In Reply Refer To:
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February 12, 2007

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM 2007.01

SUBJECT: SonTek/YSI FlowTracker firmware version 3.10 and software version 2.11 upgrades and additional policy on the use of FlowTrackers for discharge measurements.

The purpose of this memorandum is to (1) announce the availability and recommended use of new SonTek/YSI FlowTracker firmware and software and (2) clarify existing policy on the use of FlowTrackers for making wading discharge measurements described in Office of Surface Water (OSW) Technical Memorandum No. 2004.04.

New software and firmware released by SonTek/YSI offer improved quality-control methods for FlowTracker discharge measurements. FlowTracker software version 2.11 is backward compatible with all FlowTracker firmware versions. The new FlowTracker firmware version 3.10 is compatible with most FlowTrackers. However, some early versions of the FlowTracker with serial numbers below P135 have a hardware limitation that is incompatible with the new firmware version 3.10 unless the FlowTracker hardware is upgraded. Contact SonTek/YSI for information on the process and cost for upgrading the FlowTrackers with incompatible hardware. The software and firmware upgrades are free for compatible FlowTrackers. The new firmware and software updates are available on the SonTek/YSI web pages (http://www.sontek.com/product/fw/ftfw.htm).

Evaluations comparing previous FlowTracker firmware and software with test versions of the new firmware and software indicate that the new firmware and software use the same algorithms to measure velocity and calculate discharge. Differences found when comparing the new FlowTracker software with previously released versions are the result of a change in the number of decimal places used during the calculations. Results of these comparisons are shown in Attachment A.

All USGS users who collect streamflow data with the SonTek/YSI FlowTracker should upgrade to the FlowTracker software version 2.11 as soon as possible. All USGS users who collect streamflow data with a SonTek/YSI FlowTracker capable of utilizing the new firmware should upgrade to firmware version 3.10 as soon as possible. FlowTrackers that are not compatible with the firmware version

3.10 should obtain the hardware upgrade so that firmware version 3.10 can be installed to take advantage of the new firmware features.

In the following sections, enhancements to the FlowTracker firmware and software are described and existing policies regarding beam checks and velocity measurement methods for the FlowTracker are clarified.

New Firmware version 3.10 and Software Version 2.11

FlowTracker firmware version 3.10 contains many new features designed to improve discharge-measurement quality and make the FlowTracker easier to use. A number of quality-control tests have been added that verify system operation and warn the user of possible measurement problems. These built-in tests should be very helpful in making FlowTracker users aware of possible problems, allowing users to take any necessary corrective action while making a discharge measurement.

The firmware contains some new features not routinely used by the USGS such as: (a) the Mean Section and Japanese discharge calculation methods; (b) Kreps velocity measurement method; and (c) translation to four additional languages. These features (a-c) have not been verified during USGS testing. The core velocity-measurement routines and mid-section discharge-calculation algorithms used by the USGS have been verified and have not changed from previous versions of the firmware. The mid-section discharge equation should continue to be used for all FlowTracker discharge measurements. OSW-recommended settings for the new FlowTracker firmware are provided in table 1. Quality-control thresholds are checked with each velocity measurement and when the “End Section” key is pressed. Measurement locations containing suspect data may be deleted and velocity measurements redone while in the process of making a discharge measurement in the field.

The new FlowTracker software and firmware can report two different types of discharge uncertainty values. One is based on an International Organization for Standardization (ISO) method for calculating uncertainty and the other is based on a USGS developed method (the Interpolated Variance Estimator or IVE) that uses statistical comparisons of neighboring verticals. Both values can be a useful indicator of relative measurement quality. The OSW, however, still is evaluating if either method represents the desired quantitative value of measurement uncertainty. Hydrographers are encouraged to consider these estimates when developing ratings and shifts.

Table 1. Recommended FlowTracker Settings. (Values that are underlined and in **bold** differ from the default settings.)

Parameter	Recommended Value
Language	English
Units	English
Average Time	40 seconds
SNR Threshold	10 dB
Standard Error of Velocity Threshold	0.033 ft
Spike Threshold	10%
Max Angle	20°
Discharge Equation	Midsection
Repeat Depth	No
Repeat Velocity	No
Maximum Section Discharge	10%
Maximum Depth Change	50%
Maximum Location Change	100%
Reference	Rated
Methods Displayed	2-6-8=Y, Ice=Y, Kreps=**N**, 5 point=**N**, Multi point = **N**
Uncertainty	Stats

The spike filtering algorithm in the new firmware removes outliers in the 1-second velocity data more effectively than previous firmware. The new filtering algorithm may result in a greater number of spikes being identified and filtered out of the mean velocities. This is the only known change to the velocity sampling scheme from the previous firmware.

