Evolution of Spatial Mapping of the Lower Fox River (Operable Units 3 & 4)

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LimnoTech
Water | Environment | Scientists | Engineers

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Overview

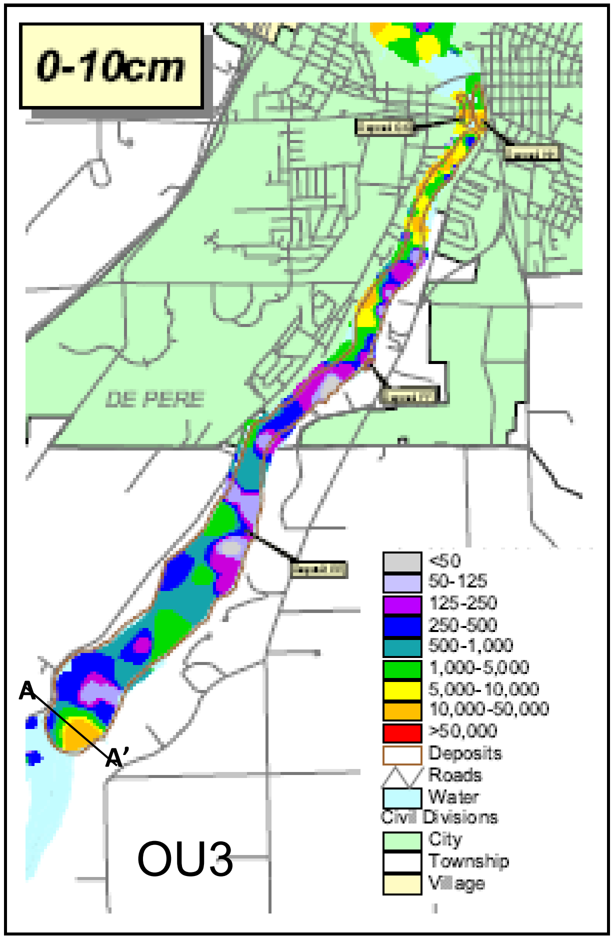
- How contaminated deposits have been characterized and mapped
  - From site investigation
  - To remedy design and implementation
- Different purposes require different densities and methods
  - Statistical tools that have been employed to best leverage the sediment data at each project stage

Roles of Geospatial Modeling in Lower Fox Site Management

- Site characterization, as part of the Remedial Investigation
- Support to PCB fate and transport modeling, to forecast time to recovery for Feasibility Study
- Determination of Remedial Action Level for remedial decision
- Extent and depth of contamination for remedial design

PCB Interpolations for the RI/FS

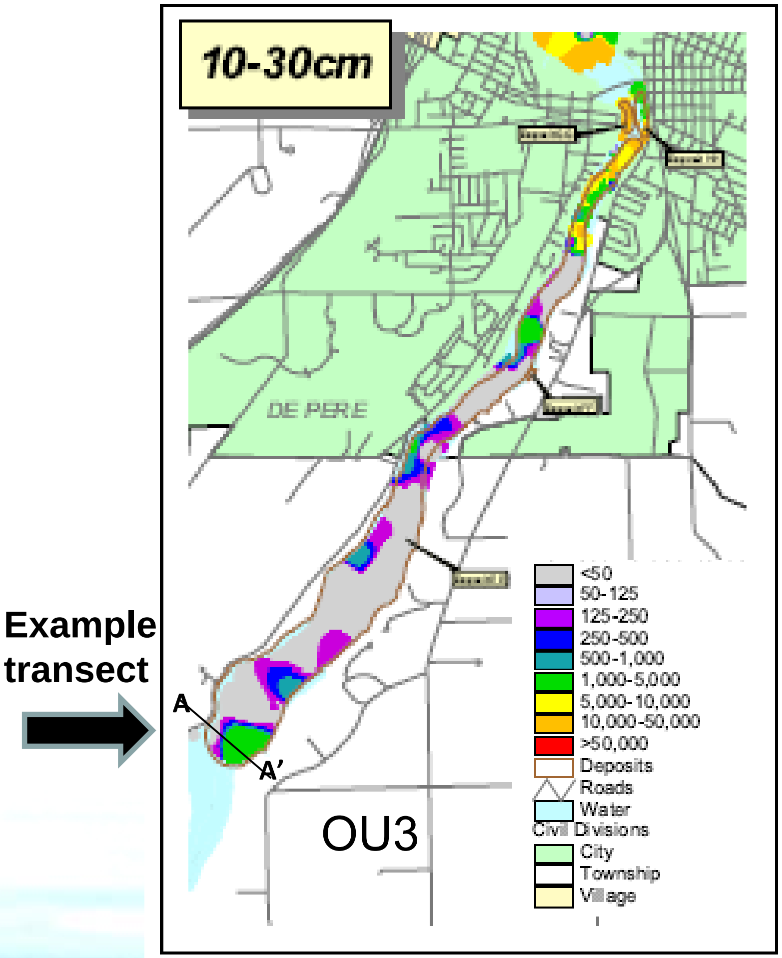
Example transect



Natural Resource Technology

- Based on about 1 core/ 14 acres in OU3 & OU4
- Used Inverse Distance Weighting
  - In vertical layers, matching core segmentation
- Maps showed spatial trends in PCB concentration, to inform remedy selection

