Chapter 2 – Temperature Monitoring

The methods presented in this chapter are standard (Bain and Stevenson 1999) and should work in most parts of the country. Chapters should consult with local agencies regarding temperature logging intervals, length of temperature logger deployment, and methods for securing temperature loggers in local streams.

2.1 Objectives

These standard protocols for temperature monitoring are intended to be used to increase the amount of water temperature data available for Michigan's coldwater streams. This document is designed to provide standard protocols for monitoring water temperature that can be used by trained volunteers participating in the Michigan Trout Unlimited (MITU) River Keepers Program.

This temperature monitoring procedure is designed to address several objectives:

- Increase available temperature information for Michigan's coldwater streams for use by MI DNR staff.
- Provide consistent temperature monitoring methods.
- Serve as a tool to identify and classify Michigan's coldwater streams
- Identify dams that are a priority for removal

2.2 Training

All temperature monitoring program leaders must have received training from a MITU staff member or fellow program leader. Temperature team leaders will be trained in logger deployment, data downloading, and downloading data into HOBOware. Leaders are then qualified to train volunteers to collect temperature data.

2.3 Equipment

Sampling will be conducted using Onset Computer HOBO Water Temp Pro v2 water temperature data loggers. The software required to download data from HOBO temperature loggers is HOBOware Pro or HOBOware lite. A Universal Optic USB Base Station is also required to transfer data. All software and necessary equipment are available from Onset Computer (http://www.onsetcomp.com/). Loggers will be housed inside PVC pipe secured to rebar in the stream bed. Complete lists of materials can be found in Appendices 2A, 2B, and 2C.

2.4 Preparation

a. Set Logging Interval

The logging interval must be set when the logger in connected to a computer prior to deployment. The logging interval will be set at 1 hour. This is the interval typically used

by the MI DNR. There may be sites at which a different interval has been determined to be more appropriate. If there is a question about the appropriate logging interval, use 1 hour.

b. Site Selection

Local DNR biologists should be contacted to help determine priority watersheds in your area. Watersheds that are of particular interest to your chapter are also good candidates for temperature monitoring. Streams with very little available data and watersheds with dams or other stressors are good candidates for temperature monitoring. Make sure the site being monitored has not recently been monitored by the MI DNR.

The general location of each logger within a watershed should be determined prior to deployment. In addition, access to planned sites should be verified prior to a deployment trip.

Before the deployment date several volunteers should go out and document the sites where loggers are to be placed. This involves taking photographs of each site, marking the spot where the logger should be placed with flagging, and recording GPS coordinates for each site. Flagging may be removed when loggers are deployed to minimize attention. Another strategy is to place flagging on the opposite side of the stream from where the logger is located. This provides a landmark for the logger, but does not attract attention to the actual deployment location.

If placing data loggers above and below a dam make sure the upstream logger is located above the dam impoundment in flowing water and the downstream logger is located no more than ½ mile below the dam.

2.5 Deployment

a. In-stream placement

Selecting a good location within the stream to place each logger is crucial. Each logger should be placed in a position so that it will remain submerged for the duration of the year. If possible, it is best to place each logger in an area that is, and will be, well-mixed and free from sedimentation (a riffle or run is preferred to a pool). Loggers should be placed in an area that is also easily accessible at all times of year (winter excluded).

b. Deployment Apparatus

Loggers will be placed in a piece of PVC pipe to protect them. The PVC pipe will allow water to flow through to ensure accurate temperature readings. The PVC will be connected to a piece of re-bar with zip ties. The re-bar will be pounded into the stream bottom. The re-bar will act as the logger anchor and will prevent it from moving downstream. Figure 1 (Appendix 2A).

- Position the re-bar in the stream making sure it is as close to the bank as possible.

- Attach the PVC pipe containing the logger to the re-bar making sure that water can flow through the pipe and the logger will remain submerged.

Extra precautions may be necessary if temperature is being monitored for an entire year. In the fall, loggers should be moved to an area of the stream where they will most likely not be vulnerable to damage or dislodgement due to ice and flooding. In addition, it is a good idea to cable or wire the loggers and the PVC to something on shore (i.e. tree, root wad, etc.) to minimize the chance losing the logger.

