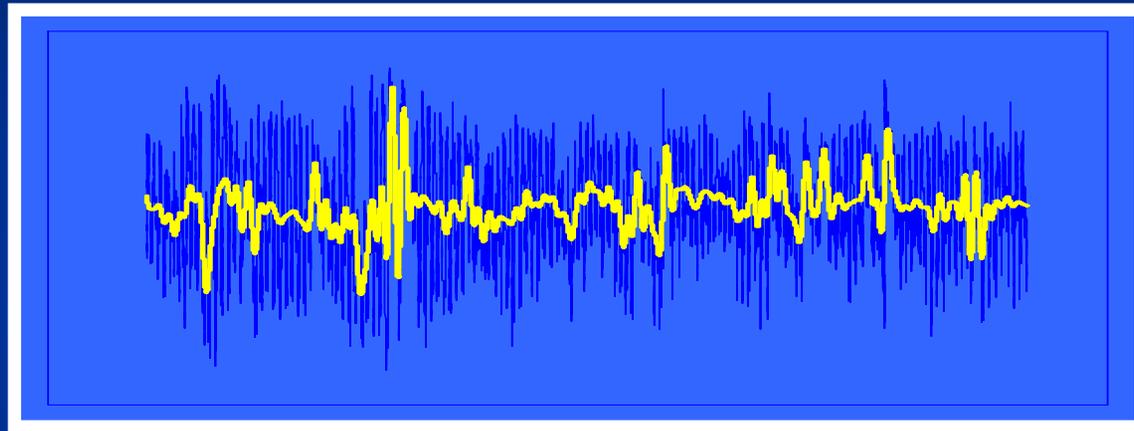


Hydroacoustics and the USGS



D. Phil Turnipseed, P.E.
Joint USACE-USGS Meeting

USGS National Center
Reston, Virginia
November 29, 2006

U.S. Department of the Interior
U.S. Geological Survey



Issues

- **Increasing coastal population**
- **Freshwater outflows to the Atlantic, the Pacific and the Gulf of Mexico**
- **Operation and maintenance of dams and floodways**
- **Coastal Restoration**

Historical roadblock

Unsteady (varied, non-uniform) open channel flow

Agenda

- **Acoustic Doppler Current Profilers (ADCPs) and the USGS**
- **Index Velocity**
- **New developments in hydroacoustics**
- **Quality Assurance**

Acoustic Doppler Current Profilers (ADCPs)

