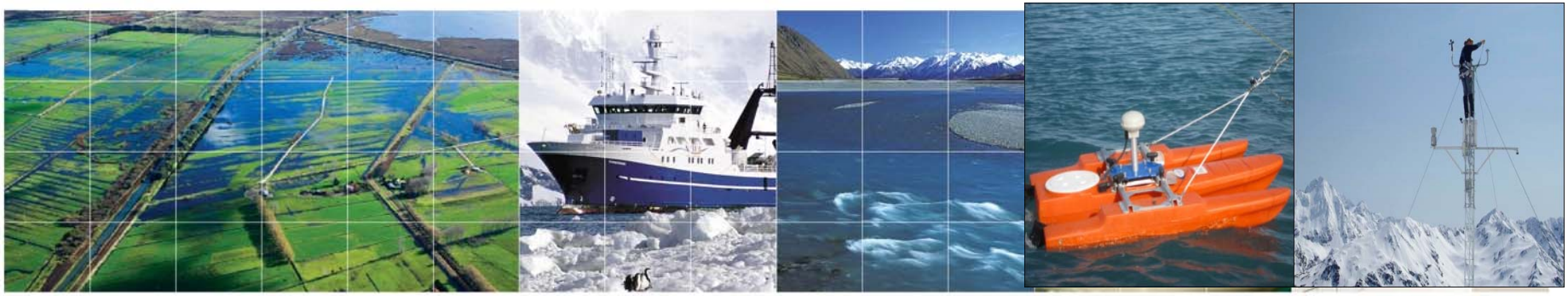

# Optimising ADCP Accuracy

NIWA
Taihoro Nukurangi

## - Calibrations, comparisons and extrapolations

John Fenwick

(& Andrew Willsman and Chris Appleby)

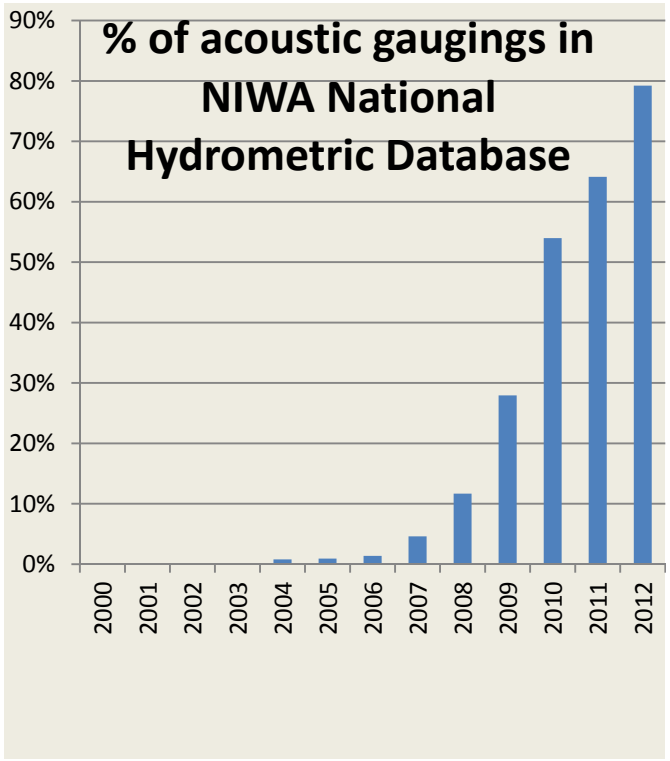


# National Institute of Water and Atmospheric Research Ltd (NIWA)

- NIWA is a government-owned research institute and is also New Zealand's National Hydrometric Service
- 500 staff carry out a wide variety of water and atmosphere related science
- Hydrometric teams, about 60 staff, at 14 locations -largest users of acoustic instruments, and greatest knowledge base within NIWA
- Provide support and solutions for acoustic instruments to other agencies in New Zealand

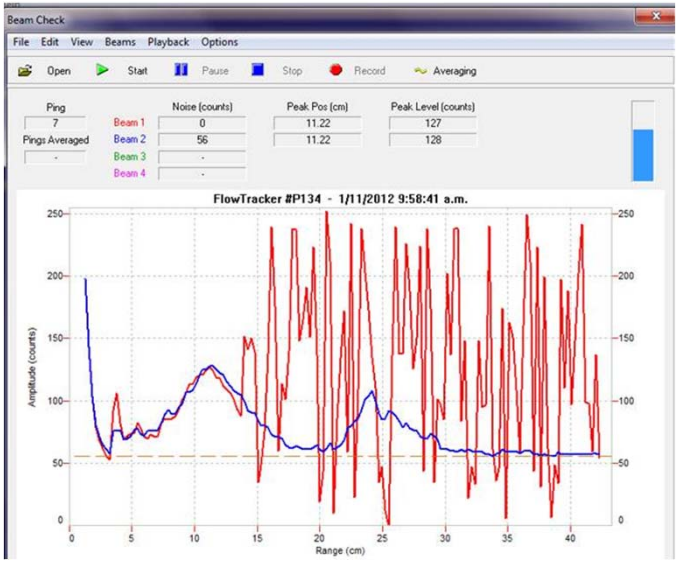
# Calibrations - the need for checking acoustic instruments

- Increasing proportion of acoustic flow measurements
- Sometimes just the change to acoustic gaugings suggest flow ratings need to be changed – so need to be confident in the technology
- Although re-calibration is not required in theory, changes and updates can cause uncertainty
- New industry standards being introduced – National Environmental Monitoring Standards - (also USGS, Australia) will see current meters and acoustic instruments calibrated more frequently.



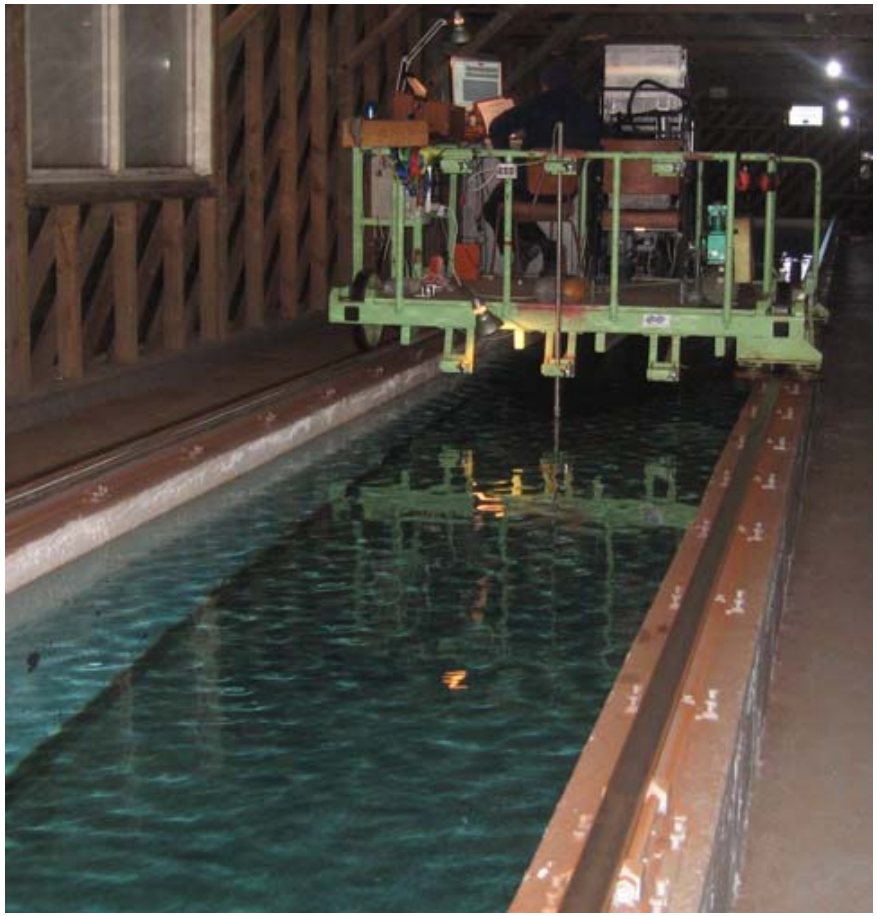

# When to check calibrations?

- Standards are suggesting 2 and 3 year intervals for some sort of check
- All incoming acoustic instruments to NIWA are tested before being put into the field
- Repaired instruments also re-tested
- Has proved worthwhile, showing
  - Incorrect beam matrices loaded
  - Single beams containing errors
- Also useful for diagnosing issues or apparent issues




*Beam 1 faulty after firmware upgrade*

# NIWA's rating tank



- Commissioned in 1963
- Calibrated and tested ~8500 current meters and acoustic meters since commissioned
- 50 metres long (too short!)
- Capable of velocities up to 3.3 m/s
- Inter-agency comparison checks done with a dedicated Seba Mini - with METAS, Switzerland, USGS HIF, Min of Primary Ind, Brisbane, and others.

# Rio Grande and StreamPro Testing

- Same testing methods used for both instruments
- Velocity testing
  - Tested at four velocities
    - 0.1 m/s
    - 0.5 m/s
    - 1.0 m/s
    - 1.5 m/s
  - Velocity runs done with beams 1 & 3 and 2 & 4 leading
  - Distance Made Good (DMG) checked at 0.25m/s for around 60 seconds

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| | |
|---|---|
| **Customer »** | ARC |
| **ADCP Type »** | Rio Grande |
| **ADCP Serial Number »** | 10911 |
| **Date Checked »** | 2012-05-31 |

| | | | | |
|---|---|---|---|---|
| **Meter Evaluation Outcome»** | | PASS | | |
| **Velocity Check Summary** | | | | |
| 0.1 m/s % Error » | -0.48% | PASS | | |
| 0.1 m/s Allowable ± Error Band » | 2.91% | | | |
| 0.5 m/s % Error » | -0.24% | PASS | | |
| 0.5 m/s Allowable ± Error Band » | 1.39% | | | |
| 1.0 m/s % Error » | 0.01% | PASS | | |
| 1.0 m/s Allowable ± Error Band » | 1.20% | | | |
| 1.5 m/s % Error » | -0.25% | PASS | | |
| 1.5 m/s Allowable ± Error Band » | 1.13% | | | |
| R2 » | 1.0000 | PASS | | |
| DMG error | -0.40% | > 0.992 | < 1.008 | |
| Average DMG Ratio | 1.004 | PASS | PASS | |
| Temperature Probe Check (°C diff from reference) » | 0.44 | PASS | | |


# Comparisons

- With different stream conditions and methods
  - Effects of differing substrate and turbulence
- With current meter gaugings
- With established rating curves
  - mainly past current meter gaugings
  - case studies

