# Relating the 4 Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk

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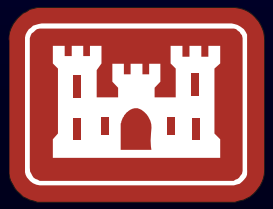
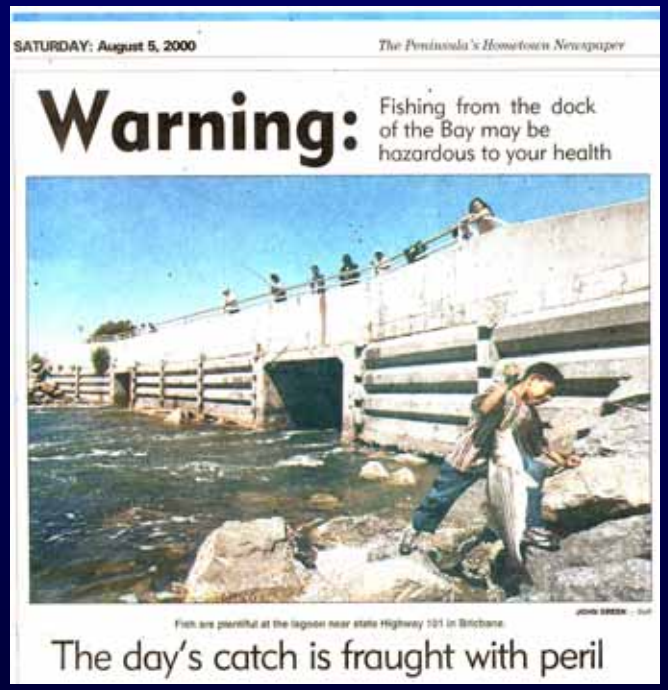


# Scope of the Sediment "Problem"

- EPA 1997 sediment survey report concludes 1.2 billion $yd^3$ surficial sediment "pose potential risks"
- Cleanup programs
  - ~ 66 Tier 1 sediment sites and 100 OUs/areas
    - ~ 30 megasites (> $50M)
- Some significant sites
  - Hudson River, NY - $460M
  - New Bedford Harbor, MA - $341M
  - Bayou Bonfouca, LA - $90 M
  - Fox River, WI - $76 M (OUs 1, 2) - $309 M (OUs 3, 4, 5)
  - Housatonic River, MA - $100 M+ (first 2 miles)


SATURDAY: August 5, 2000

The Peninsula's Hometown Newspaper

Warning: Fishing from the dock of the Bay may be hazardous to your health

Fish are plentiful at the lagoon near state Highway 101 in Brisbane.

The day's catch is fraught with peril

# 4 Rs Workshop

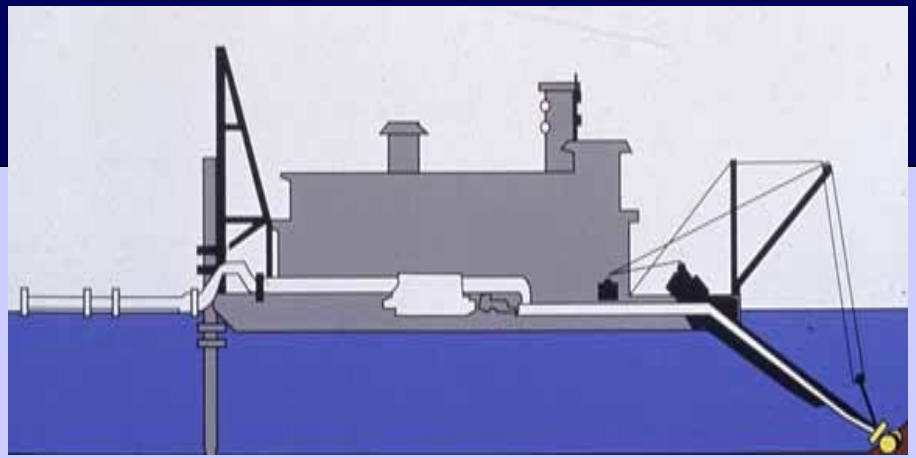
- Purpose:  Address technical issues posed by the use of environmental dredging as a remedy
  - Identify and prioritize the role of processes contributing to resuspension, contaminant release, and residual formation
  - Develop an understanding of the contribution of these processes to short and long-term risk at sites
  - Formulate research targets for critical needs
- Place: Waterways Experiment Station, 25-27 April, 2006
- Participants:
  - Todd Bridges, Steve Ells, Dave Mount, Paul Schroeder, Don Hayes, Clay Patmont, Mike Palermo, Steve Nadeau, Leah Evison, Rob Burgess, Scott Cieniawski, Dennis Timberlake, Marc Mills, Earl Hayter, Marc Greenberg, Jim Hahnenberg, Karen Keeley, Skip Nelson, Tom Borrowman, Carlos Ruiz, Doug Clarke, Tom Fredette, Tim Welp, Joe Gailani, Trudy Estes, John Connolly, Bob Engler, Ed Garvey, Mel Skaggs, Rick Fox, Paul Fuglevand, Norm Francingues, Victor Magar, Rick Wenning, Ram Mohan, Danny Reible, Louis Thibodeaux, Willy Lick, Frank Bohlen, Jeff Stern, Russ McMillan, John Lally, John Haggard, Nancy Grosso, Larry McShea, Jay Field, Karl Gustavson, Ken Richter