ADCPs Used in the USGS for Streamflow Measurement



10



9

-  RDI Rio Grande
-  RDI StreamPro
-  Nortek BoogieDopp
-  Sontek ADP



214



57

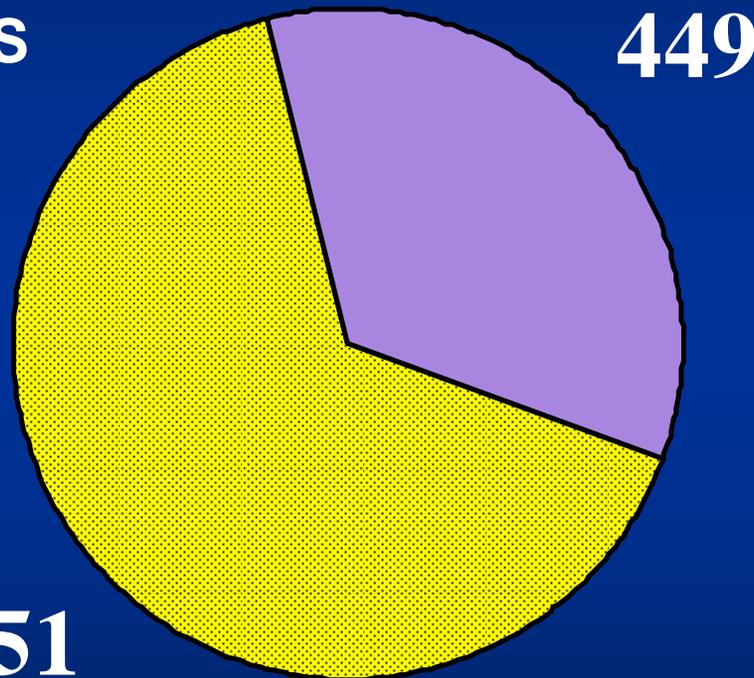
Updated July 2006



11.9% (3,522) of discharge measurements
from Oct 1, 2005 to April 15, 2006

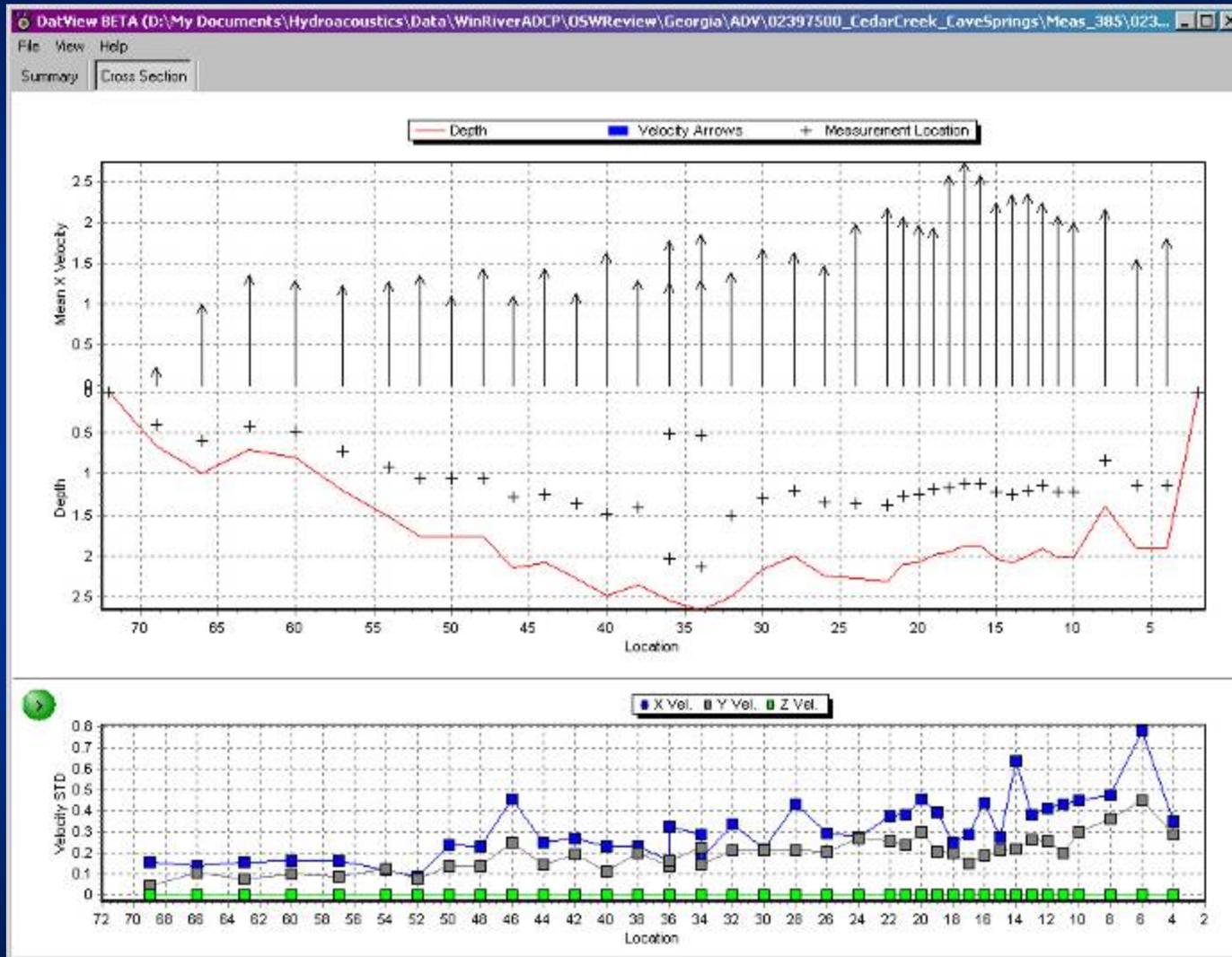
FlowTracker Use

- Other Agencies
- USGS

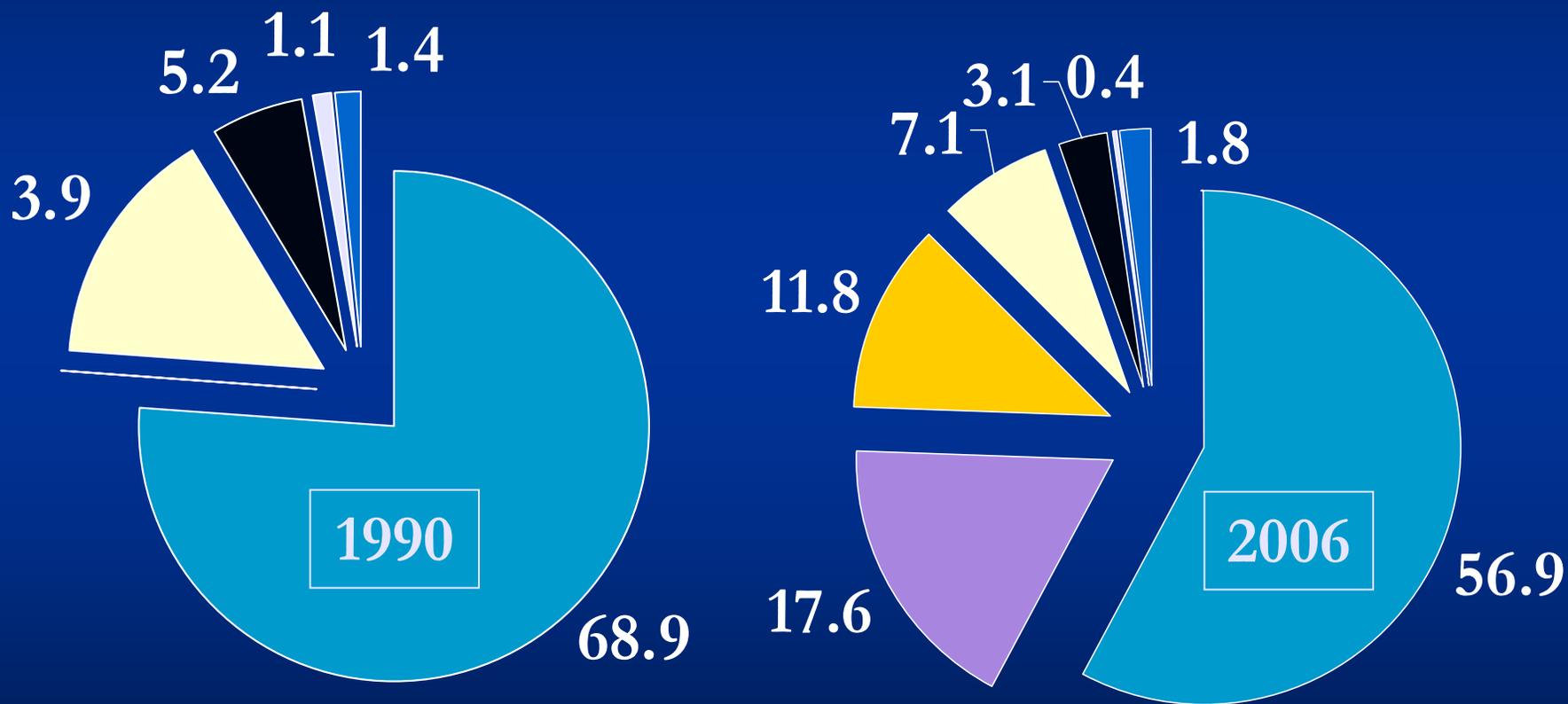


17.6% (5,244) of discharge measurements
from Oct 1, 2005 to April 15, 2006

FlowTracker Data Review



29% of USGS Qm's made with Hydroacoustic Instruments in 2006!



■ Wading ■ Flowtracker ■ ADCP ■ Bridge ■ Cableway ■ Boat ■ Ice



Flood Measurements Using ADCPs

- January 1991 flood (Current Meters)
 - 52 Discharge Measurements in 10 days
 - Average Qm time -- 96 minutes
 - 11 hydrographers
- July 2003 flood (ADCPs)
 - 62 Discharge Measurements in 10 days
 - Average Qm time -- 18 minutes
 - 6 hydrographers

Index Velocity

Conventional Stage-Discharge Rating Empirical Relationship:

$$GH = Q$$

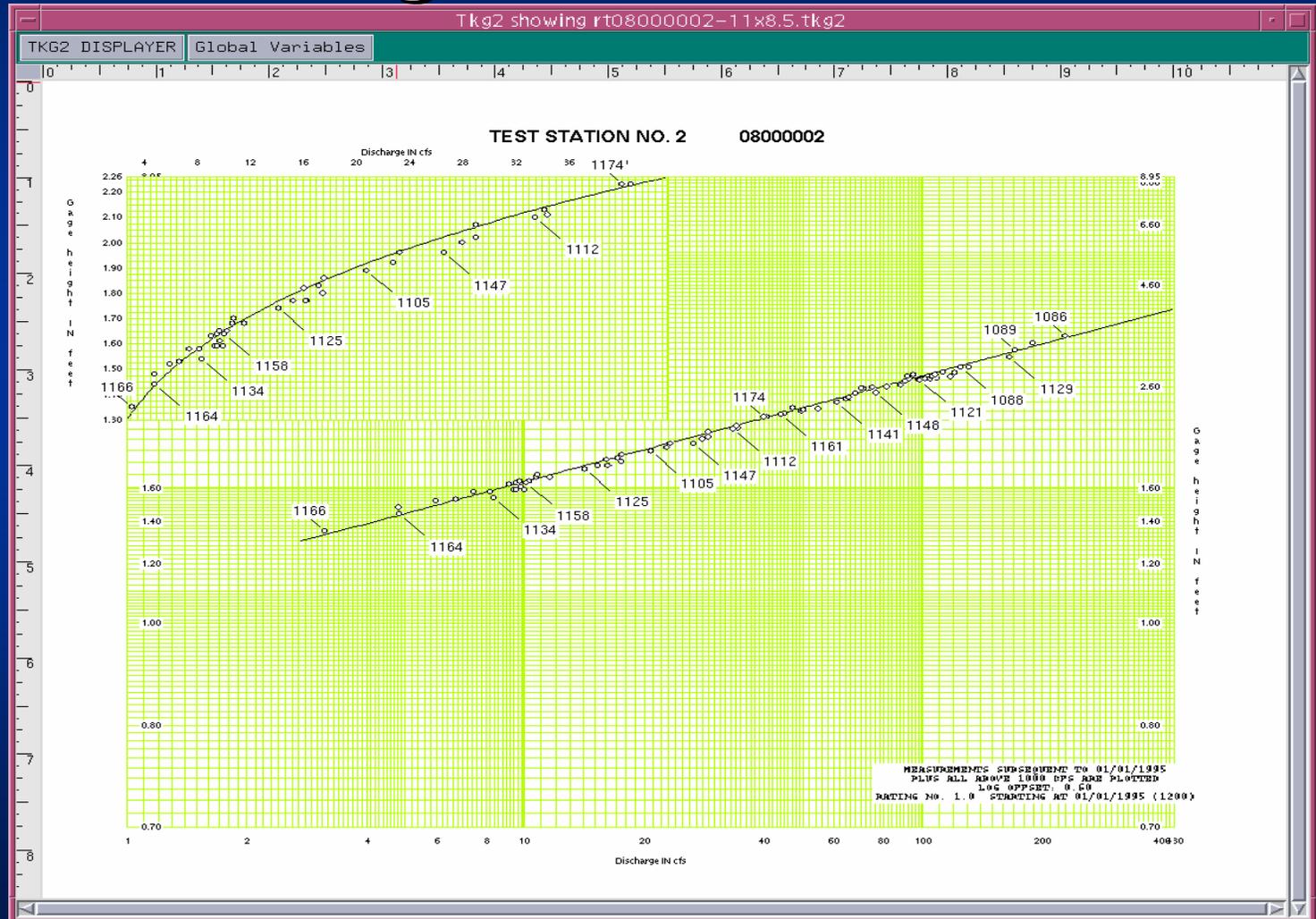
Where for a given channel cross-section:

Q = discharge in ft^3/s ;

GH = river stage in ft;

Conventional Stage-Discharge Ratings of the USGS

Stage (feet)



Discharge (cubic feet per second)

Continuity Equation:

$$Q = VA$$

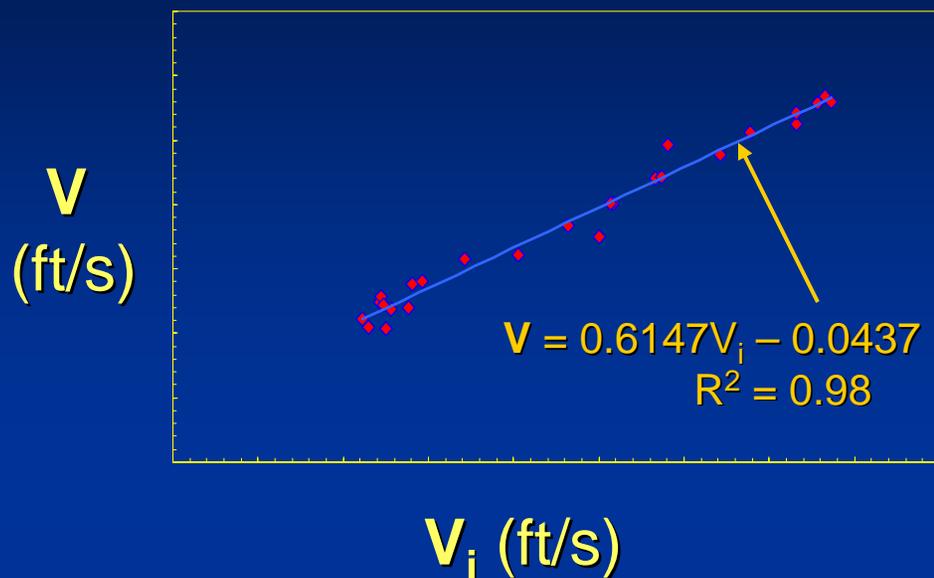
Where for a given channel cross-section:

Q = discharge in ft^3/s ;

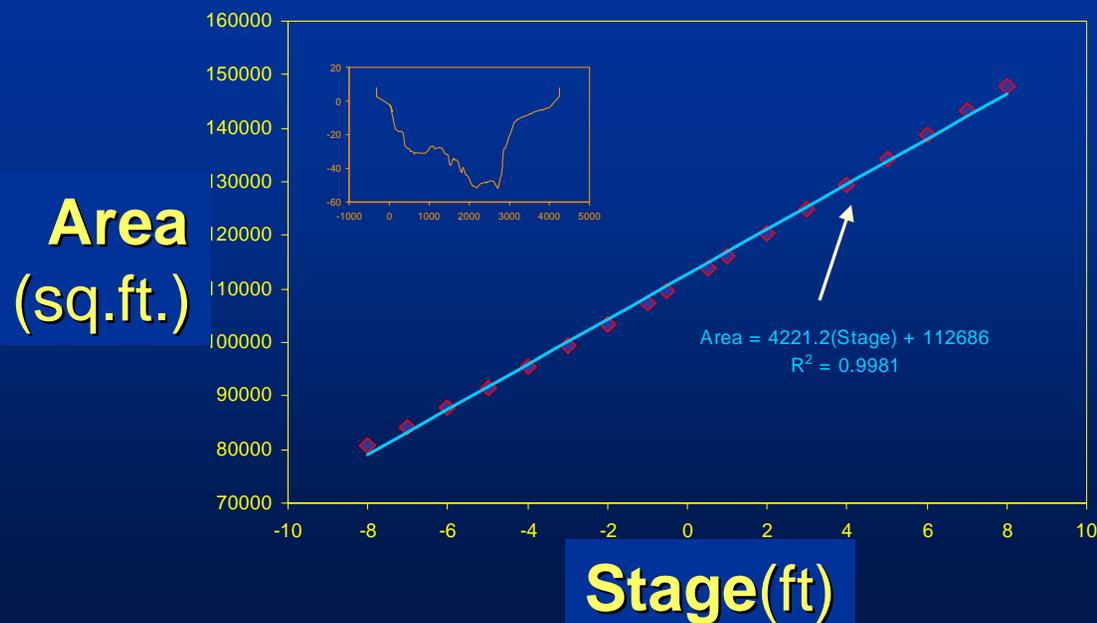
V = the **average** velocity in ft/s ;

A = cross sectional area in ft^2

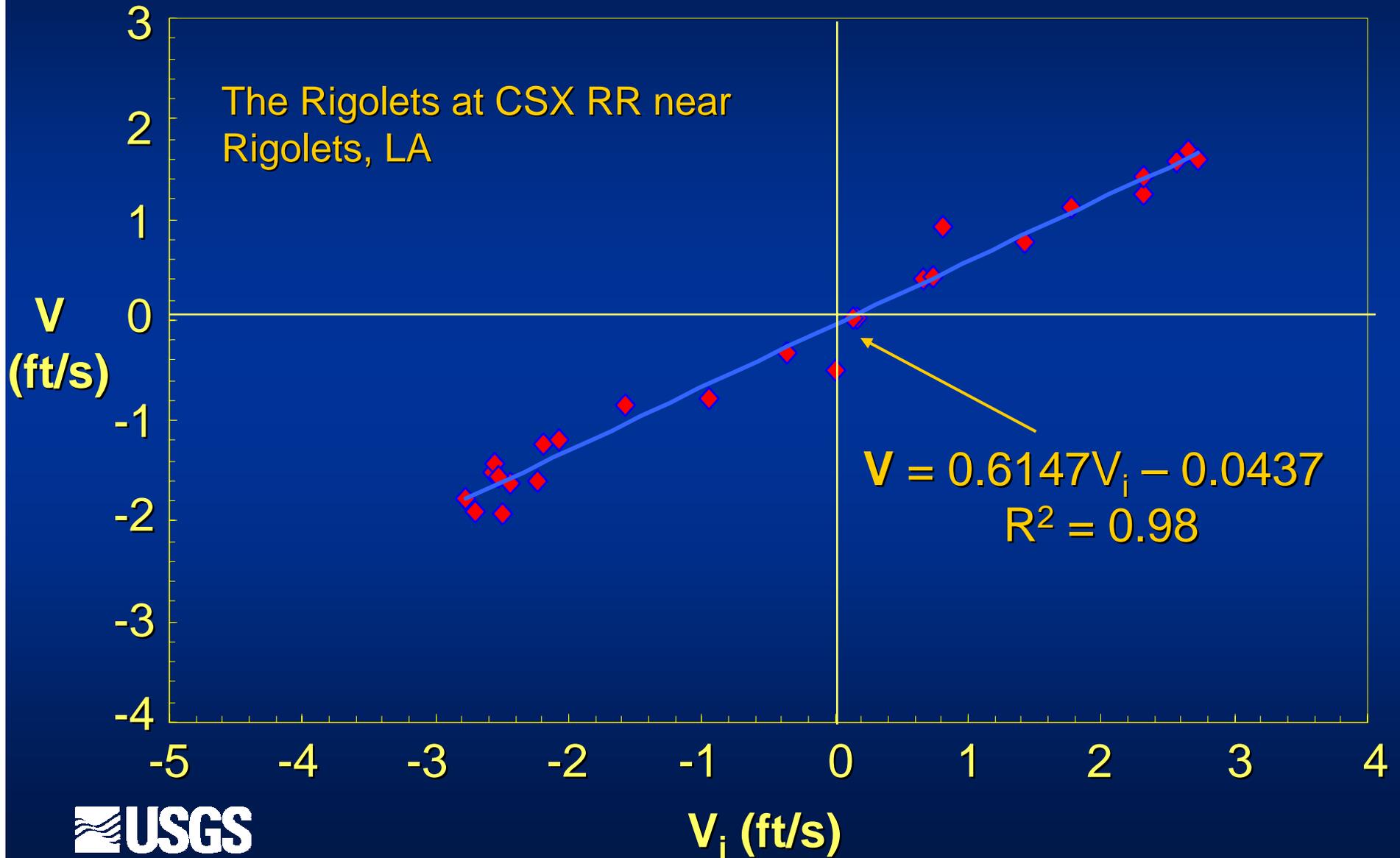
Average velocity (V) / ADVM velocity relation



