NYE COUNTY NUCLEAR WASTE REPOSITORY PROJECT OFFICE

TECHNICAL PROCEDURE

TITLE:	Revision: 2
Development of GPS Data using the Trimble® GeoXH 2005 GPS	Date: **10/25/2010**
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TECHNICAL PROCEDURE NUMBER:	SUPERSEDES:
TP-9.8	**Revision 1, 1-7-08**

APPROVAL	CONCURRENCE
Director — Date 11/1/10	Geoscience Manager — Date 10/28/10
	Principal Investigator — Date 10/28/10
	Quality Assurance Officer — Date 11/2/10

1.0 PURPOSE

This technical procedure (TP) provides instructions for the collection and post-processing of Global Positioning System (GPS) data in support of projects conducted by the Nye County Nuclear Waste Repository Project Office (NWRPO). The information contained in this TP is intended to ensure that GPS data developed by NWRPO personnel using the Trimble® GeoExplorer XH 2005 GPS (referred to hereafter as GeoXH 2005), Trimble® TerraSync™, (referred to hereafter as TerraSync) and Trimble® GPS Pathfinder Office® (referred to hereafter as GPS Pathfinder Office) software meet NWRPO Quality Assurance (QA) Program requirements. All NWRPO quality administrative procedures (QAPs), work plans, and test plans referred to herein shall be the most current revisions of those documents. This document has been prepared in accordance with QAP-5.2, *Preparation of Work Plans, Test Plans, and Technical Procedures.*

2.0 SCOPE

This procedure contains instructions for using a GeoXH 2005 with TerraSync field data collection software to collect GPS data. It also contains instructions for using GPS

Pathfinder Office software to post-process GPS collected position data, as well for archival of these data (both raw and processed) at the NWRPO Quality Assurance Records Center (QARC). Projects that require collection of GPS data include, but are not limited to, the Early Warning Drilling Program, surface geophysical surveys, the Water Level Measurement Program, the Groundwater Evaluation program, characterization of local and regional geologic features, and characterization of local and regional groundwater resources.

2.1 Applicability

This procedure applies to the principal investigator (PI), Equipment Custodian, and NWRPO field personnel, including staff and contract geologists, geoscientists, engineers, and technicians who collect and post-process GPS data for NWRPO quality-affecting technical program activities.

2.2 Training

NWRPO field personnel shall complete "hands-on" training on this procedure prior to the collection and post-processing of GPS data. Training completion shall be documented in accordance with NWRPO QAP-5.2, Preparation *of Work Plans, Test Plans, and Technical Procedures*). Training includes how to use the GeoXH 2005 with TerraSync field data collection software and the GPS Pathfinder Office software. Training will be based on current Trimble hardware and software documentation, including, but not limited to:

- Trimble *GETTING STARTED GUIDE, TerraSync* software
- Trimble *GETTING STARTED GUIDE, GeoExplorer 2005* series
- Trimble *GETTING STARTED GUIDE, GPS Pathfinder Office* software
- Trimble *Release Notes, TerraSync* software, and
- Trimble *Release Notes, GPS Pathfinder Office* software.

Current Getting Started Guides and Release Notes, along with supplemental documents (e.g., FAQs, Support Notes, and White Papers) may be found at the Trimble Support site at http://www.trimble.com/.

Personnel performing setup and maintenance of the GPS and post-processing software shall be trained to QAP-12.1, *Control of Measuring and Test Equipment.*

3.0 DEFINITIONS

The following definitions are compiled from Trimble *GETTING STARTED GUIDES*, Help Files, or the Trimble online GPS Tutorial.

3.1 Base Station – A base station, or reference station, is a GPS antenna and receiver positioned on a known location specifically to collect data for differential correction. Base data need to be collected at the same time data are collected with a rover unit.

3.2 GeoXH 2005 – The GeoXH 2005 combines a Trimble GPS receiver on a ruggedized Microsoft Windows-based handheld computer with H-Star technology for high accuracy GPS data collection.

