Sediment Resuspension by Dredges: Defining the Issues

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Topics

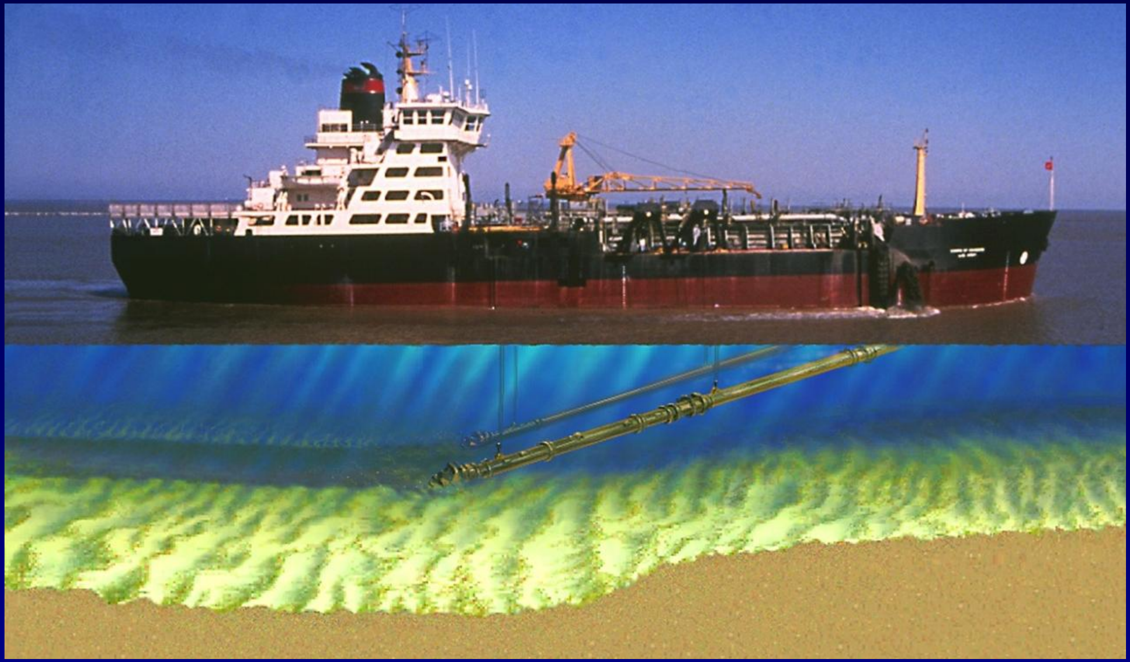
- Dredge types
- Definition
  - Related processes
- Persistent issues
  - Loss terms
  - Perceptions versus reality
- Discussion issues
  - Comparison of resuspension sources
  - Adaptive monitoring requirements
- Conclusions

