SonTek – side-looking water meter

The SonTek side looking water meter is a modular metering system for the measurement of water flow in an open channel.

The following requirements do not replace the *Argonaut-SL System Manual*. The manual is essential for the successful installation, commissioning, operation, and maintenance of these devices, and must always be used.

However, for use of these meters under this module of the standard the following requirements must be met, as a minimum, and have been formulated from:

- Recommendations/advice in the manual and where required with input from the manufacturer.
- The USGS Computing Discharge Using the Index Velocity Method – Techniques and Methods 3-A23 report.

Requirements to be confirmed by validation type	
Post-installation (new meter installation) **Existing meter installation – new SL unit**	Section 2.0, Section 3.0, Section 4.0, Section 5.0, Section 6.0, Section 9.0
Ongoing (revalidation) or Faulty meter – existing meter installation	Section 2.0, Section 3.0, Section 4.0, Section 6.0, Section 7.0, and Section 8.0, Section 9.0

1.0 Key terms

Term	Definition
ADCP	An acoustic Doppler current profiler.
AOC	An Analog Output convertor for the SL.
CPH	An Australian Hydrographers Association, Certified Practicing Hydrographer. A list can be found here: Certified Professionals - Australian Hydrographers Association <aha.net.au>.
CPH_M	A CPH that has also completed the Meter Installation and Validation course run by Irrigation Australia Ltd (IAL) and is also qualified as a Certified Meter Installer and Validator.
Measurement volume	The volume of the horizontal layer of the water flow where the SL measures velocity.
MIM	The Modbus Interface Module for the SL.
SL	The SonTek side-looking water meter.
USGS 3-A23	The USGS Computing Discharge Using the Index Velocity Method – Techniques and Methods 3-A23 report.

2.0 Authorised Meter Validator

Until 1 December 2022, the relevant person must:

- engage[#] a CPH
- nominate their CPH for appointment by the chief executive as an authorised meter validator under s109 of the Water Regulation, for their SL.

[#]The CPH is engaged to complete corrective and preventive maintenance, calibration, and validation for their SL.

From 1 December 2022, the relevant person must

- engage[##] a CPH_M
- nominate their CPH_M for appointment by the chief executive as an authorised meter validator under s109 of the Water Regulation, for their SL.

[##]The CPH_M is engaged to complete corrective and preventive maintenance, calibration, and validation for their SL.

3.0 Fit for purpose requirements

An SL must operate within these basic requirements:

- Water velocity range: ± 6 m/s.
- Channel width: SL500 – 1.5 to 120m; SL1500 – 0.2 to 20m; SL3000 – 0.1 to 5m.
- Stage measurement: SL500 – 0.2 to 18m; SL1500 – 0.15 to 10m; SL3000 – 0.1 to 5m.

An SL must not be used in a water body where insufficient reflective particles are present, noting most natural environments usually have sufficient reflective particles suspended.

3.1 Flow

The SL must:

- be located away from intake or outlet structures and must be located away from the beginning or end of a culvert or pipe
- be in a straight section of channel, away from curves that can cause variations in the flow distribution
- be located away from any underwater structures or vegetation that can cause turbulence or changes in the flow distribution.

4.0 Installation requirements

No physical obstructions must be near or in the path of the two angled acoustic beams.

The X-axis of the SL must be parallel to the primary flow direction.

The SL mounting orientation must be repeatable – the mounting structure must return the SL to the exact position when the sensor is removed for maintenance or inspection.

The SL mounting must keep the instrument stable; it should not shift or move with time and be able to resist vibration.

The SL must be installed level. That is, the measurement plane formed by the two angled acoustic beams should be parallel to the water surface, ideally within 1-2 degrees.

4.1 Depth

The SL is usually installed at the mid-point of the vertical water column. Where there are large variations in water depth, the installation depth must be installed above mid-water depth at the lowest water level e.g., if water level varies from 3 to 5 metres, the SL might be installed 2m above the bottom, placing it 1 metre below the surface at low water, and 3 metres below the surface at high water.

4.2 Cable protection

Power and communications cables must be enclosed in a mechanical conduit where not enclosed in a mounting pole.

