Addendum to Quality Assurance Project Plan

FOR ALPINE LAKES FLOW AUGMENTATION

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Contact Information

Publications Coordinator
Environmental Assessment Program
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Phone: 360-407-6764

Washington State Department of Ecology – ecology.wa.gov

Headquarters, Olympia	360-407-6000
Northwest Regional Office, Bellevue	425-649-7000
Southwest Regional Office, Olympia	360-407-6300
Central Regional Office, Union Gap	509-575-2490
Eastern Regional Office, Spokane	509-329-3400

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by Bryan Berkompas and Kelsey Mach (Aspect Consulting)

June 24, 2025

Approved by:

Signature: Bryan Berkompas — Date: 6/24/2025
Bryan Berkompas, PE, Principal Hydrologist, Aspect Consulting, Author

Signature: Kelsey Mach — Date: 6/24/2025
Kelsey Mach, LG, Senior Geologist, Aspect Consulting, Author

Signature: Mary Jo Sanborn — Date: 6/26/2025
Mary Jo Sanborn, Chelan County Natural Resources Department, Client

Signature: Ingrid Ekstrom — Date: 6/26/2025
Ingrid Ekstrom, LHG, Washington State Department of Ecology Office of Columbia River, Project Manager

Signature: McKenna Murray — Date: 6/26/2025
McKenna Murray, Washington State Department of Ecology, Quality Assurance Coordinator

Signatures are not available on the Internet version.

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Note: The numbered headings in this document correspond to the headings in the original QAPP. Only relevant sections are included here; therefore, some numbered headings may be missing.

1.0 Background and Project Description

No tasks from the original project QAPP will be eliminated. This addendum addresses modification to release flow monitoring instrumentation.

1.2.2 Release Flow Monitoring

Ultrasonic sensors will be installed at each of the three previously approved release channel monitoring locations (Colchuck, Square, and Klonoqua Lakes) to collect continuous channel stage measurements at the same location and over the same period of record as the discharge measurements and staff plate readings. These measurements will be used in tandem with the continuous discharge measurements and staff plate readings to develop an updated rating curve for the release channel. Once the rating curve is developed, the ultrasonic measurements can be converted to flow. Given that Icicle and Peshastin Irrigation Districts (IPID) only has access to two Sontek sensors, and given the added labor of installing the Sonteks, use of the ultrasonic sensors provides a cost-effective option for IPID to get discharge data from all three lakes through the entire release season.

Ultrasonic sensors were chosen to measure water level in the channel over other methods because they inherently limit potential disruption from channel debris, freezing, biofouling, or sediment interference that could occur with in-channel sensors.

2.0 Organization and Schedule

Ultrasonic sensors will be installed at Colchuck, Square, and Klonaqua lakes in July of 2025 during the same field campaign as the reservoir dataloggers and deployment of other flow monitoring equipment (Sontek). These sensors will remain in place collecting data during two lake release seasons (approximately July through September).

Table 1 from the original QAPP has been updated to include ultrasonic sensors within the schedule of activities.

No other changes to the original project schedule are proposed.

Table 1. Anticipated Schedule for Study Period

Month	Activity
July 2025	Install dataloggers in reservoirs. Survey existing staff plates (Klonoqua, Colchuck) and survey monument (Square)
July to October 2025	Deploy and check of flow monitoring equipment (Sontek-IQ Plus, ultrasonic sensors, and staff plate). Anticipated two visits to each lake per season. Check dataloggers.
September/October 2025	Download datalogger data and flow data, retrieve flow monitoring equipment.
October to December 2025	Data Entry, Verification and Analysis
January 2026	EIM Submittal
July to October 2026	Deploy and check of flow monitoring equipment (Sontek-IQ Plus, ultrasonic sensors, and staff plate). Anticipated two visits to each lake per season. Check dataloggers.
September/October 2026	Download datalogger data and flow data, retrieve flow monitoring equipment.
October to December 2026	Data Entry, Verification, and Analysis
January 2027	EIM Submittal

Notes:
EIM = Environmental Information Management

3.0 Quality Objectives

The following sections are updated to include the quality objectives relevant to the ultrasonic sensor data collection. The overall Measurement Quality Objectives (MQO) of the project remain unchanged.

