MEASURE Evaluation Global Positioning System Toolkit

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Introduction

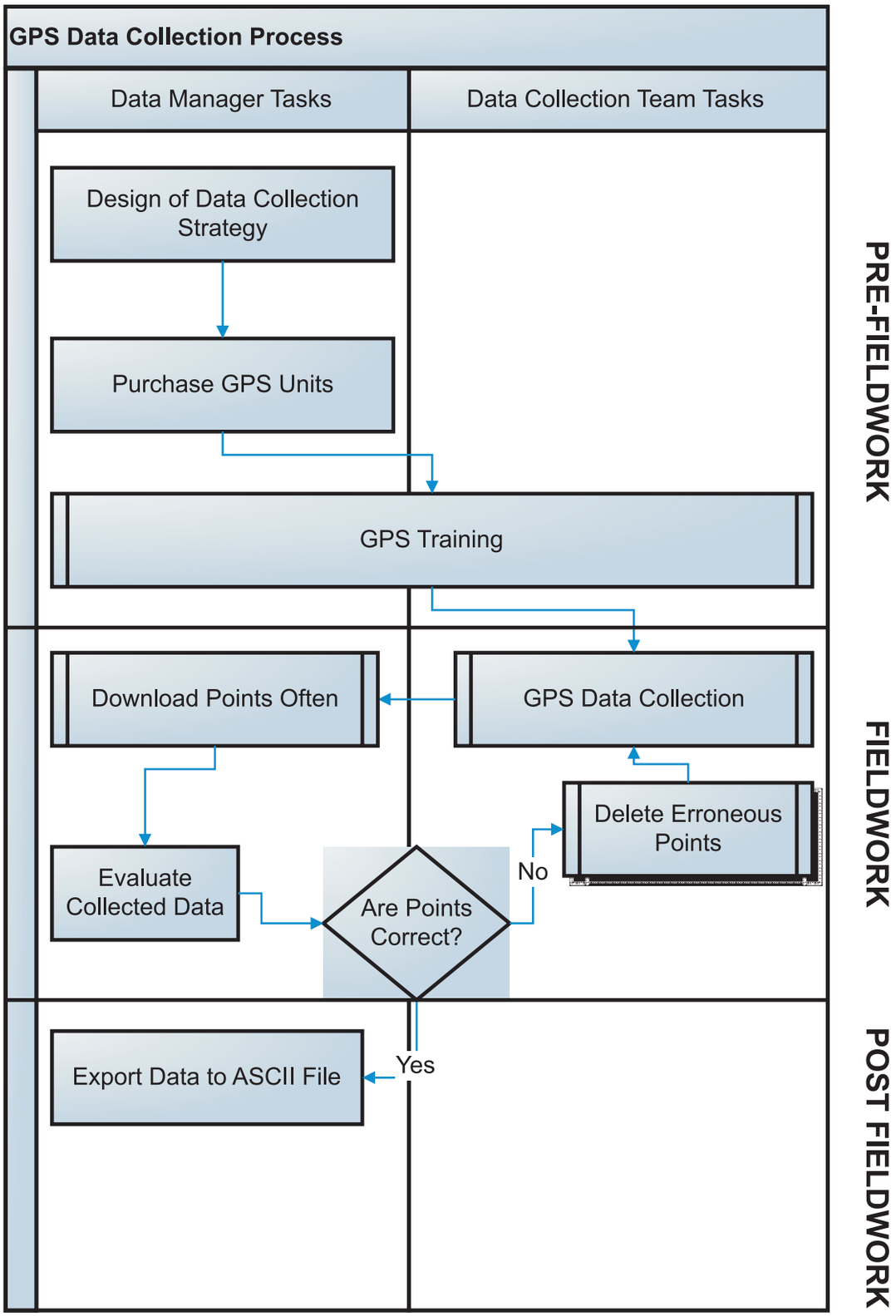
One of the fundamental principles of monitoring and evaluation is ensuring that services and interventions are effective and adequately address health needs. Knowing the location of the service or intervention, as well as the population in need, can provide meaningful context and strengthen the analysis. A vital tool for obtaining location are global positioning system (GPS) receivers.

This document provides an overview of the use of GPS receivers for MEASURE Evaluation Projects. It is intended to provide standardized data collection protocols as well as training materials and troubleshooting guides. This toolkit is designed to be taken into the field, along with the GPS units, and serve as a reference for data collection personnel.

Project Workflow

One of the strengths of GPS data collection is its simplicity. However, this simplicity can be deceiving, effective use of GPS requires a bit of planning prior to entering the field as well as some additional effort once field work is complete. Adding the collection of GPS coordinates to a project can be accomplished with only a minimal additional investment in equipment, training and extra time while in the field. The workflow in Diagram 1 shows the steps that should be undertaken when collecting data with a GPS.

Diagram 1. Data Collection Workflow



Personnel

There should be at least one person responsible for management of the GPS data. Ideally, this person holds a senior position and is responsible for ensuring that the data is collected correctly, as well as overseeing the processing of data that has been collected. This person can be thought of as the GPS data manager.

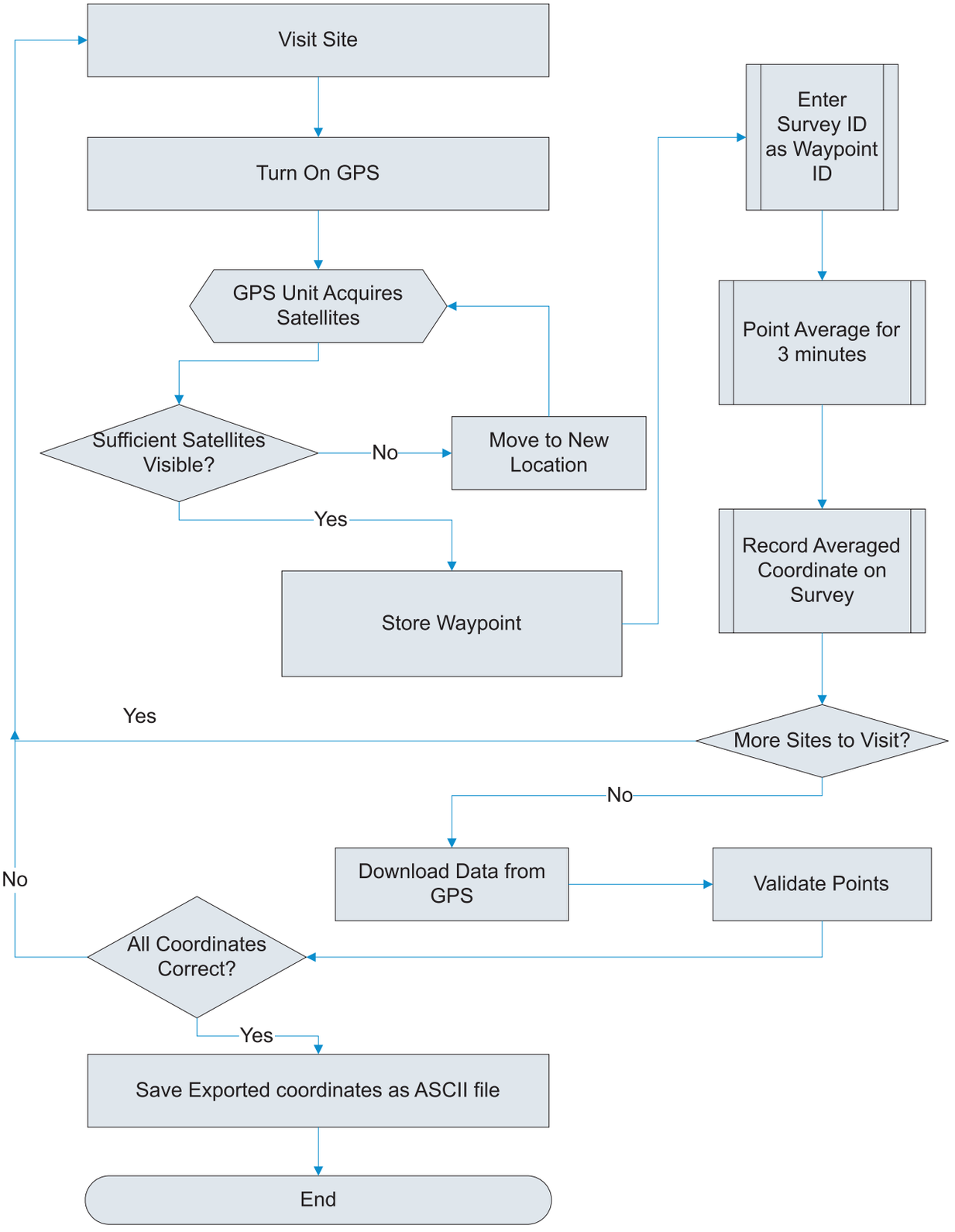
In addition to the GPS data manager, there are the data collection personnel. For small projects, the same person can perform the duties of both the data manager and data collection unit. Regardless of whether there is a dedicated GPS data manager or not, the more important issue is that ultimately someone is responsible for checking the GPS and ensuring its quality.

