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GEOPHYSICAL EXPLORATION DATA REPORT
PHASE I
KATHERINE GOLD MINE
BULLHEAD CITY, ARIZONA

February 13, 2013

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Prepared for:

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Geophysical Exploration Data Report
Phase I
Katherine Gold Mine
Bullhead City, Arizona

Kleinfelder Project No. 128357

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1 INTRODUCTION

1.1 GENERAL

This data report presents the results of geophysical surveys performed at the former Katherine Mine in Bullhead City, Arizona. The approximate location of the site is shown on Plate 1 of the attached NORCAL report.

The purposes of these surveys were to provide preliminary information regarding the subsurface soil conditions in select locations and the development of a scope for Phase II field explorations and analysis. This report presents the results of the geophysical surveys along with descriptions of the test methods and a discussion of anomalous results.

Our Phase I scope included site reconnaissance, surface geophysical surveys, and preparation of this report. A scope of services is presented in our proposal of June 22, 2012 (Kleinfelder Proposal No. 127966).

1.2 PROJECT DESCRIPTION

The project site is approximately 4 acres in size encompassing an abandoned mine, referred to as Katherine Mine, located approximately 4 miles north of the intersection of Davis Dam Road and US68 in Bullhead City, Arizona. The site currently contains the remnants of previous mining activities including the remains of structures and some mining equipment. It also appears that some previously excavated mine shafts may have been filled and portions of the site rough graded. We understand that a sink hole approximately 12 feet in diameter and 4 feet deep, possibly related to an existing mine shaft, has opened up at the ground surface along with some smaller sink holes. On discovery of the sink holes, the project site has since been closed to the public. The National Park Service has requested non-intrusive evaluations of the subsurface in three areas at the mine in support of an effort to develop a preliminary working map of the mines' underworkings (i.e., shafts, caverns, tunnels). The three areas of concern expressed by the Park Service are shown on Figure 1, Project Site Map.

Historical site information including photographs, a map of mine workings at various levels, and additional information provided by NPS was reviewed by Kleinfelder and the information gathered was used to select the locations for the geophysical surveys. Areas of both known and unknown near-surface disturbance and/or void spaces were surveyed. Information about the location of and approximate overburden thicknesses above known void spaces was provided by NPS personnel who have previously explored these void spaces. The goal of the geophysical surveys was to identify underground anomalies that indicate possible void spaces or disturbed areas related to previous mining activities at the project site.

We understand based on information provided by NPS that the primary mining method utilized at this site was shrinkage stoping. Shrinkage stoping is understood to consist of sinking a shaft to a certain depth and then excavating a horizontal working level at that depth. Once the working level has been excavated, the excavation then proceeds upward allowing the upper soils to collapse to the ground below. This mining practice would explain the existence of large open areas near the ground surface that have been observed by NPS personnel.

2 FIELD EXPLORATION

2.1 GENERAL

The project site was explored by performing nine geophysical surveys that included both electrical resistivity testing and seismic surface wave testing. Testing was performed by NORCAL Geophysical Consultants, Inc. on August 28th through 30th, 2012. Survey locations were selected both in areas of known mine underworkings and areas thought to be free of mine underworkings. A review of the provided existing site data which included photographs and a map of mine workings showing previous site conditions was performed prior to selecting the survey locations. The survey location plan was communicated with NPS staff at the project site. The locations of the geophysical surveys are shown on Plate 1 of the attached NORCAL report.

The detection of anomalies within the subsurface was attempted with electrical resistivity testing because anomalous resistivity values may be indicative of possible void spaces. Abnormally high resistivity zones may be indicative of a possible air-filled void space. The detection of disturbed ground, fill soils, and void spaces was also attempted with seismic surface wave testing because shear wave velocities of these ground conditions will be significantly lower than those of the surrounding intact rock. The methods of electrical resistivity testing and seismic surface wave testing are discussed in more detail below.

2.2 ELECTRICAL RESISTIVITY

Electrical resistivity testing measures the apparent resistivity of the subsurface using multiple electrodes connected to a resistivity meter capable of inducing current and measuring voltage. Apparent resistivity is measured by inputting electric current into the ground through electrodes and measuring the voltage drop at other electrodes. This method was chosen to detect mine underworkings because void spaces, whether filled with air or water, may have significantly different resistivity properties than those of the soil or rock around them. These anomalous values may give an indication of the location, size, and orientation of a subsurface void space or tunnel.

The electrical resistivity data was acquired using a series of 56 stainless steel electrodes, a SuperSting R1/IP resistivity meter and Swift switch box manufactured by Advanced

Geosciences, Inc. A dipole-dipole type resistivity array was used during testing. The 56 stainless steel electrodes were arranged linearly, connected to the switchbox with cable, and spaced at either 4 or 5 feet. The SuperSting and Swift switchbox were programmed to automatically collect the resistivity data by switching the appropriate electrodes on and off.

2.3 SEISMIC SURFACE WAVE MEASUREMENT

Seismic waves are generated when seismic energy is imparted to the subsurface. Seismic waves may be body waves, i.e., compression or shear waves, or surface waves. The type of surface wave generated when a vertical seismic source is used is referred to as a Rayleigh wave. The multi-channel analysis of surface waves (MASW) method takes advantage of the dispersive properties of the Rayleigh waves to estimate a one-dimensional shear wave velocity profile of the subsurface. A series of one-dimensional profiles, which can be contoured to create a two-dimensional profile, can be created by pulling the line forward, recording data, and repeating the process several times. This method was chosen to detect mine underworkings because the shear wave velocity of a soil or rock is closely related to its stiffness, and therefore a profile that contains areas of low shear wave velocities would be indicative of disturbed soil or rock. Void spaces may be detected by the presence of lower shear wave velocities of the disturbed soil or rock surrounding the void space.

Seismic surface waves were measured using the MASW method. A series of 24 geophones spaced 3 feet apart were connected with cable along a land streamer and connected to a Geode 24 channel seismograph manufactured by Geometrics, Inc. Data was collected by imparting seismic energy in the form of a 100 pound weight dropping a distance of 2 feet onto a metal plate and recording the produced surface waves. The line of geophones was then pulled by an ATV longitudinally 6 feet and the process repeated. Total line lengths for the 3 MASW lines performed ranged from 230 feet to 295 feet. The collected data was processed to develop a one-dimensional shear wave velocity profile for each shot point using the SurfSeis 3.0 software package developed by the University of Kansas. The one-dimensional profiles for each line were then collated and contoured using the software package Surfer 11.0 by Golden Software in order to produce a two-dimensional shear wave velocity profile across the line length. The contours and boundaries presented on the Figures are approximate.

3 DISCUSSION OF RESULTS AND CONCLUSIONS

3.1 GENERAL

The purpose of the geophysical surveys was to identify areas of potential void spaces including tunnels and mining excavations (stopes) and disturbed ground. Several areas were identified where anomalous resistivity values were detected, the locations of which are presented in plan view on Plate 8 of the NORCAL report.

Electrical resistivity test ER-4 was performed over a known void space within the fenced area in order to verify that the test method was successfully detecting void spaces. The known void spaces were identified as high resistivity anomalies and corresponded well in resistance magnitude with other high resistivity anomalies found in other resistivity test locations. MASW testing was not performed within the fenced area because of safety concerns related to driving an ATV and creating vibrations in an area of known subsurface voids.

The results of the shear wave velocity testing were inconclusive as to their effectiveness in the detection of voids. It is possible that void spaces were not able to be segregated from the data due to the relatively high shear wave velocity material immediately above possible void spaces or disturbed ground. Possible evidence for the presence of void spaces detected by MASW testing was found in the existence of low velocity layers below high velocity layers, a phenomenon that is relatively uncommon in competent rock.

3.2 ELECTRICAL RESISTIVITY

Resistivity values obtained from the electrical resistivity surveys ranged from less than 10 ohm-m to approximately 800 ohm-m. Moderately low to low resistivity areas are likely indicative of either water-filled void spaces or rock. We interpret these moderately low to low resistivity zones to be weathered rock or rock because it is unlikely that void spaces are water-filled due to the anticipated groundwater depth of several hundred feet below existing site grade. Moderately high to high resistivity areas are likely indicative of either dry loose sand and gravel or air-filled void spaces. We interpret some of these moderately high to high resistivity areas to be sand and gravel and others to be possible air-filled void spaces.

The subsurface generally consisted of approximately 2 to 10 feet of moderately high to high resistivity soil interpreted to be relatively dry loose sand and gravel underlain by moderately low to low resistivity material interpreted to be weathered rock or rock. Several anomalous circular to oblong areas of moderately high to high resistivity were observed within the subsurface zones interpreted to be rock. Further discussion of these anomalies is presented in the following paragraphs. The results of the electrical resistivity testing are presented as cross-sections on Plates 2 through 7 of the NORCAL report.

Areas of anomalous resistivity values indicative of potential void spaces would be areas of relatively high resistivity present within low resistivity areas. A total of 9 high resistivity anomalies were identified at the project site. Many low resistivity anomalies (lower resistivity than the background resistivity interpreted to be rock) were identified above the high resistivity anomalies indicating the possible presence of rock or fractured rock overlying dry loose sand and gravel or air-filled /void spaces which is consistent with the understood mining practices at the site. Anomaly designations discussed below are presented on Plate 8 of the NORCAL report.

Anomalies A, B, and E were identified in resistivity lines ER-1, ER-2, and ER-5, respectively. These anomalies exist at approximately the same elevation and are of the same general size, which suggests that they may be related. It is expected that a void space intersecting the resistivity line at a near perpendicular orientation would create a near circular anomaly while a void space intersecting the resistivity line at a relatively low angle would create a more elongated anomaly. These anomalies are consistent with the expected profiles if a tunnel were to be present and aligned as depicted on Plate 8.

Anomalies C and D were identified in resistivity lines ER-3 and ER-4, respectively. These anomalies were very large and relatively deep as well. Due to the consistency in their lateral extent, it is likely that these anomalies represent the same feature. The feature appears to begin at a depth ranging from 10 to 30 feet below the ground surface, dip to the north and extend in excess of 50 feet in the area of resistivity line ER-4. Resistivity line ER-4 was performed within a fenced off area of known underground voids as reported by a representative of NPS and observed mine shafts and sink holes at the ground surface.

Anomalies F through I were identified in resistivity line ER-6. The anomalies are generally of high resistivity with a few areas of low resistivity. High resistivity zones on the southwest side of the survey line exist between 5 and 30 feet below existing site grade. The high resistivity zones on the northeast portion of the survey line exist less than 5 feet below the surface and extend to a depth of approximately 30 feet. The high resistivity anomalies within 5 feet of the surface represent a potentially dangerous ground condition. These anomalies do not appear to be related to the other anomalies detected at the other resistivity test locations.

3.3 MULTI-CHANNEL ANALYSIS OF SURFACE WAVES

Shear wave velocity values obtained from the survey ranged from less than 500 to approximately 4,000 feet per second. Shear wave velocities of less than 1,000 feet per second were common in the upper 20 feet and were observed to a maximum depth of 40 feet. In general, the shear wave velocities in the upper 40 to 60 feet were 2,000 to 3,000 feet per second or less, underlain by velocities in excess of 3,000 feet per second to the maximum depth resolved by the test method. The results of the MASW testing are presented as cross-sections on Plates 9 through 11 of the NORCAL report.

Anomalous shear wave velocities were not clearly detected during MASW testing. For most soil and rock profiles, the shear wave velocity of the subsurface generally increases with depth. Although very low shear wave velocities were not measured during testing, it is possible that the portions of the profiles that show a significant reduction in shear wave velocity with depth represent void spaces, fill soils, or disturbed rock.