Table 2 (Field Equipment Accuracy) and Table 3 (Measurement Quality Objectives) from the original QAPP have been updated to include information related to the ultrasonic sensors.

Release Flow Monitoring

The MQO for the ultrasonic measurements at the release channels is the same as the MQO for the reservoir dataloggers and staff plate readings, which is acceptable for meeting the goals of the QAPP.

For example, in the Square Lake outlet channel, a stage difference of 0.01 feet (ft) represents a change in flow of approximately 0.1 cubic feet per second (cfs)[1], equivalent to an error of less than 5 percent for flows greater than 2 cfs. The flow measurements in the channel are anticipated to range between 10 and 35 cfs.

At lake release monitoring locations where both an ultrasonic and Sontek-IQ Plus sensor are deployed and collecting data over the same period, the Sontek-IQ Plus data will be considered the primary data source for release flows and the ultrasonic will be used as quality control.

[1] Depending upon the flow rates.

Table 2. Field Equipment Information

Parameter	Equipment/Method	Equipment Information		
		Accuracy	Resolution	Range[1]
Reservoir Stage Monitoring				
Water Pressure (height of water column)	Van Essen TD-Diver DI801	±0.5 cm H2O	0.2 cm H20	0 - 10 m
Barometric Pressure	Van Essen Baro-Diver DI800	±0.5 cm H2O	--	1.5 m
Lake Stage Elevation	Staff Plate (Klonoqua, Colchuck)	0.01 ft	0.01 ft	0 – 10 ft
	RTK GPS Trimble R10 (Base Station) Trimble R10-2 (Rover)	0.1 ft	--	--
	Rod and level (Square)	0.01 ft	0.01 ft	--
Bottom of Lake Elevation (existing) – see footnote 8	Leica ALS80 LiDAR (existing)	<15cm RMSE (elevation)	8 returns per square meter	NA
Reservoir Release Flow Monitoring				
Velocity/ Water Level/ Discharge	SonTek FlowTracker2	±1.0% of measured velocity[2, 3] 0.01 ft (rod)	0.0001 m/s (0.0003 ft/s) 0.01 ft (rod)	±0.001 – 4.0 m/s (±0.003 to 13 ft/s)
Velocity/ Water Level/ Discharge	Sontek-IQ Plus	±1.0% of measured velocity 0.01 m/s (0.03 ft/s)[3]	0.0001 m/s (0.0003 ft/s)	±0.001 to 10 m/s (±0.003 to 32 ft/s)
Stream Stage	Staff Plate	0.01 ft	0.01 ft	0 – 10 ft
Channel Elevation	RTK GPS Trimble R10 (Base Station) Trimble R10-2 (Rover)	0.1 ft	--	--
Continuous Stream Stage	IRU-6429 (Ultrasonic)	±0.25% of detected range	0.01 ft	1 – 30 ft (0.3 – 9.1m)

Notes:

cm H2O = centimeters of water
m = meters
ft/s = feet per second
RMSE = root mean squared error

1. The expected range of values for all parameters is within the measurement range of the equipment.
2. Resulting discharge accuracy is dependent upon data collection methods and site location as described below in Section 4.
3. Accuracy of area data is most strongly influenced by the accuracy of channel geometry, rather than uncertainty in stage data. A well-established index calibration can give real-time flow accuracy of about 2-3% of the measured flow. Theoretical flow calculations in a regular channel (i.e., trapezoidal, concrete lined) may give accuracy of about 3-5%. Theoretical flow calculations in natural streams are difficult. They can provide reasonable results in streams with a simple, uniform cross section, but are notably limited in wide, shallow streams where velocity can vary dramatically across the width of the stream.

Table 3. Measurement Quality Objectives

Measurement Type	Ideal	Qualified	Invalid
Lake/Channel Stage (datalogger, staff plate, ultrasonic)	+/- 0.01 ft	+/- 0.01 ft to 0.3 ft	>+/- 0.3 ft
Discharge (Sontek-IQ Plus and FlowTracker)	+/- 5%	+/- 5% to 13%	>+/- 13%
Lake/Channel Stage Elevation (RTK GPS)	+/- 0.1 ft	+/- 0.5 ft	>+/- 0.5 ft

4.0 Study Design

The following section is updated to include the study design relevant to the ultrasonic sensor data collection. Ultrasonic sensors are a common method for measuring distances to objects, including the water surface in streams. The sensors measure distances using the time it takes for a sound wave to bounce off the reflecting surface and return.

