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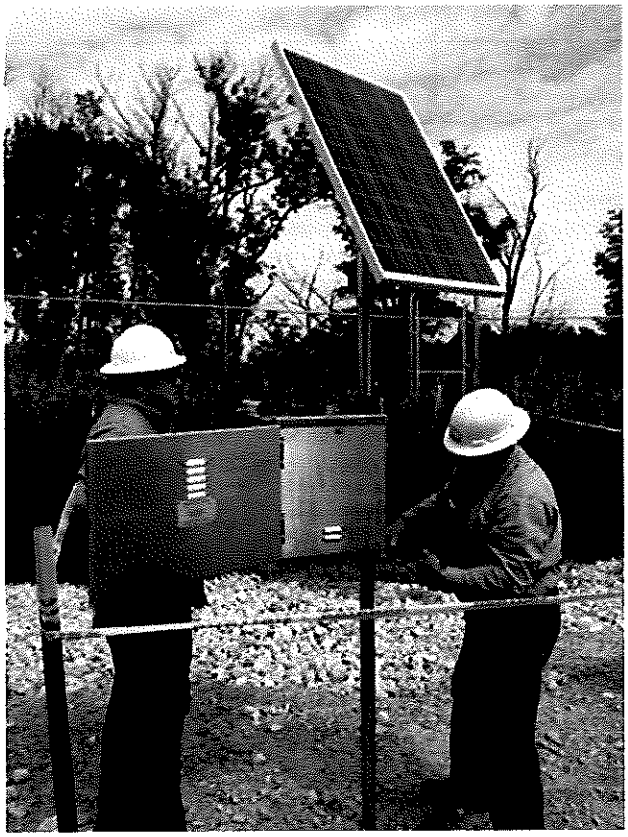
SENECA RESOURCES CORPORATION

CLASS II DISPOSAL WELL
SEISMIC MONITORING AND MITIGATION PLAN



March 2017

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Appendices

1 Introduction

This plan was developed to provide guidance on appropriate seismic monitoring and mitigation actions to be taken by Seneca Resources Corporation (Seneca) personnel operating the Class II disposal well (API No. 37-047-23835) in the Commonwealth of Pennsylvania. These actions include installation and layout of seismic monitoring equipment, initial and ongoing monitoring activities, mitigation actions to address incidents of varying type or degree that could potentially occur within the Area of Interest (AOI), which consists of the land within a three (3)-mile radius, of Seneca's disposal well operations as well as required incident and periodic reporting.

This plan does not replace or specifically cover tactical asset or facility site-specific emergency response actions but is used in conjunction with them.

The information provided in this plan is based on:

- Commonwealth of Pennsylvania, Department of Environment Protection (PADEP), Oil and Gas Management Program, Well Permit (Permit Number: 37-047-23835-00-01) for UIC Well #38268. Specifically the Special Permit Conditions that require the preparation and implementation of a Seismic Monitoring and Mitigation Plan (SMMP);
- Meetings with Seneca and PADEP;
- ALL Consulting's (ALL) experience and expertise in seismic monitoring, installation, induced seismicity, and working relationships with seismologists who do the interpretations; and
- Review, evaluation, and assessment of Class II injection operations.

For the purposes of this report, and as stated in PADEP's Permit Conditions, the following definitions will apply:

- Seismic Event: seismic activity above seismometer detection thresholds.
- Injection-Induced Seismic Events (IISE): detected seismic events that are determined to not be attributable to surface activities or system noise, nor events with hypocenters deeper than the top of the Salina Salts, after processing the data as described above.

1.1 Purpose

The purpose of this plan is to describe monitoring and mitigation elements to be implemented 30-days prior to the anticipated start of injection activities at Seneca's proposed Class II disposal well API No. 37-047-23835. This disposal well will inject into the Elk 3 Sandstone at a depth of approximately 2,354 to 2403 feet and is located in Elk County, Pennsylvania. This plan includes regulatory seismic monitoring requirements proposed in the PADEP Special Permit Conditions.

1.2 Objective

The overarching objective with respect to this Seismic Monitoring and Mitigation Plan is to establish a local seismic monitoring network and institute a traffic light system that would alert Seneca and the PADEP if seismic activity were detected within the AOI that deviated from historical baselines. The traffic light system would prescribe predetermined mitigation actions based on measured seismic events associated with injection operations to protect the safety and health of its employees and the general

2 Plan Maintenance and Review

2.1 Plan Administration

The SMMP is under the direction and control of Seneca, and will have an assigned "Plan Administrator." The Plan Administrator is responsible for document version control and will maintain the official version. Any recommended changes to the SMMP will require approval of the Plan Administrator prior to being incorporated into the SMMP document.

2.2 Plan Review

Seneca will perform regular evaluations to ensure that the SMMP is kept current and effective. To facilitate maintenance of the SMMP and to identify and rectify any plan deficiencies, the Plan Administrator will review the SMMP:

- On an annual basis at a minimum;
- Whenever there is a significant change to facility activities/operations; and
- Following any implementation of this SMMP in response to an event.

The following items will be considered during reviews:

- Telephone numbers and contact lists;
- Changes in facility operations and equipment;
- Changes in facility organization or key personnel;
- Federal, State, and local regulatory changes;
- Lessons learned during events; and
- Changes in mitigation measures.

Areas requiring revision will be identified through the review process and in consultation with Seneca, as deemed appropriate. Recommended changes to the plan will be documented by, or submitted to, the Plan Administrator and will include:

- Name and Title of person submitting the change(s);
- Description of the recommended change(s); and
- Rationale for making the change(s).

The Plan Administrator will be responsible for distributing information on the proposed change(s) to appropriate members of Seneca's management for review and comment. Once approval has been obtained, the Plan Administrator, or their designee, will prepare revisions to the plan as required. Minor revisions that are considered to be editorial in nature can be made by the Plan Administrator without further review.

