

Effective Communication with Stakeholders of Remedial Options for Sediment Sites

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Overview

- Major Remedies: Dredging, Capping, Monitored Natural Recovery
 - Misperceptions
 - Case studies
 - Advantages
 - Limitations
 - Risks
 - Conditions conducive to conducting each remedy
 - Take Home Messages
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Three Major Remedies

- ❑ Dredging
- ❑ In-situ capping
- ❑ Monitored natural recovery



Dredging



Dredging Misperception

MISPERCEPTION

- Mass removal immediately and permanently reduces risk

FACT

- "Simple mass removal ... may not reduce risk."
Sediment Dredging At Superfund Megsites: Assessing The Effectiveness. 2007 National Research Council, p. 56.
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Dredging Misperception

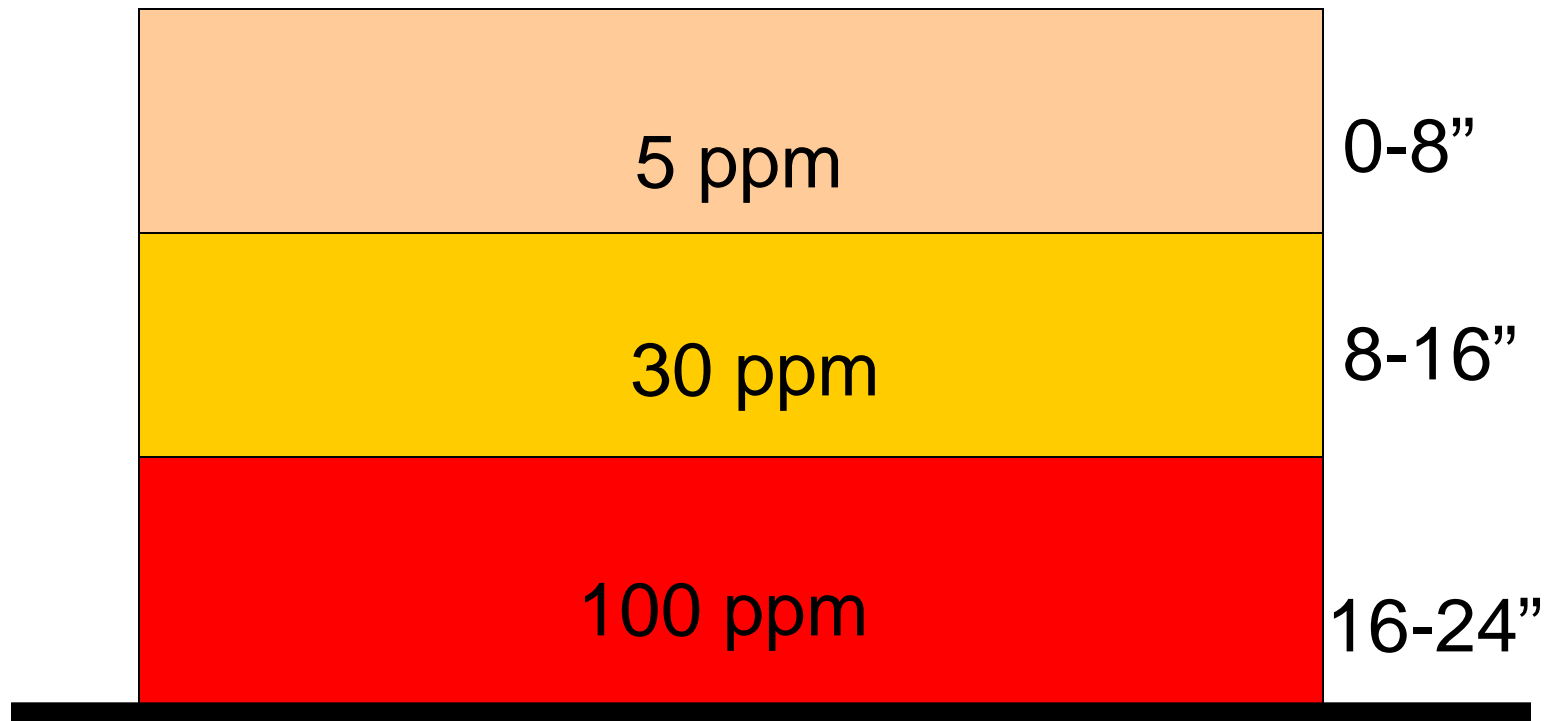
MISPERCEPTION

- ❑ Dredging will allow fish consumption advisories to be lifted immediately

FACT

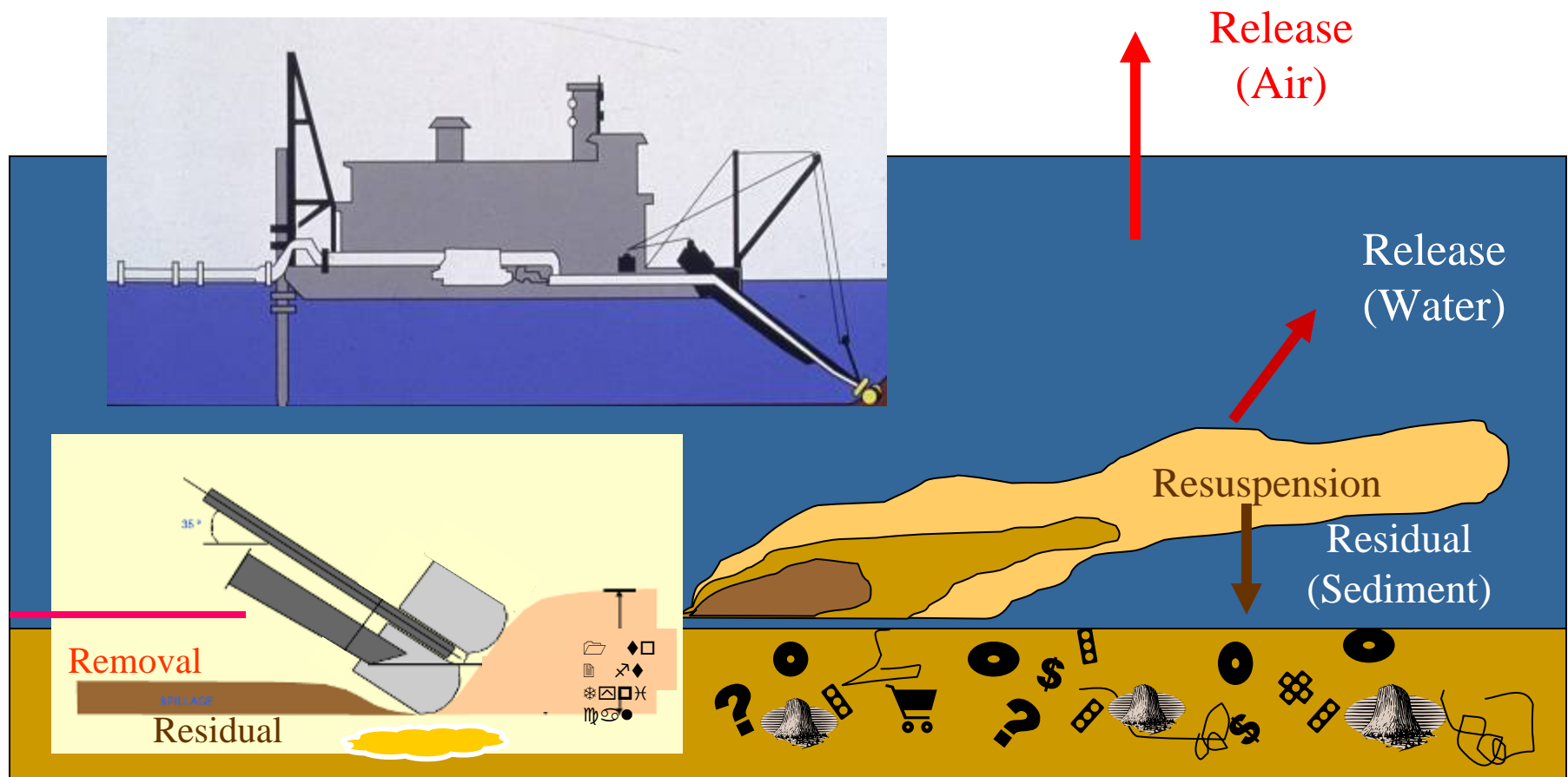
- ❑ Affecting the food chain can take a long time – from several years if all sources are controlled, to many decades if not
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Pre-Dredge Contaminant Concentration In Sediment Column



