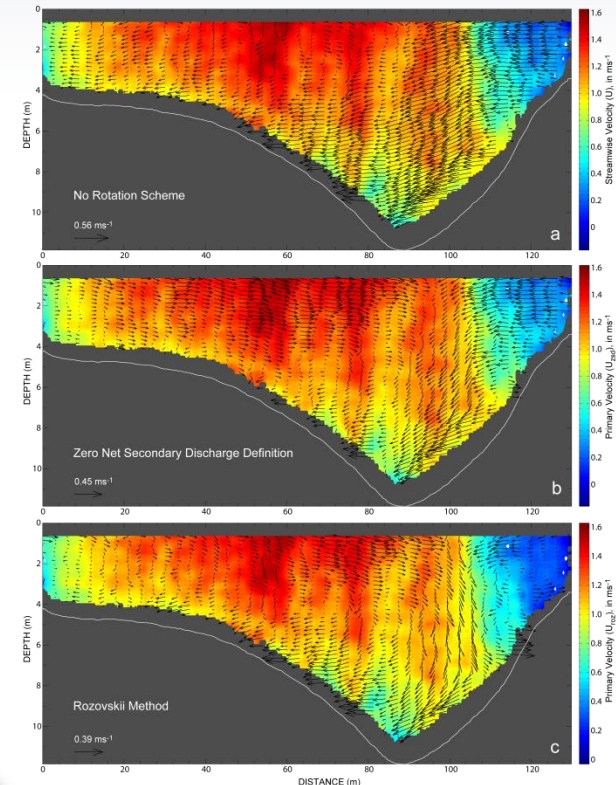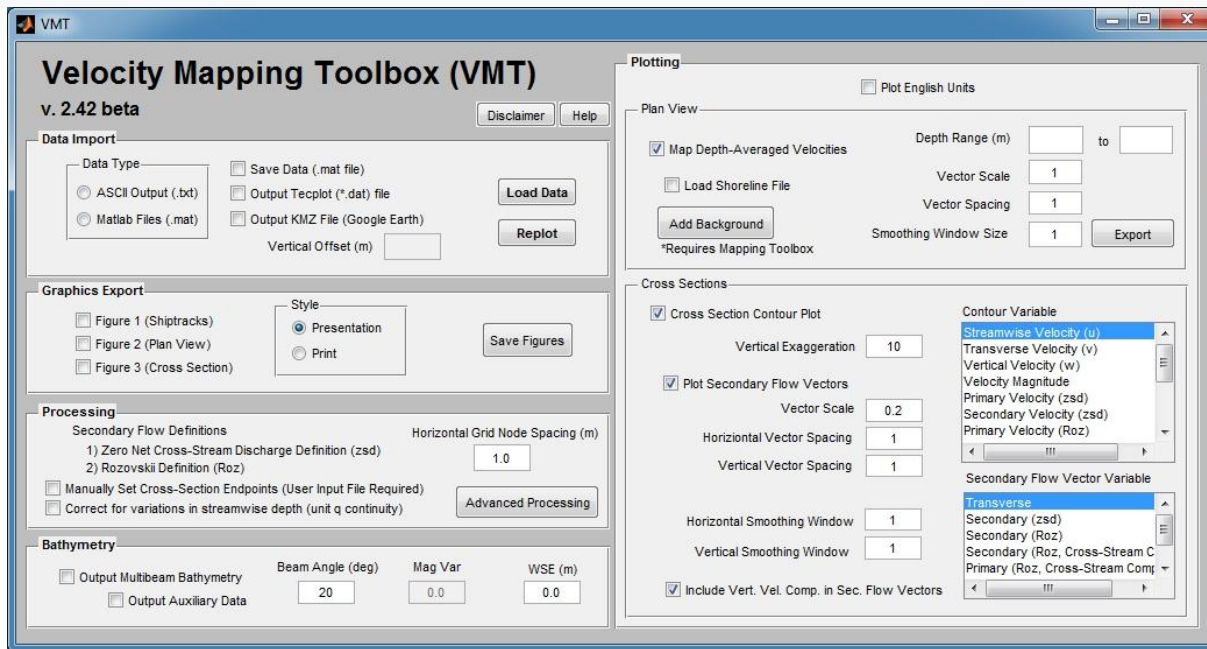# Velocity Mapping Toolbox (VMT)

Background and Applications

Overview of VMT

- **Matlab-based ADCP Data Processing and Visualization Code (GUI)**
  - Most appropriate for data collected with multiple transects at a single cross section and good positional control

