

# Ground-Penetrating Radar Methods Used In Surface-Water Discharge Measurements

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U.S. Geological Survey



## USGS Stream Gaging

Water Resources Division

~ 7000 Gaging Stations

~ \$80 M Program

Stream Gaging

**Q** = Discharge

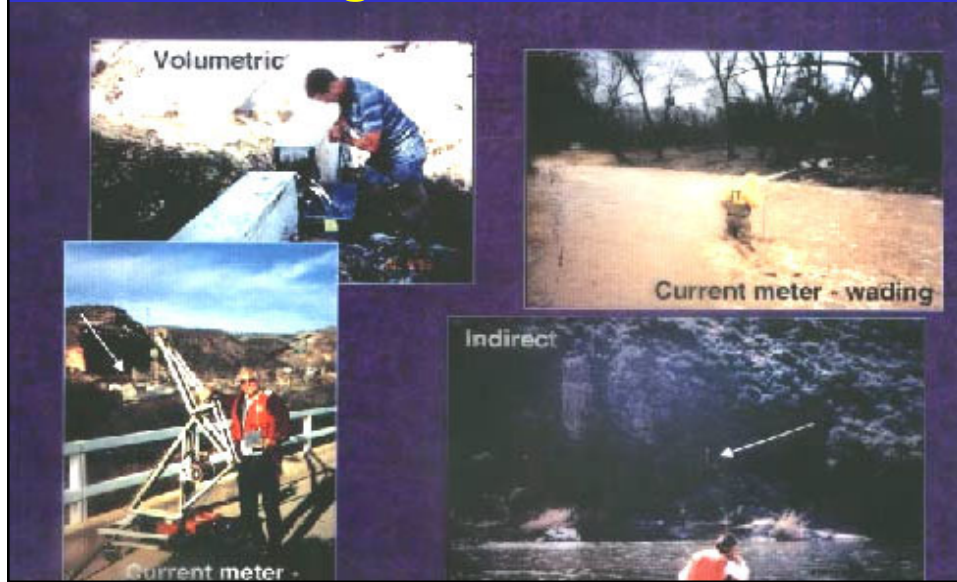
**V** = Velocity

**A** = Area

$$Q = \int_{\vec{A}} \vec{V} \cdot d\vec{A}$$

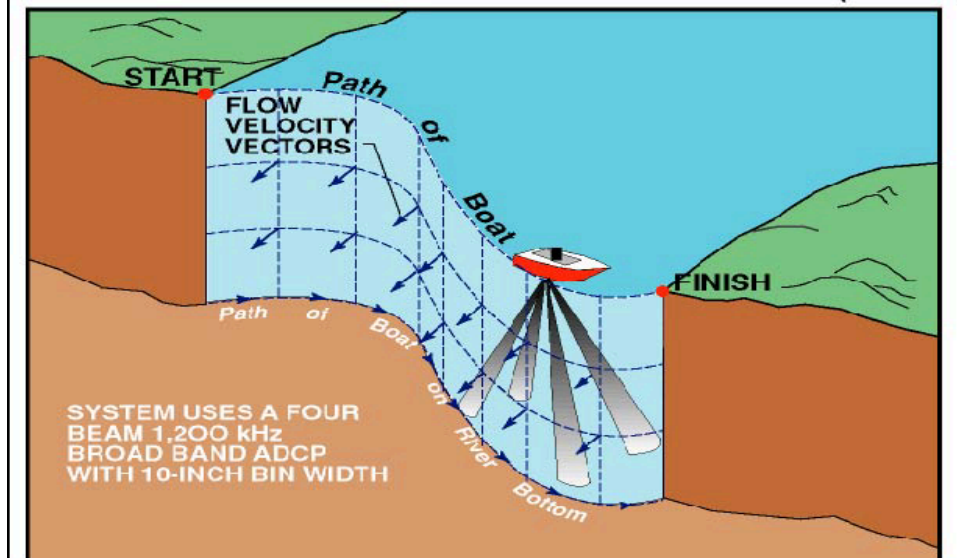


## Commonly Used Methods for Discharge Measurements



## Other Contact Methods for River Discharge Measurement

ACOUSTIC DOPPLER DISCHARGE MEASURING SYSTEM (ADDMS)

