Plant Reach Study

Objective: Determine sources/mechanisms of loadings from plant reach which exceed identified plant loadings

Plant Reach Status

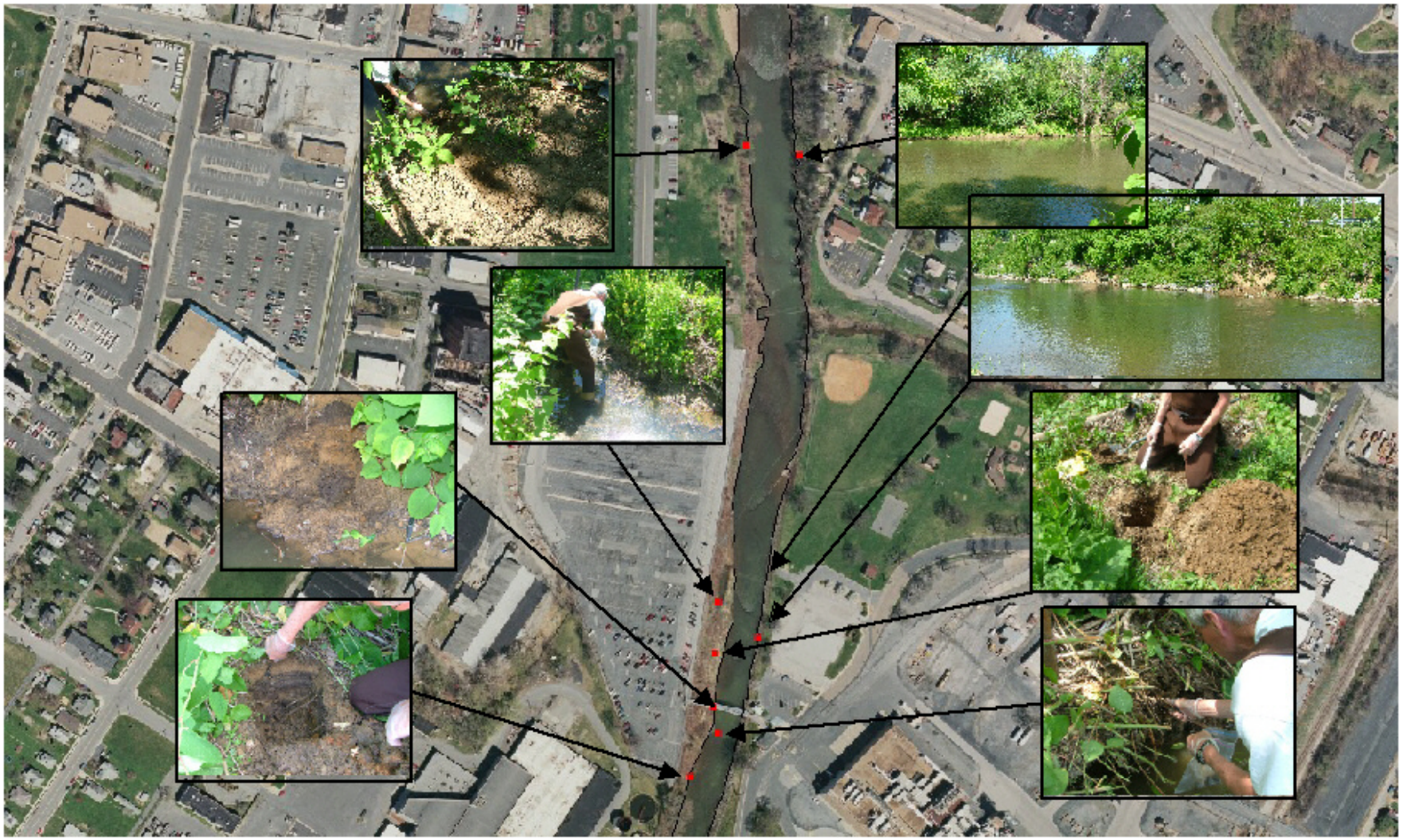
- SW survey delayed by very low water
- First task, to assess loading at elevated flow, met by June 06 episodic sampling
  - Plant reach loading much lower than 9/04
    - 71 g/day @ 1 Day (J.R.) vs 1229 g/day in 9/04
    - ~ 1 g/day accounted in outfalls and GW from plant
  - But much smaller flood than 9/04 flood
  - Exact sampling location - possible explanation
- Sampled eroding banks/floodplain in May/July 06

Possible Sources of Loading

Plant Reach

- Unidentified groundwater loading
- Exchange between clean suspended solids entering upstream with elevated Hg sediments in plant reach
- Unidentified outfall loadings from plant
- **Bank and/or floodplain soil erosions** ←
- Atmospheric deposition