# Dredging/Disposal Remedy Process Train

Dredging/ Excavation → Staging/ Transport/ Rehandling → Treatment → Disposal

- Environmental Dredging is one component of a removal remedy
- Controversy/uncertainty focused on dredging, but major costs are in treatment/ disposal

# Conceptual Illustration of Environmental Dredging and 4 Rs Processes



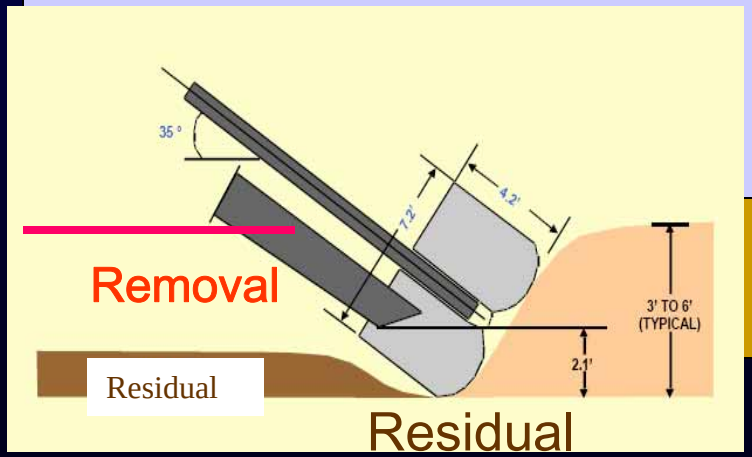
Release (Air)

Risk

Release (Water)

Resuspension

Residual (Sediment)