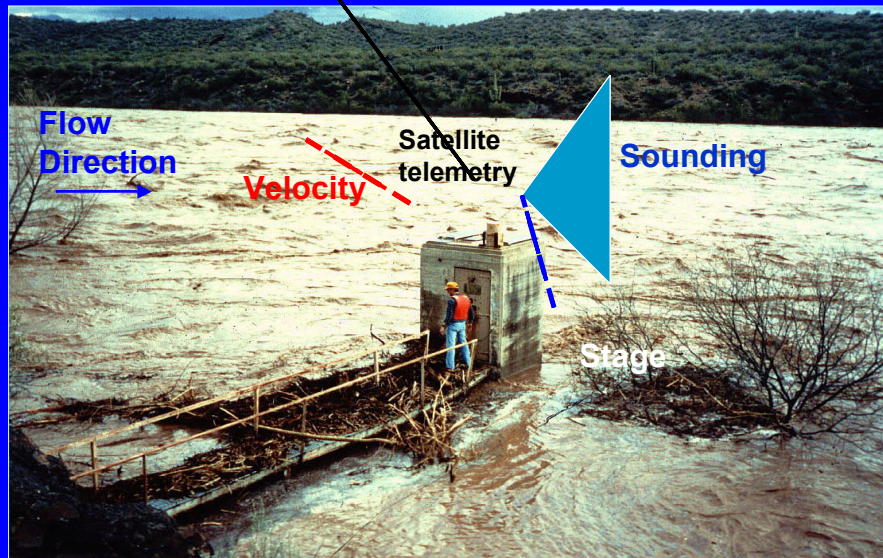


## Need for Non-Contact Methods

- Extensive labor, travel, maintenance
- Potential hazards to people
- Changing stage-discharge relationships
- Lost data during floods



## Non-Contact Measurement of River Discharge



## **USGS Uses of Contact GPR Methods**

- **Lake and river sediment studies**
- **Bridge scour studies**
- **Groundwater investigations**
- **Dam removal studies**
- **Contamination studies**

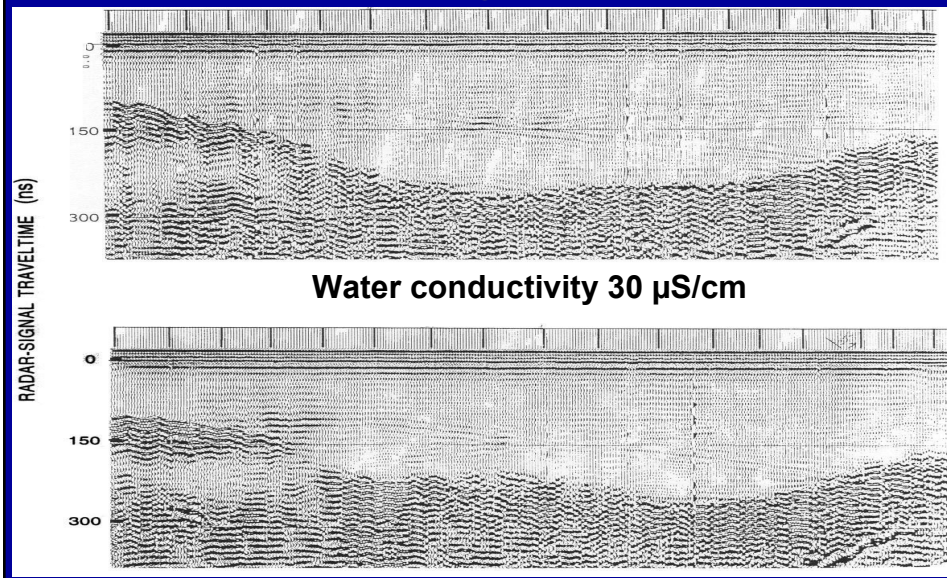


## **Early USGS Non-Contact GPR River Work**

- **Scour measurements from bridges**
  - Failed
- **Water depths from cable cars**
  - Succeeded

