Capacity Building in Hydrological Services

ADCP and Pressure Sensor Training
Ministry of Water and Energy, Ethiopia
20th – 28th February 2013

25
2013

RAPPORT

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Norwegian Water Resources and Energy Directorate
2013

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Capacity building in Hydrological Services

ADCP and Pressure Sensor training

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1. PREFACE

As part of the institutional cooperation between the Ministry of Water and Energy (MoWE) and the Norwegian Water Resources and Energy Directorate (NVE), Activity 3 (A3), "Capacity Building of Hydrological Services", a training session was held on use of ADCP river monitoring and on pressure sensor equipment on 20 - 28 February 2013. This included a two-day theoretical course held in a hotel near the MoWE head office in Addis Ababa, followed by three days of practical training at the Kessie measuring station on the Abay River. The training concluded with a one-day data post-processing session in Addis Ababa.

A3 is one of the activities under the Agreement regarding Institutional Cooperation for Feasibility Studies of the Mandaya and Beko-Abo Multipurpose Projects, between MoWE, Federal Democratic Republic of Ethiopia, and NVE of the Kingdom of Norway.

The purpose of the training was to build the capacity of MoWE hydrologists with modern discharge and water level measuring instruments (ADCP and Pressure Sensor).

This report comprises presentations, performed activities and recommendations given during the training.

Oslo, Norway, April 2013

Sverre Husebye
Head of Section
Hydrology Department NVE

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5. **MoWE Participants Evaluation of the Training**

2. Training - Agenda

Topic:	**NVE Training at MoWE – February 2013** **Activity 3 Capacity Building in Hydrological Services; Training in ADCP and Pressure Sensor Measuring Instruments**			
Date:	20 – 28 February 2013	**Hrs:** 09:00 – 17:00	**Place:**	Near MoWE HQ, Addis Ababa and Kessie/Dejen
Chairman:			**Minutes:**	
Participants NVE:	Morten Due (MND), Line Dale (LDA) and Demissew Ejigu (DKE)			
Participants MoWE:	Aregawi Dirare, Habtu Ketele, Samuel Admassu, Mihretab G/Tsadik, Gedamu Chane, Demeke Negatu, Birhanu Legesse, Hailegebreal Dejene, Yosef Hiruy, Samuel Tesfaye, Lema Asfaw, Frezer Assefa and Solomon Kebede			

Target group:	Relevant hydrological personnel at MoWE head office/regional office working with discharge and water level measurement.

Preparations:	Conference room with PC, 2 persons on each PC, participants must have basic computer knowledge, installation of pipes and logger cabin must be finished at Kessie.

Outcome:	Basic working knowledge about the use of ADCP and Pressure Sensor instrument

Day 1 - Wednesday 20 February 2013 – Preparation for training

12:00 – 17:30	Checking meeting room, PC, software, ADCP Equipment and pressure sensors	LDA/DKE/MND

Day 2 - Thursday 21 February 2013 – What is ADCP

09:00 – 09:15	Welcome and opening by MoWE	MoWE
09:15 – 09:45	Agenda and goals	NVE/LDA/ MND
09:45 – 11:00	Lecture on “what is an ADCP”	NVE / LDA
11:00 – 11:30	**Tea break**	
11:30 – 13:00	Lecture on “ADCP theory” continued	NVE / LDA

13:00 – 14:00	**Lunch**	
14:00 – 15:30	Lecture on “ADCP theory” continued	NVE / LDA
15:30 – 15:45	**Tea break**	
15:45 – 17:30	Lecture on “ADCP theory” continued	NVE / LDA

Day 3 - Friday 22 February 2013 – ADCP theory and Pressure sensor/Orpheus mini

09:00 – 09:30	Welcome and summing up day 2	NVE /LDA
09:30 – 11:00	Lecture on “Introduction to WRII”	NVE / LDA
11:00 – 11:30	**Tea break**	
11:30 – 13:00	Lecture on “Introduction to WRII”, continued	NVE / LDA
13:00 – 14:00	**Lunch**	
14:00 – 17:30	Lecture on Pressure Sensor/Orpheus mini	NVE / MND

Day 4 – Saturday 23 February 2013 – Practical training at Abbay River / Kessie

08:00 – 12:00	Travel to Kessie	MoWE / NVE
12:00 – 19:00	Practical training at Kessie	MoWE / NVE

Day 5 – Sunday 24 February 2013 – Practical training at Abbay River / Kessie

08:00 – 14:30	Practical training at Kessie, continued	MoWE / NVE

Day 6 – Monday 25 February 2013 – Practical training at Abbay River / Kessie

08:00 – 12:30	Practical training at Kessie, continued	MoWE / NVE
12:30 – 16:30	Practical training at Kessie, continued	MoWE
	NVE staff travel return to Addis Ababa	NVE

Day 7– Tuesday 26 February 2013

09:00 – 18:30	MoWE staff return to Addis Ababa	MoWE
	NVE staff working from hotel in Addis Ababa:	
	Summing up and preparation on collected data	NVE

Day 8– Wednesday 27th February 2013

09:00 – 12:30	Post processing of collected data and reviewing ADCP measurement	MoWE / NVE
12:30 – 14:00	**Lunch**	
14:00 – 17:00	Open discussion and summary	MoWE / NVE

3. Report from ADCP and Pressure Sensor Training at MoWE

Today MoWE has two ADCP instruments acquired in 2004 and, in connection with the MoWE-NVE capacity building project, NVE has procured and supplied 4 Orpheus mini pressure sensors. Based on strong emphasis of their needs from MoWE, NVE has carried out courses on ADCP and Pressure Sensor for relevant MoWE hydrologists. The goal and intensions with the ADCP and pressure sensor training was to give basic knowledge to the field hydrologists at MoWE. The training included both theoretical and practical sessions. The MoWE participants seemed interested and were active and eager to learn. The outcome of the training is considered positive.

3.1 Work carried out in the training period 21-27 of February 2013

Date	Time	Place	Activity\observations
20.02	09:00 – 15:00	Addis Ababa	Short meeting with Semunesh Golla. Received information on training venue and facilities. Information on ongoing process of mounting pressure sensors at Kessie and Bure.
21.02	08:00-17:30	Addis Ababa	The training carried out as planned. The theory course was held at a hotel near MoWE. There were 13 participants. Two\three persons on each computer. The ADCP and pressure sensor equipment was brought to the training room during the day for demonstration. Topics for the day: Agenda and goal What is an ADCP Brief Theory Introduction to WR II Gauging procedures
22.02	08:30 – 17:00	Addis Ababa	The training was carried out as planned. Topics for the day: Summing up from previous day Own time for practice on computer WRII and connecting with the ADCP Pressure sensor theory
23.02	08.15 – 19:00	Dejen\Kessie Kessie	The training was carried out as planned. Travel to Kessie. One measurement with the ADCP was performed just above the old bridge with rope for dragging the boat back and forth. Result was satisfactory.
24.02	08:00 – 1430	Kessie	The training was carried out as planned. A measurement was performed just above the old

			cableway with rope. Both of the ADCPs were tried with varied results. Useful experience to see a measuring site with non-perfect conditions.
25.02	08.00-1630	Kessie\Addis	The training was carried out as planned Topic of the day was pressure sensor training. Inspection of the site and configuration of the logger. NVE travelled back to Addis, while the MoWE participants remained at Kessie to carry out more measurements on their own.
26.02	09:00 – 18:30	Addis\Debrezit	MoWE participants continued measuring at Kessie after which they returned to Addis. NVE worked at the hotel in Addis.
27.02	09:30 – 17:00	Addis	The training was carried out as planned. The last day of the training was in the ministry HQ.. Topics were post processing of measurements data, theory and own practice and evaluation of the training.

3.2 Theoretical Course

There were 13 participants from MoWE regional and head office. In addition to presentations participants were provided with documents and manuals. Each group was given the opportunity to connect and configure the instrument in the classroom. Even though some of the participants lack basic computer skills, they were all very active during the session.


3.3 Practical Course

The practical training was carried out at Kessie measuring station on the Abbay River. Three measurements were completed; two of them with NVE staff present and the last one were carried out by the participants alone. Installation of the pressure sensor was carried out by MoWE prior to the arrival of NVE

staff. Regarding this it was agreed that the pressure sensor itself should be mounted with a sidewall in order to keep it at the same level all the time. Participants were given demonstrations and training on maintenance procedures, how to configure the data logger and how to download data.





3.4 Considerations regarding the ADCP and Pressure Sensor Training

- All participants should be given a possibility to practice more on ADCP equipment in the future. Otherwise the course has little or no sustainable value.

- Previous attempts to measure the discharge with ADCP equipment in the flood season have mostly failed due to high concentrations of suspended material. It is therefore recommended that MoWE investigates on which rivers and at which conditions (low flow, high flow) the equipment can be used to produce good measurements.

- In addition to discharge measurements the ADCP equipment can be used for cross-section measurements to detect changes that reduce the validity of rating curves. When used in combination with GPS, cross-section measurements can also provide valuable input to hydraulic models and for bathymetry of reservoirs and lakes. It is recommended that MoWE make use of these possibilities.

- It is of high importance that good routines for collecting data, data storage and maintenance of the pressure sensors are established. Control readings of the staff gauge should be continued as it is uncertain how the high concentrations of suspended material during floods will affect the pressure sensors.

- A recourse person among the hydrologist at MoWE should be appointed as responsible for ADCP and future training of the field staff.

- The participants seemed eager to learn. They were very active and engaged during the course. To preserve this engagement additional training is important. Sadly some of the participant had limited computer knowledge.

3.5 Documentation

In addition to presentations each participants were given the following important documents both in digital and hard copy. Those documents can be used as reference material in the future.

- Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat, USGS, Chapter 22 0f Book 3, Section A
- WorkHorse Rio Grande ADCP User`s Guide, P/N 957-6167-00 (April 2005)
- WinRiverII User`s Guide, P/N 957-6231-00 December 2008)
- Operating instructions Groundwater Data logger, OTT Orpheus Mini

3.6 Results from field measurements

The results of the two measurement executed with NVE staff present are summarized below. The gauge height water level given for both days was 1,310 m. The total discharge measured on the first day was 18.8 m^3/s and on the second day was 19.6 m^3/s. The two different sites measured had different conditions that illustrated the different challenges in problems to be addressed when using the equipment. The participants worked well and were very active.

Result from measurement day 1

Station Number: 112001 Meas. No: 0
Station Name: kessie Date: 02/23/2013

Party: Mowe	Width: 62.3 m	Processed by:
Boat/Motor:	Area: 178.3 m²	Mean Velocity: 0.106 m/s
Gage Height: 1.310 m	G.H.Change: 0.000 m	Discharge: 18.8 m³/s

Area Method: Avg. Course	ADCP Depth: 0.150 m	Index Vel.: 0.00 m/s	Rating No.: 1
Nav. Method: Bottom Track	Shore Ens.:10	Adj.Mean Vel: 0.00 m/s	Qm Rating: U
MagVar Method: None (0.0°)	Bottom Est: Power (0.1667)	Rated Area: 0.000 m²	Diff.: 0.000%
Depth Sounder: Not Used	Top Est: Power (0.1667)	Control1: Unspecified	
		Control2: Unspecified	
		Control3: Unspecified	

Screening Thresholds:		ADCP:	
BT 3-Beam Solution: YES	Max. Vel.: 0.741 m/s	Type/Freq.: Rio Grande / 1200 kHz	
WT 3-Beam Solution: NO	Max. Depth: 4.83 m	Serial #: 7564	Firmware: 10.17
BT Error Vel.: 0.10 m/s	Mean Depth: 2.86 m	Bin Size: 25 cm	Blank: 25 cm
WT Error Vel.: 1.07 m/s	% Meas.: 57.07	BT Mode: 5	BT Pings: 1
BT Up Vel.: 0.30 m/s	Water Temp.: None	WT Mode: 1	WT Pings: 1
WT Up Vel.: 0.07 m/s	ADCP Temp.: 27.6 ℃	WV : 175	
Use Weighted Mean Depth: YES			

Performed Diag. Test: YES
Performed Moving Bed Test: YES
Performed Compass Test: NO
Meas. Location:

Project Name: 112001TEST_0.mmt
Software: 2.08

Tr.#		Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
000	L	10.0	2.00	1063	4.49	11.0	3.06	0.817	0.082	19.4	65.0	185.6	15:20	15:24	0.22	0.11	0	8
001	R	10.0	2.00	684	4.46	10.5	3.13	0.313	0.067	18.4	63.1	180.6	15:25	15:28	0.31	0.10	0	8
002	L	10.0	2.00	1172	4.51	10.8	3.16	0.647	0.054	19.2	60.3	172.6	15:30	15:35	0.21	0.11	9	7
003	R	10.0	2.00	651	4.58	10.8	3.20	-0.162	-0.051	18.3	60.6	174.5	15:36	15:38	0.31	0.11	0	8
Mean		10.0	2.00	892	4.51	10.7	3.14	0.404	0.038	18.8	62.3	178.3	**Total**	00:18	0.26	0.11	2	8
SDev		0.00	0.00	264	0.050	0.225	0.060	0.431	0.060	0.558	2.2	5.9			0.05	0.00		
SD/M		0.00	0.00	0.30	0.01	0.02	0.02	1.07	1.59	0.03	0.04	0.03			0.20	0.04		

Remarks: very slow water speed

Result from measurement day 2

Station Number: 112001 — Meas. No: 0
Station Name: kessi — Date: 02/24/2013

Party: MOWE	Width: 66.3 m	Processed by:
Boat/Motor:	Area: 105.4 m²	Mean Velocity: 0.186 m/s
Gage Height: 1.310 m	G.H.Change: 0.000 m	Discharge: 19.6 m³/s

Area Method: Avg. Course	ADCP Depth: 0.150 m	Index Vel.: 0.00 m/s	Rating No.: 1
Nav. Method: Bottom Track	Shore Ens.:10	Adj.Mean Vel: 0.00 m/s	Qm Rating: U
MagVar Method: None (0.0°)	Bottom Est: Power (0.1667)	Rated Area: 0.000 m²	Diff.: 0.000%
Depth Sounder: Not Used	Top Est: Power (0.1667)	Control1: Unspecified	
		Control2: Unspecified	
		Control3: Unspecified	

Screening Thresholds:		ADCP:	
BT 3-Beam Solution: YES	Max. Vel.: 0.979 m/s	Type/Freq.: Rio Grande / 1200 kHz	
WT 3-Beam Solution: NO	Max. Depth: 2.70 m	Serial #: 7564	Firmware: 10.17
BT Error Vel.: 0.10 m/s	Mean Depth: 1.59 m	Bin Size: 5 cm*	Blank: 25 cm
WT Error Vel.: 1.07 m/s*	% Meas.: 58.42	BT Mode: 5	BT Pings: 2*
BT Up Vel.: 0.30 m/s	Water Temp.: None	WT Mode: 5*	WT Pings: 1
WT Up Vel.: 0.30 m/s*	ADCP Temp.: 26.4 ℃	WZ : 5	
Use Weighted Mean Depth: YES			

Performed Diag. Test: YES — Project Name: 112001DAY 2_0.mmt
Performed Moving Bed Test: NO — Software: 2.08
Performed Compass Test: NO
Meas. Location:

Tr.#		Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
003	R	3.00	8.00	635	4.34	13.0	1.71	-0.007	0.045	19.1	72.8	111.6	10:13	10:18	0.23	0.17	56	8
004	L	3.00	20.0	502	4.47	13.0	1.59	-0.015	0.575	19.6	61.9	102.2	10:18	10:22	0.30	0.19	52	7
005	R	4.00	20.0	358	4.28	13.4	1.60	-0.073	0.377	19.6	69.6	108.3	10:23	10:26	0.29	0.18	23	8
006	*L*	*4.00*	*10.0*	*326*	*4.95*	*14.8*	*1.86*	*-0.044*	*0.103*	*21.6*	*58.9*	*97.4*	*10:26*	*10:29*	*0.40*	*0.22*	*37*	*8*
007	R	*8.00*	*10.0*	*757*	*5.95*	*8.66*	*3.54*	*0.565*	*0.947*	*19.7*	*61.1*	*103.4*	*10:31*	*10:34*	*0.29*	*0.19*	*27*	*2*
008	L	*8.00*	*30.0*	*876*	*5.03*	*8.68*	*2.96*	*0.508*	*1.49*	*18.7*	*70.5*	*109.2*	*10:35*	*10:38*	*0.28*	*0.17*	*5*	*3*
009	R	*5.00*	*30.0*	*649*	*5.39*	*8.53*	*3.15*	*0.326*	*1.39*	*18.8*	*69.5*	*106.1*	*10:39*	*10:41*	*0.30*	*0.18*	*1*	*3*
Mean		5.00	18.3	586	4.92	11.4	2.34	0.180	0.704	19.6	66.3	105.4	**Total**	00:28	0.30	0.19	29	5
SDev		2.16	9.34	203	0.612	2.70	0.838	0.278	0.586	0.992	5.5	4.8			0.05	0.02		
SD/M		0.43	0.51	0.35	0.12	0.24	0.36	1.55	0.83	0.05	0.08	0.05			0.17	0.10		

Remarks: ABOVE THE GAGE 200 M SLOW WATER

* - value not consistent for all transects

4 Lectures

4.1 Introduction by Line Dale, NVE

ADCP and pressure sensor training
20-27 February

Line Dale
HHT

Goal and intentions

- Introduction to newer technology
- Just to get started
- Trying and failing
- Find out what is possible or not
- More knowlegde\resources
- Get a baseknowlege for further work

BIG challenge: Sediments

- Makes it difficult for us to compare the conditions with Norway
- Difficult to measure with just an ADCP
- Some research in Sudan with ADCP
- GPS and echo sounder
- Other technology more suited??

4.2 What is an ADCP by Line Dale, NVE

ADCP Training

Line Dale
HHT

ADCP training - Agenda

- What is an ADCP?
- Brife theory (basic)
- ADCP Set up and Data collection with Win River II
- Discharge measureme procedures
- Practical training
- After field

What is an ADCP and What Does It Do?

Acoustic
Doppler
Current
Profiler

An ADCP uses pulses of sound to measure: -

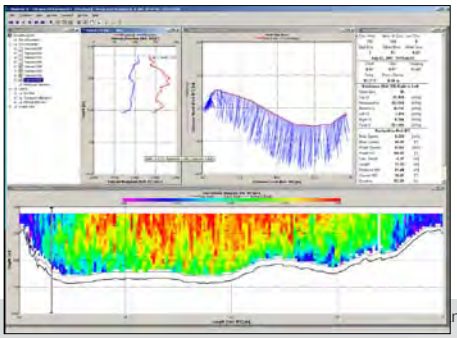
- Water speed
- Water depth
- River width

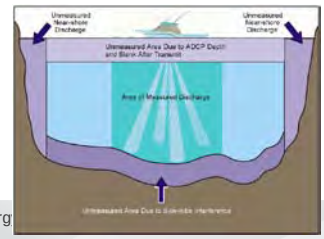
…and uses these to ***calculate discharge***

3 or 4 Transducers act as: -

- *Loudspeakers*
- *Microphones*

Discharge measurement with - ADCP





Some Commonly Used ADCP's

RDI StreamPro

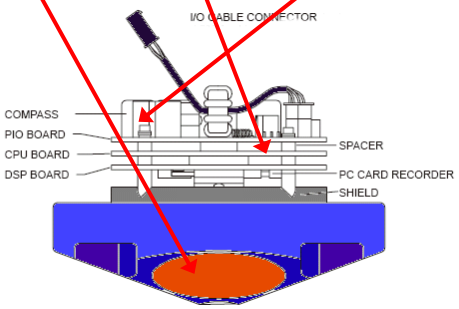
RDI Rio Grande ADCP

SonTek ADP

SonTek Mini-ADP

What's Inside an ADCP?

