Evaluating Source Allocation at an Industrial Contaminated Sediment Site

Best Practices Group Sediment Training Session

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Issues at Multi-Party Contaminated Sediment Sites

- Existence of contaminants from multiple sources raises these questions:
  - Who caused the contamination?
  - When did the contamination occur?
  - How did it occur?
  - How extensive is the contamination?
  - What levels of contamination have people been exposed to?
  - How do you allocate liability amongst sources?

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Evaluating Multiple-Source Contributions to Site Contamination

- Source contribution is one component to a conceptual site model (CSM) and focuses on the analysis of the magnitude, distribution and composition of contaminants in a system

- Methods often used to evaluate multiple-source contributions:
  - Mass balance calculations
  - Temporal-gradient analysis
  - Spatial-gradient analysis
  - Chemical fingerprinting
  - Inferences from land-side contamination
  - Quantification of fate and transport pathways

- Typically, allocation conclusions are based on a weight-of-evidence approach

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Weight-of-Evidence Approach

- Often used to recognize uncertainty inherent in the evaluation of data collected from different people, at different times, with different objectives

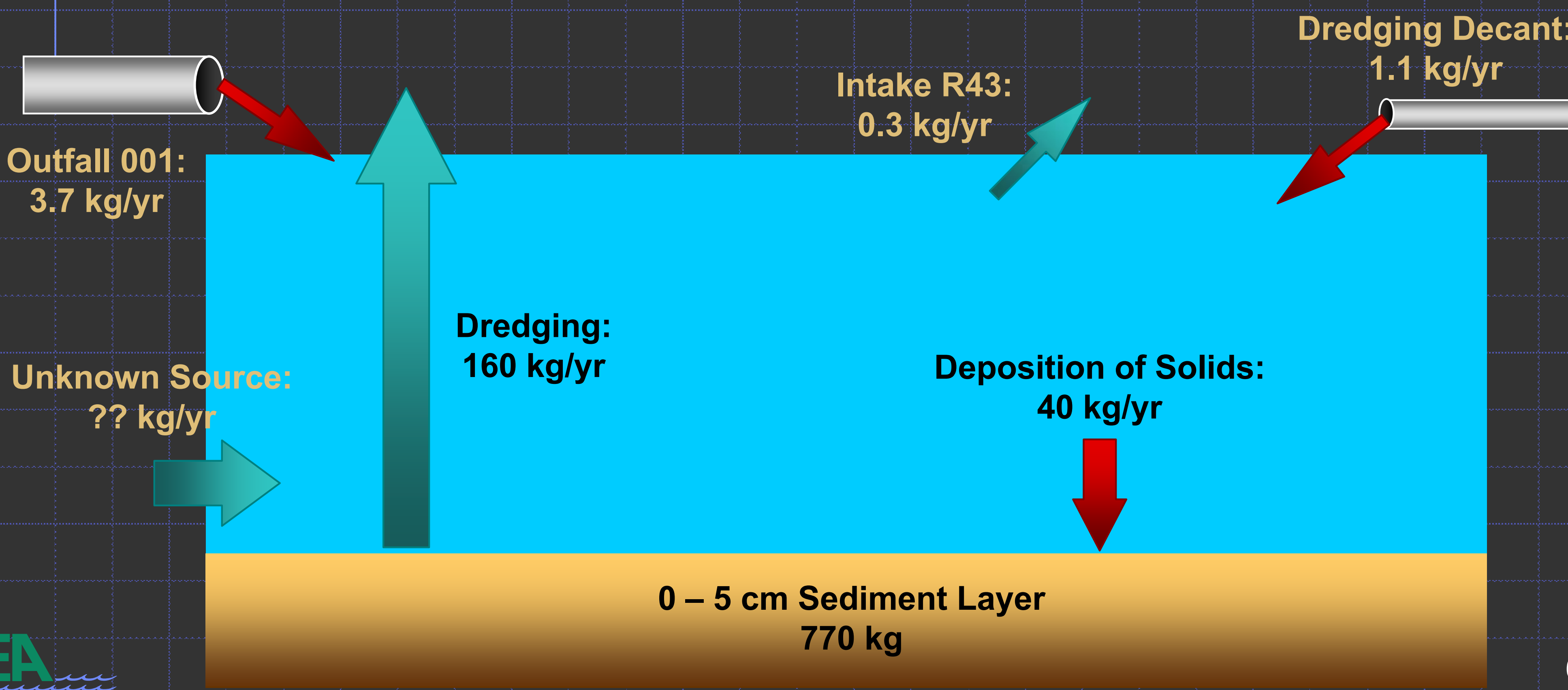
- Relies on multiple lines-of-evidence or analyses that provide confidence in a particular conclusion
  - Likelihood of a false conclusion is reduced if multiple lines-of-evidence yield the same conclusion

Keys to a Defensible Source Allocation Evaluation

- Develop and implement a well-conceived sampling plan that includes:
  - Appropriate number of samples to provide statistical rigor to analyses
  - Sufficient spatial coverage to distinguish between multiple sources and/or background concentrations
  - Appropriate analytical methods to allow for "nature and extent" characterization and "forensics" analyses
  - Strict QA/QC measures to provide proper documentation and confidence in analytical results
- In-depth understanding of fate and transport
- Models to quantify outcome of fate and transport pathways

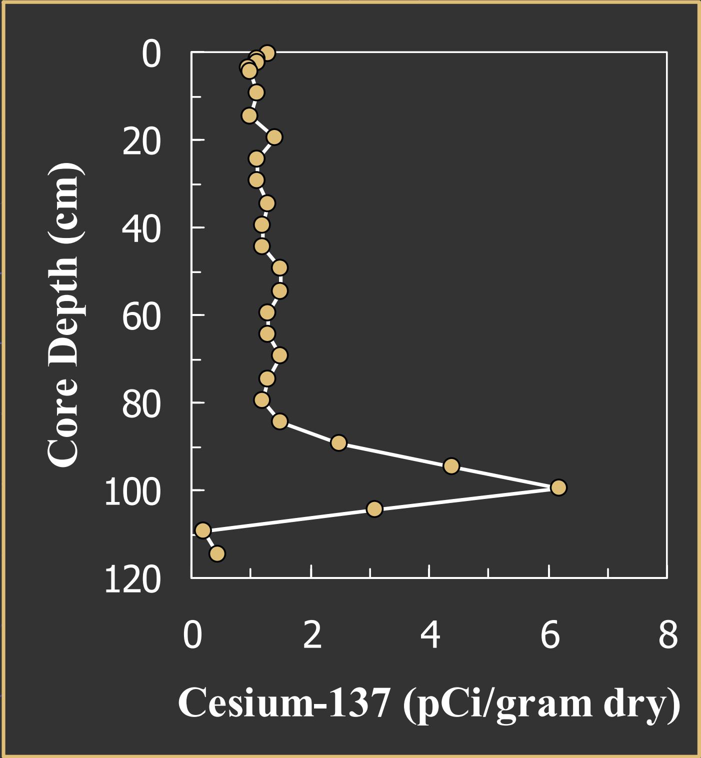
Mass Balance Calculations

- Mass balance calculations are a mathematical accounting of sources and sinks of a contaminant within a sediment site
  - Help determine relative contributions of multiple sources of contaminants to a system
  - Help identify data gaps/areas of uncertainty



