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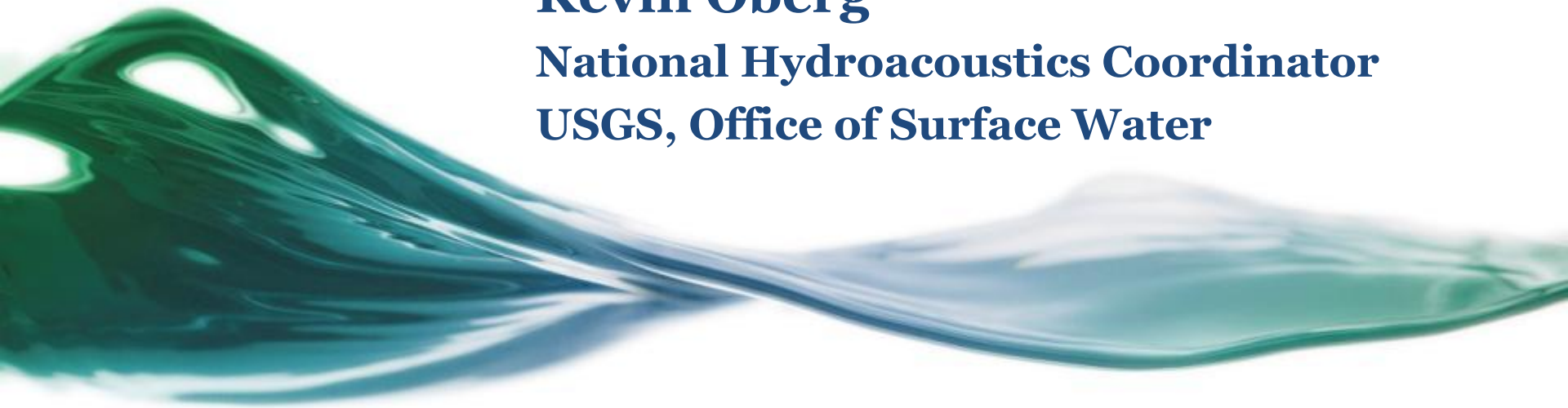
Status of Testing of Hydroacoustic Instruments – February 2013

TRDI RiverRay, SonTek M9/S5, and the Ott ADC

Kevin Oberg
National Hydroacoustics Coordinator
USGS, Office of Surface Water



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Overview

- Background and rationale for testing
- USGS Testing Program with examples
- Status of testing for
  - SonTek M9/S5
  - TRDI RiverRay
  - Ott ADC
- Plans for the future

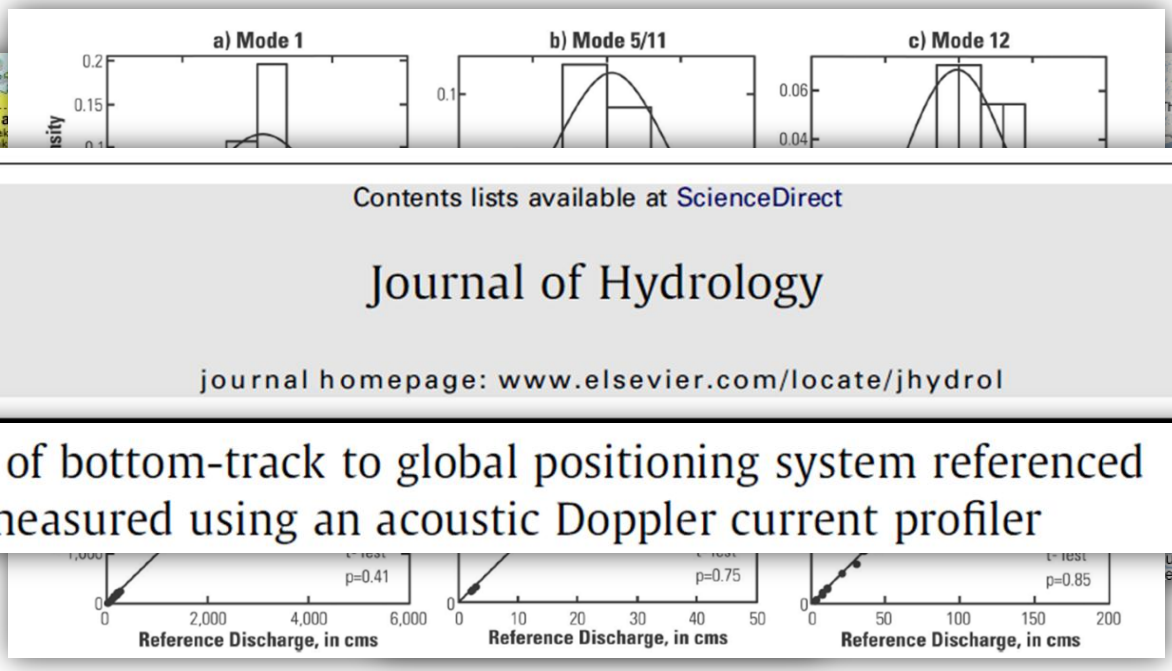
Background

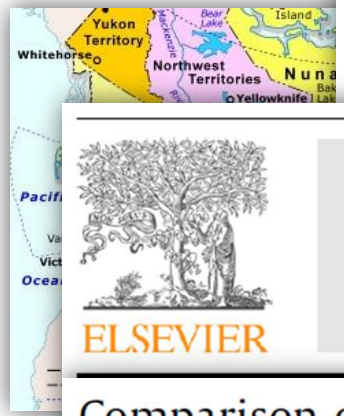
- The performance of traditional streamgaging instruments (e.g. Price AA) is well documented
- However, for new instruments such as ADCPs and acoustic point velocity meters, relatively few systematic field programs for validating acoustic instruments for streamflow and other hydraulic measurements have been documented.
- Little systematic testing is being done by other agencies, and even less in private industry.

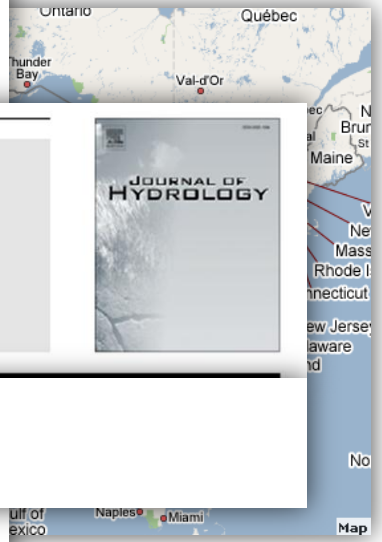
National Field Validations of ADCPs & ADVs

Evaluation of Acoustic Doppler Current Profiler Measurements of River Discharge
by Scott E. Morlock
USGS Water-Resources Investigations Report 95-4218, 1996

Validation of Streamflow Measurements Made with Acoustic Doppler Current Profilers
by Kevin Oberg and David S. Mueller
2007 -- J. Hydr. Eng., v. 133, No. 12, p. 1421-1432







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Measurements – Jan 2009 to May 2012

Model	#
Unspecified	27,386
StreamPro	19,744
Rio Grande	19,556
M9	**4,144**
S5	**224**
RiverRay	**511**
Qliner	30
WH Monitor	15
mini-ADP	3
ADP	1
	66,735

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USGS Testing Program

- Acceptance Testing **[Lab+Field]**
  - Conducted to determine if basic instrument specs/operation are met
- Routine QA **[Lab+Field]**
  - Routine tests done to insure that instrument performance is acceptable
- Post Factory-Repair Testing **[Lab+Field]**
  - Testing conducted after a repair.
  - Includes all / part of acceptance tests

Flowtracker Testing Example

- Acceptance Testing
  - 100% FTs purchased by the HIF are tested in tow tank
  - Hydrographer **ought** to make comparison measurement(s) and run routine QA checks when FT is received
- Routine QA
  - Every FT is tested in HIF tow tank on a 3 year cycle
  - Hydrographer routinely **reviews** beam checks and Qm results
- Post Factory-Repair Testing
  - All FT needing repair must be returned to HIF for tow tank testing after the repair is complete
  - Hydrographer **ought** to make comparison measurement(s) when FT is received and review routine QA output from FT

USGS Flowtracker Testing

Acceptance Tests

- Power-up check
- Thermistor test
- Beam Check
- Tow tank test @ 2 cart speeds: 18 & 33.5 cm/s

