Sediment Resuspension: Defining the Issues

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Topics

- Definition
  - Related processes
  - Measurements
- Old issues
  - Loss terms
  - Perceptions versus reality
- Emerging issues
  - Expansion to other sources
  - Changing monitoring requirements
- Conclusions

Why Does Resuspension Matter?

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

The 4 R's

RESUSPENSION

RELEASE

RESIDUALS

RISK

- **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**

The 4 R's

RESUSPENSION

RELEASE

RESIDUALS

RISK

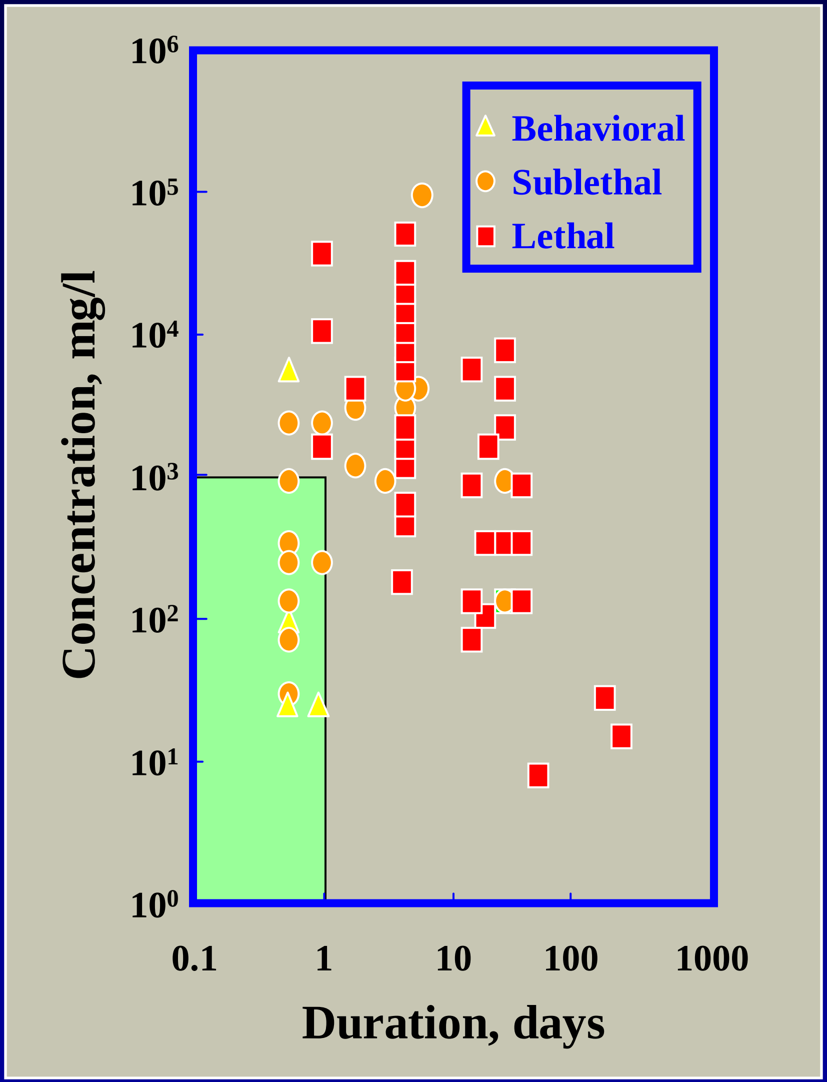
Old Issues

Unanswered questions <u>36 years</u> after NEPA

- **What are the rates of resuspension associated with basic modes of dredging?**
- **What are the relevant spatial and temporal scales of resuspension?**
- **What thresholds of suspended and deposited sediment exposure trigger biologically meaningful detrimental responses?**

Effects of TSS and Turbidity

Juvenile Salmonids



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**
  - **Atterberg Limits (Liquid and Plastic)**
- **Depth and salinity**

Factors That Influence Resuspension

- **Operational factors (e.g., bucket dredge)**
  - Bucket type
  - Size, volume, exposed surface area
  - Ascent speed
  - Descent speed
  - Reset frequency
  - Cycle time
  - Production rate
  - Sediment adhesion
  - Leakage from seals
  - Debris
  - Bottom sweeping/bed leveling
  - Anchoring and spud movements
  - Barge overflow
  - Rinse tank
  - Tug and tender maneuvering
  - Operator skill

Perceptions vs. Reality

- **Prevailing mindset that resuspension controls provide environmental protection**
- **Controls frequently slow down production rates**
- **Tradeoffs are often ignored**
  - **e.g., many critters tolerate short, intense insults better than chronic insults**
  - **e.g., air quality effects due to prolonged emissions**

