NYE COUNTY NUCLEAR WASTE REPOSITORY PROJECT OFFICE

TEST PLAN

TITLE: **Collection of Ground-Based Gravity and Magnetic Data in the Crater Flat, Jackass Flat, and Amargosa Valley areas, 2008**	Revision: **0** Date: **1-22-08** Page: **1 of 12**
TEST PLAN NUMBER: **TPN-12.2**	SUPERSEDES: **None**
APPROVAL [signature] for 1/22/08 Project Manager — Date	CONCURRENCE [signature] for 1/22/08 On-Site Geotechnical Representative — Date [signature] 1/22/08 Principal Investigator — Date [signature] 1/22/08 Quality Assurance Officer — Date

1.0 INTRODUCTION

This Nye County Nuclear Waste Repository Project Office (NWRPO) test plan (TPN) provides instructions for conducting ground-based gravity and magnetic surveys in the Crater Flat, Jackass Flat, and Amargosa Valley areas (Figure 1). Work plan WP-12.0, *Surface Geophysical Surveys*, provides the background, purpose, and general objectives of Independent Scientific Investigations Program (ISIP) surface geophysical surveys.

The purpose of these surveys is to supplement the existing geophysical data sets in the area (data collected both by the NWRPO and by other agencies), as well as resolve discrepancies between those data sets.

