Continuous Temperature Sampling Protocols for the Environmental Monitoring and Trends Section

December 2003

Publication No. 03-03-052
printed on recycled paper

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Continuous Temperature Sampling Protocols for the Environmental Monitoring and Trends Section

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Abstract

This document describes the protocols used by the Washington State Department of Ecology, Environmental Assessment Program, Environmental Monitoring and Trends Section to collect continuous water temperature data at stream monitoring stations.

The purpose of this sampling program is to (1) collect continuous temperature data that may be used for trend analyses and (2) determine compliance with current and proposed water quality standards. The data may also be used to interpret the historical monthly temperature data from each sampling station.

Although it is intended as a guidance manual for staff involved with continuous temperature sampling, it may also be useful to individuals who would like to know more about these Ecology protocols.

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Introduction

This document describes the procedures used by the Environmental Monitoring and Trends Section staff to collect continuous temperature data at stream monitoring stations located across the state. Although it is intended as a guidance manual for staff, it may also be useful to individuals who would like to know more about these Ecology protocols.

The current continuous temperature sampling program focuses on summer (June-September) stream temperatures at Ecology's long-term and basin monitoring stations where temperature and 13 other conventional parameters are monitored once a month (Hallock, 2003a, and Ward, 2001). Additional sampling may also be done at other locations based on need and available resources.

The procedures generally follow those developed by Timber/Fish/Wildlife (TFW) Stream Temperature Survey Manual (Schuett-Hames et al., 1999) with additional protocols for larger streams. The temperature equipment used is summarized in Table 1 (see below). *Note: Other equally reliable and accurate temperature equipment may also be used.*

Table 1. Summary of Temperature Equipment

Equipment	Accuracy	Reporting Limit
Certified Reference Thermometer/ # 61099-035, HB Instrument Co.	0.1 °C	0.1 °C
Field Thermometer/ # 1546RL, Brooklyn Thermometer Co.,	0.2 °C	0.1 °C
Thermistor Thermometer/ #U-08402 Thermistor & #U-93823 Probe, Cole Parmer Co.,	0.3 °C	0.1 °C
Temperature Logger (Water/Air) #TBI 32-05+37 StowAway TidbiT, Onset Computer Corp.	0.2 °C	0.1 °C
Temperature Logger (Air) #TBI 32-20+70 StowAway TidbiT, Onset Computer Corp.	0.2 °C	0.1 °C

Preparation

A checklist (Appendix A) is used to ensure that all of the necessary tasks, equipment, supplies, and safety gear have been dealt with before departure.

Note: Before departure, a completed field work plan and contact person form (Appendix B) must be submitted to the section secretary. This information enables family and other program staff to contact field staff in case of an emergency or conduct a search if there was a mishap. If plans change (lodging, cell phone number, etc.) field staff must contact a supervisor or the section secretary to update the information. Also, if field staff fail to check in with the contact person, then the contact person needs to notify the supervisor to begin efforts to locate the field staff. Also Note: Van cell phones need to be kept on during work hours.

Calibration Checks

Calibration checks are used to document logger bias and performance to assure the quality of the data. The pre-deployment calibration checks are completed in advance of logger deployment and the post-deployment calibration checks are done shortly after the sampling results have been downloaded and backed up. *Note: The field thermometer or thermistor thermometer used in the study to collect the site temperature measurements also need to be checked during this process so any necessary correction factors can be applied to results from these devices.*

Temperature loggers undergoing a calibration check should be programmed for a *delayed start* and set to record *point measurements* every five minutes[1]. In addition, the logger high, low and multiple sampling features need to be turned off.

Calibration checks should subject the temperature loggers to at least two water bath temperatures that bracket the expected sampling range (near 20 and 0°C). The preferred method is to place one open cooler half full of water over night in a room that has a constant air temperature near the lower end of temperature sampling range and another cooler (setup similarly) in a different room at the higher end of the temperature sampling range.

Temperature loggers should obtain at least five (5) relatively constant measurements at each of the two (2) target temperatures (a minimum of 10 measurements). In order to achieve this, the temperature loggers should be given about 10 minutes of acclimation time after they have been transferred into a water bath and the water should be gently stirred to ensure a uniform temperature. In addition, a Certified Reference Thermometer must be used to obtain accurate temperature measurements that can be used to evaluate the logger results. *Note: Record the Certified Reference Thermometer measurements on the Calibration Check Form (Appendix C). Also refer to the* Example of a Completed Calibration Check Form *(Appendix D).*

[1] A one minute interval may also be used.