- Transducers (transmit and receive sound)
- Electronics boards (process the signals)
- Other sensors (temperature, compass etc)



4.3 Brief theory by Line Dale, NVE

ADCP Training – Brief theory

Line Dale
HHT

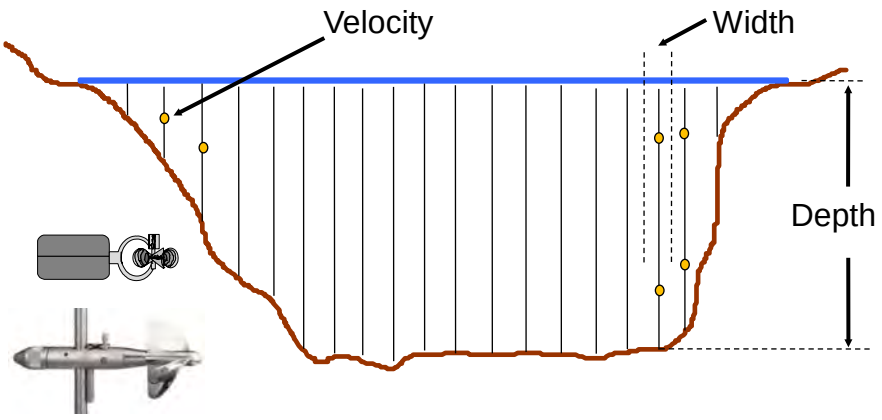
Brief theory

- Doppler Theory (very basic!!)
- Bottom tracking
- How ADCP calculates flow
- ADCP vs Current Meters – the key differences

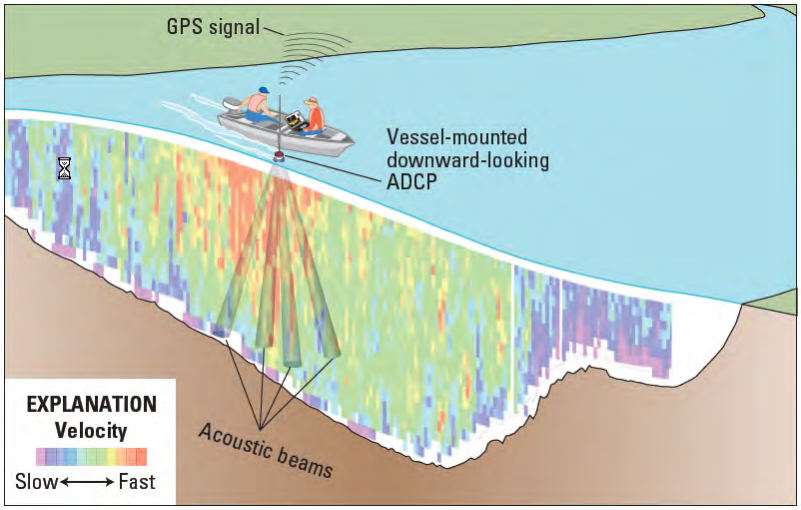
What Is an ADCP?

Acoustic	Sound Waves and the
Doppler	Doppler Shift are used to measure
Current	Water Velocity
Profiler	Profiles

Conventional Discharge Measurement

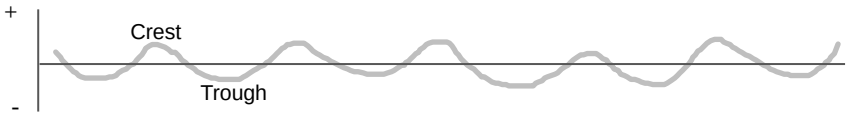


Acoustic Profiler Discharge Measurement

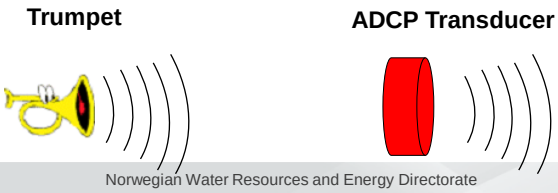


Sound Waves

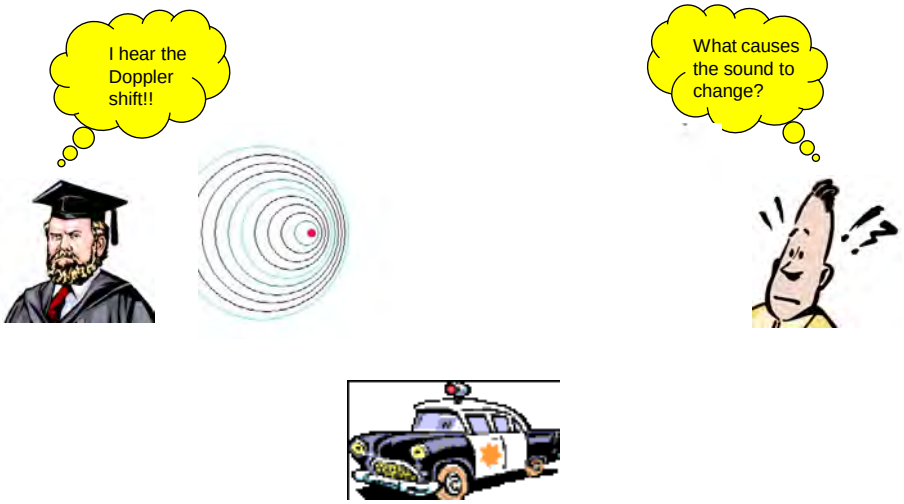
Water wave crests and troughs are points of high and low water elevations.



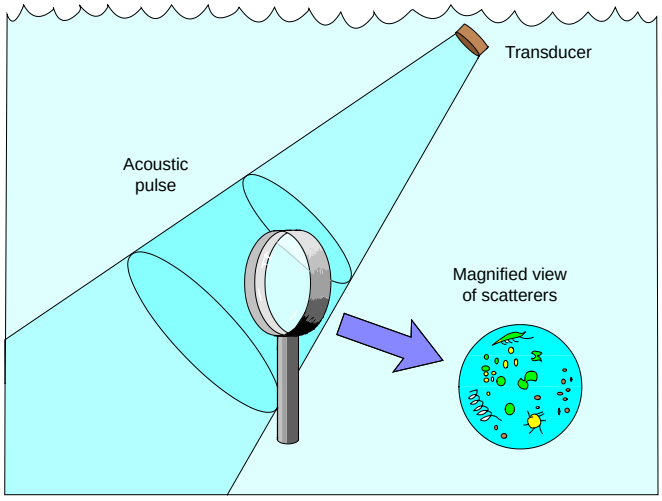
Sound wave “crests” and “troughs” consist of bands of high and low air or water pressure.



Doppler Principle

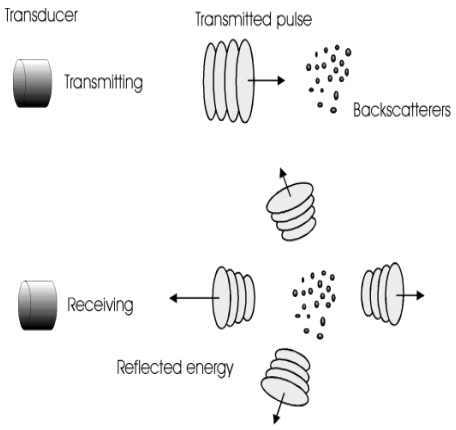


Sound Reflects from Scatterers



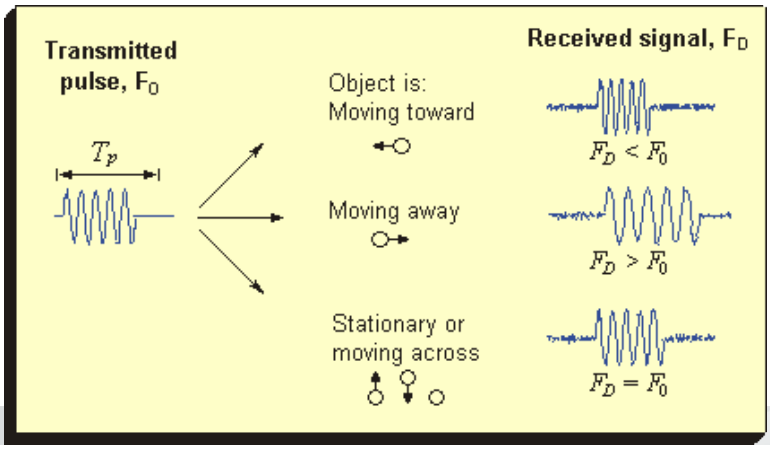
Velocity and Doppler shift

- Acoustic instruments use either travel time or Doppler shift to measure velocity
- Acoustic Doppler-instruments transmit sound, and measure the Doppler shift in the return signal from particles that are suspended in the water



Velocity and Doppler shift

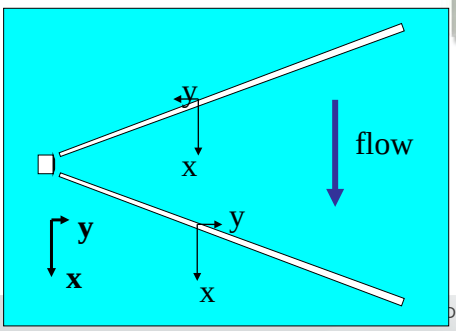
- If the particle is moving towards the instrument, the return signal has a shorter wave length (higher frequency) than the transmitted signal. And the other way round if it is moving away from the instrument.



Velocity and Doppler shift

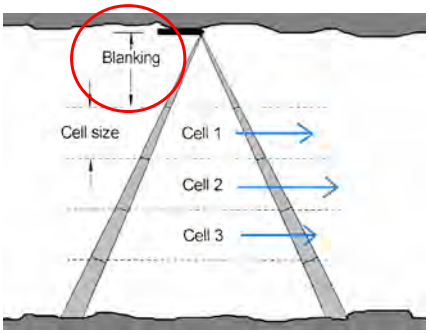
- Acoustic Doppler instruments transmit sound pulses along narrow *beams.*
- Velocities are measured along the beam

Transducer: Combined transmitter and receiver

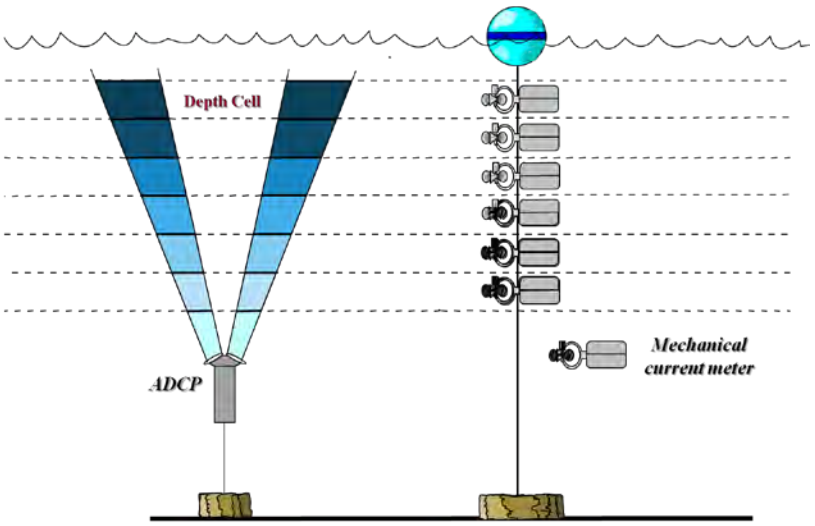


Division into cells - blanking

- After transmitting a sound pulse, the instrument need a break before it can receive a return signal. The distance the sound travels during this short break, is called the *blanking distance*
- The instrument needs this break to allow the *transducers* to stop vibrating - ringing

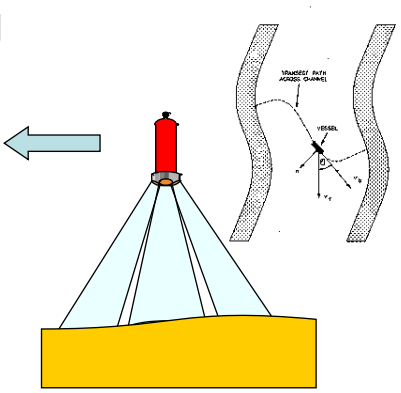


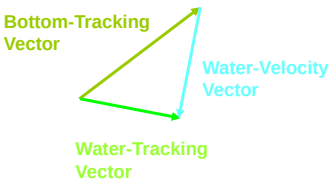
ADCP's Profile



Bottom tracking

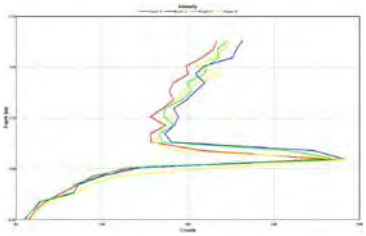
- The ADCP measures the bottom elevation using a separate *bottom tracking* signals
- The bottom track is determined from Doppler shift of sound waves reflected from the streambed
- Measures the velocity of the vessel relative to the bottom for each beam
- The bottom tracking is used to compute the true water speed





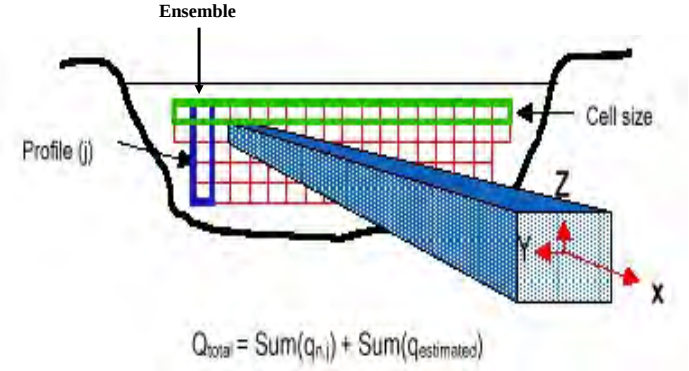
Depth measurements

- The strength of the return signal decreases with increasing distance from the instrument.
- When the signals hit the bottom the strength increases.
- The bottom is where the signal has a (clear) peak
- The ADCP uses all four beams to detect the bottom



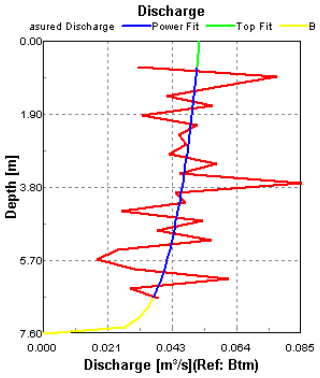
From velocity and bottom tracking to discharge

- The software computes total volume discharge (ΣQ) for each ADCP segments or *ensemble*
- Cell size depends on river depth



From velocity and bottom tracking to discharge

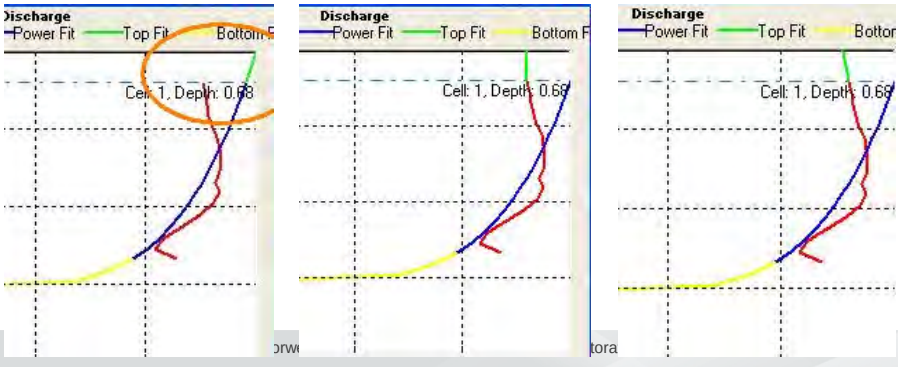
- The ADCP does not measure the entire vertical
- The software extrapolates top and bottom velocities using either the Power fit curves, constant or 3 point-slop
- Use always the power fit for extrapolate the top and bottom



How Does ADCP Calculate Discharge? Extrapolation Options

- If 'Power' does not seem to be a good fit…..
- Try constant….
- Or 3-point slope

These changes are made when processing the data. Q is recalculated using new line



From velocity and bottom tracking to discharge

- The software estimates the discharge near the shore using a ratio-interpolation method

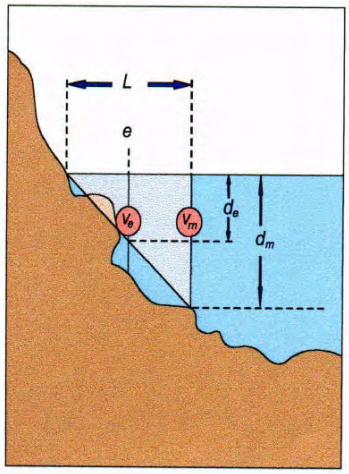
Q = C*Vm*L*dm

C = Coefficient (0.35 triangular or 0.91 rectangular)

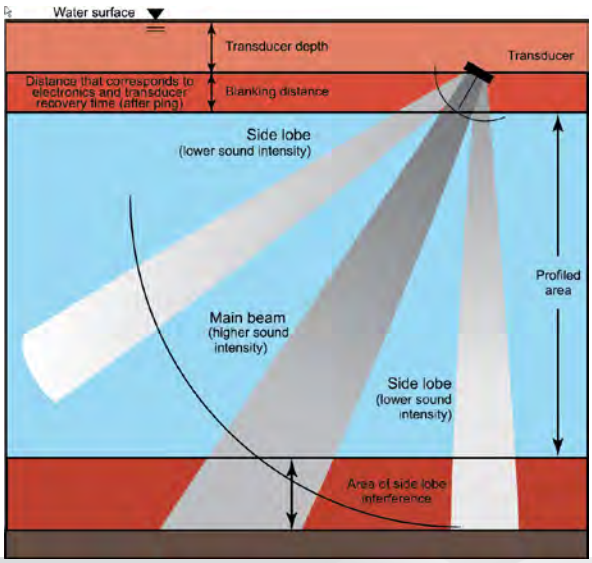
Vm = Mean velocity in first or last ensemble

