Integrated Approaches to Sustainable Sediment Management

The Paradox of Having it All

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NORDROCS 2012
4\textsuperscript{th} Joint Nordic Meeting on Remediation of Contaminated Sites
18-21 September 2012 – Oslo, Norway
Global Sediment Management Challenges

- Changes in Ocean Placement Criteria
- CDFs/CADs are nearing capacity
  - Difficulty siting / re-siting (including public opposition)
  - Loss of benthic habitat / mitigation - Natural Resource Damage Assessment
  - Long-term liability
  - Costs not including climate change adaptation / long-term monitoring
- Dredge – Dewater – Haul (> distances) – Landfill
  - Cost prohibitive
  - Paradox to Green Remediation / Sustainability
  - Long-term liability
- Integrating hybrid solutions

Moving demonstrations to commercial applications

- Competing regulatory programs
• Protective of human and ecological health
• Use in multi-environments (ocean, estuarine, lakes, fjords, urban)
• Socially and politically acceptable
  – Stakeholder buy-in
• Education and public outreach
• **No re-contamination (source control)**
• Compliance and reduced liability
• Sustainability and restoration is a part of the outcome
  ➢ Long-term monitoring consideration of the remedy?
  ➢ **Complete project before I’m 90**
  ➢ Component of a Regional Sediment Management Program
    ➢ *Transferable to other Norwegian harbors and Ports*
• Least cost / economically efficient (public, gov’t, businesses)
• Who Pays?

What is the desired outcome in a perfect sediment world?
Afghanistan Stability / COIN Dynamics

Application to Sediment Management (over the years)
Programs in United States that Addresses Sediments:

- US Commission on Ocean Policy
  - (USACE/USEPA) - Regional Sediment Management - *Policy*
  - USACE Dredged Material - *Navigation*
    - HTRW / Sec. 312b environmental dredging (USACE)
  - USEPA Superfund
    - Aquatic brownfields (weak link / economic development)
    - Urban Rivers Restoration Initiative (old) – sediments [*YES*]
      - Urban Waters (new) – sediments [*NO*]
  - Water Programs (USEPA)
    - Stormwater, CSOs, TMDLs – source control
    - National Estuary Program
    - Dredged Material
  - RCRA / Solid Waste
  - Enforcement Programs
  - US Geological Survey
  - US Department of Agriculture
Having the Heretical Debate
Sediment Management

- **Rethinking Risk Assessment / Policy**
- **Sustainable Approaches**
  - Design (early decision making)
    - Socio-economic-political-structural (defining risk)
  - Beneficial use
- **Life Cycle - MCDA Analysis**
- **Technology (driver)**
  - Innovation
- **Cost-Share Models**

*Policy-makers will have to face up to making some hard choices and perhaps accepting slightly lower levels of perceived protection to the public* — J. Waters

Contaminated Land Bulletin – July 2010
Why do we care?

- Complicated media and environmental management of the system [watershed] + **Source Control**
  - Innovation / Integration – hybrid approaches

• What is different?
  - Costs for remediation can be prohibitive
  - **Timelines to remediation can be years/decades**
  - Green Remediation/Sustainability
  - Sustainable Sediment Management
  - Climate Change Adaptation
  - Regional Sediment Management
  - **Who Pays? / long-term liability**
• Need to balance remedial project cost with:
  ❖ risk/environmental protection
  ❖ liability
  ❖ sustainability (green remediation?)
  ❖ regulatory and public/political challenges
  ❖ depth (maturity) of technology development, and
  ❖ long-term management of the system

• Innovation

• Can you have it all?
  – I don’t think so….well maybe….. not really sure…..
  – There is no one paradigm / process / technology….  
    ❑ Integrated approaches to sediment management 
    ❑ Regional Systems Approach – transferable?
Sediment Management Decision Making: Simple

- Increasing Concentration
- Increasing Hazard
- Decreasing Management Options
- Increasing Cost of Management