The Plan Administrator will also be responsible for submitting an updated plan to PADEP in cases where the risk profile associated with injection activities changes, or as otherwise requested. Such updating of the plan will follow the same general procedures outlined above.

3 Monitoring

3.1 Seismic Monitoring Hardware

The local seismic monitoring network will consist of a minimum of four (4) velocity seismometer units, with associated data loggers, and a single strong surface vibration monitor (accelerometer) and an associated data logger (recorder). The seismometers will be three (3)-component, (X, Y, and Z axes) 120 second broadband velocity sensor stations that have a minimum 250Hz sampling rate for real-time data collection. The seismometer units record data on the x, y, and z axes, with one (1) sensor detecting up and down motion, while the other two (2) sensors detect horizontal motion in the north-south and east-west directions. These units measure the body waves (P and S waves) and surface waves, thus providing data to calculate the depth and magnitude of any seismic event. A copy of a manufacturer's specification sheet representative of seismometers which might be used can be found in **Appendix A** while the specifications for a representative data recorder can be found in **Appendix B.** These or equivalent equipment will be used. Details of the equipment specifications and installation of these or similar velocity seismic units are as follows:

- Institute of Earth Science and Engineering (IESE), Shallow Posthole Seismometer Sensor: Model S31f-2.0 (see **Figure 3-1**);
- REF TEK RT 130S-01 Broadband Seismic Recorder (see **Figure 3-2**) are equipped with 3 or 6 channels, 24-bit ADC, Global Positioning System (GPS) timing, and sample rates of 1 to 1,000 samples per second.
- Model S31F-2.0 have a frequency range of 0.1 to 1,000 hertz with a natural frequency of 2 hertz;
- Uses a solar powered radio transmitter to send time-stamped data to a central receiving point where it is processed and archived.

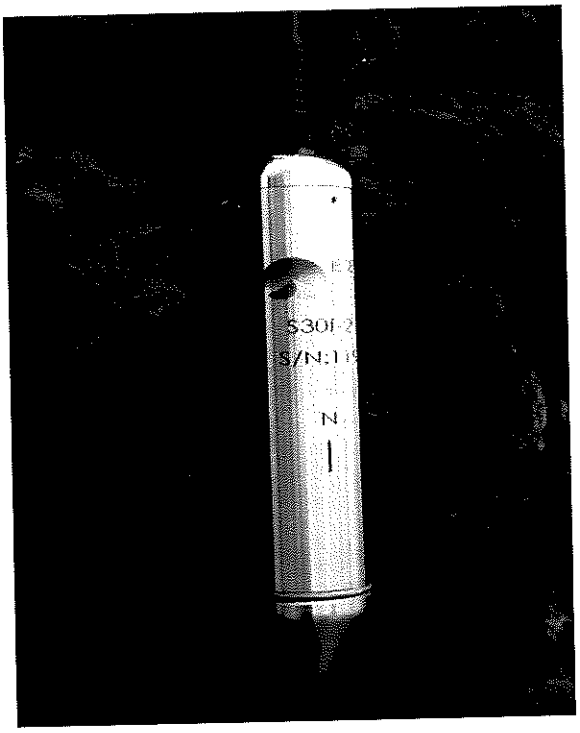


Figure 3-2: IESE Seismometer Sensor Model S31f-2.0 (Source: IESE)

Figure 3-1: Trimble REF TEK 130S-01 Broadband Seismic Recorder (Source: IESE)