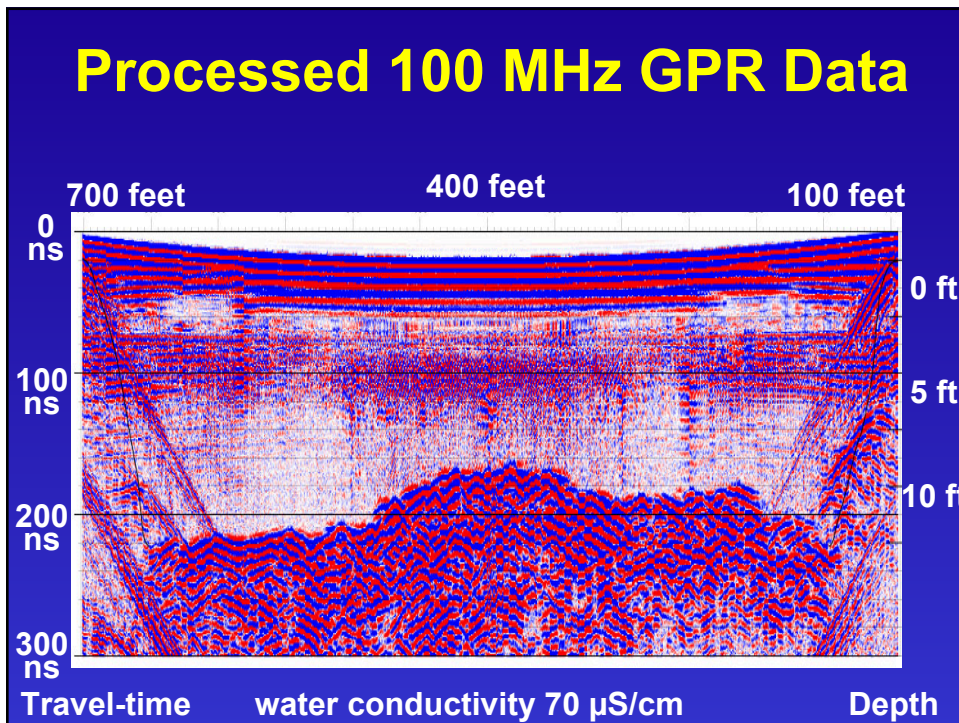


## Channel Bottom from Cable Car, Muddy River WA



## 1999 Proof of Concept Experiment Skagit River WA

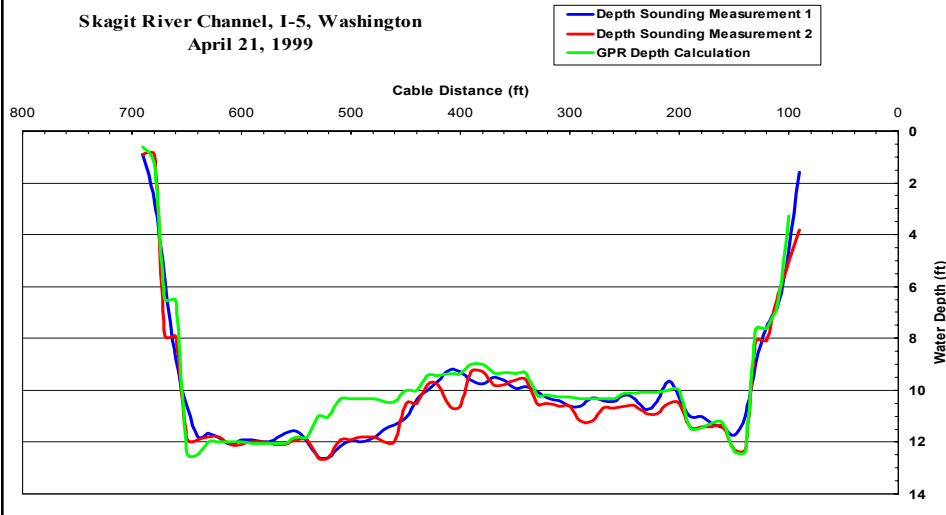
- River bottom
  - 100 MHz GPR from cable car
- Surface velocity
  - 10 GHz from stream bank
- Ground truth data
  - Standard contact methods