Hard pan

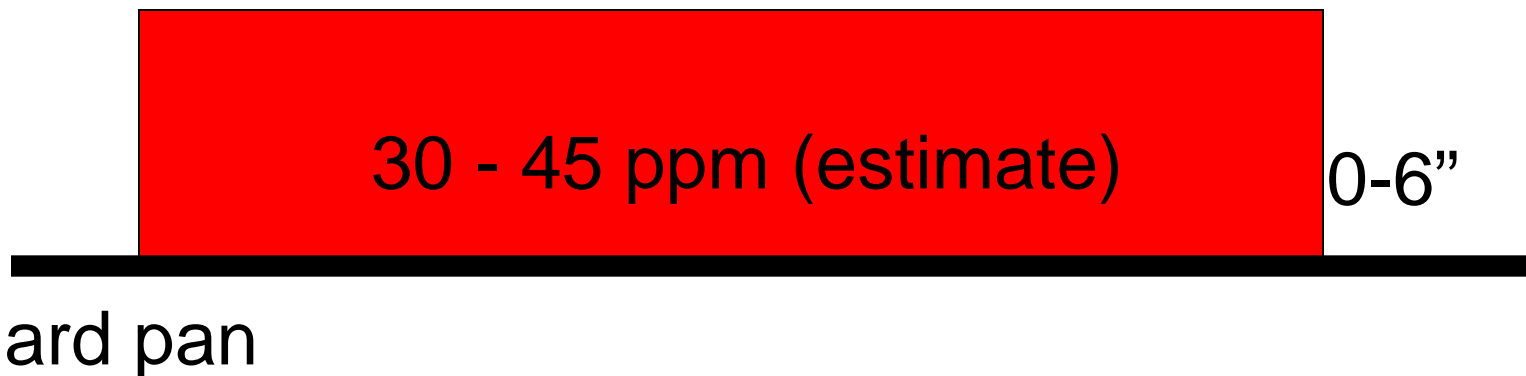
Conceptual Illustration Of Environmental Dredging And Processes



From D. Reible, 2007

Post-Dredge Surficial (0-6") Sediment Contaminant Concentrations

Hard pan and/or debris prevented dredge from removing all the contaminated sediment. The buried sediment with high concentrations of contaminant was exposed. The surficial concentration went from 5 ppm to ~30 – 45 ppm.



Case Study: Grasse River, NY – 2005

ROPS (Pilot)

- Project
 - Remedial Options Pilot Study
 - 20,600 cy dredged over 4 months
 - Contaminants
 - PCBs
 - Project Goals
 - Goal: Dredge 64,000 cy in 3 areas to test dredging's potential effectiveness under site-specific conditions
 - Results
 - Dredged only 1/3 of desired volume
 - Average surficial concentrations increased from 4.1 ppm to 150 ppm
 - 3% of PCBs lost downstream dissolved in the water column
 - Concentrations of PCBs in fish increased
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Grasse River, NY - 2005 ROPS (Pilot)

□ Lessons Learned

- Risk reduction was not achieved due to the generation of residuals despite significant dredging efforts
 - Average surficial concentration increased from 4.1 ppm to 150 ppm even though ~100 dredge cuts in each 25 ft x 25 ft unit
 - Complex site bottom conditions hampered ability to remove all targeted sediments
 - Unable to characterize site sub-bottom conditions despite state-of-the-art technology
 - Significant downstream loss of PCBs largely due to desorption of PCBs from resuspended sediments
 - PCB concentrations in fish increased
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Dredging Advantages

- ❑ Moves contaminants from a potentially mobile environment to one which can potentially be more easily and safely maintained and monitored
 - ❑ Except for continuing fish consumption advisories, does not limit future water body uses or reduce flood control capacity
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Limitations Of Dredging

- ❑ Complex and time-consuming to design and implement
 - ❑ Lack of capacity in disposal facilities
 - ❑ Resuspension and transport of contaminants
 - ❑ Release of contaminants to water, leading to an increase in bioavailability
 - ❑ Residual contamination affects ability to achieve risk reduction goals
 - ❑ “[R]esuspension, release, and residuals occur to some extent with all dredging projects.” *Sediment Dredging At Superfund Megsites: Assessing The Effectiveness.* 2007 National Research Council, p. 63.
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Dredging – Elements Potentially Continuing Or Increasing Risk