If your chapter currently has a logger deployment technique that works well it can be used. If you are monitoring year round for the first time it is probably a good idea to take extra precautions to minimize the chances of losing each logger.

c. Documentation of Placement

The location of each logger should be carefully documented. GPS coordinates; landmarks, pictures, maps, and/or flagging should be used to clearly mark each location. Make sure all information about the location is written down in a manner that will allow a person who was not present at the time of deployment to locate the logger. Keep in mind that vegetation will not be the same during all seasons, so refrain from relying on grasses or forbs to locate the logger.

d. Label

Do Not Disturb Tag

Loggers should be disguised as well as possible; however, a sign explaining who the logger belongs to and its purpose may be a good idea. This information can be attached to the re-bar or written on the PVC pipe/logger. The tag should include a caution statement and contact information for a chapter member. An example of a tag follows:

CAUTION DO NOT DISTURB
Temperature monitoring project
If you have questions please contact
John Smith, Schrems West Michigan Chapter of Trout Unlimited
Phone and/or email of contact person

Temperature Verification

In stream temperature should be measured with a hand-help thermometer at the time of deployment, when data is downloaded, and when loggers are removed. This information allows us to verify the accuracy of temperature logger readings. To measure water temperature: select a shaded area of the stream towards the middle of the channel, hold a thermometer below the water for at least 60 seconds, read the thermometer while the tip is still in the water, record the water temperature and air temperature. Air temperature should also be taken in a shaded area.

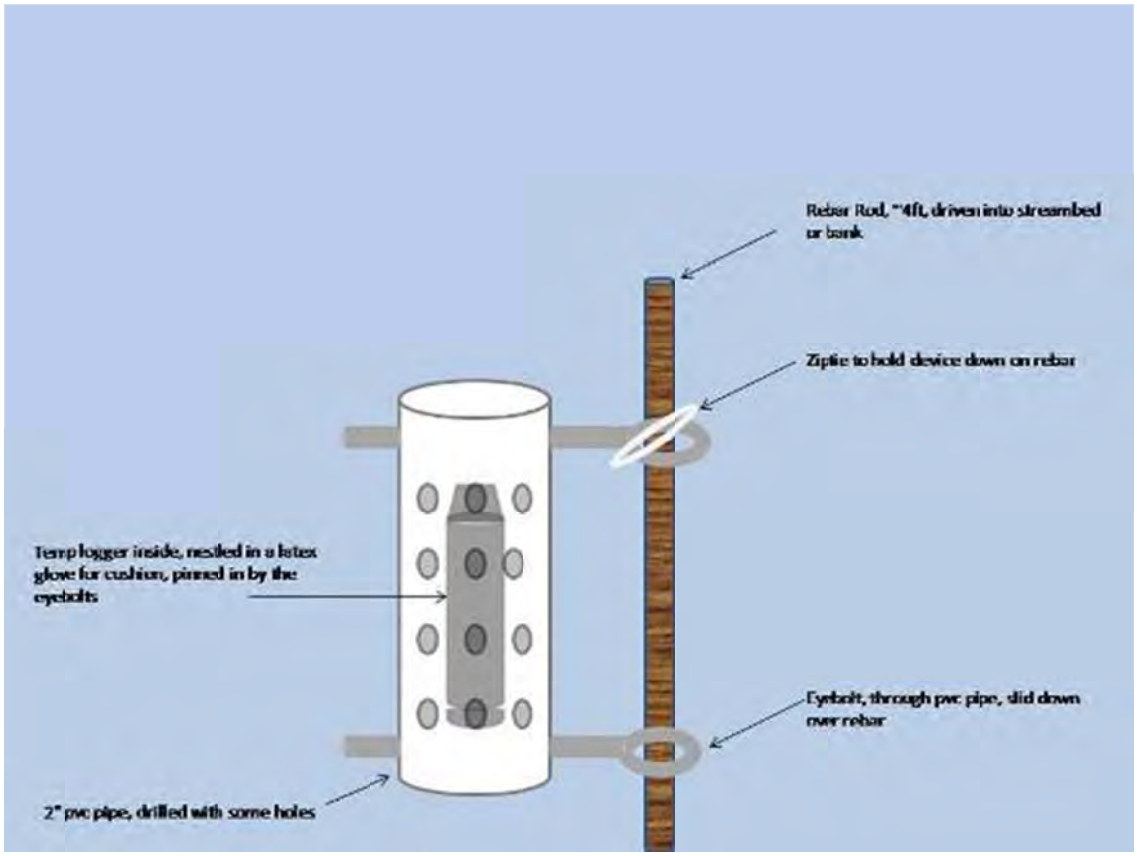


Figure 1. Data logger housing. Logger is nestled in 2 latex gloves to provide extra cushioning. PVC has a 2 inch diameter. Eyebolts bisect the PVC opening preventing the logger from falling out of the pipe.