MECHANICAL DREDGES

BUCKET DREDGE

EXCAVATOR DREDGE

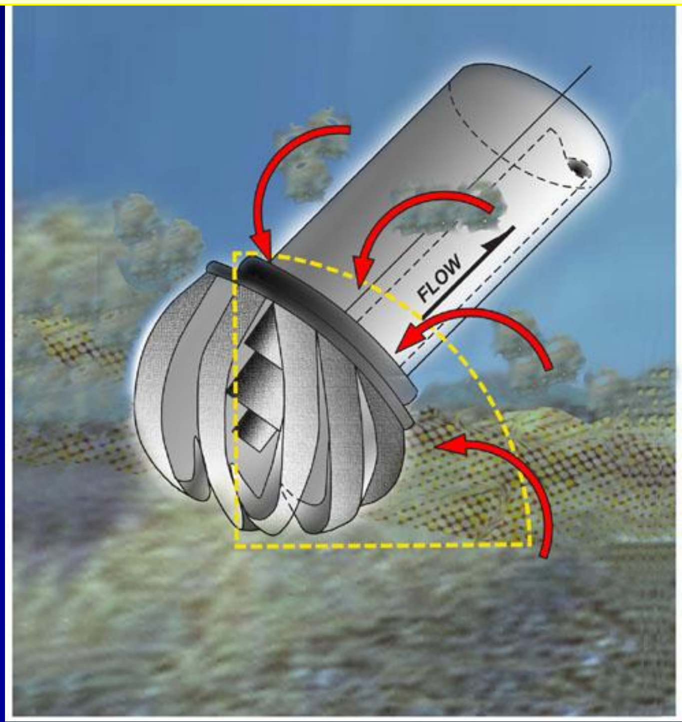
HOPPER DREDGES

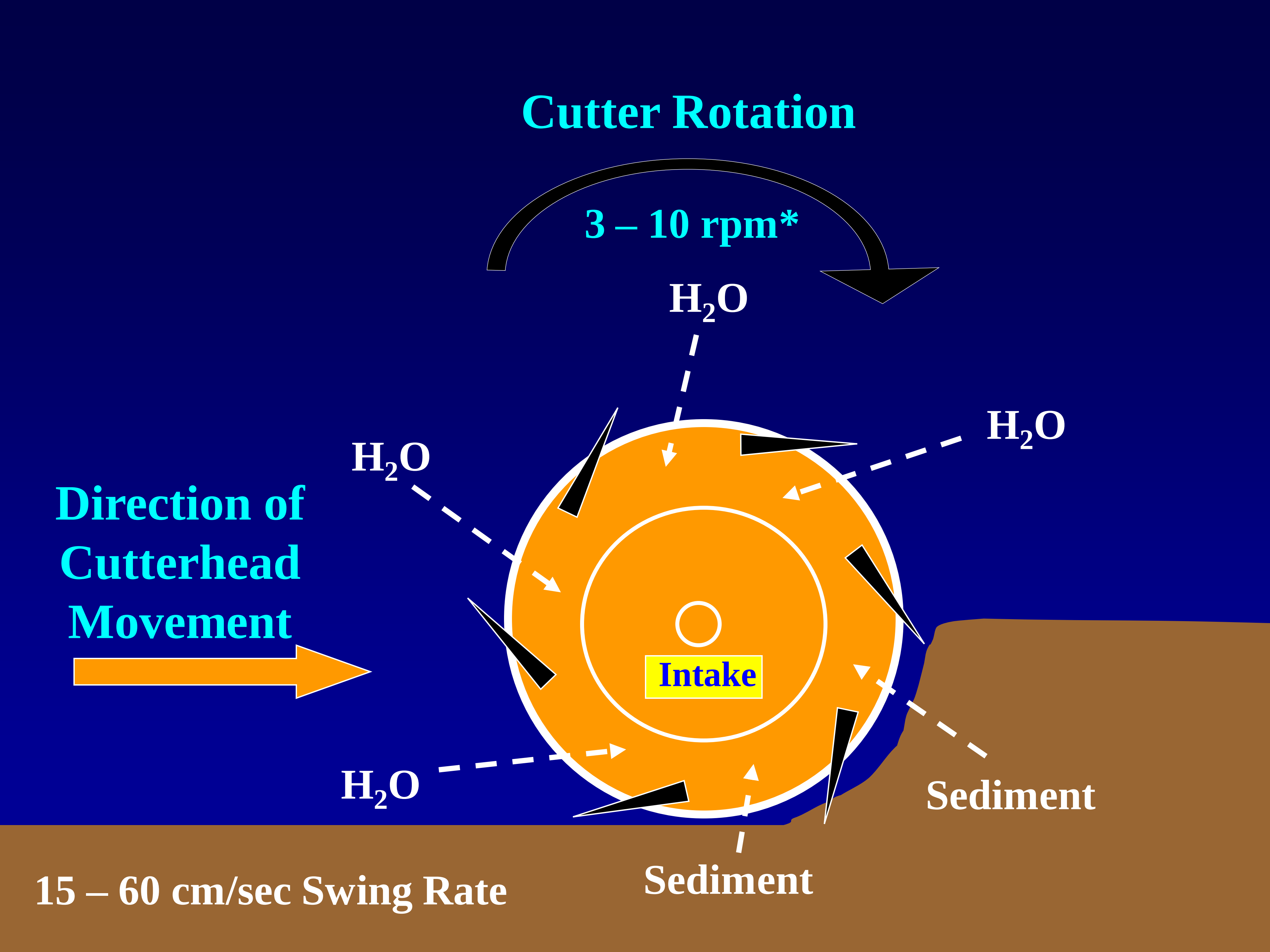


Surge Compensators

Draghead Assembly

CUTTERHEAD DREDGES





Cutter Rotation
3 – 10 rpm*
H_2O
H_2O
H_2O
Direction of Cutterhead Movement
Intake
H_2O
Sediment
Sediment
15 – 60 cm/sec Swing Rate

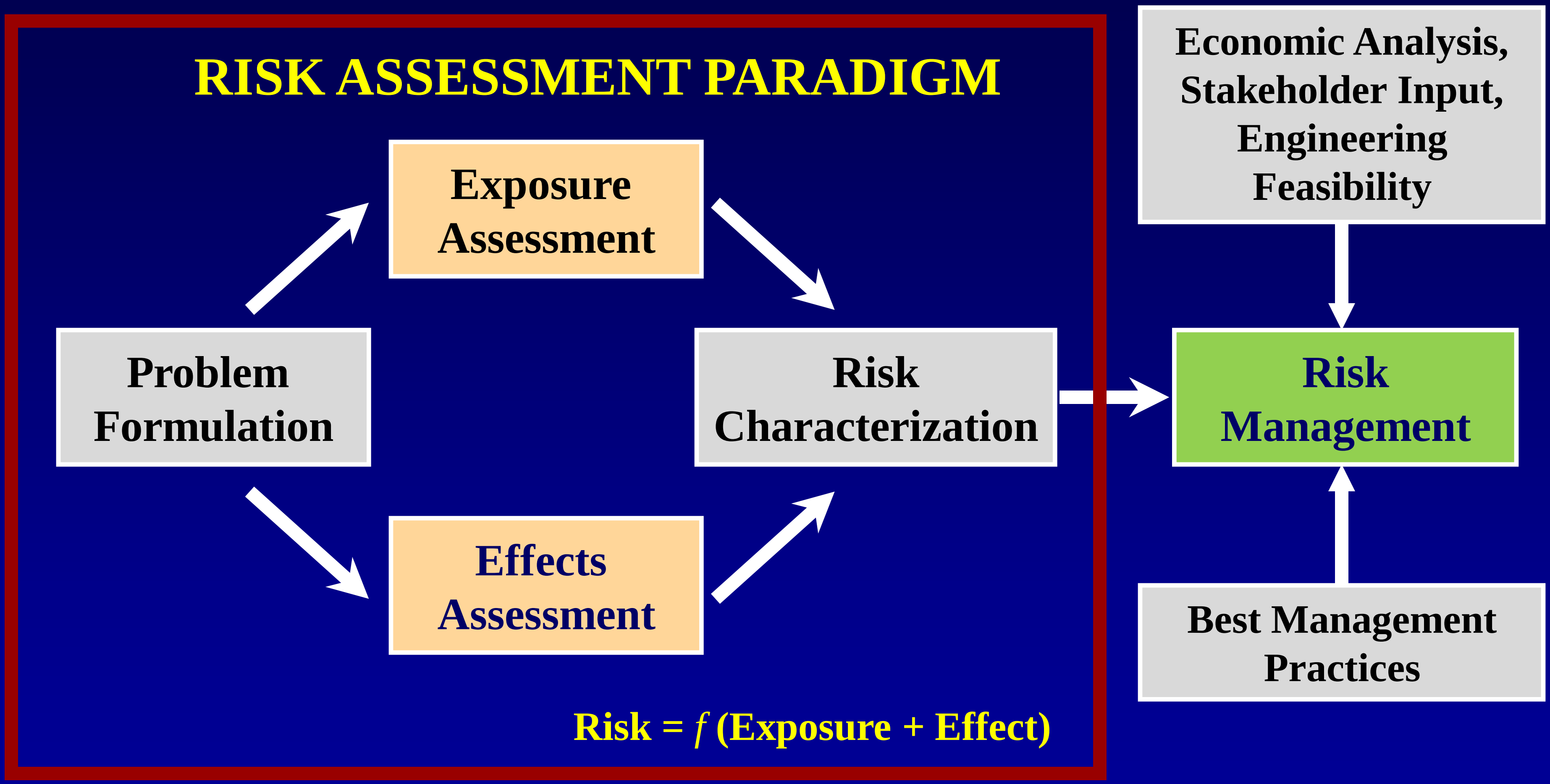
Why Does Resuspension Matter?