- **Reads ASCII output files from WinRiver II**

  - GPS required
  - Averages multiple transects at a single cross section

- **Data Processing and Visualization**

  - Computes a mean velocity field for a given cross section
  - Computes velocity components
    - V_{north} and V_{east}, $V_{streamwise}$ and $V_{Transverse}$, & $V_{primary}$ and $V_{secondary}$ (and vertical)
  - Contour plots can be constructed for numerous variables (including backscatter)
    - secondary and vertical flow vectors can be overlaid
  - Plan view plots show depth or layer-averaged velocities (for one or more cross sections)
  - Additional standalone utilities provide further processing capabilities

Contributors to VMT

Primary Developers:

- **Dan Parsons (Univ. of Hull, UK)**
- **Jon Czuba (USGS Washington WSC)**
- **Ryan Jackson (USGS Illinois WSC)**
- **Dave Mueller (USGS OSW)**
- **Frank Engel (University of Illinois)**

Input and support from:

- **Kevin Oberg (USGS OSW)**
- **Kevin Johnson (USGS Illinois WSC)**
- **Bruce Rhodes (University of Illinois)**
- **Jim Best (University of Illinois)**
- **Marcelo Garcia (University of Illinois)**
- **Jim Riley (Eastern Illinois University)**
- **Ricardo Szupiany (Universidad Nacional del Litoral, Argentina)**
- **And many others!**
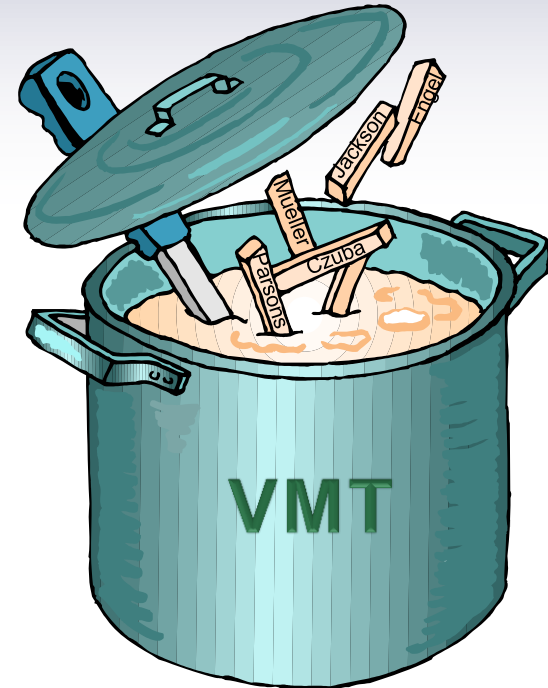
Evolution of VMT

- **Basic Matlab code developed by Dan Parsons (Univ. of Hull, UK)**
    - **Transect averaging**
    - **Secondary flow computation**
    - **Site specific**
- **Further developed by Jon Czuba (USGS ILWSC) for application to data from the St. Clair River**
    - **Refinement of original code**
    - **Modified to accept ASCII output data (TRDI)**
    - **Added basic spatial averaging and visualization**

Hydro Acoustics ≋USGS

Evolution of VMT

- **Code compiled and generalized by R. Jackson to create VMT**
  - **No longer site specific**
  - **Developed GUI interface**
  - **Further refined computations and visualization**
  - **Added layer averaging capability**
  - **Added output export capabilities**
  - **Added bathymetry export option**
  - **Added shear velocity, bed shear stress, and longitudinal dispersion coefficient computations (currently being evaluated)**

Additions by Users

- **Added Rozovskii definition for secondary flow computations (F. Engel, U of I)**