4.3 Power supply

The SL is powered from an external power supply:

- Where mains power is used, the design of the external power supply must ensure the device can continue operating for 72 hours without mains power available. This could be achieved with the use of a correctly sized external battery (or battery pack) as a back-up power supply, which is trickle charged from the mains supply.
- Where mains power is not available or not used, an external battery (or battery pack) must be used with charging of the battery by a solar panel. The external battery must be sized correctly to allow the device to continue operating for 7 days with no sun available to charge the battery. The battery must only require replacement after 5 years of operation, outside of premature cell failure.
- The cables from the solar panel to the device must be enclosed in electrical conduit when not enclosed in any mounting pole.
- The solar panel must have tri-spikes (or similar barrier mechanism) installed on the top of the solar panel to reduce the accumulation of bird droppings on the front face of the panel.
- The solar panel must be orientated to the North at the appropriate incline angle, and the panel must not be shaded by trees or structures

4.4 Flow Display

The SL must have a flow display attached, enabled, and mounted on the channel bank so that the display can be viewed and operated while extraction is occurring.

4.5 High-Temperature Environments

West of the Great Dividing Range or North of the Tropic of Capricorn (in Queensland), where the SL will be out of the water (while still operating) for extended periods, the device must have a shade structure manufactured and fitted over the device with a hole to allow operation of the stage transducer. The structure must shade the SL from the Sun without impacting the operation of the respective beams.

5.0 Measurement and assurance requirement B

After deployment of a new or replacement SL:

- A deployment report including the following parts, must be provided to the relevant person with a validation certificate (post-installation) by their CPH:
  - Site Selection (see Section 5.1 for requirements).
  - Standard Cross Section Establishment (see Section 5.2 for requirements).
  - Index Velocity (see Section 5.3 for requirements).
  - Configuration (see Section 5.4 for requirements).
- A deployment report that meets the requirements in this section is the calibration certificate for the SL, satisfying Measurement Assurance Requirement B) of this module of the standard.
- The relevant person must provide the deployment report for the new or replacement SL, with the validation certificate, to the department.

5.1 Site Selection

Prior to the installation of a new or replacement SL, the channel cross section must be measured and documented using ADCP measurements. ADCP measurements provide valuable information and can be used to evaluate the horizontal and vertical flow distribution and channel bathymetry at a potential SL site.

The ideal metering site should meet the following criteria:

a. The SL measurement volume is in a region of relatively parallel and uniform flow lines, and all acoustic beams are measuring approximately the same water velocity at all flow heights.

b. The SL measurement volume is in or near the region of maximum velocity and free from any boundary effects on flow.

c. The general course of the stream is straight for the greater of about 90 metres or 5 to 10 channel widths upstream or downstream from the meter site.

d. The SL is located a minimum of 5 to 10 channel widths upstream or downstream from any tributary inflows or flow control structure.

e. The total flow is confined to one channel at all flow heights, and no flow bypasses the site as subsurface flow.

f. The stream/channel bed is not subject to scour and fill and is generally free of aquatic growth.

g. A satisfactory reach for measuring discharge at all flow heights is available within reasonable proximity of the meter site.

h. The SL is easily accessible for installation, operation, and maintenance.

i. Flow at the site is free from excessive air entrainment in the water column, such as might occur immediately downstream of a weir, dam, or control structure.

Typically, all these requirements cannot be met at any one site; however, when at all possible, uniform horizontal and vertical flow distributions, parallel flow lines, and a stable channel shape must take precedence with locating an SL. If this is the case, the site assessment enables the CPH to decide where in the cross section the SL should be located to best measure an index velocity. After a satisfactory cross section is located, the orientation, frequency, and location of the SL in the cross section must be chosen such that reliable and accurate index velocity measurement may be obtained from the site.

The deployment report must document the rationale for the site selected and provides helpful background information about the site and the establishment of the SL.

5.2 Standard Cross Section Establishment

A standard cross section must be established as close to the new or replacement SL as possible. The section must be perpendicular to the primary flow direction. The section must be marked so that subsequent surveys can be performed at the same location. The location will be used to monitor change in the section over time.

A stage-area rating must be established at the standard cross section, and surveying techniques involving tools such as a surveying level and stadia, depth soundings and a tagline, echo sounder and tagline, ADCP, or some combination thereof, may be used.

The survey/s will result in the collection of a continuous series of two values: the horizontal position from an established reference point (typically on top of the left channel bank, looking downstream) and the elevation associated with that position. The survey method/s for measuring horizontal and vertical position must be chosen to accurately define the shape of the channel.

