# GUIDELINES FOR RECORDING NWT ARCHAEOLOGICAL SITE COORDINATES WITH THE GLOBAL POSITIONING SYSTEM (GPS)

## 1.0 INTRODUCTION

The purpose of these guidelines is to describe recommended procedures for the use of the Global Positioning System (GPS) in reporting archaeological site coordinates in the NWT.

All Canadian maps compiled prior to 1990 use the NAD27 datum, and the majority of paper maps in daily use in the NWT are based on this datum. Since 1990, all federal, provincial, territorial digital mapping products are referenced to two standard coordinate systems: the North American Datum of 1983 (NAD 83) for horizontal positions and ellipsoid heights, and the Canadian GeodeticVertical Datum of 1928 (CGVD 28) for orthometric heights. This has caused problems in the way archaeological site coordinates are recorded and maintained, and because of coordinate shifts between the NAD 27 and NAD 83, which are over 120 metres in the NWT, the potential for impacting an archaeological site in the course of a land use operation is increased.

The GNWT is establishing GPS recording standards for all new archaeological work authorized by permit to ensure coordinate data quality. We will also initiate a program to revisit archaeological sites within the NWT to obtain quality GPS coordinates for site centroids and boundaries. This work will be accomplished incrementally over a period of years by taking advantage of opportunities to revisit archaeological sites during the course of regular operations and through the help of archaeologists receiving permits to work in the NWT. It is hoped that archaeologists will take opportunities to revisit sites to record GPS coordinates during the course of their own projects.

Note that these guidelines apply to handheld GPS units only and do not include Differential Global Positioning System (DGPS) use.

## 2.0 EFFECTIVE DATE

These guidelines became effective April 1, 2003 and are a compliance requirement for all NWT Archaeologists Permits. We are grateful to Pierre Sauvé (Geodetic Survey Division, NRCan) and Dave Taylor (NWT Geomatics) for helpful comments on the 2003 version.

Revised:
February 4, 2004
June 20, 2005.

## 3.0 SURVEYING WITH GPS

All GPS surveying techniques are based upon observations of radio signals from a network of orbiting satellites. These signals are processed to compute station positions by trilateration: the positions of the satellites and computed ranges are used to determine the antenna position. These positions are normally computed in an earth-centered Cartesian coordinate (x,y,z) system, which can be converted to geodetic curvilinear coordinates (latitude, longitude, and ellipsoidal height). With the addition of a geoid height model, orthometric heights can be computed.

The accuracy of a GPS survey is dependent upon many complex, interactive factors, including:

- Observation technique used
- GPS receiver age and quality
- Amount and quality of data acquired
- GPS signal strength and continuity
- Ionospheric and tropospheric conditions
- Site obstructions
- Satellite geometry, described by the Dilution of Precision (DOP)
- Selective Availability', for GPS coordinates recorded before May 1, 2000.

Added to these are topographic errors in paper maps and 'user' error, often found in transferring data from one medium to another. The purpose of these guidelines is to eliminate as many sources of error as possible and create a reporting standard for submitting GPS coordinates with site records.

It is important that users have a basic understanding of how GPS works before collecting field data. All GPS units require the user to adjust certain settings and how these are configured can seriously affect the quality of coordinates.

## 4.0 EQUIPMENT STANDARDS

It is assumed that most archaeologists working in the NWT will be using recreational GPS receivers, such as those manufactured by Garmin or Magellan. Recent tests have demonstrated that recreational GPS receivers are of a high enough quality that they are acceptable for recording archaeological site coordinates in open areas where the zone 15˚ above the horizon is not obstructed. In areas of dense forest cover, or adjacent to high or abrupt topographic features such as cliffs, satellite signals may be blocked or interfered with. Higher quality receivers (such as those produced by Trimble) are usually associated with stronger signal strength and permit a greater range of user settings.

GPS receivers used for archaeological research in the north should have the following minimal specifications:

- A good quality hand-held GPS receiver with the following features:
    - A multi parallel channel (preferably 12 parallel channels) receiver unit.

