

## What is GPS, and how is it useful in water quality applications?

The Global Positioning System (GPS) is a network of satellites whose signals provide Earth-bound receivers accurate position data. Position information - latitude, longitude, and elevation - can be obtained almost instantly anywhere in the world, with an accuracy of five meters or better. GPS applications include aviation and marine navigation, natural resource mapping, and asset tracking (trucks, trains, etc.).

Particularly, GPS allows automated correlation of water quality data with exact spots in an aquifer, river, lake, bay, etc. For instance, a water quality investigator can use GPS to ensure that lake profiles are made in the same locations every time, to find a reef in a wide expanse of open water or a wellhead in a weed-covered field, to specify a site for remediation by another team with GPS capability, or to map a mixing zone for a discharge permit. Alternatively, water quality data can be collected at points of convenience or safety, and tagged via GPS. Later, the data can be accurately integrated into geographic databases or models

## How does GPS work?

The United States Department of Defence (DoD) maintains 24 GPS satellites in a very high (20,000-kilometre) Earth orbit. Each satellite continuously transmits a specially-coded radio signal that travels at the speed of light. The locations of these satellites are known so precisely that if the time required for the radio signal to travel from any satellite to any receiver is measured, the distance from the satellite to the receiver can be calculated accurately. Of course, there are many locations on Earth that are equidistant from any one satellite. But if a GPS receiver analyses the signals from three GPS satellites at once, a unique position on Earth is specified in a process analogous to triangulation. The information yielded by the third satellite also allows calculation of the altitude of the receiver.

Because the position calculation happens almost instantly, the speed and course of a moving receiver (for instance, on a boat) can be determined simply by noting changes in the receiver's latitude, longitude, and altitude.

There are several sources of error in GPS measurements. First, charged particles and water vapor in the atmosphere slow the speed of the satellite radio signals. Second, the same radio signal can reach a receiver several times as the signal bounces off terrestrial objects - isolating a reflected signal means an error in the distance calculation. Third, there is a small error in the synchronisation of the clocks in the satellite and the receiver (a fourth satellite is often used to minimise this error). Fourth, the satellites tend to drift slightly in their orbits. And fifth, the DoD introduces random errors to the satellite transmissions (in a process known as Selective Availability) so that enemies cannot use the DoD's own satellites to locate targets. The sum of these continually changing errors (the accuracy of GPS positioning) is about 100 meters.

## What is differential GPS?

Differential GPS (DGPS) is a process used to reduce the 100-meter error of standard GPS. DGPS uses information not just from four satellites, but also an earthbound receiver-transmitter whose position is known exactly. The DGPS station receives signals from a number of satellites, and then works backward to determine the satellites' errors by comparing those signals to the exactly known position of the station. The DGPS then immediately transmits a set of corrections for receivers using the radio signals from the satellites analysed. If a GPS system is configured to operate in the differential mode, it will not only collect data from the necessary four satellites, but also will receive and incorporate the correction information delivered by the local DGPS station. DGPS provides an accuracy of five meters for moving receivers, and better than five meters for stationary receivers.

DGPS correction can be done in real time, or can be used to correct data later (post-



processing), provided accurate times for the measurements are known.

## How is GPS implemented in Hydrolab instruments?

Hydrolab incorporates a Trimble® GPS circuit board and software into the Hydrolab Surveyor® 4a Data Display. The Surveyor 4a provides a hand-held, battery-powered, NEMA 6 (waterproof) package for the GPS. The Hydrolab implementation allows the user to read the position of the Surveyor 4a directly as latitude, longitude, and altitude, and/or to tag water quality data measured by the Surveyor 4a and a Hydrolab multiprobe with exact location data. This means that a user can sample an exact site over and over again, locate a site specified by another criterion (such as an oil spill or monitoring well), or simply avoid being lost in the woods.

The Surveyor 4a GPS requires an antenna. A small, magnet-mounted GPS antenna is available from Hydrolab. Many other types of GPS antennas, with compatible connectors, are available from other GPS suppliers.

DGPS requires an external receiver for collecting the correction data from a DGPS transmitter. The receiver is available from the provider of your local DGPS service. The signal from the DGPS receiver is sent to the Surveyor 4a through a special connector on the Surveyor 4a power adapter cable provided with each GPS

If you are near the coast, DGPS service may be available via Coast Guard or marine beacon radio transmissions; your only cost would be the DGPS receiver itself. The DGPS receiver is often provided by the DGPS service, and is not incorporated into the Surveyor 4a case). Otherwise, you must find a local DGPS provider, who often charges a periodic fee for DGPS transmissions.

## Should I consider a Hydrolab GPS?

A Hydrolab GPS, which can be used with a minimum of training, can improve your water

quality investigations by integrating your water quality data with accurate location data. This integration eliminates doubt as to the location at which data was obtained, prevents errors that can occur when matching water quality data with GPS data from another source. The time and expense of otherwise specifying location (manual site surveys, landmarks or buoys, or traditional navigation devices) is also eliminated, as is the investment in other navigation devices. Hydrolab GPS is a field-worthy, convenient, cost-effective solution to many location data needs. The Hydrolab / Trimble GPS provides the same reliability associated with Hydrolab instruments for over 30 years, and carries up to five years of full factory warranty.

For more information on this or any Hydrolab application please contact Campbell Scientific (Canada) Corp. at (780) 454-2505.