2.6 Logger Checks

Use the temperature monitoring data sheets (Appendix 2D) when checking on the loggers throughout the year. This log will ask you to indicate the purpose of the visit (download data, visual check, removal etc.). The water temperature at the time of the check should be recorded in the log so that the accuracy of the logger can be checked after the data is downloaded. Use a handheld thermometer to record the water temperature. If you are doing a visual check you are done. If you are downloading data remove the logger from the water and download the data. Redeploy the logger in the same location and record any notes or observation in the temperature monitoring log (e.g. logger buried in sediment, logger in good condition etc.). Loggers should be monitored 1 to 4 times during the course of the year.

2.7 Retrieval

The same information that is recorded on the temperature monitoring data sheets at checks should be recorded when loggers are retrieved after a year. The logger should be

removed from the water and the data should be downloaded offsite. If the logger will not be redeployed in the same location make sure to remove all related materials from the site (e.g. re-bar, flagging etc.).

2.8 Data

There are several types of data of interest. Different DNR biologist will be interested in different types of data. Each chapter is free to explore as many or as few types of data as they see fit. Data will be reported to the MI DNR in the format they desire.

Examples of data of interest include:

<u>Daily measures</u>

- Maximum
- Minimum
- Mean
- Median
- Range
- Count

<u>Monthly measures</u>

- Maximum
- Minimum
- Mean
- Median
- Range
- Count

<u>Yearly Measures</u>

- Maximum
- Minimum
- Mean
- Median
- Range
- Warmest 7 day average
- Coolest 7 day average

For MI DNR stream classifications use **July mean water temperature**

- **Cold** = July mean water temperature **≤63.5° F (17.5°C)**
- **Cold-transitional** = July mean water temperature **>63.5° F (17.5°C) and ≤67° F (19.5°C)**
- **Cool** (or warm transitional) = July mean water temperature **>67° F (19.5°C) and ≤70° F (21°C)**
- **Warm** = July mean water temperature **>70° F (21°C)**

Appendix 2A – Logger Housing

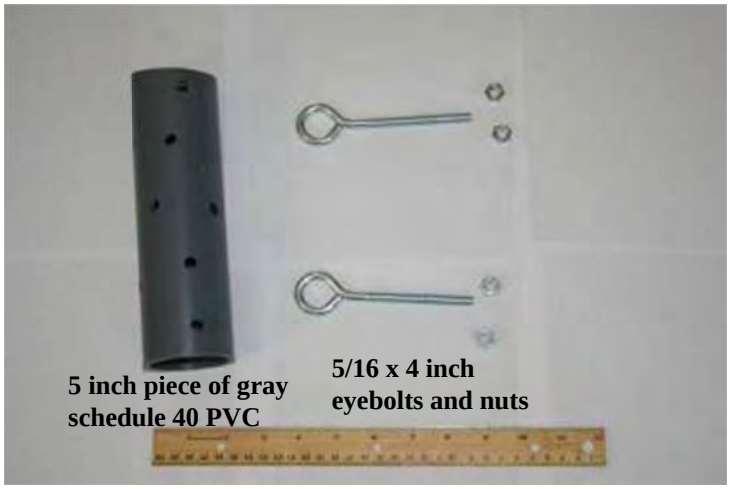
Building Temperature Logger Housing – Pendant loggers 

