LBNL TECHNICAL IMPLEMENTING PROCEDURE ELM-3.0, Rev 0

Deep Seismic Reflection Study of the Tectonic Environment

1.0 PURPOSE.

1.1 To assure the accuracy, validity, and applicability of the methods used to collect intermediate to deep seismic reflection data needed to determine the geological stability of waste storage sites, this procedure is a guide for Lawrence Berkeley National Laboratory (LBNL) personnel and contractors performing the described activity.

1.2 This procedure describes the components of the work, the principles of the methods used, and their limits. It also describes the detailed methods to be used for calibration, operation, and performance verification of any equipment, if needed. In addition, it defines the requirements for data acceptance, documentation, and control; and it provides a means of data traceability.

2.0 SCOPE.

2.1 This procedure applies to all YMP-LBNL personnel and their contractors who may perform work referred to in Para. 1.1, or use data obtained from this procedure.

2.2 For all technical activities, data collected from using this procedure and any equipment calibrations or recalibrations that may be required shall be in accordance with this technical procedure. Variations are allowed only if and when this procedure is formally revised, or otherwise modified, as described in Para. 8.

3.0 PROCEDURE.

The objectives of the intermediate to deep seismic reflection investigations are to characterize the subsurface geological framework of the crust in the vicinity of the proposed facility at Yucca Mountain. In particular, seismic reflection surveys, located in the vicinity of Yucca Mountain, are used to investigate the Paleozoic-Tertiary contact, and Paleozoic and Tertiary rocks by mapping the lateral continuity of reflecting horizons.

3.1 Objective: To describe a method of collection of intermediate to deep seismic reflection data describing the geologic stability of the tectonic environment at “Nevada Test Site (NTS).”

3.2 Methods Used: Seismic reflection profiling provides measurements used to determine the geometry of subsurface acoustic and/or elastic interfaces across the proposed waste disposal site. Lithologic contrasts at faults and across stratigraphic horizons providing acoustic/elastic interfaces can thus be mapped by seismic reflection profiling.

3.2.1 DATA ACQUISITION: During the acquisition of seismic reflection data, a digital seismic recording system records the seismic energy from a large number of seismic receivers (geophones); the seismic energy is generated by an array of large truck-mounted or explosive seismic energy sources.

3.2.1.1 Receiver Deployment - The seismic receiver (geophone) is normally a digital-grade, vertical geophone, whose output current is proportional to the vertical component of ground velocity. The output current of 3-component geophones used to record shear waves is proportional to components of ground velocity in three mutually orthogonal directions, one of which is oriented vertically.

The other two horizontal components are normally aligned in directions perpendicular and parallel to the reflection line. The placement of geophones is critical to the acquisition of seismic data. Geophones must be firmly coupled to the ground in order to give an electrical output which is a true representation of ground movement velocity. Uniformity of coupling can be ensured by the correct use of similar geophone bases, or by burying the geophones. Geophones shall always be planted close to vertical. A geophone planted at a large angle will not give full output and may negate the effectiveness of the geophone array.

a) Normally between 24 and 4096 receiver arrays, spaced along the profile at intervals between 1 and 200 m, are deployed on the surface.

b) Each receiver array consists of 1 to 96 individual geophones; the output electrical signals from each is summed electronically to yield the total signal for the array. The array is designed in part to minimize horizontally propagating seismic energy which can obscure seismic arrivals of interest. The array may be deployed at a point or in a linear array, depending on the surficial geology. The optimal configuration of the receiver array is determined during testing of acquisition parameters.

c) The arrays are also inspected prior to each day's data acquisition for proper operation. This is done by noting which sensor arrays are operational by either a "tap" test or activating the phones with a foot hit or recording a test "shot." Any phones found to be not operational are either repaired or replaced.