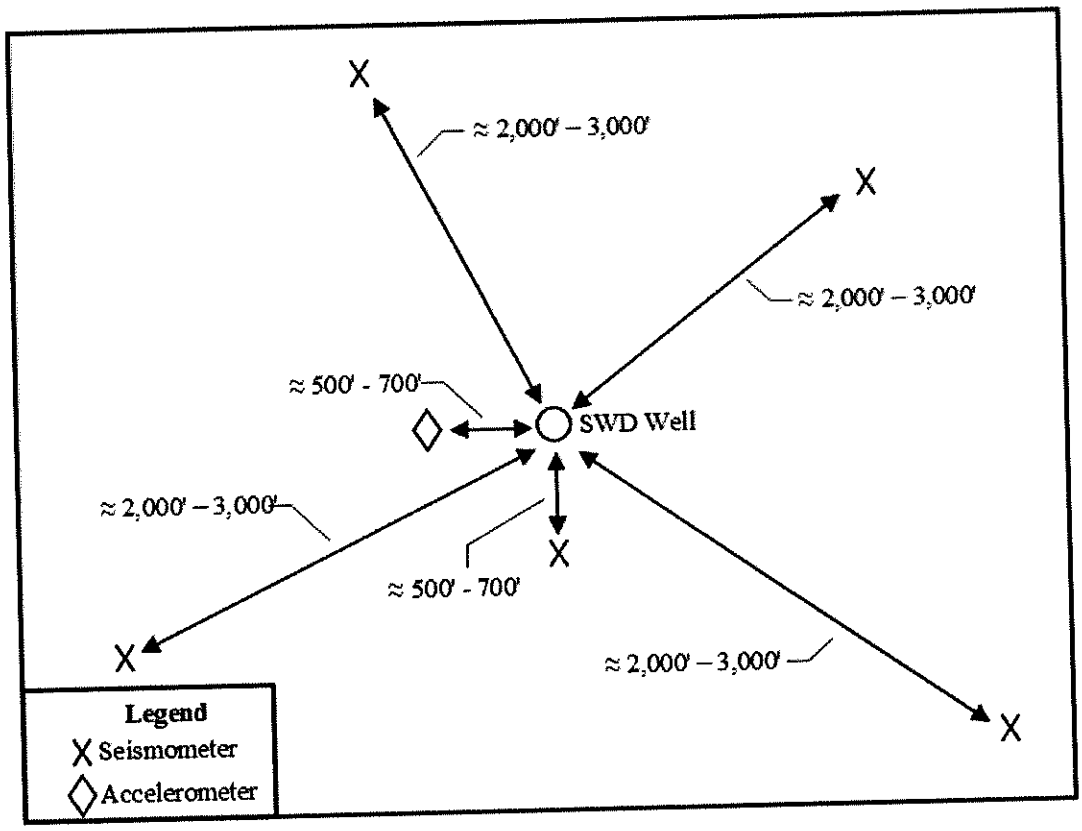


Figure 3-4: Typical seismic monitoring unit layout

The local seismic network will have a detection sensitivity of approximately magnitude (**M**) 0.5, depending upon unit placement and surface noise, with an estimated horizontal (epicenter) and depth (hypocenter) location accuracy of ± 750 feet for events greater than **M** 1.0. Calculation of horizontal and depth location errors will be based on the distance of any detected seismic events from the seismometers. The magnitude of the event will be determined based on the measured movements and the recording of peak ground acceleration at or near the site. The velocity seismometer units will continuously record data, meaning they record all the time (whether there is ground motion or not), whereas the accelerometer will only record when triggered by movement.

3.4 Seismic Monitoring Equipment Calibration

The protocol for operating and calibrating the seismometer and seismic recorder installed at the disposal well site will conform to the standards employed by the Pennsylvania State Seismic Network (PASEIS) and the manufacturer's instructions. Calibration records for both the seismometers and recorder will be maintained for a minimum of five (5) years.

Figure 3-6: Control Box Post and Sensor Installation Options

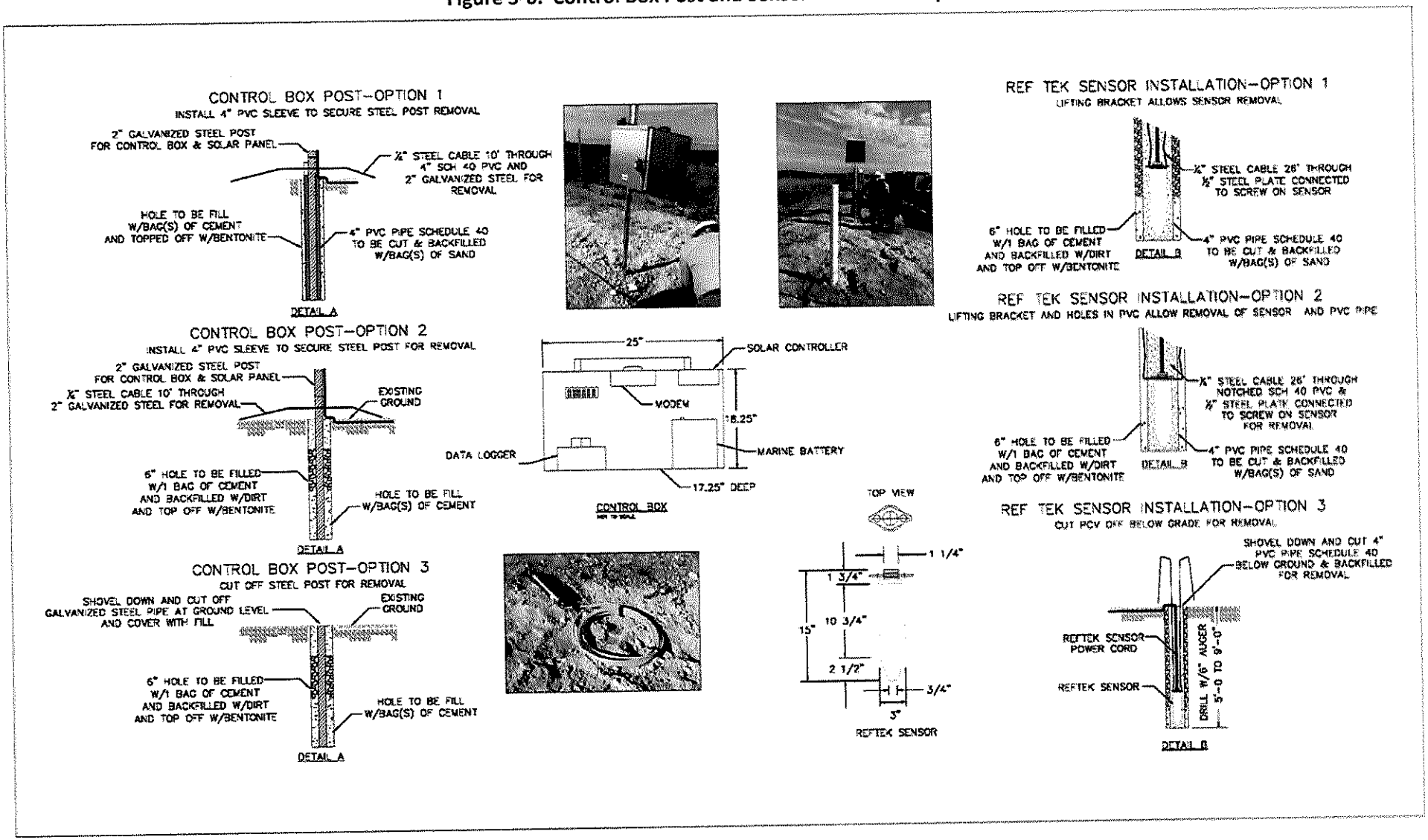
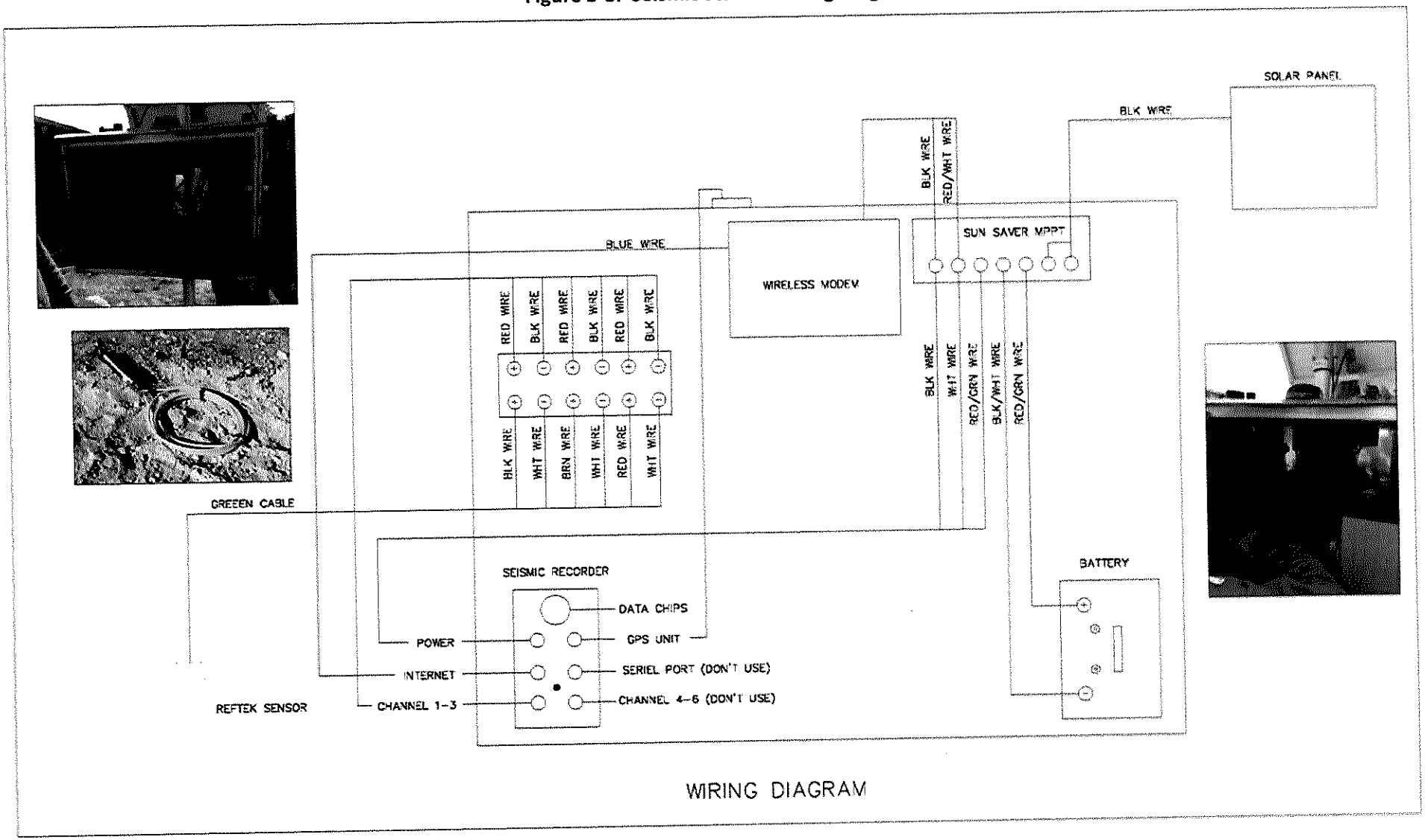


