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Langley Research Center
Hampton, VA 23681-0001
M/S 140

Geographic Information Systems Team

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LaRC tide measurement stations

Summary

The LaRC GIS Team installed two water level monitoring systems on Langley Air Force Base property. These are in addition to the existing station located on Brick Kiln Creek, on LaRC. The purpose of these new systems is to provide additional monitoring locations to support more detailed tide analysis. The systems each consist of a pressure sensor (calibrated to read water depth) and a solar charged, battery-powered datalogger which records data to internal, non-volatile memory. Collected data is uploaded to a PDA or laptop over an on-demand Bluetooth RF connection.

Installations

Relative locations of tide stations

The photo to the left shows all three tide stations in relation to each other.

“Tide 01” (upper left) is the original prototype station on LaRC.

“Tide 02” (upper right) is located on the pedestrian walk over the marsh, north of the Horse stables on LAFB.

“Tide 03” (lower right) is located on the remains of the old Tide Mill Lane bridge, near the B-52 static display, also on LAFB.

Tide station # 2 location

This photo shows details of the location of Tide Station #2. The pedestrian walkway is clearly visible. Access is via Worley Rd, visible near the bottom of the photo. The entrance to the walkway is just across the road from the horse stables (buildings in the lower left corner).

The equipment is installed on a 4X4 post attached to the observation deck. A 2” conduit runs from the enclosure to the sensor, which is extended approximately 12 feet into the waterway. The sensor mount is anchored to the bottom of the waterway with a pipe driven into the hard surface below the mud.

See drawings below for details.

Tide station # 3 location

This photo shows details of the location of Tide Station #3. Access is via a gravel path from the curve where Tide Mill Ln. becomes Burrell St. The B-52 static display serves as a visible landmark for this area.

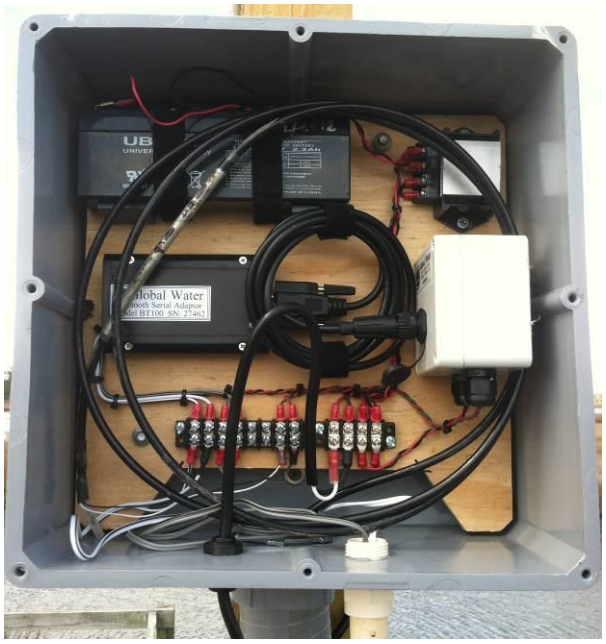
The equipment is installed on a 4X4 post attached to the bridge abutment. A 2” conduit runs from the enclosure to the sensor, which is located approximately 15 feet out into the waterway. The sensor mount is anchored to one of the bridge pilings.

See drawings below for details.

Below are photos of the completed tide station installations:

Tide Station # 2

Tide Station # 3



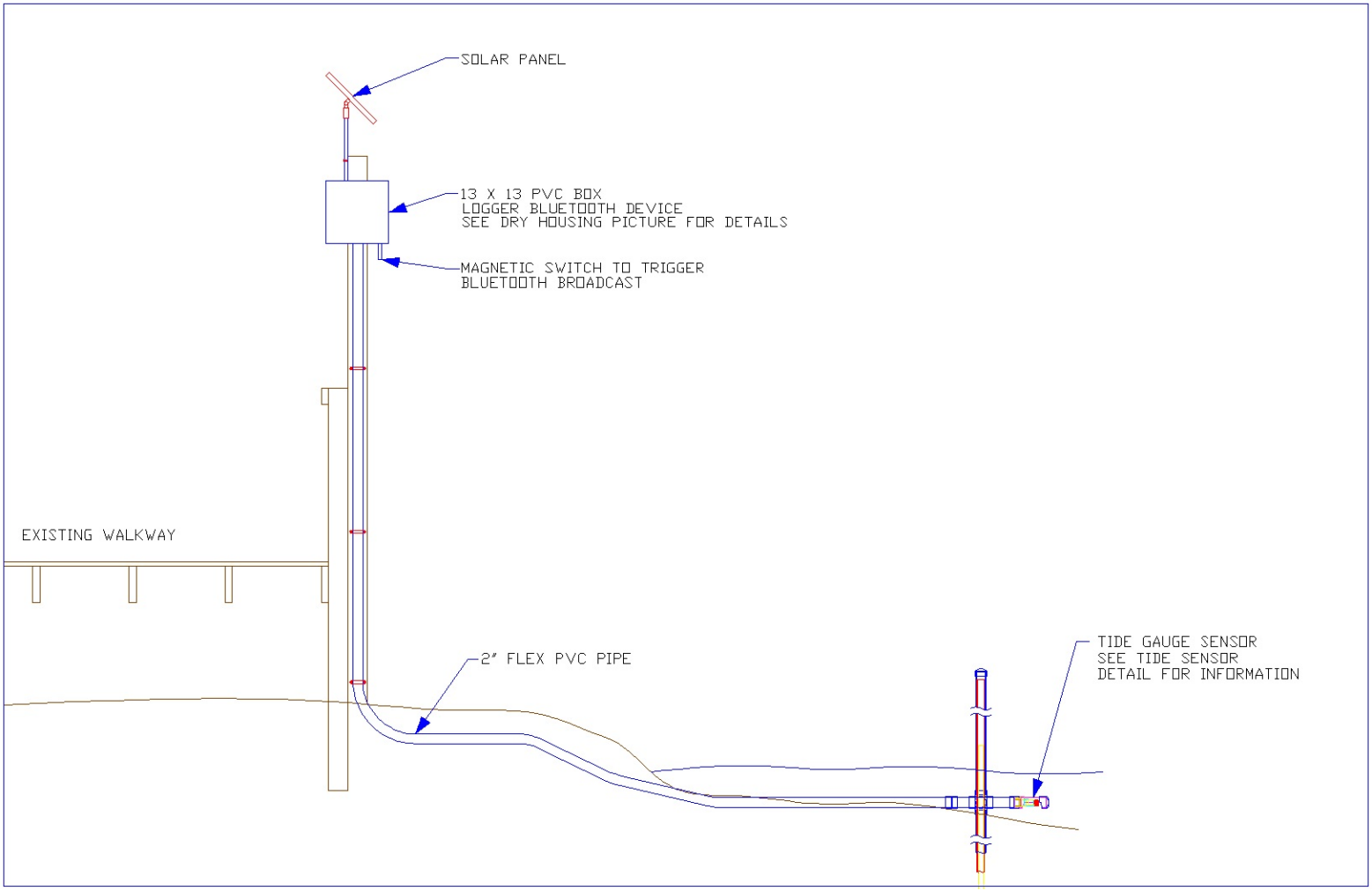
Tide station enclosure

View of enclosure with cover removed showing arrangement of equipment. Tide station # 2 shown here; #3 is similar.