May 06 Plant Reach Samples

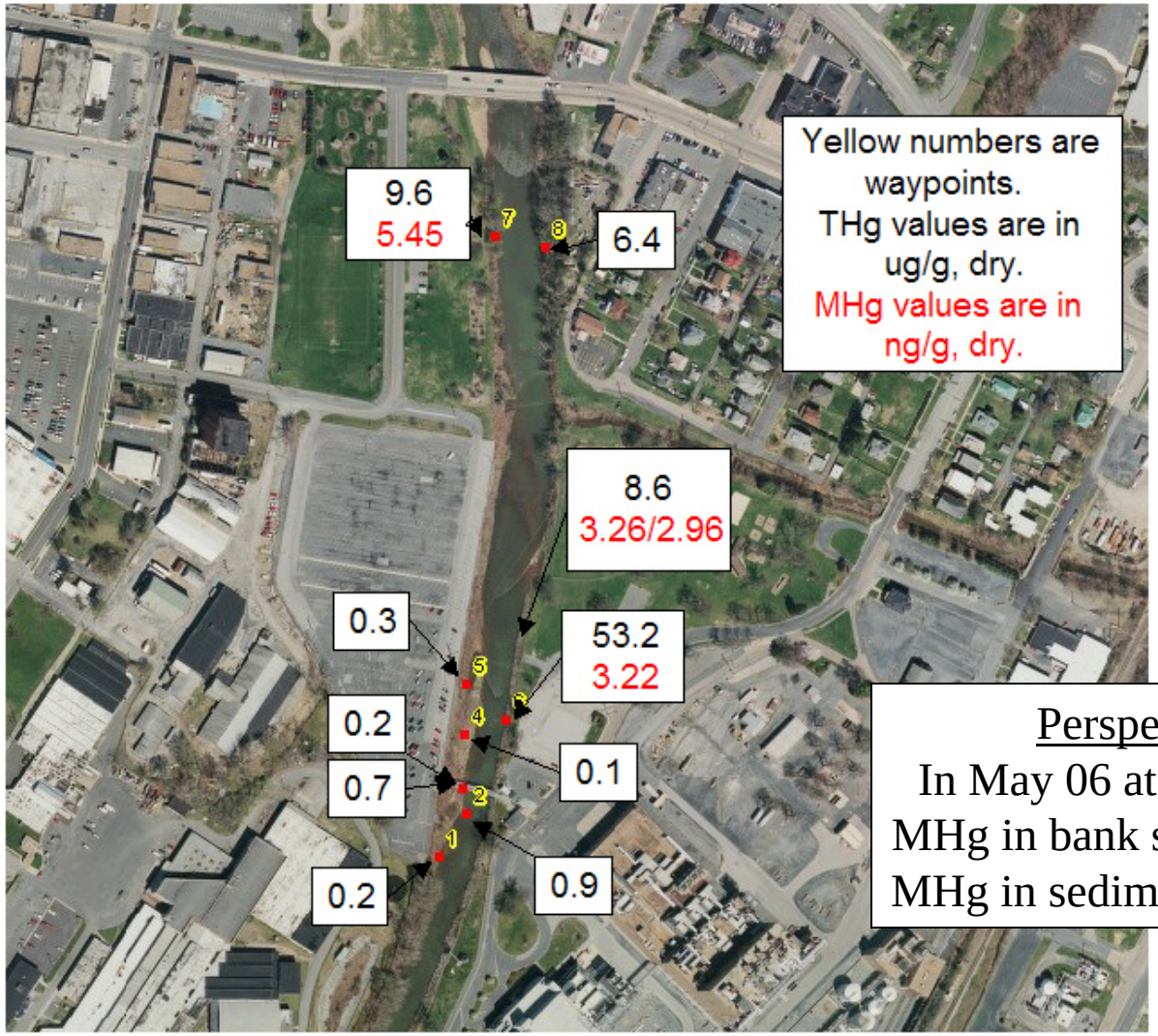


Plant Reach

Bank/Floodplain Soil Results - May 06

Plant Reach

Bank/Floodplain Soil Results - May 06



Perspective

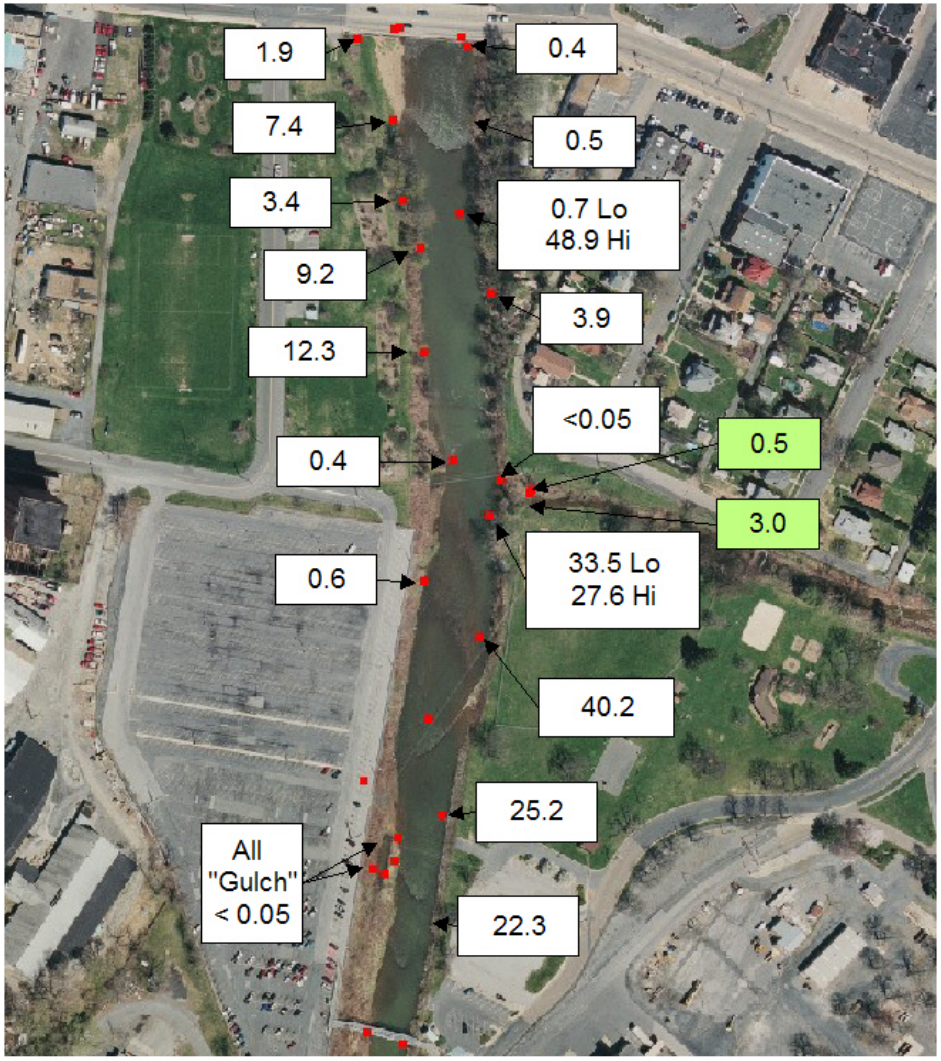
In May 06 at Basic Park

MHg in bank soil: 8.2 ng/g

MHg in sediment: 107-223

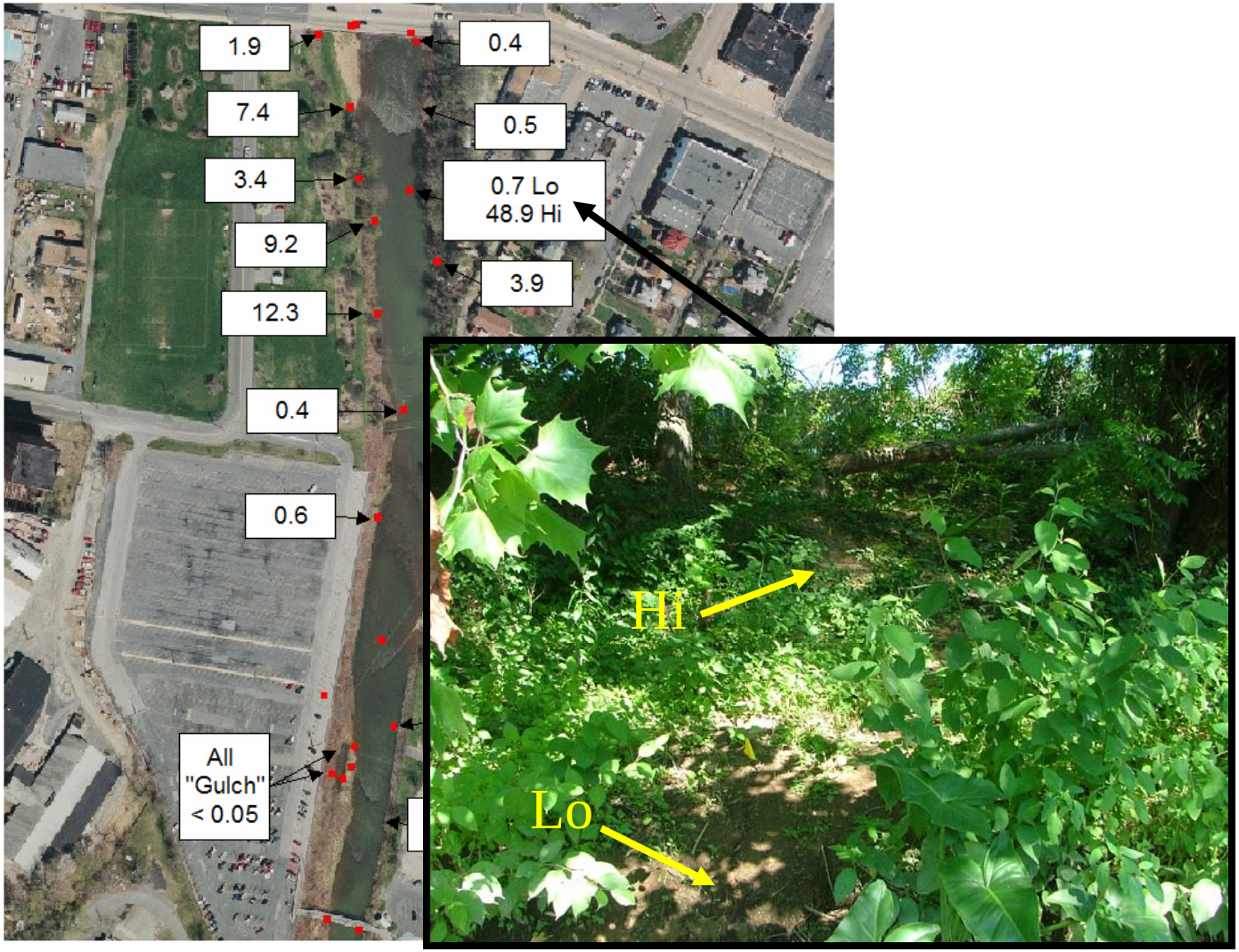
Plant Reach

Bank/Floodplain Lumex Soil Results - July 06



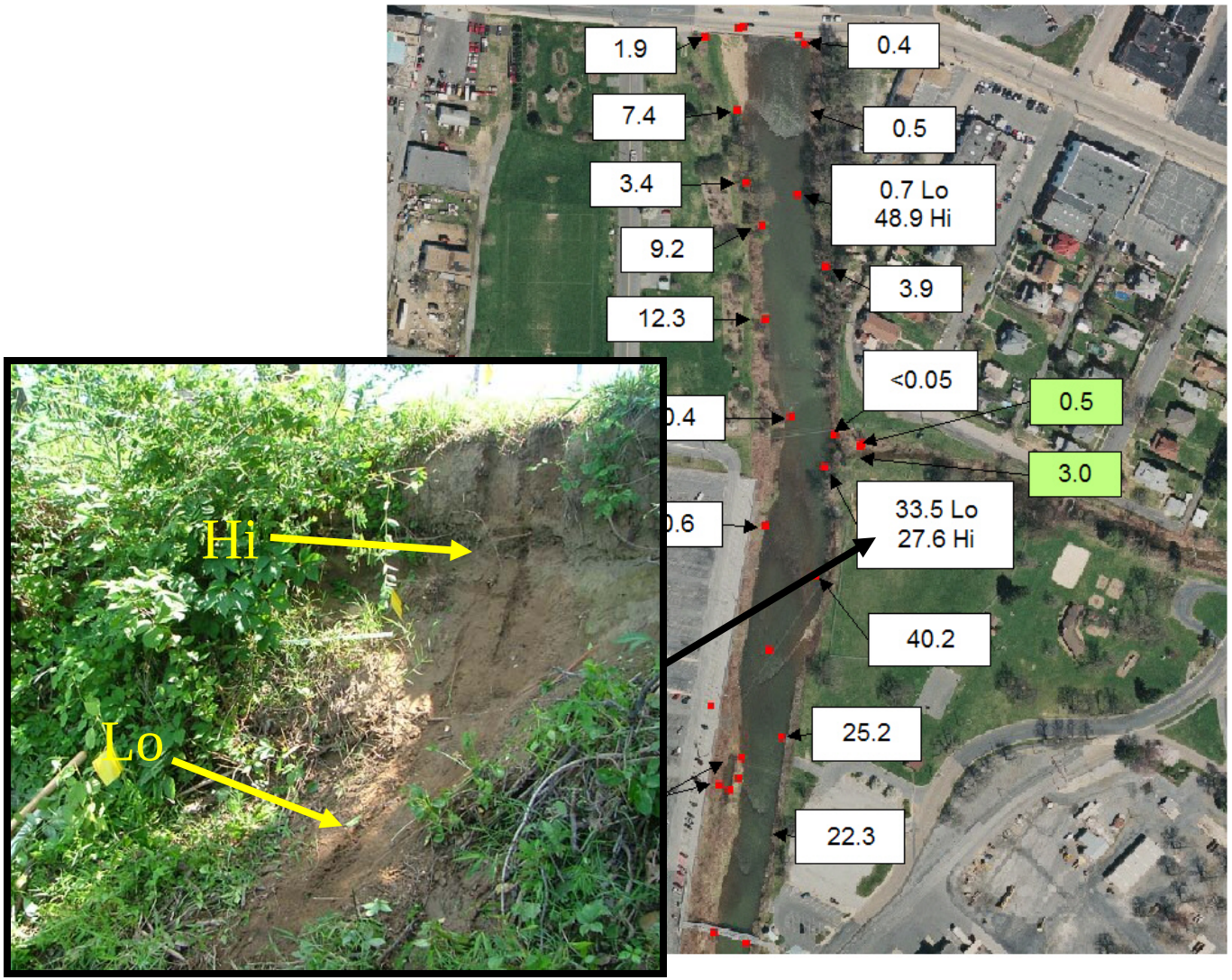
Plant Reach

Bank/Floodplain Lumex Soil Results - July 06



Plant Reach

Bank/Floodplain Lumex Soil Results - July 06



New Thoughts on Plant Reach

- Need to re-confirm June episodic result
  - Add sample location?
- Plant reach useful study reach?
  - Candidate for bank stabilization test/demo?
  - No upstream contamination - bounding case
  - DuPont owns most banks below footbridge to Main St
  - City owns remainder
  - DuPont owns river bed

September Field Activities

Plant Reach

- Continue characterizing sediments between footbridge and Main St
- Continue characterizing hyporheic zone water between footbridge and Main St.

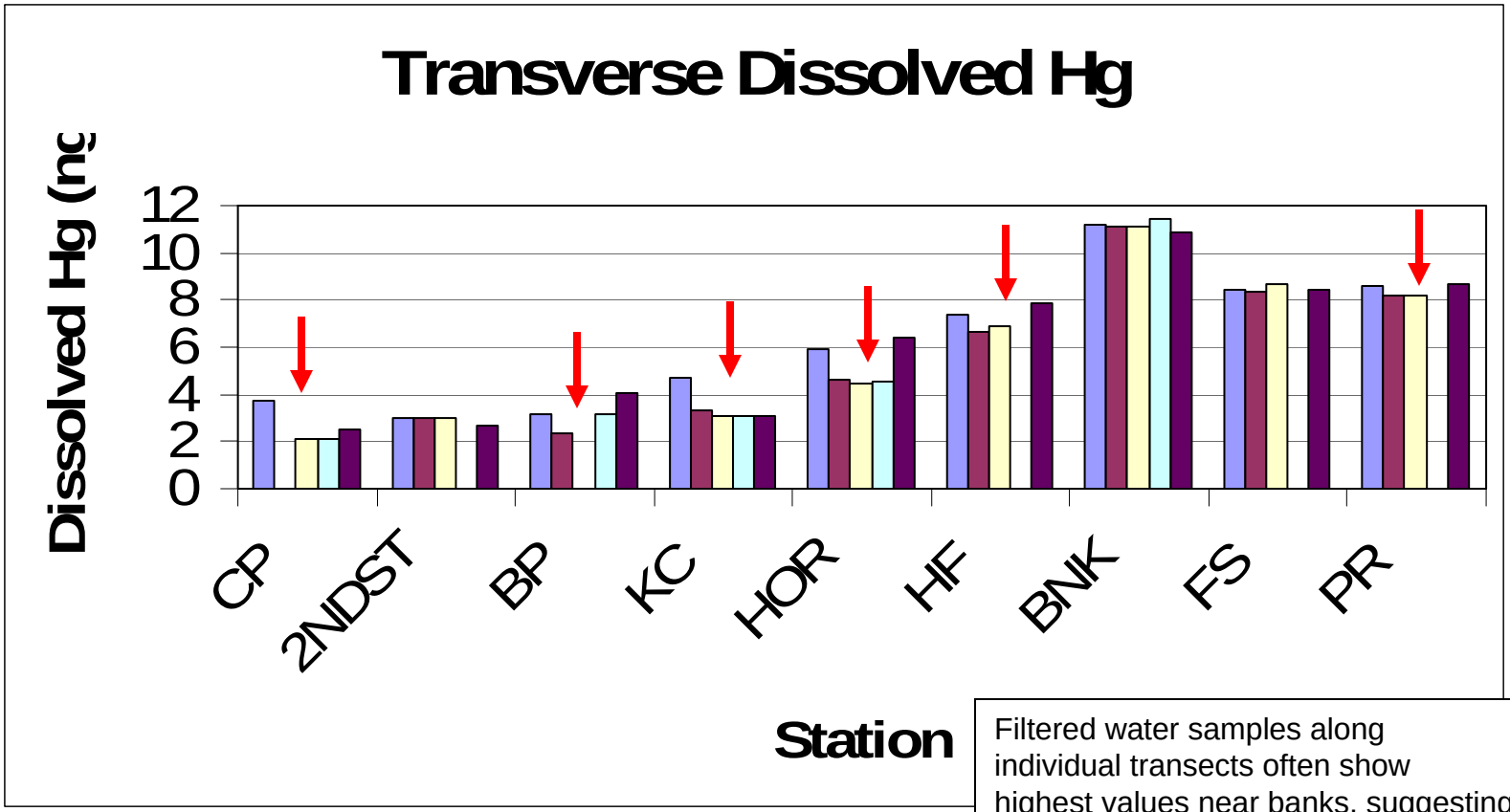
- Reason we say “continue”: Began process in 2004.