Temporal-Gradient Analysis

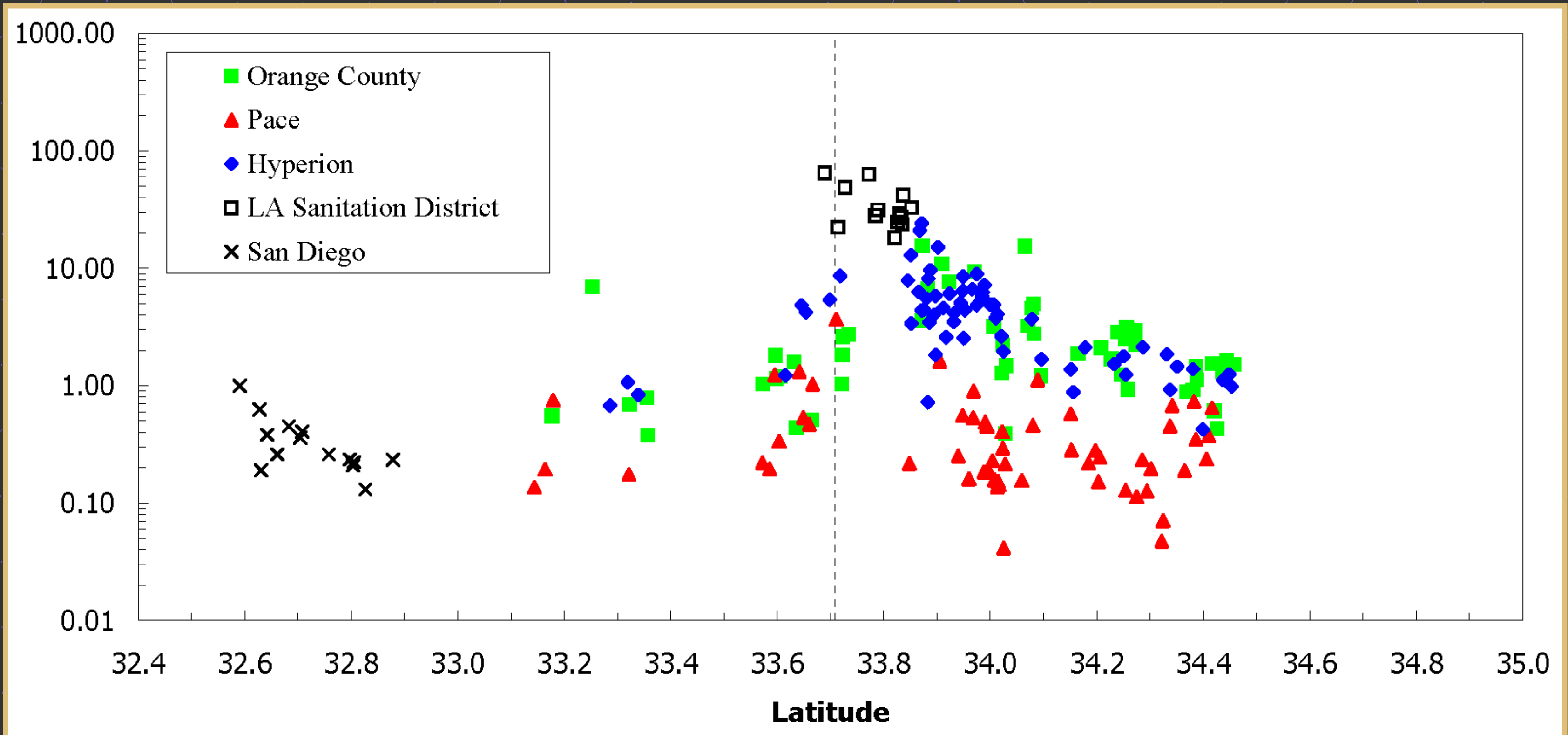
- Historical documentation is often insufficient to reconstruct contaminant discharges to the environment
- Sediments can provide a history of contaminant loading to the system
- Age dating of sediment cores is typically conducted to reconstruct contaminant loading history
  - Accomplished through evaluation of Cesium-137 and Lead-210 profiles



Spatial-Gradient Analysis

- Spatial patterns of chemical concentrations can be used to determine whether bed contamination is the result of single or multiple sources
  - Highest concentrations occur at source location, with concentrations declining as distance from source location increases

p,p'DDE Levels in Surface Sediments (µg/g OC)



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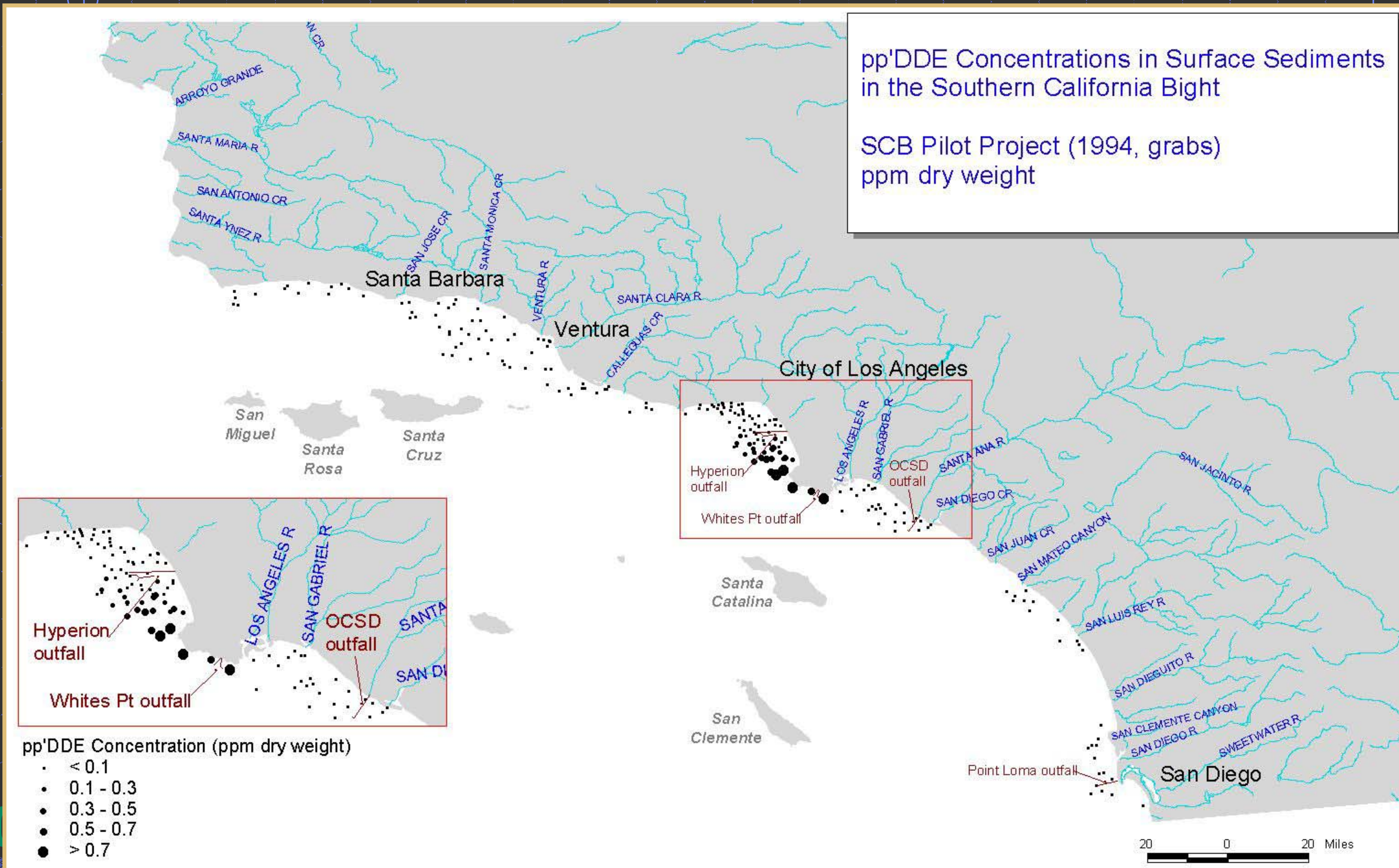
Spatial-Gradient Analysis