3.3 Global Positioning System – A system in which high-precision orbital location and timing signals are broadcast by a constellation of satellites. Handheld units can use these signals to calculate their location, direction, speed, and time on Earth. GPS was developed by the US Department of Defense, and the satellite constellation is managed by the US Air Force.

3.4 GPS Constellation – The set of GPS satellites that are visible (above the horizon) to the GPS receiver at any given time.

3.5 GPS Pathfinder Office – Trimble software, together with its associated utilities, installed on an office PC that provides the functionality to differentially correct, view, and edit GPS data collected in the field, and to export it in a format suitable for use in other software.

3.6 H-Star – The H-Star technology, patented by Trimble, is a combination of advanced GPS receiver, field software with sophisticated logging capabilities, and office software with post-processing capabilities that enables high-accuracy GPS data collection. The GeoXH uses this technology.

3.7 PPM – GPS accuracy specifications usually include a parts-per-million (ppm) factor that reflects the steady degradation of accuracy as the baseline length grows. A value for ppm is calculated relative to the distance between the rover and the base station. If a specified accuracy was 1 cm + 5 ppm, then the accuracy where a rover collected positions at a feature that was 10 km from the base station would be 1 cm + 5 millionths of 10 km = 1 cm + 5 cm = 6 cm. Similarly, accuracy with a base station at a range of 5 km would be 1 cm + 5 millionths of 5 km = 1 cm + 2.5 cm = 3.5 cm.

3.8 Rover – The GeoXH 2005 is a mobile GPS data logger or rover that collects or updates data in the field, typically at an unknown location. Data collected on a rover can be differentially corrected relative to base station data.

3.9 TerraSync – Software installed on the GeoXH 2005 that is designed for collecting and updating geographical data (Geographic Information Systems [GIS] and spatial data).

4.0 RESPONSIBILITIES

4.1 Quality Assurance Officer

The project QA Officer is responsible for the coordination of the internal review of this procedure.

4.2 Principal Investigator

The PI is responsible for the preparation and modification of this procedure, as well as ensuring that the data collection and post-processing activities described herein are conducted in accordance with this procedure.

4.3 NWRPO Field Personnel

NWRPO field personnel are responsible for conducting the development of GPS data in accordance with this procedure, as well as submitting these data to the QARC for archival. NWRPO field personnel will be responsible for working in accordance with the Site-Specific Health and Safety Plan governing the project for which GPS data are being collected.

4.4 Equipment Custodian

The Equipment Custodian is responsible for maintaining Trimble firmware and software, including versions, patches, and updates, for the GeoXH 2005 GPS with TerraSync field data collection software and the GPS Pathfinder Office software.

5.0 PROCESS

The GeoXH 2005, and TerraSync and GPS Pathfinder Office software shall be operated according to this procedure when collecting GPS positions for quality-affecting NWRPO technical program activities. Current Trimble Getting Started Guides, Release Notes, Support Notes, White Papers, and GPS Pathfinder Office Help will be used as the standard references. The primary documents include:

- Trimble *GETTING STARTED GUIDE, TerraSync software*
- Trimble *GETTING STARTED GUIDE, GeoExplorer 2005 series*
- Trimble *GETTING STARTED GUIDE, GPS Pathfinder Office software*

Other Trimble support documents are available at the Support site at http://www.trimble.com/.

A GPS Data Collection and Post-Processing Log shall be completed for each GPS data collection project (see Section 8.0 for a description of the record; see Attachment A for an example of the record).