The FlowTracker software version 2.11 contains a new discharge measurement summary report that will display and print a summary of a FlowTracker discharge measurement. The summary report includes cross-section plots of velocity, depth, and percent discharge per section. Attachment B contains a sample discharge measurement summary report.

BeamCheck

FlowTracker firmware version 3.10 contains the ability to perform and store an automated field BeamCheck with each measurement, labeled “QC Test.” It is recommended that this automated QC Test be completed as part of each discharge measurement. However, this test does not replace the office BeamCheck (called ADVCheck in previous software versions) performed with the FlowTracker software on a PC. The office BeamCheck should be performed, recorded, and archived prior to each week of use. During BeamChecks the signal amplitude for each beam should plot on top of each other and peak at the sample volume location. See attachment C for more detailed guidance on performing a BeamCheck.

Velocity Sampling Methods

The six-tenths-depth (0.6) method should be used in depths 1.5 ft or less. For depths greater than 1.5 ft, the two-point (0.2/0.8) method should be used. If the velocity measurement at the 0.8 depth could be corrupted by the sample volume being located on or near a boundary, then, in this case a six-tenths method should be used. If a non-standard velocity profile is found while making a two-point velocity measurement (for example, the 0.8 depth velocity is greater than the 0.2 depth velocity or the 0.8 depth velocity is less than half the 0.2 depth velocity), a three-point method (0.2 depth, 0.6 depth, and 0.8 depth) should be used. Users should not switch to a Price AA meter in streams with depths between 1.5 and 2.5 ft to avoid using the two-point velocity method. The existence of very low velocities at the 0.8 depth velocity measurement is not a valid reason to use the six-tenths depth method. As long as the FlowTracker can measure the water velocity accurately at the 0.8 depth, the two-point method should be used in depths greater than 1.5 ft.

The ability to use the two-point method for collecting water velocities in depths between 1.5 and 2.5 ft is an advantage of the FlowTracker over Price AA meters. The two-point method gives more consistent and accurate results than the six-tenths-depth method. Previously, the stated policy on when to switch from six-tenths-depth (0.6) method to a two-point (0.2/0.8) method was not as rigid because of concerns that the user would not recognize boundary issues during the measurement. The new quality control checks in the FlowTracker firmware version 3.1 should alert users of boundary issues during the discharge measurement, allowing them to modify the sample location to correct the problem.

If you have any questions or comments about the policies and guidance in this memorandum, please contact Mike Rehmel (msrehmel@usgs.gov) or the OSW Hydroacoustics Work Group.

Stephen F. Blanchard (signed)
Chief, Office of Surface Water

Attachment A - Software and Firmware Data Comparisons:

To compare the FlowTracker software versions 1.30 and 2.11, 40 previously made discharge measurements were processed using each version of software. The total discharges from the 40 pairs of processed discharge measurements were compared with software versions 1.30 and 2.11 (figure A-1). The new software provided accurate calculations comparable to the previous version. The largest difference in total discharge was 0.01 percent. The differences result from a change in the number of decimal places used during the calculations.

