Remediation to Restoration to Revitalization (R2R2R): Tools to Support Remedy Decisions

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US EPA Office of Research and Development
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Goal of R2R2R

Remediation to Restoration to Revitalization

To help transform remediation projects into sustainable revitalization of the surrounding community by maximizing the positive societal and environmental outcomes.
Great Lakes Areas of Concern

- Great Lakes Areas of Concern (AOC) are communities with severely impaired coastal aquatic ecosystems.
- Removing these impairments is an EPA priority under the Great Lakes Water Quality Agreement.
- Impairments include harmful algae blooms, excess nutrients and sediments, contaminated sediments, fish consumption advisories, and habitat loss.
- AOCs are communities recognized and organized by EPA that have to make decisions on how to restore beneficial uses.

“We’re committed to creating a new standard of care that will leave the Great Lakes better for the next generation.”
The $R^3$ Paradigm:
“It’s not just sediment remediation”

Remediation → Restoration → Revitalization

Courtesy M. Tuchman, S. Cieniawski
The R³ Paradigm

**R¹ Actions**
AOC: dredge, cap projects

**R¹ Outcomes**
Clean sediment, reduced fish tissue residues

**R² Actions**
AOC: habitat restoration, land-use changes

**R² Outcomes**
Increased vegetation, improved water quality

**R³ Actions**
Community: redevelopment, use, access, outreach

**R³ Benefits**
Improved human well-being (health, economic, social)

**Success Measure** (research)
- Remedy effectiveness
- Restoration effectiveness
- Revitalization progress
Why Remedy Effectiveness

• Provide decision makers with information about the outcome of the remedy (adaptive management)
• Measure risk reduction
• Improve remedy practice through time
• Communicate change to the public

Goal

Develop physical, chemical, and biological measures to determine remedy effectiveness

– Physical: bathymetry, sediment transport, particle tracking
– Chemical: chemical analyses of water and sediments, sediment core profiling, passive samplers, chemical forensics
– Biological: tissue concentration through the food web, DNA damage in fish (tumor indicator), ecological integrity, and sediment toxicity

Measure pre-, during, and post remedy
Study Area – Ottawa River
### Biological Lines of Evidence (LOE) to assess Remedy Effectiveness

<table>
<thead>
<tr>
<th>Current Practice</th>
<th>Innovative Practice</th>
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<tbody>
<tr>
<td>Fish tissue for human and wildlife consumption</td>
<td>Benthic body burden, Short lived adult fish (minnows)</td>
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<tr>
<td>Sediment toxicity and bioaccumulation testing</td>
<td>Benthic Tissue Concentrations</td>
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<tr>
<td>Benthic survey</td>
<td>Alternate and surrogate bioaccumulation measures (SPMEs, Tenax, etc.)</td>
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<td>DNA damage, “omics”</td>
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<td>Riparian indicators</td>
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<td>Bivalve uptake</td>
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<tr>
<td>OEPA Lacustrine Index of Biotic Integrity (LICIC),</td>
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<tr>
<td>Dredged and Non Dredged</td>
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#### DNA Damage in Brown Bullhead Before, During, and After Dredging

![Graph showing DNA damage](image)

**Table: DNA Damage in Brown Bullhead Before, During, and After Dredging**

<table>
<thead>
<tr>
<th>Month</th>
<th>Ashtabula</th>
<th>Conneaut</th>
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<tbody>
<tr>
<td>August 2006</td>
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<td>May 2007</td>
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<td>June 2008</td>
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<tr>
<td>June 2009</td>
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Conceptional Model for Food Web
Sediment and Sediment Toxicity Pre- vs Post-Dredge

Hyalella azteca % Survival
2009 (Pre) vs 2015 (5-yr Post) by reach

Sediment polychlorinated biphenyl compounds (PCBs) and toxicity declined post-dredging

LCL – Lower Confidence Limit, UCL – Upper Confidence Limit
Aquatic Food Web Results

Tissue ng/g Wet Wt, 2009 (Pre) vs 2013 vs 2015

PCB fillet consumption advisories converted to whole fish (1.83)
Results: DNA Damage
Tail Extent Length Comet Assay

DNA damage in Ottawa River bullheads declined 5-years post-dredge
Impact

- Remedy effectiveness is an approach to improve confidence about remedy success
  - Informs project decisions throughout process
  - Ecosystem-based: physical, chemical and biological
  - Multiple lines of evidence

