder		
7575	25					Reddish-Brown Sandy Lean Clay W/Gravel		
				X, CL-1	Pushed 0.75			
				SP-SM	26,13,12	Brown Sandstone		
7570	30					Brown Sandy Clay W/Gravel		
7565	35							
				CL-2	6,7,10			
7560	40							
7555	45					Tan Sandstone Sand W/Gravel and Cobbles		
				SP	21,36,39			

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-7 Inclinometer No. 2 Sheet 2 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, M. HANSEN, V.N.B.	
Boring Depth (ft.): 132.4 / Elev: 7600.2'	Driller: B. HARTLEY	Starting Date: 3/5/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 49', N.Q. CORE TO 58', ROTARY WASH TO 120', N.Q. CORE		Ending Date: 3/11/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 2	Comments
7550					CORE 19,0	Tan and Gray Sandstone		Slope Indicator Pipe
7545	55				CORE 32,0			Low Strength Cement Grout
						Reddish-Brown Clayey Gravel W/Sand		
7540	60			CL-2	7,10,9	Brown Clay W/Sand, Gravel and Cobbles		
7535	65							
7530	70			GC	12,11,14	Brown Clayey Sandy Gravel		
7525	75							
7520	80			CL-2	6,7,11	Reddish-Brown Sandy Clay W/Gravel		
7515	85							
7510	90			CL-2	17,9,11			
7505	95					Yellow and Brown Sandy Clay W/Gravel and Cobbles		

LEGEND

- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

Project: GRASSY TRAIL DAM	Project Number: 9712.000	Boring No.: 98-7 Inclinometer No. 2 Sheet 3 of 3
Client: CREAMER & NOBLE ENGINEERS	Logged By: M. STILSON, M. HANSEN, V.N.B.	

Boring Depth (ft.): 132.4	Elev: 7600.2'	Driller: B. HARTLEY	Starting Date: 3/5/98
Equip./Drill Method: CME-55 / H.S. AUGER TO 49', N.Q. CORE TO 58', ROTARY WASH TO 120', N.Q. CORE			Ending Date: 3/11/98

Elev. (Feet)	Depth (Feet)	Lith-ology	Smpl.	USCS	Blow-counts	Material Description	Incl. No. 2	Comments
7500				CL-2	16,28,26			Slope Indicator Pipe
7495	105					Boulder		Low Strength Cement Grout
7490	110			CL-2	15,14,14	Yellow and Brown Sandy Clay W/Gravel and Cobbles		
7485	115							
7480	120			GC	56/6", REF			
					CORE 64,45	Bedrock - Orange Sandstone Silty Sandstone		
7475	125				CORE 100,100	Gray Sandstone		Inclinometer #2
7470	130				CORE 86,75	Greenish-Gray Shaley Mudstone		Sluff
7465	135							
7460	140							
7455	145							

LEGEND

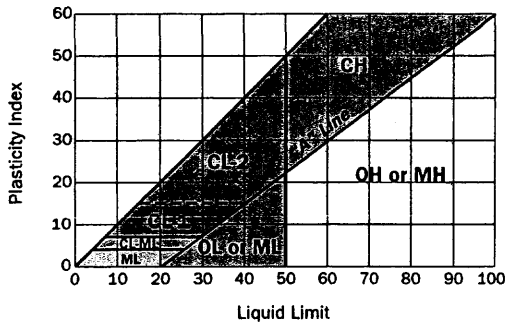
- 2,3,2 — Blow Count per 6"
- 0.45 — Torvane (tsf)
- Disturbed Sample
- Core 100,60 — Rock Quality Designation (RQD); Percent Sample Recovery
- Undisturbed Sample
- Groundwater Elevation

RB&G ENGINEERING INC.
Provo, Utah

2005 Phase II Dam Safety Study

Unified Soil Classification System

Major Divisions			Group Symbols		Typical Names	Laboratory Classification Criteria		
COARSE-GRAINED SOILS *more than half of material is larger than No. 200 sieve*	**Gravels** *more than half of coarse fraction is larger than No. 4 sieve size*	**Clean Gravels** *little or no fines*	**GW**		Well graded gravels, gravel-sand mixtures, little or no fines	*For laboratory classification of coarse-grained soils*	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines	Determine percentage of gravel and sand from grain-size curve. Depending on percentage of fines (*fraction smaller than No. 200 sieve size*), coarse-grained soils are classified as follows: **Less than 5%** GW, GP, SW, SP **More than 12%** GM, GC, SM, SC **5% to 12%** Borderline cases requiring use of dual symbols**	Not meeting all gradation requirements for GW	
		Gravels With Fines *appreciable amount of fines*	**GM***	**d**	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring uses of dual symbols
				u				
			GC		Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, or PI greater	
	Sands *more than half of coarse fraction is smaller than No. 4 sieve size*	**Clean Sands** *little or no fines*	**SW**		Well graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with Fines *appreciable amount of fines*	**SM***	**d**	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line, or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring uses of dual symbols
				u				
			SC		Clayey sands, poorly graded sand-clay mixtures		Atterberg limits above "A" line, or PI greater	
FINE-GRAINED SOILS *more than half of material is smaller than No. 200 sieve*	**Silts and Clays** *liquid limit is less than 50*		**ML**		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	*For laboratory classification of fine-grained soils*		
			CL	**1**	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
				2				
			OL		Organic silts and organic silt-clays of low plasticity			
	Silts and Clays *liquid limit is greater than 50*		**MH**		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
HIGHLY ORGANIC SOILS			**Pt**		Peat and other highly organic soils			



Plasticity Chart

NOTE: USCS Modified to include CL-type subcategories

*Division of GM and SM groups into subdivisions of d and u for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when liquid limit is 28 or less and the PI is 6 or less, the suffix u used when liquid limit is greater than 28.

***Borderline classification:* Soils possessing characteristics of two groups are designated by combinations of group symbols. (For example GW-GC, well graded gravel-sand mixture with clay biner.)

DRILL HOLE LOG

BORING NO. 05-1, I-4

Sheet: 1 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 2/2/05
LOCATION: SEE SITE PLAN: N 10513, E 9652 — ELEVATION: 7626.3'
DRILLER: D. SAMPSON, J. BAILEY — LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / N.W. CASING TO 43.8' THEN N.Q. CORE
DEPTH TO WATER - INITIAL: ▽ 39.0'? AFTER 24 HOURS: ▽ 39.5' ARTESIAN?

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	See Legend	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7625				9	0,6,6	CL	brown, moist, some roots — Top 0.5' loose from constructing drill pad; SANDY LEAN CLAY W/GRAVEL; some roots, gravel is angular sandstone & mudstone										
7620	5			9	3,4,6	GC	brown, moist — CLAYEY GRAVEL W/SAND										Slope Indicator Pipe
7615	10			11	6,8,10	SC	brown, moist — CLAYEY SAND W/GRAVEL		14.5			27	46	27			
				8	14,9,12	GM	brown, moist — SILTY GRAVEL W/SAND; some clay layers										
7610	15			4	27,53, REF	SM	brown, moist — SILTY SAND W/GRAVEL										
	20			6	13,14,14	GM	brown, moist — SILTY GRAVEL W/SAND; some clay layers										
7605				9	8,17,18	SC	brown, moist — CLAYEY SAND W/GRAVEL		13.2			36	40	24			
7600	25			7	15,17,19	GM	mottled green-gray w/red-brown — SILTY GRAVEL W/SAND, CLAY & MUDSTONE FRAGMENTS; sandstone gravel										Low Strength Grout
				7	14,11,12	GC	brown to red-brown, moist — CLAYEY GRAVEL W/SAND										
7595	30			13	7,9,12 1.00+	CL-1	red-brown, moist, med. plasticity — SANDY CLAY W/SANDSTONE & MUDSTONE GRAVEL		14.9	24	9						
7590	35			11	Pushed	GC	green, moist — CLAYEY GRAVEL W/SAND; sandstone bottom; very highly weathered bedrock?										
				9	15,14,17 1.00+	CL/CH	red-brown, moist, high plasticity — CLAY TO CLAYEY MUDSTONE; w/green sandstone fragments										
7585	40			13	12,28,57 1.00+	CL/CH	brown-red, moist, high plasticity — CLAYEY MUDSTONE; very highly weathered										
				6 4 6	Pushed 56/4" 1.00+ Core	CL-1 CL -	red-brown & gray, moist	128.3	11.0	33	14				DS		
7580	45			60	Core 100,42	-	green — SANDY MUDSTONE										
	50						100% water loss at 49.8'										

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Core 100,60 ← Rock Quality Designation (RQD)
Percent Sample Recovery
Undisturbed Sample
Groundwater Elevation

DS - Direct Shear Test
UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-1, I-4

Sheet: 2 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 2/2/05
LOCATION: SEE SITE PLAN: N 10513, E 9652 — ELEVATION: 7626.3'
DRILLER: D. SAMPSON, J. BAILEY — LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / N.W. CASING TO 43.8' THEN N.Q. CORE
DEPTH TO WATER - INITIAL: ▽ 39.0'? AFTER 24 HOURS: ▽ 39.5' ARTESIAN?

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	See Legend	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7575				60	Core 100,54	-	SANDY MUDSTONE										
	55						red-brown MUDSTONE										Slope Indicator Pipe
							green MUDSTONE										
7570				48	Core 80,42	-	green SANDSTONE										
							green MUDSTONE										
							red-brown MUDSTONE										
							green MUDSTONE										
							green SANDSTONE										
	60						red-brown MUDSTONE										Low Strength Grout
							green SILTY MUDSTONE										
							red-brown MUDSTONE										
7565							mottled red, green & yellow MUDSTONE										
				54	Core 90,84	-	mottled red-brown & green MUDSTONE W/CLAY SEAMS ~0.25" THICK										
	65						green MUDSTONE TO SANDSTONE										
7560				59	Core 98,96	-	green SILTY SANDSTONE W/FEW MUDSTONE INCLUSIONS										Sluff
	70																
7555																	
	75																
7550																	
	80																
7545																	
	85																
7540																	
	90																
7535																	
	95																
7530																	
	100																

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Core 100,60 ← Rock Quality Designation (RQD)
Percent Sample Recovery
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-2

Sheet: 1 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 2/9/05
LOCATION: SEE SITE PLAN: N 10106, E 10460 — ELEVATION: 7599.8'
DRILLER: D. SAMPSON, J. BAILEY — LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER
DEPTH TO WATER - INITIAL: ▽ 41.5' AFTER 24 HOURS: ▽ 29.6'

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests
7595	5			5	4,4,5	CL	black, moist; SANDY LEAN CLAY W/SAND & GRAVEL (embankment fill)								
7590	10			9	9,6,6	CL	brown, moist								
7585	15														
7580	20			2	6,6,7	GM	gray-brown, moist; SILTY GRAVEL W/SAND (embankment fill)								
7575	25														
7570	30			8	4,7,8	CL	brown, moist; SANDY LEAN CLAY W/SAND & GRAVEL LAYERS (embankment fill)								
7565	35														
7560	40			3	5,8,10	CL	brown, moist								
7555	45														
7550	50														

Well Detail / Well Comments:

- Locking Well Cover Rim Elev. 7601.5'
- PVC Pipe
- Low Strength Grout
- Bentonite Seal
- Sluff
- Bentonite Seal
- 10/20 Silica Sand
- Piezomter
- Bentonite Seal

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-2

Sheet: 2 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 2/9/05
LOCATION: SEE SITE PLAN: N 10106, E 10460 — ELEVATION: 7599.8'
DRILLER: D. SAMPSON, J. BAILEY — LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER
DEPTH TO WATER - INITIAL: ▽ 41.5' AFTER 24 HOURS: ▽ 29.6'

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
				8	34,19,22	SM	brown, moist — SILTY SAND W/GRAVEL some clay lenses, sandstone cut & crushed by spoon (native?)										
7545	55																Bentonite Seal
				9	9,11,16	CL,SM	brown & dk. gray, moist										
7540	60						SANDY LEAN CLAY W/GRAVEL some sand pockets & silt lenses										10/20 Silica Sand
				12	12,20,22 0.42	CL	dk. brown-gray, moist										Piezometer
7535	65			13	7,17,19	CL	dk. brown-gray, some wood & roots										Sluff
7530	70																
7525	75																
7520	80																
7515	85																
7510	90																
7505	95																
7500	100																

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RB&G ENGINEERING INC.
Provo, Utah

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

DRILL HOLE LOG

BORING NO. 05-3

Sheet: 1 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR
PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC.
DATE: 2/15/05
LOCATION: SEE SITE PLAN: N 10028, E 10171
ELEVATION: 7600.3'
DRILLER: D. SAMPSON, J. DARTER
LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER
DEPTH TO WATER - INITIAL: ▽ 49.4' AFTER 24 HOURS: ▽ 34.5'

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7600																	Locking Well Cover Rim Elev. 7601.7'
				-	4,6,11	-											
7595	5																PVC Pipe
7590	10			9	6,13,5 0.68	CL	red-brown, moist to wet										
7585	15																
7580	20			0	Pushed	-											Bentonite Seal
				7	7,4,7 0.57	CL	med. brown & yellow-brown, moist										
7575	25			5	Pushed 0.75	CL	red-brown, moist										3' Slotted PVC Pipe 10/20 Silica Sand
7570	30			14	5,6,12	CL-1	moist	126.4	10.9	27	12	12	25	63			Bentonite Seal
7565	35			14	Pushed 0.68	CL-1	brown, red-brown & green, moist to wet, water in hole after sample taken	132.9	12.0	27	13	22	19	59			
7560	40			13	7,19,19	CL	brown, moist										Mix w/Bentonite
7555	45																
	50																

