



LAURA WILDMAN, PE

Director, New England Regional Office
Fisheries & Water Resource Engineer

Princeton Hydro

w: 860-652-8911 c: 860-989-7966
lwildman@princetonhydro.com



THE ART OF DAM REMOVAL

A U.S. PERSPECTIVE

- Types of Dams We Remove
- Why We Remove Dams
- Critical Issues to Assess for Dam Removal
- Step-by-Step Dam Removal
- Potential Differences Between Dam Removal in the USA and Lithuania



TYPES OF DAMS WE REMOVE IN THE U.S.



Hoover Dam



We are NOT
trying to
remove
Hoover Dam
*(well maintained,
iconic, multiple
purposes)*

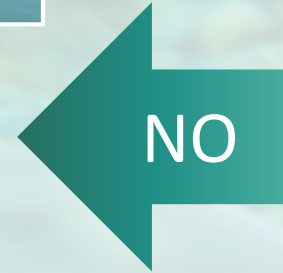
We ARE
removing
abandoned,
sediment
filled dams



Rindge Dam, CA



Lake Norris Dam, TN

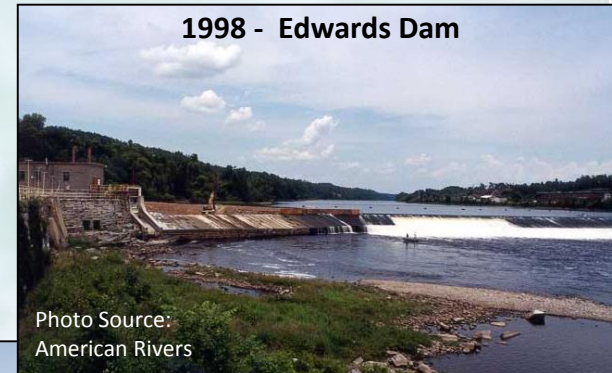


We are NOT trying to remove this active hydroelectric and flood control dam

We DID remove this hydroelectric dam where the environmental impacts outweighed the limited generating capacity

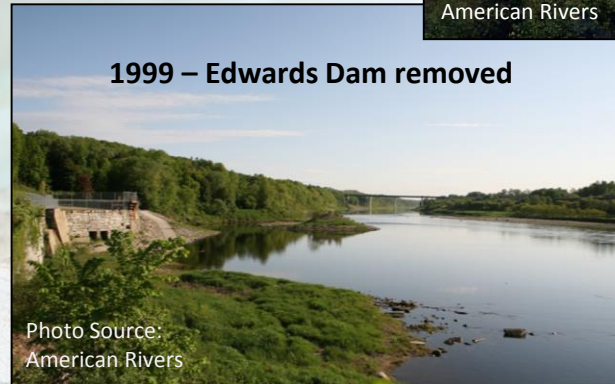


One year after removal in 1999 alewife returned by the millions for the first time in 160 years



1998 - Edwards Dam

Photo Source:
American Rivers



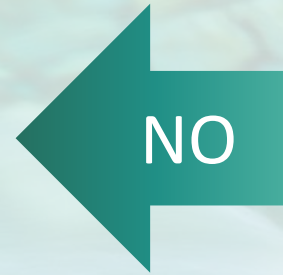
1999 - Edwards Dam removed

Photo Source:
American Rivers

Edwards Dam, ME



Lake Wyola Dam, MA



We are NOT trying to remove recreational dams with multiple lakeside homes (even though this dam had significant safety hazards)

We ARE trying to remove environmentally damaging dams with no economic purpose



W. Swanzey Dam, NH

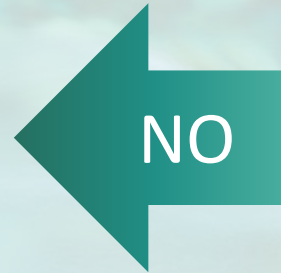




Bartlett Water Supply Dam, AZ



And not just because my grandfather designed and built it



We are NOT trying to remove active water supply dams (or flood control dams)

We ARE removing environmentally damaging dams and replacing uses such as water intakes