3.4 RECOMMENDATIONS FOR ADDITIONAL SERVICES

As stated in our proposal dated June 22, 2012, no recommendations can be made or implied concerning the reliability of the geophysical data, stability of the site or safety of people visiting the site without additional analysis and field exploration. This initial phase of geophysical testing was developed to provide a preliminary picture of the subsurface that would allow for the development of the future phases to include field exploration and analysis.

At least two additional phases will be required to complete the analysis. The next phase would include a drilling program to characterize the anomalies detected during resistivity testing and the relatively low shear wave velocity zones detected during MASW testing. After the results of the drilling program are obtained, a scope for the third phase, a final stability analysis, will be prepared. The final phase analysis would likely include additional field explorations and geotechnical analysis to estimate the stability of the site.

4 CLOSURE

4.1 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions, and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

No recommendations can be made or implied concerning the reliability of the geophysical data, stability of the site or safety of people visiting the site without additional analysis and field exploration. This initial phase of geophysical testing was developed to provide a preliminary picture of the subsurface that would allow for the development of the future phases to include field exploration and analysis. All geophysical data presented in this report should be considered preliminary.

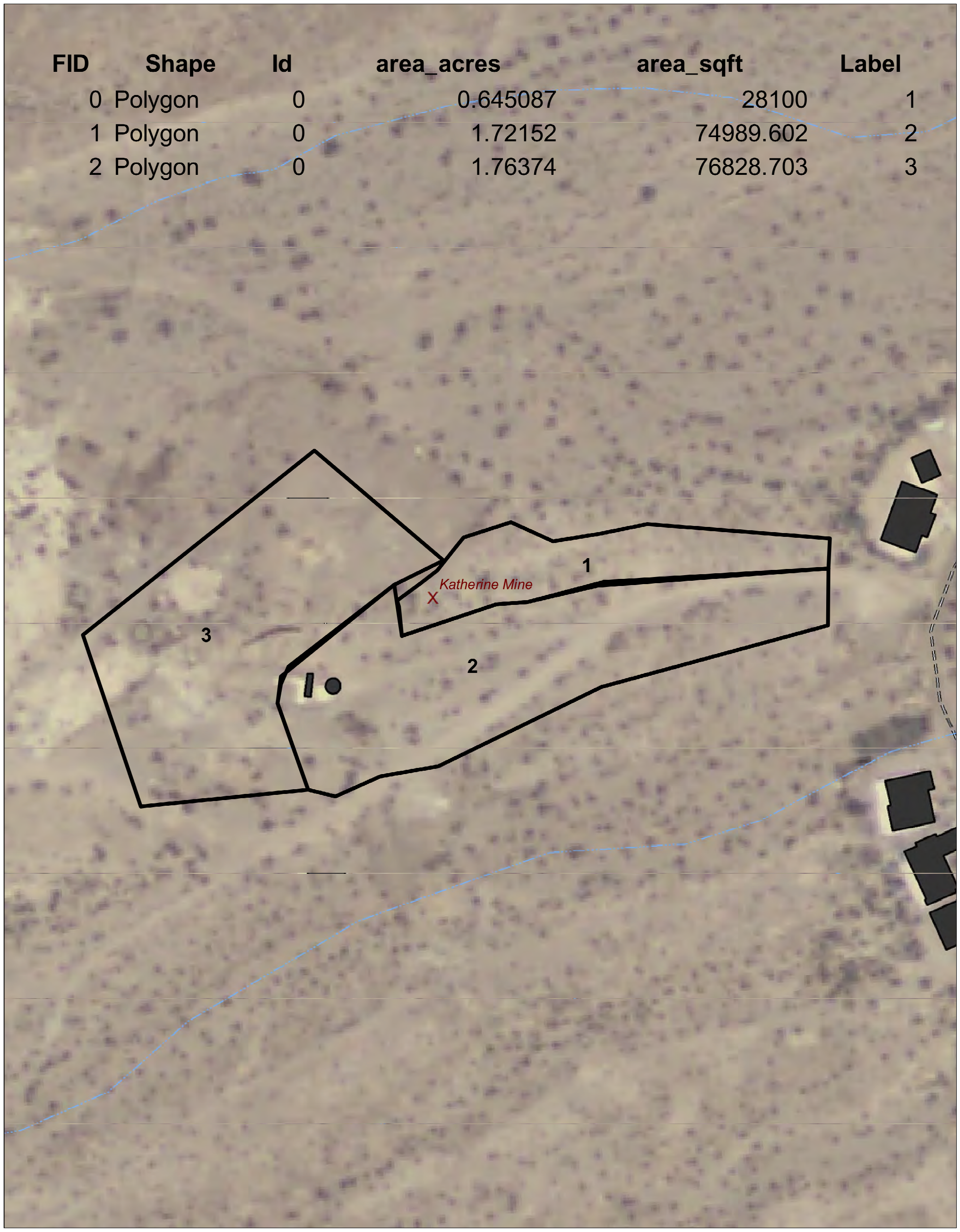
The work performed was based on project information provided by the National Park Service (NPS). This report may be used only by NPS and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than one year from the date of the report. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

We appreciate the opportunity to be of service on this project. Should you have any questions regarding this report or wish to discuss additional services, please do not hesitate to contact us.

REFERENCES

NORCAL Geophysical Consultants Inc., Katherine Mine Geophysical Investigation (NORCAL Job No. 12-177.192), October 26, 2012.

ATTACHMENTS



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Note: Map provided by National Park Service

200 100 0 200

APPROXIMATE SCALE (feet)

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PROJECT NO. 127966	**Project Site Map**	FIGURE
DRAWN: 6/21/2012		
DRAWN BY: DFR	Katherine Mine	1
CHECKED BY: DJS		
6380 South Polaris Avenue Las Vegas, Nevada 89118 (P) 702-736-2936 (F) 702-361-9094	Bullhead City, Arizona	

NORCAL GEOPHYSICAL CONSULTANTS, INC.

October 26, 2012

Kleinfelder
6380 South Polaris Avenue
Las Vegas, Nevada 89118

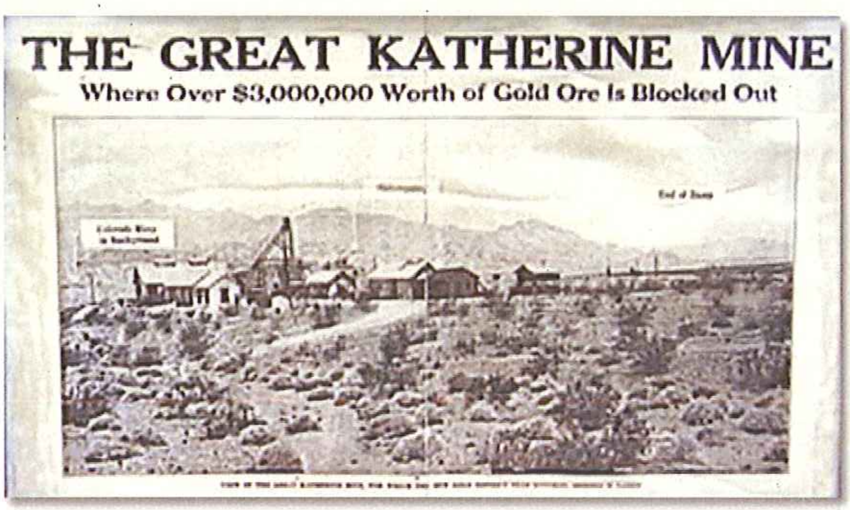
Subject: Geophysical Investigation
Katherine Mine
Mohave County, Arizona
NORCAL Job No. 12-177.192

Attention: Mr. Dustin Robbins

This report presents the findings of a geophysical investigation performed for Kleinfelder by NORCAL Geophysical Consultants at the subject location. The field work was performed during the period of August 28-30, 2012 by NORCAL Geophysicist David T. Hagin (PGp No. 1033) and Geophysical Technicians Travis W. Black and Christopher J. Bissiri. Kleinfelder geologist Dustin Robbins provided site orientation and logistical support and property owner liaison.

1.0 SITE HISTORY

Katherine Mine is a former underground Au-Ag-Cu-Be-Mn mine located in Mohave County, Arizona about two miles east of the Colorado River in the former Union Pass District (Index Map, Plate 1). The mine started in 1900 and closed in 1904, then reopened in 1907 through 1909, again in 1915 through 1929, and experienced presumed activity in 1930-31. The mine gave its name to the original Katherine District, which later became the Union Pass District, and is now consolidated into the Oatman District. The mine was owned at times, or in part, by the Katherine Gold Mining Co. (1925-1929), and the New Comstock Mining Co. (1930-1931). The mine provided water for an ore processing mill from 1924 to 1942, and for the Katherine Subdivision from 1960 to present. An unsuccessful attempt was made to process the tailings for gold between 1958 and 1960. The mine is currently part of the Lake Mead National Recreation Area under the auspices of the National Park Service.



2.0 SITE DESCRIPTION

Katherine mine is situated on a small knob of granite about 150-ft in diameter. The host rock includes the Golden Door volcanics and the Times porphyry. The shaft collar is at an altitude of 990-ft. Originally, the mine was opened for a total length of 1700-ft and included development to the 300-ft (deep) level. Later, a shaft was sunk to a depth of 950-ft and mining occurred on the 400-, 500-, and 600-ft levels. Mining activities exploited mineralization that occurred in an epithermal vein of the Comstock type that strikes N.62°E. and dips vertically. It is a stringer lode that has a width of more than 60-ft at surface but narrows underground.

Three mine shafts have been located at the site. The main shaft, No. 1, is 950-ft deep and is capped with concrete and water recovery equipment. It is used for mine water recovery for the Katherine Subdivision. Shaft No. 2 (photo at left) is located about 275-ft east of No. 1. It is open and fenced and is bottomed on the 200-ft level with a station on the 100-ft level. About 25-ft west of the shaft it appears that a stope has broken through to the surface (photo below). Attempts to close this opening vary from dirt to rock to refuse, etc. If this is an open stope then it is extremely hazardous. Shaft No. 3 is about 600-ft east of No. 2 and bottoms at the 200-ft level. It is not safely capped.

With the exception of the openings described above, the only remaining evidence of the former mining activity include some concrete slabs, some retaining walls, waste rock and tailings piles, concrete footings, and the remains of a large, rusted, metal tank (see photo on page 3).

3.0 PURPOSE

The purpose of the geophysical investigation is to use the Electrical Resistivity Profiling (ERP) and Multi-channel Analysis of Surface Waves (MASW) methods to explore for variations in subsurface electrical and seismic properties. Such variations could provide evidence of tunnels, shafts, stopes, or collapse features associated with the former mining activities.

4.0 RATIONALE

ERP was selected as one of the methods because of success we have had in using it to delineate underground openings in other investigations. Similar success has also been documented in the literature. This success stems from the fact that air-filled or water-filled openings usually have electrical properties that are significantly different from the surrounding rock. Typically, air-filled openings are more resistive and water-filled openings are more conductive.

We have also been successful in delineating underground openings using the MASW technique. This is because MASW profiles provide an indication of variations in shear (S-) wave velocity (Vs) with depth and distance beneath a profile and Vs is directly proportional to the strength of the materials through which they propagate. Since a tunnel represents a zone of weakness, not only because of the void space but also because of the disturbed rock around it, it should be resolved as a zone of low Vs. This would also hold even in the case of a collapsed debris-filled tunnel.