LEAN CLAY W/SAND & GRAVEL & W/SOME COBBLES (fill)

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-3

Sheet: 2 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 2/15/05
LOCATION: SEE SITE PLAN: N 10028, E 10171 — ELEVATION: 7600.3'
DRILLER: D. SAMPSON, J. DARTER — LOGGED BY: M. HANSEN, V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER
DEPTH TO WATER - INITIAL: ▽ 49.4' AFTER 24 HOURS: ▽ 34.5'

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
7550				5	Pushed	-	wet										
				11	14,19,20	CL	brown, moist w/wet layers										
7545	55																
7540	60			17	7,10,19	SM	med. to lt. brown, wet to moist, dk. gray — SANDY LEAN CLAY W/GRAVEL & SOME SAND POCKETS (fill)		16.0		NP	27	46	27			Mix w/Bentonite
7535	65																
7530	70			17	8,16,24 1.00+	SC	dk. gray, moist, trace roots, sligth organic odor	118.8	14.4	29	15	22	32	46			
7525	75			11	37,24,31	CL,SC	brown & dk. gray, moist — LEAN CLAY W/SAND & SANDY CLAY W/SANDSTONE GRAVEL										Bentonite Seal
7520	80			15	13,28,35	CL	brown, moist — SANDY LEAN CLAY W/SANDSTONE GRAVEL										10/20 Silica Sand; Piezometer
7515	85			18	6,8,13 0.71	CL-1	dk. gray-brown	103.9	17.6	26	12	1	39	60			Sluff
7510	90																
7505	95																
	100																

08/04/2005
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Provo, Utah

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

DRILL HOLE LOG

BORING NO. 05-4

Sheet: 1 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 6/14/05
LOCATION: SEE SITE PLAN: N , E — ELEVATION: 7557.4'
DRILLER: D. SAMPSON — LOGGED BY: M.S., V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER TO 51' THEN N.W. CASING
DEPTH TO WATER - INITIAL: ▽ 50.5' AFTER 24 HOURS: ▽ NOT MEASURED

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
				8	5,5,2	-											Locking Well Cover Rim Elev. 7558.9
7555				7	2,1,1	-											
	5			7	0,3,2	-	CLAYEY GRAVEL/ GRAVELLY CLAY										
7550																	Cement Grout
	10			8	4,7,6,7	-	(Road Fill 0' to 11.5')										
7545				21	2,4,11,14 0.75	CL-1 SC	brown, moist, very stiff — SANDY LEAN CLAY W/GRAVEL		15.8	28	13	19	25	56			
	15			7	Pushed	CL/SC -	tan, moist; cobble — ALTERNATING LAYERS OF: SANDY CLAY, SANDY CLAY W/GRAVEL, CLAYEY SAND W/GRAVEL, CLAYEY GRAVEL W/SAND										
7540				18	5,15,13	SC	tan, moist, dense-very stiff										
				18	4,7,10	CL GC	dk. brown, moist										
	20			18	8,10,15 1.00	CL	dk. brown, moist — INTERMIXED CLAY, SAND & GRAVEL W/OCCASIONAL COBBLE										
	25			0	Pushed	GC	sandstone cobble										
				18	5,15,13	GC-GM	brown, moist, med. dense — SILTY CLAYEY GRAVEL W/SAND		13.1	22	6	39	33	28			Bentonite Seal
7530				-	Pushed	CL	dk. brown, moist, hard										
	30			18	6,16,26	GC CL	crushed rock; brown										
				18	11,15,19	CL	brown, moist, hard — SANDY LEAN CLAY W/GRAVEL										
7525				18	8,17,24	SC	dk. brown, moist, dense										10/20 Silica Sand
	35			18	12,16,15	SC	blackish-brown, moist, dense-hard — CLAYEY SAND W/GRAVEL	94.8	11.2	26	11	15	42	43			Piezomter
7520				12	Pushed	SC	brown, moist			27	14	18	33	49	TS		
	40			18	11,16,20	CL	dk. brown, moist, hard										
7515				7	Pushed	CL	dk. brown, moist										
				15	12,20,34	CL	dk. brown, moist, hard — SANDY LEAN CLAY W/GRAVEL										Bentonite Seal
	45			18	10,22,30	GC	dk. brown-gray, moist, dense — CLAYEY GRAVEL W/SAND		15.0	27	12	36	31	33			
7510						CL	dk. brown, moist, — SANDY LEAN CLAY W/GRAVEL (Embankment Fill 11.5' to 48.5')										
				15	5,9,8	SM	SILTY SAND										
	50					ML	dk. gray — SILT										

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LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

TS - Triaxial Shear Test
UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

RB&G ENGINEERING INC.
Provo, Utah

DRILL HOLE LOG

BORING NO. 05-4

Sheet: 2 of 2

PROJECT: GRASSY TRAIL DAM & RESERVOIR — PROJECT NO.: 200404.006
CLIENT: WEST RIDGE RESOURCES, INC. — DATE: 6/14/05
LOCATION: SEE SITE PLAN: N , E — ELEVATION: 7557.4'
DRILLER: D. SAMPSON — LOGGED BY: M.S., V.N.B.
EQUIP./DRILL METHOD: CME-55 / H.S. AUGER TO 51' THEN N.W. CASING
DEPTH TO WATER - INITIAL: ▽ 50.5' AFTER 24 HOURS: ▽ NOT MEASURED

Elev. (Feet)	Depth (Feet)	Lithology	Sample Type	Rec. (In.)	Blows Per 6" & Torvane (tsf)	USCS	Material Description	Dry Density, pcf	Moisture Content, %	Atter. Liquid Limit, %	Atter. Plasticity Index, %	Gradation Gravel, %	Gradation Sand, %	Gradation Silt/Clay, %	Other Tests	Well Detail	Well Comments
				17	18,21,34	GP-GM	brown to yellow-brown, moist, dense — POORLY GRADED GRAVEL W/SILT, SAND & CLAY LENSES		10.9		NP	52	36	12			Bentonite Seal
	55			17	22,13,32	SM	brown to dk. brown, wet, dense — SILTY SAND W/GRAVEL & FEW CLAY LENSES										10/20 Silica Sand; Piezomter
	60			15	16,16,23	GP-GM	brown, wet, dense — POORLY GRADED GRAVEL W/SILT & SAND										

7505, 7500, 7495, 7490, 7485, 7480, 7475, 7470, 7465, 7460

65, 70, 75, 80, 85, 90, 95, 100

07/21/2005
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RB&G ENGINEERING INC.
Provo, Utah

LEGEND

2,3,2 ← Blow Count per 6"
0.45 ← Torvane (tsf)
Disturbed Sample
Undisturbed Sample
Groundwater Elevation

UC - Unconfined Compression Test
CT - Consolidation Test
SG - Specific Gravity Test

Table 1

SUMMARY OF TEST DATA

PROJECT Grassy Trail Dam & Reservoir
LOCATION Carbon County, Utah

PROJECT NO. 200404-006
FEATURE

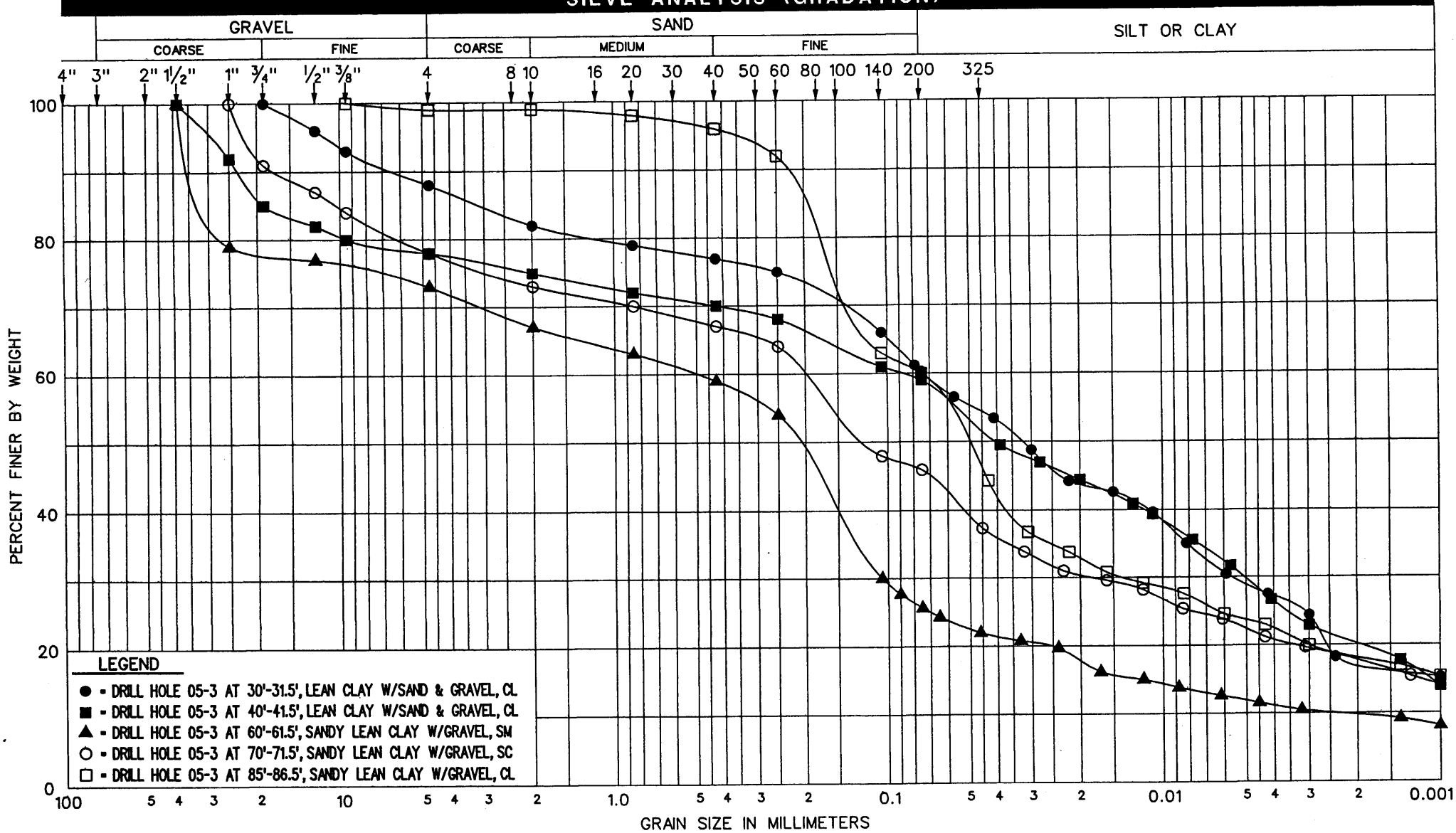
HOLE NO.	DEPTH BELOW GROUND SURFACE (ft)	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE		UNCONFINED COMPRESSIVE STRENGTH (psf)	ATTERBERG LIMITS			MECHANICAL ANALYSIS			UNIFIED SOIL CLASSIFICATION SYSTEM (modified)
			DRY UNIT WEIGHT (pcf)	MOISTURE (%)		LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT & CLAY	
05-1	10-11.5	18		14.5					27	46	27	SC
	22-23.5	35		13.2					36	40	24	SC
	31-32.5	21		14.9		24	15	9				CL-1
	43-43.5		128.3	11.0		33	19	14				CL-1
05-3	30-31.5	18	126.4	10.9		27	15	12	12	25	63	CL-1
	40-41.5	38	132.9	12.0		27	14	13	22	19	59	CL-1
	60-61.5	29		16.0				NP	27	46	27	SM
	70-71.5	40	118.8	14.4		29	14	15	22	32	46	SC
	85-86.5	21	103.9	17.6		26	14	12	1	39	60	CL-1
05-4	12-13.5	15		15.8		28	15	13	1	25	56	CL-1
	25-26.5	28		13.1		22	16	6	39	33	28	GC-GM
	36-37.5	31	94.8	11.2		26	15	11	15	42	43	SC
	39-40			15.0		27	13	14	18	33	49	SC
	45-46.5	52		15.0		27	15	12	36	31	33	GC
	51-52.5	55		10.9				NP	52	36	12	GP-GM

NP=Nonplastic

RB&G ENGINEERING INC.
1435 West 820 North, Provo, Utah 84601
801 374-5771 Provo
801 521-5771 Salt Lake City

PROJECT NO.	200404.006

SIEVE ANALYSIS (GRADATION)