Logger results should be downloaded soon after the testing process has been completed to shut them off and to also minimize battery life impacts.

Logger results may then be transferred into spreadsheet software programmed to calculate the mean absolute value of the difference between the logger measurements and the Reference Thermometer (see example in Appendix E). This difference indicates the accuracy range of the instrument (see Quality Control Procedures for more details).

Temperature loggers evaluated during a pre-deployment check that have a mean absolute value difference beyond 0.2°C for water sampling (-5°C to +37°C Stow-Away TidbiT) or 0.4°C for air sampling (-20°C to +50°C Stow-Away TidbiT) should be rejected until the problem has been corrected and the logger passes another calibration check. *Note: Only those temperature loggers that pass the calibration check requirements may be programmed for deployment.*

If a temperature logger fails a post-sampling calibration check, then another calibration check must be performed. If it fails a second calibration check, then the raw data should be adjusted by the mean difference of the pre and post calibration check results to correct for the instrument bias (Schuett-Hames et al., 1999).

Deployment Procedure

Safety is the primary concern when deploying temperature loggers. Based on the Environmental Assessment Program, Safety Manual (Ecology, 2003), two field staff are required when streams are waded. One can deploy the stream temperature loggers and the other can assist with documentation. If stream side hazards such as high flow, weather, and debris make temperature logger installation dangerous, then an alternate location or different deployment time should be considered.

Prior to departure, the temperature loggers should be programmed for a *delayed start* and set to record *point measurements* every half-hour. In addition, the logger high, low and multiple sampling features need to be turned off. *Note: Prior to beginning the process to program a temperature logger, the desk top computer clock and the watch used to record deployment times, need to be set to atomic clock time for the Pacific Time Zone. Also note: the delayed start time for the temperature loggers may be set for the first planned deployment time of the season or based on daily or weekly needs.*

During the deployment process, all field data including station number, station name, temperature logger ID numbers, and air and water temperature measurements obtained with a thermometer or thermistor thermometer need to be recorded on the Continuous Temperature Station Survey Form (see Appendix D). A sketch and description of the logger locations that note a landmark reference point such as a unique rock, log, root, or tree should also be recorded (see Figure 1). In addition, a picture of the water temperature logger location, including a landmark, should be taken to use to help relocate it in the future.

