Monitored Natural Recovery at Contaminated Sediment Sites in Canada and the U.S.

Victor S. Magar and Karen Merritt (ENVIRON International Corporation)
Roger Santiago and Janette Anderson (Environment Canada)





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Why Monitored Natural Recovery (MoNR)?

- Minimize ecological impacts associated with remedy implementation
- Cost-effectively reduce risk by incorporating natural processes into remedy decision making
- MoNR should be considered among the full range of risk management alternative for sediment sites
- The impulse to remove contaminated sediments from the environment does not always reflect proper environmental stewardship and risk management

MoNR Definitions

Monitored Natural Recovery involves *leaving contaminated sediment in place* and allowing ongoing aquatic, sedimentary, and biological processes to reduce the bioavailability of the contaminants in order to *protect receptors*

NRC, 1997. *Contaminated Sediments in Ports and Waterways*

[MoNR] uses known, ongoing, naturally occurring processes to contain, destroy, or otherwise *reduce the bioavailability or toxicity of contaminants* in sediment.

[MoNR] includes…monitoring to assess whether risk is being reduced as expected.

USEPA, 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*

2005 *EPA Guidance*

MoNR Processes

- Contaminant **transformation** to a less toxic form
- Reduced contaminant **mobility/bioavailability**
- Reduced **exposure** at the **sediment surface** (e.g., burial)
- Contaminant release and off-site transport