- Remedy effectiveness assessment is scaled to the project
  - Reach-scale vs project-scale
  - Anticipated long-term clean up goals would be met approximately 10 years post remedy (2020)
Why Restoration Effectiveness

• Provide decision makers with information about the outcome of the restoration (adaptive management)
• Measure change in ecological health
• Improve restoration practice through time
• Communicate change to the public

Goal

Develop tools and approaches to assess habitat restoration in AOCs

– Appropriate targets
– Relevant metrics
  • Program goals
  • Ecological integrity
– Responsive at the project-scale (time, space)
– Responsive to project activities
Develop a “surgical” tool to identify and diagnose project-scale impairment

Process - St. Louis River AOC
- Choose wetland-dependent fish species (project-scale)
- Characterize reference conditions
- Determine target concentration
- Develop approach to relate sediment quality and habitat to bioaccumulation

St Louis River Area of Concern (AOC) indicating sediment remediation and assessment needs (Sept 2015)
Biota-Sediment Accumulation Factor (BSAF) model

- **Goal:** Create a geospatial model of fish tissue concentration based on sediment characterization data
- **Use BSAF model to predict fish tissue concentration**
  - BSAFs are empirically determined
  - From EPA BSAF database for Yellow Perch
- **Model surface sediment PCBs and total organic carbon**
- **Model fish home range, habitat preference**
  - Life-history
  - Habitat use

**Easy to use, publicly available database:**
BSAF Model Projected PCBs in Yellow Perch tissue

Output undergoing 2018 update. Please do not cite.
Munger Landing Assessment

• 2018: Minnesota Pollution Control Agency (MPCA) and Wisconsin Department of Natural Resources (WI DNR) requested BSAF model for St. Louis River AOC
  – Evaluation remediation alternatives
  – Support sediment quality targets, project effectiveness
• Novel approach for AOCs; initial development at multiple remediation sites
Impact

• The BSAF model successfully diagnosed problem spots (e.g., Munger Landing)
  – Not obvious from typical screening approach
  – Defines sediment risk

• BSAF model has multiple potential applications
  – Initial project screening
  – Develop an appropriate remedy target
  – Estimate a project’s potential impact to improve the quality of the fishery, risk reduction to public
  – Track progress toward target
Health Impact Assessment (HIA)
HIA is a process that uses scientific data, health expertise and public input to factor public health considerations into the decision making process

- HIAs give decision makers the information they need to consider health in pending programs, policies, plans and projects
- Conducted and communicated in advance of a decision
- Identifies and evaluates public health consequences of a pending decision
- Develops and provides recommendations intended to shape the final proposal based on health protection and health promotion
- Brings together environmental science, public health science, and social science

Health
“A state of complete physical, mental, and social well-being; not merely the absence of disease and infirmity.”

- Preamble to the Constitution of the World Health Organization
"I don't know why I don't care about the bottom of the ocean, but I don't."
Health Impact Assessment (HIA)

How does the proposed project, plan, policy, program affect determinants of health, leading to health outcomes? Provide recommendations.

Determinants of Health

- Social, Economic & Political Factors
  - Segregation
  - Inequality
  - Jobs
  - Working Environment
  - Economic Development
  - Wages & Benefits
  - Poverty
- Living & Working Conditions
  - Air, Water, & Soil Quality
  - Health Care
  - Noise
- Public Services & Infrastructure
  - Access to Food
  - Education
  - Housing
  - Parks
- Individual Behaviors
  - Exercise
  - Diet
  - Coping
- Individual Factors
  - Age
  - Gender
  - Genetics

EPA

United States Environmental Protection Agency
Health Impact Assessment

- Project: 200 acres, 350K cubic yards sediment, $14M
- Goals:
  - Remove wood waste
  - Cover contaminated sediments, restore two coastal wetland ecosystems
  - Improve amenities (board walks, trails, water access for recreation, interpretative signage)
- Decision makers
  - MN DNR: Habitat restoration
  - City of Duluth: Park improvements
HIA began with knowledge co-production

- Participatory mapping for HIA
- Engage in conversation around the restoration sites
- Used maps to capture different types of knowledge based on relationships to the river
  - Traditional
  - Professional
  - Local
  - Scientific
- Used maps and literature to identify seven health topics ("pathways") to assess
Health Pathways