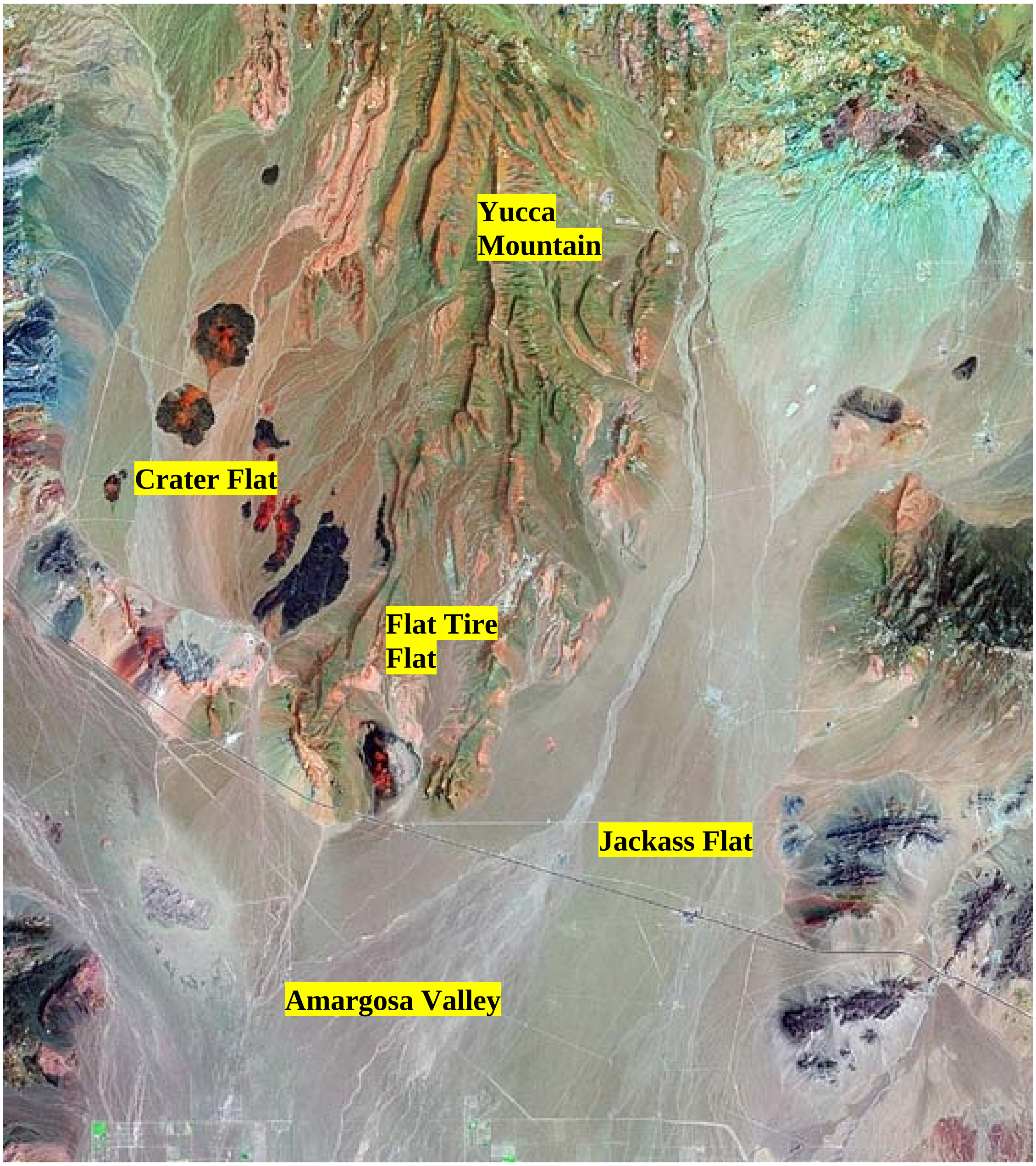

Figure 1. General survey area.

2.0 BACKGROUND AND PURPOSE

The NWRPO has collected several geophysical data sets in the vicinity of Yucca Mountain and Amargosa Valley, including Crater and Jackass Flats. These consist of aeromagnetic data (Blakely et al, 2000), large-scale electrical resistivity (Hoffman, 2006 and 2007), and seismic reflection (collected under TPN-12.1). In addition, other agencies have collected large-scale geophysical data sets in the region, including gravity (Ponce et al, 2001), aeromagnetic data (Ponce and Blakely, 2001), seismic reflection and refraction (Oliver et al, 1995), and others.

These data have been used by the ISIP to help further the understanding of the hydrogeologic framework between Yucca Mountain and Amargosa Valley, including the features that affect the flowpath (i.e., subsurface stratigraphy and structural mechanisms). However, some of the large-scale data sets, while showing regional character, are locally sparse within regions of Crater and Jackass Flats (Figure 2), or conflict with each other. These inconsistencies may be due to the geologic heterogeneity, or related to data density.

