DREDGING RESUSPENSION:

DEFINING THE ISSUES

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Topics

- Definitions
- Old issues
- Emerging issues
- Confounding factors
- Sources of uncertainty
- Conclusions

Why Does Resuspension Matter?

- Fundamental determinant of impacts related to exposure to elevated suspended sediment concentrations, turbidity, and contaminants
- Longstanding concerns for a host of potentially sensitive receptors, including SAV, coral reefs, migratory fishes, etc.
- Critical consideration for the conduct of environmental/remedial dredging projects
- Substantial economic consequences

The 4 R's

RESUSPENSION

RELEASE

RESIDUALS

RISK


ERDC/EL TR-08-4

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Dredging Operations and Environmental Research Program

The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk

Todd S. Bridges, Stephen Ells, Donald Hayes, David Mount, Steven C. Nadeau, Michael R. Palermo, Clay Patmont, and Paul Schroeder

February 2008

Environmental Laboratory

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DEFINITIONS

- **Resuspension – Dislodging of bedded sediment particles during the dredging process, and consequent transport and settlement of those particles at a new location**
- **Release – Transport of dissolved constituents of disturbed pore water or constituents desorbed from sediment particles**
- **Residuals – Disturbed sediments remaining after cessation of dredging**
- **Risk – Consequences of resuspension, release, and creation of residuals**

Old Issues

Unanswered questions 40 years after NEPA

- **What are the principal drivers affecting the rate of resuspension?**
- **What are the rates of resuspension associated with basic modes of dredging?**
- **What are the relevant spatial and temporal scales of resuspension?**

Old Issues

Unanswered questions <u>40 years</u> after NEPA

- **What thresholds of suspended and deposited sediment exposure trigger biologically meaningful detrimental responses?**
- **What management practices and control measures actually provide protection benefits?**
  - **The current practice of resorting to environmental windows underscores a need to explore new approaches and technologies**