Selecting a Remedial Action Level for the Record of Decision

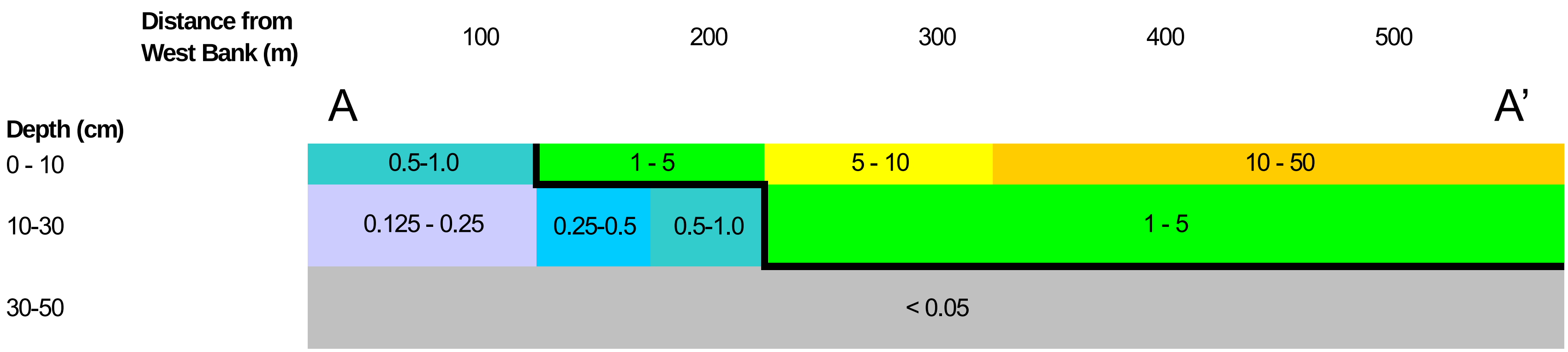


Natural Resource Technology

- Feasibility Study looked at a range of targets (0.125 to 5 mg/kg PCB)
  - For each, the FS estimated time to meet risk targets after removal of all layers exceeding that target
- ROD: remediate material exceeding 1 mg/kg PCB
  - RAOs would be achievable after 30 additional years

Basis for 1 mg/kg Remedial Action Level (RAL)

- Using PCB interpolations, all layers exceeding 1 mg/kg were assumed to be removed



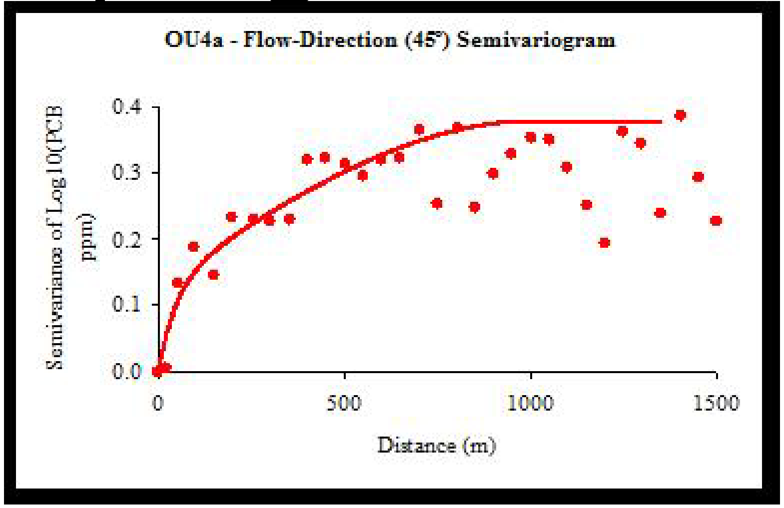
- Surface weighted average concentration (SWAC) was computed for remaining layers
  - As post-dredge conditions for PCB fate modeling

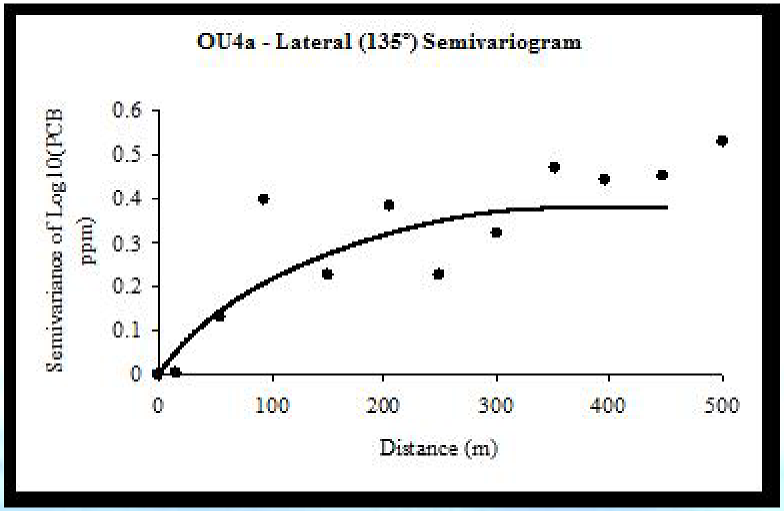
Result: Dual Criteria

- Performance standard: remediate all sediment > 1 mg/kg (RAL)
  - Remaining SWAC was about 0.25 mg/kg, and time to achieve RAOs was deemed acceptable
- If RAL can't be met everywhere in OU, it's sufficient to meet SWAC goals
  - 0.25 mg/kg in OU1 and OU4
  - 0.26 mg/kg in OU3