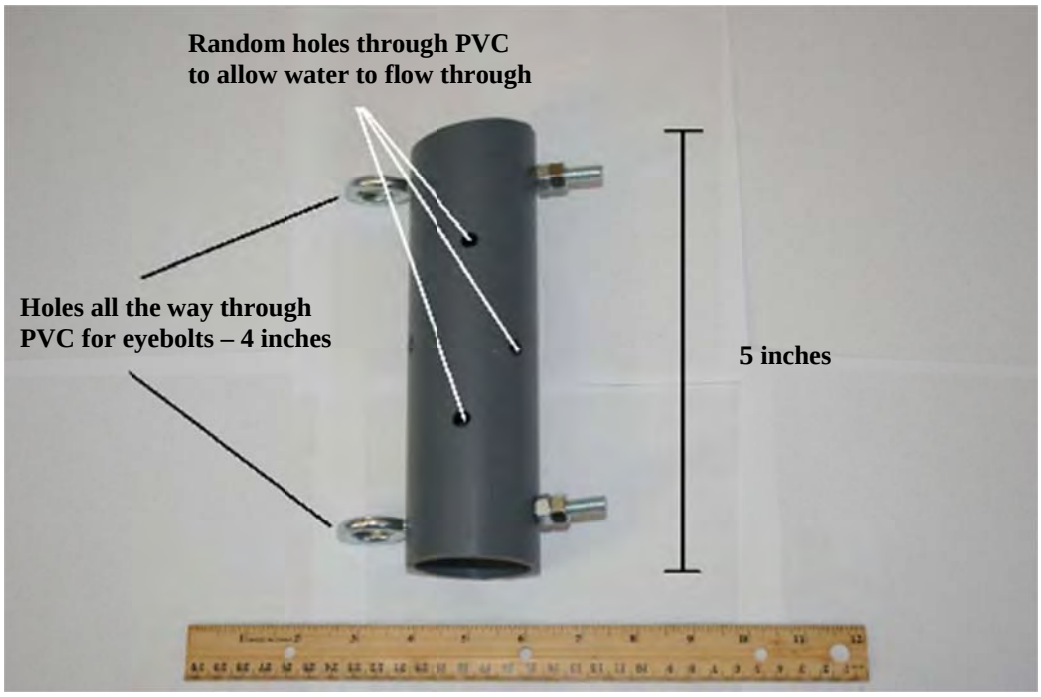
Materials

- ¼ to ½ inch Re-bar (make sure it fits in the eye bolts you buy) –pieces about 4 feet long
- Schedule 40 gray 1 ½ inch PVC Pipe – cut into 5 inch pieces
- 2 5/16 inch by 4 inch plated eyebolts per logger
- 4 5/16 inch plated nuts per logger
- 4-5 Heavy duty zip ties per logger
- Wrench nuts may be needed for removal
- Several cinder blocks (only needed if re-bar method will not work)
- Wire (only needed if re-bar will not work)
- Several wire clamps (only needed if re-bar will not work)
    - Cinder blocks, wire, and wire clamps are an alternative in case rebar will not work in some places. Rebar should work in most instances.
- Wire cutters
- Hack saw with a metal blade
- Plug in drill (cordless is not ideal)
- Drill bit slightly larger than 5/16 of an inch

Step 1

- Cut rebar into 3-4 foot pieces
    - You should be able to saw about ¼ to ½ way through with a hack saw and then break it the rest of the way
- Cut PVC into 5 inch pieces
    - A hack saw works great for this
- Drill two holes all the way through the PVC 4 inches apart
    - The gray schedule 40 PVC is very hard – a regular plug in drill works best – drilling holes with a portable, battery powered drill is pretty tough.
        - Use a drill bit that is slightly larger than the 5/16 eyebolts so they will easily slide through the holes.
    - Make sure the top and bottom holes are drilled in line with one another.
    - This is important because the eyebolts that go through these holes will hold the temp logger in place.