Bucket Dredge Loss Terms

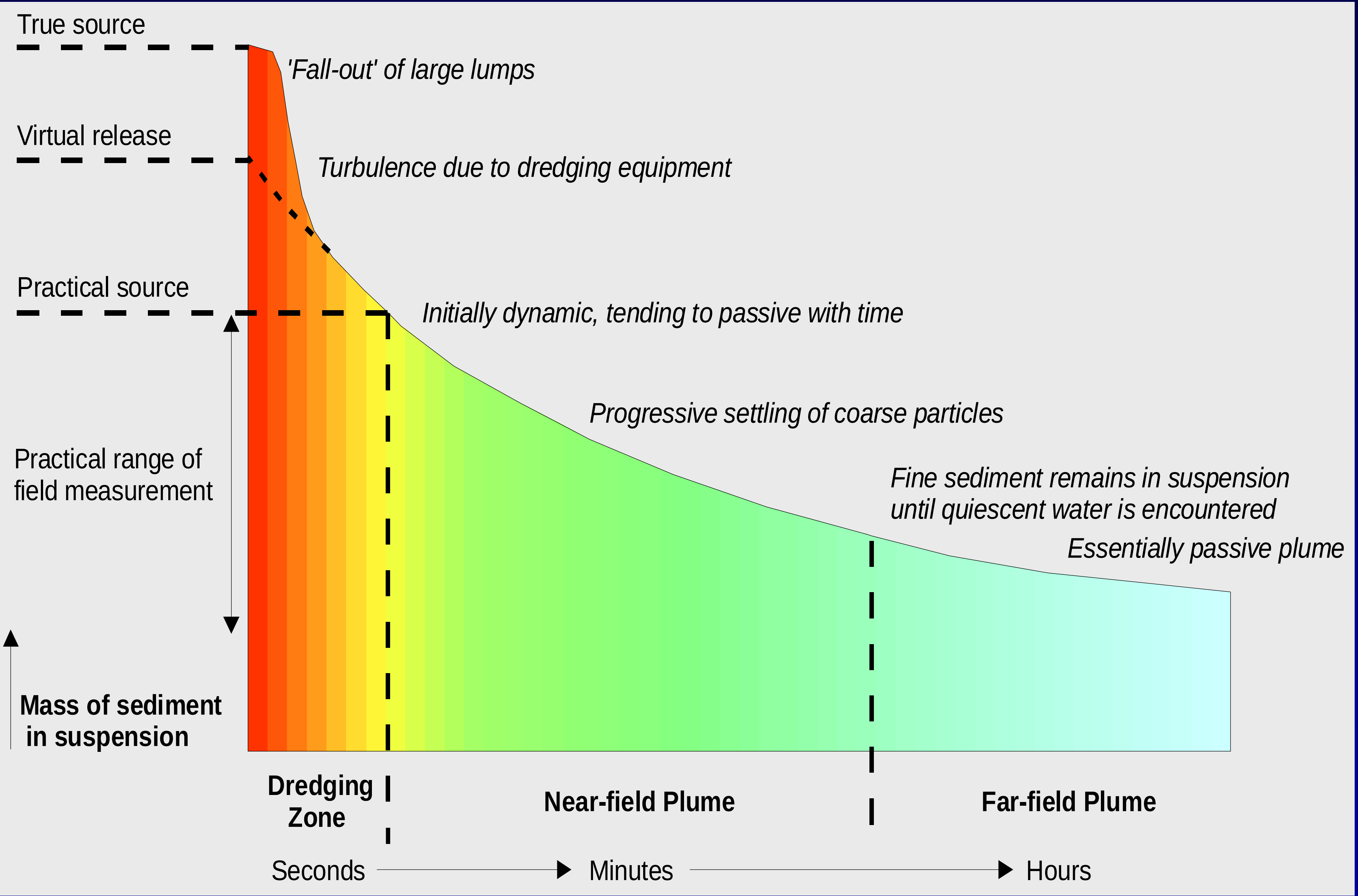
Pick a number

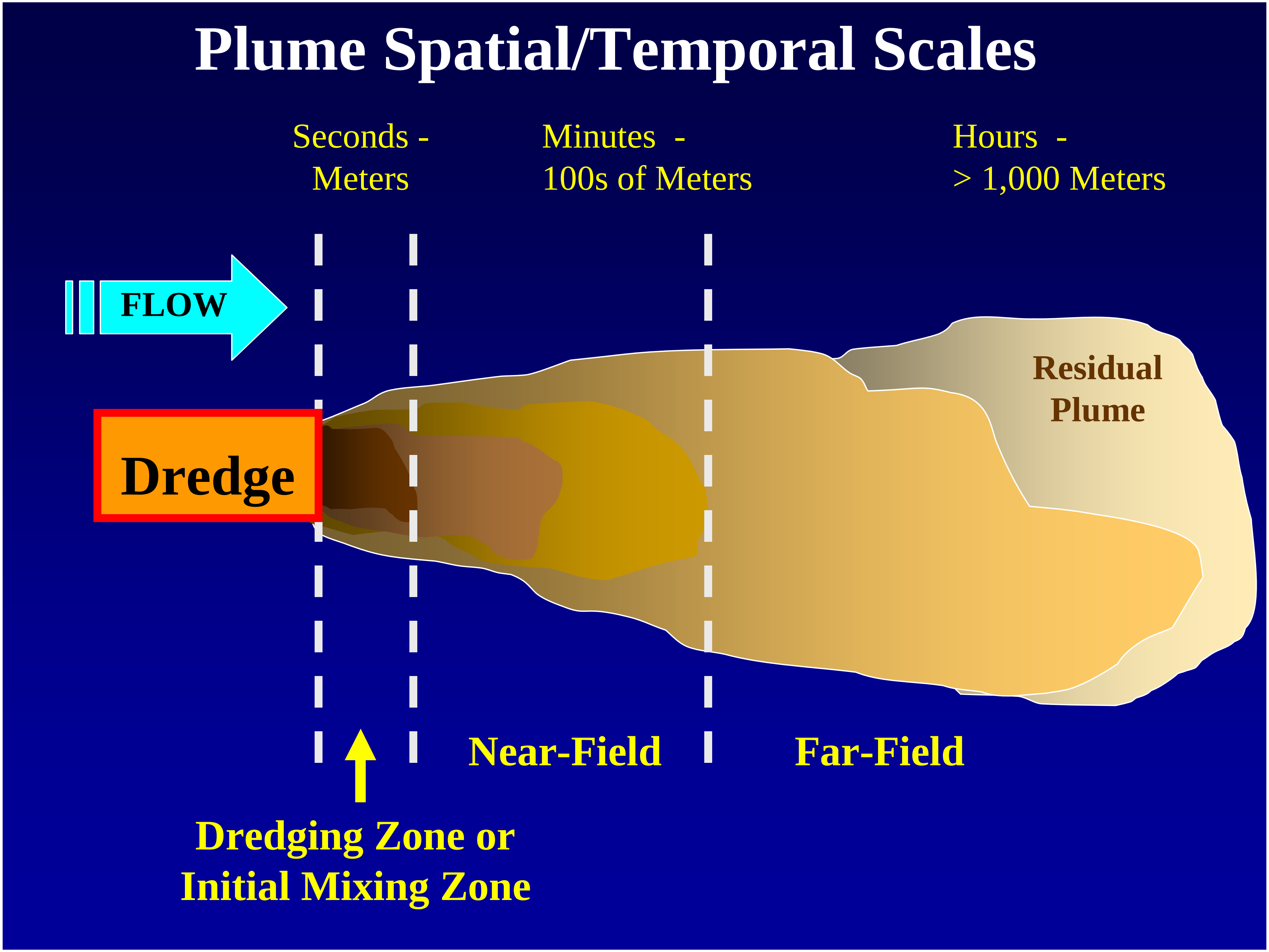
- 0.02 to 0.6% (Nakai)
- 0.2 to 0.9% (Hayes and Wu)
- 0.3 to 1% open bucket, 0.3 to 2% closed bucket, 0.6 to 5% excavator (Pennekamp)
- 1 to 3% (Bohlen, Anchor Env)
- 5 to 9% (Land and Clarke)