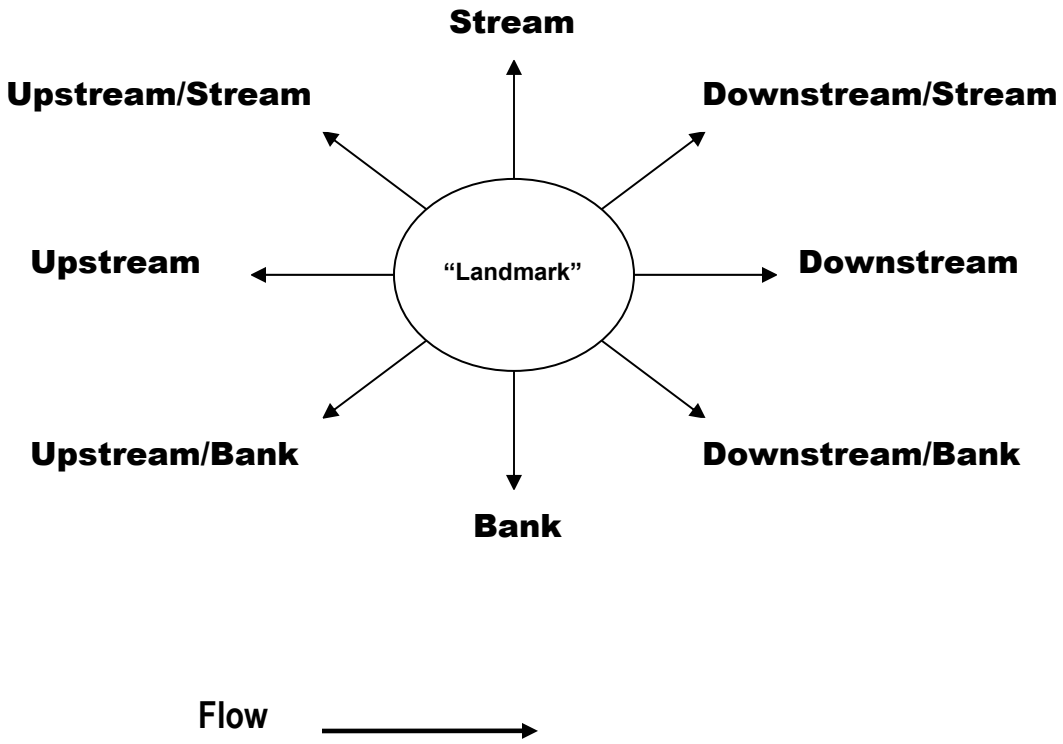

Figure 1. Landmark Reference Points for Temperature Loggers

Water Temperature Loggers

The deployment procedure for the water temperature loggers generally follow the procedures described in TFW Stream Temperature Survey Manual (Schuett-Hames et al, 1999). In small streams, loggers should be installed as close to the thalweg as possible and six (6) inches off the bottom. In large streams, areas of potential temperature stratification (resulting from eddies, groundwater, and tributaries) need to be avoided. In addition, a 2 – 2 ½ foot deep location downstream or alongside a landmark rock or stream bed feature improves the chance of it staying submerged during its deployment period and being located for retrieval.

The most common water temperature logger deployment method utilizes the following equipment:

- Water Temperature Logger (Onset Computer StowAway TidbiT Part No. TBI32-05+37).
- Air Temperature Logger (Either a water temperature logger (noted above) or an Onset Computer StowAway TidbiT Part No. TBI32-20+50 for those locations where air temperatures may exceed 100 °F).
- 16 inch Red Liquid Thermometer (Brooklyn Thermometer Co. Part No. 1546RL).
- 2 to 3-foot piece #4 rebar (⅜ inch diameter).

- 4# Hammer.
- Rebar pounder (see Appendix E).
- 2-2 ½ inch length of 1 ½ inch camouflage-painted PVC pipe (gray - electrical conduit) with ⅜ inch holes drilled through it, about ⅜ inch from one end (see Appendix F).
- Three seven-inch black nylon cable ties (TY-RAP 7″) or clear ones that have been camouflage painted.

The installation process begins streamside by first putting the red liquid thermometer as close as possible to the location where the air temperature logger will be located. Then a cable tie should be threaded through one ⅜ inch hole in the PVC pipe, the attachment hole of a pre-programmed temperature logger, and through the other ⅜ inch hole of the pipe. Next, the cable tie needs to be cinched over the end of the PVC pipe. Finally, a second cable tie should be cinched around the first one leaving an approximately one inch diameter loop (see Figure 2), and the entire assembly put in a pocket of the person who will install it.