- ❑ Contaminant releases during sediment removal, transport, and disposal
 - ❑ Continued exposure to contaminants currently in food chain
 - ❑ Community impacts (e.g., accidents, noise, residential and/or commercial disruption)
 - ❑ Worker risk during sediment removal, handling, and transportation
 - ❑ Residual contamination following sediment removal
 - ❑ Releases from contaminants remaining outside of dredged/excavated area
 - ❑ Disruption of benthic community
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Conditions Especially Conducive To Dredging

- Contaminated sediment is underlain by clean sediment (overdredging is feasible)
- Low incidence of hardpan, bedrock, and/or rocks (overdredging is feasible)
- Low incidence of debris (e.g., logs, scrap materials)
- Low incidence of low dry density sediment ("fluff")
- Higher contaminant concentrations cover discrete areas
- Water diversion is practical; or current velocity is low or can be minimized to reduce resuspension and downstream transport during dredging

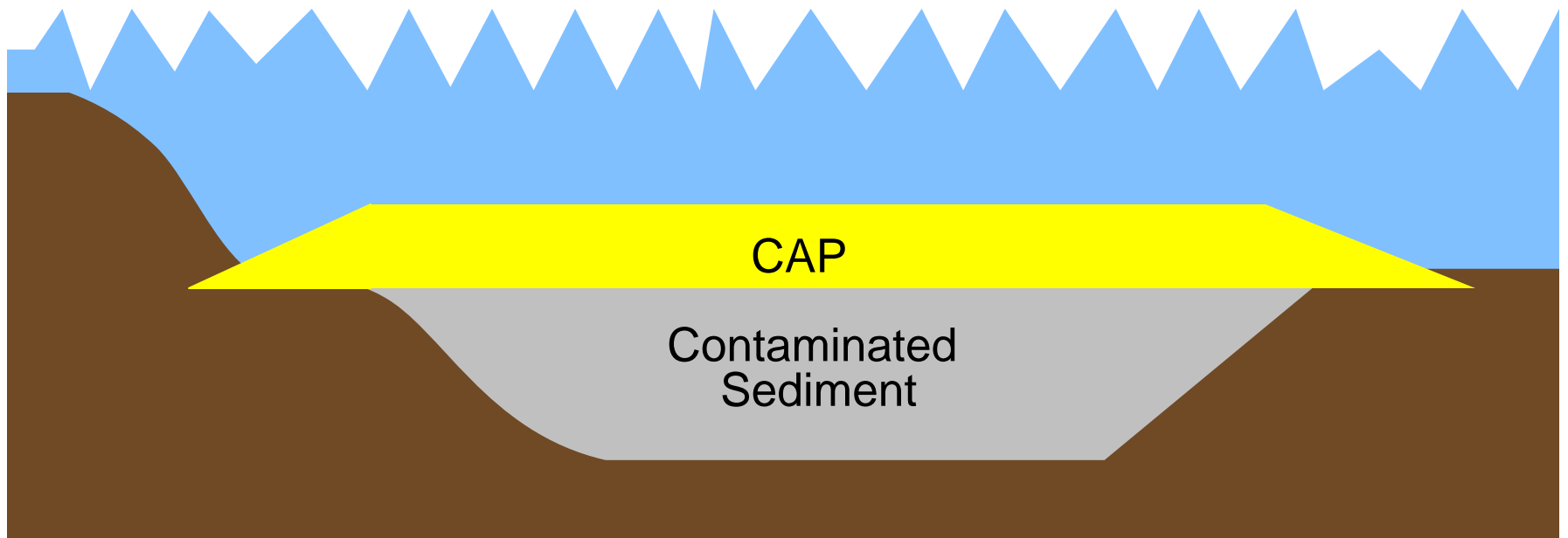
Note: Not all of the listed conditions must be present to select dredging.