Pre-Fieldwork

Prior to any data collection certain key decisions have to be made. First, and of foremost importance, is the design of a data collection strategy. Simply put, this strategy is a plan for the data collection which answers the following questions (among others): Who will collect the data? At what stage of the survey will data collection commence? How will the data be validated?

Also, prior to fieldwork, the individuals responsible for collecting the GPS coordinates should be trained in the proper protocols. This training should include material on "How GPS Works," "Introduction to the GPS Unit," and "Collection Protocols." Lastly, the training should include opportunities for the data collection team to practice the protocols.

Diagram 2. GPS Collection Flowchart



Fieldwork

During fieldwork, the data collection team will use the GPS units to collect coordinates. If feasible, the data manager should be monitoring all aspects of the data collection effort to make sure that points are being collected correctly and that points do not show up outside of the expected project area. If there are data collection problems, catching them at this stage will make it much easier to correct problems. Diagram 2 illustrates the flowchart of the steps taken in the field during GPS data collection.

Post Fieldwork

After fieldwork is complete, the data manager should review the points collected and validate them, making certain they are within the acceptable ranges. If the data manager has access to mapping software, an initial map can be created to validate the locations. If problems are detected, the incorrect coordinates will need to be corrected. If there are no problems, the data manager should then create an ASCII text file for the complete set of coordinates.

GPS Unit

The GPS unit featured in this toolkit is a Garmin GPS 72. This particular model was selected because of its low cost, reliability and ease of use. The unit is a recreational grade receiver that is water-resistant, rugged and suitable for a variety of environments. The unit is powered by two "AA" batteries and has a download port on the back which allows users to download the stored data directly to a computer.

The front of the Garmin GPS72

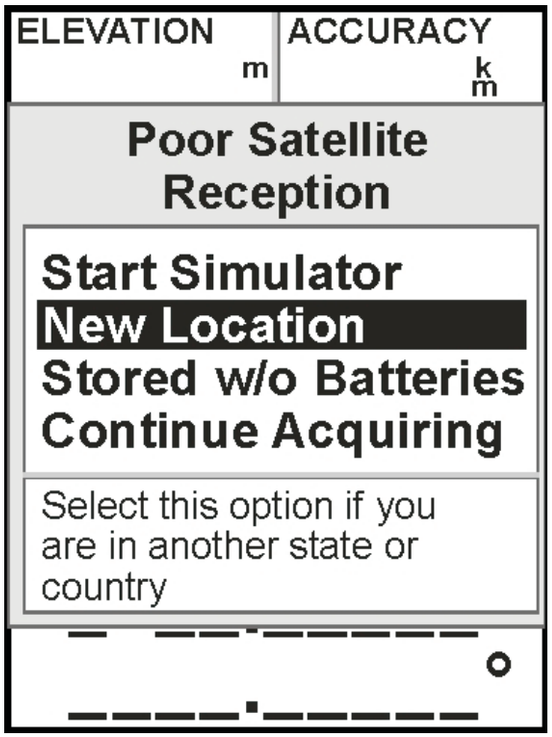
The back of the Garmin GPS72

GPS Preparation

Before the GPS units are distributed to the team member(s), it is important that they be properly set up. The following three steps should be completed prior to taking the receiver into the field.

1) Initialization

If the receiver has not been turned on in the location before, or if it has been powered off for an extended period of time, the GPS receiver may need to be Initialized. If the receiver displays the error message **POOR SATELLITE RECEPTION**, select **NEW LOCATION** and then select **AUTOMATIC** from the subsequent dialog box.



2) System Setup

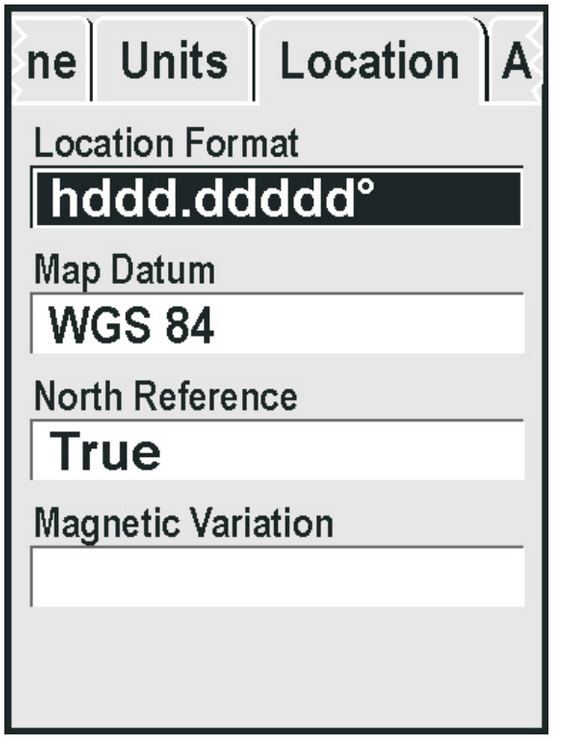
It is important that the receiver be configured properly before being taken into the field. There are a variety of settings that may need to be modified. For instance, it is important that the GPS unit displays the correct coordinate system and uses the proper datum.

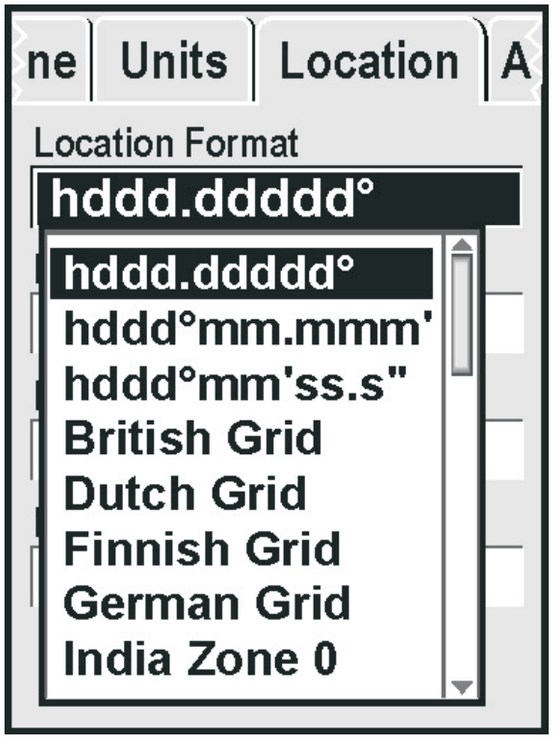
MAIN MENU

Press the **MENU** button twice from any screen to access the **MAIN MENU**. From the **MAIN MENU** highlight **SETUP** and press the **ENTER** button.

Scroll, using the Direction Keypad, until the **LOCATION** tab is highlighted.

