Thermal profiling of focused groundwater discharge along a channelized stream in western Kentucky

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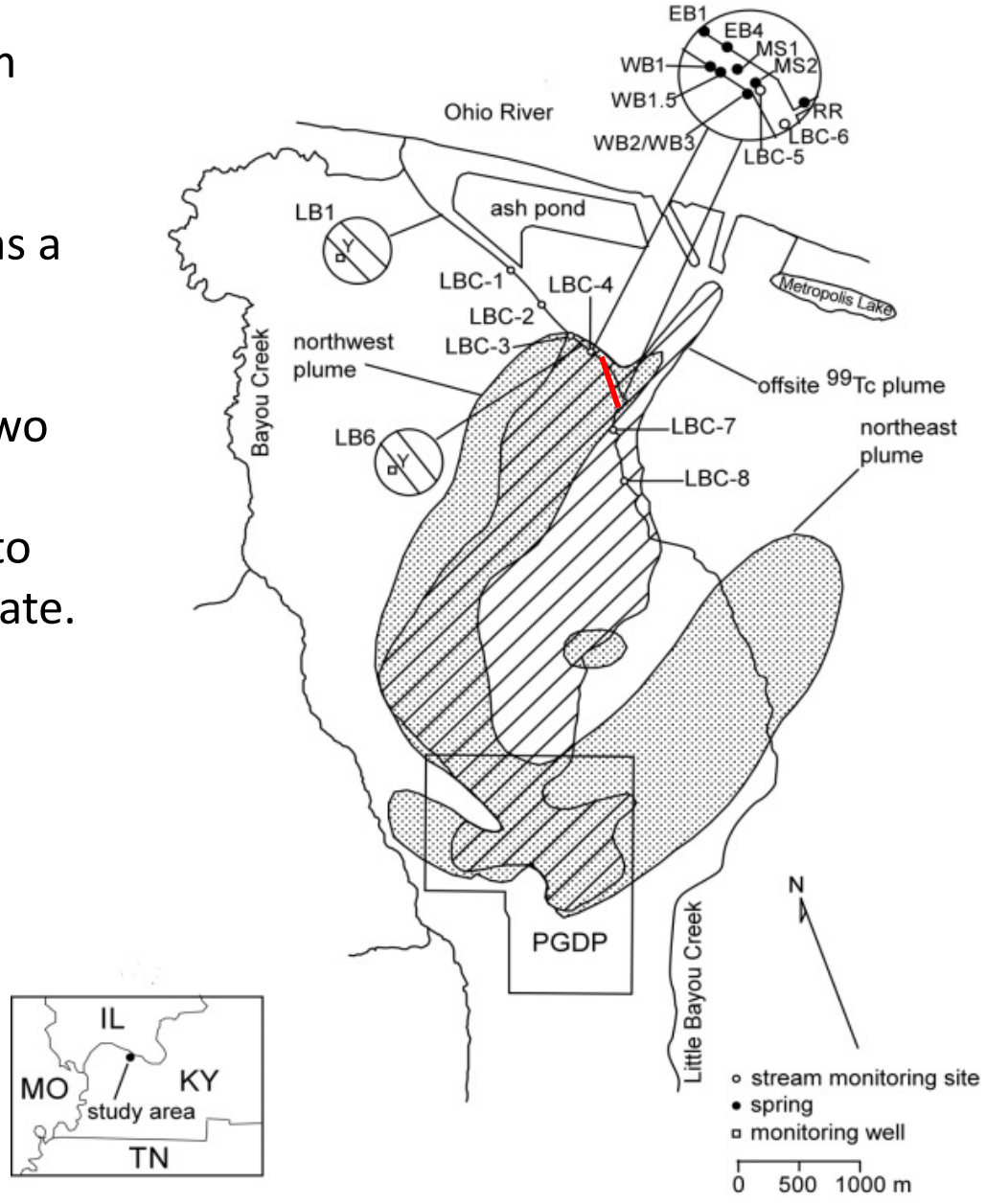
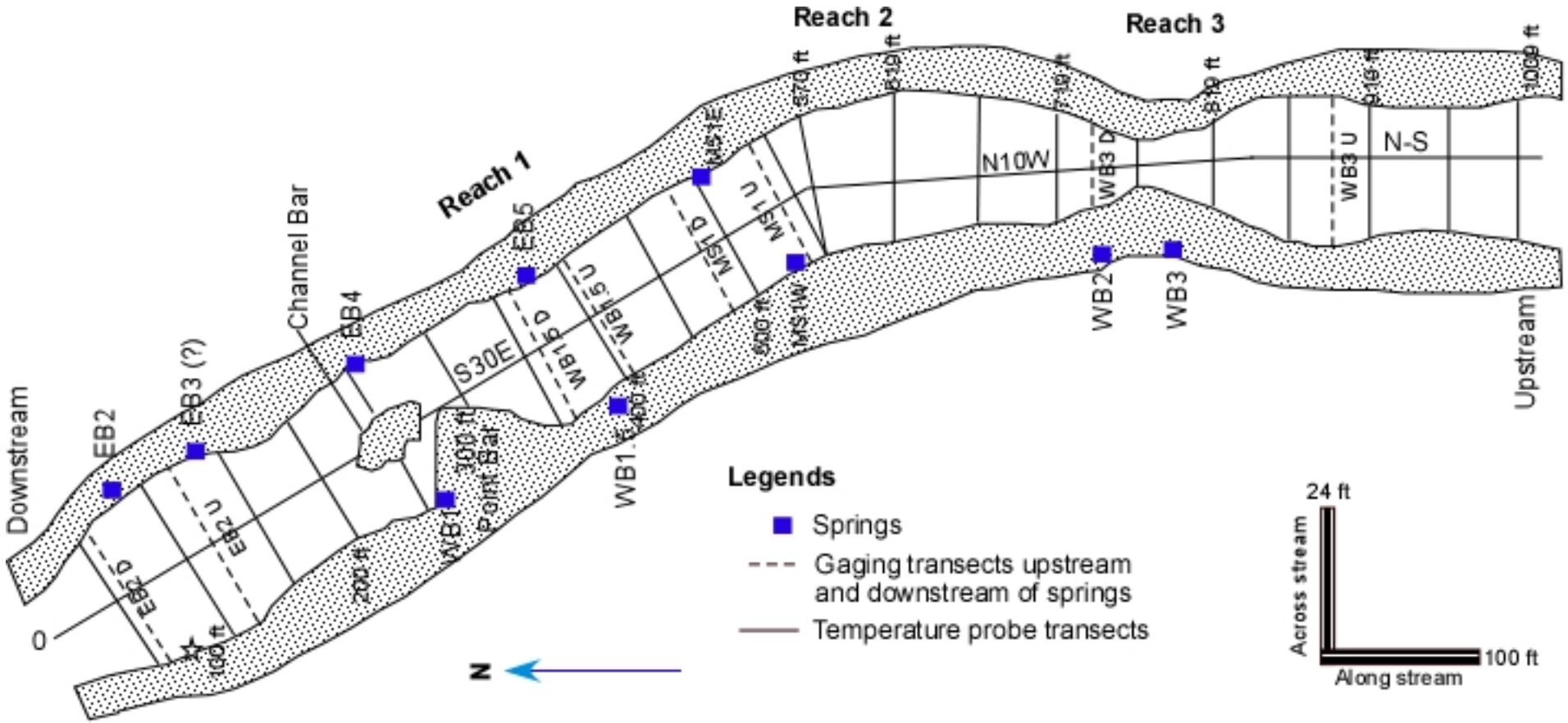
Background