Conditions Especially Conducive To Dredging

- Existing shoreline areas and infrastructure can accommodate dredging (e.g., piers, pilings, buried cables)
- Navigational dredging is scheduled or planned
- Suitable area is available for staging and handling of dredged material
- Suitable disposal sites are available
- Long-term risk reduction outweighs sediment disturbance and habitat disruption
- Contaminants are highly correlated with sediment grain size (i.e., to facilitate separation and minimize disposal costs)

Note: Not all of the listed conditions must be present to select dredging.

Capping



From D. Reible, 2007

Capping Misperception

MISPERCEPTION

- Capping is experimental and not proven

FACT

- Caps have been placed as the final remedy or pilot at over 100 sites worldwide
(www.sediments.org/capping-chart.html)



Capping Misperception

MISPERCEPTION

- All caps will fail eventually

FACT

- When caps are eroded, it usually is in localized areas
 - Erosion by water is relatively easy to predict
 - Predicting ice effects can be more difficult (not impossible), but also usually localized
 - Erosion can be effectively addressed by designed engineering solutions (e.g., armor)
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Capping Misperception

MISPERCEPTION

- Groundwater flow will make most caps fail

FACT

- Contaminant movement is highly dependant on rates of groundwater advection (if any)
 - Based on site-specific measurement, groundwater flow may be, but often is not, a large risk to caps, because ...
 - Higher flow rates tend to be in limited areas & to occur for limited time periods and can be predicted by models
 - Most sediment contaminants are hydrophobic
 - Engineering solutions for high flow areas are available
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Capping Misperception

MISPERCEPTION

- You can't cap in rivers

FACT

- It depends where you are in the river
 - Some river areas may be better suited to capping, such as:
 - Outside of main channels
 - Slower flowing channels & back-waters
 - Reaches with sufficient depth for flood control and navigation after capping
 - However, many river conditions (including reaches with higher flows) can be addressed with design/engineering solutions
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Case Study: St. Paul Waterway, WA

- Project
 - Early capping project - 1988
 - 17 acres capped in situ plus habitat enhancement
 - Contaminants
 - phenols, PAHs, Cu, dioxins, furans
 - Project Goals
 - Maintain integrity of the cap
 - Chemically stable
 - Biological recovery within 2 yrs of completion of cap
 - Results
 - 10 yrs of intensive monitoring showed:
 - No chemical migration through cap
 - No contaminants in the surficial layer of cap
 - Rapid recolonization of cap by benthic and epibenthic organisms and macrophytes
 - Communities indistinguishable from reference area communities
 - Lessons Learned
 - As an added benefit to the cap's demonstrated long-term reduction of risk, it provided intertidal habitat in industrial bay
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Capping Advantages

- ❑ Can achieve greater risk reduction more quickly (almost immediately)
 - ❑ Creates less short-term risk and fewer quality of life issues
 - ❑ Can be implemented quicker and at less cost
 - ❑ Requires much less space for staging, handling, and treatment of sediment
 - ❑ Can facilitate habitat restoration by using an eco-friendly surface layer
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Limitations Of Capping

- Sediments remain in the aquatic environment, but isolated by an engineered barrier
 - Water depths reduced
 - Must evaluate if subject to episodic storms, floods, etc.
 - Long term monitoring/maintenance required
 - Institutional controls may be required
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Elements Potentially Continuing Or Increasing Risk - Capping

- ❑ Contaminant releases during capping
 - ❑ Continued exposure to contaminants currently in the food chain
 - ❑ Community impacts (e.g., accidents, noise, residential and/or commercial disruption)
 - ❑ Worker risk during transport of cap materials and cap placement
 - ❑ Potential contaminant movement through cap
 - ❑ Disruption of benthic community
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Conditions Especially Conducive To Capping

- ❑ Sediment has sufficient strength to support cap (e.g., has high density/low water content)
- ❑ Rate of contaminant flux through cap is not likely to create unacceptable risk or can be accommodated in cap design

Note: Not all of the listed conditions must be present to select capping.

Conditions Especially Conducive To Capping

- ❑ Anticipated or existing infrastructure needs (e.g., piers, pilings, buried cables) are compatible with cap
- ❑ Water depth is adequate to accommodate cap with anticipated uses (e.g., navigation, flood control) or surcharge capping can be used to maintain adequate water depth
- ❑ Suitable types and quantities of cap material are available

Note: Not all of the listed conditions must be present to select capping.