5.1 Update GPS Software

Prior to a GPS data collection project, the installed GPS Pathfinder Office and TerraSync software will be reviewed by the Equipment Custodian for currency using the software

update functionality built into the software or via the Trimble Support site at http://www.trimble.com/. When new GPS Pathfinder Office and TerraSync software updates are available, Trimble documentation related to the software updates (e.g., Release Notes or Getting Started Guides) will be reviewed by the Equipment Custodian, or designee, for installation instructions, new features and changes, known issues, and to determine whether the updates will require any changes to this Technical Procedure. The PI will determine if the available updates will be installed prior to the GPS data collection project.

If the PI determines the updates should be installed, the Equipment Custodian will install the software using Trimble integrated software procedures or in accordance with procedures on the Trimble Support site at http://www.trimble.com/.

If current versions of firmware and software will not be updated before a GPS data collection project, the custodian will document why current versions of firmware and software are not being used.

User Name, and GPS Pathfinder Office and TerraSync Version Numbers should be recorded in the GPS Data Collection and Post-Processing Log (Attachment A).

5.2 GPS Planning

Current Trimble documents will be used to determine the current accuracy capabilities, and to select from the alternative data collection and post-processing methods available for the Trimble GeoXH 2005.

The PI will identify the Data Quality Objective (DQO) for each GPS data collection project. The DQO will state the minimum required accuracy for horizontal positions, and may additionally specify a minimum required accuracy for vertical positions.

If a DQO is not specified, the DQO will be the horizontal accuracy for H-Star processing, as specified in the Trimble GeoXH 2005 Datasheet, with no requirement for vertical accuracy.

Table 1 presents DQOs, along with requirements for field data collection parameters and post-processing. These DQOs are specified for collecting GPS data in static mode (i.e., while holding position over the feature being located). Note that when in dynamic mode (i.e. when collecting line or polygon feature positions while moving) the accuracies of Code post-processing may apply, rather than for H-Star post-processing.

Table 1. Range of Data Quality Objectives with field and post-processing parameters.

Data Quality Objective (DQO)		Field Parameters		Post-processing Parameters		
Desired Horizontal Accuracy (cm)[1]	Potential Vertical Accuracy (cm)[2]	Antenna Used	Minimum Minutes Continuous Carrier Lock[3]	Number Base Stations	Maximum Base Station Distance (km)	Type
<100	2x to 3x Horizontal	Internal GeoXH 2005	NA[4]	1+	200	Code
30	2x to 3x Horizontal	Internal GeoXH 2005	2	1	80	H-Star
20	2x to 3x Horizontal	External Zephyr	2	1	80	H-Star
30	2x to 3x Horizontal	Internal GeoXH 2005	2	3+	200	H-Star
20	2x to 3x Horizontal	External Zephyr	2	3+	200	H-Star
10 + 5ppm[5]	2x to 3x Horizontal	External Zephyr	20	1	10	Carrier
1 + 5ppm[5]	2x to 3x Horizontal	External Zephyr	45	1	10	Carrier

1 - Horizontal accuracy is reported as Horizontal Root Mean Squared (HRMS) accuracy. HRMS is reported to the first standard deviation, such that 67% of logged positions should fall within the stated accuracy. This means that 33% of positions may fall outside the accuracy specification. Longer carrier locks (10 or 45 minutes rather than 2 minutes for H-Star post-processed positions) may improve the number of positions that meet the accuracy statement and a greater number of averaged logged positions may improve the accuracy of a horizontal position for a given feature .

2 - There is no vertical accuracy statement from Trimble for the GeoXH 2005. This is only a rule-of-thumb that is potentially achievable.

3 - Uninterrupted carrier lock must be maintained for the minimum specified time period. GPS positions must be logged at 1 second intervals for the same time period. The PI may specify longer continuous carrier lock periods or more logged positions to help ensure collecting better feature positions.

4 - For code post-processing, there is no minimum carrier lock time. This generally applies to collecting positions for lines and polygons.

5 - ppm is parts per million. This formula suggests that accuracy with a base station at a range of 10 km will be in the region of 6 cm (1 cm + 5 millionths of 10 km = 1 cm + 5 cm) when carrier lock is maintained for 45 minutes. Similarly, accuracy with a base station at a range of 5 km will be in the region of 3.5 cm (1 cm + 5 millionths of 5 km = 1 cm + 2.5 cm).