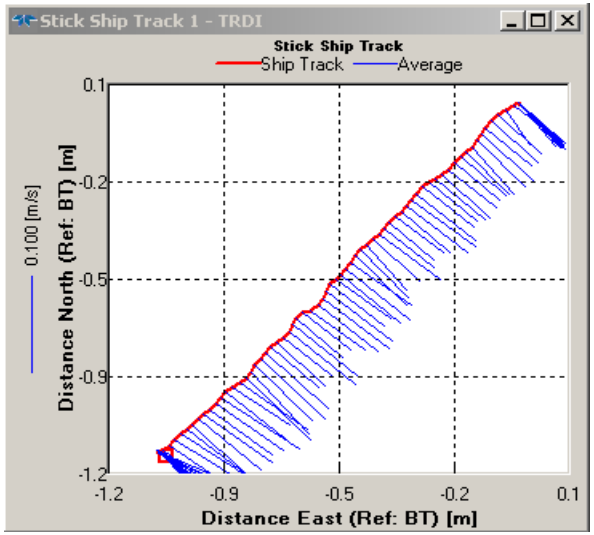
# The effects of turbulence and boat stability on StreamPro Mode 13 flow measurements

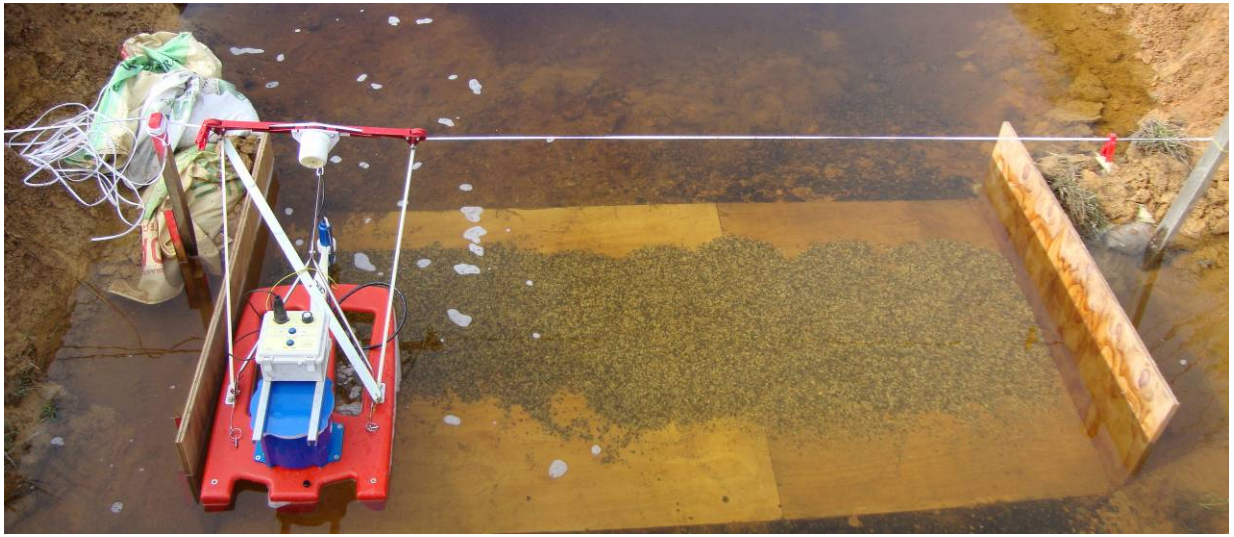
- 20 transects for each test, averaged

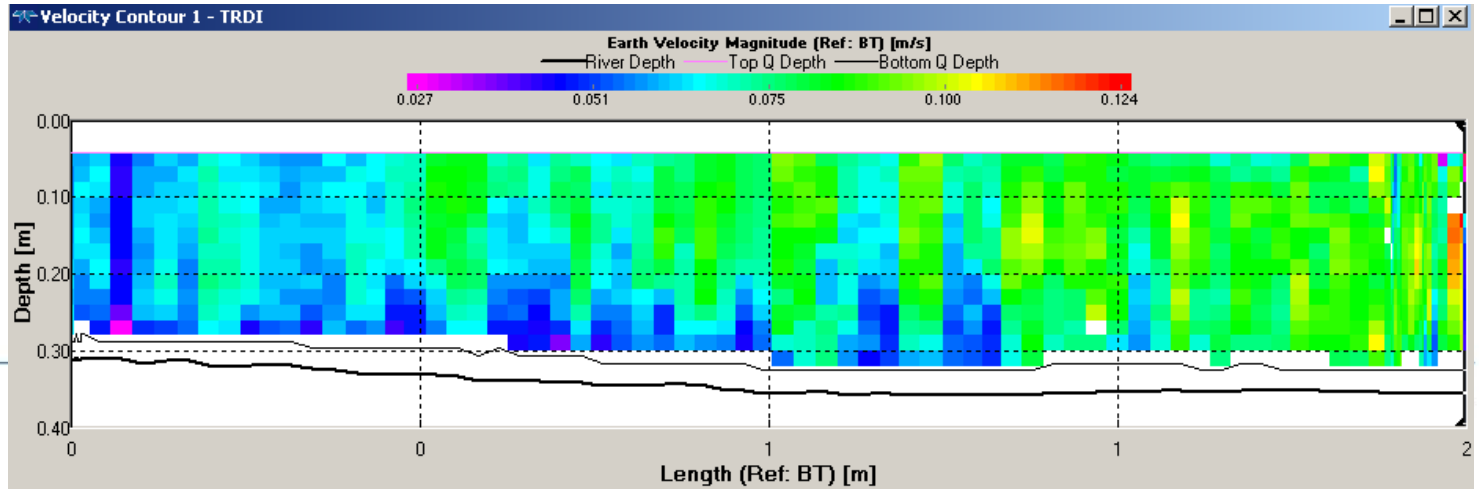
# Low turbulence

## No upstream obstacles, 3 mm substrate under beam path:

## average bad bins 1%, max dev +/- 1.8%

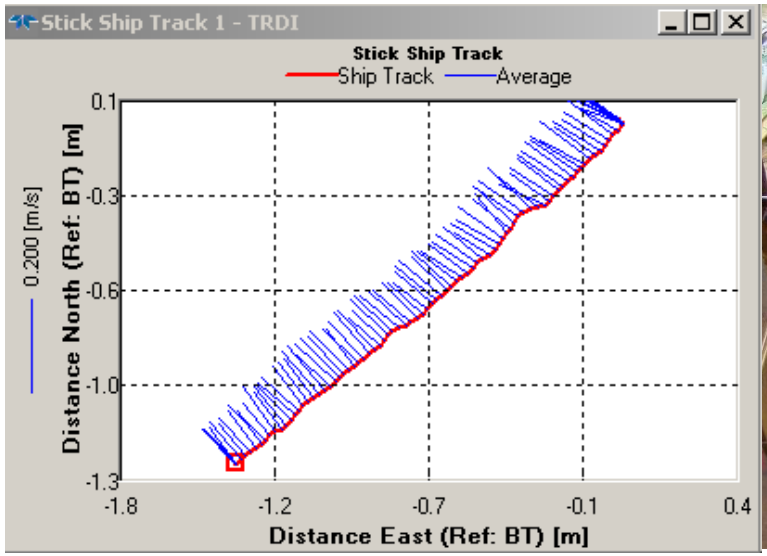


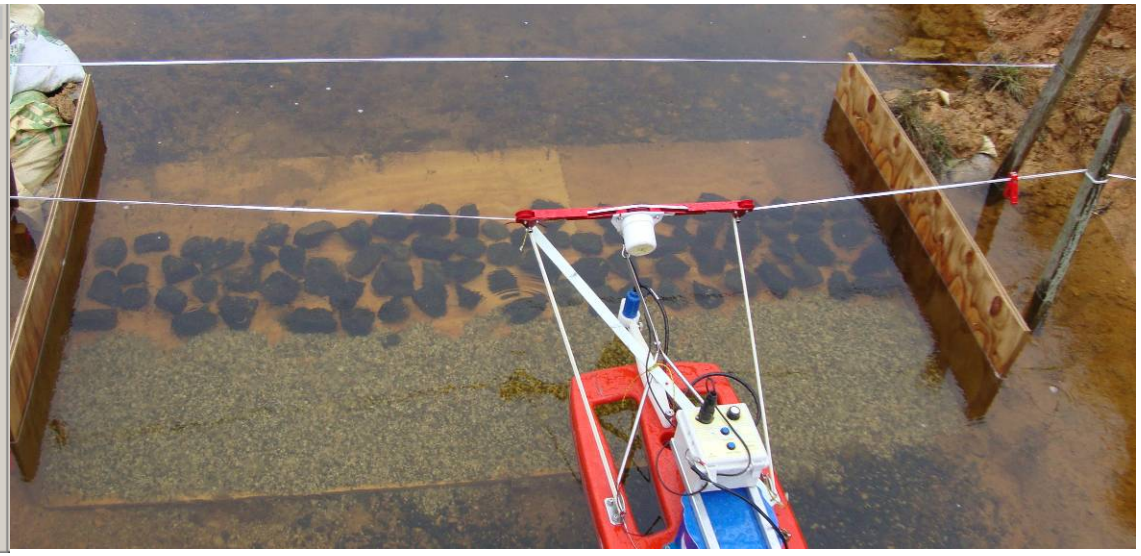



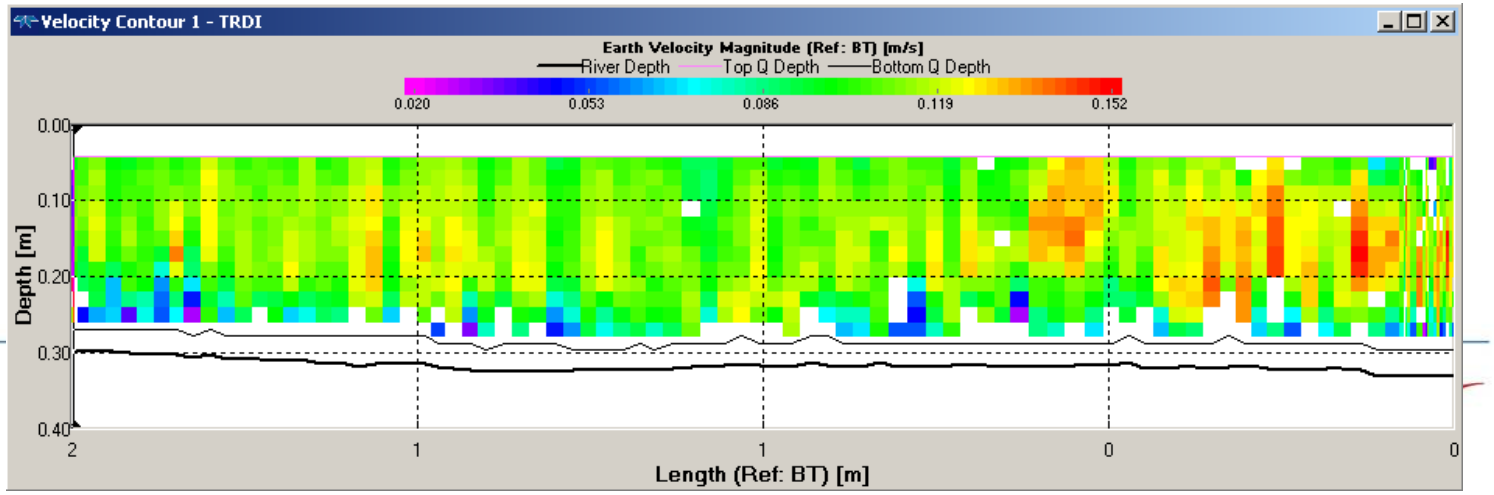


# Moderate turbulence - 100 mm angular upstream:

average bad bins 6%, max dev. +/- 2.4%

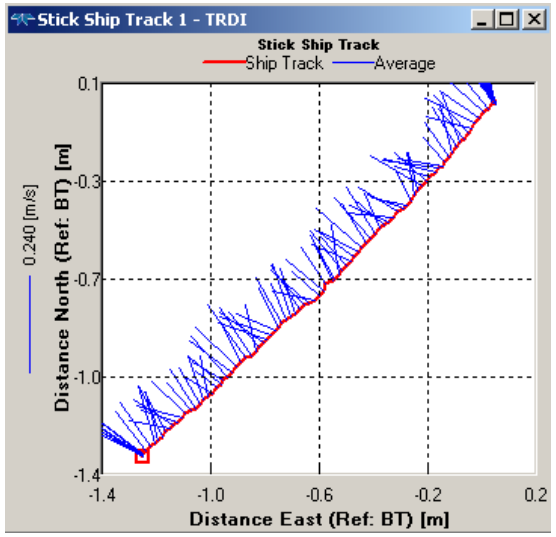


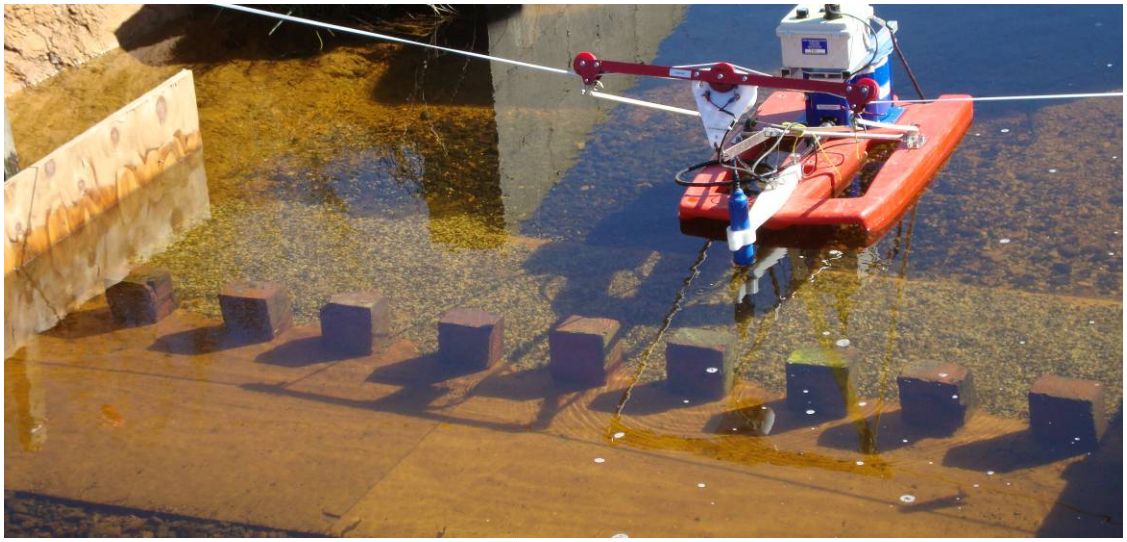



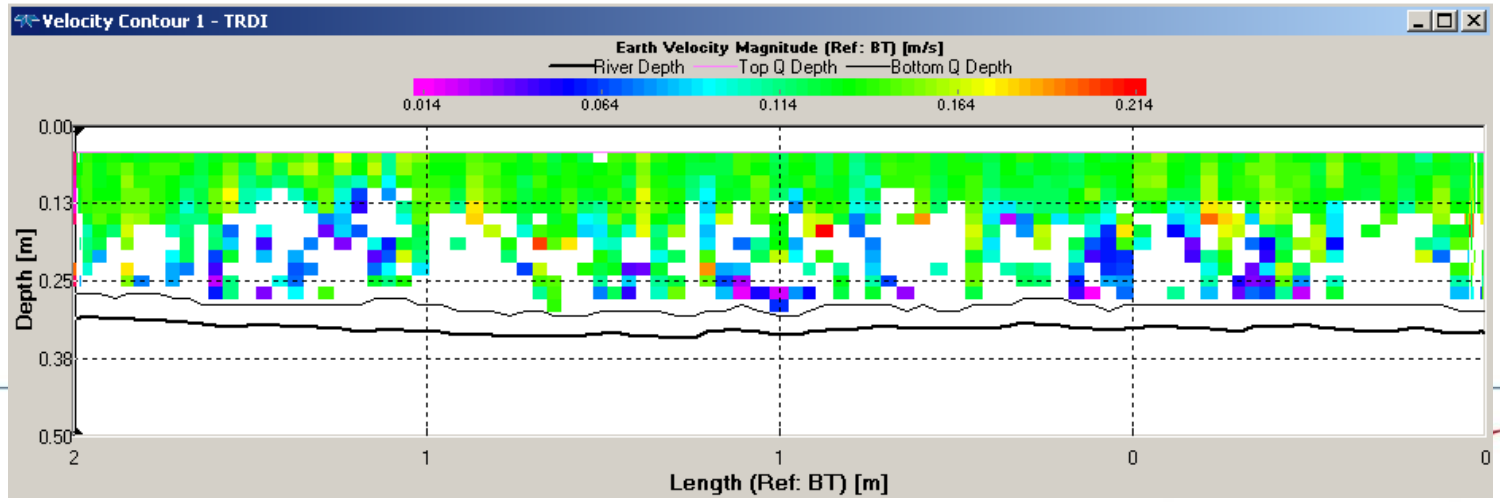


# Higher turbulence: single row bricks upstream

## average bad bins 32%, max dev. +/- 4.6%

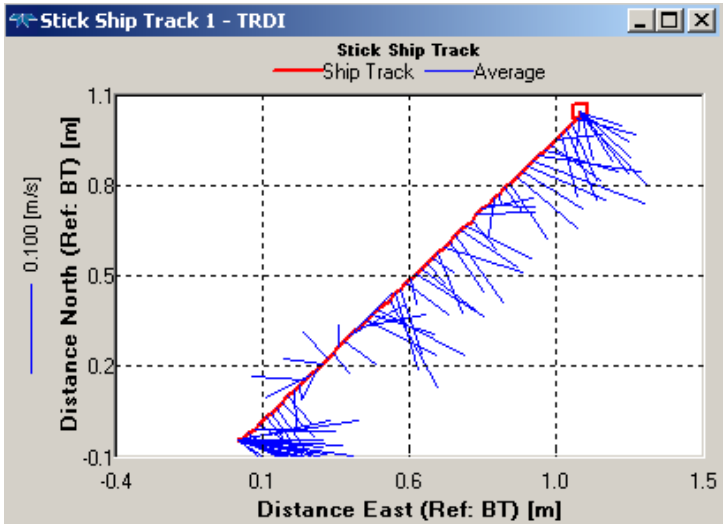


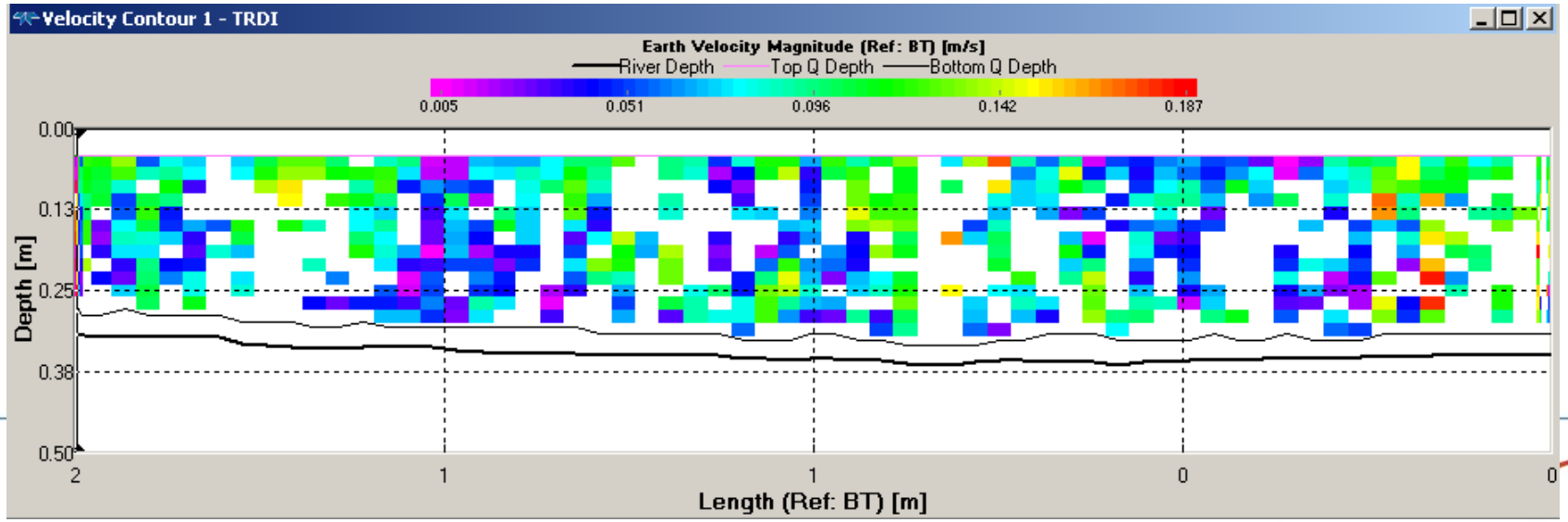



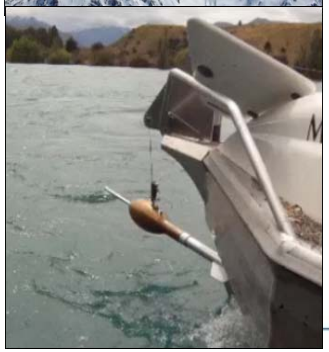