- The ability to store at least 500 waypoint positions in the receiver's memory.
- The ability to list waypoint positions and their distance and direction from the current position.
- The unit should be able to handle the UTM (Universal Transverse Mercator grid) data, especially if you wish to plot points on NTS topographical maps.
- The ability to upload/download waypoints and routes to a computer (most GPS dealers have their own or will recommend software that will help you do this) according to the NMEA standard.
- The ability to store routes, especially if you are recording your movements, roads, rivers in the field. Most will allow you to store 10-20 routes.
- Consider a position-averaging feature; this helps improve the accuracy of waypoints.

➢ Software and equipment to export your waypoints to a PC.
- A data cable. These sometimes come bundled with the GPS unit.
- Software. Most GPS manufacturers sell software that allows users to download and export data from their GPS units. Free downloads are available on the web as well.

## 5.0 GPS CONFIGURATION:

Most recreational GPS receivers permit users to configure some settings. Ensure your GPS is configured to the following settings:

### 5.1 Datum:

Your GPS receiver should be set to NAD83. If your GPS does not permit datum configuration then it will be factory set to WGS84, which is the standard for the GPS satellite grid. Coordinate shifts between NAD83 and WGS84 are extremely minor, and consequently acceptable. Regardless, GPS units that do not permit datum configuration are likely substandard for mapping purposes and should be replaced. When downloading coordinate data from your GPS please note that for most recreational GPS receivers the format is set at WGS 84.

### 5.2 Units:

All units should be metric.

### 5.3 Coordinate System:

Decimal degrees or UTM are acceptable. Decimals degrees should be set to provide 6 digits following the decimal point. For submitting coordinates to the Canadian Museum of Civilization Sites Office (CMC) the following formats are acceptable:

64.768063 -110.618615 **or**

64.76806 N 110.618615 W

If using UTM ensure that the Zone is recorded and that Eastings are 6 digits long and Northings are 7 digits. For submitting coordinates to the CMC the following formats are acceptable:

Zone 12 Easting: 518145 Northing: 7182683 **or**

12 E518145 N7182683

When reporting coordinates to the CMC please note that military 100,000 metre square identification letter codes should not be included with coordinates.

**5.4 Antenna Height**:
This setting is important for purposes of mathematical triangulation, but widely misunderstood in practice. It refers to the height above the ground you typically hold your GPS unit at while taking readings. Using a tripod or similar device (e.g. always setting it on top of your daypack) helps to eliminate sources of error in antenna height, and keeps the unit off the ground where low level vegetation could affect reception. Measure the height of the receiver on the tripod (or daypack) and set this distance as the antenna height. Be sure to change it if you alter the way you take readings.

**5.5 Accuracy Estimate:**
Most recreational GPS receivers today typically provide an accuracy estimate directly related to satellite geometry and expressed in metres. Coordinate readings with an accuracy estimate of more than 10 metres should be discarded.

Some older models of GPS receivers provide an accuracy reading called Position Dilution of Precision (PDOP). If your GPS unit allows PDOP settings ensure that it is configured according to manufacturer specifications and when recording coordinates an accuracy reading no greater than 6 is acceptable.

**5.6 3-D Mode**:
All GPS readings should be taken in the 3-D mode, requiring signals from a minimum of four satellites.

**5.7 Signal Strength**:
A minimum signal level of 6, or the manufacturer's recommended level for good signal quality. Some models, for example Garmin provide only a bar graph indication.

**5.8 Satellite Elevation:**
A satellite elevation angle of 15 degrees is typically regarded as a minimum. Note that dense forest cover or abrupt topographic features will affect signal strength and angle of visibility.

## 6.0 RECORDING GEOGRAPHIC COORDINATES IN THE FIELD:

The actual process of creating a waypoint for a position will vary depending on the type of GPS receiver you are using. The following are general guidelines and tips for creating a useful waypoint with any GPS receiver.

- Be sure you have initialized your GPS receiver according to your individual unit's instructions. The first time a GPS unit is used in a new location (or whenever it has been moved 500 miles from where it was last used), the unit will need up to 15 minutes to orient itself. The more often you use the unit in its new location, the faster it will receive satellite data and record positions. Batteries should be checked frequently and replaced or recharged as needed.

