Precision of Environmental Dredging – Factors and Processes

Michael Palermo - Mike Palermo Consulting, Inc.
John Kern – Kern Statistical Services, Inc.

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Overview of Presentation

“...... in some cases, the attainable accuracy in locating the cut is greater than the accuracy of the sediment characterization data.....”

This presentation builds on that statement, focusing on Dredging Precision and Removal Precision for Environmental Dredging.

- Background
- Definitions
- Factors Related to Dredging Precision and Removal Precision
- Potential Influences and Sources of Errors
- Conclusions
- Next Steps
Background – The Applicable Scenario

- “Full Dredging” is a common remedy approach (i.e., not a combined dredging/capping remedy)
- Removal of all target sediment with COC concentrations above a set clean up level (not a dredge to elevation requirement) with minimal removal of non-target sediment
- Conditions with no visual/physical distinction between contaminated and underlying clean sediments (i.e., no rock or hardpan)
- Post dredging monitoring for verification

The Environmental Dredging Removal R

Objective: Precise removal of all inventory with last production pass
Definitions

- **Accuracy vs Precision** - How close we can come to the target vs. How tight is the pattern around the target – both terms are used interchangeably in the dredging context.

- **Dredging Precision** – How precisely we can place the dredgehead to a desired target elevation (related to dredging equipment, positioning instrumentation).

- **Removal Precision** – How precisely we can remove targeted sediment with minimal removal of underlying non-targeted sediment (related to multiple factors including dredging precision and how precisely can we define where the contamination is located, usually by coring).
Dredging Precision ≠ Removal Precision

- Sample Locations
- Neatline
- Target
- Non-target
Factors Affecting Dredging Precision

- Dredging equipment type and design
- Positioning equipment and software
- Linkages for positioning installation
- Stabilization of floating plant via spudding, etc.
- Site conditions (debris, waves, water depth)
- Operator experience and skill
- OTHERS?

Bottom line: Modern dredging equipment and state-of-the-art electronic positioning systems now available will allow placement of the dredgehead to within a few inches of a target elevation.
Factors Affecting Removal Precision

- Surveying
- Characterization and Sampling Design
- Sediment Coring
- Data Interpretation
- Dredging Design/Operations Plan
- Contracting
- Dredging and Positioning Equipment (Dredging Precision)
- Generated Residuals
- Monitoring considerations
- OTHERS?

Each of these is subject to or may cause error (error here in the broadest sense includes mistakes, inaccuracies, uncertainties).
Surveying

Potential influences or sources of error:

- Referencing core data only to sediment depth
- Inaccuracy of acoustic surveying to define the water or sediment surface
- Poor survey control for nearshore sites
- Uncertainty of rodding to define sediment surface
- Misapplication of data from Tide gages, etc.
- **Golden Rule:** Tie core data to elevations.
Fox River

- RI Cores were tied to the Mudline (a big mistake); sediments move
Characterization and Sampling Design

Potential influences or sources of error:

- Incomplete definition of the area of concern
- Poor selection of boring locations, spacing, etc.
- Error in selection of boring depths
- Inappropriate core segmentation for testing
- SOPs for addressing refusal, core loss/compaction, sampling handling, etc.

Sediment Coring

Potential influences or sources of error:

- Depth of cores insufficient to define EOC
- Core loss and Core Compaction
  - Core recovery is usually less than core push
  - Fluff and soft sediment near the mudline (core barrel pushes through without material entering the core tube)
  - Loss from the core bottom (very soupy sediment or poor performance of core catcher)
  - Compression in the sediment column (sandy sediment vs fine grained)
  - 80% recovery is normally considered satisfactory (but 80% recovery is 20% uncertainty in geometry of the sediment profile)
- Inappropriate core transport, handling, and processing
DoC Variation in Paired Type 1A Cores
Maximum Distance 20 Feet -- N=255
(Hudson River Phase I Program)
Data Interpretation

Potential influences or sources of error:

- Inaccurate correlation of EOC between discrete boring locations
- Geospatial modeling error (error of the model, selection of alpha value)
- Isolated anomalies in stratigraphy
- Time lag effects – from characterization to implementation – due to sedimentation or additional contaminant sources

Golden Rule: “ID the EOC”
**EoC Uncertainties**

**Modeled Surface**

**Bathymetry**

**True Surface**

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**Moderate Problem Typical of unknown extent**
- Failure to Incorporate bathymetric gradient into interpolation
- Could be improved by explicitly incorporating relationship between thickness and slope
- Data are available to investigate

**Small problems in shallow deposits**
- Due to errors in measurement of DoC
  - Incomplete Cores
  - Poor recovery
  - DoC relative percent deviation (+/- 9 inches)
- Larger errors due to incomplete sampling of 80 foot grid and failure to tie deposits in through sampling near the banks (i.e. within 40 feet or so)

**Major Problem Typical of CU1-4**
1. Problem due to incomplete cores
2. Exacerbated by regression to the mean due to failure to stratify modeling based on nav-channel boundaries—vertical and lateral
Residual Dredging and Sand Cover Rates at Fox River

- Statistical analysis forecasted approximately 10 to 15% need for re-dredging to correct un-captured target inventory with infill sampling.

- Actual rates for correcting inventory “misses” have been approximately 17% in OU-3.

- Overall re-dredging and sand cover rates including disturbed residuals management and inventory misses have been approximately 25% to 30%
Dredging Design/ Operations Plan

Potential influences or sources of error include:

- Inappropriate selection of target dredge cut elevations as compared to EOC
- Dredge Prism – level cuts result in more non-target sediment removed vs. contour dredging
- Slopes and transitions
- Selection of number and thicknesses of production cuts
- Insufficient tolerance or overdredging allowances
Contracting

Potential influences or sources of error:

- Type of contract - Rental vs. Fixed Cost
- Performance based vs. defined methods
- Specified overdredging allowances
- Pay items and payment methods
- Incentives or Disincentives
- Contractors means and methods
- Operator experience and skill
Generated Residuals

Potential influences or sources of error:

- Generated residuals erroneously characterized as undisturbed residuals (inventory)
- Misinterpretation of thickness and concentration of generated residual layers due to resettlement, fallback, and sloughing
- Bathtub geometries can exacerbate this problem
Monitoring/Verification

If no one looks, environmental dredging is always precise.

Potential influences and sources of error:

- Overly restrictive or complex criteria for re-dredging or residuals management
- Method of sampling (grab vs. core)
- Selection of increment(s) for testing
- Method of sample handling and processing
- Misinterpretation of generated vs. undisturbed residuals (density and thickness)
Conclusions

- Dredging precision is a function of the dredging equipment type and design, positioning instrumentation, operator skill, and site conditions. Modern dredges commonly used for remediation equipped with state-of-the-art positioning can place the dredgehead within a few inches of a target elevation under conditions common to most remediation projects.

- Removal precision is influenced by differing project activities and technical factors including dredging precision, site characterization, and decisions made during project design and implementation.

- Potential inaccuracies in defining the EOC can greatly reduce removal precision and outweigh operational inaccuracies in cutting to a desired target elevation.

- Selecting a target cut elevation with a tolerance below the EOC and/or setting an appropriate overdredging allowance is one approach for improving removal precision.

- The criteria for removal success should include appropriate balancing of “complete removal” with approaches for residuals management.
Next Steps

- Solicit input – mike@mikepalermo.com
- Determine a range of the various inaccuracies based on field experiences
- Evaluate methods to consider the aggregate errors for precision removal
- Battelle 2013 Dallas – paper and platform presentation
QUESTIONS?