



United States Department of the Interior
U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

In Reply Refer To:
Mail Stop 415

March 27, 2017

Memorandum

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM 2017.08

SUBJECT: SonTek 1500 kHz SL 3Gs Data Quality Problems

The purpose of this memorandum is to make you aware of some problems that have been identified with some SonTek 1,500 kHz SL 3G acoustic Doppler velocity meters (ADVMs), to provide tips on identifying SL 3Gs with the problem, to inform you of steps that SonTek will be taking to address repairing affected instruments, and to share guidance from the Office of Surface Water (OSW) on how to respond. In order to facilitate the response to this issue, the OSW also is requesting information be submitted via a form below.

SonTek, with the help of USGS hydrographers, has identified a problem with hardware components of the SonTek SL1500 (3G) ADVM. The hardware problem is caused by a malfunction of a relay that opens and closes the circuits between the SL1500 transducers and the ADVM electronics. Under some circumstances, a relay to one of the velocity transducers may become stuck causing data for the other two transducers to become contaminated. The primary symptom for this condition is “noisy” or erroneous velocity data in one beam. This defect can result in an abrupt change or long-term deterioration in the quality of the velocity and signal to noise ratio (SNR) or amplitude data. At this time, no other frequencies of the SL3G are thought to be affected by the relay defect.

SonTek has prepared a technical service bulletin (TSB, attached) describing the problem and providing information on how to detect the problem. The following are a list of possible symptoms:

- When doing a beam check, the vertical beam will show the same boundary interference in its beam profile as one or both of the profiling beams.
- Large differences between Beam 1 SNR and Beam 2 SNR.
- Beam velocities do not mirror one another. Instead, one of the beam velocities is biased heavily toward zero. In extreme cases, both beam velocities will be nearly zero.

- Beam velocities for one of the beams are highly variable, particularly relative to the variability in the velocity data for the other beam.
- The multi-cell velocity data located at the farthest distance from the instrument exhibits an unexpected increase in velocity standard deviation. One or both of the beams may exhibit this symptom. This symptom may also result in a range achieved by the instrument (cell end) that is substantially less than expected for the site.

When looking at your data for these symptoms, make sure to review an extended period of the data (e.g., not just the last month's data). The attached document provides examples that illustrate some of these symptoms (see pp. 6–8).

OSW is requiring that those offices that have purchased or rented SL1500 (3G)'s review their velocity, SNR, and ancillary ADVm data to determine if any of their data stored in the USGS National Water Information System (NWIS) are adversely affected. It is our belief that when the procedures documented by [Levesque and Oberg \(2012\)](#) and [Landers and others \(2016\)](#) are followed, these problems are readily detected. In fact, that is how this problem came to be known. For every SL1500 3G that has been deployed, the data must be reviewed to determine whether or not questionable data were recorded and stored in NWIS. For those sites where questionable or erroneous data are found, WSC staff should determine whether the data can be corrected or must be deleted. At the moment, this will require a case-by-case analysis, but OSW personnel are available to assist, if needed. In the TSB, SonTek outlines a procedure describing (a) how to use beam checks to evaluate relay performance (beginning on p. 6) and (b) how to remove contaminated data (TSB Appendix). We believe that the beam check procedure is of limited usefulness for instruments already deployed. OSW will release additional guidance on correcting or deleting and qualifying erroneous data once we understand the scope of the problem and its effect on computed discharges.

SonTek has offered to provide assistance in analyzing SL1500 (3G) data for those ADVm's purchased by the USGS. You are welcome to take advantage of this offer. If so, please follow the steps outlined below.

1. Send an email to Daniel.Wagenaar@xyleminc.com requesting assistance in reviewing SL 3G data, supplying the USGS site number and a contact's email address and phone number. Please cc OSW staff (kaoberg@usgs.gov and mswood@usgs.gov) on this email.
2. SonTek will forward the contact a ShareFile link to upload the data.
3. The user will upload the SL 3G files for review, and will include both the data file (*.sl) and beamcheck files (*.bng). Data for longer duration deployments are preferred.
4. A report on SonTek's review will be supplied to the USGS contact and to OSW staff. SonTek has indicated that data review will have a high priority.

Based on the information provided by SonTek, **all affected 1,500 kHz SL3G instruments must be returned to SonTek for repair regardless of whether 1,500 kHz SL3G data are questionable.** The affected instruments are those 1,500 kHz SL3G shipped prior to January 26, 2017 or having a 15003G-I-1 part number. It is possible that the data for some SL1500 (3G)

ADVMS will not be adversely affected. For those SL1500 (3G)'s that are deployed, provision will need to be made to temporarily replace that ADVMS with another SL. SonTek has a pool of five SL1500 (3G)'s available for loan during the repair. In order to facilitate the process of identifying ADVMS affected by this problem and which ADVMS should have priority for repair, **we request that the following form be completed by all USGS users of the SL1500 (3G)'s:** <https://goo.gl/forms/OUV8A1ZWb24Aay0o1>. After offices have completed responding to the form, OSW will assess the scope of the problem, assist with assigning priorities for repairs as needed, and will communicate with the offices affected. It is not necessary to send the instrument to the HIF first, nor for it to be returned via the HIF, since the HIF does not conduct velocity tests on ADVMS.

If additional information is required or you have questions, please contact Kevin Oberg (kaoberg@usgs.gov) or Molly Wood (mswood@usgs.gov).

//signed//

Robert R. Mason, Jr.
Chief, Office of Surface Water

References

Landers, M.N., Straub, T.D., Wood, M.S., and Domanski, M.M., 2016, Sediment acoustic index method for computing continuous suspended-sediment concentrations: U.S. Geological Survey Techniques and Methods, book 3, chap. C5, 63 p., <http://dx.doi.org/10.3133/tm3C5>.

Levesque, V.A., and Oberg, K.A., 2012, Computing discharge using the index velocity method: U.S. Geological Survey, Techniques and Methods 3–A23, 148 p., <http://pubs.usgs.gov/tm/3a23/>.

SonTek, 2017, Technical Service Bulletin 17-002 for SL1500-3G Model Only, Release Date: March 20, 2017, 21 p. (attached).

Attachment: SonTek Technical Service Bulletin

Distribution: GS-W All

SonTek

9940 Summers Ridge Road, San Diego, CA 92121
Tel +1.858.546.8327 Fax +1.858.546.8150



TECHNICAL SERVICE BULLETIN

Release Date: March 20, 2017

Service Number: 17-002

PRODUCT: SL1500-3G Model Only

SUMMARY: A quality issue was recently identified on hardware components of the SonTek SL1500 (3G) instrument. Not all SL1500 (3G) systems will display the issue, but if the issue occurs, the primary symptom is very noisy or erroneous velocity data. Secondary symptoms may include unaccounted-for changes in signal-to-noise ratio (SNR) and amplitude data. If the issue does occur, it is most likely to show up upon initial power-up of the system after being in an un-powered state. Therefore, prior to the issue being identified at the factory, some SL1500 (3G) systems that passed factory testing might be found faulty at a later date, or upon installation at a field site.