Emerging Issues

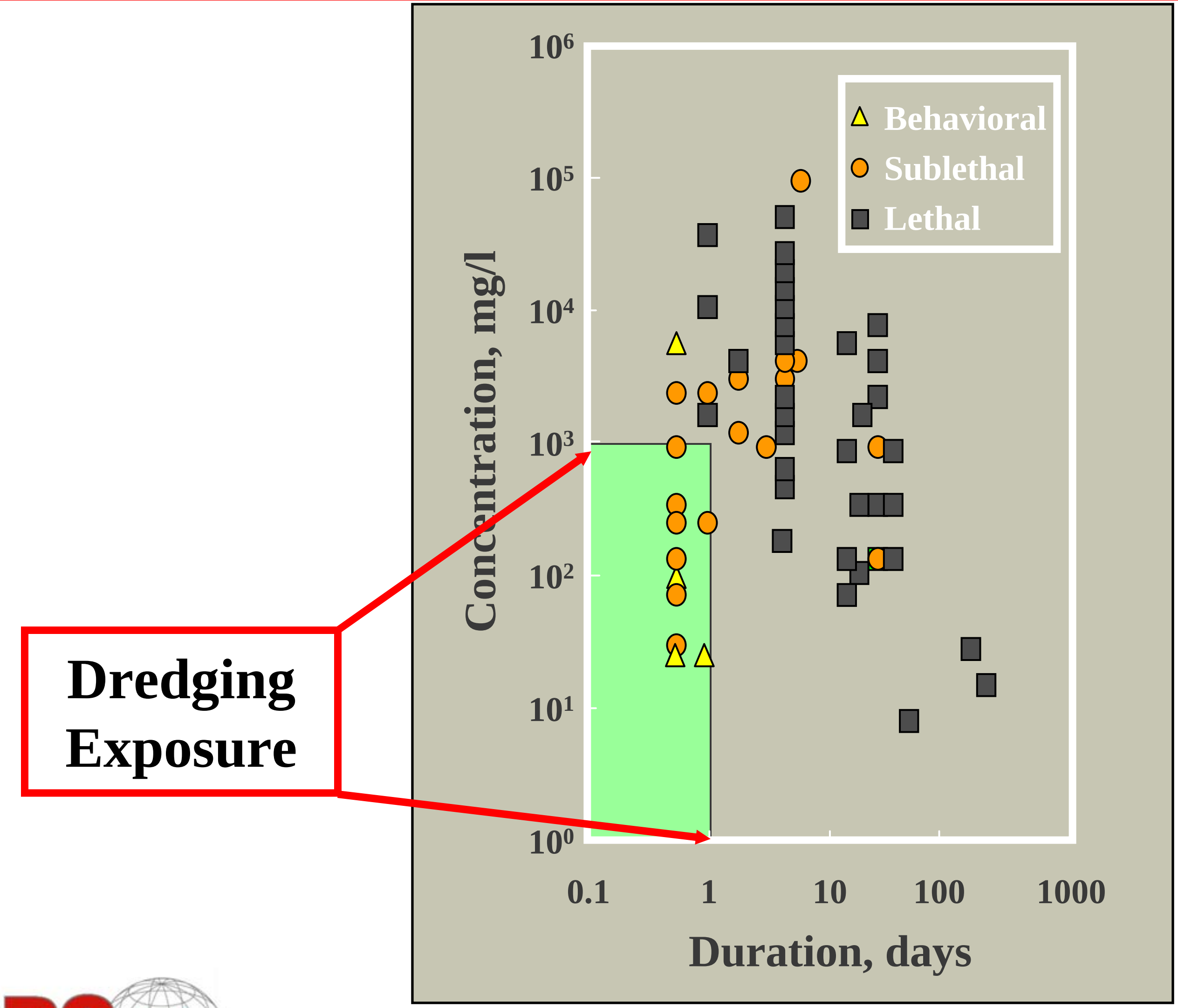
- **Concerns being extended to other sources, including ship traffic**
- **Increasing pressure for continuous, real time monitoring without established means of interpreting data or providing risk-based responses/controls**
- **Restrictions and controls applied to remedial projects are increasingly being incorporated into navigation dredging WQ certificates without a prior risk assessment or documented need**

Confounding Factors and Sources of Uncertainty

- Diverse receptors and pathways
- Lack of standardized methodologies
- Many physical factors influence resuspension
- Many operational factors influence resuspension
- Regulatory inconsistencies

Effects of TSS and Turbidity

Juvenile Salmonids



Many studies have not used protocols that establish dose-response relationships.

Physical Factors That Influence Resuspension

- Mode of dredging
  - Mechanical vs. hydraulic
- Hydrodynamics
  - Prevailing current velocities and vectors
  - Bathymetry
- *In situ* sediment properties
  - Grain size distribution
  - Water content/bulk density/liquidity
  - Atterberg Limits (Liquid and Plastic)
- Depth and salinity

Operational Factors That Influence Resuspension (e.g., bucket dredge)

- Bucket type
- Size, volume, exposed surface area
- Ascent speed
- Descent speed
- Reset frequency
- Cycle time
- Production rate
- Sediment cohesion/adhesion
- Leakage from seals
- Debris
- Bottom sweeping/bed leveling
- Anchoring and spud movements
- Barge overflow
- Tug and tender maneuvering
- Operator skill

