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Standard Operation Procedure 8: Hydrological Measurement for Digitally-Measured Groundwater Wells

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Standard Operation Procedure 8: Hydrological Measurement for Digitally-Measured Groundwater Wells

Overview of Ecotone® Water Level Loggers

To develop detailed hydrological signatures within reference wetlands, we installed an Ecotone® water level logger (Ecotones) in each site (n=8). Ecotones measure water tables in each well using capacitance sensor technology. Capacitance values vary according to the amount of water present on the capacitance sensor probe. The water level is determined by correlating the capacitance value between two known calibration points on the sensor. We have programmed the Ecotones to collect data twice daily (12:00 am / 12:00 pm).

Ecotones are factory assembled. They may be as accurate at +/-3mm at optimal temperatures (71° to 73° F), with a resolution of approximately +/-1mm, and have a submersion rating of 1 meter for 4 weeks. Ecotones have a low-powered circuit and industrial lithium battery that provides excellent battery life and stores up to 16,000 water level measurements. The battery is factory installed upon ordering, runs continuously, and the batteries last for 2 years on average.

Each Ecotone logger has a serial number provided by the manufacturer (Table 8.1). The serial number is the primary way to identify the unit. Most ecotone loggers have a 40-inch sensor range (40-inch Ecotones). However, we selected loggers with an 80-inch sensor (80-inch Ecotones) for mainstem riverine wetlands along the Cuyahoga River.

Installation of Ecotone® Water Level Loggers

Navigation to Wetlands or Loggers

See SOP 2. Use monitoring well locations waypoint file.

Well Installation

The installation of an Ecotone water level logger (Figure 7.4) is similar to the installation of a manually measured groundwater well (see SOP 7) with two exceptions:

1. All 40-inch Ecotone water level loggers are reinforced with angle iron, which is driven into consolidated ground to limit vertical movement (Figure 8.1) and
2. The logger head is protected with an animal barrier (“beaver-defeater”).

Table 8.1. Ecotone water level logger location ID, identification numbers, installation specifications for loggers deployed in reference wetlands in Cuyahoga Valley National Park. Base level indicates depth of well without water (i.e., maximum depth).

Ref Site	Ecotone Serial Numbers	Deployment Date	Sensor range (in./m)	Model	NPS Property #	Well Diameter (in.)	Base Level (cm)
398	00001130EF2B	11/10/2010	40 / 1.0	WM16K1015	02697	1 ½	105.918
554	00001130CD9C	11/10/2010	40 / 1.0	WM16K1015	02698	1 ½	106.172
683	000011312BFF	11/23/2010	40 / 1.0	WM16K1015	02699	1 ½	106.172
970	00001130EC9B	11/09/2010	80 / 2.0	WM16K2030	02700	3	211.582
526	000014E13D6C	11/10/2010	40 / 1.0	WM16K1015	02701	1 ½	106.2
241	0000138BC5C4	11/23/2010	40 / 1.0	WM16K1015	02702	1 ½	106.172

124	000014E 1AC02	11/23/2010	40 / 1.0	WM16K1015	02703	1 ½	105.918
1427	000014E14D35	11/9/2010	80 / 2.0	WM16K2030	02704	3	211.582

Calibration

All data collected using an Ecotone is dependent on the calibration point (Figure 7.4). This point must be positioned at ground level to collect data that do not require post-collection correction. If the calibration point is above the ground level, the data must be adjusted by adding the distance from the calibration point to the ground to all recorded values. Therefore, the calibration point must be recorded upon deployment of the device and periodically thereafter.

Placement Considerations

1. The Ecotone loggers are left in position throughout the winter. Resurvey the calibration point in early spring to account for any adjustments from frost heave.
2. Ecotones are designed to measure lateral flow. In wetlands with horizontal flow (riverine):
 - o Attempt to locate the calibration point above the highest water level expected at a site.
 - o Use natural (trees) or artificial barriers (V-shaped, no metal) upstream of the unit to divert floating debris. Alternatively, install ecotones in areas near the edge of the wetland where floating debris is not a concern.

Materials for 40-inch Ecotone Installation

1. Measuring tape
2. Gloves
3. 3-inch bucket auger
4. 1.25" x 1.25" x 0.25" angle iron (10ft long)
5. Post driver
6. Sledge hammer
7. Hacksaw
8. Hose clamp
9. Screwdriver or socket wrench
10. Sand
11. Bentonite clay

Installation Procedure for 40-inch Ecotones

1. Lay plastic tarp next to well location
2. Use a 3-in bucket auger to dig well hole. Auger soil from the top 16 inches, then push the top 6-8 inches out of the top of the auger.
3. Lay out the samples onto the tarp in sequence for a stratigraphic soil analysis (SOP 10).
4. Continue in 6-8 inch increments, until auger is approximately 2 ft. or more below the water table, where water is expected to fluctuate
5. If groundwater is present in the hole, use a well bailer to bail as much water out as possible.
6. Place a 10 ft. piece of angle iron against the wall of the hole; make sure the angle is pointing North.
7. Wearing leather gloves, drive the angle iron into the ground using a post driver. A sledge hammer may be used once the angle iron is low enough to be hit safely. Drive the angle iron into the ground until it can no longer be moved by pulling up or pushing down on it with your hands.