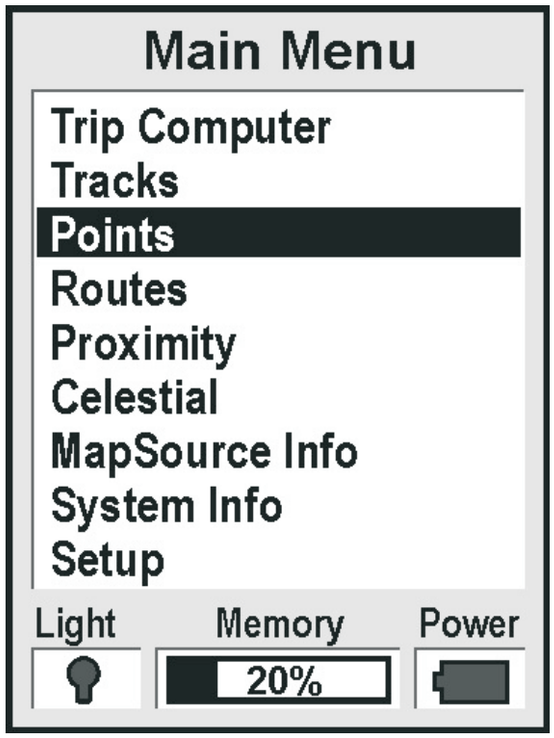
From this screen make sure the **LOCATION FORMAT** field is set for **hddd.ddddd°** and the **MAP DATUM** is set for **WGS 84**. If the values are different use the Direction Keypad to highlight the field, press the **ENTER** button and select **hddd.ddddd°** from the drop down list and/or **WGS 84**.





3) Clear Memory of Waypoints

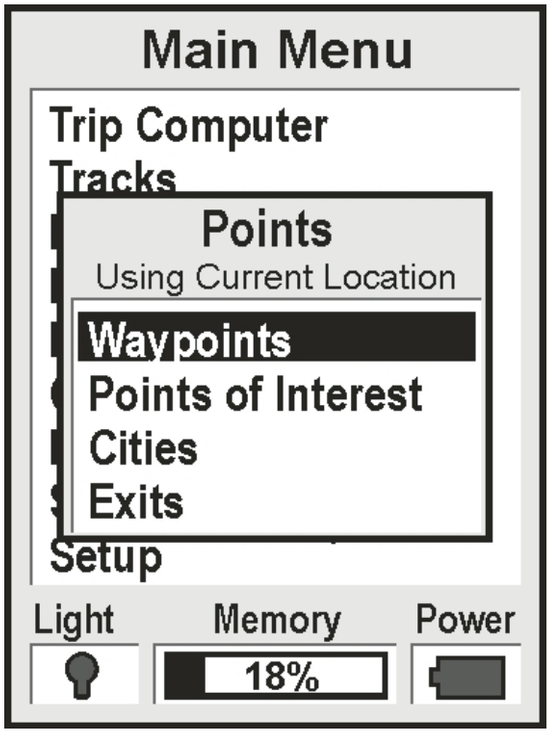
Before beginning data collection in the field, any waypoints stored in the unit's memory should be cleared. **WARNING: Do not clear waypoints once data collection has begun without having first downloaded the waypoint file to a computer. Otherwise, all data that you have collected since your last download will be lost!**



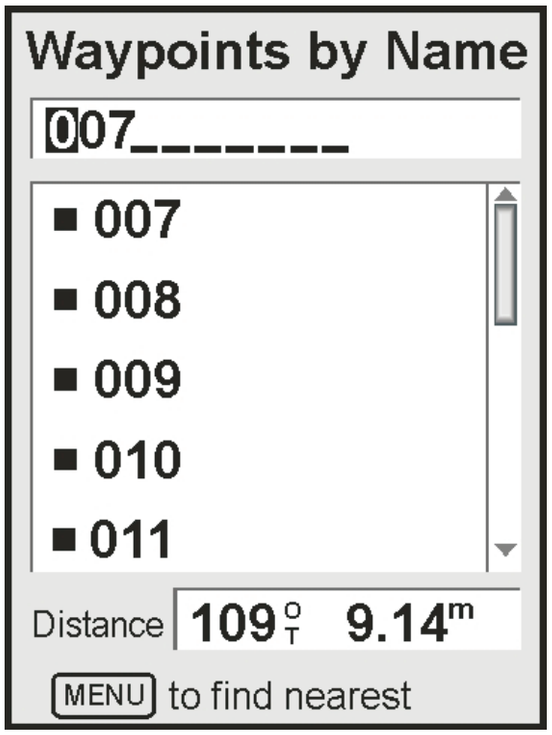
Press the **MENU** button twice from any screen to access the **Main Menu.**

From the list of options, highlight **POINTS** and press the **ENTER** button.

From the **POINTS** submenu, select **WAYPOINTS** and press the **ENTER** button.

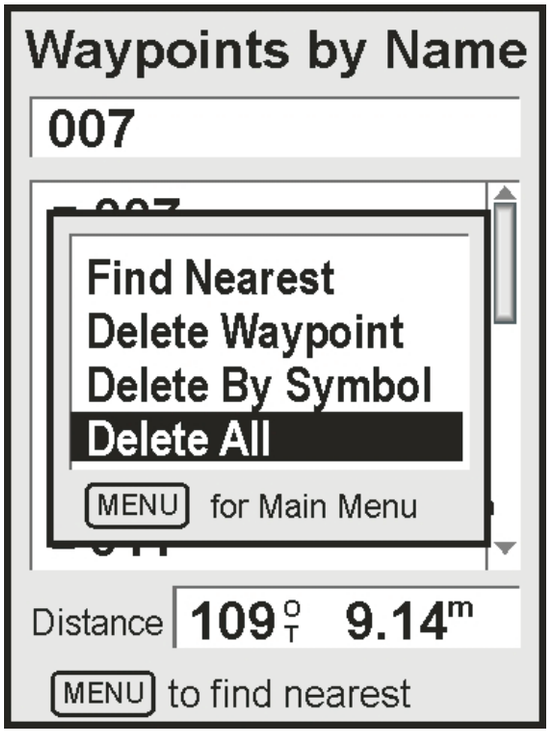


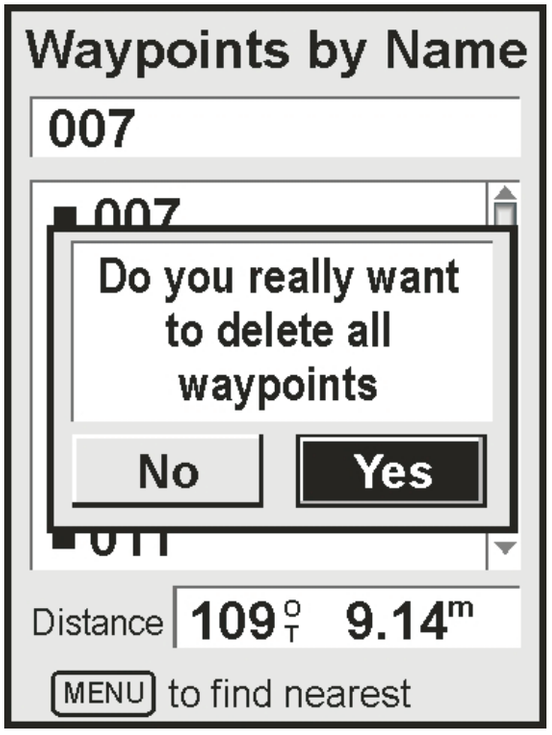
From the **WAYPOINTS BY NAME** screen, press the **MENU** button to bring up the options menu.



Select **DELETE ALL** from the options presented, and press the **ENTER** button.