Perceptions vs. Reality

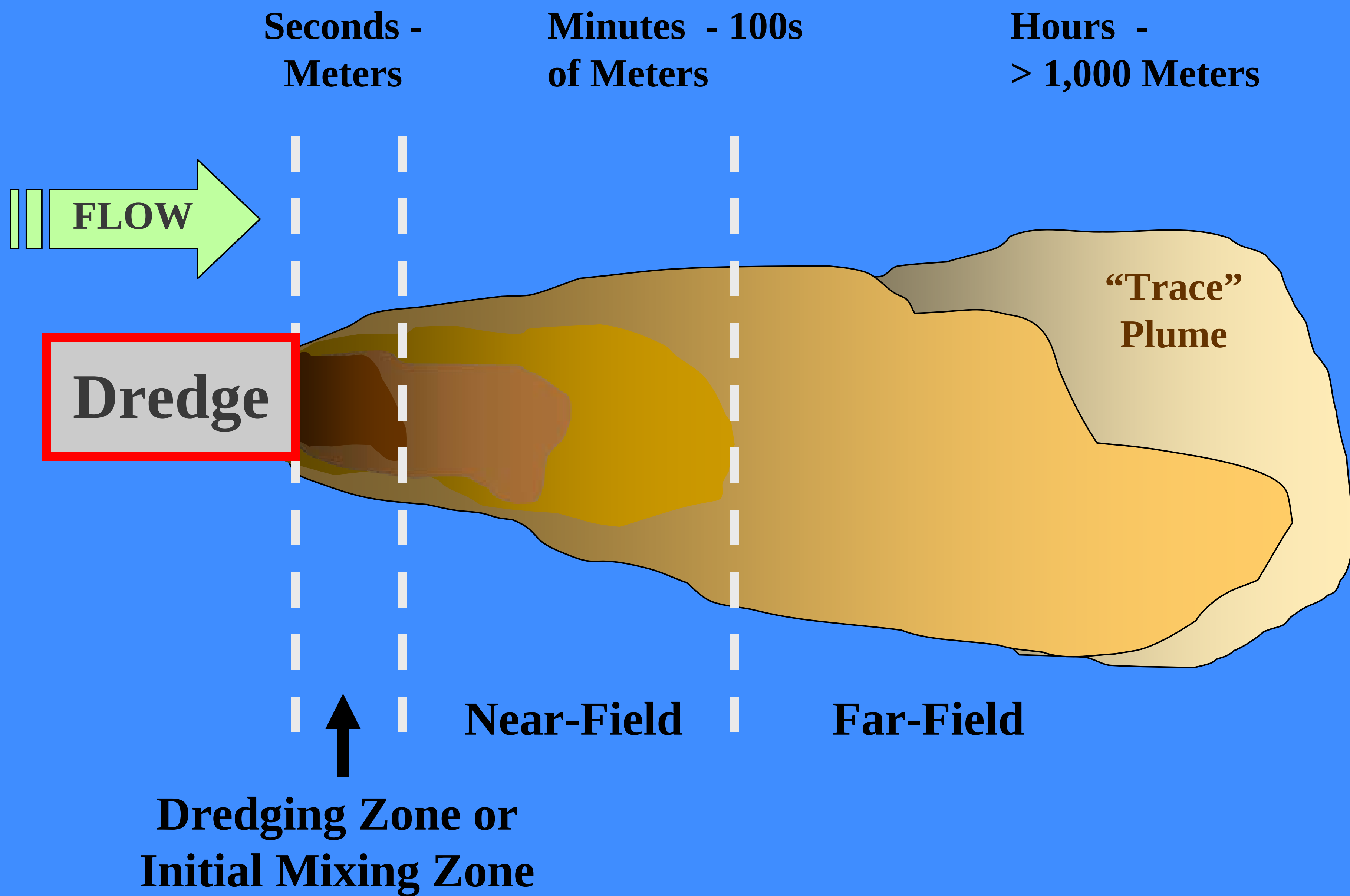
- **Perception**
  - **Resuspension controls provide environmental protection**

- **Reality**
  - **Controls frequently slow down production rates, but do not decrease mass loss**
  - **Tradeoffs are often ignored**
    - **e.g., many critters tolerate short, intense exposures better than chronic exposures**
    - **e.g., air quality effects due to prolonged emissions**