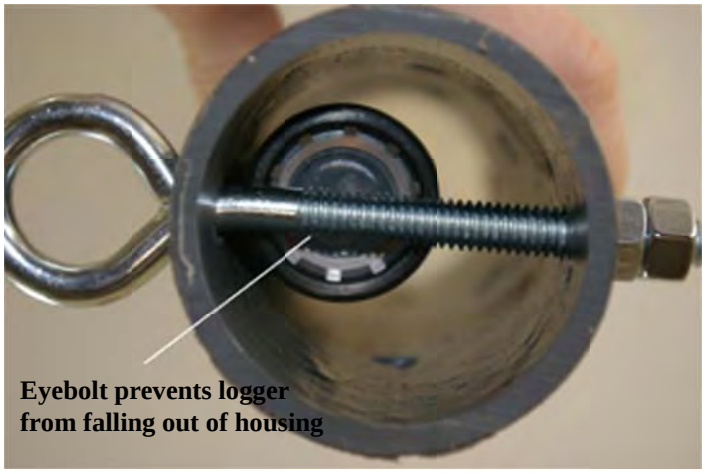


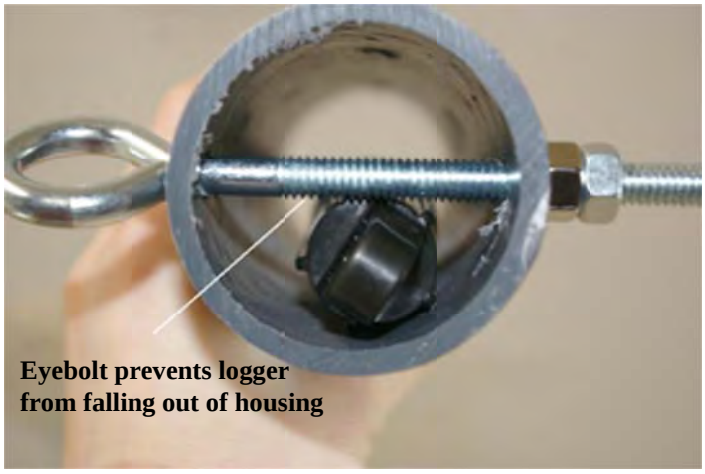
Step 2

- Drill holes randomly in PVC to allow water to flow through the pipe
- These holes do not need to go straight through the PVC pipe

Step 3

- Put in eye bolts and screw on nuts





Cinder Block Alternative Preparation

- If rebar won't work loggers will be housed in and attached to a cinder block
- The only prep for this is cutting the wire
    - If rebar won't work loggers (inside PVC housing) will be placed in a hole of a cinder block
    - Wire will then be strung through both eyebolts and around the cinder block
    - Wire ends will be secured with wire clamps tightly to make sure the logger will not be separated from the cinder block
        - Wire needs to be cut into sections long enough to be secured around a cinder block in this manner.

If neither rebar or a cinder block with work loggers can be placed in protective housing and tethered to a secure object on the stream bank with wire

- Loggers inside PVC housing will be tethered to a tree or root wad on shore with wire and wire clamp

Appendix 2A – Logger Housing

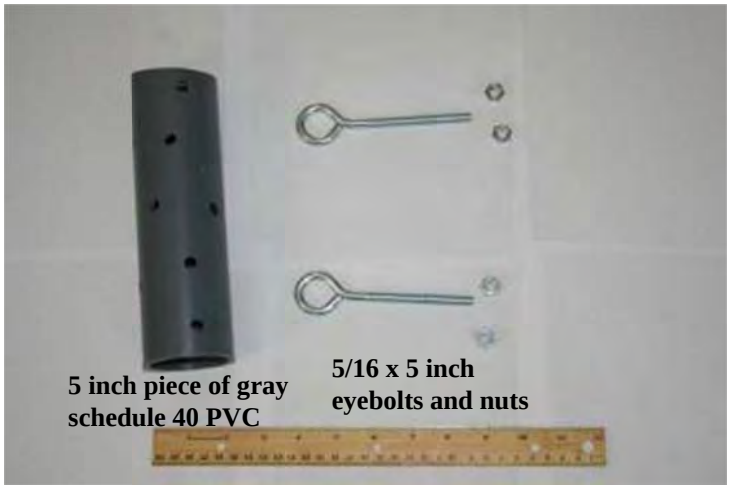
Building Temperature Logger Housing – PRO V2 Loggers 