- The proposed study reach of the stream has been contaminated by plumes of groundwater containing trichloroethene (TCE) and technetium-99 (^{99}Tc) released as a result of past activities at PGDP.

- Contaminated groundwater occurs in two main plumes (northeast and northwest), which were informally named according to the parts of PGDP from which they originate.

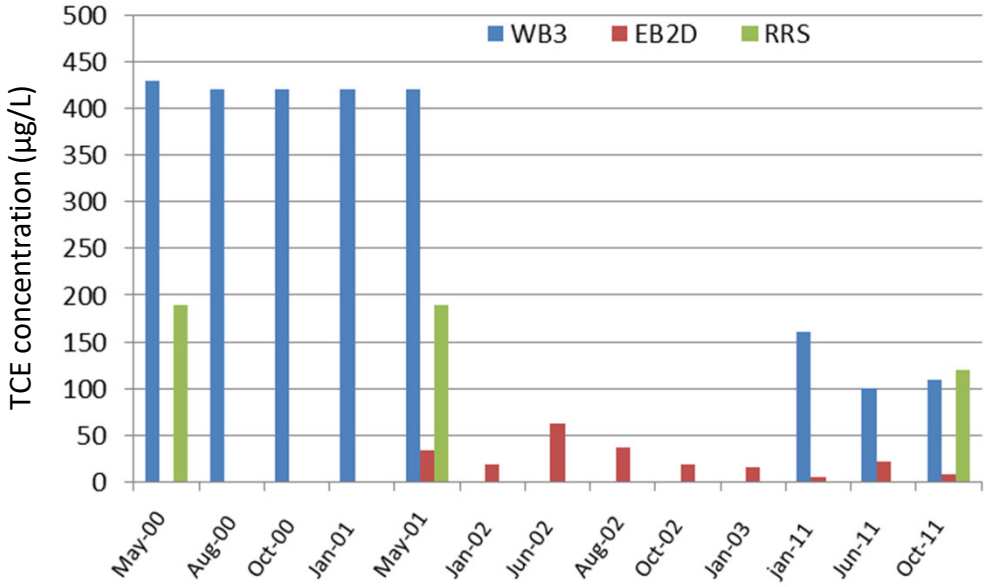




➢Springs along Little Bayou Creek intercept the northwest plume, thus partly "short-circuiting" flow of contaminated groundwater toward the Ohio River.

