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**INCORPORATING GEOGRAPHIC INFORMATION  
INTO MEASURE SURVEYS:  
A Field Guide to GPS Data Collection**



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## HOW TO USE THIS GUIDE

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This document is designed to be a start-to-finish guide to Global Positioning System data collection in MEASURE projects. This guide provides background information on GPS, how the technology works, how GPS data is collected, and how it is used in the context of MEASURE surveys. Checklists are provided to identify hardware, software and training needs during the course of a survey. Also included are copies of training materials that can be used in the field, and instructions on downloading and processing GPS data. Electronic copies of this manual, forms, downloading software, and how-to instruction sheets are provided on the enclosed CD.

Project managers can refer to this guide to develop data collection protocols, identify personnel and equipment needs and to conduct training. Specific instructions for the two types of receivers commonly used are included in the appendices of this manual. These materials have been designed to be photocopied and distributed to the field team. Training materials on GPS and point collection methods are also provided for both types of receivers as well as instructions specific to each type of receiver.

It is recommended that project managers review the introductory materials in the earliest stages of the project planning. This will help provide guidance on how to most efficiently incorporate GPS. Throughout the project life cycle this document will guide users on the purchase of equipment, training, and data collection.

The materials included in this publication can be redistributed, however the following citation must be included: “Incorporating Geographic Information Into MEASURE Surveys: A Field Guide to GPS Data Collection.” Livia Montana, John Spencer. Macro International Publication. 2001, updated 2004.

# INTRODUCTION TO GEOGRAPHIC DATA AND GPS

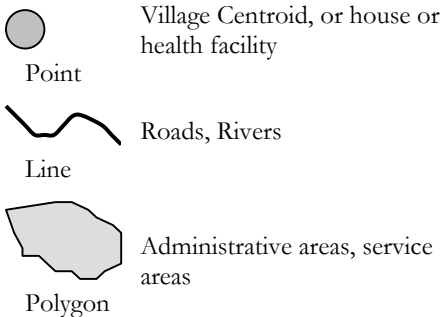
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

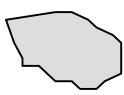
Researchers, policymakers, and program managers have long recognized geographic location as an important factor in population and health outcomes. Knowing how the health of women and children may differ by where they live can lead to a better understanding of where and why events occur and how interventions can be implemented effectively. But demographic and health data collection has not traditionally included the detailed locational information needed to incorporate geography into complex analyses. To broaden the uses of its data, MEASURE has expanded the Demographic and Health Surveys (DHS) and Service Provider Assessments (SPA) to include geographic data. With this new locational information, MEASURE data can be analyzed as part of a geographic information system (GIS) to gain new perspective on the health and well being of communities around the world.

Geographic information is made up of two components, location and attribute. Location represents *where* on the earth the items of interest are located, while the attributes provide information about *what* is occurring there. Geographic data is made up of three basic elements: points, lines and areas. A point could be a latitude/longitude reading from a GPS (global positioning system) unit, which might represent the center of a village, a health facility, or a household. Line data could represent road networks, or rivers. Points and lines can also make up areas, or polygons. Polygons could be administrative or political units such as states, or provinces. They could also represent other non-political regions such as health clinic service areas, or places prone to flooding during the rainy season.

All geographic data—whether point, line or polygon—can be geographically located on the earth’s surface, or georeferenced. Attribute information such as the number of people in the household, maximum travel speed on a given road surface type, or population in a district can then be linked to geographic locations.

**POINTS, LINES, AND POLYGONS**



	Village Centroid, or house or health facility
Point	
	Roads, Rivers
Line	
	Administrative areas, service areas
Polygon	

Points, lines and polygons are stored as a series of x,y coordinates. Points are a simple x,y location, while lines and polygons are recorded as a series of x,y, locations.

Once the locations are recorded attributes can be linked to the objects.

## Coordinate Systems

By definition geographic data must refer to a location—or locations—on the earth. Locations are usually referenced with a coordinate system. Though there are many different coordinate systems in use around the world, perhaps the most familiar is latitude and longitude. Latitude defines position in a north-south direction and uses the equator as its starting point. Positions that are north of the equator have a positive latitude value while positions south of the equator have a negative value. The earth’s poles represent the maximum values for latitude. The North Pole is at 90 degrees north latitude, while the South Pole is 90 degrees south latitude. Longitude defines position in an east-west direction and uses a line known as the Prime Meridian as its starting point. The Prime Meridian, as established by international convention, is a line that runs through the Greenwich Observatory in Greenwich England. Positions that are east of this line have positive longitude coordinates while positions west of the line have negative values. On the other side of the planet from the Prime Meridian is the International Date Line. The International Date Line has a longitude of 180 degrees and is the maximum longitude value.

Prior to the advent of the Global Positioning System (see next section), obtaining accurate positional data was complicated. To achieve high accuracy, sophisticated survey equipment was required along with a considerable amount of time and resources. After the introduction of GPS technology, accurate and cost-effective geographic data collection became attainable worldwide.

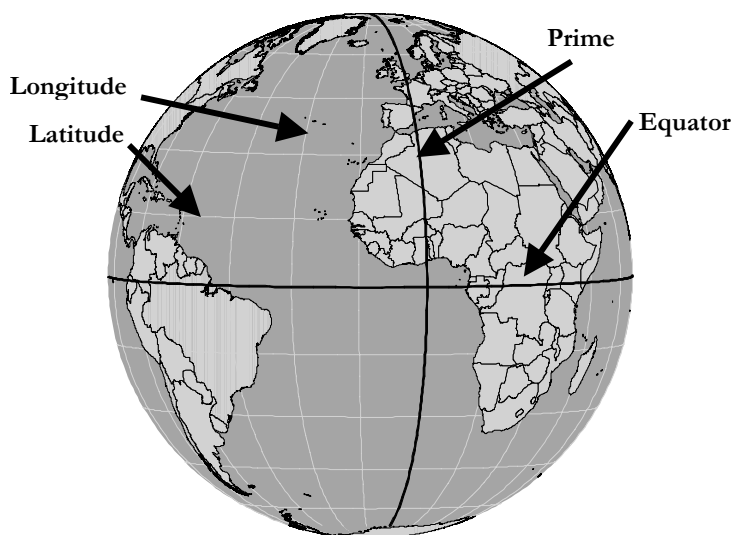
Although GPS is the focus of this manual, it should be noted that GPS is by no means the only source of geographic data. Existing hand-drawn maps, such as those outlining census enumeration areas, are common sources of geographic information. Hand-drawn maps can be digitized, georeferenced and merged with other sources of information. Remotely sensed data such as air photos, satellite and radar images provides a immense amount of land use and land cover data for almost any place on Earth. A wealth of remotely sensed data is commercially available but it can be expensive to purchase and process. Public domain digital datasets are increasingly available at little or no cost from the internet, but the quality and resolution of these datasets is not always good. Many countries are beginning to establish their own collections of digital geographic data, often supported through international donor agencies. But because of the multidisciplinary nature of geographic data, it is rarely centralized under one ministry or government agency.