4.2.1 Sampling Locations and Frequency

Sampling locations and frequency will not change as a result of this QAPP amendment. The ultrasonic sensors will be installed at the release outlet channel locations at Colchuck, Square, and Klonoqua Lakes. The ultrasonic sensors will collect continuous channel stage measurements at the same location and over the same period of record as the discharge measurements and staff plate readings.

5.0 Field Procedures

The following sections are updated to include the field procedures relevant to the ultrasonic sensor data collection.

5.2 Measurement and Sampling Procedures

The procedures for collecting ultrasonic stage measurements for flow monitoring proposed under this QAPP amendment are typical for hydrology investigations. Relevant Standard Operating Procedures (SOPs) to be followed are publicly available in digital format online and include the following:

- Standard Operating Procedure EAP042, Version 1.2 – Measuring Gage Height of Streams (Ecology, 2018)
- Standard Operating Procedures EAP056, Version 1.3 – Measuring and Calculating Stream Discharge (Ecology, 2018)
- Standard Operating Procedures EAP057, Version 1.1 – Conducting Stream Hydrology Site Visits (Ecology, 2018)

- Standard Operating Procedure EAP082, Version 1.2 – Correction of Continuous Stage Records Subject to Instrument Drift
- Stage Measurement at Gaging Stations, USGS, Techniques and Methods 3-A7, 2010

5.2.2 Release Flow Measurements

Ultrasonic Sensor IRU-6429

The methodology described here is specific to the ultrasonic sensor IRU-6429 and is described in further detail in the IRU Series Ultrasonic User Manual (APG, 2023) and Installation Guide (APG, 2024); both documents are included in Appendix A.

A single IRU-6429 (or equivalent) ultrasonic sensor will be installed at the release outlet channels of Colchuck, Square, and Klonoqua Lakes in close proximity of or adjacent to (within the same pool or hydraulic condition as) the staff plate and Sontek flow monitoring location.

If site conditions allow, a stilling well will be installed for housing the ultrasonic sensor. Stilling wells provide protection against natural hazards (trees falling, wind, rain) and dampens the fluctuations in the channel caused by wind and turbulence to allow for more accurate data collection. Stilling wells can be composed of various materials, but the proposed stilling well will likely be installed with a PVC pipe. The PVC pipe will have a large enough diameter such that it does not interfere with the beam spread of the ultrasonic sensor (approximately 4-inches). The PVC pipe will also be long enough such that it can cover the maximum channel depth plus additional freeboard for the sensor. The stilling well should maintain direct hydraulic connectivity with the channel under all expected flow conditions and should be installed such that it does not interfere with the flow path in the channel weir.

The stilling well will either be clamped onto a post pounded into the channel, clamped to the existing staff plate, or bolted to the side of the rock channel (where applicable). The ultrasonic sensor will be mounted using its ¾" threaded fitting (as shown on Figure 1 below) and installed such that it fits within the center of the PVC stilling well and is facing directly perpendicular to the channel surface. An example of the proposed field set up for Square Lake is provided as Figure 2 below. If site conditions do not allow for installation of a stilling well, the ultrasonic sensor will be suspended over the channel using a wood plank or metal strut secured to the channel sides.

The ultrasonic sensor will be connected to a datalogger and external battery. Prior to the field installation, the sensor will be programmed to collect continuous stage measurements on at least 15-minute increments. Sensor programming includes documenting the distance to the dry channel such that the sensor will calculate dry channel depth minus water signal depth to report water depth in the channel.