Evaluation of Resuspension

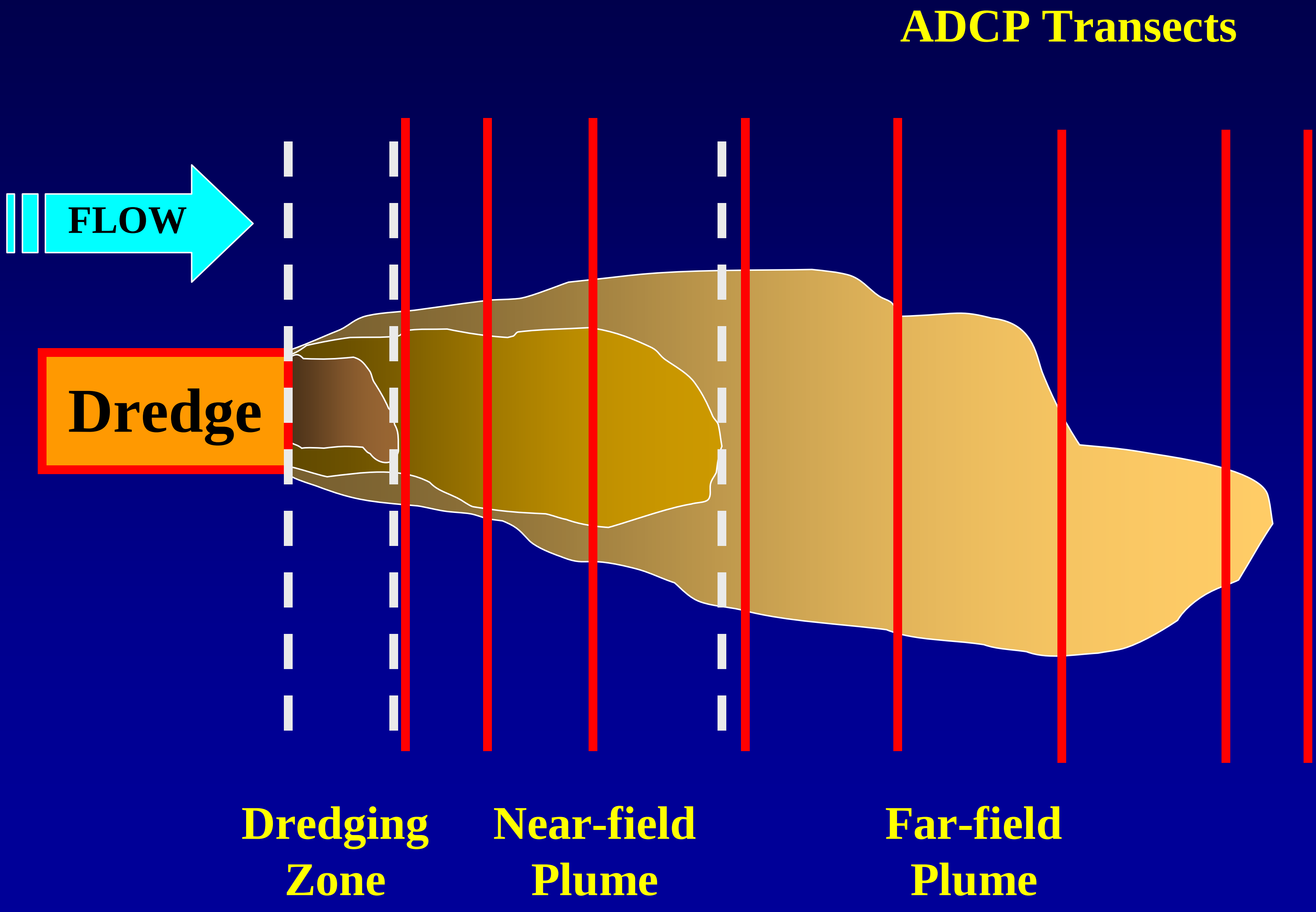
- Fate and transport models have become more sophisticated with improved understanding and handling of fundamental processes
- Large uncertainty surrounds source terms (results for similar equipment are sometimes vastly different, possibly due to undocumented sediment differences)
- Only empirical source models exist and they are derived for a limited range of dredges, equipment, and site, sediment and operational characteristics
- Reliable, comprehensive dredging source models are needed for accurate assessment of risk associated with resuspension