### Geographic Information Systems

The key tool for maximizing the use of this type of data is a geographic information system, or GIS. Put simply, GIS is a combination of computer hardware and software used to store, manipulate, analyze, and display geographic data. Using a GIS for data analysis inherently places importance on where events or phenomena occur. Looking at a range of data from this spatial perspective can often add valuable context to human activity. GIS facilitates this type of analysis by integrating common database operations, such as query and statistical analysis, with unique visualization and geographic analysis benefits that maps can provide. The powerful analytical capabilities of the software mean that attributes can be queried and more complex questions can be explored. For example, a dataset of health facilities containing their location, and attributes such as how many doctors and nurses are on staff, may be useful in and of itself. But knowing the location of the communities they serve, and how easy or difficult it may be to reach the facilities might be more important. Knowing where the catchment population is and its

#### LATITUDE/LONGITUDE COORDINATE SYSTEM

The Latitude longitude coordinate system is commonly used to describe a position on the earth. Latitude measures position north/south relative to the equator, while longitude measures position east/west relative to the prime meridian.

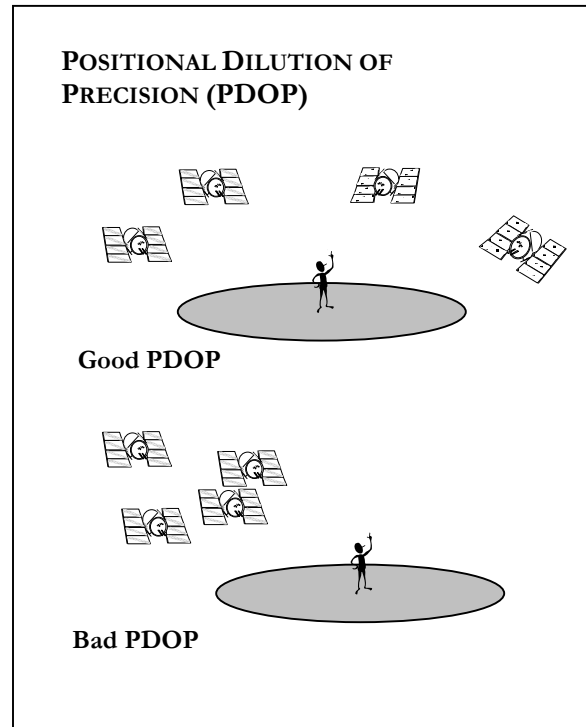


relation to the facilities, and routes of travel can answer this kind of question. GIS gives users the opportunity to analyze these layers of information simultaneously.

### The Global Positioning System

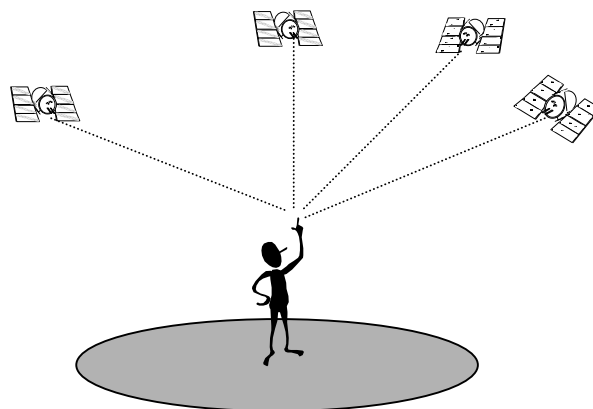
The Global Positioning System (GPS) is a satellite-based navigation system developed by the United States Department of Defense (DoD) to provide a consistent and accurate method of determining location. While it was originally designed for military applications, GPS also provides commercial and recreational users with worldwide navigation coverage. A GPS receiver determines its position using a set of 24 DoD satellites that orbit the earth. Each satellite's position, as well as the current time, is transmitted via radio signals. The GPS unit receives these signals and uses them to calculate its position in terms of latitude, longitude, and altitude.

Despite advanced GPS technology, there are many opportunities for error to be introduced in the coordinate. Most of the sources of errors are unavoidable, but users should be aware of them and be prepared to take steps to minimize their impact. Unavoidable errors include those caused by atmospheric conditions that bend and delay the signal from the satellites. Errors can also arise from multi-path interference that happens when signals bounce off of tall buildings, mountains or other objects. The greatest source of error is a factor of the positions of the satellites in the sky. Positional Dilution of Precision or PDOP refers to the spread of satellites in the sky and can be quantified by a number. The ideal condition is that the satellites are evenly distributed throughout the sky and not clustered in one quadrant. The effect of PDOP error is multiplicative. In other words, if all other errors combine to introduce two meters of error and there is a PDOP value of 7, the error present is 14 meters. While some GPS receivers will display a PDOP, most recreational grade receivers do not. Users must rely on the display of satellite locations to make sure that satellites are evenly spread throughout the sky.



### HOW GPS WORKS

Once a GPS unit receives a signal from 4 satellites, it can use that signal to calculate a location in X (longitude), Y (latitude), and Z (elevation). The satellites' signals include time information, which the GPS unit uses to calculate distances. The GPS unit then finds its location using principles of geometry.





Prior to May of 2000, there was an additional source of error present in GPS coordinates, Selective Availability (S/A). For reasons of US national security the DoD intentionally degraded the accuracy of the GPS positions for non-military users. While S/A was in effect most GPS users achieved a horizontal accuracy of 100 meters. In May of 2000, President Clinton discontinued S/A for most of the world. The effect of discontinuation of S/A essentially improved the horizontal accuracy of GPS to 10 meters or less. However, the DoD can reinstate S/A at any time on a global or regional basis if it feels US national security is threatened.