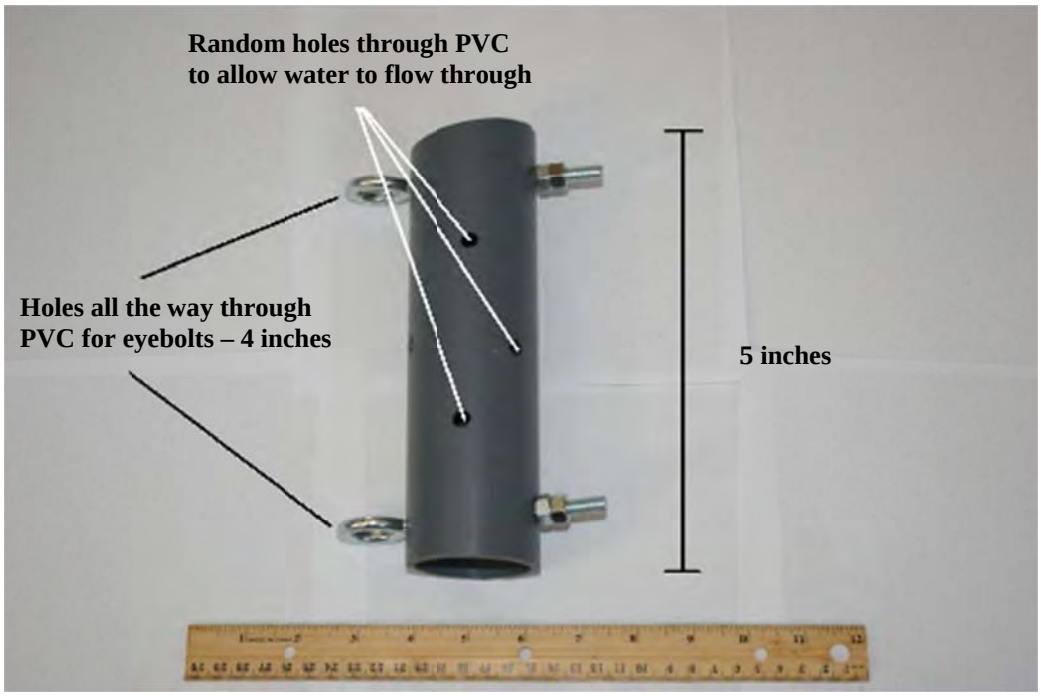
Materials

- ¼ to ½ inch Re-bar (make sure it fits in the eye bolts you buy) –pieces about 4 feet long
- Schedule 40 gray 2 inch PVC Pipe – cut into 5 inch pieces
- 2 plated eyebolts per logger(5/16 x 5 inch)
- 4 5/16 plated nuts per logger
- 4-5 Heavy duty zip ties per logger
- Wrench for lock nuts
- Several cinder blocks
- Wire
- Several wire clamps
    - Cinder blocks, wire, and wire clamps are an alternative in case rebar will not work in some places. Rebar should work in most instances.
- Wire cutters
- Hack saw with a metal blade
- Plug in drill (cordless is not ideal)
- Drill bit slightly larger than 5/16 of an inch

Step 1

- Cut rebar into 3-4 foot pieces
    - You should be able to saw about ¼ to ½ way through with a hack saw and then break it the rest of the way
- Cut PVC into 5 inch pieces
    - A hack saw works great for this
- Drill two holes all the way through the PVC 4 inches apart
    - The gray schedule 40 PVC is very hard – a regular plug in drill works best – drilling holes with a portable, battery powered drill is pretty tough.
        - Use a drill bit that is slightly larger than the 5/16 eyebolts so they will easily slide through the holes.
    - Make sure the top and bottom holes are drilled in line with one another.
    - This is important because the eyebolts that go through these holes will hold the temp logger in place.