Chemical Fingerprinting

- Use of unique chemical signature, tracer, or pattern to:
  - Distinguish different chemical sources
  - Reconstruct historical loading patterns
  - Date a particular event

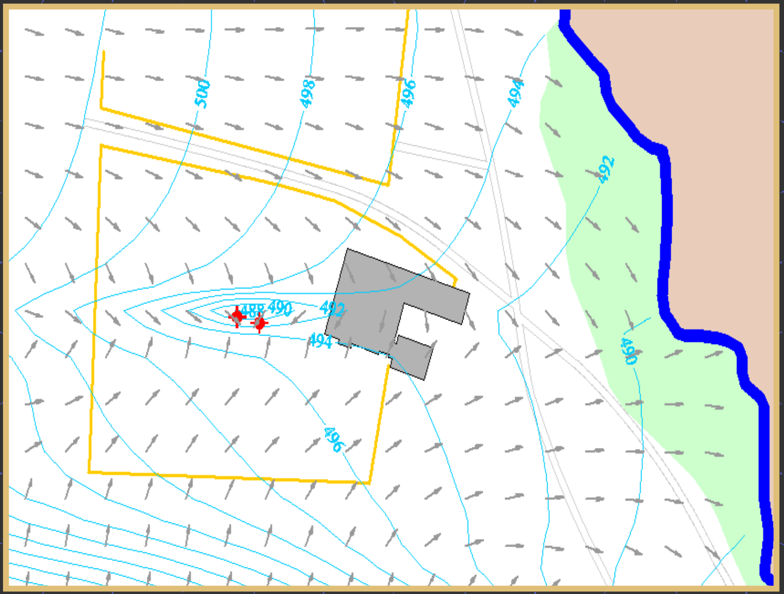
- Methods typically focus on examining chemical composition similarities/differences between potential sources and impacted system

- Standard RI/FS analytical methods are sufficient for determining magnitude and extent, but insufficient to conduct forensic analyses
  - High resolution analytical techniques are required for forensic analysis, which is typically needed for source allocation

Inferences from Land-Side Contamination

- Two potential sources
  - Runoff or erosion of soil from land surface
  - Groundwater transport beneath land surface

- Potential contributions can be made by examining:
  - Land type/characteristics surrounding aquatic system
  - Point discharges
    - Stormwater outfalls
    - Combined sewer overflows
  - Groundwater flow patterns/rates
    - Recharge
    - Discharge
    - Variable
  - Contaminant levels in groundwater



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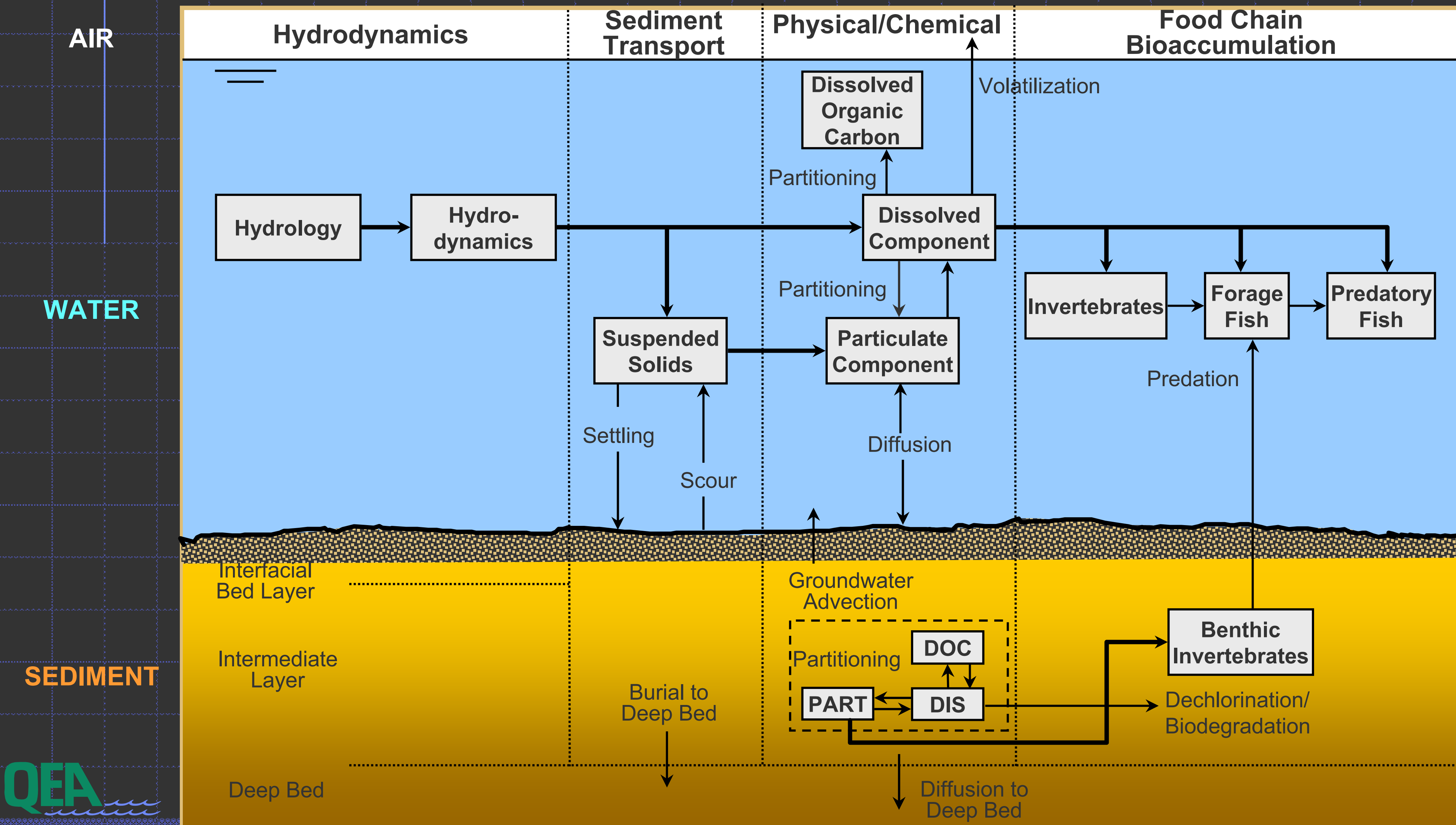
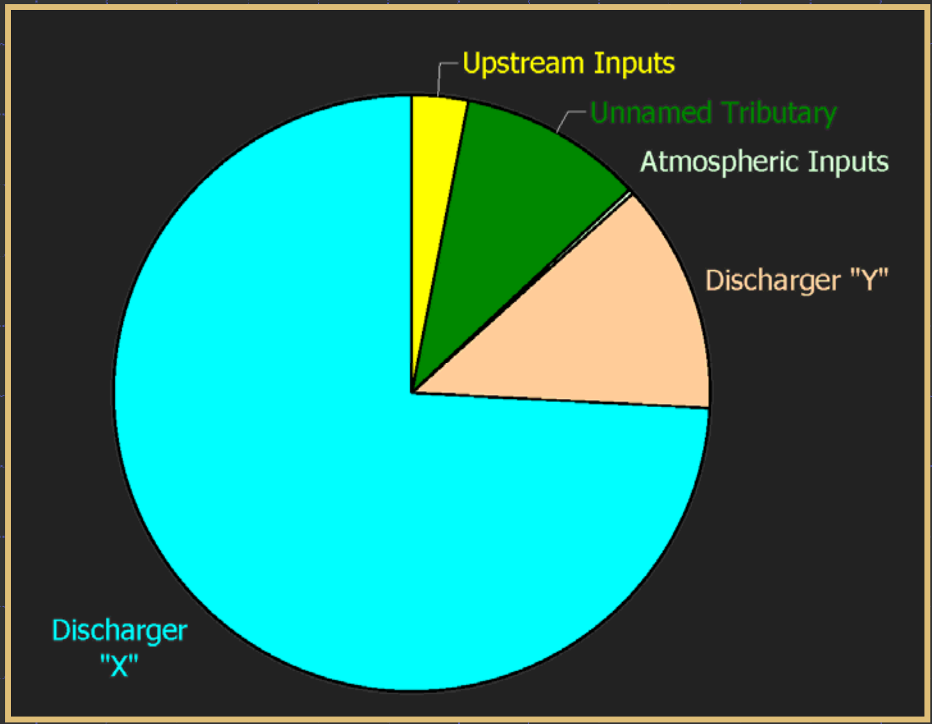
Quantification of Fate and Transport Pathways