Basic Park Bank Flux Study

Objectives: Confirm bank flux of THg and quantify/partition source between desorption from solids and alluvial groundwater. Develop tools.

Near-Bank Study Background

Continued



Filtered water samples along individual transects often show highest values near banks, suggesting that banks are a key input location.

Special Clarification

- Elevated dissolved Hg results for near-bank SW samples **do not** rule out possible additional center stream inputs/fluxes.
- They **are** a strong indicator that a reach is an active input location for SW.
- They **are** a strong indicator that the near-bank locations are active input locations to SW.

Near-Bank Study

Investigative Approaches in Phase I

- Choose location coincident with ecostudy
- Synoptic measurement of
  - Surface water Hg, transverse and longitudinal in study area, to verify elevated near-banks and provide baseline.
  - Near-bank sediment Hg
  - Pore water/groundwater Hg
  - Sequential extraction of near-bank sediments

Near-Bank Study

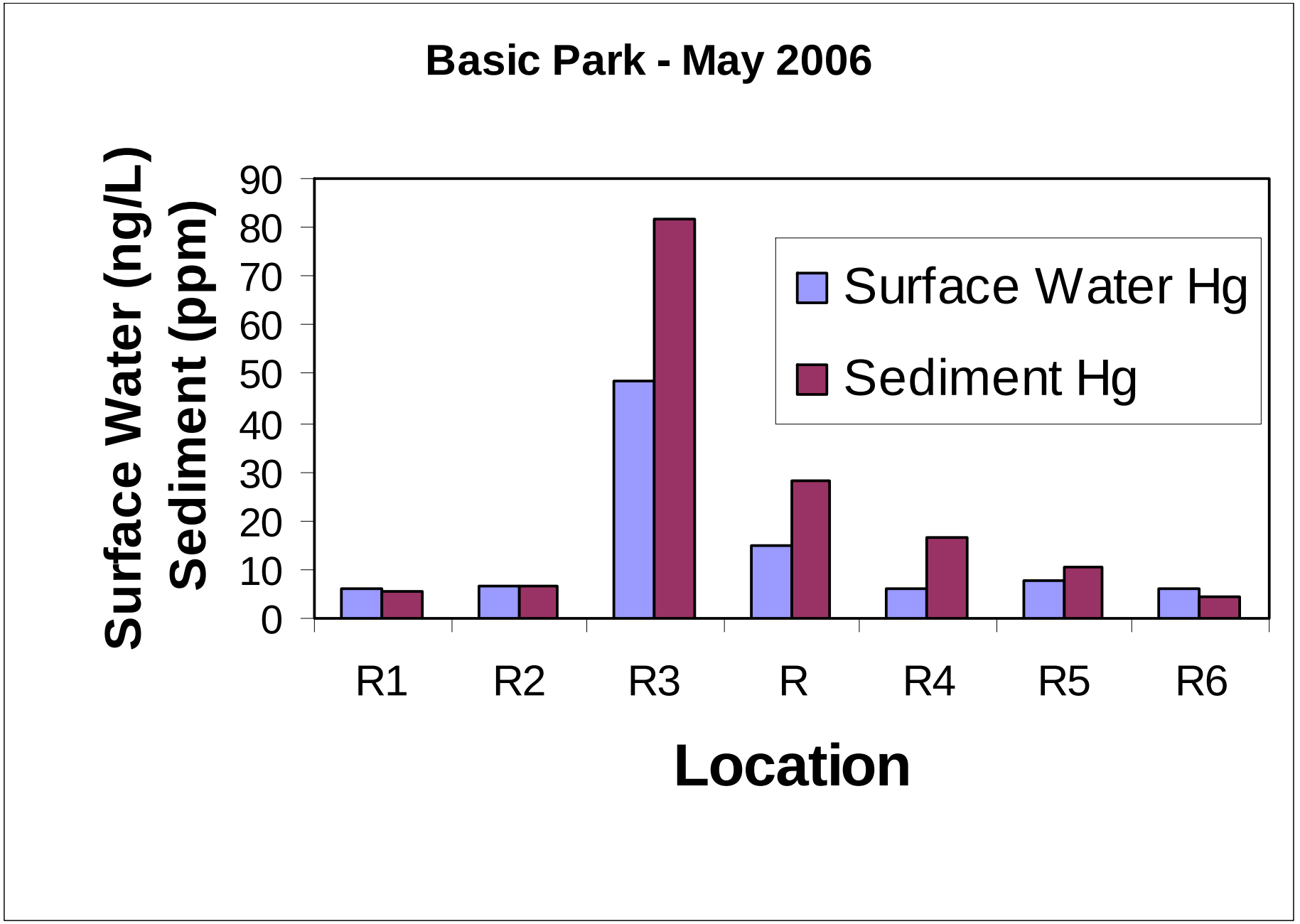
Have initially chosen Basic Park for Phase I

Surface Water Pattern

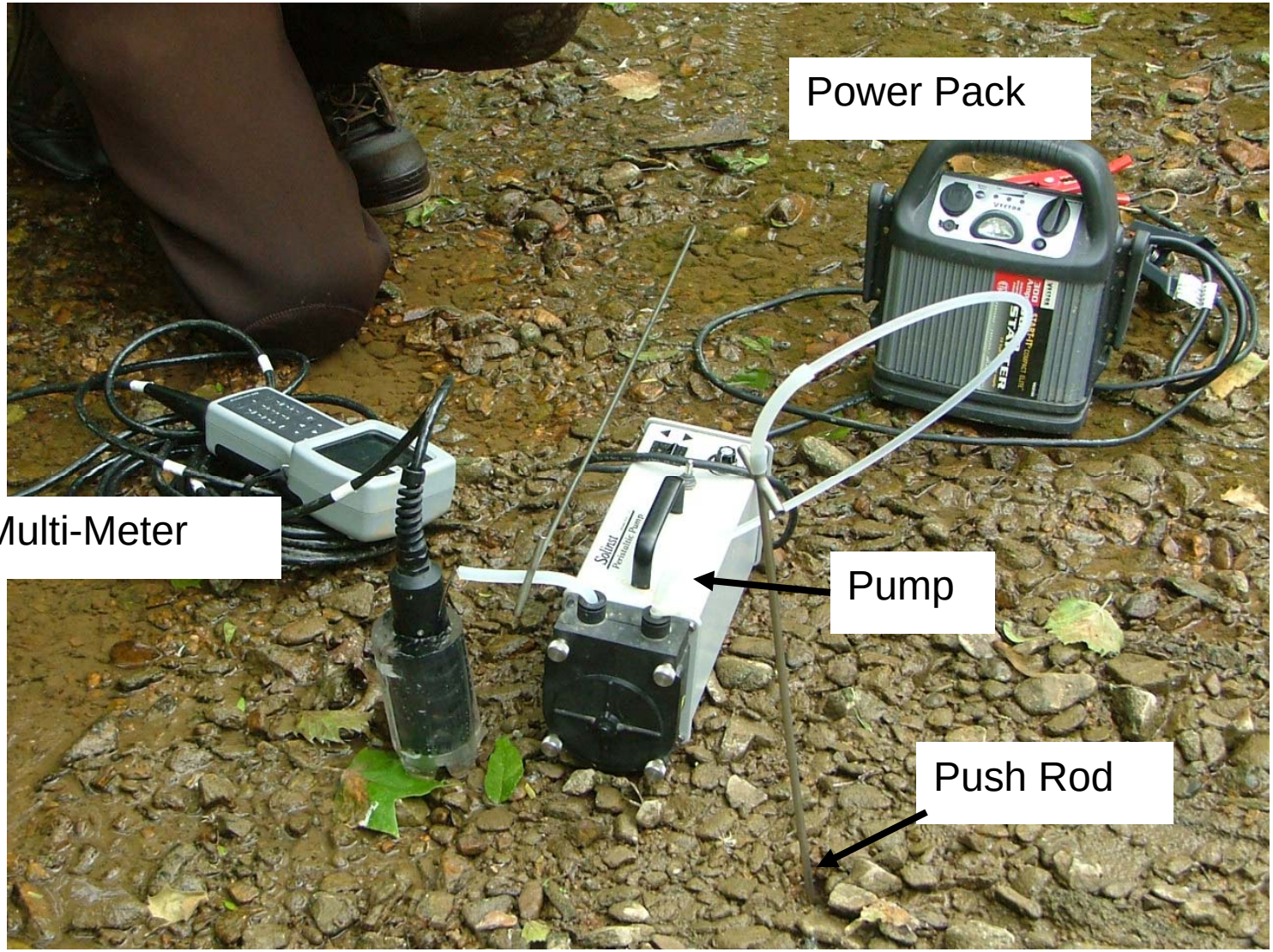
Filtered THg (ng/L), May 2006

Shallow Sediment Pattern

THg (μg/g), MHg (ng/g)

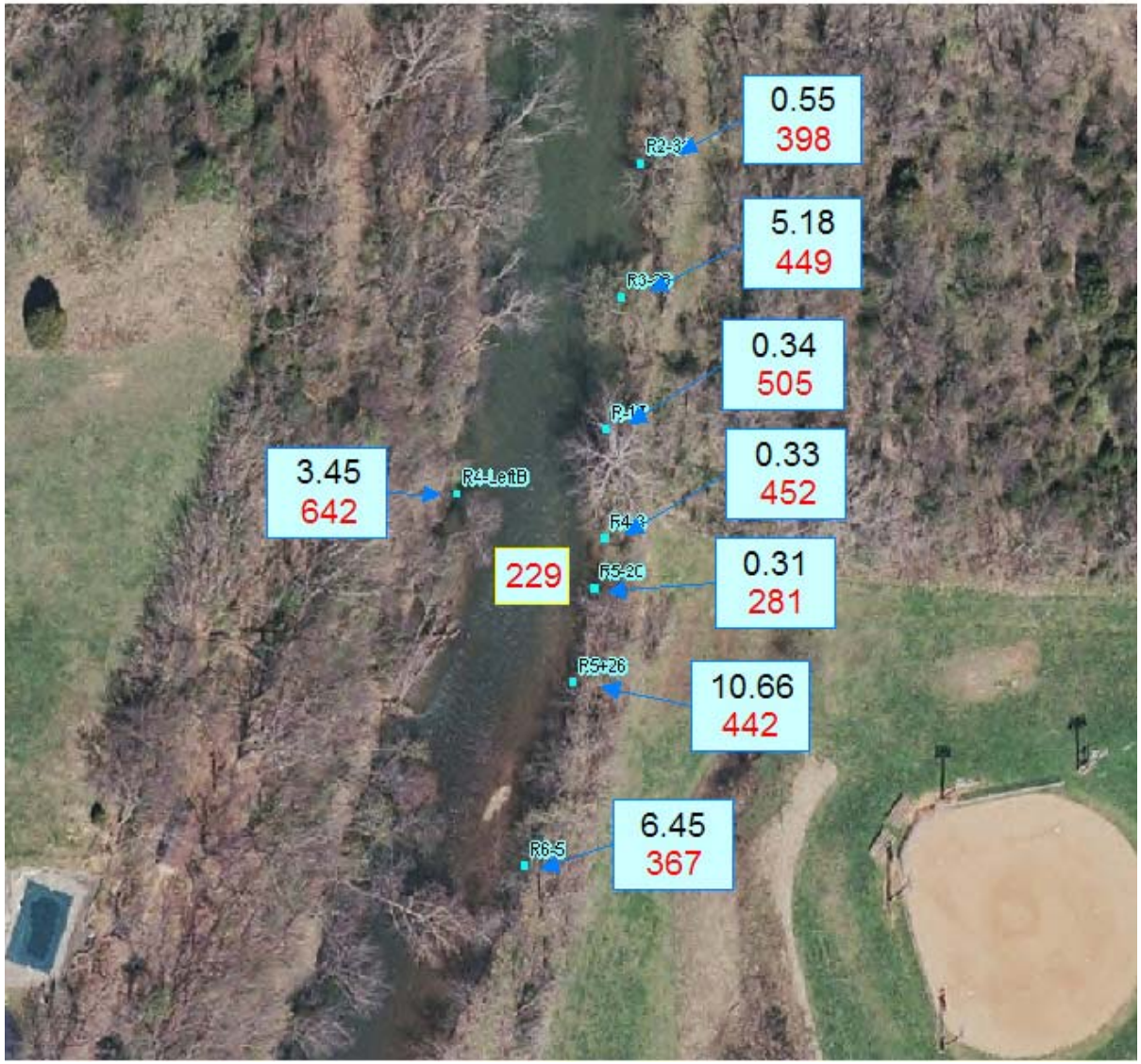

Basic Park - May 2006
Surface Water (ng/L)
Sediment (ppm)
90
80
70
60
50
40
30
20
10
0
Surface Water Hg
Sediment Hg
R1
R2
R3
R
R4
R5
R6
Location