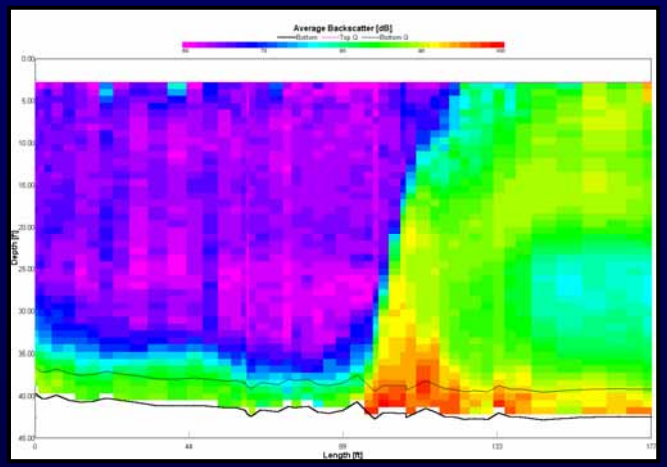


# Sediment Resuspension

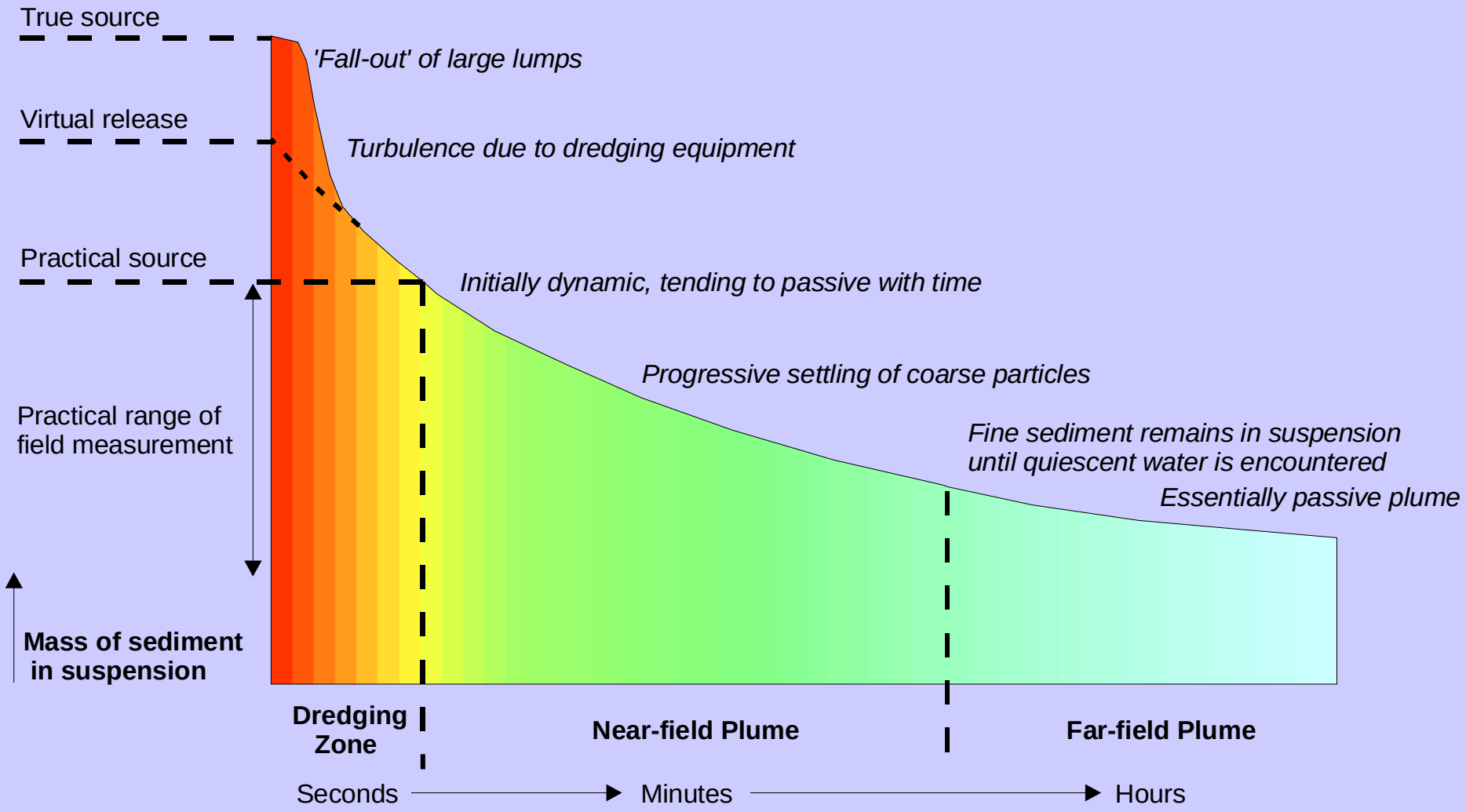
- Resuspension = *the processes by which a dredge and attendant plant operations dislodge bedded sediment particles and disperse them into the water column*
- Resuspended sediment may settle in the dredging area or be transported down-current as a plume.
- Causes: Dredgehead forces, Spillage/leakage, Sloughing of cut-face, Barge/tug movement, Non-related events, etc.