Figure 3-8: Seismic Station Wiring Diagram



transmission is interrupted, ALL will notify the PADEP verbally within 24-hours and in writing within seven (7) days.

3.7 Injection Well Monitoring

Many types of tests are available to assess injection well operational conditions including down-hole geophysical tests and traditional testing methods. A common example of a traditional testing method is annual pressure fall-off/shut-in testing, which involves monitoring pressure buildup in the well. This test can also be used to evaluate reservoir pressure characteristics and stabilization. Pressure fall-off tests will be performed annually to assess injection zone performance. Other testing that might be considered to detect faulting or fractures can include:

- Down-hole caliper logging to detect fractures;
- Down-hole resistivity logging to detect fractures and lithologic changes;
- Down-hole spontaneous potential logs;
- Down-hole gamma ray logging to detect formation changes;
- Down-hole porosity determinations;
- Fracture-finder logs to detect fractures;
- Compression tests on formation samples to determine rock strength; and
- Geotechnical tests on formation samples (porosity and permeability measurements).

Various injection well characteristics will be monitored and recorded to facilitate demonstration of mechanical integrity, evaluate formation pore pressures, and support potential seismicity assessments. **Table 3-1** summarizes the anticipated monitoring parameters, monitoring frequency, and reporting frequency to be implemented. Records of this injection information will be maintained in accordance with the permit conditions and be available to the PADEP upon request.