5.0 METHODOLOGY

The methodology as well as general data acquisition and analysis procedures for the two geophysical methods used in this investigation are described in Appendix A. The salient features of the data acquisition and analysis procedures, as they apply to this investigation, are described in the following sections.

6.0 ELECTRICAL RESISTIVITY PROFILING (ERP)

6.1 DATA ACQUISITION

We collected ERP data along six traverses designated ER-1 through ER-6. The locations of these lines, which were designated by Kleinfelder, are shown on Plate 1. During the field investigation we used GPS to record the geographic locations of selected points along each of the lines. We used hand leveling in conjunction with the GPS survey to determine the elevations of those points.

We collected the ERP data using a ***SuperSting R1/IP*** resistivity meter and ***Swift*** switch box manufactured by Advanced Geosciences, Incorporated. The resistivity system included four multi-conductor cables with 14-connectors (take-outs) per cable and 56-stainless steel electrodes. On each line the electrodes were distributed at predetermined intervals in a collinear array and connected to the four cables which were, in turn, connected end-to-end and to the switch box and resistivity meter which were positioned in the center of the array. A portion of one of the electrode arrays is shown in Figure 1. A brine solution was poured on the ground at the base of each electrode in order to minimize the contact resistance and, thereby, improve signal quality. Prior to collecting data we ran a test procedure that is part of the ***SuperSting*** built-in software to check the contact resistance on each electrode. Where necessary, we improved the contact by checking the cable connections, driving the appropriate electrode further into the ground, and/or by adding more brine. The ***SuperSting*** and ***Swift*** were then programmed to automatically collect the dipole-dipole resistivity data by switching the appropriate electrodes on and off in sequence. Typically, it took about 1-1/2 hours to collect the data using all 56-electrodes and dipole lengths ranging from one to six times the electrode spacing.

Figure 1 - Electrode Array

On Lines ER-1 through ER-3 we used an electrode spacing of 5-ft resulting in an array length of 275-ft. On Lines ER-4 through ER-6 we used an electrode spacing of 4-ft resulting in an array length of 220-ft.

6.2 DATA ANALYSIS

After completing the data acquisition, we downloaded the dipole-dipole resistivity data to a desk top computer using the software ***AGI Administrator*** by AGI. We also used this software to convert the data to a format suitable for inversion. We then used the computer program ***EarthImager***, also by AGI, to invert the data. This program uses a finite element method to model the dipole-dipole resistivity data. First, the program plots the measured apparent resistivity data in pseudo-section form (see Methodology, above). Next, it sub-divides the pseudo-section into a mesh of cells and assigns resistivity values to each cell. The values used are derived from the measured apparent resistivities. It then calculates the apparent resistivity that would be measured above this model and compares those values with the measured values. The program then adjusts the model and repeats the process. This procedure is repeated until the percent error between the calculated values and the measured values drops below a specified level. Once a model is derived that provides an appropriate fit to the measured data, we used the computer program ***Surfer 11.0*** by Golden Software to contour the calculated data. This resulted in two-dimensional cross-sections representing variations in true electrical resistivity with depth and distance beneath each line.

6.3 RESULTS

The results of the ERP surveys on Lines ER-1 through ER-6 are illustrated by the electrical resistivity cross-sections (profiles) shown on Plates 2 through 7, respectively. The sections are color contoured to better illustrate the variations in resistivity. The relationship between resistivity values are color and indicated by the electrical resistivity scale shown below each profile. The electrical resistivity values range from less than 10 to 800 ohm-m. In order to adequately cover such a large range without the sections being too cluttered, we have used a logarithmic contour interval. In addition to illustrating the distribution of resistivity values, the sections also show the locations of crossing lines and the locations of zones with anomalously high resistivity values (Section 6.4).

For purposes of discussion, we have differentiated the electrical resistivity values into four ranges as follows:

Low: 10-100 ohm-m (blue shaded contours)
Moderately Low: 100-350 ohm-m (green shaded contours)
Moderately High: 350-600 ohm-m (yellow shaded contours)
High: >600 ohm-m (orange to red shaded contours)

In general, the ER profiles are characterized by a relatively thin (2- to 10-ft) surface layer consisting of moderately high to high values overlying a background matrix of moderate low values. We interpret the surface layer as representing loose, dry, unconsolidated materials such as sands and gravels. The moderately low values comprising the remainder of the profiles probably represent moderately weathered bedrock. The exceptions to this pattern are horizontal zones of low values and localized oblong to circular contour closures consisting of moderately high to high values (see Section 6.4).

6.4 INTERPRETATION

Information provided by Kleinfelder indicates that groundwater is several hundred feet deep. Consequently, any mine tunnels within the geophysical depth of investigation are probably air-filled. That being the case, we would expect the tunnels to be more resistive than the surrounding rock. In areas where tunnels intersect an ER profile at a high angle we would expect the resulting ER anomaly to have roughly circular symmetry and to contain high ER values. In areas where the tunnel intersects a profile at a low angle, we would expect the resulting anomaly to have a more elongate shape depending on the angle of the tunnel alignment relative to the profile. In these cases, the ER anomaly would exhibit high values where the tunnel directly intersects the plane of the profile and moderately high values where the tunnel is out of the plane but close enough to affect the measured resistivity values.

Our interpretation of the ER Profiles has identified a total of nine ER anomalies that could be related to mine tunnels according to the characteristics described above. The lateral extents of these anomalies, labeled A through I, are depicted on the ER profiles shown on Plates 2 through 7. The geographic locations of the anomalies are shown on Plate 8. We have noticed that many of the ER anomalies are capped by a zone of low resistivity. This could indicate a zone of highly fractured rock overlying the tunnels. The low resistivities of these zones could be explained by their being in-filled with fines and, consequently, having retained moisture from meteoric run-off.

Brief descriptions of the ER anomalies and their possible sources are provided in the following paragraphs.

Anomalies A, B and E: These anomalies are all of the same approximate size and approximate elevation (920-ft) and align along a general east-west trend. For these reasons we have interpreted the three anomalies as being caused by a generally east-west trending tunnel. The anomalies exhibit all the characteristics of tunnels that intersect a profile at a high angle (ER-1) and at relatively low angles (ER-2 and ER-5), as described above.

Anomalies C and D: These anomalies are very large and extensive. For these reasons and because of their general proximity we interpret them as being caused by the same feature; a large opening that dips to the north. Beneath ER-3 (Anomaly C) the opening is 10- to 20-ft deep and about 15- to 20-ft thick. Beneath ER-4 (Anomaly D) the opening is 30- to 35-ft deep. The thickness of the opening at this location cannot be determined because the anomaly extends below the depth of investigation. This change in the depth of the anomaly is about 20-ft over a horizontal distance of 60-ft.

Anomalies F-I: All of the remaining ER anomalies occur beneath Line ER-6 and, consequently, cannot be related to any other anomalies. Anomaly F has roughly circular symmetry suggesting a tunnel that intersects the profile at a relatively high angle. Anomalies G and H are more oblong suggesting tunnels that intersect the profile at a lower angle. Anomaly I is indicative of an opening such as a stope that dips to the southwest. If this anomaly is caused by an opening, its northeast extent is dangerously close to the surface.

7.0 MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

We collected MASW data along Lines MASW-1 through MASW-3. The locations of these lines, which were designated by Kleinfelder, are shown on Plate 1. MASW-1, MASW-2 and MASW-3 coincide with ER-3, ER-5, and ER-6, respectively.

During the field investigation we used GPS to record the geographic locations of selected points along each of the survey lines. We used hand leveling in conjunction with the GPS survey to determine the elevations of those points. The general data acquisition procedures for both geophysical methods are described in the methodology section. Salient features of the data acquisition for this investigation are described in the following paragraphs.

7.1 DATA ACQUISITION

We conducted the MASW survey along three lines labeled MASW-1, MASW-2, and MASW-3, as depicted by the solid blue lines shown on Plate 1. MASW-1 was 295-ft long and coincided with ER-3. MASW-2 was 240-ft long and coincided with ER-5. Finally, MASW-3 was 230-ft long and coincided with ER-6. We collected the MASW data over each line using a towed geophone array. This consisted of 24-geophones attached to a nylon strap at 3-ft intervals. The array was towed behind an all-terrain vehicle (ATV) equipped with a ***Digipulse*** accelerated weight drop (AWD-1) seismic energy source, as shown in Figure 2. This device consisted of a vertically mounted, cylindrically shaped, 100 lb weight that was accelerated downward by large elastic bands through a 24-inch drop onto an aluminum plate on the ground surface. An accelerometer attached to the strike plate transmitted a triggering pulse to the seismograph each time the weight impacted the plate. The AWD-1 was used to produce surface waves (ground roll) at 6-ft intervals along each line. The geophone array was positioned so that the closest geophone was always 6-ft from the shot point (AWD-1).

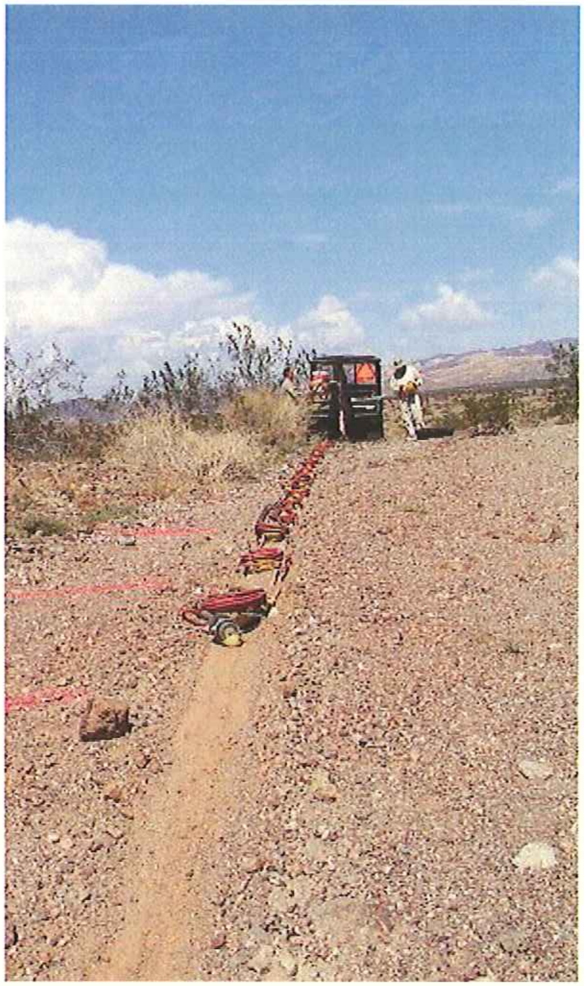


Figure 2 - Towed Geophone Array

We began the survey by positioning the array at the beginning of the respective line and initiating a shot. After recording the data (shot gather) we moved the ATV and array 6-ft up the line and initiated another shot. We continued in this manner, moving the ATV/array 6-ft at a time until the total length of each line was covered.

We recorded the seismic data using a ***Geometrics Geode*** 24-channel signal enhancement seismograph networked to a field computer. No acquisition filters were applied during data collection. Refracted and surface wave energy produced at the shot points were detected using ***Oyo Geospace*** 8-Hertz geophones. The resulting seismic records were written to the field computers hard drive for subsequent processing and analysis.

7.2 DATA ANALYSIS

We processed the surface wave data using the software package ***SurfSeis 3.0*** which was developed by the University of Kansas. Using this software, the data from each shot point was processed to develop a dispersion curve representing variations in Rayleigh wave velocity with frequency. Each dispersion curve was then inverted to compute a 1D model representing Vs versus depth beneath the center of the 24-geophone array used to record the respective data. We then used the software package ***Surfer 11.0***, by Golden Software, to collate and contour all of the 1D models. This resulted in a 2D cross-section illustrating variations in Vs with depth and distance beneath the seismic line.

