STANDARD OPERATING PROCEDURE (SOP)	
Title: Analysis of *In Situ* Specific Conductance, Water Temperature, and Sample Depth for the Bosque River Environmental Monitoring Response System Using Aqua TROLL 200 Multi-probes	
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1.0 PURPOSE

This document describes sampling, analytical, and quality control (QC) procedures for *in situ* monitoring of Specific Conductance (SC), water temperature, and sample depth for the Continuous Water Quality Monitoring Network (CWQMN) Bosque River Environmental Monitoring and Response System (EMRS) project using Aqua TROLL 200 Multi-probes

2.0 SCOPE AND APPLICABILITY

2.1 These procedures are intended for use by the Texas Commission on Environmental Quality (TCEQ) Stephenville Special Projects Office. CWQMN Continuous Ambient Monitoring Stations (CAMSs) are located at various locations on dry rain fall-dependent creeks in the Upper Bosque River watershed. When SC measurements exceed notification-level values, email notifications are sent to assist TCEQ Stephenville staff target field investigations to identify potential Dairy-related discharge sources.

2.2 Leading Environmental Analysis and Display System (LEADS) data records for the stations are not validated.

2.2 Electrical conductivity measurements are temperature corrected to 25.0 degrees Celsius (C) and are reported as SC.

2.3 Sample depth measurements are used for water quality data interpretations.

2.5 Multi-probe QC check criteria are used to ensure measurement equipment is operating within limits.

2.6 The working ranges of the multi-probe sensors are listed in Table 1.

Table 1

Parameter	Working Range
SC	0 – 5,000 µS/cm
Temperature	-20 to +65 Degrees Celsius (°C)
Sample Depth	0 -35 feet/0 – 11 meters

3.0 METHOD SUMMARY

3.1 When instantaneous near real-time in-stream SC values from run-off events exceeds notification-levels at a CAMSs, LEADS automatically sends email notifications to TCEQ Stephenville Special Projects Office staff. Email notifications are intended to provide Stephenville staff awareness of conductivity levels and staff may review station data to determine if field investigations are warranted. LEADS email SC notification levels for a station(s) can be modified by TCEQ Monitoring and Assessment staff upon request by the Stephenville Special Projects Office at any time

3.2 The multi-probe's conductivity and depth sensors outputs zero or near zero values in ambient air when water is not present. The temperature sensor measures ambient air temperatures when no water is present

3.3 Water temperature is measured by a resistance thermistor.

3.4 The depth sensor utilizes a pressure transducer that measures changes in pressure (in force per square unit of surface area) exerted by water. The transducer is vented and measures pressure of the water column plus atmospheric pressure above the water. Vented sensors subtract the atmospheric pressure component from the absolute pressure measurement.

4.0 LIMITATIONS

4.1 Multi-probe conductivity sensors respond to ionic solutes associated with the various forms of dairy manure. Microwatersheds receiving industrial land applications containing ionic solutes may not be suitable for the EMRS SC application.

4.2 Ideally, EMRS stations need to be in close proximity to potential dairy manure point discharges sources. Depending on monitoring station location, dairy point source discharges can be diluted by storm-water run-off originating from other micro-drainages. Ideal monitoring locations may not be accessible due to the lack of landowner approval.

4.3 Elevated SC measurements collected from stations located downstream of waste application fields may not be usable to distinguish between point and non-point source dairy-related run-off.

4.4 During storm water run-off events, the interface between measurement sensors and

the environment can become fouled by sedimentation and other debris. Sensor fouling can compromise data quality. Sediment fouling generally causes SC measurements to be biased low

5.0 SAFETY

This procedure includes processes that can be hazardous. Therefore, before attempting this process, operators should review the *TCEQ Chemical Hygiene Plan* for proper equipment and procedures necessary for the safe completion of this procedure. Operators must also read and be familiar with the Material Safety Data Sheets for the various chemicals that can be used in this procedure. Lab coats, safety glasses with side shields and/or splash goggles and chemical resistant gloves should be worn when handling chemicals

6.0 EQUIPMENT AND REAGENTS

6.1 Equipment

- In-Situ Aqua TROLL 200
- Personal computer (PC) or lap top computer with Win-Situ 5 software
- TROLL communication cable (connects rugged cable to PC's serial port)
- Rugged communication cable
- Male communication cable stripped and tinned with outboard desiccant pack (connects Level TROLL to data logger)
- C-spray anti-fouling nanopolymer
- Multi-probe deployment structure
- Pool noodles for Aqua TROLL 200 deployment in PVC deployment tubes
- Calibration vessel for the Aqua TROLL 200
- Spare desiccant
- Large tie wraps
- Personal computer with access to the Internet
- Calibration worksheets
- Instrument logbook