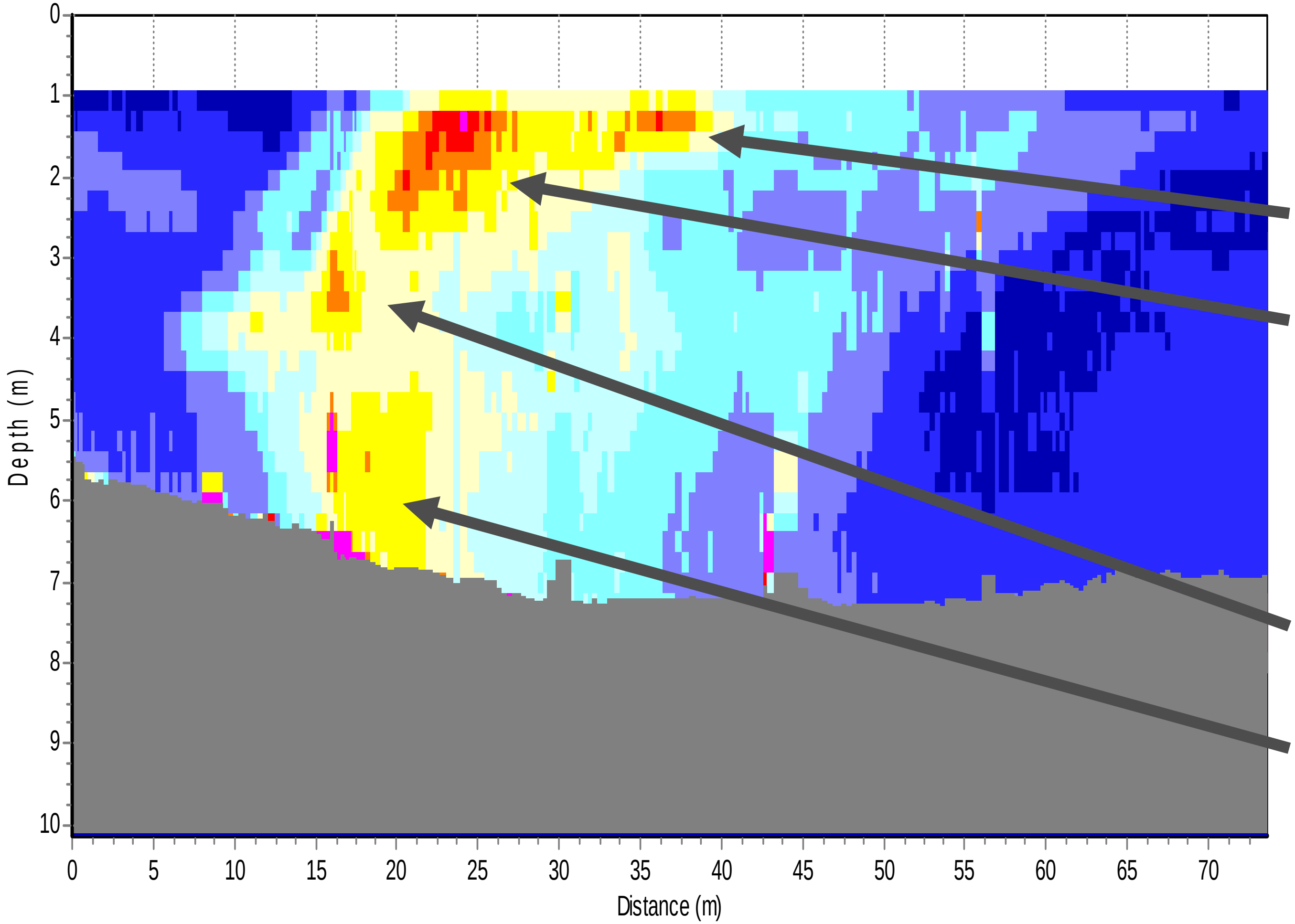
Evaluation of Resuspension

- Fate and transport models have become more sophisticated with improved understanding and handling of fundamental processes
- Uncertainty still surrounds source terms
- Empirically-derived source models exist only for a limited set of dredge types and equipment, site conditions, and sediment and operational characteristics
- Reliable, comprehensive dredging source models are needed for accurate assessment of risk associated with resuspension
- Monitoring is required to verify source term