Routine QA: 100% FTs Tested every 3 years

All repaired FTs are tested

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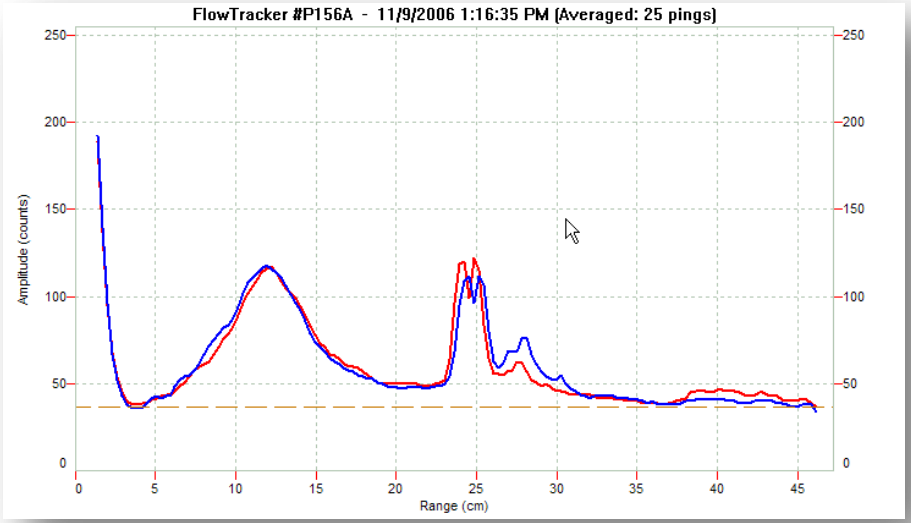
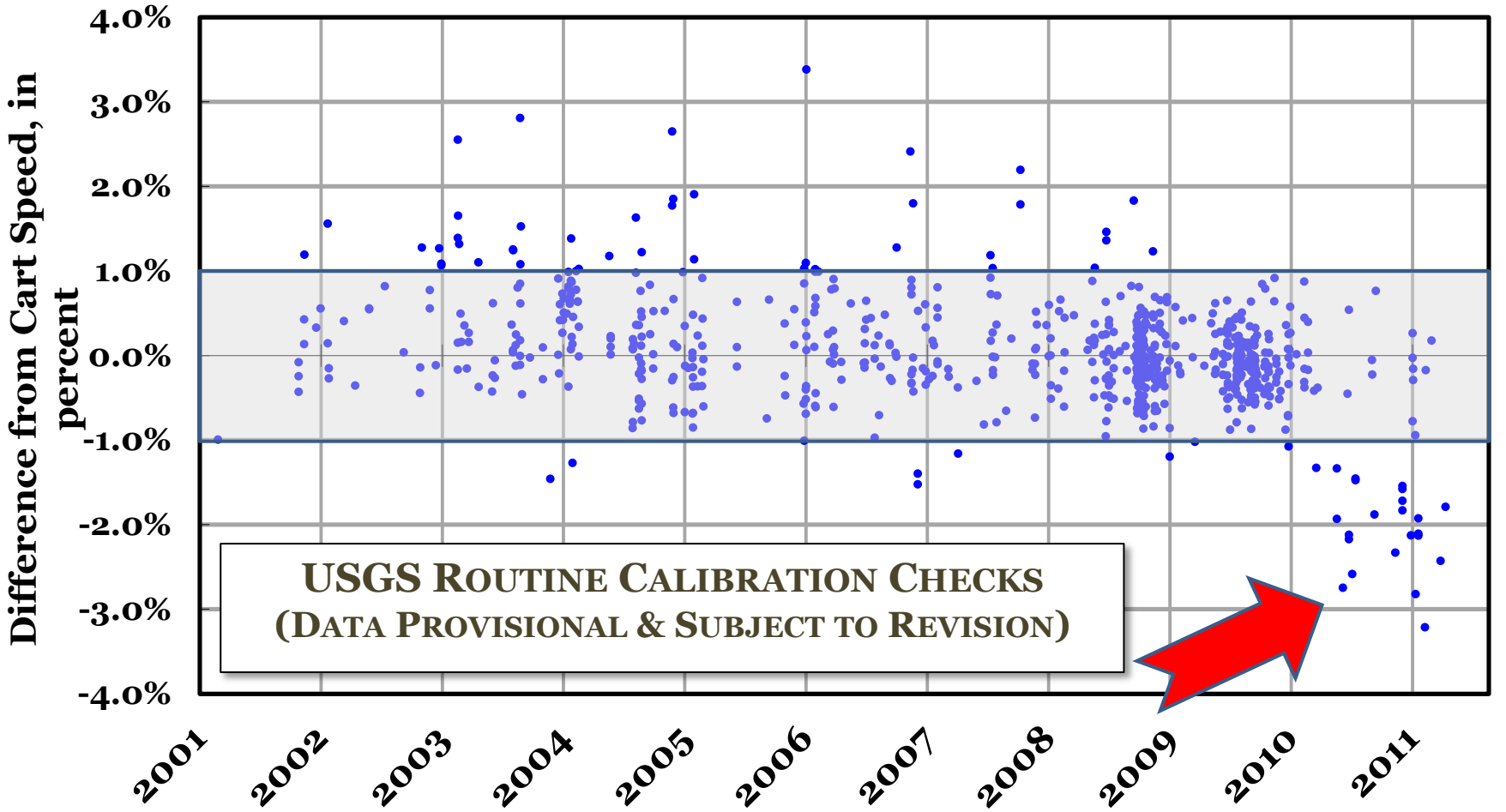
Routine QA - Flowtrackers

- Bucket tests
  - After questionable results on auto-beam check
  - After possible damage to instrument (a drop, etc.)
  - Log and compare with previous log tests – should be consistent over time



Value of Independent Testing



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ADCP Testing Example

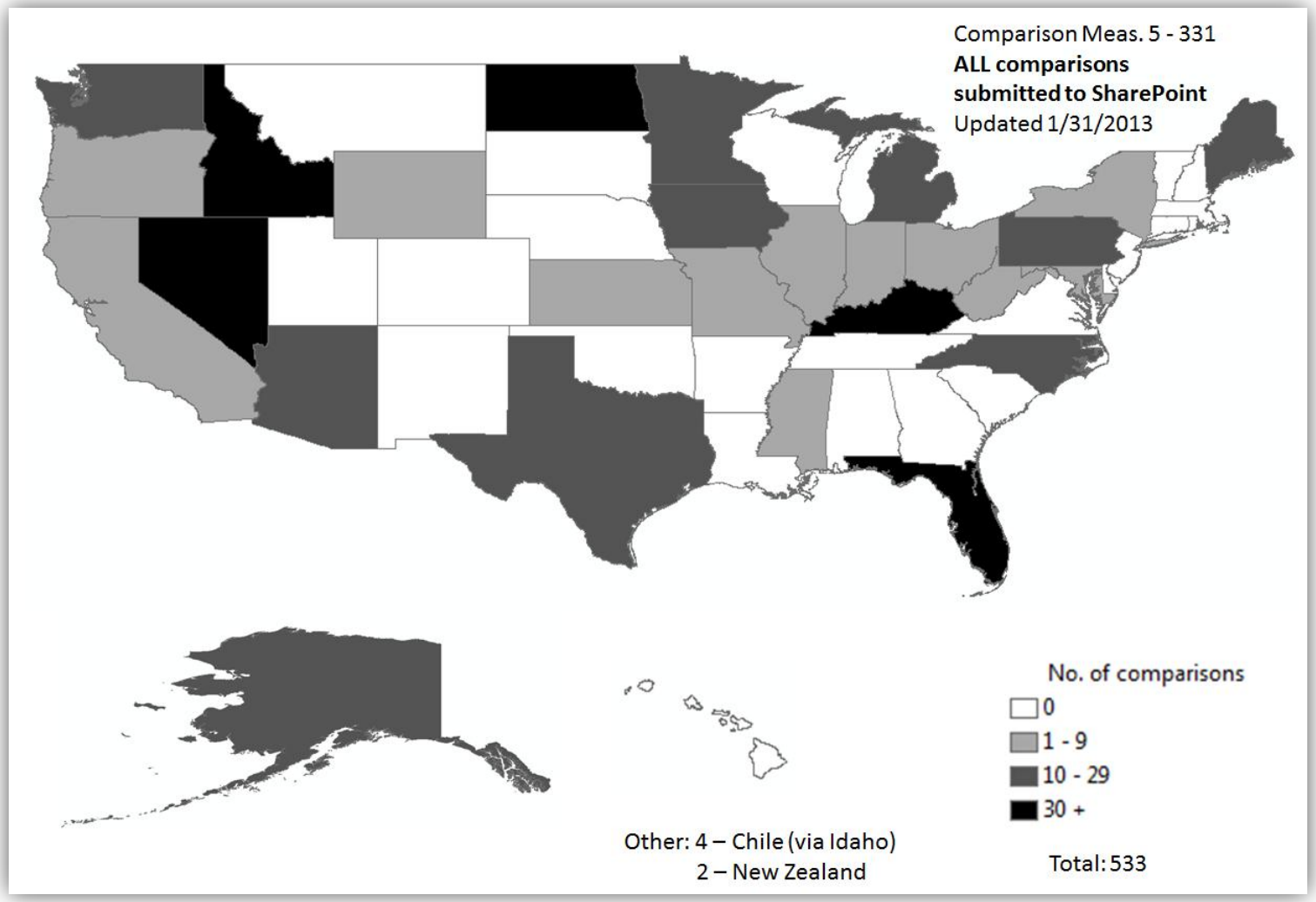
- Acceptance Testing
  - 100% ADCPs purchased by the HIF are tested in tow tank
  - Hydrographer **ought** to make comparison measurement(s) and run routine QA checks when ADCP is received
- Routine QA
  - Periodic tow tank testing is planned (see Future Plans)
  - Annual comparison Qms or ADCP regattas
  - Beam angle tests
- Post Factory-Repair Testing
  - No policy at present for lab testing after repairs
  - Hydrographer **ought** to make comparison measurement(s) and run routine QA checks when ADCP is received

New ADCPS

Comparison Requirement

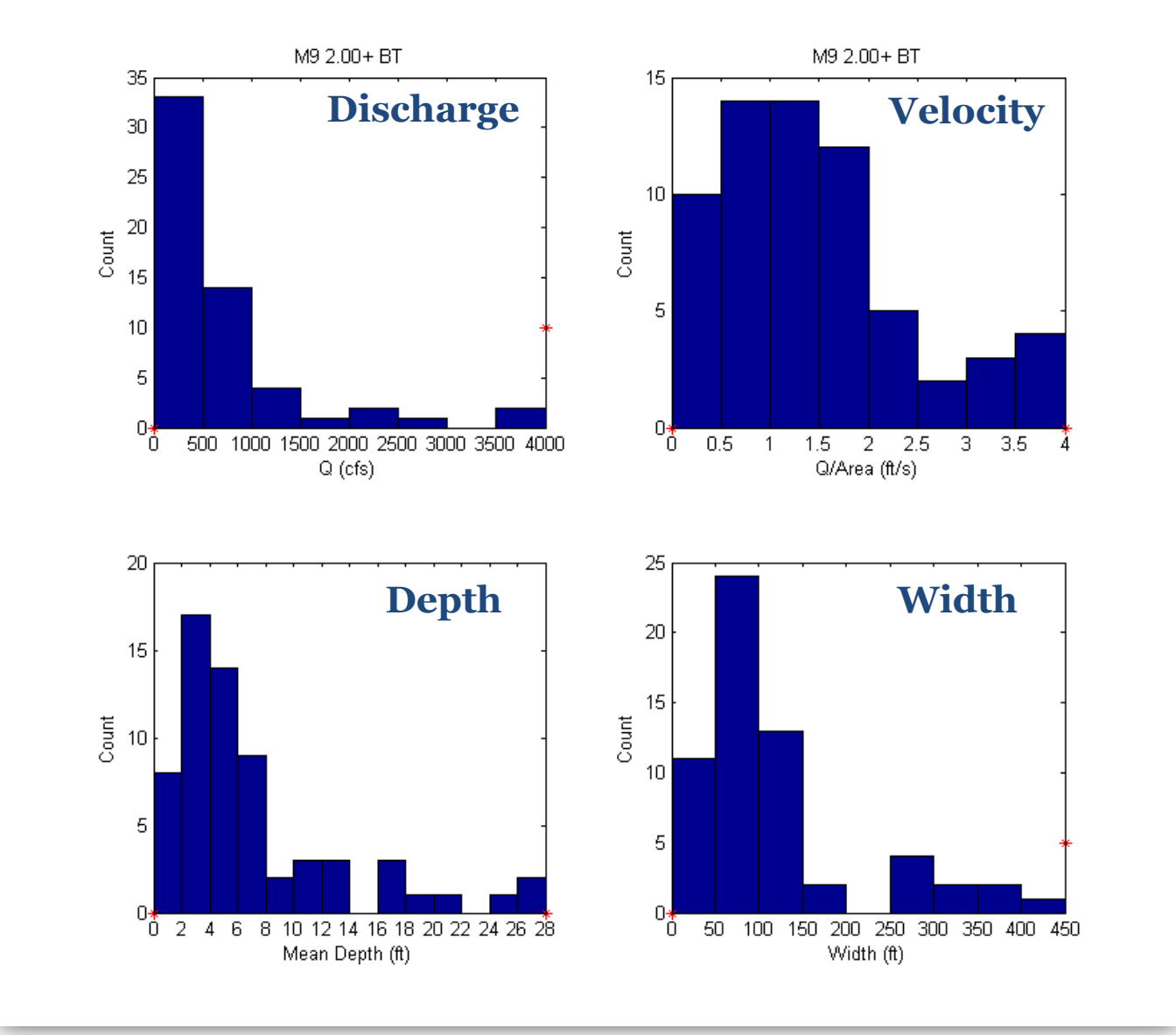
- With the introduction of new instruments such as the M9/S5, OSW has required that WSCs conduct comparison measurements for the range of field conditions for which the instrument will be used.
- Testing should consider such factors as ranges in water velocity, boat velocity, streambed type, flow depth, turbulence, sediment concentrations, and GPS quality.
- Not all offices have submitted comparisons, but many are using new ADCPs/ADVs