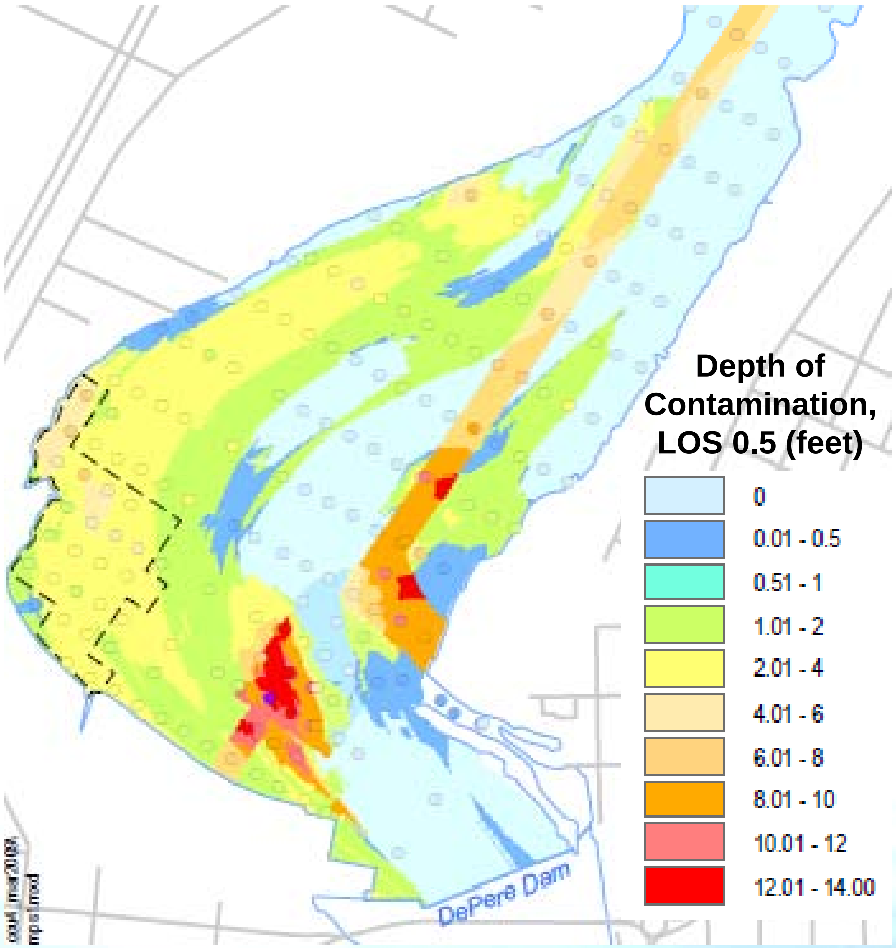
Implementing the ROD - Planning Design Sampling

- Design team used RI data to plan sampling grid
  - Used semivariograms to assess correlation ranges
    - With anisotropy based on flow
    - Resulted in 1 core/ 1.5 acres
- Adjusted densities based on known concentrations
    - Higher density where TSCA levels could be encountered and edges of deposits
    - Intervals selected for analysis near bottoms of deposits





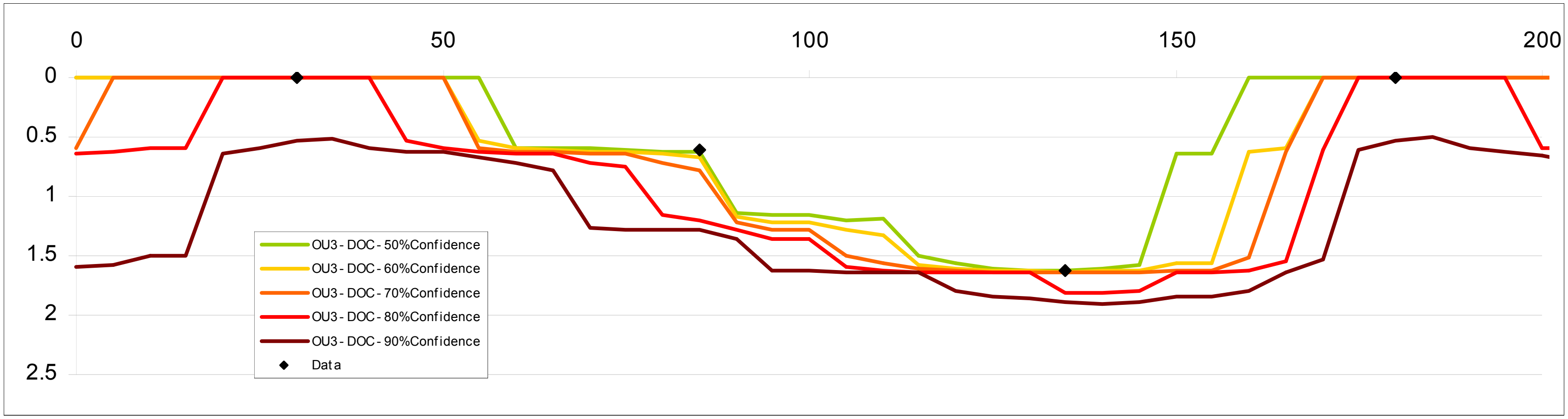
Interpolating Depth of Contamination for Remedy Design