Pore Water Equipment



Pore Water Pattern

THg dissolved, ng/L; Spec Cond, uSiemens

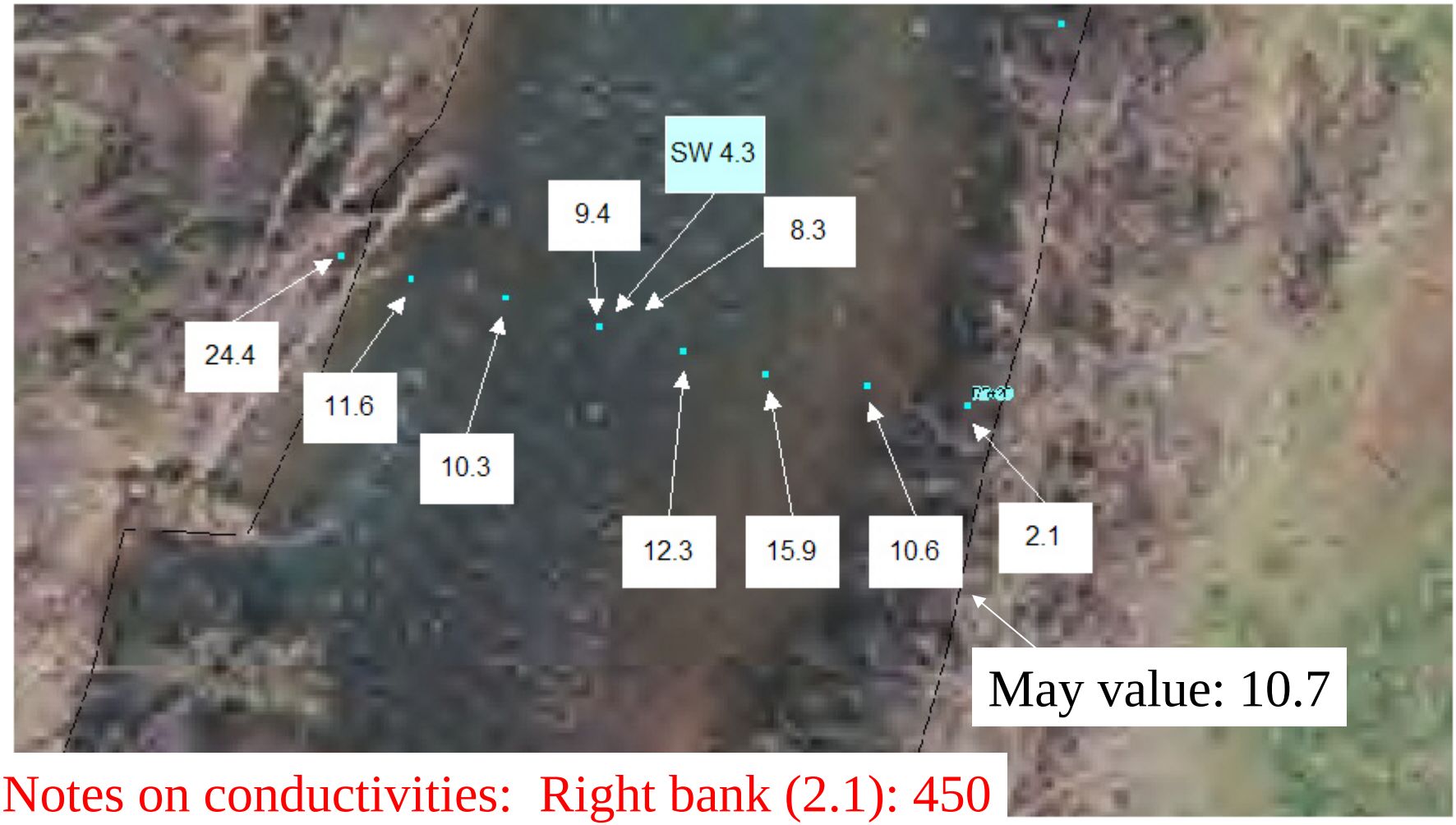


Pore Water Pattern

Added Transect in July 06, Including one SW

Pore Water Transect - July 06

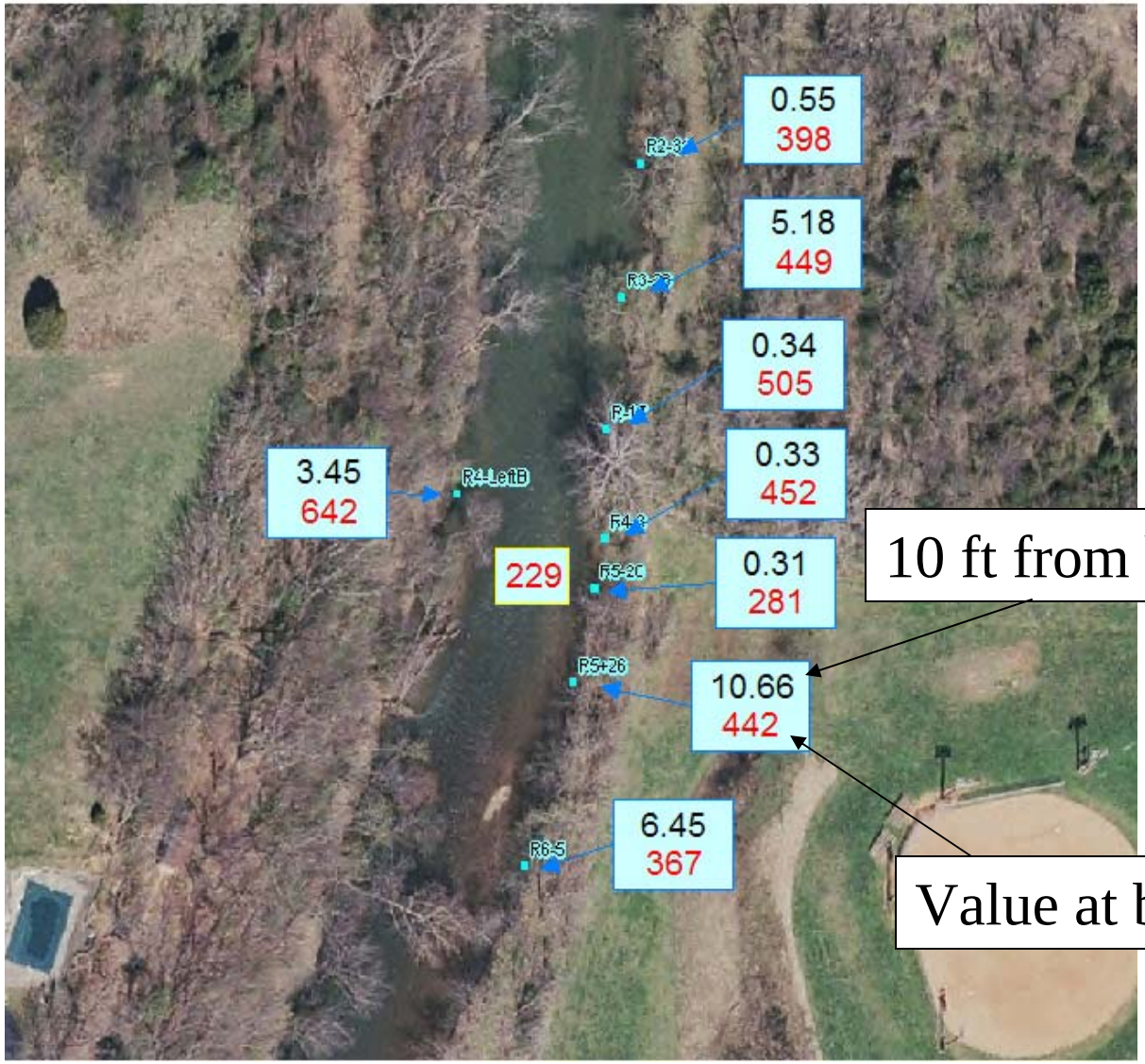
All results, THg, dissolved, ng/L



Notes on conductivities: Right bank (2.1): 450
All others, including SW: ~275

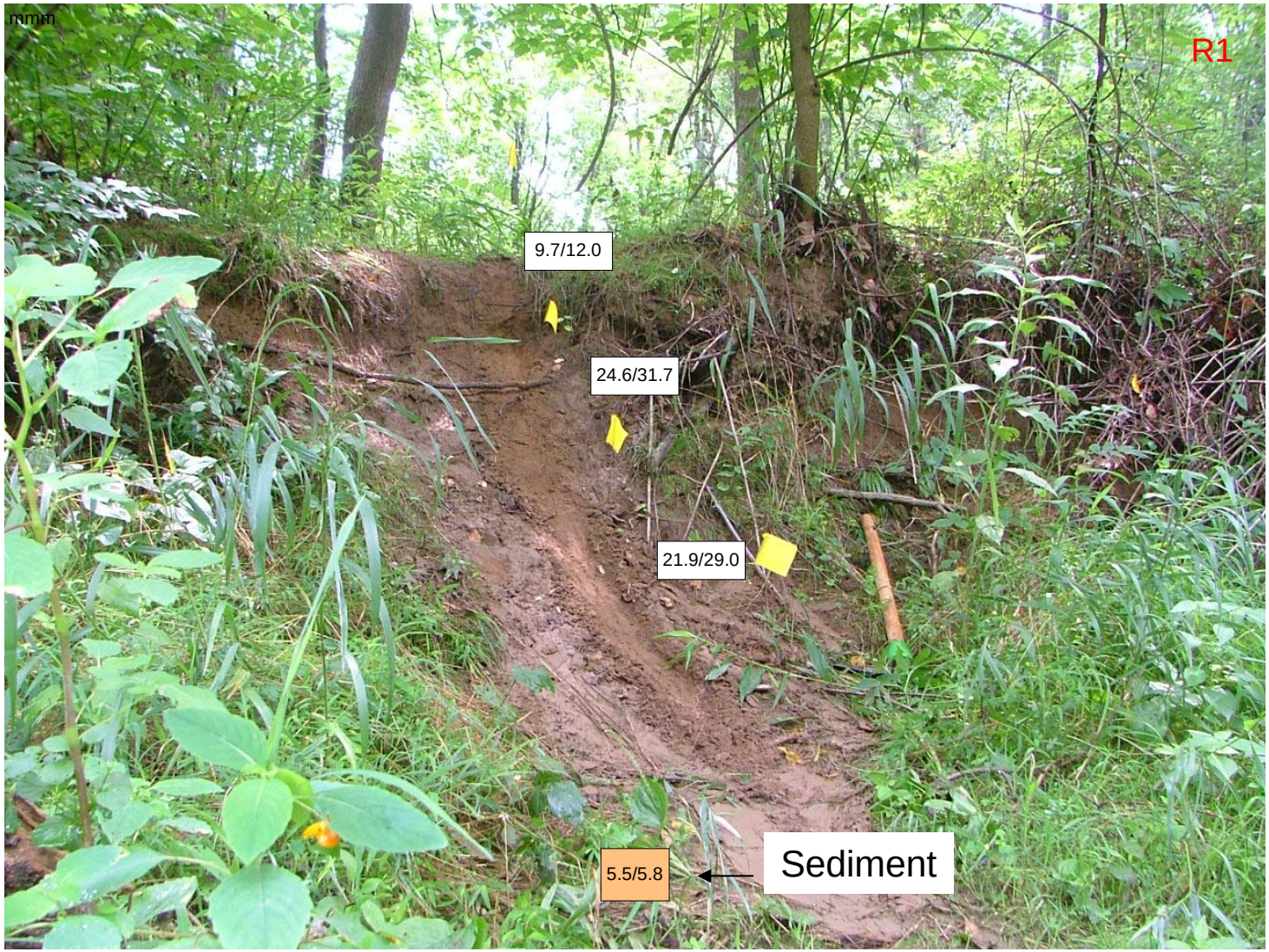
Pore Water Pattern

THg dissolved, ng/L; Spec Cond, uS/cm



Bank Soil Characterization, R1

vertical channels between flags in ppm

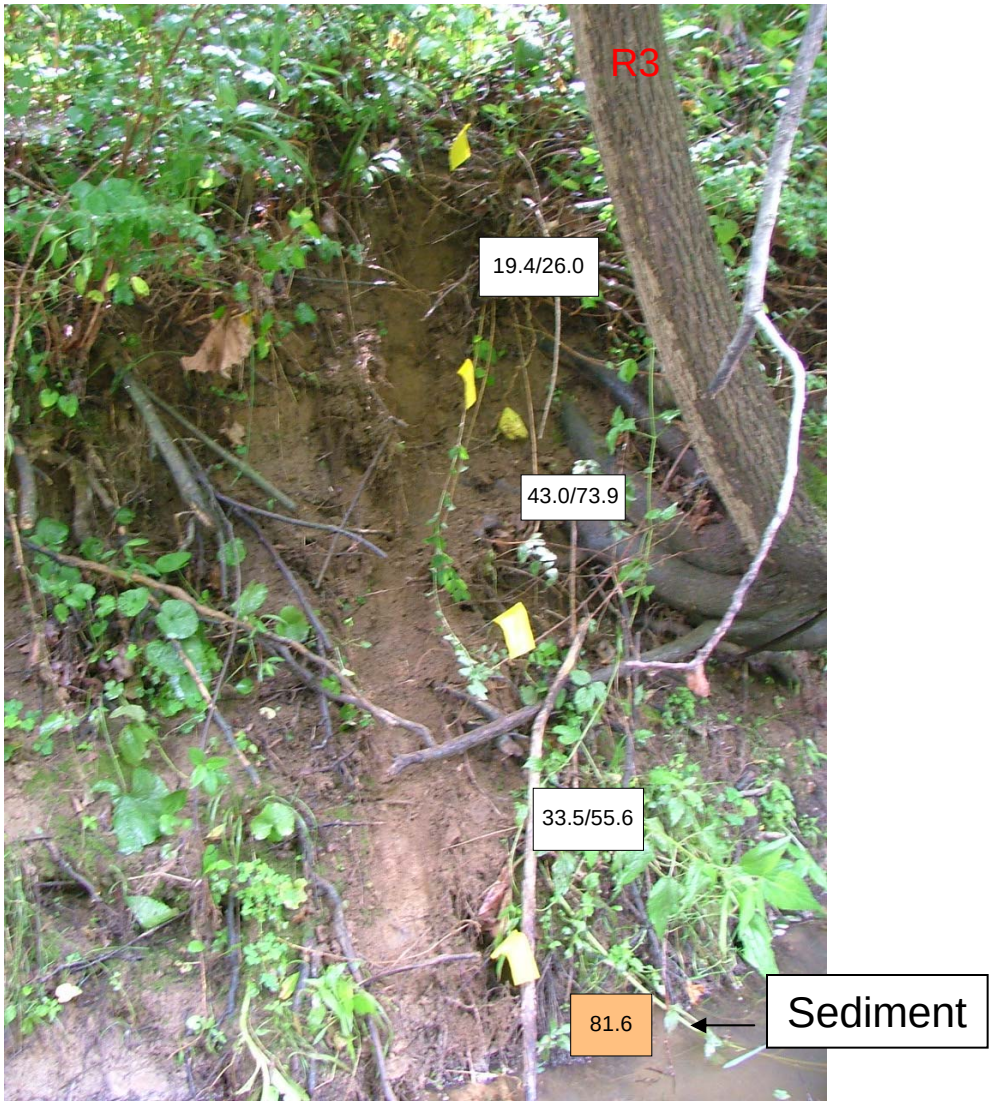


Bank Soil Characterization, R2

vertical channels between flags in ppm

Bank Soil Characterization, R3

vertical channels between flags in ppm

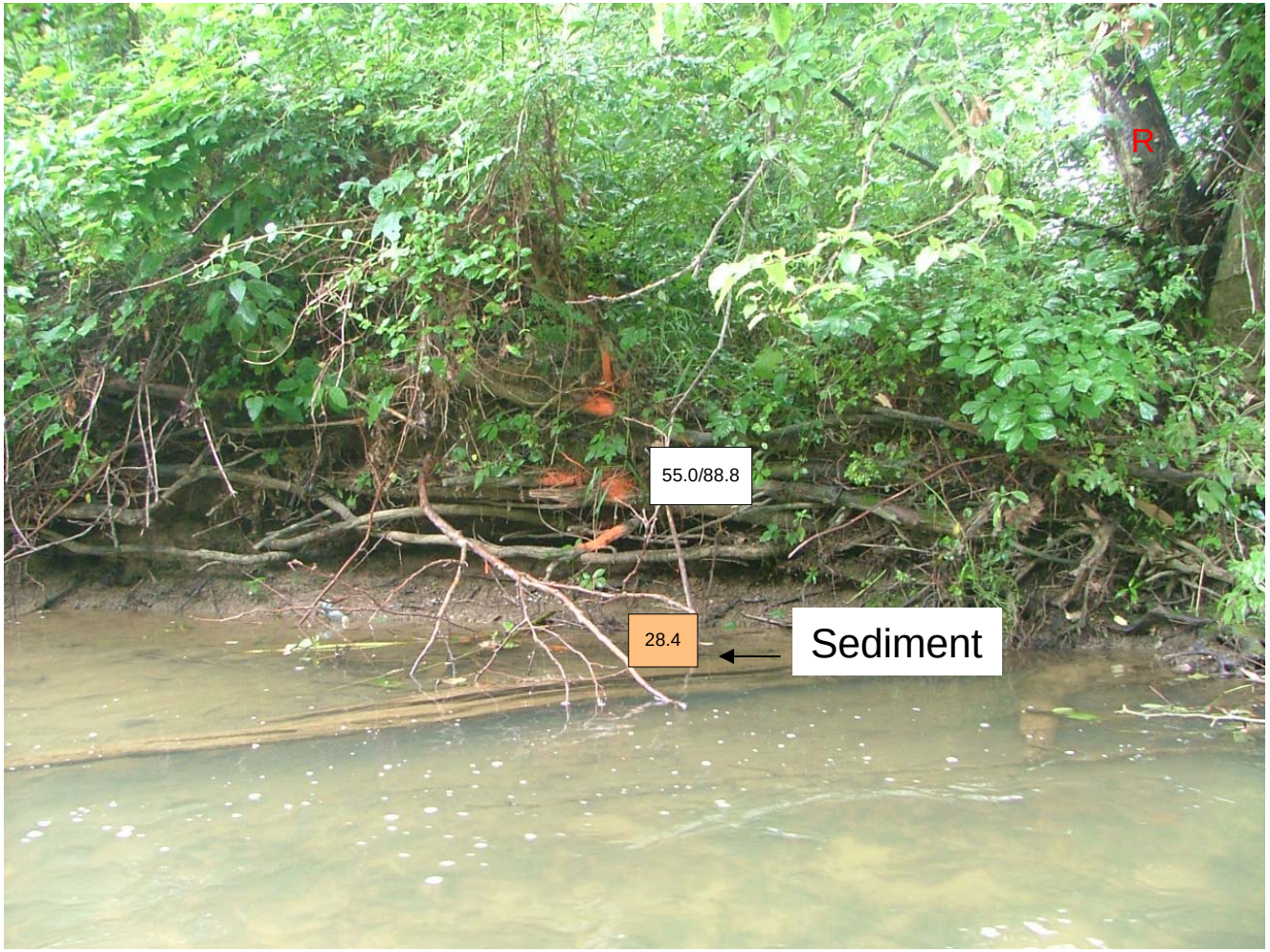


Bank Soil Characterization, R3.5

vertical channels between flags in ppm