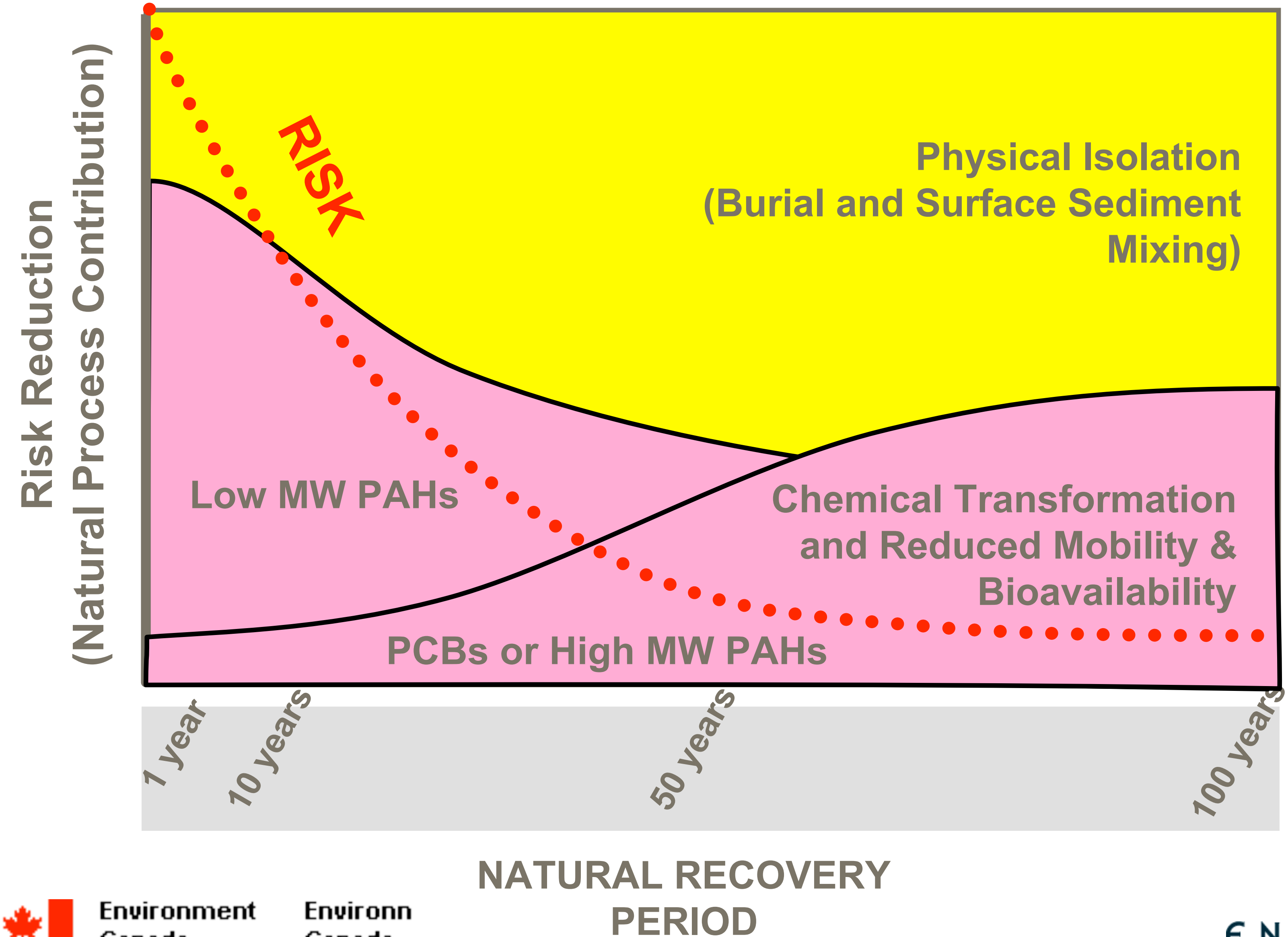
MoNR Principles

- No presumed remedy
- Implement source control
- Combine MoNR with source control and other remedies
- MoNR can be effective and permanent
- Comprehensive monitoring before & after implementation

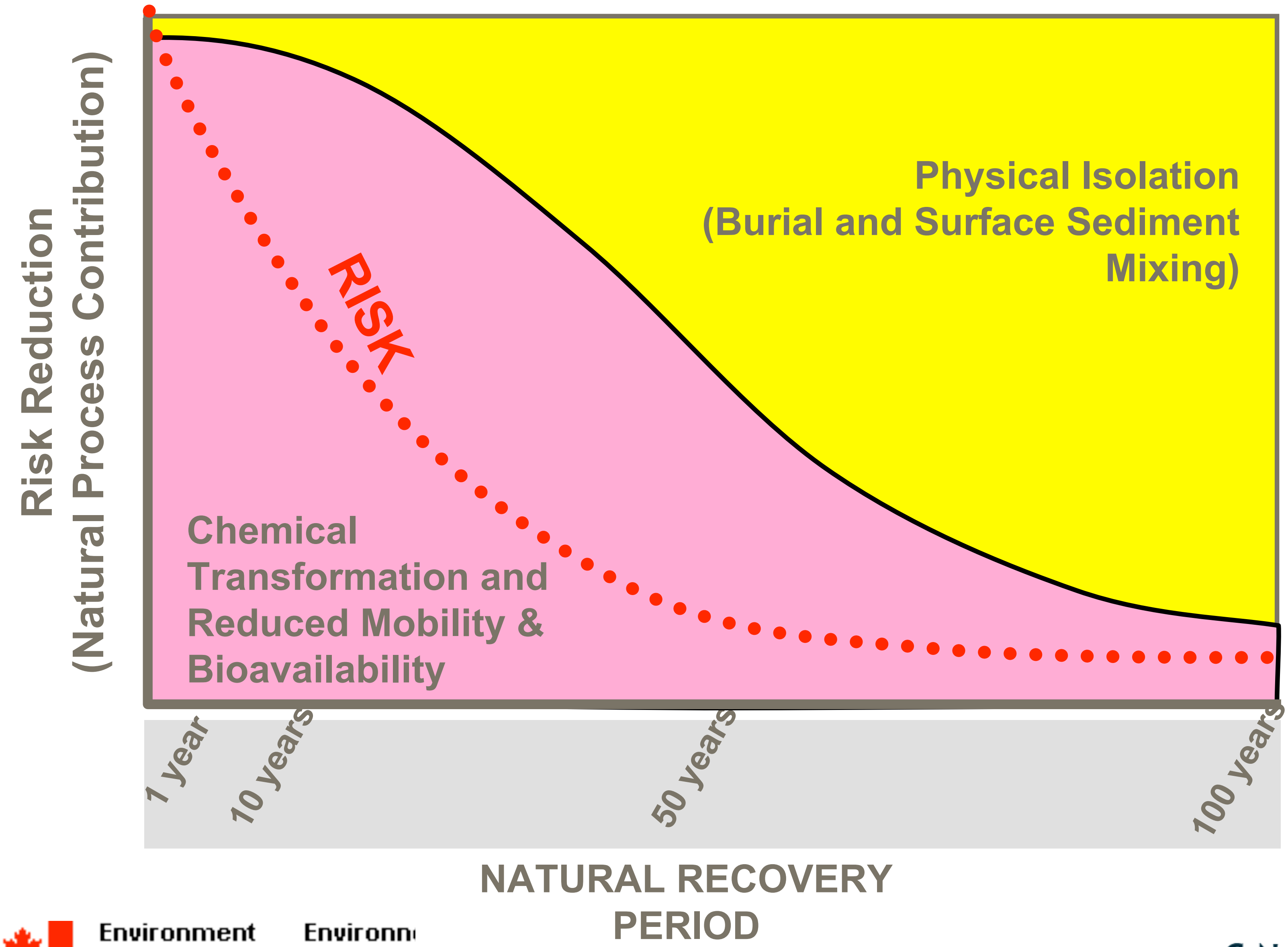
Primary Lines of Evidence Supporting an MoNR Assessment