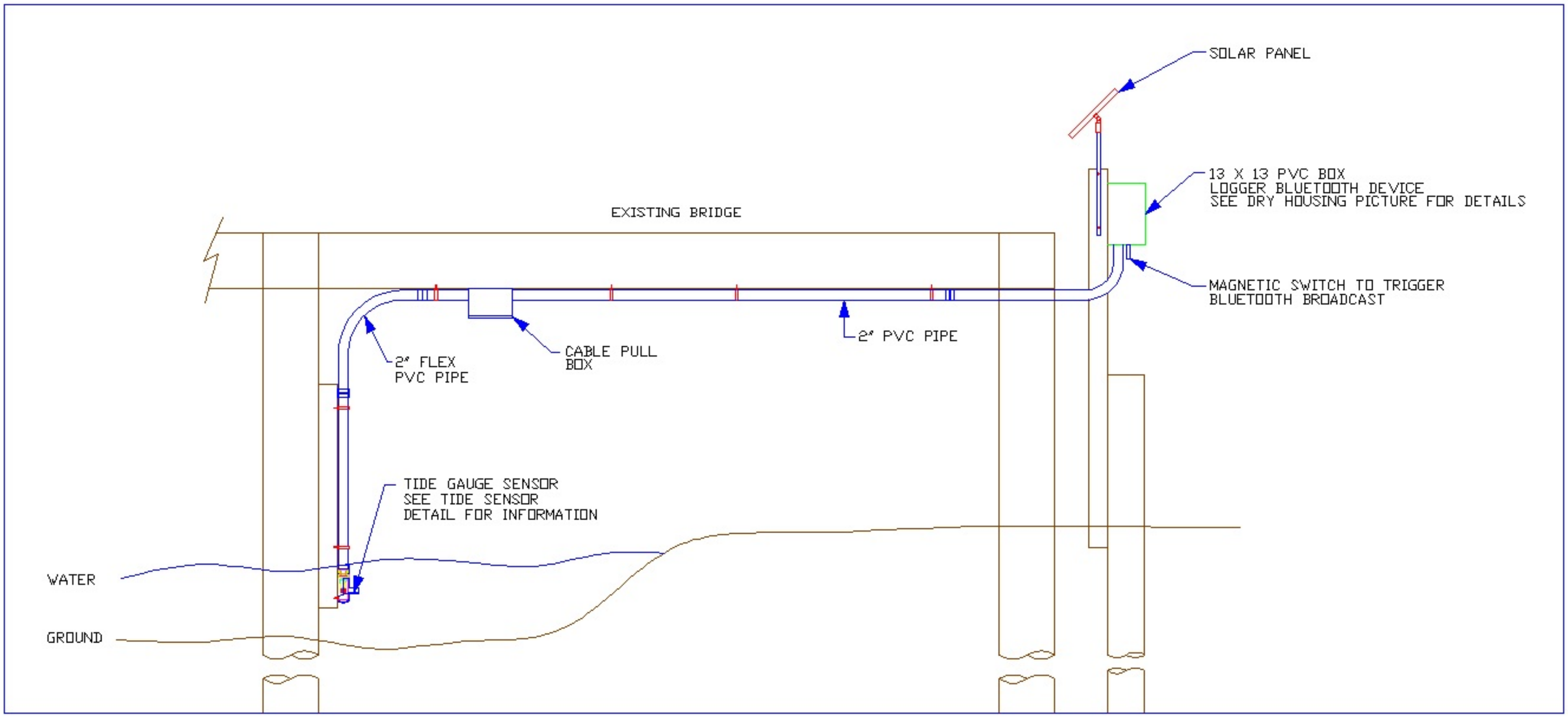
Clockwise from upper left: 2.2 A-H SLA battery, 12 VDC regulator/battery charger, GL500-2 datalogger, terminal strips for connections, and Bluetooth module.

The cover is fitted with a neoprene gasket; the enclosure is weather-tight with the cover installed.

Elevation view of the
station #2 installation



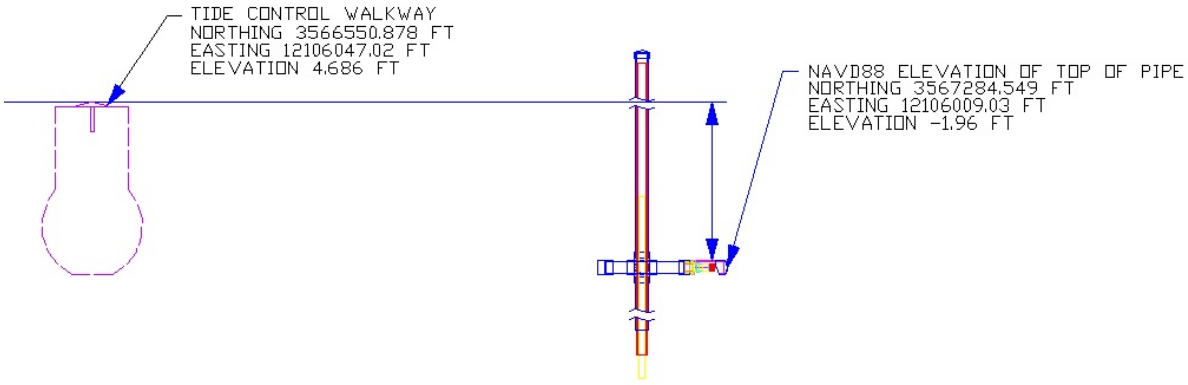
Elevation view of the
station #3 installation