Make sure to leave several inches exposed above ground to attach the well. Remove excess angle iron with a hacksaw, if necessary.

8. Insert the well into the hole and attach it to the angle iron with a hose clamp, tighten with a screwdriver or socket wrench (Figure 8.1).
9. Making sure pipe is vertical and centered in hole, backfill with silica sand for the entire length of the well screen. A layer of bentonite (several inches or to ground surface) should cover the sand, and excavated sand / soil can be used to backfill around the riser pipe.
10. Using sharpie or wax pencil, write well number on outside of the well casing.
11. Record the distance from the calibration point to the ground.
12. Complete soil stratigraphy analysis on soil sample (SOP 10) and document well deployment (Attachment 7.1)



Figure 8.1. All 40-inch Ecotone water level loggers are reinforced with a 10-inch piece of angle iron and secured with a hose clamp.

Materials for 80-inch Ecotone Installation

1. Measuring tape
2. Gloves
3. Shovels
4. Mold (to hold sand)
5. Sand
6. Bentonite clay

Installation Procedure for 80-inch Ecotones

The 80-inch Ecotones require a larger bore hole diameter and depth, so the disturbance footprint is larger (Figure 8.2). Holes are hand-dug with a team and shovels to about 70 inches, leaving the

calibration point close to 10 inches above the ground level. Soil stratigraphy analyses were not completed for the 80-inch logger installations and angle iron was not needed because of the logger depth.

1. Hand dig a 70-inch hole.
2. Place the ecotone in the hole.
3. If the hole is large, restrict the sand backfill to an 8-inch diameter width around the Ecotone screen using an 8-inch concrete building form tube. The tube is placed around the Ecotone and flush with the bottom of the hole.
4. Backfill the hole in 1-2 ft. increments using native soil material to back fill the area around the form tube, then silica sand is poured inside the form tube.
5. Pull the form tube up and continue working in 1-2 ft increments until the entire Ecotone hole is backfilled.
6. Record the distance from the calibration point to the ground.
7. Document well deployment (Attachment 7.1).



Figure 8.2. The Installation of an 80-inch logger may require hand-digging a hole. Silica sand is packed against the well screen using a concrete building form tube and the hole is backfilled with native soil.

Well Protection

If groundwater wells are located in an area with curious animals, the tops may be vandalized and ruined. For the Ecotone loggers, this could mean the loss of several months of data! To prevent well damage, a low cost “beaver defeater” can be assembled for wells (Figure 8.3). This design is for most ecotone loggers, where the well-head is less than two feet above the ground. The design is modified as need for larger well heads.

Materials

1. 2 x 2 Pressure-Treated Lumber
2. 2 x 4 Pressure-Treated Lumber
3. Circular saw
4. Drill bits
5. 2” wood screws
6. Rope
7. ½ inch or 1 inch Galvanized poultry netting
8. Staple gun

Construction

1. Measure the height from a hard surface to the cap of the well.
2. Cut four sections of 2 x 2 pressure-treated lumber to the length of the well plus an extra six inches to make the legs. For example, if the well is 13 inches above the ground you would cut the 2 x 2 into four, 19-inch lengths.
3. Cut one end of each 2 x 2 into a tapered point that is four inches long.
4. Cut eight sections of 2 x 4 pressure-treated lumber into 4 inch lengths for the sides.
5. Place the four legs in a square (standing vertical on the flat-end), place a cut 2 x 4 side between each leg. Pre-drill holes and screw the legs to the sides. Place the other four cut 2 x 4 sides between the legs, where the legs start to taper off to a point. Pre-drill and screw the legs to the sides.
6. Drill two ½ inch holes into the top. Both holes need to be located opposite each other near the center of a 2 x 4 side. Feed three pieces of rope through one of the holes and tie a knot to prevent the rope from pulling back through the hole. Braid a one foot section of rope and feed it through the other hole, tie a knot to prevent it from pulling out the hole. This will be used as a carrying handle and to remove the device from the well when monitoring water levels.
7. Cut the galvanized poultry netting so it covers the gap between the top and bottom 2 x 4 side pieces. Cut this long-ways so you can wrap the netting around the outside with one piece. Staple the netting to the legs and sides.
8. Cut another piece of netting to cover the top. Holes may be cut to accommodate the rope handle. Staple the netting to the top.

Installation

1. The “beaver defeater” can be carried to the well using the rope handle.
2. Before installation, clear the soil surface of obstructions (sticks, rocks, etc.)
3. Press the “beaver defeater” into the soil until the bottom side pieces are flush with the soil surface. This may require a hammer if the soil is dry and hard.

Measurement in Ecotone® Water Level Loggers

Ecotones are programmed to record measurements twice daily using a Rugged Digital Assistance (RDA: Measura, Figure 8.4). The Measura is also used to download Ecotone data at least quarterly throughout the year (March, June, September, December). An Ecotone will record 16,000 measurements in flash memory before it is full, and the Measura can store nearly 300,000 measurements before transfer is required. Data stored on the Measura is transferred to a PC for analysis and archiving.