- Demonstrate acceptable baseline risk conditions
- Identify (and quantify) trends toward reduced chemical exposures and reduced risk
- Characterize long-term remedy stability (e.g., remedy effectiveness)
  - Physical stability
  - Geochemical stability
  - Long-term ecological stability and integrity

Example: Organic Compounds



Example: Metals



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MoNR Case Studies

- Hackensack River, New Jersey, USA
- Ketchikan Pulp Company, Alaska, USA
- Cornwall, St. Lawrence River, Ontario, Canada

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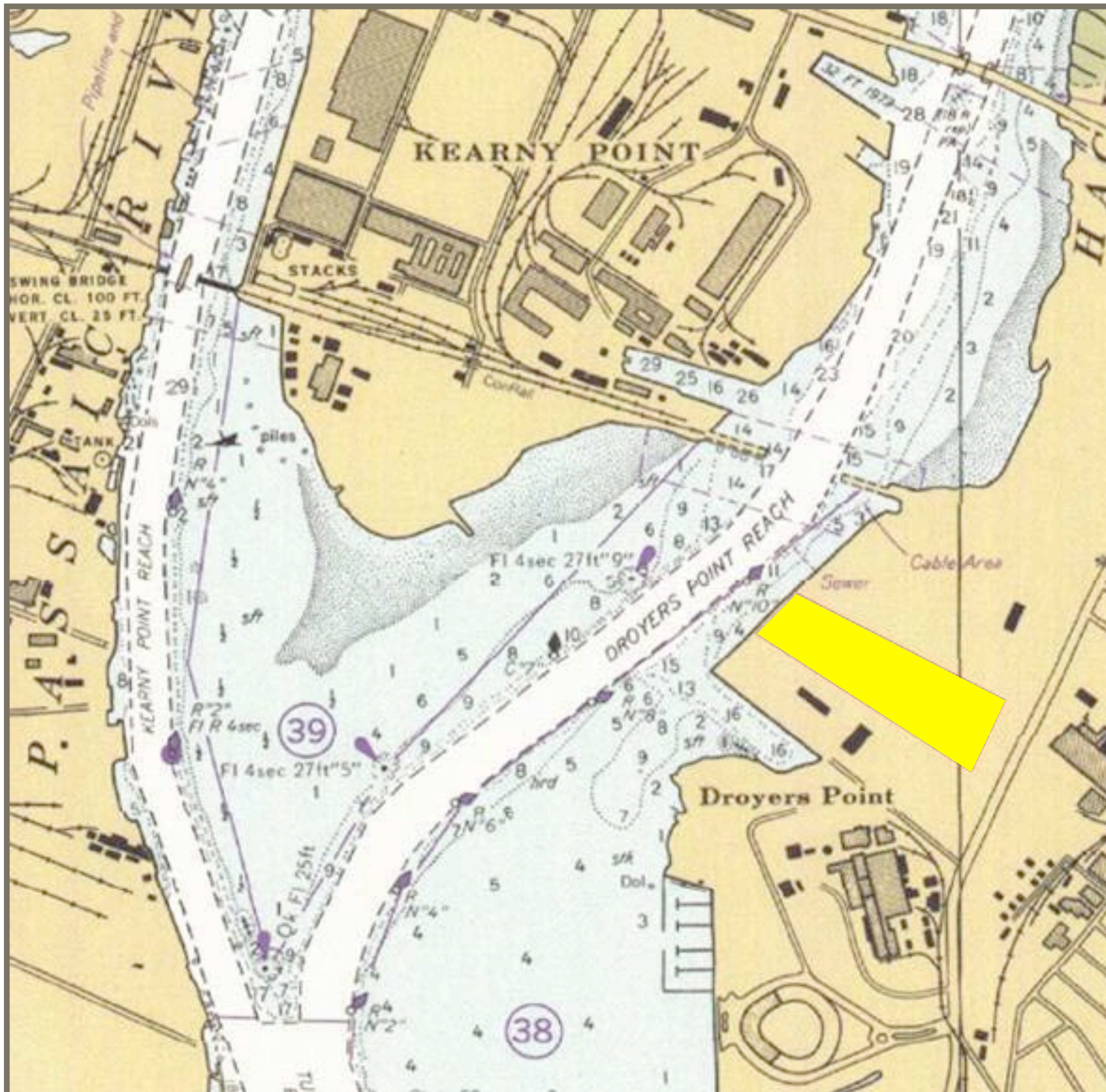
1. Lower Hackensack River Case Study