Background (contd.)

- Samples from springs and the stream were collected by LaSage et al. (2008b) from June 1999 through May 2001 for analysis of VOCs and ^{99}Tc.



- TCE and ^{99}Tc were detectable in surface water downstream of the springs and did not appear to be attenuated within the discharge zone.

Background (contd.)

- Contaminant concentrations progressively decreased from upstream springs to downstream springs
  - ➢ minimal evidence of reductive biodegradation and TCE sorption to stream bed sediments (LaSage et al., 2008b).
- Attenuation of TCE was primarily due to volatilization from the stream surface (Mukherjee et al., 2005).

Objectives

- Assess variability in groundwater discharge utilizing heat as a proxy to delineate groundwater discharge locations.

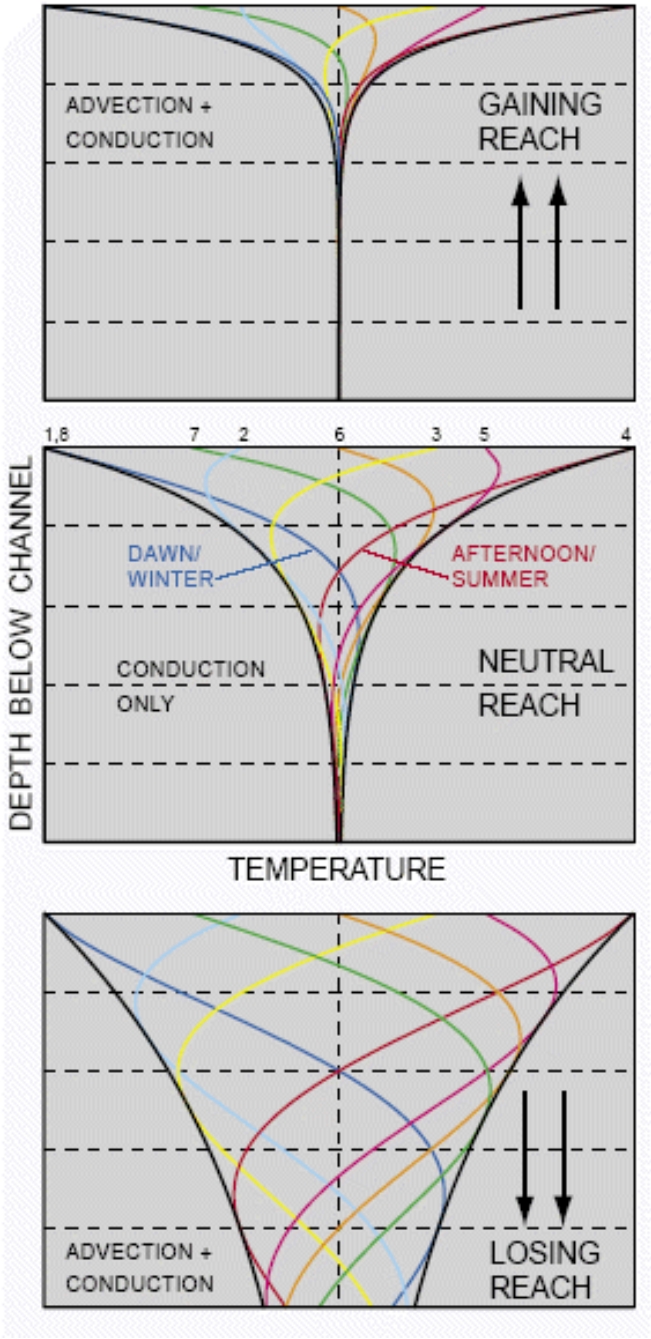
- Assess the spatial consistency in groundwater discharge locations on seasonal basis.

- Compare findings with previous studies conducted along the same reach (1999-2002) and assess the changes over time and space.

Method

Heat as a tracer

- In general, groundwater temperature remains constant year-round while stream temperature fluctuates seasonally.
- Heat exchange between surface and ground water takes place mainly by advection and conduction.
- Neutral reach transfers heat mainly by conduction while gaining and losing reaches exhibit both advective and conductive heat transport.