7.3 RESULTS

The results of the MASW surveys on lines MASW-1 through MASW-3 are illustrated by the seismic velocity cross-sections (profiles) shown on Plates 9 through 11, respectively. The sections are color contoured to better illustrate the variations in shear (S) wave velocity (Vs). The relationship between velocities and contour colors are indicated by the velocity scale shown below each profile. The Vs values range from less than 500 to almost 4,000 ft/sec. In addition to illustrating the distribution of Vs, the sections also show the locations of intersecting profiles and ER anomalies.

We have differentiated the range of Vs values into three velocity ranges as follows:

Low: 500- to 2,000-ft/sec (light blue shaded contours)
Moderate: 2,000- to 3,000-ft/sec (light brown shaded contours)
High: > 3,000-ft/sec (dark brown shaded contours)

In general the MASW profiles indicate five Vs layers within the upper 70- to 90-ft of the subsurface. The velocities, depths, and thicknesses of these layers are listed in the following table:

LAYER	VELOCITY RANGE (FT/SEC)	DEPTH RANGE (FT)	THICKNESS RANGE (FT)
1	Vs Low	0	5-25
2	Vs Moderate	5-25	10-20
3	Vs Low	20-40	5-25
4	Vs Moderate	5-55	5-50
5	Vs High	35-85	undetermined

Layer 2 and 3 are absent beneath MASW-2. This accounts for the minimal value at the low end of the Layer 4 depth range (5-ft at the northeast end of Line 2). In most areas Layer 4 is at least 30-ft deep. The MASW profiles do not exhibit any localized Vs anomalies that we would attribute to open mine workings or zones of weakness. Consequently, the variations in Vs illustrated on Plates 9-11 are probably related to variations in the degree of weathering of the rock and/or changes in lithology.

8.0 CORRELATION

The general relationship between electrical resistivity and S-wave velocity is indicated by the Vs interfaces which are superimposed on ER Profiles 3, 5 and 6 (Plates 4, 6 and 7) and by the ER Anomaly outlines superimposed on the MASW profiles (Plates 9-11). In general, the Vs interfaces roughly coincide with broad scale ER changes. For example, the deepest Vs interface shown on Plate 4 roughly coincides with a change from moderately high to high resistivities overlying low to moderately low resistivities. In other areas, Vs interfaces generally coincide with the tops or bottoms of ER contour closures. The ER Anomalies shown on Plates 9-11 all occur within Vs layers 1 and 2 except for ER Anomaly C which extends into Vs layer 3. There are no ER anomalies within Vs layers 4 or 5. Furthermore, there are no Vs contour closures exhibited on Plates 9-11 that are indicative of underground openings, as stated previously.

9.0 DISCUSSION

If the ER Anomalies described in Section 6.4 are caused by underground openings, we would expect to see coinciding contour closures of low Vs on the MASW profiles. The fact that matching MASW anomalies are absent raises the possibility that the ER anomalies are caused by some other phenomena such as lithologic variations, localized changes in moisture content, and/or in the degree of fracturing. However, given the fact that some of the ER anomalies are so close to the surface (e.g. Anomaly I on Line 6) we believe that, in the interest of safety, it would be prudent to proceed on the assumption that the ER anomalies are, indeed, caused by underground tunnels and voids.

10.0 STANDARD CARE AND WARRANTY

The scope of services for this project consisted of using geophysical techniques to delineate variations in the physical properties of the subsurface that might be associated with underground mine workings. The accuracy of our findings is subject to specific site conditions and limitations inherent to the seismic refraction technique. We performed our services in a manner consistent with the level of skill ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the performance of services or products delivered under this agreement, expressed or implied, is made by NORCAL.

We appreciate the opportunity to provide our services to Kleinfelder for this project. Should you require additional geophysical services or have questions regarding this survey, please do not hesitate to call.

Sincerely,

NORCAL Geophysical Consultants, Inc.

William E. Black
Professional Geophysicist GP-843

WEB/tt

Enclosures: Plates 1 through 11
Appendix A

APPENDIX A

METHODOLOGY

NORCAL

Appendix A

METHODOLOGY

ELECTRICAL RESISTIVITY PROFILEING (ERP)

The electrical resistivity (ER) method is used to measure variations in the electrical resistivity (ER) of the subsurface. Variations in ER can be related to factors such as permeability, porosity, clay content, and moisture content. ER can be measured in a variety of ways. One way is to measure the change in ER beneath a single point. This is referred to as a vertical electric sounding (VES). Another way is to measure variations in ER with depth and distance along a traverse. This is referred to as resistivity profiling. All of the ER methods involve the use of four electrodes. Electrical current is input to the ground through two of the electrodes and the resulting potential drop (voltage) is measured across the remaining two. All four electrodes are typically arranged in a collinear array. However, the relative configuration and spacing of the electrodes can vary.

One of the most commonly used ER profiling techniques is the dipole-dipole array. This array consists of four electrodes arranged in a collinear fashion. Electrical current is input to the ground through two adjacent electrodes, referred to as the "current dipole". The resulting potential is then measured across the remaining two electrodes, referred to as the "potential dipole". Both dipoles have the same length, "a", and are always separated by a multiple (n) of their length. The survey is initiated with the current dipole at the beginning of the profile, and the potential dipole one dipole length further along the profile. The potential dipole is then moved along the profile for successive readings until it is about six dipole lengths away from the current dipole. The current dipole is then moved one dipole length along the profile, the potential dipole is moved back to a distance of one dipole length from the current dipole, and the procedure is repeated. This process is continued until the end of the profile is reached.

For each reading, the measured potential (V) is divided by the current (I), and the quotient is multiplied by a geometric factor (k) that is unique to the dipole-dipole array. The resulting value represents the electrical resistivity of the volume of earth sampled. This volume varies according to the separation between dipoles and the electrical structure of the subsurface. Since the computed value represents the resistivity of a volume of earth rather than a discrete layer, it is referred to as an "apparent resistivity". The computed apparent resistivity values are then plotted in cross-section form, at points that are half-way between the current and potential dipoles, and at a depth equal to one-half the distance between the centers of the dipoles. The resulting set of values is then contoured to illustrate the variation in apparent resistivity with distance and dipole separation along the profile. This is referred to as a "pseudo-section" because the values are "apparent", that is they represent the resistance of a volume of material rather than discrete layers. In addition, the vertical axis of the section is a function of dipole separation, not necessarily depth. Computer techniques can then be used to invert the pseudo-section to produce a two-dimensional cross-section depicting variations in true resistivity versus actual depth and distance.

MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

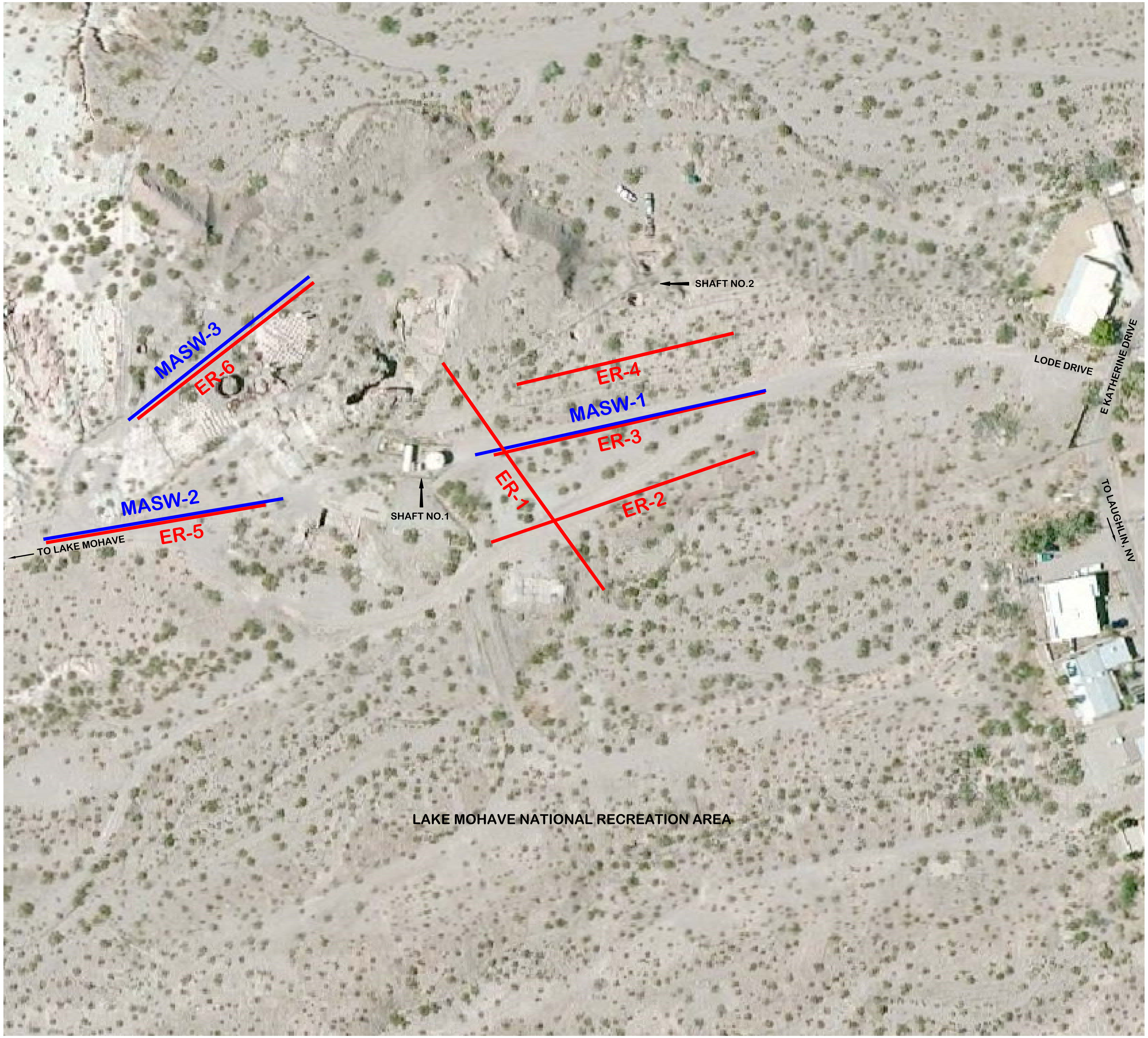
When seismic energy is generated at or near the ground surface, seismic waves are produced. Those that travel through the subsurface are referred to as body waves. Those that travel along the ground surface are referred to as surface waves. Body waves consist of both compressional (P) and shear (S) waves. P waves cause particles in their path to oscillate in the same direction that the wave is propagating. S waves cause particles to oscillate perpendicular to the direction that the wave propagates. Surface waves are similar to S waves. If a vertical energy source is used, Rayleigh type surface waves are produced. These are commonly referred to as ground roll in seismic surveys. Rayleigh waves travel at approximately 0.9 times the velocity of shear waves (Vs).

Surface waves account for more than two-thirds of the energy produced by vertical impact seismic energy sources. As a result, surface waves are the most prominent signal on multi-channel seismic records. In addition, surface waves have dispersion properties that body waves lack. That is, different wavelengths have different penetration depths and, therefore, propagate at different velocities. By analyzing the dispersion of surface waves it is possible to obtain a near-surface Vs profile. Since Vs is directly proportional to shear modulus, this provides a direct indication in the variation of stiffness (or rigidity) of subsurface materials.