- Chromium in sediment
- MoNR contributed to the overall remedy
- Primary MoNR processes
  - Chromium geochemistry
  - Sediment burial



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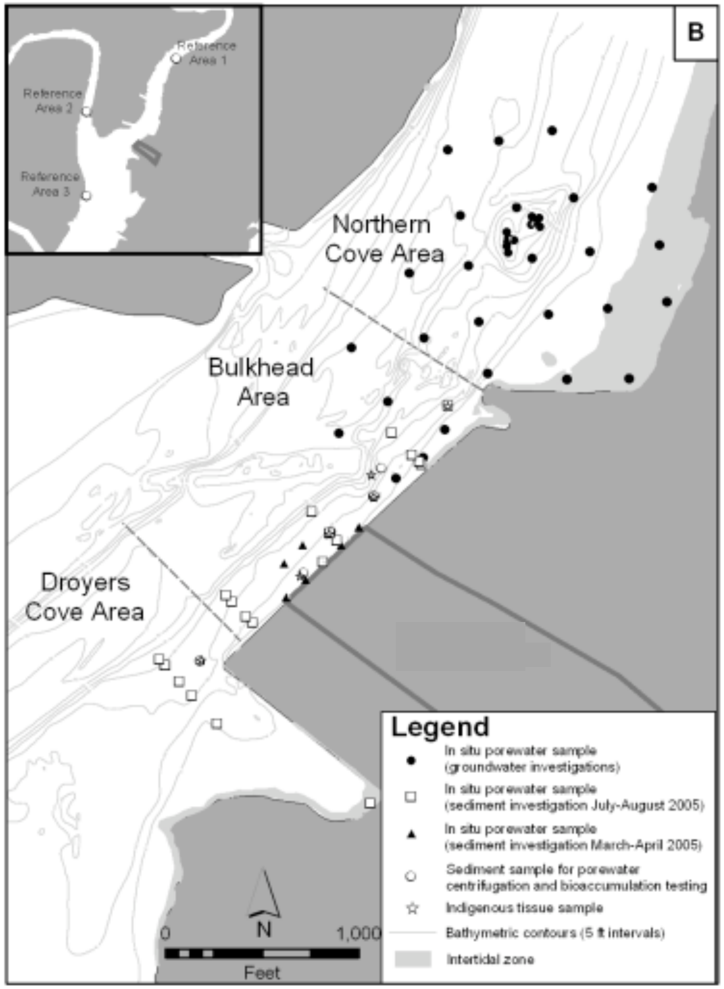
Hackensack River Case Study: Sediment Pore Water Sampling