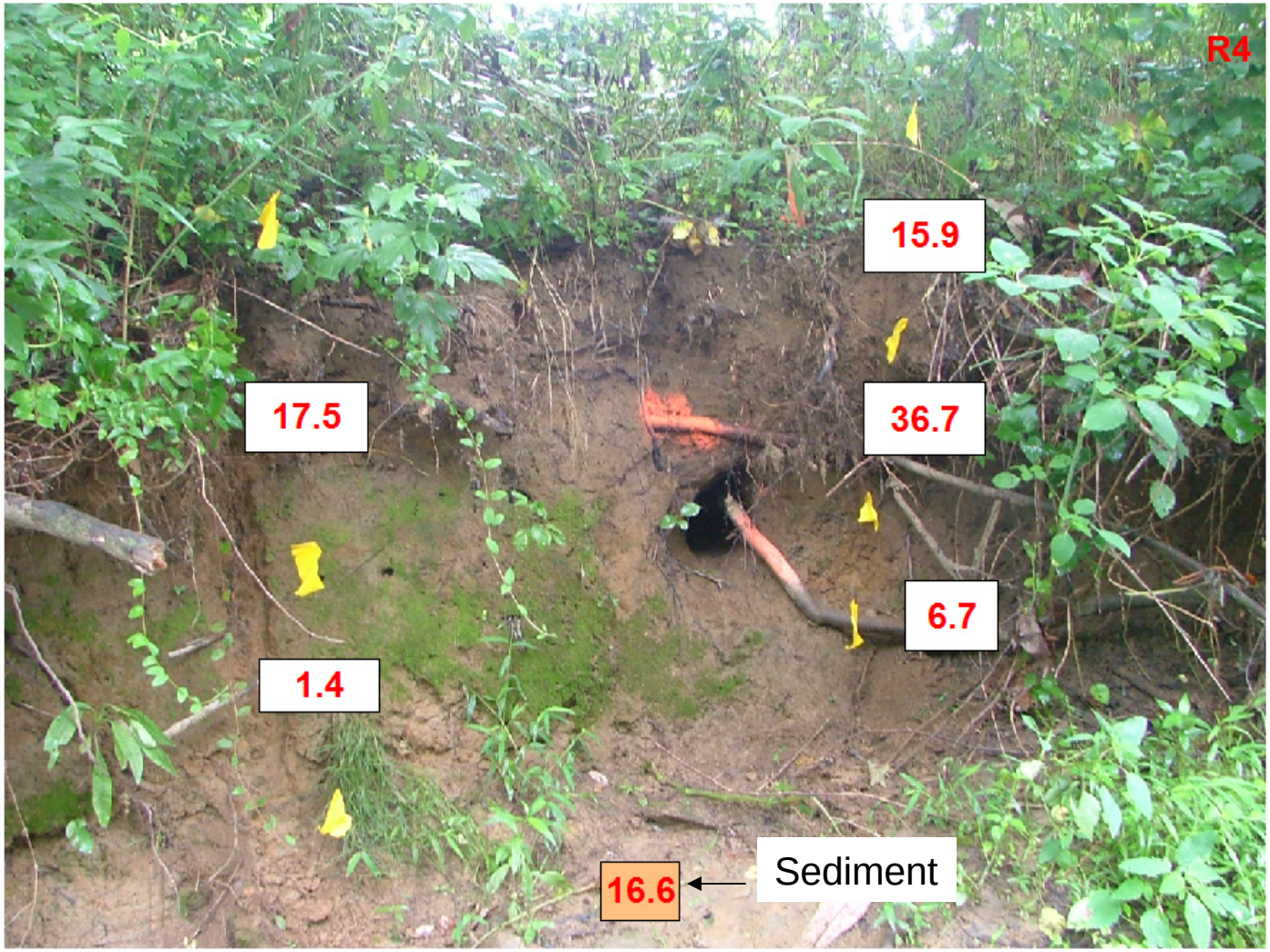
Bank Soil Characterization, R

Composited grabs between roots in ppm



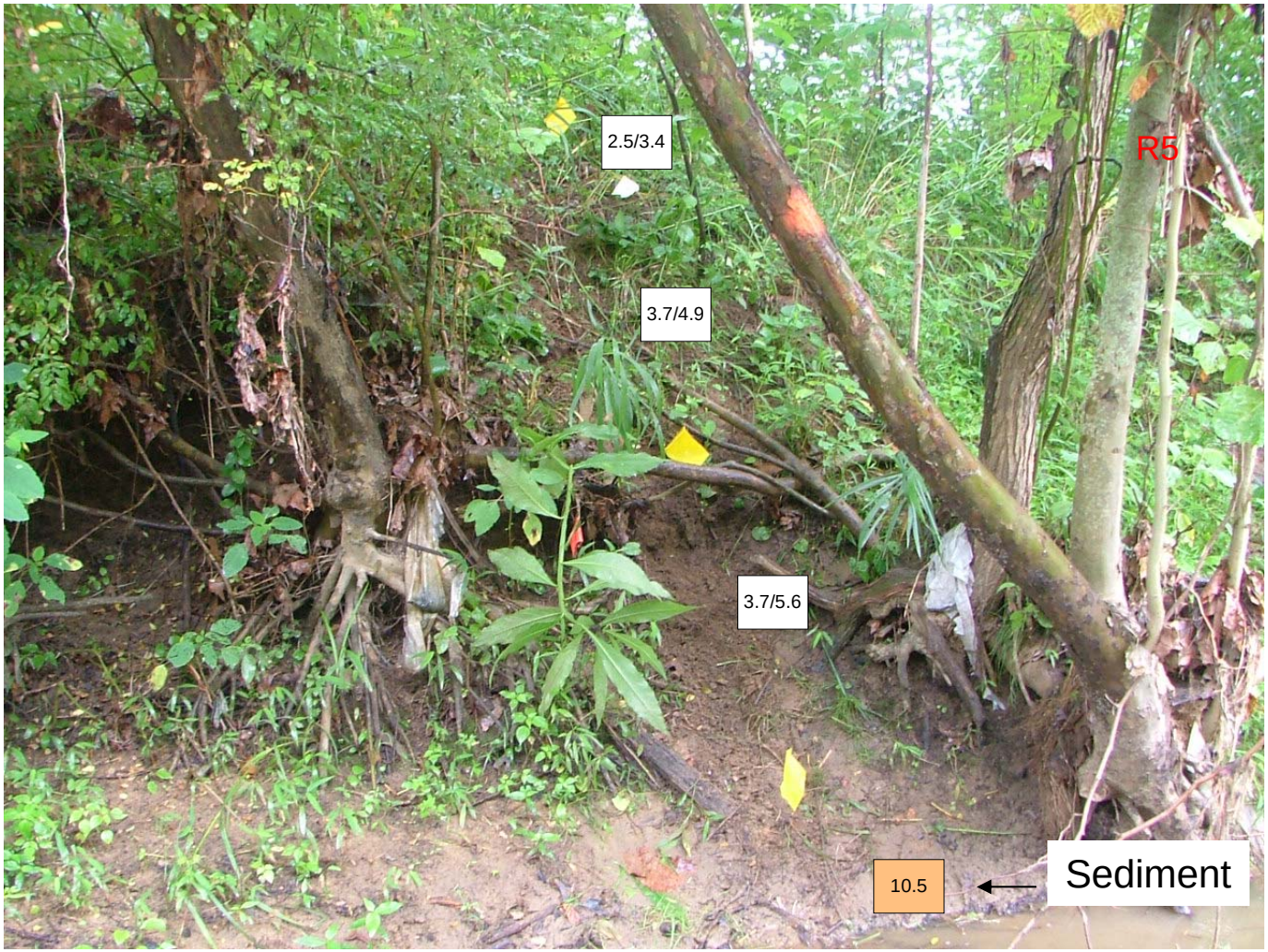
Bank Soil Characterization, R4

vertical channels between flags in ppm



Bank Soil Characterization, R5

vertical channels between flags in ppm



Tabular Bank Soil Results
July 06 - Lumex

	R1	R2	R3	R3.5	R	R4-1	R4-2	R5	R6-1	R6-2	R6-3	R6-4
High Bank	12	14.2	26	40		15.9	17.5	3.4				
Mid Bank	31.7	11.3	73.9	12.6	88.8	36.7		4.9				
Low Bank	29	8.6	55.6	10.5		6.7	1.4	5.6	11.8	3.5	3.2	2.8
Sediment	5.5/5.8	6.6	81.6		28.4	16.6	16.6	10.5	4.4	4.4	4.4	4.4

Notes: Bank results, ug/g, ashed basis
Sediment results, ug/g, dry wt basis
Bank Soil LOIs (R4, 8/05): 7.07% near top
1.51% near bottom

Diffusion Bucket QA - May 06

Diffusion Dam QA Results

All samples are filtered.

1) Test blank water, filtered. 1 bottle. wsr-w-fblk 0.17 ng/L