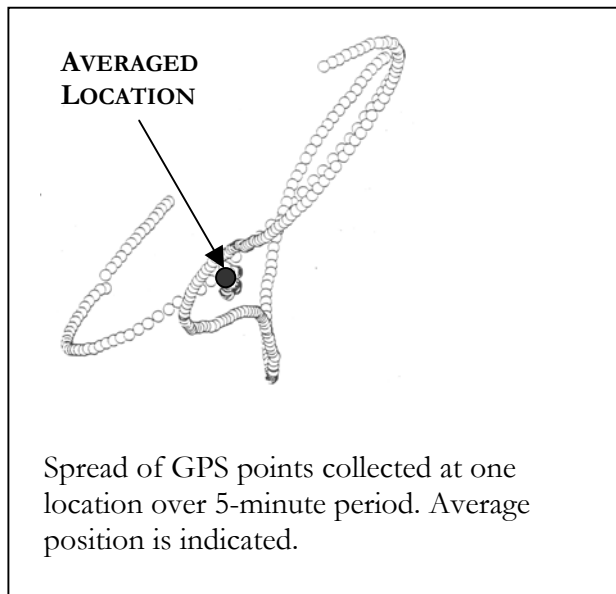
## GPS Accuracy

There are several types of GPS receivers in use. Survey grade receivers are the most accurate and the most expensive. Typically these receivers have sub-centimeter accuracy and cost in the tens of thousands of US dollars. Mapping grade receivers typically can produce sub-meter accuracy and cost between US\$1,000 and US\$5,000 and are designed for high-end cartographic activity. Recreational grade GPS units are designed for use when hunting, hiking, boating etc. Of the three types described, recreational receivers are particularly well suited for use in MEASURE projects. The cost of the unit is typically less than US\$200 and positions recorded are accurate to within 15 meters or less.

Understanding and defining the accuracy needs of the project is crucial to ensure successful GPS point collection. For most projects 10-15 meter accuracy is acceptable, and this level of accuracy can be achieved with nearly all recreational grade receivers. Some receivers provide the ability to improve accuracy through the use of point averaging. Multiple readings are collected at one location over a specified period of time, then the mathematical average of the points is derived. This minimizes the effect of the errors present in the coordinates.

While the automatic point averaging feature in GPS units was developed specifically to counter the effect of S/A, the technique still has merit today. Averaging points can smooth out the variation introduced due to the other errors present in the signal. Point averaging can improve accuracy down to 5 or 10 meters. The extra effort involved in achieving this level of accuracy is minimal so it is advisable to use point averaging when the option exists on the receiver. (Note: the averaging feature is not available on the Garmin Etrex units commonly used for Measure surveys.) When the averaging feature is turned on,

the unit starts collecting points. After a specified time, the user stops the point collection, and all points collected within that time frame are averaged, yielding a more accurate point. Experiments have shown that averaging points over a period of time as short as three to five minutes can reduce error to as little as 5 meters (Carolina Population Center, Spatial Analysis Unit 1998). Collection of points over longer periods of time can improve accuracy even further, but the amount of error reduction achieved by averaging for periods over 10 minutes is not proportionally as large. Since an error range of 5 to 10 meters is adequate for most MEASURE applications, averaging points for five minutes is sufficient.



### Benefits of Collecting GPS Data

The benefits of GPS point collection are substantial. For example, latitude and longitude readings taken for each sample cluster (see Collection Approach) provide a set of point locations that can be linked to all of the household and individual level attributes contained in the full DHS dataset. Locations for health facilities can be linked to the inventory and information on health workers. Rather than constraining a geographic analysis to national or provincial levels, point data for the sample clusters can be aggregated to new units of analysis, such as climatic zones or ethnic regions, as in the example below. New variables can also be attributed to the point locations and used in multivariate analysis.

### **Drawbacks to GPS**

The accuracy of the GPS receiver's calculated position depends on the strength and number of signals that it receives. The receiver will always collect data from as many satellites as it can, and will choose the best four according to angle and strength of signal from which to compute a position (see previous section on GPS accuracy). But obstacles such as buildings, mountains, and tree canopies can distort the signals and introduce error to the reading. Even more serious, user mistakes such as inaccurate or incomplete waypoint identification can be extremely difficult to rectify after the teams and GPS units have returned from the field.

## PLANNING FOR AND MANAGING GPS DATA COLLECTION

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Collecting GPS data during a MEASURE survey is simple and requires little additional work. GPS data can be collected within the existing framework of the survey, once the receivers are purchased GPS data is free, many GPS receivers are inexpensive and survey staff can be trained quickly in their use. This section describes the benefits and drawbacks of GPS data collection as well as an overview of the steps required to add a GPS component to projects.

Before beginning any project that will incorporate GPS, preliminary planning is essential. It is important to coordinate equipment purchases and arrange for training and personnel needs. The specifics of the project will determine how some decisions will be made however there are some things that will be common to all projects.

### Required Equipment

Project managers should make equipment purchases should be made as soon as the contract is signed. The following equipment is required:

- **GPS units:** one unit per team, plus two backup units. Measure surveys generally use Garmin Etrex GPS units (\$100-200/each)
- **GPS carry cases:** one per GPS unit
- **AA batteries:** 8 AA batteries should be ordered for each GPS unit
- **GPS/PC connector cables:** at least two per survey should be ordered – because cables are easily misplaced, purchasing additional cables is advised (\$35/each)
- **GPS Utility software:** GPS Utility software is used to download data from the GPS units into a PC. This software is described in a subsequent section (\$40)
- **Paper record:** In addition to recording the cluster coordinates in the GPS units, field teams must record locations on a paper form. A form template is included as an appendix to this report, but these fields can also be incorporated into the main questionnaire.