3.2.1.2 Cable Deployment - The individual receiver arrays are connected by electrical cables that transmit the output signals to the recording truck. Strong wind striking geophone cases and cables can cause noise. Geophone cables therefore should be laid upon the ground and *not* strung over bushes, etc. Each cable connector must be in good (not worn) condition such that electrical continuity is obtained for all traces.

a) The cables may be standard twisted pair CDP, coaxial, or fiber-optics cables. Sign-bit recording involves the digitization of analog signals from array terminals located along the cable every 5 to 20 receiver arrays such that only the polarity of the signal is transmitted. Signals may also be transmitted by radio telemetry links in which case cables are not used.

b) The integrity, electrical continuity, and leakage of cables is monitored during acquisition to insure data integrity. Indications of incorrect array resistance or leakage less than one (1) megaohm shall be sufficient cause for the test to be halted and the problem corrected. If more than one (1) out of twenty-four traces are bad the operation will be stopped and the cause of the faulty trace determined. The determination of whether or not acquisition shall be halted due to cable problems shall be at discretion of the geophysicist in charge. Data collection shall be halted when wind-generated noise seriously degrades data quality on more than 20% of the data channels or when the wind-noise intrusion exceeds 24 dB on the recording system, whichever being the more stringent condition.

c) In some cases repeaters positioned along the cables, called array terminals (or remote units), may be monitored in realtime for the condition and performance of the power supply. Array terminals are also tested monthly to confirm their analog and digital operations.

d) It is critical that the roll-along CDP switch, if used, be in the correct position when recording. The observer shall check the CDP switch at the start of each recording, and shall record the position of the roll-along switch for each recording in the observer's log.

3.2.1.3 Data Collection - Cables transmitting the seismic signals are connected to the recording truck where the input signals are processed and recorded using the following equipment: time code generator, amplifiers, low-cut filters, anti-alias and notch filters, analog to digital converter, correlator (sign-bit), multiplexer, memory (accumulator), monitor camera, and digital tape or cartridge drives. When array terminals are employed, the signals are collected, amplified, filtered, and digitized by the array terminal prior to transmission to the recording truck. Most systems used today have internal self calibration. Before each day's run, a "calibration" run is made to determine proper system operation.

a) The time code generator controls the multiplexer.

b) Analog amplifiers operate on the input electrical signals from the receiver arrays as necessary to increase the amplitude in 6dB steps.

c) The anti-alias and notch filters apply analog filters to suppress high-frequency (signals outside the frequencies of interest) and narrow-band electrical signals that can arise from causes such as nearby power transmission or telephone lines.

d) The analog to digital converter performs digital sampling of the analog electrical signals received from the receiver arrays. Digital sampling is performed at intervals between 1/8 and 8 msec, depending on the frequency characteristics of the source.

e) For systems using real-time correlation, a correlator performs the real-time cross correlation between the input signal sweep and the received seismic signals. Daily tests of the correlator are performed by correlating a series of synthetic sweeps with synthetic traces to verify the output.

f) The multiplexer arranges the digital data in a scan sequential order for efficient writing of the data to digital tape or cartridge.

g) Digitized signals are stored in memory to be accumulated for a specified number of repeated source efforts.

h) The monitor camera displays the digitized seismic traces as they are recorded on digital magnetic tape. Up to 4096 channels may be displayed at once to confirm total system performance. Demultiplexed, correlated, and summed (if a vibroseis source is used) data from all active channels are displayed to verify source position and operation, geophone response, array terminal response, data transmission along the cables, correlator operation (for vibroseis sources), memory retention, seismic noise characteristics, and geologic response.

i) Digital tape or cartridge drives write the data to digital magnetic tapes or cartridges. Only magnetic tapes or cartridges certified for the density of recording shall be used. The digital magnetic tapes or cartridges are labeled with at least the following information: date, location, line number, tape number, tape density in BPI, number of source sweeps, sample rate, total number of samples per trace, and number of channels. During field operations the parity error indicators shall be observed for error indication. If errors occur, the condition of the tape, and tape drive heads shall be examined and the fault corrected. Recording tapes and cartridges shall be stored in a location that is cool and dust free. Tapes and cartridges should, where possible, be temperature normalized prior to use.

j) Observer's Report: The observer will maintain a current observer's report which contains all pertinent record information. It becomes part of the record set of the seismic acquisition.

k) Spare parts, manuals and schematics should be maintained in an orderly fashion. Care must be taken to protect parts and cards from damage.