L = distance from vessel to shore

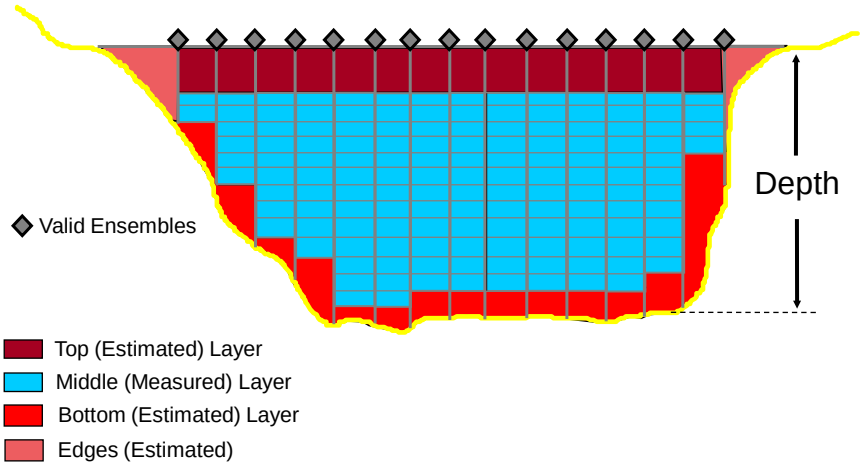
dm = Depth of the first or last ensemble



Unmeasured Top and Bottom

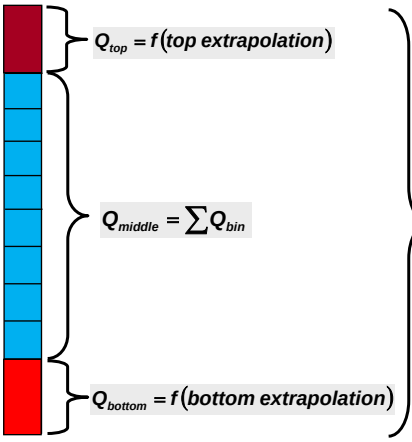


Measured and Unmeasured Areas



Top (Estimated) Layer
Middle (Measured) Layer
Bottom (Estimated) Layer
Edges (Estimated)

Discharge in a Profile (Ensemble)



$Q_{top} = f(\text{top extrapolation})$

$Q_{middle} = \sum Q_{bin}$

$Q_{bottom} = f(\text{bottom extrapolation})$

$$Q_{ens} = Q_{top} + Q_{middle} + Q_{bottom}$$

Terminology

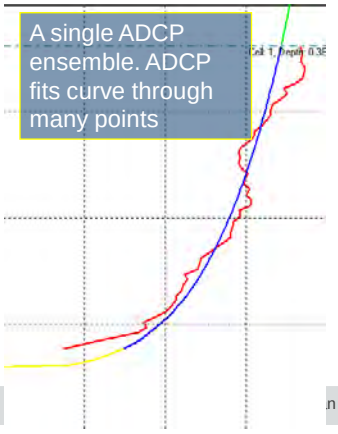
Pings	• Acoustic pulses of a known frequency
Depth Cells (Bin)	• A segment of a velocity profile, similar to a point velocity measurement
Ensembles	• A collection of 1 or more pings averaged together to obtain a water velocity profile and/or a boat velocity at a single point
Transect	• A group of ensembles collected while traversing a stream that constitute a single measurement of discharge
Bottom tracking	• Acoustic method used to measure boat speed and direction. Typically, the depth is also measured during bottom tracking.

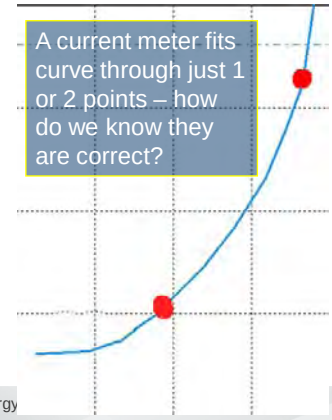
How Does ADCP Calculate Discharge? Velocity Profiles

Same basic rules for calculating discharge – a velocity profile for each ensemble

ADCP uses up to 100 points to generate velocity profile – for each ensemble

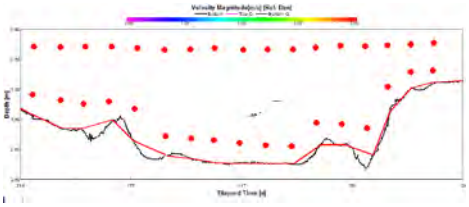
Current meter uses just one or two points

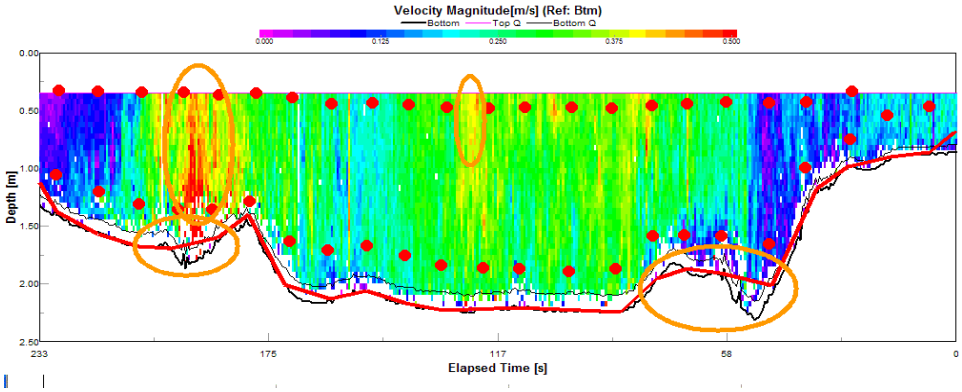




ADCP vs Current Meter

- Large area of high velocities not measured
- Smaller pockets of high velocities missed
- Bed profile (and therefore total area) not as accurate





IMPORTANT!!

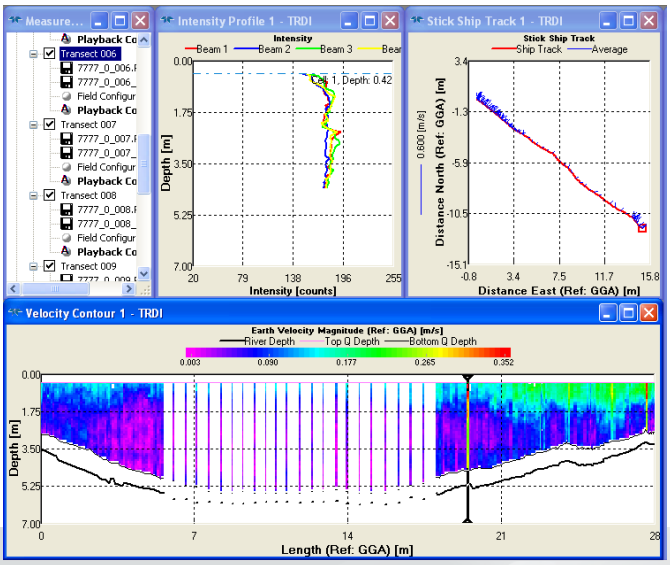
Your water track data can only be as good as your bottom track data

If bottom tracking is bad, so is water speed data

Common causes of bottom tracking problems: -

- Weed
- Sticks and debris
- Too much sediment (absorbs acoustic energy before it reaches bed)
- Irregular boat speed
- Very fast, turbulent water
- Aeration of water
- Moving bed

Bottom tracking problems - too much sediment in water

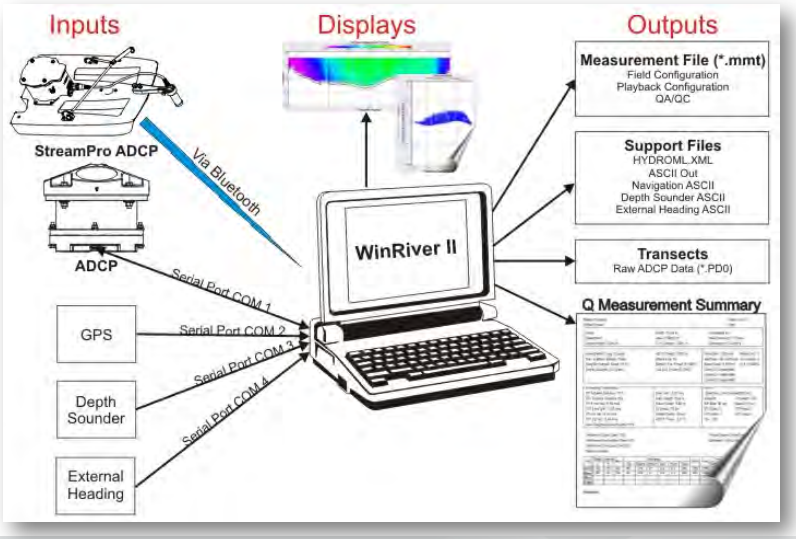


4.4 Introduction to WinRiver II by Line Dale, NVE

Topics Covered

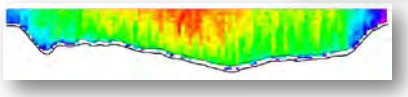
- Displays (viewing data)
- Opening a Measurement
- Measurement Control Basics
- Maneuvering in a Transect
- Files and Configurations

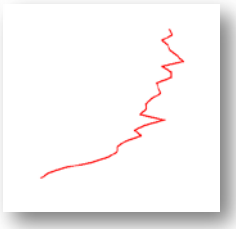
WinRiver II Overview



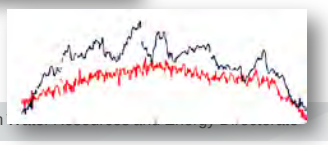
Viewing Data In WinRiver II

- Ship Track
- Contour
- Profile
- Tabular
- Time Series



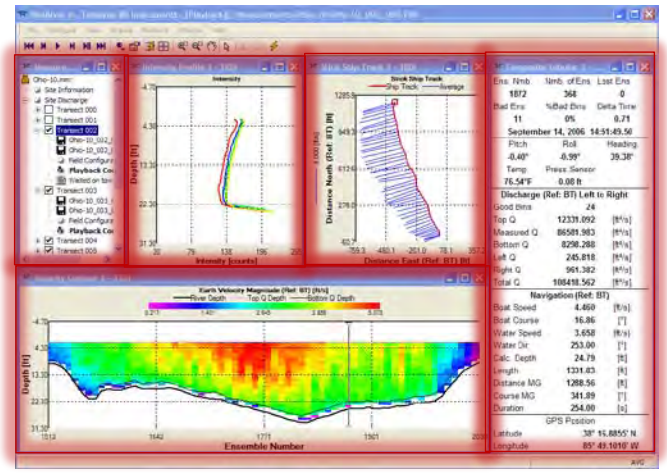


Ens. Numb.	Numb. of Ens.	Lost Ens.
1750	246	0
Bad Ens.	%Bad Bins	Delta Time
8	0%	0.69
September 14, 2006 14:50:24.15		
Pitch	Roll	Heading
0.16°	4.13°	6.20°
Temp.	Press Sensor	
76.53°F	0.08 ft	
Discharge (Ref: BT) Left to Right		
Good Bins	24	
Top Q	7482.072	[ft³/s]
Measured Q	44407.076	[ft³/s]
Bottom Q	4740.992	[ft³/s]
Left Q	245.818	[ft³/s]
Right Q	1142.141	[ft³/s]
Total Q	58018.010	[ft³/s]



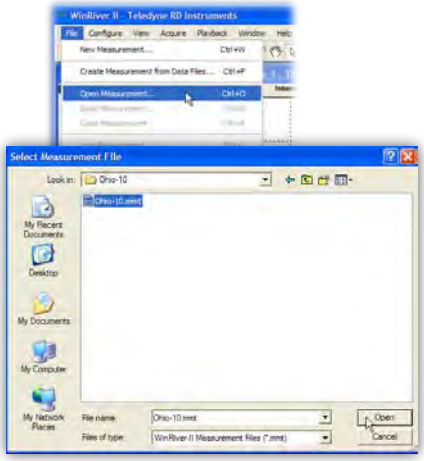
Default WinRiver II Screen Layout (Workspace)

- Intensity Profile
- ShipTrack
- Velocity Contour
- Composite Tabular
- Measurement Control



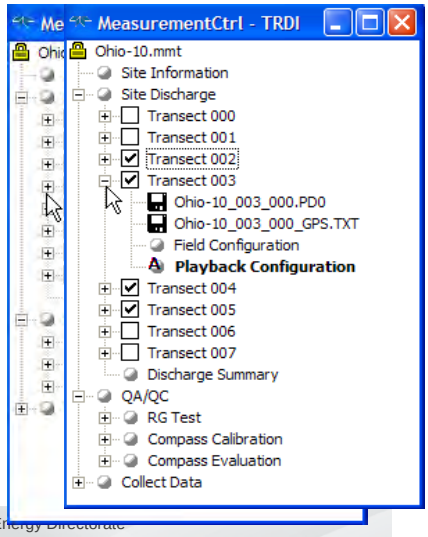
Opening a WinRiver II Measurement

- Select File… Open Measurement… from the menu
- Locate the measurement (.mmt) file for the data file you wish to process or review
- Use this method to open measurements collected with WinRiver II



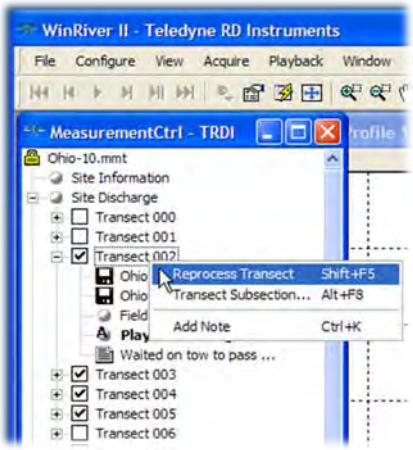
Introduction to Measurement Control

- After opening a measurement (.mmt) all data files and QA/QC are displayed in the measurement control window
- The Measurement control displays information in a tree structure
  - Press + to expand “branches”
  - Press – to compress



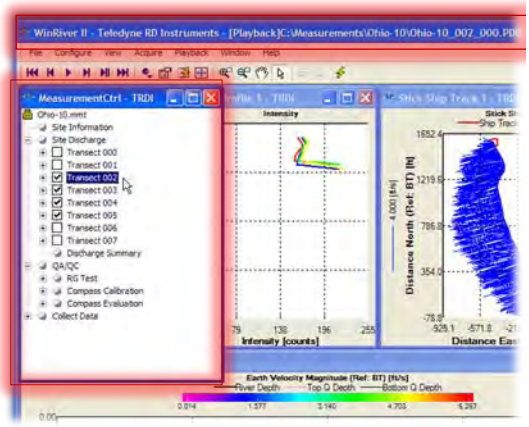
Measurement Control Reprocess Transect

- Pressing the right mouse button while over items in the measurement control displays context sensitive menus
- To load a transect
  - Right click on the desired transect
  - Select reprocess transect



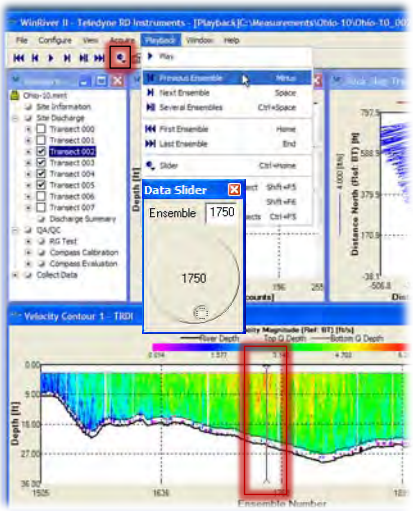
Measurement Control Now Processing

- Transect being processed by is indicated by
  - Highlighted name in measurement control
  - Filename in top of window



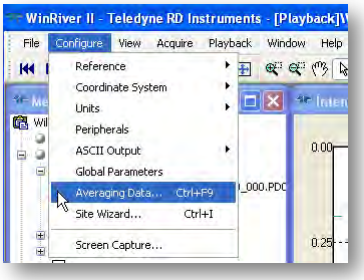
Maneuvering in a Transect

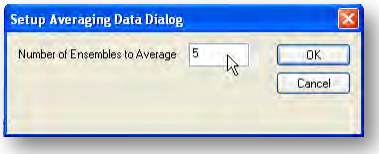
- When a transect is reprocessed the entire transect is loaded in memory and displayed in the open graphs
- Go to a specific Ensemble (profile) by:
  - Using the playback controls
  - Using the data slider
  - Dragging the ensemble marker on a contour plot
  - Press [minus] or [space]



Averaging Ensembles

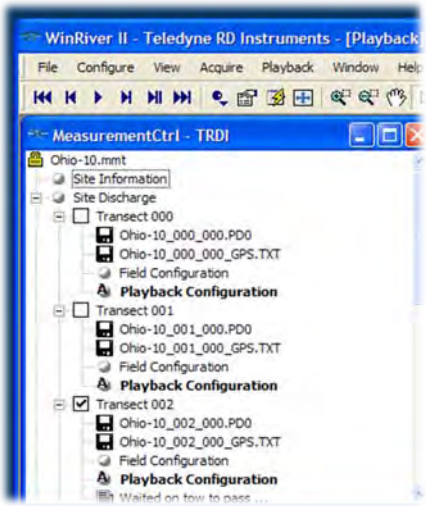
- Under the Configure menu, select Averaging Data… or right-click Site Discharge
- Enter Number of ensembles to average
- Only affects graphs and ascii output files, does not change calculations





WinRiver II: Files and Configurations

- Files created as part of a discharge measurement
- Viewing and modifying
  - site information
  - transect configuration settings



WinRiver II Files

File Types	Function of File	Suffix
▪ Measurement	Stores Configuration settings & QA/QC logs	*.mmt
▪ Raw data	Transect raw data as acquired from ADCP	*.PD0
▪ Navigation	Navigation data (GPS) output	*_GPS.txt
▪ Depth sounder	Depth Sounder data output	*_SND.txt
▪ Ext. Heading	Heading data output	*_EH.txt
▪ HYDROML	Discharge summary output	*.xml
▪ ASCII out	ASCII output file	*_ASC.txt

Filename Format:
prefix_meas_MMM_date-time.PD0

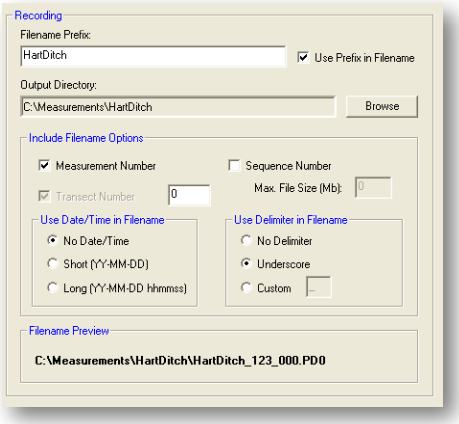
Filename determined when creating a new measurement

prefix = Filename prefix
(Default = Station number)

meas = Measurement number

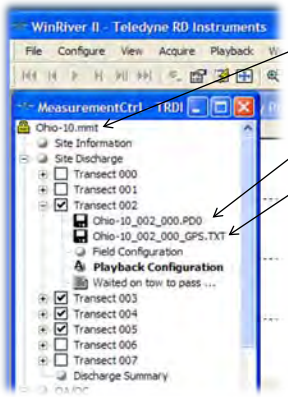
MMM = Transect number
(starts with 000)

date-time = Date time of transect (optional)