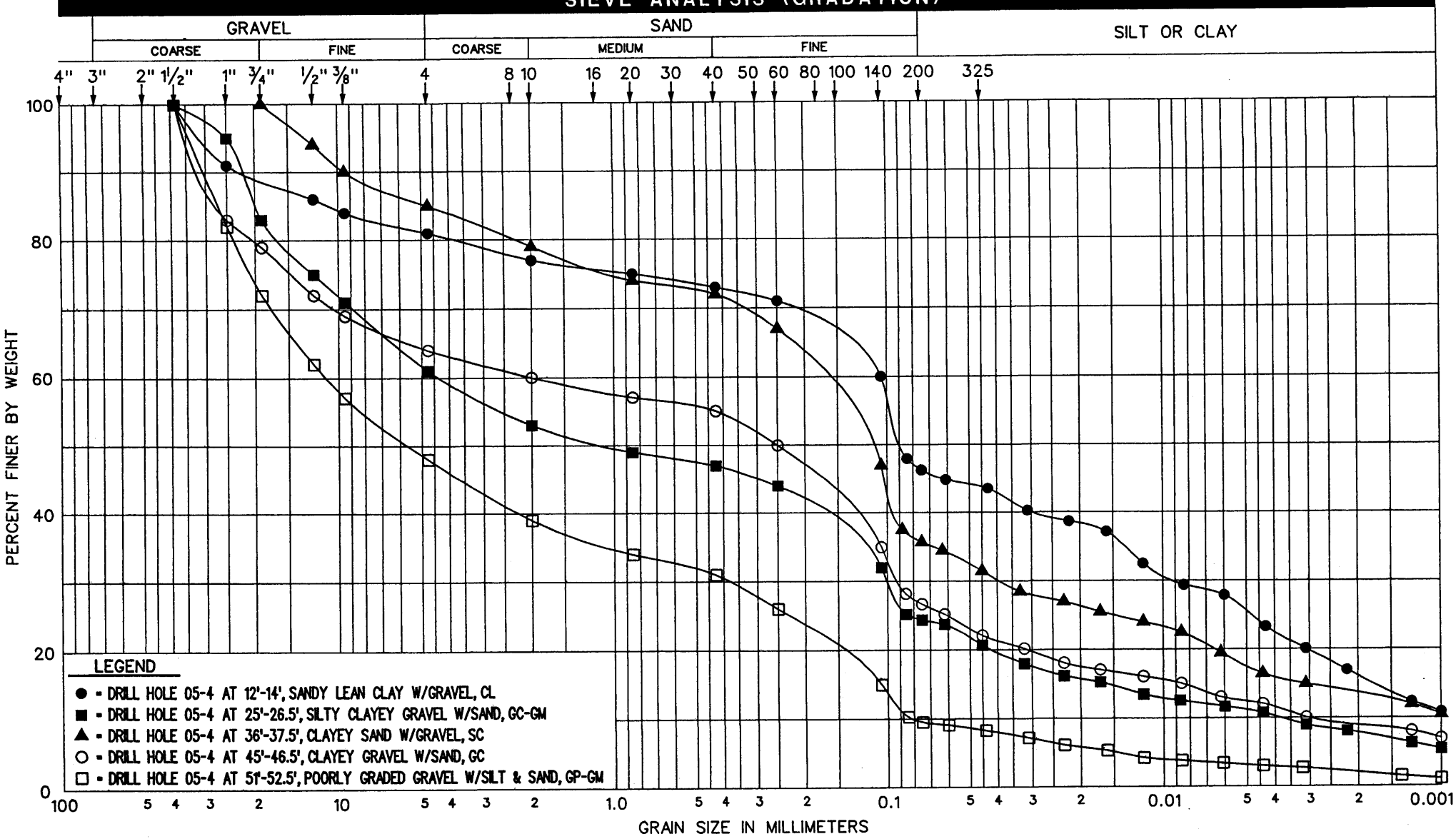
Project	GRASSY TRAIL DAM		
Location	EAST CARBON, UTAH		
Sample No./Depth	SEE LEGEND		
Material Description	SEE LEGEND	USCS	SEE LEGEND

Date	7/7/05 TO 7/11/05
Technician	S. NEIL
Procedure	PLAIN WATER
Method	ASTM C117, C136, C566, D422

RB&G ENGINEERING INC.
1435 West 820 North, Provo, Utah 84601
801 374-5771 Provo
801 521-5771 Salt Lake City

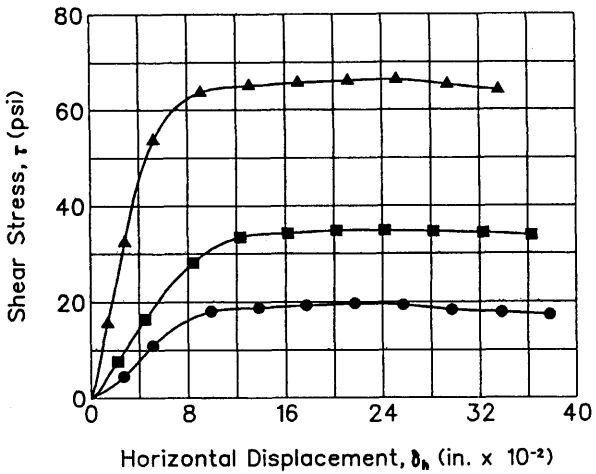
PROJECT NO.	200404.006

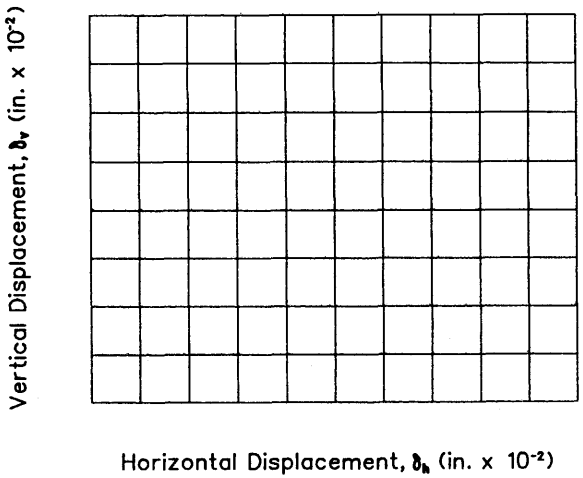
SIEVE ANALYSIS (GRADATION)

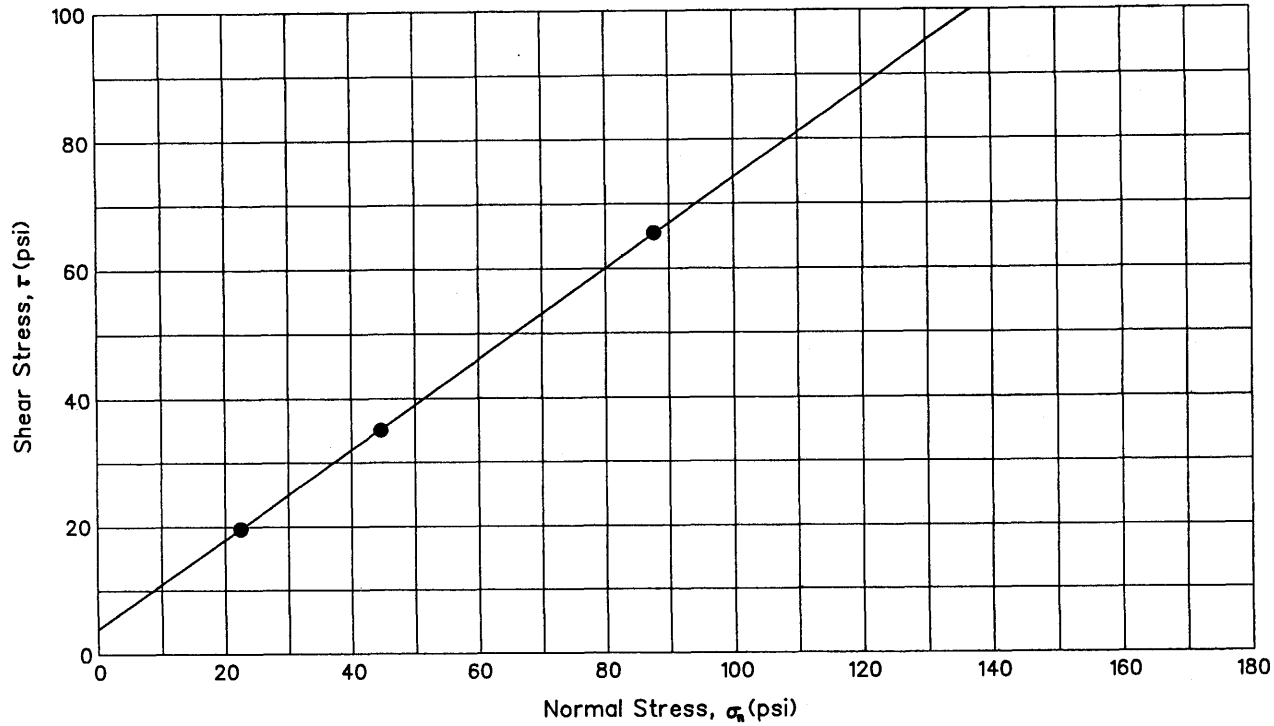


Project	GRASSY TRAIL DAM		
Location	EAST CARBON, UTAH		
Sample No./Depth	SEE LEGEND		
Material Description	SEE LEGEND	USCS	SEE LEGEND

Date	7/7/05 TO 7/12/05
Technician	S. NEIL
Procedure	PLAIN WATER
Method	ASTM C117, C136, C566, D422







Test No. or Symbol	Sample Size (inches)	Sample Data		Degree of Saturation (%)	Normal Stress δ_n (psi)	Maximum Shear Stress τ (psi)	Strain Rate (inches/ minute)	Shear Strength Parameters	
		Dry Density (pcf)	Moisture Content (%)					Friction Angle φ (degrees)	Cohesion (c/psi)
●	2.375	128.3	11.0	~ 100	22.4	19.7	.0012	35.0	4
■	2.375	128.3	11.0	~ 100	44.6	34.9	.0012		
▲	2.375	128.3	11.0	~100	87.6	65.7	.0012		

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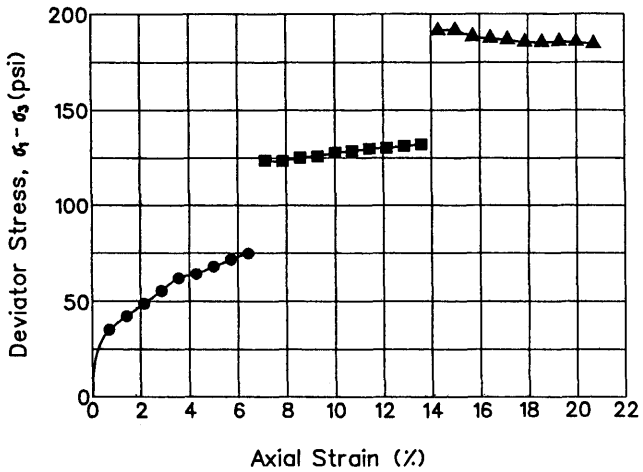
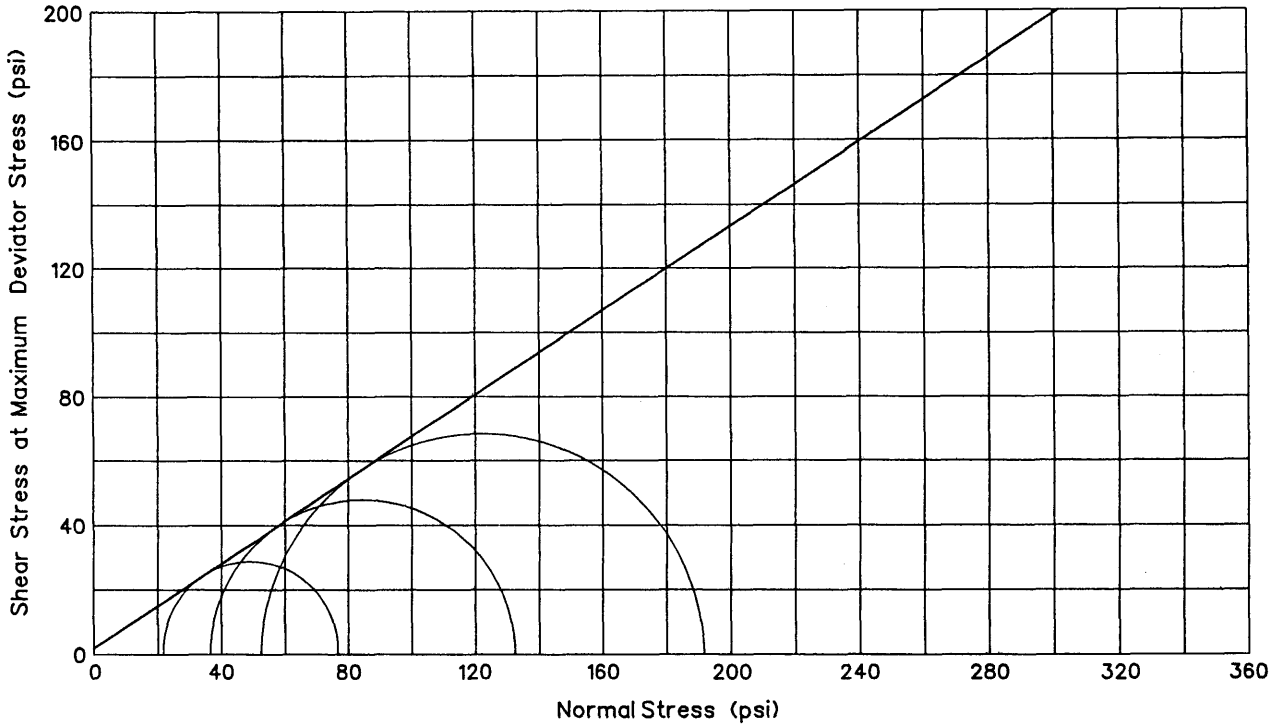
Provo, Utah