- **Added Tecplot output option (F. Engel, U of I)**

- **Recent additions (under evaluation)**

  - **Added processing option for data without GPS (F. Engel, U of I)**

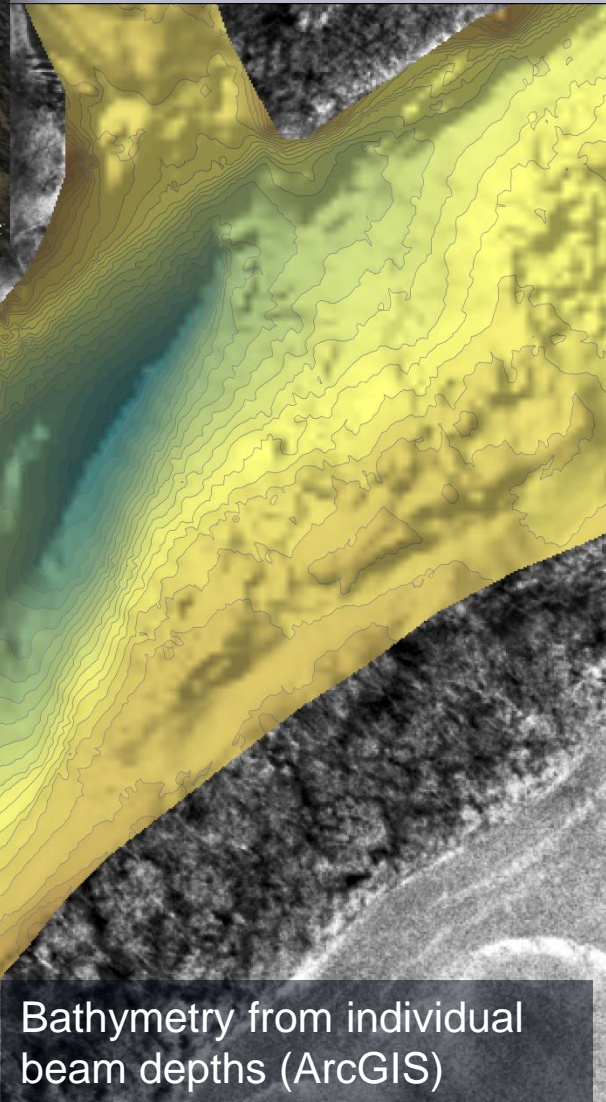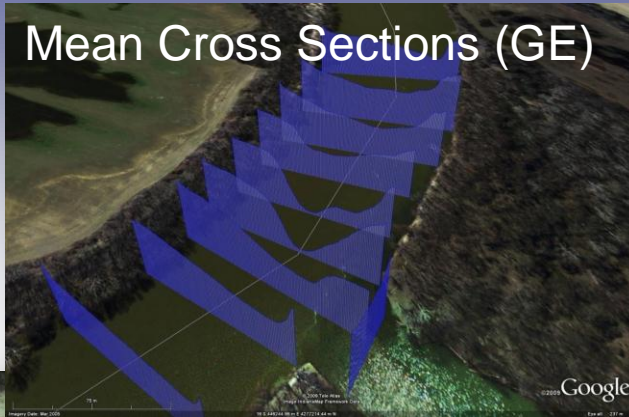 - **Added vorticity computation (F. Engel, U of I)**

Applications of VMT

- Morphodynamics of large river meanders
- Wabash River cutoff study
- Fluvial dynamics of stream confluences
- Yorkville Dam bypass evaluation
- Arkansas River flow reversal evaluation
- Umpqua River outfall mapping
- Lake circulation studies
- Real-time Dye/Contaminant tracking
- Evaluation of Lake Michigan Tributaries for Asian Carp Spawning
- Evaluation of flows in Great Lakes connecting channels (St. Clair, St. Lawrence)
- Circulation and mixing in nearshore Lake Erie and Lake Michigan

- Milwaukee Harbor mixing study
- Evaluation of flow structure in the Lower Congo River and Parana River
- CSSC/Des Plaines River fractured rock hydraulic connection evaluation
- Flow monitoring for Asian Carp eDNA sampling
- Mapping of density currents in the Chicago Sanitary and Ship Canal and Chicago River
- Evaluation of flow structure and secondary flows at index velocity gages
- Fluvial dynamics and hydrodynamics in large rivers
- Pier scour
- Secondary flows in a large submarine bend