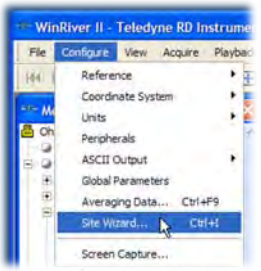
Example : HartDitch_123_000.PD0

Filenames in the Measurement Control



- Measurement file
- Raw data file
- Navigation (GPS) log file

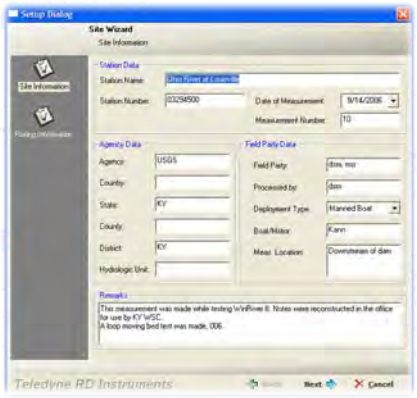
Modifying Site Information



- To view and/or modify Site Information
  - Right mouse click on Site Information in the measurement control and select Site Wizard,

    OR
  - Select Configure… Site Wizard from the main menu

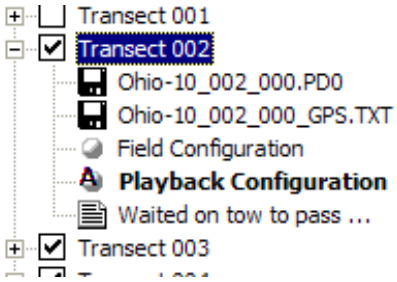
Site Wizard



Configurations Settings

Each Transect Processed in WinRiver II will contain:

- Field Configuration
  - Contains all configuration settings as they were during data collection
  - Can not be modified or deleted or renamed
- Playback Configuration
  - Created the first time a transect is reprocessed
  - Values may be changed
  - May be deleted or renamed



Viewing Configuration Settings

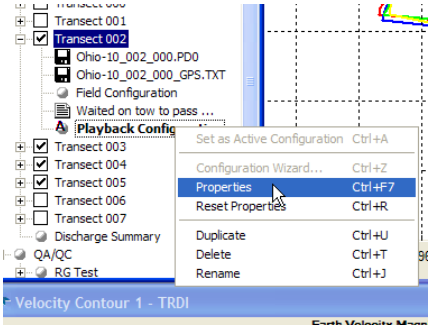
To view or change settings in a transect configuration

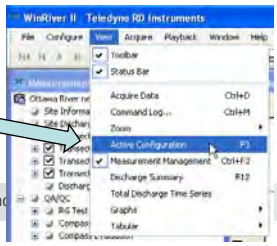
- In the measurement control, right mouse click on the configuration under the transect
- Select *Properties* from the menu

OR

- Double left mouse click on the configuration

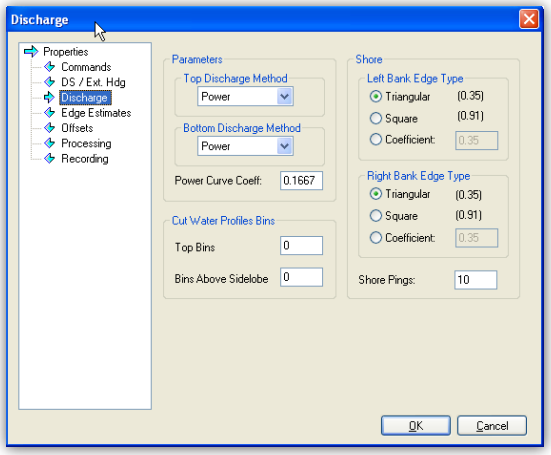
- From menu View… Active Configuration (F3)





Configuration Dialog

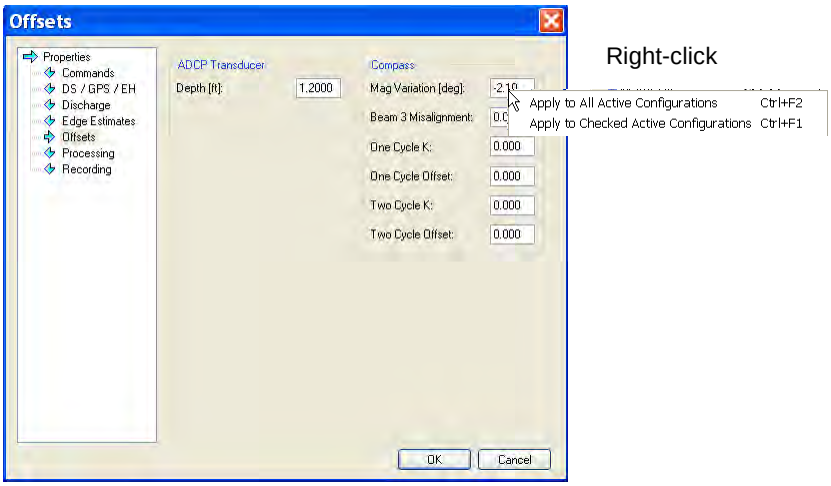
- Configuration dialog contains 7 pages of settings
  - Commands
  - DS / Ext. Hdg
  - Discharge
  - Edge Estimates
  - Processing
  - Recording



Changing Configuration Settings

- Edit the playback configuration to the desired value
- Change can be applied to:
  - Edited configuration only
  - All checked active configurations
  - All active configurations

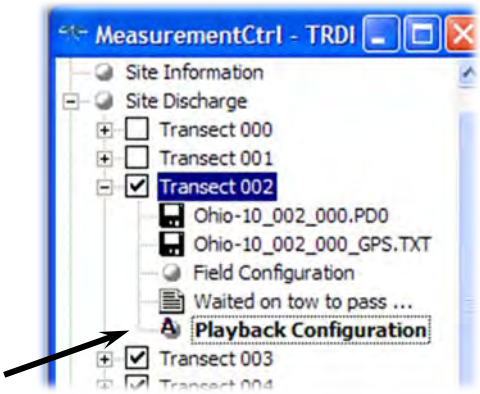
Applying Configuration Settings



Right-click

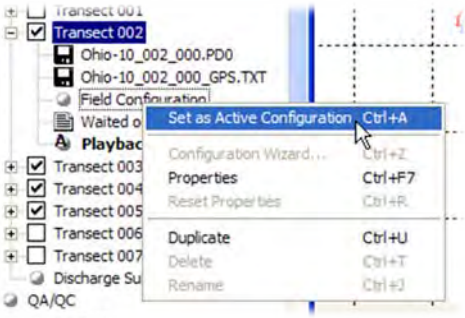
Active Configuration

- Transect can have multiple configuration nodes
- The configuration being used to process the transect is call the Active Configuration
- The Active configuration is in BOLD with an A over the node icon

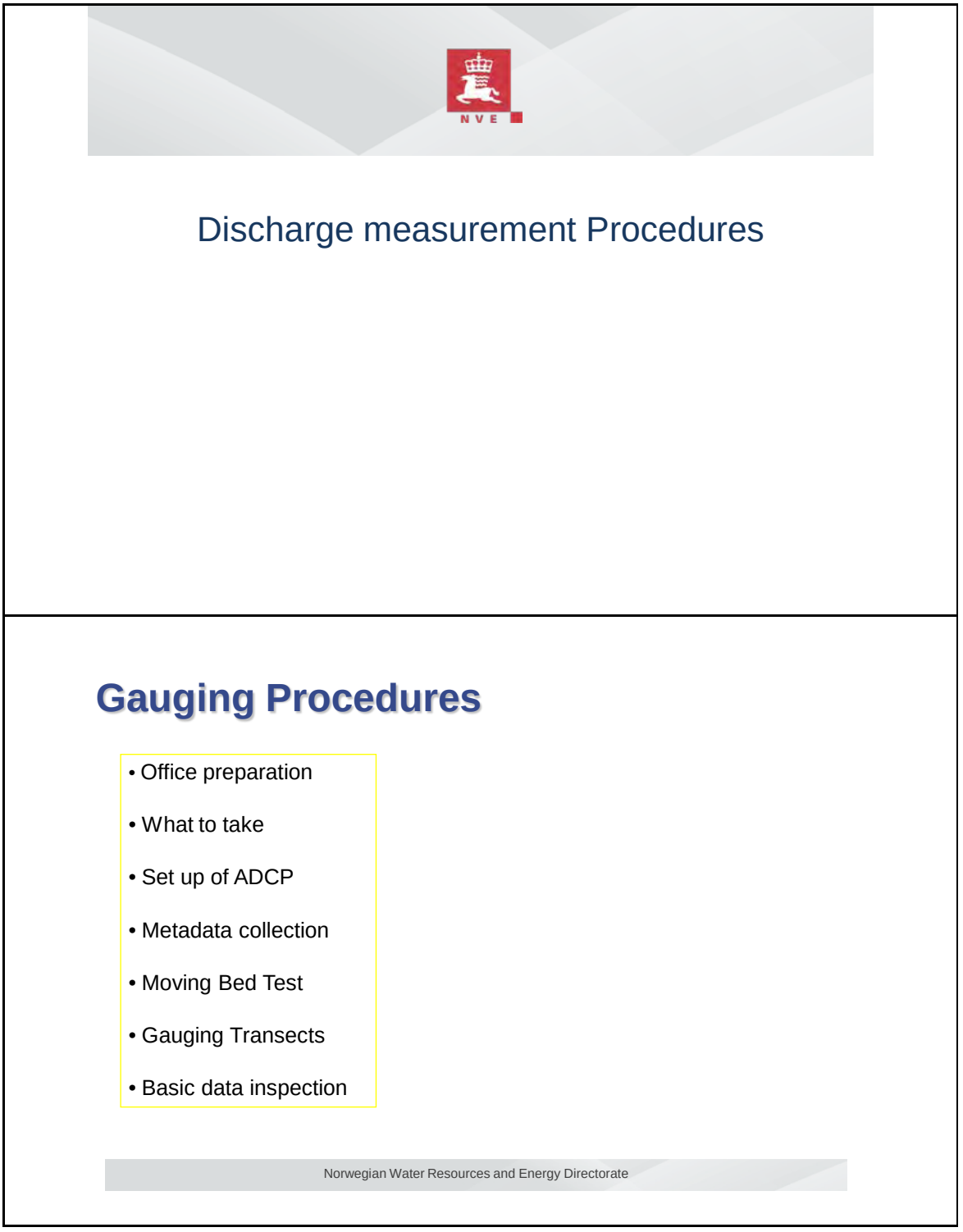


Making a Configuration Active

- To change the Active Configuration
  - Right mouse click on the desired configuration
  - Select Set as Active Configuration from the menu (Ctrl+A)
- The settings in the activated node will be used the next time the transect is reprocessed



4.5 Discharge measurement procedures by Line Dale, NVE



Office Procedures

Before you even leave the office you should…..

- Learn about the site and conditions
- Choose suitable instrument (Streampro, RG600, RG1200, Sontek)
- Look at previous data from the site
- Take suitable deployment equipment (ropes, pulleys, RC boat?)
- Check comms equipment – radios, cables etc
- Check laptop and software

Things to take – ADCP kit

Ex.

- An ADCP (that suits the sites to be gauged)
- Flotation boat
- Ropes/pulleys
- Fishing rod or similar (for getting rope across river)
- Laptop (and a spare)
- Radio/Bluetooth modems (if needed
- Direct comms cable for Rio Grande
- Other.....

Things to take – other useful stuff

You'll also be wanting…..

- Spare ADCP batteries
- Laptop charger
- Camera
- Tape measure
- Tool box
- A thermometer!
- GPS (for site location or for gauging)
- Other.....

Set up of ADCP

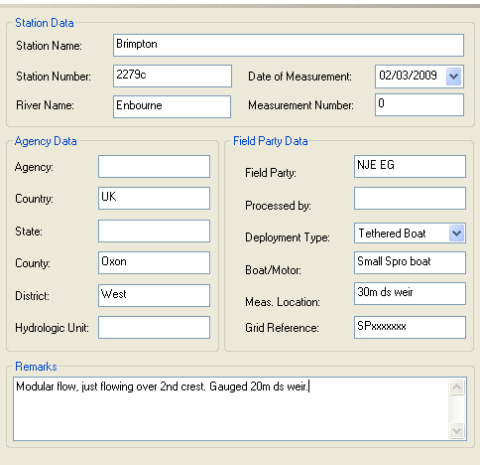
- Choose measurement location
- Check ADCP batteries
- Assemble ADCP boat
- Measure ADCP draft (with batteries etc installed)
- Do a test transect
- Record reference water level and flow (if known)

Config wizard - Metadata

Record the following

- Site name
- Site number (used to name data now)
- River name
- Gauging Team
- Deployment Type
- Boat/motor if applicable
- Location
- Comments

- Anything else that might be relevant (weather conditions, wind, rising/falling stage etc)



Rating Information

Record the following:

- Stage (and change)

- Rated discharge (if known)

- Water temperature

Configuration Dialog – Rio Grande

Set the following:
- Transducer depth
- Max water depth
- Max water speed
- Max boat speed
- Streambed
- Bottom mode
- Water mode
- Edge shapes

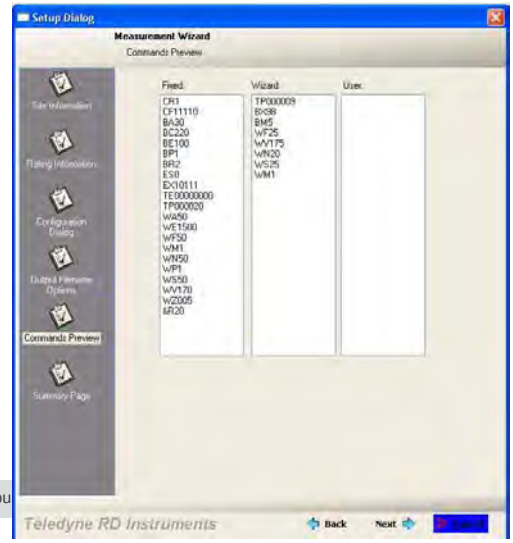
Data recording tab

Details of data recording location/naming

ADCP commands

Commands sent to ADCP

- Factory settings
- Wizard generated settings
- User settings



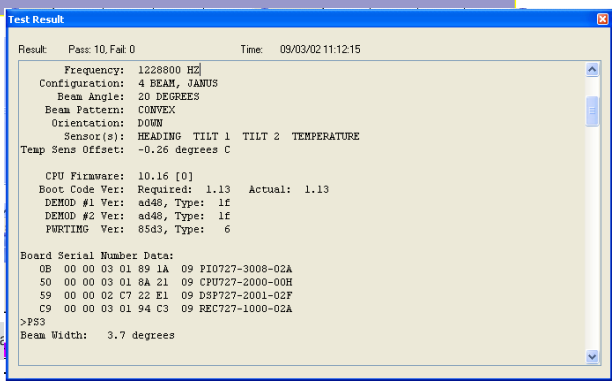
Summary page

- Details of ADCP
- Discharge settings
- Measurement limits

Check settings will work for your site.

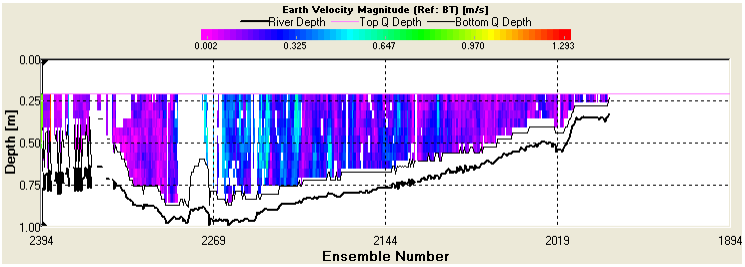
Instrument Test

Always do an ADCP test before gauging
- Put ADCP in water for test
- Instrument systems checked
- Test recorded and saved with gauging
  - TRDI might ask for these files if instrument fails and must be repaired



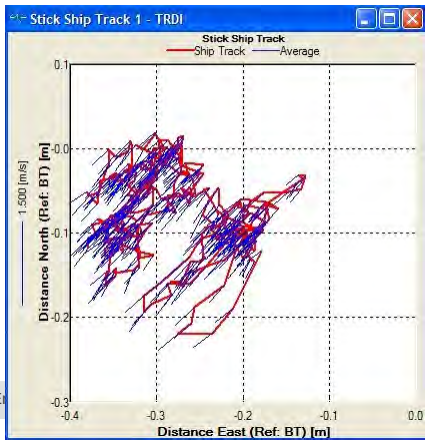
Do a Test Transect

Once ADCP is set up for gauging, do one crossing of the river (don't need to record data, just look at screen)
You should check:
- River depth (deep enough for measurement?)
- Water speed (too fast/slow for chosen mode?)
- Bottom track – any problems in bottom track (as below)



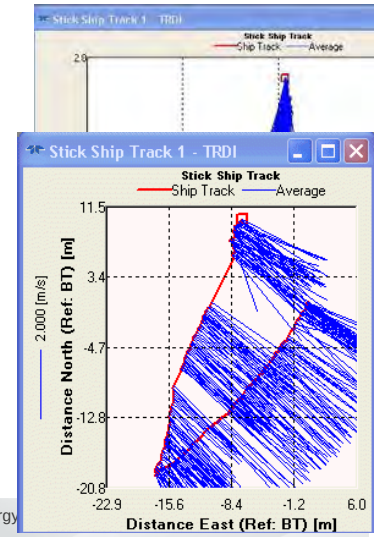
Moving Bed Test

Always do a moving bed test before gauging:
- Do a stationary test (minimum 5 minutes)
- Look for signs of upstream boat movement in Ship Stick Track



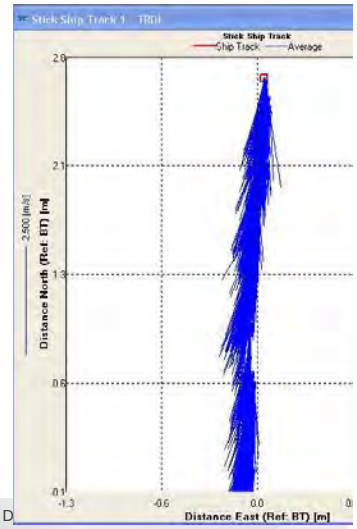
Moving Bed Test

If moving bed detected
- **Try different gauging location**
- Try a Loop moving bed test as well
- If Loop test fails, do several stationary tests



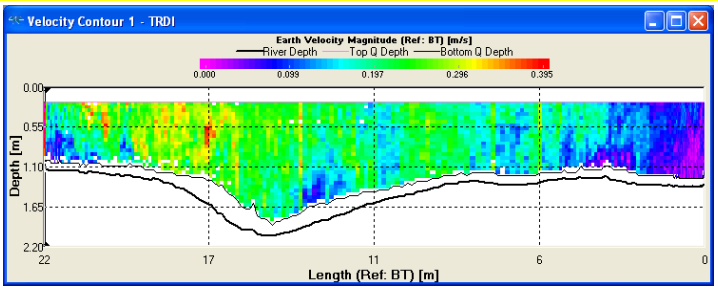
Moving Bed Test

Other options moving bed
- Use Stationary or SxS modes
- Use GPS for boat speed



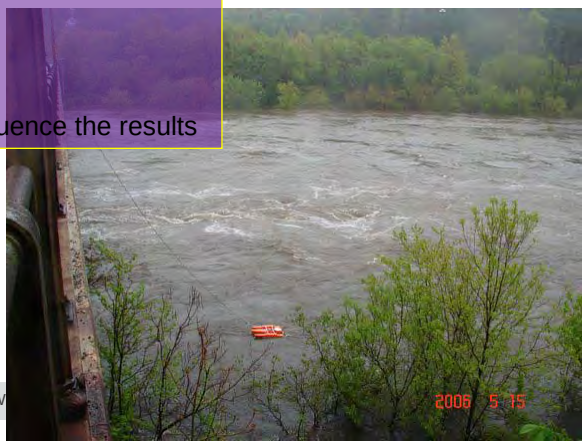
Now you can gauge!