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## Comparison of Depth Sounding and GPR Measurement

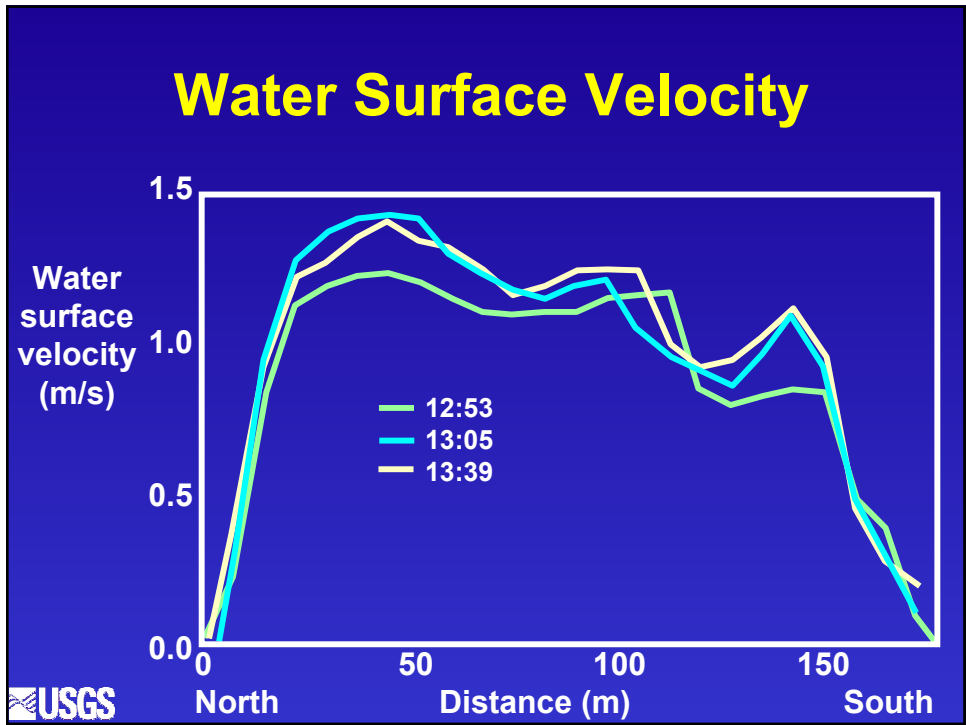
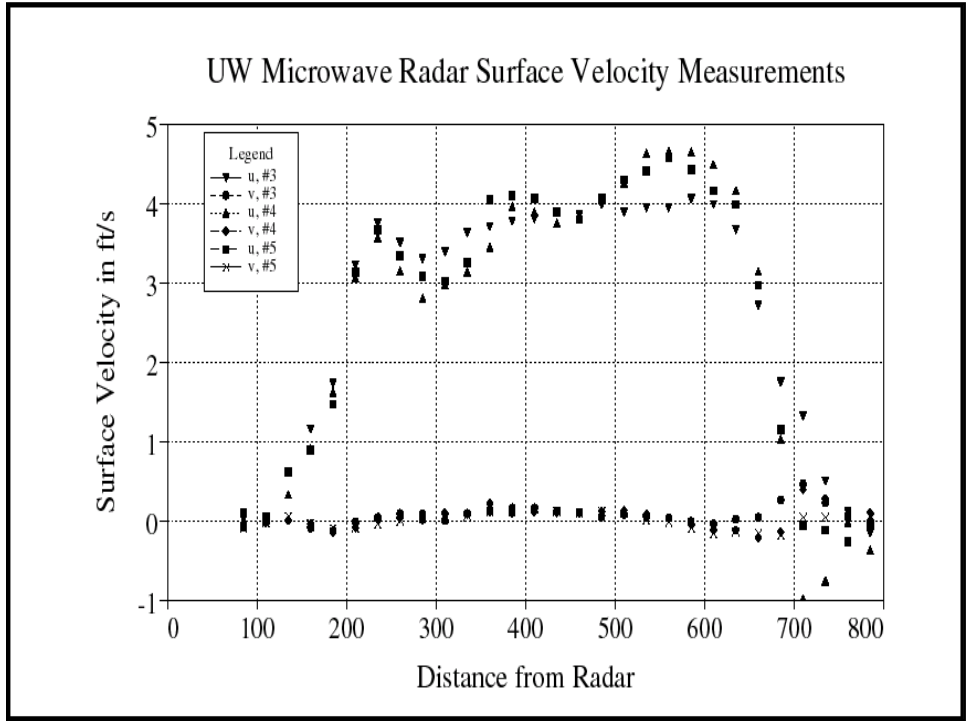
Skagit River Channel, I-5, Washington  
April 21, 1999