Verify your choice by answering **YES** to the question **DO YOU REALLY WANT TO DELETE ALL WAYPOINTS?"**





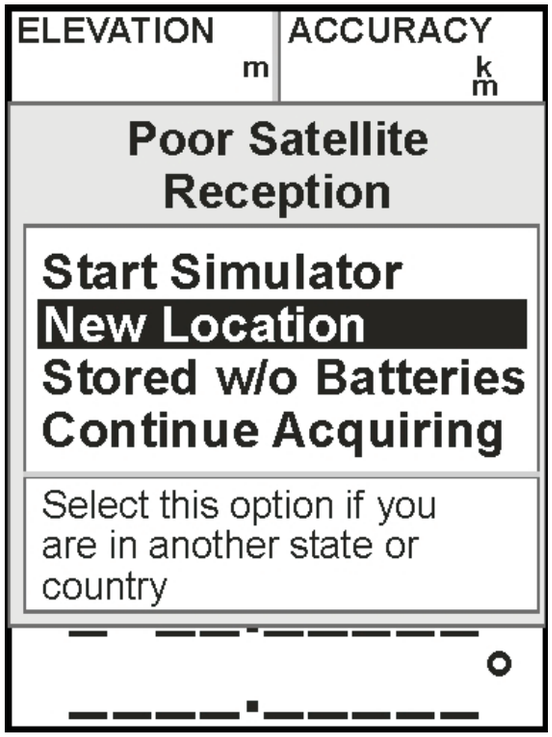
Data Collection Using Garmin GPS 72

Once the instructions in the *GPS Preparation* section have been followed, the user is ready to capture points using the GPS receiver. This section provides instructions for collection data.

1) Initialization (OPTIONAL)

Sometimes when the receiver is turned on after being powered off for a long period of time, or is activated in a location that is far away from where it was last activated, it may be necessary to reinitialize the receiver. This process was covered in the *GPS Preparation* section, but is also presented below for convenience.

If the receiver displays the error message **POOR SATELLITE RECEPTION**, select **NEW LOCATION** and then select **AUTOMATIC** from the subsequent dialog box.



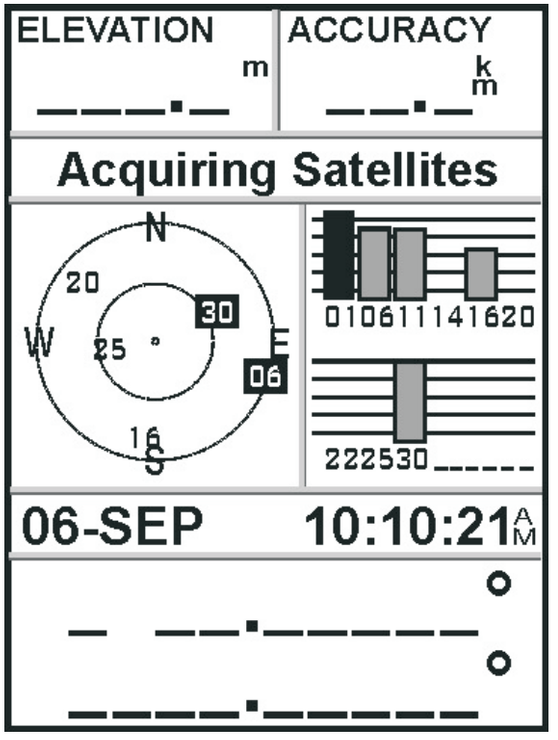
2) Data Collection Steps

The Garmin GPS72 utilizes a 360° antenna, which means that the best reception can be obtained by holding the GPS unit perpendicular to the ground.

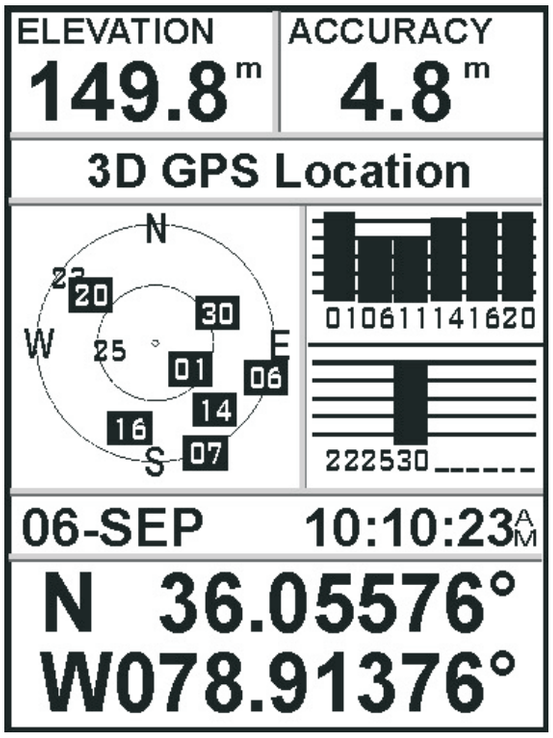
The proper way to hold the Garmin GPS72

The improper way to hold the Garmin GPS72

When first turned on, the receiver will display the **SATELLITE POSITION** page. This screen can be used to determine the number of satellites the Garmin 72 is receiving signals from, as well as where in the sky the satellites are. The sky map section of the **SATELLITE POSITION** page is in the left section of the screen and has a dot in the center of the sky map which represents the area of the sky directly overhead of the receiver. The middle ring represents 45 degrees above the horizon

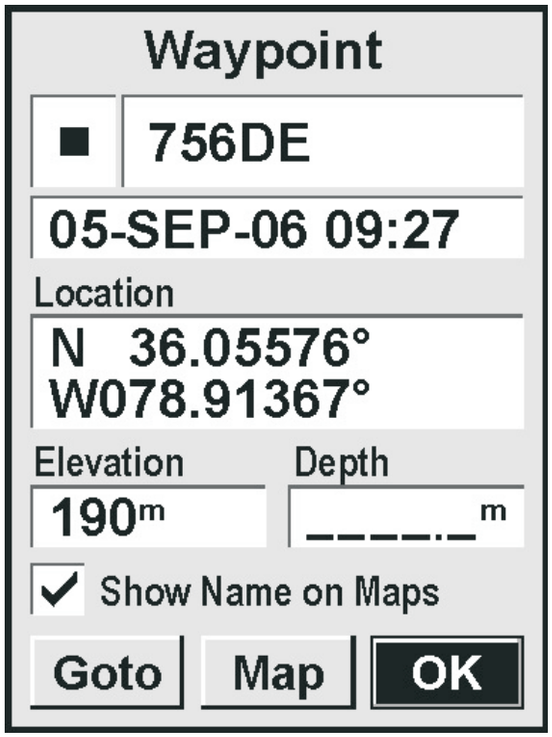


and the outer ring corresponds to the horizon. The sky map also provides a directional indicator for North, South, East and West. The user can read the sky map to determine if sections of the sky might be blocking reception of satellite signals.



Once enough satellites have been locked onto and an accurate coordinate can be calculated, the screen will display **3D GPS LOCATION.**

Note: Make sure the screen displays either **3D GPS LOCATION** or **2D GPS LOCATION** before collecting points. **3D GPS LOCATION** will provide a more accurate coordinate, so it is worth waiting to allow the unit to switch to **3D GPS LOCATION**. If after five minutes the screen does not indicate **3D GPS LOCATION**, follow the steps in the *Troubleshooting* section of this guide.



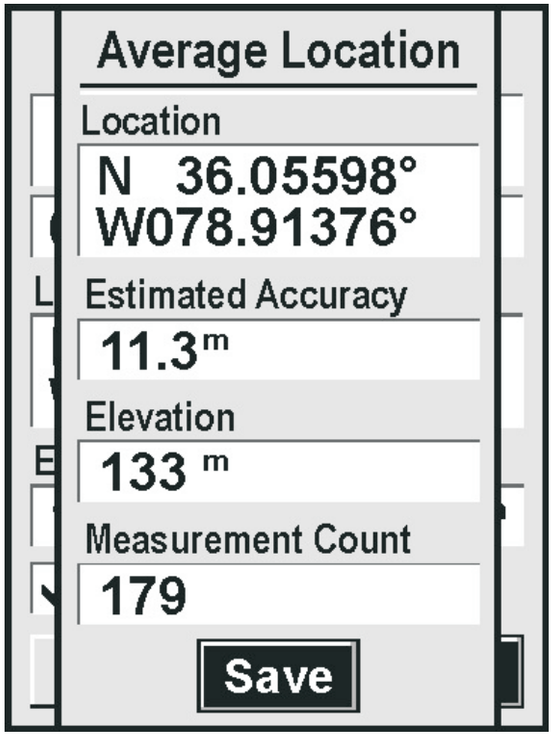
From the **SATELLITE POSITION** page, press and hold the **ENTER** button until the **WAYPOINT** screen appears.