- Spatial and temporal distributions of contaminants in a system are affected by various transport, transfer and reaction processes



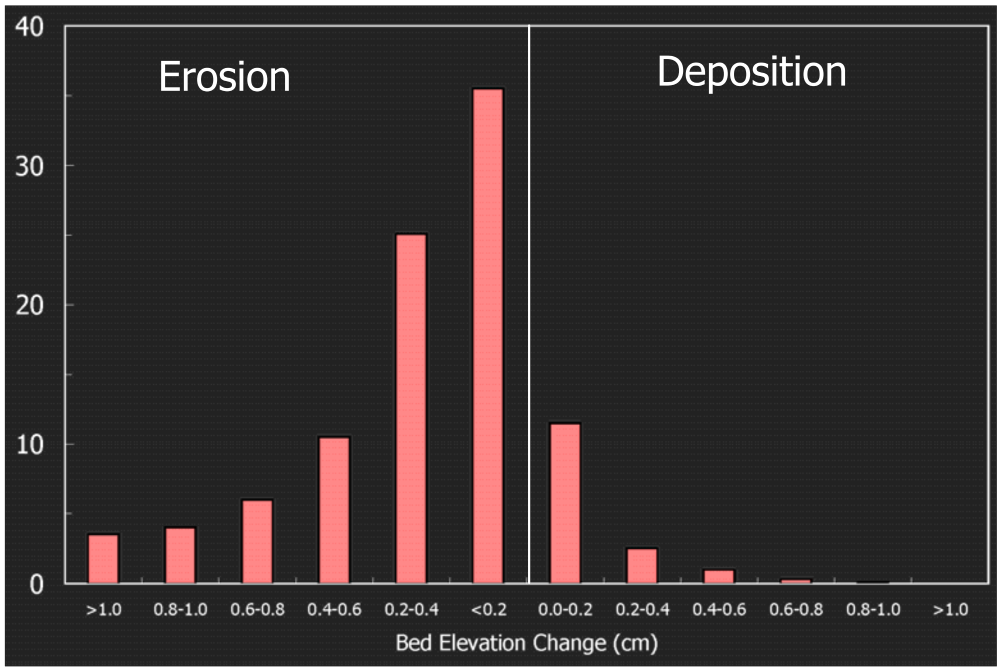
Benefits of Computer Models

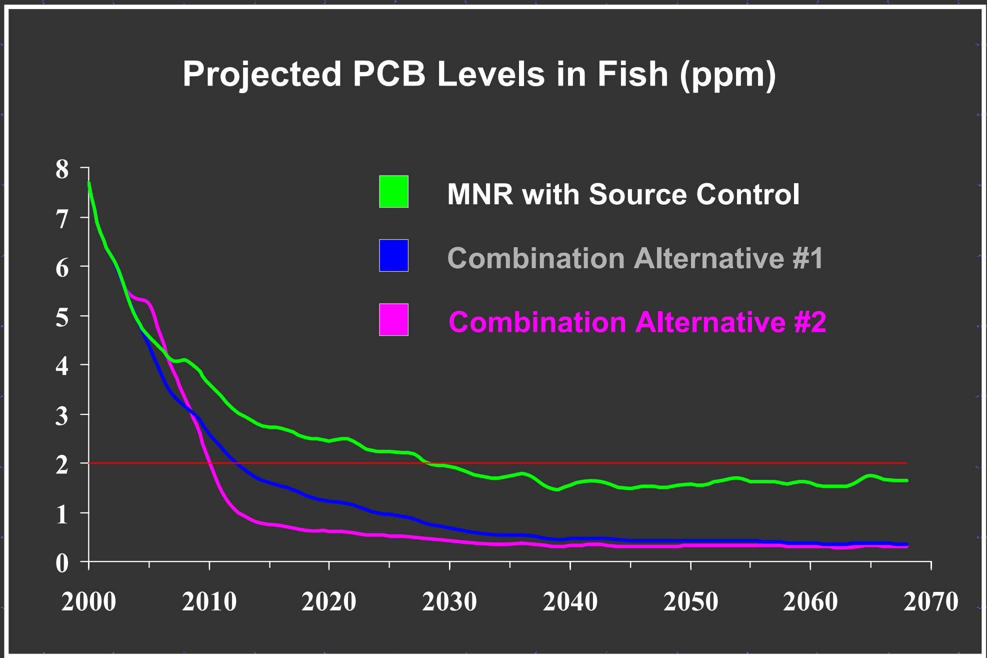
- A computer model can be a reliable diagnostic tool to further develop portions of the CSM and provide quantitative support for source allocation
  - Identify sources
  - Evaluate importance of fate and transport mechanisms
  - Identify data gaps
  - Constrain the CSM



Benefits of Computer Models

- Computer models can also be used to:
  - Address specific technical issues related to the CSM
  - Predict sediment and surface water quality in the future
  - Evaluate potential effectiveness of remedial alternatives