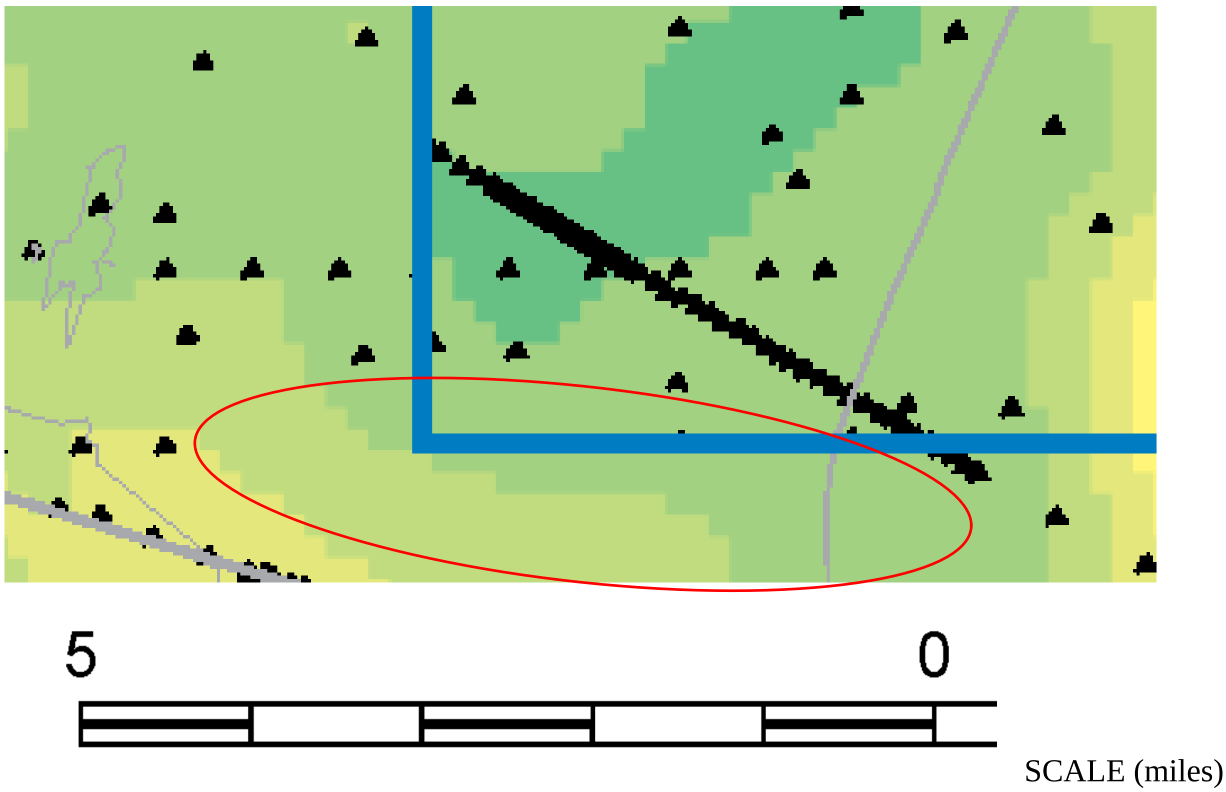

Figure 2. Portion of *Isostatic Gravity Map of the Death Valley Ground-Water Model Area, Nevada and California*, showing data acquisition points (black triangles). Red ellipse indicates area of lower data density.

In order to supplement existing geophysical data sets and resolve (or at least provide more control on) these inconsistencies, the ISIP will collect ground-based gravity and magnetic data along select lines in the Crater Flat, Jackass Flat, and Amargosa Valley areas.

3.0 SCOPE OF WORK

3.1 Responsibilities

The Principle Investigator (PI) is responsible for supervising the data collection activities described in this TPN. NWRPO personnel, including staff and contract geologists and technicians, are responsible for conducting the activities described in this TPN.

The Field Safety Supervisor (FSS) is responsible for monitoring the health and safety of workers relative to the guidelines established in Health and Safety Plan HSP-1.0, *Independent Scientific Investigations Program Health and Safety Plan for General Field Activities*.

The Site Supervisor is responsible for ensuring the completion of work in a safe manner according to the guidelines established in this TPN.

Nye County Field Personnel, as assigned by the PI, FSS, or Site Supervisor are responsible for the completion of the activities described in this TPN. Field Personnel are also responsible for the documentation of these surveys in the appropriate scientific notebook in accordance with Quality Administrative Procedure QAP-3.2, *Documentation of Technical Investigations*.

3.2 Survey Area

These surveys will be conducted along the lines shown on Figure 3. The extents of the lines surveyed will depend on field conditions, the speed at which the surveys progress, and other factors, and may change at the discretion of the PI. If time permits, additional data may be collected on “grid” spacing, to be determined by the PI. Many of the lines shown are intended to cross apparent structures visible in the *Isostatic Gravity Map of the Death Valley Ground-Water Model Area, Nevada and California* (Ponce et al, 2001). Others will be run near existing geophysical survey lines.

3.3 Equipment Requirements

Equipment for the gravity and magnetic surveys are being provided by different companies: the gravimeter will be provided by Exploration Instruments, Inc., of Austin, TX; the magnetometer will be provided by Geometrics, Inc., of San Jose, CA. A comprehensive list of equipment is provided in Tables 1a, 1b, and 2, below.

3.4 Safety and Environmental Compliance

NWRPO health and safety information, responsibilities, and procedures are described in detail in HSP-1.0. NWRPO personnel will adhere to the provisions of HSP-1.0 when conducting the activities described in this WP.

No land-disturbing activities (i.e., building of roads for access) are necessary for this survey; thus no permits, permissions, or waivers are necessary.

Processes to ensure compliance with applicable federal and state of Nevada requirements for the handling of hazardous, nonhazardous, and universal wastes are described in Environmental Management Procedure EP-1.0, *Waste Management*. Wastes generated during the activities described in this WP will be handled and disposed of by NWRPO personnel in accordance with EP-1.0.

