DAM DECOMMISSIONING WORKSHOP:
OPTIONS, OPPORTUNITIES AND CHALLENGES

Northwestern Michigan College – Great Lakes Campus, Hagerty Center
Traverse City, Michigan

April 24-25, 2006

Overview of Current Dam Decommissioning Activities

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US Army Corps of Engineers

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Current Dam Decommissioning Activities

- Talking Heads
  Remain In Light (1980)

- Cemetery headstone in a small Vermont town

The importance of making connections

Corps Environmental Activities

- 1880s and 1890s: Congress directed the Corps to prevent dumping and filling in the nation's harbors
- 1883: Congress directed Yellowstone Park improvement by the Corps of Engineers and authorized the Secretary of the Interior to call upon the Army to patrol the area (National Park Service assumed control of Yellowstone in 1918)
- 1899: Rivers and Harbors Act gave the Corps the authority to regulate most kinds of obstructions to navigation, including hazards resulting from effluents
- 1924: Oil Pollution Act authorized Corps to apprehend those who discharged oil into tidal waters
- 1983: Defense Environmental Restoration Program
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- 2002: Environmental Operating Principles

US Army Corps of Engineers

Dam Decommissioning Workshop, Traverse City MI, 24-25 April 2006

ERDC

1. Strive to achieve environmental sustainability
2. Consider environmental consequences
3. Seek balance and synergy
4. Accept responsibility
5. Mitigate impacts
6. Understand the environment
7. Respect other views

USACE Environmental Operating Principles

Strive to Achieve Environmental Sustainability. *An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.*

Consider Environmental Consequences. *Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.*

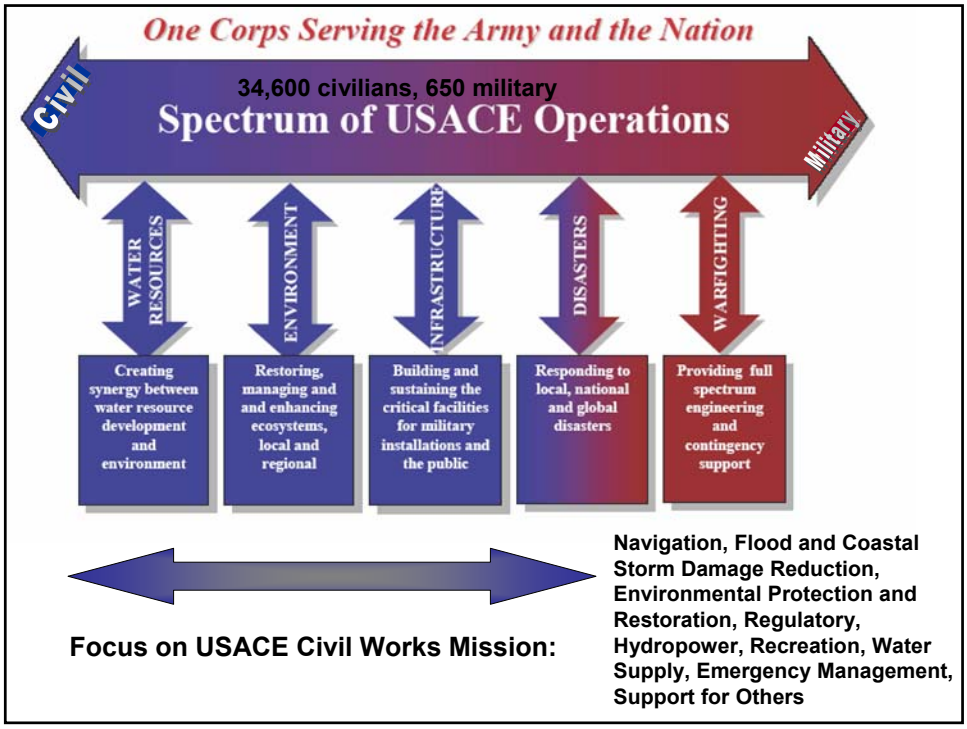
Seek Balance and Synergy *among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.*

Accept Responsibility. *Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.*

Mitigate Impacts. *Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.*

Understand the Environment. *Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.*