### Personnel Needs

GPS data collection can almost always be done without hiring additional personnel. The details and number of people will vary according to specific projects. However, there should be a field team which will collect points, and a field GPS coordinator. The project manager must identify a local staff person to serve as the GPS coordinator and must also decide which field staff will be charged with the responsibility of actually collecting the GPS points. The main responsibilities of the field GPS coordinator are to ensure that:

- field staff are well-trained
- points are collected for all locations in the survey
- technical and protocol questions raised by the collection team are resolved
- team members are following the established point collection protocols
- data is regularly downloaded and verified from the GPS units
- data from the paper forms is entered and verified
- all necessary data is collected
- copies of the data is provided to the managing institutions

## **Training of GPS Coordinator and Field Team**

Adequate training of personnel is crucial to promote an understanding of proper use of the GPS receivers and to troubleshoot problems that may occur in the field. The GPS coordinator should be identified early on so that s/he can fill the role for the duration of the training, data collection and processing. This person should be someone who has existing knowledge and/or experience with GPS, or the willingness and ability to learn quickly. Because of the advanced tasks the coordinator must perform, s/he will need additional training beyond that which is given to the collection teams. This training will include how to transfer points from the GPS receiver to a computer, as well as some more advanced training with the GPS units. At a minimum the coordinator should understand the basic operation of the unit and how to reinitialize and modify the system settings (e.g. coordinate system, datum, measurement units).

The GPS coordinator should be trained by the project manager or designee. The training of data collectors can then be conducted by the GPS coordinator in collaboration with the project manager.

The field team must be trained in the basics of the unit, the point collection protocols, and simple troubleshooting techniques. In order to prevent a “black-box” syndrome where the team does not understand how the units work it is also helpful to cover the basics of how the global positioning system operates. Lastly, the team should be given time to practice collecting points. This training can last from a half- to a full-day, depending on the number of people and the specifics of the project. The GPS training site should have access to a field or park where there is a clear view of the sky. Detailed training materials are presented later in the packet. It is essential to incorporate GPS training, including a hands-on session, in the regular project training regime.

### **Suggested Training Components**

A training presentation with notes is attached at the back of this manual, and an electronic copy is also provided. This can be used as-is for standard MEASURE data collection, or modified for other needs. The training should include the following:

#### ***1. Overview of GPS***

Everyone using the GPS receivers should have a basic understanding of the global positioning system and the underlying theory behind the technology. This allows users to understand how the system works and the importance of following proper protocols. Users who have an understanding of the workings of GPS will be more likely to recognize problems that may arise in the field and know the necessity of resolving the problem. Typically this section of training need not last more than a half-hour and should cover the following topics:

- History of GPS
- Description of the components of GPS: satellites, ground stations, receivers
- How the receiver calculates a position
- Errors that are present in coordinates and how to minimize them

## ***2. Introduction to the GPS Unit***

Everyone on the data collection teams should be introduced to the GPS unit in the training session. The basics of using the unit should be covered: on/off, initializing the unit and adjusting settings (datum, coordinate system, measurement units), acquiring a position, checking satellite coverage, marking a position with point averaging, changing the waypoint name, renaming and deleting waypoints, as well as adjusting contrast, light, and time/day.

## ***3. Point Collection Protocols***

Well-defined point collection protocols are essential to obtain accurate positions. These protocols should explicitly describe how IDs are assigned and where points should be collected. This section of training should describe the protocols in detail.

## ***4. Troubleshooting***

Guidance should be given on solving problems that might be faced in the field. This includes replacing batteries, checking the unit settings, and finding adequate satellite coverage in the sky. Typically this section of training should last 30 minutes.

## ***5. Hands-on Practice Session***

GPS technology is relatively simple to use, however it does require some practice for people to become proficient in the use of the receivers. Therefore it is vital that time be set aside in each training session for the GPS users to practice collecting points and filling out the point collection logs. This hands-on training *must* be conducted outside and should take at least 60 minutes.

## GPS DATA COLLECTION IN THE FIELD

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The following chapter presents general information and suggestions for collecting GPS data in the field, including when to collect data during the survey process and how to name and store the data. Specific instructions for collecting data using the Garmin Etrex GPS unit are included in the following chapter.

### **Determining the Appropriate Collection Approach**

GPS point collection can take place during the listing process or during the administration of the survey itself. MEASURE fieldwork is often divided into two phases: the listing and the main fieldwork. After the survey population has been stratified and enumeration areas identified, teams go out to the field to carry out the listing. In each enumeration area or cluster that has been selected, all of the households must be identified on a sketch map. The final sample selection is drawn from the listed households. DHS surveys generally always have a listing component, but health facility surveys may not.

If a listing phase is part of the survey, it may be easier for the teams to collect the GPS data during this time, when they are not occupied with the survey itself. Because there are typically fewer listing teams than interviewing teams, fewer units are required. Also, field supervisors are not preoccupied with the main survey, so GPS data collection is easier to incorporate during this stage of the survey.

If GPS data is collected during survey fieldwork, one unit per interviewing team is required. Since field supervisors are very busy with other responsibilities, GPS data collection is more likely to be forgotten or lower on the priority list. The GPS coordinator must pay careful attention in surveys where data is collected during main survey fieldwork.

### **Collecting the GPS Data**

One GPS reading or latitude/longitude must be taken for each location in the survey. For health facilities, this is generally taken at the front door of the facility. For DHS surveys, the location is collected at the cluster. DHS clusters are usually census enumeration areas, sometimes villages in rural areas or city blocks in urban areas. One location is taken at the center of the settlement area of the cluster. Collecting only one point for the cluster greatly reduces the chance of compromising confidentiality of the respondents, but it is enough to allow the integration of multiple datasets for further analysis.

The DHS cluster point should always be taken at the center of the main village or settlement in the EA. If there is more than one settlement in the EA, one point should be taken for each settlement. If the EA is segmented, one point should also be taken for each segment. In cases where multiple points are taken for one EA, notes should be made on the paper form indicating which waypoint ID goes with which point on the sketch map. Symbols should be added to the sketch map indicating the location where the point was taken.

DHS surveys typically conduct household interviews in 250 to 500 clusters. Each listing team usually visits 10 to 25 clusters, depending on the topography of the area and total number of clusters to be surveyed. It is unlikely that any one team would need to collect more than 500 points. The Garmin Etrex units, for example, have a maximum capacity of 500 stored points. If a team needs to collect more than that, special arrangements must be made. The data can be downloaded to a laptop in the field (as long as each team has access to a laptop and PC cable), or it can be returned to the central office for download. The unit's memory can be cleared and sent back out for more data collection.