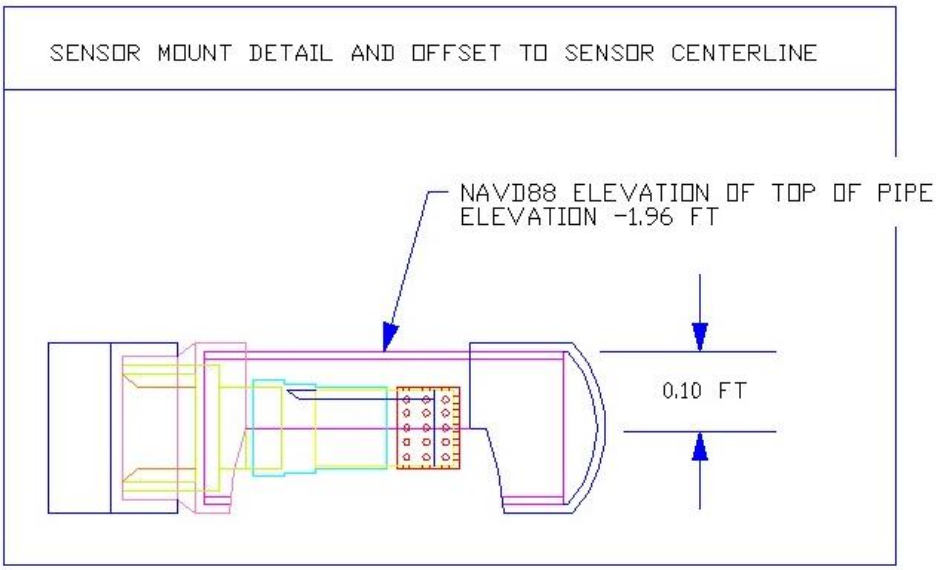
The sensors are each installed in a special mount, designed to allow free intrusion and flow of water, while protecting the sensor from animals, mud and debris. The sensor is installed in (nominal) 1” ID copper conduit, capped on the end, and perforated to allow water flow. A spacer at the top of the conduit forces the sensor to the bottom, preventing movement of the sensor within the conduit. Copper was chosen so as to discourage marine fouling.

This copper housing is mated to the remainder of the sensor mount; constructed of PVC. The mount is attached to the end of a 2” PVC conduit extending from the sensor location to the equipment enclosure. This conduit protects and supports the sensor and vented cable.

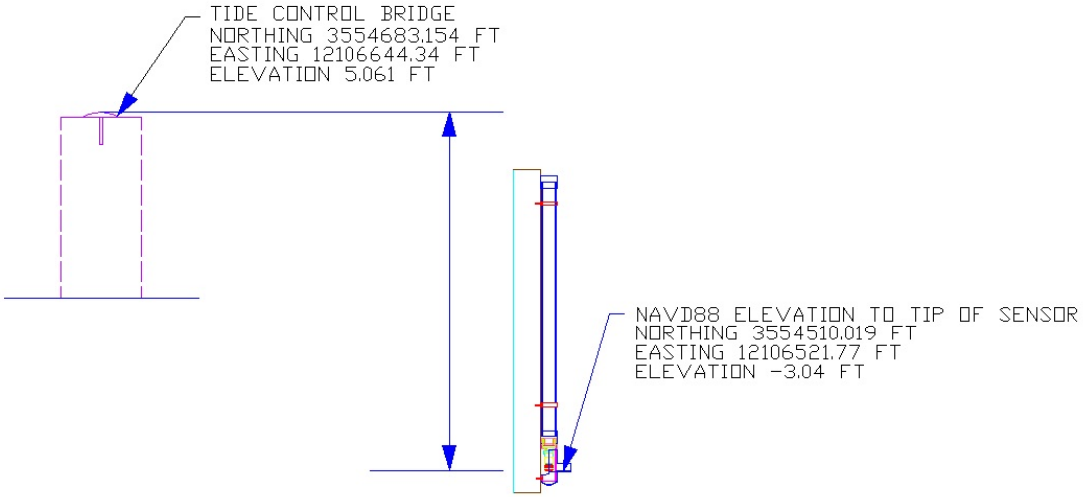
The sensors are each positioned below predicted Mean Lower Low Water (MLLW)), and calibrated to read in feet of water above the sensor. Each sensor is designed to register between zero and 15 feet of water depth, which will cover any anticipated situation, including severe storms, hurricanes and other flooding events.