Table 3-1: Anticipated Monitoring Requirements for Seneca's Injection Facility

Parameter	Monitoring Frequency	Reporting
Injection Surface Pressure	Continuous	Monthly
Bottomhole Pressure	Calculated every four (4) hours	Monthly
Casing-Tubing Annulus Pressure	Continuous	Monthly
Temperature	Continuous	Monthly
Injection Flowrate	Continuous	Monthly
Fluid Density	Weekly	Monthly
Specific Gravity	Weekly	Monthly
pH	Weekly	Monthly
Composition of Injectate	Quarterly	Quarterly
Cumulative Volume	Daily	Monthly

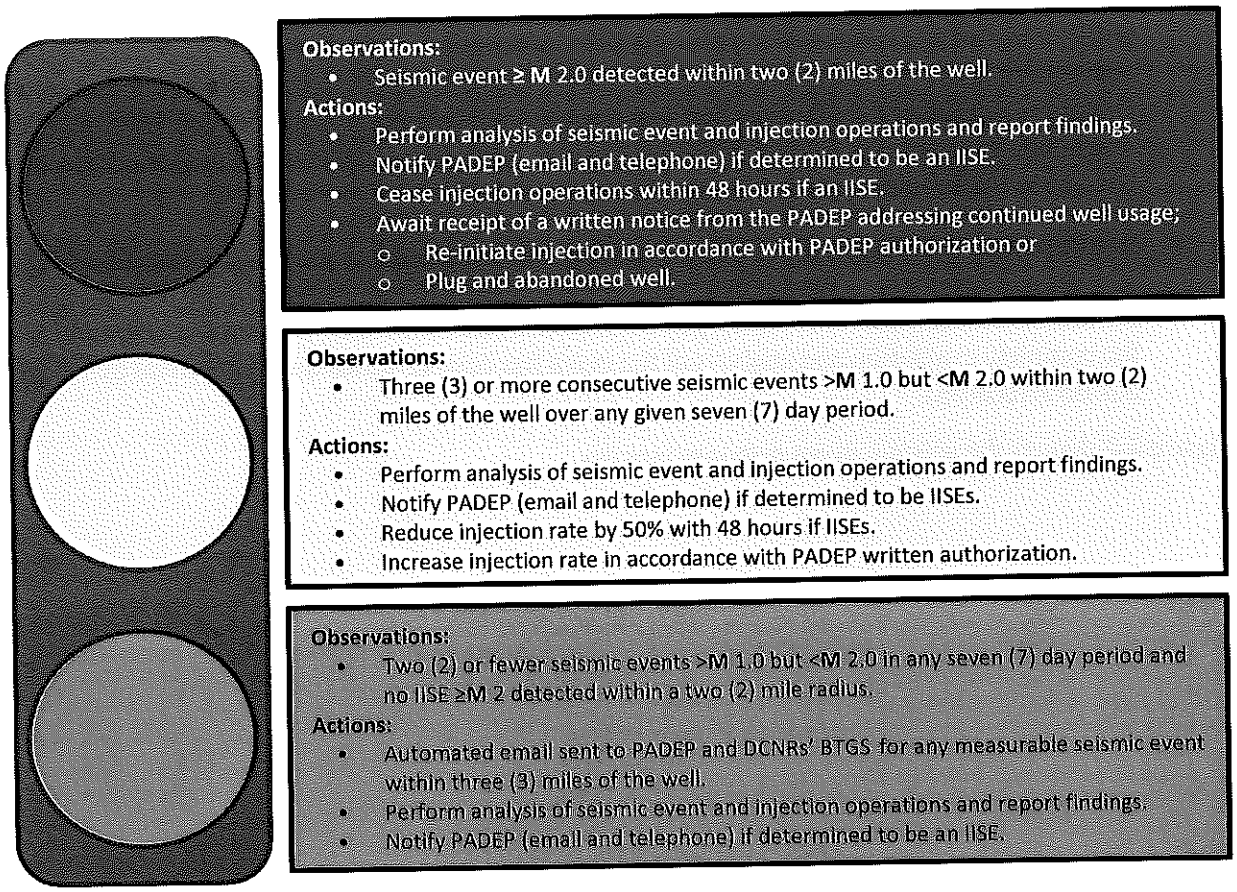
If the injection well data indicates that mechanical integrity of the subject injection wells may have been compromised, PADEP will be notified verbally within 24 hours and in writing within seven (7) days and injection operations will cease immediately.

3.8 Monitoring Modification

Pursuant to condition 17 of Seneca's UIC Well Permit, following five (5) years of injection activities, Seneca may submit a Summary Report and Plan (SRP) to modify or discontinue the SMMP. The SRP may propose to modify or discontinue SMMP in no less than 90 days absent an objection in writing

The traffic light system presented in **Figure 4-1** is based on site-specific, real-time risk management system observations that will become increasingly effective when updated as new data becomes available. The level of risk at a site will determine the proper mitigation measures and any necessary operational adjustments.