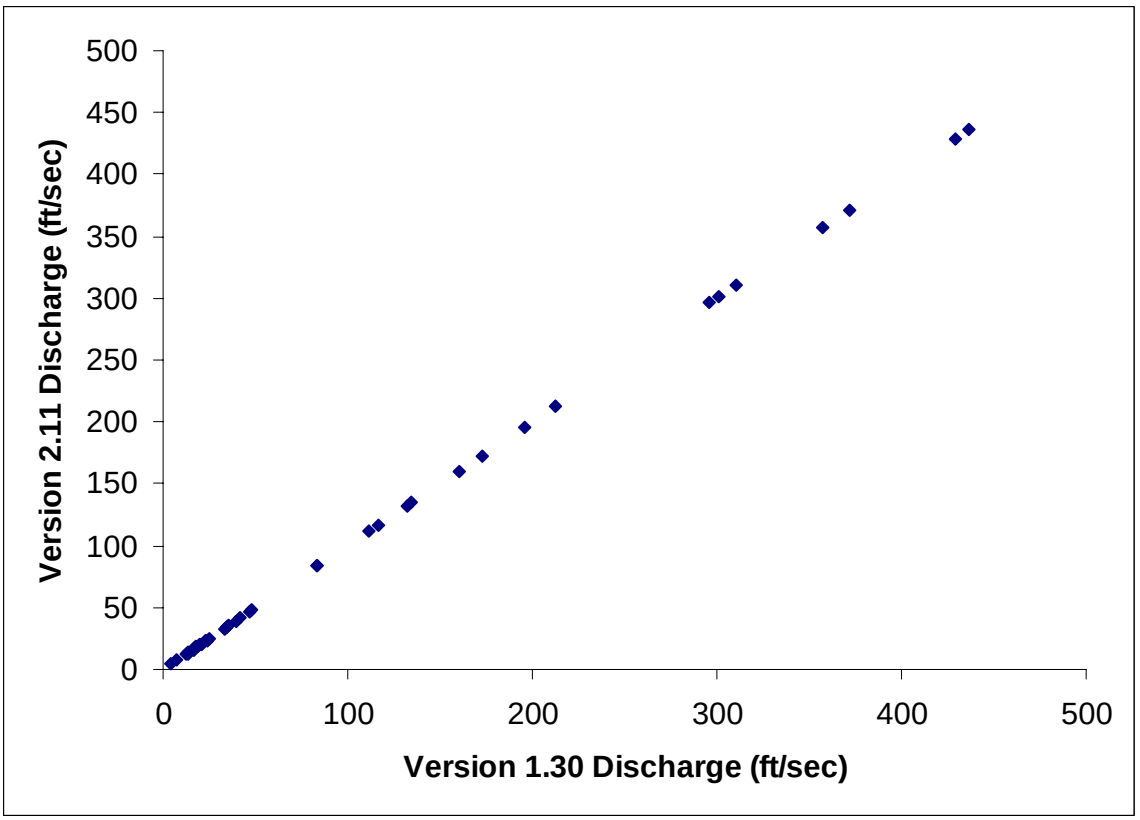


Figure A-1. Comparison of 40 discharge measurements computed, using version 1.30 and 2.11 FlowTracker Software.

To compare the FlowTracker firmware versions, two FlowTracker discharge measurements were made at the same site, using the same tagline stationing. The measurements were made at existing USGS streamgaging stations under near-steady flow conditions. The FlowTracker discharge measurements were made in accordance with all USGS methods, procedures, and policies regarding conventional discharge measurements. There was typically more than 30 minutes between the collection of the two velocity samples at a location. While effort was made to use the same sample locations with each firmware, small differences in sample volume placement are