Hydro Acoustics
≋USGS

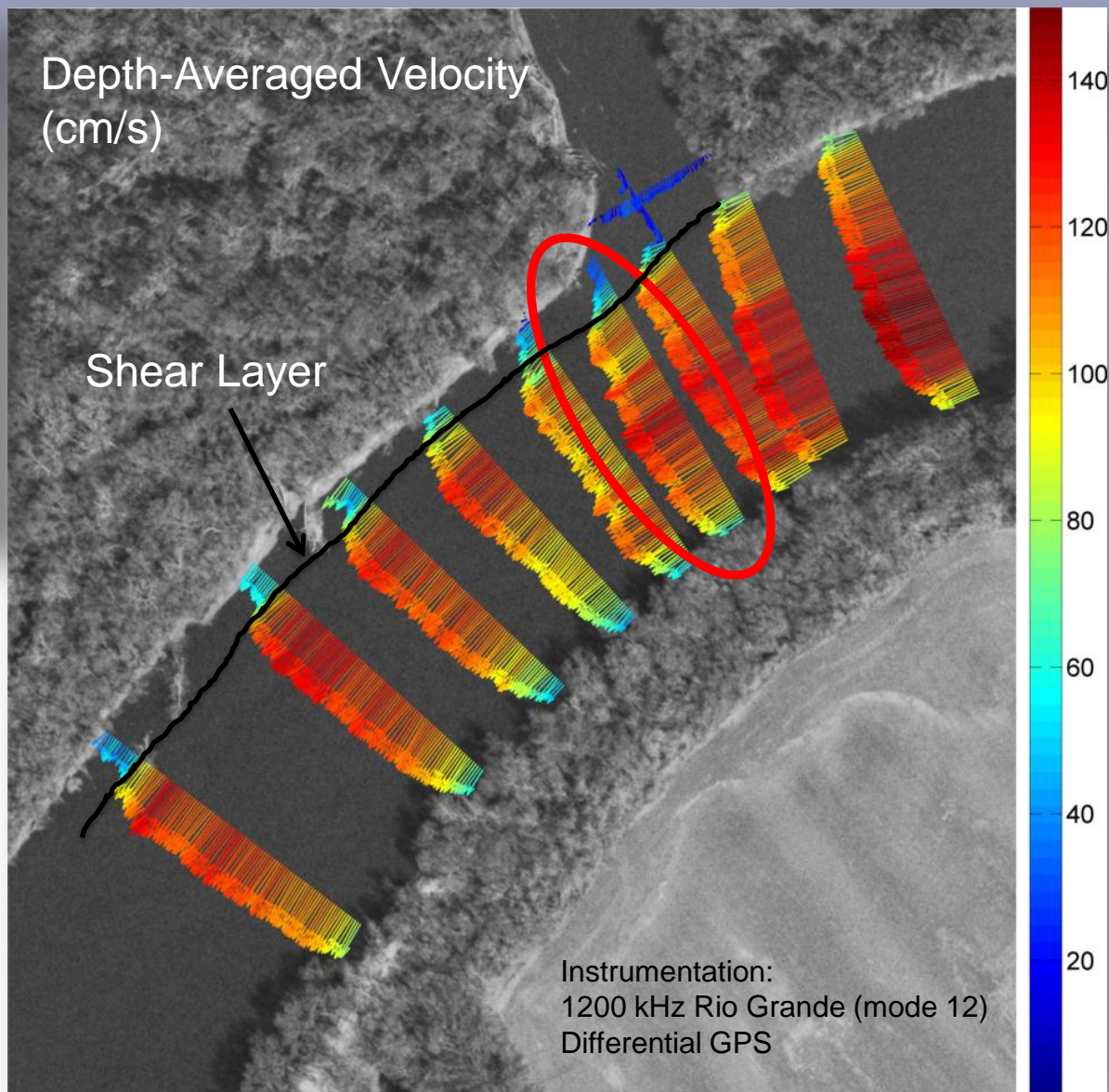# Example #1: Wabash-Embarras Confluence

Mean Cross Sections (GE)

Shiptracks
(ASC2KML)

VMT Extensions
•Google Earth export tool
•Bathymetry export tool
•GIS export tool (ASCII2GIS)

Bathymetry from individual
beam depths (ArcGIS)

HydroAcoustics
≋USGS

Wabash-Embarras Velocity Structure

Depth-Averaged Velocity (cm/s)

Shear Layer
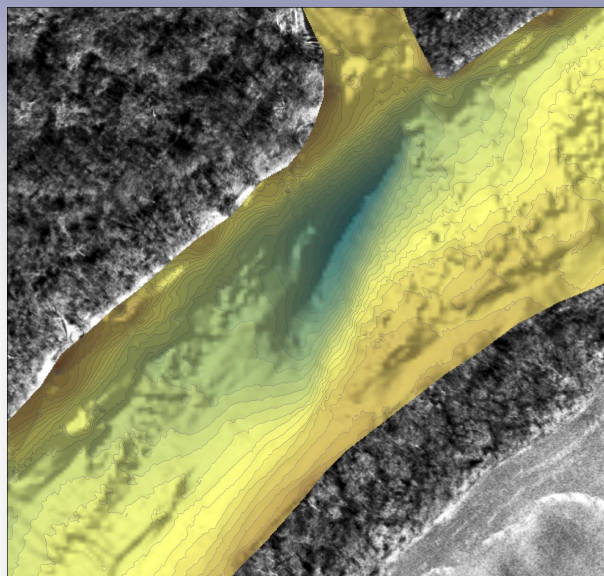
Can also layer-average between user-specified depths