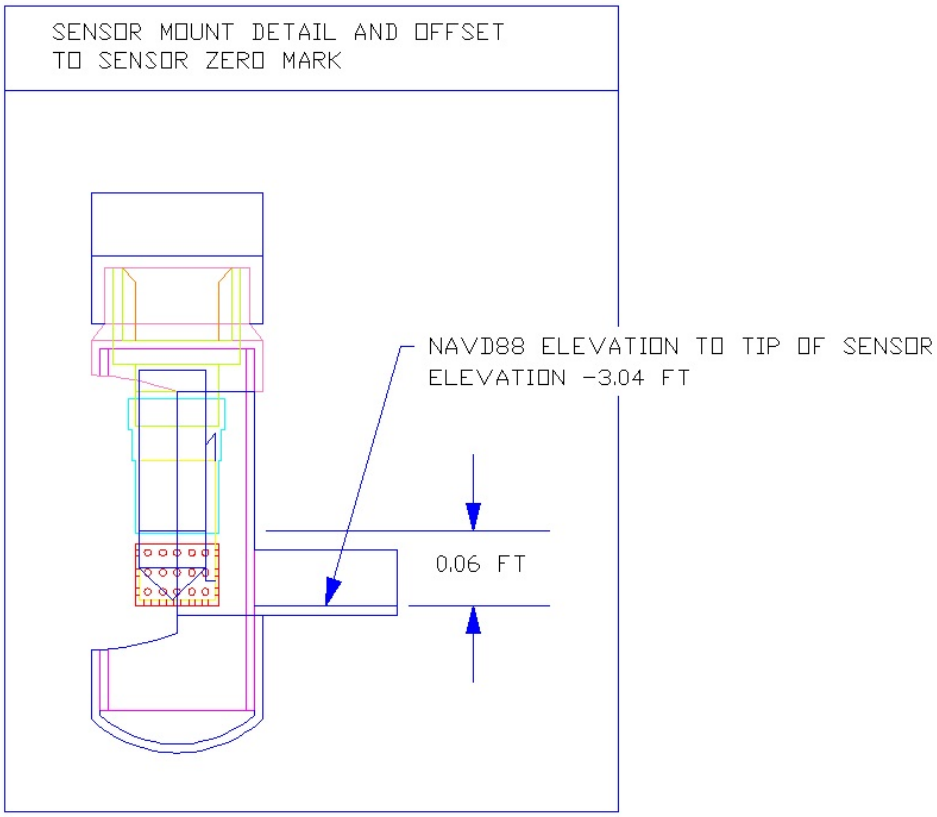
Tide Station # 2 survey details



Tide Station # 2 sensor enclosure details



Tide Station # 3 survey details



Tide Station # 3 sensor enclosure details

Data

Data is collected at 6 minute intervals, matching the tide data available from the original LaRC tide station and NOAA stations in the area, including Sewell's Point and the Yorktown USCG station. The use of similar vertical references and time intervals allows easy comparisons between these datasets. Data files are in comma separated value (CSV) text format and include columns for date, time, water level and battery voltage.