TerraSync configuration files should be used to define all other TerraSync data collection parameters. One configuration will be maintained for Code or H-Star post-processing and one configuration for Carrier post-processing. It is the responsibility of the PI, or designee, to develop TerraSync configuration files. The filename of the TerraSync configuration file that specifies data acquisition parameters (as well as any deviation from this TP) shall be documented in the comment section of the GPS Data Collection and Post-Processing Log in accordance with QAP-3.2, *Documentation of Technical Investigations*.

The Data Quality Objective should be entered on the GPS Data Collection and Post-Processing Log (Attachment A).

5.3 GeoXH 2005 and TerraSync Software Setup

5.3.1 GeoXH 2005 Setup

Prior to each field session, the GeoXH 2005 and TerraSync software configurations must be verified to ensure that collected GPS positions meet DQO and QA requirements. Collecting GPS positions requires the proper setup of the hardware, firmware and software. The necessary information to complete these configurations is found in the current:

- Trimble *GETTING STARTED GUIDE, TerraSync* software
- Trimble *GETTING STARTED GUIDE, GeoExplorer 2005 series*, and
- Trimble *Release Notes, TerraSync* software.

When collecting GPS point data for quality-affecting NWRPO technical program activities, the Zephyr™ antenna is required, and must be mounted on a range pole (or other object) of known height.

5.3.2 GPS Pathfinder Office and TerraSync Software Setup

Within the GPS Pathfinder Office software use Trimble methodology to create a new Project Folder for a GPS data collection project. Default sub-folder names should be accepted in order to provide consistent naming conventions for GPS Pathfinder Office processing activities.

NWRPO field personnel will upload and install a configuration file to the GeoXH 2005 GPS unit.

TerraSync configuration files will be saved as a QA Record, in accordance with QAP-3.2.

The GPS Pathfinder Office Project Name, and TerraSync Configuration File used should be recorded in the GPS Data Collection and Post-Processing Log (Attachment A).

5.4 GPS Data Collection

Operation of the GeoXH 2005 requires use of the installed TerraSync software. GPS positions will be collected in accordance with:

- Trimble *GETTING STARTED GUIDE, TerraSync software*,
- Trimble *GETTING STARTED GUIDE, GeoExplorer 2005 series*, and
- Trimble *Release Notes, TerraSync software*.

Additional resources on how to operate and troubleshoot the GeoXH 2005 and TerraSync software are available on the Trimble Support site at http://www.trimble.com/.

When collecting GPS positions, use the Trimble naming convention for Rover files collected by the GeoXH 2005 with TerraSync field data collection software. The rover filename convention is "RMMDDHHX," where:

"R" signifies a Rover file,
"MM" signifies the month of data collection,
"DD" signifies the day of data collection,
"HH" signifies the hour of data collection, and
"X" increments from "A" to "Z" for separate and successive files collected on the same month, day, and hour.

The Data Collection Date and the SSF Rover File(s) collected should be recorded in the GPS Data Collection and Post-Processing Log (Attachment A)

5.5 GPS Data Transfer, Post-Processing, and Export

After completing a data collection session, use a NWRPO computer with the GPS Pathfinder Office Software installed to download the Rover files and post-process using differential correction. Only then may the corrected GPS positions be exported for use in other software programs.

5.5.1 Data Transfer

Transfer the data collected in the field from the GeoXH 2005 to the NWRPO computer, using the methods described in the current:

- Trimble *GETTING STARTED GUIDE, GPS Pathfinder Office software*,
- Trimble *Release Notes, GPS Pathfinder Office* software, and
- Trimble GPS Pathfinder Office Help

For data transfer, the Rover files must be downloaded to the same Project directory established at the beginning of the data collection project, as described in Section 5.3.2. Upon successful completion of the download (using GPS Pathfinder Office) the Rover files will automatically be converted to SSF files. These files will have the same name as the Rover files, but with an *.ssf file extension (i.e., RMMDDHHX.ssf).