# High turbulence - Double row bricks upstream

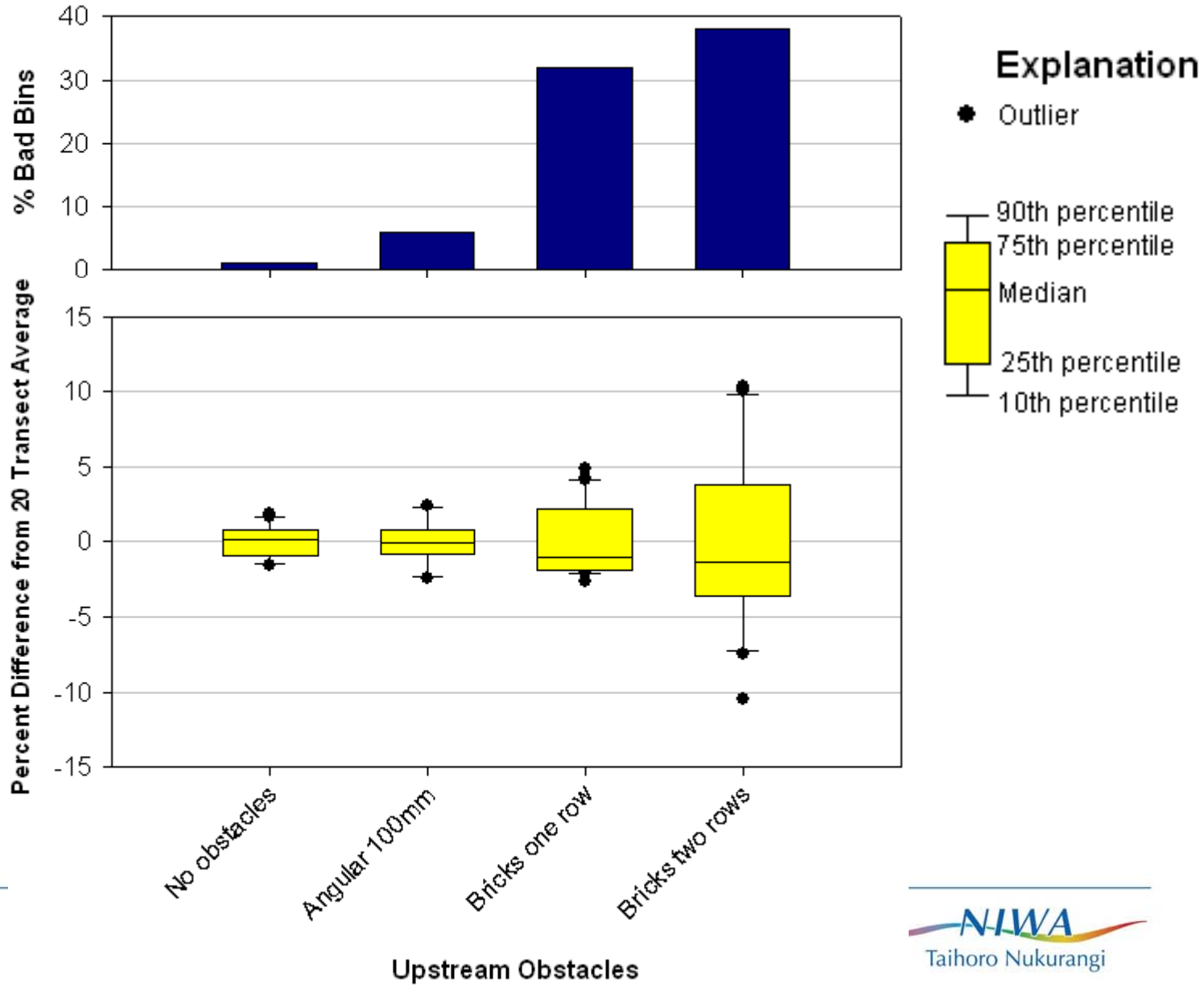
## average bad bins 38%, max dev. +/- 10.5%





# Turbulence comparison results

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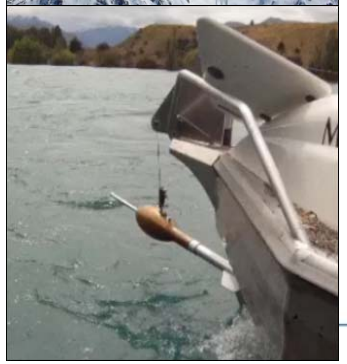
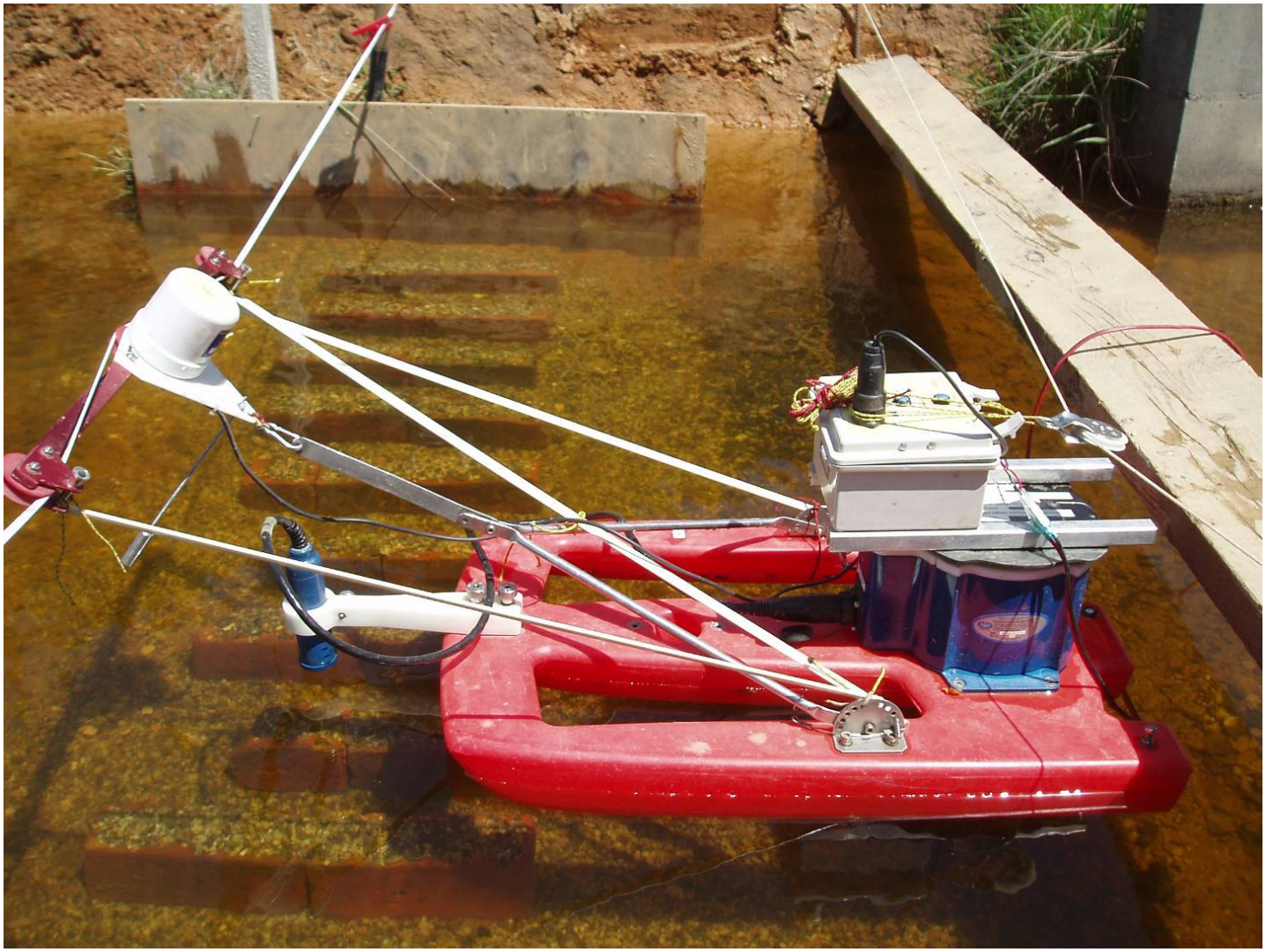


# Conclusions

- (For water mode 13, low velocity mode)
- Variability of results not affected significantly by substrate size or shape until…
  - size is 100 mm AND edges are square
- Turbulence, especially once bad bins > 30%, has a significant effect on variability of results.
  - But shows no apparent bias
- Water Mode 13 performance – excellent over a wide range of substrates.
- Deployment technique is very significant
  - Stabilise the boat on windy days
  - Use a powered traveller to get uniform boat speed

# Boat stability makes a difference on windy days




# StreamPro Tools

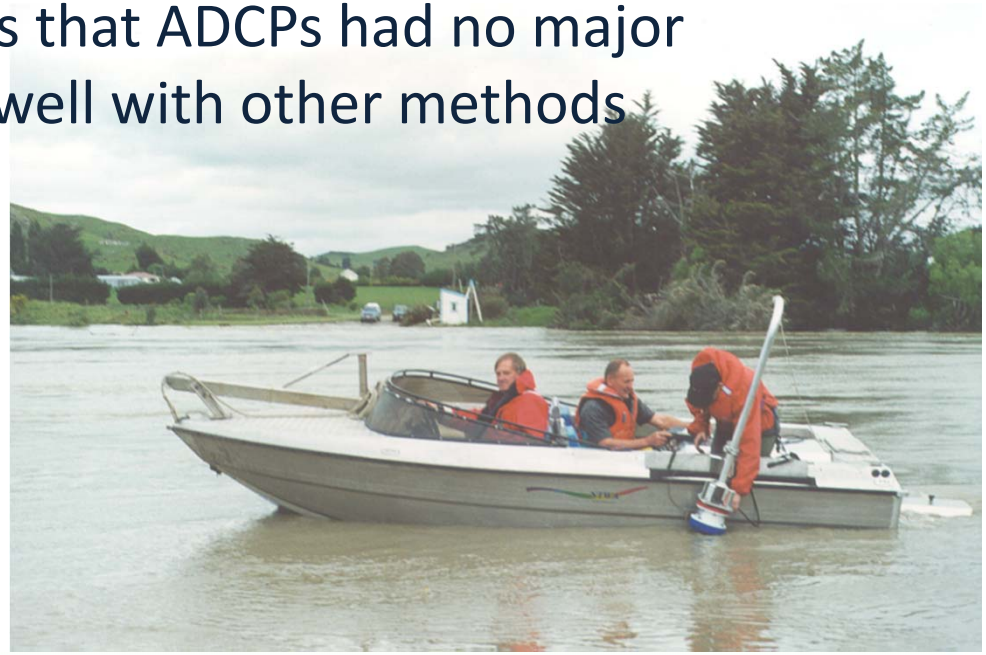
- Remote control traveller developed to fill a need
  - Constant transit (boat) speed important on small streams
- Compass-equipped StreamPros:
  - Allows for the incorporation of external GPS data for correcting for moving bed
  - Pitch and Roll data
  - Precision heading data

**Indicators of data quality**

- Mount StreamPros (and Rios) in Riverboats
  - Riverboats set up to take either instrument
  - Parani Bluetooth used for comms
  - Options to plug in sounders and GPS
  - GPS uses VTG string, very limited WAAS available in NZ
  - Currently looking a new models of GPS

# Initial comparisons with current meters

- Clutha River floods, 1999 – first set of gaugings with new Rio Grande
  - Not enough confidence, so did concurrent c-meter gaugings
  - Results: differences ranged from -2% to + 6%, flows in the order of 2000 – 3000 m3/s
- Eventually satisfied ourselves that ADCPs had no major flaws and results compared well with other methods