Stonestrom and Constantz, 2004

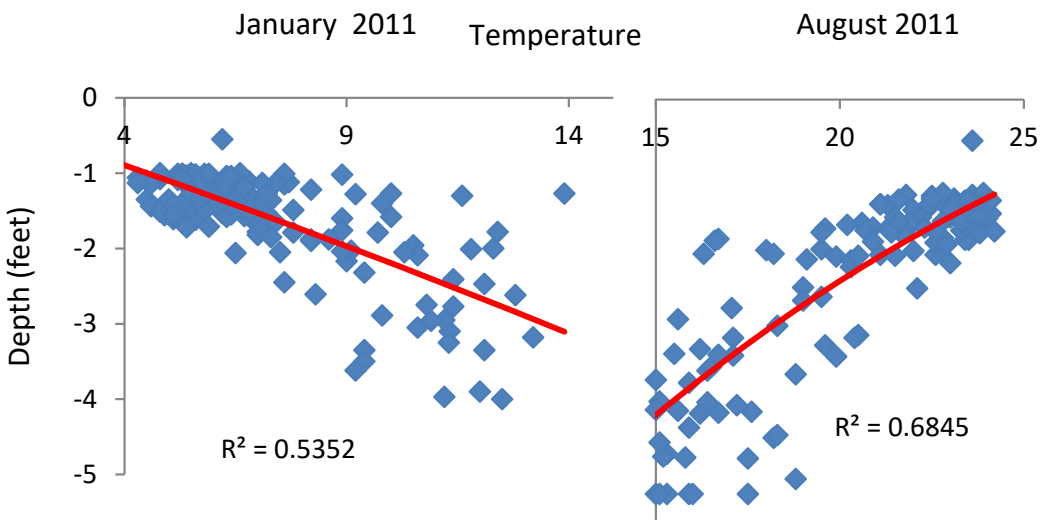
Temperature probing

Stream bed temperatures have been measured:

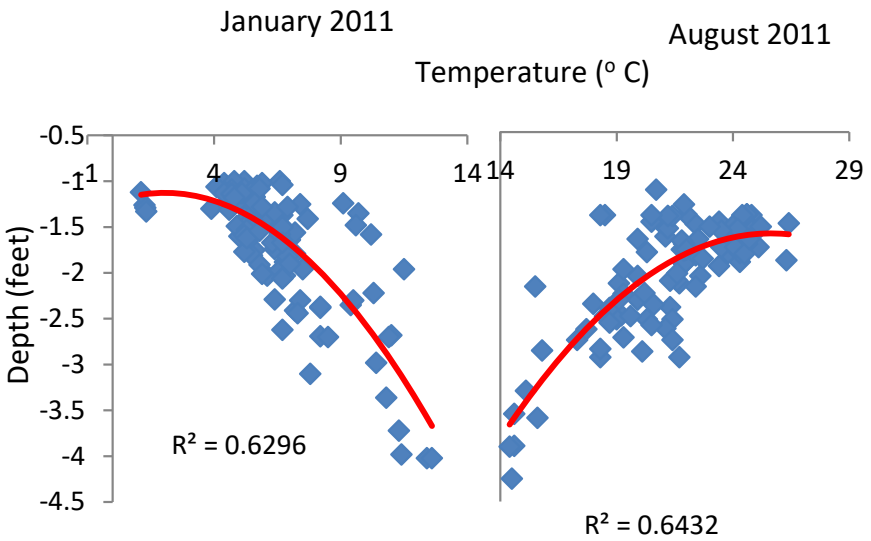
- along transects at intervals of 10 feet along the stream and 3 feet across the stream
- at the top of the stream bed and at refusal depth by inserting 4-foot stainless steel probe
- resolution = 0.01^{o}C