Comparison Measurement Submissions



SonTek M9

Qm Charact-eristics



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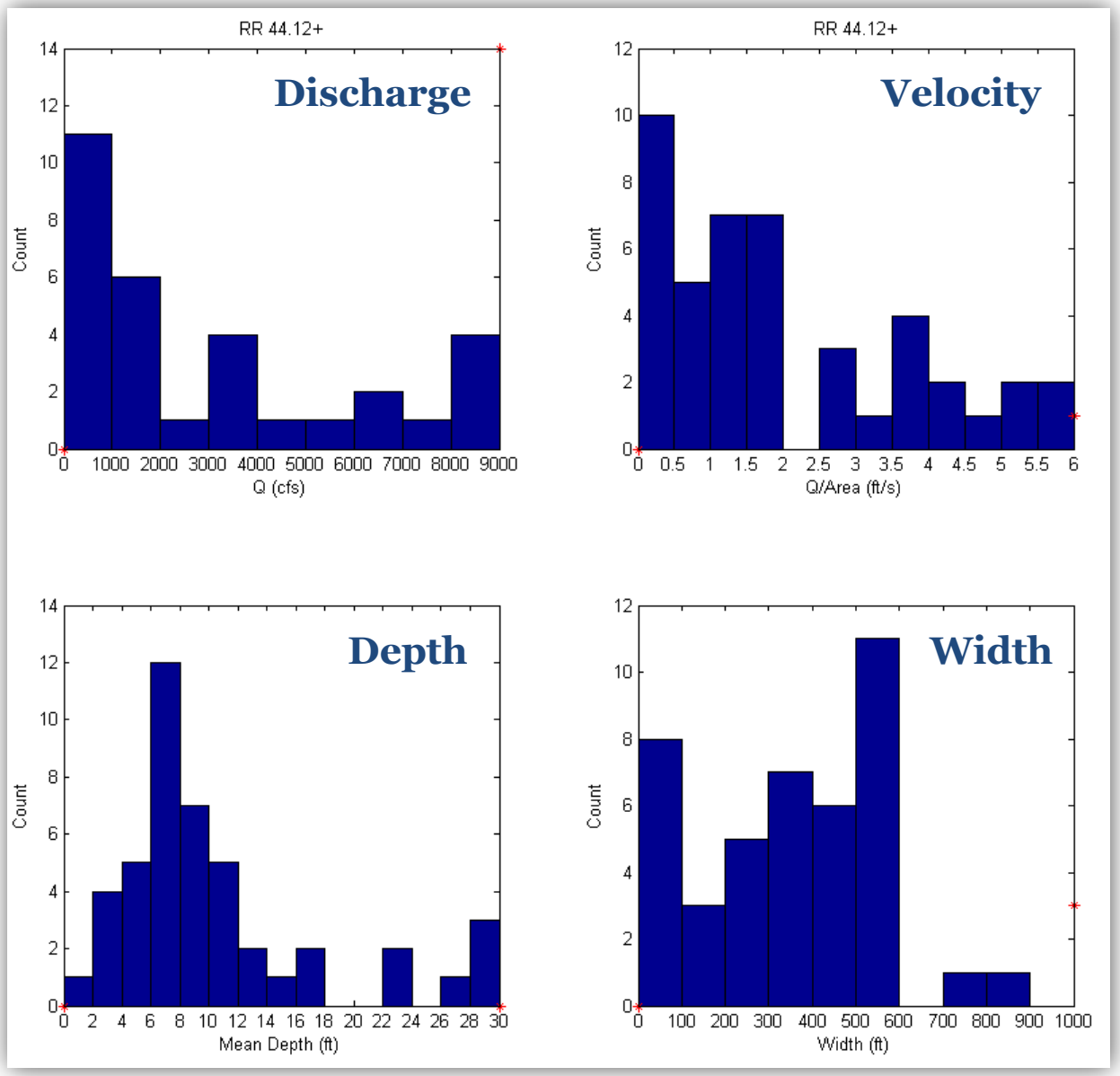
TRDI RiverRay Testing Results



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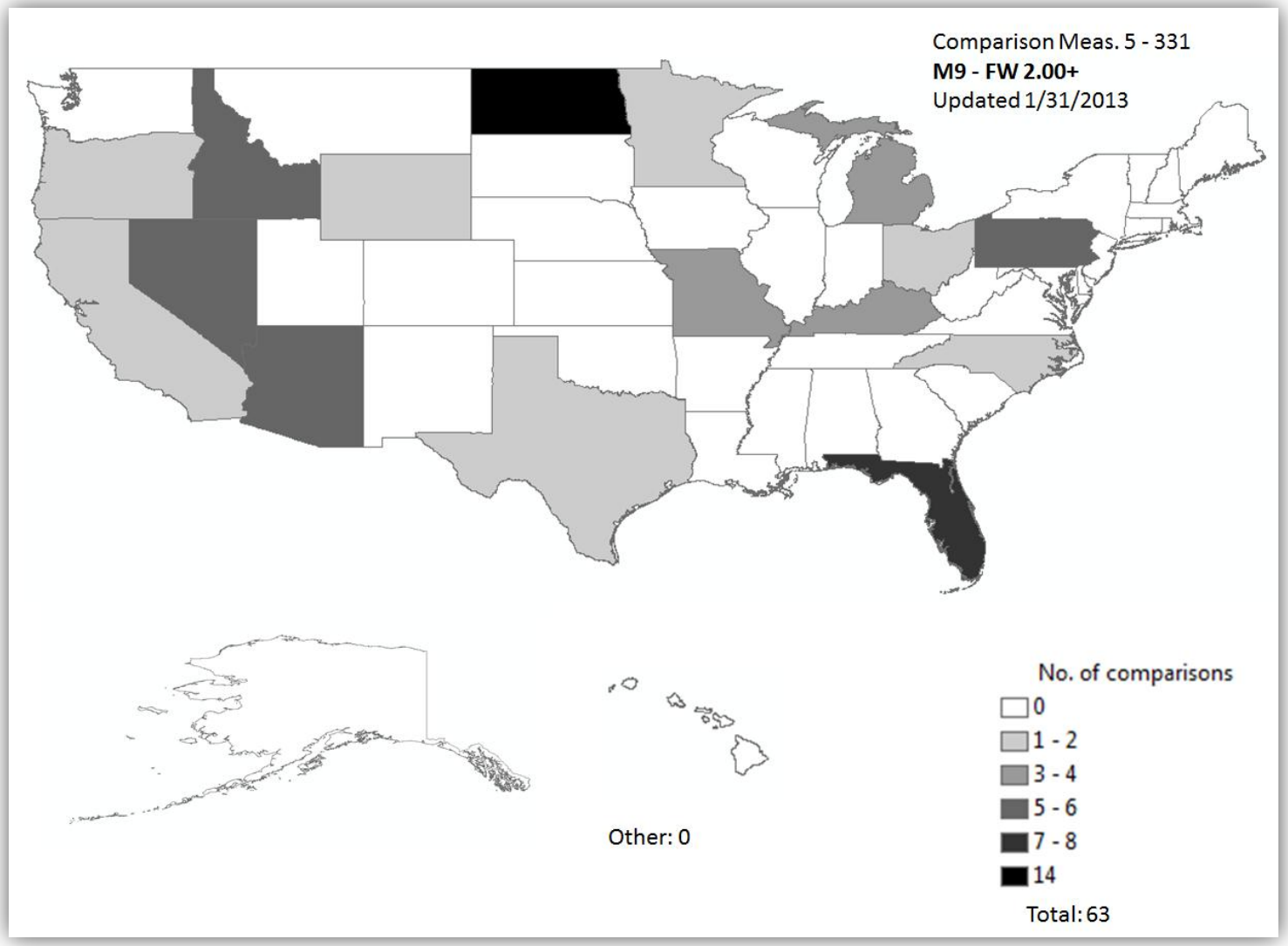
M9 Submissions – Firmware ≥ 2.00