Rover (*.SSF) files shall be maintained as QA records.

5.5.2 Post-Processing

GPS positions collected by the GeoXH 2005 are subject to various errors. A majority of these errors can be removed from the data by differential correction (i.e., post-processing). Differential correction improves the accuracy of GPS positions to the specified accuracy of the receiver when used under recommended conditions. Procedures in the following current Trimble documents will be used to perform differential correction:

- Trimble GETTING STARTED GUIDE, GPS Pathfinder Office,
- Trimble Release Notes, GPS Pathfinder Office software, and
- Trimble GPS Pathfinder Office Help

Post-processing will be performed to the meet the DQO that was determined by the PI at the initiation of the GPS data collection project. Parameters for the specified DQO are shown in Table 1 in Section 5.2 and should be used to perform post-processing.

If the DQO is achieved, no further post-processing is required.

If differential correction results do not meet the DQO, notify the PI. The PI, or designee, will troubleshoot the unsuccessful results in order to implement alternative post-processing runs or to schedule recollection of GPS positions.

If the PI, or designee, achieve the DQO with an alternative differential correction run, the resulting Trimble generated reports and corrected position files (*.cor) will be documented. Provide an explanation why alternative differential correction was used in the GPS Data Collection and Post-Processing Log comments field or an attachment to the log.

All standard reports developed for the differential correction process will be maintained as QA Records. Any optional reports provided by the differential correction process will be maintained as QA records. The corrected data (i.e. the *.COR files) will be maintained as QA Records. These should be found in the same Project directory established at the beginning of the data collection project, as described in Section 5.3.2.

Results will be identified and documented in the comment section of the GPS Data Collection and Post-Processing Log, in accordance with QAP-3.2.

COR Files created (including whether the DQO was met) and Correction Report Filenames should be recorded on the GPS Data Collection and Post-Processing Log (Attachment A).

5.5.3 Data Export

The Trimble Export utility in the GPS Pathfinder Office software converts COR files to formats that can be read by GIS, Computer Aided Drafting (CAD), database, or other software. The PI, or designee, will create Export Setups using the Export utility. These

setups are created to ensure standardized data export with position and data quality attributes.

A standard data export setup will be selected for exporting from a COR file(s). The default Export directory will be used to receive the exported data. **The default Export directory will contain Trimble generated reports that will be maintained as QA Records.** The Export report(s) should identify the COR files exported, the export files created, and the parameter settings used in the selected Export Setup.

Exported Filenames and Export Report(s) Filenames should be recorded in the GPS Data Collection and Post-Processing Log (Attachment A).

5.5.4 Project Archive

The final step for the development of GPS data is to archive the work. The files identified in Section 8.0 must be compiled and transmitted to the QA Records Center.

5.5.5 Reprocessing

In the event that the raw GPS data need to be reprocessed and exported, the processing steps outlined in this document will be followed, a new GPS Data Collection and Post-Processing Log (Attachment A) completed, and the new files archived to the QARC (either superseding the old ones, or as a new version), as appropriate.

6.0 DATA COLLECTION LIMITATIONS

GPS data must be developed in compliance with requirements and guidelines provided by this TP, Trimble documentation and help files, and as provided in the documented training. Specific data collection limitations are described in Section 5.0.

7.0 REFERENCES

QAP-3.2, *Documentation of Technical Investigations,* Quality Administrative Procedure: Nye County Nuclear Waste Repository Project Office (NWRPO). Pahrump, Nevada.