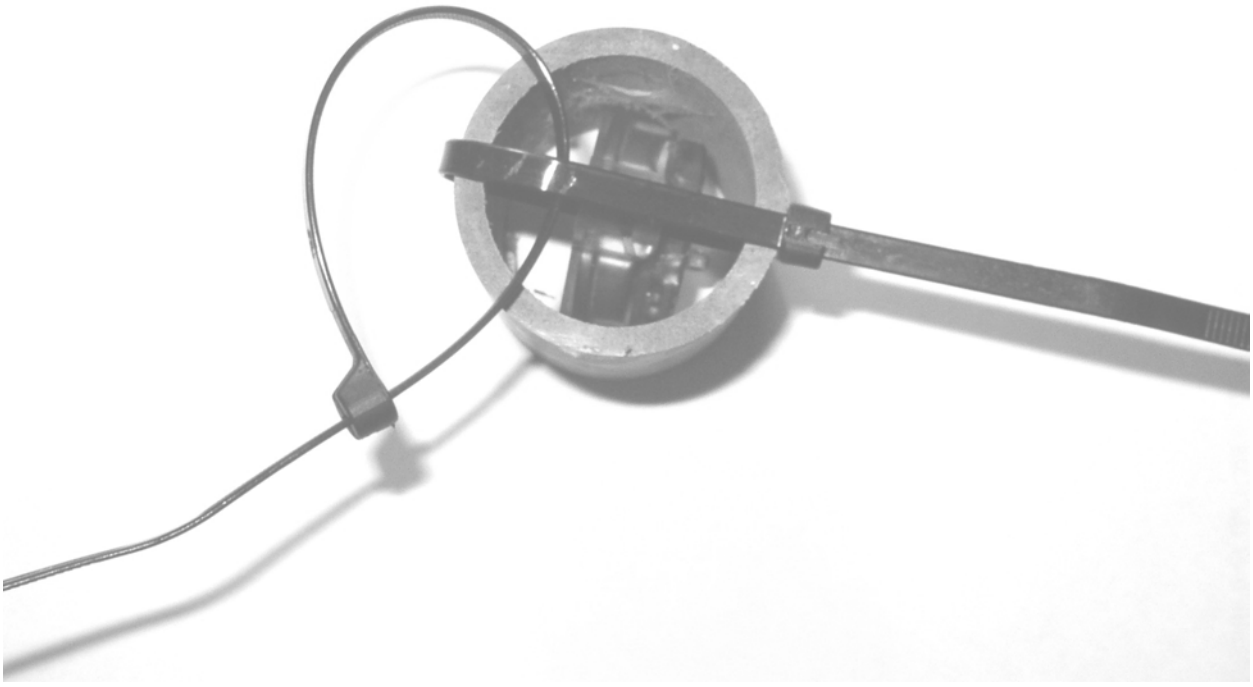

Figure 2. Temperature Logger/PVC Pipe Assembly

The next step in the process is to find a water temperature logger deployment location in the stream that is safe to get to and where representative stream temperature data may be obtained during lower flows. In most cases the preferred location is on the downstream or downstream-stream side portion of a large landmark rock or log. The recommended method of anchoring a

temperature logger in this type of location requires the use of a 4# hammer or sledgehammer and a rebar-pounder to hammer all but eight inches of a piece of rebar into the stream bed. The next step is to attach temperature logger assembly to the rebar about ½ foot off the bottom with the second cable tie. In fast-flowing locations an additional cable tie should be attached to the rebar just above the temperature logger assembly attachment point to prevent its loss should the second cable tie loosen on the rebar.

Other possible water temperature logger deployment locations/methods include attachment to near-shore submerged tree roots or limbs, to piling or anchored pipes using chain, or to a pier block that has been set in deeper water and secured to a near-shore submerged root or structure with a chain tag line or cable.

Air Temperature Loggers

The preferred air temperature logger locations in Western Washington should be as near to the water temperature logger as possible but 3 to 10 feet into the riparian zone from the bankfull width and also about 3 feet off the ground. Air temperature loggers in Eastern Washington should also be as close as possible to the water temperature logger location but because a riparian zone may not exist, the only choice may be the nearest tree or shrub. Regardless of the location, the air temperature logger needs to be shaded from sunlight by deploying them in camouflage-painted PVC pipe and by attaching them on the north side of a tree or shrub.

Mid-Deployment Check Procedure

In all locations, the mid-deployment check procedure relies heavily on monthly ambient water temperature measurements, stream flow information, and staff observations made at the ambient monitoring stations. Based on this information, the water temperature logger site may be visited during its deployment to check the logger depth and if necessary re-locate it to a deeper location. If the site is visited, air and water temperature measurements, and any other observations need to be noted on the Continuous Temperature Station Survey Form (Appendix D) for that station.

Retrieval Procedure

The retrieval procedure should go quickly, if the temperature loggers or locations were relatively undisturbed during deployment and if deployment locations were well documented. The air and water temperature measurements, the depth of the water temperature logger, and any other observations need to be noted on the Continuous Temperature Station Survey Form. In some instances, the rebar, chain, or pier block should be removed to prevent their loss or to prevent them from causing injury to others who may happen to wade through the location.

Downloading Procedure

The temperature loggers should first be gently cleaned to remove any biofouling or sediment that may affect its ability to communicate optically during the downloading process. The preferred way has been to use a little water and a soft cloth or soft bristled brush.

Prior to beginning the process to download the temperature loggers, the desk top computer clock needs to be set to atomic clock time for the Pacific Time Zone. The loggers should then be connected and downloaded following the manufacturers' procedures. The logger results should then be saved in a file type that may be opened in Excel or another type of spread sheet software.

Quality Control Procedures

Stream and air temperature data, recorded before and after the deployment period, must be identified and deleted from each raw data set based on the information noted on the Continuous Temperature Station Survey Form (deployment/retrieval times and temperatures).