Plume Spatial/Temporal Scales



Bucket Dredge Plume Components



- slewing
- exit and initial leakage
- hoisting
- bed impact and separation

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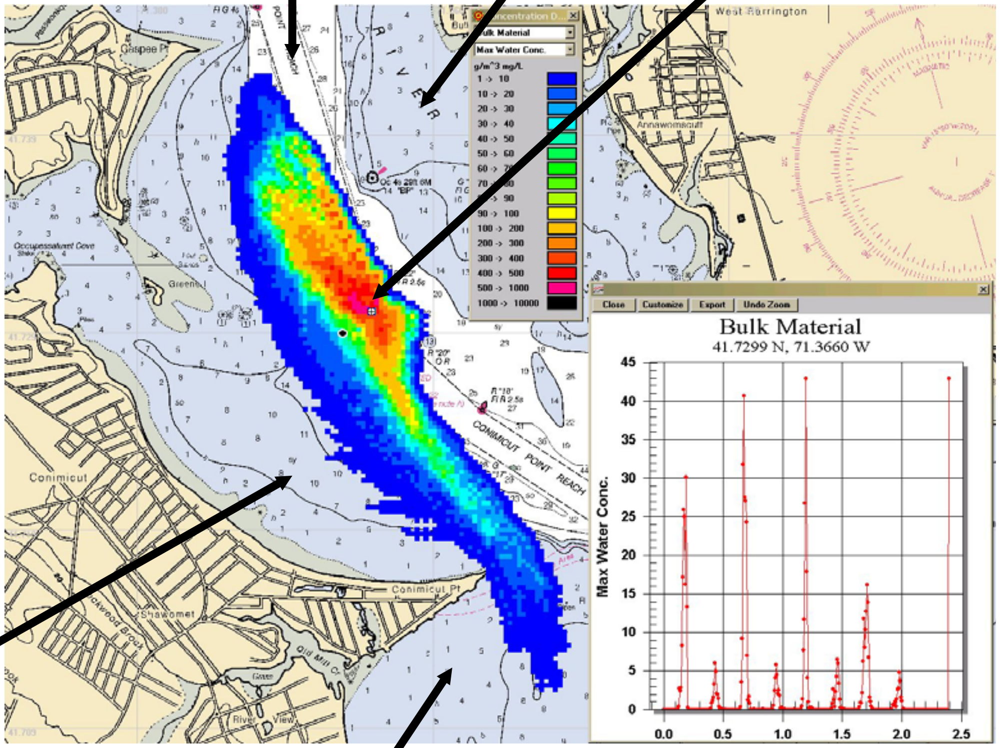
Characterization of Temporal Scales of Resuspension

- Difficult but necessary step in determination of exposures
- Exposures for different receptors may vary by orders of magnitude based on location in relation to the source over time
    - ➢ Even mechanical dredges are not stationary, but advance at a certain rate
    - ➢ Receptors may be mobile or sessile, thus exposures may change substantially based on the dredging scenario