Who is affected: Potentially affected units can be identified by ship date or part number. If the unit shipped prior to January 26, 2017, or if the SL1500 (3G) part number is 15003G-I-1, the system is potentially affected and is recommended to be upgraded. If the part number is 15003G-I-2, the unit has the latest hardware changes and is not affected. If your SL1500 (3G) is accessible, you can locate the part number by looking on the serial number label.

How to identify if your SL1500 (3G) is experiencing the issue: Please see attachment "Procedure for Identifying SL3G-1500 Relay Issue in Data Review."

Remedy: The issue was isolated to components of the system's analog board. Using different components on the board will prevent the issue from occurring. Please contact either SonTek or your local Service Center to make arrangements for your unit to be upgraded at no charge.

SonTek also released SW/FW 2.2. The firmware release addresses a timing issue affecting a hardware component (relay) that controls beam switching. Due to incorrect timing in the relay switching path, the beam relays may experience premature aging. All users are encouraged to upgrade existing SL 3G systems in the field when possible.

What you should do: If you are unsure, or if you think your SL1500 (3G) system is experiencing the problem, please contact our Technical Support department and they can analyze the system's data to identify whether a problem is occurring. If your system is experiencing the issue, you will be advised to return it for repair. If your SL1500 (3G) system is not experiencing the issue, we highly recommend returning the unit for the upgrade whenever is convenient. SonTek will perform the upgrade free of charge until 31 December 2018. Technical support can be reached at support@sontek.com, or +1.858.546.8327.

We do apologize for this inconvenience. Please contact us with any questions or concerns you may have.

Sincerely,

SonTek Support Team



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Procedure for Identifying SL1500-3G Relay Issue in Data Review

Introduction: How to Use This Guide

On March 20, 2017, SonTek Technical Service Bulletin 17-002 was released for a hardware issue related to the relays on the SL1500-3G. This document serves as a data review guide to assist in determining whether:

- a) a certain dataset is affected by the relay issue or related issues
- b) a certain instrument is exhibiting the relay issue or related issues

This guide assumes that the user has installed the SL1500-3G properly at a good site (no interference with boundaries, perpendicular to the main flow, little turbulence, etc.). Each data example will show a graphic of the data followed by a table of features in the data to look for. For each data example, ensure that **ALL bold features in blue** apply to your dataset; *if you notice only one of several of these highlighted features in your dataset, this will not necessarily mean that you are experiencing that example.* Below the table of features is a Data Quality statement regarding what parts of your data are accurate (can be kept) and what data are contaminated (should be rejected).

Background: Relay Issue

The relay is a mechanical part that opens and closes the signal from a beam. It was discovered that one or more of the SL1500-3G relays would get “stuck” when exposed to fluctuations in temperature when not powered. When power is then applied, a relay can remain “stuck,” causing the other beams to always “hear” the acoustic signal from the “stuck” beam, thus contaminating the signal of those other beams. Because of the mechanical nature of the relay, vibrations in the system can cause a “stuck” relay to release and become “un-stuck” and resume normal operation. The data collected when relays are “stuck” will be very obvious to the user, and examples are shown in the following pages.

We have observed other consequences of the “stuck” relay issue in some systems. Due to the design, the relay can exhibit degradation over time. SonTek has made changes to the relay design to prevent this moving forward. Data examples are given in the following pages to show how data are affected and how to preserve good data.

The relay issue can potentially affect all SL1500-3G systems. Because a system’s relay can become “unstuck” and resume normal operation, a system currently functioning properly does not guarantee that previous data collected by that system did not encounter the relay issue at some point. It is advised that a thorough data review be performed on existing datasets



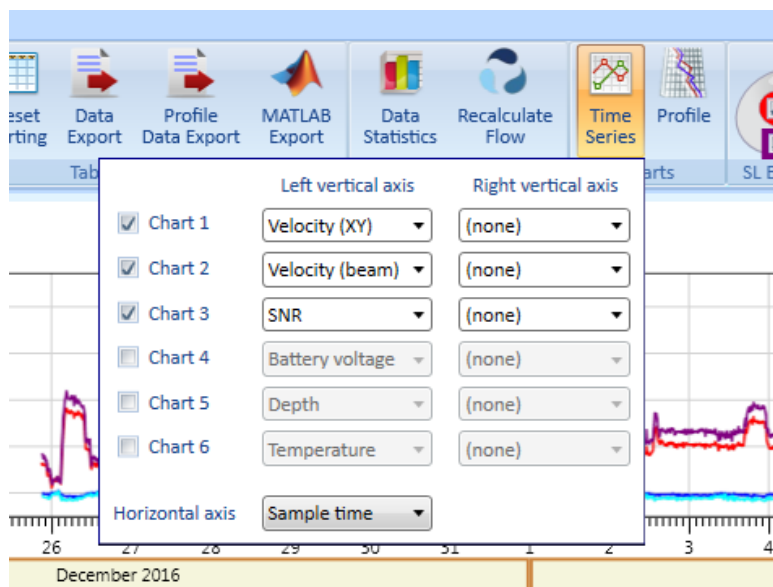
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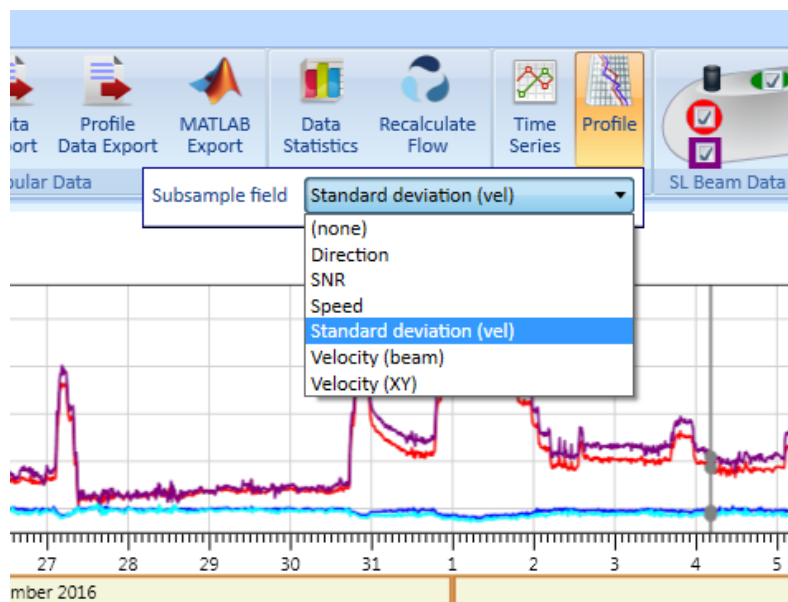
following the guidelines explained in this document. Whenever possible, historical data at a given site should be used for cross-checking and comparison.