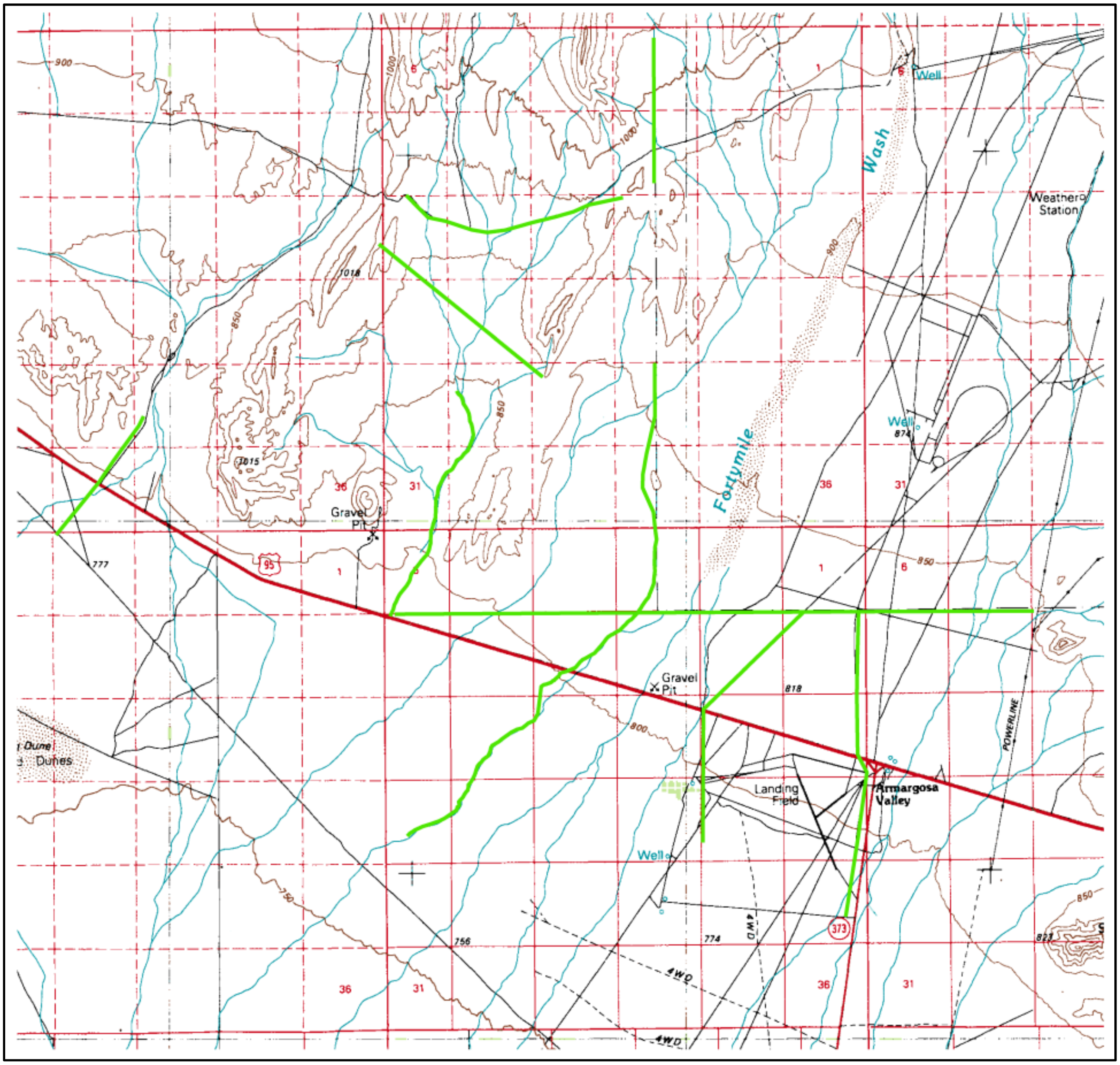

Figure 3. Topographic base map with planned geophysical survey lines in green.

Equipment Nomenclature	Quantity
L&R G400 Gravity Meter w/Aliod	1
Palm handheld w/case	1
Li-ion batteries w/case	2
Battery Charger w/AC adapter & power cord	1
AC Power supply for meter w/power cord	1
COM cable from palm to G400 meter	1
Palm charger w/AC plug and USB connection	1
Hex Screwdriver	1
Flathead Screwdriver	1
Spare Fuse	1
Leveling Plate	1
Palm Desktop CD	1
Floppy Disk w/Gravlog program	1

Table 1a. Required equipment for gravity surveys.