# Further comparisons

- But – from time to time we have seen differences that need explaining
- Changing from current meters to ADCPs causes a re-think
- One example: suggested rating changes because of technology change?!
- Is this phenomenon real?
- A case study – Clutha River

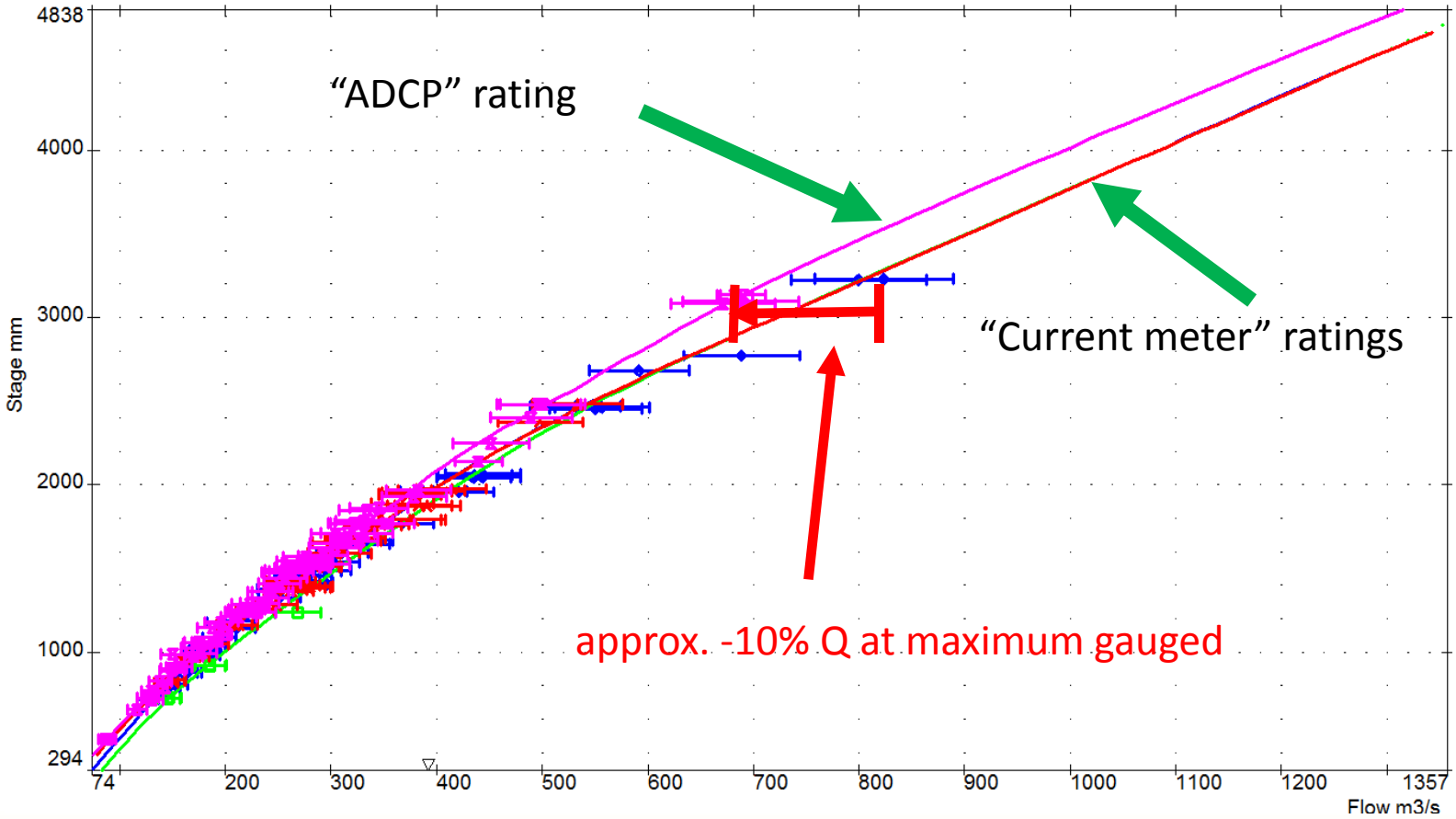
# Initial conclusion – is it valid?

- **Data Comment at 16-March-2003 10:00:00**
- **Data Type: Rating**
- **Site: Clutha River at Below Cardrona Confluence**
- **Rating change 16-March-2003 (10:00) is not the result of any channel alteration but reflects the better accuracy of ADCP measurements which commenced at this date.**

- Prior to 2003 – boat gaugings used Large Ott propeller meters above a 75lb sounding weight
- After 2003 – boat mounted ADCP – Rio Grande 1200 kHz.

# Rating Plot

- ADCP rating (pink) < historic current meter Q ratings (red)



# Historic current meter gaugings

- Non purpose-built boat
- Boat tended to pitch up with velocity (V8 in back)
- No vertical angle corrections – not visible
- Single point 0.6 velocity measurements

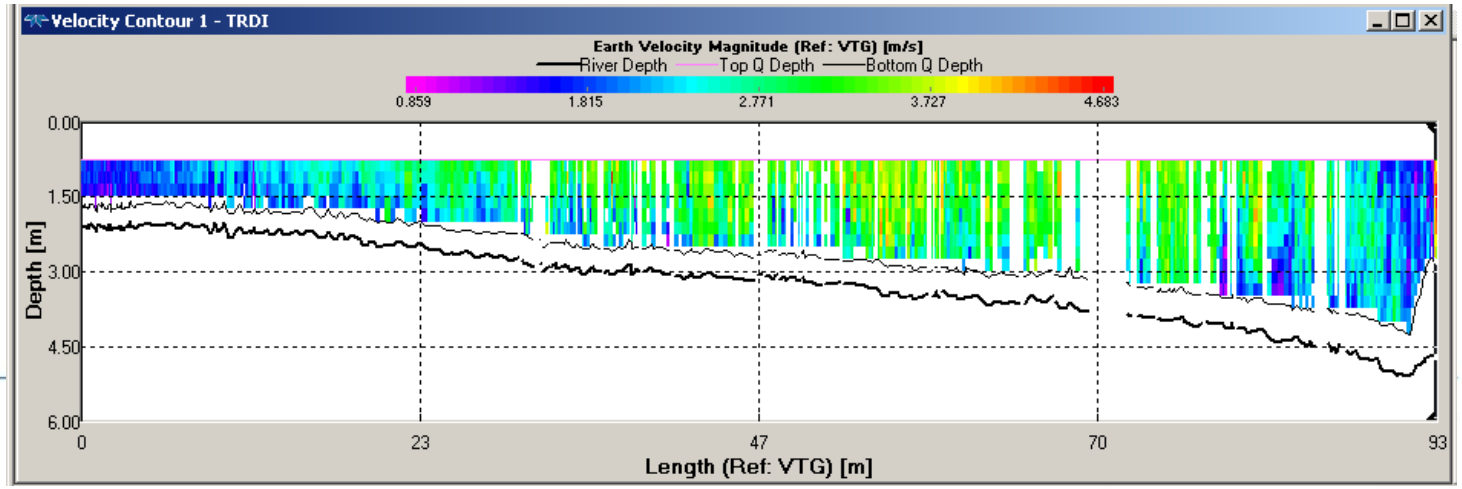
# Comparison gauging series

Done during a high flow event on 15 Jan 2013

- Used a variety of instrumentation
  - Rio Grande (1200KHz)
  - RiverRay
  - Large Ott current meter above a 75lb sounding weight
  - “POEM” pitot velocimeter
- The second-highest flow measured, reasonably stable

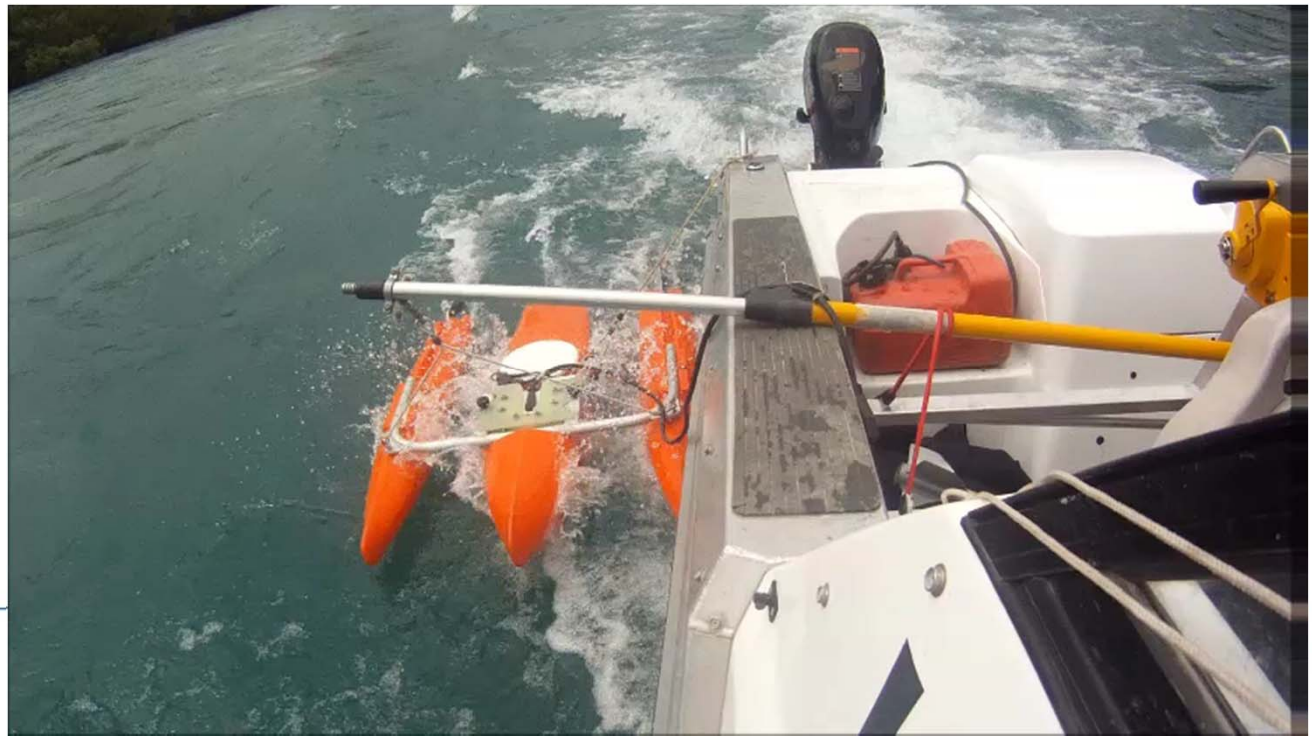
# Rio Grande gauging

- Discharge = 683 m3/s, max dev. +/- 2%, 4 transects
- Upper velocities up to 3.5 m/s
- Some missing data (due to turbulence and/or air under the transducer)
- Loop moving-bed test not valid (BT breaks)
  - So VTG used as reference
- Widths agreed with tagline (so VTG worked well)
- Top extrapolation significant (25% of flow)