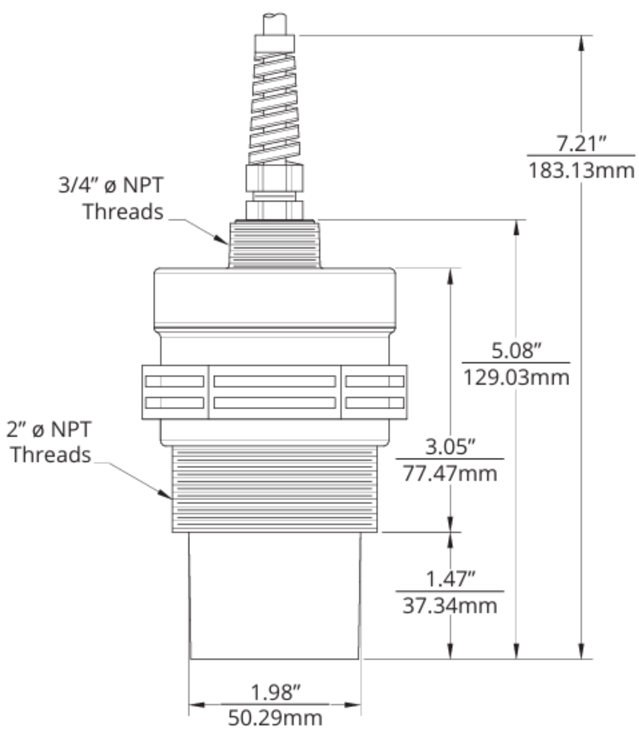

Figure 1. Ultrasonic Sensor Specifications

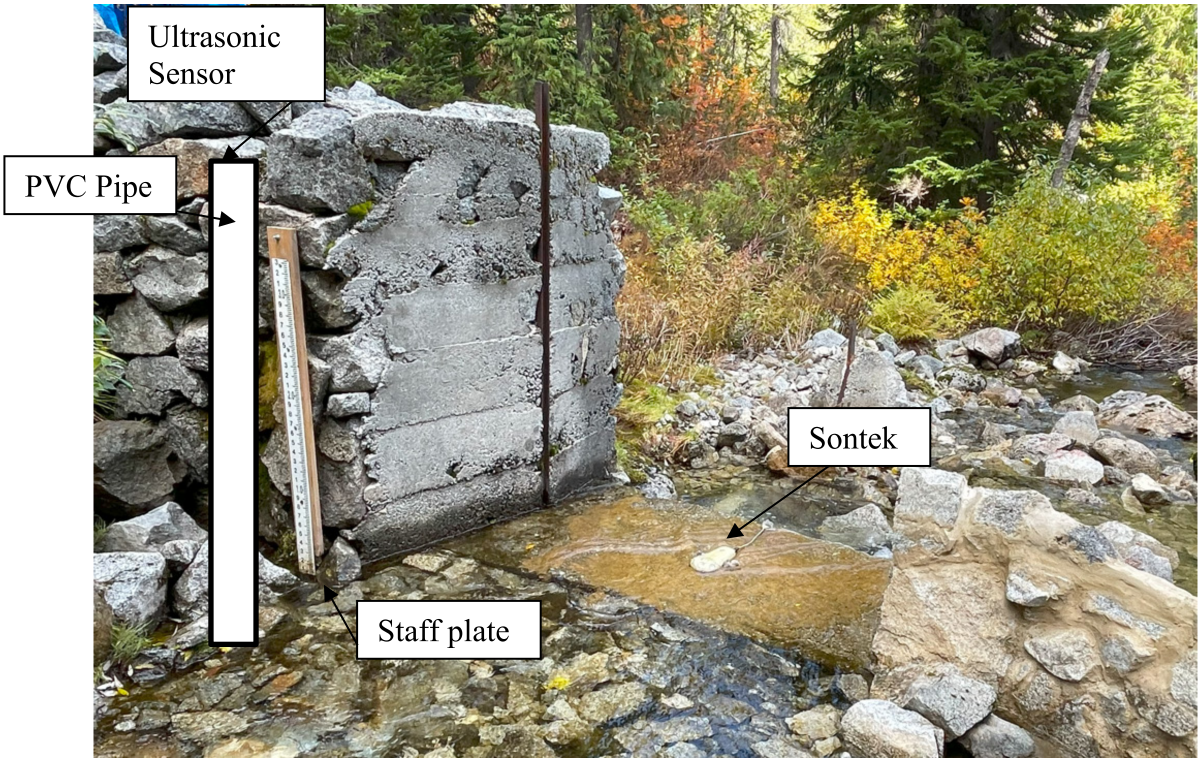

Figure 2. Illustrative Example Setup of Stilling Well for Ultrasonic Sensor at Square Lake

5.3 Outlier Resolution

5.3.2 Release Flow

Should *in-field* ultrasonic flow measurements at the reservoir outlet channels be measured as unexpectedly high or low with comparison to expected or previous measurements, measurements will be taken again to verify measurements are correct. Upon verification, further analysis and investigation will occur in a stepped response.