3.2.1.4 Vibroseis Sources - The seismic signals may be generated by an array of large Vibroseis trucks.

a) One to six Vibroseis trucks, each weighing 20,000 to 65,000 lbs., form a linear array to provide the needed seismic signals transmitted to the earth. These trucks operate in the following manner: the rear-end of the truck is jacked up on a hydraulically powered base plate raising the truck off of its rear wheels; the truck then vibrates the baseplate simultaneously with the other Vibroseis trucks upon command from the recording truck to send an oscillatory signal (typically lasting for 6 to 40 seconds) down into the ground. P-waves are generated when the baseplate oscillates in the vertical plane. S-waves are generated when the baseplate oscillates in a horizontal plane.

b) The Vibroseis trucks begin their vibration cycle (called a sweep) upon receiving a start-tone radio signal transmitted by the recording truck. The transmission of this start tone is also used to start the recording system instrument cycle.

c) The sweep is an oscillatory vibration, in which frequency varies linearly or nonlinearly with time, starting at one specified frequency and ending at another in a time period which may typically be varied between 6 to 40 seconds, depending on surficial geologic conditions and desired depth of penetration.

d) Force-control electronics varies the total force applied to the ground by the Vibrator baseplate to avoid decoupling of the baseplate from the ground and to minimize harmonic distortion of the input signal.

e) Similarity Tests: Daily similarity tests are performed, normally before data acquisition is commenced, to insure that each Vibroseis truck is vibrating in phase with the other trucks and with the proper sweep. The sweep similarity test is performed by comparing the input from the sweep generator with the output from an accelerometer attached onto the baseplate of each Vibroseis truck. A plot at large time scale, sufficient to resolve 1 millisecond, is produced to compare input and output signals. A cross-correlation of the signals is also used to evaluate the phase response of the baseplate.

f) Vibrator operators shall not adjust instruments, modify the force-control instrument settings, move the vibrator or perform any other act which could negate the test for at least five (5) seconds after the end of each sweep.

g) Vibrator operators shall locate their units accurately relative to the pin flags as per the written instructions for the particular pattern being performed.

3.2.1.5 Land Airgun Sources - The seismic signals may be generated by an array of large land-airgun trucks.

a) One to six land-airgun trucks, formed in a linear array, are used as the source of seismic signals. These trucks operate in the following manner: an airgun within a water-filled tank mounted on a baseplate on each truck is lowered to the ground and is then fired simultaneously with airguns in other trucks upon receipt of a radio fire command from the observer in the recording truck. Airguns emit seismic energy by rapidly releasing a large volume of compressed air into water. Each airgun is nominally operated at high air pressures.

b) The signal produced by the land-airgun truck is impulsive in character. The airguns are fired about 50 milliseconds upon receipt of a fire command tone radio signal transmitted by the observer in the recording truck. Upon receipt of the fire-command-tone each airgun truck fires its airgun and transmits a shot break tone back to the recording truck. This shot break tone sends the origin time to the recording truck.

c) Synchronicity Test: Daily synchronicity tests are performed to insure that each land-airgun truck is firing within ± 1 millisecond of the desired firing time as controlled by a microprocessor on each truck. The microprocessor, an AutoSync One microprocessor, is manufactured by Input/Output Co. to control the firing time of the airgun. The microprocessor has a self-test which tests its proper function upon being powered up each work day. This self-test also tests the proper functioning of the source sensor mounted on the baseplate. The synchronicity test is performed by firing the airgun and counting the delay between the desired 50 millisecond delay and the actual delay using the source sensor attached to the baseplate. An alarm will sound to alert the observer if the difference between the desired and actual delays exceed ± 1 millisecond. During production, this time difference for each truck is also written to tape, insuring that a permanent record of these differences will be maintained.

d) To optimize repeatability of the land-airgun source signal, a minimum time interval of 10 to 12 seconds between repeats of land air-gun source efforts should be used.

e) Land-airgun truck operators shall locate their units accurately relative to pin flags as per written instructions for the particular pattern being performed.

f) The operating pressure of the airguns should be 2000 pounds per square inch (PSI) ± 50 PSI.

3.2.1.6 Explosive Sources - The seismic signals may be generated by explosive sources.

a) Explosions, located either in a single shothole or an array of shotholes, can also be employed as sources of seismic signals. Explosive sources are fired in the following manner: shotholes are drilled to specified depths and patterns; deep explosive charges are double-capped (minihole shots may be single capped) and lowered to the base of the hole leaving electric fuse lines at the surface, the hole is refilled with drilling cuttings and loose soil, sand or gravel; a functioning shot hole geophone is placed over the shot; a shot box is attached to the fuses and is manually armed; a start-tone radio transmitted from the recording truck activates the shot box and fires the explosive shot; simultaneously the shot box transmits via radio a shot-tone back to the recording truck to activate recording of data by the recording truck.