Perhaps the greatest limitation for DHS data is the sampling scheme. DHS samples are drawn from population-based clusters. While they are an accurate representation of the population, the observations are clustered and thus not randomly spread across geographic areas. Additionally, the number of observations needed to create a nationally and provincially representative sample is simply too small to represent small areas. However, methods of small area estimation and interpolation can overcome some of these limitations. Representations at areas different from original sample stratifications must be done with care.

For health facility surveys, one reading is taken for each health facility. If community questionnaires are part of the SPA, one reading is also taken in each community. In facility data collection, the reading should be taken at the front door. If the door is covered and/or satellite coverage is insufficient to take a reading, the data collector should go to the road at the border of the yard or compound of the facility. The location should be relatively open, away from tall buildings and out from under tree canopy, in order to receive adequate satellite signals.

### Establishing Naming Conventions

Each location, whether a DHS cluster or SPA health facility, must be saved in the receiver’s memory. Each saved position is called a waypoint, and each waypoint has a unique name. When a waypoint is saved, the receiver assigns it a default name. Normally the waypoint ID should be the same as the case ID given following the sample selection. The Garmin units, for example, store a maximum of 6 characters for the waypoint ID. If the case ID is longer than 6 characters, an alternative naming convention must be established.

When the point is saved in the GPS unit, the default name must be changed to the right-aligned cluster or facility ID number. For example, the waypoint for DHS cluster 101 would be named “000101”. Cluster 1101 would be named “001101”. In some cases, it is necessary to include an alpha character or additional number to differentiate a particular location. In figure 1, data collectors may be collecting one point for each cluster, and other points for health facilities accessible to each particular cluster. Or, multiple points may be collected for one cluster. These scenarios should be determined prior to data collection, so that all teams follow the same format. Naming conventions must be strictly followed!

In the example above, the ID field is the identification assigned when the point is saved by the data collector in the field. Clusters 104 and 129 have multiple points associated with them. The “A” prefix refers to the government health center in that area. A00104 is the government health center for cluster 104, and A00129 is the government health center for cluster 129. The “C” prefix may refer to another type of facility; cluster 104 does not have a “C” type facility, while cluster 129 does. This type of naming convention allows flexibility in sorting and matching the data in later stages of data analysis.

**FIGURE 1: NAMING CONVENTIONS FOR MULTIPLE TYPES OF LOCATIONS**

ID----	Latitude	Longitude
000104	+27.647116	+085.277370
A00104	+27.717165	+085.333155
B00104	+27.710256	+085.291103
000129	+27.647104	+085.277059
A00129	+27.717111	+085.333042
C00129	+27.710240	+085.291169

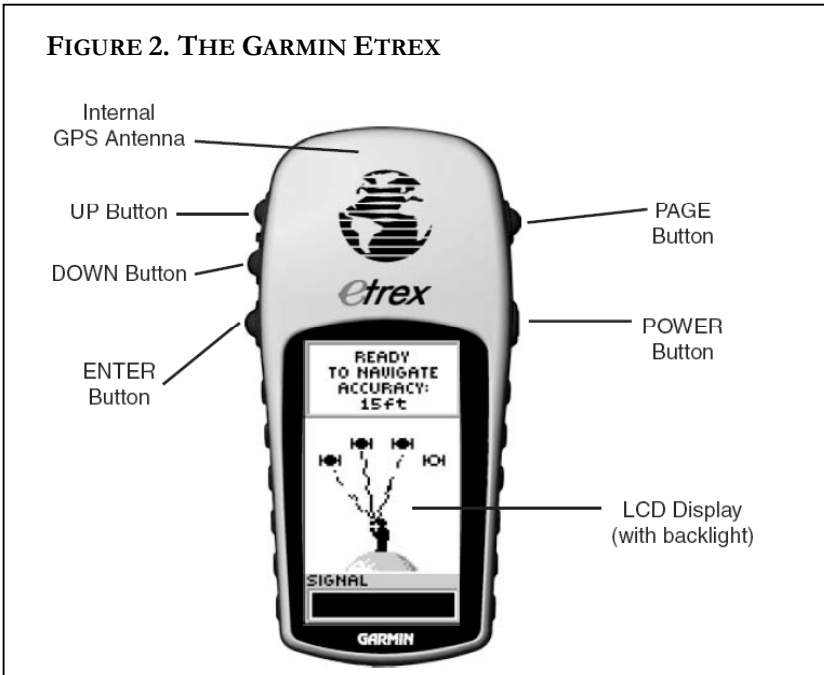
## **Collecting and Storing Data**

The latitude/longitude reading for a location is stored in two places: on the GPS unit and on a paper form. GPS units can be broken or lost, and experience has shown that a hardcopy backup is essential. In addition, the paper form provides a backup should the data in the GPS unit be changed, deleted, or misidentified (i.e., the operator names the cluster incorrectly in the unit). The paper form is also where notes should be made in cases where multiple points are taken for one cluster. The GPS coordinator must be in charge of making sure the data management protocols are strictly followed.



# COLLECTING DHS CLUSTER POINT DATA USING GARMIN ETREX

The following is a step-by-step guide to collecting points using the Garmin Etrex, with is the GPS unit most frequently used in Measure surveys. An abbreviated field guide to the Garmin Etrex and instructions for another GPS unit, the Garmin X12, are included in the appendices.



## Finding a Suitable Location

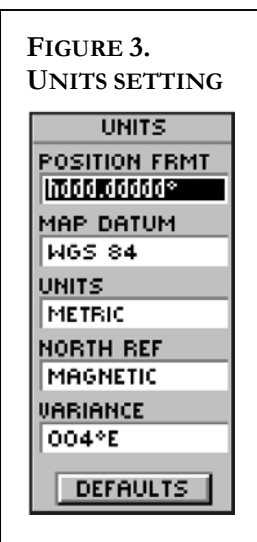
For DHS clusters, the reading should be taken in the geographic center of the settlement or village, as estimated from the sketch map.

In urban areas, a street corner or other open area is best, as far away from tall buildings as possible. Alternatively, a reading can be taken from a rooftop.

In rural areas, the location should be in a clearing, outside of the tree canopy, as far away from buildings or mountains as reasonably possible.

## Readying the GPS Unit

Press the **Power** button on the right side of the unit. This action will turn on the GPS receiver and display the welcome screen and then, after a short delay, the satellite page. (See figure 1.)