Cr(VI) + Sulfide (AVS) + TOC + Iron → Cr(III)

- Cr(VI) is transformed to Cr(III) under reducing conditions
- Cr(III) is relatively insoluble, thermodynamically stable, and is the dominant species in sediment
- Cr(III) exhibits very low mobility and toxicity

- Cr(VI) was ND in 100 porewater samples
- Oxidation tests showed no Cr(III) to Cr(VI) conversion

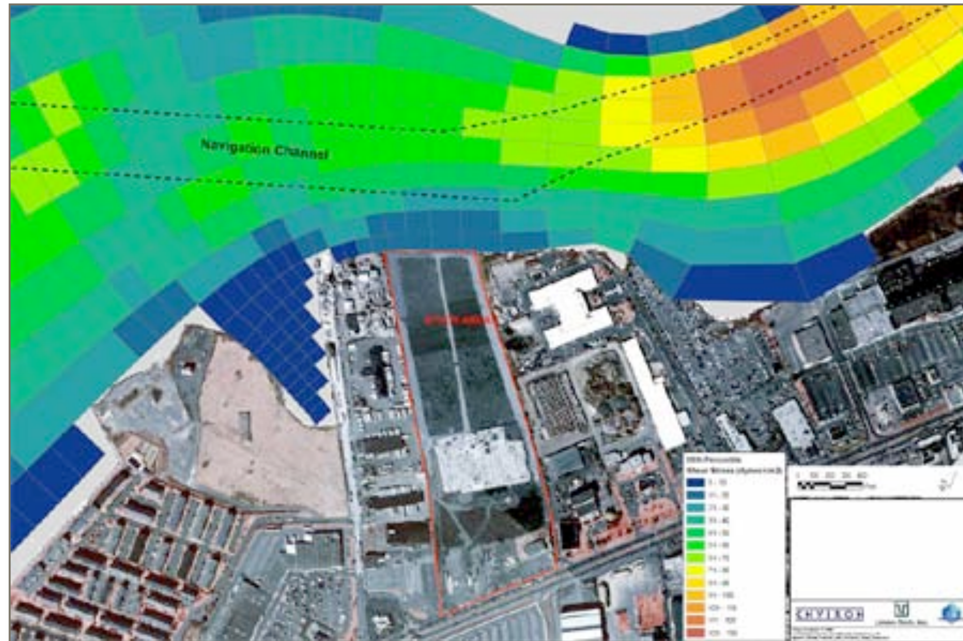
Martello, L., et al. 2007. *J. Arch Environ. Contam. Toxicol.* 53(3):337-350.

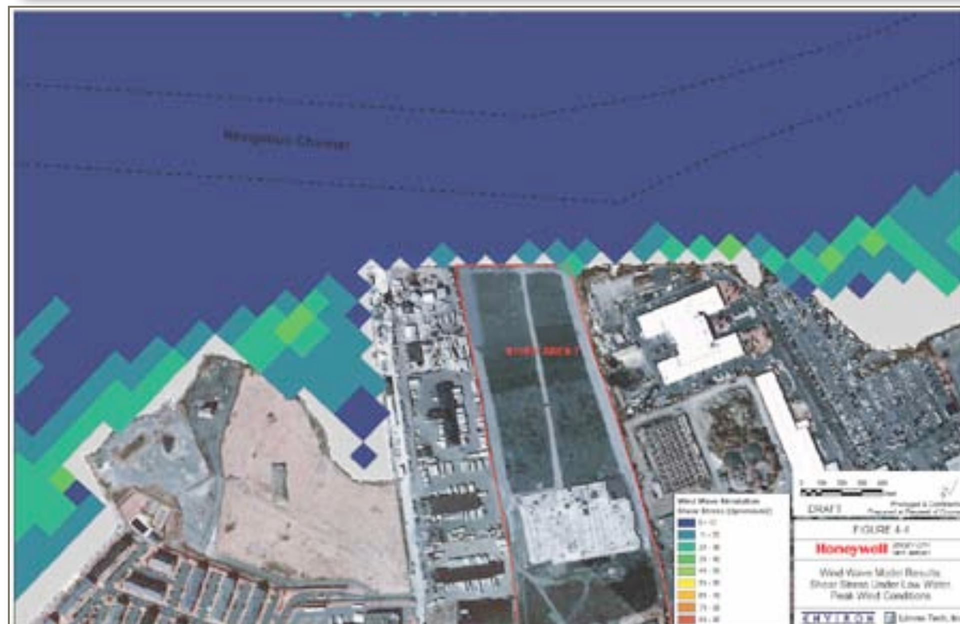
2000

Depth (ft)