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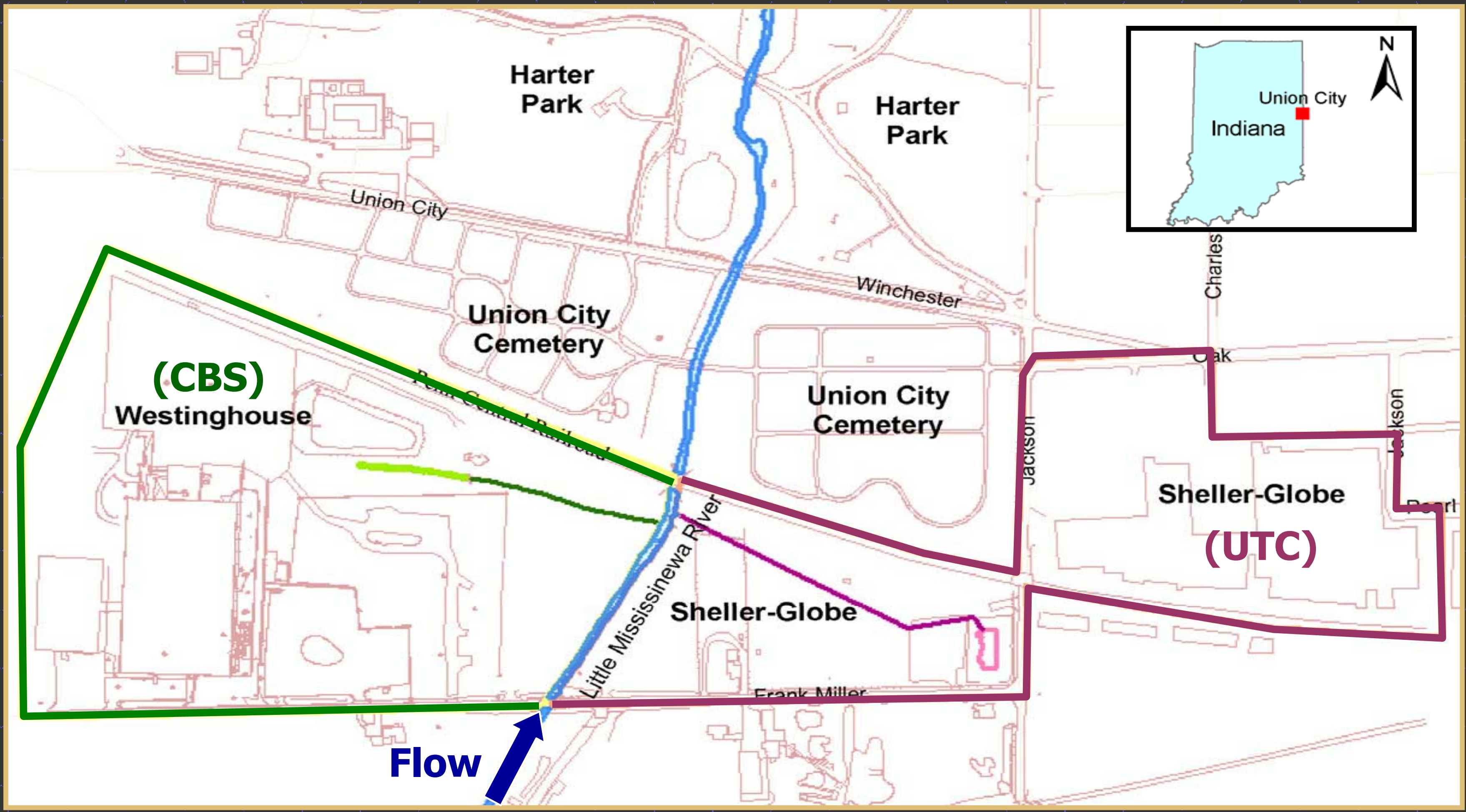
Case Study: Little Mississinewa River

- CBS (formerly Westinghouse) and UTC (formerly Sheller-Globe) identified as dischargers of PCBs to Little Mississinewa River (located near Union City, Indiana)
- In 2004, USEPA issued ROD outlining remediation of river sediments
- CBS and UTC responsible for costs of investigation and remediation of affected media
  - Soils
  - Groundwater
  - Surface water
  - Sediment
  - River floodplain

Case Study: Objective

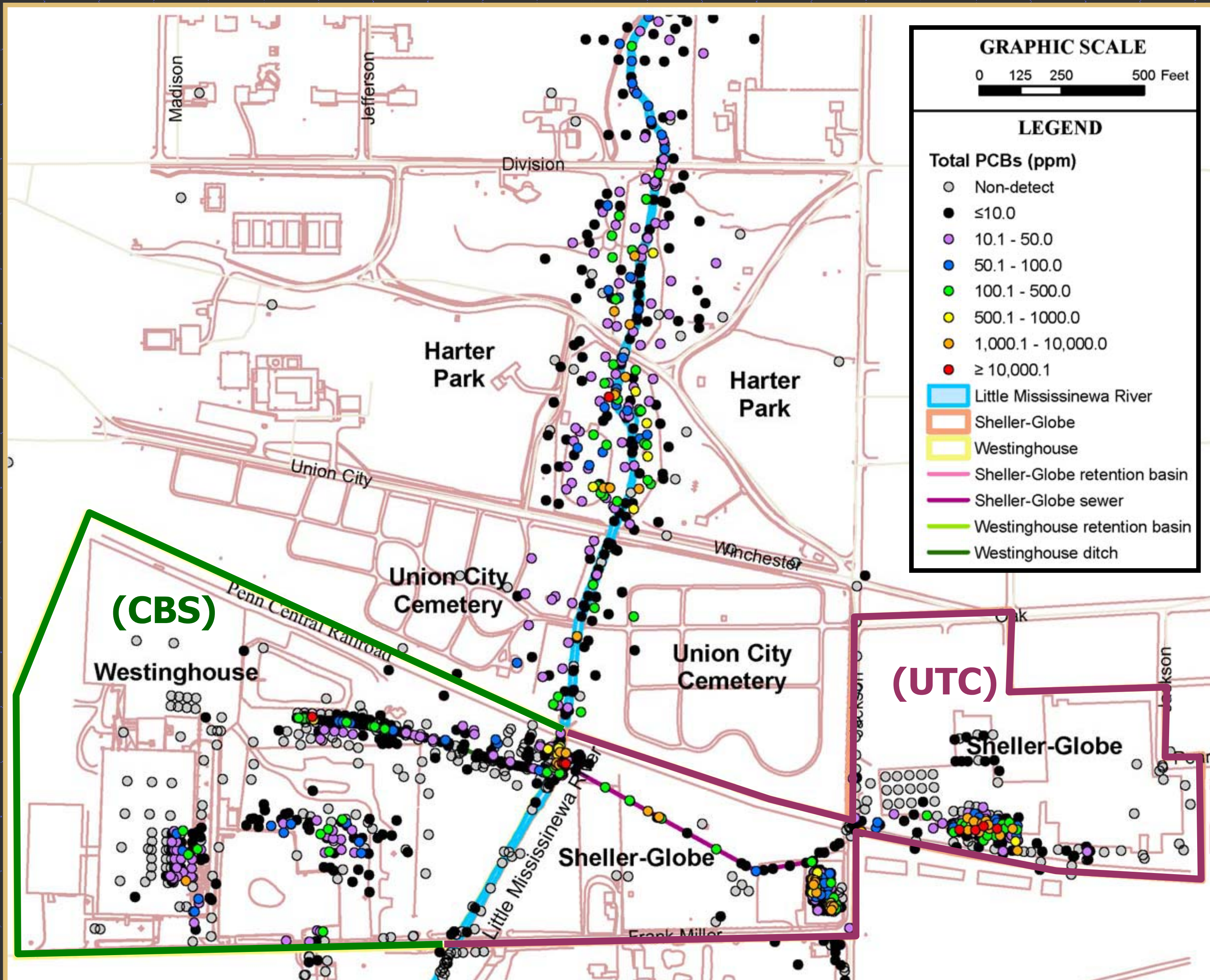
- Objective: determine the relative contributions of the CBS- and UTC-owned facilities to PCB contamination present in soils and sediments targeted for remediation