likely. From these discharge measurements, one-hundred-fifty 40-second velocity samples where compared (figure A-2). The mean difference between the 40-second sample data collected

with firmware version 2.4 and the test versions of firmware 3.10 was +1.1 percent with a median difference of +0.6 percent. The small positive differences may be a result of fewer boundary issues in the data collected with new firmware versions that contain the additional quality indicators. However, temporal and sample volume placement differences, along with the natural stream pulsations, likely account for most of the variation found.

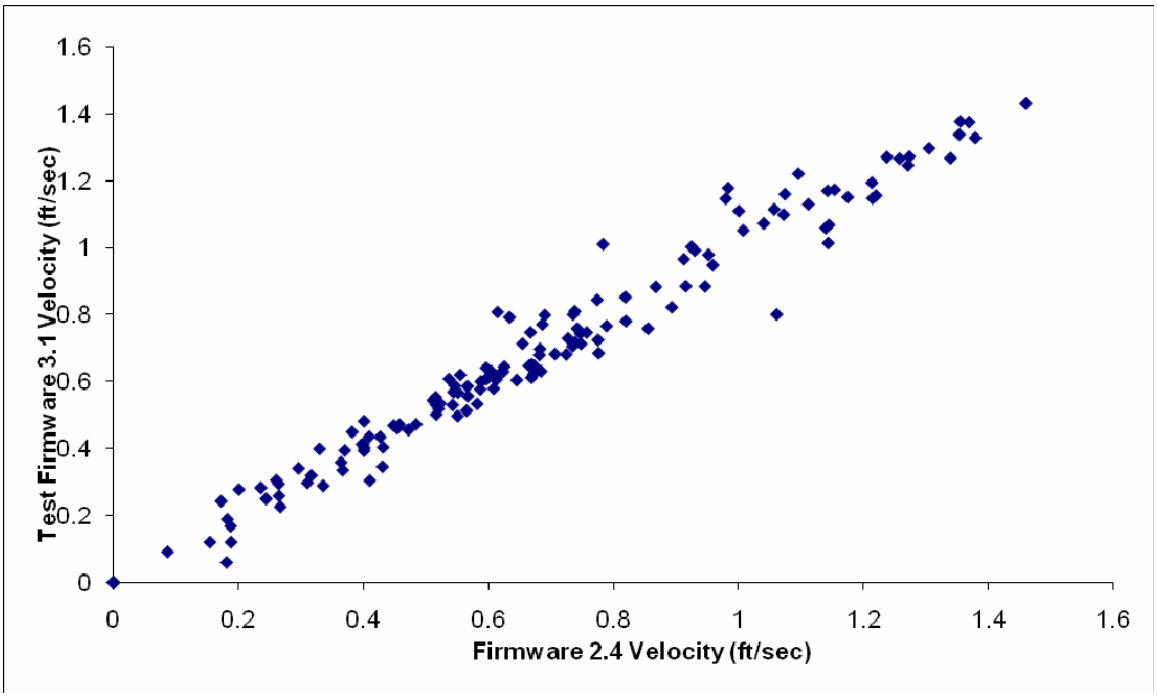


Figure A-2. Comparison of one-hundred-fifty 40-second velocity samples collected with FlowTracker firmware 2.4 and 3.1 (test versions).