CONCEPTUAL PLUME DYNAMICS

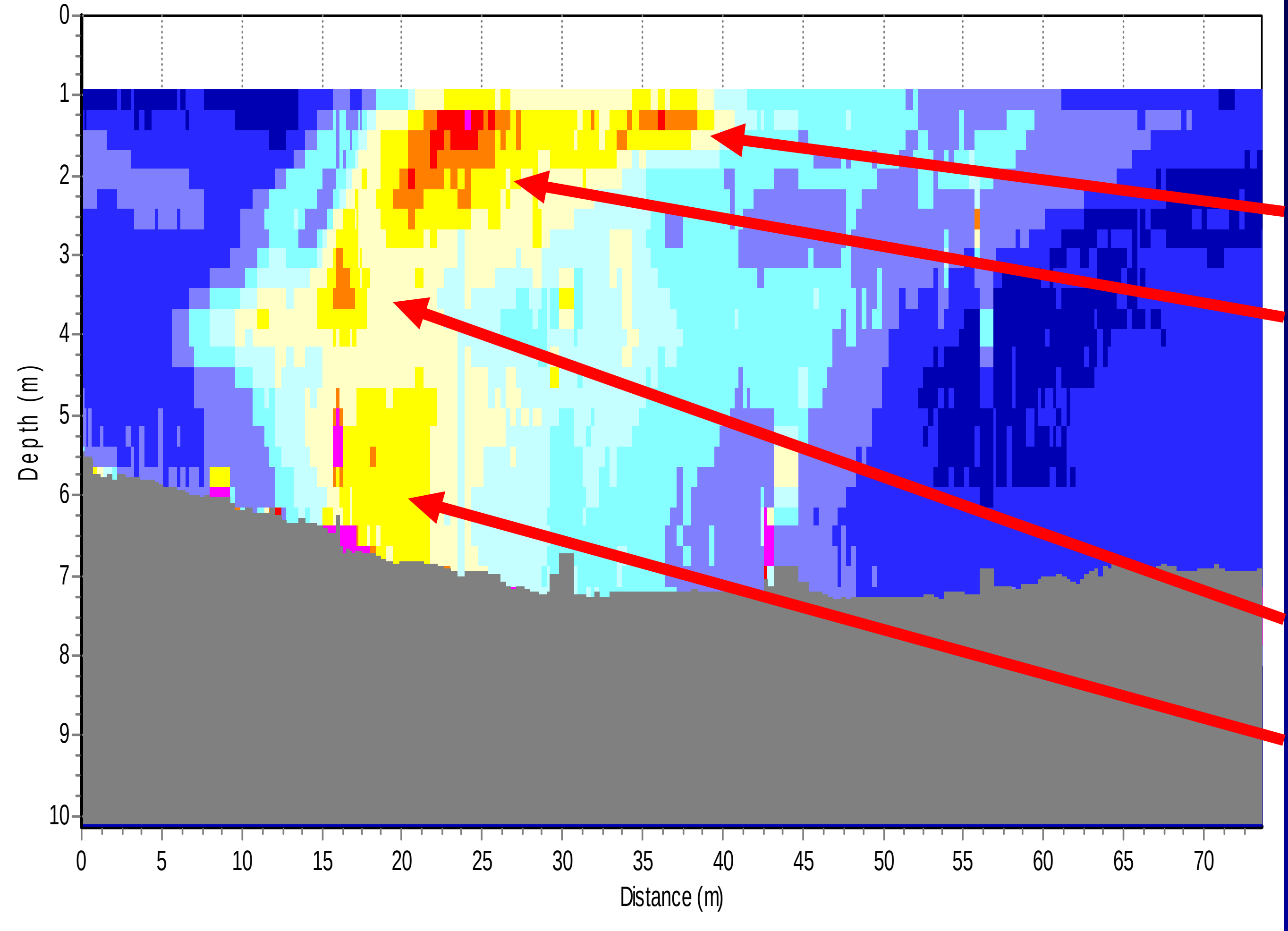



Plume Spatial/Temporal Scales
Seconds -
Meters
Minutes -
100s of Meters
Hours -
> 1,000 Meters
FLOW
Dredge
Residual
Plume
Near-Field
Far-Field
Dredging Zone or
Initial Mixing Zone