Case Study: Approach

- Weight-of-evidence approach
  - Land-side
    - Examine PCB levels on CBS and UTC properties and in soils and sediments along the drainage paths that carried PCBs from the respective facilities to the river
    - Estimate approximate rate of PCB discharge from the two facilities
  - In-River
    - Inspect PCB bed concentrations in the immediate proximity of facility discharge locations
    - Examine spatial patterns of PCB bed concentrations downstream of both facilities
    - Investigate bed concentration patterns of polychlorinated terphenyls (PCTs), which is a tracer of the CBS discharge

PCB Concentrations in Soils and Sediments



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PCB Concentrations on CBS and UTC Properties and in Drainage Ways

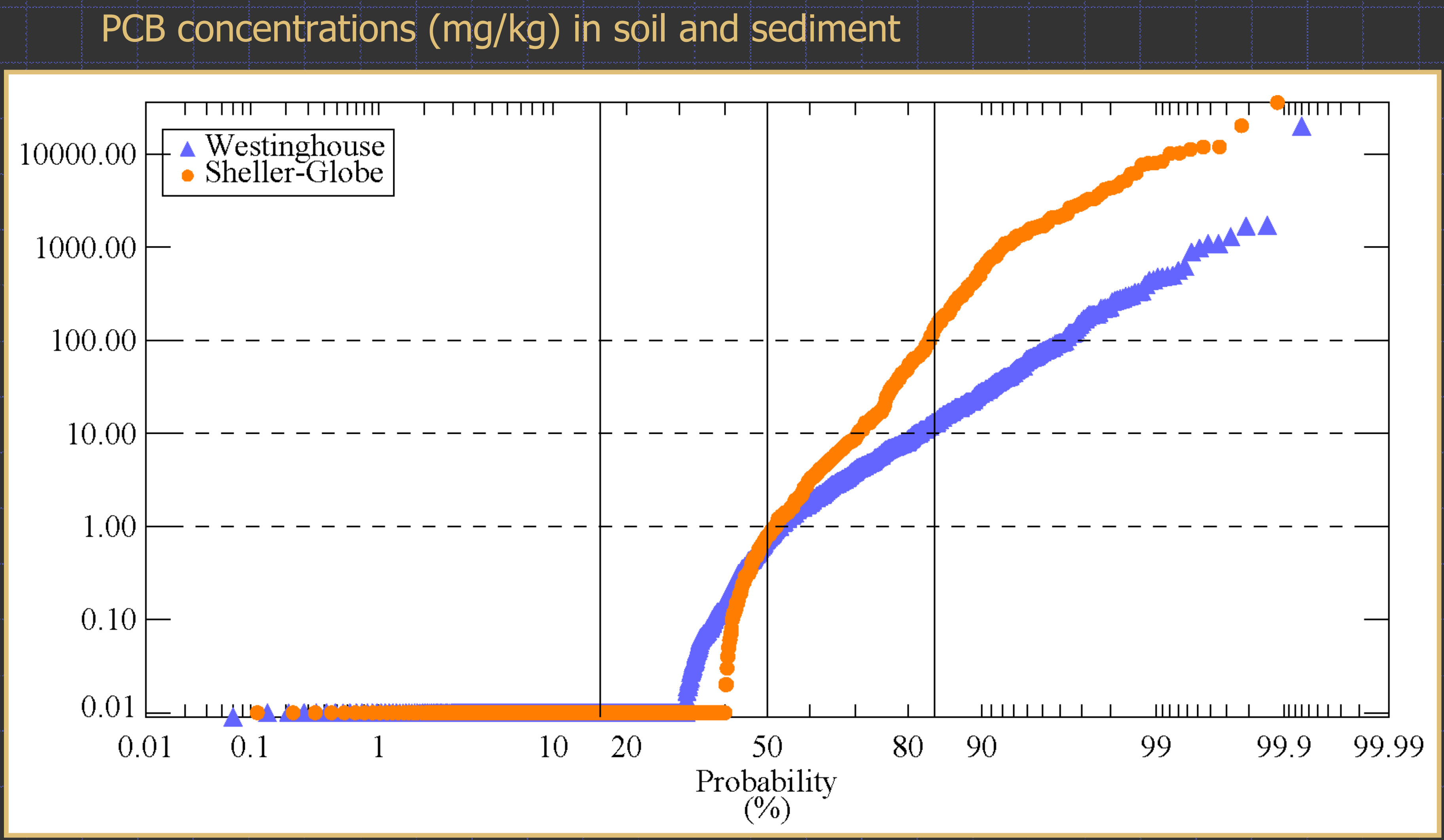
- PCB concentrations on site properties

Location	No. Samples	Range (mg/kg)	Mean (mg/kg)	No. ND	No. > 100 mg/kg
CBS (pre)	586	ND – 1,730	14.5	336	15
CBS (post)	657	ND – 1,700	26	43	29
UTC (pre/post)	520	ND – 12,000	417	205	100

- PCB concentrations in drainage ways

Location	No. Samples	Range (mg/kg)	Mean (mg/kg)	No. ND	No. > 100 mg/kg
CBS	136	ND – 150	6	49	1
UTC	27	ND – 1,180	100	4	6

PCB Concentrations on CBS and UTC Properties and in Drainage Ways



PCB Loadings from the Two Facilities

- Relative contributions of the two facilities to PCB contamination in the river were determined through mass loading analysis

- PCB loadings from each facility were estimated using:
  - PCB concentrations in the water moving through the drainage way
  - Water flow through the drainage way

- Estimated daily-average PCB load to the river from the UTC outfall was approximately 55 times greater than the estimated PCB load from the CBS outfall