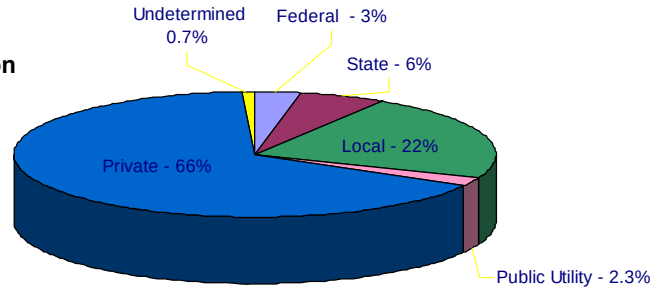
Respect Other Views. *Respect views of individuals and groups interested in Corps activities, actively listen, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems, solutions that also protect and enhance the environment.*


One Corps Serving the Army and the Nation
Civil
34,600 civilians, 650 military
Spectrum of USACE Operations
Military
WATER RESOURCES
ENVIRONMENT
INFRASTRUCTURE
DISASTERS
WARFIGHTING
Creating synergy between water resource development and environment
Restoring, managing and and enhancing ecosystems, local and regional
Building and sustaining the critical facilities for military installations and the public
Responding to local, national and global disasters
Providing full spectrum engineering and contingency support
Navigation, Flood and Coastal Storm Damage Reduction, Environmental Protection and Restoration, Regulatory, Hydropower, Recreation, Water Supply, Emergency Management, Support for Others
Focus on USACE Civil Works Mission:

Support to the Army and Nation
Civil Works Value to the Nation
Recreation areas 376 M Visitors/yr Generate $15 B in economic activity, 500,000 jobs
¼ of Nation's Hydropower: $500 M + in power sales
11,000 miles of Commercial Inland Waterways: ½ the cost of rail 1/10 the cost of trucks
299 Deep Draft Harbors
400 miles of Shore protection Destination for 75% of U.S. Vacations
627 Shallow Draft Harbors
8500 Miles of Levees
Emergency Operations
Stewardship of 11.7 Million Acres Public Lands
Environmental Restoration
Regulatory Responsibilities
• US Ports & Waterways convey > 2B Tons Commerce
• Foreign Trade alone creates > $160 B Tax Revenues

Dam Decommissioning: Background

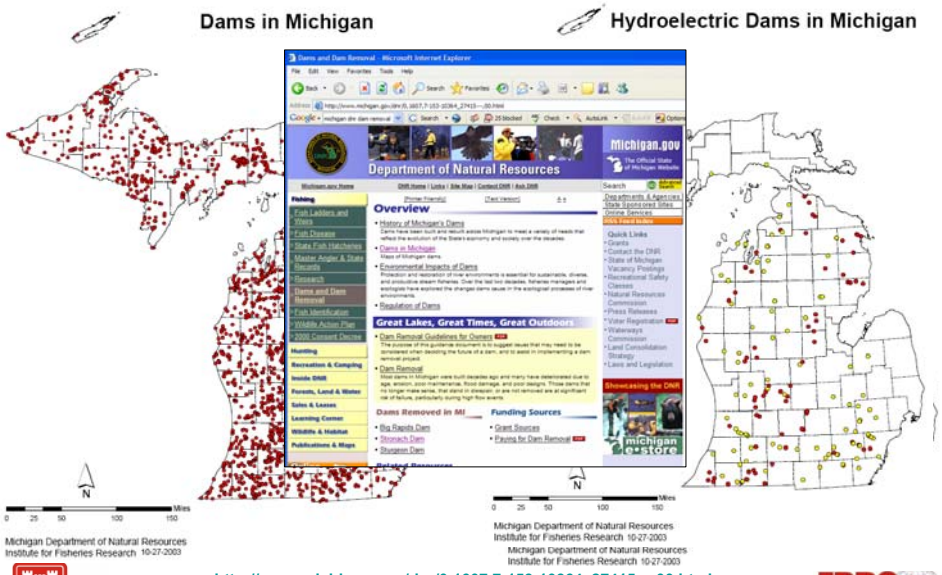
- Dam building associated with early colonization
  - Recreation (most common purpose for privately-owned dams)
  - Water supply
  - Agriculture
  - Transportation
  - Industry



- NRC estimated 2.5 million dams in 1990
- Corps lists between > 79,000 dams in National Inventory of Dams (NID) 2006 http://crunch.tec.army.mil/nid/webpages/nid.cfm
- >38,00 dams ≤ 25 ft high
- <2% ≥ 100ft high