The spectral analysis of surface waves (SASW) is not a new technique. This method has been used by engineers and geophysicists for many years. However, the conventional method involves using two receivers (geophones) to record multiple impacts at a fixed point. The survey is initiated with the geophones at close proximity to the impact (shot) point. With succeeding impacts the geophones are moved further and further away. This is done so that the surface wave can be sampled at numerous locations. The data from all of the geophone locations are then analyzed to determine the variation in the velocity of the surface wave with respect to frequency. This results in what is referred to as a dispersion curve. With this technique, it may take several hours to obtain a dispersion curve at a single point.

Recent advances in computer software and processing techniques developed by researchers at the University of Kansas have made it possible to analyze surface waves using a large number of shot points and receivers. This is referred to as the multi-channel surface wave (MASW) technique. Dispersion curves at dozens of points distributed along a profile can now be obtained with MASW in the same amount of time it previously took to obtain a single dispersion curve using SASW. The surface wave data are gathered in much the same way as high resolution seismic reflection data. Seismic waves generated by vertical impacts on the ground surface are detected by an array of closely spaced geophones (spread). The energy source and the geophones are sequentially moved along a profile as the survey progresses.

We analyze MASW data using the computer program ***SurfSeis***, which was developed at the University of Kansas. The software analyzes the data from each seismic record and determines the variation in velocity versus frequency (dispersion curve). The software then inverts the dispersion curve to determine the variation in Vs versus depth beneath a point half-way between the energy source and the center of the spread. The data gathered from multiple shot points and geophone locations can be collated to produce a two dimensional (2D) cross-section showing the variation in Vs with depth and distance along a profile.



VICINITY MAP

SCALE

0 50 100 200

(1 inch = 100 feet)

LEGEND	
(red line)	ELECTRICAL RESISTIVITY LINE
(blue line)	MASW LINE

NORCAL

SITE LOCATION MAP
GEOPHYSICAL INVESTIGATION
KATHERINE MINE

LOCATION: MOHAVE COUNTY, ARIZONA

CLIENT: KLEINFELDER

JOB #: 12-177.192

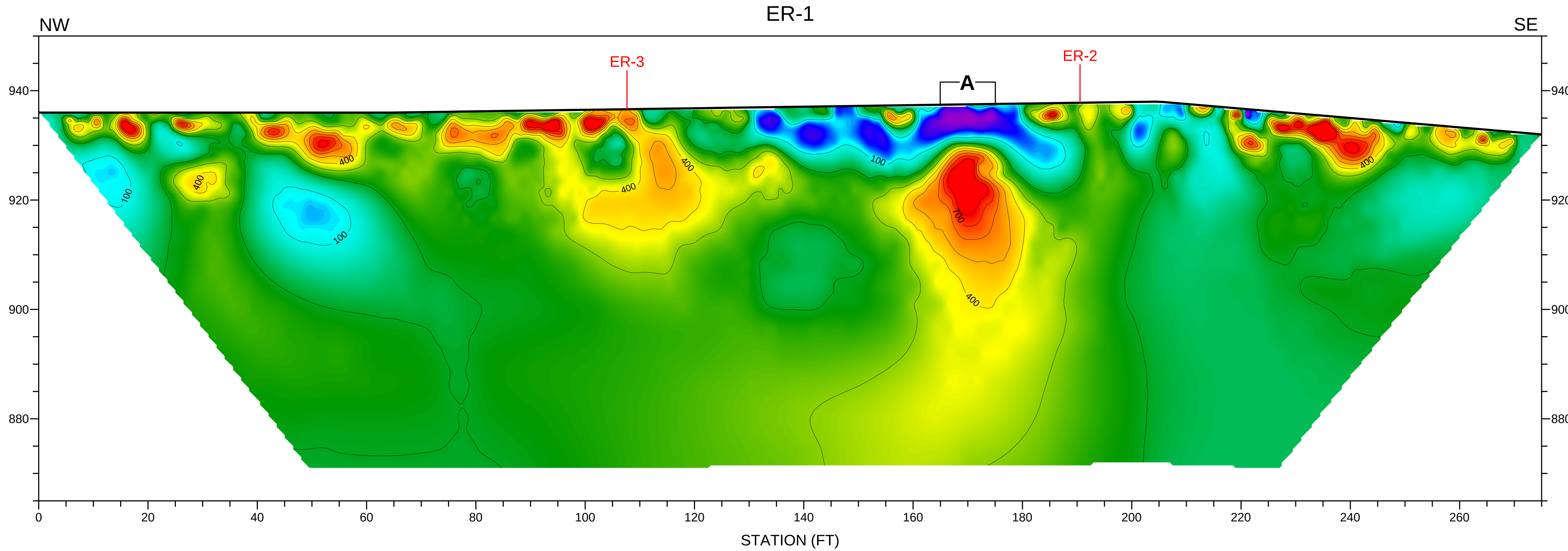
NORCAL GEOPHYSICAL CONSULTANTS INC.

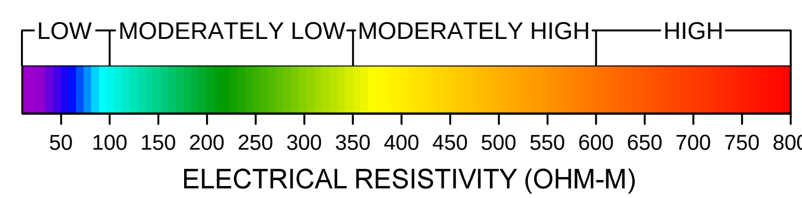
DATE: OCT. 2012

DRAWN BY: G.RANDALL

APPROVED BY: DTH

PLATE 1





LEGEND

A	ELECTRICAL RESISTIVITY ANOMALY

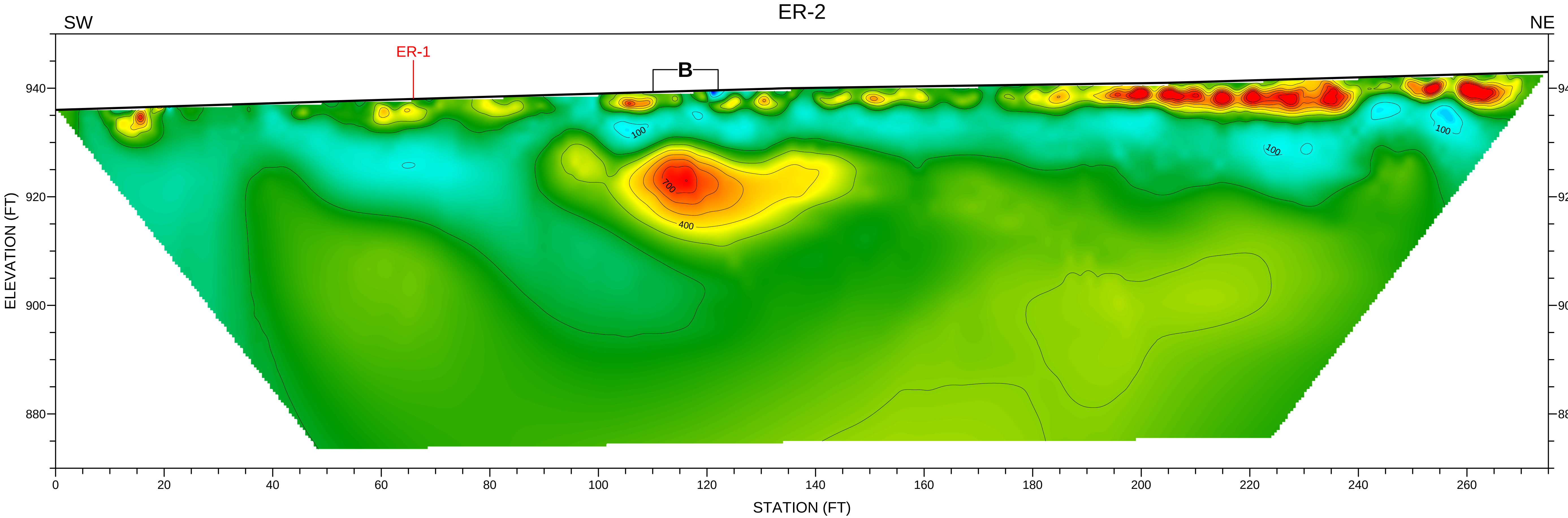
SCALE

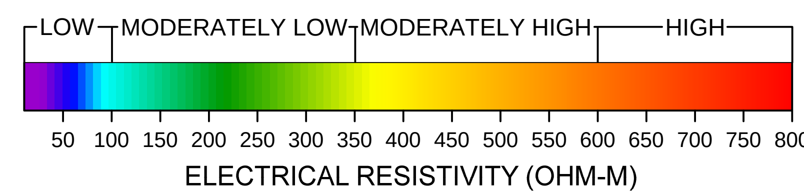
0 10 20 40

(1 inch = 20 feet)

NORCAL	ELECTRICAL RESISTIVITY PROFILE ER-1 GEOPHYSICAL INVESTIGATION KATHERINE MINE	
	LOCATION: MOHAVE COUNTY, ARIZONA	
	CLIENT: KLEINFELDER	PLATE
JOB #: 12-177.192	NORCAL GEOPHYSICAL CONSULTANTS INC.	2
DATE: OCT. 2012	DRAWN BY: G.RANDALL / APPROVED BY: DTH	

ER-2





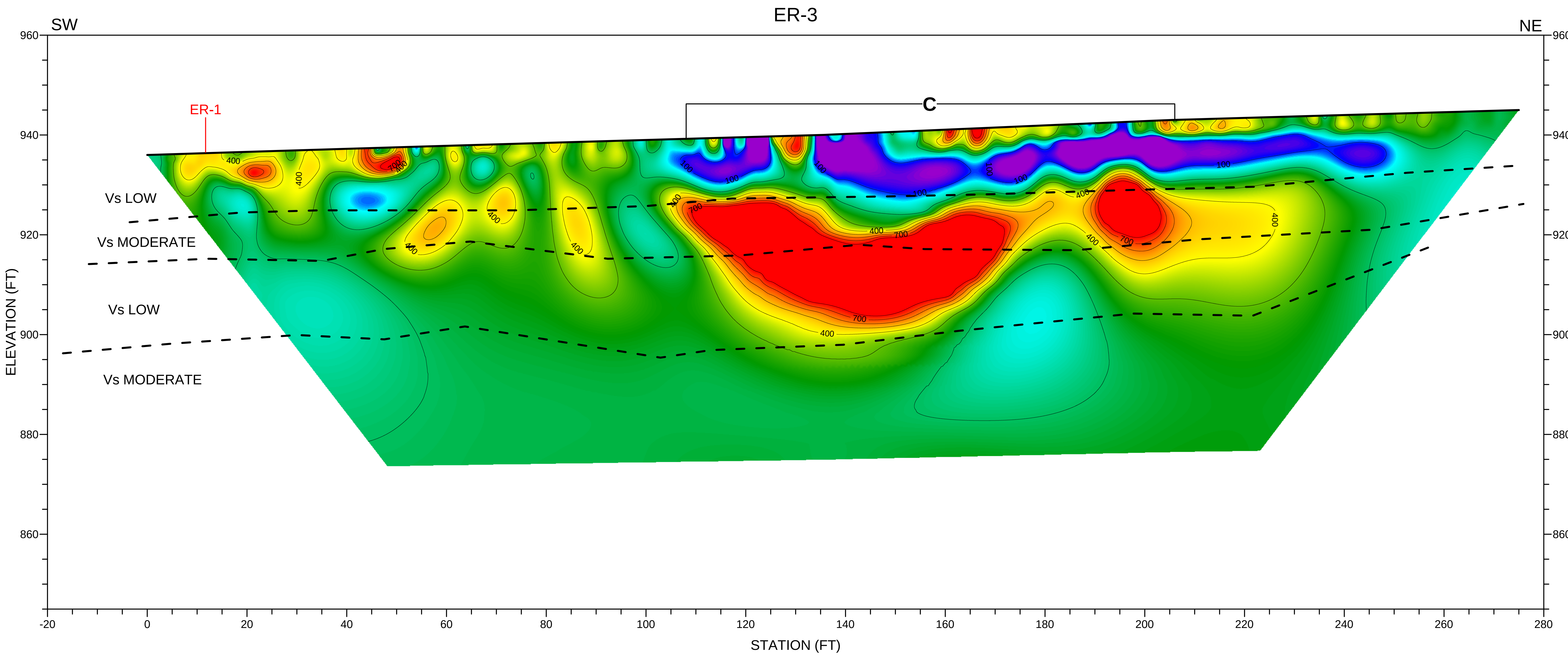
LEGEND	
A	ELECTRICAL RESISTIVITY ANOMALY