2) Put 2.5 gallons of blank water through all 5 buckets and leave for 12 hours in 4th bucket. Take one sample at T=0 and one sample at T=12 hours. 2 bottles. wsr-w-eqblk1, wsr-w-eqblk2

0.05, 0.11

3) Fill 2 more buckets with DI water, one stirred and one bubbled, for 12 hours and sample. 2 bottles wsr-w-eqblk3, wsr-w-eqblk4 (3 is stirred and 4 is bubbled)

0.08, 0.09

4) Put RW in 2 buckets and take T=0 sample of that water. 1 bottle wsr-w-sr0

15.67

5) Bubble one RW bucket and manually stir one RW bucket for 12 hours and sample each at 12 hours. 2 bottles. wsr-w-sr12S, wsr-w-sr12B (for stirred and bubbled)

14.45/15.01, 14.68

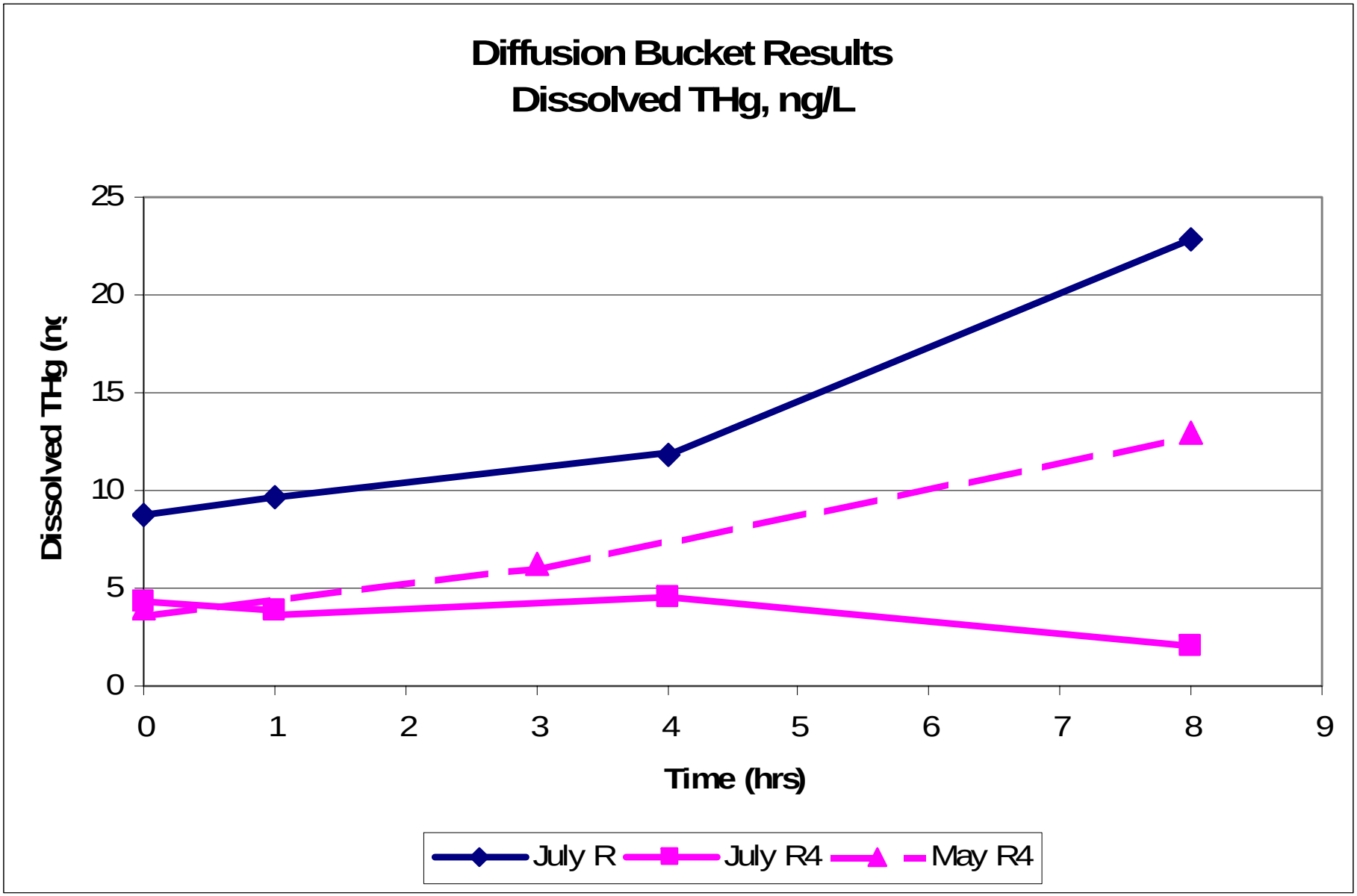
6) Rinse the 2 RW buckets with DI water twice and pass DI water through each again into sample bottles. 2 bottles. wsr-w-eqblk5, wsr-w-eqblk6 (5 is stirred and 6 is bubbled)