USSD 2006: http://www.ussdams.org/ben_0303.html, ERWI 2006

From the Michigan DNR



http://www.michigan.gov/dnr/0,1607,7-153-10364_27415---,00.html

Relevant Parties and Agencies

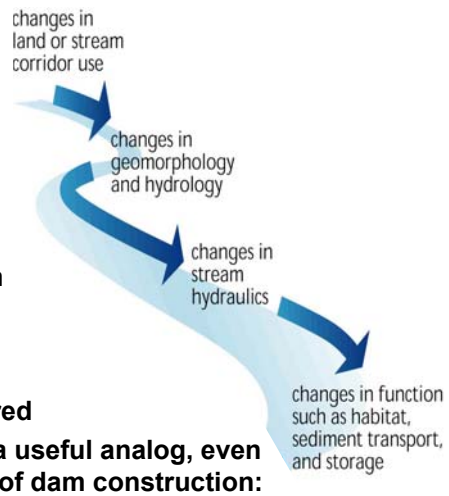
- Affected landowners
- Tribes
- Taxpayers
- State dam safety personnel
- State regulatory and wildlife management agencies
- Federal agencies
  - USACE, Reclamation, FERC, USFWS, NOAA, NRCS, BLM, National Park Service, USGS
- NGOs
  - The Nature Conservancy, Trout Unlimited, American Rivers
- Stakeholders Groups: theboardman.org THE FATE OF THE BOARDMAN RIVER DAMS

Overview and Problem Scope

- Public Health and Safety:
  - FEMA estimates 58,000 (85% of NID) large dams will exceed their design lifespan by 2020
  - ASCE reported 61 dam failures and 520 incidents, 2100 structures classified as unsafe (2001)
  - High cost to repair (plus liability)
- Ecological:
  - Failure of efforts to date to restore threatened and endangered or economically and ecologically significant species
  - alternatives to dams may now be available
- Socioeconomic
  - Community contexts and values have changed

Dam Decommissioning is a Nontrivial Issue

- Dynamic equilibrium of rivers has been significantly disrupted by cumulative impacts of
  - natural events
  - human activities
  - combined with watershed changes associated with urbanization and deforestation
- Watersheds reach some equilibrium after dam construction
- Further adjustments due to disturbances associated with dam decommissioning must be considered
- Dam construction impacts provide a useful analog, even though removal is not the opposite of dam construction:
  - some processes are reversible, others are not



Social Benefits and Costs of Dams

Benefits

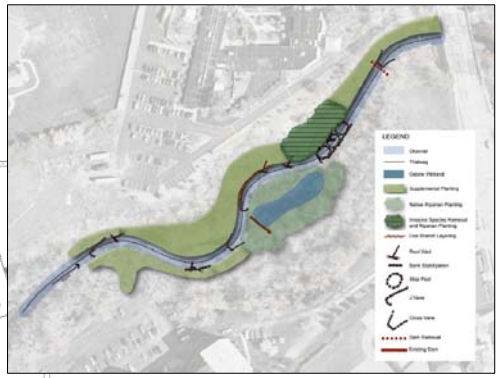
- Water quality and delivery for domestic, agricultural, and industrial uses
- Hydropower
- Navigation, including canals
- Control of flooding and ice regime
- Control of invasive populations
- Flatwater recreation
- Waste disposal and trapping
- Archeological and aesthetic values

Costs

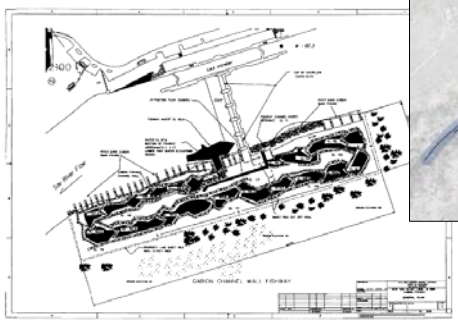
- Ecosystem impacts
- Water quality impacts
- Legal and financial liability
- Safety
- Maintenance requirements for structure, headpond, associated erosion
- Impacts on T&E populations
- Recreation associated with unregulated hydrography and ecological integrity
- Archaeological and aesthetic impacts

Decommissioning Alternatives

- **Nature-like fishways bypass dam**
  - **West Creek Preservation Committee, OH**
  - **New Savannah Bluff Lock and Dam By-Pass, Corps Savannah District**



Concept for Bypass for West Creek, OH (http://www.westcreek.org/west%20creek%20DAE%20report%204-5-06.pdf)