Characterization of Spatial Dimensions

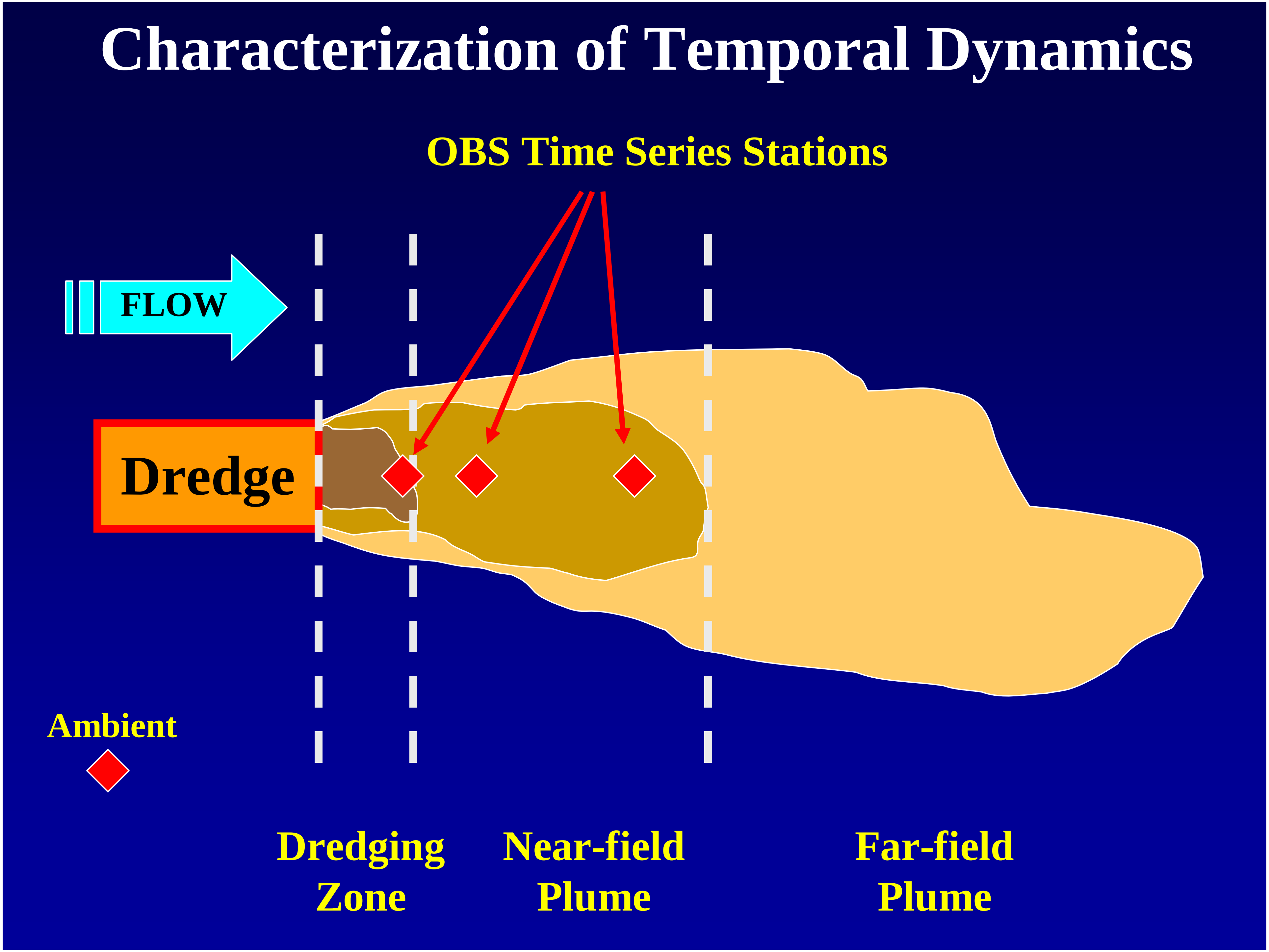


Bucket Dredge Plume Components…



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

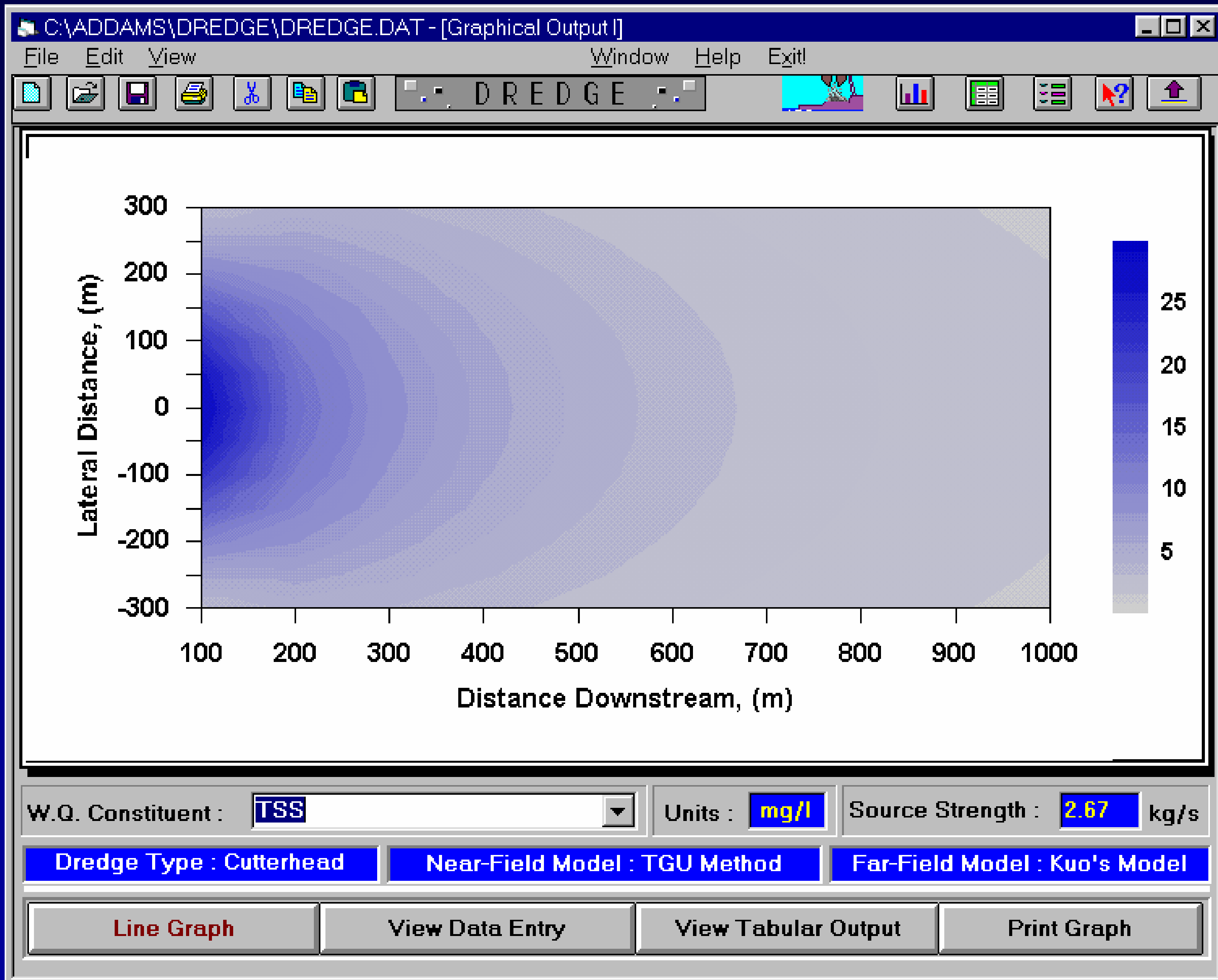
Dredging Research Ltd

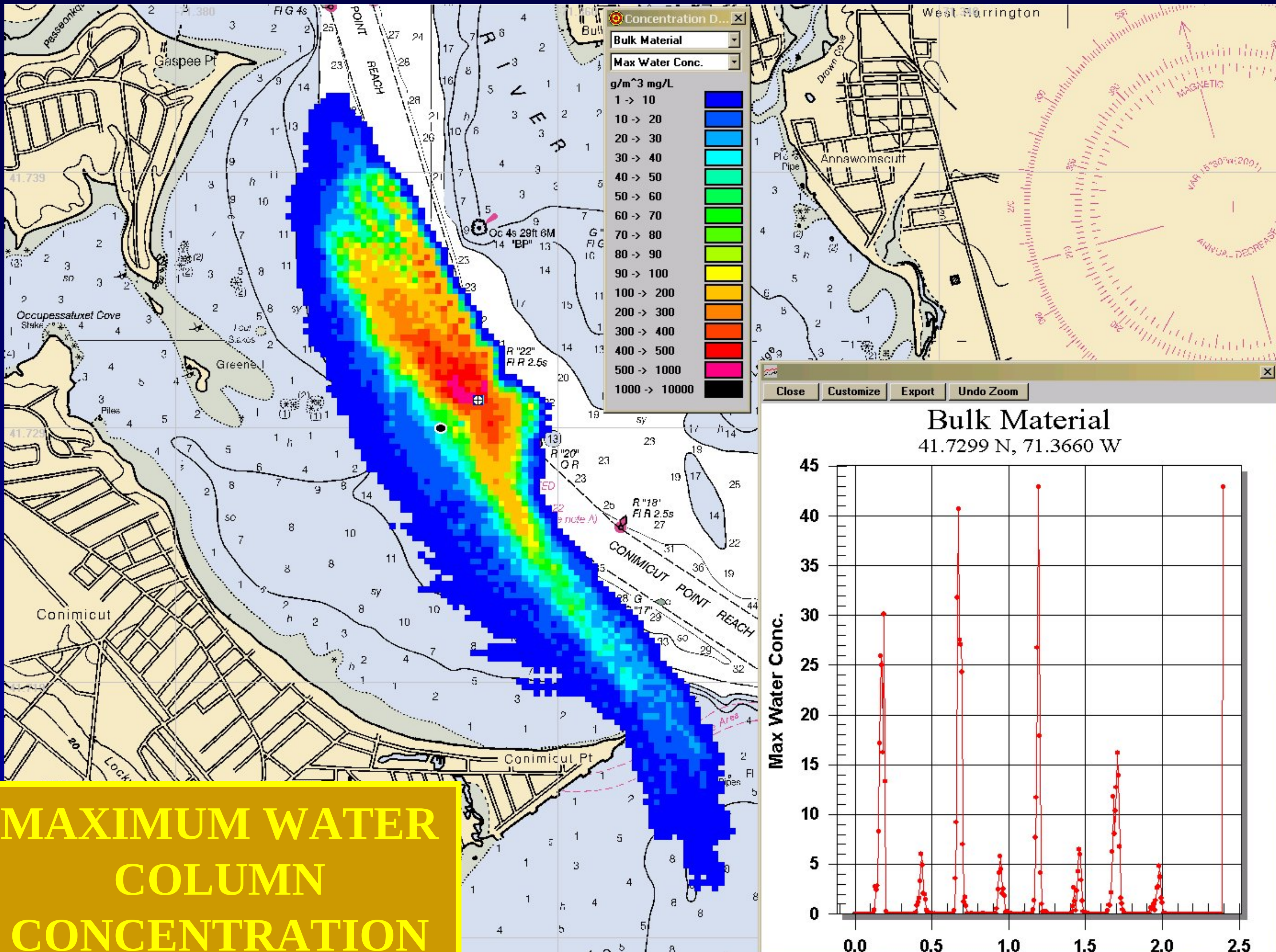

Characterization of Temporal Dynamics
OBS Time Series Stations
FLOW
Dredge
Ambient
Dredging Zone
Near-field Plume
Far-field Plume

Technical Challenges