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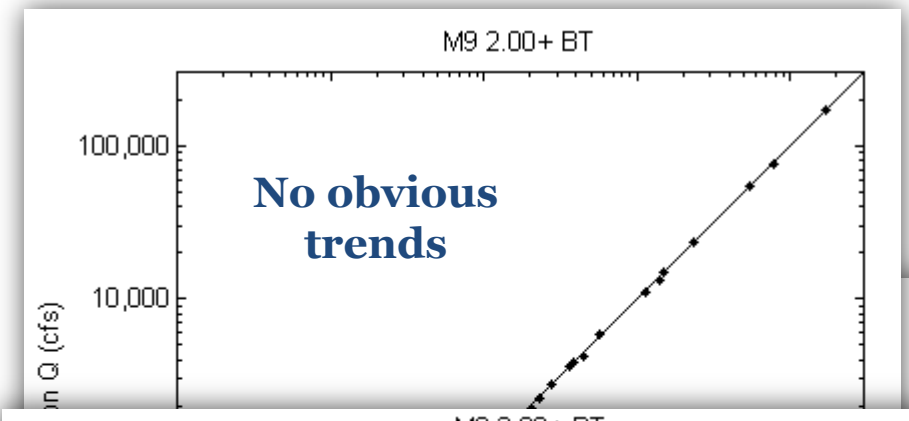
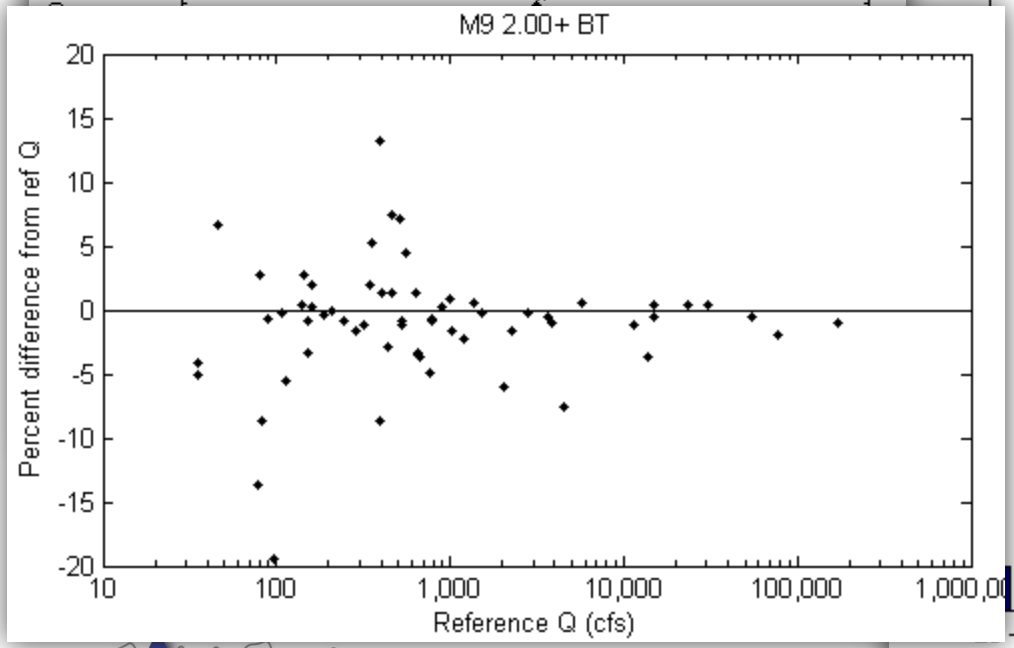
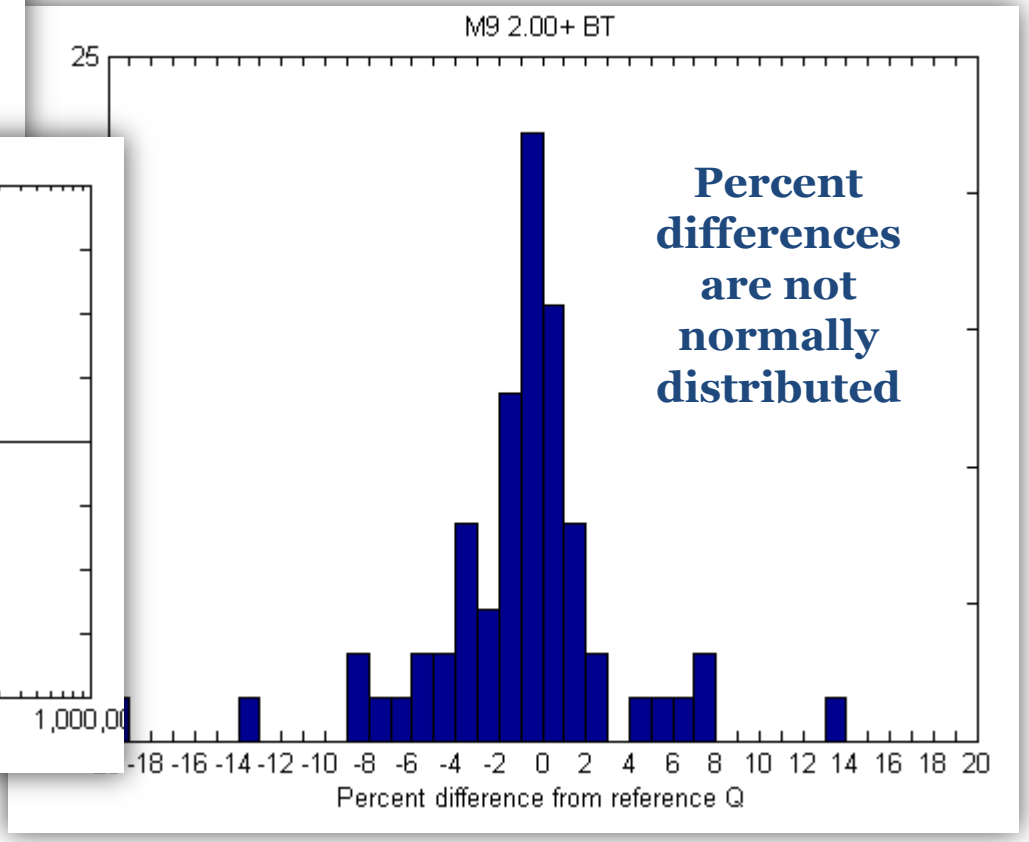
M9 Test Results – FW 2.0+ BT







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M9 Test Results

No. of Qms		M9 Firmware			
		0.8x	1.0x	1.50	2.00+
Ref.	BT	46	27	29	63
	GGA	21	13	14	41
	VTG	21	13	15	41

Number of M9 measurements

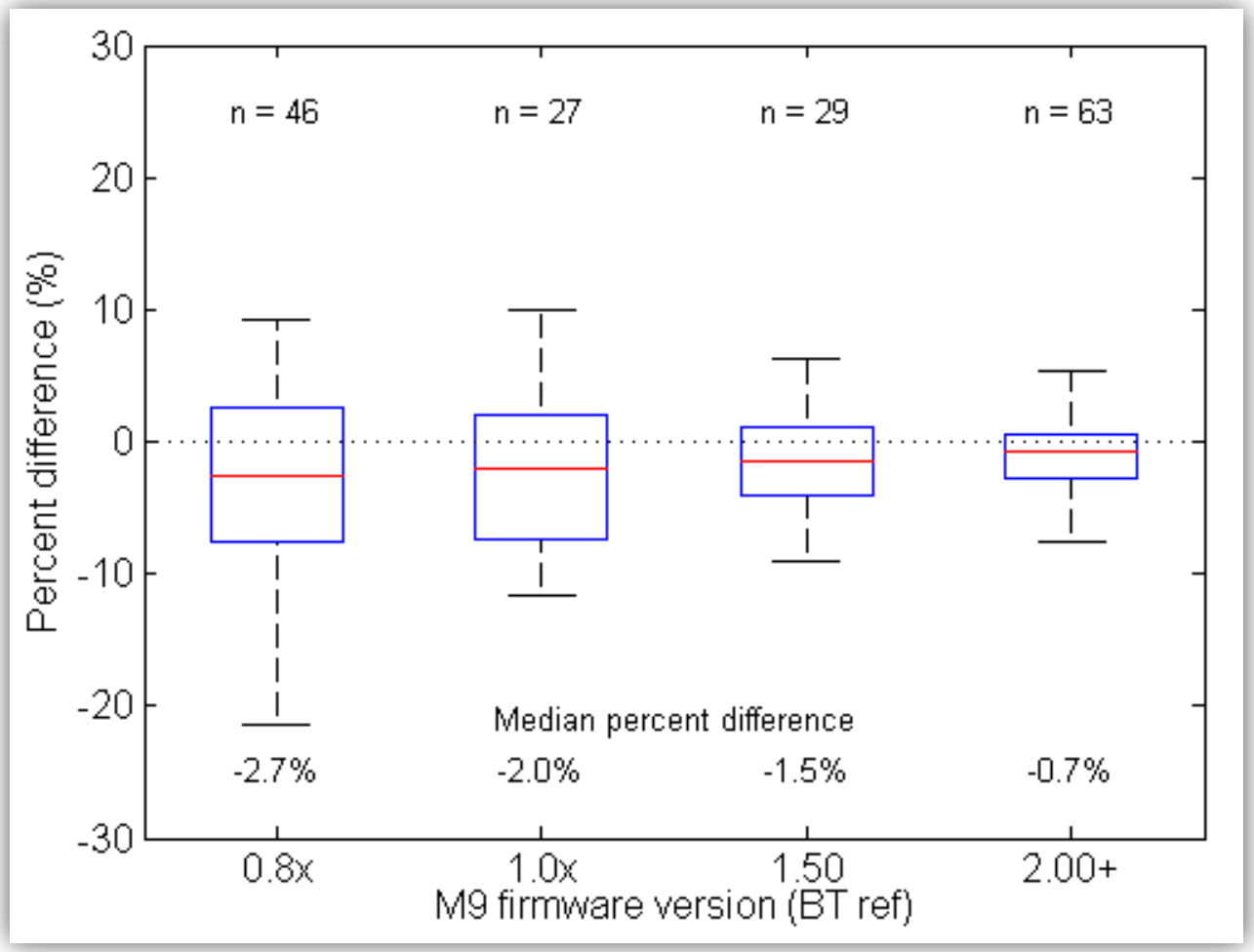
p values		M9 Firmware			
		0.8x	1.0x	1.50	2.00+
Ref.	BT	0.02	0.10	0.02	0.03
	GGA	0.01	0.04	0.12	0.21
	VTG	0.01	0.01	0.02	0.16

M9 discharge not equal to Ref. discharge (in red)

Median % diff.		M9 Firmware			
		0.8x	1.0x	1.50	2.00+
Ref.	BT	-2.7	-2.0	-1.5	-0.7
	GGA	-4.1	-6.2	-2.1	-1.1
	VTG	-3.0	-6.1	-3.6	-0.9

General improvement in accuracy

Changes in M9 Accuracy Over Time



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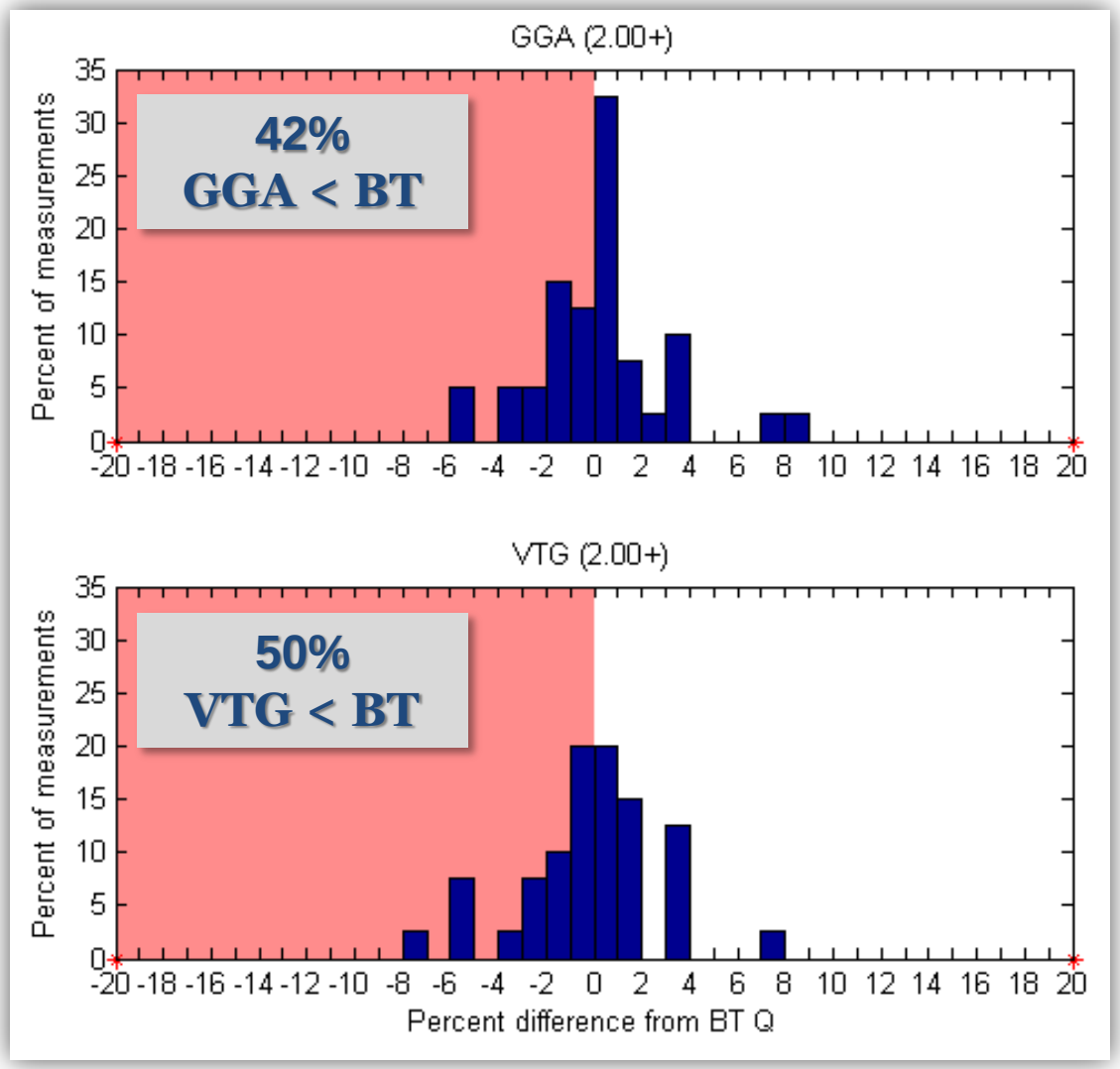
Issues to be Aware Of