Charging Rugged Digital Assistant

Keep the Measura charged at all times and turned off when not in use. The unit may be set to sleep after a designated amount of time. When in sleep mode, the unit appears to be off but will drain the battery. (If unsure, turn the power back on and then back off.) Since memory in the Measura is RAM, if the battery is completely drained all data and installed programs will be lost. A backup card is used to prevent accidental loss of data.



Figure 8.3. The beaver deflector used to protect Ecotone water level loggers from animal vandalism.

Downloading Data from Ecotones to Measura

Use the WMConfig and WMDData programs when downloading data from the Ecotone loggers. These programs are installed on the Measura.

Important: Prior to connecting the Measura to the Ecotone, observers must ensure that the well head cap is clear of condensation. If condensation is present, pull the logger from the well casing and bring it back to the office to dry completely before collecting data.



Figure 8.4. The Aceeca Measura Rugged Digital Assistant (Measura) is used to download data from Ecotone water level loggers and then to upload the data to a desktop computer.

Configuring Ecotone Settings Using WMConfig

WMConfig is used to configure the settings (i.e., date, time, units, and intervals for measurements) for the Ecotone logger. These settings should be read, checked and corrected if necessary at every visit.

1. Open WM config and click *Read*.
2. Verify the accurate *Time*, *Date*, *Logging Interval* and *Units* (meter) are selected. Change if necessary.
3. Press the *Current Time* button last.
4. Press *Send*.

Retrieving Datalogs with WMData

WMData is used to extract and review the data logs stored in the Ecotones. When the WMData program is opened, the serial number (e.g. 00001130EF2B) of all available units are listed. Use the following steps to upload data from the loggers.

1. Click *Read*. If the download is successful, the serial number will update to include the Upload Date and Time. For example, if Unit 00001130EF2B is read on September 16, 2014 at 1:00 pm; the list will show: 00001130EF2B_20140916_1300. New data logs cannot be uploaded from the Ecotone if the previous log has not been downloaded to the PC.
2. Open the data log file to make sure the readings are complete and accurate.

3. By default, the memory will “wrap when full” (i.e., the earliest measurement is replaced by latest measurement). Erase the logger memory by clicking on *Datalog, Erase Logger*. Click *Erase* again to proceed through the warning message.
4. Back up data after every Ecotone download by selecting *Card Backup* on the Measura (Main Screen), then select *Backup Now* and *Begin Backup*.

Downloading Data from Measura to Desktop Computer

1. Connect the Measura cable to the desktop computer.
2. (Note: Hotsync may also need to be activated in the system tray of the PC before the sync.)
3. Select HotSync (Figure 8.5) in the System folder of the Measura. Click the HotSync icon in the center of the screen to perform the sync. When the unit has successfully synchronized with the desktop PC, the datalog is transferred to a folder on the computer and erased from the Measura.
4. Logs are stored by default in
C:\Users\SBingham\AppData\Local\VirtualStore\Program Files (x86)\Palm\Sonia\WMCond.
5. Navigate to the stored location to verify the transfer after each HotSync.
6. Copy all files to appropriate folder at
C:\Users\SBingham\Documents\HTLN\Wetlands\CUVA_WetlandMonitoring\FieldData\Ecotone\EcotoneLogs\. Always leave the original datalog files in the WMcond folder. Copy the logs as needed to an appropriate working folder before editing

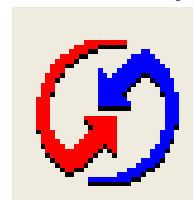


Figure 8.5. Hotsync is the mechanism used to synchronize data between the Measura and PC.

Data Recovery

If the battery is drained and Ecotone data is lost, the data should be restorable as long as a backup was completed.

1. On the Measura, click on the *Backup Card* icon
2. Click *Restore* and select *Partial Restore*
3. Select the relevant files and click *Restore*

If a backup was not available, programs will need to be reinstalled on the Measura using the following procedures:

1. Log in as an administrator
2. Connect Measura to PC
3. Exit the Hotsync Manager by right clicking the blue/red arrow circle in start menu
4. Go to C:\Program Files (x86)\Palm\Sonia\Backup
5. Double click on *j9_vm_bundle.prc* to bring up the Palm Quick installation application
6. Select the receiver name and click OK
7. Click Add and Select *j9cl.prc* and all other Palm software desired *WMConfig, WMData*
8. Exit
9. The items will be added during next HotSync

Post-Processing Ecotone Measurements

Ecotone datalogs are saved as .txt files. Water level measurements are recorded from the calibration point so measurements are adjusted based on the distance between the calibration point and actual distance to ground. This is done as a step that follows the data import process in to an Excel

spreadsheet and prior to upload into Aquarius (SOP 16). The data are also reviewed and corrected for inaccuracies due to unexpected flooding, especially in the Cuyahoga River floodplain.