Instrumentation:
1200 kHz Rio Grande (mode 12)
Differential GPS

Hydro Acoustics
USGS

Velocity Contour 1 - TRDI

Earth Velocity Magnitude (Ref: VTG) [m/s]
— River Depth — Top Q Depth — Bottom Q Depth

0.024   0.594   1.164   1.734   2.304

WinRiver II (single transect)

Acoustic Backscatter (db)
with Secondary Flow Vectors
(cm/s)

78 cm/s

VMT (4 transect average)
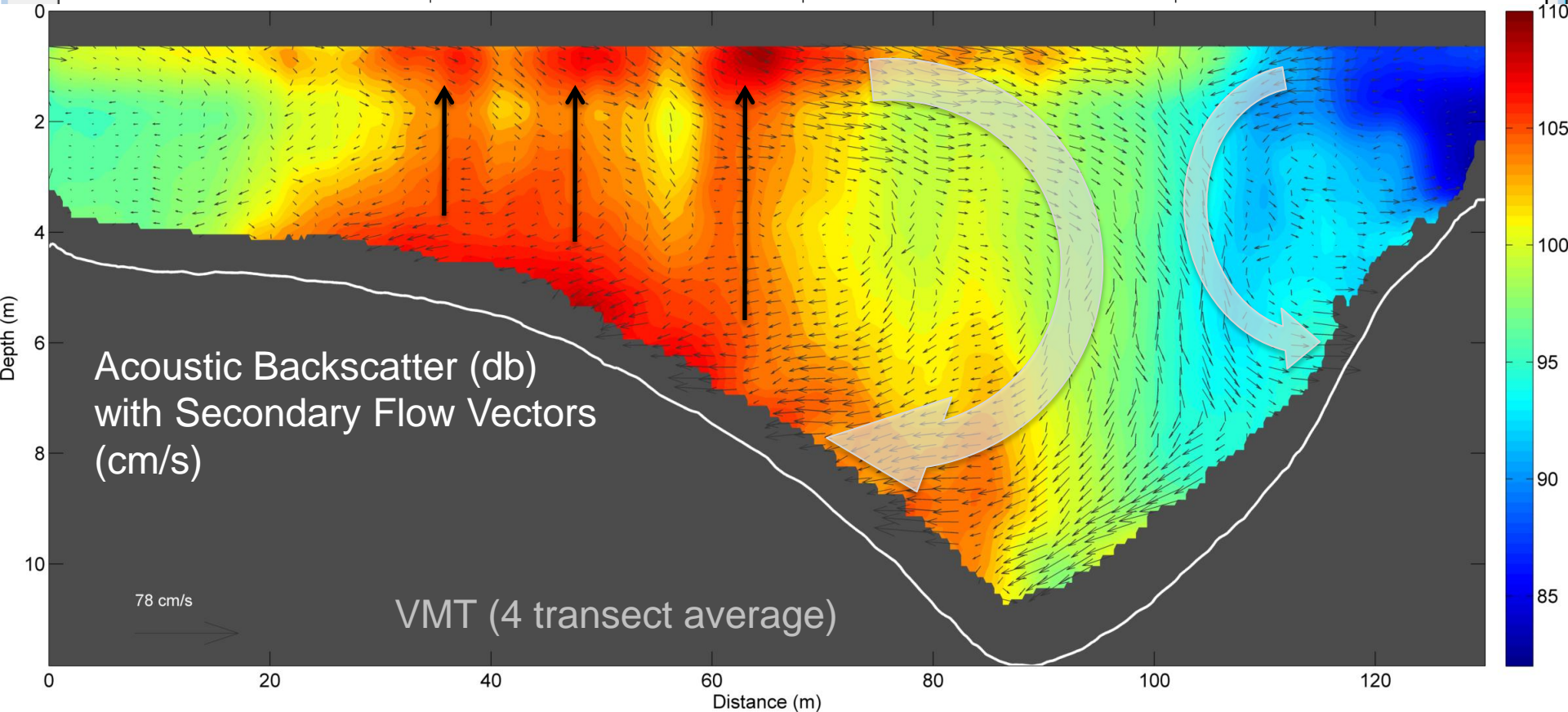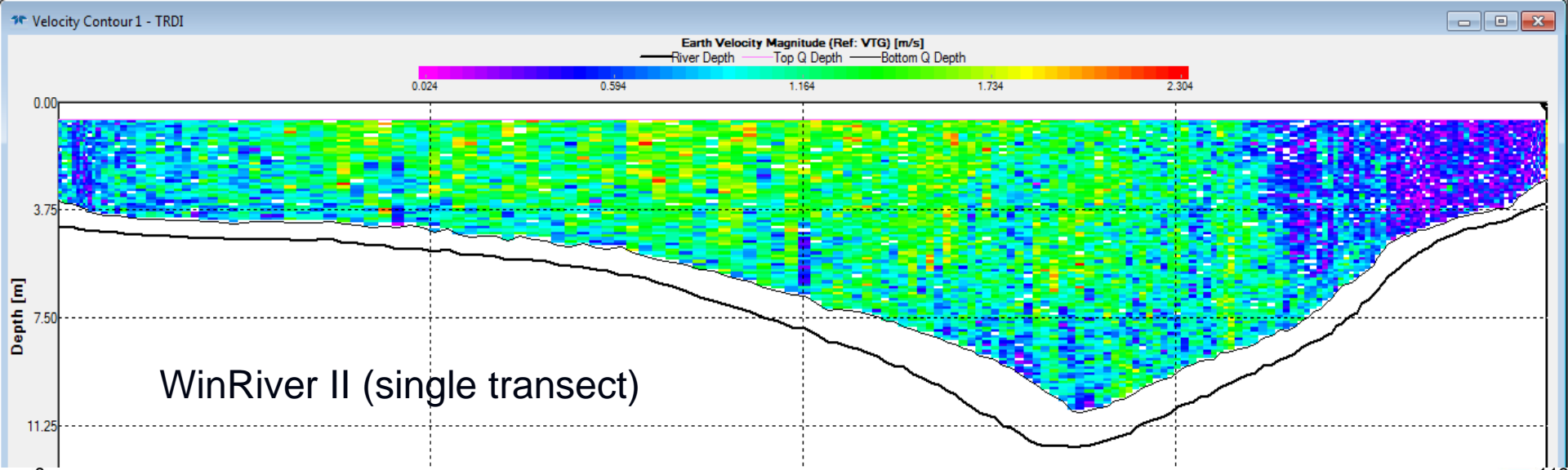
Example #2: Yorkville Bypass (Fox River, Illinois)