- Start Transect
- Collect edge data (10 ensembles)
- Move slowly and smoothly across river
- Take about 2-3 minutes to cross (longer for large rivers)
- Collect far bank edge data (10 ensembles)
- End transect



Gaze into the water……

Always look at the river while you gauge.
Look for:
- Circulation
- Wind driven surface
- Changing stage
- Locks, boats
- Debris, logs... Danger!
- Anything else that could influence the results

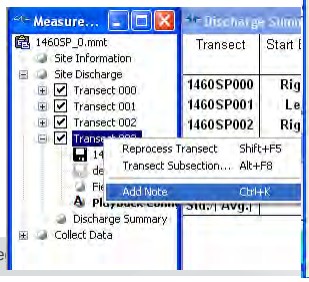


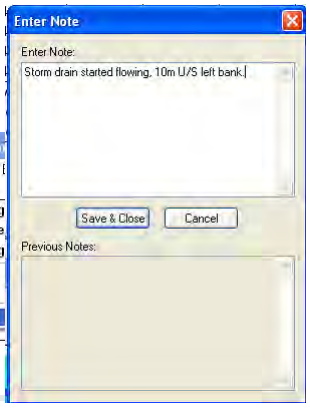
Make notes……

Note anything that could influence the gauging

- Right click transect
- 'Add note'
- A free text field – record whatever is relevant

- Wind conditions
- Lock/weir/gate movements
- Aborted transects
- Other.....





How Many Transects?

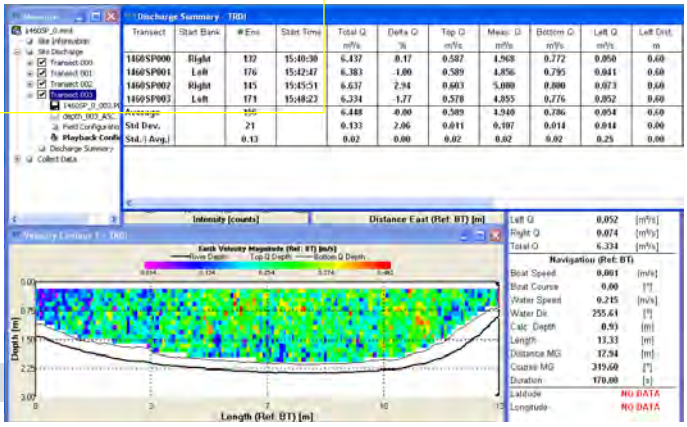
- Do 6 transects?
- Do reciprocal transects
  L to R then R to L etc
- Look at F12 summary table
- If any are more than 5% diff, do another 4 transects
- Use mean of 8 unless good reason not to

Try to understand reasons for variation in flow – make notes, take pics when on site.

Transect	Start Bank	# Ens.	Start Time	Total Q m³/s	Delta Q %	To n
sutton courtenay000	Right	106	13:09:23	171.602	-1.75	21
sutton courtenay001	Right	116	13:11:03	177.308	1.51	22
sutton courtenay002	Left	105	13:12:11	164.329	-5.92	19
sutton courtenay003	Right	138	13:13:16	185.414	6.16	22
Average		116		174.663	0.00	21
Std Dev.		15		8.921	5.11	1.
Std./| Avg.|		0.13		0.05	0.00	0

Finish gauging - Review the results

- Quickly review each transect – look at
  - Velocity Contour and
  - Stick Ship Track plot
- Look at F12 table – check consistency of results
- Back data up to a flash card or USB pendrive



Duration of Measurements or Number of Measurements?

Should I do 2, 4 or 8 transects?

What's most important –
- No. of transects?
- Time spent measuring?

It is now thought that total measurement time may be most important
USGS research (Dec 2007)
- Optimum total duration of measurement was approx 600 seconds
- Minimum of two transects to eliminate any directional bias

Boat Speed

Move boat smoothly.
Change speed, heading and direction slowly and gradually

This rule of thumb is not valid any more: "Aim to keep boat speed slower than water speed."

Keeping boat speed steady is more important than keeping slow

3 minutes per transect is a good target – regardless of river width (within reason!)

Edge Distances and Shapes

Measure edge distances – do not guess!
- Use marked ropes
- Edge markers
- Laser range finders

Best thing if edge Q is not important! (Slow, shallow water, short distance)

Think about real edge shape
Is it REALLY square or triangle?
Often something in between

Location Location Location……

4.6 Water level measurement with Pressure sensor (OTT Orpheus mini) by Morten Due, NVE

Water level measurement with pressure sensor

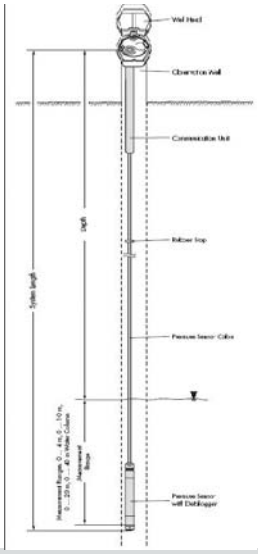
Morten Due
Hydrometry section

OTT Orpheus mini

General

- Suitable for water pipes, wells, tanks and open water
- Designed with a rugged, ceramic-capacitive measuring cell, wich provides precise data of pressure (water level) and temperature
- An easily programmable logger stores the measured values in a 4MB non-volatile memory
- IR-interface provides easy access and transfer of data to an external device, e.g. PC
- Selectable logging: linear, logarithmic, event triggered delta data logging

Technical data 1



Water level

Measuring ranges: several

0-4 m water column(0 – 0.4 bar)

0-20 m water column(0 – 2 bar)

Resolution: 0,1cm

Accuracy: +/- 0,05%

Measuring cell: Ceramic-capacitive

Temperature-compensated: (-5°C - +45°C)

Communication unit: withstand immersion depth up to 2m for max. 24 h

Water temperature

Measuring range, temp.: -25°C - +70°C

Resolution, temp.: 0,1°C

Accuracy, temp.: +/- 0,5°C

Gage(vented) vs. sealed transducers

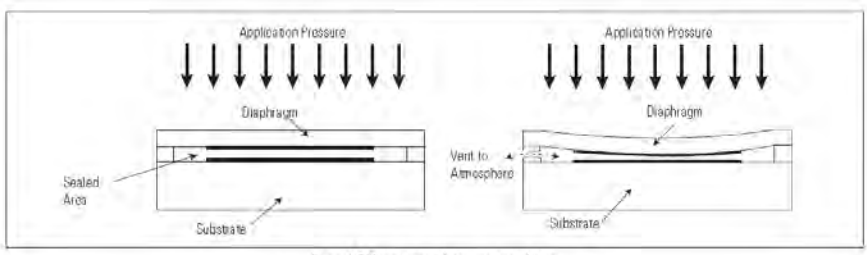


Figure 1. Different types of pressure transducers
Figure 2. Gage vs. sealed device for measuring open or closed pressure vessels

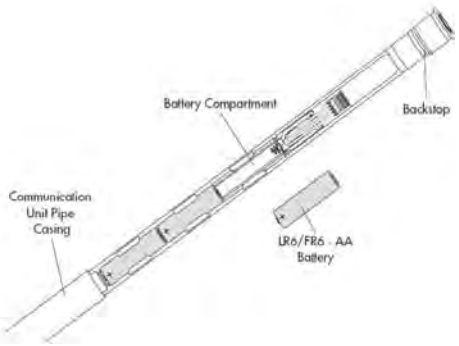
Technical data 2

Power supply

3 x 1,5 V cells (LR6 / AA)
Power consumption:
Active (measuring): 30mA
Active (communication): 50mA
Passive: 30µA
Battery lifetime (at 1 h sample int.):
Lithium batteries: min. 5 years
Alkaline batteries: min. 1,5 years

Lithium recommended for temp. below 0°C
Change batteries when voltage is below 3,6V
At the same time change desiccant

NB! Check voltage on new batteries before they are inserted!



Technical data 3

Clock:

+/- 1 minute/month

Buffer periode during battery change: max. 10 minutes

Data memory:

Measurements: 4MB

Number of measurements: App. 500 000 (App. 19 years at1h measurements)

Measurement time interval: 1s – 24h

Storage time interval: 1s – 24h

Addition:

Measures water level and depth (ground water)

Various advanced measuring settings

Firmware and software

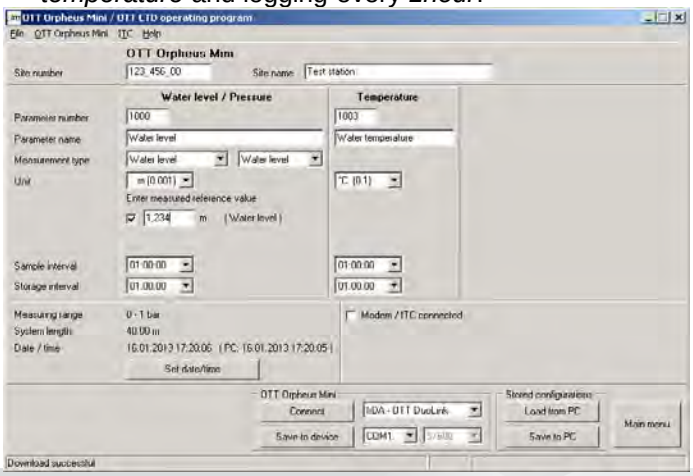
- Aim at using latest versions of FW and SW:
  - Orpheus Mini – Firmware *V1.53.1*
  - If using Hydras3 - *V 2.80.0*
  - Orpheus Mini – Operating program *V1.52.0*

Configuring the logger

- Connect the IR-cabel (OTT DuoLink) and start *Orpheus Mini operating program – WBSPL0*
- Press: *Setup device – Connect*. The present configuration will be read and displayed
- Fill in correct station number, name etc.
- Set present water level
- Press *Save to device* to program the logger

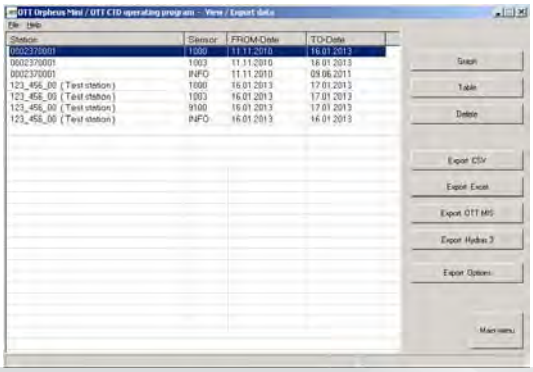
Configuring the logger - contd

- A typical setup for a gauge station with *water level, temperature* and logging every *1hour*:



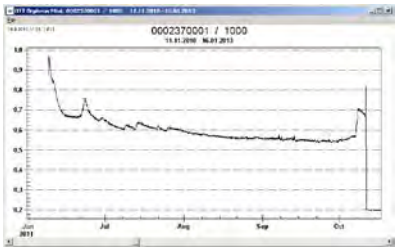
Download data from logger

- Connect the IR-cabel (OTT DuoLink) and start *Orpheus Mini operating program – WBSPL0*
- Press: *Download* and fill in parameters and date, then press *Download data*



Data may be inspected graphically or in a table format.
Data may also be exported.

View/Export data from logger



Possible to zoom in on data.

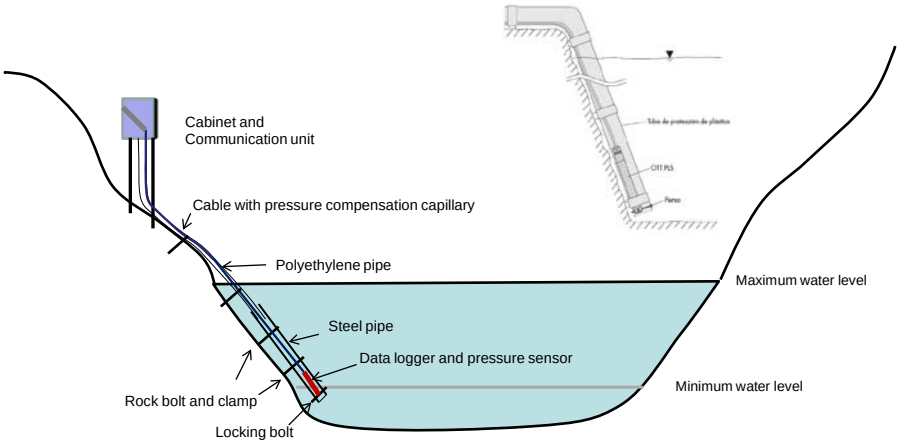
To view two or more graphs in the same window, you need another program, e.g Hydras 3, as seen in the figure to the right.

Data export possible, e.g. to an XLS-file, to Hydras3 etc…

IR-communication problems

- IR-communication may fail on some (older) loggers making the accessability difficult/impossible
- Data recording will continue as long as the batteries are ok, even though the IR-com fails
- Logger should be replaced and sent to the manufacturer (Ott) to save data and repair the IR-unit

Installation of pressure sensor



Installation examples

The staff gauge and pressure sensor must be located close together to avoid differences in water level readings

Operation and maintenance

- Download frequency
- Reference measurements(reading of staff gauge)
- Replacing of batteries
  - At least once a year if alkaline batteries
  - If the battery voltage is < 3,6 V
- Replacing dessicant capsules
  - Once a year(when replacing batteries)
- Cleaning the pressure sensor
  - At least once a year, more often if clogging occurs

Options for automatic water level measurements

OTT CBS
Compact Bubbler

OTT RLS
Radar Sensor

Features / Benefits
- Indirect drift free measurement
- Suitable for lightning areas
- Low installation costs
- Compact size
- Standard interfaces 4 ... 20 mA / SDI-12 / RS-485
- Purge function

The OTT CBS is a lightweight, compact water-level bubbler gauge that operates on a drift-free air bubble principle.

The unit utilizes an integrated small piston pump to compress the air through the measuring tube and bubbler chamber into the water. By comparing the barometric pressure to the bubble pressure, the unit calculates the water-level height. Because the unit only produces a bubble when a measurement is initiated, the need for an air pressure tank, connected to the unit is eliminated.

The OTT CBS can output water-level readings in SDI-12, as 4 ... 20 mA, or RS-485 (SDI-12 protocol). The unit can be configured to any of the three output modes by simply using the 8 dual in-line package (DIP) switches located on the underside of the device.

Due to the indirect measurement principle with no electronic parts in the water, the OTT CBS is especially suitable for areas which are prone to lightning.

Features / Benefits
- Low power radar
- Designed for open field applications
- Temperature compensation
- Standard interfaces 4 ... 20 mA / SDI-12 / RS-485
- Compact size
- Contactless measurement

The OTT RLS is a radar sensor for non-contact water level measurement at surface water locations. The sensor uses impulse radar technology to determine the water level.

The sensor is mounted above the water surface at bridges or auxiliary constructions. Its solid, light and water-proof housing is easy to install. Its extremely low energy consumption (active: <12 mA @12 V), the large power supply range and standardized interfaces make the OTT RLS very flexible for use in various applications.

The OTT RLS covers a measurement range of up to 35 m. It is specifically designed for the use in open as locations without mains power infrastructure. The OTT RLS is an economical, practical and reliable alternative to conventional level gauges.

Specifications

Measuring range	0 ... 15 m
Accuracy	± 5 mm
Power supply	10 ... 30 V DC, typ. 12/24 V DC
Power consumption	
1 min interval	typ. 320 mAh/day
15 min interval	typ. 25 mAh/day
Interfaces	4 ... 20 mA; SDI-12; RS-485 (SDI-12 protocol)
L x W x D	165 mm x 205 mm x 115 mm
Weight	approx. 1.5 kg
Operating temperature	-20 ... +60 °C
Relative humidity	0 ... 95 %; not condensing

EPS 50 bubble chamber for accurate values

Specifications

Measuring range	0.5 ... 35 m
Accuracy	± 3 mm
Aperture radar beam	12 °
Power supply	9.6 ... 28 V DC, typ. 12/24 V DC
Power consumption	Active <12 mA @12 V
Interfaces	4 ... 20 mA; SDI-12; RS-485 (SDI-12 protocol)
L x W x D	222 mm x 152 mm x 190 mm
Weight (incl.swivel mount)	approx. 2.1 kg
Operating temperature	-40 ... +60 °C
Relative humidity	0 ... 100 %, non condensing

Low power radar for field applications

OTT PLS
Pressure Probe

OTT SE 200
Shaft Encoder

Features / Benefits
- Robust ceramic sensor
- Reliable data
- Standard interfaces 4 ... 20 mA / SDI-12 / RS-485
- Suitable for dia. less than 1"
- Barometric pressure compensation
- Temperature compensation
- Also available with plug-in pressure probe cable

The pressure probe OTT PLS reliably measures the water level in ground- and open surface waters.

The PLS features a long-term stable, highly precise, capacitive ceramic pressure cell. This cell is extremely robust and insensitive against mechanical overload as well as against aggressive media.

The sensor electronics measure pressure and temperature values. Compensating for temperature and barometric effects, the sensor delivers highly precise and repeatable actual water levels. The OTT PLS is supplied with a high quality and particularly tough stainless steel housing and even the cable for the probe is extraordinarily tough due to Kevlar fibres incorporated.

As output signals serial SDI-12 or RS-485 or a programmable 4 ... 20 mA interface is available.