1. How to Review a Data File Using the SL3G Software

- a. From the SL3G software, open your data file.
- b. View the Time Series plots of Velocity (XY), Velocity (beam), and SNR:

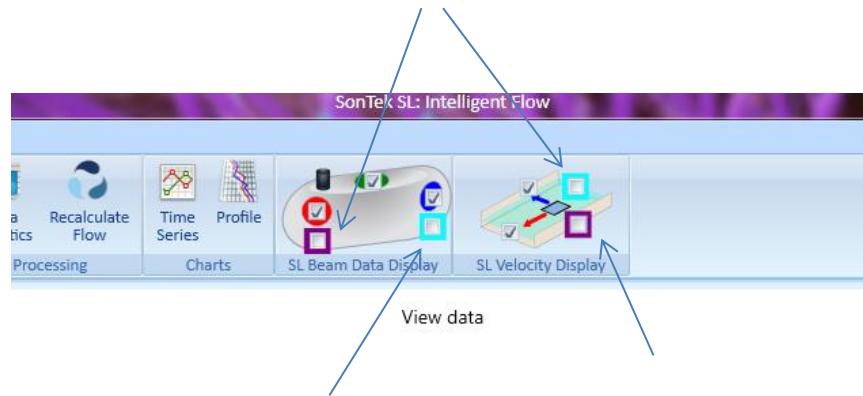


- c. View the Profile plot of Standard deviation (vel):



Procedure for Identifying SL1500-3G Relay Issue in Data Review

- d. Turn off the Integrated Velocity Cell (IVC) component by unclicking the cyan and purple check boxes on the top display banner:

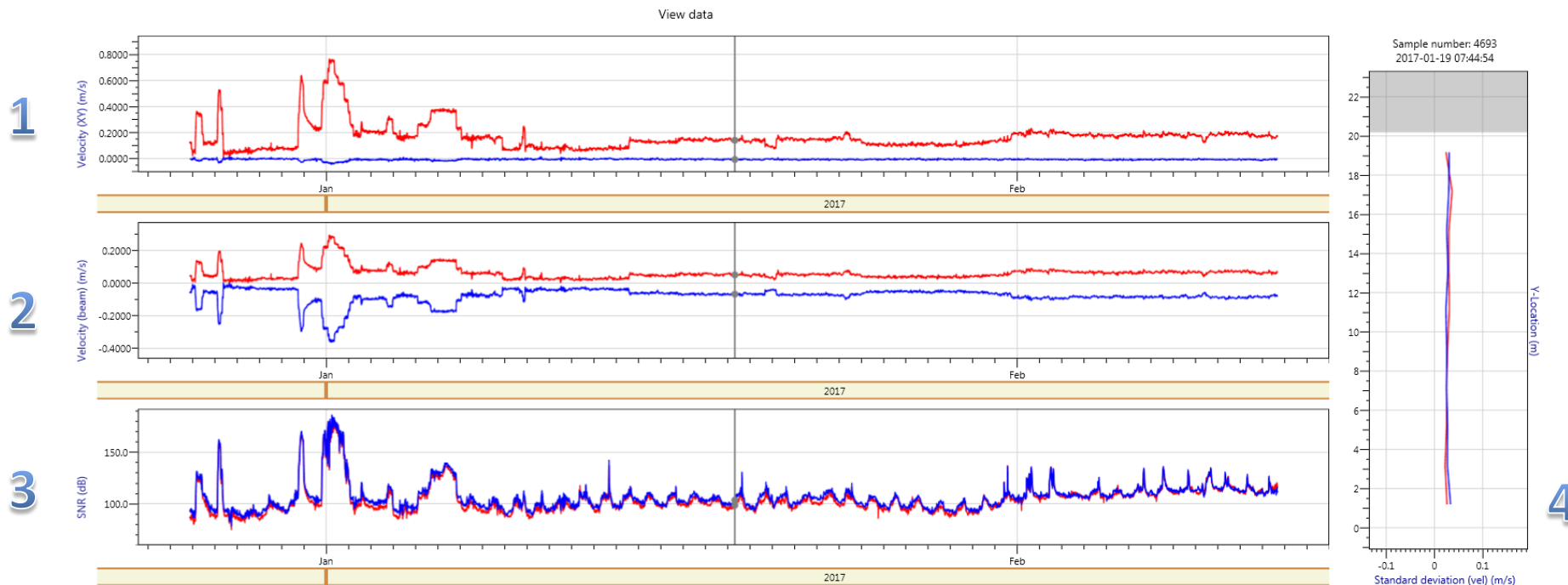




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Procedure for Identifying SL1500-3G Relay Issue in Data Review