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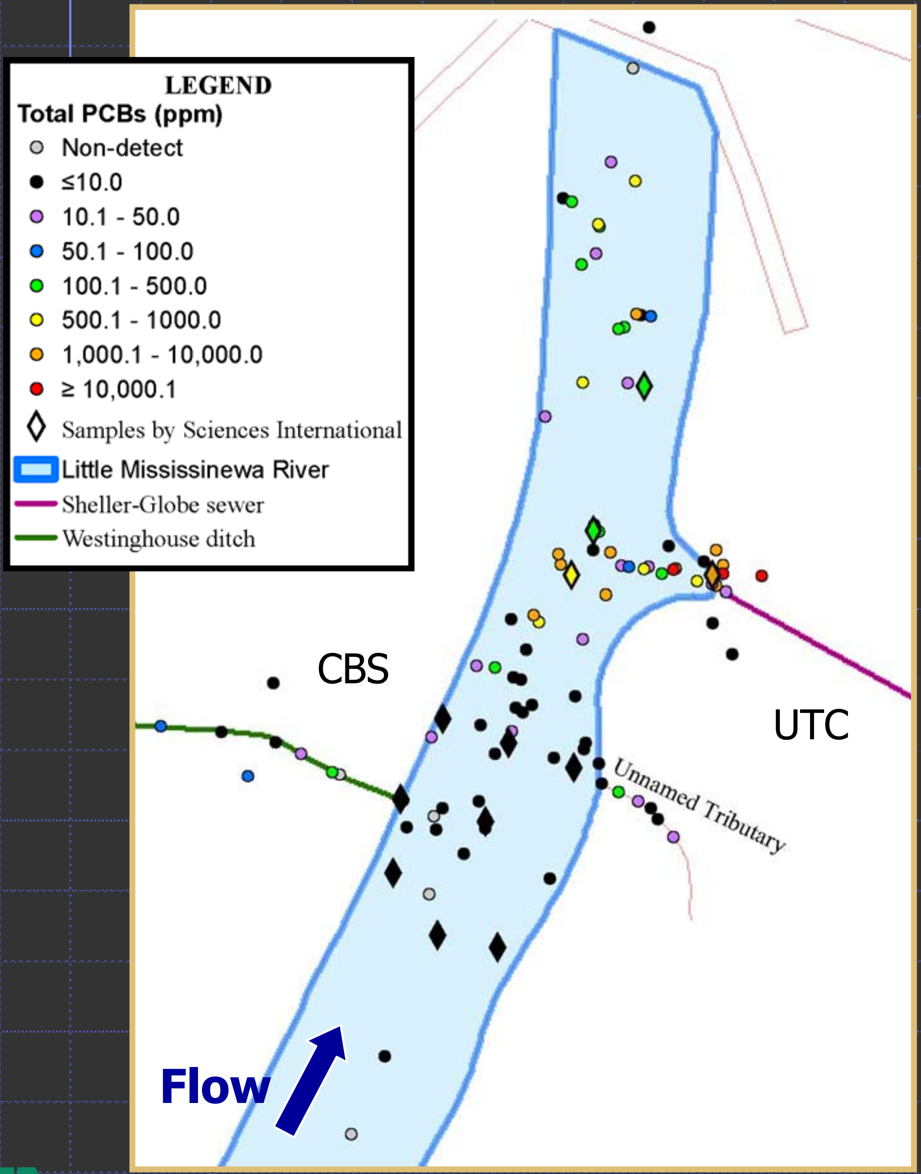
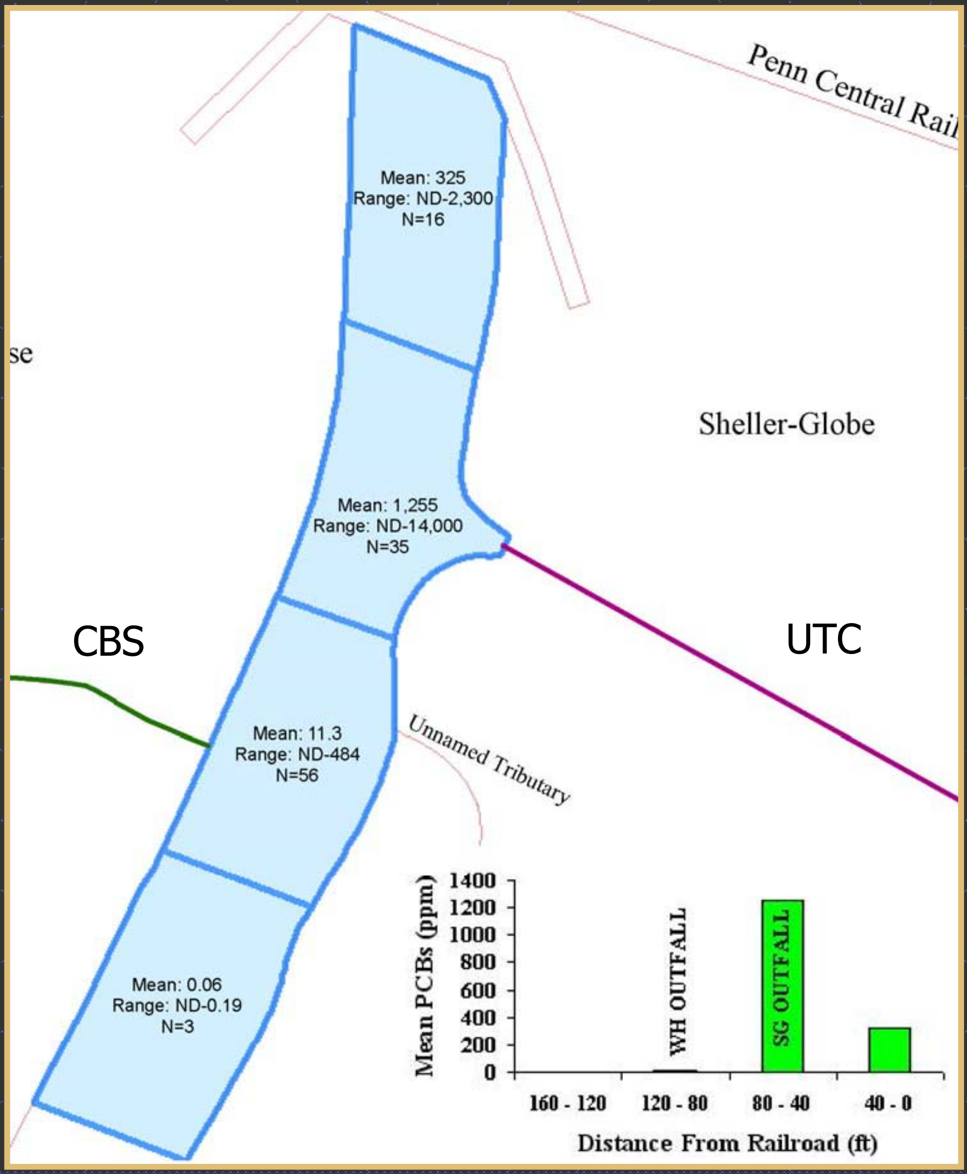
PCB Bed Concentrations in Immediate Proximity of Facility Discharge Locations