Probe depth and temperature

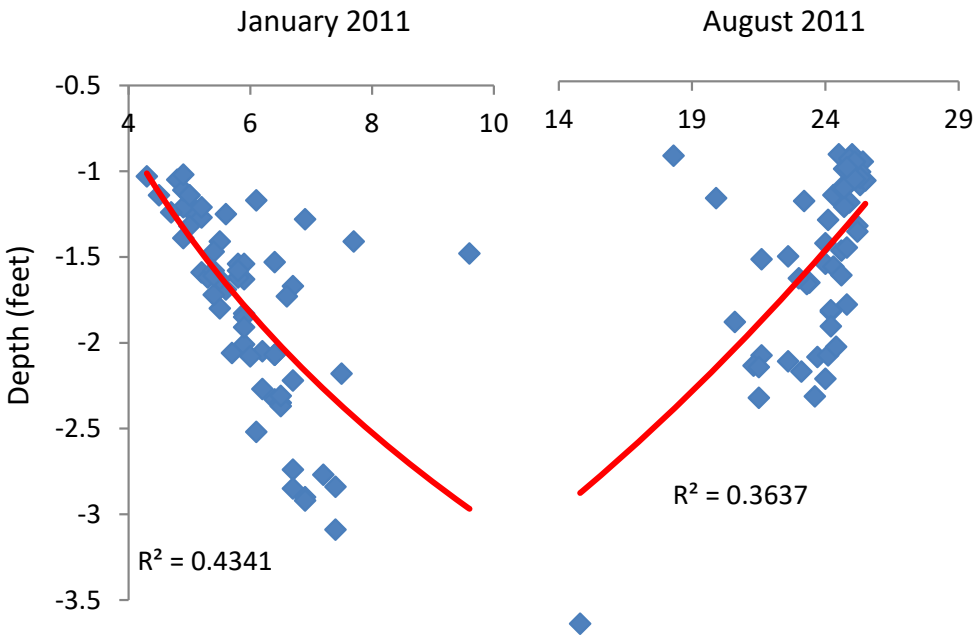
Reach 1



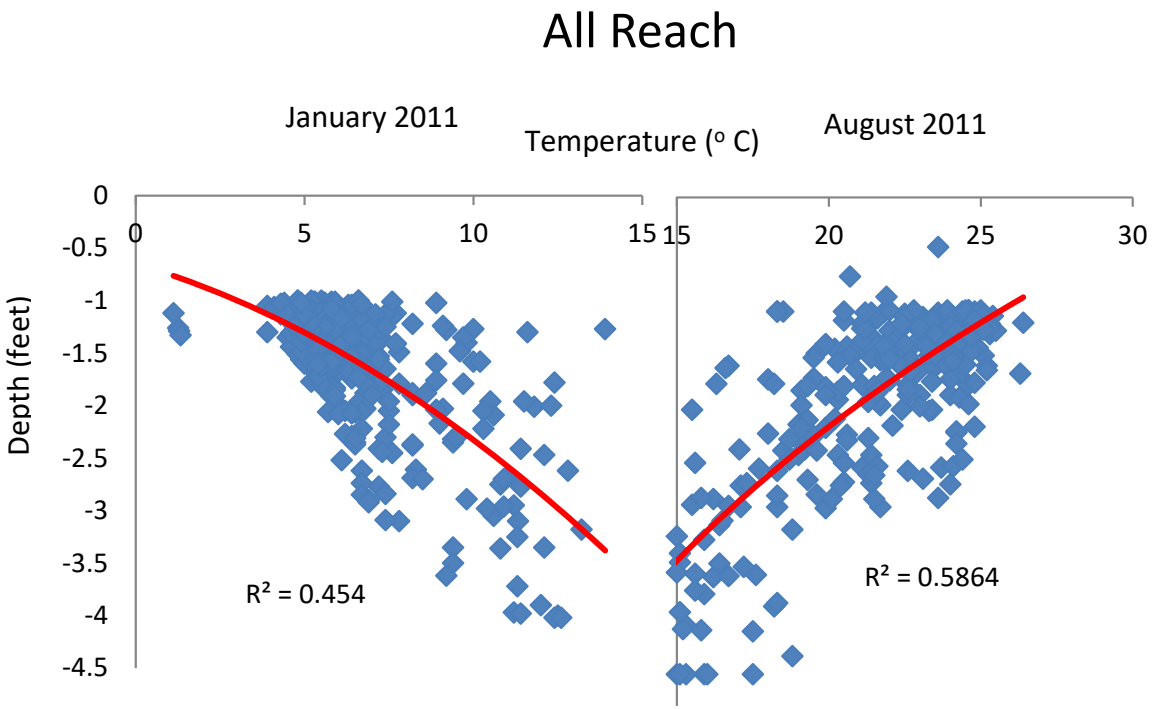
Reach 2

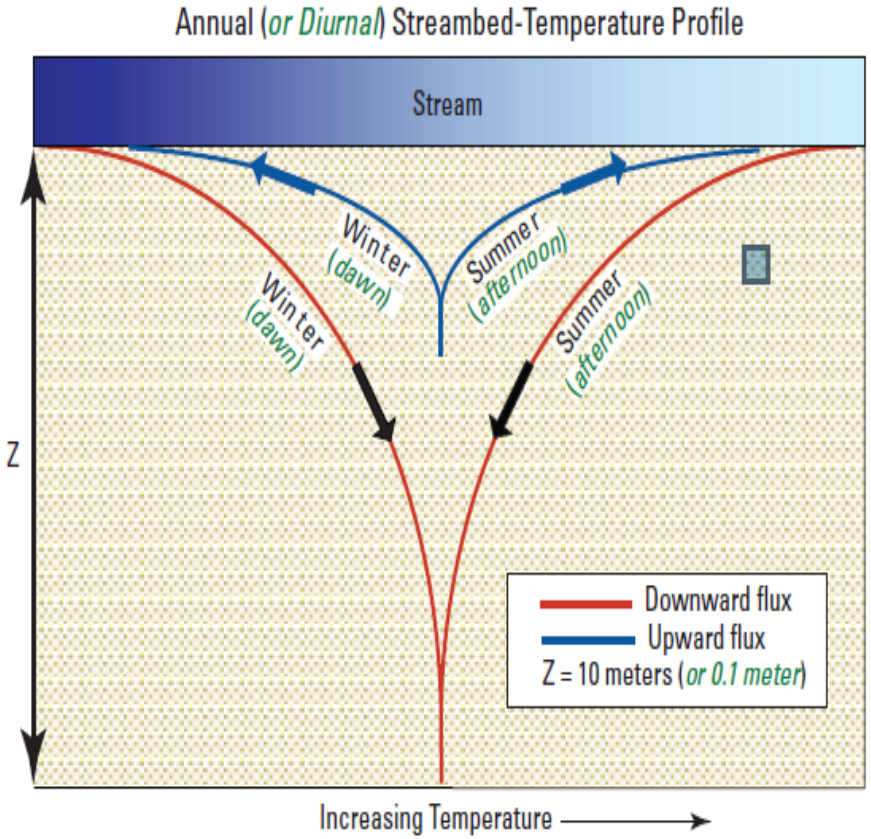


Reach 3



Probe depth and temperature