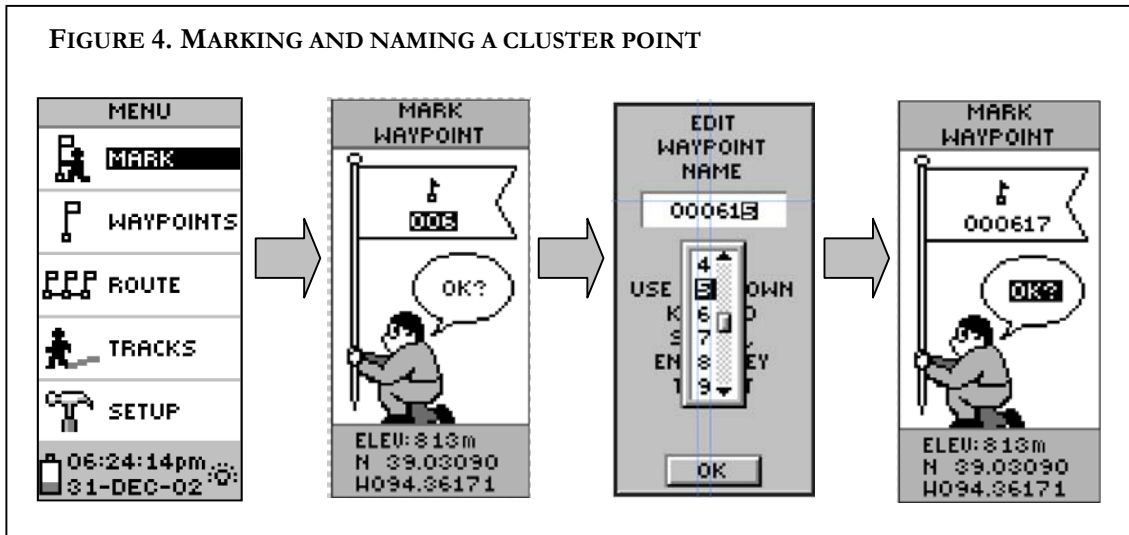


Hold the GPS receiver away from your body or, if possible, place it on a flat, elevated surface.

Standing still, wait until the **“Ready to Navigate”** message is displayed; this may take up to 5 minutes. Note that the estimated accuracy should also be shown; this should be 15 m or less.

The first time each GPS unit is used, the data formats may need to be changed to conform with DHS standards. Press the **Page** button on the right side of the unit until you reach the **Menu** page, and scroll down to **Setup** using the **Up/Down Buttons**. Scroll down to **Units** and change them using the **Up/Down Buttons** to scroll and **Enter** to select. The units should read as follows: Position Format: hddd.ddddd°; Datum: WGS84; Units: Metric; North Reference: Magnetic. (See figure 3.)

FIGURE 4. MARKING AND NAMING A CLUSTER POINT



### Recording the Cluster Location and Naming the Waypoint

Press the **Page** button on the right side of the unit until you reach the **Menu** page. Use the **Up/Down Buttons** to select **Mark** at the top of the screen and then press the **Enter** button. (See figure 4.)

Use the **Up/Down Buttons** to highlight the waypoint ID number in the flag. Press **Enter**. Note that the first digit of the waypoint ID is highlighted and ready to be edited. Use the **Up/Down Buttons** to select the number you want, then press **Enter**. Repeat this process until you have renamed the waypoint to the cluster number. (Note that this new waypoint name must have six digits so cluster 122 should be named 000122.)

### Saving and Recording the Waypoint

Record the coordinates shown at the bottom of the GPS unit screen onto the paper **GPS Cluster Position Form**. (See figure 5.)

Record the coordinates into the GPS unit by using the **Up/Down Buttons** to highlight the word **OK**, then pressing **Enter**. Your waypoint is now saved.

FIGURE 5. GPS CLUSTER INFORMATION FORM

POSITION INFORMATION	
Waypoint ID (as entered in GPS unit)	0 0 0 2 0 1
Altitude	8 4 1 Meters
Latitude	(circle one) Degrees      Decimal degrees N S 3 9 . 3 0 5 1 3 0
Longitude	(circle one) Degrees      Decimal degrees E W 0 7 6 . 9 3 4 9 0

To check the waypoint location after it has been saved, press the **Page** button until you reach the **Menu** page. Use the **Up/Down Buttons** to highlight the **Waypoints** option and press **Enter**. Use the **Up/Down Buttons** to select the waypoint for the cluster you are in and press **Enter** to select. To turn off the unit, press the **Power** button for several seconds.



## DOWNLOADING AND PROCESSING GPS DATA

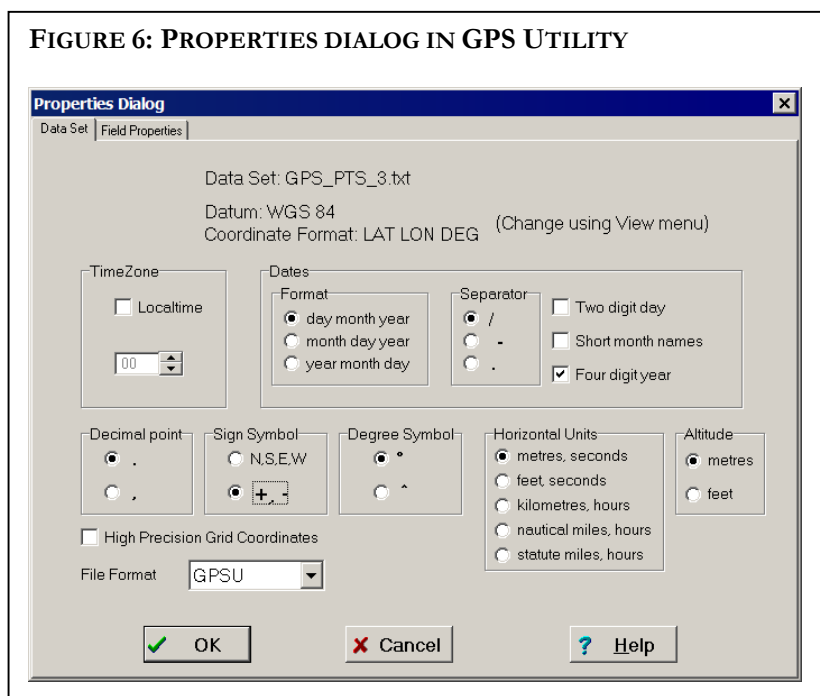
As noted before, it is best to download and check all GPS data as soon after it is collected. If any data is missing, the interviewing teams can recollect the data when they return to the clusters. See the following section for unit-specific downloading instructions.