- When you have located a site you wish to record make sure you have as clear a view of the sky as possible. Most newer multi-channel GPS receivers need to have a fairly open view of the sky. Leaves and branches of trees and low-growing shrubs cause interference and slow the reading process down but multi-channel receivers should still function in these conditions. If your site is significantly below the level of the ground the reading process will slow down due to the limited view of the horizon. Most GPS receivers will not receive satellite data indoors.

- Start your GPS according to the manufacturer's instructions. Most GPS receivers operate in different modes. The receiver will usually tell you something about the mode in which it is operating as it locates satellites. Ensure settings conform to those in s. 4.0 above.

- Leaving your GPS unit turned on for several minutes (15 minutes or more are best) allows it to take multiple readings which are then averaged by internal software. This provides a more accurate location.

- Record your position as a waypoint. There are various ways to do this, and your unit may have a Position Averaging feature which will allow you to take a slightly more accurate waypoint reading, so follow the instruction of your individual unit.

- Give your waypoint a record number. Most GPS units allow you to give your waypoints some kind of text or numeric identifier so that each waypoint is easy to index in the GPS unit's memory. Keep track of your individual waypoint's ID and record it in your notes. Marking the ID at its corresponding location on a 1:50,000 scale map can help ensure that errors are minimized.

## 7.0 REQUIRED DATA FOR SUBMITTING SITE LOCATION COORDINATES

For small archaeological sites (less than $100m^2$) a single coordinate taken at the site centre is adequate. For larger sites, five readings are required. These should be taken at the site centre, and at its furthest extent on the northern, eastern, western, and southern

margins. This will permit better use of site coordinate data in Geographic Information System (GIS) applications.

When reporting archaeological sites to the CMC, the following information for each site should be submitted. This information should also be recorded in your final report.

- GPS type and model.
- Date coordinates were taken.
- Weather conditions.
- Datum used.
- Site ID (including Borden number if you are revisiting a site.)
- Geographic coordinates (up to five depending on the site size. If submitting more than one coordinate, the location [centre, north, south, east, west] should be clearly indicated.)
- NTS 1:50,000 field map (or photocopy with the map edition indicated) showing site locations.
- It is preferable that site data be forwarded in Excel, Access or tab-delimited text files.

If you are releasing your report publicly, please separate your site forms and data in a separate volume and do not distribute it with your report.

## 8.0 USEFUL INFORMATION SOURCES

http://www.geod.nrcan.gc.ca/
http://www.edu-observatory.org/gps/
http://pwnhc.ca/programs/archa.htm
http://www.tapr.org/~kh2z/Waypoint/
http://www.gpsu.co.uk/
http://gpsinformation.net/

## 9.0 SOME GPS PRINCIPLES AND TERMS DEFINED

Geoid:
The geoid is a level, or equipotential surface, where the gravity potential is a constant value. The gravity force vector acts perpendicular to this surface. A good example of a level surface would be a large body of water where the force of gravity acts on the water such that a constant surface is formed. This is where the Mean Sea Level (MSL) height stems from. The surface of the ocean, after some generalization, can be considered as a good approximation to the geoid.

Ellipsoid:
An approximation of the shape of the earth. The earth is not quite spherical because centripetal forces cause it to bulge at the equator, and also due to topographic relief. The ellipsoid is an approximation to the geoid. It can be derived mathematically and is

generally referred to as a terrestrial reference frame. The World Geodetic System 1984 (WGS-84) is an ellipsoid that all GPS measurements reference.

Orthometric Height (MSL):
Orthometric height is the height above mean sea level (MSL). Most recreational GPS receivers display ellipsoidal height which can be converted to orthometric heights by using transformation software. Those receivers that have an option to display heights above MSL would most likely use an rough geoid model resulting in approximate heights.