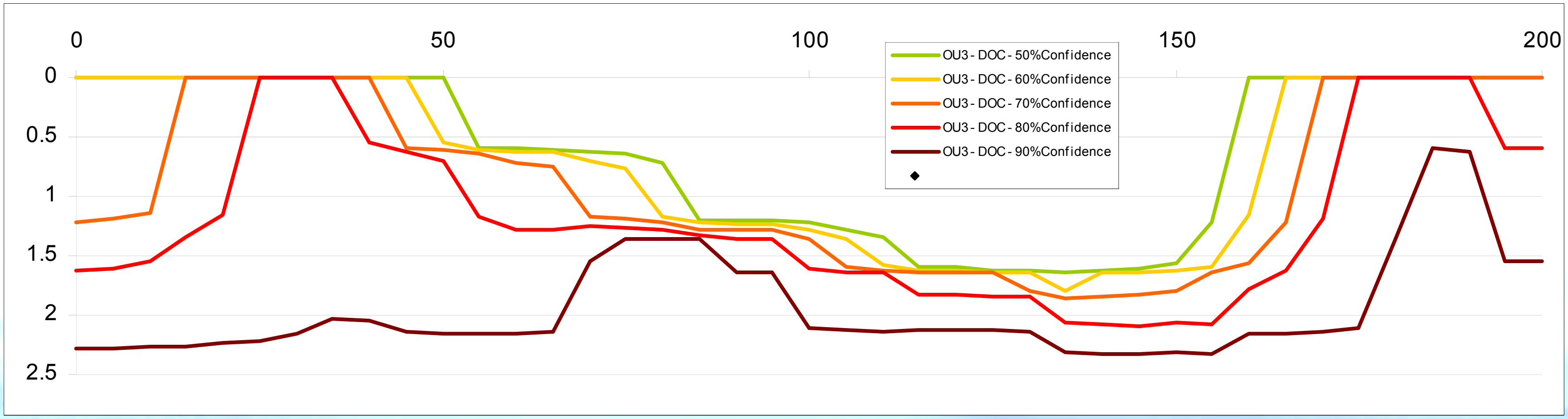
- Full Indicator Kriging
  - Interpolates indicators of depth to less than RAL, not concentrations
  - Predicts P(PCB < RAL) at every location in bed
  - "Level of Significance" ≡ 1 – P(PCB > RAL)
- Can obtain a DOC surface for desired LOS

Transect Profiles, P = 0.5 to 0.9

Along transect through data



Offset from data transect



Choosing a Level of Significance

- LOS = 0.5 matches total contaminated volume most closely
  - Provides median DOC prediction at any given spot
  - Underpredicts DOC in about half of locations
- Higher LOS would be more conservative, but at the cost of removing much more volume:

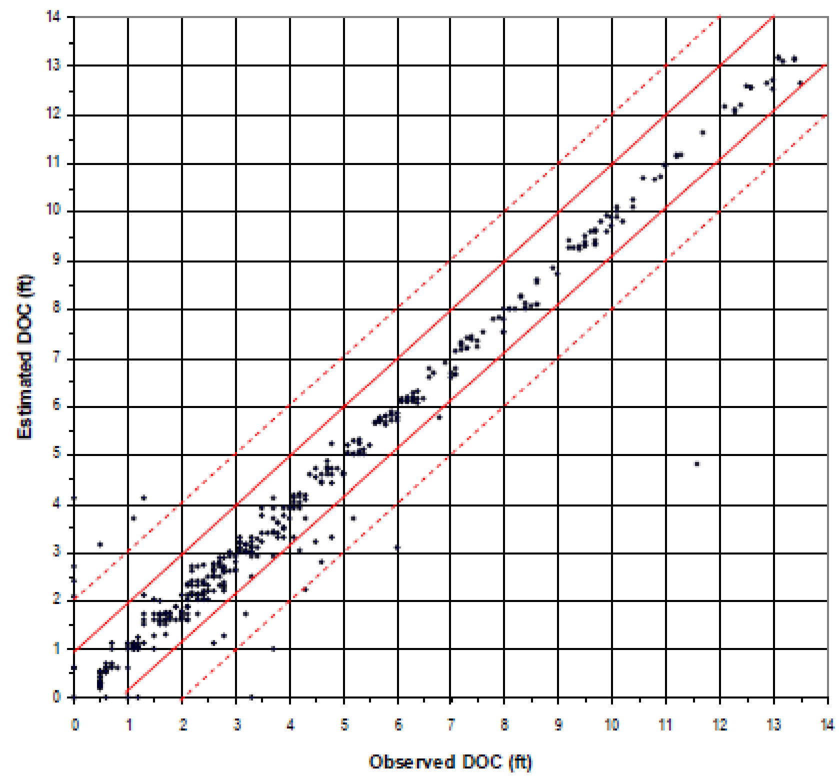
P	0.5	0.6	0.7	0.8	0.9
Volume (million cy)	5.0	6.2	7.5	9.0	11.3

Additional Protections

- Set depth to achieve LOS of 0.5 (P = 0.5)
- Add overdredge allowance
- Sample each 1-2 acre dredging “certification unit” to verify effectiveness
  - Take 5 samples/acre and composite them
  - If greater than 1 mg/kg, add sand or redredge, depending on concentration and depth