Figure 4-1: Disposal Well Traffic Light System



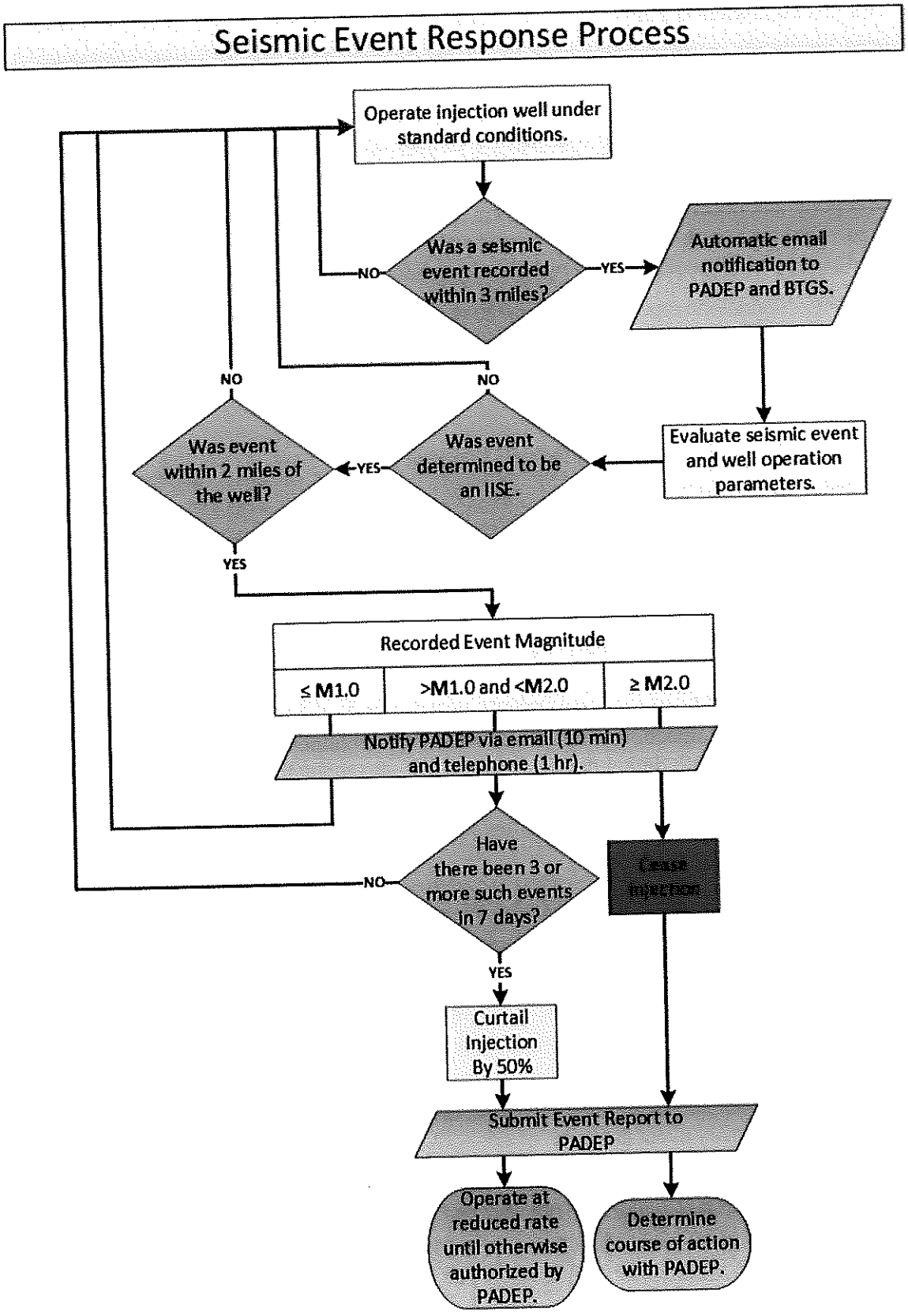
4.2 Mitigation Measures

All injection operations will begin in the green zone of the traffic light system, where operations and monitoring would be carried out as planned. If injection operations moves into the yellow zone of the Traffic Light System due to the occurrence of an IISE that meets prescribed thresholds, then caution will be exercised at all times in the form of heightened awareness, enhanced monitoring and the reduction of injection rate by the prescribed percentage. It should be noted that the yellow of the traffic light may not necessarily be interpreted as a disadvantageous phase nor should it be thought that the well would inevitably move to the red zone.

Listed below are the mitigation measures to be implemented based on observed seismic events, as depicted in the Traffic Light Figure (**Figure 4-1**):

- For seismic events determined to not be IISEs, no changes to operations (injection rates or volumes) is required.

Figure 4-2: Seismic Event Response Process



Appendix A

Manufacture's Specifications - IESE Seismometer, Model S31f-2.0

IESE
Institute of Earth Science and Engineering Aotearoa

OSOP
Distributor of IESE Products

Shallow Posthole Seismometer: Model S31f-2.0

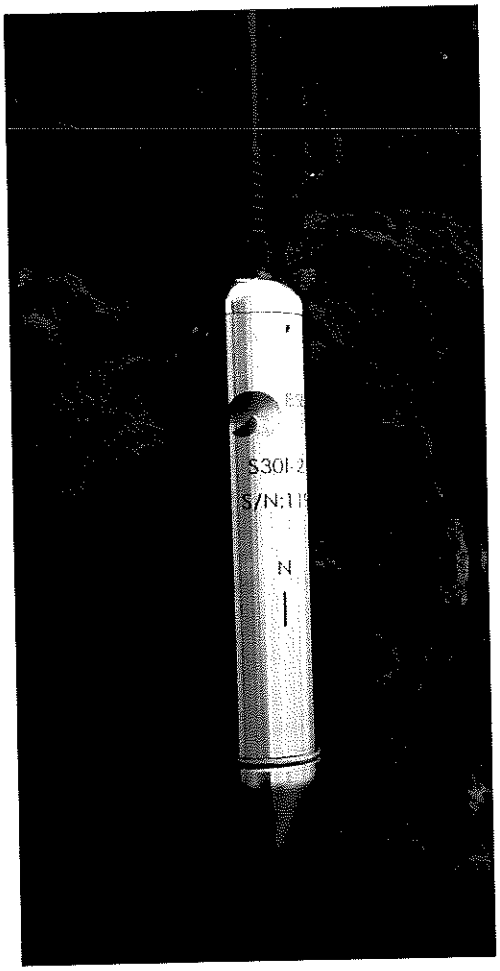
Easily installed seismometer for micro-earthquake monitoring

The S31f-2 is IESE's readily deployed shallow posthole sonde for use in micro-earthquake detection and analysis. The S31f-2 is designed for installation in up to 100m vertical holes.

The S31f-2 features the highest current performance level in sensitivity, reliability, and longevity for micro-earthquake detection.