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

THE 4 R'S

- **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**

RISK FRAMEWORK



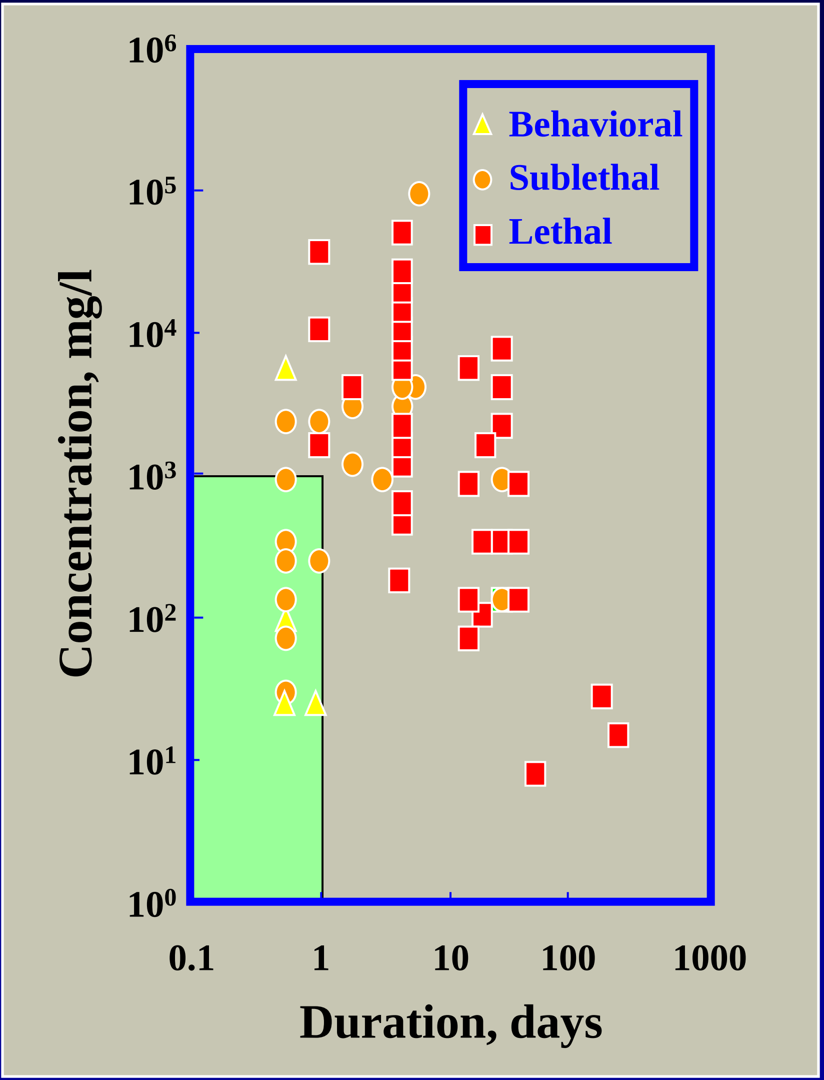
Persistent Issues

42 Years 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**

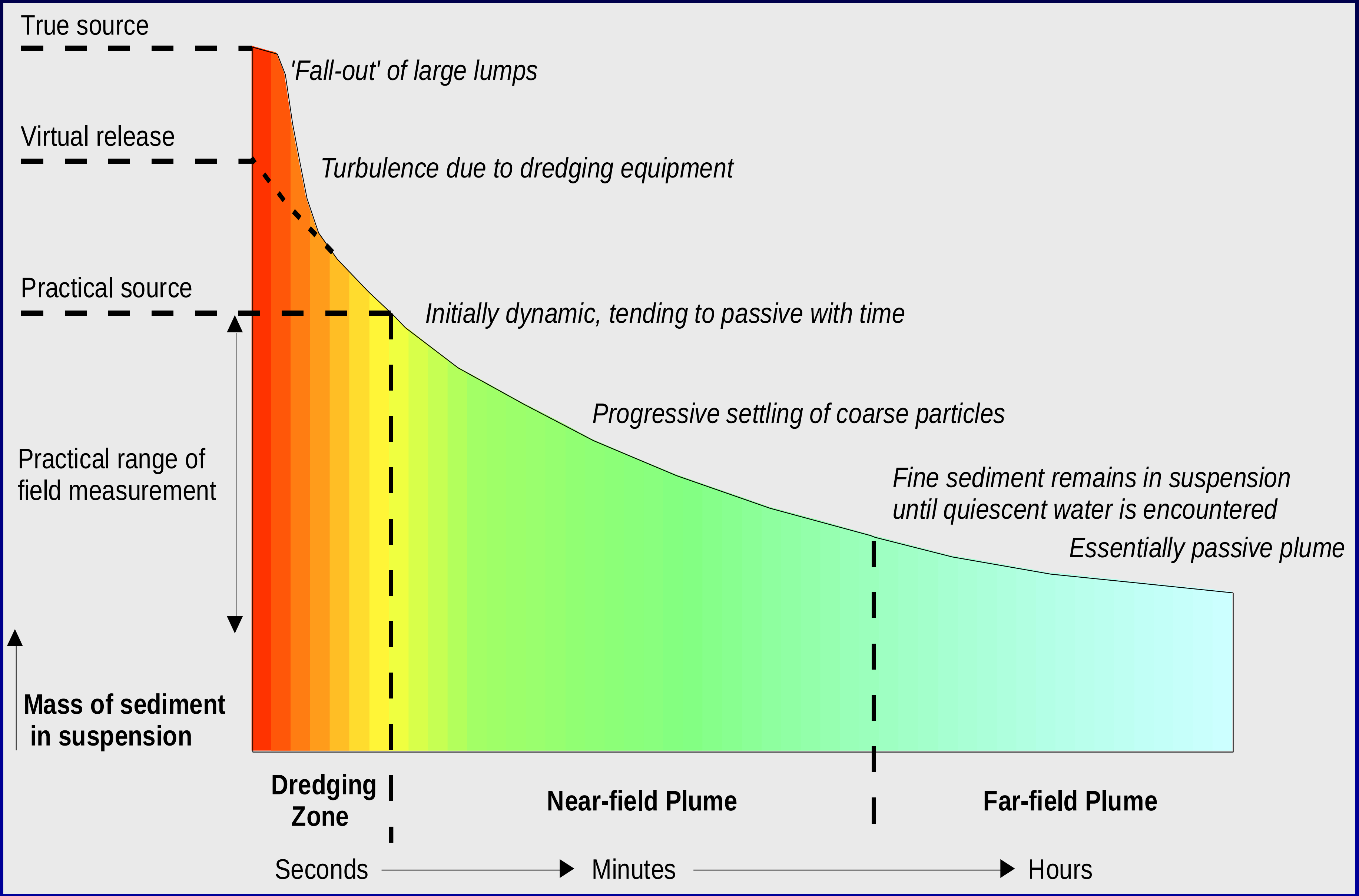
Factors That Influence Resuspension

- 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
  - Tug and tender maneuvering
  - Operator skill