Preindustrial Zone
- SQV: Background
- Assessment Tool Depends on Situation

Judgment Zone

Hazardous Waste Zone
- SQV: RCRA
Passaic River, NJ Proposed Cleanup Phase 1 Public Meeting – 2 Dec. 2008
Program Commonality
Observation:

- Urban Rivers Restoration / Waters (New)
- Containment
- Navigation Restoration Planning
- Urban Watershed RSM
- Water Programs Watershed/Basin Management Pollution Prevention
- National Estuary Program
- Source Control
- Supercfund (remediation)
- Brownfields

(Stern, 2009)
This stuff keeps me up at night..............

Stern at 0300
Applications to Regional Urban Sediment Management

The paradox of having it all
Integrated Approach to Sediment Management

Source / Site Assessment and Control

Risk Management

Sustainability

Watershed Management Integration

Pollution Prevention

Green Remediation

Climate Change Adaptation

Sustainable Upland Development

Innovative Remediation & Disposition
The Perfect Storm: 2012 - 2022
Remediation / Restoration +
USACE Navigation dredging with placement (non-ocean placement material)

Regional (Urban) Sediment Management

NY/NJ Watershed: The R [urban] SM Perfect Storm

- Gowanus Canal
- Jamaica Bay
- Port Newark
- JFK
- Hudson River
- Jamaica Bay
- Newtown Creek
- Passaic
- Hackensack
- Berries Creek
- East River
- Manhattan
- Brooklyn
- Staten Island

USACE O&M Nav Material Start-up in 2014
Superfund
Passaic, Gowanus, Newtown Navigation / Dredged Material

Regional Processing Facility

Renewable Storage

CDF/CAD Compartment cells

(1) Dewatering / Stabilization - Landfill (Haz/non-H)

(2) Treatment / Beneficial Use

Regional Sediment Management Integrated Approach
Application to Sustainable Sediment Management

Comprehensive (*Integrated*) approach for addressing the *long-term* management / conservation of sediments within a *watershed* in order to maintain current and future uses while promoting *beneficial uses* (as a resource).

To be in synch with addressing regional *Environmental, Economic, Social and Political* challenges…


(modified by Stern)
Intergenerational Equity [Sustainability] Decision Making - Restoration

• Do not make decisions that have irreversible consequences
  – Don’t get over your head…….

• Do not make decisions that could seriously threaten the resource base over the long-term
  – Don’t mess up…….

✓ Do not make decisions that could foreclose options for future generations to utilize resources
  – Don’t really, really mess up!! [sustainability]

  - Implications of long-term monitoring and site use

  - Effects of climate change adaptation (design)
Apply Integrated Management

- Environmentally efficient
- Economically affordable
- Socially acceptable
- Ensure human health and safety
- Must reduce as much as possible the environmental impacts of waste mgmt (long-term)
  - Energy consumption
  - Pollution of air, land and water and loss of amenity
  - *Take it out of the system* – *(treatment)*

- Reduce/extinguish liability

- Operate at a cost acceptable to private citizens, businesses, and government
Remediation of Sediments
Integrated System Approaches

Integrate BMPs to drive sustainable solutions to reduce long-term impacts and liability

Multi-complex contaminants – Urban Environments (TCDD, PAHs, Pb, Hg, Cr, TBT.....)

• Environmental Precision Dredging
  – Geophysical surveys – debris fields
  – Mechanical, Hydraulic

• Materials Handling (most critical step - economics)
  – Pumping slurries
  – Dewatering (passive – geotubes): mechanical (filter presses)
  – Transport / Carbon footprint consideration for LCA

• Sediment Remediation Applications:

  ✓ Capping
    – Active/Reactive Core Mats – specialized caps (Organoclay, Activated Carbon, Thin Layer Cap), Polymeric Marine Mattress
      - AquaBlok\textsuperscript{tm}, BioBlok\textsuperscript{tm} SediMite\textsuperscript{tm} (delivery systems)
  ✓ Stabilization/Solidification + (ISCO) (portland cement) + (oxidation)
    – $\text{H}_2\text{O}_2$, $\text{KMnO}_4$, $\text{NaS}_2\text{O}_8$
Confined Disposal Facility (upland & nearshore)

Confined Aquatic Disposal (aquatic)
  - Siting is becoming a challenge / aquatic real estate

Containment Islands (near capacity / expand? $$$$)

Landfills (significant transport – Carbon footprint) / liability?