Attachment B – New FlowTracker Software Version 2.11 Output

The following files should be exported (figure B-1) and archived with the original binary data file (.WAD) in accordance to OSW Policy Memorandum 2005.08 “Policy and Guidance for Archiving Electronic Discharge Measurement Data”:

- ASCII Discharge file (.DIS)
- ASCII Control file (.CTL)
- ASCII Summary file (.SUM)
- ASCII Data file (.DAT)

At a minimum, a printout of either the discharge-summary portion (figure B-2) of the new Discharge Summary Report or the ASCII Discharge file (.DIS) must be attached to each discharge-measurement note sheet. A printout of the entire Discharge Summary Report (figures B-2, B-3, B-4, B-5) may be attached, depending on office policy. A Water Science Center should have a written policy for consistency of discharge-measurement notes within each office.

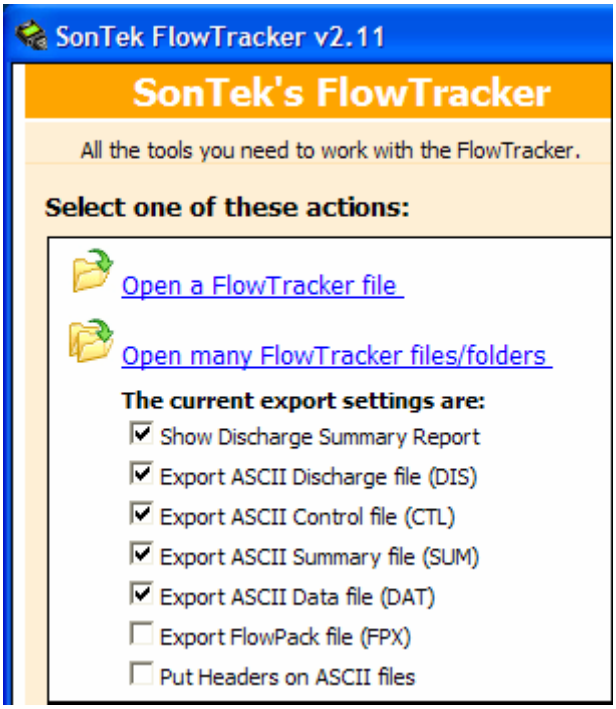
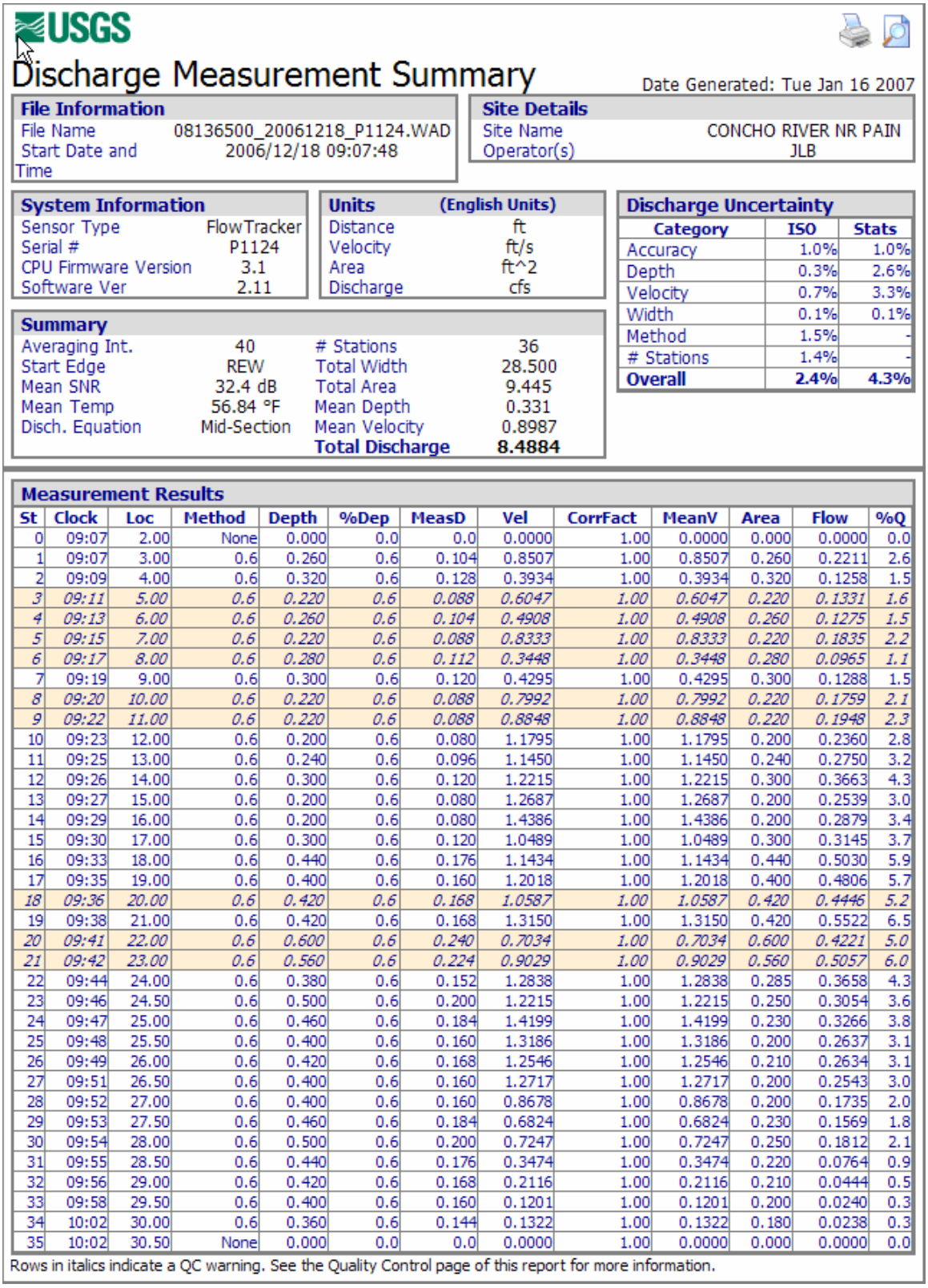