## 10 GHz Surface Velocity Radar System



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## Experimental Results

Conventional method	18.6 kcfs
Stage-discharge rating curve	18.2 kcfs
ADCP discharge measurement	18.3 kcfs
Non-contact discharge measurement	18.0 kcfs



## New Experiments

Two small contracts awarded

- **METRATEK**

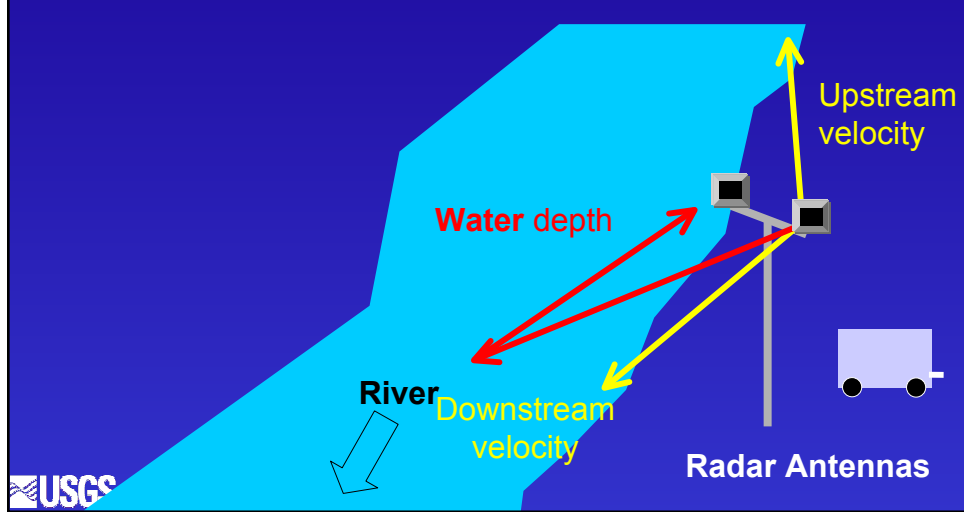
Transmitter and receiver on same side of river