Visual comparisons will be made from the previous flow conditions to current flow conditions to better understand if flow conditions are truly different, or if channel conditions have changed.

Second, equipment should be evaluated to confirm it is functioning as expected in accordance with the user manual, and confirm the equipment is installed properly with no interference. Next, if equipment is determined to be working properly, a confirmation measurement should be taken from either the Sontek or staff plate.

Should ultrasonic flow readings collected *between* field visits be measured as unexpectedly high or low with comparison to expected or previous measurements, the measurements should be compared to Sontek readings (where available) and otherwise evaluated based on professional judgement and range of expected measurements based on known site conditions. A determination should be made as to whether those measurements are considered outliers and if so, they should be removed in post-data processing and measurements interpolated using the preceding and the following data points.

Where Sontek-IQ Plus measurements exist for the same sampling location and time period, Sontek-IQ Plus readings should be used in preference of ultrasonic flow measurements unless the Sontek-IQ Plus data is determined to be invalid.

5.4 Data Verification and Validation

The ultrasonic data collection will follow the same verification and validation procedures as established in the original QAPP.

5.5 Data Quality (Usability) Assessment

The ultrasonic data collection will follow the same data quality assessment procedures as documented in the original QAPP.

6.0 Quality Control

The following sections are updated to include the quality control procedures that are relevant to the ultrasonic sensor data collection. Specific quality control procedures (both in field and out of field) along with corrective actions for each data collection method are described below and summarized in Table 4.

6.1 Steps in Preparation of Field Work

Prior to each mobilization, staff should pack and charge (where appropriate) the following equipment for the ultrasonic data collection:

- IRU-6429 or equivalent ultrasonic sensor (3)
- Battery (3)
- Datalogger (3)
- Programmer (1)
- Field laptop with battery (1)

For installing the stilling well, staff should pack the following equipment:

- Threaded pipe connector or mounting plates for sensor sized to fit into 4" PVC stilling well
- 4" PVC Pipe (5 ft lengths)
- Portable drill with rock bits
- Clamps for 4" PVC with bolts
- Post pounder (1)
- Posts (3)
- Level

Prior to field work, staff will program the ultrasonic sensor with the corresponding datalogger and battery and test the sensor under similar conditions as proposed to confirm that the selected stilling well diameter is adequate for reducing false positive responds from interference of the ultrasonic beam spread.

Staff will also check the ultrasonic sensor the manufacturer's user manuals (included as Appendix A) to check equipment functionality, upgrade firmware, and charge batteries as needed. Additionally, calibration of meters will occur in accordance with manufacturer recommendations.

6.2 Steps Taken in Field

6.2.2 Release Flow

Where determined feasible, a stilling well will be installed for housing the ultrasonic sensor. Stilling wells can protect sensors from natural hazards (trees falling, wind, rain), dampen channel fluctuations and allow for more accurate and complete data collection. The stilling well will be installed such that the ultrasonic sensor is approximately nadir to the stream channel flow to avoid any interference from the side of the PVC pipe.

Data will be viewed in the field in graphic and tabular format to observe for any outliers in reading values or missing data. If equipment malfunction is observed, steps should be taken in accordance with Section 5.3 and troubleshooting will occur in the field if possible. Where available, data will be compared to Sontek and staff plate measurements. If the data collected with the ultrasonic sensor is deemed inadequate for the MQOs of this Study, the Study will instead rely on stage and discharge measurements from the Sontek (if installed at that location). A new ultrasonic sensor should be ordered and replaced at the following field event.

6.3 Steps Taken After the Field

6.3.2 Release Flow

Following end of season data download, the full season of ultrasonic measurements will be reviewed for outliers in accordance with Section 5.3.2 or gaps in data collection. Outlier data will be removed from the dataset, and actions will be taken to fix the malfunctioning sensor where appropriate or evaluate if adjustments to the methodology of the sensor deployment are warranted for the following data collection period.