Cs-137
Total Cr

Substantial recovery and stability





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2. Ketchikan Pulp Case Study

- 80 Acre AOC, located along the shoreline of Ward Cove (Ketchikan, Alaska, USA)
- Source: degradation of organic-rich pulping by-product
  - Anaerobic conditions
  - Ammonia production
  - 4-methylphenol
- Remedial action: October 2000 and February 2001
  - MoNR was used for 52 acres of the AOC
  - eMoNR (thin-layer cap) was implemented for remaining 28 acres (6−12 inches of clean sand)
  - Dredging of approximately 10,000 cubic yards (cy)

Ketchikan Pulp Company Site

COC	Area	Station	Concentration (mg/kg) 1996-1997	Concentration (mg/kg) 2004
4-Methylphenol	MNR Shallow	No. 38	8.3	4.1
		No. 47	1.8	0.085
	MNR Mod/Deep	No. 13	1.7	0.52
		No. 6	8.3	18
	Thin Layer Placement	All	1.1 - 16	0.004 - 0.11
Ammonia	Shallow	No. 38	260	54
		No. 47	120	6.7
	Mod/Deep	No. 6	360	110
		No. 13	280	110
	Thin Layer Placement	All	57 - 300	1.4 - 5.6

Ketchikan Pulp Company Site

Area	Summary: Amphipod % Survival
MNR Shallow-Thin Organic Deposits	• >90% all stations (2004) • Station 47: 73% (1996), 100% (2004)
MNR Shallow-Thick Organic Deposits	• Range 20-100% (2004) • Station 38: 0% (1997), 89% (2004)
MNR Mod/Deep	• ≤60% except 2 stations • Station 13: 36% (1996), 15% (1997); 46% (2004)
Thin Layer Placement	• ≥80% all stations (2004) • Station 8: 43% (1996); 99% (2004) • Station 9: 54% (1996); 91% (2004)