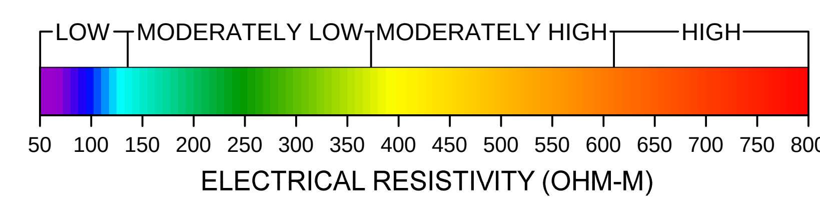
SCALE

0 10 20 40

(1 inch = 20 feet)

NORCAL	ELECTRICAL RESISTIVITY PROFILE ER-2 GEOPHYSICAL INVESTIGATION KATHERINE MINE		
	LOCATION: MOHAVE COUNTY, ARIZONA		
	CLIENT: KLEINFELDER		PLATE
JOB #: 12-177.192	NORCAL GEOPHYSICAL CONSULTANTS INC.		3
DATE: OCT. 2012	DRAWN BY: G.RANDALL	APPROVED BY: DTH	





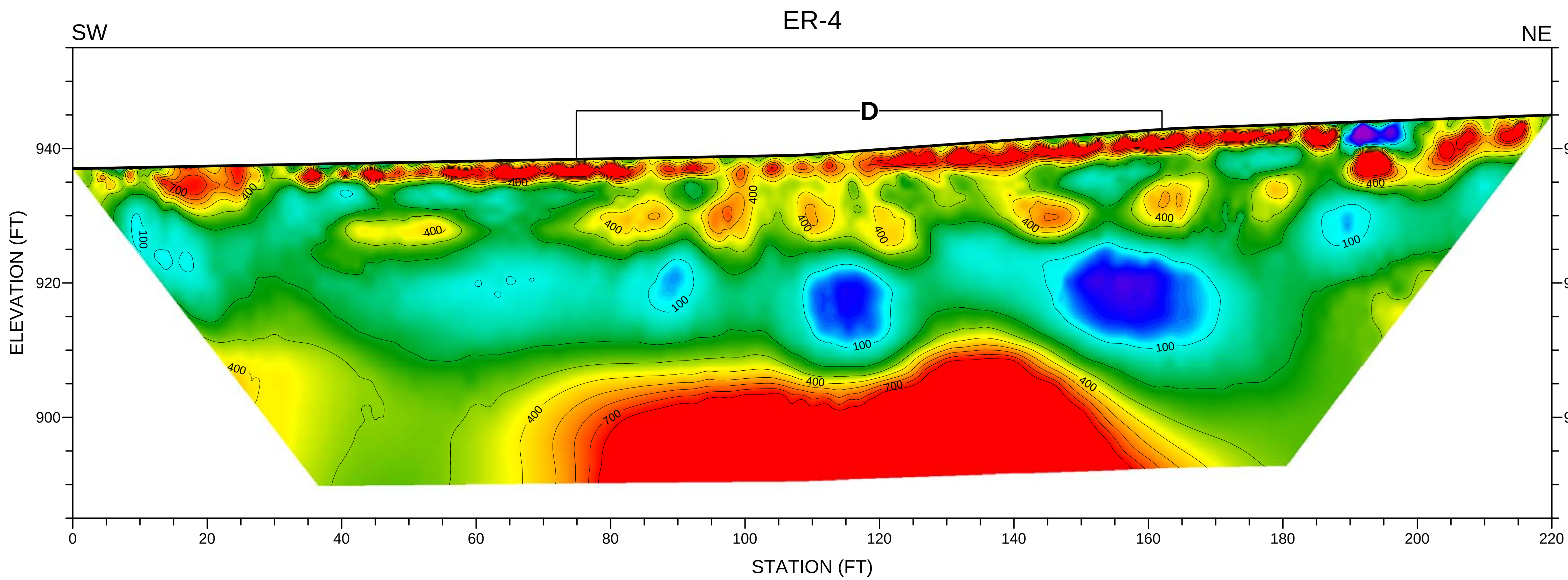
LEGEND	
- - - -	S-WAVE VELOCITY INTERFACE (FROM PLATE 9)
A	ELECTRICAL RESISITIVITY ANOMALY

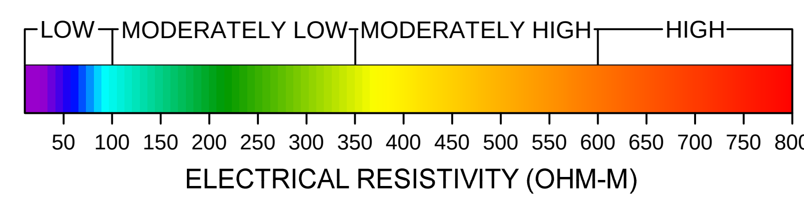
SCALE
0 10 20 40
(1 inch = 20 feet)

NORCAL

ELECTRICAL RESISTIVITY PROFILE ER-3
GEOPHYSICAL INVESTIGATION
KATHERINE MINE

LOCATION: MOHAVE COUNTY, ARIZONA
CLIENT: KLEINFELDER
JOB #: 12-177.192
NORCAL GEOPHYSICAL CONSULTANTS INC.
DATE: OCT. 2012
DRAWN BY: G.RANDALL
APPROVED BY: DTH
PLATE 4





LEGEND	
A	ELECTRICAL RESISTIVITY ANOMALY

SCALE

0 10 20 40

(1 inch = 20 feet)

NORCAL

ELECTRICAL RESISTIVITY PROFILE ER-4
GEOPHYSICAL INVESTIGATION
KATHERINE MINE

LOCATION: MOHAVE COUNTY, ARIZONA

CLIENT: KLEINFELDER

JOB #: 12-177.192

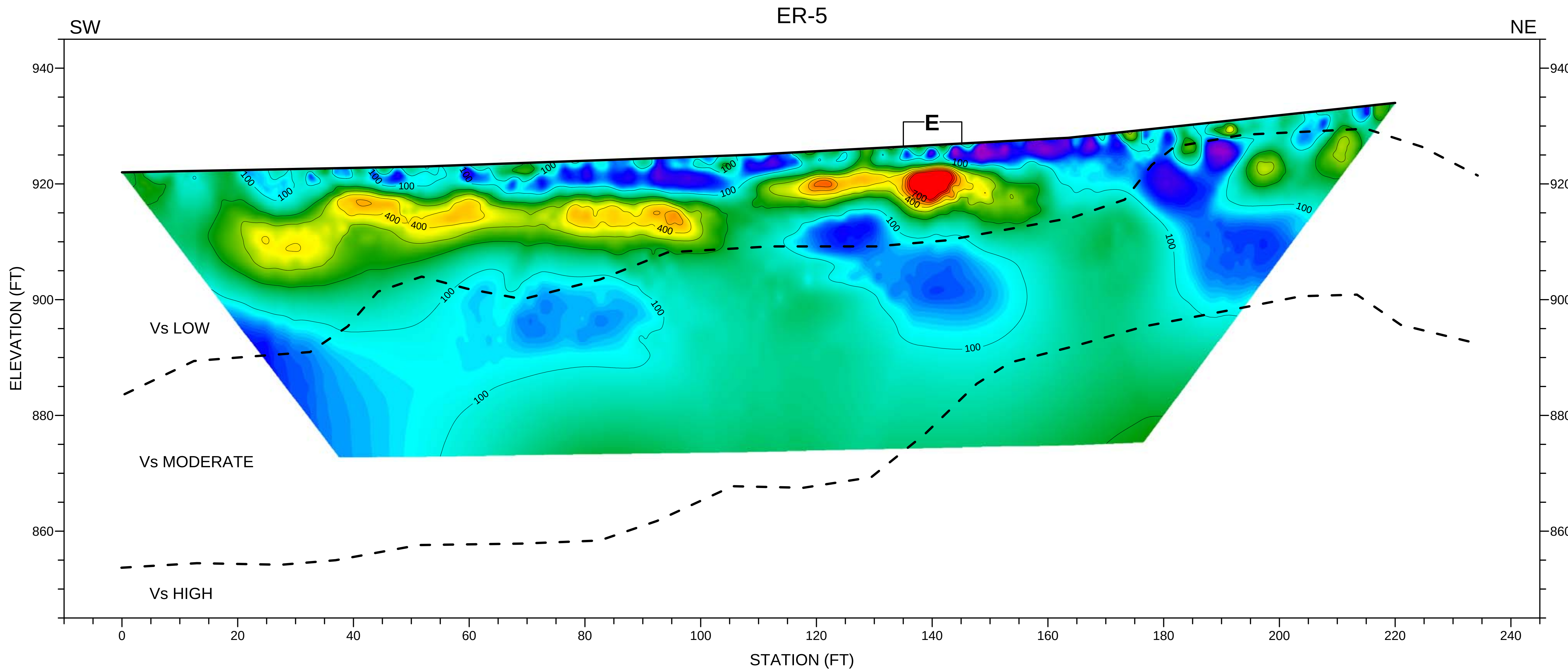
NORCAL GEOPHYSICAL CONSULTANTS INC.