Figure B-1. New FlowTracker software version 2.11 export options.



USGS

Discharge Measurement Summary

Date Generated: Tue Jan 16 2007

File Information

File Name	08136500_20061218_P1124.WAD
Start Date and Time	2006/12/18 09:07:48

Site Details

Site Name	CONCHO RIVER NR PAIN
Operator(s)	JLB

System Information

Sensor Type	FlowTracker
Serial #	P1124
CPU Firmware Version	3.1
Software Ver	2.11

Units (English Units)

Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.3%	2.6%
Velocity	0.7%	3.3%
Width	0.1%	0.1%
Method	1.5%	-
# Stations	1.4%	-
Overall	**2.4%**	**4.3%**

Summary

Averaging Int.	40	# Stations	36
Start Edge	REW	Total Width	28.500
Mean SNR	32.4 dB	Total Area	9.445
Mean Temp	56.84 °F	Mean Depth	0.331
Disch. Equation	Mid-Section	Mean Velocity	0.8987
		Total Discharge	**8.4884**

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	09:07	2.00	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	09:07	3.00	0.6	0.260	0.6	0.104	0.8507	1.00	0.8507	0.260	0.2211	2.6
2	09:09	4.00	0.6	0.320	0.6	0.128	0.3934	1.00	0.3934	0.320	0.1258	1.5
3	*09:11*	*5.00*	*0.6*	*0.220*	*0.6*	*0.088*	*0.6047*	*1.00*	*0.6047*	*0.220*	*0.1331*	*1.6*
4	*09:13*	*6.00*	*0.6*	*0.260*	*0.6*	*0.104*	*0.4908*	*1.00*	*0.4908*	*0.260*	*0.1275*	*1.5*
5	*09:15*	*7.00*	*0.6*	*0.220*	*0.6*	*0.088*	*0.8333*	*1.00*	*0.8333*	*0.220*	*0.1835*	*2.2*
6	*09:17*	*8.00*	*0.6*	*0.280*	*0.6*	*0.112*	*0.3448*	*1.00*	*0.3448*	*0.280*	*0.0965*	*1.1*
7	09:19	9.00	0.6	0.300	0.6	0.120	0.4295	1.00	0.4295	0.300	0.1288	1.5
8	*09:20*	*10.00*	*0.6*	*0.220*	*0.6*	*0.088*	*0.7992*	*1.00*	*0.7992*	*0.220*	*0.1759*	*2.1*
9	*09:22*	*11.00*	*0.6*	*0.220*	*0.6*	*0.088*	*0.8848*	*1.00*	*0.8848*	*0.220*	*0.1948*	*2.3*
10	09:23	12.00	0.6	0.200	0.6	0.080	1.1795	1.00	1.1795	0.200	0.2360	2.8
11	09:25	13.00	0.6	0.240	0.6	0.096	1.1450	1.00	1.1450	0.240	0.2750	3.2
12	09:26	14.00	0.6	0.300	0.6	0.120	1.2215	1.00	1.2215	0.300	0.3663	4.3
13	09:27	15.00	0.6	0.200	0.6	0.080	1.2687	1.00	1.2687	0.200	0.2539	3.0
14	09:29	16.00	0.6	0.200	0.6	0.080	1.4386	1.00	1.4386	0.200	0.2879	3.4
15	09:30	17.00	0.6	0.300	0.6	0.120	1.0489	1.00	1.0489	0.300	0.3145	3.7
16	09:33	18.00	0.6	0.440	0.6	0.176	1.1434	1.00	1.1434	0.440	0.5030	5.9
17	09:35	19.00	0.6	0.400	0.6	0.160	1.2018	1.00	1.2018	0.400	0.4806	5.7
18	*09:36*	*20.00*	*0.6*	*0.420*	*0.6*	*0.168*	*1.0587*	*1.00*	*1.0587*	*0.420*	*0.4446*	*5.2*
19	09:38	21.00	0.6	0.420	0.6	0.168	1.3150	1.00	1.3150	0.420	0.5522	6.5
20	*09:41*	*22.00*	*0.6*	*0.600*	*0.6*	*0.240*	*0.7034*	*1.00*	*0.7034*	*0.600*	*0.4221*	*5.0*
21	*09:42*	*23.00*	*0.6*	*0.560*	*0.6*	*0.224*	*0.9029*	*1.00*	*0.9029*	*0.560*	*0.5057*	*6.0*
22	09:44	24.00	0.6	0.380	0.6	0.152	1.2838	1.00	1.2838	0.285	0.3658	4.3
23	09:46	24.50	0.6	0.500	0.6	0.200	1.2215	1.00	1.2215	0.250	0.3054	3.6
24	09:47	25.00	0.6	0.460	0.6	0.184	1.4199	1.00	1.4199	0.230	0.3266	3.8
25	09:48	25.50	0.6	0.400	0.6	0.160	1.3186	1.00	1.3186	0.200	0.2637	3.1
26	09:49	26.00	0.6	0.420	0.6	0.168	1.2546	1.00	1.2546	0.210	0.2634	3.1
27	09:51	26.50	0.6	0.400	0.6	0.160	1.2717	1.00	1.2717	0.200	0.2543	3.0
28	09:52	27.00	0.6	0.400	0.6	0.160	0.8678	1.00	0.8678	0.200	0.1735	2.0
29	09:53	27.50	0.6	0.460	0.6	0.184	0.6824	1.00	0.6824	0.230	0.1569	1.8
30	09:54	28.00	0.6	0.500	0.6	0.200	0.7247	1.00	0.7247	0.250	0.1812	2.1
31	09:55	28.50	0.6	0.440	0.6	0.176	0.3474	1.00	0.3474	0.220	0.0764	0.9
32	09:56	29.00	0.6	0.420	0.6	0.168	0.2116	1.00	0.2116	0.210	0.0444	0.5
33	09:58	29.50	0.6	0.400	0.6	0.160	0.1201	1.00	0.1201	0.200	0.0240	0.3
34	10:02	30.00	0.6	0.360	0.6	0.144	0.1322	1.00	0.1322	0.180	0.0238	0.3
35	10:02	30.50	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

Figure B-2. Page 1 of the FlowTracker software version 2.11 measurement summary.