Anadromous Fish Migratory Pathway

Shellfish Bed

Dredge



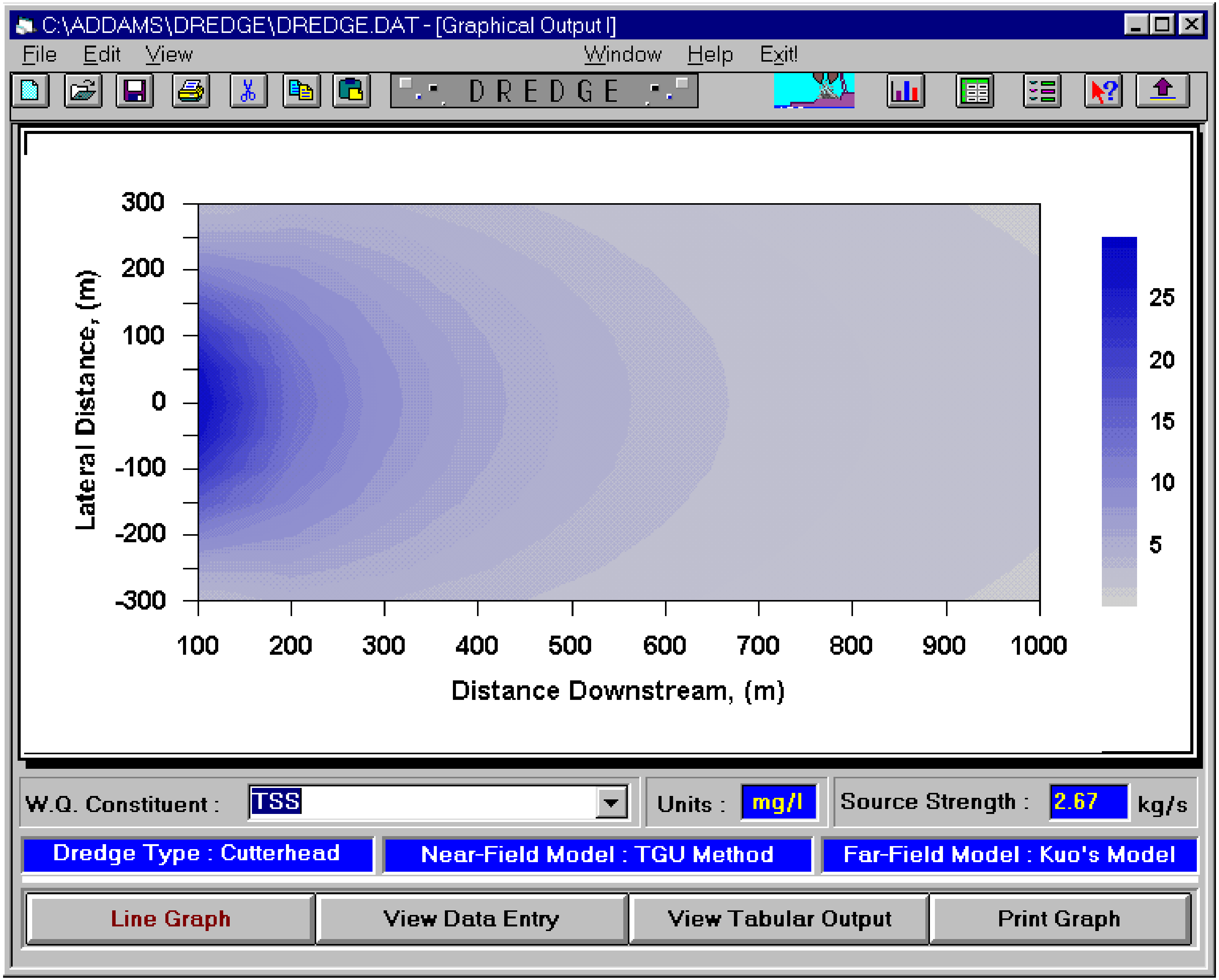
Spawning Habitat

Submerged Aquatic Vegetation

Technical Challenges

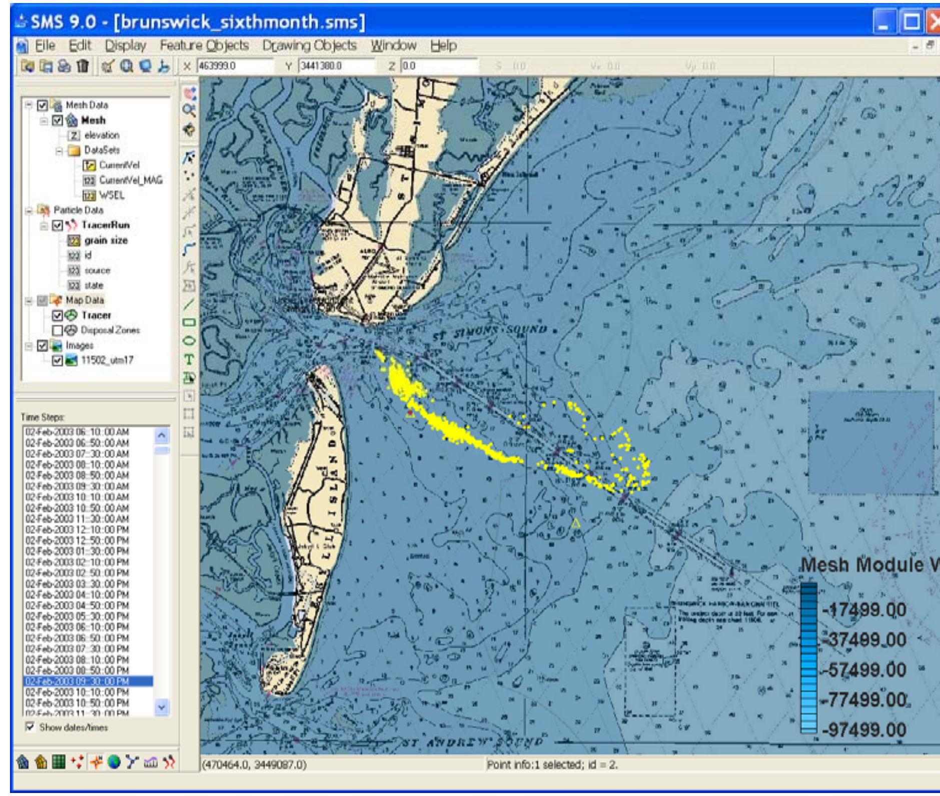
- **Resuspension is difficult to characterize quantitatively because acute effects are seldom observed**
  - **Harm, if any, occurs at sublethal levels**
- **Predictive near- and far-field models have many advantages in support of risk-informed decisions**
  - **Require validation, calibration, and verification**
  - **Very few empirical data sets exist**
  - **Data expensive to obtain**