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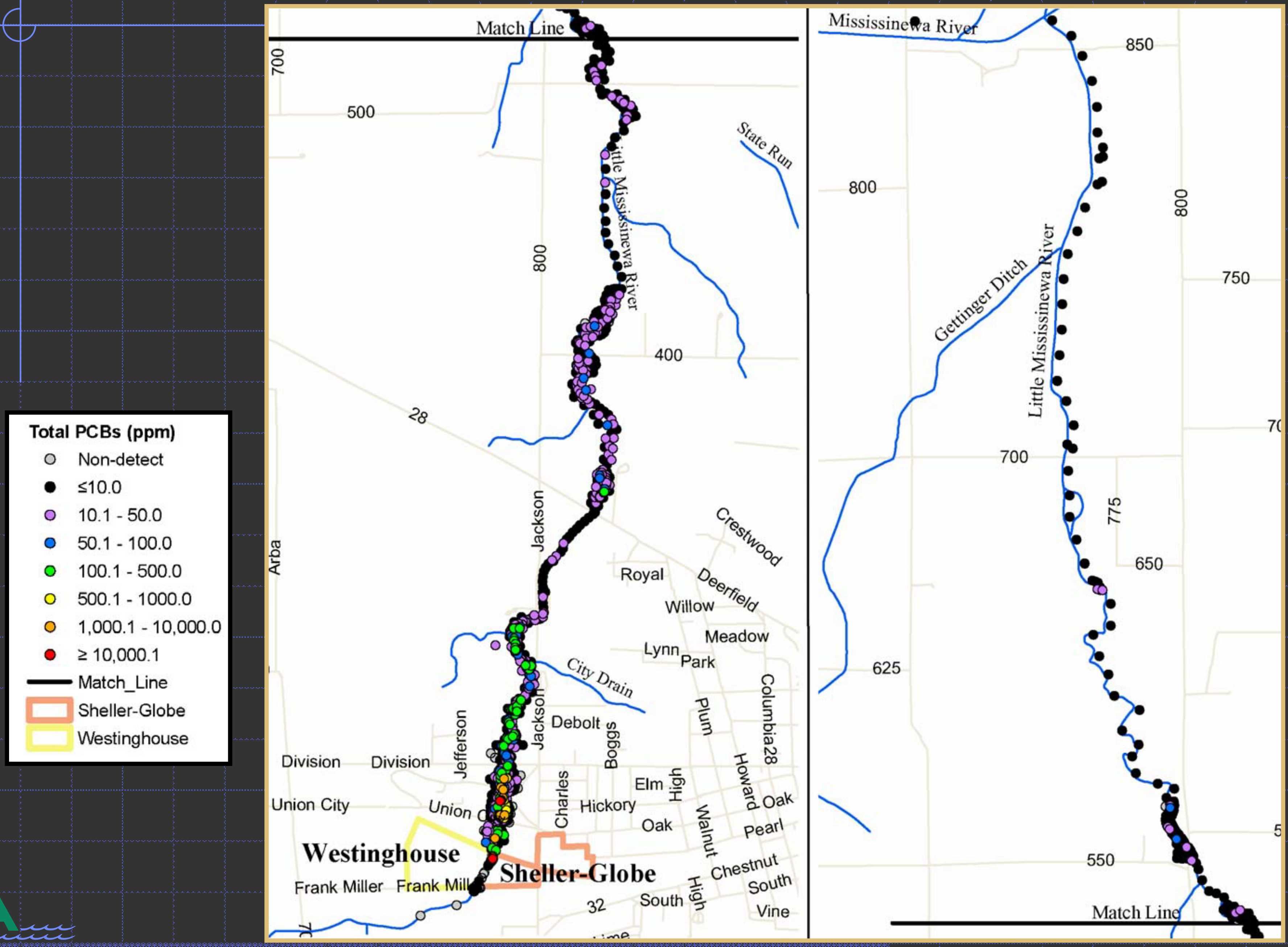
Downstream PCB Bed Concentrations

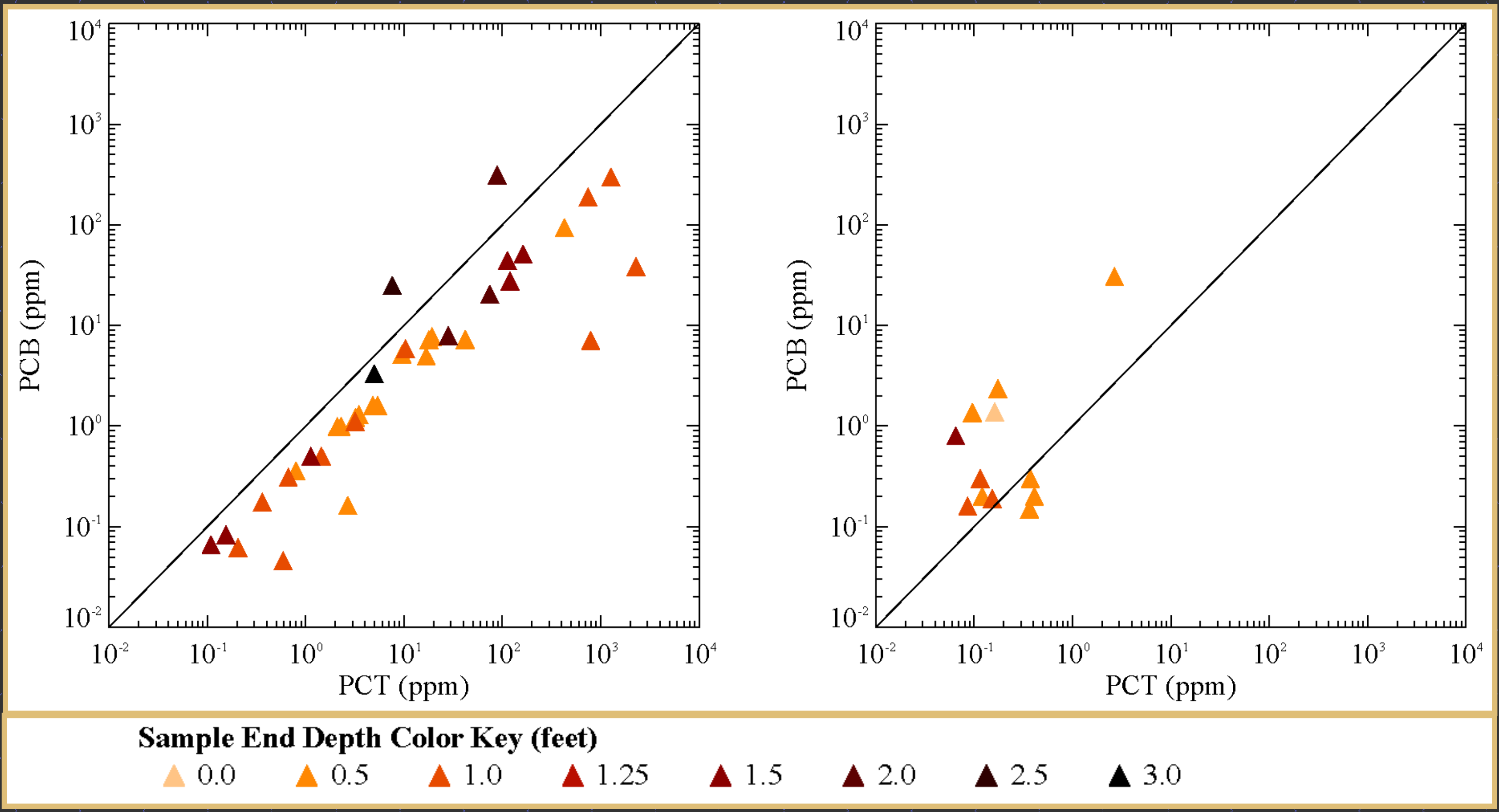


PCTs as a Tracer of the CBS Discharge

- CBS used PCB fluids that contained PCTs whereas UCT did not
- Therefore, PCTs were used as a tracer for the CBS discharge

Drainage-Way Sediments

River Sediments Near Discharge



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Case Study: Conclusions

- The UTC facility was the dominant contributor of PCBs to the Little Mississinewa River
  - UTC property and drainage way has much higher PCB concentrations than the CBS property/drainage way
  - UTC discharged PCBs at a much higher rate
  - River sediments in the immediate proximity of the UTC discharge are much more highly contaminated than river sediments in the immediate proximity of the CBS discharge
  - PCB bed concentrations downstream of both facilities are much higher than concentrations in the CBS drainage way
  - PCTs discharged by CBS show that the CBS discharge was substantially diluted in the river