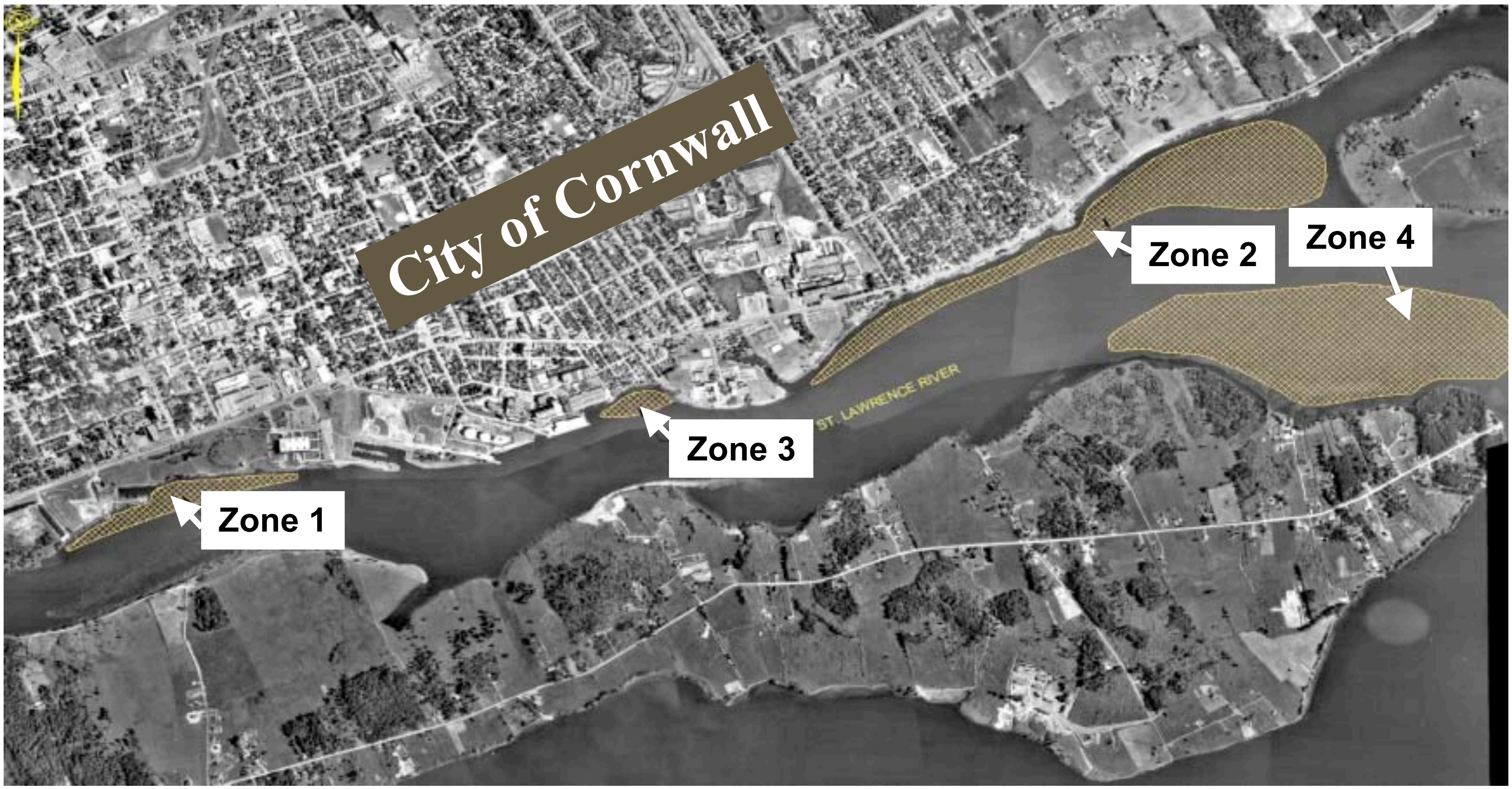
3. Cornwall Sediment Management Strategy

→ Scientific Findings

- Mercury is the main contaminant of concern in sediments
- Surface sediment mercury levels are much lower than in deeper sediment
- Low concern with regard to sediment toxicity to fish and sediment-dwelling organisms
- Low concern with regard to accumulation of sediment mercury into the food chain
- Sediments are stable