- Resuspension is extremely difficult to characterize quantitatively
  - Considerable uncertainty surrounds loss terms
  - Methods not standardized
- Predictive models require validation, calibration, and verification
  - Very few empirical data sets exist
  - Data are difficult and expensive to obtain
  - Acceptance of, confidence in models difficult to promote

DREDGE Model

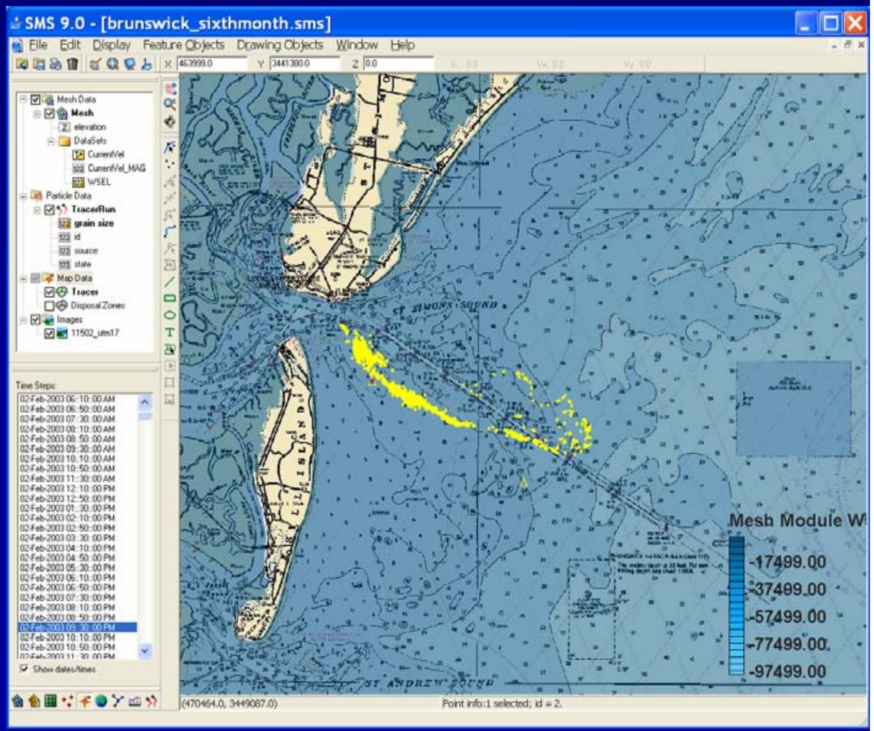




MAXIMUM WATER COLUMN CONCENTRATION

Particle Tracking Model (PTM)