Equipment Nomenclature	Quantity
G-859 Mining Magnetometer Sensor	1
Pack Frame	1
Sensor clamp	1
Console w/cable	1
Battery in pouch	1
Novatel SmartAntenna GPS system kit	1
GPS Mast Wrap	1
GPS Antenna Shroud	1
GPS Mast Clamp	1
Serial Data Cable	1
Battery Charger	1
Adapter Plug Kit	1
Application Manual	1
Operation Manual	1
MagMap2000 PC Software	1
Shipping Case	1

Table 1b. Required equipment for magnetic surveys.

Equipment Nomenclature	Quantity
Pinflags (non-metallic staff)	300
Flagging Tape (roll)	10
Trimble® GeoXH GPS	1

Table 2. General equipment required for mapping survey lines.

4.0 DATA COLLECTION

4.1 Gravity Data Collection

The gravimeter used for this survey will be a LaCoste & Romberg G meter, modified with an Aliod 100 upgrade. The Aliod 100 upgrade consists of a linear electronic feedback system that increases accuracy, removes the potential for subjective readings due to the user (via a Liquid Crystal Display [LCD] readout), and onboard data storage using a Palm® computer. This Aliod system has a range of approximately 100 milliGals (mGal), with a resolution of 0.001 mGal (MicroG Lacoste, 2006). More information is available in the user manuals for the G meter and the Aliod upgrade; these manuals are available at the NWRPO Quality Assurance Records Center (QARC).

Data will be collected on the lines shown in Figure 2 at stations spaced 528 ft apart. The 3-dimensional (X,Y,Z) position of these features will be recorded using the Trimble® GeoXH GPS, according to TP-9.8, *Development of GPS Data using the Trimble® GeoXH GPS*, with the highest possible accuracy. Note that for post-processing gravity data, having a highly accurate elevation (Z) is crucial.

Procedures for the setup of the gravimeter and instructions for data collection are detailed in *Aliod 100 Upgrade User's Manual, revision 2.5* (MicroG Lacoste, 2006) and *Instruction Manual Model G & D Gravity Meters* (LaCoste & Romberg, 2004). Note that the Aliod 100 system provides relative gravity measurements; that is, measurements made relative to an arbitrary zero point. In the case that measurements along a particular line are outside the 100 mGal window defined at the start of the day, the range of the meter must be adjusted so the readings are within the window.

When shifting the range of the meter, first acquire a reading at the nearest station where the measurement is within the range. This measurement must be recorded in the appropriate scientific notebook. Next, shift the range of the meter so the measurement is near the middle of the range, or near the end (either high or low) of the range, whichever is appropriate. Take another reading, and record it in the scientific notebook. This will serve to "tie" the line together. Refer to the manufacturer's documentation for specific procedures.

All data collected with the gravimeter will be recorded on the Palm® computer, as well as in the appropriate scientific notebook. Data recorded on the Palm® computer will be downloaded daily upon returning to the NWRPO. At the conclusion of the survey, all data will be archived at the QARC.

4.1.1 Pitfalls

Gravimeters are extremely sensitive instruments, and should always be handled carefully. The more care the instrument is handled with, the better it will perform in the field. Several of the most important precautions are described in this section.

4.1.1.1 Instrument Drift

Instrument drift is one of the largest sources of error in gravity surveys. Instrument drift is generally caused by vibrations the meter receives, including those due to rough handling, transportation in a vehicle, wind, and other sources. Precautions should always be taken to shield the meter from vibrations **as much as possible:**

- Never shake or tilt the meter during the survey. The meter should be placed as level as possible at the locations where measurements are to be made, then leveled using the level screws.
- **Always lock the nulling dial and the arrestment knob before moving the meter. The nulling dial is locked using a small thumbscrew, and the arrestment knob is locked by turning it to its clockwise limit.**
- Minimize the amount of vibration the meter receives during transportation by always transporting it in its case, strapping it to a vehicle seat, etc.
- Shield the meter from the wind to the maximum extent possible. If it is not possible to shield the meter, orient the meter so that the wind is 90° to the beam (Figure 4).

Figure 4. Aliod100 Electronic Beam Nulling Gravity Meter (black arrows indicate desired wind direction).

4.1.1.2 Instrument Temperature

Due to the physics involved in calculating a gravity measurement, temperature variations inside the meter must be minimized to the maximum extent possible. The meter is equipped with a heating element that keeps the internal temperature in the ideal range for measurements. While taking gravimeter readings in the field, the batteries provide power for the internal heater. In order to maximize operating time in the field, take the following precautions:

- Ensure the gravimeter is always plugged in when in storage in the office.
- Plug the gravimeter into a DC to AC inverter while it is in a vehicle under transport from the office to the field measuring station.