Sediment Management Strategy

- Leave the sediment in place for Zones 1, 2, 3
- No action required for Zone 4



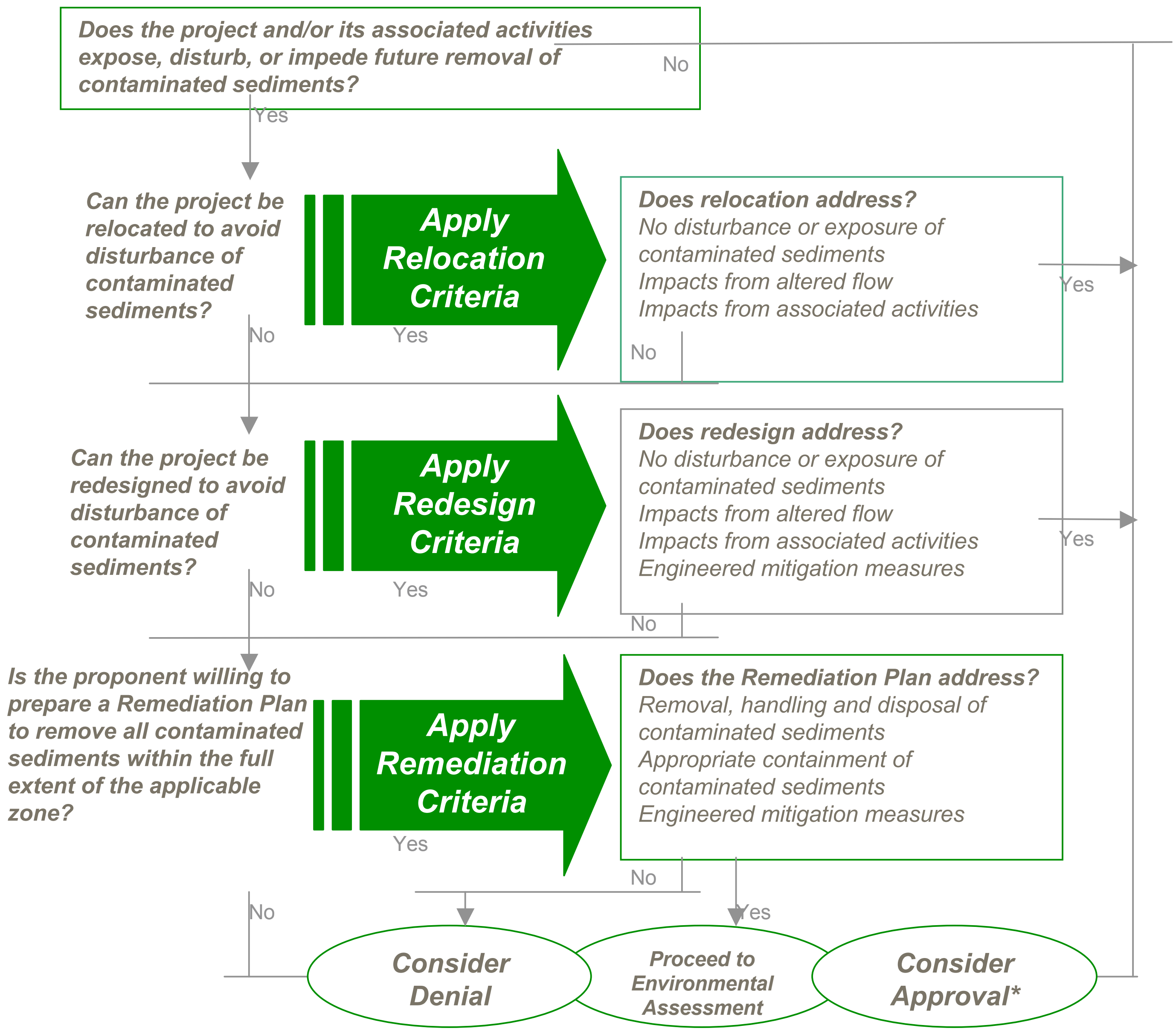
Administrative Controls

- Applied to protect sediment from disturbance
- Ensures integration of permitting, approval and planning processes of seven participating agencies
- Objectives
  - Common administrative approach
  - Accord and Protocol to harmonize processes of all levels of government
  - Establish common decision principles
  - Clear roles and responsibilities
  - No wrong point of contact
  - Collective commitment to long-term public education and awareness

Guiding Principles

- ***Prevent Disturbance*** – no disturbance, exposure or re-suspension of contaminated sediments
- ***Apply Design Criteria*** – projects assessed based upon design criteria: Relocate, Redesign and Remediate.
- ***No Impediment to Future Removal*** – No development or activity may impede the future removal of contaminated sediments.
- ***Remediate Full Extent of Zone*** – Projects that cannot be relocated or redesigned must have a remediation plan
- ***Proponent is Responsible for Costs*** – proponent is responsible for all costs (engineering, removal, handling and disposal)

Decision Process



* Pending consideration of all appropriate legislation

Successful Environmental Assessment

- Rigorous source characterization
- Characterize sedimentation processes (e.g., deposition)
- Understand hydrodynamics
- Characterize contaminant transformation processes
- Understand biological and human health effects
- Quantify ecological and human health risk
- Quantify sediment scour potential / bed stability
- Characterize chemical / geochemical stability
- Characterize ecological integrity

Recipe for MoNR Success

- Recognize that natural processes are **always** ongoing
- Maximize MoNR to **reduce negative impacts** of more aggressive remedies
- **Integrate** MoNR with other remedies
- Monitor to **reduce uncertainty**

Questions

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