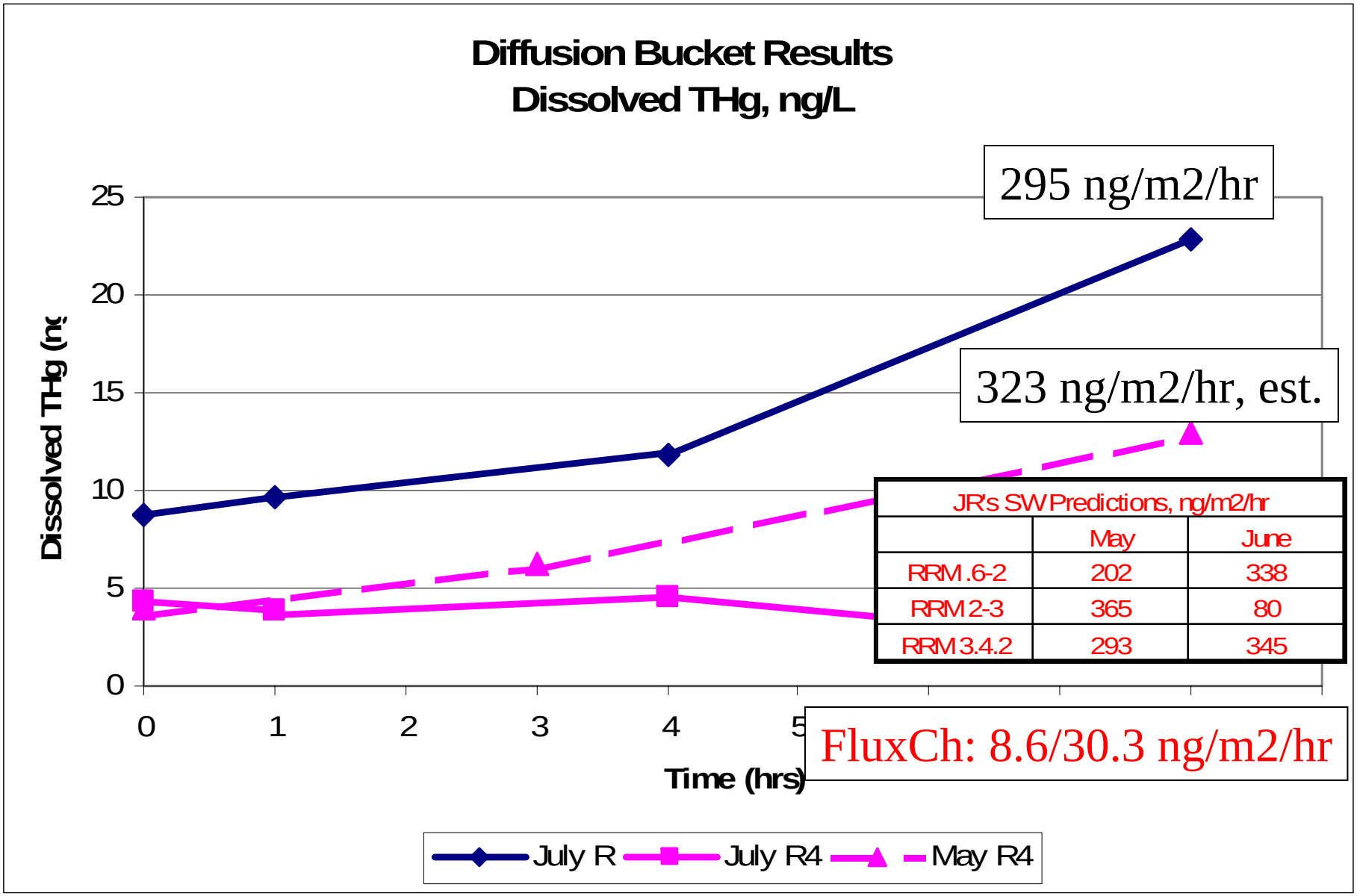
0.11,0.20

Diffusion Buckets - July 06

R-4

R


Diffusion Bucket Results
Dissolved THg, ng/L
Dissolved THg (ng
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
Time (hrs)
July R
July R4
May R4


Diffusion Bucket Results
Dissolved THg, ng/L
295 ng/m2/hr
323 ng/m2/hr, est.
JR's SW Predictions, ng/m2/hr
May
June
RRM .6-2
202
338
RRM 2-3
365
80
RRM 3.4.2
293
345
FluxCh: 8.6/30.3 ng/m2/hr
Dissolved THg (n
25
20
15
10
5
0
0
1
2
3
4
Time (hrs)
July R
July R4
May R4

Near Bank Results - May/July 06

- Strong SW “signal” at chosen location
  - Did we “luck out”, or is this common?
- SW results seem to “follow” sediments
- Sediments perhaps more “localized” than previously expected? (See Pizzuto draft Ch 13)
- Sufficient bank soil Hg to account for sediments
- Pore water relatively clean in most locations
  - Pore water elevations do not “follow” SW or seds
- Will discuss sediment/soil extractions next
- Flux dam QA successful, Shakedown results mixed
- Wells?

Soil/Sediment Leaching Study

Objective: Determine whether Hg release from bank soils and near-bank sediments follows a “simple” desorption equilibrium.

Background

- If soil and sediment “sorb” mercury in “exchange” positions then “exhaustive” extraction with water should produce a near constant aqueous [Hg] regardless of the number of extractions.
- If soil and sediment contain a highly soluble Hg compound (e.g., $HgCl_2$, HgO) then exhaustive extraction with water should produce an exponentially decreasing aqueous [Hg] with increasing numbers of extractions.

Experimental Approach

- Collect representative soil and sediments from study area at Basic Park.
- Perform four (4) successive extractions of each sample with DI water at solution/solid=10 (40 mL/4g)
- Analyze extracts for filtered (0.4 micron) mercury.
- Compare leaching patterns.

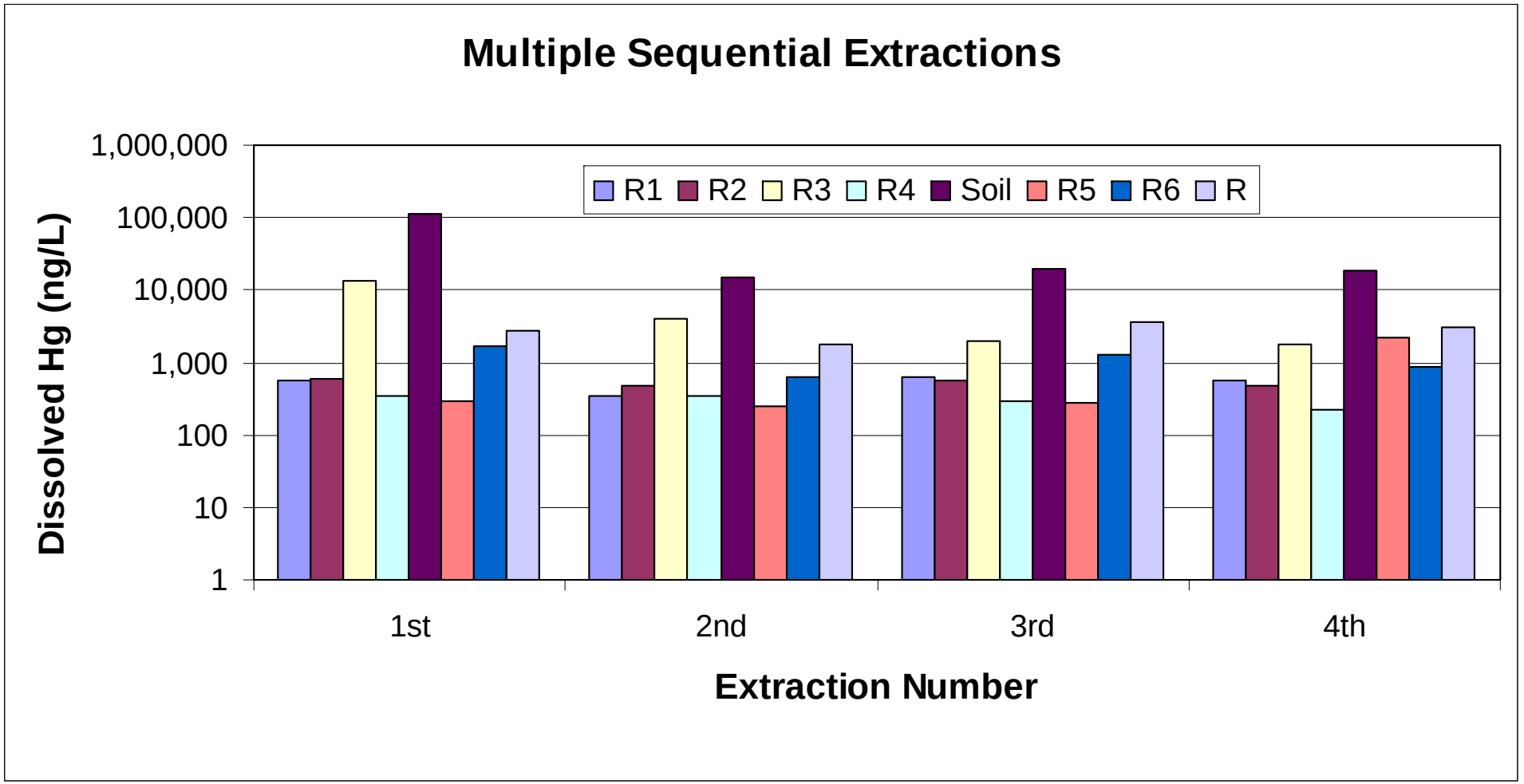
Possible Leaching Patterns

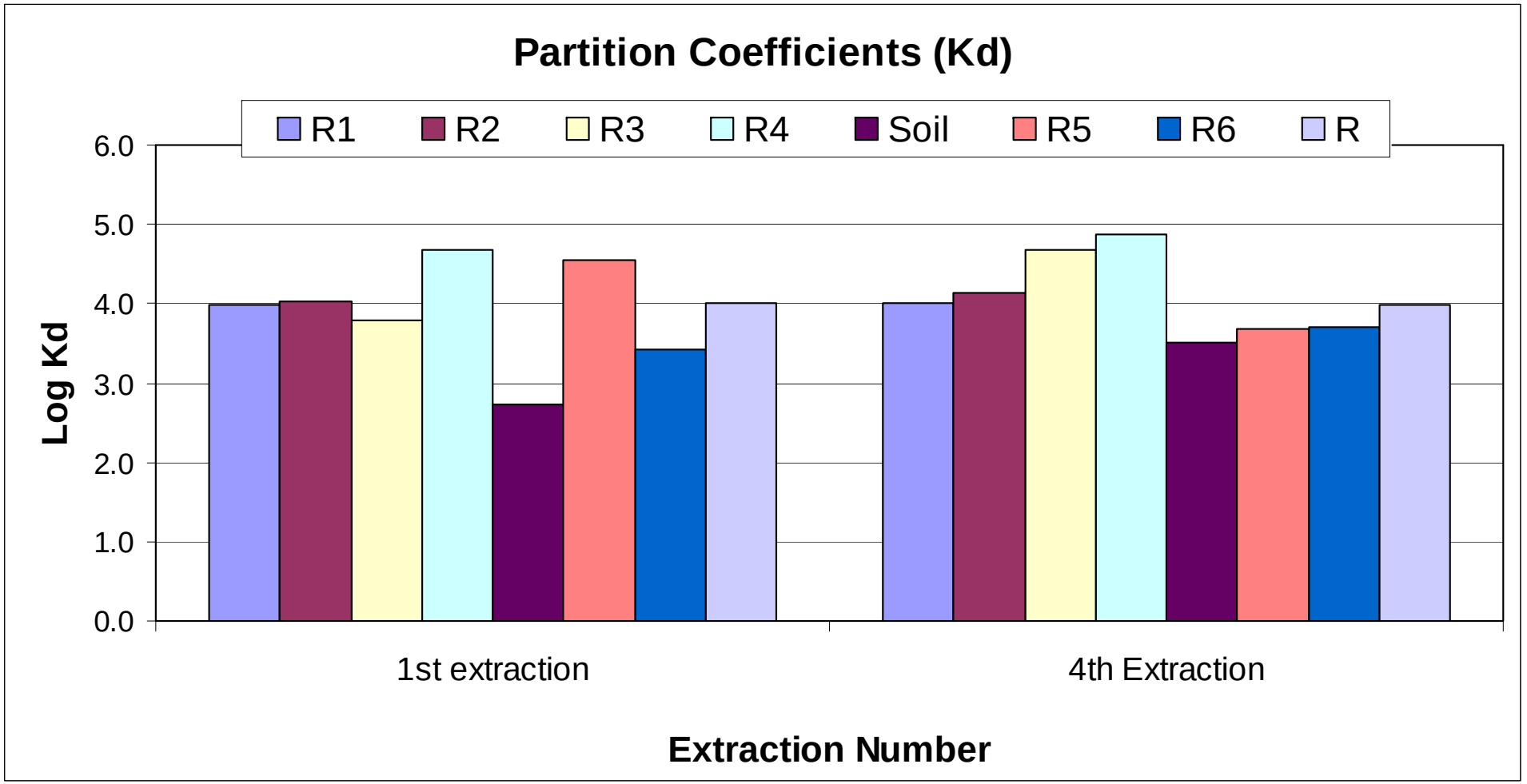
- Constant aqueous [Hg]
  - Suggests sorption/solubility “equilibrium” (infinite source)
- Decreasing aqueous [Hg]
  - Suggests “washout” of a highly soluble compound (e.g., HgO, $HgCl_2$)
- Increasing aqueous [Hg]
  - Suggests dissolution of an “occluding” compound or presence of a sparingly soluble compound (e.g., Hg_2O_2, Hg_2Cl_2, HgS) affected by redox reaction(s)