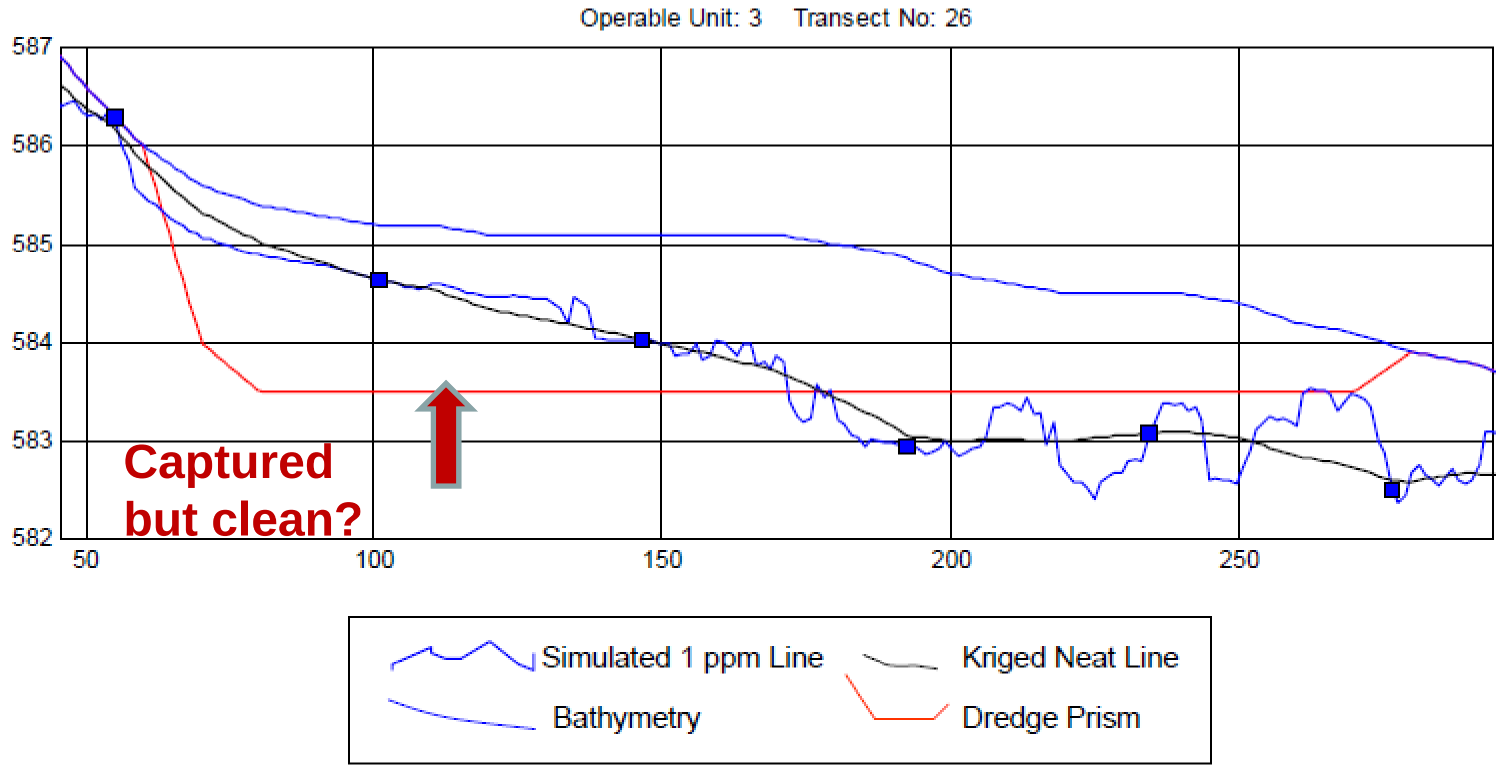
Performance Metrics for Interpolation Method

- Model with LOS 0.5 matches data closely
- Outperformed other models in bootstrap testing, based on:
  - RMSE, mean average deviation, and bias
  - False negatives, false positives, sensitivity, specificity, and percent correct



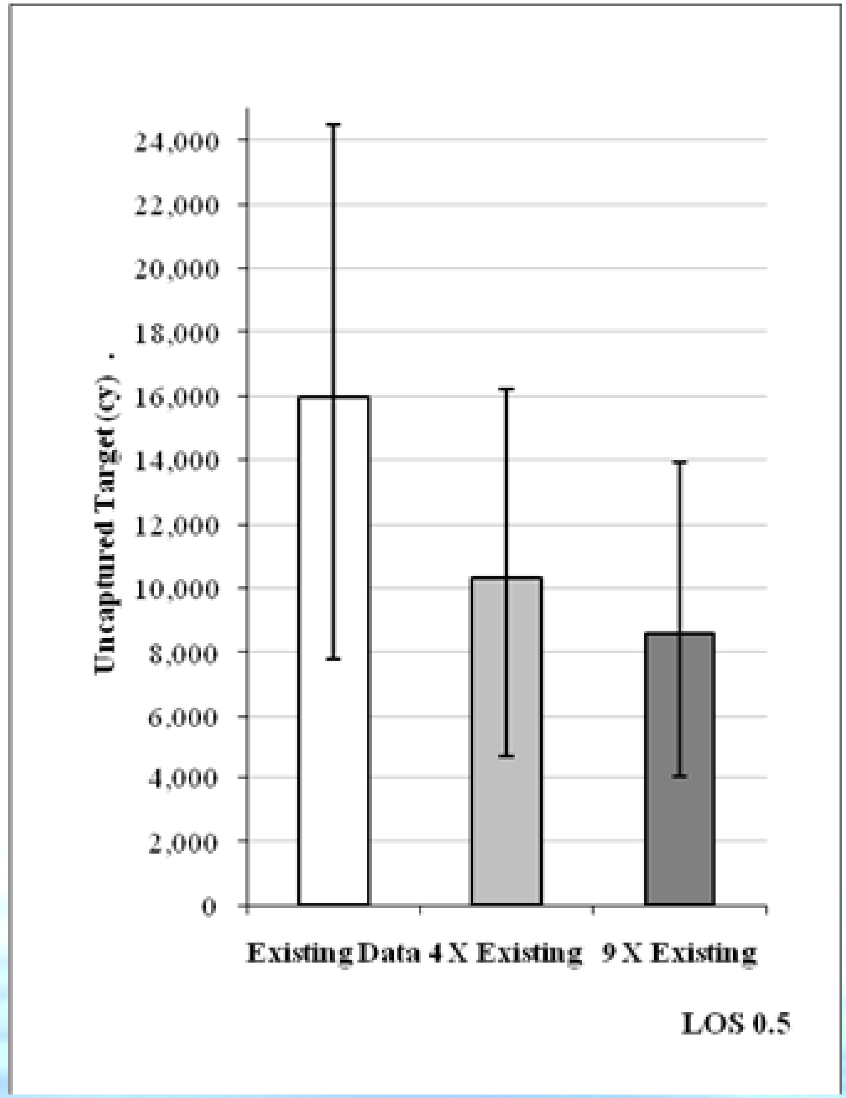
From Dredge Prisms to Neat Line

- 30% design created terraced dredge prisms
  - Captured significant volumes of clean sediment
- 60% design: "neat line" dredging to LOS 0.5