# Sediment Resuspension

- **Sediment resuspension <u>will</u> occur at dredging projects--the extent varies**
- **Generally less than 1%**
- **Factors:**
  - **Sediment properties such as bulk density, particle size distribution, and mineralogy**
  - **Site conditions: water depth, currents, and waves, presence of hardpan, bedrock, or loose cobbles or boulders**
  - **Nature and extent of debris and obstructions**
  - **Operations: production, thickness of dredge cuts, dredging equipment type, methods, operator skill**

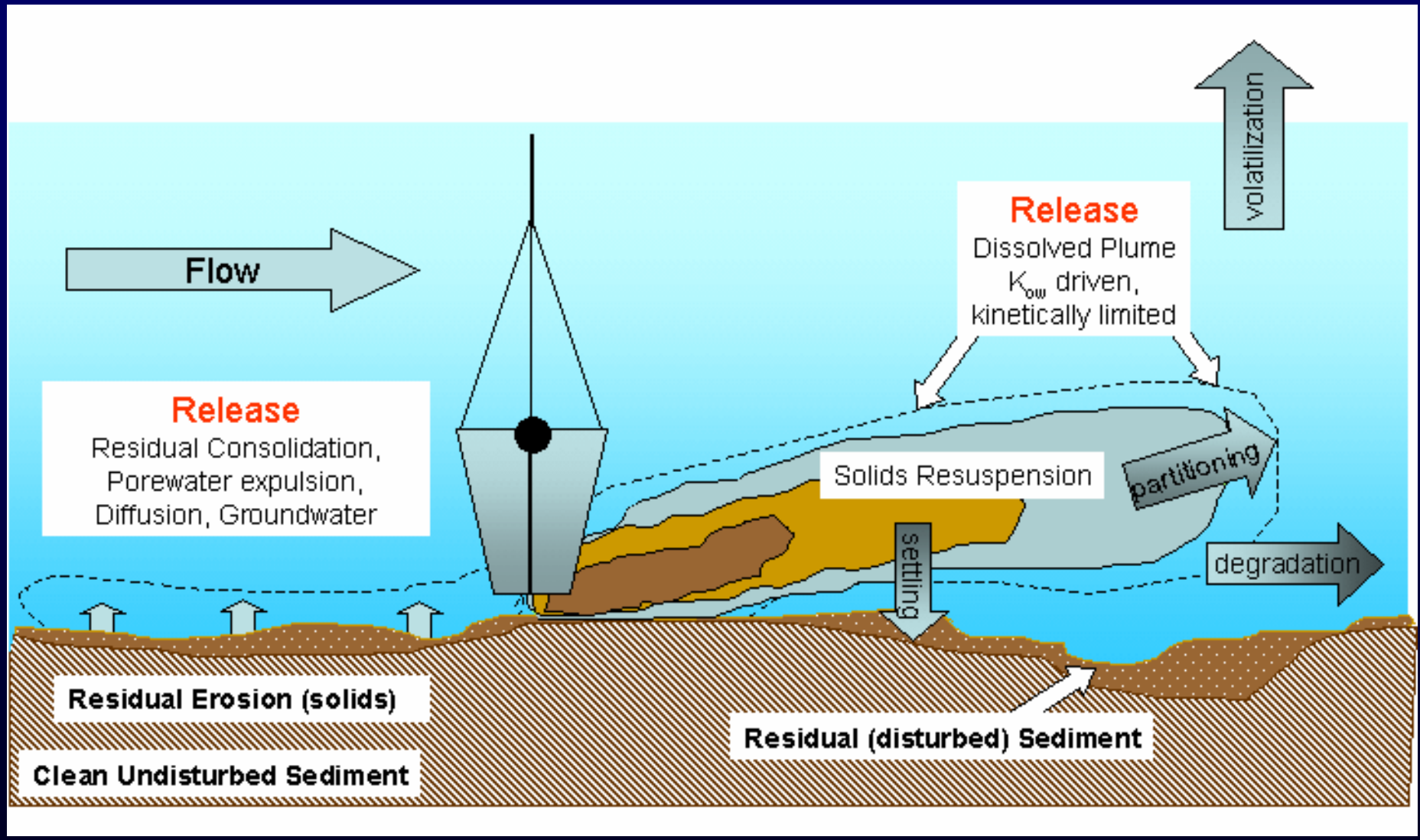


# Temporal and Spatial Scales



# Contaminant Release


- Contaminant Release = *The process by which the dredging operation results in loss of contaminants from sediment pore water and sediment particles into the water column or air*
- Releases can be in particulate, dissolved, or volatile fractions
- Reported losses greater than resuspension, perhaps as much as 3%
- May be a function of residuals as well as resuspension