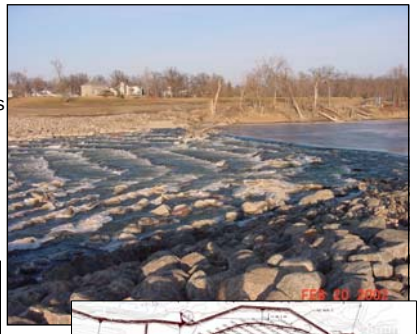


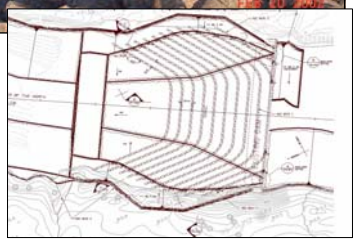
New Savannah Bluff Lock and Dam, GA ~$5.4M

Decommissioning Alternatives

- **Rock arch ramps/Boulder vanes**
  - Red River of the north, St. Paul District
  - Desired:
    - Public safety to remove rollers at base of dams
    - Fish passage
  - Constraints:
    - Water supply
    - Bank stability
    - Resistance to change

Grand Forks Riverside $4.8M

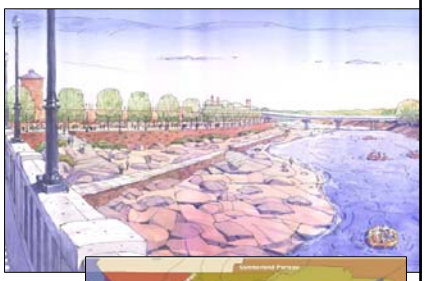


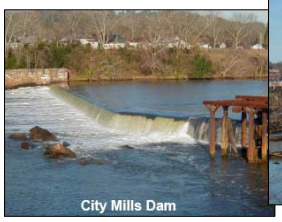


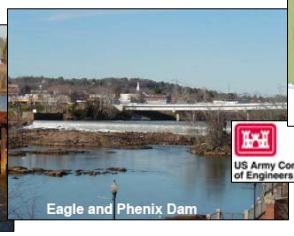
Fargo Midtown $260K

Decommissioning Alternatives

- **Partial breaching**
  - Chattahoochee River, Mobile District
  - 2 dams: Eagle & Phenix Dam,City Mills Dam
  - Desired:
    - Increase Fall Line shoal fish habitat
    - Recreation
  - Used incremental analysis to evaluate 71 alternatives
    - various increments of breaching (100-, 150-, 175-, 200-, 300-, and 400-feet)
    - complete removal of one or both dams
    - plus various combinations of rock ramps and/or backwater refuges.







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IWR PLAN
COST EFFECTIVENESS
INCREMENTAL COST ANALYSIS

Decommissioning Alternatives

- **Dam Reoperations**
  - **Restore Natural Flow Regime**
    - **Restore historic flood disturbance patterns**
    - **Can target key species which require specific flow magnitude/duration/ season**
    - **Release sediment to downstream ecosystems**
    - **Impacts to water temperature**
  - **Potential drawbacks:**
    - **Usually highest magnitude flows aren't possible**
    - **Sediment transport issues**

http://nature.org/success/dams.html

Decommissioning Alternatives

- **Dam Removal**
  - **Cited reasons for removal** (American Rivers et al., 1999)
    - **Environmental--43%**
    - **Safety--30%**
    - **Economics--18%**
    - **Failure--6%**
    - **Unauthorized structure--4%**
    - **Recreation—2%**
  - **Born et al 1998: Public safety and desire to save costs of repair usually drive removal, not restoration goals**
  - **Potential drawbacks:**
    - **Mitigation costs may be higher than removal costs**
    - **Altered hydrologic and hydraulic regime**
    - **Sediment transport issues, especially for contaminated sediments**

Table 1. Number of dams removed per state (American Rivers et al., 1999). States with less than 5 dams removed are not listed.