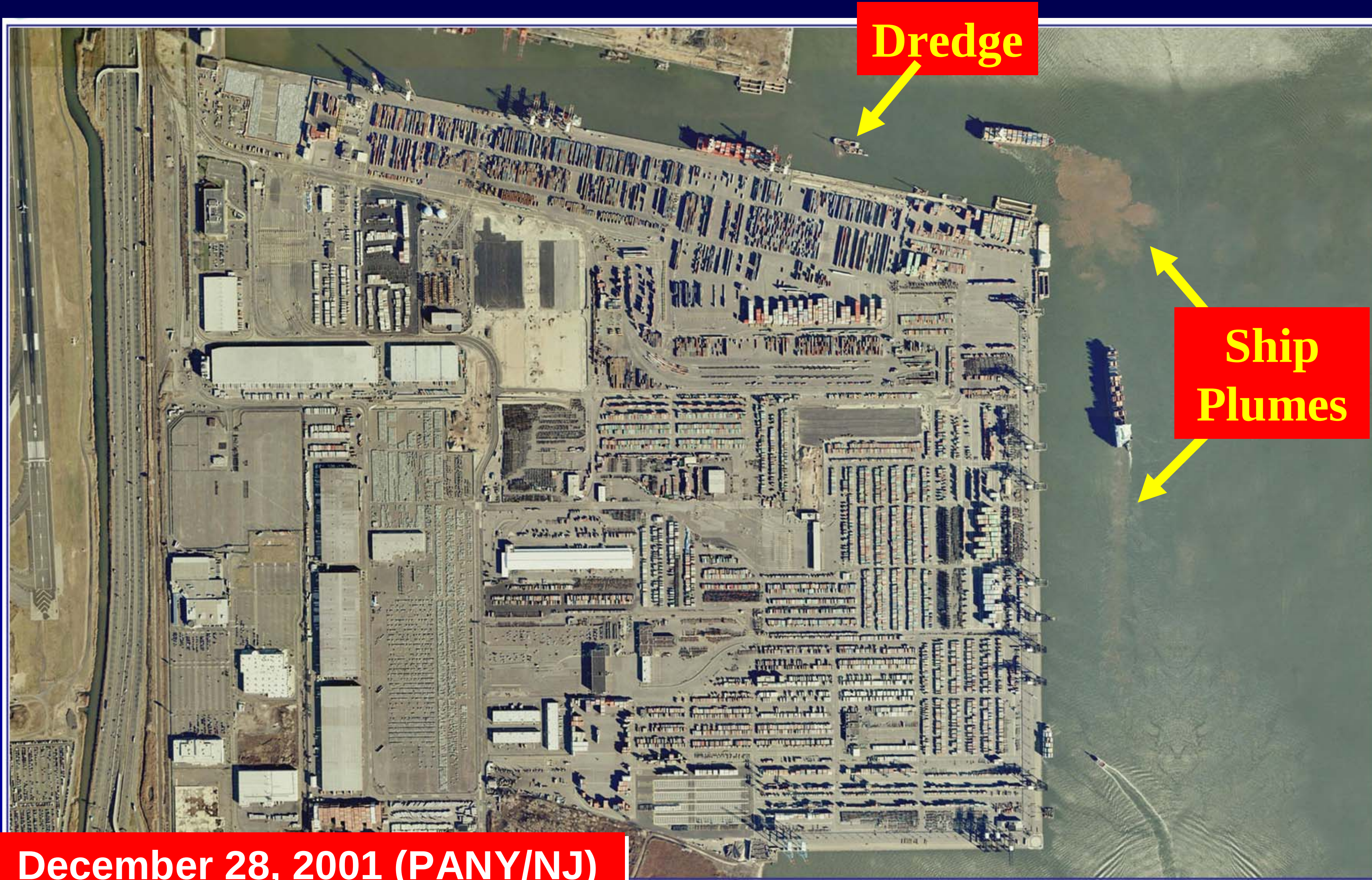
- **3D dynamic transport**
- **Follows size classes of sediment through complex grids**
- **Accepts external source term**
- **Ability to compute deposition and re-entrainment**
- **Adding modules to track water quality and contaminants**
- **Adding module to calculate exposures of organisms to suspended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



Emerging Issues

- Concerns being extended to other sources, including ship traffic
- Increasing pressure for continuous, real time monitoring
- Restrictions and controls applied to remedial projects are increasingly being incorporated into navigation dredging WQ certificates