- Validity of compass calibrations is an ongoing concern
- 42% of the M9 Qms had a GGA Q < BT Q
- 50% of the M9 Qms had a VTG Q < BT Q



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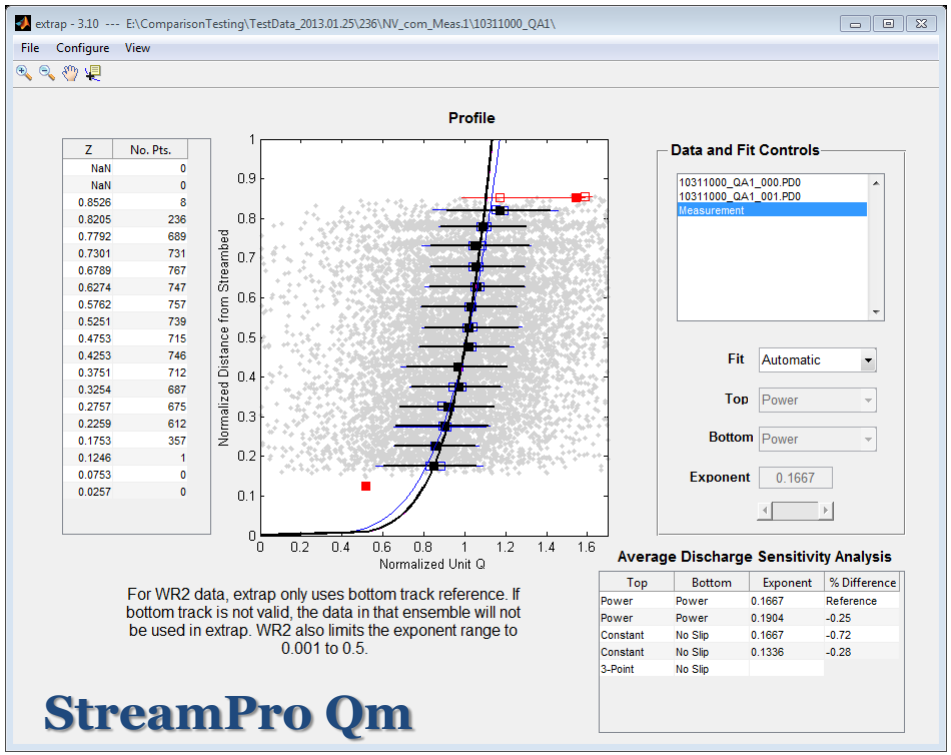
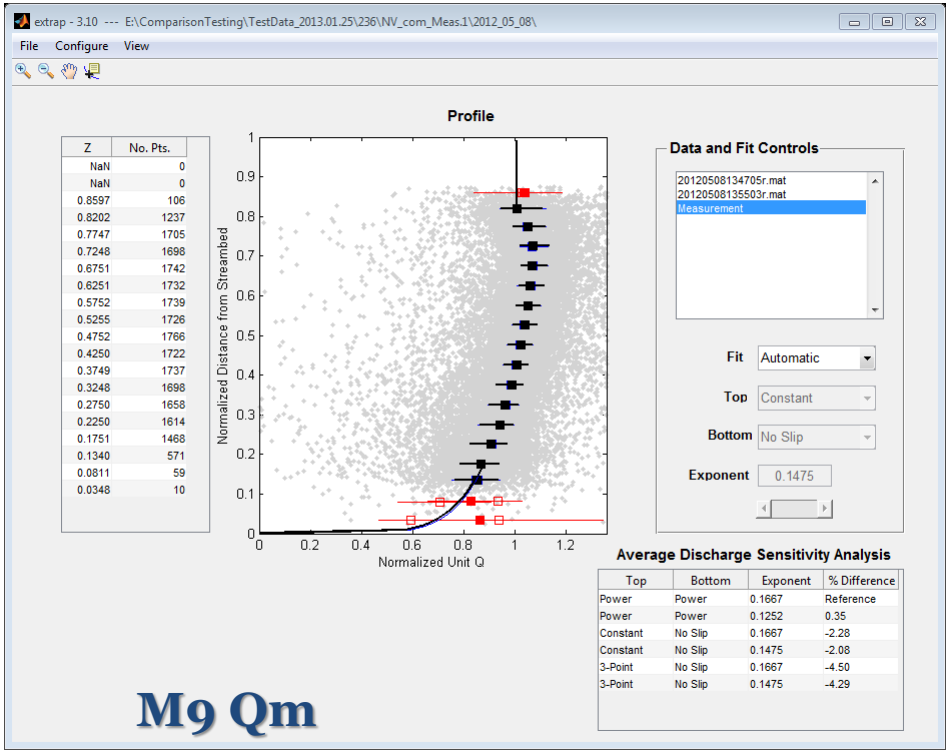
Issues to be Aware Of

- Be sure to follow best practices for compass calibrations for SonTek M9s / S5s. https://simon.er.usgs.gov/smf/index.php?topic=516.0
- When in doubt, make sure that you make stationary moving bed tests (SMBTs)

Issues to be Aware Of

- Potential for flow disturbance when using 3 Mhz – especially HD ‘mode’





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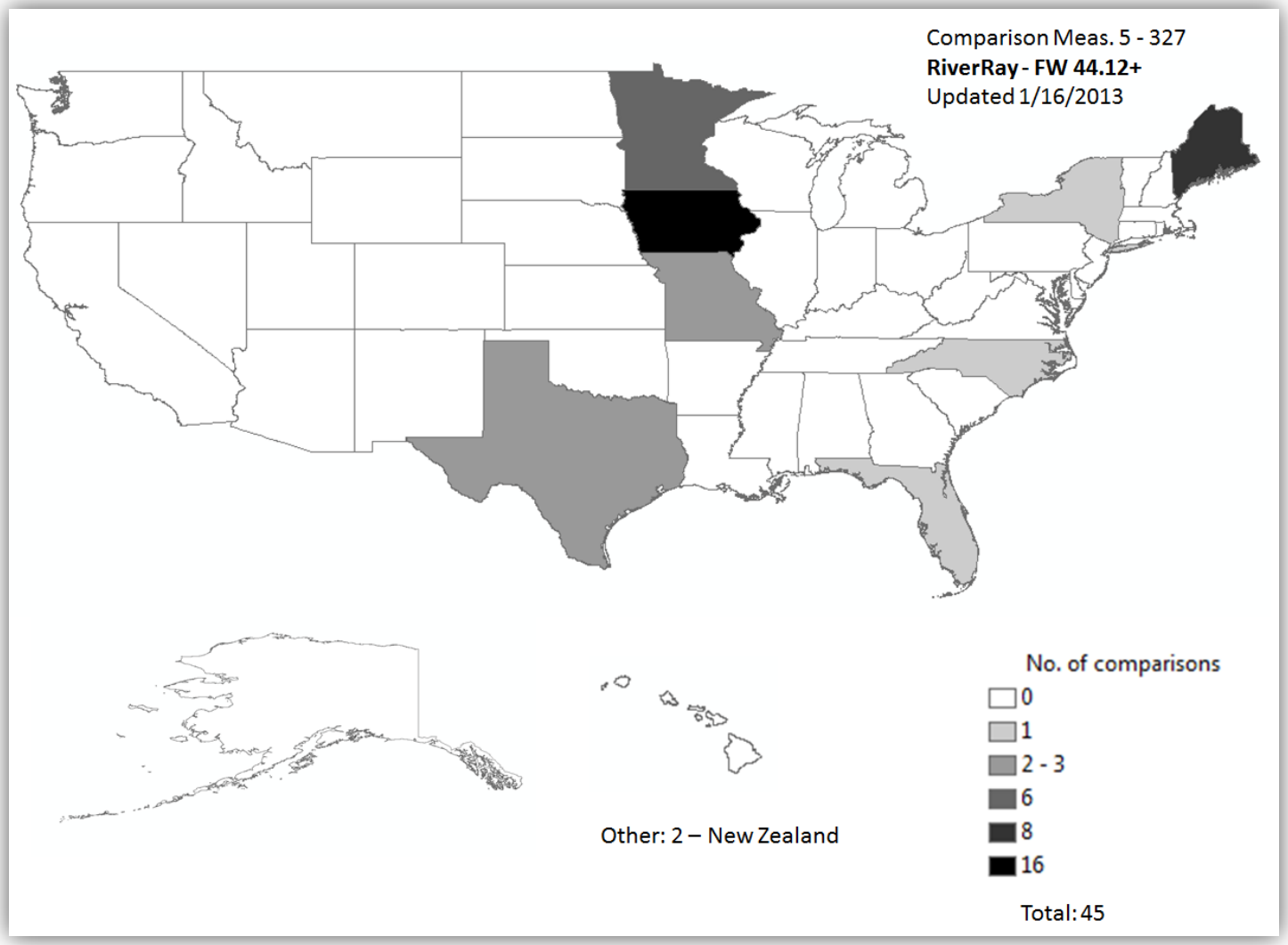
Testing Priorities/Plans in 2013