The continuous survey series must then be used to compute the stage-area rating for the standard cross section. This rating provides the basis for the geometry uploaded to the SL.

The deployment report must document:

- the standard cross section chosen
- the methods used and data from the survey
- the approach to compute the stage-area rating.

Documenting the standard cross section establishment provides a starting point for analysis of change in the stage-area rating over time.

5.3 Velocity Equation

Where a theoretical velocity equation (only the 1/6-power law relationship must be used, with the location of the SL velocity cell relative to the channel geometry) is used, the SL must only be used with these regular channel geometries:

- concrete lined open channels

- concrete lined rectangular or trapezoidal culverts
- natural lined open channels with near-trapezoidal shape
- round and elliptical pipes.

Where an index velocity equation is used, the SL may be used with:

- natural streams with complicated cross-sectional geometry
- complicated flow structures.

The deployment report must explain the basis for use of:

- a theoretical equation; or
- an index velocity equation (see Section 7.1 for requirements).

5.4 Configuration

The deployment report must record the following parameters and where specified provide an explanation for the parameter used.

The maintenance report developed in Section 7.0, must also record the parameters in the following table and where specified provide an explanation of the parameter used.

Parameters	Notes
Firmware version	The CPH must confirm if there are firmware updates available as part of any activity, and the updates must be uploaded to the SL. Prior to upgrading the firmware on an existing SL, the CPH must download the internal recorder of the SL. Where configuration and total volume information is lost because of the firmware upgrade it must be uploaded to the SL after the update is complete.
Internal clock	Deployment → date and time must be set to Australian Eastern Standard Time by synchronising the SL clock with an electronic device (e.g., computer). This is a record of this. Maintenance → the date and time must be confirmed to be correct. This is a record of this.
Internal recorder	The internal recorder must be turned on (enabled).
Averaging interval	Settings of 300 to 900 seconds (5 to 15 minutes) are typical. Where a setting outside of this range is used, an explanation of why is required.
Sampling interval	Setting this interval equal to the averaging interval is typical. Where a different setting is used, an explanation of why is required.
Cell Begin **Cell End** **Coordinate System** **ReverseXVelocity**	Maintenance → where changes to these parameters are made an explanation of why must be provided.
Temperature Mode	This is usually set to ‘measured’. Where it is not: • provide an explanation of why • record the ‘Default Water Temperature’ used.
Default Water Salinity	An explanation of the source for this setting is required.

Profiling Mode	An explanation of the selected mode must be provided. Where enabled, record the Blanking Distance, the Cell Size, and the Number of Cells.
Channel Type **Geometry** **SL Elevation**	This must be 'Irregular'. Deployment → see Section 5.2 for requirements. Maintenance → see Section 7.3 for requirements.
Velocity Equation	Deployment → see Section 5.3 for requirements. Maintenance → see Section 7.0 for requirements.
Total Volume	Must be enabled.
Remember Total Volume	This will typically be set to 'Continuous'. Where 'Initialise' is used, an explanation of why must be provided.
Allow Volume Reset	This must be set to 'No'.
Total Volume Criteria	Where the default setting of 'Disabled' is not used, an explanation of why must be provided.

6.0 Output

Where the department requires meter health as an output from the meter:

The SL must have a MIM installed and operating. To have a validation certificate issued, where an SL:

- Is installed after this document came into effect - it must have a MIM installed as part of the process of validation, post-installation.
- Was installed prior to the effect of this document - it must have a MIM installed as part of the next process of validation.

The MIM provides output from the SL for interface with third party transmission devices.

Where the department requires pulse output only:

The SL must have an AOC installed and operating, as a minimum. Noting: this requirement can also be satisfied using the meter health option above. To have a validation certificate issued, where an SL:

- Is installed after this document came into effect - it must have an AOC installed as part of the process of validation, post-installation.
- Was installed prior to the effect of this document - it must have an AOC installed as part of the next process of validation.

The AOC provides output from the SL for interface with third party transmission devices.

7.0 Periodic calibration

After each interval of maintenance in this section is complete for an SL.

- A calibration report including the following parts, must be provided to the relevant person by their CPH:
  - index velocity calibration (see Section 7.1 for requirements) or Index velocity remeasurement (see Section 7.2 for requirements). This includes standard cross section remeasurement (see Section 7.3 for requirements)
  - analysis of the Internal Recorder download (see Section 7.4 for requirements); and Record-of and explanation-for the configuration parameters now used in for the SL (see Section 5.4 for requirements).