Use the direction keypad to highlight the waypoint ID number and press the **ENTER** button. Enter the appropriate ID number and press the **ENTER** button again to save the number.

While still in the **WAYPOINT SCREEN,** press the **MENU** button and highlight the **AVERAGE LOCATION** entry on the submenu that appears and press the **ENTER** button.

This begins the point averaging process. During this process, the receiver is automatically recording a coordinate, once every second, and then averaging coordinates to derive a more accurate location.

It is important that the GPS operator not move from their position, or block the antenna of the receiver while point averaging is occurring.



On the **AVERAGE LOCATION SCREEN**, the **MEASUREMENT COUNT** field tracks the number of points being collected. Continue collecting points until the **MEASUREMENT COUNT** is 180.

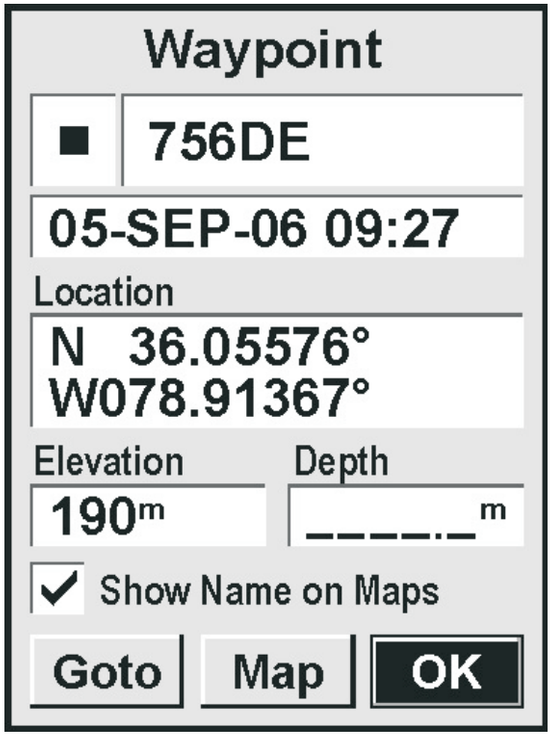
When 180 points have been collected, make sure the word **SAVE** is highlighted and press the **ENTER** button. At this point, the screen will revert back to the **WAYPOINT SCREEN**. The coordinate that displays in the **LOCATION** field represents the averaged location. This is this coordinate that should be recorded.

For instance, the coordinate to the right would be recorded as:

N for the latitude direction and **36.05576** for the latitude coordinate; and

W for the longitude direction and **78.91367** for the longitude coordinate.

Once the coordinates have been recorded, the unit can be turned off.



To review, below are the 10 steps to follow for successful data collection using the Garmin GPS72.

1. Turn on the receiver.
2. Initialize the receiver, if needed.
3. Acquire satellites until a **3D GPS LOCATION** is obtained.
4. Press the **ENTER** button until the **WAYPOINT** screen appears.
5. Enter the appropriate ID value in the **WAYPOINT ID** field.
6. Press the **MENU** button and highlight **AVERAGE LOCATION.**
7. Collect data until the **MEASUREMENT COUNT** is 180.
8. **SAVE** the averaged coordinate.
9. Record the coordinate displayed on the GPS log or the survey form.
10. Turn off the GPS receiver.

GPS Troubleshooting

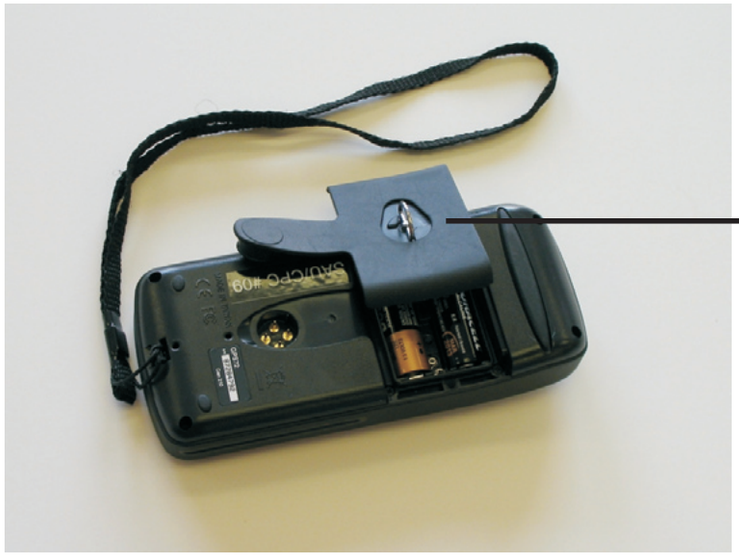
It is difficult to anticipate every potential problem that might arise with GPS receivers; however there are certain situations that can be easily resolved. This section presents some of the most basic troubleshooting that may be necessary. For more information about the receiver and its operation refer to the operating manual for the GPS 72.

1) Replace Batteries

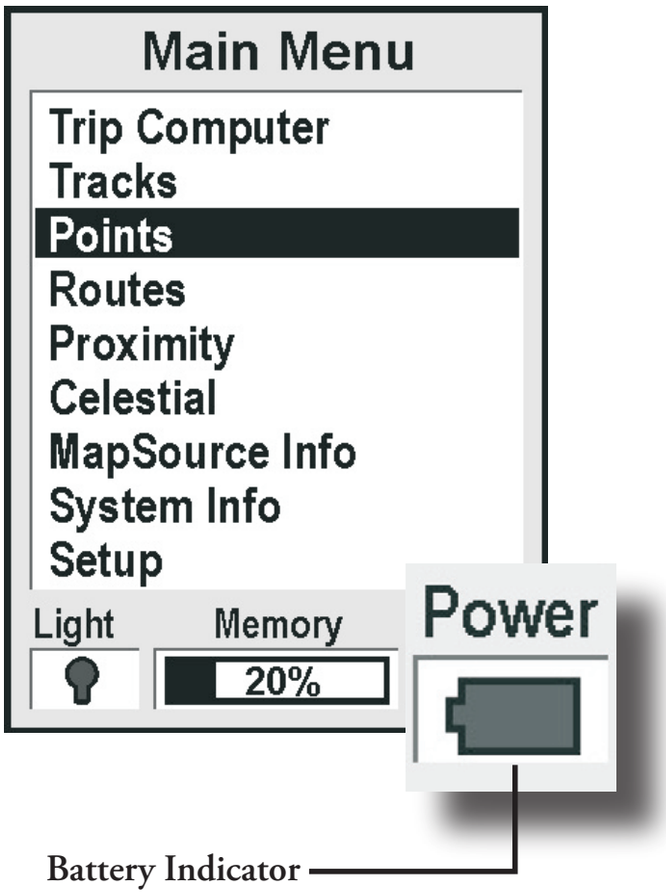
The Garmin GPS72 operates on two "AA" batteries. These should be replaced when the battery indicator on the **MAIN MENU** screen indicates a low battery.

The batteries can be replaced by turning the metal ring on the back of the unit, one-quarter turn, and pulling the rubberized battery cover off.

Once the new batteries have been inserted, replace the cover.



Rubberized Battery Cover



Battery Indicator

2) Poor Satellite Reception

If the receiver is having difficulty acquiring signals from enough GPS satellites it will display the **POOR SATELLITE RECEPTION** error message. There are multiple possible reasons why the receiver could be having difficulty with the signal. One possible reason could be the receiver's view of the horizon is blocked by buildings, trees or other obstacles. If this is a problem, then it will be necessary to move slightly to try and avoid the obstacle. The survey team can use the sky map on the **SATELLITE POSITION** page to help determine areas of the sky where no satellite signals are being received. If there are obstacles such as tree canopies, buildings or other structures blocking that section of the sky, the survey team can move to obtain a clearer view of the sky. The survey team should not move more than 20 meters. After moving, the user can highlight **CONTINUE ACQUIRING** and try to obtain a signal.

Another reason the receiver might have difficulty obtaining satellite signals is because the unit is not being held perpendicular to the ground. The antenna for the Garmin GPS 72 is designed to receive signals using both the front and back of the receiver. If the unit is held parallel to the ground, instead of perpendicular, the receiver can have difficulty locking in on satellites. The solution for this is to make sure to hold the unit perpendicular to the ground.