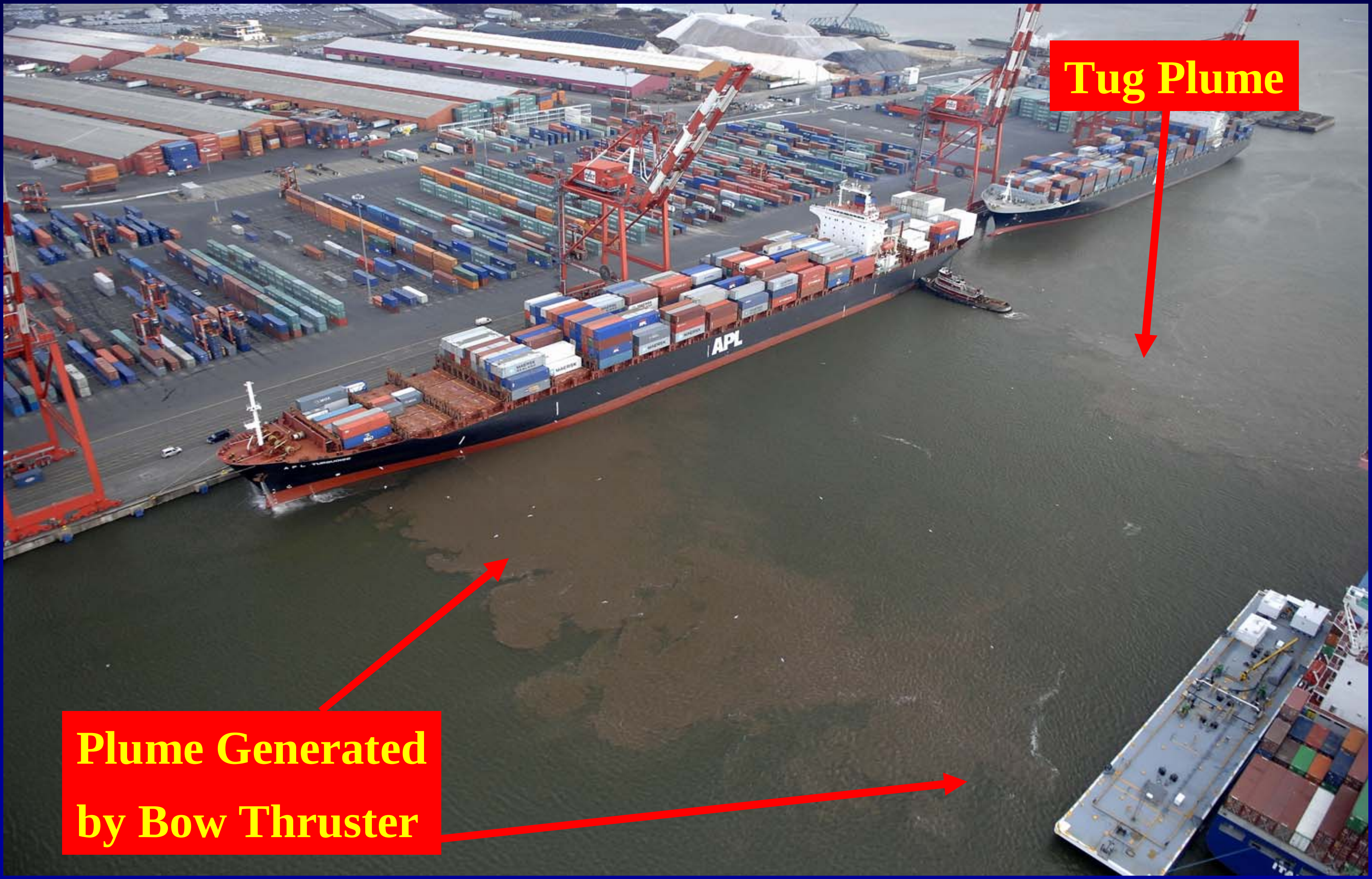
Ships as a Source of Resuspension



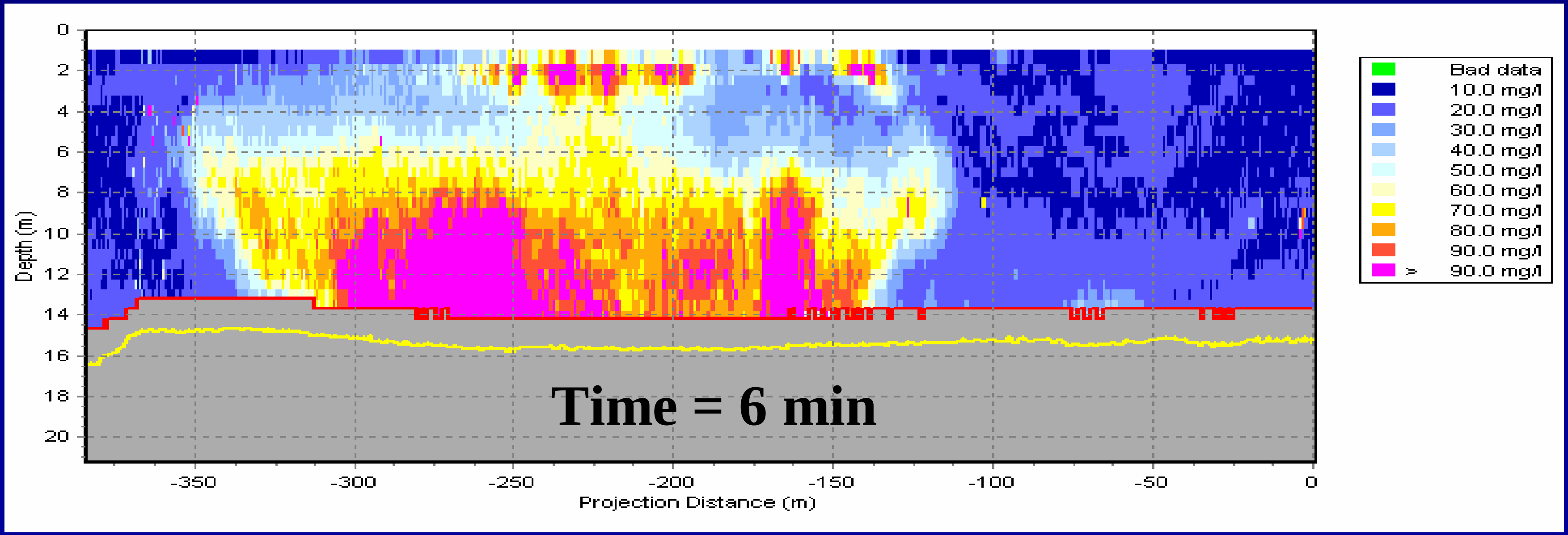
December 28, 2001 (PANY/NJ)

Side-Scan Mosaic of Main Newark Bay Navigation Channel

APL Turquoise Berthing



Vertical Profile of *YM North* Plume



Conclusions

- Resuspension issues form a basis for a majority of problematic environmental concerns
- These issues have proven to be exceedingly difficult to resolve
- Progress toward reasonable, technically defensible solutions will be dependent on collaborative, focused R&D
- Proposed first step: a dedicated symposium/ workshop to create a forum to explore opportunities and partnerships

The End