DREDGE Model

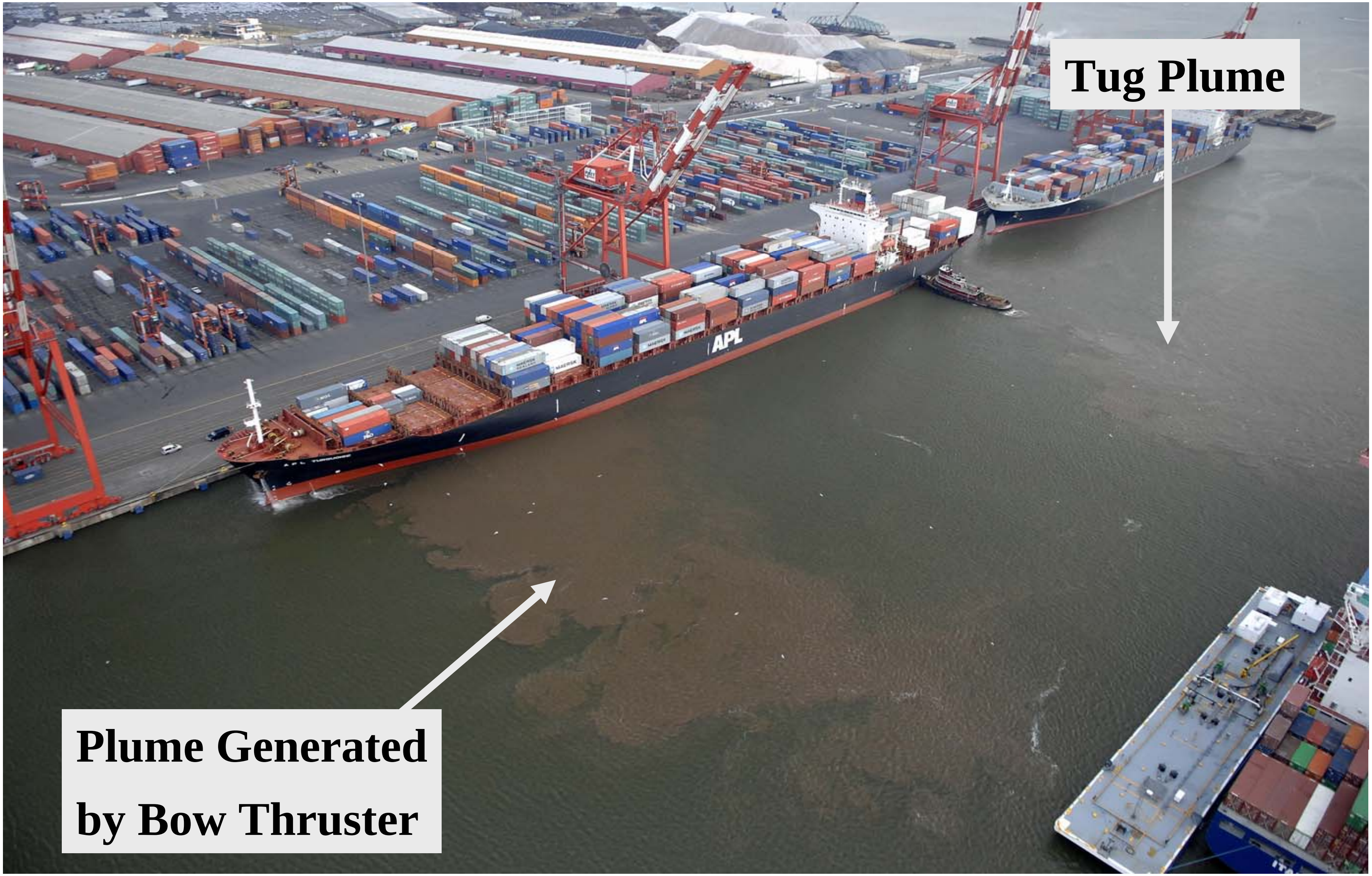


Particle Tracking Model (PTM)

- 3D dynamic transport
- Follows size classes of sediment through complex grids
- Accepts external source term
- Ability to compute sediment deposition and re-entrainment
- Adding modules to track water quality and contaminants
- Adding module to calculate exposures of organisms to suspended or deposited sediment



Ships as a Source of Resuspension



Conclusions

- Resuspension issues form a basis for a majority of problematic environmental concerns associated with dredging and dredged material disposal
- These issues have proven to be exceedingly difficult to resolve
- Many sources of uncertainty exist regarding critical aspects of the process
- Risk-informed approaches represent a promising direction for instigating progress in an otherwise stagnant arena

The End

References

- Bridges, T., Ells, S., Hayes, D., Mount, D., Nadeau, S., Palermo, M., Patmont, C., and Schroeder, P. 2008. The four Rs of environmental dredging: Resuspension, Release, Residues, and Risk. U.S. Army Engineer Research and Development Center, Environmental Lab ERDC/EL TR-08-4, 56pp. http://el.erdc.usace.army.mil/elpubs/pdf/trel08-4.pdf

- Clarke, D. 2004. Environmental windows and the precautionary principle: Does practice make perfect? Proceedings of the 17th World Dredging Congress (WODCON XVII), Hamburg, Germany