2. Good Data (no relay issue)

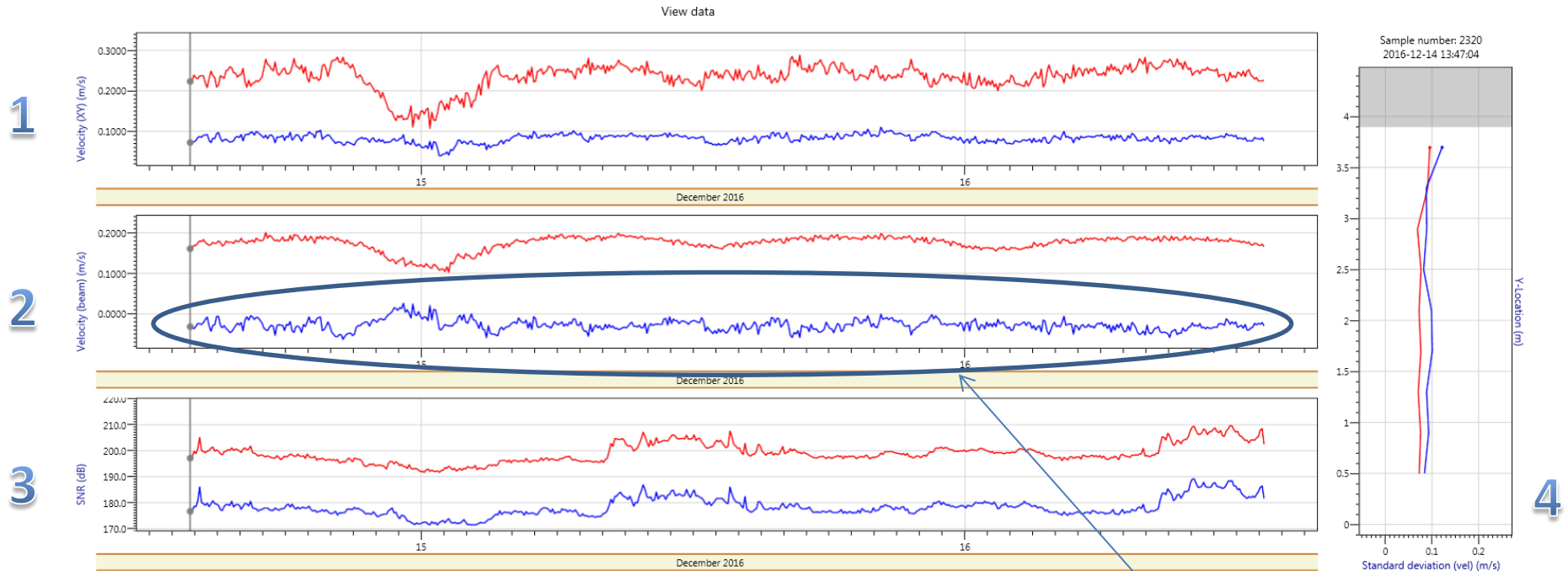


1	Velocity (XY)	X component (red) will be non-zero when there is flow. Y component (blue) will be near zero at all times.
2	Velocity (beam)	Mirrored images of Beam 1 (red) and Beam 2 (blue). When one beam is positive, the other beam is negative, and vice versa.
3	SNR	Need not be on top of one another but should not diverge from each other over time. Note: many other factors can cause SNR from beams to diverge over time (algal growth on one beam, changing water conditions, etc.) and this alone should not be used as a diagnostic tool for the relay issue.
4	Standard deviation (vel)	Profiles from Beam 1 (red) and Beam 2 (blue) follow each other closely through the entire profile. Standard deviation values should remain relatively constant (straight line) through the entire profile.

Data Quality: All data are accurate and meet or exceed specifications of the system.

Procedure for Identifying SL1500-3G Relay Issue in Data Review

3. Data Affected by One Relay Stuck

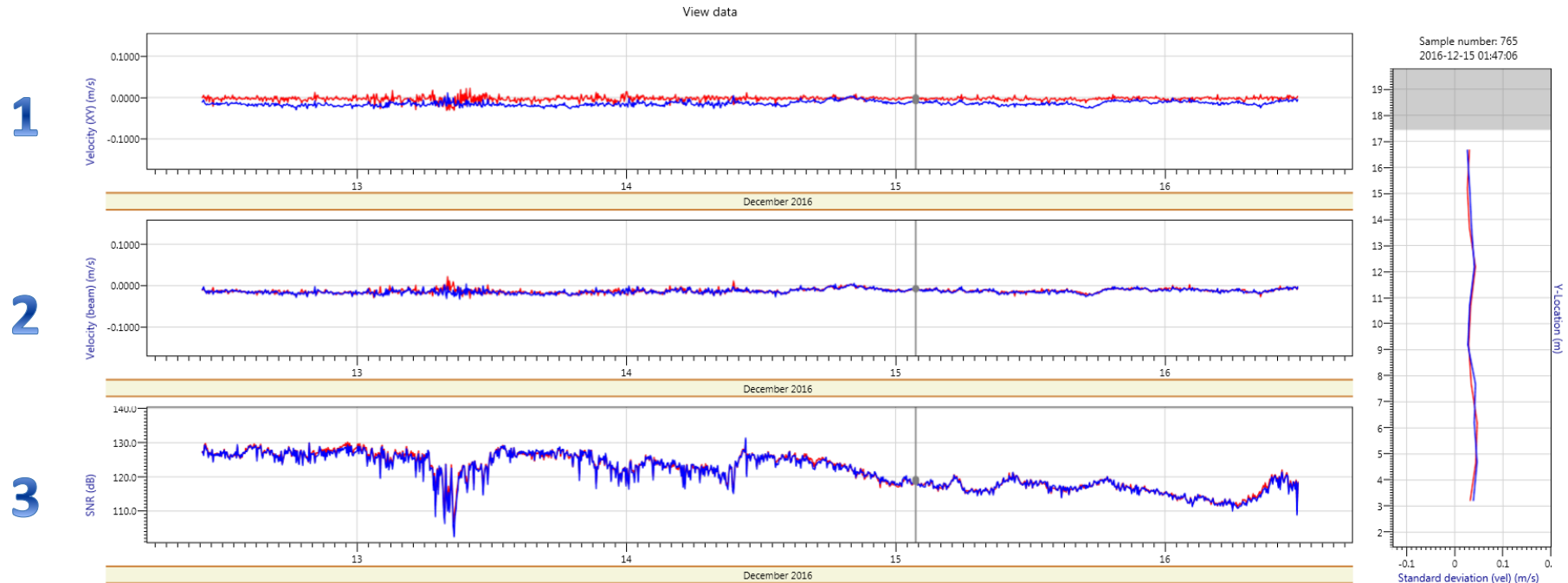


1	Velocity (XY)	Y component (blue) is no longer near zero at all times and has a significant value.
2	Velocity (beam)	No longer have mirrored images between beams. One beam is very near zero.
3	SNR	May see a large separation in SNR (>20 dB) that did not exist at this site with this instrument previously. This may not always occur.
4	Standard deviation (vel)	Profiles from Beam 1 (red) and Beam 2 (blue) may diverge more than what was observed at this site with this instrument under similar flow conditions. This may not always occur.

Data Quality: Data from the beam with the non-zero Beam Velocity (Red Beam 1 in above example) can be used to calculate X/Y velocities using a one-beam algorithm (currently being developed at SonTek). Please contact Technical Support for more details.