Proper hold

Improper hold

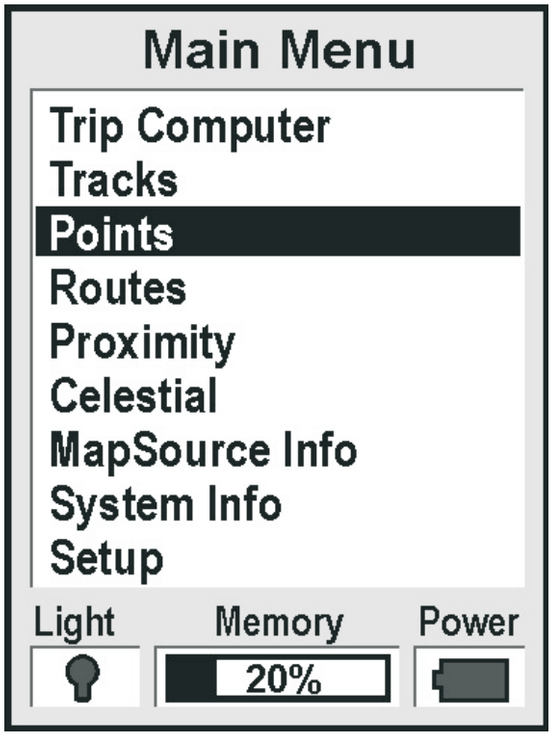
The other reason the receiver might display the **POOR SATELLITE RECEPTION** error message is due to the position of satellites in the sky. On rare occasions the satellites may be arranged in a manner that limits the number of satellites visible overhead. If there are no obvious obstacles in the sky, it is possible that poor satellite geometry is responsible. The survey team can use the sky map on the satellite position page to verify where the satellites are and determine their signal strength. The only solution for this problem is to wait for the satellites to change position or for additional satellites to become visible. In this situation, the survey team may have to wait an hour or possibly revisit the site at a later time. It should be noted that this is quite a rare occurrence. The other troubleshooting steps should be attempted before assuming that the satellite geometry is poor.

3) Clear Waypoints

The Garmin GPS72 will hold 500 waypoints, so it is unlikely that the memory would get full, however it is a good idea to clear the waypoints stored in memory before beginning a new project. WARNING: **Do not clear waypoints once data collection has begun without having first downloaded the waypoint file to a computer. Otherwise, all data collected will be lost!**

Press the **MENU** button twice from any screen to access the **MAIN MENU**.

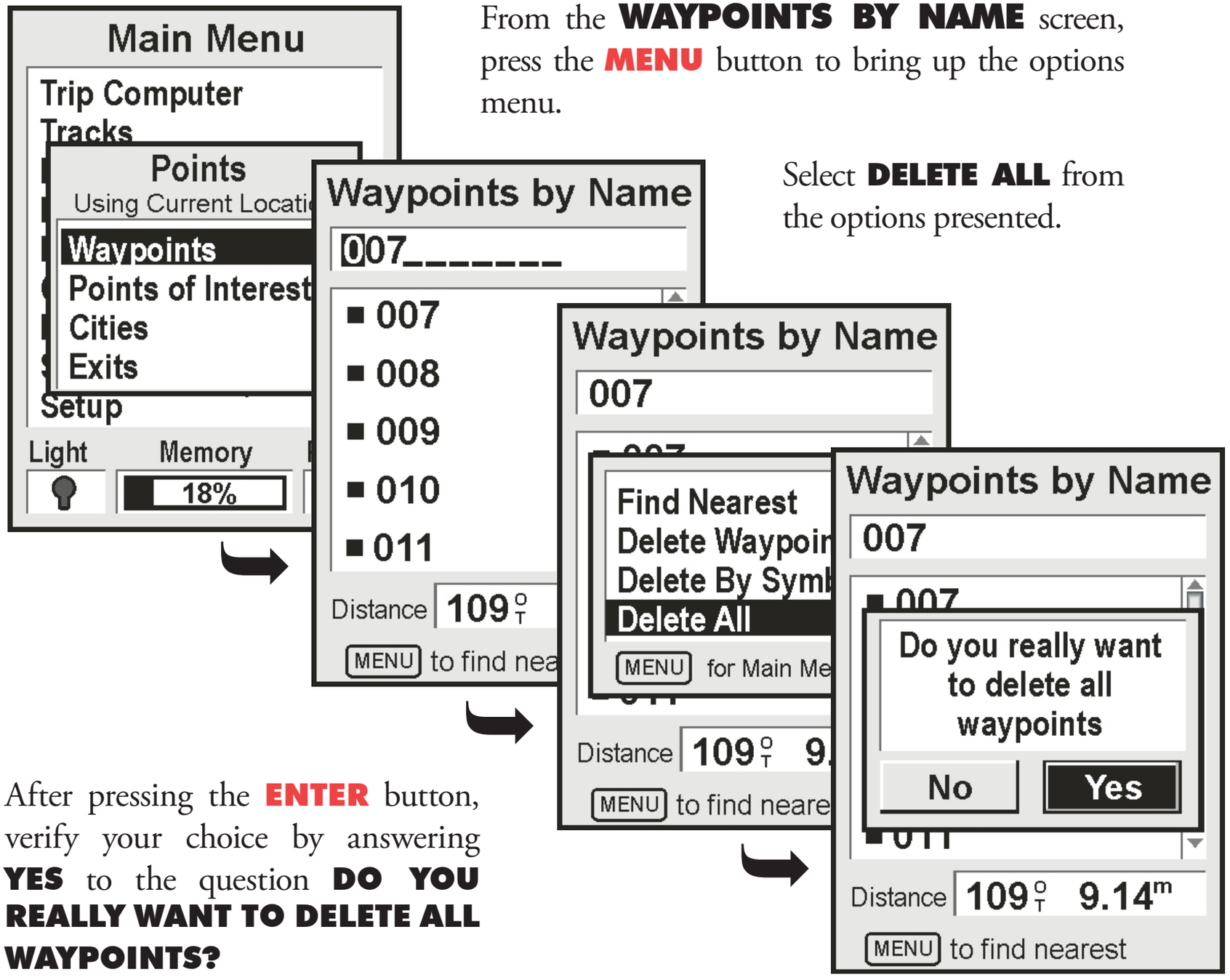
From the list of options, highlight **POINTS** and press the **ENTER** button.



From the **POINTS** submenu, select **WAYPOINTS** and press the **ENTER** button.

From the **WAYPOINTS BY NAME** screen, press the **MENU** button to bring up the options menu.

Select **DELETE ALL** from the options presented.



After pressing the **ENTER** button, verify your choice by answering **YES** to the question **DO YOU REALLY WANT TO DELETE ALL WAYPOINTS?**

Download GPS Coordinates

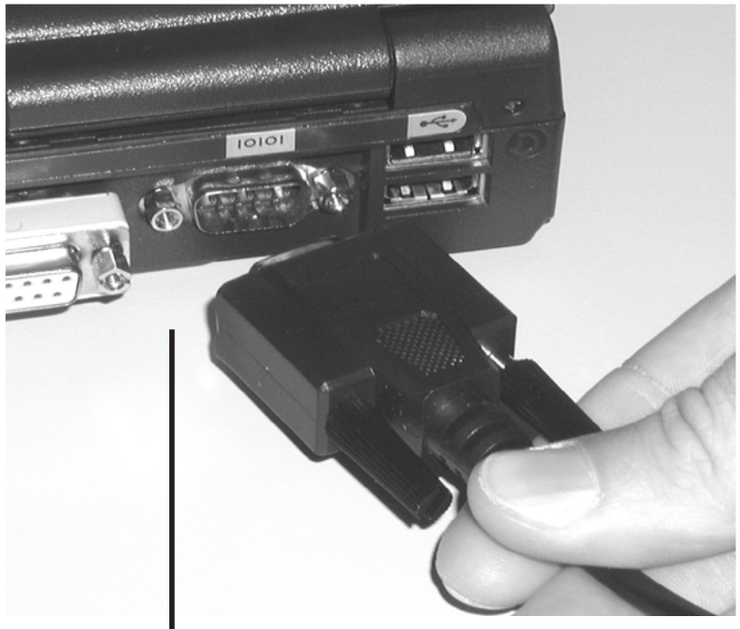
The coordinates stored by the GPS receiver can be downloaded using the program, *GPS Utility*.