QAP-5.2, *Preparation of Work Plans, Test Plans, and Technical Procedures.*

QAP-12.1, *Control of Measuring and Test Equipment.*

Trimble *GETTING STARTED GUIDE, TerraSync software*

Trimble *GETTING STARTED GUIDE, GeoExplorer 2005 series*, Version 1.10, Revision A. April 2007: Trimble.

Trimble *GETTING STARTED GUIDE, GPS Pathfinder Office software.*

Trimble *RELEASE NOTES, GPS Pathfinder Office software*,

Trimble GPS Pathfinder Office Help

8.0 RECORDS

All data and records associated with planning, collection, post-processing, and export of GPS positions will be transmitted to the NWRPO QARC following the conclusion of a GPS data collection project. The Project Folder created per Section 5.3.2 with all subdirectories and files shall be archived to the QARC. A GPS Data Collection and Post-Processing Log (Attachment A) will be generated for each GPS Project, containing the following:

1. Name of Data Collector – Name of the person that collected the GPS data,
2. GPS Pathfinder Office Version Number – Enter the current version number,
3. TerraSync Version Number – Enter the current version number,
4. Data Quality Objective (DQO) – Enter horizontal and vertical accuracy required. Depending on the project, it may be acceptable to have no requirement for vertical accuracy,
5. GPS Pathfinder Office Project Name – Enter the project directory name (DescriptiveName_MMDDYY, for example, Geophones_010108),
6. TerraSync Configuration File Name – Enter the filename (e.g. GeoXH2005_Zephyr.tcf),
7. GPS Data Collection Date – Enter the date of GPS field data collection,
8. SSF Rover file(s) – Enter the names of the uncorrected Trimble Rover SSF collected. (e.g., RMMDDHHX.ssf, where "R" signifies a rover file, MM signifies the month of data collection, DD signifies the day of data collection, HH signifies the hour of data collection, and "X" increments from "A" to "Z" for successive files collected on the same month, day, and hour.),
9. COR file(s) – Enter the name(s) of the final Trimble differentially corrected files created. These use the same name as the Rover files but with a *.cor extension (e.g., RMMDDHHX.cor). Also designate with a yes or no whether the DQO was achieved. Identify mixed results in the Comment field,
10. Correction Report Filenames – Enter the name of Trimble generated differential correction report files, including standard and any available optional reports,
11. Exported Filename(s) – Enter the names of the exported files created (e.g., ExportFilename.shp/txt/dbf/mdb/dxf),
12. Export Report Filenames – Enter Trimble generated Export report filenames, and
13. Comments – Enter other comments relevant to developing the GPS data.

The GPS Data Collection and Post-Processing Log and the relevant pages of the scientific notebook associated with a GPS data collection project will be transmitted to the QARC in Acrobat PDF format.

9.0 ATTACHMENTS

Attachment A
GPS Data Collection and Post-Processing Log

Required Record Information	Entry
1. Name of Data Collector	NWRPO Field Person's Name:
2. GPS Pathfinder Office Version Number	#.##: Checked for new version: ☐ Installed new version: ☐
3. TerraSync Version Number	#.##: Checked for new version: ☐ Installed new version: ☐
4. Data Quality Objective (DQO)	Horizontal and Vertical Accuracy Required:
5. GPS Pathfinder Office Project Name	DescriptiveName_MMDDYY:
6. TerraSync Configuration File	Filename:
7. GPS Data Collection Date	MMDDYY:
8. SSF Rover File(s)	RMMDDHHX.ssf:
9. COR File(s)	RMMDDHHX.cor: DQO Achieved (yes/no):
10. Correction Report Filenames	Filename:
11. Exported Filename(s)	ExportFilename.shp/txt/dbf/mdb/dxf:
12. Export Report Filenames	Filename:

13. Comments	Other comments relevant to developing the GPS data:

MMDDYY - Month, Day, and Year of GPS data collection.
RMMDDHHX -Rover file collected on a given Month, Day, and Hour (24hr clock) incremented alphabetically from A to Z for successive files.