b) The shot depth, shot size of explosive (in weight), number of shotholes and their array pattern can be varied as desired to optimize reflector quality. However, these parameters should be held constant, if possible, during the acquisition of any given seismic line. Shothole depths to the foot shall be estimated by the driller using the drillstem length providing an estimated accuracy of several feet. Uphole shot times are determined as described in 3.2.1.6,e.

c) Shot Box Tests: Daily tests are performed to insure that each shot box to be used that day is functioning properly. In this test a start-tone radio signal is broadcast by the recording truck to the shot box. This start-tone activates the shot box and causes the shot box to transmit a shot-tone back to the recording truck. These start-tone and shot-tone signals are displayed and if the delay between these times exceeds 1 millisecond the shot box cannot be used until it has been repaired and retested.

d) It is good practice to perform a daily cap test of the shot box. In this test a single cap is electrically connected to the shot box using a long electric fuse. Then the shot box test described in Para. 3.2.1.6.c is repeated, to test whether the shot box is sending a sufficient electrical current to trigger the blasting cap. A successful test is judged simply by whether the cap detonated or not. Successful completion of the cap test indicates that the shot box is ready for use that day.

e) Uphole shot times are recorded for each explosive shot using the output from the shot geophone placed at the top of the shothole. These times may be inferred from the shot records in the recording truck or automatically by the shot box itself. The uphole times must be entered into the Observer's Log in a timely manner each day. These times are used to determine the static time shift required to correct for minor variations in shot depth along the seismic line.

f) Shothole locations must be surveyed.

g) Daily instrument tests must by performed and written to digital magnetic tape or cartridge prior to the acquisition of explosion shothole data. A memory check should be performed prior to each explosive shot to insure no loss of data via faulty memory.

h) All crew-related traffic along the seismic reflection line must be halted for every explosive shot to minimize cultural noise.

i) where shallow holes for minihole explosions cannot be reasonably drilled, poulter charges exploded in the air can be used. A pattern of individual charges are placed on short stakes of identical lengths a few to several feet off the ground and are simultaneously detonated by Primacord.

Impulse Weight Drop Source. the Seismic signal may be generated by a weight drop or a hammer hit on the surface.

a) One or more seismic weight drop sources, or hammer impulse devices can be used to create a seismic signal. The operation is usually via a weight raised mechanically above the ground and propelled downward with elastic extenders at high velocity towards the ground. The hammer head strikes the ground and creates a seismic signal.

(b) Critical to the operation is the time at which the weight hits the ground. At least 1 millisecond accuracy is needed in the time at which the weight strikes the ground, and this time mark must be recorded on the data recording device.

3.2.1.7 Surveying - Source and receiver locations are surveyed and marked by pin flags. Elevations of the sources and receivers are also surveyed.

a) Initially, pin flags are placed along the proposed reflection line at chained intervals corresponding to the receiver group interval, between 5 to 200 meters. The locations of these pin flags are then tied to known geodetic positions or to known tie points with an accuracy that meets or exceeds horizontal and vertical closure requirements that are even less stringent than 3rd order surveying.

b) Prior to obtaining survey data that will be cited to support licensing the YMP, all theodolites and Electronic Distance Measurers (EDM) will either be field checked for accuracy against a known line length in the vicinity of Yucca Mountain or tested in a laboratory against known standards. Successful completion of this field check within one part in 2000 in the horizontal plane and less than 0.5 feet times the square root distance in miles in the vertical plane must be submitted in writing prior to the acquisition of survey data. For the purposes of this procedure a known line length is defined by any two first-order surveying markers such as LBNL or NOAA bench marks such as those located in Crater Flat or Midway Valley. Required accuracies for the theodolite and EDM (described below in Para. 3.2.1.7,c will be satisfied by this procedure. This field check, combined with the closure requirements described in Para. 3.2.1.7,c, will insure adequate survey data quality.

c) Closure standards are a maximum error of 1 foot in 2000 feet in the horizontal plane. Vertical closure standards are a maximum of 0.50 feet times the square root of distance in miles under 20 miles, 0.70 feet times the square root of distance in miles over 20 miles.

d) Survey traverses are completed using standard instrument procedures. For closed loop surveys, two independent azimuths are used.