Constantz et al., 2008

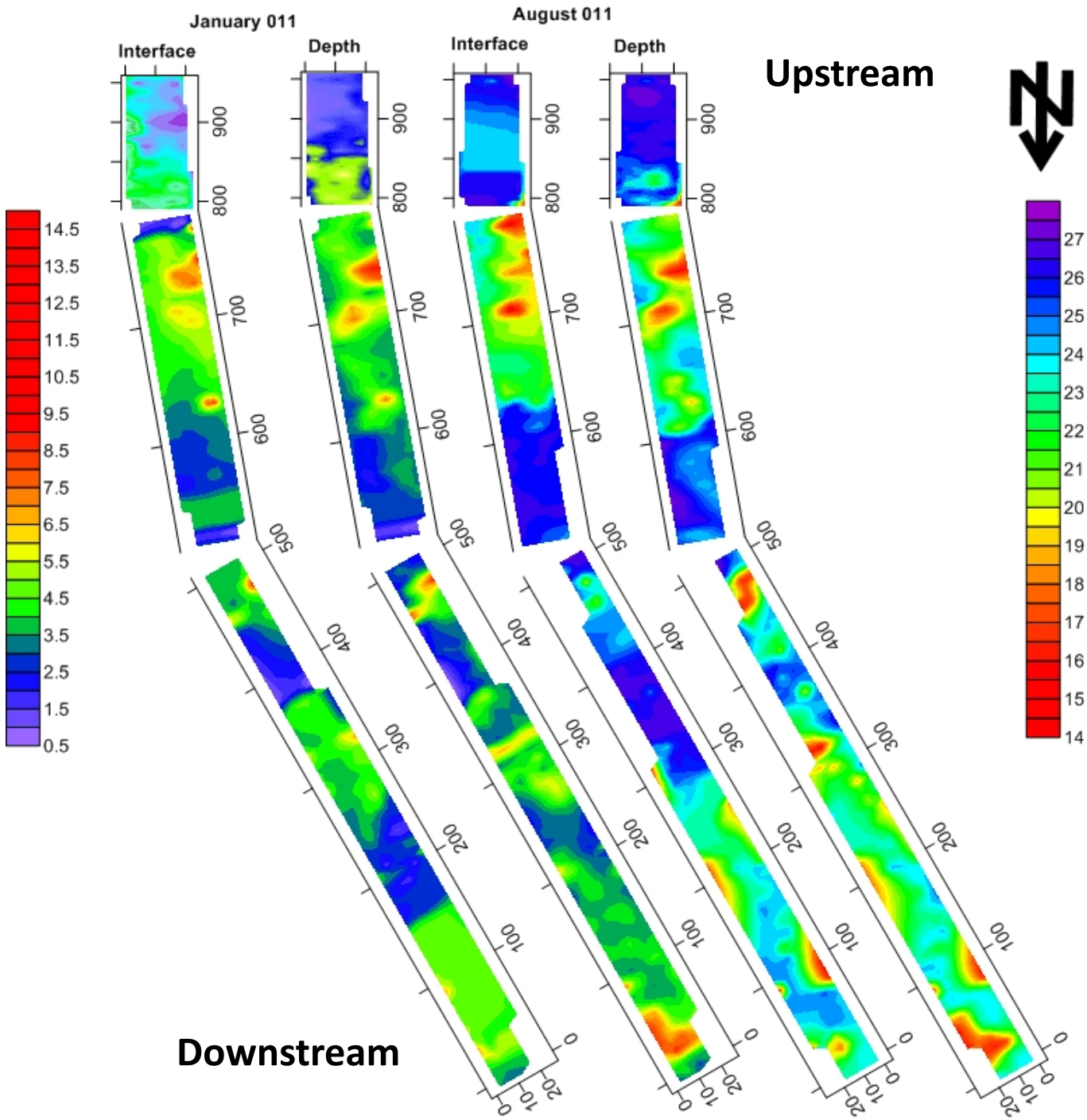
Results and discussion

- We measured temperature at 1638 and 1396 points along the 1009-foot long section in January and August 2011 respectively.