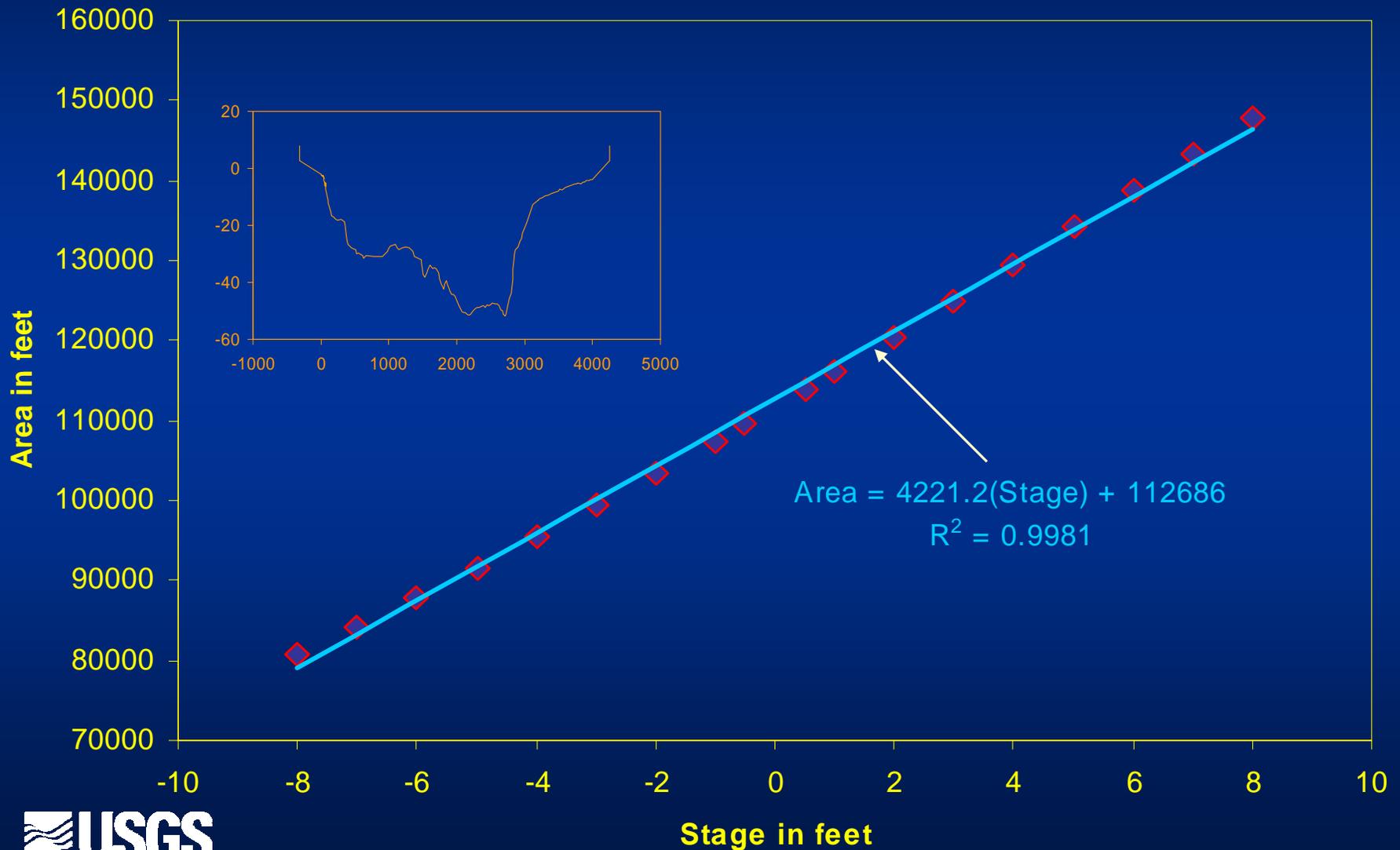
Cross-sectional area (A) computation



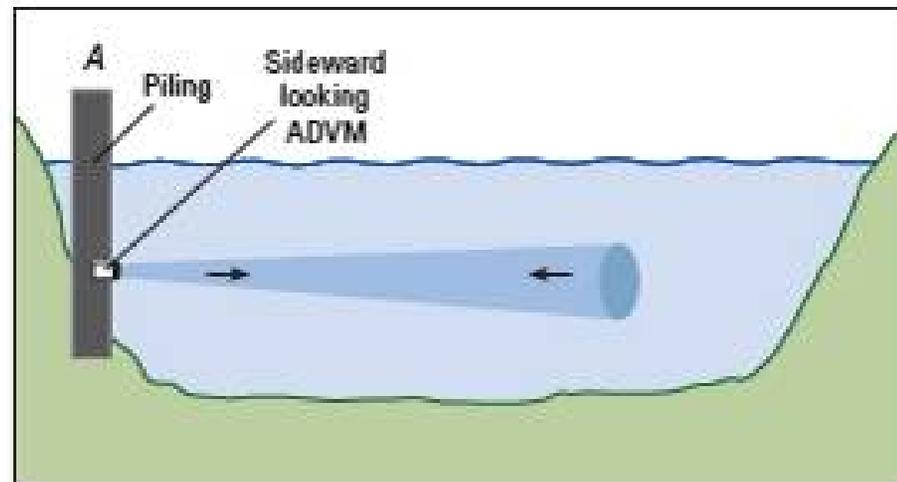
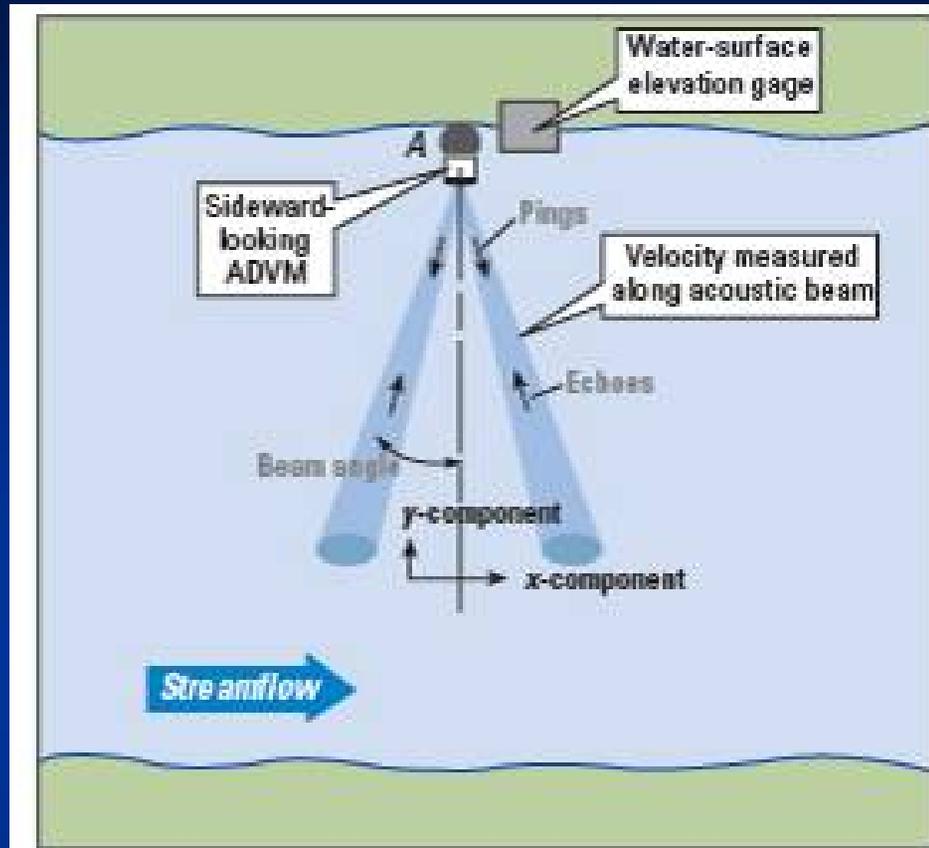
Average velocity (V) / ADVM velocity relation