Mine Reclamation

- Ex-situ / In-Situ Innovative Sediment Technologies
  - Thermal
  - Non-thermals
  - In-Situ Stabilization (cement injection) / caps

- In / Ex-Situ Bioremediation
  - Mudflats – ecosystem restoration
    - Space limitation

- Monitored Natural Attenuation/enhanced (eMNR)

INTEGRATE PHYSICAL INFRASTRUCTURE IN ALL ALTERNATIVES:
  - Climate Change
  - Hurricanes
  - Earthquakes
US Nationwide Tier 1 Sites – Probable Adverse Aquatic/Human Health Effects

8,348 sites

43% of sites surveyed

8.8 % of river reaches

Norwegian National Sediment Policy
Clean and Rich Oceans

Regional Sediment Management (Watershed Level)

Urban Sediment Management

Continuing Discharges
Stormwater Controls
Engineering Controls
BMPs

Sustainable Development (Upland)

EU Water Framework Directives
SedNET 2000

Sediment Quality
Sediment Quantity
Dredged Material Management
Ecosystem Restoration/Services
Beneficial Use

Integrated Technologies Tools (LCA/MCDA)

Stakeholders
KLIF (EPA) / Municipalities
Port Authorities
Military Installations
Academia & Research Organizations
Sediments and Society (NGI)

Contaminated Sediments
Material Management
Remediation
Restoration
Economic Development

Long – Term Implementation / Monitoring
Adaptive Management
[Urban] / Port Sediment Management

- Sustainability (long-term)

- **Eco-psychology** (Urban Sed. Mgmt.)
  - Behavioral understanding of moving forward
    - Open to Change
    - Urban – City / Port Environment
    - Leadership
    - Education (K-12) / Stakeholder Outreach
  ➢ *Different brain wiring (political) – short vs. long-term*

- **Integrated Sediment Management**
  - Hybrids – Holistic – Treatment Train Approaches
    - Multi Contaminants / Multi Media / Cultural Resources
  - Regional Sediment Management (watersheds/basins) – **SOURCE CONTROL**

- Beneficial Use
  - Un-renewable resources (economic re-development)
Competing / Integrated Uses of the Gowanus Canal, New York: Case Study
To Place on Superfund National Priority List or Not – *debate*:

- **Superfund (State to Federal lead)**
  - 10-11 years / $500M+

- **Water Resource Development Act + Superfund (NYC / Mayor Bloomberg)**
  - 6 years (cost-share)…..(Great Lakes Legacy Act Model)
    - Federal/State/City – PRPs
  - Economic Development and Revitalization
  - Source Control – Combined Sewer Overflow abatement

- (Opinion): Debate was more political – socio – economic
  - To develop or not develop…..
RSM Sediment Sustainability:

Historical – Economic Engine

Present

Linkage between sediment remediation / restoration and upland economic development

DISCONNECT

Gowanus Canal – Brooklyn, New York

TMDLs CSOs
Sponge Park – Gowanus Canal

Public open space that slows, absorbs and filters surface water runoff to remediate contaminated water, activate the private canal waterfront and revitalize the neighborhood.