1) Connect Download Cable

The first step when downloading data from the GPS receiver is to connect the download cable to the GPS unit. To do this, pull back the rubberized flap on the back of the GPS receiver to reveal the connection port for the download cable and insert the cable.

First, connect the download cable to the GPS unit.

The download cable should connect to the COM port of the computer.



Next, connect the download cable to the COM port on your computer.

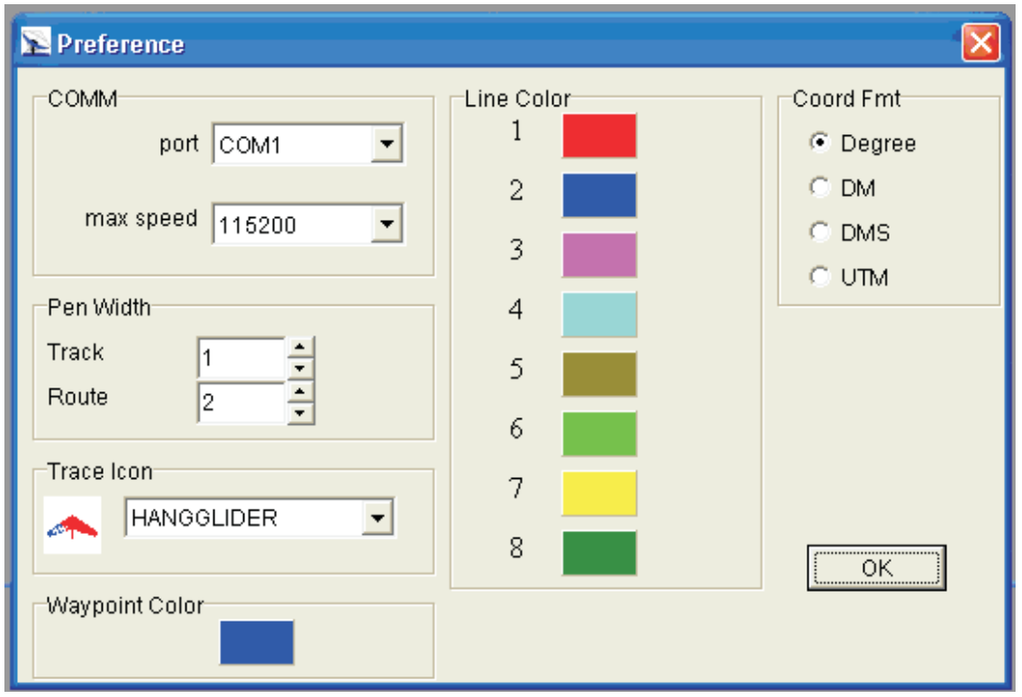
2) Start the Downloading Software

The program *Garmap2* can be used to transfer files from the receiver to the computer.

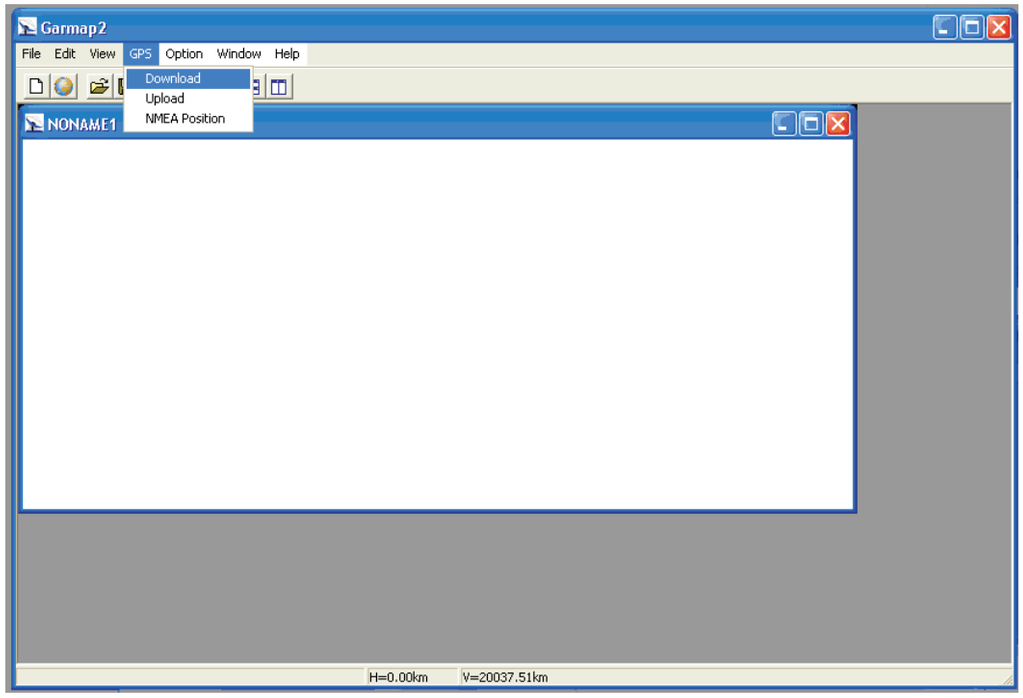
1. Start *Garmap2.*

2. Turn on the GPS unit.

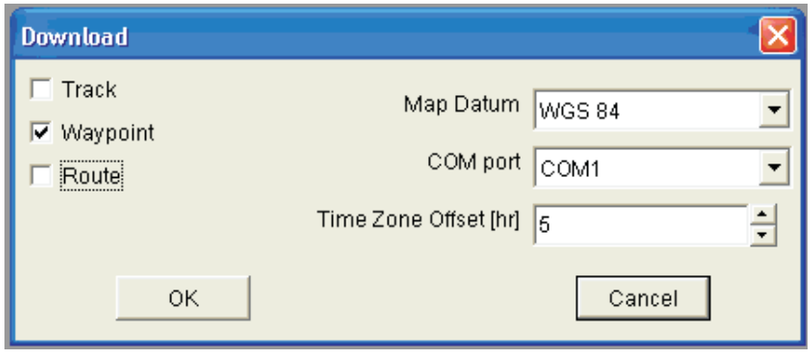
3. Select **PREFERENCE** from the **OPTION MENU** and make sure that the setting for **COORD FMT** is set for **DEGREE**.



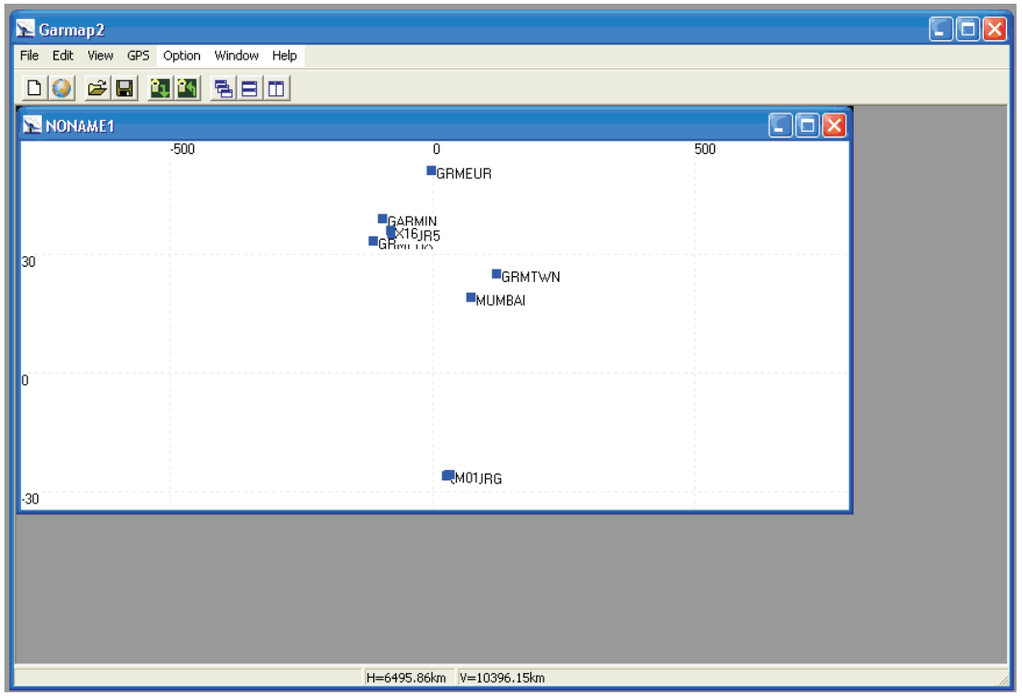
4. Select **DOWNLOAD** from the **GPS MENU**