Anomalous data[2], may then be identified by reviewing a plot of the air and water temperature results and by comparing any questionable results to ambient monitoring temperature data, flow information, and field notes. Identified data anomalies then may be deleted from the record provided the reason has been noted on the Continuous Temperature Station Survey Form for the station and also noted in the electronic version of the data record.

The accuracy of the temperature loggers need to be verified by evaluating the results of pre- and post-deployment calibration checks (see Calibration Checks, page 3). If the results indicate a consistent bias of more than 0.2º C, then the raw data may need to be adjusted or flagged with the appropriate data qualifier.

[2] A typical example would be when a deployed water temperature logger nears or goes above the surface of the water due to low stream flow. The results plot would begin to show a significantly higher daily swing of water temperatures when the logger was affected by being close to the water surface. The results plot may also show water temperatures that swing higher and lower than the daily air temperatures.

Literature Cited

Hallock, D. 2003. *River and Stream Ambient Monitoring report for Water year 2002.* Washington State Department of Ecology, Environmental Assessment Program, Olympia, WA. Publication No. 03-03-032, 17pp. + appendices.

Schuett-Hames, D., A. E. Pleus, E. Rashin, and J. Mathews. 1999. *TFW Monitoring Program method manual for the Stream Temperature Survey*. Prepared for the Washington State Department of Natural Resources under the Timber Fish and Wildlife Agreement, Olympia, WA. TFW-AM9-999005. DNR # 107. June.

Ward, W. 2002. *Stream Sampling Protocols for the Environmental Monitoring and Trends Section*. Washington Department of Ecology, Environmental Assessment Program, Olympia, WA. Publication No. 01-03-036, 31pp. + appendices.

Appendix A

Continuous Temperature Sampling Checklist

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Continuous Temperature Sampling Checklist

Pre-Deployment Preparation

_____ Determine Number of Stations
_____ Determine Deployment Equipment Needs
_____ Obtain or Make Deployment Equipment
_____ Check Calibration of:
_____ • Temperature Loggers
_____ • Thermometer
_____ • Thermistor
_____ Plan Deployment Schedule
_____ Schedule Field Assistance
_____ Program Temperature Loggers
_____ Make Motel Reservations
_____ Fill out Field Work Plan and Contact Person Designation Form
_____ Gas Van

Van/Safety Equipment

_____ Tire Chains
_____ Yellow Hazard Beacon
_____ Flashlight
_____ Tool Chest
_____ Jumper Cables
_____ Flares/Reflectors
_____ First Aid Kit
_____ Foil Blanket
_____ Orange Vests
_____ 2 Gallons Drinking Water
_____ Hand Towels
_____
_____

Sampling Equipment and Supplies

_____ Programmed Temperature Loggers
_____ Continuous Temperature Survey Forms
_____ Thermometer
_____ Thermistor
_____ Compass
_____ Maps
_____ Watch
_____ Camouflaged PVC Pipe
_____ Cable Ties
_____ Rebar Pounder
_____ 3/8 inch x 2 – 3 Ft. Rebar Pieces
_____ 4# Hammer
_____ Several lengths of Chain
_____ Pyramid Blocks
_____ Small Wire Cutters
_____ 6’ Pole W/Hook
_____ Knife
_____ Hand Trimmer
_____ Machete
_____ Survey Flagging
_____ Digital Camera

Personal Gear

_____ Rain Gear
_____ Knee Boots
_____ Waders
_____ Gloves
_____ Extra Clothing
_____ Hat
_____
_____
_____
_____

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Appendix B

Field Work Plan and Contact Person Form

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FIELD WORK PLAN & CONTACT PERSON FORM (page 1 of 2)

Field leader completes needed information on both pages. Field leader must add a *Float Plan* if Ecology boats are to be used. Field Leader must add information about non-Ecology boats if they are to be used.

Field Leader Name _____

Field Staff Name(s)_____

_____

Vehicle Info (make, model, color, license) _____

_____

Vehicle Phone Number _____

Non-Ecology Boat Name & Phone Number _____

Non-Ecology Boat Operator's Name & Phone Number_____

_____

Date/Time of Departure _____

Estimated Date/Time of Return _____

Sampling "Run" or station list description (attach separate sheet or map if preferred):

Run/Station/Facility/Site	Location
_____	_____
_____	_____
_____	_____

Driving Directions (attach separate sheet or map if preferred):

Lodging Plan:

Date	Hotel/Motel	Phone
_____	_____	_____
_____	_____	_____
_____	_____	_____

FIELD WORK PLAN & CONTACT PERSON FORM (page 2 of 2)

Complete this page if field work goes after regular working hours or involves overnight stays.