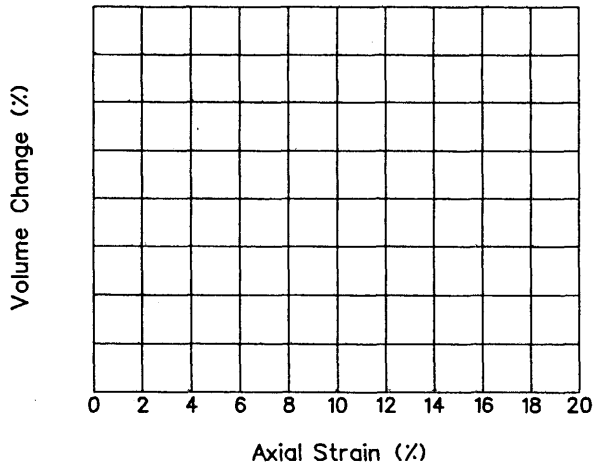
DIRECT SHEAR TEST
Project: *Grassy Trail Dam & Reservoir*
East Carbon, Utah

HOLE NO.: 05-1, I-4
DEPTH: 43-43.5'

Figure







MULTI-STAGE CONSOLIDATED UNDRAINED W/PORE PRESSURE MEASUREMENTS:

EFFECTIVE STRESS FAILURE ENVELOPE

Test No. or Symbol	Sample Data		Degree of Saturation (%)	Confining Pressure (psi)	Maximum Deviator Stress (psi)	Strength Values at Failure		Sample Size, L/D (inches)	Strain Rate (inches/minute)
	Dry Density (pcf)	Moisture Content (%)				Friction Angle ϕ (degrees)	Cohesion (c/psi)		
●	119.0	15.1	~100	23.3	75.0	33.2	2	2.8/1.32	.0016
■	119.0	15.1	~100	36.4	132.3				
▲	119.0	15.1	~100	52.3	191.5				

RB&G ENGINEERING INC.
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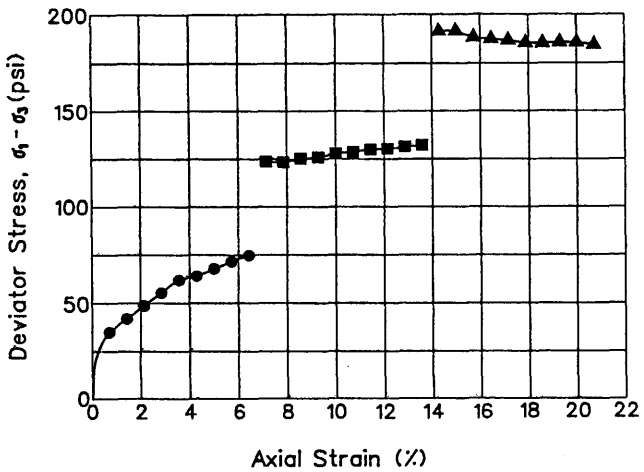
TRIAXIAL SHEAR TEST

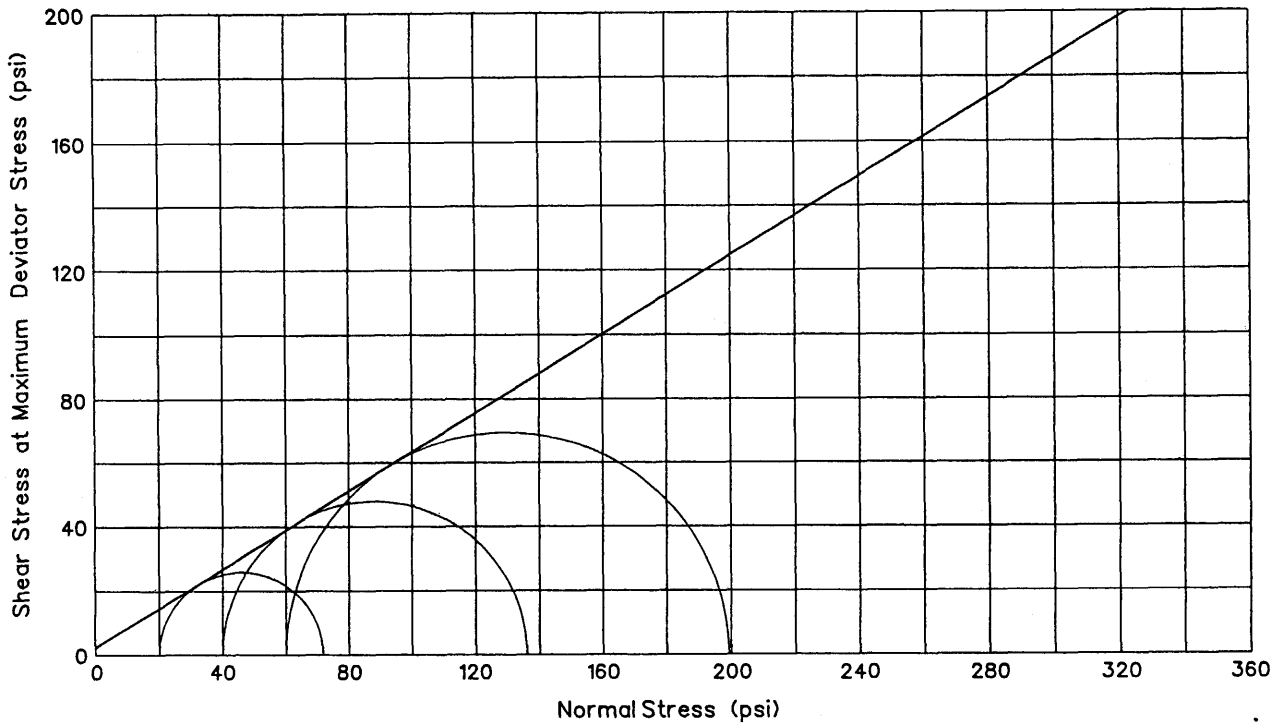
Project: *Grassy Trail Dam*

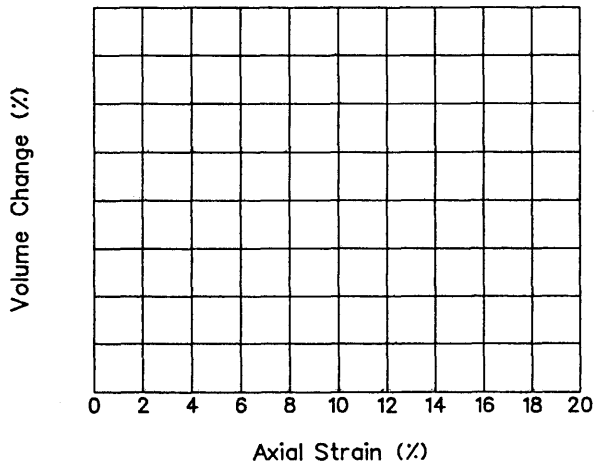
HOLE NO.: 05-4

DEPTH: 39'-40'

Figure







MULTI-STAGE CONSOLIDATED UNDRAINED W/PORE PRESSURE MEASUREMENTS:

TOTAL STRESS FAILURE ENVELOPE

Test No. or Symbol	Sample Data		Degree of Saturation (%)	Confining Pressure (psi)	Maximum Deviator Stress (psi)	Strength Values at Failure		Sample Size, *L/D* (inches)	Strain Rate (inches/minute)
	Dry Density (pcf)	Moisture Content (%)				Friction Angle ϕ (degrees)	Cohesion (c/psi)		
●	119.0	15.1	~100	20	75.0	31.7	2	2.8/1.32	.0016
■	119.0	15.1	~100	40	132.3				
▲	119.0	15.1	~100	60	191.5				

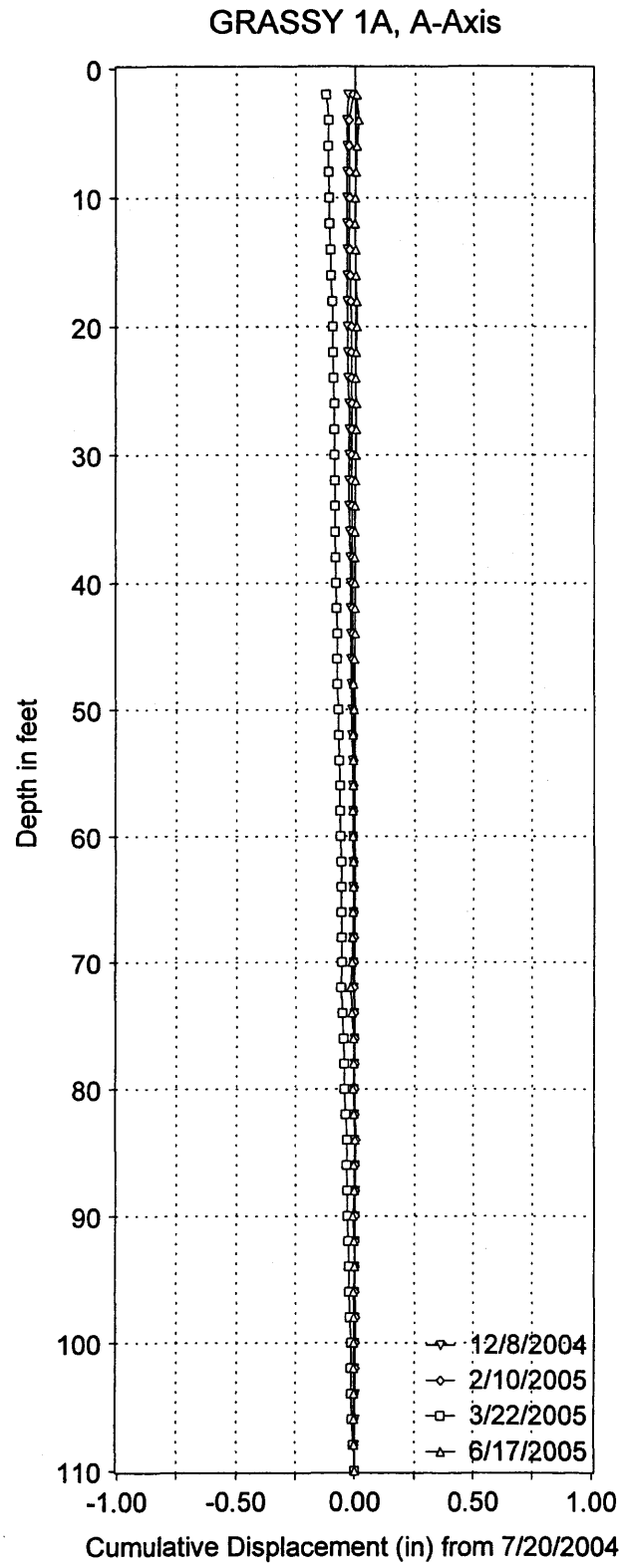
RB&G ENGINEERING INC.
Provo, Utah

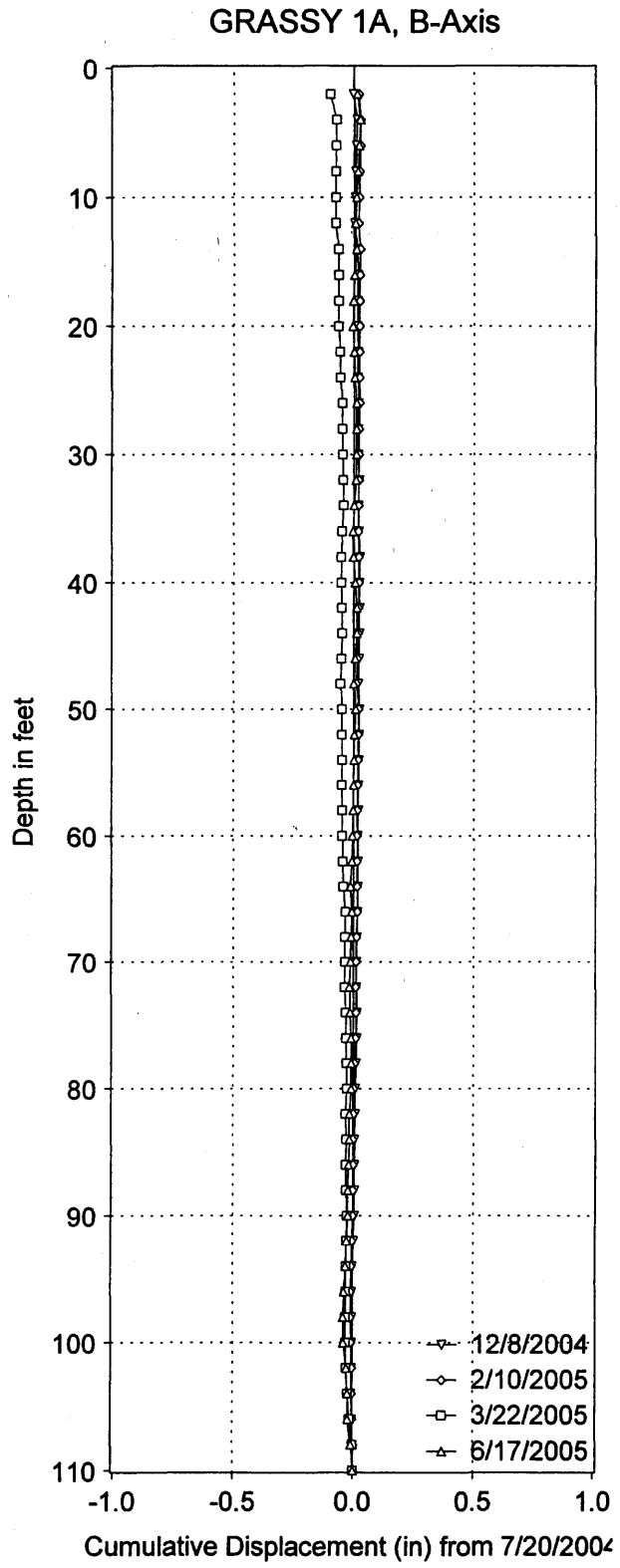
TRIAXIAL SHEAR TEST
Project: *Grassy Trail Dam*