Develop strategies to direct, collect and absorb excess SW runoff – phytoremediation and wetland habitat creation.
Bionautics™ Bulk and Tiering System
Sediment Management Decision Making Tools

• **Life-Cycle Assessment**

  – Evaluating total effects a product has on the environment over its entire existence (production through disposal)

    - Energy (consumption) + resource use (un-renewable resources/beneficial use)
    - Transportation (carbon footprint)
    - Final disposition (landfill, CAD, CDF, capped site)
    - Applications of beneficial use
    - Climate change adaptation
    - Habitat and ecosystem recovery/restoration
      - treatment technologies + beneficial use, CDFs/CADs, capping, landfills etc.
      » Short vs. long-term options (in it for the long-term)
Sediment Management Decision Making Tools

• **SiteWise™** Baseline LCA Assessment Tool (Battelle, Navy, USACE)/Microsoft Excel *(not applied to sediments)*
  - metrics: GHGs, energy usage, air pollutants (SO\textsubscript{x}, NO\textsubscript{x}), particulate matter, H\textsubscript{2}O usage and accident risk
    - Remedial Investigation, Remedial action construction/operations and long-term monitoring
    - Transportation/material production/equipment use/residual management

• **Multi-Criteria Decision Analysis**
  - *(USACE ERDC: Linkov, Bates / NGI: Sparrevik, Oen)*
  - Supports selection of suitable sediment remediation alternatives
    - Environmental, technical, social and economics relative to the remedy
      - Probability and sensitivity analysis (stakeholders/risk perception)
        » Critical in making decisions with imperfect information (time and $$)
Use of Innovative Sediment Management Programs and Technologies
Positioning for the Future

Regional Processing
Beneficial Use
Sustainability
Sediment Treatability Treatment
Train Development: (Ex/In-situ)

TECHNOLOGY
BLACK BOX
We can figure this out

Basic vs Applied Research
Proof of Concept
Does it Work???

FRONT END MATERIALS HANDLING
outside the box

Bench Pilot Full-scale Commercial

POST TREATED BENEFICIAL USE

Impediment to Technology Development
Ex-Situ Treatment Technologies Tested
USEPA/NJDOT Decontamination Programs (1995-2010)

✓ Sediment Washing *
✓ Thermo-Chemical Rotary Kiln *
✓ Plasma-Arc Vitrification
✓ Base-Catalyzed Decomposition
✓ Rotary Kiln - Thermal Desorption
✓ Solvent Extraction
✓ Solidification/Stabilization with Oxidation *
✓ Fluidized Bed Reactor

* Full – Commercial Scale
Ex-situ Technologies with Beneficial Use

- **Cement-Lock™ Technology*** ++F
  - Commercialized by Volcano Partners LLC
  - Thermo-chemical rotary kiln (cement and WTE)

- **BioGenesis™ Enterprises*** ++F
  - Sediment washing (soils, bricks, polymer coating)
  - Upcycle / BayCycle Aggregates * ++
    - Existing Rotary Kiln (light-weight aggregate)

- **Harbor Resource Environmental Group, Inc** *
  - Oxidation/dewatering/Stabilization (structural fill)
  - Westinghouse/The Solena Group + *
    - Plasma-arc vitrification (glass tiles / gasification – biofuels / BA)

- Full Scale F Pilot Scale *
- ERDC Review ++
Sediment Based Products

Polymer/Composite Research
BASF Corporation
SUNY Stony Brook
Brookhaven National Laboratory
USEPA Region 2/ORD

(after Stern, 2005)
Montclair State University, NJ Manufactured Soil and EcoMelt™ Sustainable Landscape Demonstration (2010)

BioGenesis Sediment Washing Process

Sand

39.3%

12.3%

5.8%

Manufactured soil compared against residential/non-residential soil criteria
Treated Manufactured Soil / Construction-grade Cement: MSU/Fall 2011

Meets NJ Residential Soil Criteria

30-40% replacement for Portland cement
To Place on Superfund National Priority List or Not – *debate:*

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Accelerating Progress at Contaminated Sediment Sites: Moving from Guidance to Practice


- Development of detailed and explicit project vision & accompanying objectives
  - Achievable short-long term goals
  - Metrics of remedy success at beginning of project
  - Dynamic – adjust