To set some expectation around the provision of the calibration report by the CPH to the relevant person, within 28 business days of the internal recorder download would be appropriate.

The calibration reports conforming to the requirements in this section is the calibration certificate for the SL, satisfying Measurement Assurance Requirement E of this module of the standard.

The relevant person must provide the calibration report/s received since the last process of validation for the SL, with the next validation certificate, to the department.

7.1 Index Velocity Calibration

Commencing 1 December 2022, where a theoretical velocity equation is used for an SL, 'index velocity calibration' must be completed at the following interval as a minimum. A CPH will often refer to this activity as index velocity rating development, but for this document we will use calibration.

For this circumstance the relevant person must engage their CPH to undertake calibration on the SL until an index velocity equation of sufficient quality has been developed and is used in the configuration of the SL. The index velocity equation is an empirical relation developed by making several independent discharge measurements using ADCP in a variety of flow and stage conditions, while measuring velocity with the SL.

7.1.1 Interval

'Index velocity calibration' must be undertaken during any single extraction event by the relevant person within this 12-month period – 1 December to 30 November (where extraction occurs during this period). More frequent calibration can be undertaken, this is a minimum requirement. Calibration does not need to occur for the duration of the extraction event, the CPH should time the calibration opportunity to expedite the development of the index velocity equation only.

7.1.2 Report

Each calibration event in the development of the index velocity equation must be thoroughly documented to show what steps were taken and what logic was used to develop and choose a particular index velocity equation for use in the configuration for the SL. Each new calibration event will build on earlier calibration events. This part of the calibration report must provide analysis:

- on the quality of the index velocity equation at the completion of this latest calibration event, and consider the data and analysis from any earlier calibration events for the SL
- of the standard cross section (see Section 7.3 for requirements).

USGS 3-A23 provides the method and approach which must be used for compiling and analysing data, and the development of a quality index velocity equation.

Where an index velocity equation of sufficient quality is developed, this will be confirmed in the report and the equation must be used in the configuration for the SL (see Section 5.4 for requirements).

In some situations, the index velocity equation may take several calibration events to develop.

7.2 Index Velocity Remeasurement

Commencing 1 December 2022, where an index velocity equation is used for an SL, 'index velocity remeasurement' must be completed at the interval below. A CPH will often refer to this activity as index velocity rating validation, but for this document we will use remeasurement.

For this circumstance the relevant person must engage their CPH to undertake remeasurement on the SL using ADCP, to maintain the index velocity equation for the SL.

Remeasurement is just an extension of the calibration under Section 7.1 above, with each new event building on earlier remeasurement and/or calibration events.

7.2.1 Interval

'Index velocity remeasurement' must be undertaken at the interval in the following table and subject to the requirements shown. More frequent remeasurement can be undertaken, this is a minimum requirement. Remeasurement does not need to occur for the duration of the extraction event, the CPH should time the remeasurement opportunity to maintain the index velocity equation only.

Interval	Trigger for interval change
During any single extraction event by the relevant person within the 12-month period – 1 December to 30 November (where extraction occurs during this period).	Where no change is required to the index velocity equation for 3 consecutive remeasurement events, the interval changes to 36 months (see next row). Where there is a change to the index velocity equation, remeasurement must continue at this 12-month period until no change is required to the index velocity equation for 3 consecutive remeasurement events, the interval then changes to 36 months (see next row).
During any single extraction event by the relevant person within the next 36-month period commencing 1 December (where extraction occurs during this period) – recurring.	

7.2.2 Report

Each remeasurement event to maintain the index velocity equation must be thoroughly documented to show what steps were taken and what logic was used to maintain the equation in the configuration for the SL. This may involve no change to the equation, but a report must still be provided.

This part of the calibration report must provide analysis:

- on the quality of the index velocity equation at the completion of this latest remeasurement event, considering the data and analysis from any earlier remeasurement/calibration events for the SL
- of the standard cross section (see Section 7.3 for requirements).

USGS 3-A23 provides the method and approach which must be used for compiling and analysing data, and how to maintain the index velocity equation.