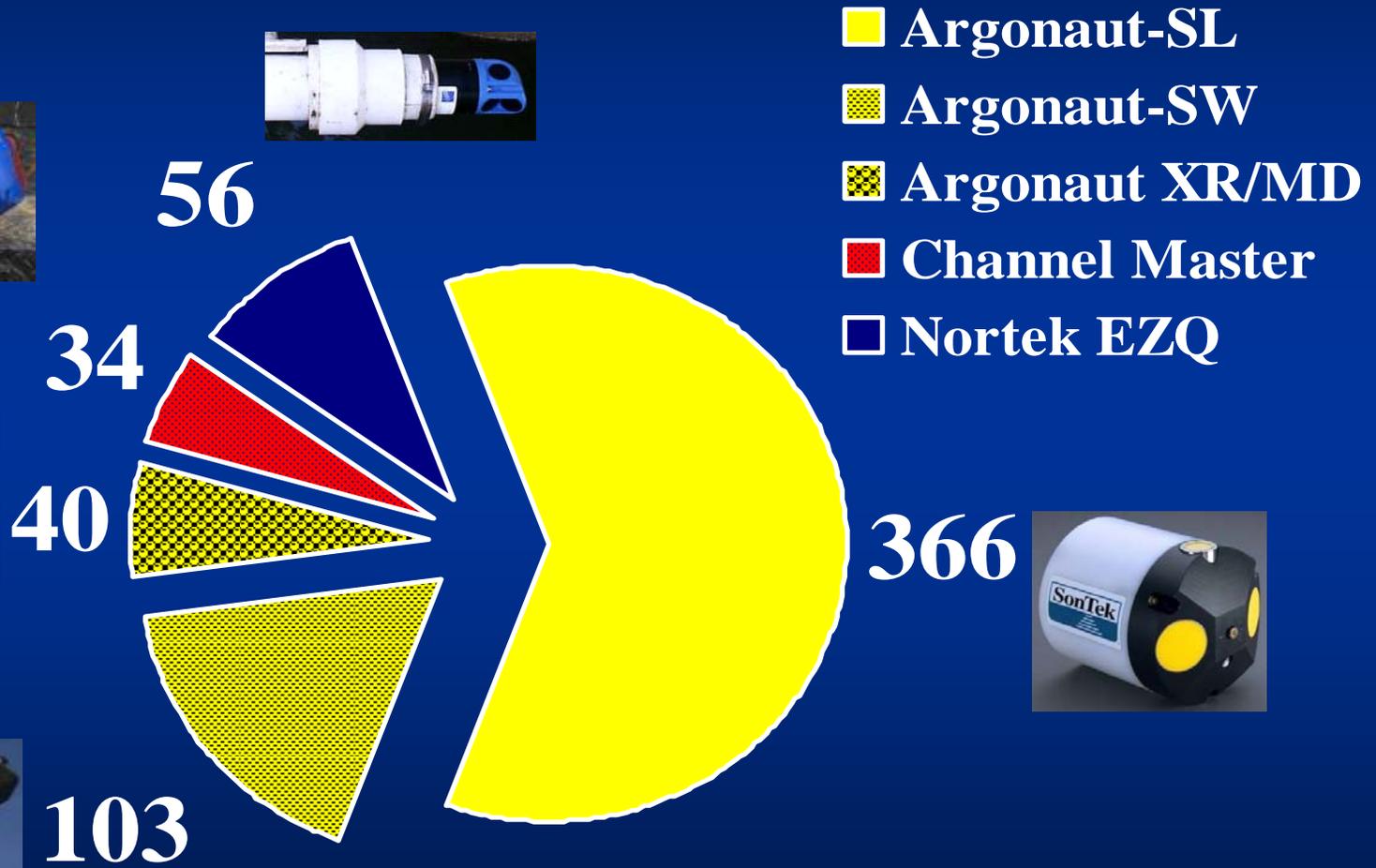
Cross-sectional area (A) computation



Index Velocity Meters

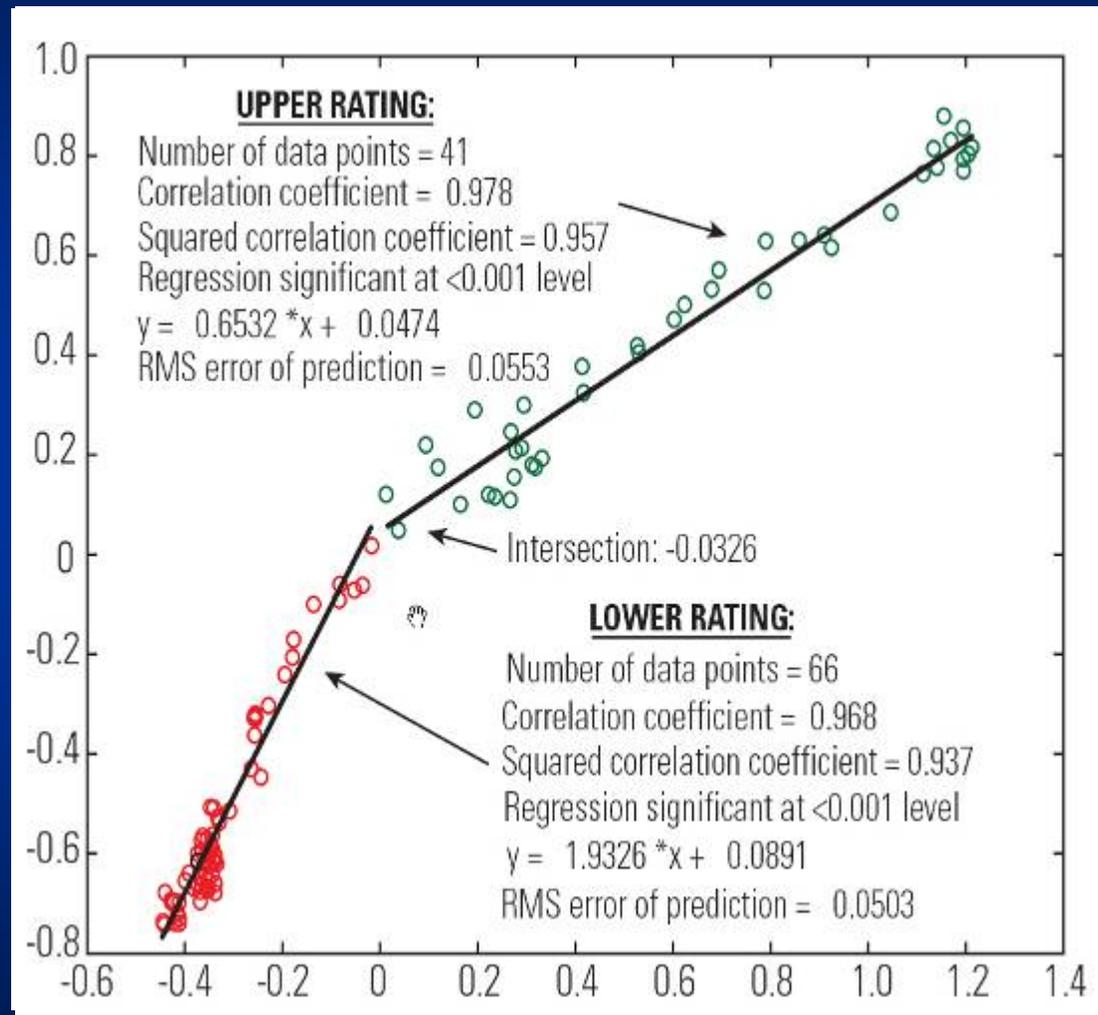


Index-Velocity Instruments