Each station can collect and store data for over ten months in its current configuration. Data is retrieved from the stations using a Bluetooth RF connection. This connection is activated using a magnetic key to engage a reed switch inside a water-tight housing.

The data logger software is available for both Windows and Windows Mobile, so a laptop computer or a PDA can be used to collect the data. The software can also be used to re-program the datalogger in the field to change its operating parameters if desired.

Engineering

Pressure sensor

Each system consists of Global Water, Inc. components, including WL-450 sensor (rated 0-15' of water), vented cable, GL500-2 datalogger, and a modified AK-1500 Bluetooth transceiver. The vent inside the cable provides an atmospheric pressure signal to the back side of the sensor diaphragm, eliminating a separate barometric pressure sensor to null out atmospheric pressure variations.

The sensor was calibrated as per the manufacturer's procedure, using a 36" water column and the Global Logger II software provided.

Communication between the datalogger and sensor is accomplished through an analog current loop (4-20mA) circuit. The datalogger interface is a serial RS-232 connection using simple DTR signaling to initiate communications. A 4 pin DIN to 9 pin D-sub serial cable connects the datalogger to the AK-1500 Serial to Bluetooth module.

Each system is powered by a 10W solar photovoltaic panel, charging a 2.2 A-H Sealed Lead-Acid battery through a 12 VDC regulator/charger unit.

The Bluetooth module was modified to allow remote activation of the module. This was done in order to both conserve battery life and to prevent unauthorized access to the data logger. The DTR signal (used to activate the Bluetooth module) is controlled with a magnetic reed switch, using a magnetic "key." This switch and the remote LED are located in the PVC pipe stub below the cabinet. The red LED indicates when the Bluetooth module has been powered on.

Surveying:

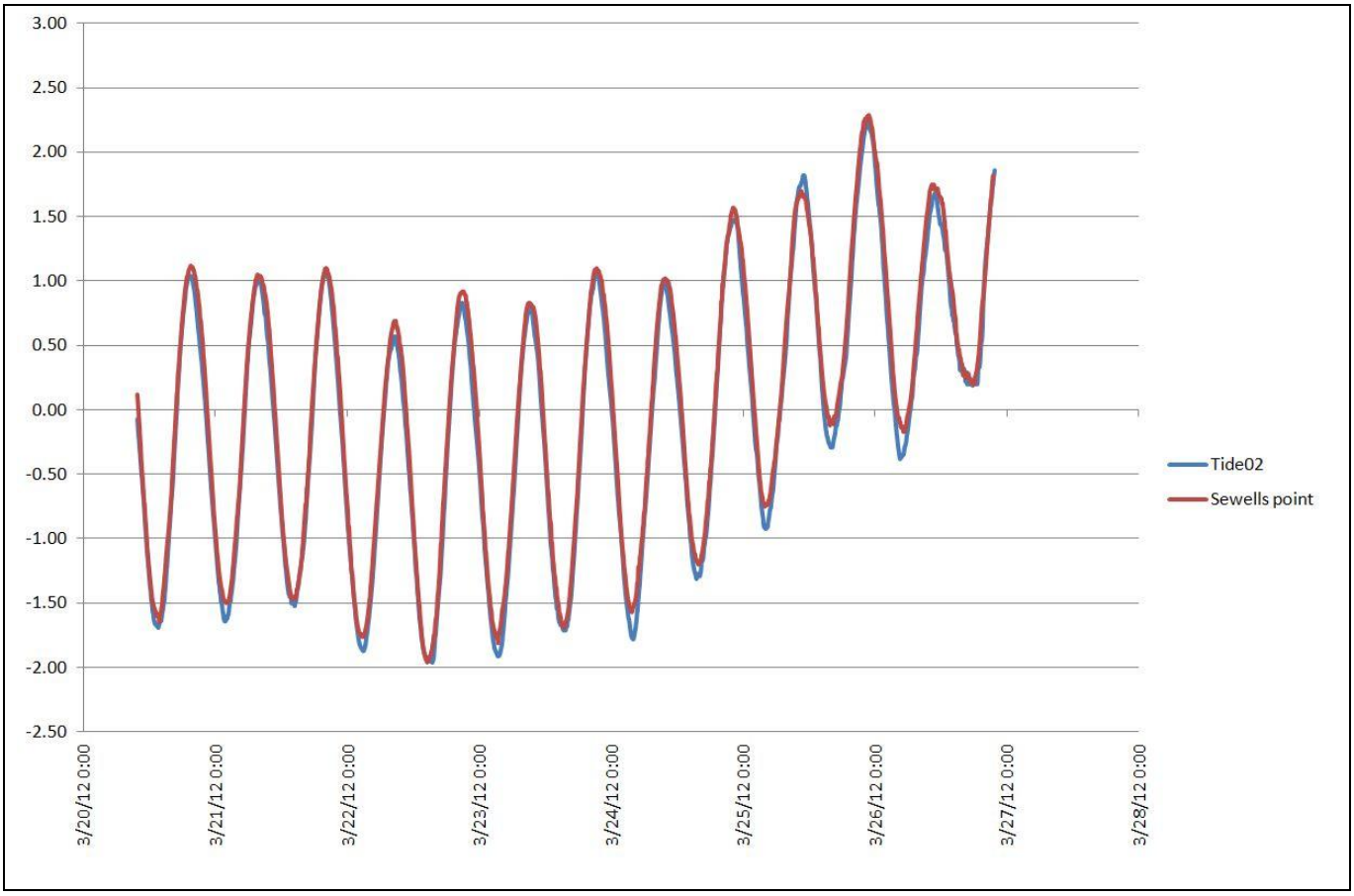
The sensors were each surveyed in reference to new local benchmarks to obtain NAVD88 heights using a Trimble “VX” Optical Total Station. The benchmarks were established using Fast Static GPS techniques.