HOLE NO.: 05-4
DEPTH: 39'-40'

Figure

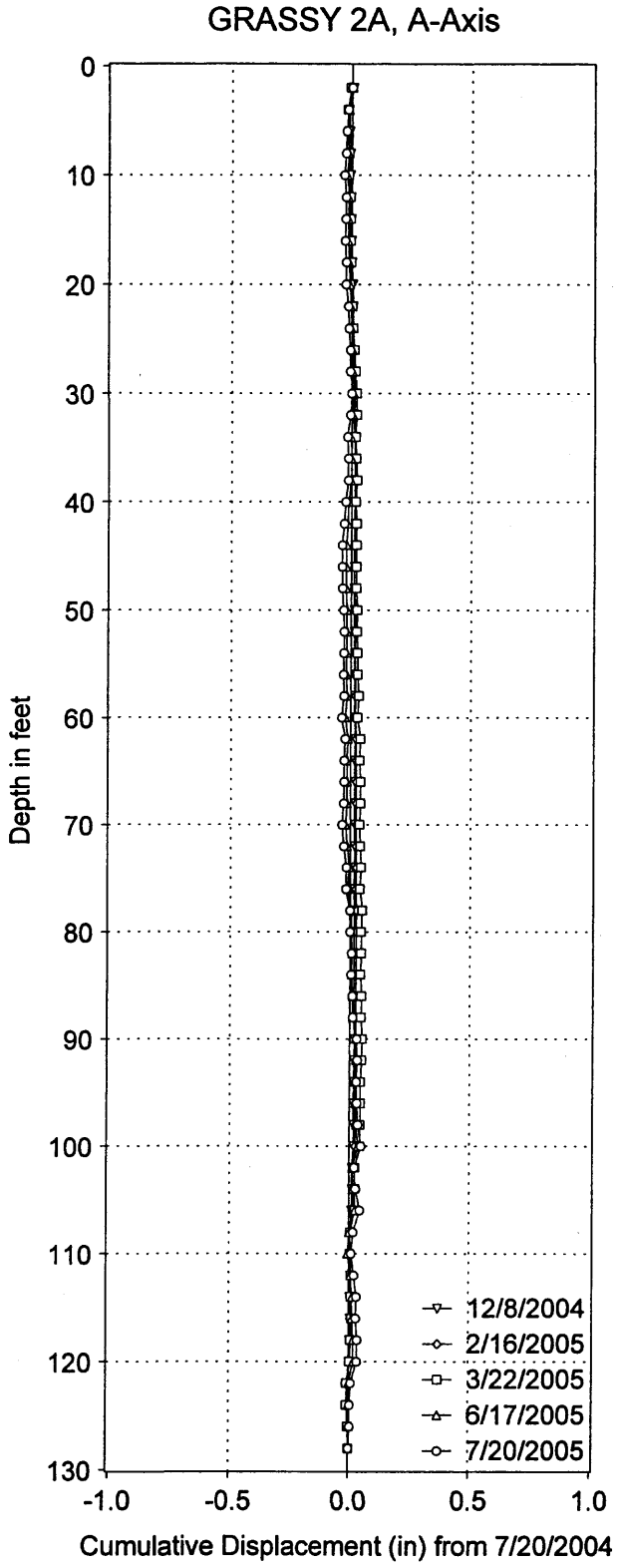
Inclinometer Readings

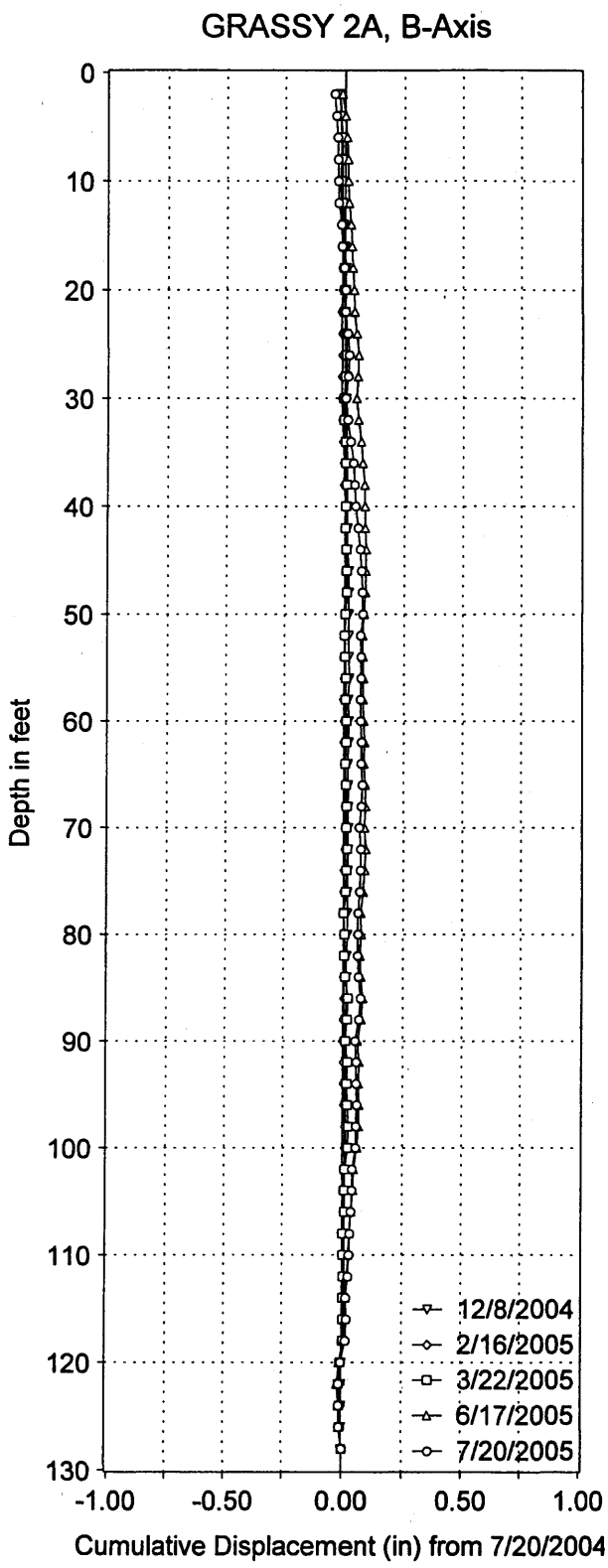




A - axis is to the Southeast

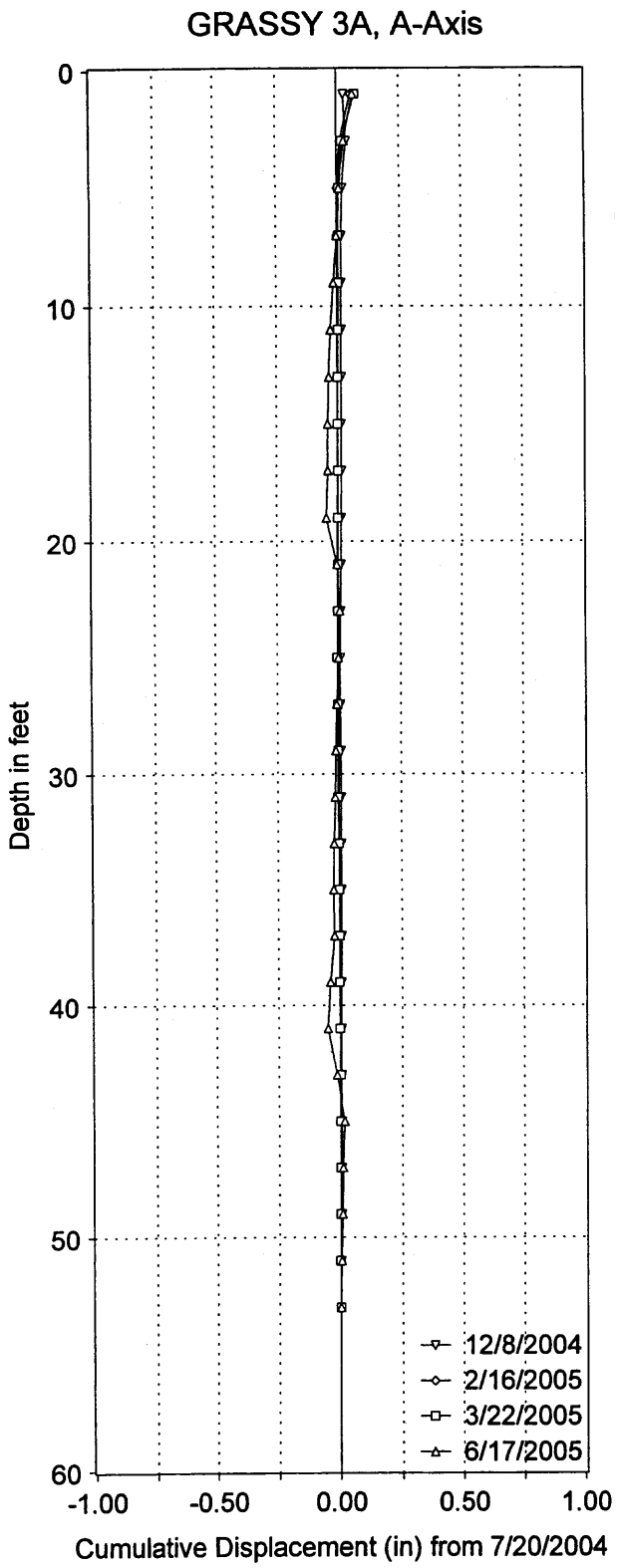
Corrected for rotation error
7/21/05 pem