6.2 Cleaning equipment/supplies

- Simple Green all-purpose cleaner in spray bottle
- Water and white vinegar solution (hard fouling)
- Soft-bristle brush
- Cotton swabs
- Pipe cleaners
- Paper towels

6.3 Standards and Reagents (All reagents/chemicals must be analytical reagent grade).

- 5,000 µS/cm KCl solution calibration standard traceable to National Institute of Standard and Technology (NIST)

- Control Company Model 400 or equivalent thermistor certified or traceable to NIST. *Requires re-certification every two-years*
- De-ionized (DI) water

7.0 PROCEDURE

Before the multi-probe is deployed, the sensors are cleaned and calibrated. The multi-probe is deployed and every business day the station's measurement parameters are monitored remotely by the station operator to evaluate operational status of the station. At the end of the deployment period, multi-probe QC checks are conducted.

7.1 Station Service

7.1.1 The station is serviced and multi-probe sensors are calibrated at a minimum of once every month. Additional station service visits may be needed to clean sensors after run-off events.

7.1.2 During routine station visits, the station operator brings a newly calibrated multi-probe to the station and exchanges the currently deployed multi-probe with the newly calibrated multi-probe. The multi-probe is taken back to a temperature-controlled environment where Calibration Verification Samples are (CVS) analyzed.

7.1.3 During station service visits, the multi-probe's flying lead outboard desiccant pack is inspected. The desiccant keeps the vented pressure sensor line free of excess moisture. As moisture is removed, the blue desiccant will change to a pink color. Replace with fresh desiccant as needed.

7.1.4 Prior to any station service event that disrupts multi-probe data collection, the station's SUTRON data logger must be placed in "P" code (Preventative maintenance code) from "K" code (ambient sampling mode). Placing the station into P code prevents any erroneous data collected during station service events from being reported in LEADS as ambient data. When station service is complete, the station is returned to K code and an operator log is entered. See CWQMN QAPP Appendix E for SUTRON data logger instructions and Appendix F for operator log content instructions (www.texaswaterdata.org).

7.1.5 Before returning the station to K code, ensure the data logger is receiving multi-probe SC, depth, and temperature measurements. If measurements are not being received perform corrective action

7.2 Station Monitoring

Station operators should monitor water quality measurements and station communications every business day to ensure the station is operational.

7.2.1 Every business day, the station operator will monitor (via TCEQ daily report on Rhone website) the station's measurements and station

communications for anomalies. The multi-probe's conductivity and depth sensors outputs zero or near zero values in ambient air when water is not present. The temperature sensor measures ambient air temperatures when no water is present. If problems are identified, a station visit may be needed to correct any problems.

7.3 Multi-probe Deployment and Sampling

Multi-probes are typically deployed in poly vinyl chloride (PVC) tubing. The tubing can be in a trench that is attached to the creek bed. Tubing can also be attached to the bank and bed of the creek. PVC deployment structure can also be used.

7.3.1 The multi-probe must be secured to the PVC deployment tube via pool noodle, tie wraps, or by other means. The multi-probes conductivity cell and depth sensor must not be covered by deployment hardware

7.3.2 As part of each station service event, any debris must be removed from the deployment tube and the area of the creek channel where the multi-probe is deployed.

7.4 Multi-probe QC Checks

Station data are not validated. Multi-probe QC checks and criteria are used to ensure SC and temperature measurement sensors are operating within limits.

7.4.1 After each deployment period, the multi-probe's conductivity sensor analytical drift is measured using standards. For further details, see Section 9.2.

7.4.2 After each deployment period, the multi-probe's temperature sensor is checked. For further details, see Section 9.3.

7.5 Conductivity and Depth Sensor Calibrations

Sensor calibrations are performed immediately prior to each deployment period. Calibration information is recorded in the Aqua TROLL 200 Calibration Worksheet (Appendix A).