- **CODAR**

Transmitter and receiver on opposite banks of river

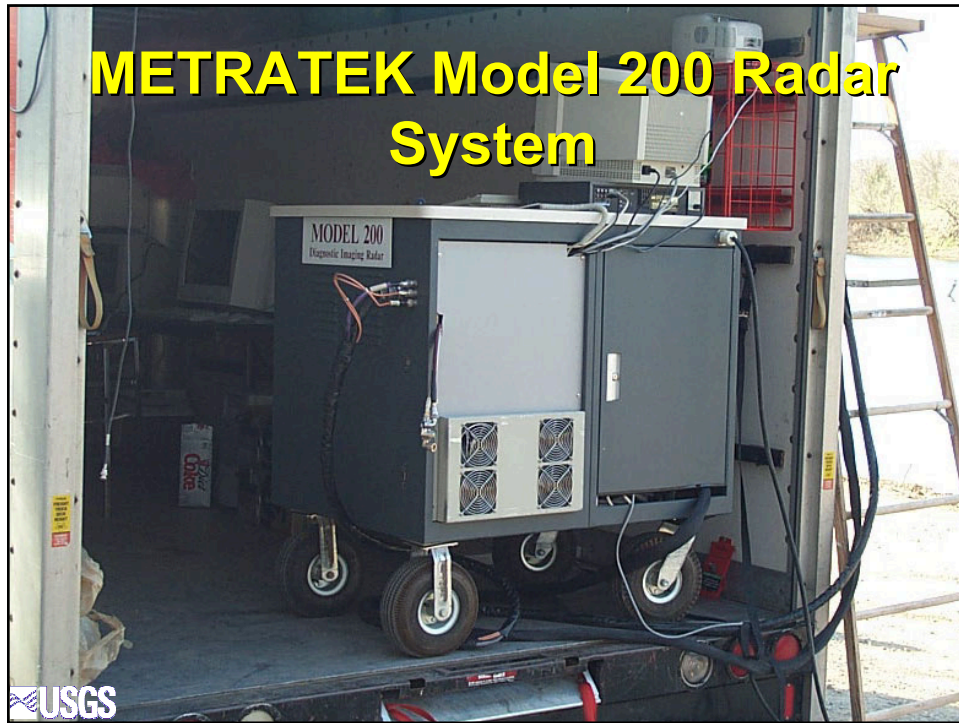


# METRATEK Experiment, South Fork Shenandoah River VA



## METRATEK System





## **METRATEK Model 200 Radar System**

- 100 MHz — 1 GHz