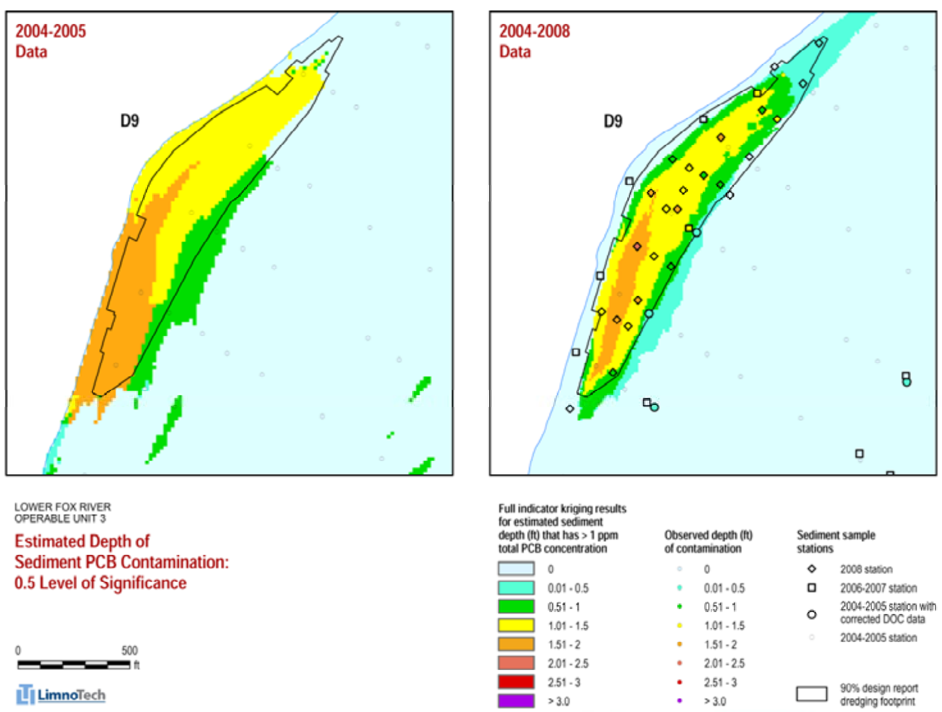


Infill Sampling Added

- To provide agencies with comfort with closer tolerances
- Increased density four-fold in dredge areas
  - To about 1 core/ 0.4 acres
- Conditional simulation predicted less target material left in place



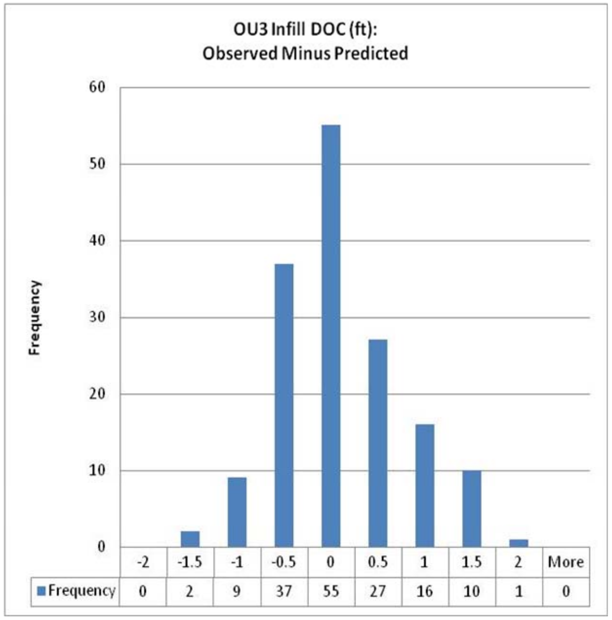
Infill Supplemented by Off-grid Sampling



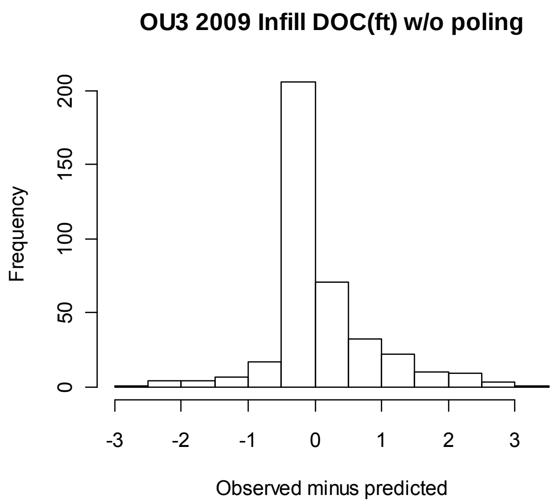
- Extent of contamination depends on physical features
  - Shoreline
  - Channels and slips
  - Bathymetric transitions
- Coring and poling augmented infill sampling
  - Design footprints refined