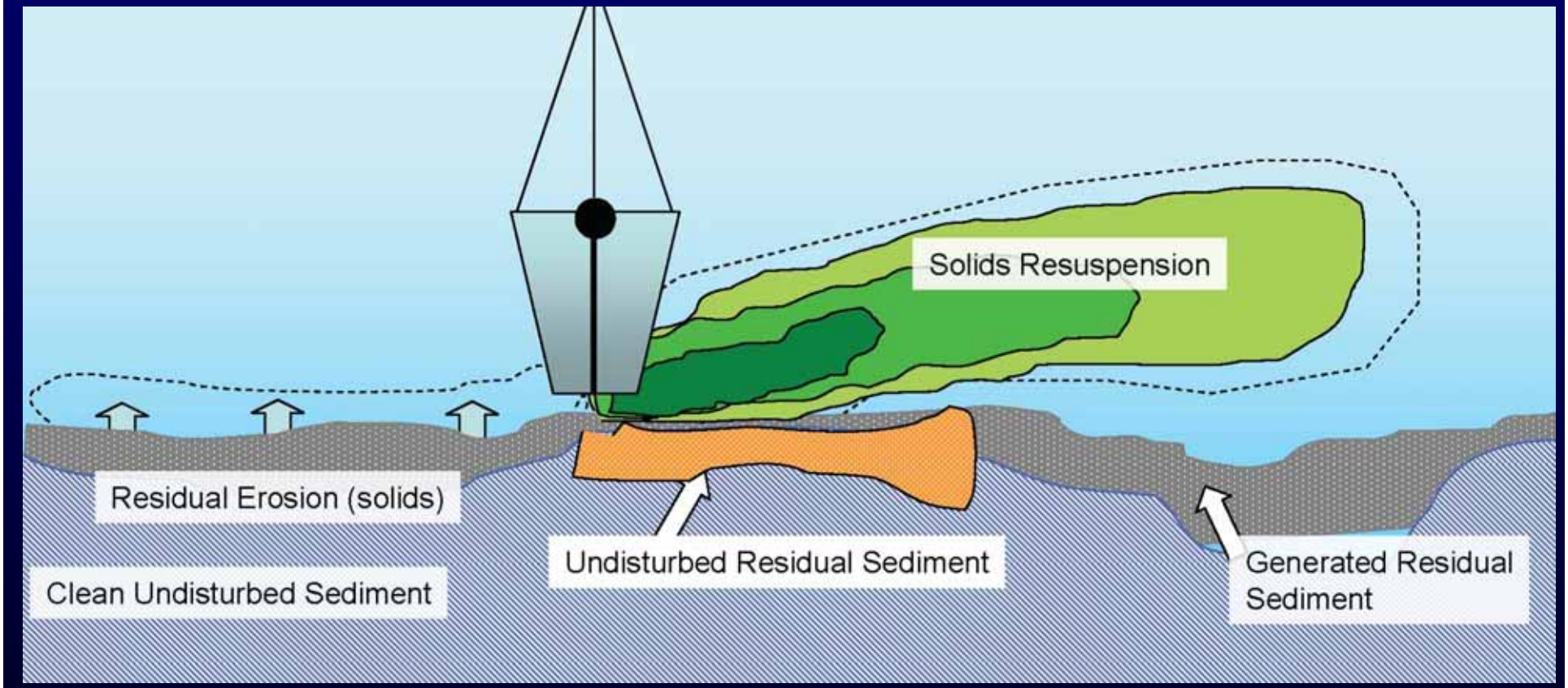

volatilization
Release
Dissolved Plume
$K_{ow}$ driven,
kinetically limited
Flow
Release
Residual Consolidation,
Porewater expulsion,
Diffusion, Groundwater
Solids Resuspension
partitioning
degradation
settling
Residual Erosion (solids)
Clean Undisturbed Sediment
Residual (disturbed) Sediment