Conditions Especially Conducive To Capping

- ❑ Long-term risk reduction outweighs habitat disruption and/or habitat improvements are provided by the cap
- ❑ Hydrodynamic conditions (e.g., floods, ice scour) are not likely to compromise cap or can be accommodated in design
- ❑ Rate of ground water flow in cap area is not likely to create unacceptable contaminant releases
- ❑ Incidence of cap-disrupting human behavior, such as large boat anchoring, is low or controllable

Note: Not all of the listed conditions must be present to select capping.

Monitored Natural Recovery



MNR Misperception

MISPERCEPTION

- MNR is a “do nothing” remedy

FACT

- Selection of MNR as a remedy recognizes that:
 - Risk is unacceptable
 - Natural processes are the best alternative for reducing risk in this area
 - Resources should be expended to monitor it
 - MNR decisions should include a risk-based remediation goal for sediment and an estimated time-frame for achieving it
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MNR Misperception

MISPERCEPTION

- We don't need MNR; if risk from sediment is unacceptable, we should address it with an active remedy

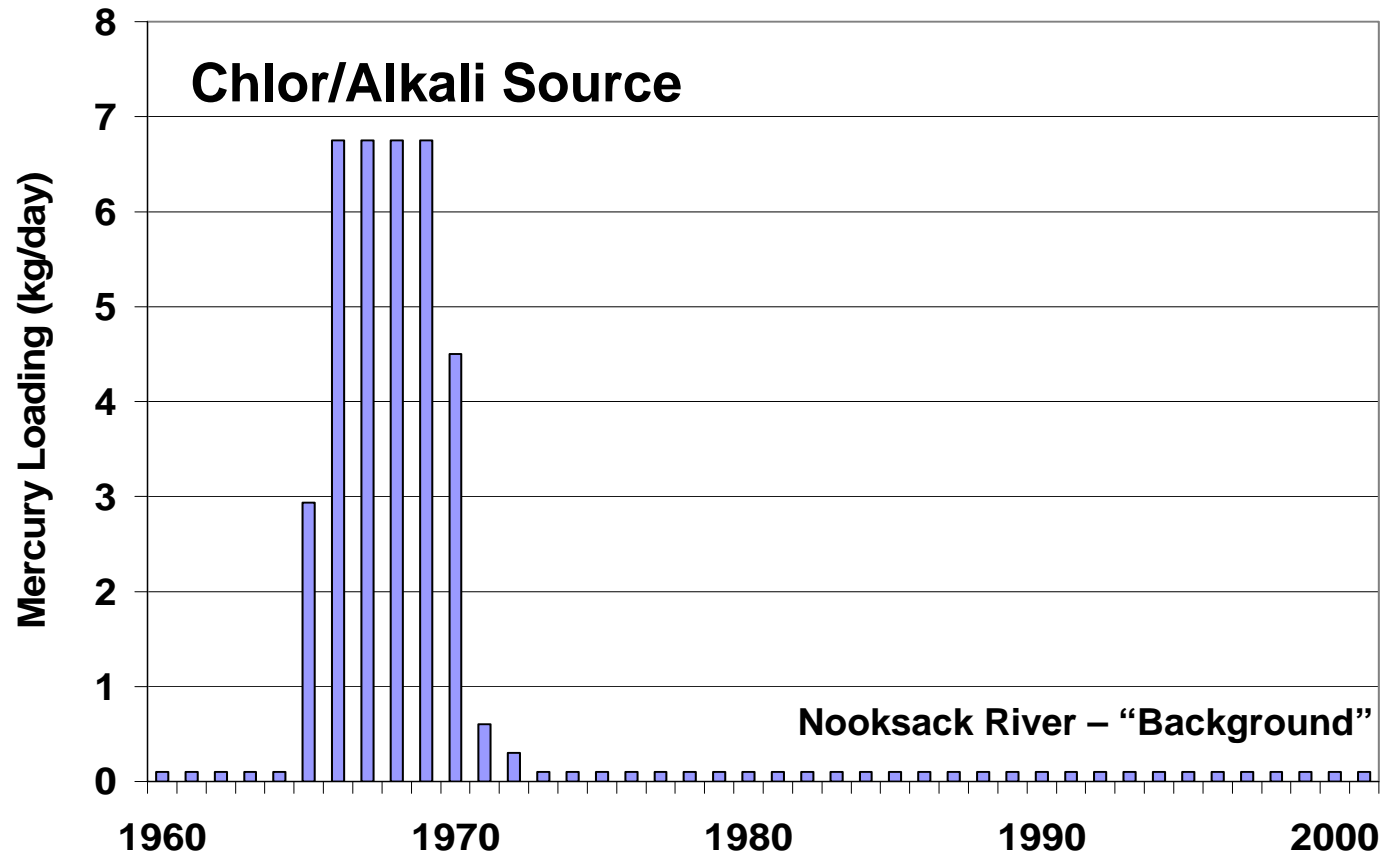
FACT

- EPA policy is to consider MNR on a equal footing with dredging and capping