- The entire multi-probe, conductivity sensor cell, depth sensor, and plastic nose cap must be cleaned before calibration.
- The multi-probe must be allowed to equilibrate to room temperature prior to calibrations or analyzing CVSs.
- Anti-fouling C-spray nanopolymer coating must be applied to the conductivity sensor prior to calibration.
- The pressure sensor's plastic nose cone must be removed before conductivity and pressure sensor calibrations.
- Conductivity standards must be within expiration date.
- Before the conductivity sensor is calibrated the conductivity sensor zero reading must be checked in ambient air. SC measurements must be ≤ 5 µS/cm.

- Conductivity sensors and the calibration vessels must be rinsed twice with DI water before the introduction of KCl standards.
- The conductivity sensor and calibration vessel must be pre-rinsed twice with KCl calibration standards.
- Conductivity sensors must be immersed in KCl calibration solutions.
- The temperature sensor interface is a button located near the conductivity sensor. As compared to other temperature sensors, more time is needed for the sensor to equilibrate to the temperature of calibration standards. SC calibration errors can result if the probe has not stabilized to the temperature of the calibration standard.
- The multi-probes must be allowed to equilibrate in calibration solution ten minutes prior to calibration.
- Air bubbles in the conductivity cell will cause calibration errors. Extreme care must be used to eliminate and to ensure air bubbles are not in the conductivity cell during calibration. Hard water scale deposits on the electrodes can also cause calibration errors. White vinegar is used to remove scale deposits
- After calibration the conductivity cell constant must be between 0.98 – 1.02. If conductivity cell constants are not within these criteria, corrective action must be performed before proceeding. Corrective action can include additional sensor cleaning with white vinegar, ensuring air bubbles are not in the conductivity cell, and ensuring the multi-probe's temperature sensor has equilibrated to the temperature of the calibration standard.
- After calibration the multi-probe and SC sensor is rinsed with clean tap water.

7.5.1 C-Spray Anti- Fouling Sensor Application

Prior to sensor calibration, apply two coats of C-spray nanopolymer to all sensor bodies and interfaces. This will require time to dry.

7.6.1.1 Ensure multi-probe body and sensors interfaces are clean and dry. Apply C-spray to all sensors and allow to air dry. Apply a second coat of C-spray and allow to air dry. Proceed with calibration.

7.7. Single-Point Conductivity Calibration

Calibration of the conductivity sensor consists of a single-point calibration with a KCl 5000 µS/cm solution. Prior to calibration, the sensor's zero response must be checked in ambient air. During the calibration, the multi-probe will measure the temperature of the standard and automatically calculate the SC of the standard. Record calibration results into the Calibration Worksheet (Appendix A).

After calibration ensure the multi-probe's SDI address and LEADS measurement sequence configuration is correct

7.7.1 Ensure sensor body and sensor interface are clean and dry. In ambient air, SC measurements must be ≤ 5 µS/cm. If measurements are greater than 5 µS/cm, the sensor must be replaced prior to calibration or deployment. Note: If the sensor fails this check indoors, take multi-probe outside away from all potential electrical interferences and redo the check. If sensor is

still failing, replace sensor

7.7.2 Rinse sensor and calibration vessel twice with DI water and conductivity standard.

7.7.3 Click the **Sensors Tab** and highlight the sensor.

7.7.4 Click the **Calibrate Button** A calibrate window will appear. Select conductivity and click calibrate.

7.7.5 Enter the SC of the calibration solution in µS/cm. Click . Instructions will prompt you to slowly insert probe in calibration solution. Inspect conductivity cell for air bubbles. If bubbles are present "tap" the calibration vessel against a hard object to dislodge bubbles. Inspect cell after tapping, if bubbles are still present repeat procedure.

7.7.6 Allow the probe 10 minutes to equilibrate to the calibration solution.

7.7.7 The Software monitors conductivity and temperature readings used to calculate the cell constant and will inform you when the response meets the criteria for *Nominal Stability.* Wait until *Full Stability* is reached. At that time, the next screen is displayed automatically.

7.7.8 Review the *Proposed Conductivity Cell Constant.* If the cell constant is outside the range of 0.98 – 1.02, determine cause and repeat calibration.

7.7.9 If Conductivity Cell Constant is between 0.98 – 1.02, click to write the calculated cell constant to the sensor. Record *Conductivity Cell Constant* on the Aqua TROLL 200 Calibration Worksheet. In the next window, you are given the option to save the calibration summary. Either save it or click cancel. The next window gives the option to print the calibration summary. Click to exit SC calibration.