Basic Park Sample Locations

Soil-Sediment Samples

Sample ID	Total Hg (mg/kg dw)
R1	5.64
R2	6.57
R3	81.6
R	28.4
R4 - Soil	59.6
R4	16.6
R5	10.5
R6	4.36


Multiple Sequential Extractions
Dissolved Hg (ng/L)
1,000,000
100,000
10,000
1,000
100
10
1
R1
R2
R3
R4
Soil
R5
R6
R
1st
2nd
3rd
4th
Extraction Number


Partition Coefficients (Kd)
R1
R2
R3
R4
Soil
R5
R6
R
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Log Kd
1st extraction
4th Extraction
Extraction Number

Conclusions

- Some samples produced very high leachate [Hg]
  - Soil = 113,000 ng/L !!
  - R3 sediment = 14,000 ng/L
- Leaching patterns (constant [Hg]) suggest all samples have Hg in “exchange” positions.
- Soil produced the lowest partition coefficients (Kds) especially at the initial extraction.
- Suggests that release and diffusion of Hg from these materials could account for longitudinal and transverse patterns in South River surface water Hg.
- Results conflict strongly with those of Rob Mason (shake & bake) and somewhat with earlier simulated TSS leaching.

Path Forward

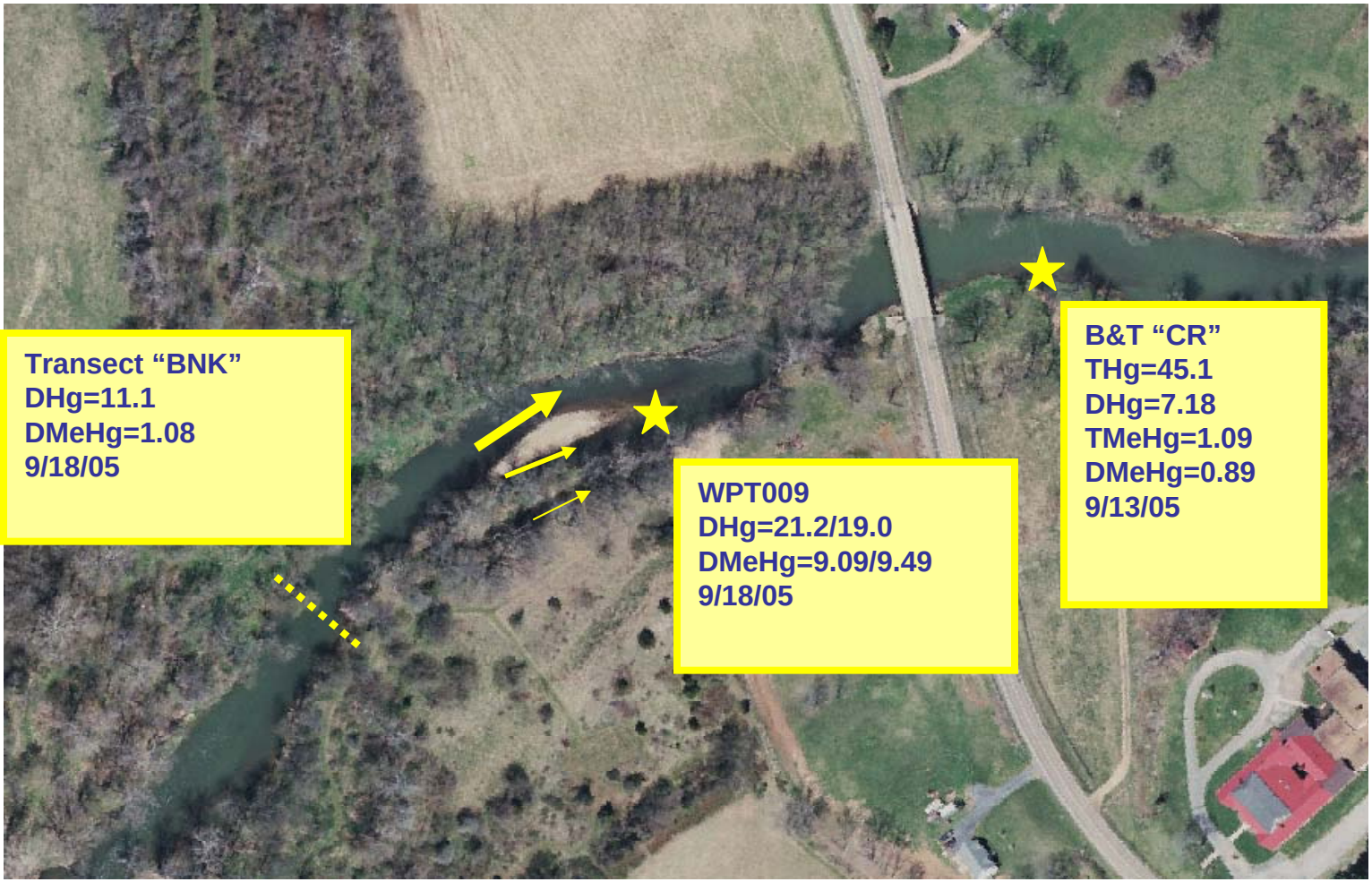
- Verify high aqueous [Hg] associated with the sediment samples by collecting porewater samples from each location.
- Repeat extraction of one sample from set with filtered river water from SR-01 (Lyndhurst).

Crimora Anomaly

Objective: Verify/understand
THg/MHg anomaly near Crimora

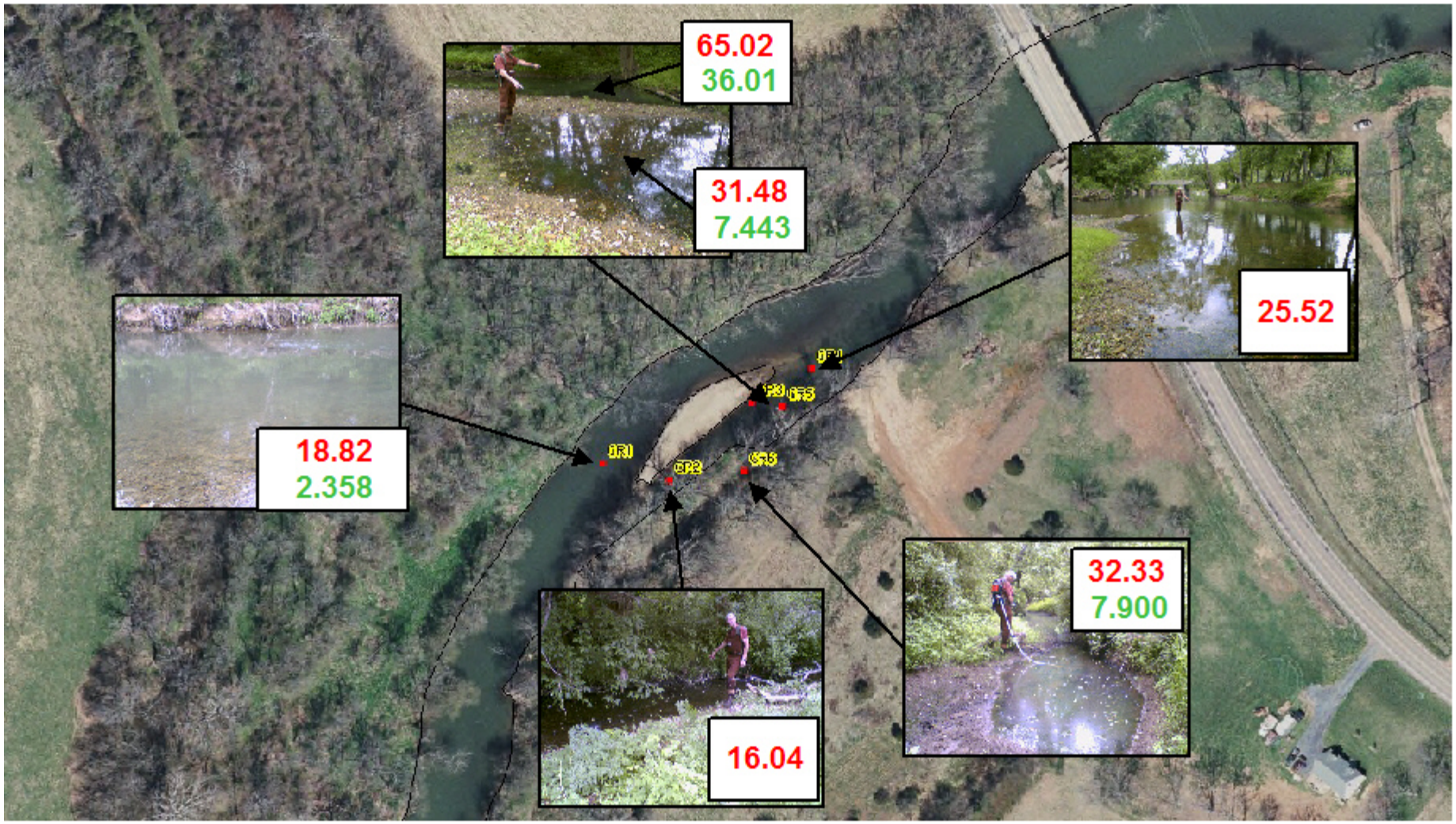
Unusual THg/MeHg Results

Near Crimora-Sept 2005 (ng/L)



May 06 Crimora SW Results

THg; MHg; all ng/L dissolved



July 06 Crimora SW Results

THg; all ng/L dissolved

May/July 06 Crimora SW Results

All ng/L dissolved

Location	**THg**	**MHg**
Main Channel	18.82/11.51	2.36
Sept 05 Location	25.2/13.4	-
Mid Channel Upstream	16.04/0.44	-
Mid Channel Downstream	31.48/6.10	7.44
Inner Channel Upstream	32.33/27-39	7.90
Inner Channel Downstream	65.01/NA	36.01

July 06 Crimora Pore Waters

Also resampled all SW except CR-5