- **Publish OSW Tech Memo (and possibly a journal article) summarizing results**
- Work with SonTek to improve compass cal
- Evaluate software update to compass cal procedure in RSLive software (Feb-Mar??)
- Resolve issues with 3 Mhz flow disturbance

	SonTek M9/S5
Discharge	**> 1, 500 cfs**
Mean Velocity	**> 2.0 ft/s**
Mean Depth	**> 8 ft**
Width	**> 150 ft**

RiverRay Submissions – Firmware ≥44.12



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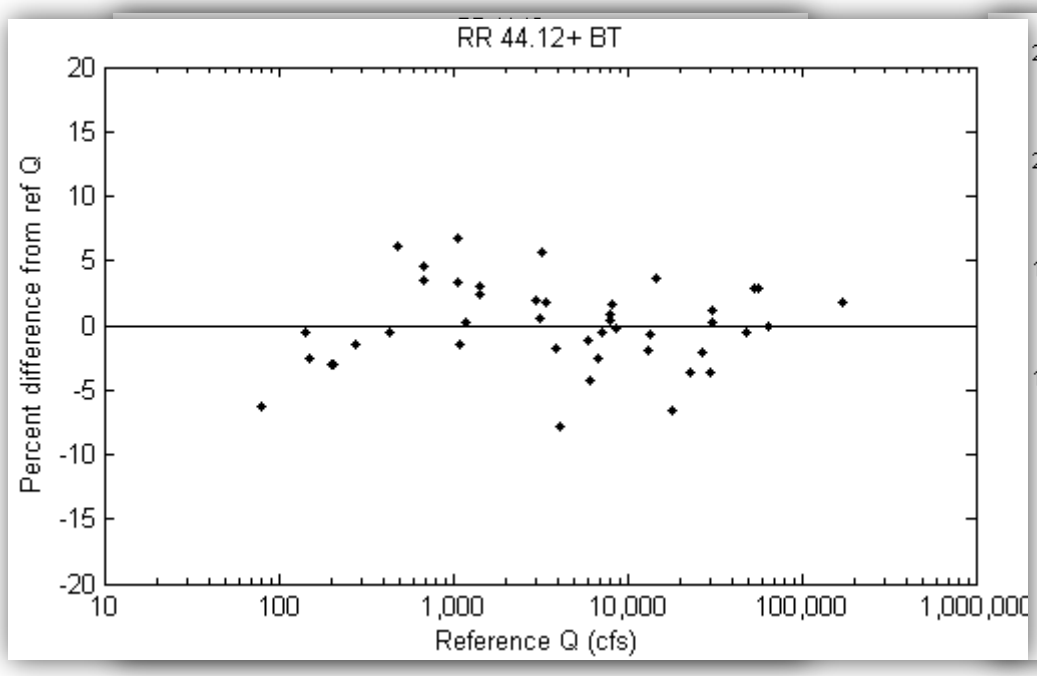
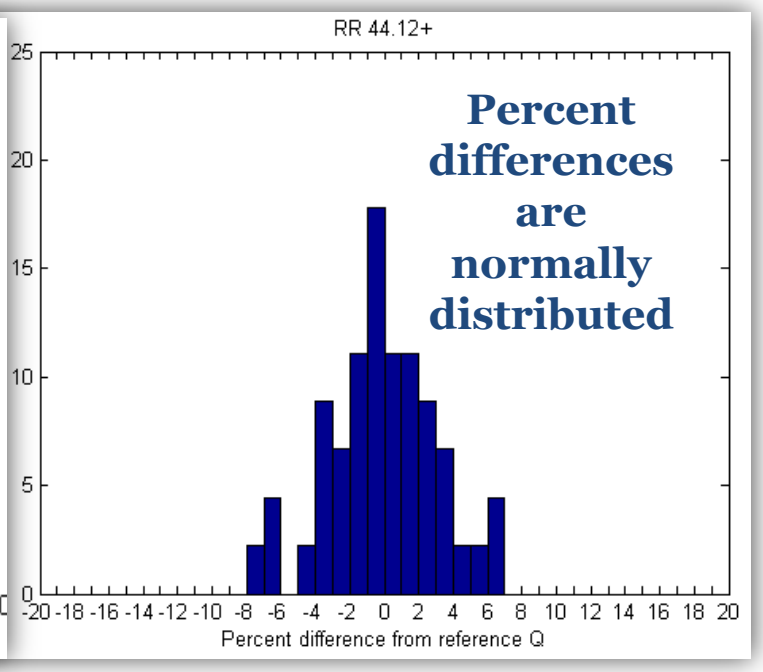
RiverRay Test Results





Statistically, there is no difference between RR Qs and Reference Qs

	RiverRay (ref: BT)	
	44.12+	Low BS
No. (n)	45	5
p value	0.935	0.063
Mean % difference	0.0	-18.0
Median % difference	-0.3	-17.1

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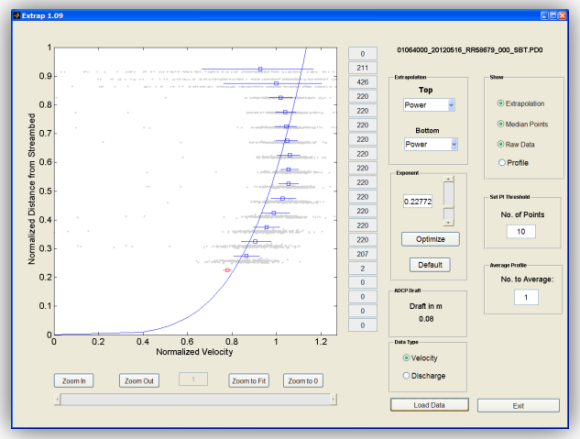
Testing Priorities/Plans in 2013

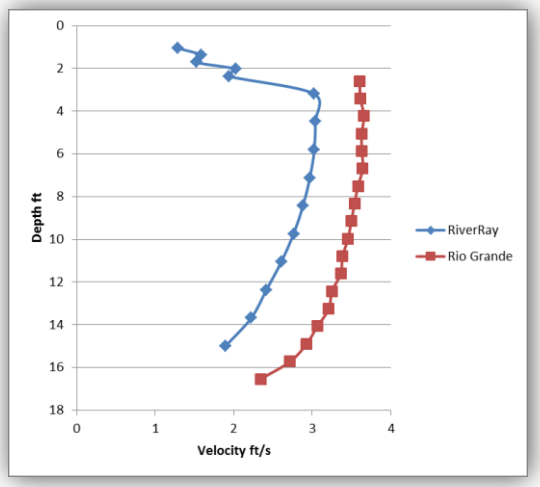
- **Publish OSW Tech Memo (and possibly a journal article) summarizing results**
- Evaluate performance of new compass
- Any enhancements / firmware upgrades
- Coordinate with other agencies

	TRDI RiverRay
Discharge	**> 2,000 cfs**
Mean Velocity	**> 2 ft/s**
Mean Depth	**> 10 ft**
Width	**> 600 ft ??**

Issues to be Aware Of

- Some reports of issues in low backscatter environments even after TRDI degaussing and firmware modifications. Not substantiated yet



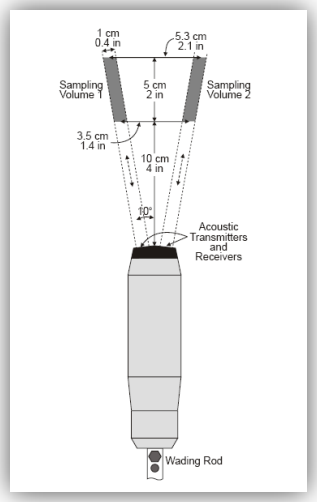


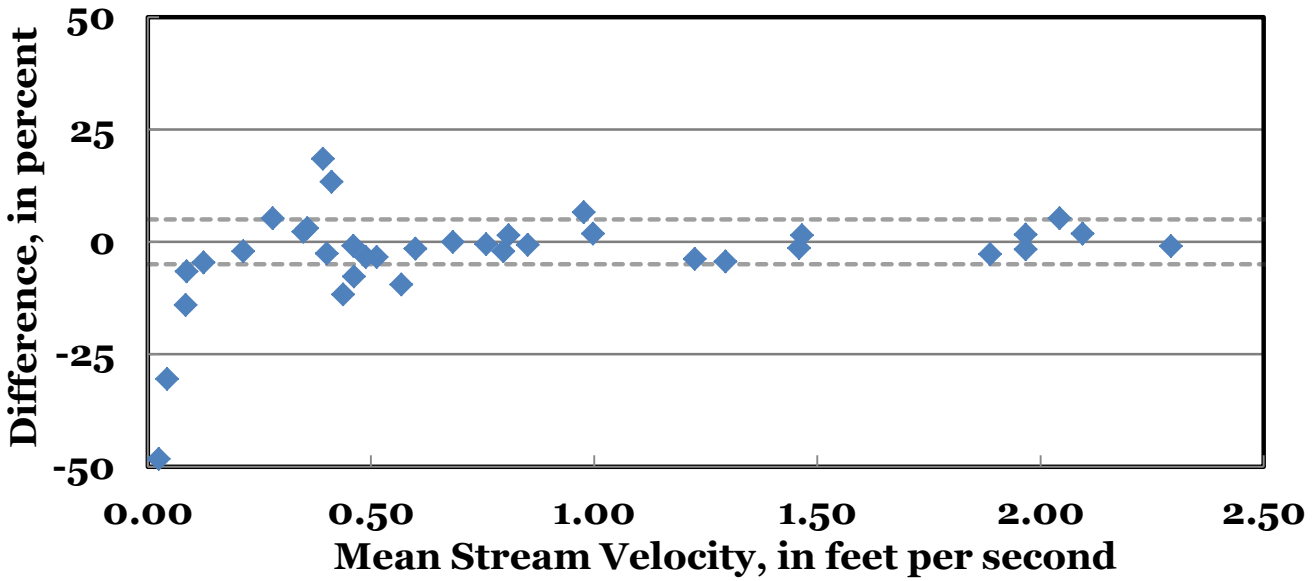
- Follow best practice guidance for RiverRays with Honeywell compass. https://simon.er.usgs.gov/smf/index.php?topic=514.0

Ott ADCs

ADC Testing Status

- Lab and Field Comparisons: 2008-2009
  - 36 field comparison Qms were made
  - Various tow tank tests
  - Bias found in very low velocities
  - Various usability issues