Contact Person & phone to notify to close Field Work Plan _____

_____

(Contact Person can be anyone able and willing to perform search operations).

Date/time to begin search operations if field crew hasn't checked in _____

Search Operations

The following steps should be taken by the contact person if the field crew doesn't check in by the time given above to close the Field Work Plan.

1. Call the vehicle or boat's phone _____ (can try VHF ch.16 if boat).
2. Call the field leader. Office _____ Home _____
3. Call other field staff. Office _____ Home _____
4. Call the scheduled hotel(s).
5. Call other places or persons who may have information on whereabouts of field crew (e.g. friends, family, co-workers).
6. Check Ecology or other parking lots for the vehicle.
7. Call the Unit Supervisor or designated backup to inform them of the situation and reach a decision whether to contact the Washington State Patrol and/or pursue other search activities.

   Unit Supervisor: Name _____ Office_____Home____

   Designated Backup: Name _____ Office_____Home____

If warranted, call the *Washington State Patrol Emergency Dispatch (360) 438-7700* and request a road check of the route the vehicle would take while doing field work. Give WSP a vehicle description (make, model, year, color, license plate number). Ask WSP dispatch whether you should contact the local County Sheriff's office.

8. In case of extended search operations or emergencies, the contact person should call the following persons designated by the field staff (e.g. family members, friends):

Name_____ Phone_____

Name_____ Phone_____

Name_____ Phone_____

Name_____ Phone_____

Appendix C

Calibration Check Form

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Temperature Logger Calibration Check Form

Technicians: **Date: _____**

Pre-

Time	NIST SN-	Thermister SN-	Red Liquid SN-	Red Liquid SN-	Red Liquid SN-

Technicians: **Date: _____**

Post-

Time	NIST SN-	Thermister SN-	Red Liquid SN-	Red Liquid SN-	Red Liquid SN-

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Appendix D

Example of a Completed Calibration Check Form

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Temperature Logger Calibration Check Form

Technicians: B. WARD, B. STRONG **Date:** 6/3/02

Pre-

Time	NIST SN- 2L2087	Thermister SN- LLTS	Red Liquid SN- 8N935	Red Liquid SN- 8N358	Red Liquid SN-
0930	5.4	5.4	5.3	5.4	
0935	5.4	5.4	5.3	5.4	
0940	5.4	5.4	5.3	5.4	
0945	5.4	5.4	5.3	5.4	
0950	5.4	5.4	5.3	5.5	
0955	5.4	5.4	5.3	5.4	
1000	—	—	—	—	
1005	18.4	18.4	18.3	18.4	
1010	18.4	18.4	18.3	18.4	
1015	18.45	18.4	18.4	18.5	
1020	18.5	18.5	18.4	18.5	
1025	18.5	18.5	18.4	18.5	
1030	18.5	18.5	18.4	18.5	

Technicians: B. WARD, B. STRONG **Date:** 11/18/02

Post-

Time	NIST SN- 2L2087	Thermister SN- LLTS	Red Liquid SN- 8N935	Red Liquid SN- 8N358	Red Liquid SN-
0930	4.2	4.3	4.1	4.3	
0935	4.2	4.3	4.1	4.3	
0940	4.2	4.3	4.1	4.3	
0945	4.2	4.3	4.2	4.3	
0950	4.2	4.3	4.2	4.3	
0955	4.2	4.3	4.2	4.4	
1000	—	—	—	—	
1005	18.5	18.5	18.4	18.5	
1010	18.5	18.5	18.4	18.6	
1015	18.5	18.5	18.3	18.6	
1020	18.4	18.5	18.3	18.6	
1025	18.4	18.5	18.3	18.6	
1030	18.4	18.5	18.3	18.5	
1035	18.4	18.5	18.3	18.5	