- Swept or pulsed output
- Variable power



## Ground Truth Data

### Surface Velocity Measurements

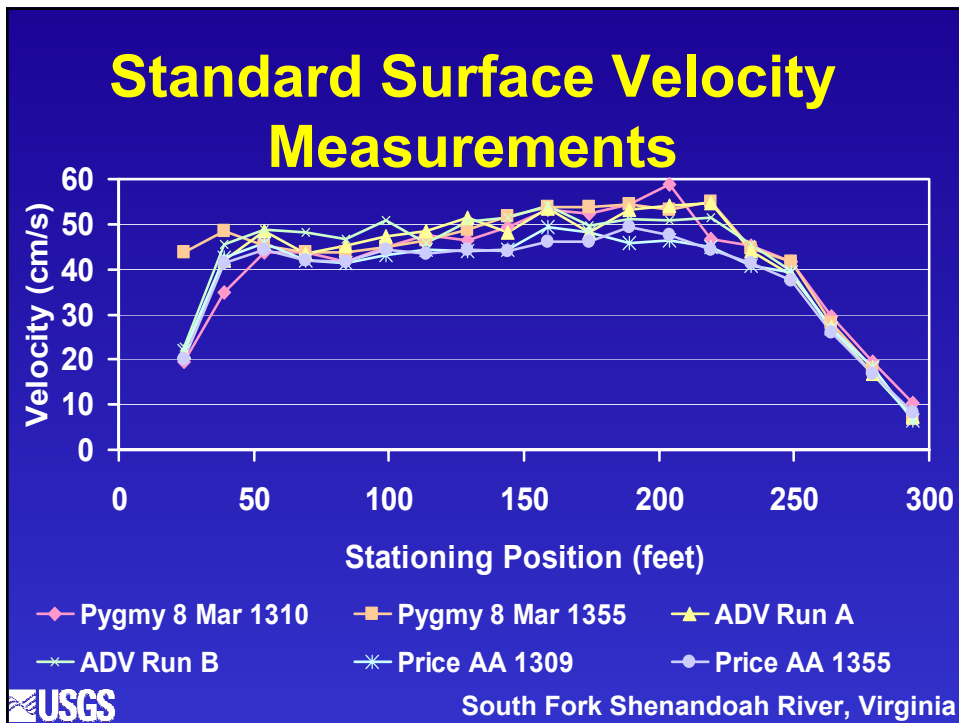
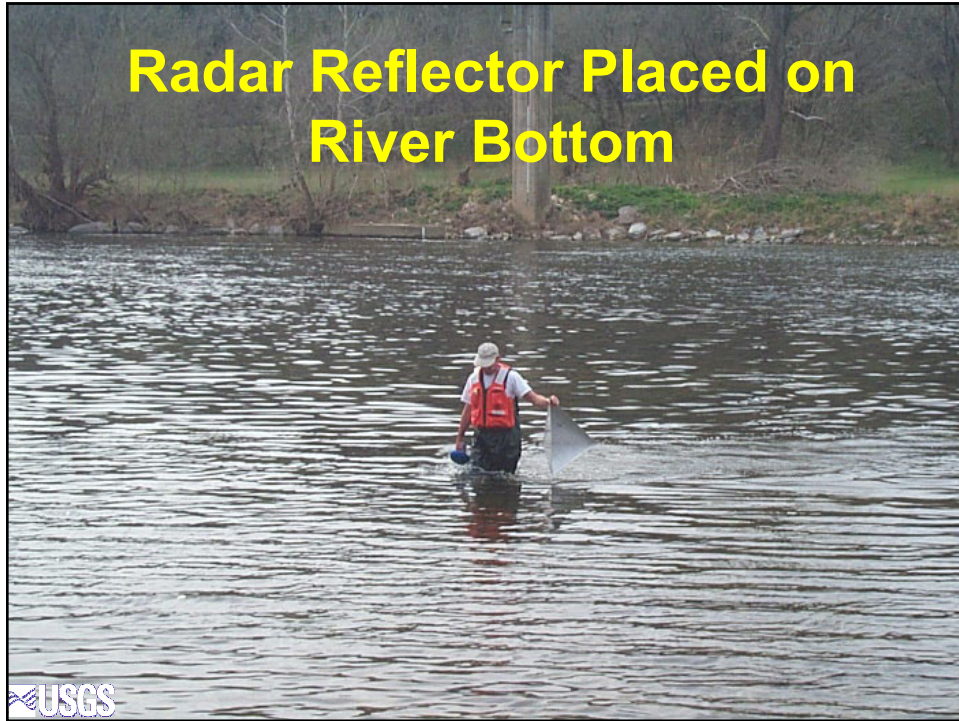
- Acoustic Doppler velocity (ADV)
- Pygmy meter
- Floats