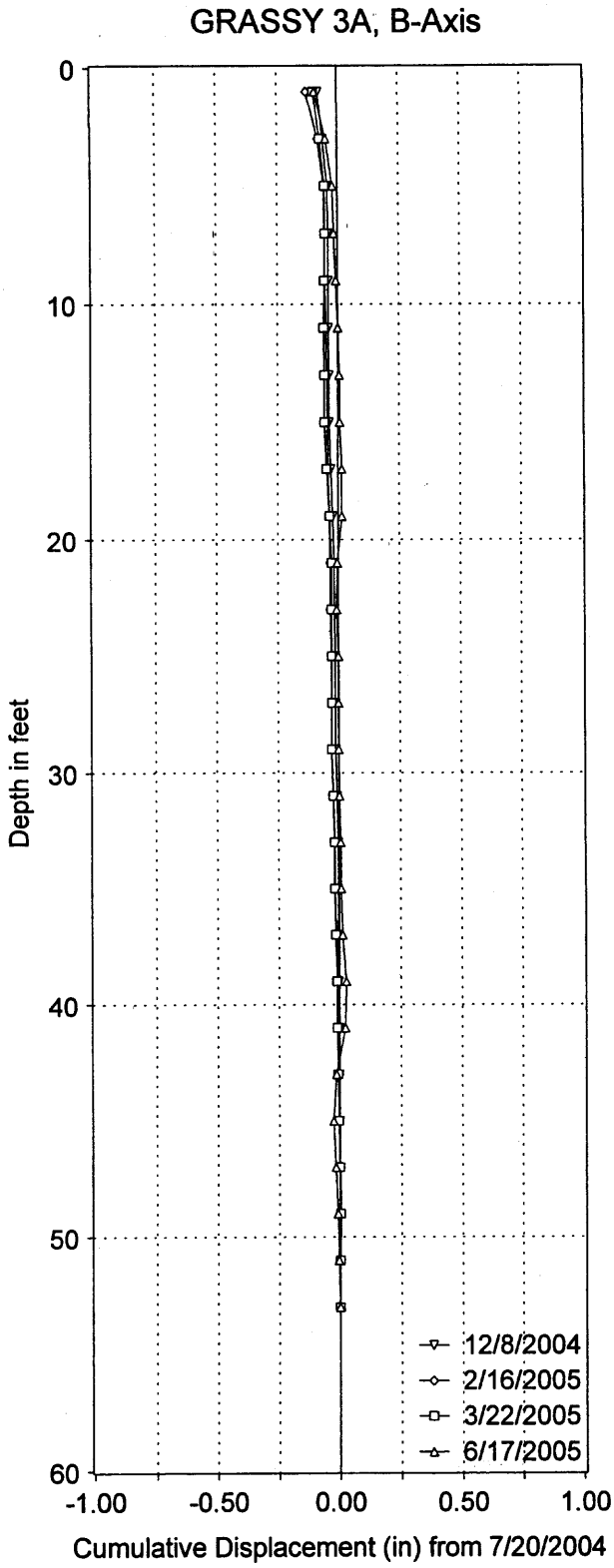




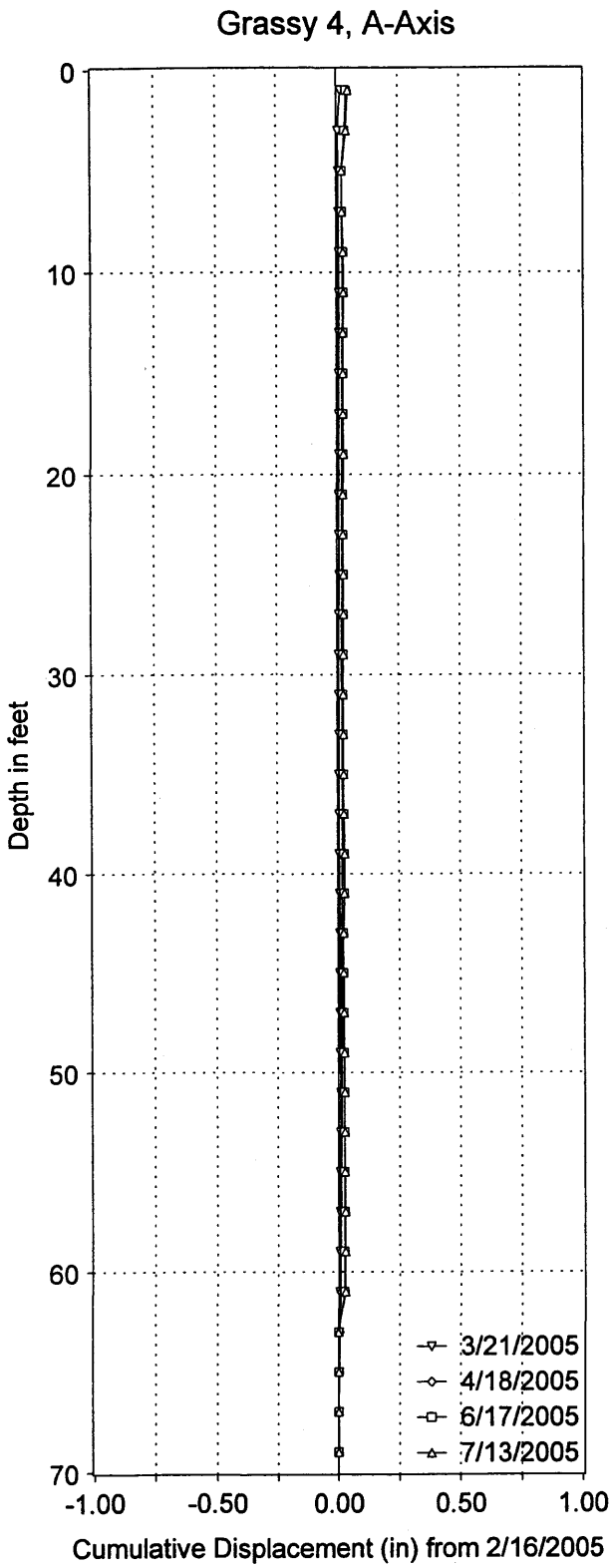
Gassy Trail Dam Inclinometers
Corrected Cum. Displacements 2A
by pem 7/21/05
GeoMetron Inc PS

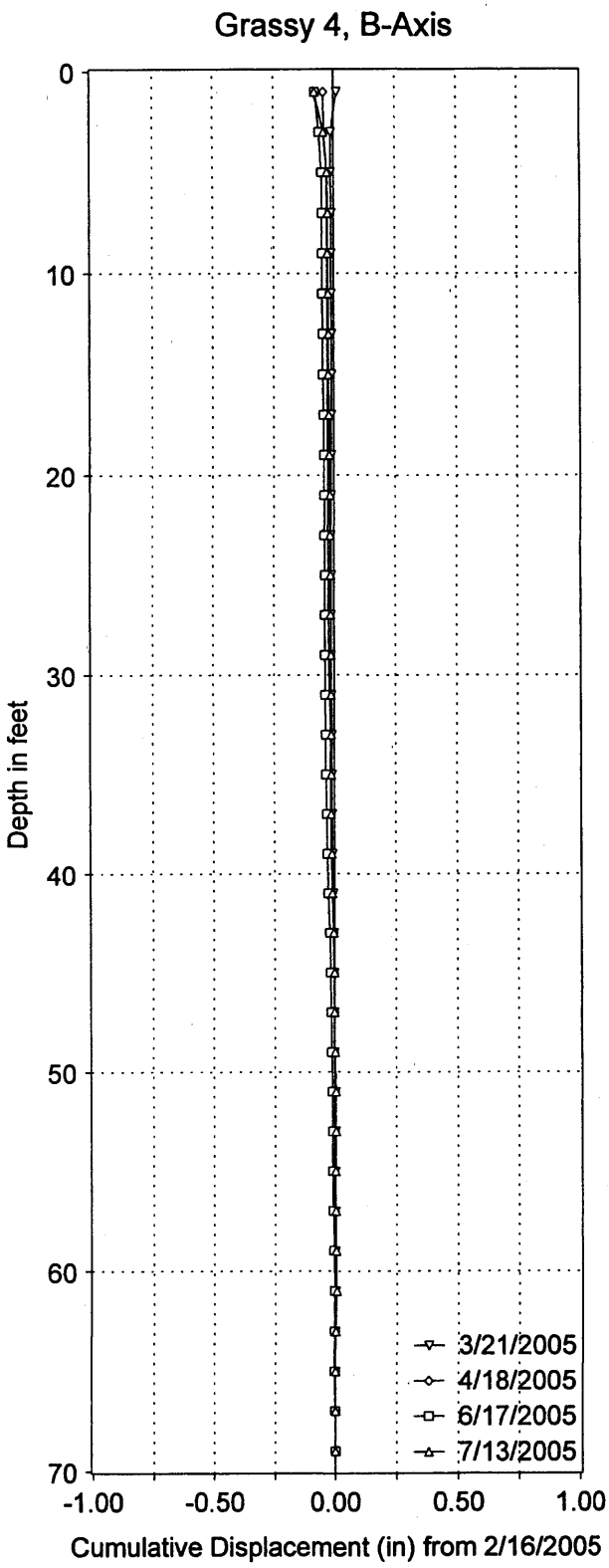
Data by RB&G Engineering Inc
A - axis is to the west
Data corrected for rotation errors



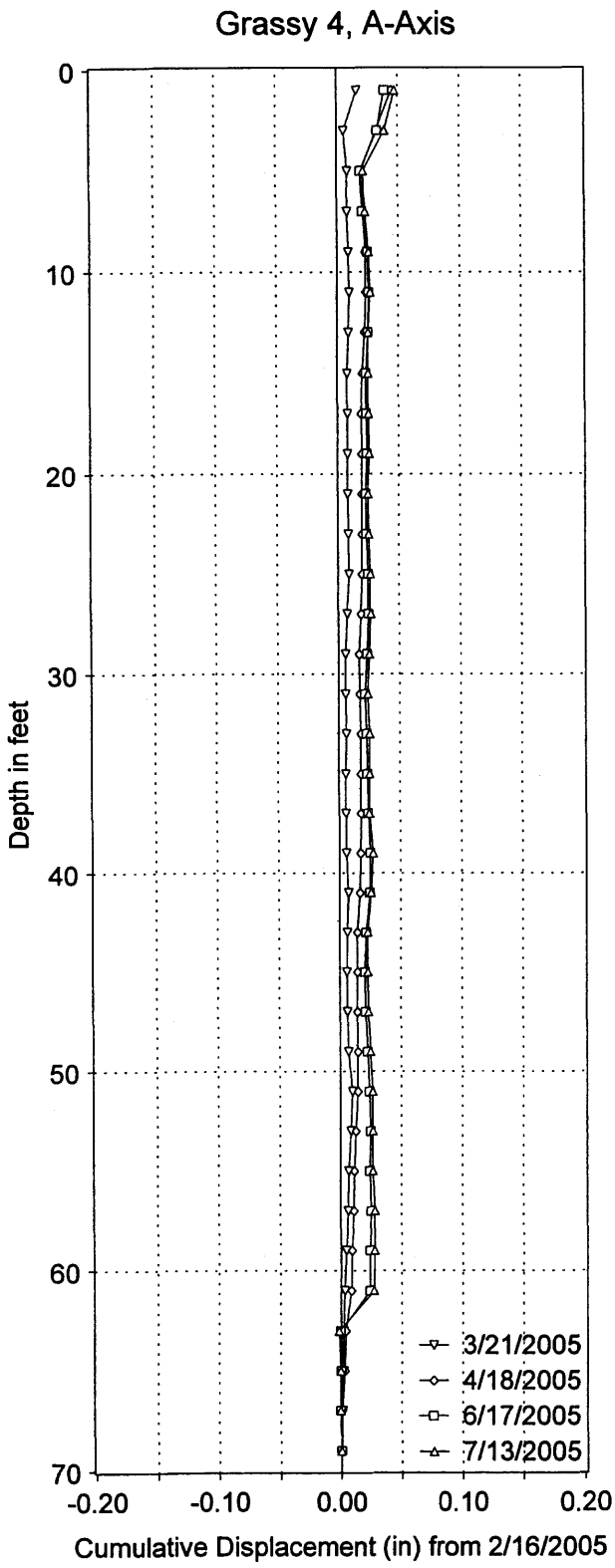


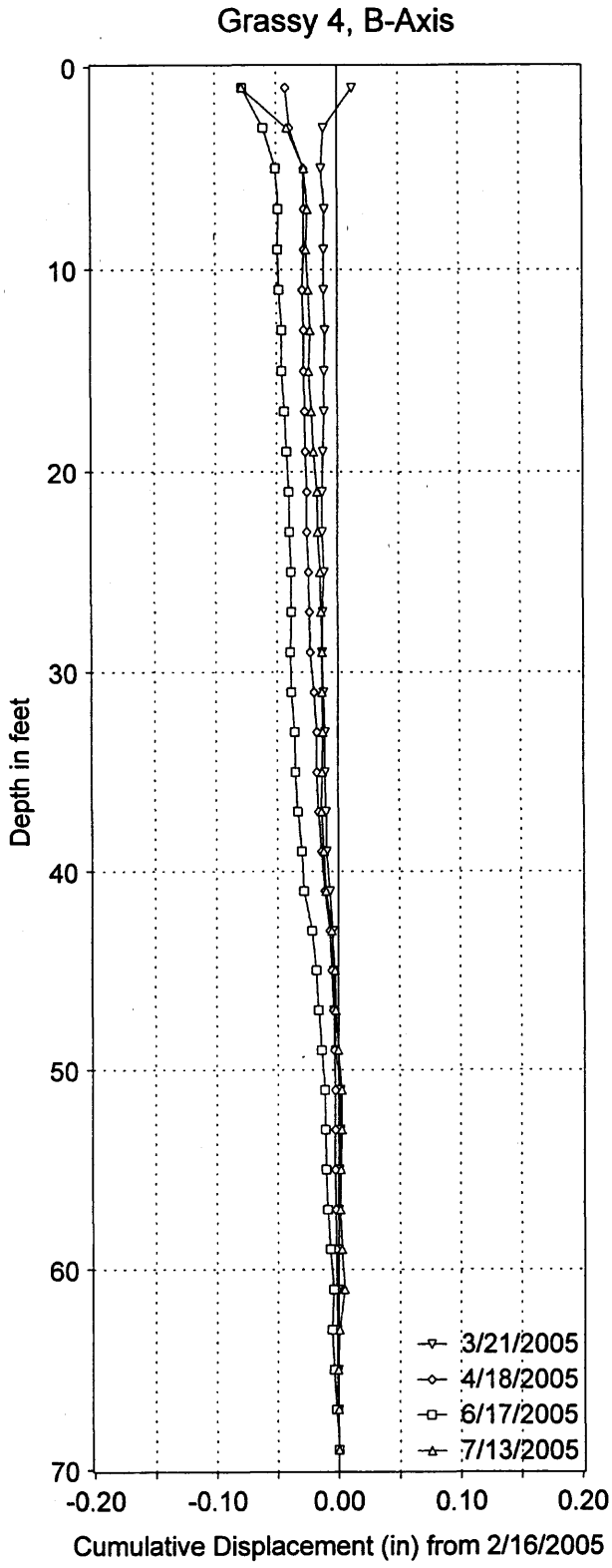
A-axis is to the West





A- axis face East in about the direction of the slide
shows slight movement to the east
B- axis is to the South