GPS Utility is the software program used to download the data from the GPS machines. GPS Utility is software that is available for download from the Internet; the latest version of the software and additional information is available from: <http://www.gpsu.co.uk>. While a limited version of the software is available for free download, a license code is required for full functionality. Licenses are already available for most DHS surveys, but Country Managers should ensure that the license is ordered along with GPS units if it is not already available.

### Installing and Registering GPS Utility

Copy the self-extracting executable (.exe) file from the CD provided to an easy-to-remember place on your computer's hard drive, such as the desktop, or download an executable file from <http://www.gpsu.co.uk>. Double-click this file to begin installation and follow the instructions given. When the installation is complete, open the program by clicking on the **Start** menu and **GPS Utility**. In this folder you will find a link to the program along with a GPS Utility manual that covers technical issues related to the software.

To register your copy of GPS Utility, open up the program and select **Options**, then **General**. Click on the text "GPS Utility – Unregistered" at the top of the dialog box; two text entry fields will appear for the user name and registration code. Carefully enter the user name and code exactly as given to you; the program is sensitive to case and punctuation. Click **Validate Registration**, and a message will indicate that the codes were successfully entered.

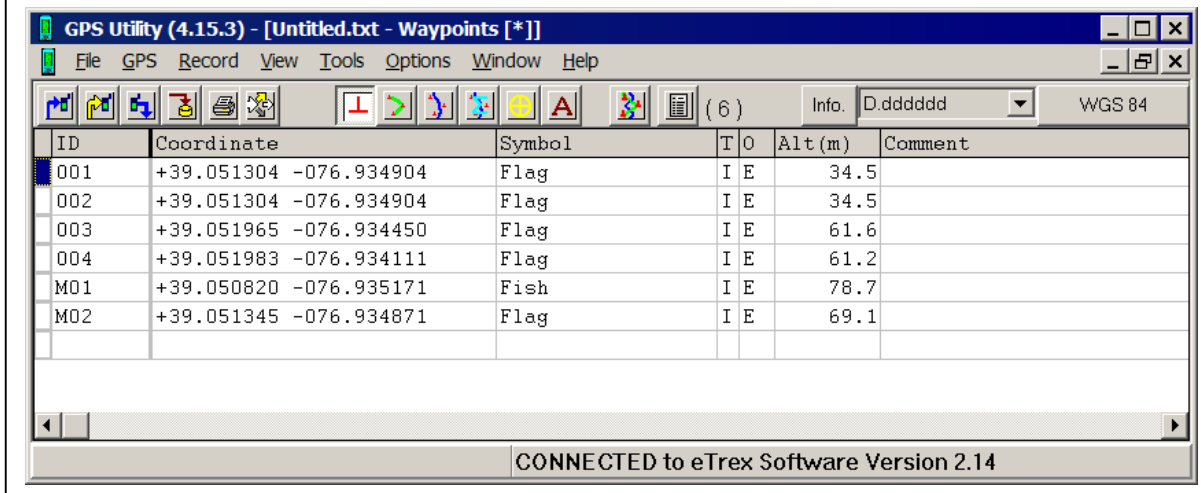


Making a few changes to the program's preferences will make the GPS data easier to compile and use. Go to **Options**, then **Data Set**. In the resulting dialog box, select "day month year" under **Dates**, and "+, -" under **Sign symbol**. (See figure 6.) These changes will be retained each time you open the program.

### Downloading Data from the Garmin Etrex

Plug in the GPS unit to the serial port and turn it on. On the GPS Unit, press the **Page** button until you get to the **Menu** screen. (Note: scroll through menus and options using the **up**, **down**, and **enter** keys on the left side of the

FIGURE 7: DATA IN GPS UTILITY

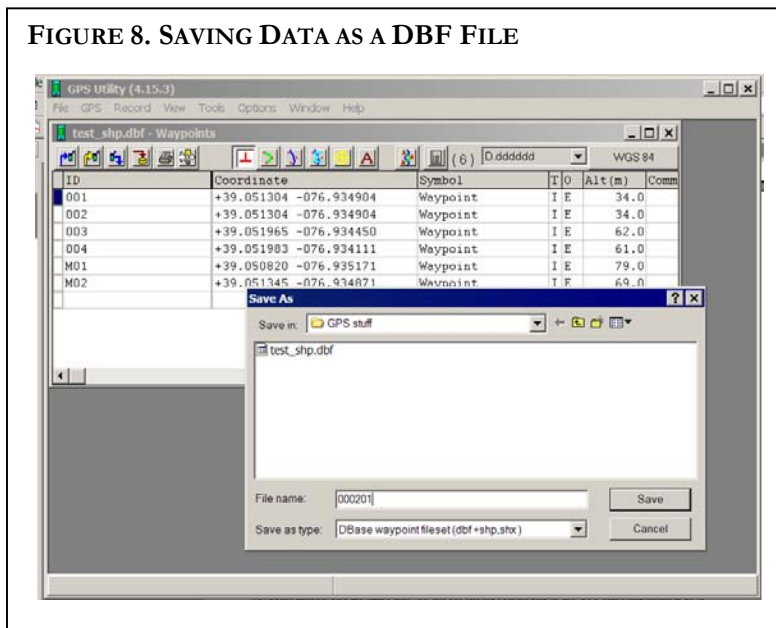


Etrex unit.) Select **Setup**, then **Interface**, and confirm that the interface i/o format is set to **Garmin**.

In GPS Utility, select the **GPS** menu, then select **Download All...** A dialog box will prompt you to choose which types of records you wish to download. Ensure that **Waypoints** is selected. The data will download and appear on the computer screen; this may take up to a minute (see figure 7). At this time, you can disconnect the GPS unit from the computer by selecting the **GPS** menu, then **Disconnect**. The unit can then be turned off and physically unplugged from the computer.