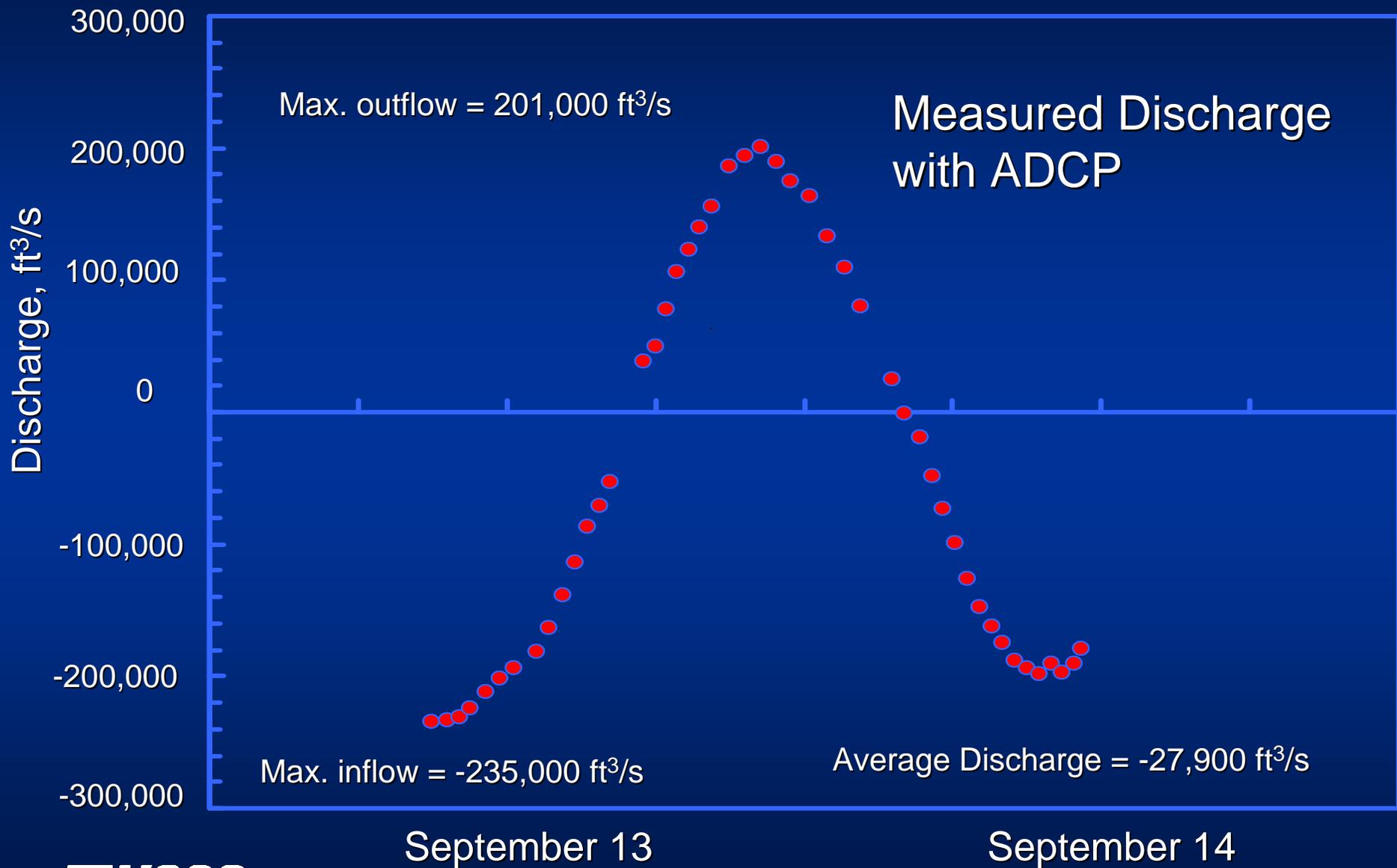
Index Velocity Ratings

Ave. Velocity
(ft/s) from Qm

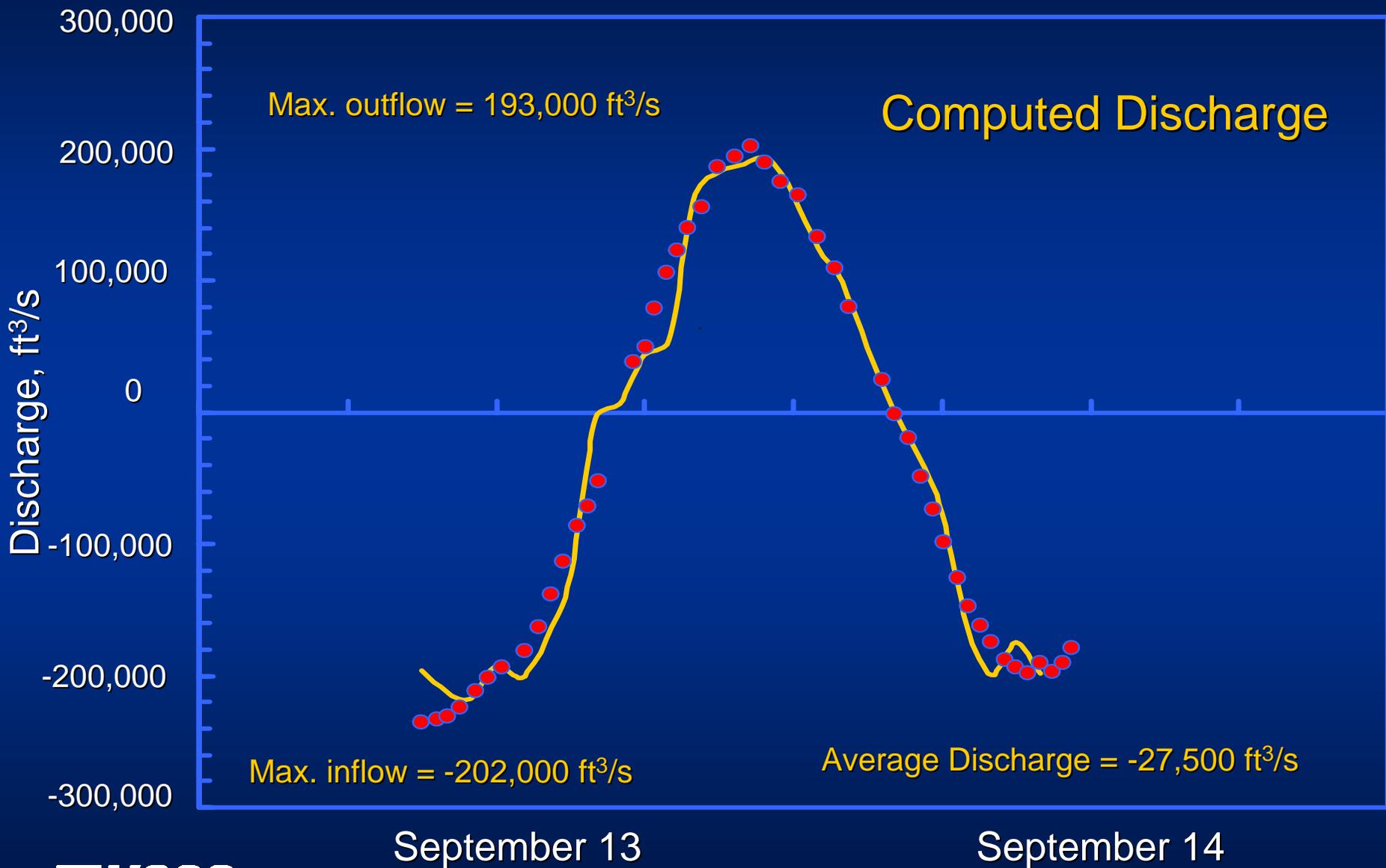


Instantaneous Velocity (ft/s)