State	Number of dams removed
WI	73
CA	47
OH	39
PA	38
TN	26
WA	19
IL	17
CT	16
ID	13
TX	12
SD	11
KS	10
CO	9
ME	9
MI	9
MN	9
VA	9
NJ	9
VT	8
WY	8
MD	7
MT	7
NE	6
OR	5
SC	5

From Doyle et al., 2000

Dam Removals to Date (>500)

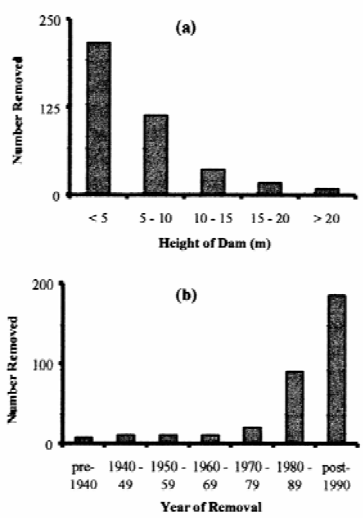
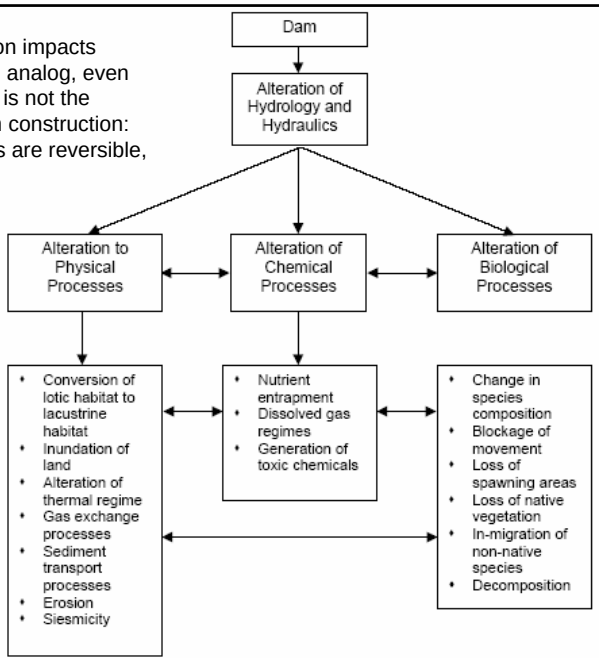


Figure 1. Number of dams removed as a function of (a) dam height, and (b) year of removal (adapted from American Rivers et al., 1999).

From Doyle et al., 2000

- **Cost examples** (from Aspen Institute 2002)
  - **Old Berkshire Mill Dam, MA (15' high, 120' long)**
    - **$133K to remove**
    - **$336 public infrastructure protection upstream**
  - **Good Hope Dam, PA (7' high, 400' long)**
    - **$38K to remove**
    - **$200K riparian restoration and infrastructure mitigation**

Dam construction impacts provide a useful analog, even though removal is not the opposite of dam construction: some processes are reversible, others are not



From Bizer, J.R. (2000) "International Mechanisms for Avoiding, Mitigating and Compensating the Impacts of Large Dams on Aquatic and Related Ecosystems and Species."IN Berkamp, G., McCartney, M., Dugan, P., McNeely, J., Acreman, M. (2000) Dams, ecosystem functions and environmental restoration, Thematic Review II.1 prepared as an input to the World Commission on Dams, Cape Town, South Africa: http://www.dams.org

Potential Adverse Impacts From Removal

- **High Turbidity**
- **Downstream Aggradation**
- **Upstream Headcutting and Erosion**
- **Release of Contaminants or Nutrients (e.g., Fort Edwards Dam, Hudson River)**
- **Exotic Species Exploitation**
- **Vegetation Impacts**
- **T&E Species Stress**
- **Altered Ice Regime**