Features

- Fixed
- Withstands up to 50°C
- Passive sensors
- For permanent or temporary installations



Parameter	Specification
Geophone orientation	Triaxial, Orthogonal
Natural frequency	2 Hz
Operational temperature	45° to +50°C
DC resistance	3810 Ω
Sensitivity	2.0 V/in/sec
Open circuit damping	0.61
Moving mass	23 g
Max coil excursion p-p	0.30 in (0.76 cm)
Normalised transduction constant	0.0317 $\sqrt{R_c}$ V/in/sec

Dimensions	
Outer diameter	2.8 in (7.2 cm)
Wall thickness	0.213 in (0.541 cm)
Height	3.5 ft (106.68 cm)
Weight	11 kg
Casing Material	304 stainless steel

For more information, please email us at sales@osop.com.pa
WEB - www.osop.com.pa

Appendix B

Datasheet – Trimble REF TEK 130S-01 Broadband Seismic Recorder

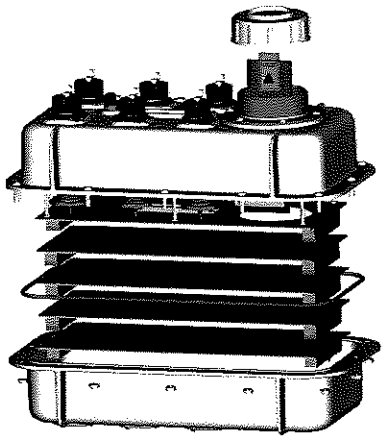
HARDWARE MODULARITY

The 130S is constructed with up to five internal boards stacked together – an arrangement that is more reliable and less costly than a traditional backplane arrangement. The 130S comes with a Lid Interconnect Board, a Microcomputer Board, one or two ADC Boards and a Sensor Control Board.

One or two removable disks reside in a sealed compartment that is accessed by opening a lid located on the top of the 130S case. The main electronics section is sealed with the lid open or closed.

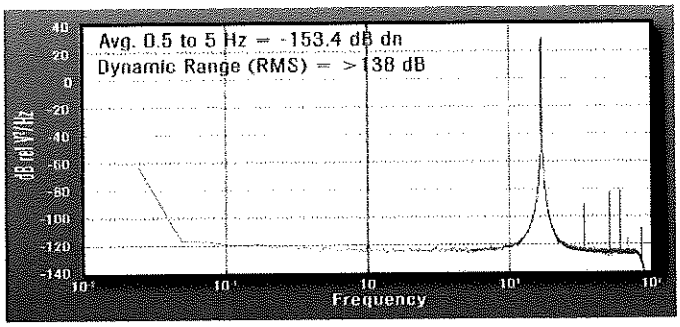
The GPS Receiver is separate from the main unit in order to allow the GPS antenna to be located some distance away.

Module	Description	Contents
1	Lid Interconnect Board (RT520) (⚠)	Power Supply Lightning Protection Physical Interface DC-DC Converter
2	Microcomputer Board (RT506) (⚠)	CPU Battery Backed SRAM (up to 16 MBytes) Serial Ports Real-time Clock Ethernet Controller, full stack Enhanced Integrated Drive Electronics (EIDE)
3	ADC (RT649) (⚠)	24-Bit ADC Channels (3 each) Input Pre-Amplifier Digital Anti-Alias Filters 1M SRAM Direct Memory Access (DMA) Controller DC-DC Converter
4	Sensor Control Board (RT527) (⚠)	Monitoring of Mass Position Re-Centering Command; Mass Lock/Unlock Calibration Commands Calibration Signals DC-DC Converter
5	Removable Mass Storage (External)	Compact Flash (two slots available) 2 to 32 Gbytes total capacity RT526 Interface Board
6	GPS Receiver (External)	Garmin GPS Receiver



NOISE PERFORMANCE

The 130S series recorder incorporates the 3rd generation 24-bit delta sigma type analog-to-digital converter with state-of-the-art design. The combination produces the highest performance low power 24-bit seismic recorder. Below is the power spectral density of the ADC with the full scale sine wave input.



DATA RETRIEVAL

The 130S series recorder may be equipped with one or two Compact Flash Type I or Type II storage media (disks). CF flash storage is available in 8GB or 16 GB capacity. For example, 8 GB is enough storage to hold more than 200 days of three channel, 100 sps data recorded with Steim 2 compression.

Files are written in FAT32 format allowing high capacity disks to be used. To swap a disk during acquisition, simply open the cap that seals the disk compartment. A red LED indicates the disk is busy.

When inactive a green LED signals to remove the disk and insert another one in its place. Replace the cap resealing the compartment.

Data from the disk may be read on any PC / Workstation using a CF-II reader. Data can also be remotely downloaded from the 130S disk using FTP over LAN/WAN.

DATASHEET

130S-01 BROADBAND SEISMIC RECORDER

Model	130S-01/3 (P/N 97100-00) 130S-01/6 (P/N 97100-01)
Mechanical	
Size	6.3" high x 6.9" wide x 13.1" long (16 cm x 17.5 cm x 33.3 cm)
Weight	4.5 lbs (2 Kg)
Watertight Integrity	IP68
Shock	Survives a 1 meter drop on any axis
Operating Temperature	–20° to +70°C
Power	
Input Voltage	9 to 24 VDC (ethernet) 11 to 24 VDC (writing to disk)
Average Power (no communications)	1 W (3 ch., GPS, writing to disk) –1.45 W (6 ch., GPS, writing to disk)
Average Power (with communications)	1.25 W (3 ch., GPS, writing to disk) –1.7 W (6 ch., GPS, writing to disk)
Communications	
NET Connector:	
Ethernet	10-BaseT, TCP/IP, UDP/IP, FTP, RTP
Serial	Asynchronous, RS-232, PPP, TCP/IP, UDP/IP, FTP, RTP
Serial Connector:	
Terminal	Asynchronous, RS-232, 130 Command
A/D Converter	
Type	Δ-∑ Modulation, 24-bit Output Resolution
Dynamic Range	>138 dB @ 100 sps
Channels	3 or 6
Input Impedance	2 Mohms, 0.002 uFd, differential @ x32; 25 Kohms, 0.002 uFd, differential @ 1
Common Mode Rejection	>70 dB within ±2.5 VDC
Gain Selection	x1 and x32
Input Full Scale	40 VPP @ x1 and 1.24 VPP @ x32
Bit Weight	2.724 µvolts @ x1 and 85 nV @ x32
Noise Level	~1 count RMS @ 50 sps @x1
Sample Rates	1000, 500, 250, 200, 125, 100, 50, 40, 20, 10, 5, 1 sps
FIR Filter	130 dB down passband to Nyquist
Compliance	
Compliance	CE