Procedure for Identifying SL1500-3G Relay Issue in Data Review

4. Data Affected by Two Relays Stuck

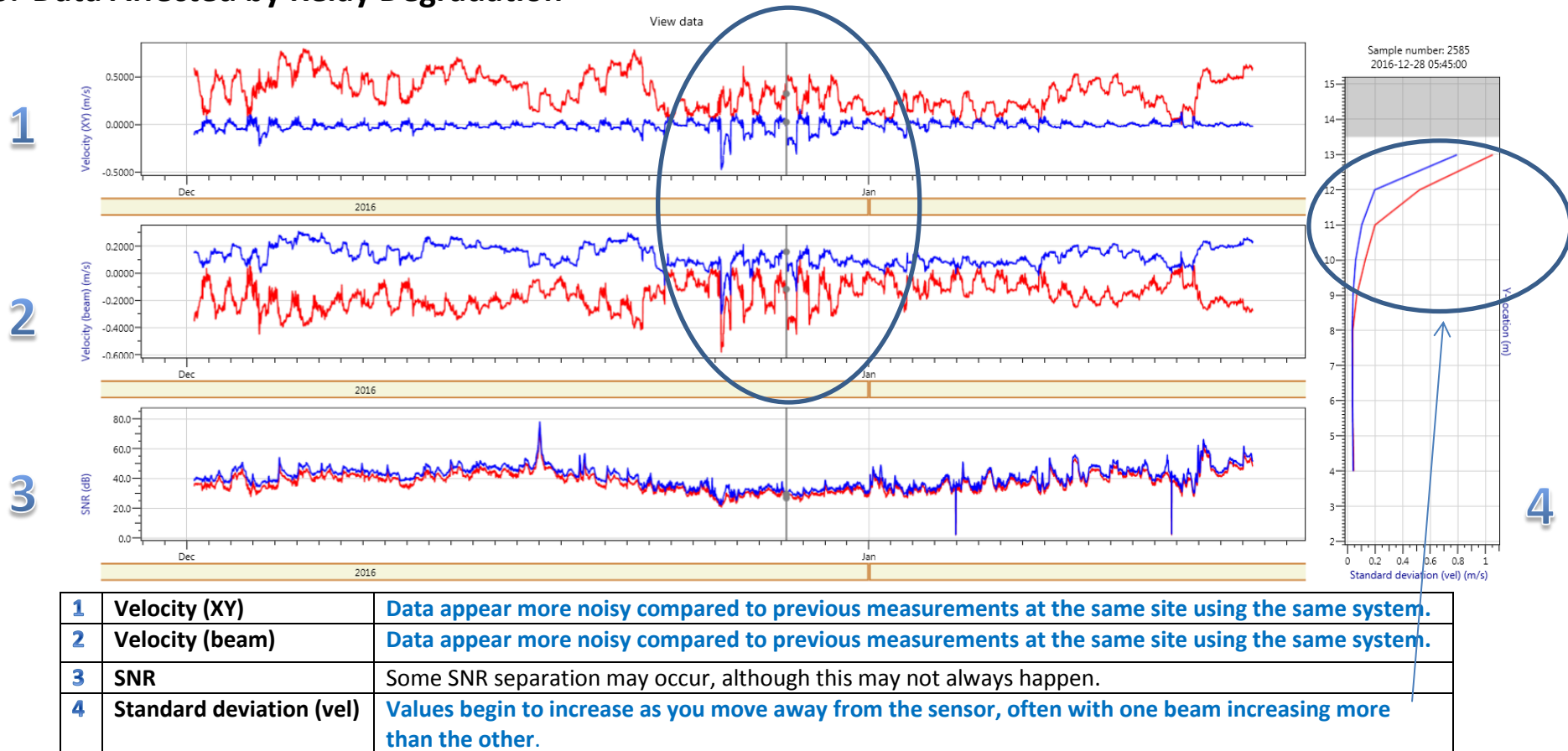


1	Velocity (XY)	X component (red) and Y component (blue) are both near zero at all times when there is obvious flow in the X direction (perpendicular to the system).
2	Velocity (beam)	Both beams are near zero at all times while there is obvious flow at the site.
3	SNR	May see a large separation in SNR (>20 dB) that did not exist at this site with this instrument previously. As in the above example, this may not always occur.
4	Standard deviation (vel)	Profiles from Beam 1 (red) and Beam 2 (blue) may diverge more than what was observed at this site with this instrument under similar flow conditions. As in the above example, this may not always occur.

Data Quality: Data from both beams are contaminated and should be rejected.

Procedure for Identifying SL1500-3G Relay Issue in Data Review

5. Data Affected by Relay Degradation



Data Quality: Data from both beams can be reprocessed to remove the contaminated data in the Integrated Velocity Cell by pulling back the Integrated Cell End parameter. Please refer to the methods and standards recommended by your agency before reprocessing any data. Instructions and details on one way to handle this procedure can be found in the Appendix of this document (optional).



Procedure for Identifying SL1500-3G Relay Issue in Data Review



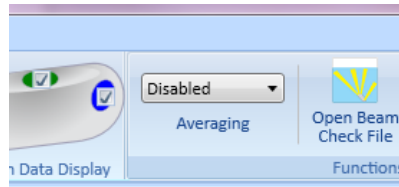
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Procedure for Identifying SL1500-3G Relay Issue in Data Review

6. Using Beam Check to Evaluate Relay Performance (Optional)

In the case where the SL3G system is accessible, performing a Beam Check is a useful tool to determine whether you have stuck relay issues. If you are able to move your system, a good test is to examine the beam check while **only submerging one beam at a time**. This can be done in a bucket of water and does not require a lot of space.

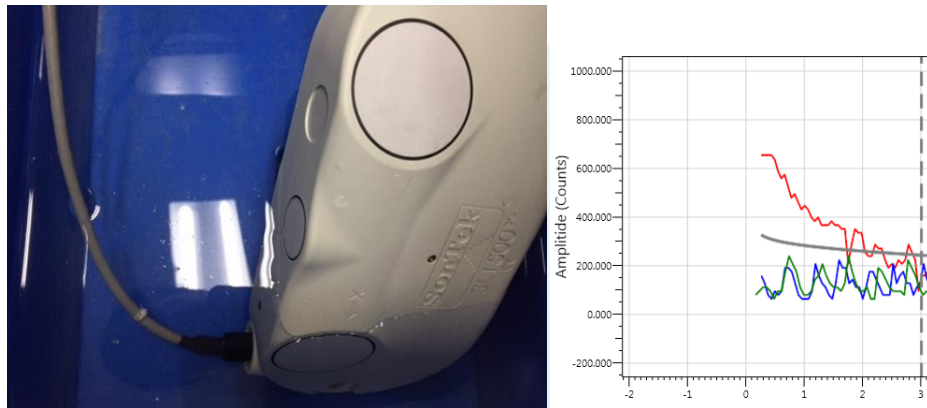
Make sure to have Averaging **Disabled** during your Beam Check:



a. Good Beam Check (no stuck relays)

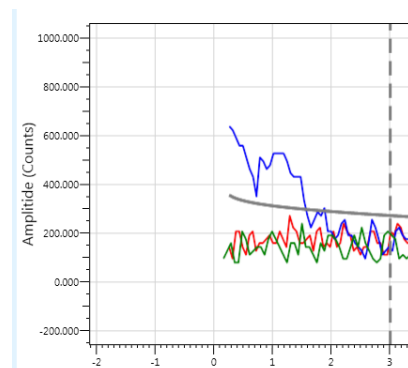
The submerged beam will show a noticeable increase in Amplitude compared to the beams above the water surface.

Submerging **Beam 1 only** will produce the following:



Submerging **Beam 2 only** will produce the following:

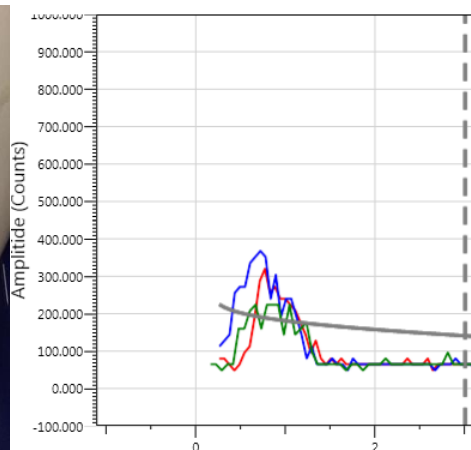
Procedure for Identifying SL1500-3G Relay Issue in Data Review



b. Beam Check with Stuck Relay

If one or more relays is stuck, at least two beams will show a noticeable increase in Amplitude despite only one beam being submerged. Be sure to try submerging both Beam 1 and Beam 2 separately. The response from both beams separately needs to be taken into account to decide whether your system has a stuck relay.