### Discharge Measurement

- Standard Method

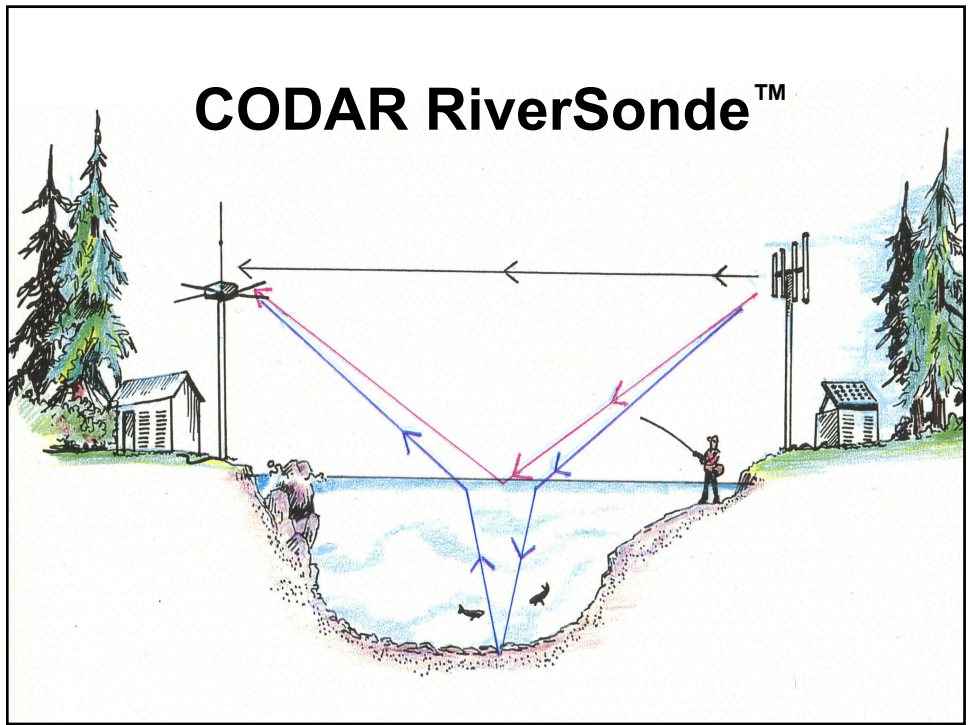
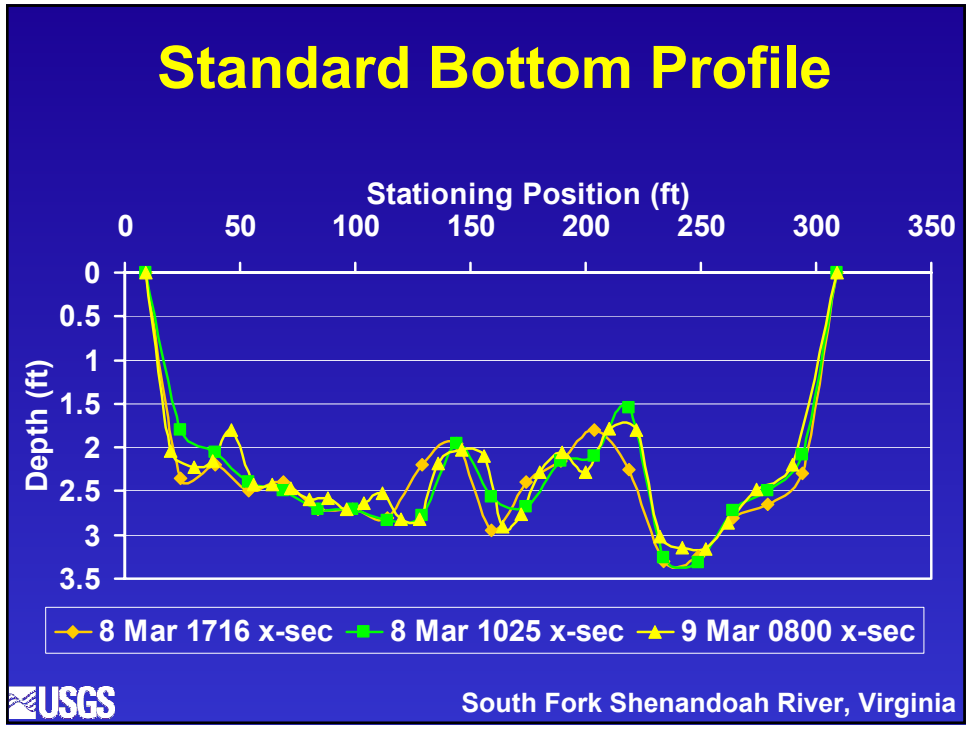
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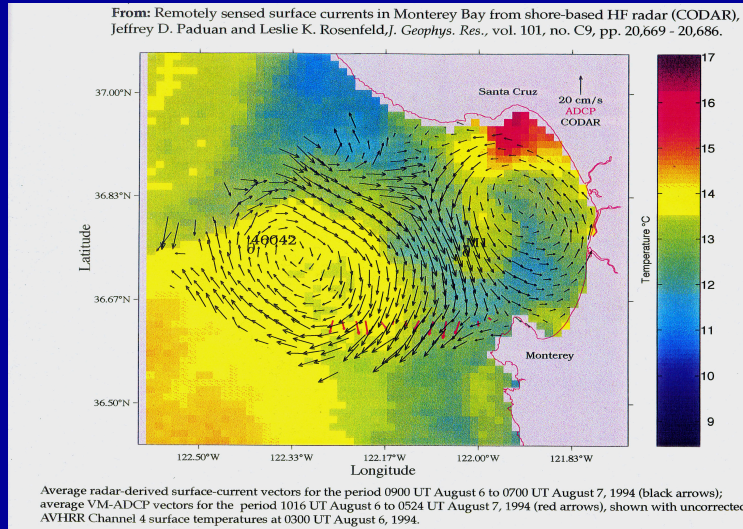


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# Standard Bottom Profile



## Ocean Surface Velocities Monterey Bay CA



## CODAR Field Experiment

- Delta-Mendota Canal, Tracy CA
- American River, Sacramento CA





## Conclusions

**Non-contact river discharge proof of concept experiment was successful**

- **Radar antennas on one bank**
  - Surface velocity measured
  - Depth to bottom questionable
- **Radar antennas on opposite banks**
  - Work in progress



## Website

<http://or.water.usgs.gov/hydro21/>