Infill Samples Also Provided a Test of the Full Indicator Kriging Model

- Minimal bias, most errors within +/- 0.5 feet

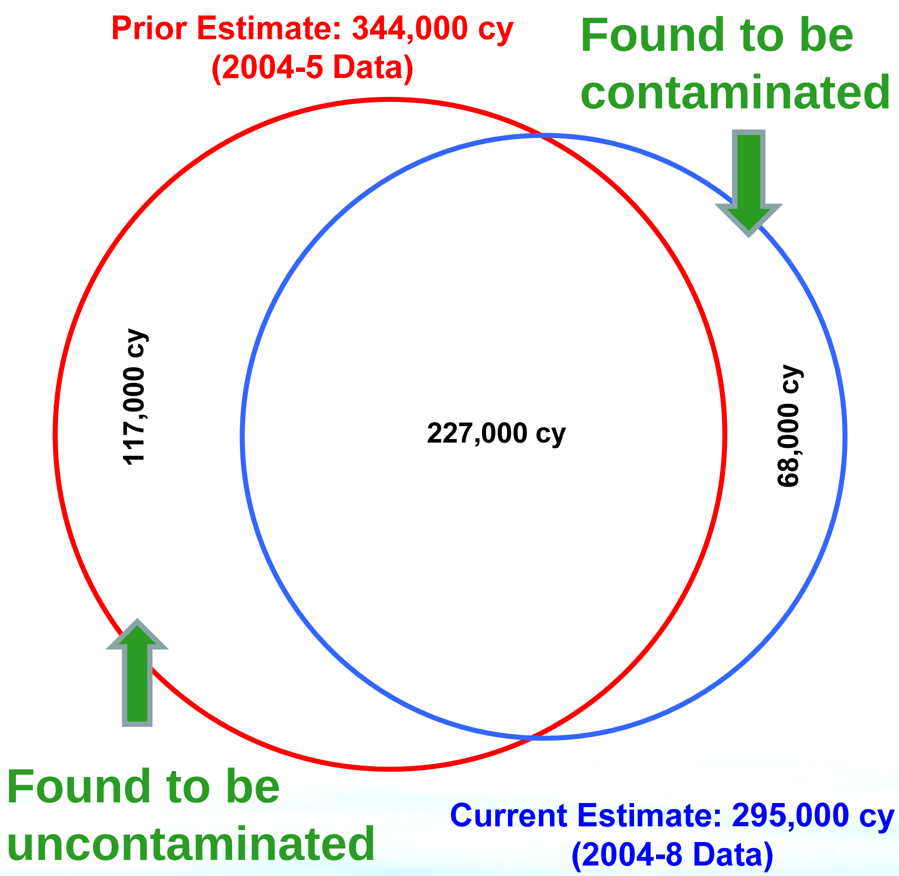


Upper OU3, 2008



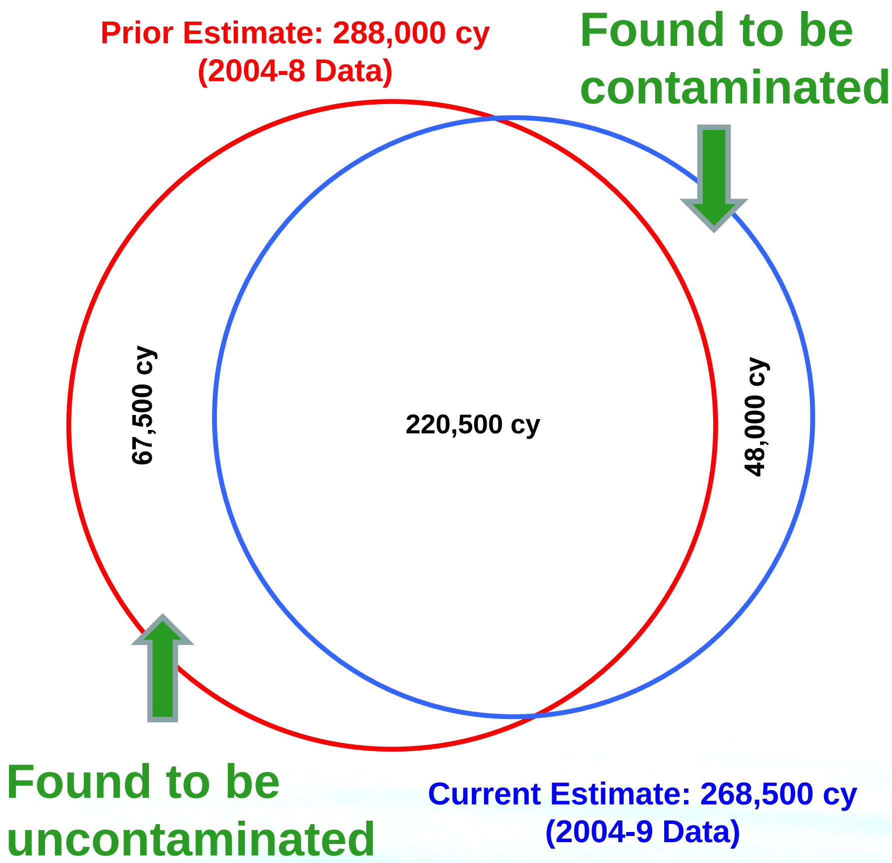
Lower OU3, 2009

Benefits of 2008 Infill Sampling, Upper OU3



- "Delisted" 117,000 cy as uncontaminated
  - 34% of contaminated volume
- Added 68,000 cy as contaminated
  - 23% of new contaminated volume