# RiverRay gauging

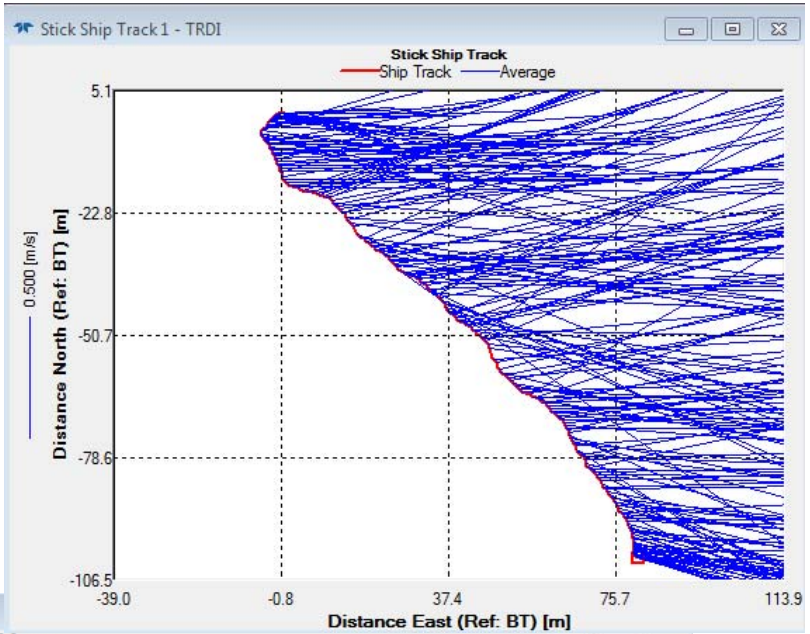
- At first unsuccessful, as velocities too high (at 3.5 m/s) for mounting method
- Trimaran lifted in the fast water and and air appeared to get under it
- So tried drifting diagonally downstream

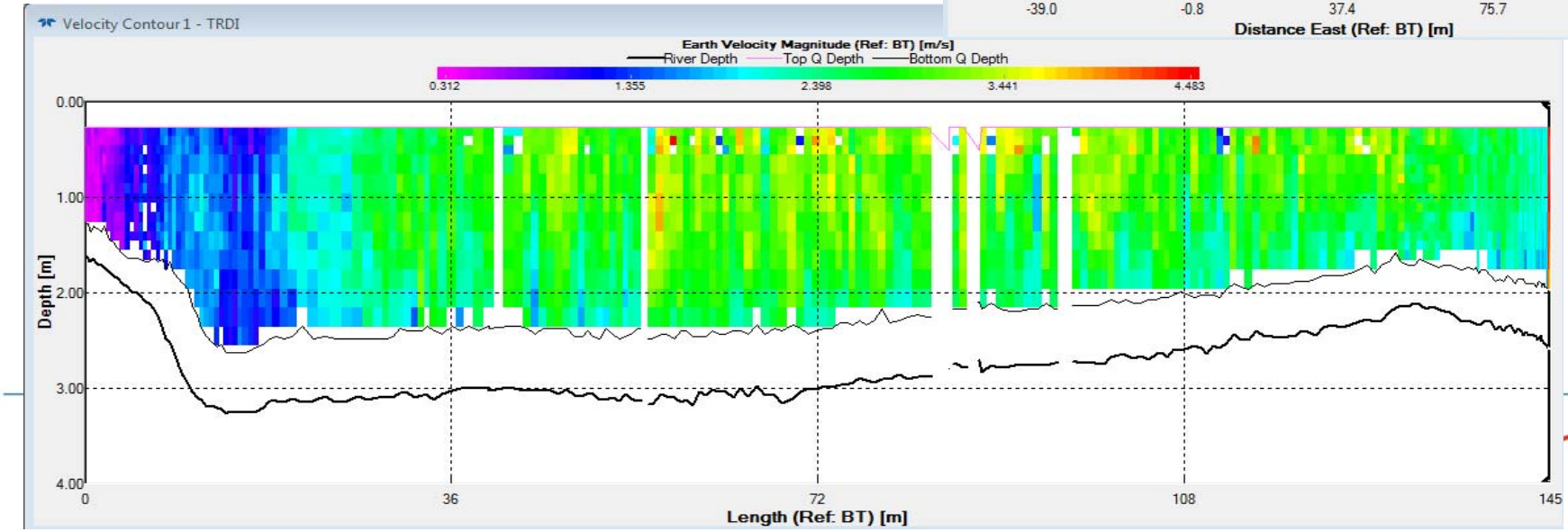


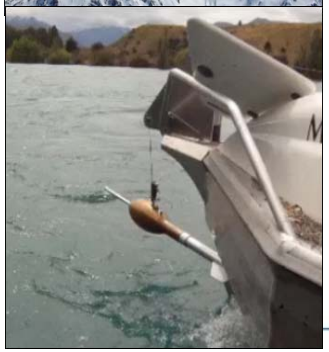
# RiverRay gauging

**Downstream ferry-glide transects**

- This lowered surface water velocities (in relation to boat speed)
- Successful using BT only (no GPS)
- The RiverRay with this technique provided very good data:
  - 690 m3/s  and max. deviation +/- 2%)



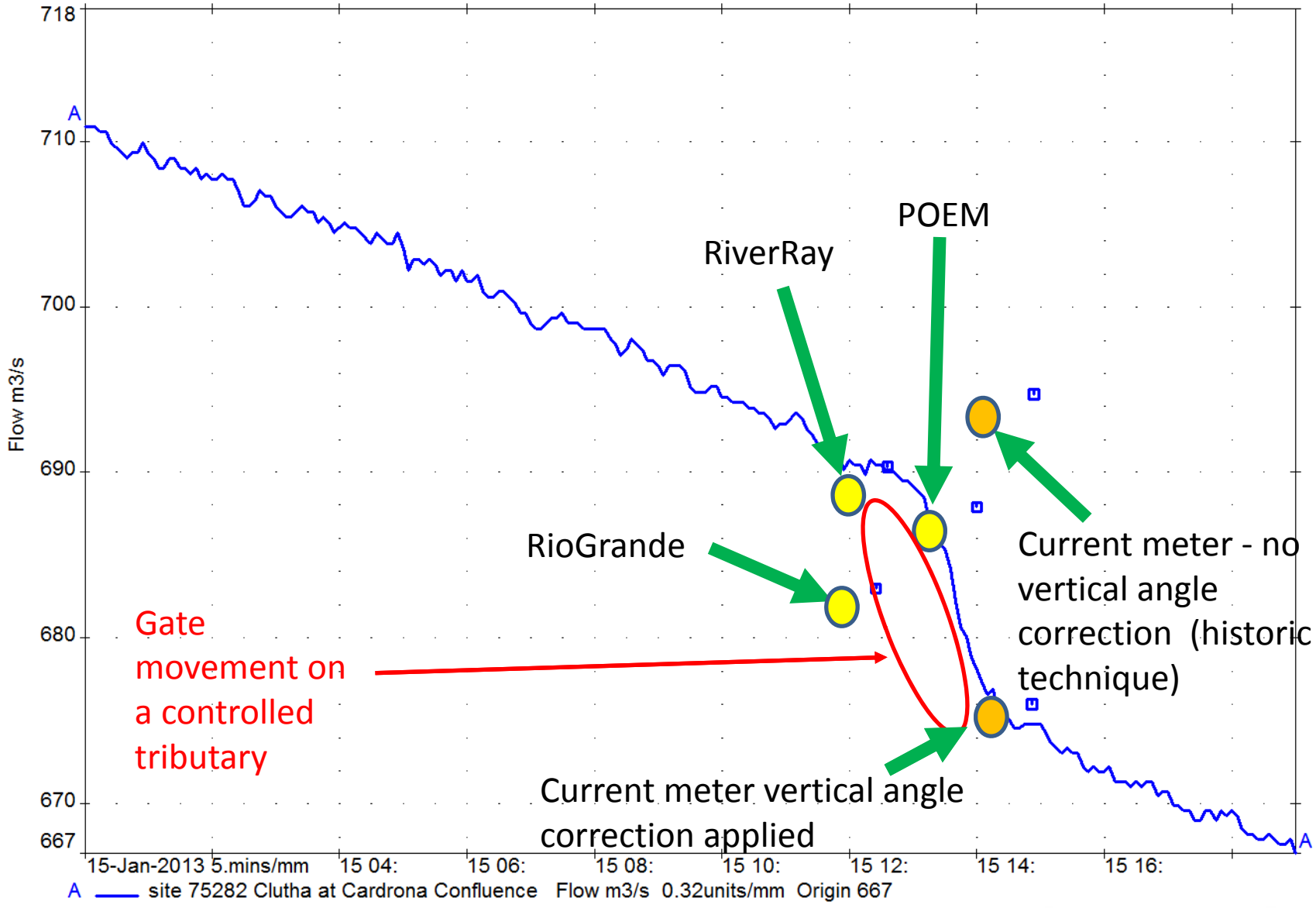
# Large Ott and sounding weight

- Is the sounding technique correct?
  - Between the boulders or on top of large cobbles/boulders?
  - Does the winch operator take the “first touch” depth or repeat and sound a deeper depth?
  - Boat movement a factor?
- Does the boat movement make the current meter over-register the velocities?

# POEM gauging

- 686 m3/s
- Is a pitot velocimeter
- Developed for high velocities
- Velocity range 1 m/s to 9 m/s
- Samples V and D at 28Hz
- Wound up and down at each vertical over 40 seconds
- Can sample close to both top and bottom of water column
- Standard area-velocity calculation