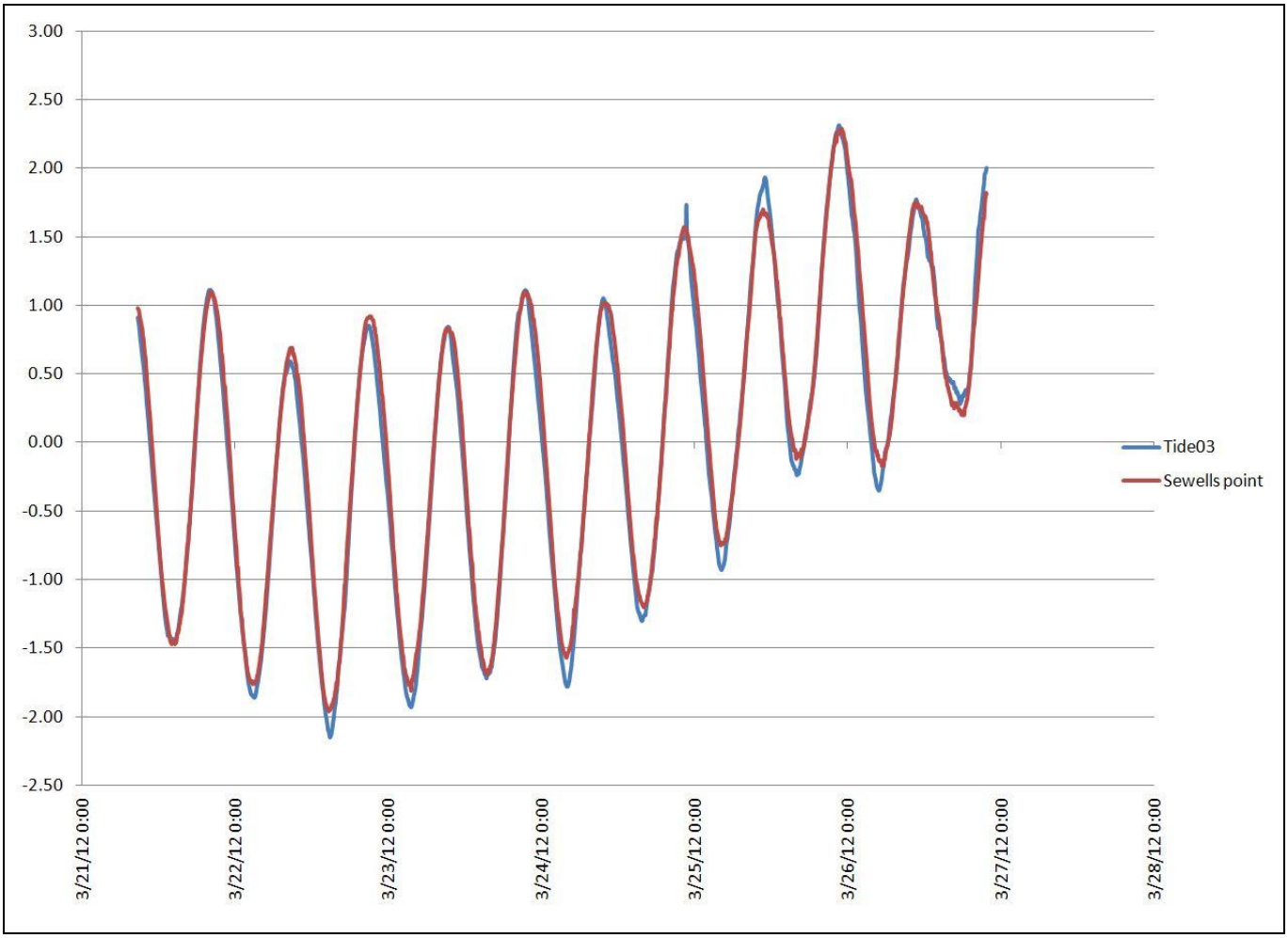
These surveys indicate heights for the sensors as follows:

Tide Station #2	**-2.06 Feet (NAVD88)**
Tide Station #3	**-2.98 Feet (NAVD88)**

Evaluation:

Both units have been deployed for several weeks. Data files were sampled from each unit and compared with Sewell’s Point tide data. The new units track the Sewell’s point data quite closely, as can be seen on the graphs below:





Specifications

GL500-2 Water Level Data Logger:

- Power: 5 VDC min to 24 VDC absolute maximum
    - Current: standby 65uA, logging 5mA + sensor
- Resolution: 12 bit
- Temperature: -40° to +185°F (-40° to +85°C)
- Humidity: 0-95% non-condensing
- Memory: Non-volatile flash memory
    - Storage Capacity: 81,759 time and date stamped data points (including battery voltage)
- Sample Modes: High Speed (10 samples per second), Fixed Interval (Programmable from 1 sec to >1 year), Logarithmic, Exception
- Data Overwrite: Select memory wrap or unwrap (unwrap will stop logging data once memory is full)
- Clock: Synchronizes to the time and date of user's computer

- Clock Accuracy: 0.0025% or 1 minute in 1 month
- Clock Format: Month/Day/Year Hour/Minute/Second

Submersible Pressure Transducer:

- Sensor Element: Silicone Diaphragm, Wet/Wet Transducer
- Water Level Measuring Range: 0-15 ft
- Linearity and Hysteresis: ±0.1% FS
- Warm-Up Time: 3 seconds recommended
- Overpressure: Not to exceed 2 x full scale range
- Accuracy: ±0.2% of full scale, over 35°F to 70°F (1.37° to 21.1°C) range
- Compensation: Uses dynamic temperature compensation 30 to 70°F (-1.1 to 21.1°C). Automatic barometric pressure compensation

Error estimates

The minimum change in water level discernable by the system is 0.04” (1.11 mm) based on a 12 bit ADC and 15’ range. Variation between readings is governed by the Linearity and Hysteresis of the sensor; which for this system is ±0.18” (±4.57 mm). Therefore the error between readings is within ±0.22” (±5.68 mm).

The sensor is accurate to ±0.2% of full scale or ±0.36” (±9.10 mm) of water above the sensor. As shown above, the error associated with any given reading is ±0.22” (±5.68 mm). These together yield a combined absolute accuracy error of ±0.58” (±1.48 cm).

The one-sigma error in NAVD88 height of the sensor is < 1.18” (2.99 cm) based on the survey methods used for this prototype. Therefore the predicted error in absolute water level referenced to NAVD88 is within ±1.76” (±4.47 cm).

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