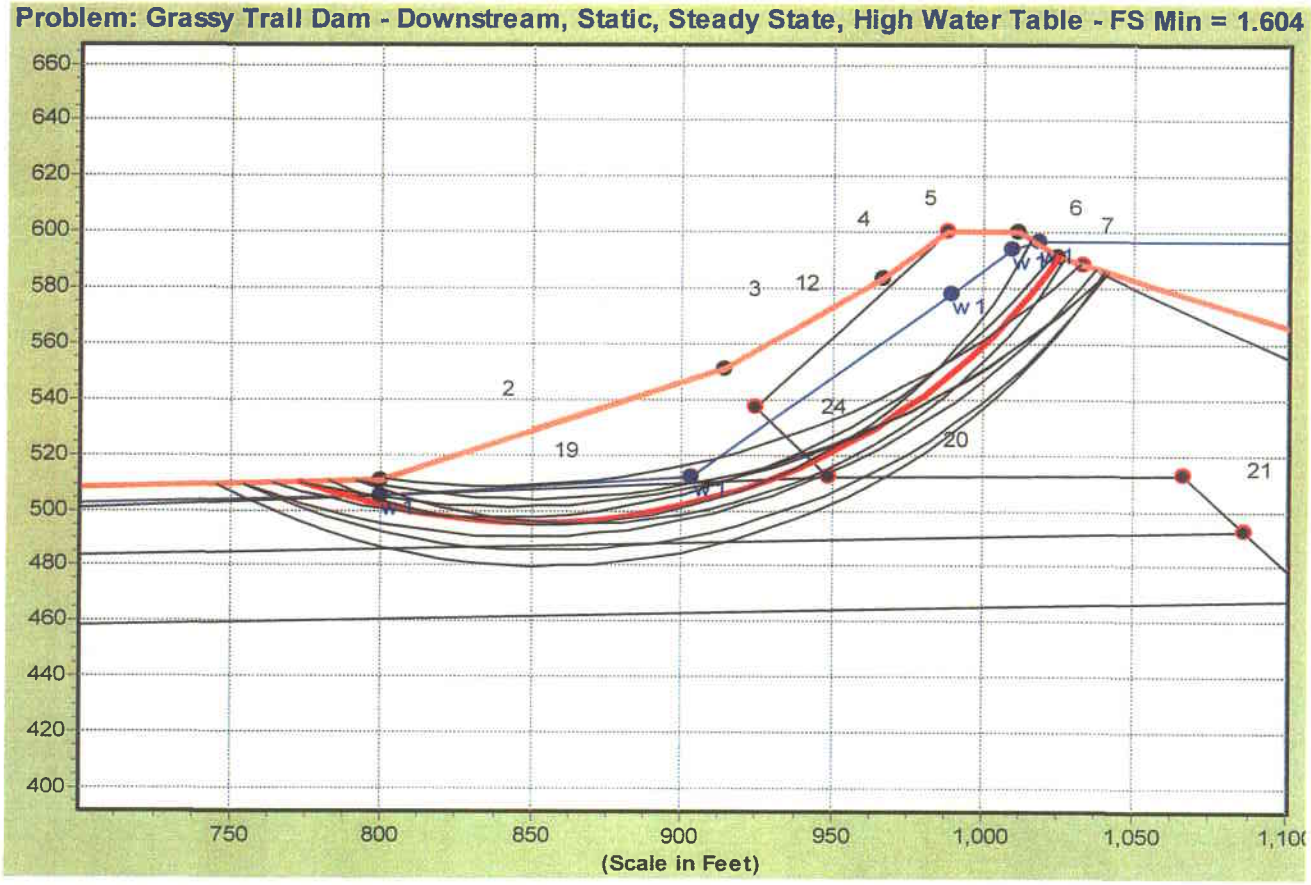


A- axis face East in about the direction of the slide
shows slight movement to the east
B- axis is to the South
edited by pem 7/21/05, but no corrections. Displ. indicated 61' to 63' interval

Slope Stability Analyses

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method
Ten most critical failure surfaces shown



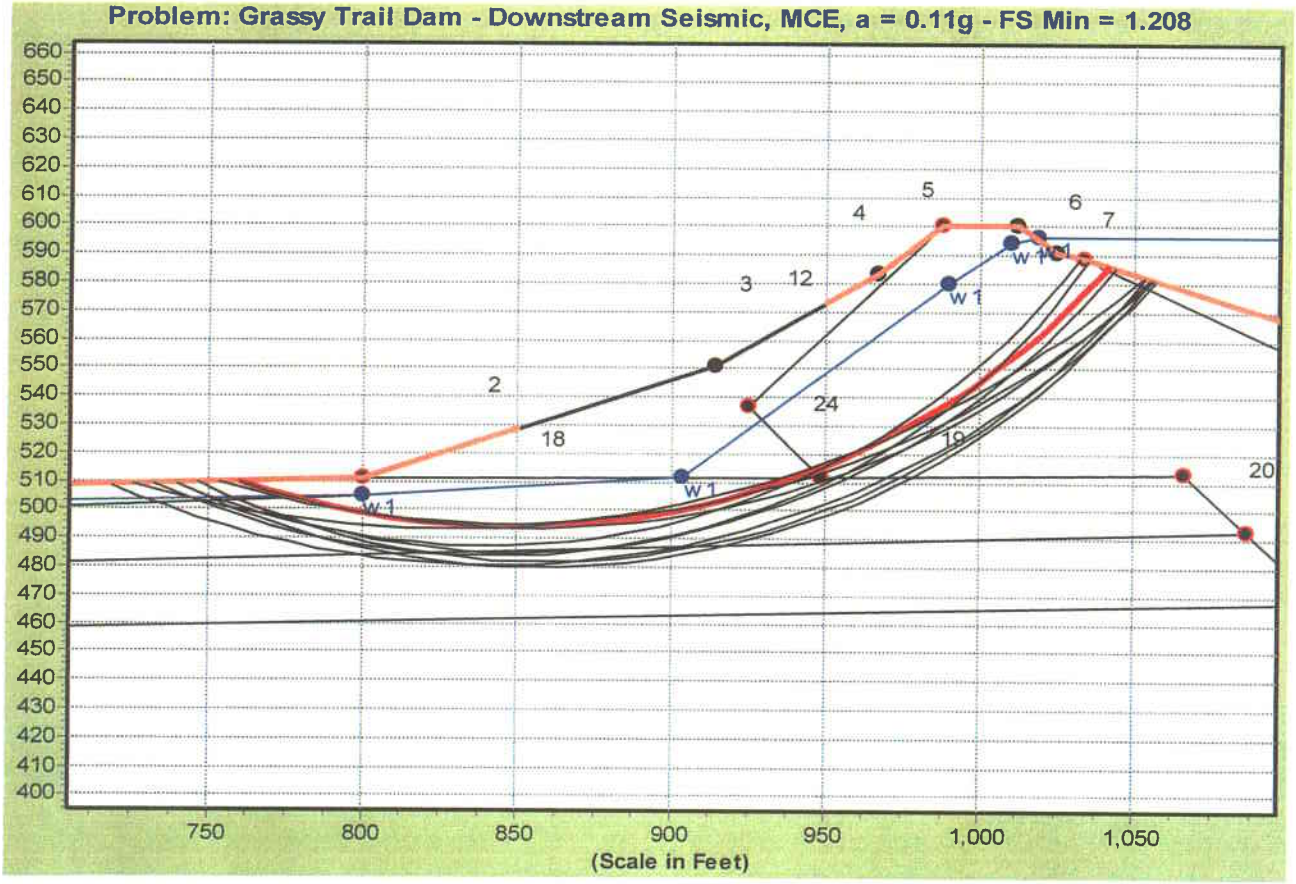
RB&G ENGINEERING INC.
Provo, Utah

Slope Stability Analysis Results
Downstream Slope - Static Steady State Seepage Condition
Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



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Provo, Utah

Slope Stability Analysis Results

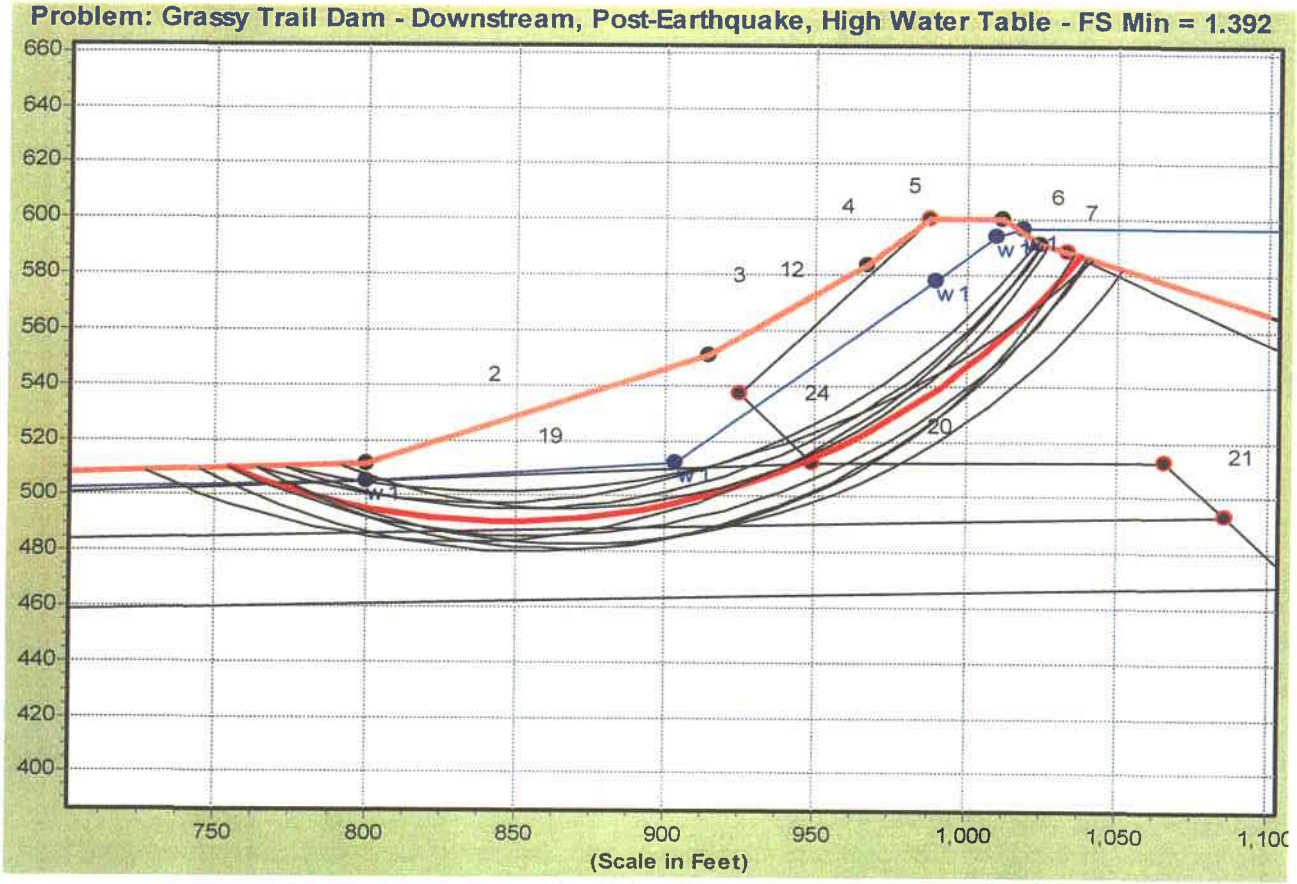
Downstream Slope - Maximum Credible Earthquake (non-mining)

Grassy Trail Dam and Reservoir

Spencer's Method

Pore pressure parameter = 0.1 in Layers 1 and 2
Pore pressure parameter = 0.2 in Layer 3
Ten most critical failure surfaces shown

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0



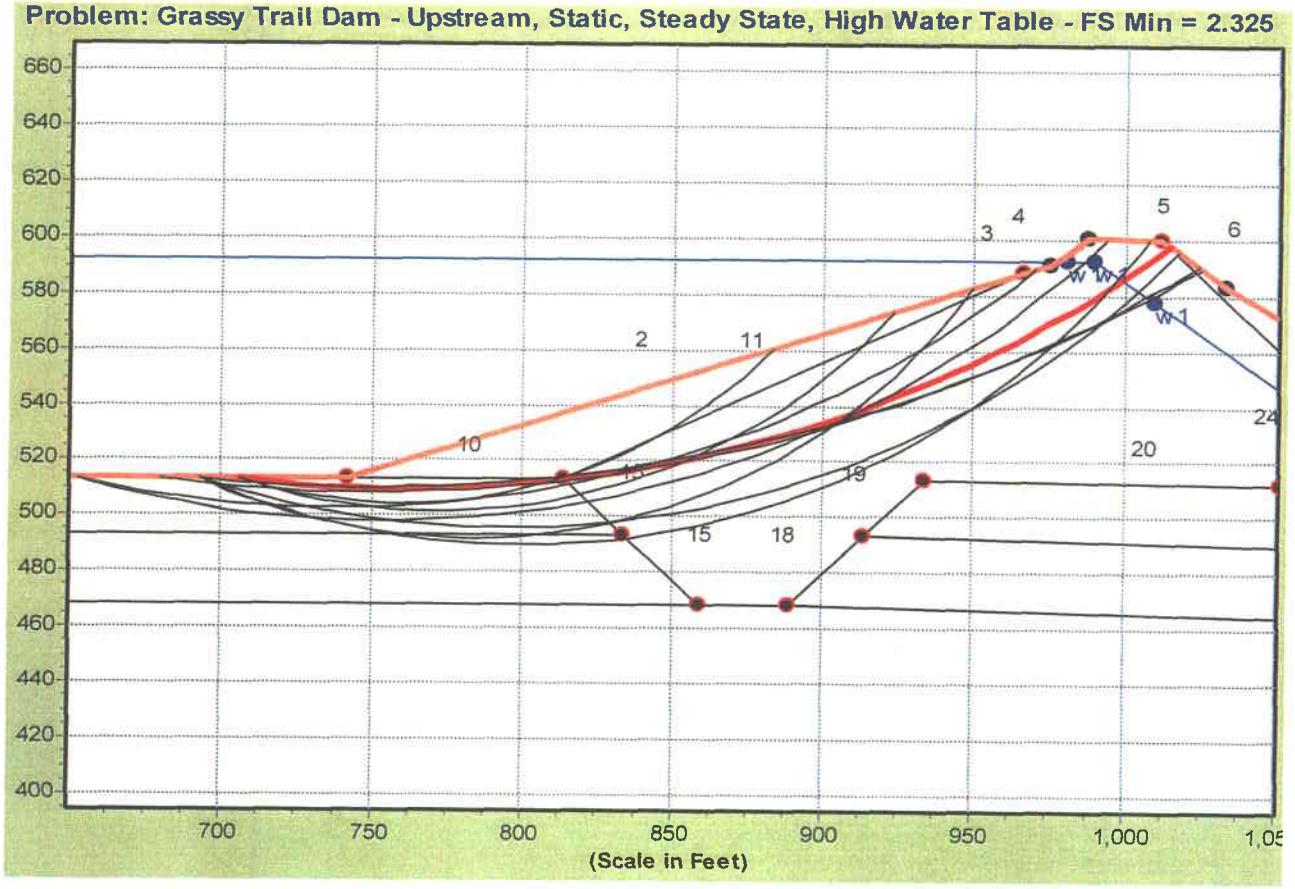
RB&G ENGINEERING INC.
Provo, Utah

Slope Stability Analysis Results
Downstream Slope - Post-Earthquake Condition
Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