 - Where natural processes are working at an acceptable rate, MNR may be the best use of resources and is less disruptive
 - Site-specific conditions may make dredging or capping very difficult or unlikely to materially speed up risk reduction
 - For large areas of relatively low contamination, dredging or capping may not be cost-effective
 - MNR may be needed to reach low risk-based sediment remediation goals even in areas where you dredge or cap
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Bellingham Bay, WA

- Project
 - Chronic toxicity to benthic invertebrates from Hg in sediment (source: chlor-alkali plant)
 - MNR following source control (partial source control – 1971; complete source control – 1979)
 - Contaminants
 - Mercury
 - Project Goals
 - Cleanup level: 1.2 mg/kg
 - Results
 - After source control, Hg reduced to near or below target cleanup level
 - Toxicity to benthic invertebrates significantly reduced
 - Lessons Learned
 - Source control is a crucial first step to achieving project goals
 - Natural recovery is functioning well
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Bellingham Bay: Mercury Release and Source Control



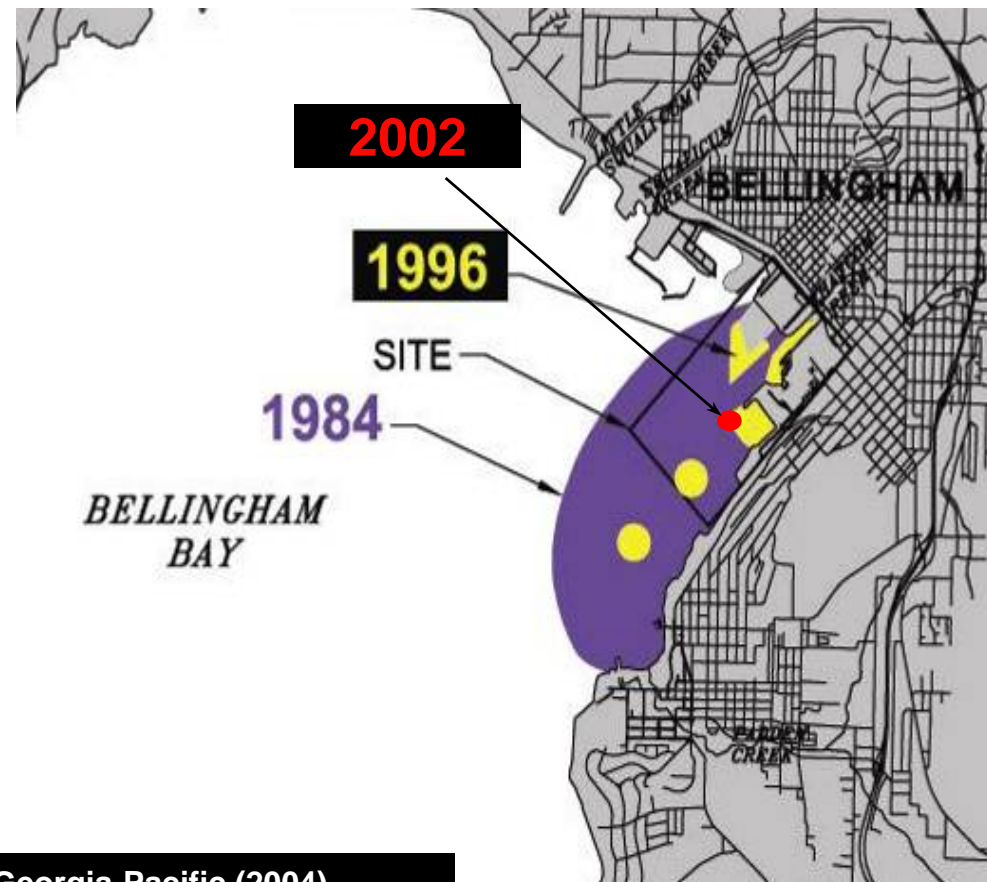
Data Source: Georgia-Pacific (2004)