Next, ensure that the data is formatted correctly. Under the **View** menu, go to **Datum** and confirm that **WGS84** is selected. Then under **View** again, click on **Coordinate Format** and ensure that **D.ddddddd** is selected. To save the data to be used in a GIS, go to **File** and choose **Save As...** Select **DBase waypoint fileset**. The file name that you choose should correspond to the GPS unit serial number or to the number of the team that collected the data. (See figure 8.)

FIGURE 8. SAVING DATA AS A DBF FILE



This process will save a DBF table of coordinates and attribute information that can be edited using a spreadsheet program like Microsoft Excel, as well as geographic data in a shapefile that can be viewed and edited with ArcGIS software.

Next, save a backup copy of the GPS points in a text file by going to **File**, **Save As...**, and selecting **text**. Give the file the same name as the DBase waypoint file saved previously. After the DBase waypoint file and text backup files have been saved, you can close the waypoint file on your computer, and connect a new GPS unit to download more data.

When you are finished, you can exit out of GPS Utility.

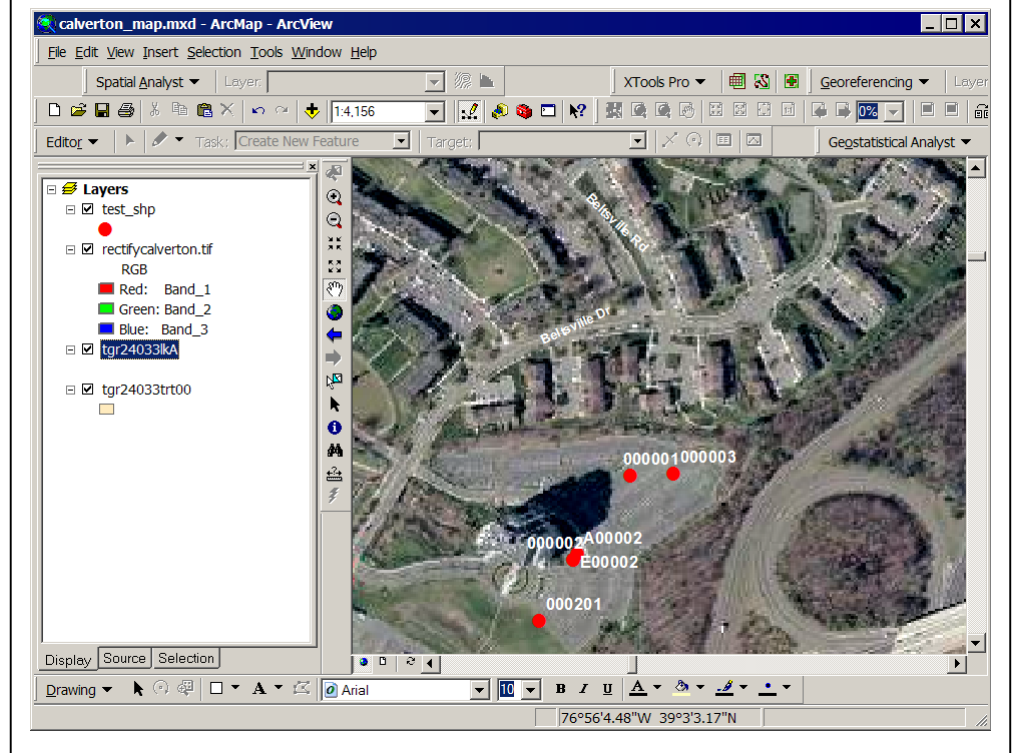
### Using the Data in ArcGIS Software

The waypoint shapefile created in GPS Utility can be viewed and manipulated in ArcMap, ArcView, and other ESRI GIS software.

To view the data in ArcMap, start the program, choose **File**, the **Add Data....** Navigate to the shapefile created by GPS utility and click **OK**. In ArcMap, you can enter additional attribute data, such as place names and types, and view the data in conjunction with other

GIS data on roads, political boundaries, and environment. For example, figure 8 shows GPS point data together with streets data and an aerial photograph. (See figure 9.)

FIGURE 9. THE DATA IN ARCMAP



## **LIST OF APPENDICES AND SUPPLEMENTAL DOCUMENTS**

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### **Planning checklists [in this document]**

- Appendix A-1: Project Manager Checklist
- Appendix A-2: GPS Coordinator Checklist

### **Materials for dissemination [separate document]**

- Appendix B-1: Sample GPS Cluster Position Form
- Appendix B-2: Field Guide to Collecting GPS Data with Garmin Etrex
- Appendix B-3: Collecting data with Garmin X12

### **Training materials [PDF copies]**

- Appendix C-1: Etrex overview (powerpoint slides)
- Appendix C-2: Collecting GPS data for DHS surveys powerpoint slides

### **Additional documents available on CD**

- Garmin Etrex owner's manual (PDF)
- GPS Utility user's manual and readme (Microsoft Word document; text document) – necessary?

## **APPENDIX A-1: CHECKLIST FOR PROJECT MANAGER**

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### **Six months prior to any fieldwork...**

- ✓ Schedule data collection, preferably during listing process

### **As soon as contract is signed...**

- ✓ Identify number of teams to calculate hardware needs
- ✓ Order equipment:
  - ✓ One GPS unit per team plus 2 backups
  - ✓ 8 batteries per GPS unit
  - ✓ At least two cables per survey
  - ✓ One copy of GPS Utility Software per survey

### **Three months prior to fieldwork...**

- ✓ Identify and train GPS coordinator
- ✓ Coordinate general GPS training



## **APPENDIX A-2: CHECKLIST FOR GPS COORDINATOR**

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### **At beginning of GPS data collection...**

- ✓ Clear out any existing waypoints in all units, and set units to correct data display formats (Datum: WGS84; Position format: hdd.ddddd; Units: metric)
- ✓ Log all units and other supplies out by recording serial and team number [standard form?]

### **During data collection...**

- ✓ Spot check field teams throughout data collection to make sure data is saved in GPS units and on paper forms.
- ✓ Verify data in GPS units against paper form data.
- ✓ Monitor waypoint naming convention

### **After data collection...**

- ✓ Log in units and return supplies to central office
- ✓ Ensure that a waypoint was collected for each cluster or facility.
- ✓ Download data from all units and enter data collected on paper forms
- ✓ Verify that GPS unit data and data collected on paper match
- ✓ Ensure that any missing data is recollected.
- ✓ Send copies of both datasets back to the managing institution.