# Flow hydrograph – during gaugings

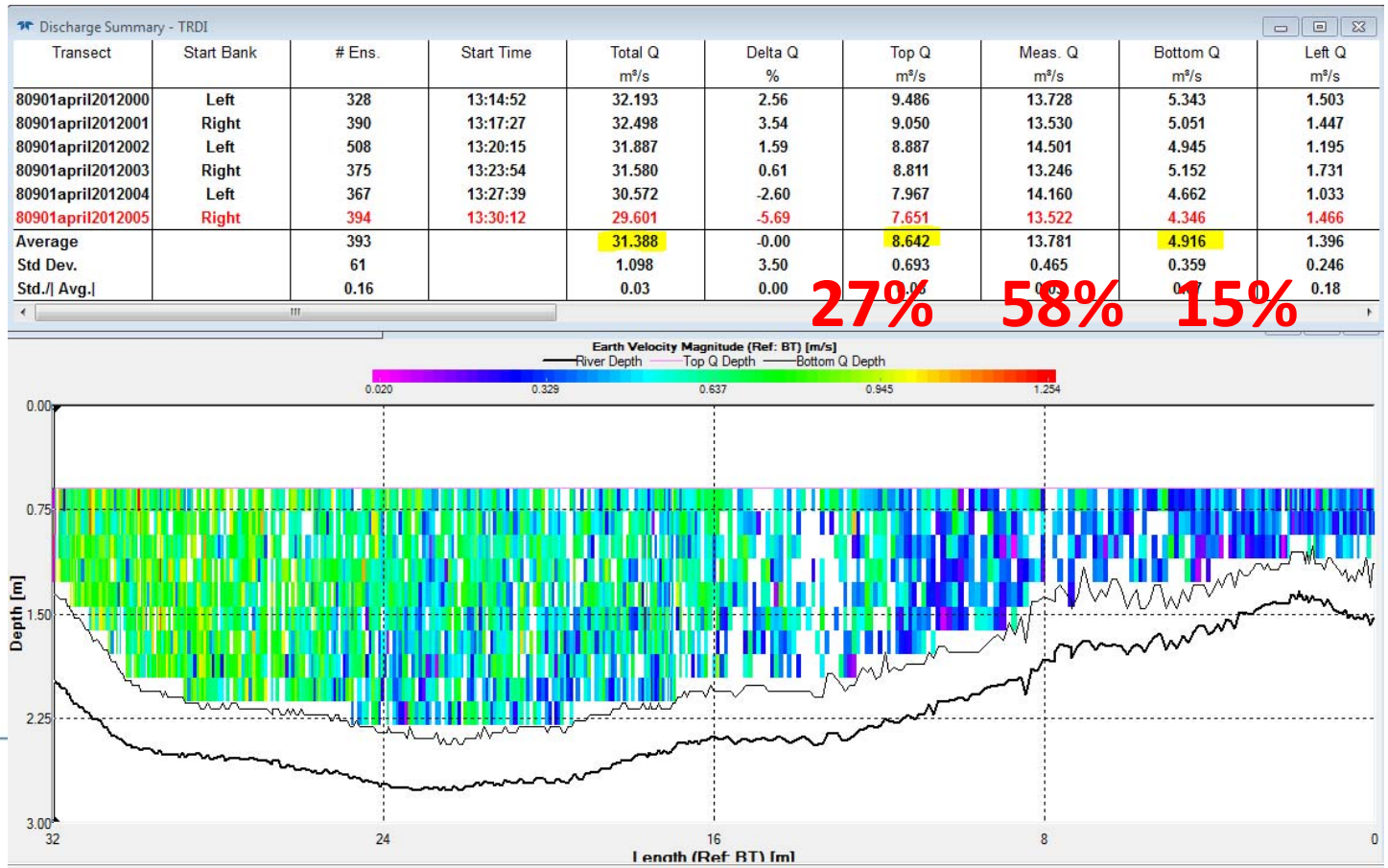


# Conclusions

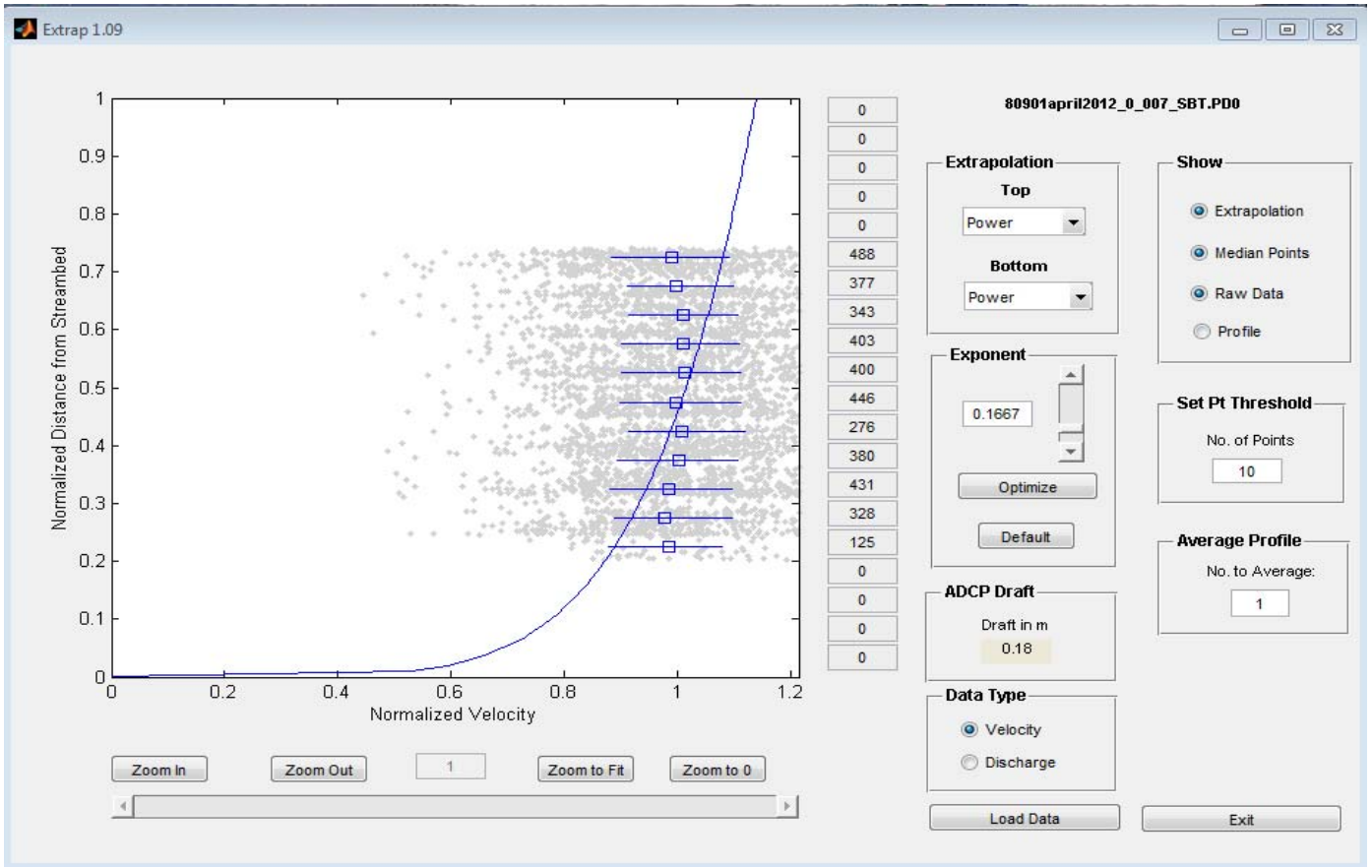
1) Comparison gaugings suggest no issue with the Rio Grande or RiverRay discharge results.
2) The POEM confirmed the velocity profile extrapolations – and its flow estimate agreed
3) The historical Ott/sounding weight gaugings at high flow appear to:
   - Have vertical angle issues (lack of on-board visibility)
   - Have questionable depth-sounding issues
   - Thus have large uncertainties (calculated and unknown)
   - Be biased high by at least 3%
4) Outcome – we fully believe the ADCP results, and the historic ratings will be shifted at least 3% towards the ADCP measurements.

# Extrapolation for unmeasured regions

- Especially important in shallow rivers
- "Extrap" software from USGS enables plotting of vertical velocity profiles
  - Enables us to estimate if extrapolations look reasonable

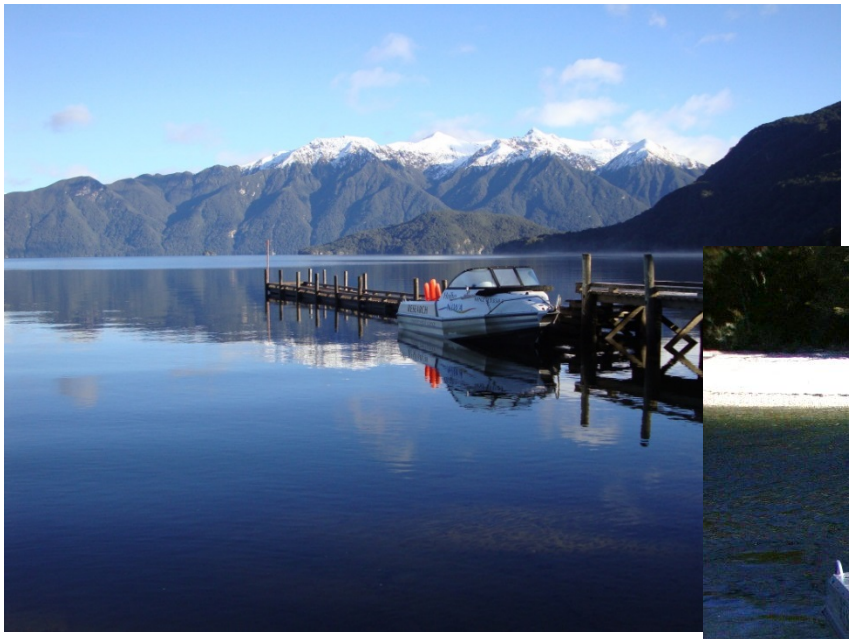


# Wairaurahiri example

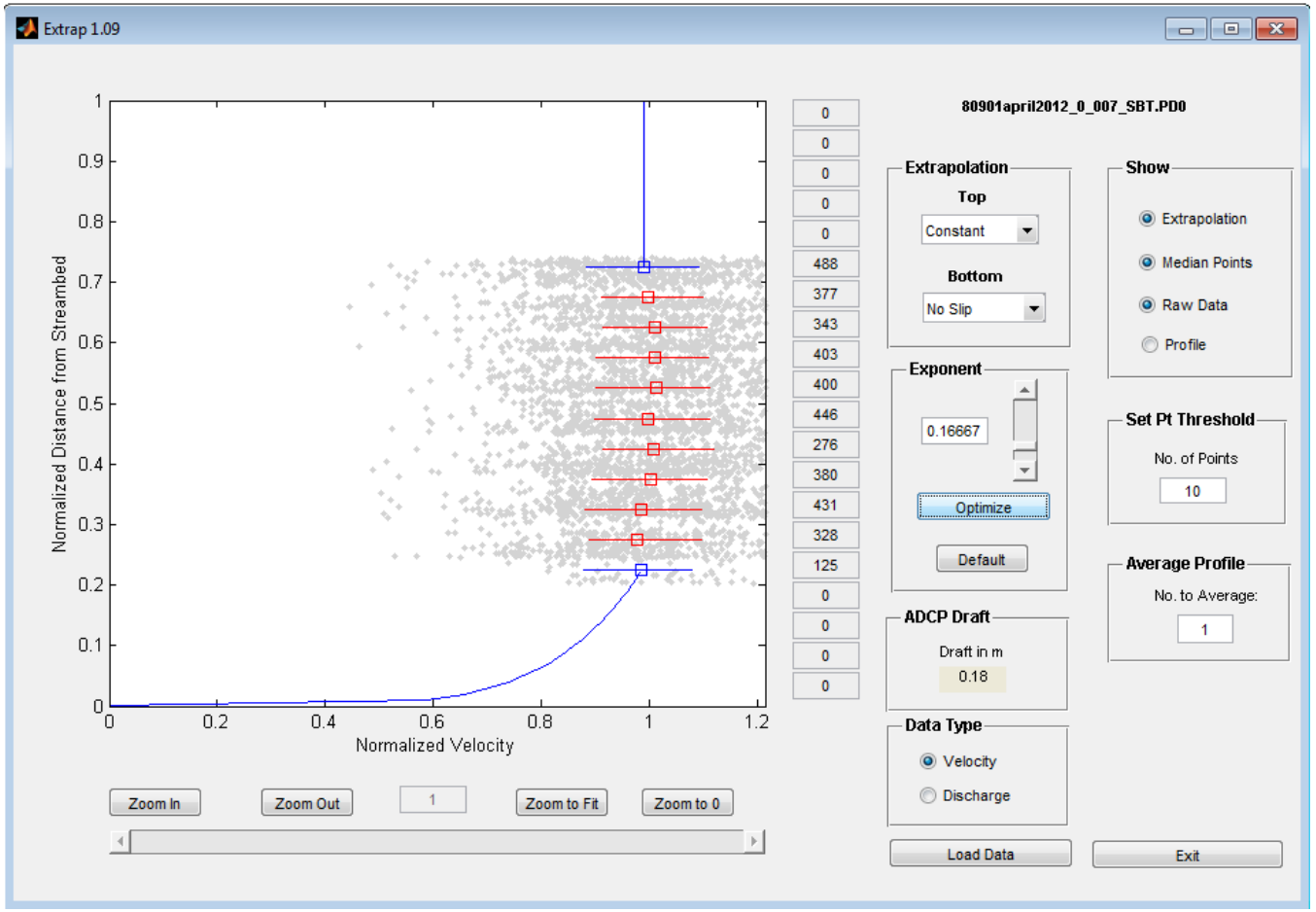



This example indicates that the defaults of power curve top and bottom aren't such a good fit