Table 4. Quality Control Procedures

Data Type	Out of Field: Action	Out of Field: Frequency	In Field: Action/Correction	In Field: Frequency
Real Time Kinematic (RTK) GPS Measurements	Correction of measurements using National Oceanic and Atmospheric Administration's (NOAA) Online Positioning User Service (OPUS)	Following each mobilization	**Duplicate measurements.** Take duplicates until two in a row are within the Measurement Quality Objectives (MQO) of error.	One random
Flow Measurements (Sontek-IQ Plus and Sontek FlowTracker2)	Check equipment battery level and functionality. Charge batteries and replace equipment as needed.	Prior to each mobilization	**Confirmation measurement of discharge from Sontek-IQ Plus (with FlowTracker2).** If >20% relative percent difference (RPD) different, take repeat confirmation measurement with FlowTracker2. Perform service on Sontek-IQ if needed.	Each site mobilization
	Calibrate and check flow meters	Per manufacturer recommendations	**Confirmation measurement of water depth reading from Sontek-IQ Plus (with staff plate).** If >0.02 ft different, take repeat confirmation measurement with Sontek-IQ and staff plate, and calibrate Sontek-IQ if needed.	Each site mobilization
Staff plate readings	Bring replacement staff plate in case of damage	For each mobilization	**Duplicate measurements.** Take duplicates until two in a row are within the MQO of error.	Each measurement
			Confirm staff plate location with RTK GPS measurement. If staff plate moved, make note in field log.	Once per year **or** if staff plate damage is observed
			Check staff plate for obvious damage. If staff plate moved, make note in field log and repair and resurvey at next visit.	Each measurement
Rod and level survey	NA	NA	**Duplicate measurements.** Take a reverse measurement (i.e., going back to the survey monument from the reservoir level), retake if reverse measurement is >0.02 ft different.	Each measurement
Ultrasonic sensor	Program the sensor and check with the same set up as planned for the field (including with PVC stilling well)	Prior to installation	**Confirmation measurements** with staff plate, if >20% RPD difference, take repeat confirmation measurement with staff plate. Trouble shoot equipment and set up as needed.	Each site mobilization
	Check manufacturer user manual for set up needs	Per manufacturer recommendations	**Install stilling well** where feasible given sampling site conditions to provide protection against the sensor and improve data accuracy.	During initial installation
	Sensor calibration	Prior to installation	**Look at data graph on field computer and observe for outliers, time discrepancies, and missing data.** Note date/time of any observed outliers in data that may indicate change in datalogger elevation or hardware issues. Reassess datalogger deployment method and update deployment method/location if feasible/appropriate. Make note in field log of updated location. Reset datalogger time to compensate for drift if time discrepancy is observed. Replace datalogger if needed.	Each site mobilization
	Plot manual measurements against ultrasonic readings to observe discrepancies and make corrections.	End of season		
Pressure transducer data	Bring replacement pressure transducers	For each mobilization	**Confirmation measurement.** Take measurement from staff plate, RTK GPS and/or rod and level survey. If >0.02 ft different, correct datalogger readings based on manual measurement.	Each data download
	Compensate pressure transducer readings using barometric pressure	End of season	**Look at data graph on field computer and observe for outliers, time discrepancies, and missing data.** Note date/time of any observed outliers in data that may indicate change in datalogger elevation or hardware issues. Reassess datalogger deployment method and update deployment method/location if feasible/appropriate. Make note in field log of updated location. Reset datalogger time to compensate for drift if time discrepancy is observed. Replace datalogger if needed.	Each data download
	Plot manual measurements against pressure transducer readings to observe discrepancies and make corrections.	End of season		

7.0 Data Management Procedures

Data management procedures are updated to include the ultrasonic sensor data.

7.2 Release Flow Monitoring

Flow data collected from the ultrasonic sensor include distance measurements and water level (in feet), date and time, and other associated metadata. This data will be recorded on a corresponding datalogger and will be saved in .csv format or equivalent on field laptops at time of download.

8.0 Reporting and Field Activity Assessments

Reporting and field activity assessments are updated to include the ultrasonic data. Data from the ultrasonic sensor will be compiled as a part of the annual EIM submittals for the Study (EIM Study ID: WROCR-VER1-00015).

Data specific to the ultrasonic sensor will include the following:

- Channel water depth in feet in 15-minute increments
- Date and time of measurements

9.0 References

APG, 2023, IRU Series Ultrasonic Sensors Installation Guide, November 2023. https://www.apgsensors.com/wp-content/uploads/2023/11/IRU-User-Manual.pdf

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