Submerging a single beam will produce the following:



In the above example, one relay is stuck. When that beam is submerged in water, an increase in amplitude occurs in all beams, including beams that are not submerged. **This signifies a relay issue.**



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Procedure for Identifying SL1500-3G Relay Issue in Data Review

7. Contact Information

As stated in the Introduction, please refer to the Technical Service Bulletin on this issue for instructions on how to contact SonTek if you require further assistance. Or, simply contact SonTek Technical Support by sending an email to support@sontek.com or calling 858-546-8327.

Appendix: Data Affected by Relay Degradation – How to Remove Contaminated Data



Please use this as a guide only, and refer to the methods recommended by your agency for this type of data processing. The following methods to remove contaminated data are optional, and are a few of many different ways to reprocess your data, if necessary.

As mentioned in Section 5, data affected by relay degradation can be reprocessed to remove the contaminated data due to the degradation. The process to do this for Integrated Velocity Cell data can be performed using the SL3G software. Doing the same for the Multi-cell data must be done manually through file exports. Both methods are outlined below.

Please note that if you are using Velocity Indexing, the type of change outlined below will require a shift or change in your Velocity Index Equation.

A. Removing Contaminated Data from Integrated Velocity Cell (IVC) Data

This option should be used if you use the SL3G software Integrated Velocity Cell X and Y Velocities, use the Theoretical Flow calculation for Flow values, or perform velocity indexing using any component of the Integrated Velocity Cell. If you have followed this document, you should see the view presented in Section 5 (Page 7) and have ensured that your dataset satisfies all of the required features to be sure your system is experiencing relay degradation.

- 1) Re-enable viewing the Integrated Velocity Cells by checking the all boxes below:



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Procedure for Identifying SL1500-3G Relay Issue in Data Review

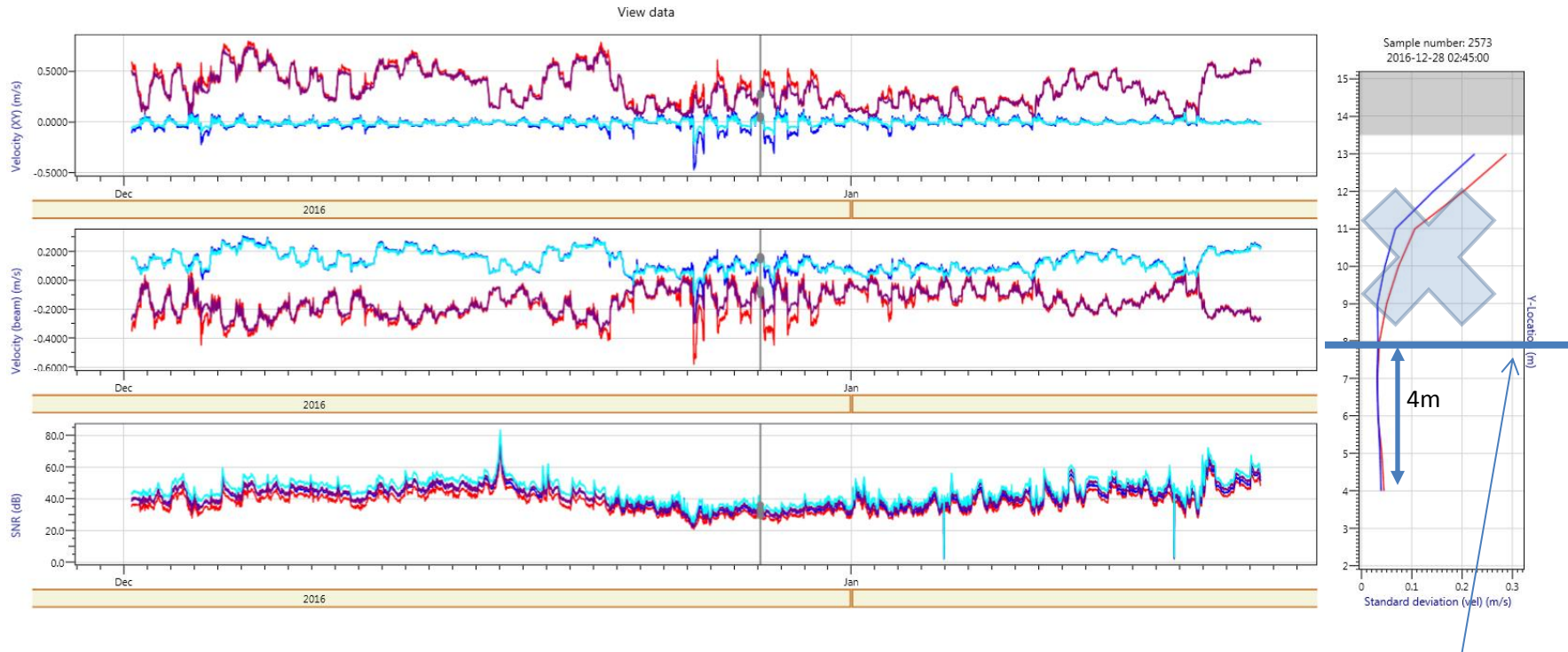


- 2) You will see the cyan and purple lines appear, as well as your red and blue lines:



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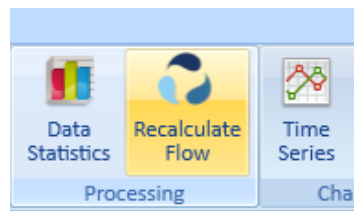
Procedure for Identifying SL1500-3G Relay Issue in Data Review



Click through the dataset to view data at different times, and notice the Standard deviation (vel) profile plot. Recall that normally the standard deviation of velocity profile plot should be very straight for both beams throughout the entire profile. The standard deviation from both beams shows an increase beginning at the blue horizontal line in this dataset. Here, data beyond this line should be rejected, and good data before this line can be kept. For this dataset, the amount of data that should be kept ends at **4m** from the instrument itself.

- 3) Click the Recalculate Flow button on the top banner:

Procedure for Identifying SL1500-3G Relay Issue in Data Review



- 4) Notice that the Integrated velocity cell end is set at 10m. Under Channel Shape, click “Change.”