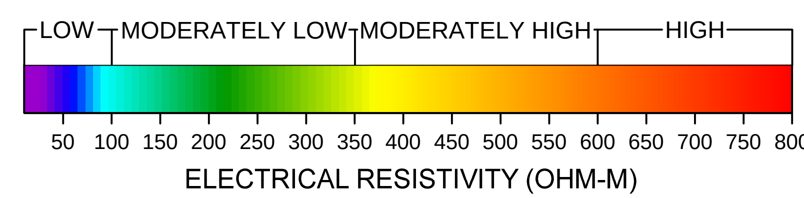
DATE: OCT. 2012

DRAWN BY: G.RANDALL

APPROVED BY: DTH

PLATE 5





LEGEND

- - - -	S-WAVE VELOCITY INTERFACE (FROM PLATE 10)
A	ELECTRICAL RESISITIVITY ANOMALY

SCALE

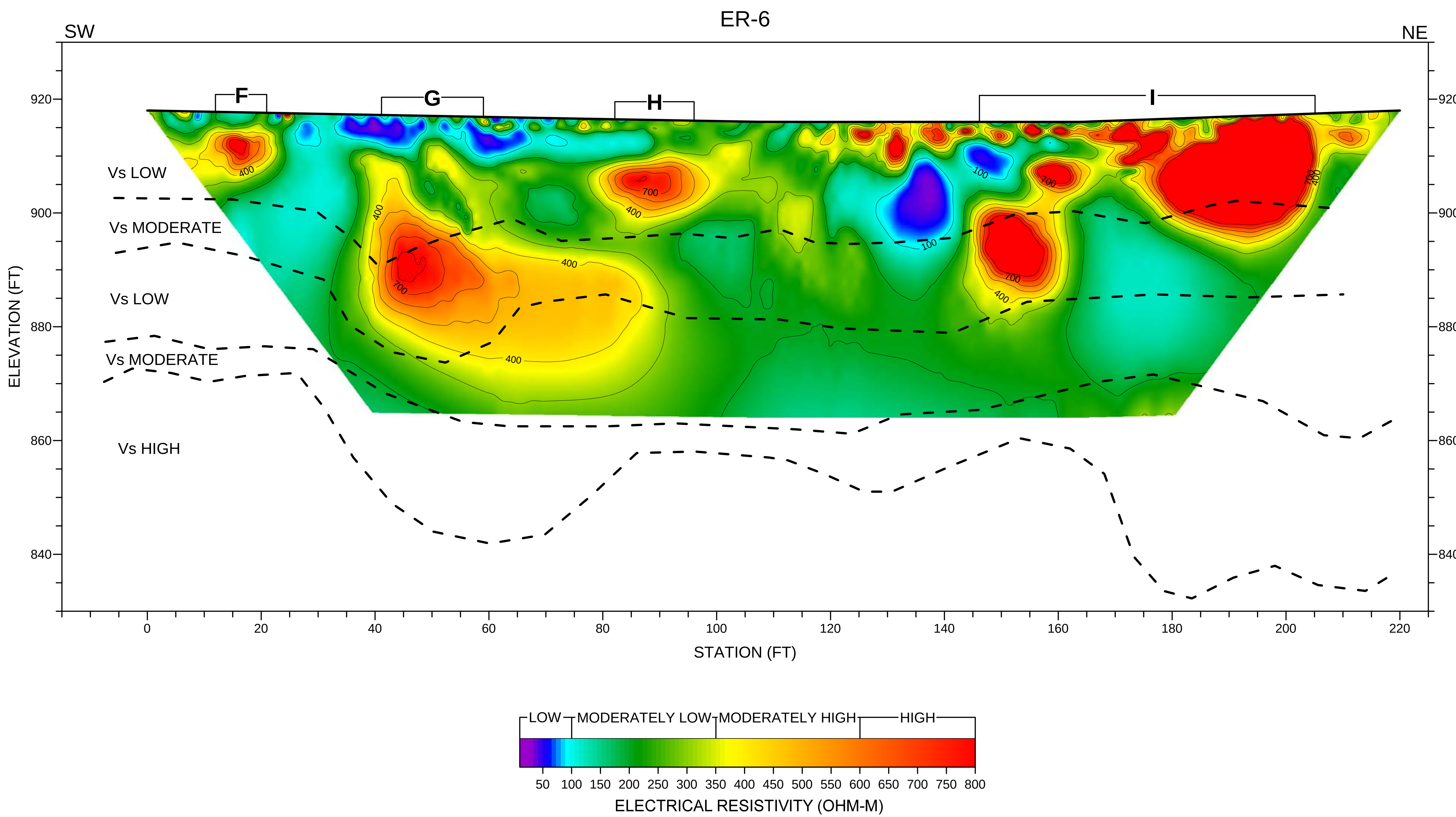
0 10 20 40

(1 inch = 20 feet)

NORCAL

ELECTRICAL RESISTIVITY PROFILE ER-5
GEOPHYSICAL INVESTIGATION
KATHERINE MINE

LOCATION: MOHAVE COUNTY, ARIZONA			
CLIENT: KLEINFELDER			PLATE 6
JOB #: 12-177.192	NORCAL GEOPHYSICAL CONSULTANTS INC.		
DATE: OCT. 2012	DRAWN BY: G.RANDALL	APPROVED BY: DTH	



LEGEND

- - - -	S-WAVE VELOCITY INTERFACE (FROM PLATE 11)
A	ELECTRICAL RESISITIVITY ANOMALY

SCALE

0 10 20 40

(1 inch = 20 feet)

NORCAL

ELECTRICAL RESISTIVITY PROFILE ER-6
GEOPHYSICAL INVESTIGATION
KATHERINE MINE

LOCATION: MOHAVE COUNTY, ARIZONA

CLIENT: KLEINFELDER

JOB #: 12-177.192

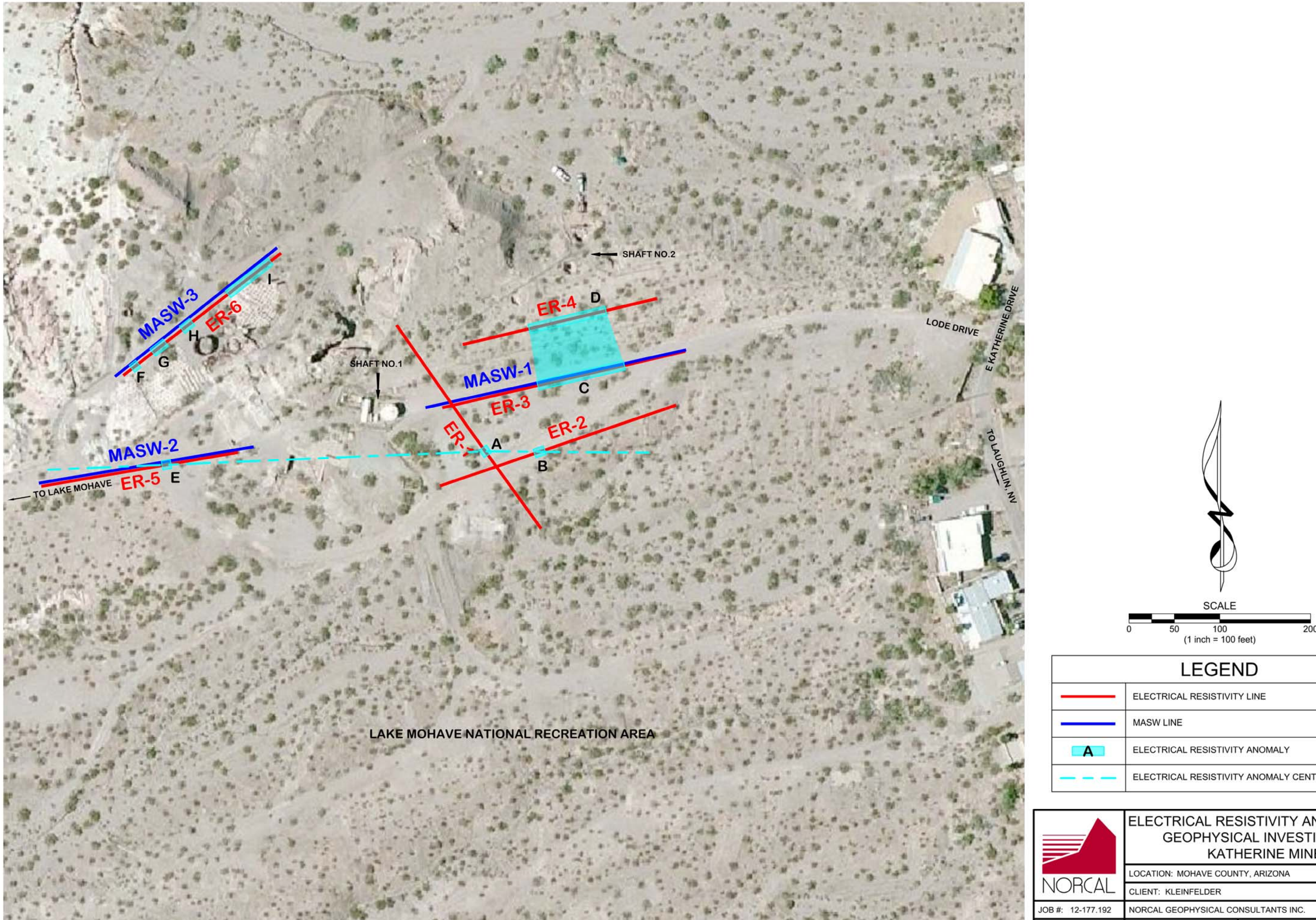
NORCAL GEOPHYSICAL CONSULTANTS INC.

DATE: OCT. 2012

DRAWN BY: G.RANDALL

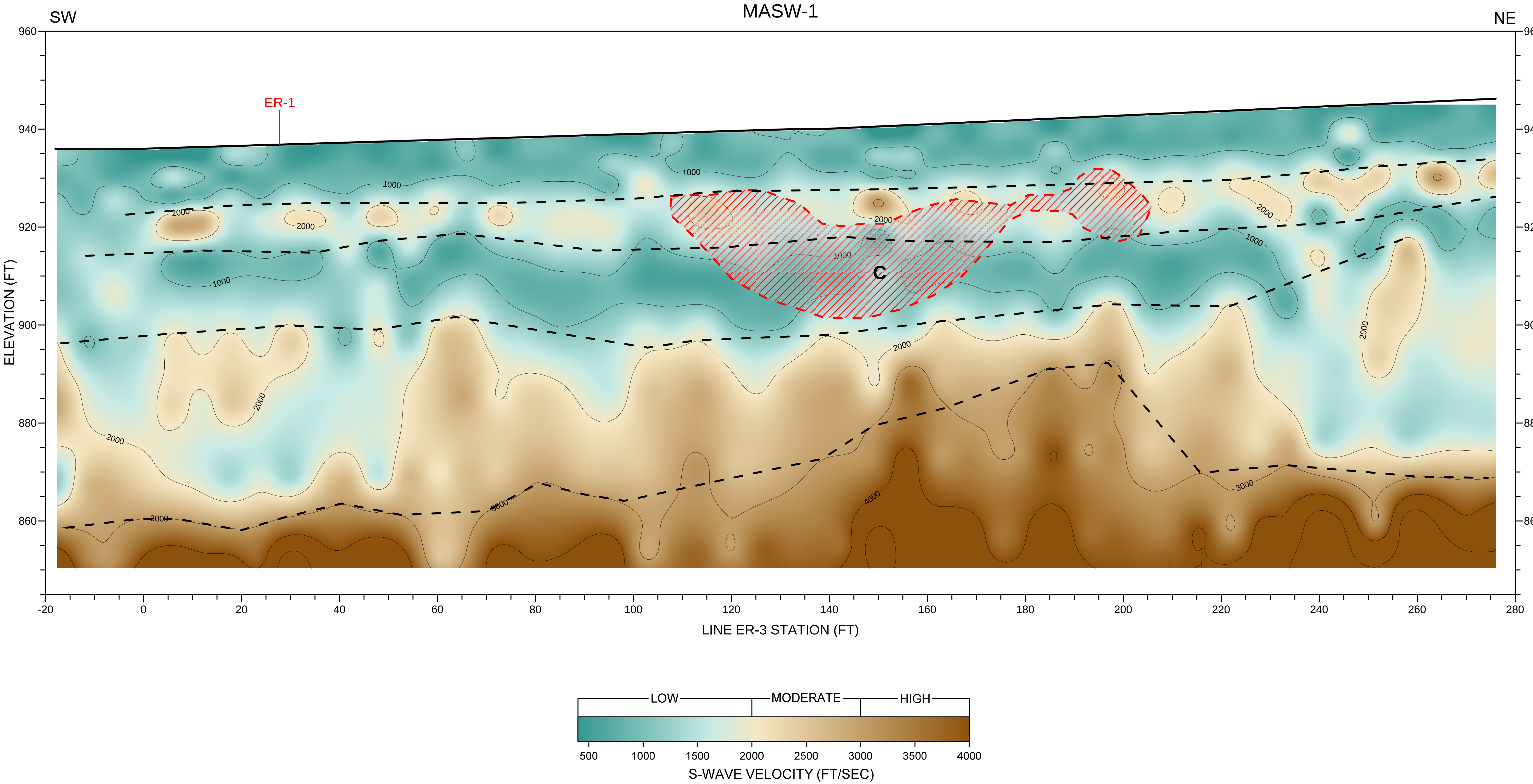
APPROVED BY: DTH

PLATE 7



LEGEND	
(red line)	ELECTRICAL RESISTIVITY LINE
(blue line)	MASW LINE
A	ELECTRICAL RESISTIVITY ANOMALY
(dashed cyan line)	ELECTRICAL RESISTIVITY ANOMALY CENTERLINE