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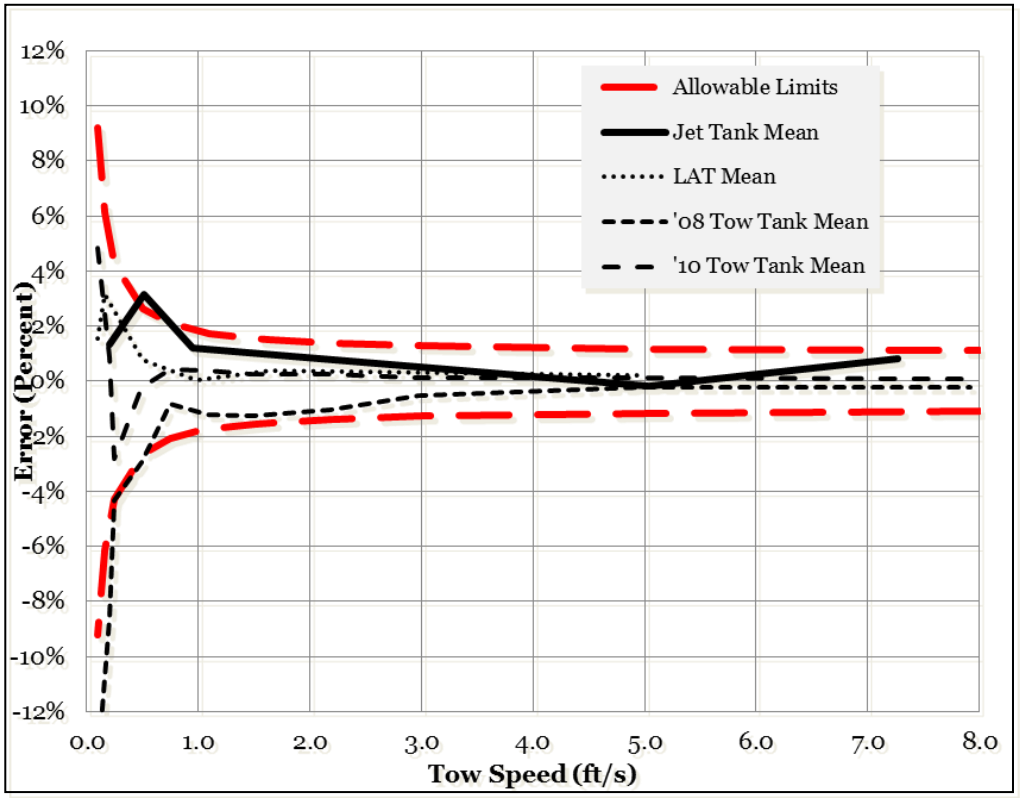
ADC Testing Status

- Ott modified firmware and software to address above and other issues
- Lab and Field Comparisons: 2010-present
  - 10-12 comparison Qms
  - Lab comparisons are still on-going
  - Completed boundary checks

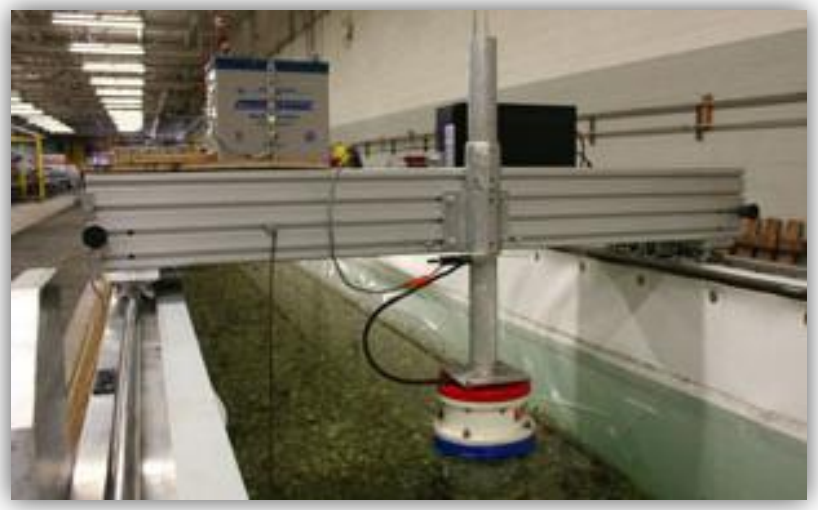
Some Issues with Lab Testing

- Recent HIF testing in new large acoustic towing tank and jet tank indicate possible problems with ADCs
- However, these apparent problems may have to do with tank differences or other factors
- Don't match results from 2008/2010



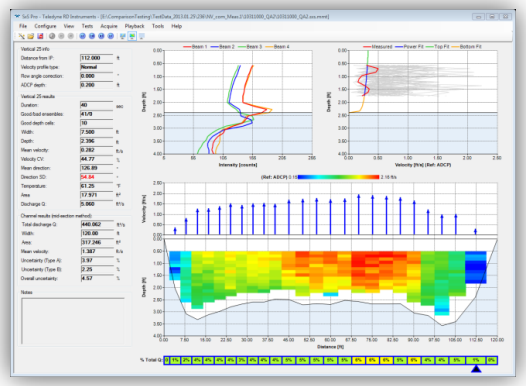
Future Testing Activities (FY 2013)

- Implement an ADCP Lab Testing Program
  - Similar to Flowtracker program
  - Distance tests in tow tank
  - StreamPros implemented first (Sept 2013)
- Implement program for other ADCPs in next fiscal year(s)



Future Plans (FY 2013)

- More formal testing of mid-section software for ADCPs
  - We are aware of some nuances (or possible issues) in the current software that need investigated
  - However, it seems the results obtained are generally OK
- Comparison measurements for flow under ice – especially if software changes are forthcoming
  - Provided long list of changes required to vendors, but no response as yet



Future Testing Activities (FY 2013)

- Field and lab testing of Ott ADCs
- Conduct testing of Hemisphere A101 GPS (and possibly other models) because A100 is no longer being sold
- Test SX Blue GPS (for use with StreamPros). We have seen anomalous results with SX Blue (GGA performs better than VTG in locations with multipath

Future Plans (FY 2013)

- Update on guidance/requirements for Routine QA/QC testing - in revisions to Moving Boat ADCP T&M- Sept 2013) (Current Draft)

Instrument Condition	Quality Assurance Test		
	Beam Alignment Test[a]	Transformation Matrix Check	Comparison Measurement
New	Required		Required
Transducer repair or replacement	Required		Required
Non-transducer hardware repair or upgrade		Required	Required
Required, recommended or allowed firmware change		Required	
Unapproved or testing firmware change		Required	Required

  - Comparison measurement should be made with each ADCP at least once during a three year period
  - Maintain an instrument history log
  - Store comparison measurements and QA info permanently

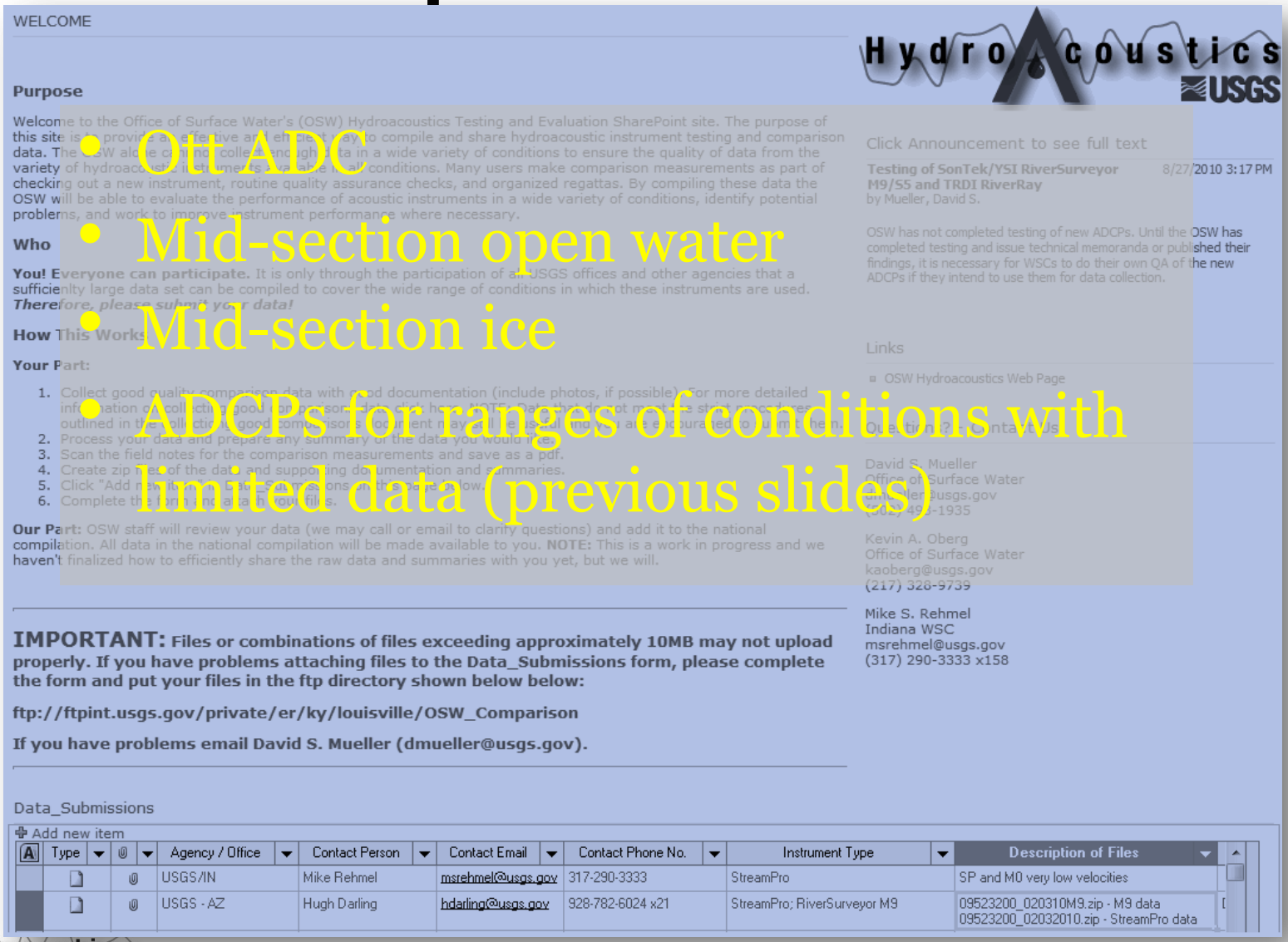
Conclusions/Recommendations

- Preliminary indications: No differences between RiverRay & Reference discharge measurements
- For SonTek M9s: No substantive differences between M9s & Reference discharge measurements, with the following caveats:
  - Need to investigate why BT results seem different than GPS results
  - When using GPS and (or) Loop MBT, the compass calibration is valid (not necessarily easy)
  - Proper MBTs are done
  - 3 Mhz HD used in high percentage of cross section (being investigated)

Conclusions/Recommendations

- When compass calibration is suspect, **always use stationary MBT**. Use multiple SMBTs where possible.
- Hydrographer is responsible to make sure equipment is working properly. When a new or repaired HA instrument is received, conduct 1 or more comparison measurements and other tests to make sure that the instrument is working correctly.

Share Comparison Measurements



- Ott ADC
- Mid-section open water
- Mid-section ice
- ADCPs for ranges of conditions with limited data (previous slides)

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ADCP Comparisons Needed

	SonTek M9/S5	TRDI RiverRay
Discharge	> 1, 500 cfs	> 2,000 cfs
Mean Velocity	> 2.0 ft/s	> 2 ft/s
Mean Depth	> 8 ft	> 10 ft
Width	> 150 ft	> 600 ft ??