Channel shape

Change

Geometry type: Irregular open channel

Survey origin: Left Bank

Orientation: Left Bank

Heading offset (degrees): 0.000

Integrated velocity cell begin (m): 1.000

Integrated velocity cell end (m): 10.000

Number of multi-cells: 10

Multi-cell blanking distance (m): 1.000

Multi-cell size (m): 1.000

Instrument Y (m): 2.500

Instrument Z (m): 3.496

Flow settings

Change

$Q = V \cdot A$

Mean velocity equation type: Index - Velocity(XY).X-MC

$V_{mean} = -0.66 + Velocity \cdot (1.08 + Stage \cdot 0.00)$

Remember total volume (m³): Continuous

Velocity threshold (m/s): Disabled

Flow threshold (m³/s): Disabled

Stage threshold (m): Disabled

Use Reverse Flow: Disabled

Use Velocity Filter: Disabled

Use SNR to adjust sample volume: Disabled

Use SmartPulse: Enabled

☒ Use site memory

Recalculate flow with new settings

Revert to original flow calculations

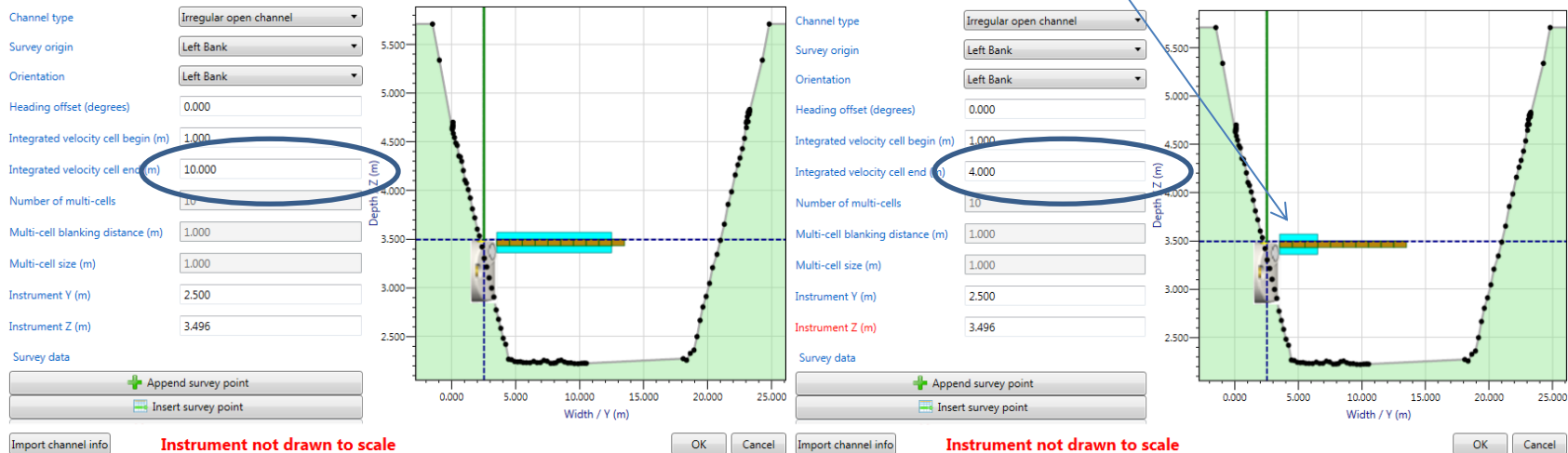
Exit without changes



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Procedure for Identifying SL1500-3G Relay Issue in Data Review

- 5) Determine to how much you must pull back your Integrated velocity cell for your dataset. In the above example, we observed an increase in standard deviation of velocity at about 8m, which corresponded to good data ending at **4m** from the instrument. Change the value of Integrated velocity cell end accordingly. Here we change it from 10m to 4m. See before (left) and after (right), below. Notice how the Integrated velocity cell in the diagram is pulled back. Press OK.



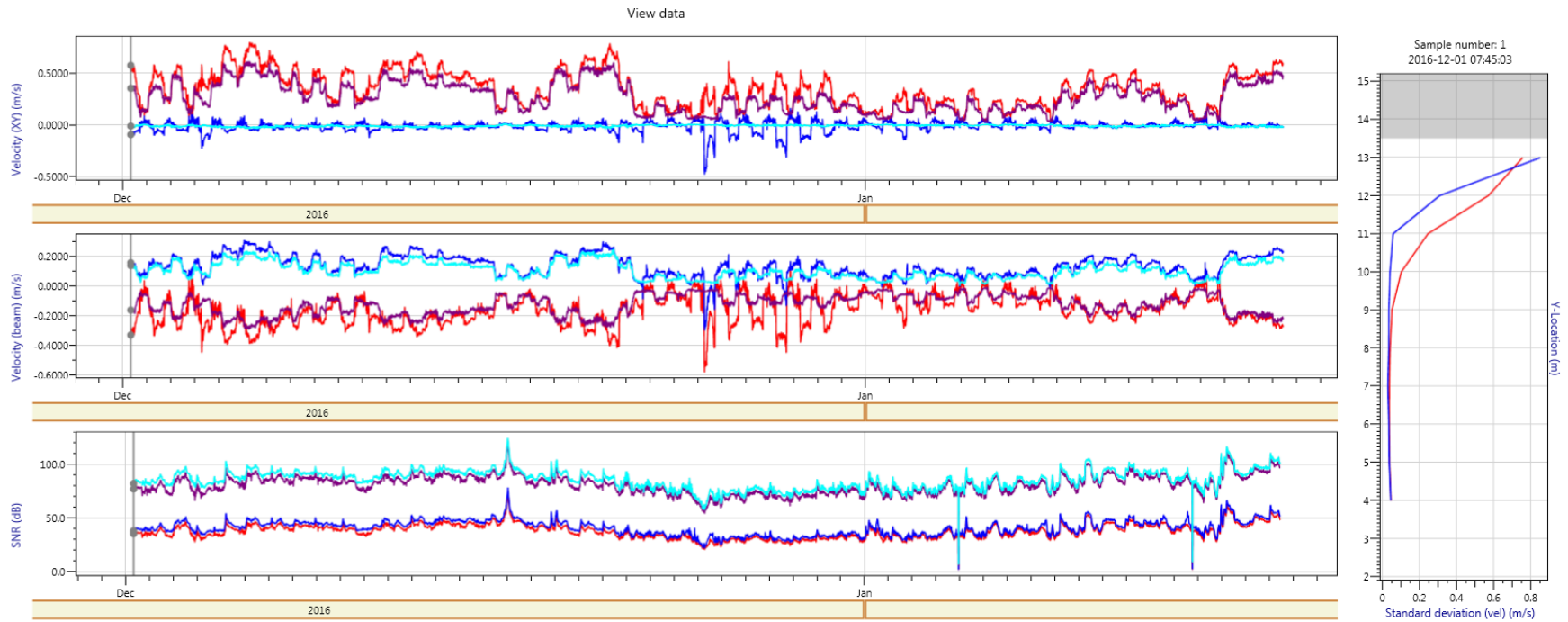
- 6) Click on "Recalculate flow with new settings" to recalculate the Integrated velocity cell velocities using the new settings.