NORCAL	ELECTRICAL RESISTIVITY ANOMALY MAP GEOPHYSICAL INVESTIGATION KATHERINE MINE	
	LOCATION: MOHAVE COUNTY, ARIZONA	
	CLIENT: KLEINFELDER	PLATE
JOB #: 12-177.192	NORCAL GEOPHYSICAL CONSULTANTS INC.	8
DATE: OCT. 2012	DRAWN BY: G.RANDALL / APPROVED BY: DTH	



LEGEND

- - - -	S-WAVE VELOCITY INTERFACE
A	ELECTRICAL RESISITIVITY ANOMALY (FROM PLATE 4)

SCALE

0 10 20 40

(1 inch = 20 feet)

NORCAL

S-WAVE VELOCITY PROFILE MASW-1
GEOPHYSICAL INVESTIGATION
KATHERINE MINE

LOCATION: MOHAVE COUNTY, ARIZONA

CLIENT: KLEINFELDER

JOB #: 12-177.192

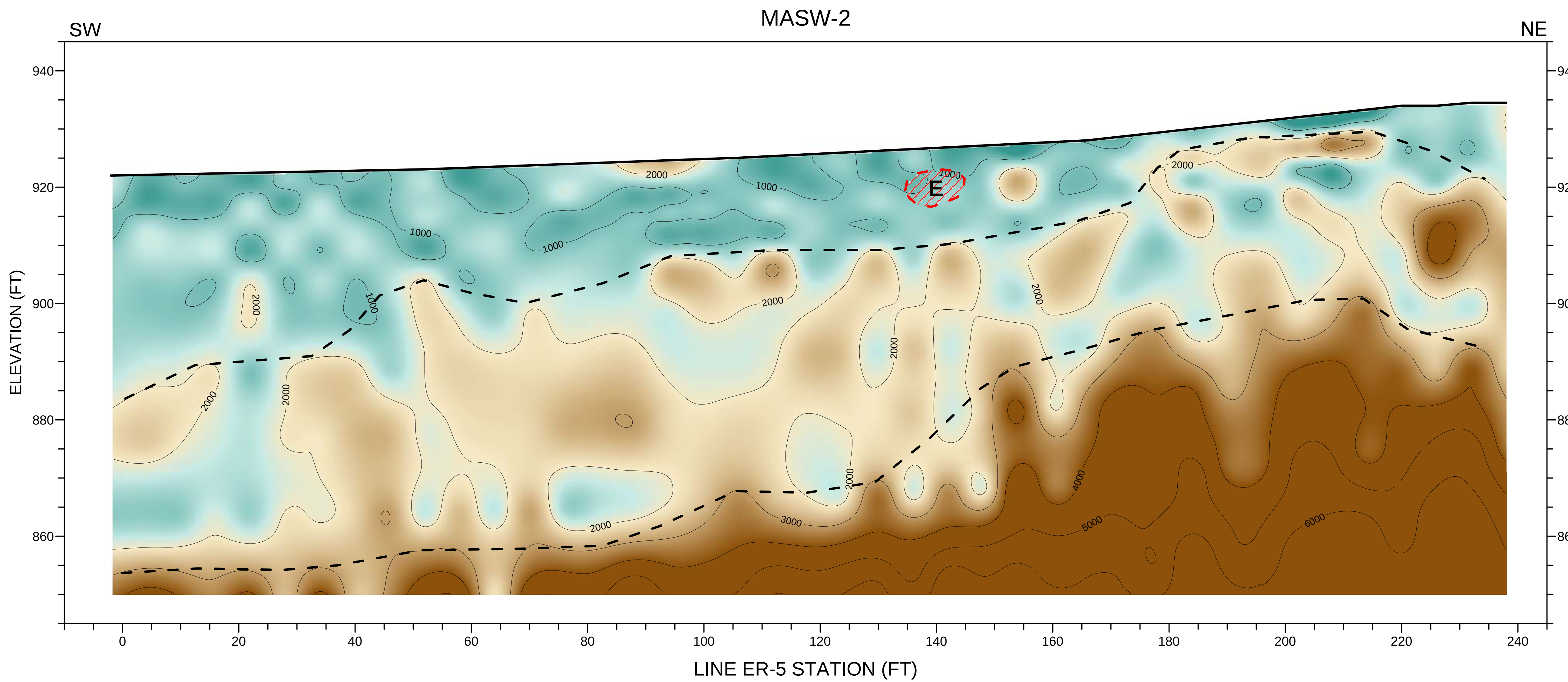
NORCAL GEOPHYSICAL CONSULTANTS INC.

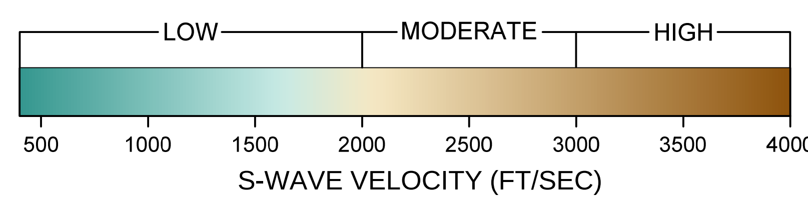
DATE: OCT. 2012

DRAWN BY: G.RANDALL

APPROVED BY: DTH

PLATE 9





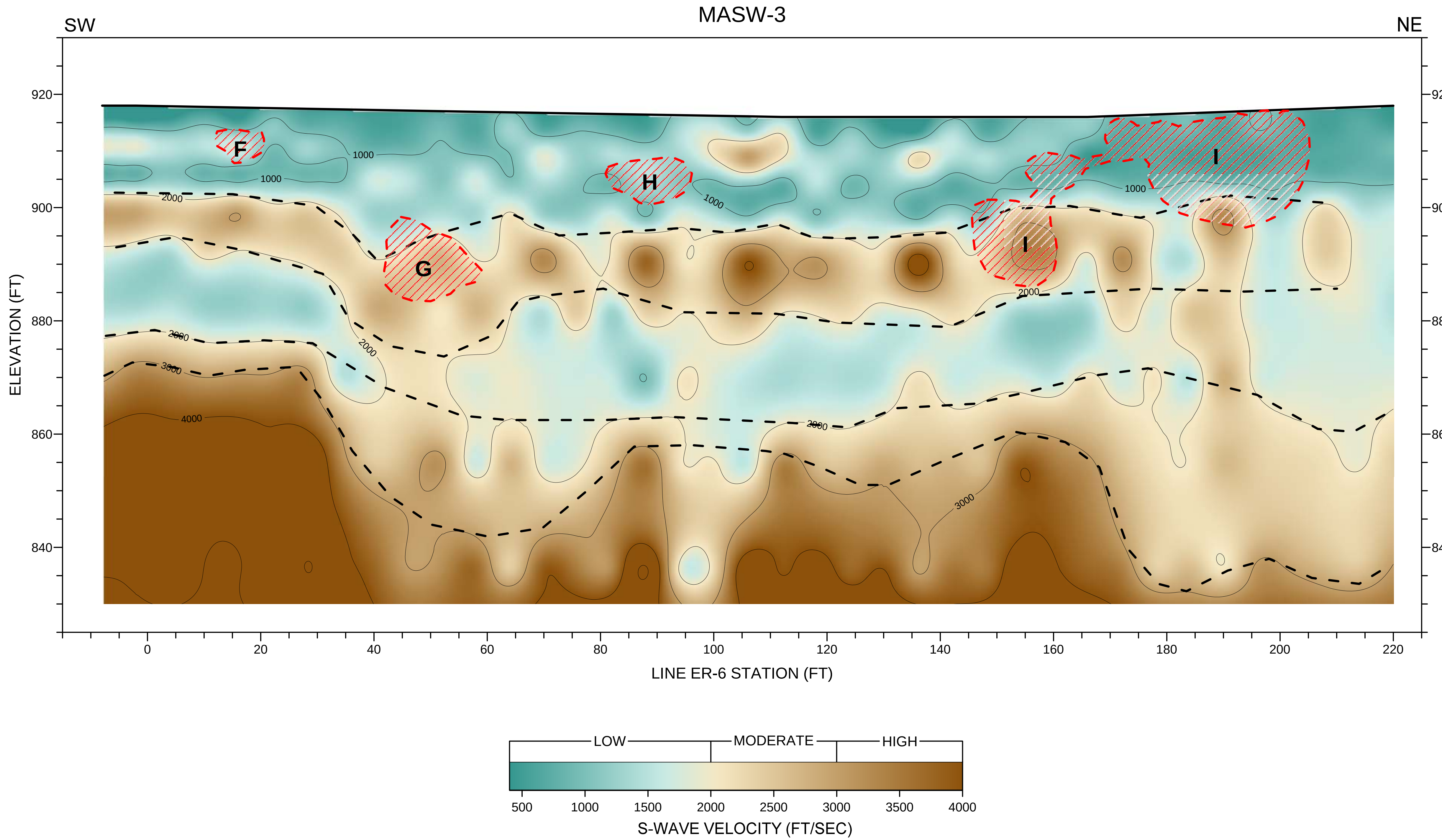
LEGEND	
- - - -	S-WAVE VELOCITY INTERFACE
A	ELECTRICAL RESISITIVITY ANOMALY (FROM PLATE 6)

SCALE

0 10 20 40

(1 inch = 20 feet)

NORCAL	S-WAVE VELOCITY PROFILE MASW-2 GEOPHYSICAL INVESTIGATION KATHERINE MINE		
	LOCATION: MOHAVE COUNTY, ARIZONA		
	CLIENT: KLEINFELDER		PLATE 10
JOB #: 12-177.192	NORCAL GEOPHYSICAL CONSULTANTS INC.		
DATE: OCT. 2012	DRAWN BY: G.RANDALL	APPROVED BY: DTH	



LEGEND

- - - -	S-WAVE VELOCITY INTERFACE
A	ELECTRICAL RESISITIVITY ANOMALY (FROM PLATE 7)

SCALE

0 10 20 40

(1 inch = 20 feet)

NORCAL

S-WAVE VELOCITY PROFILE MASW-3
GEOPHYSICAL INVESTIGATION
KATHERINE MINE

LOCATION: MOHAVE COUNTY, ARIZONA

CLIENT: KLEINFELDER

JOB #: 12-177.192 | NORCAL GEOPHYSICAL CONSULTANTS INC.

DATE: OCT. 2012 | DRAWN BY: G.RANDALL | APPROVED BY: DTH

PLATE 11