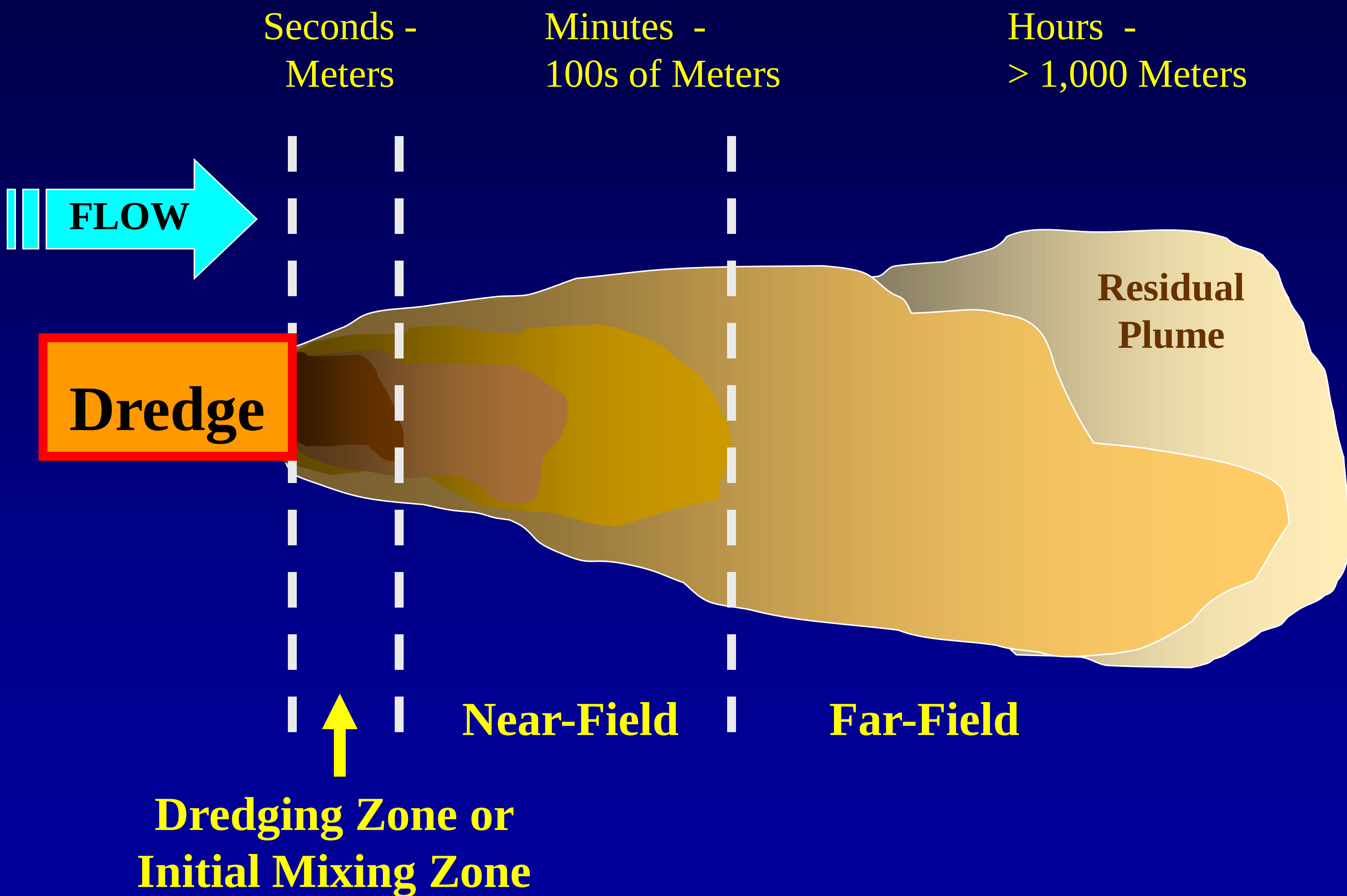
Perceptions vs. Reality

- Prevailing assumption 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

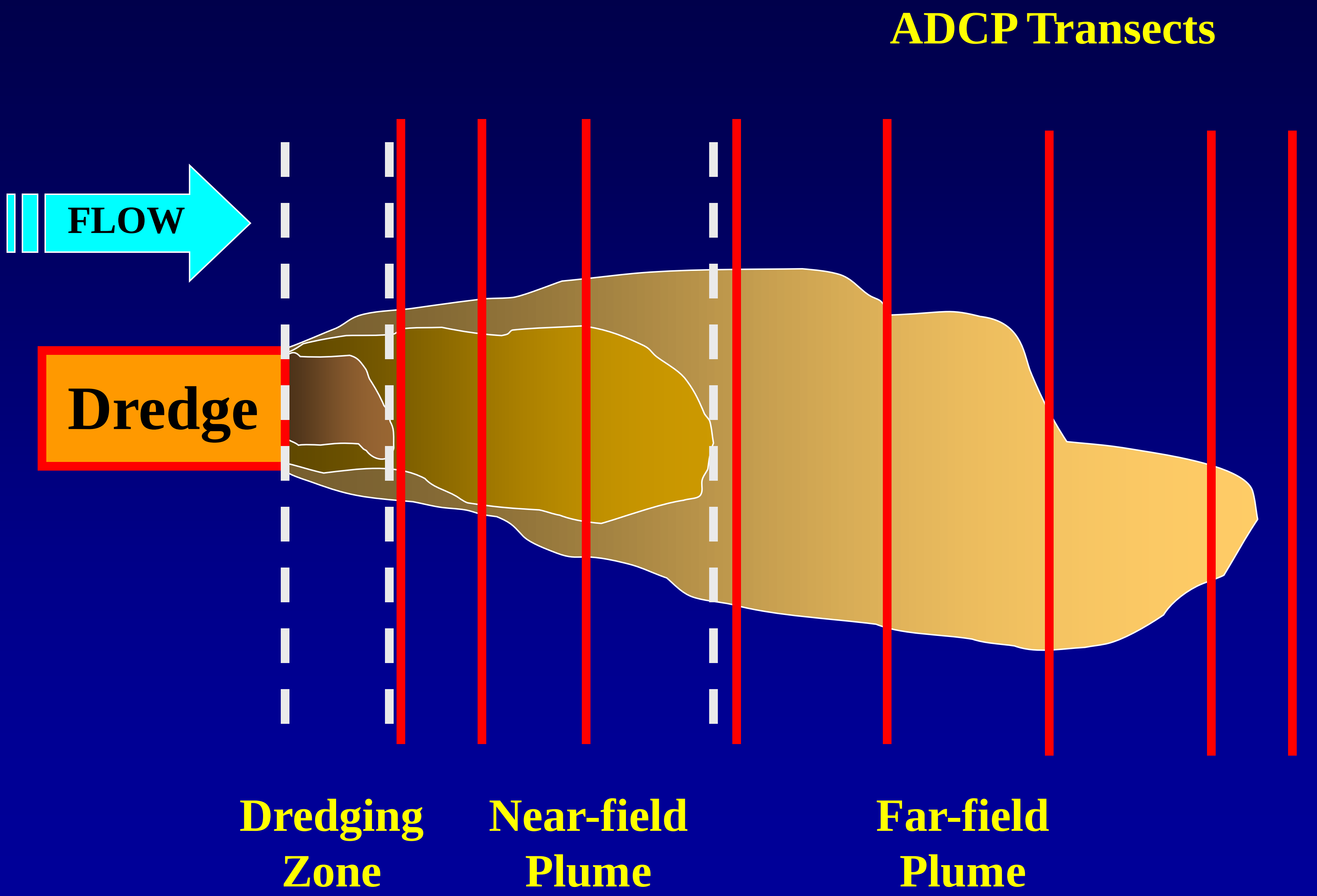
CONCEPTUAL PLUME DYNAMICS



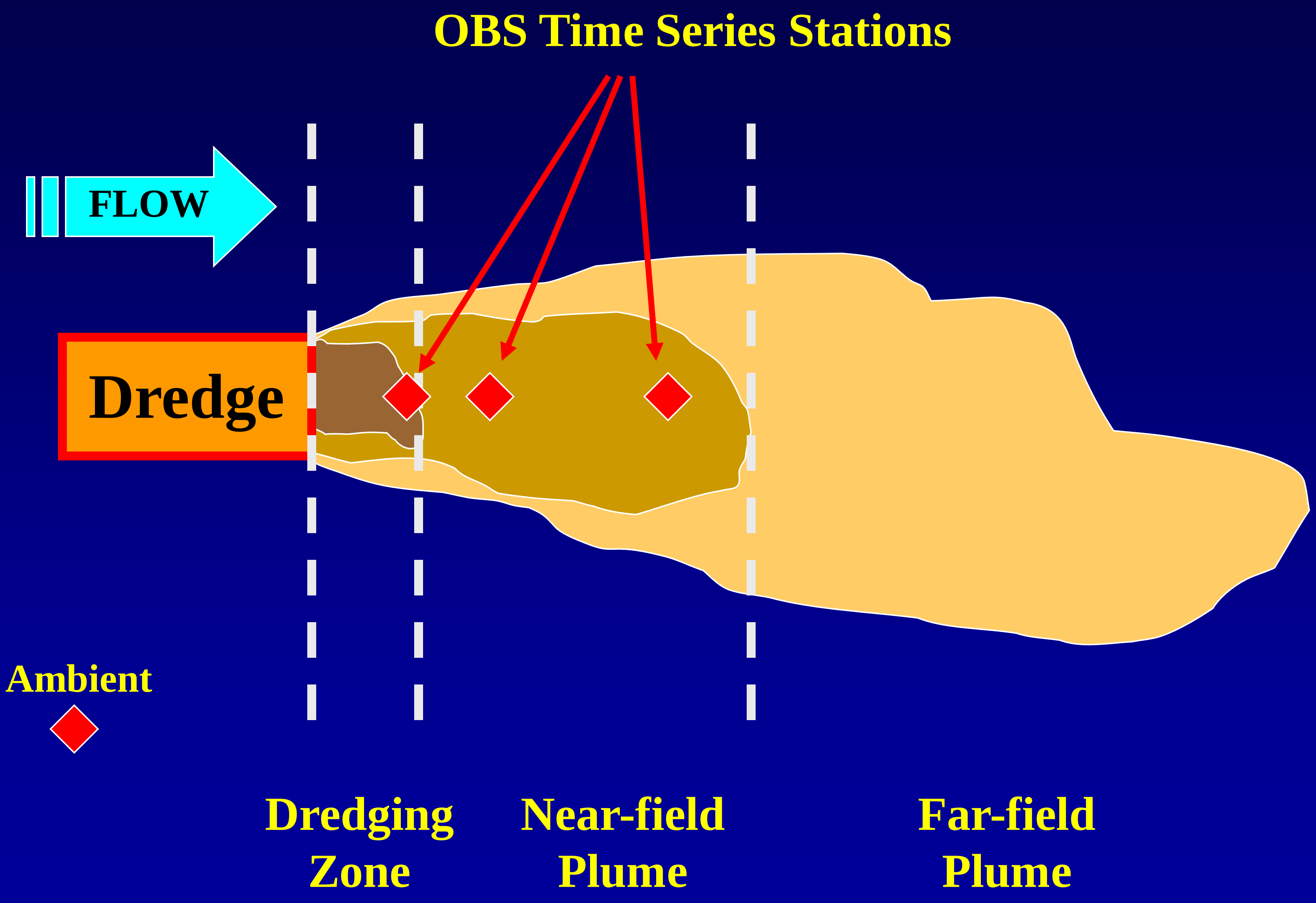
Plume Spatial/Temporal Scales