Legend:
- Discharge Measurements
- Velocity Distribution Measurements
- Low Flow Velocity Distribution Measurements with Open Culvert

Instrumentation: 1200 kHz Rio Grande ADCP StreampPro with Compass Differential GPS

Lower Challenge Waterway

Upper Challenge Waterway

Low Flow Augmentation Culvert

Overflow Weir

Bypass Entry and Stoplogs

Lower Moderate Waterway

Upper Moderate Waterway

Exhibit A

Depth-Averaged Velocities (ft/s)

Primary Velocity (Rozovskii Definition) (ft/s)
with secondary flow vectors (secondary_roz_y)
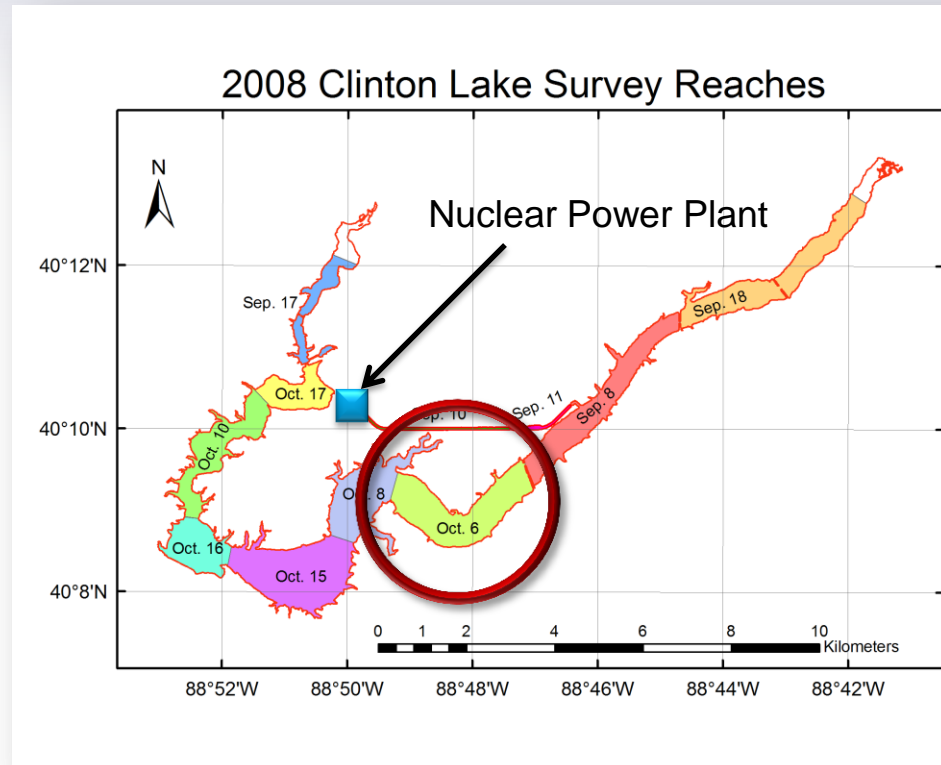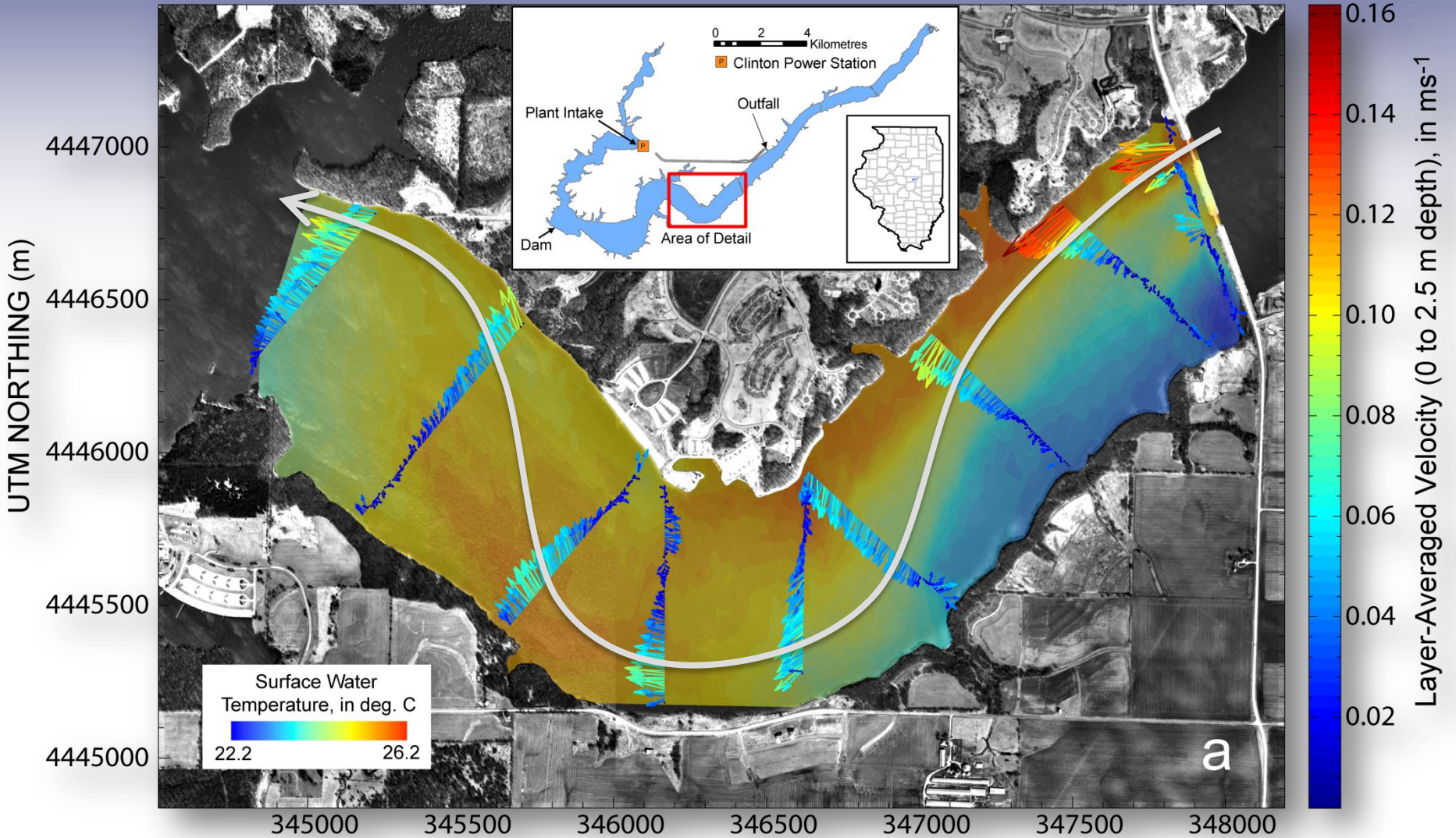
Example #3: Lake Circulation