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Slope Stability Analysis Results

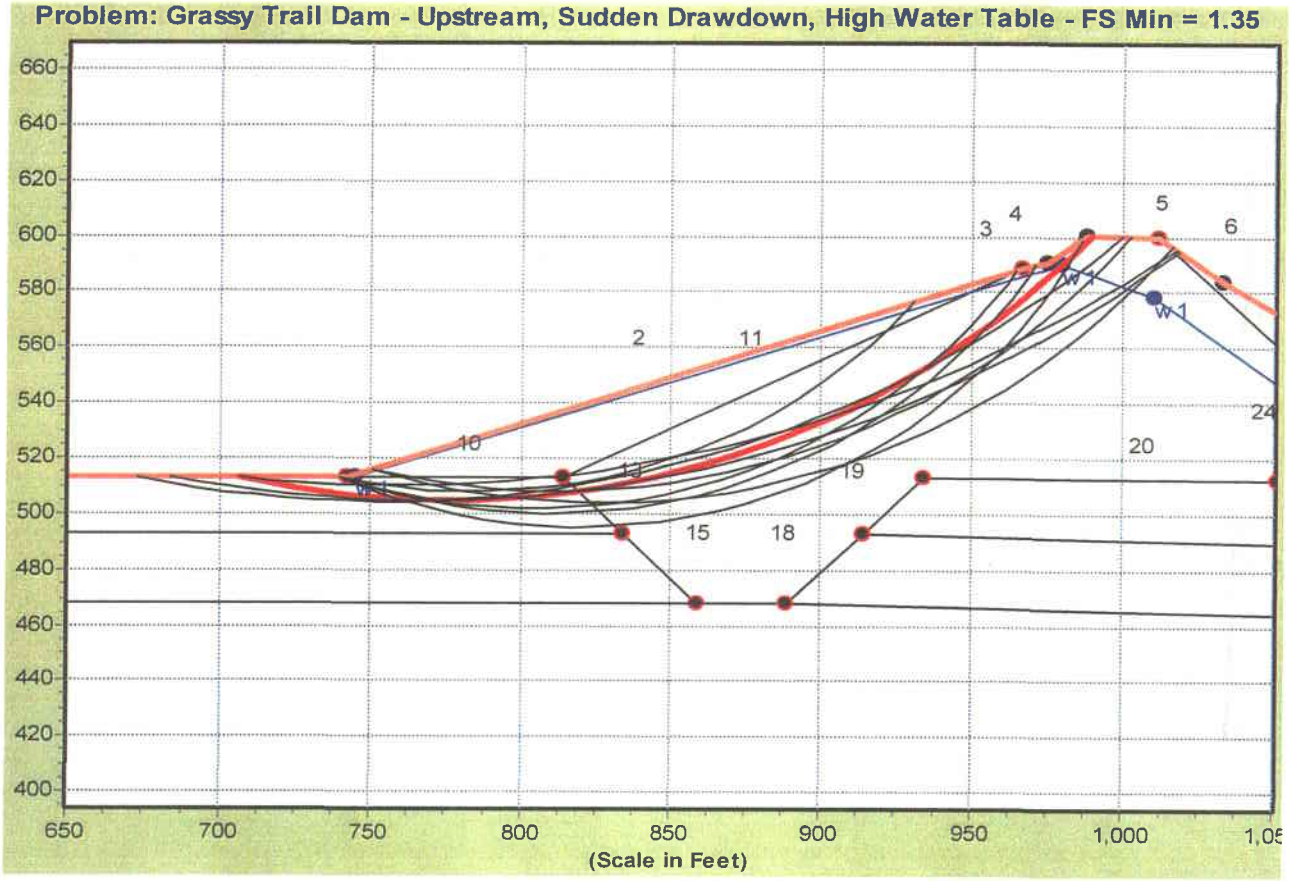
Upstream Slope - Static Steady State Seepage Condition

Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



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Slope Stability Analysis Results

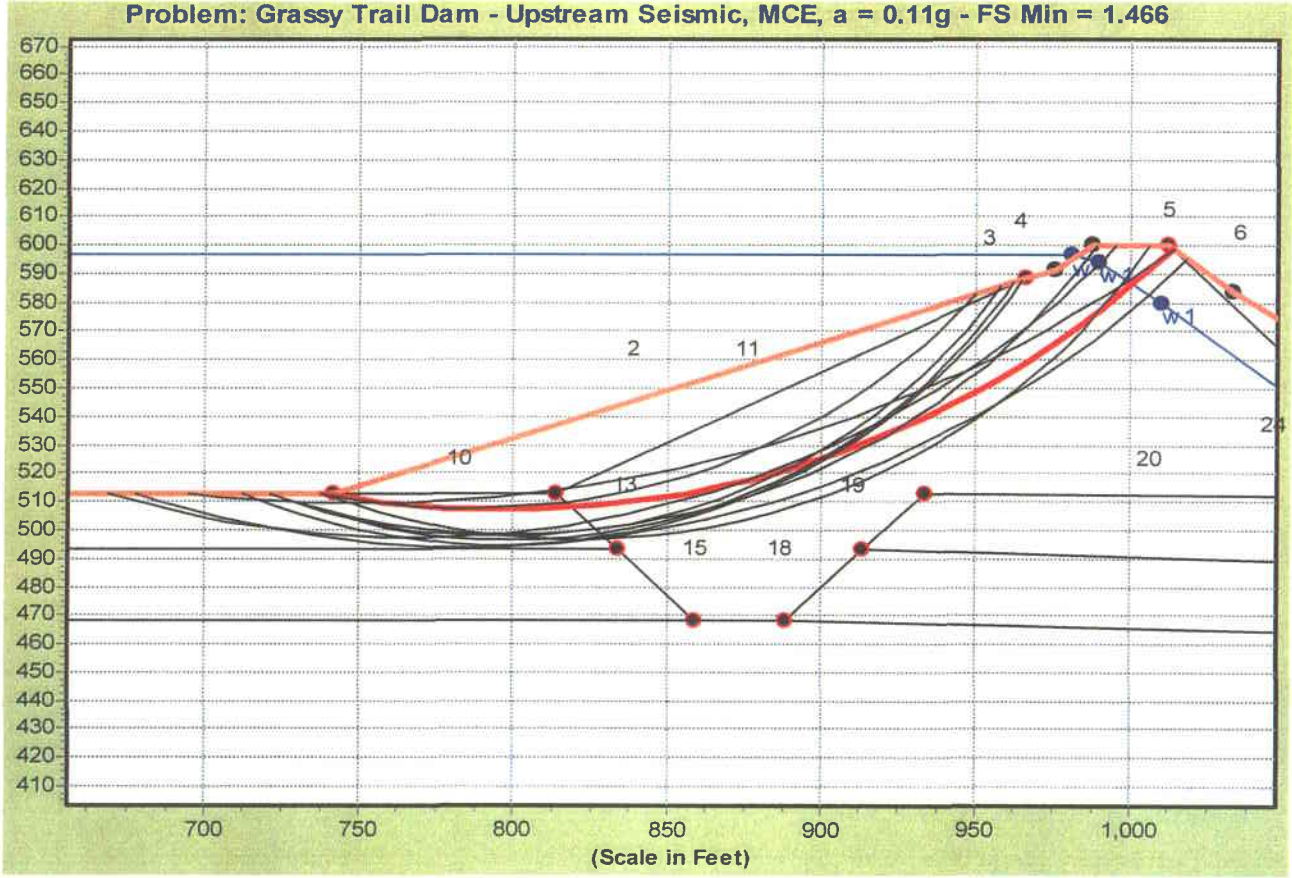
Upstream Slope - Static Sudden Drawdown Condition

Grassy Trail Dam and Reservoir

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0

Spencer's Method

Ten most critical failure surfaces shown



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Slope Stability Analysis Results

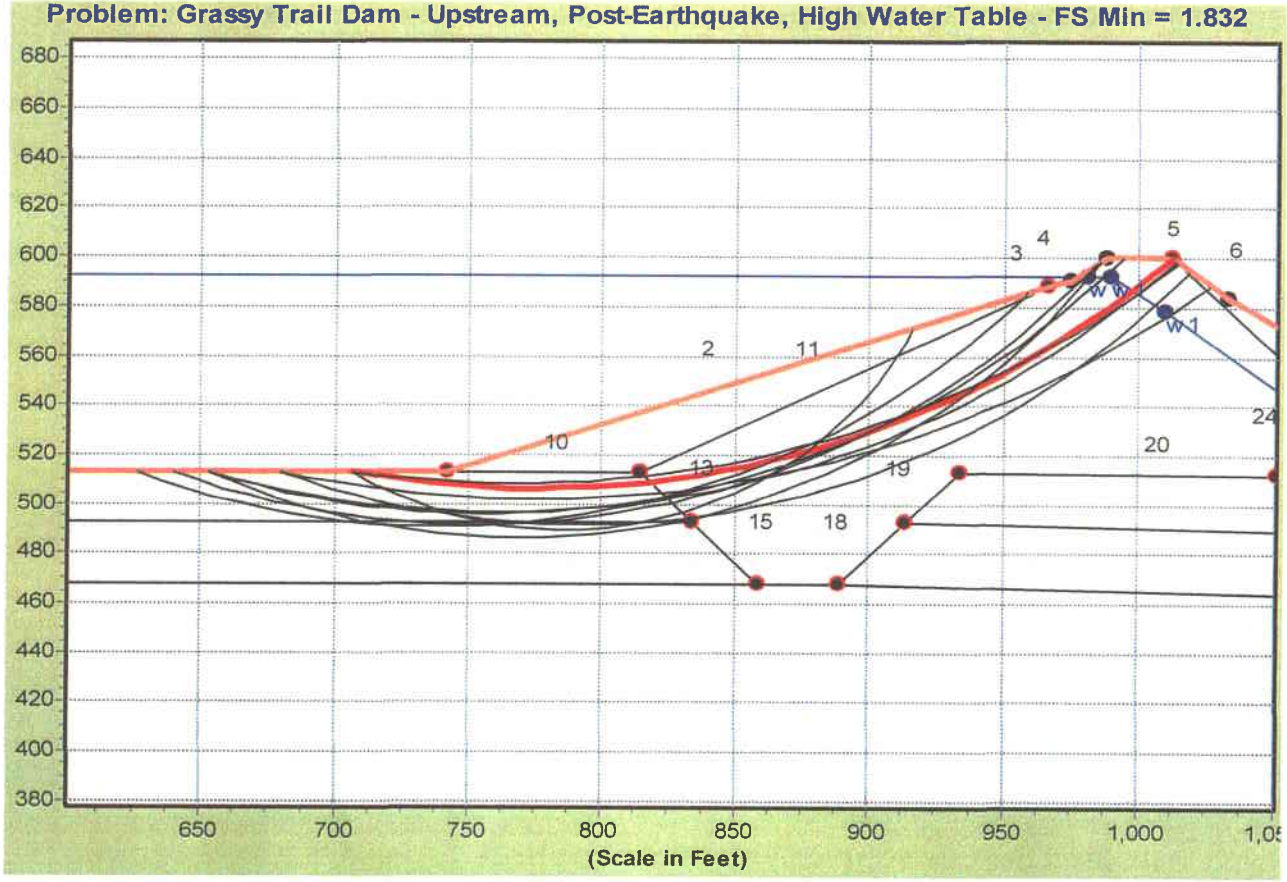
Upstream Slope - Maximum Credible Earthquake (non-mining)

Grassy Trail Dam and Reservoir

Spencer's Method

Pore pressure parameter = 0.1 in Layers 1 and 2
Pore pressure parameter = 0.2 in Layer 3
Ten most critical failure surfaces shown

Layer No.	Material Type	Moist Wt. (pcf)	Sat. Wt. (pcf)	Friction Angle (degrees)	Cohesion (psf)
1	Zone I Fill	130	135	31	250
2	Zone II Fill	130	135	31	250
3	Clay Foundation	125	130	34	0
4	Granular Foundation	130	135	37	0



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Slope Stability Analysis Results
Upstream Slope - Post-Earthquake Condition
Grassy Trail Dam and Reservoir