Specifications

Measuring range	0 ... 4 m, 0 ... 10 m, 0 ... 20 m, 0 ... 40 m
Accuracy	0.05 % FS
Long term stability	≤0.1 % FS max. per year
Power supply	+9.6 V ... +28 V DC, typ. 12/24 V DC
Power consumption	
(SDI-12)	Active ≤ 2.6 mA
Interfaces	4 ... 20 mA; SDI-12; RS-485 (SDI-12 protocol)
L x Ø	195 mm x 22 mm
Weight	approx. 0.3 kg
Operating temperature	-25 ... +70 °C

Robust ceramic membrane for reliable measurements

Features / Benefits
- Reliable drift free measurement
- Compact size
- Low power
- Standard interfaces 4 ... 20 mA / SDI-12
- Upgrade of mechanical recorders
- For sites with stilling well or tube

The float-operated shaft encoder OTT SE 200 takes proven level measurement technology to the next stage. It is designed for direct water level measurements in stilling wells or tubes.

Time-tested, the highly reliable float and pulley mechanism of the shaft encoder is actuated by even the slightest changes in waterlevel, providing highly accurate water level measurements every time.

The measured values are available as analogue or digital signal through industry standard interfaces SDI-12 and 4 ... 20 mA output.

The SE 200 is extremely easy to connect to existing paper chart recorders, making a digital upgrade simple and cost-effective.

Specifications

Measuring range	≤ 30 m
Accuracy (SDI-12)	≤ 0.002 % FS
Accuracy (4 ... 20 mA)	≤ 0.1 % FS
Power supply	9 ... 30 V DC, typ. 12/24 V DC
Power consumption	Active < 2 mA (SDI-12 mode)
Interfaces	4 ... 20 mA; SDI-12
L x W x H	60 mm x 60 mm x 34 mm
Weight	approx. 0.250 kg
Operating temperature	-20 ... +70 °C
Relative humidity	0 ... 95 %, non condensing

Braided cable for tide measurements

4.7 Processing and Reviewing ADCP measurements_01 by Line Dale, NVE

Processing and Reviewing ADCP Measurements

Processing ADCP Qm's

- Purpose of this set of procedures is to serve as a way to learn to review and process ADCP discharge measurements.

- This is only an introduction. You will not learn how to spot problems or anomalies without practice.

Processing will never make a bad measurement good!!!!

The most important job is done out in the field!

Steps for Processing ADCP Data

- Review and Playback of ADCP Files
  - Review procedure
  - Make necessary adjustments or corrections
  - Finalize (Lock) the measurement
- Archive Final Data
- Reporting Final Discharge (Qm Wizard)

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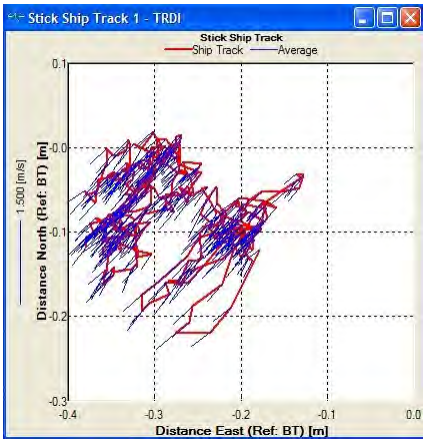
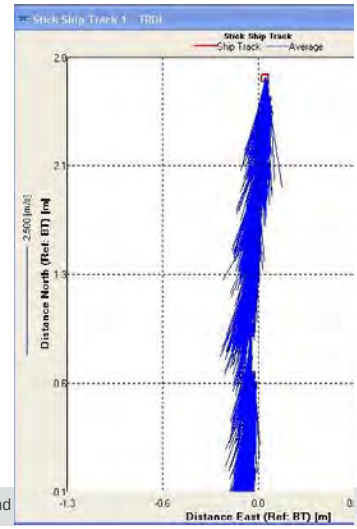
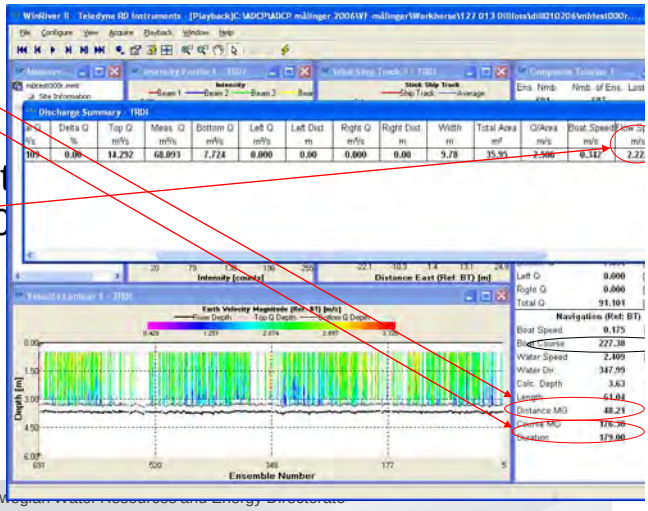
If moving bed is detected?
Another site? Correcting discharge?
Serveral tests





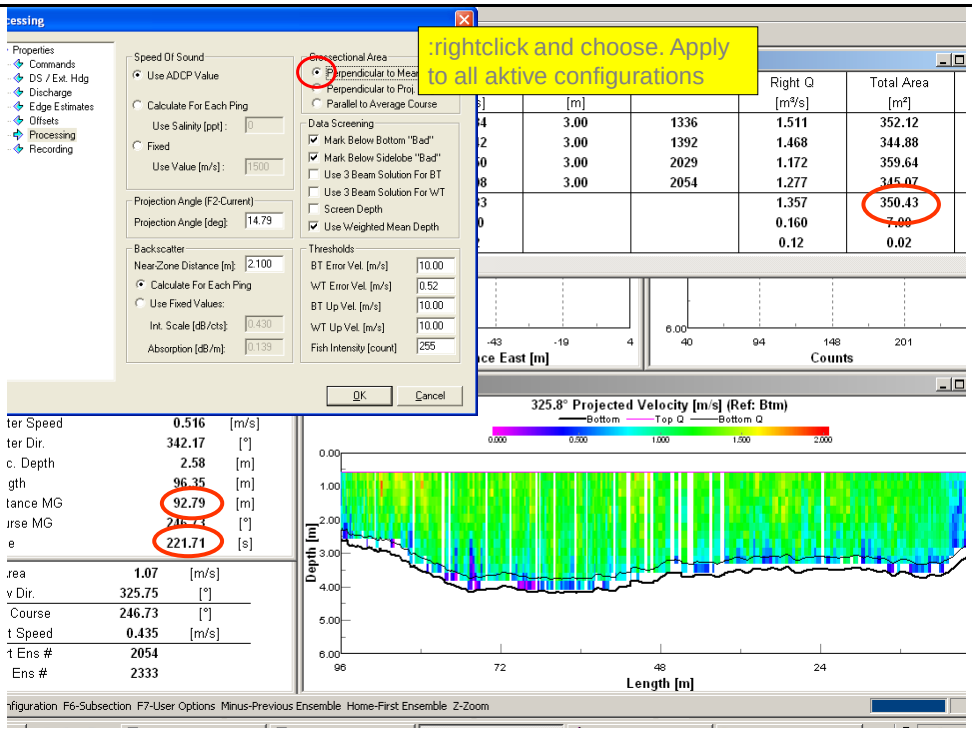
How to calculate the speed of moving bed

- Distance MG/Duration= movbedvelocity
- (Movbedvelocityt /Flowspeed)*100 =% movingbed relative to the water velocity
- More than 2%, correct the dicharge



Moving bed correction

1. Run ”SMB” file in WinRiver – note Distance Made Good (DMG) and duration
2. Calculate the average speed of”Moving Bed” – DMG/duration (m/s)
3. Changing area use estimation to”Perpendicular to Mean Flow” (F3)
4. Run all transects (F5) transectene and averaging area(m^2) (tast F12)
5. Calculate the additional(DMG/tid * A)
6. The final result is calculated by:
7. Qcorrected = QTot(average)+Calculated additional



Processing will never make a bad measurement good!!!!

The most important job is done out in the field!

Closure

Goal and intentions

- Introduction to newer technology
- Just to get started
- Trying and failing
- Find out what is possible or not
- More knowlegde\resources
- Get a baseknowlege for further work

- Important to have right equiptment avaible!!!!!!!

Questions or comments??

GOOD LUCK ☺

Thanks for your attention !!!!

Processing and Reviewing ADCP Measurements

USGS

Hydro Acoustics USGS

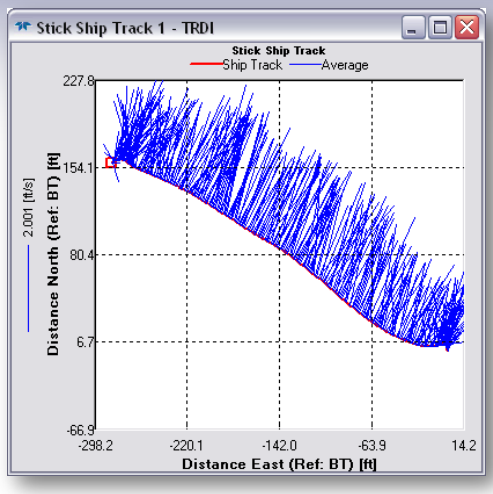
Review and Playback

- Review data in WinRiver
  - If necessary, correct edge distances, ADCP depth, shore pings, or adjust extrapolation method
  - Identify any measurement problems, such as ambiguity errors, bad ensembles, etc.
- Print a discharge measurement summary for your records
- Have someone periodically review your measurements

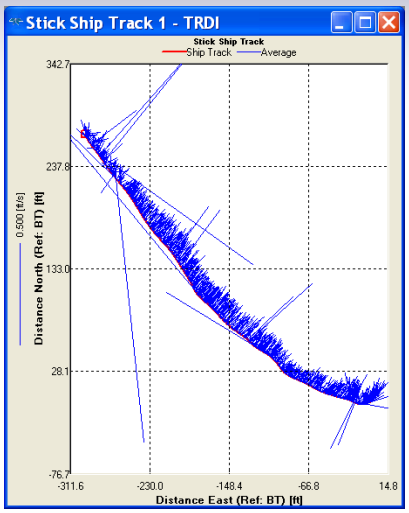
Hydro Acoustics USGS

Ship Stick Plot - Steps 1-2

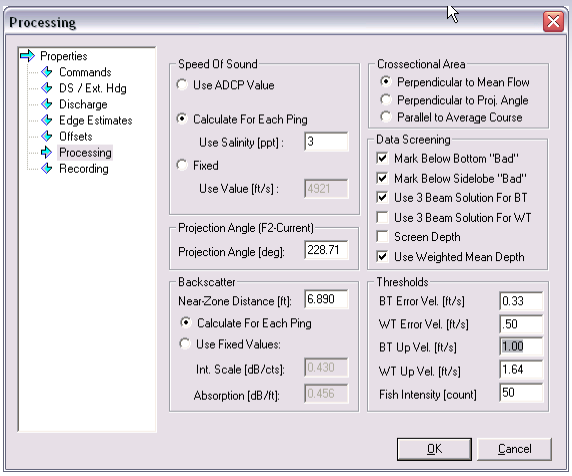
- Load your default workspace for reviewing data
- Load Data
  - Load measurement file (*File-Open Measurement – Ctrl-O*)
  - Select transect and *Reprocess Transect* (Shift-F5)
- Look at ship track plot for any irregularities
  - Cycle through range in depths (Page Up / Page Down)



Ambiguity Errors in Ship Stick Plot

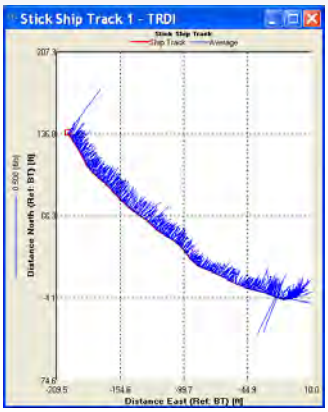


Screening Data Using Thresholds

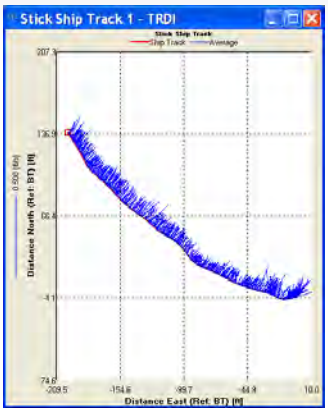


Hydro Acoustics USGS

Water Track
Error Velocity
Threshold=0.5



Water Track
Error Velocity
Threshold=0.5
+
Bottom Track Error
Velocity =0.2



Hydro Acoustics USGS

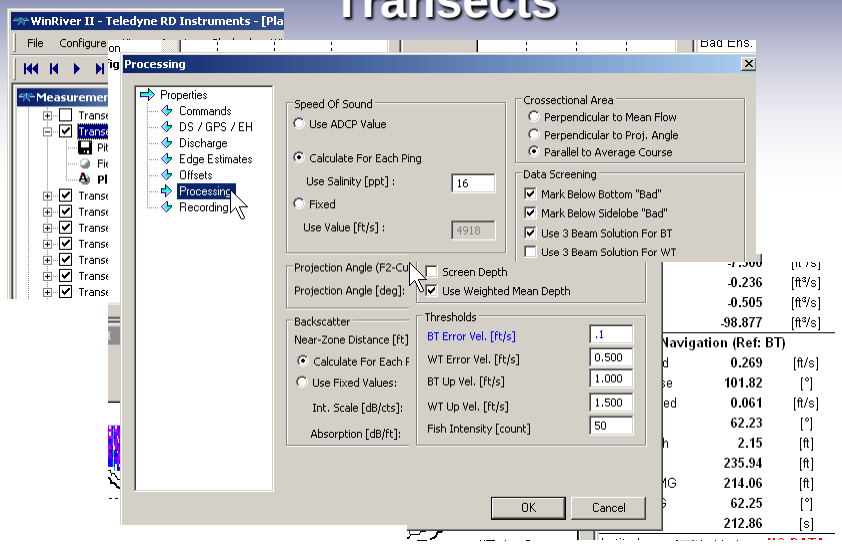
Error Velocity Thresholds

- **Think of Velocity Thresholds as filters that you can tune**
- **Default values OK most of the time**
- **If spikes and noise**
  - **Try to increase threshold values**
- **If loosing a lot of data**
  - **Try lower values**
  - *Check correlation! Can not be fixed by tuning these thresholds. Must changed in user commands before collecting data*
- **If trouble with bins**
  - **WT error vel or WT up vel**
- **If trouble with ensembles**
  - **BT error vel or BT up vel**

ADCP Frequency (kHz)	Water Mode [WM]	Depth Cell Size (m) [WS]	Standard Deviation[1] (ft/sec)	Reasonable Error Velocity Threshold (ft/sec)
300	1	1	0.59	1.8
	5	.2	0.03	0.1
	8	.2	0.86	2.5
600	1	0.5	0.59	1.8
	5	0.1	0.03	0.1
	8	0.1	0.86	2.5
1200	1	0.25	0.59	1.8
	5	0.1	0.02	0.1
	8	0.1	0.81	2.5

ADCP Frequency (kHz)	Water Mode [WM]	Depth Cell Size (m) [WS]	Standard Deviation[1] (ft/sec)	Reasonable Error Velocity Threshold (ft/sec)
300	1	1	0.59	1.8
	5	.2	0.03	0.1
	8	.2	0.86	2.5
600	1	0.5	0.59	1.8
	5	0.1	0.03	0.1
	8	0.1	0.86	2.5
1200	1	0.25	0.59	1.8
	5	0.1	0.02	0.1
	8	0.1	0.81	2.5

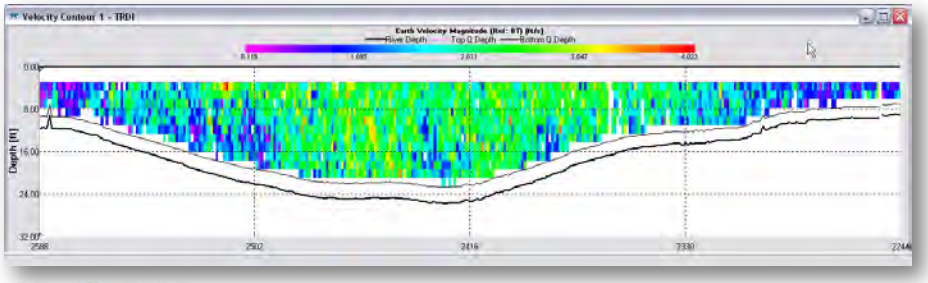
Applying changes to multiple Transects



Hydro Acoustics USGS

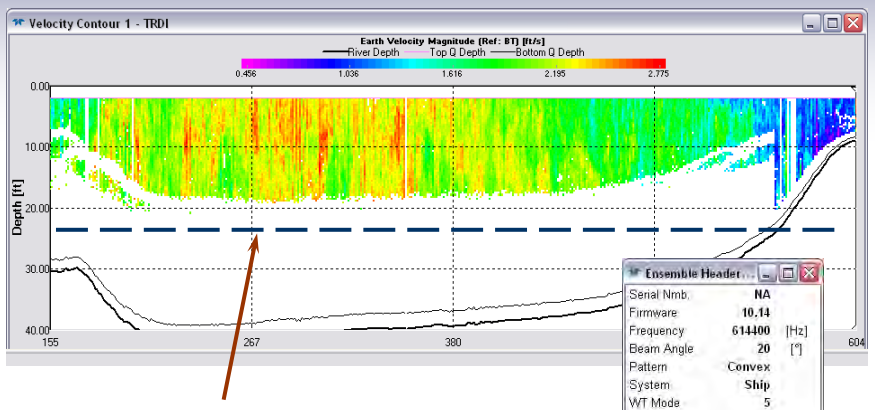
Velocity Magnitude Contour

- Look at velocity magnitude contour for
  - Irregular bottom profile
  - Unusual velocities
  - Missing data



Hydro Acoustics USGS

Depth Beyond Mode 5 Limit



Maximum Range for 600 kHz

Ensemble Header ...

Serial Nmb.	NA	
Firmware	10.14	
Frequency	614400	[Hz]
Beam Angle	20	[°]
Pattern	Convex	
System	Ship	
WT Mode	5	
BT Mode	5	
Bin Size	0.33	[ft]
Number of Bins	150	
Blank	0.82	[ft]
# WT Pings	1	
# BT Pings	1	

Composite Tabular

- **What are Bad/Lost Ensembles?**
  - **Lost Ensembles:** Usually a power management or communication problem
  - **Bad Ensembles:** ADCP lost bottom track or entire beam was obstructed
- **Number of ensembles vs**
  - **Bad ensembles**
  - **Lost ensembles**
- **Percent bad bins**
- **Water temperature OK?**
- **Edge estimates reasonable and with correct sign?**

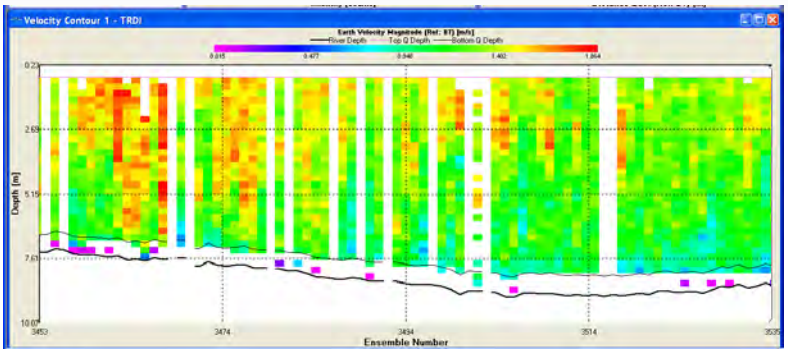
Composite Tabular 1 - ...