- Temperature grid was created and interpolated using natural neighbor interpolation technique.

- The interpolated results were contoured to generate the temperature anomaly maps for interface and probe depth for different seasons.

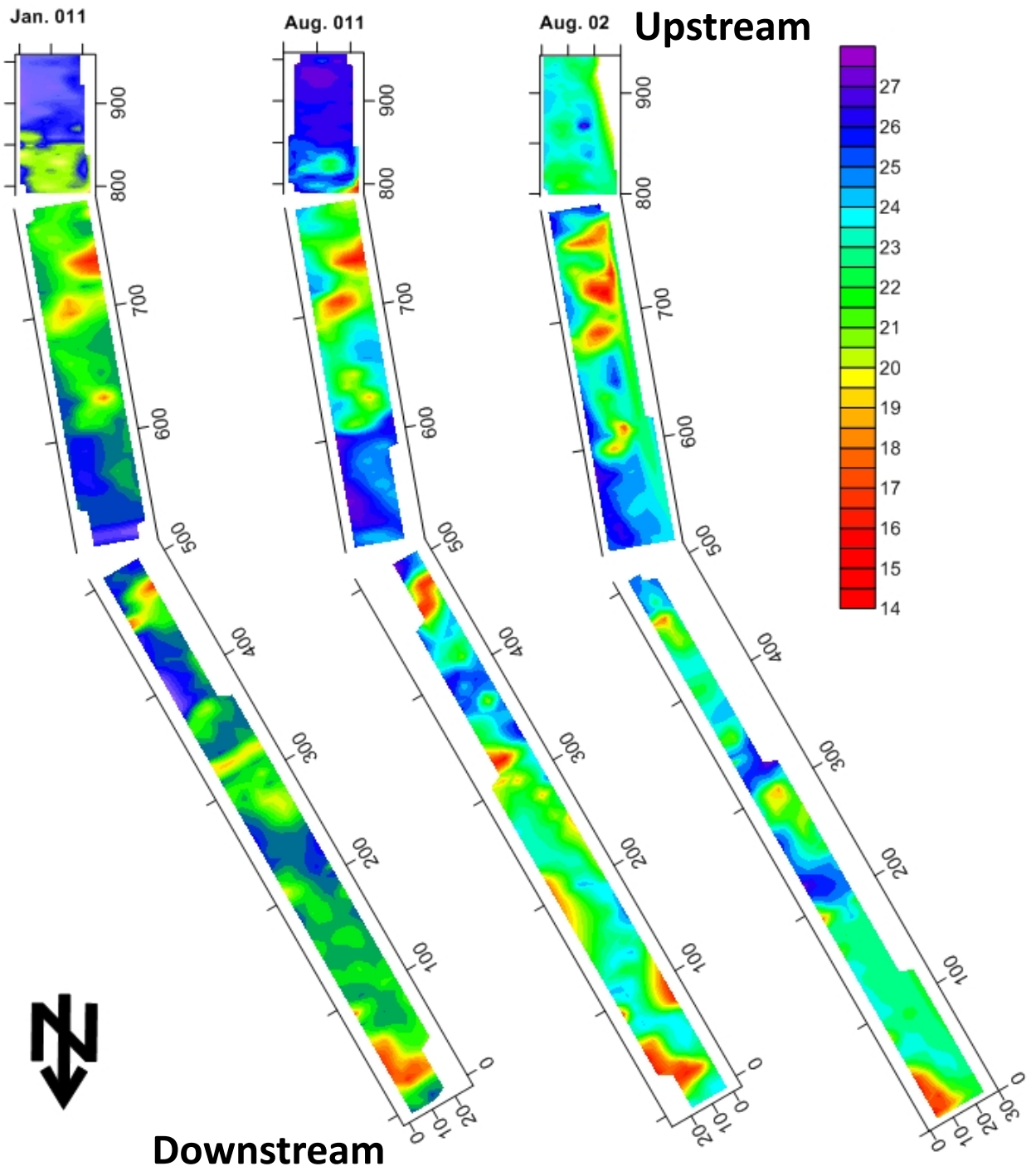
Temperature distribution at the interface and at depth along the entire study reach