# Release Sources/Mechanisms

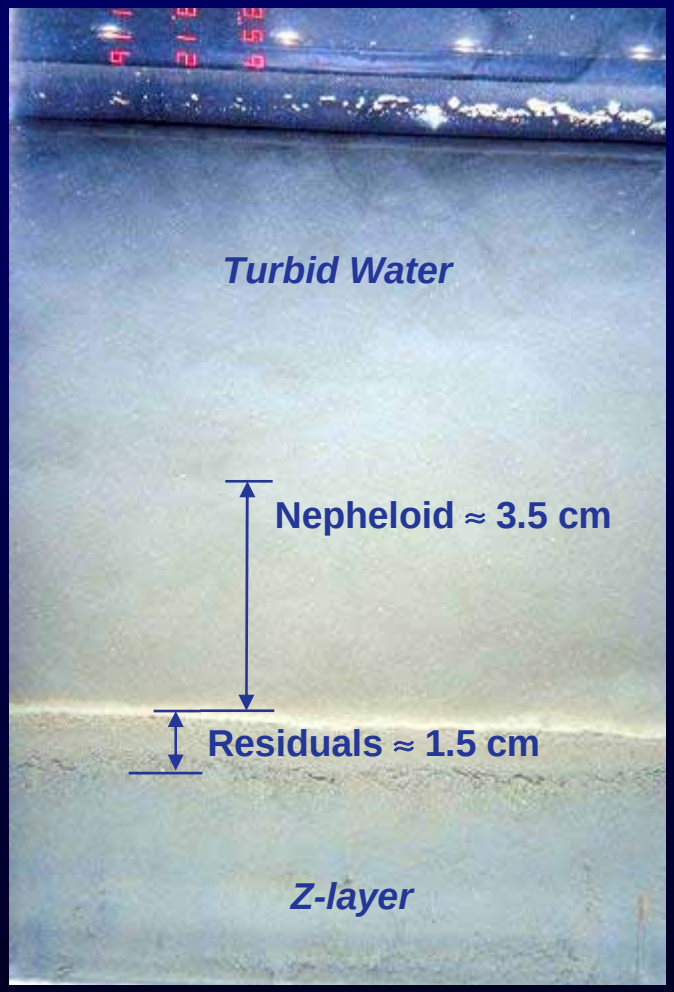
- Resuspension from Dredging Operations
- Diffusion from Cut Face and Residuals
- Erosion of Residuals
- Pore Water Release during Removal by Drainage or Exchange
- Expulsion of Pore Water from Residuals during Densification
- Pore Water Release by Groundwater Advection
- Bioturbation
- Biouptake/Trophic Transfer/Depuration/Renewal

# Residual Sediment

- Residuals = *Contaminated sediment (at concentrations above the action level) found at the post-dredge surface of the sediment profile, either within or adjacent to the dredging footprint*
- Because there are numerous potential sources of residual sediment, residuals can be broadly grouped into two categories:
  - 1) Undisturbed residuals (Ru); and
  - 2) Generated residuals (Rg)
- Causes
  - Incomplete characterization
  - Inaccuracies of dredging
  - “Fallback” – dislodged sediment not picked up
  - Sloughing from cut-face
  - Resettlement of resuspended sediments


Solids Resuspension
Residual Erosion (solids)
Undisturbed Residual Sediment
Generated Residual Sediment
Clean Undisturbed Sediment

# Generated Residual Characteristics




*Typical physical properties*

- Fine-grained
- Unconsolidated
- High moisture content
- Surface layer may be comprised of fluid mud or “fluff” layer

*Typical chemical properties*

- Constituent concentrations in the residual layer (dry weight basis) typically equal the depth averaged dredge prism concentration