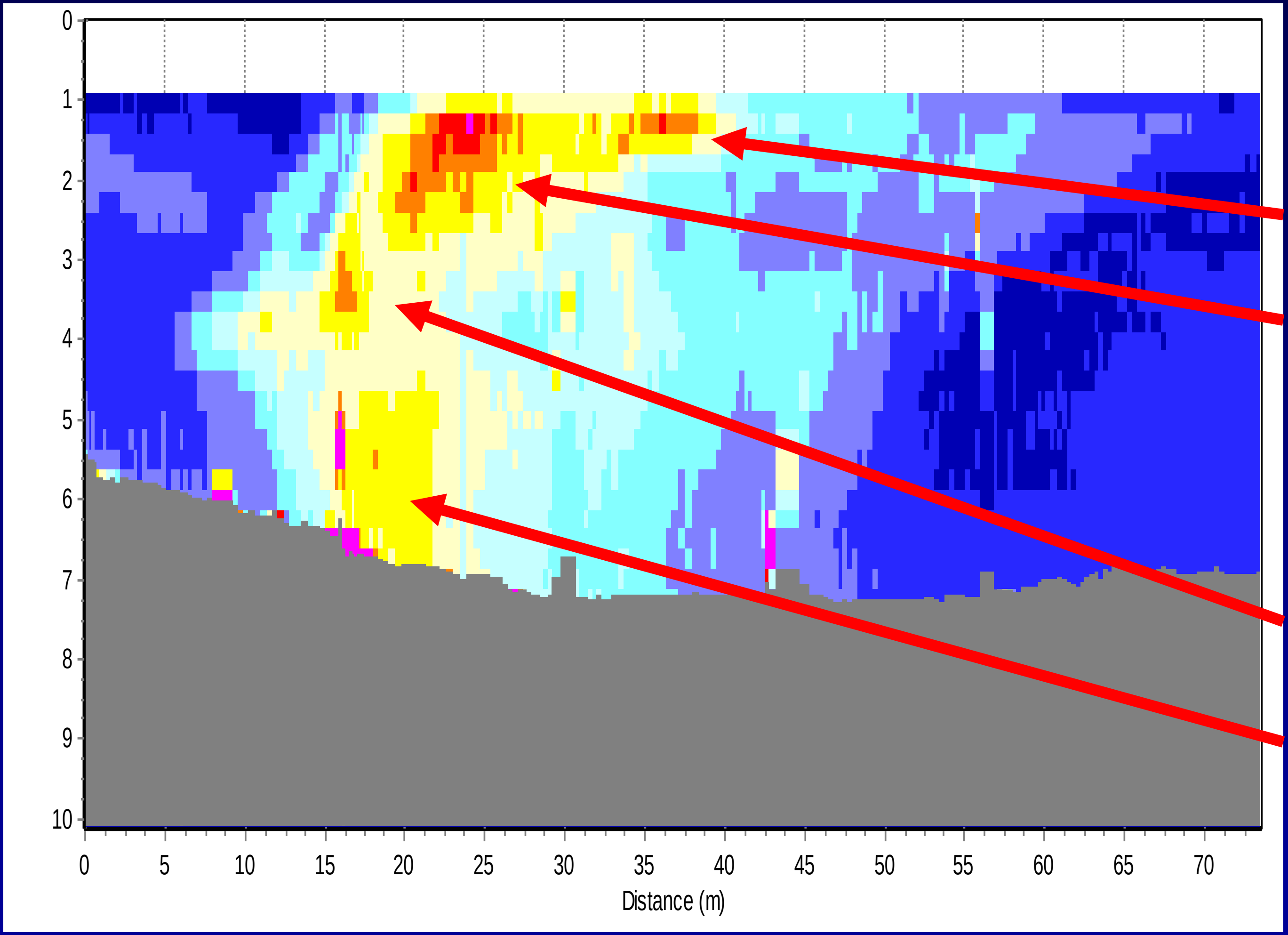
Characterization of Spatial Dimensions



Characterization of Temporal Dynamics

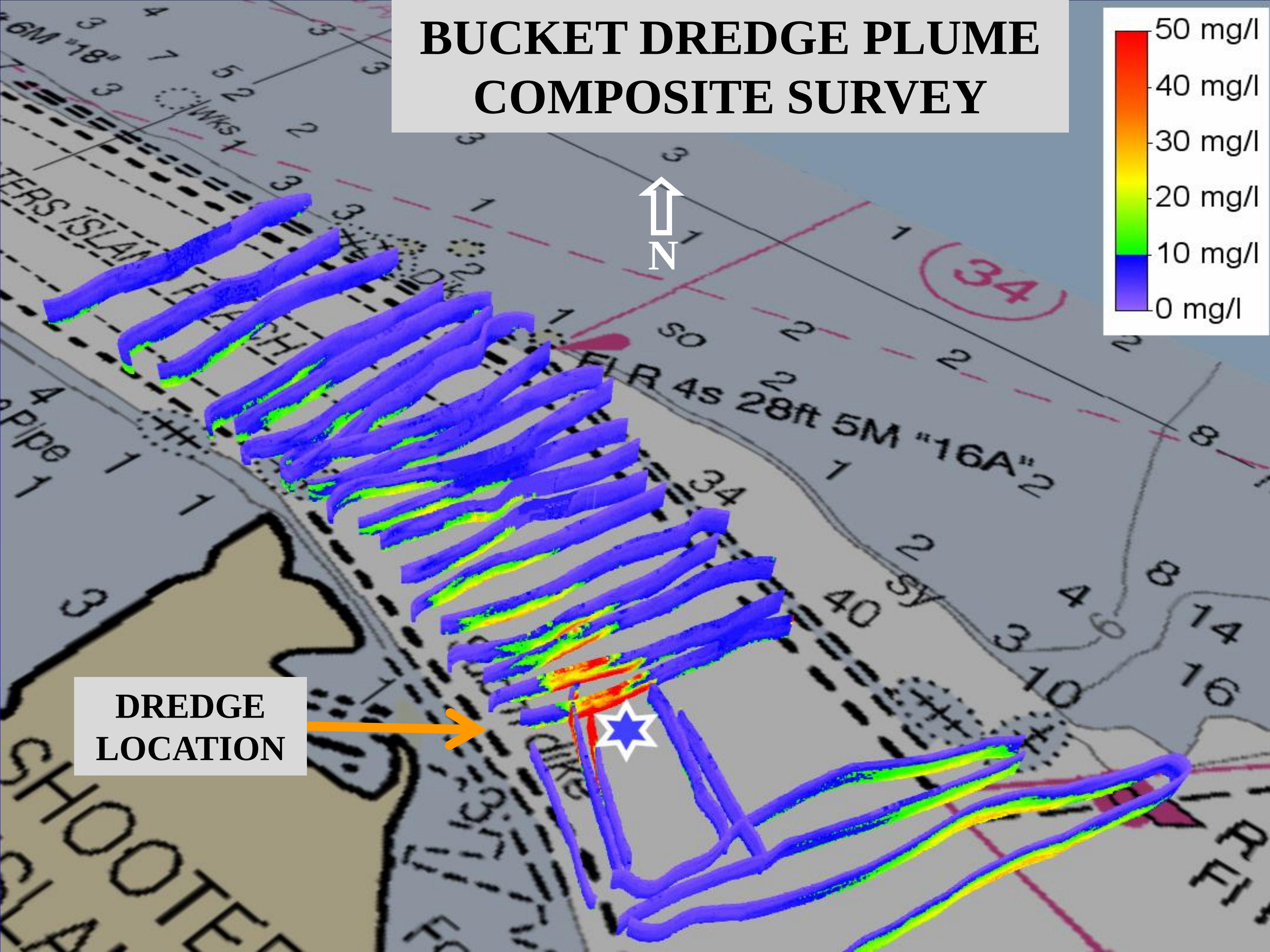


Bucket Dredge Plume Components…



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