4.1.1.3 Miscellaneous Techniques

Measurement methodology and technique can induce error into the measurements. In order to minimize these potential sources of error, ensure the following techniques are implemented.

The meter must be allowed to settle after it is moved into position at each measurement station.

In order to correct for the effects of drift, gravity measurements at a base station (each line will have its own base station) will be made at regular time intervals (e.g., every 4 hours), at the discretion of the PI. This interval will be recorded in the scientific notebook in accordance with QAP-3.2.

Each survey day begins with a measurement taken at a base station (the base station should be located on a central portion of the line, to minimize the travel time to reach the base station from any part of the line). The gravity meter is then moved to the next station, and a measurement made. This progresses until the amount of time specified by the PI has passed, then another base station measurement is made. The survey line or day, whichever comes first, must always begin and end with a measurement at the base station.

4.2 Magnetic Data Collection

The instrument used for the magnetic data collection will be the Geometrics G-859 “Mining Mag” Cesium Vapor Magnetometer. This model is pack frame mounted and has an integrated Novatel GPS system which records positional data (latitude and longitude) simultaneously with the magnetometer readings. More information is available in the *G-859 Mining Mag Cesium Vapor Magnetometer Operation Manual* (Geometrics, 2005).

As in section 4.1, data will be generated continuously along the lines shown in Figure 3. Positional data will be recorded by the on board Novatel GPS, and tied to locations mapped by the Trimble GeoXH GPS at the discretion and direction of the PI. Tie points will be recorded in the appropriate scientific notebook, in accordance with QAP -3.2. Specific data recording rate for each line will be determined by the PI and recorded in the appropriate scientific notebook.

Procedures for the assembly and setup of the magnetometer and Novatel GPS are detailed in the operation manual. Items of special concern for the setup and survey include angular position of the cesium sensor, storage and assembly of the pack unit, and interference from anthropomorphic items (i.e., culture).

Angular position of the cesium sensor will be determined based on the program CSAZ, which is included on the magnetometer CD listed in Table 1. Results of this determination as well as specific software title and version information shall be recorded in the appropriate scientific notebook in accordance with QAP-3.2.

The assembled unit can be stowed for transport from location to location as shown in Figure 5a. The final assembly configuration is shown in Figure 5b. Detailed instructions for setup and assembly are in the operation manual.

Magnetic field interference from culture such as power transmission lines, ferromagnetic surface casing on wellheads, buried utilities, underground storage tanks, and other sources can influence the readings taken by the G-859. Specific distances to offset from known interference sources have been taken into account during survey planning and are reflected in the survey lines in Figure 2. Any other specific offsets will be determined by the PI and noted in the scientific notebook as decisions are made. Additionally, personal attire and equipment can affect the magnetometer readings. While wearing the magnetometer pack frame, users must have non magnetic clothing to the maximum extent possible. Specifically, no steel-toed boots or shoes, no steel knives, and no key rings can be worn. Only brass or other non ferromagnetic belt buckles may be worn. The PI or Field Safety Supervisor will approve magnetometer user attire after each day's tailgate safety brief, before the unit is powered up.

Figure 5a. Transport stowage configuration.

Figure 5b. Final assembly configuration.

4.3 Data Processing

Data processing will be conducted according to standard methods similar to those discussed in *Gravity and Ground Magnetic Data from Selected Traverses in the Amargosa Desert and Vicinity, Nevada and California* (Mankinen et al, 2005), and the *MagMap2000 4.0, User Guide* (Geometrics, 2002) included on the Magnetometer CD listed in Table 1.

Files will be downloaded from the instruments on a daily basis, and the filenames and locations will be recorded in the appropriate scientific notebook, in accordance with QAP-3.2. All raw (unprocessed) data files from each instrument will be submitted to the QARC upon completion of the survey.

All processed output files will be recorded with their directory location in the scientific notebook as they are created, in accordance with QAP-3.2. Alternate processing methods, multiple processing runs, and output variations (as directed by the PI) will be documented along with the rationale for the decisions in the scientific notebook.