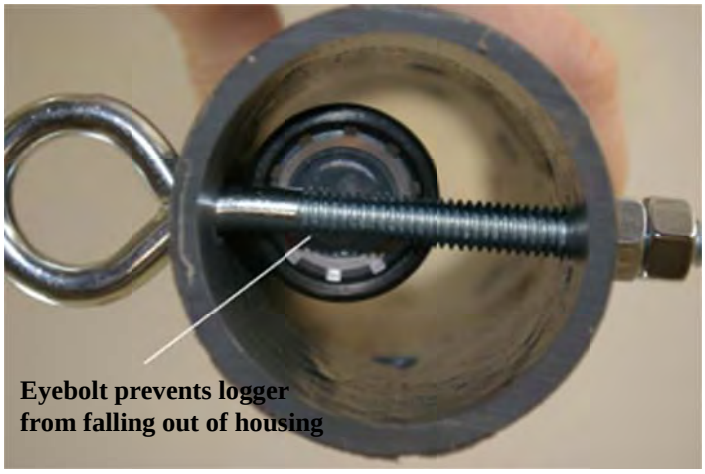


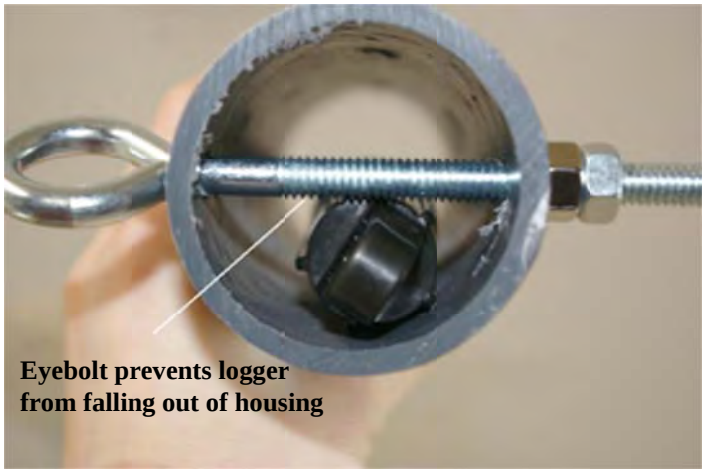
Step 2

- Drill holes randomly in PVC to allow water to flow through the pipe
- These holes do not need to go straight through the PVC pipe

Step 3

- Put in eye bolts and screw on nuts





Cinder Block Alternative Preparation

- If rebar won't work loggers will be housed in and attached to a cinder block
- The only prep for this is cutting the wire
    - If rebar won't work loggers (inside PVC housing) will be placed in a hole of a cinder block
    - Wire will then be strung through both eyebolts and around the cinder block
    - Wire ends will be secured with wire clamps tightly to make sure the logger will not be separated from the cinder block
        - Wire needs to be cut into sections long enough to be secured around a cinder block in this manner.

If neither rebar or a cinder block with work loggers can be placed in protective housing and tethered to a secure object on the stream bank with wire

- Loggers inside PVC housing will be tethered to a tree or root wad on shore with wire and wire clamp

Appendix 2B – Logger Deployment

Temperature Logger Deployment

Materials for deployment

- Temp logger
- Logger housing and rebar
- Zip ties and latex gloves
- Permanent marker
- Cinder block (in case rebar will not work)
- Wire and wire cutters
- Heavy duty hammer/sledge hammer for pounding in rebar
- Handheld GPS (if available)
- Data sheets and pencils
- Digital camera (if available)

Deployment Procedure

- Write on PVC or attachable tag with permanent marker
    - Please Do Not Disturb
      Temperature Logger your chapter of Trout Unlimited
      Contact chapter rep (fill in email and/or phone) with questions
- **Select appropriate site for logger placement**
    - For sites with maps and photos choose a location near where photos were taken
        - The logger does not have to be in the exact location depicted use your judgment
        - Try to choose a spot in the area where the logger can be placed up against the bank
        - Make sure to document the logger location well
    - Make sure water is flowing (run or riffle)
    - Make sure logger will stay submerged all summer
    - Pound rebar into streambed
        - Place rebar out of the way; very close to the bank. We want it to be camouflaged and we don't want it to be a hazard to stream users.
            - Try to pound the rebar down far enough that it is slightly below the waters surface
            - Place the PVC a couple of inches off the bottom
        - If rebar simply won't work (can't be pounded, no good spot etc.) use a cinder block instead (see directions below).
    - Make sure the number on the logger matches the logger number to be used at that site
        - Sites and corresponding logger number are written on the outside of each Ziploc bag
        - The logger number is the last 2 digits of the serial number which is written in black on the blue logger label
        - There is also a label affixed to each logger with the correct site
            - Remove this label just before you deploy the logger

- **When rebar is in place**
    - Remove top eye bolt from PVC and put the logger in the PVC pipe

    - Replace top eye bolt
    - Loosely connect the top eye bolt to the rebar with 2 to 3 zip ties
        - Leave zip ties loose enough to allow you to move the housing down the rebar
    - Lower the housing into place and tighten the zip ties

- **When logger is in place in the stream**
    - Record the GPS location of the logger (if you have a GPS)
    - Write down/draw landmarks describing where the logger is located
    - Fill in information on "Temperature Logger Status Log"
    - Take LOTS of pictures of the logger, logger housing, and site (If you have a camera)
    - Record your time and mileage in your volunteer time and travel log!