Auxiliary Channels	
Inputs	3 Channels available on each Sensor Connector: Supply Voltage, Backup Battery Voltage, Temperature
Time Base	
Type	GPS Receiver/Clock plus Disciplined Oscillator
Accuracy with GPS	±10 µsec after validated 3-D Fix and Locked
Free-Running Accuracy	0.1 ppm over the temp. range of 0° to 70°C and 0.2 ppm from –20° to 0°C
Recording Capacity	
Battery Backed SRAM	8 to 16 MB user specified
Hard Disk	8 GB or 16 GB CFII Card, settable in "Ring-Buffer" Configuration
Recording Modes	
Continuous	Record length
Time Trigger	Specific record length at periodic interval
Time List Trigger	A list of record times and lengths
Event Trigger	STA/LTA with advanced features including bandpass filter LTA hold, etc.
Level Trigger	Absolute value, user selectable: g, or % of full scale, or counts including bandpass filter
Vote Trigger	Level trigger with weighting
External Trigger	External pulse on trigger input line
Cross Trigger	One stream triggers recording of another
Recording Format	
Format	PASSCAL Recording Format

RELATED SUB-SYSTEMS:

Strong Motion Accelerographs, 130-SMHR &
Accelerometers, 147A-01
Broadband Seismometers, 151B-120, 151B-60, 151B-30

Specifications subject to change without notice.

Contact your local dealer today

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Wesminster, CO
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DATASHEET

147A

HIGH RESOLUTION ACCELEROMETERS

The 147A High Resolution Accelerometers are a force-balance accelerometer that converts acceleration signals into voltage signals to measure various low frequency and ultra-low frequency motion. The 147A accelerometer is available in both triaxial and uniaxial packages.

The 147A accelerometer uses a stateof-the-art force balance feedback technique to make up for the mechanical characteristic limitations of conventional accelerometers. This overcomes the shortcomings of nonlinear distortion and threshold of sensitivity of elastic measuring parts.

The advanced features of the 147A accelerometer include high sensitivity, large linear range, high resolution, and high dynamic range.

The 147A accelerometer has DC response. The 147A Low Noise model is +/- 4g full scale and provides excellent dynamic range, which is useful when used with 24-bit digitizers like the 130-MC Multi-Channel Recorder and 130S Series Data loggers. High sensitivity, large linear range, high resolution, and high dynamic range make the 147A model best suited for free field applications such as micro zonation, site response, earthquake monitoring, and more.

The 147A housing is sealed to meet IP67 standards for watertight integrity. For the triaxial package, mounting is accomplished with a single bolt, and 3 point leveling.

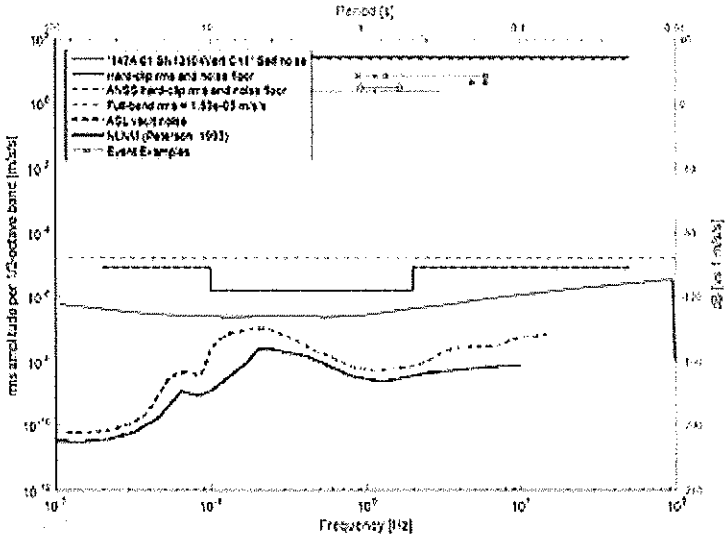
The chart below is a graphic presentation of the sensor amplitude operating range via the ANSS method.

Key Features

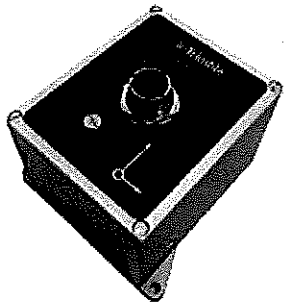
- Low Noise
- State-of-the-Art Accelerometer
- Sensitivity & Offset Stable

Applications:

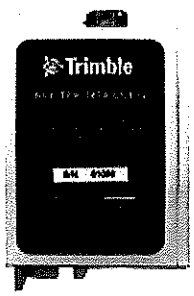
- Free Field Reference
- Building Arrays
- Structural Monitoring
- Site Response
- Aftershock Studies



Amplitude Operating-Range Diagram in Acceleration Units; Strong-Motion Acceleration Sensor "Class A"; Test of "147A-01 Ch. 1"



Trimble 147A Triaxial Accelerometer



Trimble 147A Uniaxial Accelerometer