e) Map coordinates are based on the state plane system in effect where the work is being done. On lines crossing differing state plane systems, the first state plane system encountered is used throughout the survey.

f) A minimum of two sets of vertical and horizontal angles at or from each control station are observed. A direct and reverse sighting to each station are included.

g) Tribrachs, used to precisely locate surveying tripods over survey monuments, are collimated on a monthly basis. Electronic distance measuring instruments and total stations are tested daily.

h) Field surveying notes are written legibly on surveying forms.

i) Differential Global Positioning Satellite (GPS) Receivers may be used to determine absolute locations of the flags in place of theodolites and EDMs if they can provide horizontal coordinates accurate to within a meter and vertical coordinates accurate to within a meter. If gravity surveying is to be performed along the line, however, Differential Global Positioning Satellite (GPS) Receivers must provide vertical coordinates accurate to within 10 cm. In either case, the GPS receiver shall be tested prior to and after the completion of the survey to ensure proper functioning of the receiver within these specifications.

3.2.1.8 Monitors - During data acquisition the following recording diagnostics are monitored: the number and location of nonfunctioning geophone sensors, broken electrical connections on cables, malfunctioning array terminals along the cable, the time-break circuit, and whether or not excessive wind generated noise is present on the seismic data. The presence of any of these conditions can lead to the cessation of data acquisition until the condition is rectified.

a) A malfunctioning Vibroseis or land-airgun truck or explosion shot box is replaced by a spare whose similarity or proper functioning has been tested that day. Data acquisition is halted when the number of functioning Vibroseis or land-airgun trucks is insufficient to insure adequate signal quality.

3.2.1.9 Testing of Acquisition Parameters - Prior to the acquisition of reflection data, a noise test, in which a variety of acquisition parameters is tested, is performed in order to show that the selected parameters maximize the recording of signal energy while attenuating both coherent and incoherent noise. Receivers and sources are deployed in a linear array with a maximum source-receiver distance of at least 4 km. For high resolution shallow reflection work where small (less than 15 m) receiver spacings are used, much shorter array lengths will be used, 1 km or less. Data are recorded with these minimum offsets to insure accurate determination of the seismic velocities of all arrivals as well as signal loss with range. The characteristics of seismic noise are also determined. At this stage, various receiver array configurations are tested; the need to bury geophones to minimize wind-generated noise may also be tested.

a) For the source array, different configurations of the number of Vibroseis, land-airgun trucks impulse sources, or of explosive shotholes may be tested and compared. For Vibroseis sources, the optimal number of Vibroseis sweeps, the sweep length, and the start-end sweep frequencies are also determined. For land-airgun sources, various array patterns may be tested to determine the optimal pattern for the suppression of air wave and surface wave energy. The optimal number of airgun pops is also determined. For explosive sources, the number of shotholes, depth of shotholes, and weight of the explosive charge in each shothole may be tested.

3.2.1.10 Daily Tests - The following tests of equipment are made daily prior to the acquisition of seismic reflection data.

a) The condition of the geophone receiver arrays and the array terminals (if used) along with the continuity and leakage of the electric cables are checked.

b) Components of the recording system are checked including: dynamic range of the amplifiers; impulse response; equivalent input noise; oscillator test. This is normally accomplished with the system self test.

c) Daily tests of the Vibroseis trucks are described under Para. 3.2.1.4,e under "Similarity Tests".

d) Daily tests of the land-airgun trucks are described under Para. 3.2.1.5,c under "Synchronicity Tests".

e) Daily tests of the explosive shot boxes are described under Para. 3.2.1.6,c under "Shot Box Tests".

3.2.1.11 Data Processing - Upon completion of data acquisition, reduction of the data commences through digital signal processing. These processes may include, but are not restricted to, the following steps: demultiplexing the field data; cross-correlating and amplitude gain recovery of the seismic traces; editing and the assignment of the line geometry; applying field and refraction statics with respect to a floating datum; optionally, deconvolution and dip filtering to remove reverberations and coherent noise trains; sorting traces into a common-depth-point (CDP) geometry, and, when dictated by a sufficiently crooked line geometry, using CDP bins specified on a reconstructed line; optional trace balancing; bandpass filtering; preliminary normal-moveout (NMO) corrections; preliminary stack of the CDP gathers; velocity analysis tests to determine the optimal type of velocity analysis; velocity analysis every 2 km along the reflection line; final normal moveout corrections; residual, surface-consistent statics are applied to the CDP gathers; muting of the CDP gathers; final stack of the CDP gathers; bandpass filtering and deconvolution; post-stack wave-equation migration; depth conversion of the final migrated stacked section.