Bellingham Bay Natural Recovery

Biological Endpoint: Sediment Toxicity

Toxicity tests:

- Amphipod: toxicity
- Larval: acute toxicity & abnormality
- Polychaete: chronic toxicity & growth



Data Source: Georgia-Pacific (2004)

MNR Advantages

- ❑ MNR is the least invasive sediment remedy, and allows the existing eco-system to remain in place
 - ❑ MNR avoids the disruption to the use of the waterbody, to the surrounding neighborhood and roads, avoids the need for large staging and storage areas, and, in the case of dredging, avoids the need for large treatment areas
 - ❑ MNR is less costly than dredging and capping (although long-term monitoring costs can be costly as well)
 - ❑ MNR avoids the need to transport contaminated sediment or capping materials through the neighboring community and beyond
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Limitations Of Monitored Natural Recovery

- ❑ Leaves contaminants in place
 - ❑ Time to reduce risks may be longer compared to other remedies, although when realistic timeframes for dredging or capping design and implementation are considered, this time difference may not be significant
 - ❑ Long-term liability
 - ❑ Uncertainty
 - ❑ Potential disruption of natural recovery by external events
 - ❑ Future natural recovery processes and rates may not be similar to historical natural recovery processes and rates
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Elements Potentially Continuing Or Increasing Risk - MNR

- Continued exposure to contaminants present at sediment surface and in food chain
 - Potential for undesirable changes in the site's natural processes (e.g., lower sedimentation rate)
 - Potential for contaminant exposure due to erosion or human disturbance
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Conditions Especially Conducive To MNR

- Anticipated land uses compatible with MNR
- Anticipated water body uses compatible with MNR
- Contaminant concentrations in biota and in the biologically active zone of sediment are moving towards risk-based goals

Note: Not all of the listed conditions must be present to select MNR.

Conditions Especially Conducive To MNR

- ❑ Natural recovery reasonably anticipated to reduce risk within an acceptable time frame
- ❑ Current human exposure is low or can reasonably be controlled by institutional controls
- ❑ Site includes sensitive or unique habitats that could be irreversibly damaged by capping or dredging
- ❑ Sediment deposition is occurring in areas of contamination
- ❑ Hydrodynamic conditions are not likely to compromise natural recovery

Note: Not all of the listed conditions must be present to select MNR.

Take Home Messages

Take Home Message - Dredging

- Dredging can be an effective remedy if conditions are conducive (e.g., low debris or underlain by clean sediment – overdredging is feasible)
 - Dredging also has limitations, particularly at sites with debris, rock and hardpan
 - Debris, rocks and hard pan significantly affect residuals and decrease the risk reduction potential of this remedy
 - All dredges require skilled operators, but:
 - All dredges re-suspend sediment
 - All dredges leave residuals
 - Dredging alone is unlikely to be effective in achieving both short-term and long-term cleanup levels at many sites that exhibit conditions unfavorable for dredging
 - Is a highly complex and costly integrated train of processes (e.g., removal, transport, rehandling, treatment, disposal)
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Take Home Message - Capping

- Capping has been successfully implemented at a number of Superfund sites and its advantages and limitations are better understood
 - Can be an effective remedy
 - Capping provides immediate exposure control
 - Conventional sand caps are easy to implement
 - Caps have been placed as the final remedy or pilot at over 100 sites worldwide (www.sediments.org/capping-chart.html)
 - Methods are available to address key cap design issues (e.g., erosion control, bioturbation, contaminant flux, etc.)
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Take Home Message - MNR

- ❑ Can be an effective remedy either as a stand alone remedy or as part of a combination remedy
 - ❑ Can provide long-term exposure control
 - ❑ Can be integrated with other remedies: MNR is a component of virtually every remedy
 - ❑ Monitoring is an integral component of MNR to reduce long-term uncertainty
 - ❑ Enhanced MNR also may be used to reduce uncertainty
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For Further Info ...

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