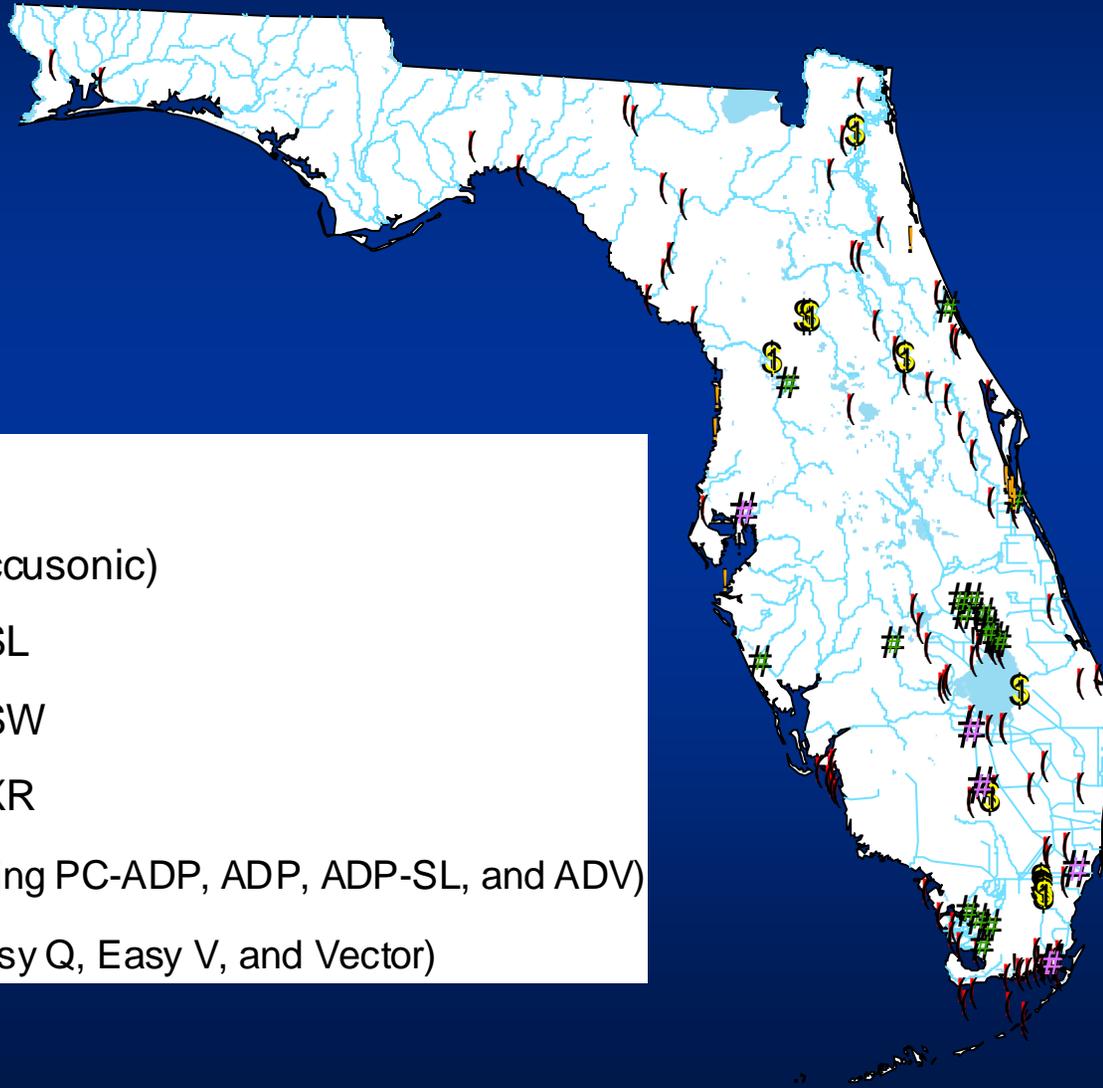
The Rigolets at CSX RR near Rigolets, LA



The Rigolets at CSX RR near Rigolets, LA



Florida In-situ Hydroacoustic Deployments



Legend

- \$ AVM (Affra and Accusonic)
- (Sontek Argonaut SL
- # Sontek Argonaut SW
- ! Sontek Argonaut XR
- ! other Sontek (including PC-ADP, ADP, ADP-SL, and ADV)
- #/ Nortek (including Easy Q, Easy V, and Vector)

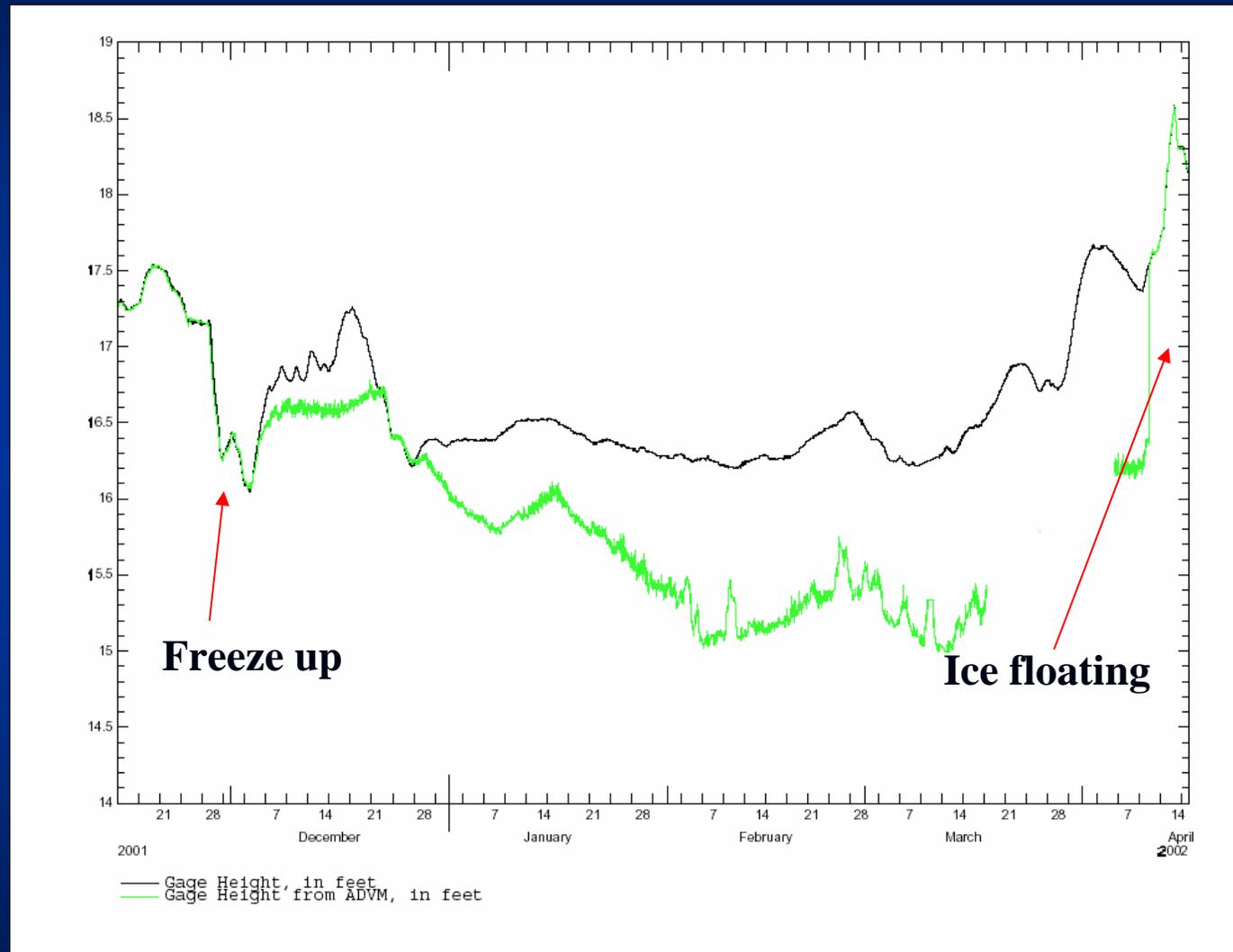
Measurement of Flow under Ice



SonTek
Argonaut SL

Pressure Transducer Stage and Acoustic Stage Measurement

Gage Height
(ft)



Time

Summary of Hydroacoustic Instruments



290

- River Profilers
- Index Velocity
- FlowTrackers



449



610

New developments in hydroacoustics

OceanScience High-Speed Boat



7 Slow-speed boats in use in USGS

RC Boat - SeaRobotics



Semi-Autonomous Controlled Boats



Next Generation ADCP

- Integrated system
 - ✓ Compact 600kHz Phased Array Transducer
 - ✓ New compact, low power electronics set
 - ✓ Bluetooth wireless comms
 - ✓ More automated, wizard-based software
 - ✓ Trimaran float, 10-18 VDC
 - ✓ External options: DGPS, depth sounder



WinRiver II

- New user interface - Site-centric design
- Improved configuration wizard supplied by USGS
- Automated data analysis supplied by USGS
- Improved handling of GPS
- Support for section by section Qm's

The screenshot displays the WinRiver II software interface, which is used for configuring and analyzing data from Teledyne RD instruments. The main window, titled "ProjectCtrl - Teledyne RD I...", shows a hierarchical tree view of a project named "chest12__000r.prj". The tree includes sections for "Site Information", "Site Discharge", and "Collect Data". Under "Site Discharge", there are five transects: "Transect 000", "Transect 001", "Transect 002", "Transect 004", and "Transect 005". Each transect has associated sub-items for "Field Configuration", "Playback Configuration", and "Discharge Summary". The "Transect 005" item is highlighted with a blue selection box. Below the tree view, there are several data tables and a navigation panel. The "Discharge (Rat. BT) Right to Left" table shows data for "Top Q", "Measured Q", "Bottom Q", "Left Q", "Right Q", and "Total Q". The "Navigation (Rat. BT)" table shows data for "Boat Speed", "Boat Course", "Water Speed", "Water Dir", "Calc. Depth", "Length", "Distance MG", "Course MG", and "Duration".