4.4 Records

In order to preserve the transparency and traceability of technical data, accurate and thorough recordkeeping is essential. As specified above, raw data will be archived and logged daily, in addition to being submitted for archive in the QARC. Scientific notebook entries will be used to accurately complete the metadata for these entries.

All processed data and the specific procedures, programs, and methods used to generate them will be archived to the QARC at the end of the processing period. Scientific notebook entries will be made during processing to indicate the specific procedures used.

5.0 REFERENCES

EP-1.0, *Waste Management*, Environmental Management Procedure: Nye County Nuclear Waste Repository Project Office (NWRPO), Pahrump, Nevada.

HSP-1.0, *Independent Scientific Investigations Program Health and Safety Plan for General Field Activities*, Health and Safety Plan: NWRPO, Pahrump, Nevada.

QAP-3.2, *Documentation of Technical Investigations*, Quality Administrative Procedure: NWRPO, Pahrump, Nevada.

TP-9.8, *Development of GPS Data using the Trimble® GeoXH GPS*, Technical Procedure: NWRPO, Pahrump, Nevada.

TPN-12.1, *Test Plan for Seismic Reflection Survey Near NC-EWDP-29P*, Test Plan: NWRPO, Pahrump, Nevada.

WP-12.0, *Surface Geophysical Surveys*, Work Plan: NWRPO, Pahrump, Nevada.

Aliod100 Upgrade User's Manual, revision 2.5. March 2006: MicroG LaCoste, Lafayette, Colorado.

G-859 Mining Mag Cesium Vapor Magnetometer Operation Manual, May 2005: Geometrics, Inc., San Jose, California.

Instruction Manual Model G & D Gravity Meters, 2004: LaCoste & Romberg, Austin, Texas.

MagMap2000 4.0, User Guide, October 2002: Geometrics, Inc., San Jose, California.

Blakely, R.J., Langenheim, V.E., Ponce, D.A., and Dixon, G.L., 2000, *Aeromagnetic Survey of the Amargosa Desert, Nevada and California: A Tool for Understanding Near-Surface Geology and Hydrology*: Administrative Report to Nye and Clark Counties, Nevada, Inyo County, California, and Death Valley National Park, U.S. Geological Survey, Menlo Park, California.

Blakely, R.J., and Ponce, D.A., 2001, *Map Showing Depth to Pre-Cenozoic Basement in the Death Valley Ground-Water Model Area, Nevada and California*: U.S. Geological Survey Miscellaneous Field Studies Map MF-2381-E, U.S. Geological Survey, Denver, Colorado.

Mankinen, E.A., Sweetkind, D.S., McKee, E.H., and Morin, R. L., 2005, *Gravity and Ground Magnetic Data from Selected Traverses in the Amargosa Desert and Vicinity, Nevada and California*: U.S. Geological Survey Open File Report OFR-2005-1444, U.S. Geological Survey, Menlo Park, California.

Hoffman, J.P., 2006, *Square-Array-Direct-Current Resistivity Measurements Conducted at Nye County near Borehole NC-EWDP-29P*: U.S. Geological Survey Letter Report, U.S. Geological Survey Arizona Water Science Center, Tuscon, Arizona.

Hoffman, J.P., 2007, *Dipole-Dipole Direct-Current Resistivity Survey Along the Southern Fortymile Wash in Nye County, Nevada*: U.S. Geological Survey Letter Report, U.S. Geological Survey Arizona Water Science Center, Tuscon, Arizona.

Oliver, H.W., Ponce, D.A., and Hunter, W. C., eds., 1995, *Major Results of Geophysical Investigations at Yucca Mountain and Vicinity, Southern Nevada*: U.S. Geological Survey Open File Report OFR-95-74, U.S. Geological Survey, Menlo Park, California.

Ponce, D.A., and Blakely, R.J., 2001, *Aeromagnetic Map of the Death Valley Ground-Water Model Area, Nevada and California*: U.S. Geological Survey Miscellaneous Field Studies Map MF-2381-D, U.S. Geological Survey, Denver, Colorado.

Ponce, D.A., Blakely, R.J., Morin, R.L., and Mankinen, E.A., 2001, *Isostatic Gravity Map of the Death Valley Ground-Water Model Area, Nevada and California*: U.S. Geological Survey Miscellaneous Field Studies Map MF-2381-C, U.S. Geological Survey, Denver, Colorado.