- Strategic engagement of stakeholders

- Optimization of risk reduction / risk management & remedy selection
  - Deliberate use of early action remedies (IRMs) to accelerate risk reduction (Bergen Capping Studies)
  - Systematic/sequential development of suite of actions applicable to ultimate remedy
    - Starting with Monitored Natural Recovery and adding engineering actions to meet objectives

- Incentive process that encourages and rewards risk reductions to industry
  - Don’t sue…

- Pursuit of sediment remediation projects as public-private collaborative enterprises (cost share)

  - USEPA Legacy Act
USEPA Great Lakes Legacy Act Cost Share Model

- **Goal:** Accelerate the pace of sediment remediation at Areas of Concern (AOCs)

- **Mechanism:** Use partnerships as an innovative approach to conducting sediment remediation

- **Cost Sharing:** Requires a minimum 35% non-federal cost share
  - Not been implemented anywhere outside the Great Lakes
Great Lakes Legacy Act Project Types

• Must be in U.S. Areas of Concern (AOCs) and:
  – 1) Implement a plan to remediate contaminated sediment (highest priority)
  – 2) Monitor or evaluate contaminated sediment
  – 3) Prevent further or renewed sediment contamination
  – 4) **Habitat Restoration** in conjunction with sediment remediation
USEPA Legacy Act Industry Project Cost Share (2011)

- DuPont Co.
- GenCorp Inc.
- Honeywell International Inc.
- Illinois Tool Works, Inc.
- United Technologies - BP-Husky Refining
- Cleveland Illuminating Co.
- Mallinckrodt Inc
- Millenium Inorganic Chemicals
- Ohio Power
- Olin Corp
- Occidental Chemical
- RMI Titanium Co
- Sherwin Williams
- Union Carbide

- CBS Operations (Viacom Intl)
- Elkem Metals
- Perstorp Polyols, Inc.
- Chevron USA
- Sunoco, Inc
- Pilkington North America, Inc
- Allied Waste Industries, Inc.
- Phelps Dodge (Now Freeport-McMoRan)
- Cabot Corp
- Detrex Corp
- XIK Corp
- Consumers Energy
- Varta Microbattery, Inc.
- The Mosaic Co.
Legacy Act Regional Sediment Treatment Program (example)

- Partner with GLNPO (Legacy Act) to provide non-federal cost share (65-35%)
- Dredge, decontaminate, recycle to useful products instead of placement in CDF or landfill
- **PROCESS AT CENTRAL LOCATION**
  - Standardized materials handling approach
  - Combine several projects for sediment volume throughput: Regional facilities (Lake Michigan/Erie)
  - Improved efficiencies

Sustainable reclamation of a non-renewable resource

Long Term Disposal and Placement Options
CDFs nearing capacity
Landfills?
Long-term monitoring
LEGACY?
Summary:

- [environmentalists] have become more equity conscious, and through their adoption of the sustainable growth logic of the appropriate technology movement, they have largely cast off changes of obstructionism
  - Cicin-Sain and Knecht (1998)
    - Integrated Coastal and Ocean Management

- Need to be open to new ideas – behavioral (shift)
  - Innovation grinds to a halt (no intellectual motivation) if the most desired outcomes are long-term dumps or that clean-ups continue to take decades
• Don’t believe when someone tells you “If it ain’t broken – don’t fix it” – translates globally
  – It probably is broken and you just don’t quite yet know how to fix it.. - stuck in the mud…
  – Impedes innovative technology development

Move demonstrations to full-scale/commercial applications

• Application of Regional Sediment Management
  – Integrated solutions (play nice with each other)
  – Understand / apply sustainability component
    - Integrate Life Cycle Assessment - MCDA / Sustainability / Environmental Cost Benefit of paying more in the short-term as it relates to long-term sustainable approaches

• Don’t discount sediment treatment as too expensive Technologies over a decade that have stayed in the game have advanced through bench/pilot/full-scale programs with better environmental economic data
  – This has caught up (w/in magnitude) with other alternatives (LCA)