Discharge (Rat. BT) Right to Left			
Distal Bins	38		
Top Q	18978.539	(%)	
Measured Q	77432.471	(%)	
Bottom Q	6425.522	(%)	
Left Q	3378.488	(%)	
Right Q	465.759	(%)	
Total Q	92260.279	(%)	

Navigation (Rat. BT)			
Boat Speed	2.849	(ft/s)	
Boat Course	33.81	(°)	
Water Speed	4.145	(ft/s)	
Water Dir	142.53	(°)	
Calc. Depth	32.27	(ft)	
Length	9971.21	(ft)	
Distance MG	9930.84	(ft)	
Course MG	28.21	(°)	
Duration	278.49	(s)	

Automated Data Screening Tool

Automated Data Screening For RDI ADCP Data

Water Track Error Velocity Filter

Percent Bad Data: 2.32
 Number of Bad Bins: 400
 Filter Criteria Maximum: 0.0375
 Filter Criteria Minimum: -0.0375

Filter Parameters
 Filter Multiplier: 4

Show Apply Filter Defaults Apply

Boat Velocity Filter

Percent Bad Data: 0.06
 No. of Bad Ensembles: 7

Filter Parameters
 Loess Smooth Width: 10
 Filter Halfwidth: 10
 Filter Multiplier: 9
 Cycles: 3

Show Apply Filter Defaults Apply

Beam Depth Filter

No. Bad Depths

Beam 1: 4
 Beam 2: 6
 Beam 3: 1
 Beam 4: 13

Filter Parameters
 Loess Smooth Width: 20
 Filter Halfwidth: 10
 Filter Multiplier: 15
 Cycles: 3

Show Apply Filter Defaults Apply

Edge Assessment

	Distance Traveled (m)	Bad Ensembles	Bad Nav Data
Start Edge:	1.49	11	0
End Edge:	23.93	49	0

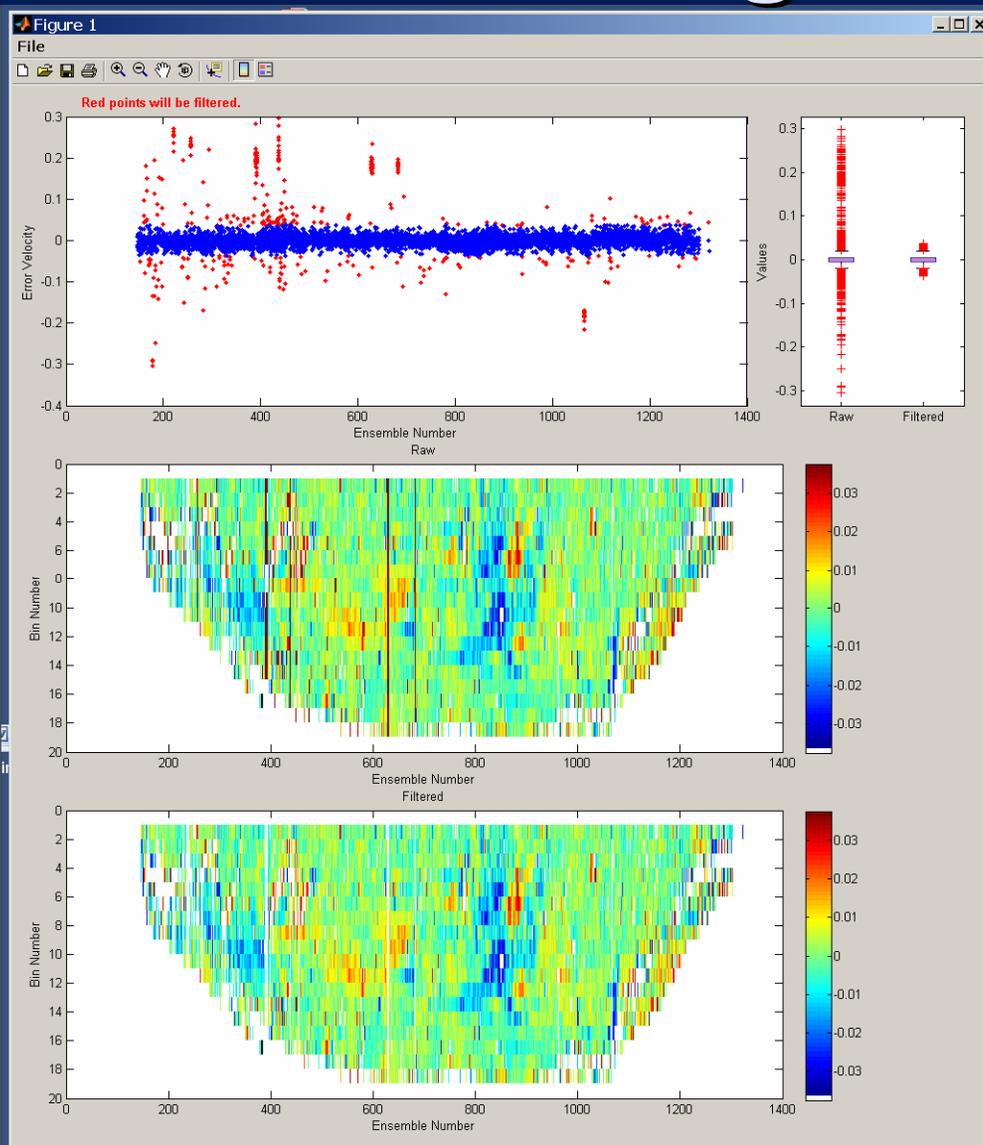
Summary

Measured Discharge (m³/s)

Raw Data: 2.8574
 Filtered Data: 2.757

Show Final

Load Raw Data Close



Quality Assurance

QA of ADCP Measurements

New information:

- Criteria for moving bed tests
- Temperature measurement
- Detailed procedures for Qm's



In cooperation with the U.S. Army Corps of Engineers, Detroit District

Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers



Scientific Investigations Report 2005-5183

U.S. Department of the Interior
U.S. Geological Survey

<http://pubs.usgs.gov/sir/2005/5183/>



Quality Assurance is Important!



OSW Technical Training

- ✓ Streamflow Measurements using ADCPs
- ✓ Advanced ADCP Applications
- ✓ Index Velocity Measurements and Ratings

<http://il.water.usgs.gov/adcp/training/>

OSW Technical Memos

- 2000.03 Mandates use of WinRiver
- 2002.01 Configuration of RDI ADCP's
- 2002.02 Policy on ADCP Qm's
- 2002.03 Release of WinRiver 10.03
- 2003.01 Discharges computed using SonTek RiverSurveyor
- 2003.04 Release of WinRiver 10.05
- 2005.04 Release of WinRiver 10.06
- 2005.05 Guidance on use of RDI StreamPro
- 2005.08 Archiving ADCP Discharge Measurement Data
- 2006.02 Quality Assurance Plan for ADCP Qm's
- 2006.xx Moving Bed Test Procedures and Corrections
- 2006.xx Calibration of ADCP's used for Discharge Meas.



Questions?

pturnip@usgs.gov
<http://water.usgs.gov/osw/>