If rebar won't work

- Use a cinder block.
- Place the logger in the housing as described above
- Place the housing in one of the holes in the cinder block
    - It is ok if it hangs out at one end
    - String a length of wire through both the top and bottom eyebolts and around the cinder block
    - Secure the ends of the wire around the cinder block
    - Place the cinder block in the appropriate location in the stream
    - Document the site as described above

Appendix 2C – Downloading Data

Temperature Logger Data Download Directions

Materials

- Data shuttle and water temp pro v2 coupler
- Heavy duty zip ties
- Hammer/small sledge hammer
- Knife or scissors to cut zip ties
- Temperature Logger Status Log and Volunteer Time and Travel Log sheets
- Pencils
- A soft cloth
- A watch
- A wrench if you used lock nuts

1. **Locate** the logger of interest
2. **Remove PVC and logger from stream**
    a. Cut the zip ties connecting the logger housing to the rebar
    b. If zip ties cannot be cut
        i. Remove rebar and housing together
    c. When you have the housing out of the water remove the logger from the PVC pipe by removing one of the eyebolts and sliding the logger out
3. When you have the logger out of the water remove it from the rubber gloves and **gently dry the wide (infrared) end with a soft towel**
4. Put the **"Water Temp Pro V2" coupler** on the data shuttle
5. **Slide the wide end of the temperature logger into the coupler** making sure to align the arrow on the logger and the arrow on the coupler
6. Press on the **coupler lever** (bar to right of arrow on coupler)
7. The shuttle LED light will be illuminated when a connection is made
8. The **orange LED** light blinks continuously while **download is in progress**
    a. Do not remove the logger when the orange LED is blinking
    b. This is important because after reading the logger the shuttle synchronizes the logger's clock to the shuttle's internal clock. If the logger is removed early the time will not be correct.
9. The logger is **ready to be re-deployed when the green LED light blinks**.
    a. This light will blink for 15 minutes or until you briefly press the coupler lever
10. Remove the logger from the coupler
11. Put it back in the rubber gloves
    a. Make sure the sensor end (has a hole) is not covered, tie gloves in place using glove fingers
12. If you only removed the PVC housing
    a. Slide eyebolts onto the rebar
    b. Loosely attach the top eyebolt with 2 zip ties
    c. Slide the housing into place and tighten the zip ties to secure the housing
13. If you removed the entire housing apparatus pound the rebar back into the streambed
    a. **Do not** pound PVC with housing and logger attached

b. Remove housing and reattach after rebar is pounded
c. When rebar is in place slide the eyebolts onto the rebar
d. Loosely attach the top eyebolt with 2 zip ties
e. Slide the housing into place and tighten the zip ties to secure the housing

14. Fill in information on the "Temperature Status Log"

15. Record your **time** and **mileage** on your **volunteer time and travel log**

Troubleshooting

Red "fail LED Blinks
The red "fail" LED blinks whenever the shuttle encounters an error. Causes of this error may be:

- **Shuttle is full**: If the red LED blinks when you try to download data from a logger, check whether all of the banks are full. The shuttle has 63 banks each of which can hold 1 logger download.
  - To check if the shuttle is full, remove the logger and press the coupler lever for at least 3 seconds. When you release the lever, the green LED blinks once for each unoccupied bank in the shuttle memory.
  - If the green light blinks clean the surfaces and try again.
  - If the green light does not blink indicating the shuttle is full put the logger back into the stream and return the shuttle to the chapter project manager so the data can be downloaded.

- **Can't communicate with logger (LED lights do not light up)**: Remove the logger and coupler. Inspect the logger and the shuttle to ensure they are free of dirt that could block the sensor. Reassemble the shuttle, coupler, and logger and shield the shuttle from strong sunlight and try again. If the shuttle still will not download the logger data put the logger back into the stream and notify the chapter project manager or a MITU staff person of the problem.

- **Shuttle batteries are low**: If you cannot download any logger data the batteries may need to be charged. The battery must be checked with a computer with HOBOware installed. Put logger back into the stream and notify the chapter project manager or a MITU staff person about the shuttle.

- **Other logger problems**: If you can download data from some loggers but not others the unreadable loggers will need to be checked in HOBOware. Put these loggers back into the stream and notify the chapter project manager or a MITU staff person on the problem.

Please note, each time you charge the shuttle batteries you must relaunch the shuttle in HOBOware. If the shuttle is not relaunched in HOBOware after the batteries are charged it will NOT download data.

If you cannot get the logger data to download put the logger back into the stream and notify Kristin Thomas (616-460-0477) knelson@michigantu.org) or your chapter project manager.

Appendix 2D – Temperature Logger Log

Location	Date mm/dd/yy	Activity	Time	Water Temp.	Notes

Activity examples = deploy, download, visual check, etc.
Water temp - record if using Celsius or Fahrenheit
Notes examples = logger buried in debris/sediment, logger in good condition, etc.