Questions?

SonTek M9 Qms

Jan 2009-April 2012

WSC	SonTek M9/S5 Qms	WSC	SonTek M9/S5 Qms
Alabama	7	New Hampshire	109
Arizona	559	New Mexico	43
Arkansas	1	New York	121
California	316	North Carolina	86
Florida	1531	North Dakota	1
Georgia	70	Ohio	112
Idaho	177	Oregon	39
Kansas	1	Pennsylvania	39
Kentucky	174	South Carolina	4
Louisiana	78	Tennessee	123
Minnesota	47	Texas	44
Mississippi	47	Virginia	44
Missouri	303	Washington	2
Montana	2	West Virginia	183
Nevada	115	Wisconsin	57

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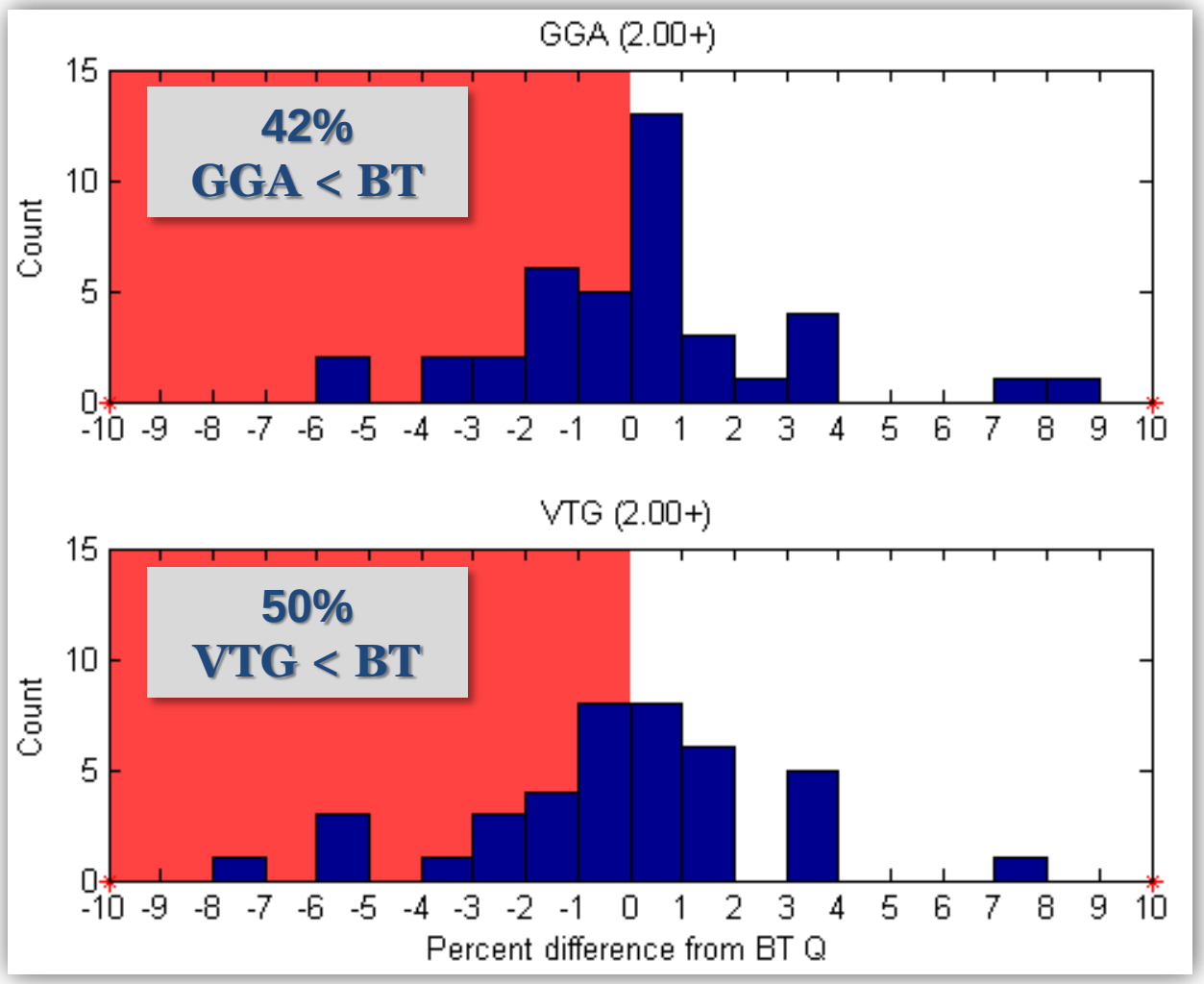
TRDI RiverRay Qms
Jan 2009- April 2012

WSC	TRDI RiverRay Qms	WSC	TRDI RiverRay Qms
California	4	Mississippi	25
Florida	58	New York	141
Iowa	55	Oklahoma	9
Maine (MA)	67	Texas	57
Michigan	47	Washington	23
Minnesota	25		

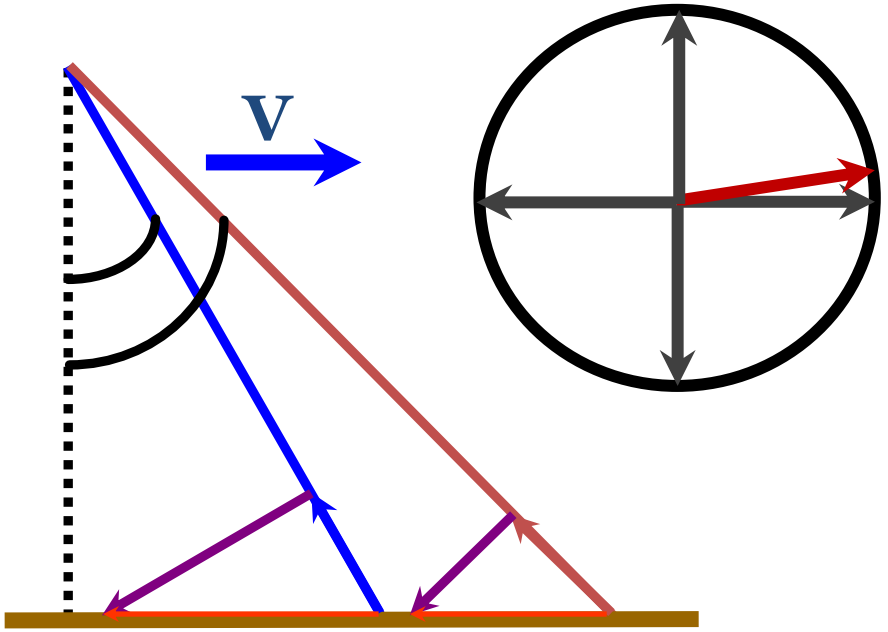
Issues to be Aware Of

- Validity of compass calibrations is an ongoing concern
- 42% of the M9 Qms had a GGA Q < BT Q
- 50% of the M9 Qms had a VTG Q < BT Q



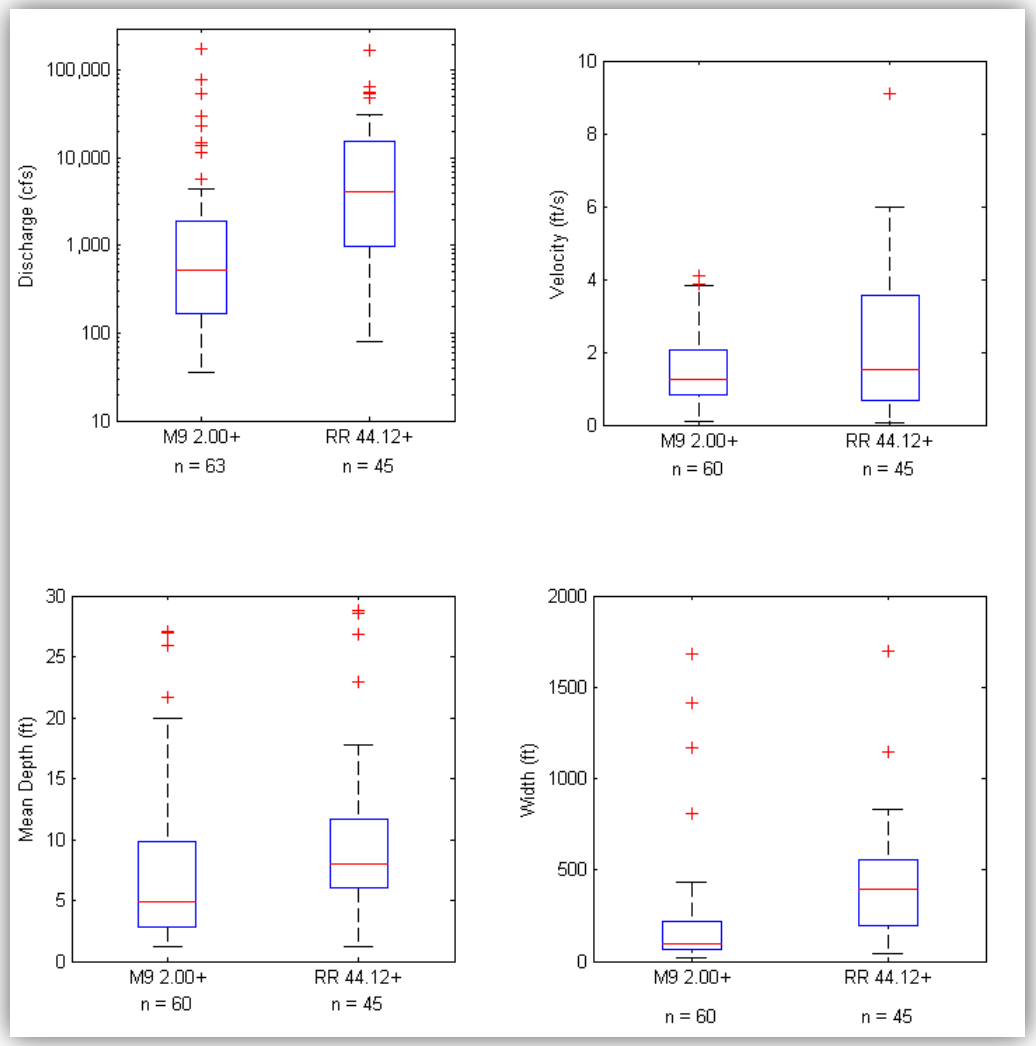
Routine QA Examples – Regattas

- 19 - TRDI Rio Grandes
- 3 - TRDI StreamPros
- 1 - TRDI RiverRay
- 1 - Sontek/YSI RS-M9



- Beam angle tests check for errors in both horizontal and vertical beam alignment

Measurement Characteristics for M9 and RiverRay Comparison Measurements



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