7.3 Standard Cross Section Remeasurement

Regarding the requirement for the establishment of a ‘standard cross section’ (see Section 5.2), remeasurement of the cross section must occur as part of the index velocity calibration (see Section 7.1) or remeasurement (see Section 7.2) event, above.

A stage-area rating must be developed for each velocity calibration (see Section 7.1) or remeasurement event (see Section 7.2), at the standard cross section. This part of the calibration report must include the stage-area rating developed:

- documenting the methods used and data from the survey
- the approach to compute the remeasured stage-area rating
- analysis of the remeasured rating
- documenting the reason for adopting the remeasured rating as a revised configuration parameter, or not.

Analysis to be provided in this part of the report:

- Does the standard cross section show a substantial change in shape?
- A comparison of the stage area ratings over the last 3 years, where available (e.g., deployment and remeasured), and do the ratings show substantial change?
- Has a change in the stage-area rating had an impact on the index velocity?

The CPH must also document the magnitude of the change and explain whether the stage-area rating has been revised as a configuration parameter, in this part of the report.

7.4 Download internal recorder, including analysis

As soon as possible after the finalisation of the extraction events used for Section 7.1 or 7.2 above, the relevant person must engage their CPH to:

- download the internal recorder
- undertake the following data analysis.

The internal recorder must not be downloaded during an extraction event by the relevant person.

The analysis in the following table must be completed and provided as a part of the calibration report. Importantly, the report must identify where data shows a feature which is 'of-concern' and must record the action taken to address these features where this is required. Where data is not available this will be noted in the report, with justification why. Examples of this analysis are in the SL System Manual.

Data	Analysis
Velocity – plot	Are velocity values realistic based on the deployment environment? Is the velocity data consistent with time?
SNR – plot	What are the typical SNR values? Are they high enough for reliable data? How much variation is seen in SNR values? Does the variation appear reasonable for real-world variations in water conditions? Was the SL out of the water at any time during the deployment? Is there any suggestion that the SL or a beam were blocked (e.g., vegetation or sand bank)?
Stage – plot	Does stage appear reasonable for the deployment environment? Are there periods when stage is not reported? Do these match periods when the SL was out of the water, or when something else interfered with stage measurements?
Stage – view	Check the Flow Datum loaded into the SL to ensure accurate channel geometry was entered.
Stage and cross-sectional area – plot	Is the calculated cross-sectional area reasonable based on changes in stage?
Velocity, stage, and flow – plot	Are calculated flow values reasonable based on changes in stage and flow velocity? Are flow values reasonable based on the deployment environment?
Signal strength and noise level – plot	Do changes in signal strength match changes in SNR? Is noise level constant to within 2-3 counts?
Velocity and standard error of velocity – plot	Does standard error of velocity values match predicted values? Do standard error of velocity values seem to match the sample-to-sample variation seen in the velocity data?
Temperature, pressure, and battery voltage – plot	Is temperature data reasonable for the deployment environment? Is pressure data reasonable for the deployment environment? Does pressure data show the same general variations as stage data Is battery voltage consistent with the power supply? Does the system have sufficient power for reliable operation?

Data	Analysis
Internal diagnostic data – view	Is the signal strength profile reasonable for the environment? Do both beams show similar signal strength profiles? Are reflections from the opposite bank or underwater obstacles where you expect them? How does the signal strength profile compare to the theoretical decay curve? How does the signal strength profile change with time within the data file?

8.0 Maintenance

8.1 Cleaning the Transducers

Periodic cleaning of the transducers may be needed to maintain optimal performance.

Carefully clean the transducers with a non-metallic brush.

8.2 O-rings and Desiccant pouch

The SL housing must only be opened by SonTek personnel. Where an SL is opened by SonTek, the O-rings and Desiccant pouch should be replaced.

8.3 Battery replacement

Noting the requirements of Section 4.3, after 5 years of operation and irrespective of perceived battery life, the following batteries must be replaced:

- Where mains power is used, the external battery (or battery pack) used as a back-up power supply.
- Where mains power is not available or not used, the external battery (or battery pack).
- The real-time Clock Back-up Battery.

9.0 Tamper-evident/preventive sealing

9.1 Mechanical tamper-evident sealing

9.1.1 Deployed position

When the SL is in the deployed position for measurement, a mechanical tamper-evident seal must be applied to the mounting - the seal must be applied so that it must be broken to move the SL from the exact position for measurement.