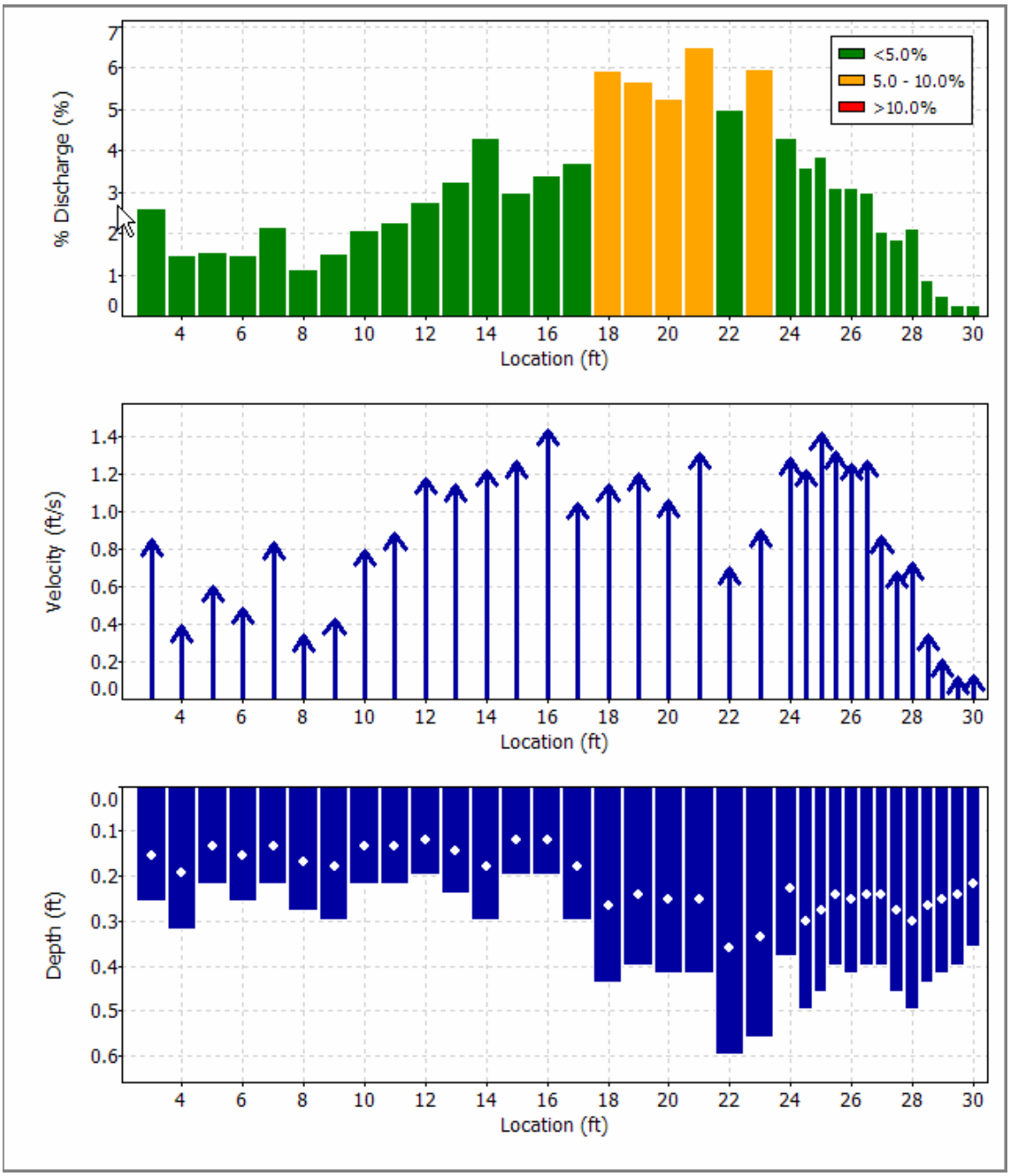


Figure B-3. Cross-section plots from FlowTracker software version 2.11.

Quality Control

St	Loc	%Dep	Message
3	5.00	0.6	High angle: -20
4	6.00	0.6	High angle: -26
5	7.00	0.6	High angle: -20
6	8.00	0.6	High angle: -33
8	10.00	0.6	High angle: 21
9	11.00	0.6	High angle: 20
18	20.00	0.6	High standard error: 0.064
20	22.00	0.6	High standard error: 0.038
21	23.00	0.6	High standard error: 0.045

Figure B-4. Quality-Control information output from FlowTracker software version 2.11, listing all stations that exceed a quality-control threshold.

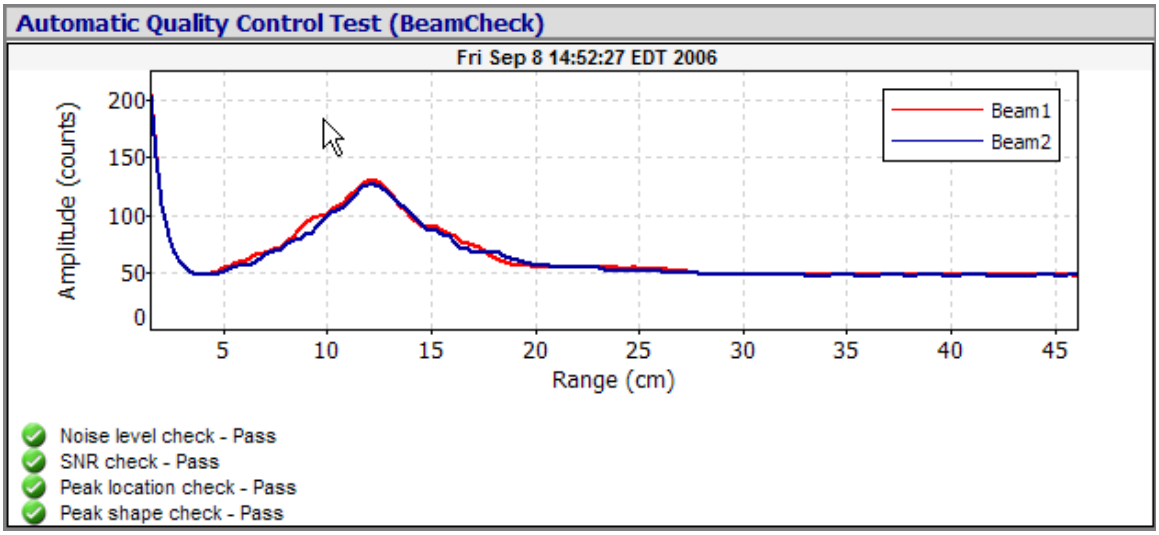


Figure B-5. FlowTracker software version 2.11 Automatic Quality-Control Test output that is in the measurement summary when a QCTest is performed in the field with the discharge measurement.