# Generated Residual Case Studies

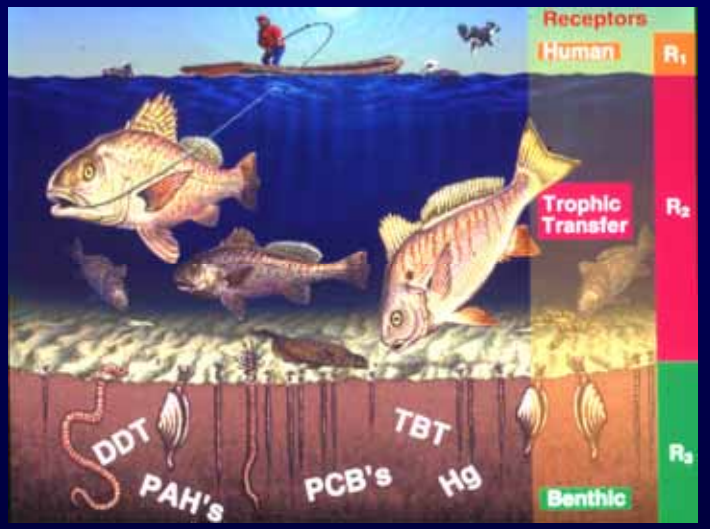
| Site | Dredge Volume (cy) | Date | Equipment Type | Generated Residual Mass (%)[1] |
|---|---|---|---|---|
| | | | | |
| Fox River 56/57 Pilot | 31,000 | 1999 | 10” Horizontal Auger | 6 |
| Lavaca Bay Pilot | 10,000 | 1999 | 14” Cutterhead | 4 |
| New Bedford Harbor | 2,300 | 2000 | 4.5 cy Horiz. Profile Grab | 6 |
| Reynolds Aluminum | 87,000 | 2001 | 5.5 cy Cable Arm™ | 4 |
| Hylebos Wtwy. Sed. 1,2 | 400,000 | 2006 | Clamshell | 3 |
| Middle Waterway | 90,000 | 2003/ 04 | 6-12-16 cy Clamshell | 4 |
| Hylebos Wtwy. Seg. 5 | 390,000 | 2003/ 04 | 20 cy Clamshell | 2 |
| Hylebos Wtwy. Seg. 3,4 | 200,000 | 2004 | 20 cy Clamshell | 5 |
| Todd Shipyards | 120,000 | 2004/ 05 | Cable Arm™/Clamshell | 2 |
| Fox River OU 1A | 54,000 | 2005 | 8” Cutterhead | 9 |
| Fox River OU 1C/D2S | 17,000 | 2005 | 8” Cutterhead | 5 |

[1] Calculated as the ratio of the generated residual mass to the total dredged sediment mass