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Appendix E

Example of Calibration Check Worksheet

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Calibration Check Worksheet

Date Time	NIST Ref Temp	Serial # 406600	Diff.	Serial # 406601	Diff.	Serial # 410740	Diff.	Serial # 415594	Diff.
1/7/03 9:30	19.1	18.89	0.21	18.9	0.20	18.94	0.16	19.31	0.21
1/7/03 9:35	19.1	18.89	0.21	18.9	0.20	18.94	0.16	19.31	0.21
1/7/03 9:40	19.1	19.06	0.04	18.9	0.20	19.1	0.00	19.31	0.21
1/7/03 9:45	19.2	19.06	0.14	19.06	0.14	18.94	0.26	19.37	0.17
1/7/03 9:50	19.2	19.06	0.14	19.06	0.14	18.94	0.26	19.37	0.17
1/7/03 9:55	19.2	19.06	0.14	19.06	0.14	18.94	0.26	19.37	0.17
1/7/03 10:00									
1/7/03 10:05	3.9	3.68	0.22	3.73	0.17	3.63	0.27	3.66	0.24
1/7/03 10:10	3.9	3.68	0.22	3.73	0.17	3.63	0.27	3.66	0.24
1/7/03 10:15	3.9	3.68	0.22	3.73	0.17	3.63	0.27	3.66	0.24
1/7/03 10:20	3.9	3.68	0.22	3.73	0.17	3.63	0.27	3.66	0.24
1/7/03 10:25	3.9	3.68	0.22	3.73	0.17	3.63	0.27	3.66	0.24
1/7/03 10:30	3.9	3.68	0.22	3.73	0.17	3.63	0.27	3.66	0.24
	Mean Difference		**0.18**		**0.17**		**0.23**		**0.22**
	Accuracy		***0.20***		***0.20***		***0.20***		***0.40***

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Appendix F

Continuous Temperature Station Survey Form

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Continuous Temperature Survey Form

Station #: _____ **Station Name:** _____ **Samplers:** _____

Interval Frequency 00:30

Water Temperature Logger

I.D. # _____

Water Depth _____ ft Deployment Depth _____ ft

Height (Abv Bottom) _____ ft Retrieval Depth _____ ft

Air Temperature Logger

I.D. # _____

Height (Abv Stream) _____ ft

Date	Time	Water Temp	Air Temp	Weather/ Comments

Air Temperature Logger Location:

Water Temperature Logger Location:

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Appendix G

Manufactured Field Equipment

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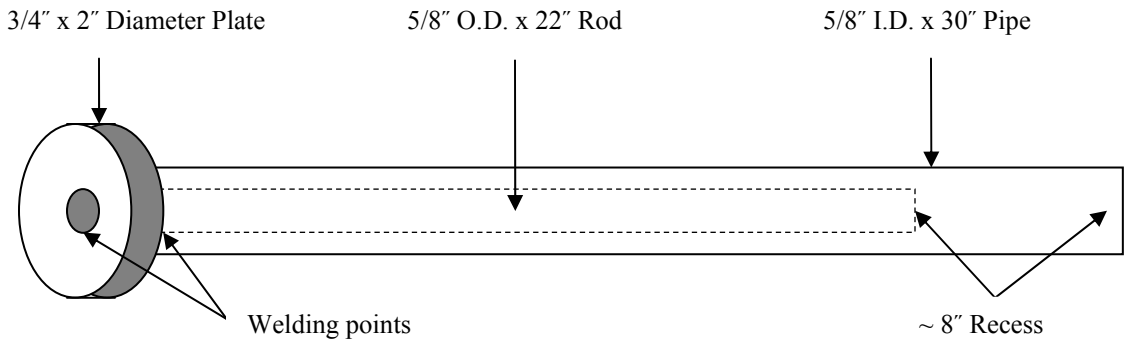
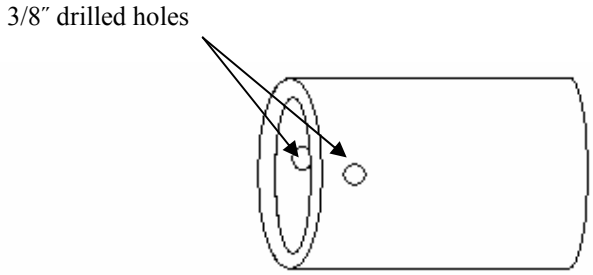
Steel Rebar Pounder (Drawing not to scale**)**



PVC Pipe Shade Device (Drawing not to scale**)**



2-2½″length of 1½″ PVC pipe - camouflage-painted