- 7) Notice how this change decreases the noise/variability in the cyan and purple lines:



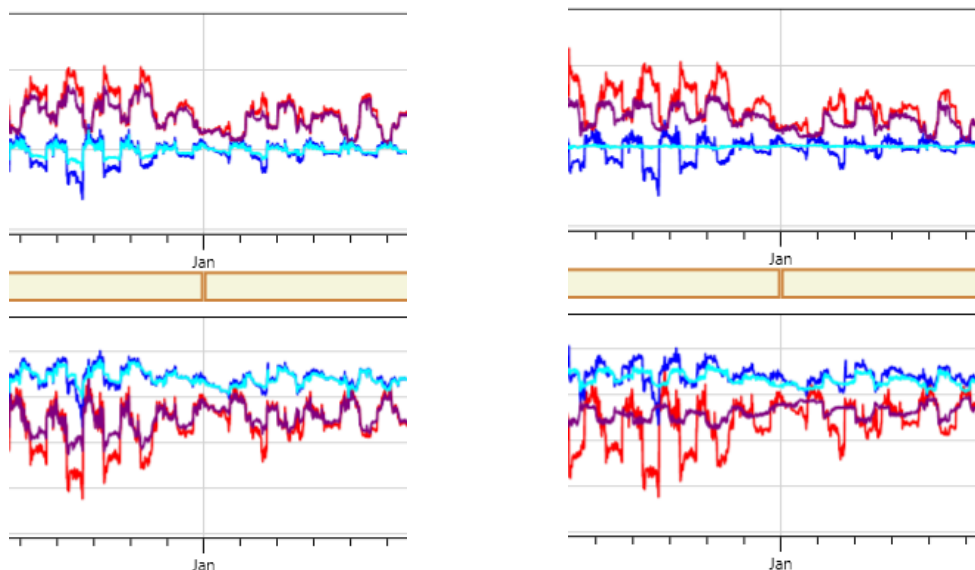
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Procedure for Identifying SL1500-3G Relay Issue in Data Review



Procedure for Identifying SL1500-3G Relay Issue in Data Review

Below are snapshots of a piece of the dataset before (left) and after (right) the recalculation. Notice how the cyan and purple Integrated velocity cell data (both XY and beam) show less noisy variability compared to before. Now the IVC velocity data are reprocessed properly.



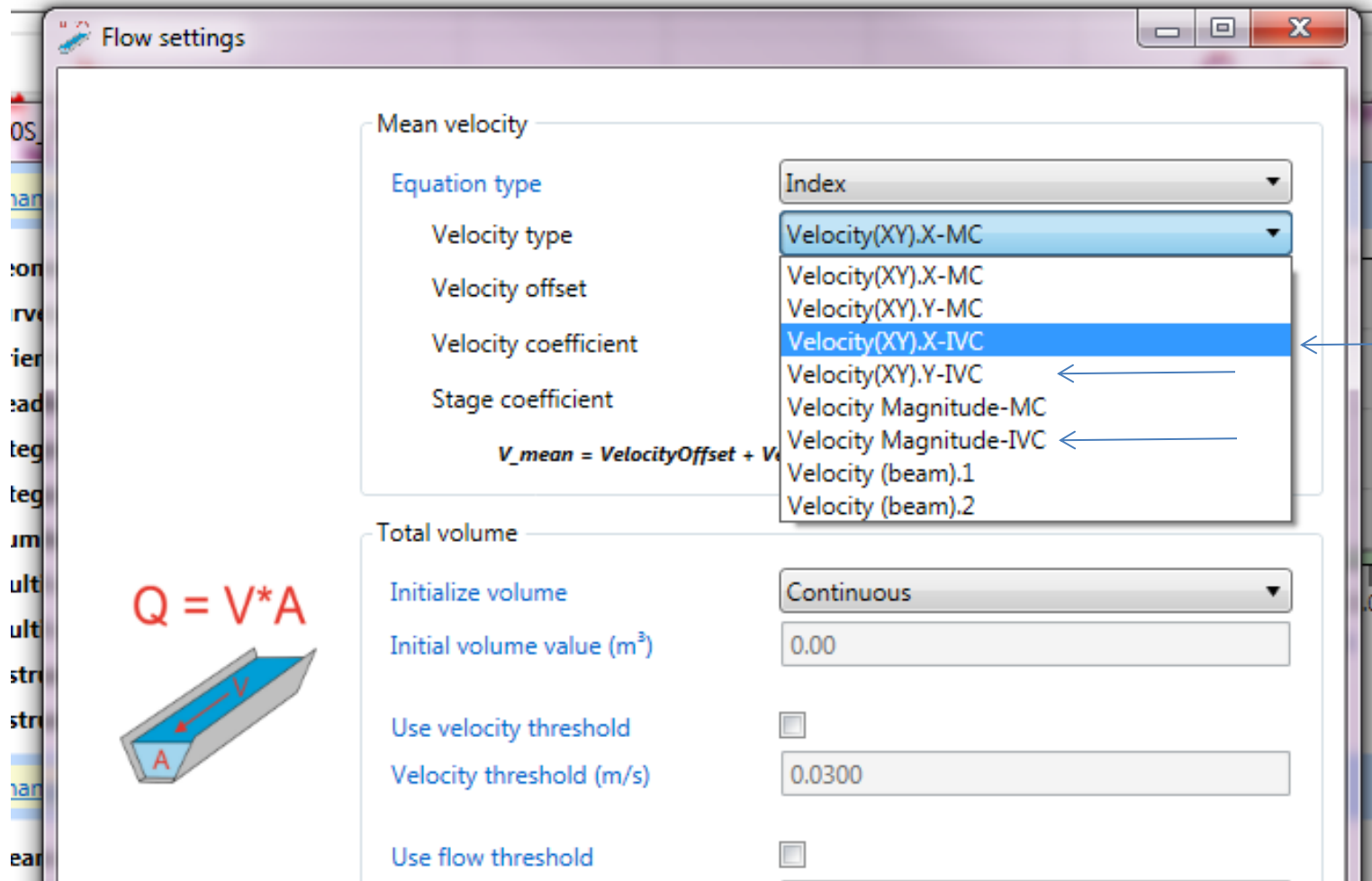
- 8) If you are using Theoretical Flow, the reprocessed IVC velocity values will be used to calculate flow values automatically after hitting the "Recalculate" button.



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Procedure for Identifying SL1500-3G Relay Issue in Data Review

- 9) If you are using "Index Velocity," make sure to select a velocity option using the IVC for velocity type:



- 10) If you prefer to calculate flow manually or use any IVC parameter for your Velocity Indexing, you can now export the Profile Data as you typically do to perform your calculations.



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Procedure for Identifying SL1500-3G Relay Issue in Data Review

B. Removing Contaminated Data from Multi-cell Data

This option should be used if SL1500-3G Multi-Cell X and Y velocities are used for developing Index Velocity Ratings and performing Flow Calculations. The SL3G software is currently not capable of changing any Multi-cell physical configurations, so you will need to do this manually. First, follow steps 1 and 2 above to determine by how much you must pull back your data to remove the contaminated data. Export the Multi-cell data using SL3G software without any additional software changes. The Multi-cell data collected beyond the location of increasing velocity standard deviation can be removed using any third party software (Excel, Notepad, etc.). The user can now proceed with their standard procedure for reviewing Index Velocity Ratings and Flow Calculations.