BUCKET DREDGE PLUME COMPOSITE SURVEY



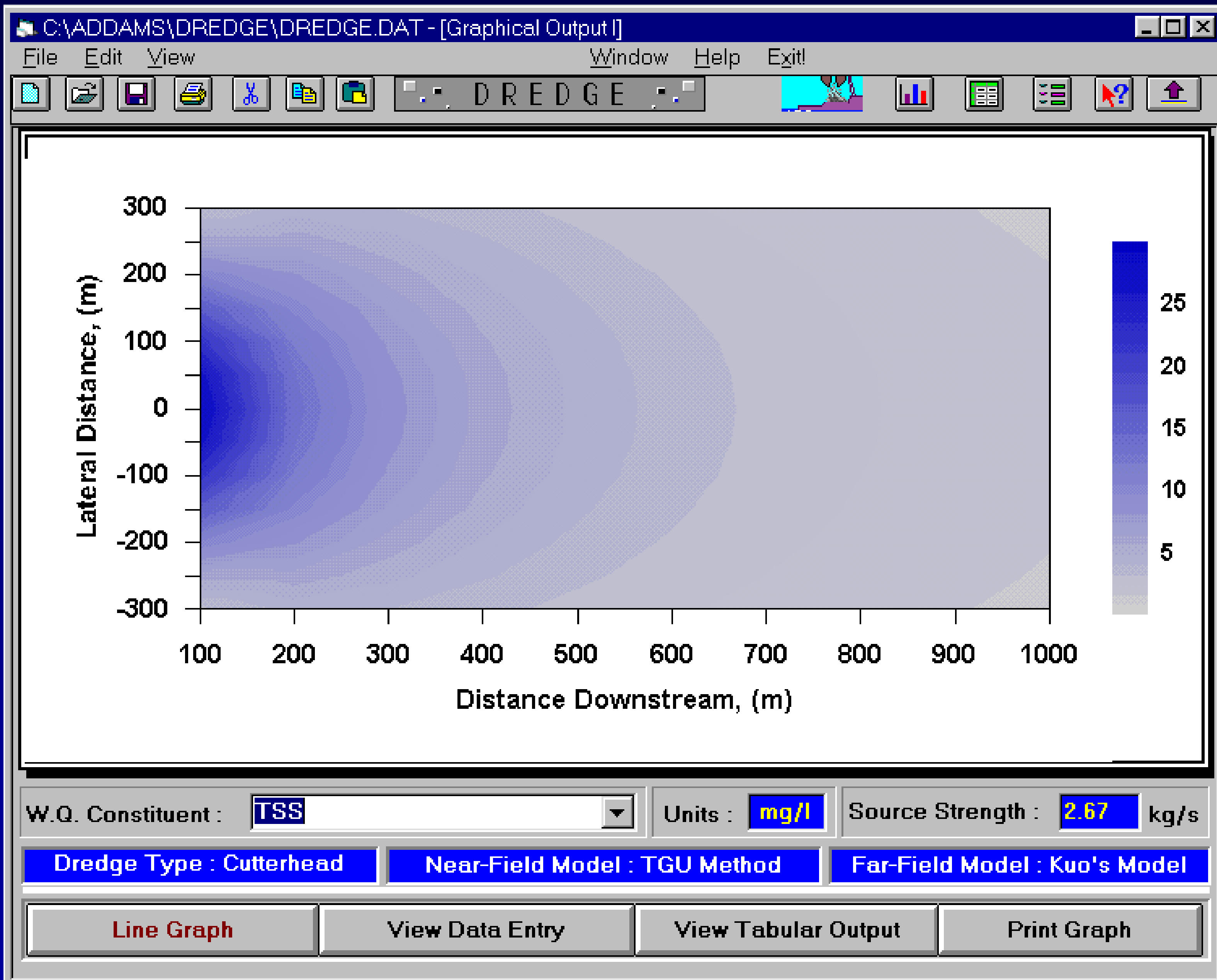
Comparative Resuspension Rates

- Mean loss rate for mechanical dredges = 2.1%
  - Nakai – 0.02 to 0.6%
  - Hayes and Wu – 0.2 to 0.9%
  - Pennekamp - 0.3 to 1% open bucket, 0.3 to 2% closed bucket
  - Tavolaro – 2%
  - Bohlen, Anchor Environmental – 1 to 3%
  - Land and Clarke – 5 to 9%
- Mean loss rate for hydraulic dredges = 0.77%
  - Nakai – 0.01-0.04% in sand
  - Nakai – 0.17-2.56% in silty clay
  - Pennekamp – 0.01%
  - Hayes and Wu – 0.02-0.13% in clay and silt