# At a lake outlet, so there is potential for a different velocity profile

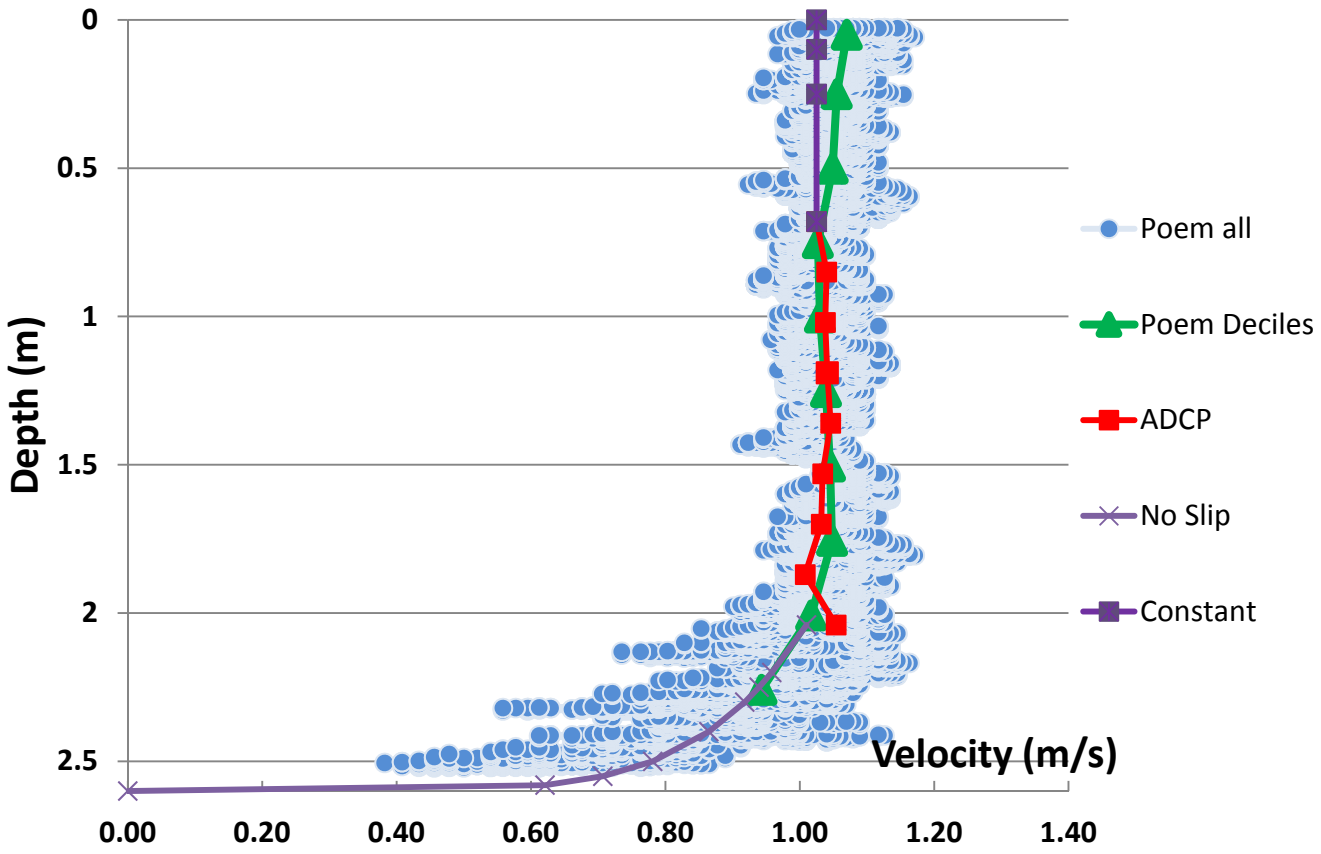


# Extrap plot suggests:




Best visual fit is: Top = constant, Bottom = No Slip

# POEM data confirm this




Also indicates: top = Constant, bottom = No Slip

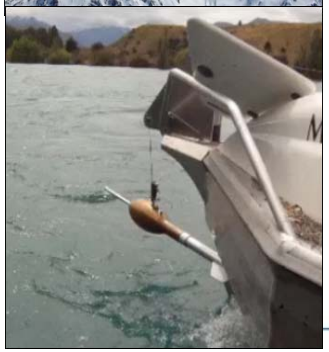
# Conclusions and learning

- Calibration – value in tank testing (and “regatta” testing) all instruments regularly – gives confidence and can diagnose issues
- Where possible avoid turbulence - will cause missing bins which in turn causes more variation – keep below 30 % missing bins
- Smooth transit rates (boat speed) make for more accurate results
- Comparisons with other methods are still useful to resolve issues with historic and current data
- Comparisons with other technology can build confidence in the excellent accuracy of ADCPs
- It is worthwhile to check the extrapolations used for unmeasured areas of flow (use Extrap)
- ADCPs have proved revolutionary, pushed out the boundaries around river flow measurement, and we are still learning

# That's it…….

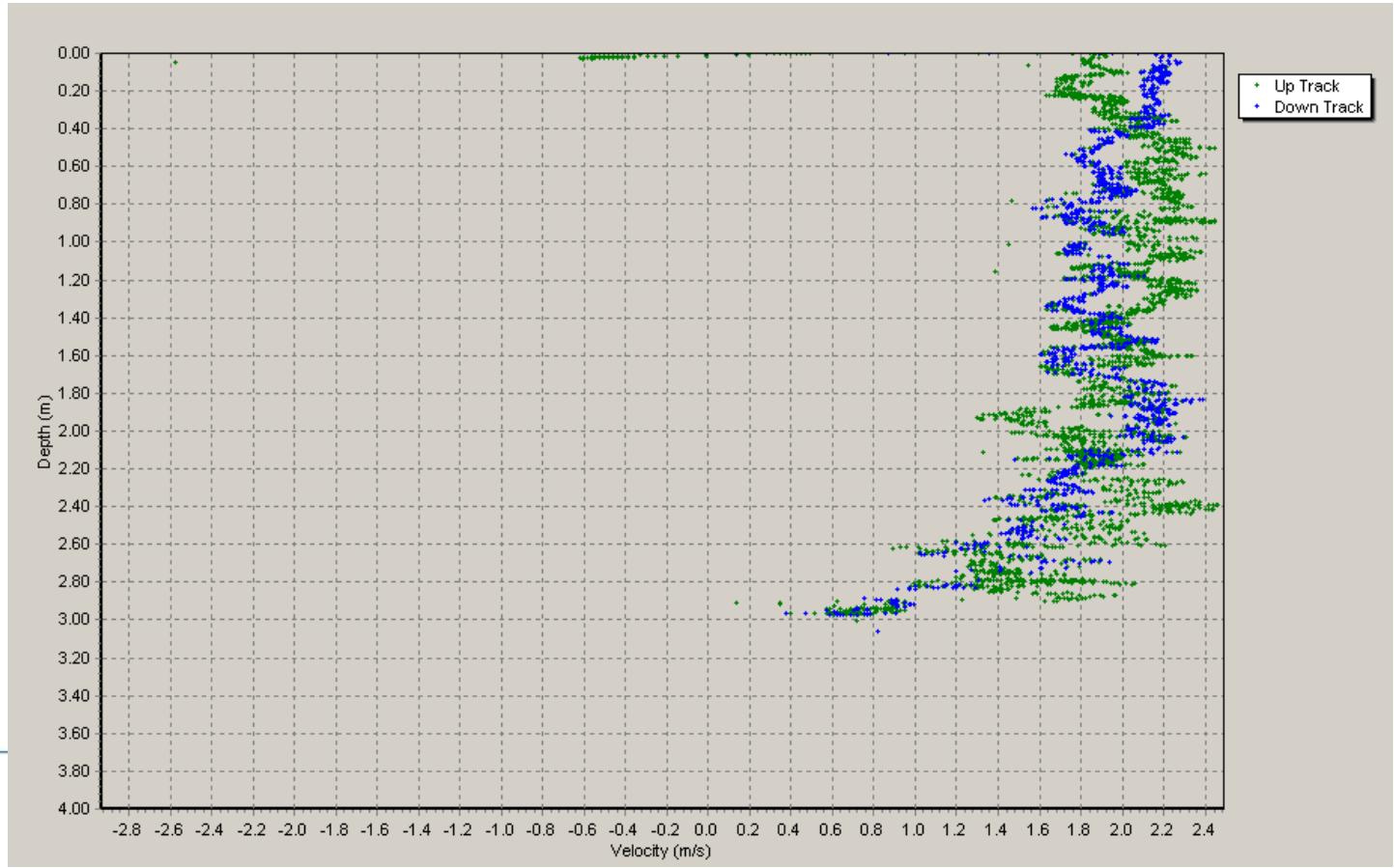
Thank you for your attention.

Enjoy the rest of the conference.

# POEM results

- Q = 688 m3/s
- 1000 – 1300 depth velocity pairs at each vertical
- Data averaged into deciles
- Blue is the downward track, green the up one



# Differences – the possible reasons

## Gauging technique/instrumentation

1) ADCP under-estimates flow:

- Moving bed? (under-estimates Q)
- Depths register top of cobbles (under-estimate Depth)
- Top & bottom extrapolations (could they under-estimate V?)

2) Current meter/sounding technique - could it over-estimate flow?

- Drag angle issue? (over-estimate both Depth and Velocity)
- Velocity profile? (how valid is the 0.6 method?)

Or

## Site-specific physical change

- Rating change (bed movement and or bank change)
- Datum shift (recorder issue)