Ens. Nmb.	Nmb. of Ens.	Lost Ens.
1112	177	50
Bad Ens.	%Bad Bins	Delta Time
31	14%	0.70
April 26, 2003 10:46:27.07		
Pitch	Roll	Heading
1.50°	0.00°	76.13°
Temp.	Press.Sensor	
6.77°C	NA	

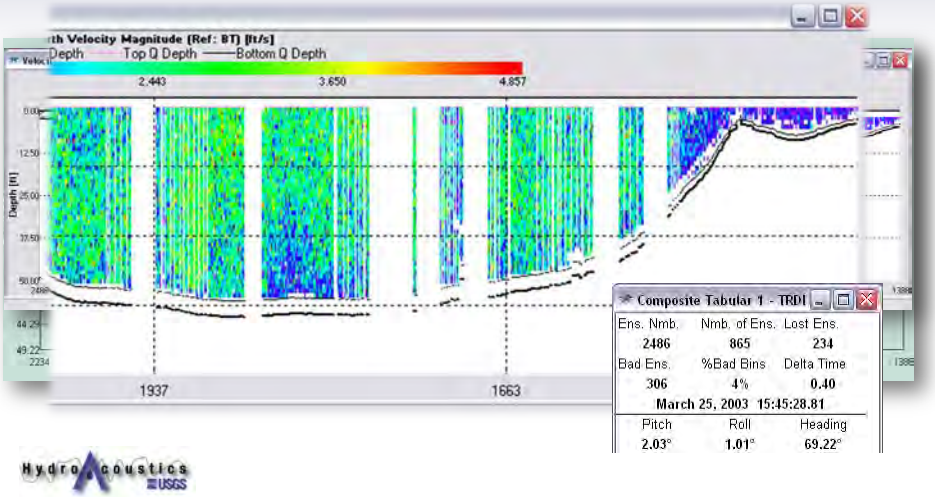
Discharge (Ref: BT) Right to Left		
Good Bins	13	
Top Q	0.498	[m³/s]
Measured Q	1.580	[m³/s]
Bottom Q	0.361	[m³/s]
Left Q	0.092	[m³/s]
Right Q	0.085	[m³/s]
Total Q	2.615	[m³/s]

Navigation (Ref: BT)		
Boat Speed	0.008	[m/s]
Boat Course	142.93	[°]
Water Speed	0.110	[m/s]
Water Dir.	212.72	[°]
Calc. Depth	1.19	[m]
Length	17.34	[m]

Example of Bad Bins and Ensembles

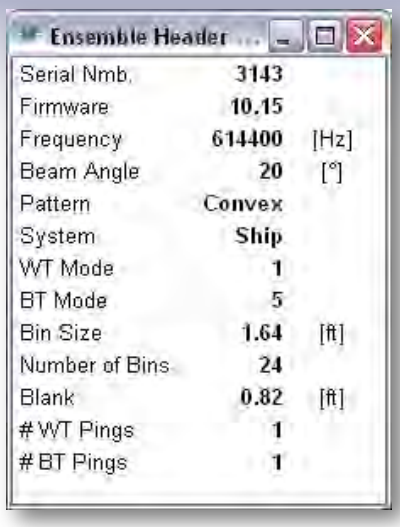


Example of Lost Ensembles



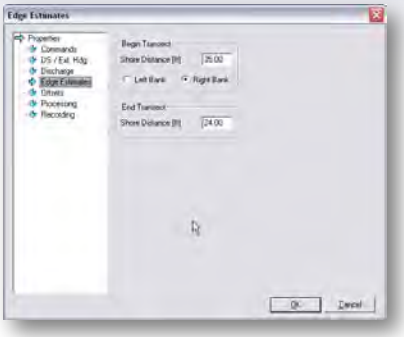
System Parameters – Step 5

- **Check System Parameters (F9)**
  - **Number of pings**
  - **Water / bottom mode**
  - **Frequency**
  - **Blank**
  - **Bin size**



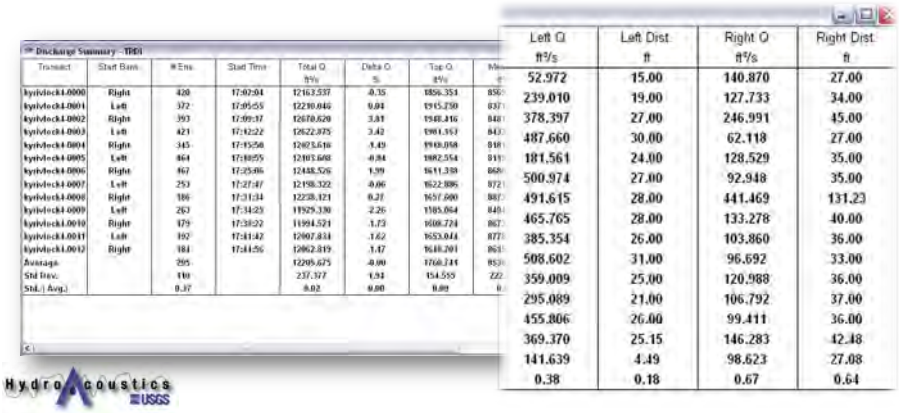
Edge Estimates – Step 11

- **Starting edge correct?**
- **Are edge distances consistent w/ field sheet?**
- **If not, has an explanation been supplied?**



Edge Estimates

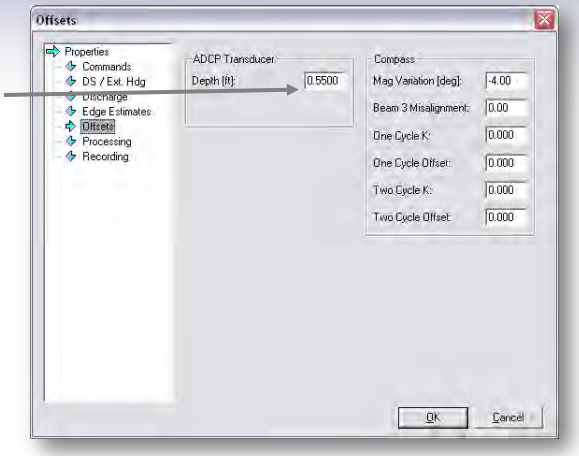
- **Discharge Summary (F12)**
  - **Are edge distances consistent with notes?**
  - **Are edge distances estimated rather than measured?**
  - **Are the estimated edge discharges reasonable for this section?**



Left Q ft³/s	Left Dist ft	Right Q ft³/s	Right Dist ft
52.972	15.00	140.870	27.00
239.010	19.00	127.733	34.00
378.397	27.00	246.991	45.00
487.660	30.00	62.118	27.00
181.561	24.00	128.529	35.00
500.974	27.00	92.948	35.00
491.615	28.00	441.469	131.23
465.765	28.00	133.278	40.00
385.354	26.00	103.860	36.00
508.602	31.00	96.692	33.00
359.009	25.00	120.988	36.00
295.089	21.00	106.792	37.00
455.806	26.00	99.411	36.00
369.370	25.15	146.283	42.48
141.639	4.49	98.623	27.08
0.38	0.18	0.67	0.64

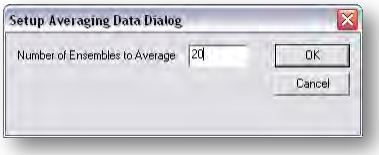
Offsets – Step 12

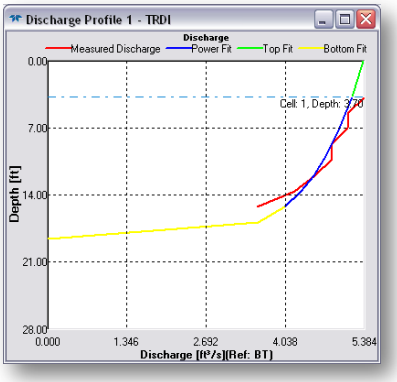
- **Does the transducer depth match field sheet value?**



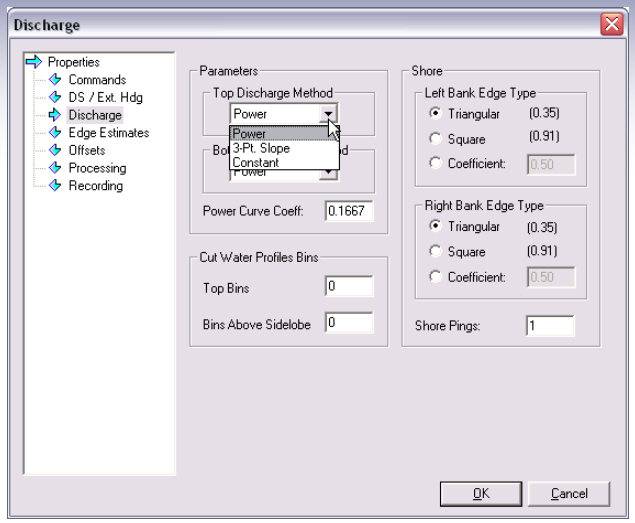
Extrapolation Method

- **Evaluate Extraploation Method**
  - **Average Ensembles (10-20)**
  - ***View-Graphs- Profile-Discharge***
  - **Step through the data**





Set Extrapolation Method

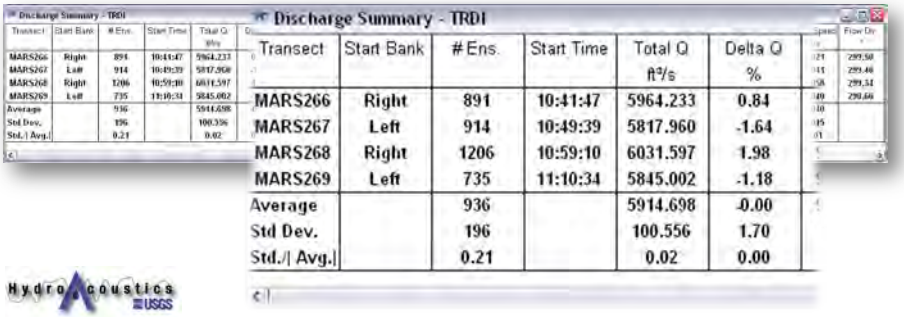


Repeat – Step 17

- Repeat review for each transect

Review Measurement

- Check Entire Measurement
  - Open Discharge History Tabular (F12)
  - Are all discharges within 5%? In other words, are any lines red?
  - Were reciprocal transect pairs obtained?



Discharge Summary - TRDI

Transect	Start Bank	# Ens.	Start Time	Total Q ft³/s	Delta Q %
MARS266	Right	891	10:41:47	5964.233	0.84
MARS267	Left	914	10:49:39	5817.960	-1.64
MARS268	Right	1206	10:59:10	6031.597	1.98
MARS269	Left	735	11:10:34	5845.002	-1.18
Average		936		5914.698	-0.00
Std Dev.		196		100.556	1.70
Std./| Avg.|		0.21		0.02	0.00

Discharge Summary – Step 18

- **Check Entire Measurement -- Check the following for consistency**
  - **Total area**
  - **Widths**
  - **Boat speed**
  - **Flow direction**
  - **Compare boat speed to water speed**
  - **Duration**

Discharge Summary - TRDI

Transect	Start Bank	# Ens.	Start Time	Width ft	Total Area ft²	Q/Area ft/s	Boat Speed ft/s	Flow Speed ft/s	Flow Dir. °
MARS266	Right	891	10:41:47	571.91	5723.81	1.042	1.270	1.021	299.50
MARS267	Left	914	10:49:39	573.85	5689.96	1.022	1.272	1.041	299.48
MARS268	Right	1206	10:59:10	571.63	5756.23	1.048	0.932	1.058	299.34
MARS269	Left	735	11:10:34	574.66	5767.21	1.013	1.465	1.040	298.60
Average		936		573.02	5734.30	1.031	1.235	1.040	
Std Dev.		196		1.48	34.83	0.016	0.222	0.015	
Std./ Avg.		0.21		0.00	0.01	0.02	0.18	0.01	

Hydro Acoustics USGS

5% Criteria

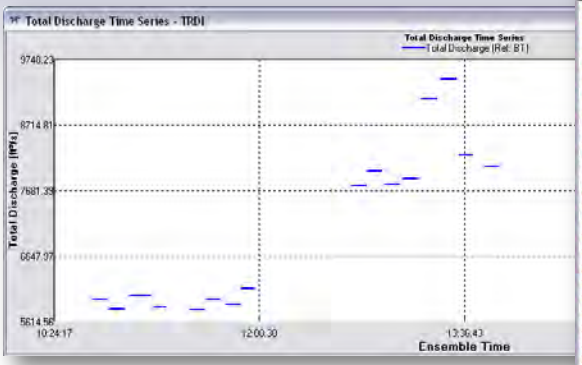
- **Example of Qm where one or more transects are > 5% different from the mean discharge for the Qm**

Discharge Summary - TRDI

Transect	Start Bank	# Ens.	Start Time	Total Q ft³/s	Delta Q %	Top Q ft³/s	Meas. Q ft³/s	Bottom Q ft³/s
henr689	Left	932	11:27:27	4903.632	5.18	1013.377	3578.809	252.312
henr690	Right	1145	11:37:01	4512.835	-3.20	935.164	3196.886	238.116
henr691	Left	408	11:49:59	4745.827	1.80	951.321	3351.069	242.622
henr692	Right	826	12:08:21	4485.553	-3.78	1016.932	3109.727	255.274
Average		827		4661.962	0.00	979.198	3309.123	247.081
Std Dev.		310		198.995	4.27	42.064	205.626	8.057
Std./ Avg.		0.37		0.04	0.00	0.04	0.06	0.03

Hydro Acoustics USGS

Total Discharge Time Series



Discharge Summary - TRDI

Transect	Start Bank	# Ens.	Start Time	Total Q m³/s	Delta Q %
MARS266	Right	891	10:41:47	5964.233	-21.26
MARS267	Left	914	10:49:39	5817.960	-23.19
MARS268	Right	1206	10:59:10	6031.597	-20.37
MARS269	Left	735	11:10:34	5845.002	-22.83
MARS270	Right	910	11:27:17	5802.449	-23.39
MARS271	Left	806	11:35:06	5963.193	-21.27
MARS272	Right	838	11:44:27	5867.991	-22.26
MARS273	Left	737	11:51:38	6133.638	-19.02
MARS274	Right	799	12:43:36	7762.143	2.48
MARS275	Left	830	12:50:48	7992.243	5.52
MARS276	Right	825	12:58:49	7778.573	2.70
MARS277	Left	860	13:07:32	7863.031	3.81
MARS278	Right	917	13:15:50	9132.297	20.57
MARS279	Left	884	13:25:02	9443.005	24.67
MARS280	Right	786	13:33:39	8247.663	8.89
MARS281	Left	816	13:45:35	8063.705	6.46
MARS282	Right	758	14:46:26	8080.516	6.68
MARS283	Left	915	14:52:53	8633.374	13.98
MARS284	Right	942	15:00:58	9560.334	26.22
MARS285	Left	888	15:11:49	8281.939	9.34
MARS287	Left	774	15:24:10	8064.049	6.46
MARS288	Right	723	15:31:27	7967.536	5.19
MARS289	Left	921	15:38:04	7790.571	2.85
MARS290	Right	717	15:47:33	8009.717	5.75
MARS291	Left	822	15:55:25	8156.536	7.69
MARS294	Left	425	16:18:06	7174.675	5.32
MARS295	Right	191	16:23:08	9426.850	24.46
MARS296	Left	139	16:26:14	8533.103	12.66
MARS297	Left	149	16:30:11	6253.373	-17.44
Average		762		7574.424	0.00
Std. Dev.		242		1220.365	16.11
Std./ Avg.		0.32		0.16	0.00

Review Measurement

- Look at discharges for all transects
  - Are edge discharges consistent?
  - Are edge discharges or top/bottom Q's radically different?