7.7.10 Rinse sensor with tap water

7.8 Pressure Sensor Configuration and Calibration

Calibrate and configure sensor for sample depth. This procedure will store the configuration settings in the Aqua TROLL sensor.

- The pressure sensor must be cleaned and dry before calibration.
- The pressure sensor's plastic nose cone must be removed before calibration

7.8.1 Sensor Configuration

7.8.1.1 Click the **Sensors tab** and highlight the sensor.

7.8.1.2 Select the **Configure button** . In the Sensor Setup Menu, select the Pressure sensor.

7.8.1.3 In the *Sensor Setup Window*, under Parameter select depth and under Units (meters) select meters, then click **Configure.**

7.8.1.4 In the *Level Setup Wizard*, select (under surface water) **Depth** (this is sample depth).

7.8.2 Sample Depth Configuration

7.8.2.1 After **Depth** is chosen click the **Next** button 

7.8.2.2 A *Level Setup Wizard* window will appear containing Specific Gravity options. Select *Fresh Water* and click the **OK** button  .

7.8.2.3 The *Sensor Setup* window will appear and click the **OK** button  . The sensor is now configured.

7.9.3 Pressure Sensor Calibration

The following procedure is used to zero the senor's offset. This is accomplished with a dry sensor in air. Record calibration results into the Calibration Worksheet (see Appendix A)

7.9.3.1 Click the **Sensors Tab**  and select the sensor.

7.9.3.2 Click the **Calibrate Button**  A calibrate window will appear.

7.9.3.3 Select **Pressure** parameter and click calibrate.

7.9.3.4 In the next screen, select **Zero the Level/Pressure Sensor.** Make sure the probe is dry and exposed to air.

7.9.3.5 Click **OK**  The software will inform you when the pressure reading is set to zero. Record calibration results into the Calibration Worksheet (see Appendix A)

7.10 Multi-probe SDI and Parameter Sequence check

After calibration ensure the multi-probe's SDI address and LEADS measurement sequence configuration is correct.

7.10.1 The correct sequence for LEADS measurements is Specific Conductivity, Depth in meters, and Temperature. If these are not specified in this order in the "Win Situ 5" software parameter sequence, the parameters will be displayed incorrectly in LEADS.

7.10.2 The SDI-12 address for the multi-probe should be set to 5In Win-Situ 5, Click Preferences, Comm Settings, and set the Device Address to 5.

7.10.3 The SDI-12 settings must also be checked under the  tab. Click on SDI-12 Setup. Make sure the Address Character is 5 and the Output order is Specific Conductivity (µS), Depth (m), and Temperature (C).

8.0 CALCULATIONS

8.1 Sample Specific Conductance

Electrical Conductivity is reported as SC (KCl solutions).

$$SC = \frac{AC}{1 + 0.0191 \times (t - 25.0)}$$

Where:

SC = is normalized conductivity in µS/cm,
AC = is non- normalized conductivity; and,
t = is the solution temperature in degrees C.

8.2 QC Calculations

Sensor Calibration Drift Calculation

8.2.1 Multi-probe conductivity sensor calibration drift (C_d) over the deployment period is evaluated using relative percent error:

$$C_d = \frac{(S_r - S_v)}{S_v}(100)$$

Where:

S_r = sensor response; and,
S_v = specific conductance KCl standard value

9.0 QUALITY CONTROL

9.1 QC Samples

QC samples are used to ensure that acceptable data quality is maintained throughout the measurement process.

9.2 Conductivity Sensor Drift Measurement Procedure

CVSs are analyzed as part of monthly routine station service. Allow the multi-probe to equilibrate to room temperature for a minimum of two hours before analyzing CVSsThe Aqua TROLL 200 should be allowed ten minutes to stabilize to the temperature of the standard. Results should be entered CVS worksheet (see Appendix B). Follow procedures in Section 7.7 to ensure no air bubbles are in the conductivity cell when analyzing CVSs.

Conductivity Sensor CVS

9.3.1 An SC CVS is analyzed at a minimum of once monthly to assess analytical drift from the previous calibration. The CVS should be the same standard used to generate the initial single-point calibration.

9.3.2 The multi-probe and conductivity sensor must be cleaned prior to analysing CVSs.

9.3.2 The CVS KCl solution is introduced using the calibration vessel Rinse calibration vessel and sensor twice with DI water and calibration standard before measuring standard.