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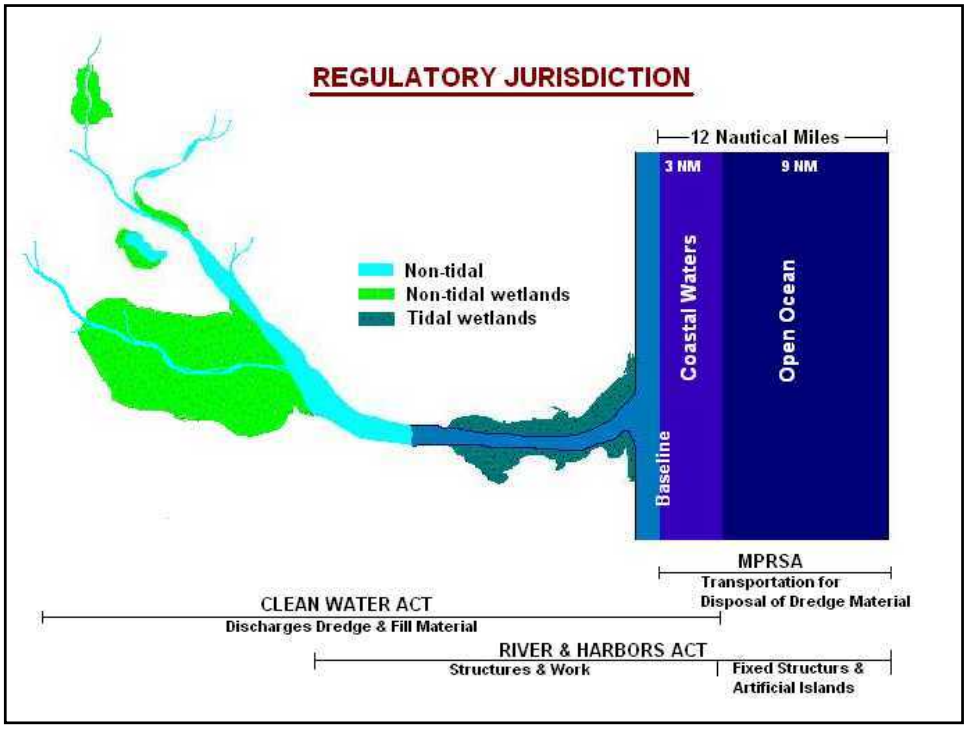

Dam Decommissioning Alternative Decision Metrics

- **Physical**
  - Hydrology and hydraulics
  - Sediment budget, storage, and properties
  - Channel and valley morphology
  - Headpond capacity
  - Flood damage reduction
- **Chemical**
  - WQ and temperature
  - Sediment contamination
- **Biological**
  - Aquatic and riparian ecosystems' processes and functions
  - Recovery of T&E populations
  - Keystone population needs
- **Economic values**
  - Site, reach, and system values with and without dam(s)
  - Regional economies
  - Flood risk
  - Relevant infrastructure
  - Recreation
- **Social and legal**
  - Ownership
  - Tribal rights
  - Safety and liability
  - Aesthetics and cultural resources
  - Historic

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Decision-Making for Dam Decommissioning

- **Consider:**
  - **Acceptable risk and uncertainty**
  - **Degree of potential impact**
  - **Recovery potential**
  - **Physical and economic constraints**
  - **Public impacts and perceptions**
  - **Quality and quantity of available data**
  - **Costs** } Cost allocation (can be nontraditional, e.g. game theory example by Tanimoto 2003
  - **Benefits** } Non-market valuation (e.g. contingent valuation
  - **Multi-objective optimization model (e.g., Kuby et al 2005)**

Tanimoto, K. (2003) "Cost allocation in dam removal project." Proceedings, IEEE International Conference on Systems, Man and Cybernetics [Washington, DC, 5-8 Oct. 2003] Volume 4, p. 3308 – 3313.

Abdul-Mohsen, A.A. (2005) "Economic efficiency and income distribution evaluation of toxics and dam removal using contingent valuation." Ph.D. Thesis, The Ohio State University.

Kuby, M.J., W.F. Fagan, C.S.ReVelle, W.L. Graf (2005) "A multiobjective optimization model for dam removal: an example trading off salmon passage with hydropower and water storage in the Willamette basin." Advances in Water Resources (28) 845-855.

Decision-Making for Dam Decommissioning

- **Define desired end state(s) and goals (e.g., safety, fish and wildlife, aesthetics, recreational use)**
- **Define existing regime**
  - **Ecological: understand relationship between aquatic resources and watershed hydrology and hydraulics (riparian, reservoir, wetlands)**
  - **Identify water uses (e.g., hydropower, water supply, recreation, flood damage reduction, ecosystem)**
  - **Describe hydraulics (e.g., diurnal, seasonal, flood, low-flow, surface, groundwater)**
  - **Socio-economic considerations (recreation, real estate, cultural resources)**
- **Identify optimization model**