3.2.1.12 Interpretation - Interpretation of the data involves the search for laterally coherent patterns in the arrivals of acoustic reflections and the correlation of these patterns with gravity, geology, well data, aeromagnetic data, and other sources of information. Interpretation is done by or under the direct supervision of the Principal Investigator geophysicist, usually with a doctorate in geophysics from a major university. He is usually assisted by geophysicists of grade 7 and above with specialties in computer science, statistics, or various interpretation techniques.

3.3 Materials/Equipment Required: (No special handling, storage and/or shipping is required unless otherwise noted.)

- o Examples of Materials/equipment required listed by category and type are as follows:

CATEGORY	TYPE
Survey	
Differential Global Positioning Satellite (GPS) Receivers	
Maps	15" LBNL topographic maps of survey area
Mylar Map Enlargements	7 1/2" from the above topographic maps
Notebooks	survey data logs
Compass	optical sighting
Survey Chains	100 meters fiberglass (or equivalent)
Theodolite	Wilde T1, Wilde T2 (or equivalent) tripod
Electronic Distance	Leitz Red 2 EDM (or equivalent)
Meter	prism set prism rod
Flagging	color ribbon flagging
Pin Flags	color pin flags
Directional Stakes	pointed lath
Computers	
Field Computers	HP 41CV calculators (or equivalent)
Magnetic Card Readers	HP 41CV (or equivalent)
Office Computer	Apple IIe (or equivalent) Imagewriter printer (or equivalent) dual floppy disk drive (or equivalent) survey software
Expendables	data diskettes printer paper 8.5 x 11 inches print ribbon
Truck Mounted Field Processing Computer	
Main CPU	386 PC (or equivalent)
Processor	Array Processor
Tape Driver	Tape Drives (1600 to 6250 BPI) 9 inch reel digital magnetic tape
Plotter/Printer	Dot matrix plotter printer/plotter paper
Terminals	computer terminals
Recording	
Instrument Truck	6x6 truck
Recording Cab	Truck mounted
Power Supply	110 Volt

Recording Instrument Central System	MDS-18 or I/0 System One (or equivalent) Memory Tape or cartridge drives Oscilloscope Laser camera Vibrator control Correlator
Recording Instrument Ground Electronics	Array terminals (as necessary)
Cables	Geophone fiber optics (if used) or twisted wirecables
Geophone Strings	Hardwired geophones
Radios	2-way radios

<u>Source Equipment</u>

Impulse Weight Drop Sources	
Poulter charges and Primacord	
Transporters	6x6 trucks
P-wave Vibrators	Mertz TR3 or Litton L311 (or equivalent) with force control
S-wave vibrators	Mertz M-13 (or equivalent) with force control
Land-airguns	Omnipulse or land airguns
Shot Boxes	
Central Electronics	TI VCS V (or equivalent) vibrator controls
Radios	2-way radios
Marking Equipment	Road hazard signs

<u>Support Equipment</u>

Vehicles	4x4 trucks
Radios	2-way radios
Safety	First aid kits Fire control
Powder Truck Drilling Rig Augers	

<u>Processing Hardware</u>

Computer	IBM-4381-M01 Computer (or equivalent) Controller (as required)
Controller	Controller
Tape Drives	1600 to 6250 BPI capability 9 inch reel digital magnetic tapes
Cartridge Drives	
Printer	Line printer printer paper
Terminal	computer terminal

Plotting Computer	Tempus Seismic System (or equivalent)
Plotters	11 to 36 inch dot-matrix plotters Plotter paper

3.4 Assumptions Affecting the Procedure: The following assumptions affect the validity of this procedure:

a) Instruments used to acquire data are checked to determine whether they are functioning properly prior to data acquisition.

3.5 Data Information: Data are in various forms as described in Para. 3.2.1.12 including, raw data sheets, magnetic tape, cartridges, and location maps.

3.5.1 QUANTITATIVE/QUALITATIVE CRITERIA: Job completeness, performance, and adequacy can be judged from whether the data sheets are properly completed and signed off, whether the requisite verifications of proper equipment function have been properly completed, whether qualified personnel perform the work; completeness may be qualitatively judged from the number of acquisition tests and number of miles obtained during the reflection survey.