Attachment C – Correct BeamCheck Procedures

BeamCheck is a diagnostic program for the FlowTraker that displays and records the return signal strength versus the range for each receiver on the probe. A BeamCheck should be performed in the office prior to each week of use. The FlowTrackers built-in automated QC field test does not replace the requirement to perform the office BeamCheck.

All users should read section 6.5 of the FlowTracker Technical Manual. The manual provides detailed instructions on how to use the BeamCheck software and interpret the results.

Items of importance when performing a BeamCheck:

- Keep the FlowTracker at least 2 inches from the bottom of the bucket and the transmitting transducer about 8 to 12 inches from the far wall of the bucket (figure C-1).
- Start pinging and allow the FlowTracker to collect a few pings prior to enabling recording. If the FlowTracker is placed correctly in the bucket, the plot should look similar to figure C-2. If the plot looks very noisy (i.e., figure C-3), change the placement of the probe to ensure the sample volume is not too close to a boundary.
- Record at least 20 pings with the probe properly located in the bucket.
- BeamCheck should be archived in accordance with the electronic archival policies stated in accordance to OSW Policy Memorandum 2005.08 “Policy and Guidance for Archiving Electronic Discharge Measurement Data.”

Figure C-1. Picture showing correct placement of FlowTracker probe in bucket of water to perform a BeamCheck. Note that the probe is located 2 inches from the bottom of the bucket.

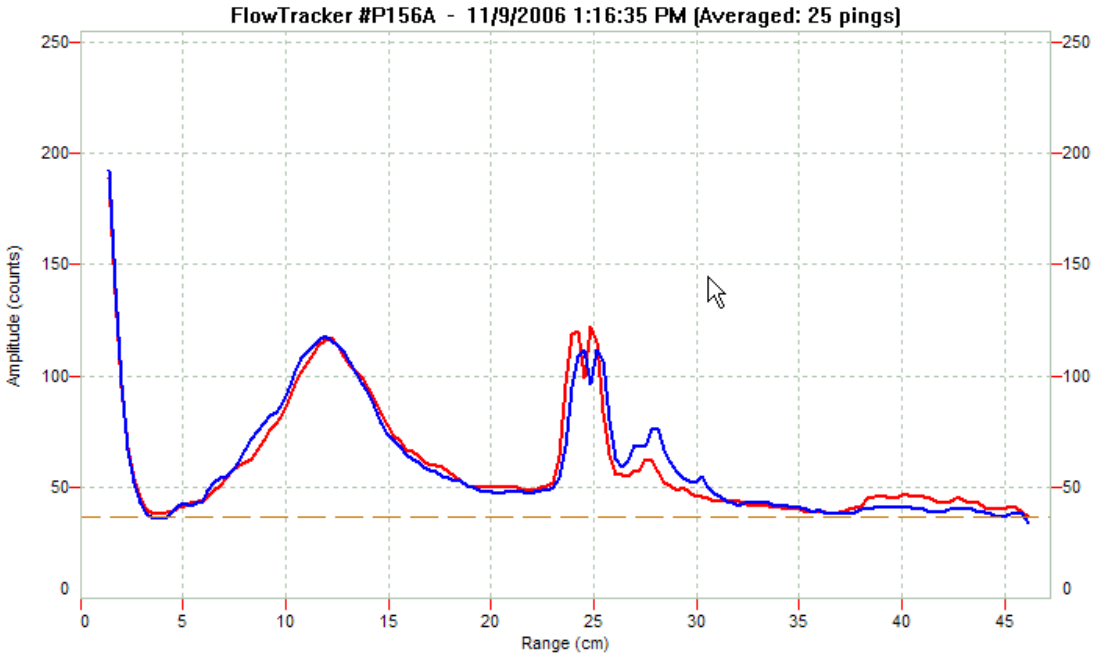


Figure C-2. Example output for a good BeamCheck result. Probe held approximately 2 inches from the bottom of a bucket and 10 inches from the far boundary (side of bucket).

Figure C-3. Example output from a poor BeamCheck result. Probe placed on bottom of bucket. Sound bouncing off of bottom causes very noisy amplitude plot.