Results and discussion

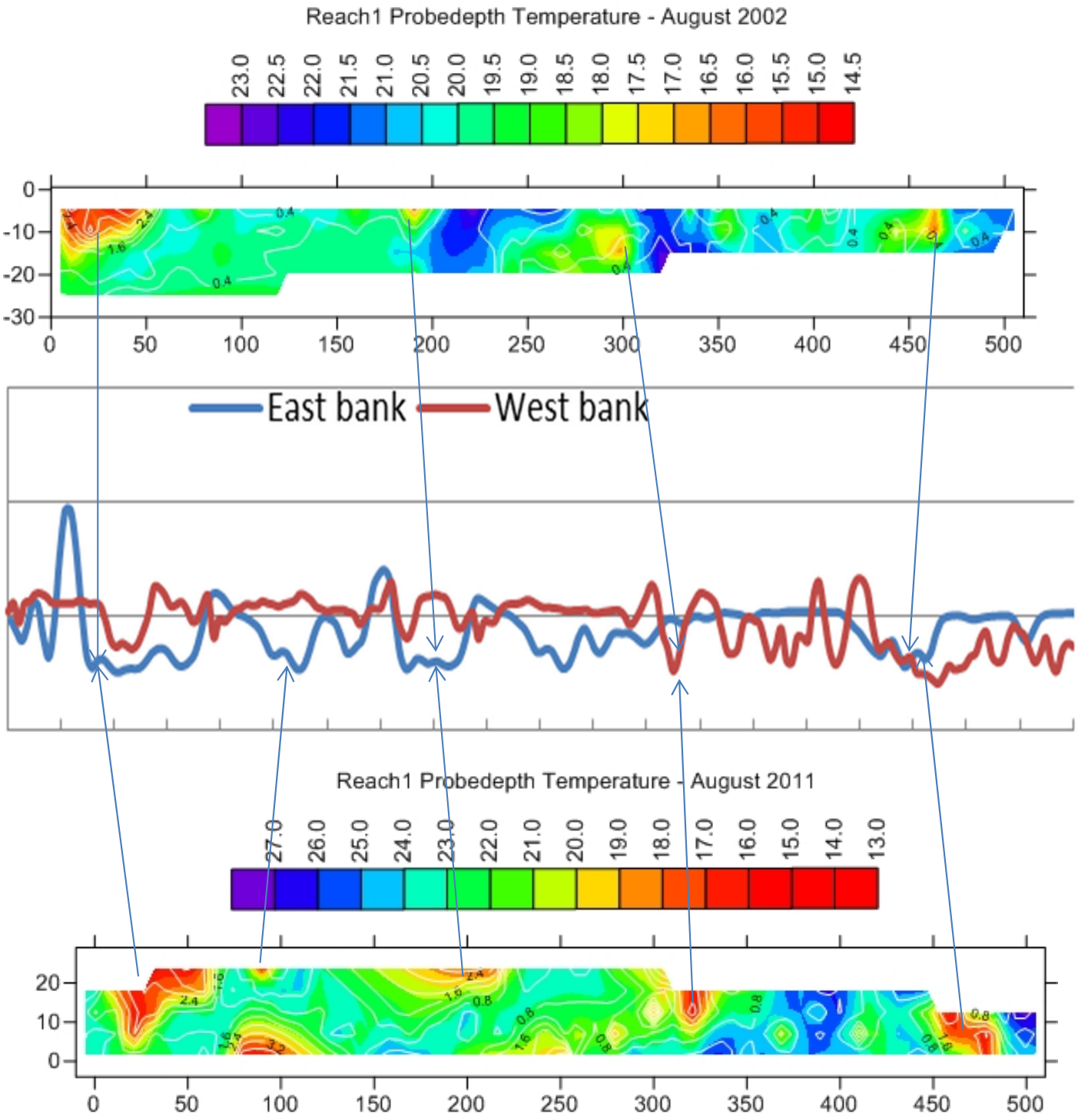
- Temperature anomalies were compared with results from 2002 probing.

- Some discharge locations have persisted since 2002, while others have emerged since then.



DTS system

- DTS system was deployed in the field in September 2011 for 3 weeks of monitoring.
- Records temperature along the entire reach every 5 minutes at 1-meter interval.
- Data are being downloaded remotely at the office.


Reach1 Probedepth Temperature - August 2002
23.0 22.5 22.0 21.5 21.0 20.5 20.0 19.5 19.0 18.5 18.0 17.5 17.0 16.5 16.0 15.5 15.0 14.5
0 -10 -20 -30
0 50 100 150 200 250 300 350 400 450 500
East bank
West bank
Reach1 Probedepth Temperature - August 2011
27.0 26.0 25.0 24.0 23.0 22.0 21.0 20.0 19.0 18.0 17.0 16.0 15.0 14.0 13.0
20 10 0
0 50 100 150 200 250 300 350 400 450 500

Conclusion

- The entire reach is dominated by focused discharge.
- Some discharge locations have not changed significantly since 2002.
- However, upstream or downstream migration of some springs and evolution of new springs has been observed and reflected in the temperature anomaly maps.

Acknowledgement

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Thank You!
Questions!!