3.6 Limitations: Explosion shotpoints must be located at safe distances from existing boreholes and/or facilities. During data acquisition certain unavoidable noise sources may adversely affect data quality.

3.7 Other: Data acquisition shall not proceed until all Vibrators have been checked according to Paras. 3.2.1.4,e, 3.2.1.5,c, and 3.2.1.8,a, all land-airguns have been checked according to Para. 3.2.1.5,c, and all shot boxes have been checked according to Para. 3.2.1.6,c.

3.8 Calibration Requirements. Calibration is not required as a part of this technical procedure.

3.9 Identification And Control Of Samples. Samples will not be collected or handled as part of this procedure.

4.0 QUALITY ASSURANCE RECORDS. Documents and data will be prepared and submitted per appropriate YMP-LBNL-QIP-17.0.

4.1 Technical data is not considered to be a QA Record or a QA Record Package controlled by YMP-LBNL-QIP-17.0 until it is authenticated by the Record Source and submitted in support of a final report or publication, or when YMP-LBNL approves it for transmittal per YMP-LBNL-QIP-SIII.3.

Anticipated documents and data generated from implementation of this procedure may include the following: The observer's report (Para. 3.2.1.3,j), surveyor's notes (Para. 3.2.1.7,h) inventory log (Para. 3.2.1.10,a), individual field magnetic tapes or cartridges, data sheets, vibrator point location maps.

4.2 Notebooks, forms, or other organized documentation shall be prepared, as appropriate, by the PI or a contributing investigator to record data from this procedure and shall include the unique identifier of equipment used to collect/record the data and any information considered by the originator to be pertinent. When in loose-leaf form, each page shall be numbered consecutively and chronologically. All documents shall be signed (or initialed) and dated by the investigator as entries are made. Any revisions shall be lined out, initialed, and dated. Notations by pencil shall be submitted in legible photocopy form.

4.3 Modifications. When modifications become necessary, the PI shall fully document the changes per YMP-LBNL-QIP-5.1, submit the documentation for the same review signature and distribution process as for the original procedure, and indicate whether the change should result in a subsequent revision to the technical procedure.

5.0 PERSONNEL RESPONSIBILITIES.

The Principal Investigator (PI) is responsible for assuring full compliance with this procedure. The PI shall require that all personnel assigned to work to this procedure shall have the necessary qualifications and training to adequately perform the procedure; and they shall have a working knowledge of the YMP-LBNL QA Program. When procedure-specific responsibilities are to be delegated to contributing investigators or other personnel, the details of these responsibilities are as stated in this procedure. Special qualifications and/or training unique to the conduct of this procedure are as follows: In the acquisition phase of the project, field supervisors and/or managers (or their designates) shall have a working knowledge of mechanical and electronic equipment. In the data processing phase of the project, trained personnel are needed to properly process the seismic reflection data. All ongoing investigations shall be identified, at the location of the scientific investigation, to preclude inadvertent interruption and to ensure compatibility of the investigations.

The Lawrence Berkeley National Laboratory shall be responsible for the quality of the acquired data and its analysis.

- The field Crew Manager directs seismic operations in the field and is responsible for the technical and logistical support of the data acquisition operation.
- The Surveyor has responsibility of the layout and surveying of the seismic test area.
- The Field Observer has the responsibility for the maintenance of the data acquisition systems and recording of required data.
- The Data Processing Specialist(s) has responsibility for the processing of seismic reflection data at the job site and at a remote processing center.
- The head driller has responsibility for the drilling, and loading of explosive shotholes (If shot holes are used).

6.0 ACRONYMS AND DEFINITIONS.

None.

7.0 REFERENCES.

Quality Implementation Procedure: YMP-LBNL-QIP-17.0.

Quality Implementation Procedure: YMP-LBNL-QIP-SIII.3.

Quality Implementation Procedure: YMP-LBNL-QIP-5.1.

8.0 ATTACHMENTS.

None

9.0 REVISION HISTORY.

None

10.0 REVIEW AND APPROVALS.

EFFECTIVE DATE:

Preparer	Date	QA Reviewer	Date
Principal Investigator	Date	YMP-LBNL QA Manager	Date
Technical Reviewer	Date	YMP-LBNL Project Manager	Date