9.3 Temperature Sensor Check

After every deployment period check the accuracy of multi-probe temperature sensor with a NIST certified or traceable thermometer or thermistor. In a temperature controlled environment allow the multi-probe to equilibrate to room temperature, fill a vessel with water and immerse the whole multi-probe. Allow the sensor to stabilize for 10-minutes. Place the end of the thermometer or thermistor thermocouple next to the temperature sensor of the multi-probe (allow the measuring device time to stabilize). The multi-probe temperature measurement should be within ± 0.50°C of the NIST certified or traceable thermometer or thermistor. The temperature check results should be entered into the CVS Worksheet

Table 9-1: QC Checks

QC Check	Purpose	Frequency	Acceptance Criteria	Response Action
SC zero check in ambient air	To assess sensor zero response and to assess internal sensor water leakage	Prior to calibration and deployments	≤ 5 µS/cm	1) Analyse standard again outdoors away from all potential electrical interference sources 2) Ground sensor while outdoors (place multi-probe on ground) 3) Replace sensor
Single-Point SC Calibration	To establish slope used for quantitation	Before every deployment. A minimum of once monthly	Conductivity Cell Constant is between (0.98 – 1.02)	1) Re-calibrate 2) Perform corrective action as necessary 3) Replace sensor
SC and Depth Sensor Cleaning	Improve Conductivity and Depth Sensor Responses	As needed and at the conclusion of deployment periods	None	Clean sensors more frequently
Conductivity Calibration Verification Sample (CVS)	To Assess Sensor Drift	At the conclusion of every deployment period. A minimum of once monthly	± 5 RPE	1) Perform corrective action as necessary 2) Replace sensor
Temperature	To assess thermistor accuracy	At the conclusion of every deployment period. A minimum of once monthly	± 0.50 °C	1) Perform corrective action as necessary 2) Replace sensor

10.0 DEFINITIONS

See Appendix A of the *Continuous Water Quality Monitoring Network Quality Assurance Project Plan.*

11.0 REFERENCES

Continuous Water Quality Monitoring Network Quality Assurance Project Plan
North Bosque River Specific Conductance Environmental Monitoring and Response System Project Plan
In Situ Aqua TROLL200 user manual
TCEQ Operating Policies and Procedures, Chapter 6.13

12.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Supervisors, sampling personnel, and laboratory analysts should identify and implement innovative and cost-saving waste reduction procedures as part of the method development, review, and revision of standard operating procedures. Wastes that do result from these procedures are managed and disposed of in accordance with appropriate state and federal regulations.

Refer to Chapter 6.13 of the *TCEQ Operating Policies and Procedures* for guidelines on general recycling, waste reduction, and water and energy conservation. Review these procedures for specific employee responsibilities and mechanisms for office-related waste prevention and management. Consult the *Monitoring Operations Hazardous Waste Disposal Plan* for laboratory-specific waste minimization recommendations and requirements for proper handling of hazardous waste that result from laboratory procedures.

The reagents, washes, standards, and waste associated with this procedure do not require special disposal. Before disposing waste into a municipal sewer system, operators should check with respective municipal sewer system personnel on what concentration levels are allowed to be put into their system.

Appendix A

AQUA TROLL 200 CALIBRATION WORKSHEET					
Analyst:	Date		Time:		
Aqua Troll Serial No.			Date Deployed:		
CAMS Station:			**Conductivity Sensor Zero Air Check Result (Criterion ≤ 5 µS/cm)**		
Standard	**Manufacturer**		**Lot No.**		**Expiration Date**
Conductivity					
Parameter	**Temperature**	**Calibration Standard Value**	**Pre - Calibration Value**	**Post - Calibration Value**	**Comments**
Specific Conductance (µS/cm)		5,000			
Cell Constant					Result: (Criteria 0.98 to 1.02)
Sample Depth (M)					

Appendix B

AQUA TROLL 200 CALIBRATION VERIFICATION WORKSHEET					
Analyst:	Date:		Time:		
Aqua Troll Serial No.			Date Retrieved:		
CAMS Number:			Thermometer Serial No.		
Standard	**Manufacturer**		**Lot No.**	**Expiration Date**	
Conductivity					
Parameter	**Temperature**	**CVS Standard Value**	**CVS \ Temperature Result**	**Difference**	**Criteria**
Specific Conductance (µS/cm)		5,000			≤ 5.0 RPE
Temperature (°C)	NA	Therm Reading			± 0.50 °C
Sample Depth (M)	NA	0.000			NA