PLUME SIMULATION TOOLS & FIELD CHARACTERIZATIONS

- Monitoring methodologies
  - To calibrate and verify models
  - To provide adaptive management input
- Dredging process models
- Far-field plume models

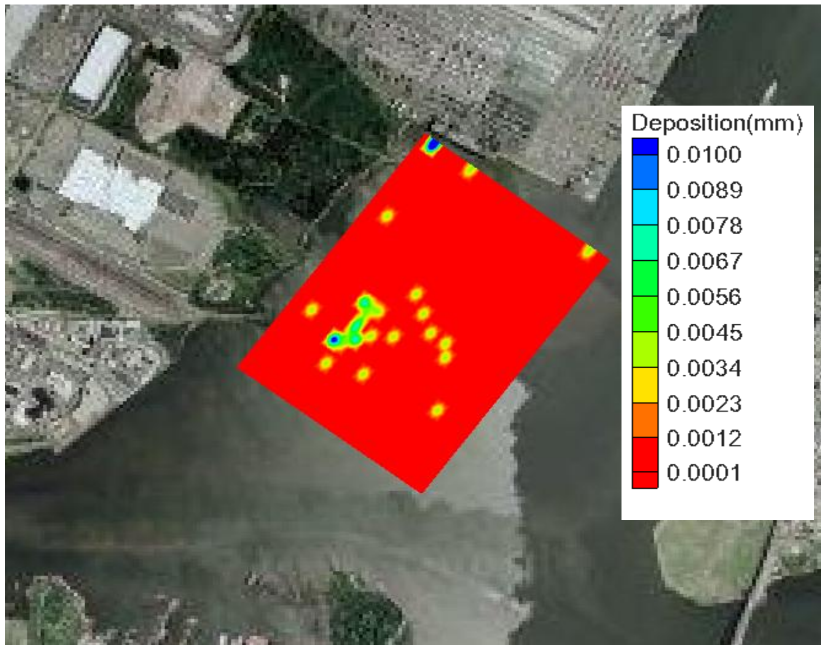
DREDGE Model



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

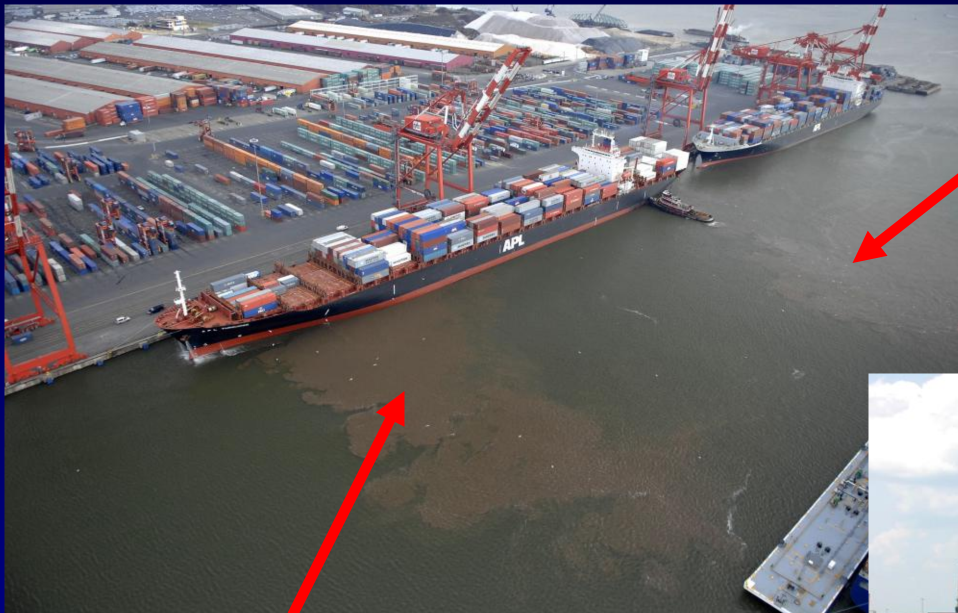
PTM Deposition Output



Discussion Issues

- Placing dredging into perspective with other sources (e.g., ship traffic, storms, freshets)
- Effectiveness of controls incorporated into navigation dredging WQ certificates
  - silt curtains
  - bucket types
  - operational measures
  - environmental windows

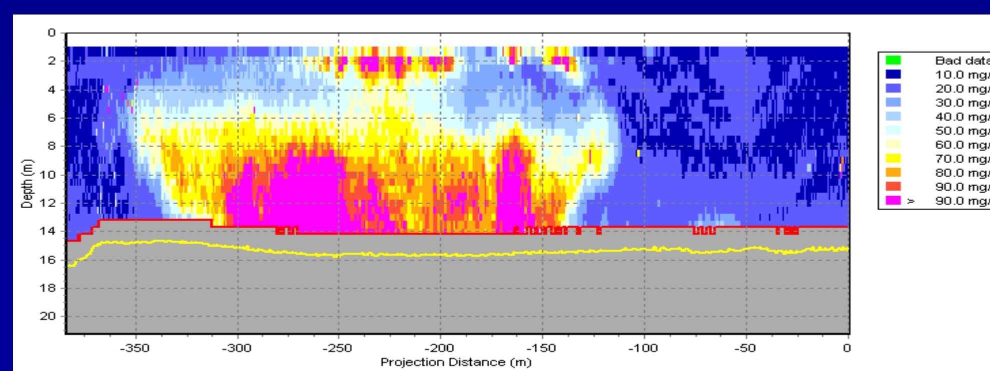
Ships as a Source of Resuspension



Tug Plume

Plume Generated

by Bow Thruster



Conclusions

- Resuspension issues form a basis for a majority of problematic environmental concerns
- These issues have proven to be exceedingly difficult to resolve
- Progress needed toward reasonable, science-based, technically defensible solutions
- Mutual objective – management practices that minimize risk while maintaining dredging project flexibility

Questions?