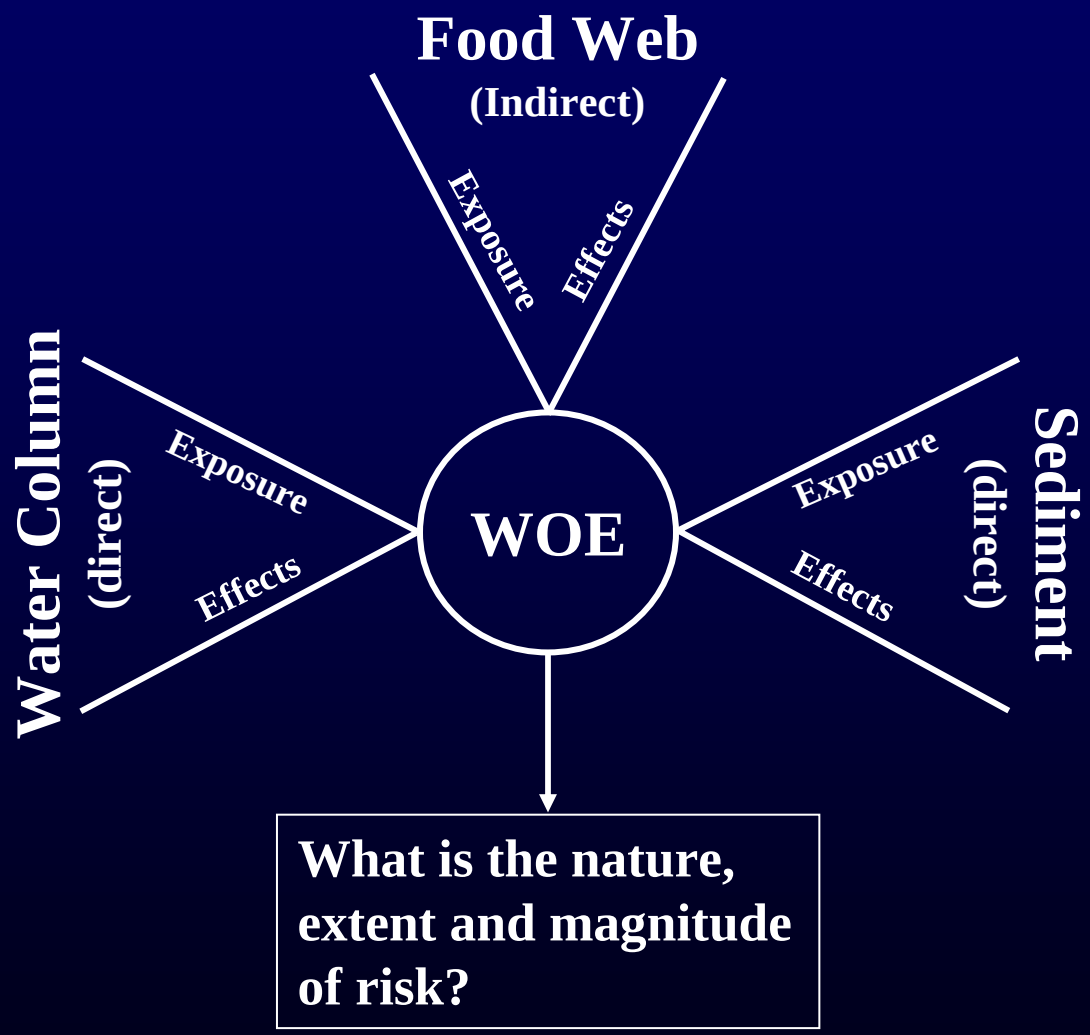
*From Patmont and Palermo, In Pre

# Risks for Environmental Dredging

- Risk = *the probability for an adverse impact on human health or the environment*
- Concern depends on magnitude of risk and spatial/temporal scale.
- Short Term Risks (during, soon after dredging)
  - Increases in dissolved water column conc.
  - Increases in fish tissue conc.
  - Habitat destruction
- Long Term Risks (post-dredging)
  - Reduced fish tissue conc.
  - Reduced sed tox
  - Benthos recovery



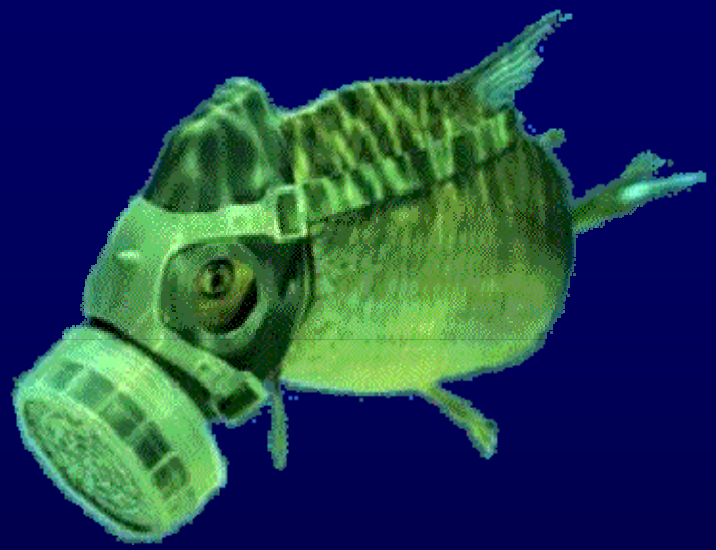
# Lines and Weight of Evidence in Sediment Assessment



# Magnitude of Risk (duration x area)

- How long elevated risk conditions will persist depends on:
  - The duration of dredging
  - Physical, chemical and biological dynamics at the site
- The size of the area over which the elevated risk condition exists
  - How will this change with time?
  - If the area affected is expected to shrink in size rapidly are management actions warranted?

# Summary



- Many conclusions that have been reached about the relation of the 3 Rs to the 4th R have been conjectural
  - There are many questions to answer
- Site-specific information will be key to credible analysis of risks
- An analysis of the 4 Rs should be included in a comprehensive comparison of net risk reduction among all the alternatives
  - Prior to remedy selection