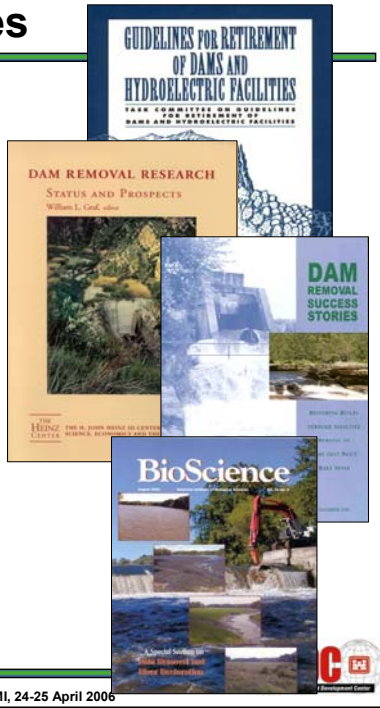
Decision-Making for Dam Decommissioning

- Quantify all benefits and costs of existing regime
- Identify alternative methods to reach desired end state
  - Address modification; partial or full removal; removal sequenced over time; sequential grade control for head pond maintenance, organism passage, or channel stability; reoperations
  - Explicitly characterize transition processes (e.g., sediment management plan, stream bank stabilization, channel restoration)
  - Assign values to individual components
- Quantify all benefits and costs of end state(s)
- Select optimum plan

Conclusions and Future Directions

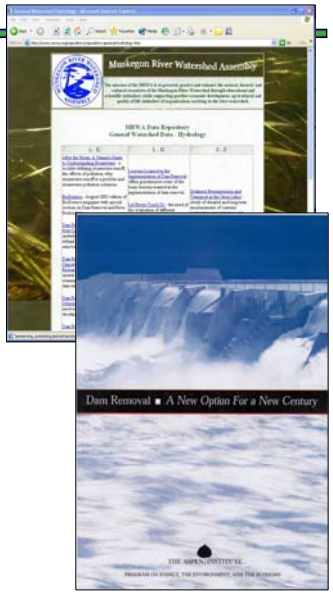
- Dam decommissioning is a powerful new tool from the standpoints of
  - public safety
  - management of aging infrastructure
  - ecosystem restoration
  - management of threatened and endangered populations
- The lessons learned in removal of smaller structures will be critical to efficient and technically sound removals of the looming cohort of large dam removals – but better documentation is required.
- In most cases dam removal has significant restoration costs that are not considered in alternatives analyses.
- Cost-benefit and alternatives analyses are demanding and central to decision making process.
- **Connections are important!**

Resources



- ASCE (1997) ***"Guidelines for Retirement of Dams and Hydroelectric Facilities"*** **American Society of Civil Engineers: Washington, DC.**
  http://www.asce.org/bookstore/book.cfm?book=3118
- Graf, W.L. (ed.) (2003) ***"Dam Removal Research: Status and Prospects."*** **The Heinz Center: Washington, DC.**
  http://www.heinzctr.org/NEW_WEB/PDF/Dam_Research_Full%20Report.pdf
- American Rivers, Friends of the Earth, and Trout Unlimited (1999) ***"Dam Removal Success Stories."*** **American Rivers: Washington, DC.**
  http://www.amrivers.org/index.php?module=HyperContent&func=display&cid=1743
- *BioScience* **- Special Issue on Dam Removal and River Restoration, Vol. 52, No. 8, August 2002**

Resources



- Muskegon River Watershed Assembly**:** **MRWA Data Repository, General Watershed Data - Hydrology**
  http://www.mrwa.org/repository/repository-general-hydrology.htm
- EWRI dam removal series**:**
  http://www.ewrinstitute.org/damremoval04/
- Conyngham, Fischenich, and White, 2004. ***Engineering and Ecological Aspects of Dam Removal—An Overview*****.**
  http://www.wes.army.mil/el/emrrp/tnotes.html
- White, K.D., 2001. ***Considerations for dam removal in ice-affected rivers*****.**
  http://www.crrel.usace.army.mil/ierd/tectran/27InDesign.pdf
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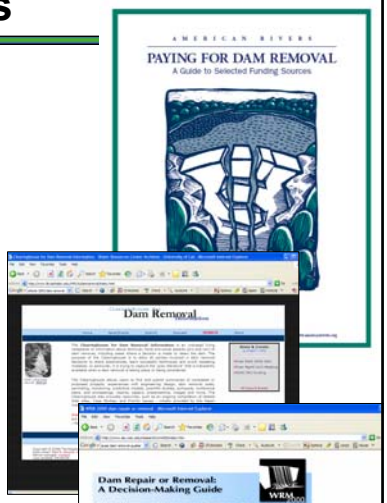
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  http://www.wisconsinrivers.org/documents/dams/Paying%20for%20Dam%20Removal%20-%20A%20Guide%20to%20Selected%20Funding%20Sources.pdf
- University of Wisconsin Water Resources Management Practicum (2000) ***Dam Repair or Removal: A Decision-Making Guide***
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