Clinton Lake

- **5,000 acre cooling reservoir for a nuclear power plant**

- **2008 Integrated survey**
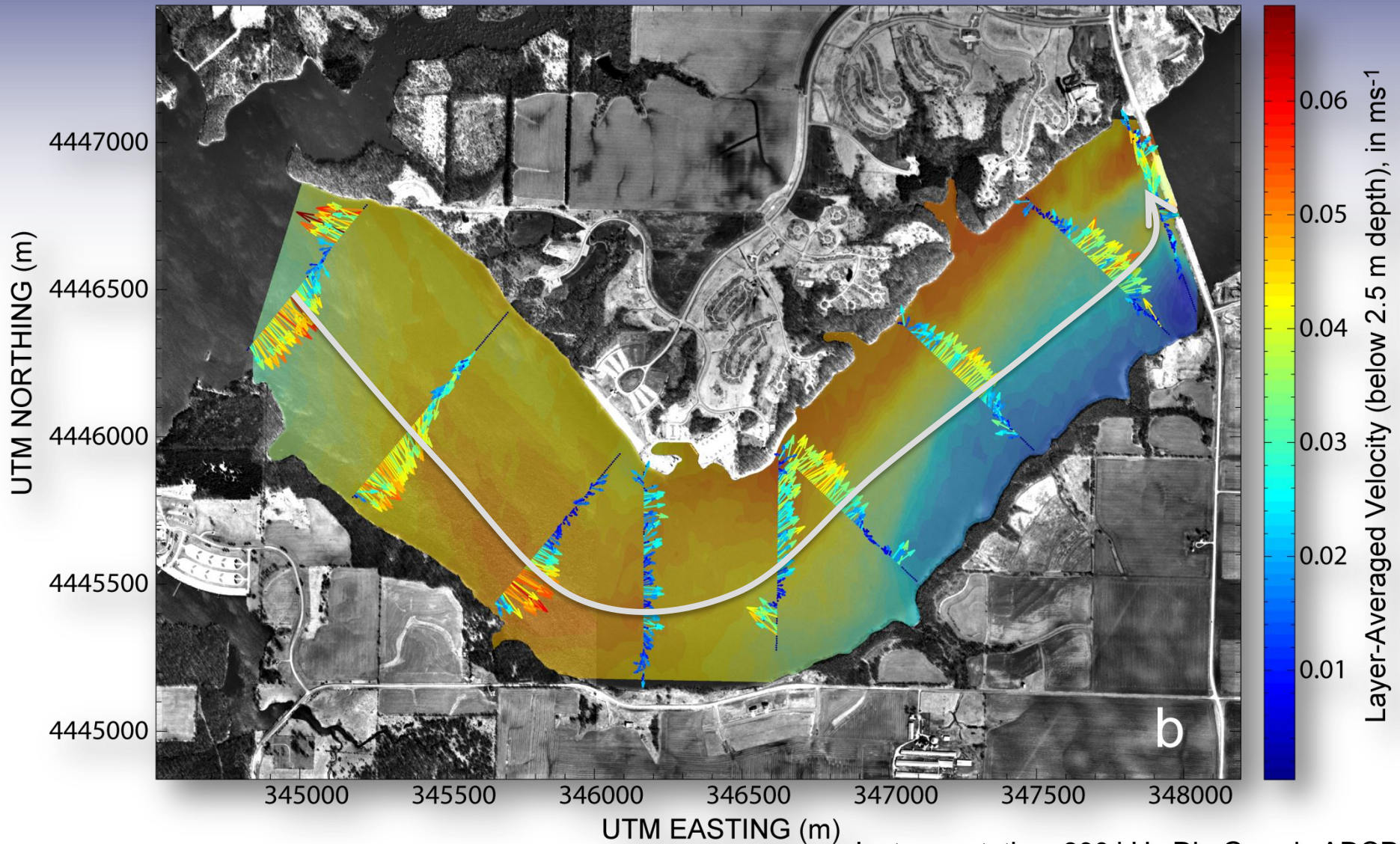 - **Bathymetry**
  - **Velocity**
  - **Temperature**

2008 Clinton Lake Survey Reaches

Nuclear Power Plant

HydroAcoustics
USGS

Clinton Lake (IL)

Instrumentation: 600 kHz Rio Grande ADCP
Mode 11
Differential GPS

Clinton Lake (IL)

Instrumentation: 600 kHz Rio Grande ADCP
Mode 11
Differential GPS

Questions?