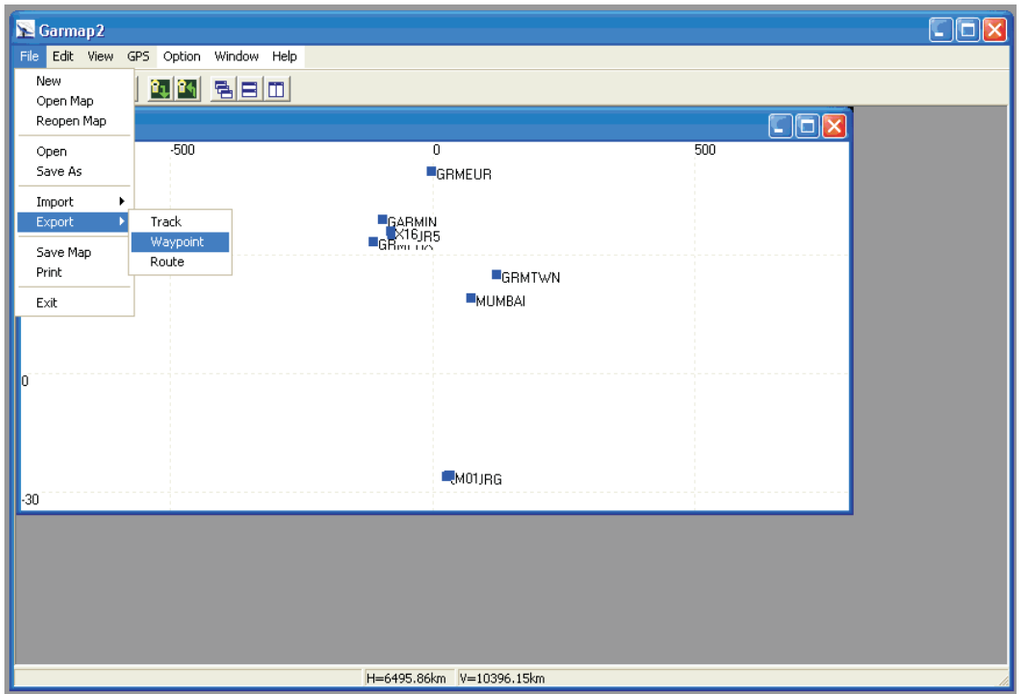
Next, make sure that only **WAYPOINTS** and the **MAP DATUM** value is **WGS84**. You can also declare which COM port the GPS unit is connected to. Once that is done click **OK.** After the data has been downloaded from the receiver using *Garmap2*, it should be saved and backed-up to a CD or floppy disk.



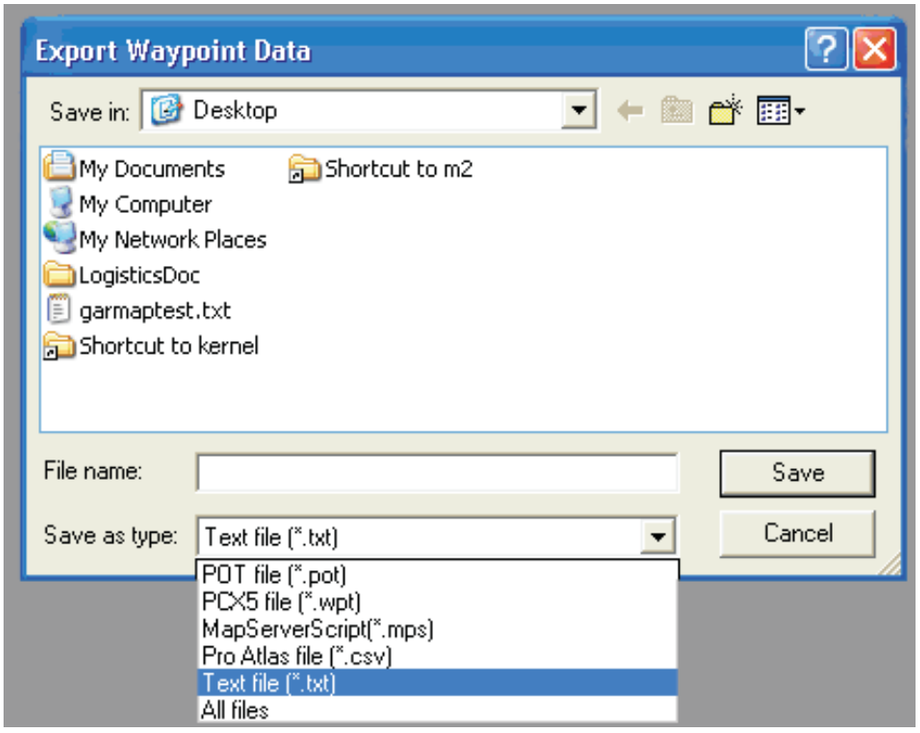
5. The program will download all of the waypoints in the receiver and display them in a map. You can use this map to perform a spot check to ensure that the points are in the correct relationship to each other.



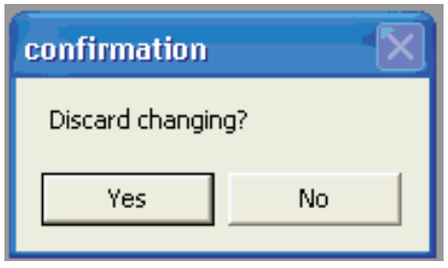
6. Save points to a text file by selecting **EXPORT->WAYPOINTS** from the **FILE MENU**.



Next, make sure that the entry in the **SAVE AS TYPE** box is set for **Text**. Then, enter the file name and click the **SAVE** button on the dialog box.



7. Exit *Garmap2*. Click the **YES** button on the dialog box that asks **DISCARD CHANGING?**



Troubleshooting *Garmap2*

If the program cannot download the waypoints, there are several items to check:

1. Make sure the program is set to use the correct COM port.
2. Check the cable and make sure the connections to the GPS unit and computer are secure.
3. Make sure the GPS unit is turned on.

Processing an Exported File

The text file created by *Garmap2* can be imported into a mapping program such as ArcGIS, HealthMapper, or SIGEPI. Users can refer to the instructions of their mapping program for detailed guidance on how to import an ASCII text file.

Conclusion

If proper planning takes place prior to fieldwork, GPS data collection can be an easy, cost-effective way of adding a locational component to data. The steps required to collect data are relatively simple and the burden on the field team is minimal.

It is important, however, to remember that if proper data collection protocols aren't followed, GPS collected data can turn out to be unusable. Users should follow the workflows in Diagrams 1 and 2 as a guide to help them as they plan and execute a GPS data collection project, and remember the ten steps for GPS data collection:

1. Turn on the receiver.
2. Initialize the receiver, if needed.
3. Acquire satellites until a **3D GPS LOCATION** is obtained.
4. Press the **ENTER** button until the **WAYPOINT** screen appears.
5. Enter the appropriate ID value in the **WAYPOINT ID** field.
6. Press the **MENU** button and highlight **AVERAGE LOCATION.**
7. Collect data until the **MEASUREMENT COUNT** is 180.
8. **SAVE** the averaged coordinate.
9. Record the coordinate displayed on the GPS log or the survey form.
10. Turn off the GPS receiver.

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