Ionospheric Weather:
The ionosphere is the part of the Earth's upper atmosphere, 80 - 1000 km above the Earth's surface, where ions and electrons are present in quantities sufficient to affect the propagation of radio waves. GPS signals are radio waves at a high enough frequency as to pass through this layer of the atmosphere but changes in the ionosphere can still ultimately effect how they arrive to the GPS receiver. The total electron "content" of the ionosphere in the auroral regions (65˚-75˚ latitude) and the polar caps (75˚-90˚ latitude) is higher than in other places on earth, making GPS use in the NWT during periods of high ionospheric activity (especially during periods of solar flares) more susceptible to ionospheric interference. Using dual, or parallel channel receivers can help to compensate for ionospheric interference and consequently this is why we have recommended that single channel receivers be replaced.

Tropospheric Weather:
The troposphere is the lowest layer of Earth's atmosphere and site of all weather on Earth. The troposphere is bounded on the top by a layer of air called the tropopause, which separates the troposphere from the stratosphere, and on the bottom by the surface of the Earth. The troposphere is wider at the equator (10mi) than at the poles (5mi). Bad or heavily cloudy weather can affect GPS reading quality. The lightning associated with thunderstorms may cause cycle slips or excessive signal noise, and other weather elements existing in the troposphere delay the propagation of GPS signals thereby affecting the accuracy of the measurements. Avoid using GPS during bad weather or on very cloudy days.

Selective Availability:
Selective Availabilty was an intentional error factor incorporated into GPS radio transmissions by the US government to prevent the technology from being used to target US installations. Selective Availabilty introduced an error factor of over 100 metres in GPS coordinates. However the Clinton administration, on May 1, 2000, turned Selective Availability off, increasing the accuracy of GPS coordinates by a factor of 10. Location coordinates collected before May 1, 2000 cannot be adjusted. Whenever possible revisit locations recorded before May 1, 2000 and take new readings.

# Field Guide for
# GPS use in the NWT

**GPS Settings**:

**Datum**: NAD83.
**Units**: metric.
**Coordinate System**:
Decimal degrees
64.768063 -110.618615 **or**
64.76806 N 110.618615 W
or UTM
12 E518145 N7182683
**Antenna Height**:
Use a tripod or the top of your daypack and enter this height.
**Accuracy:** Let the unit average readings over 15 minutes.
**3-D Manual Mode**: Minimum of four satellites.
**Signal Strength**: Minimum level of 6.
**Satellite Elevation:**15° angle of visibility.

**Record the following information**:

- GPS type and model.
- Date coordinates were taken.
- Weather conditions.
- Datum used.
- Site ID (including Borden number if you are revisiting a site.)
- Geographic coordinates (up to five depending on the site size. If submitting more than one coordinate, the location [centre, north, south, east, west] should be clearly indicated.)
- Mark the location on NTS 1:50,000 field map.

Be sure you have initialized your GPS receiver according to your individual unit's instructions. The first time a GPS unit is used in a new location (or whenever it has been moved 500 miles from where it was last used), the unit will need up to 15 minutes to orient itself. Batteries should be checked frequently and replaced or recharged as needed.

When you have located a site you wish to record make sure you have as clear a view of the sky as possible. Leaves and branches of trees and low-growing shrubs cause interference and slow the reading process down but multi-channel receivers should still function in these conditions.

Start your GPS according to the manufacturer's instructions. Most GPS receivers operate in different modes. The receiver will usually tell you something about the mode in which it is operating as it locates satellites. Ensure settings conform to those above.

When your GPS receiver has four satellites in view it is ready to calculate your position. Leave your GPS unit in the centre of the site for at least 15 minutes to allow it to average a more accurate position.

Record your position as a waypoint. There are various ways to do this, and your unit may have a Position Averaging feature which will allow you to take a slightly more accurate waypoint reading, so follow the instruction of your individual unit.

Give your waypoint a record number. Most GPS units allow you to give your waypoints some kind of text or numeric identifier so that each waypoint is easy to index in the GPS unit's memory. Keep track of your individual waypoint's ID and record it in your notes. Marking the ID at its corresponding location on a 1:50,000 scale map can help ensure that errors are minimized.