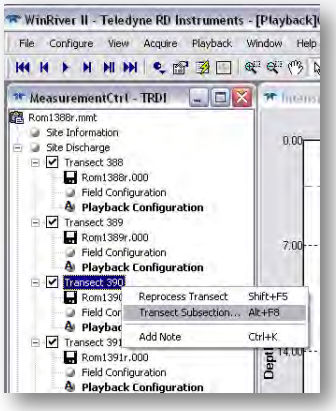
Discharge Summary - TRDI

Transect	Start Bank	# Ens.	Start Time	Total Q	Delta Q
MARS266	Right	891			
MARS267	Left	914			
MARS268	Right	1206			
MARS269	Left	735			
Average		936			
Std Dev.		196			
Std./ Avg.		0.21			

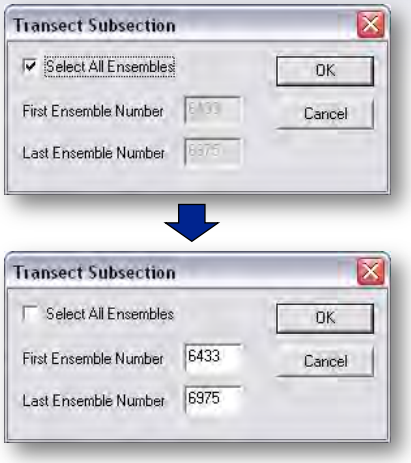
Top Q ft³/s	Meas. Q ft³/s	Bottom Q ft³/s	Left Q ft³/s	Left Dist. ft	Right Q ft³/s	Right Dist. ft
918.464	4500.925	498.255	13.949	25.00	32.631	29.00
901.336	4385.234	484.341	14.161	25.00	32.878	28.00
930.718	4502.479	540.032	20.094	25.00	38.246	28.00
900.030	4374.569	523.540	13.349	25.00	33.514	28.00
912.637	4440.802	511.542	15.388	25.00	34.317	28.25
14.692	70.459	24.981	3.156	0.00	2.645	0.50
0.02	0.02	0.05	0.21	0.00	0.08	0.02

Step for Subsectioning

Right-click on Transect
"Transect Subsection"
or hit ***Alt+F8***

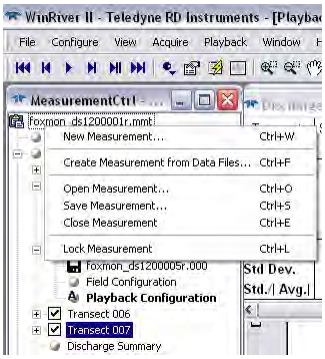


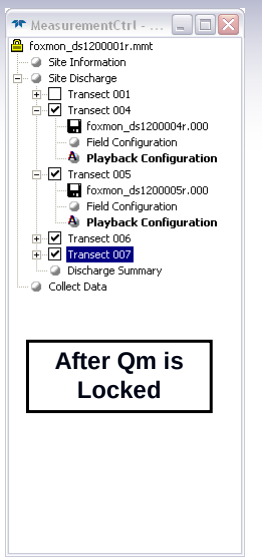
Identify new 'starting' and 'ending' ensemble



Lock Files

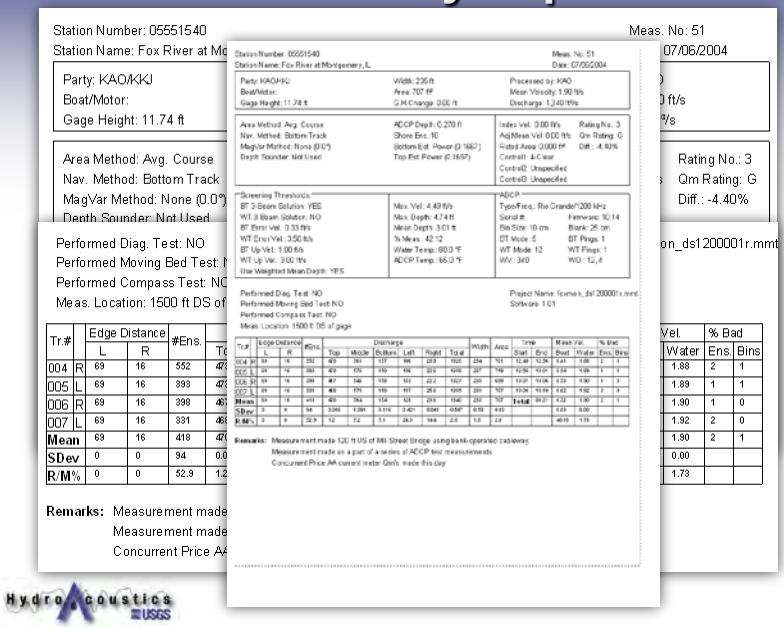
- **Right-click on Measurement file or "File… Lock" from menu**
- **Should be used after initial processing**
- **Prevents accidental change by reviewer**
- **Noted on summary report**





After Qm is Locked

Summary Report



Station Number: 05551540
Station Name: Fox River at Mo
Party: KAO/KKJ
Boat/Motor:
Gage Height: 11.74 ft
Area Method: Avg. Course
Nav. Method: Bottom Track
MagVar Method: None (0.0°)
Depth Sounder: Not Used
Performed Diag. Test: NO
Performed Moving Bed Test:
Performed Compass Test: NO
Meas. Location: 1500 ft DS of

Tr.#		Edge Distance L	Edge Distance R	#Ens.
004	R	69	16	552
005	L	69	16	393
006	R	69	16	398
007	L	69	16	331
Mean		69	16	418
SDev		0	0	94
R/M%		0	0	52.9

Remarks: Measurement made
Measurement made
Concurrent Price AA

Meas. No.: 51
07/06/2004
ft/s
Rating No.: 3
Qm Rating: G
Diff.: -4.40%
on_ds1200001r.mmt

Vel. Water	% Bad Ens.	% Bad Bins
1.88	2	1
1.89	1	1
1.90	1	0
1.92	2	0
1.90	2	1
0.00		
1.73		

Hydro Acoustics USGS

27.02.2013 - Shortcut.lnk

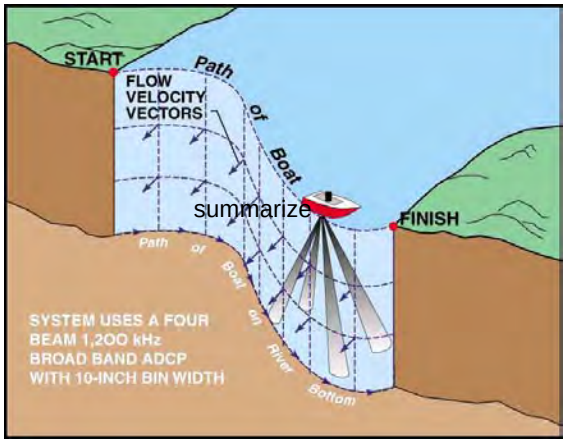
Hydro Acoustics USGS

4.9 Summery by Line Dale and Morten Due, NVE

quick summarize

ADCP

Acoustic Doppler Current Profiler



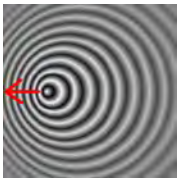
2

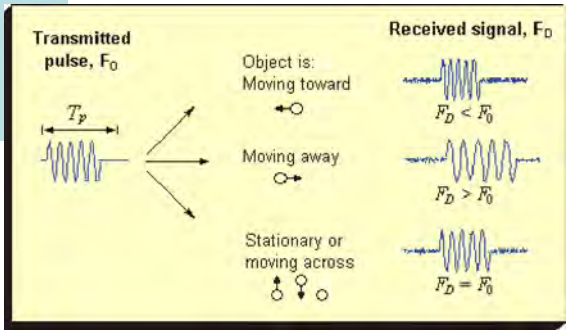
25.03.2013

ADCP

Acoustics Doppler…
A change in the apparent frequency of sound

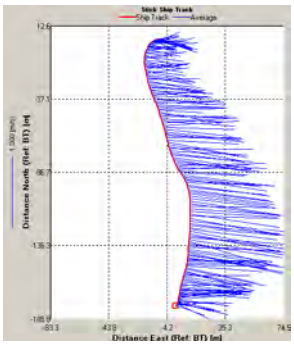
When either ***source*** or ***receiver*** is moving.

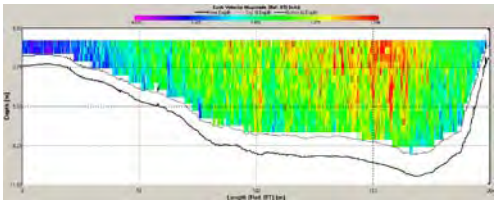




ADCP

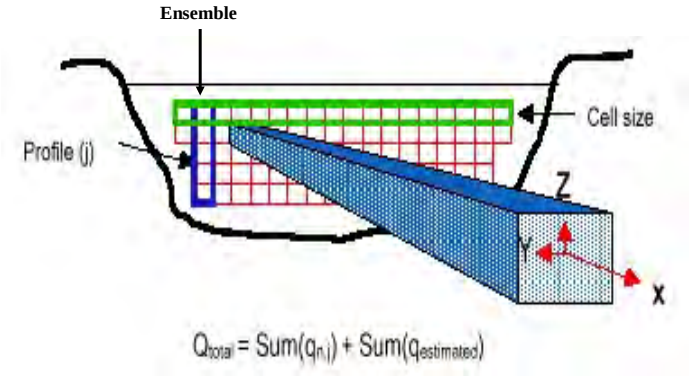
- Current Profiler
- Measure velocityprofiles
  - vertical
  - horizontally
- Measure its own movment (bottom track)





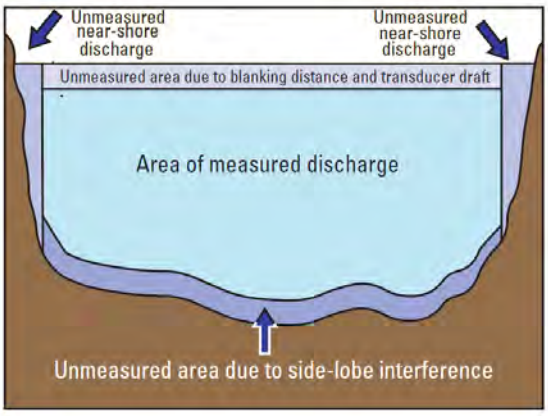
From velocity and bottom tracking to discharge

- The software computes total volume discharge (ΣQ) for each ADCP segments or *ensemble*
- Cell size depends on river depth

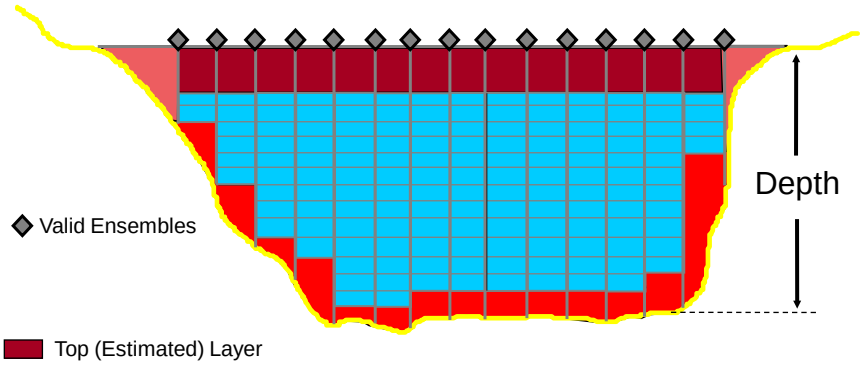


Discharge calculation

- $Q_{total} = Q_{measured} + Q_{topp} + Q_{bottom} + Q_{edge}$

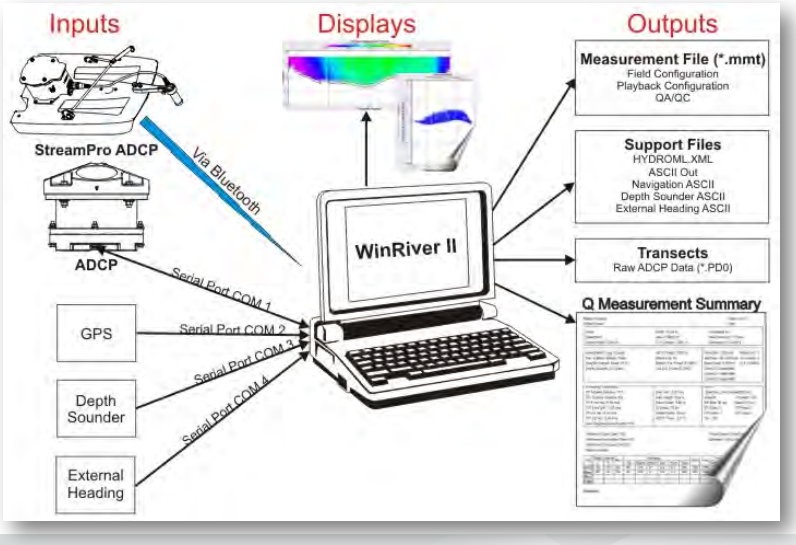


Measured and Unmeasured Areas



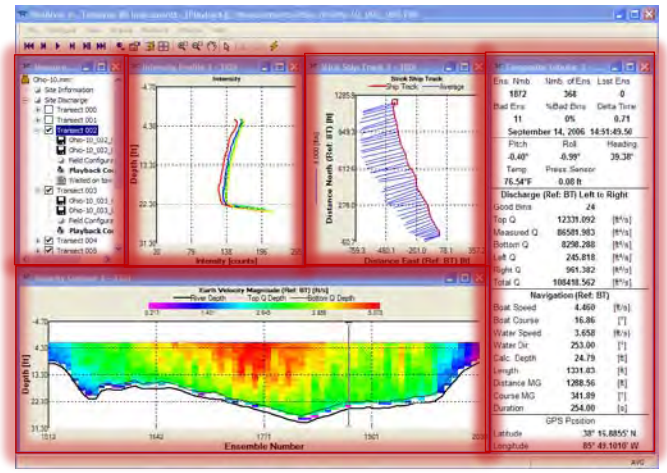
- Top (Estimated) Layer
- Middle (Measured) Layer
- Bottom (Estimated) Layer
- Edges (Estimated)

WinRiver II Overview



Default WinRiver II Screen Layout (Workspace)

- Intensity Profile
- ShipTrack
- Velocity Contour
- Composite Tabular
- Measurement Control



ADCP Measurement (Procedures) - Shortcut.lnk

Location, location, location……..

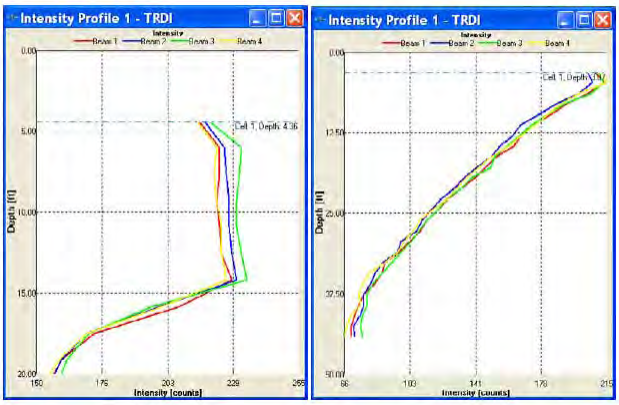
IMPORTANT!!

Your water track data can only be as good as your bottom track data

If bottom tracking is bad, so is water speed data

Common causes of bottom tracking problems: -

- Weed
- Sticks and debris
- Too much sediment (absorbs acoustic energy before it reaches bed)
- Irregular boat speed
- Very fast, turbulent water
- Aeration of water
- Moving bed



Water Modes and Where They Can Be Used

Water Mode	Min Water Speed	Max Water Speed	Min Depth	Max Depth	Comments
Mode 1	0.5m/sec	10m/sec	1.5m	20m	The original default water mode. Noisy but very robust. Good for fast and turbulent deep water.
Mode 5/11	0.01m/sec	1m/sec	0.8m	4m	Pulse-coherent, high-resolution modes. Very low noise in measurement. Need slow, laminar flows to work. Little difference between the two modes.
Mode 12	0.25m/sec	10m/sec	1.3m	20m	A 'multi-ping' Mode 1 variant. Same noise in single ping, but faster ping rate reduces noise in use allowing use in shallow water. Firmware should be 10.16 or higher.

Rio Grande Bottom Modes

Bottom Mode	Where should it be used?	Comments
Mode 5	All sites, all conditions	The standard bottom track mode. Seldom fails unless site has problems – often best to choose another site if poor bottom track from Bottom Mode 5.
Mode 7	Very shallow water. Where Mode 5 gives poor results (weed, sediment) *Note: In most cases a better site should be sought*	Slower mode, needs slower boat speed. Uses two bottom pings.

5. MoWE Participants Evaluation of the Training

At the end of the training all participants were given an evaluation form which contained five questions. The forms were anonymous and participants were asked to provide comment on each question. The collective comments are listed below.

1. **Which themes and presentations did you like best and why?**
    - Almost all of the training days were good especially the field days were very interesting and useful.
    - I like all because it is a new technology and new for me besides that it is scientific knowledge to get more reliable data.
    - I like both because in Addis Ababa theoretical training and on field demonstration of ADCP and pressure sensor. The training was interesting for hydrological work/field work. I have got good idea how ADCP used and work.
    - Both presentations are good but I am very interested on ADCP. Because it is a new technology.
    - I like all which is presented on the training especially presentation on the field.
    - The training is the best because the simple understanding of new measurement or ADCP measurement or not complicated. The best explanation of ADCP by practical. We show the wrong or correct done.
    - Actually I like all presentations presented by Line and Morten. But I personally like most the pressure sensor because it requires small number of crew to do except during installation. So I prefer pressure sensor than ADCP due to this reason.
    - With out theoretical aspect practical application does not fruitful, so that I can not split them. All approaches were good for me.
    - All practical things
2. **Your expectation before training?**
    - I was expecting the training was all about a generalized measurement techniques same as the trainings that were conducted before.
    - My expectation was that it wouldn`t be more far from our day to day work on hydrology but differs; I admire the new technology given theoretically and field practice on Abbay at Kessie.
    - Now I can work with ADCP but before I knew nothing about it.
    - I expect the practical training day will be 10 days but it is 3 days only. It is too short.
    - My expectation before is as I expected after the training since this training is good and makes me happy.
    - My expectation before the training is it would be best training.

- Before the training I was not aware of the topic of the training and I was not able to predict it. So it was difficult to expect such a new technology for our country.
- My expectation was that much not good.
- To have good knowledge about ADCP and Pressure sensor instrument.

3. **Your out come of the training**

- Very specific for the measurement, important and to the point we need, any one can be able to work with ADCP and Pressure sensor and very effective, the trainees know our problem and strive for our best of things, high potential to work in each individual.
- The out come is joining with the new technology and if conditions are fulfilled for the future to make it practical in our rivers.
- I can challenge the ADCP now easily after this training, I am glad.
- I am very happy with the new technology, if the ADCP available I want to master the new technology.
- In this training I attended properly and have got good knowledge of this ADCP instrument, water measurement soft ware and water level pressure sensor instrument, generally I take a good out come.
- The training is very good in building our capacity especially those of for field technician. It combines theory as well as practice and I suggest it is nice training.
- I think more or less I have got good knowledge about ADCP as well as pressure sensors, but still extra training will be needed.
- Good knowledge on ADCP and pressure sensor instrument, but needs further practice (reading the document).

4. Your suggestion of lectures for upcoming training.

- Now you are listening to us. We can see from your feed back. This training was very good and important. For the upcoming training it is very good to make it about data quality checking, how to measure effectively and to make us highly equipped with instruments and potential. If we can see how measurements done in your country that will be good for those who take field measurements especially.
- Both our lecturers made a great effort for upcoming the training theoretically and practically. Especially the field practice site was very hot and troublesome, confronting this they tried their best to teach us.
- We need ADCP in all regional offices otherwise it is useless. So NVE expert can do their best to help.
- The lecture is very clear and it includes the practical, so very nice

- On the lectures my suggestion is excellent because the lectures were supported by documents and memory stick then it is good.
- The lectures for the training are very interesting and good.
- Please continue like this which combines theory and practice.
- Training with practical works are important.

5. Other comments

- You have been good. We thank you very much and good luck
- I think the training will not end by this and will continue for the future to have more knowledge.
- This training must continue for future. That is all, thank you
- I think NVE support the Ministry of water and Energy for capacity building. If it is possible we need the instruments from NVE.
- My comment on this, training like this new technology are very important to our country and must be continued.
- Please continue your support in building our capacity. We thank you for your support.
- Such introductions of new technologies are very necessary since we are still working on older technologies, full of hardships.

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Utgitt i Rapportserien i 2013

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Nr. 4 Faresonekart skred Odda kommune
Nr. 5 Faresonekart skred Årdal kommune
Nr. 6 Sammenfatning av planlagte investeringer i sentral- og regionalnettet for perioden 2012-2021
Nr. 7 Vandringshindere i Gaula, Namsen og Stjørdalselva
Nr. 8 Kvartalsrapport for kraftmarknaden. Ellen Skaansar (red.)
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Nr. 23 Naturfareprosjektet: Delprosjekt Kvikkleire. Nasjonal database for grunnundersøkelser (NADAG) – forundersøkelse
Nr. 24 Flom og skred i Troms juli 2012. Inger Karin Engen, Graziella Devoli, Knut A. Hoseth, Lars-Evan Pettersson
Nr. 25 Capacity Building in Hydrological Services. ADCP and Pressure Sensor Training Ministry of Water and Energy, Ethiopia 20th – 28th February 2013

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