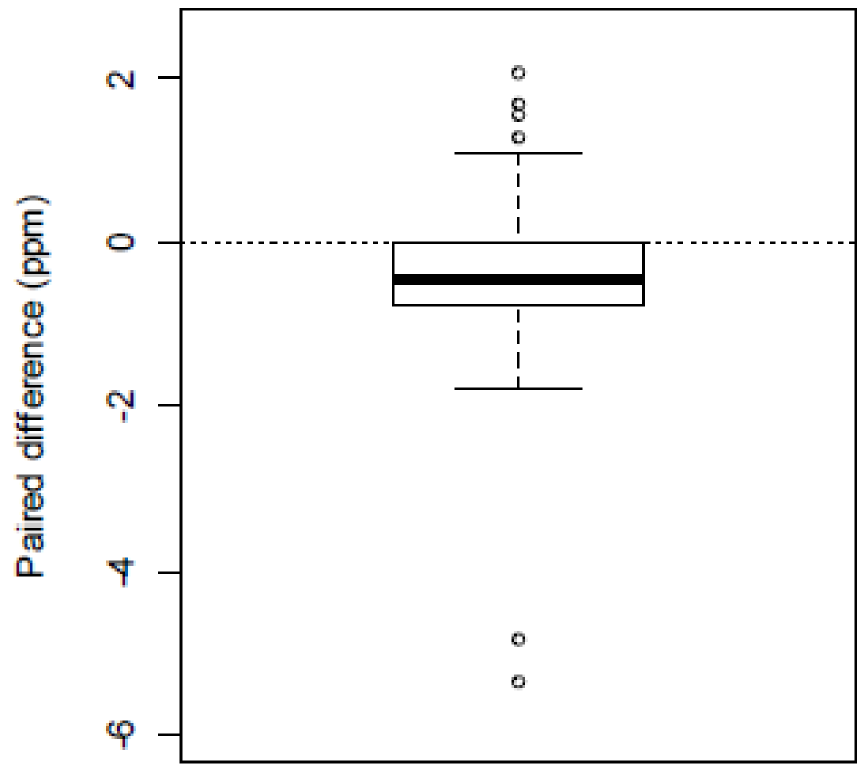
Benefits of 2009 Infill Sampling, Lower OU3



- "Delisted" 67,500 cy as uncontaminated
  - 23% of contaminated volume
- Added 48,000 cy as contaminated
  - 18% of new contaminated volume

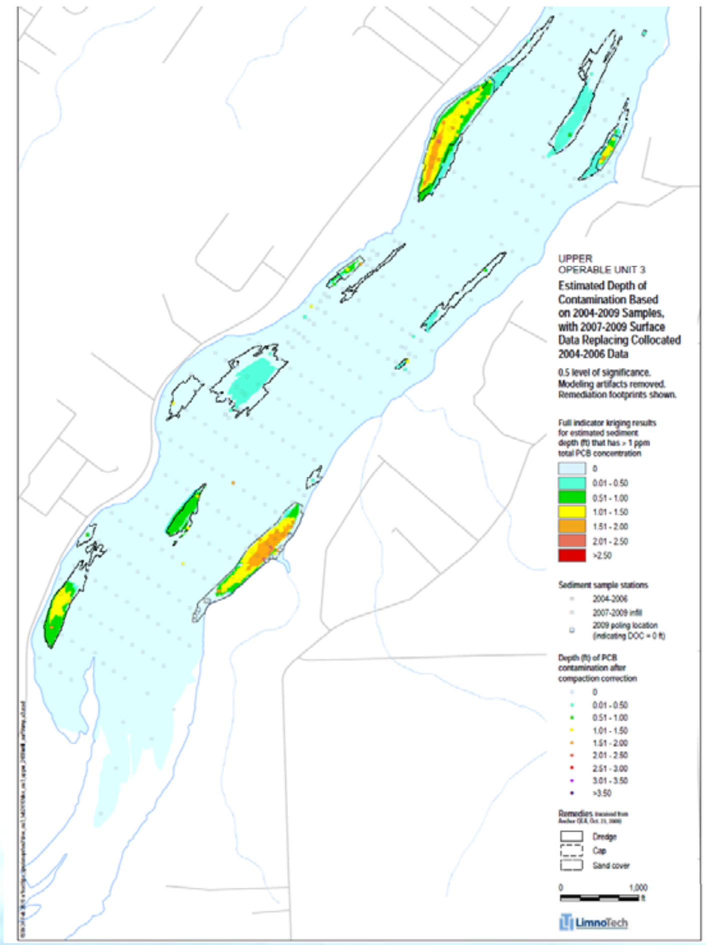
Accounting for Temporal Trends

- Design/infill sampling spans 2004-present
- Evident downward trend in OU3 surface
- Conducted test by revisiting 80 surface sample locations
- Rejected hypothesis of no change, replaced older data with newer



Resulting Changes in Remedy

- Some OU3 sand cover areas were reduced or eliminated
  - Surface concentrations fell by enough between 2004 and 2009 to meet clean-up target



Ongoing Developments

- Remediation proceeding upstream- to downstream
  - OU1 and OU2 complete, OU3 in progress
- Infill samples taken in Upper OU4 in 2010
  - Reinterpolation of DOC is underway to refine dredge, cap, and sand cover designs, incorporating those new data

Lessons Learned

- Understanding sediment uncertainty is an important part of remedy selection and design
  - Required data density depends on intended use as site progresses from investigation to remedy
  - At each stage, data needs can be estimated based on analysis of uncertainty in existing data
  - It's the key to understanding tradeoffs between:
    - Conservatism of design
    - Density of sampling
    - Intensity of confirmation sampling

Questions?

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