Habitat Restoration Project
Kingsbury Bay and Grassy Point
(MN Department of Natural Resources)

- Noise and Light Pollution
- Water Habitat and Quality
- Air Quality
- Equipment Operation, Traffic, and Transport
- Recreation, Aesthetics, & Engagement with Nature
- Social and Cultural
- Crime and Personal Safety

Park Improvements
Kingsbury Bay and Grassy Point
(City of Duluth)
Social and Cultural Pathway

Habitat Restoration
Construction/Operations

- Δ Water Habitat/Vegetation (incl. invasive species)
- Δ Natural Areas and Green Space
- Δ Beautification/Aesthetics (Maintained)

Delta Access to Parks and Recreation at project and nearby sites (including WWFT and Indian Point Campground)

Delta Parks and Recreation Amenities at project and nearby sites (including WWFT and Indian Point Campground)

Δ Parks and Recreation Experience (due to water pollutant, air pollutant, or noise exposure) at project and nearby sites (including WWFT and Indian Point Campground)

Park Improvements
Construction Operations and Maintenance

Δ Engagement with Nature

Δ Crime and Personal Safety
Actual and Perceived (see Crime and Safety)

Δ Fauna/Flora Composition

Δ Recreation

Δ Physical Activity

Δ Chronic Disease (cardiovascular disease, hypertension, stroke, cancer, obesity)

Δ Stress and Stress-Related Conditions (poor mental health, high blood pressure, heart disease, obesity, diabetes, decreased immune response)

Δ Overall Health and Well-being

Δ Nutrition

Recreation, Aesthetics, and Engagement with Nature

1 From Water Habitat and Quality Pathway
2 From Water Habitat and Quality, Air Quality and Noise Pathways
3 From Crime and Personal Safety Pathway
Restrictions on Fish and Wildlife Consumption

(Edible) Game Fish

- Diet
- Social Economic Status
- Cultural, Recreation

Health Outcomes

Ecosystem Service

Health Determinant

Impairment
Ecosystem services are the biophysical outputs of ecosystems that directly contribute to the well-being and social welfare of humans.
Health Impact Summary

Long-term effects on health determinants from the project include:

• Improved water quality and green space
• New space for recreational opportunities, cultural value, and spiritual reflection
• Increased social cohesion
• Potential improvements in safety and security

Together, these benefits can improve a variety of health outcomes:

• Decrease risk of injury and illness
• Improve nutrition
• Reduce stress, stress-related conditions, and chronic disease
• Improve overall health and well-being
Prioritization of HIA Recommendations

- Social and Cultural: Stakeholder Votes = 8, Community Votes = 4
- Recreation, Aesthetics, and Engagement with Nature: Stakeholder Votes = 10, Community Votes = 4
- Crime and Personal Safety: Stakeholder Votes = 11, Community Votes = 8
- Noise and Light Pollution: Stakeholder Votes = 7, Community Votes = 5
- Air Quality: Stakeholder Votes = 3, Community Votes = 5
- Equipment Operation, Traffic, and Transport: Stakeholder Votes = 3, Community Votes = 5
- Water Habitat and Quality: Stakeholder Votes = 14, Community Votes = 10

Legend:
- Stakeholder Votes
- Community Votes
• Improves health-related outcomes of the project
• Provides science-based information to justify the project on the basis of health (permitting)
• Early participation in the process = input shaped the health determinants evaluated in the assessment
• Evaluation based on themes or determinants MOST important to community and stakeholders
• The result was a larger range of recommendations considered and the inclusion of voices that might normally be marginalized

www.epa.gov/healthresearch/health-impact-assessments
**Summary**

- **Remedy effectiveness** provides an ecosystem-based approach to determine remedy success
  - Informs project decisions
  - Physical, chemical, biological – multiple LOE
  - Compatible with restoration effectiveness

- **Restoration effectiveness** can help identify site-scale vs system-scale effects
  - Tailor work to the most relevant habitat impacts
  - Diagnose hotspots

- **Revitalization** is an opportunity to rethink how the community relates to its local environment
  - Health Impact Assessment supports decision makers to improve health outcomes
  - The process is designed to be equitable, just and inclusive
  - Pathways are rooted in community values
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