Great Works Dam, ME



We are NOT trying to remove this historic dam at the head of a waterfall

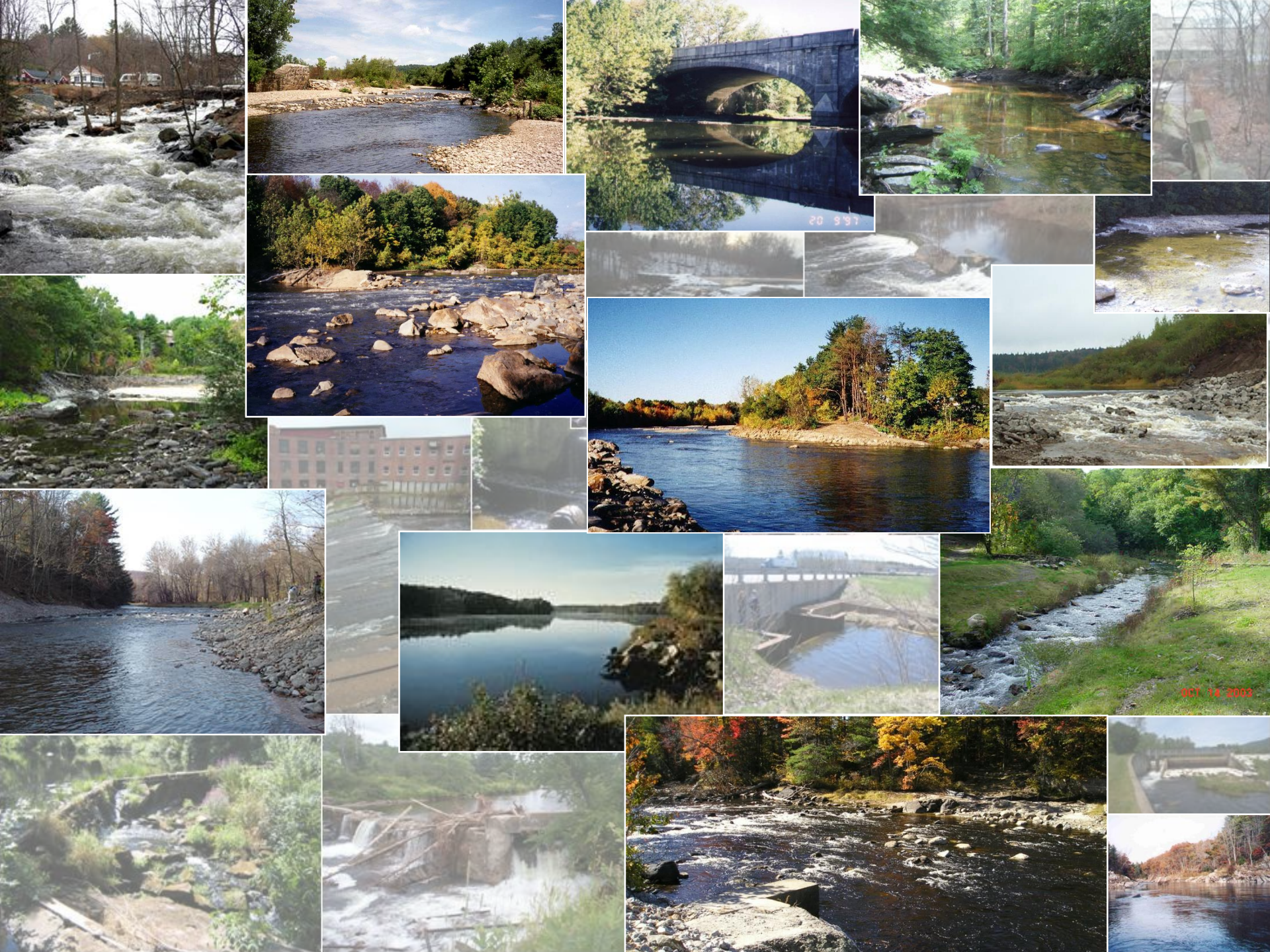
Lower Case Pond Dam, CT

We ARE removing abandoned industrial dams. This dam was also actively undermining a sewer line



Anaconda Dam, CT





Why We Remove Dams in the U.S.

1. Economic

- Loss of original purpose
- Maintenance Cost (i.e. **dam safety regulations**)
- No longer economically justified

2. Dam Safety

- Aging dam structure
- Reservoir sedimentation
- Dam failure
- Attractive nuisance
- Liability

3. Environment

- Environmental impact is too great
- Proactive restoration (river, fish, WQ, sediment, etc.)
- Fish Passage Requirement (Cost > \$Benefit)





CRITICAL ISSUES TO ASSESS FOR DAM REMOVAL

BASED ON COMPLETED CASE STUDIES

Issues Assessed

ENGINEERING

DATA COLLECTION
TYPE & CONDITION OF DAM (dam safety)
SCALE OF PROJECT
SITE LIMITATIONS (Topo., Encroachment, etc.)
UPSTREAM & DOWNSTREAM IMPACTS
UTILITIES/INFRASTRUCTURE
SCOUR ASSESSMENT
PROJECT PERMITTING
ALTERNATIVES ANALYSIS
FIELD WORK AND CONDITIONS (survey, probes,
photographs, resource delineation, etc.)
ENGINEERING COST ESTIMATES

HYDROLOGIC

WATERSHED HYDROLOGY
FLOODWATER STORAGE / ATTENUATION
IMPOUNDMENT DRAWDOWN/DEWATERING
WELL IMPACTS
GAUGING

HYDRAULIC

CHANNEL HYDRAULICS (& safety)
FLOODPLAIN HYDRAULICS
FLOODING IMPACTS
ICE JAMS
WATER INTAKES & DIVERSIONS
FLOOD MAPPING REVISIONS

FLUVIAL GEOMORPHIC

TESTING (probes, borings, samples)
SEDIMENT QUANTITY & QUALITY
SEDIMENT STABILITY/TRANSPORT
SEDIMENT MANAGEMENT
SEDIMENT DISPOSAL
CHANNEL MORPHOLOGY/DESIGN (equilibrium
slope, form, function, process, materials,
geomorphic assessment)
GEOLOGY/BEDROCK/GRADE CONTROLS
TRIBUTARY IMPACTS
REFERENCE REACHES
SITE RESTORATION

SOCIOECONOMIC

WHY REMOVE A DAM?
OWNERSHIP (Water Rights; Easements) & BUY-IN
ABUTTERS & OTHER USERS
EXISTING USES & ALT. USES (hydro., navigation,
flood control, water supply, recreation, etc.)
AESTHETICS (mud flats, water fall, fear of unknown)
RECREATION
LIABILITY & PUBLIC SAFETY
ECONOMIC ISSUES & ANALYSIS
FUNDING
ARCHEOLOGICAL/HISTORICAL
SENTIMENTAL VALUE
PRESS & POLITICS

ECOLOGICAL

FISH: DIADROMOUS/RESIDENT/PASSAGE
AQUATIC HABITAT
HABITAT CONNECTIVITY
ECOLOGICAL STUDIES & INTERCONNECTIONS
VEGETATION / PLANTING PLANS
REGULATED RESOURCES (i.e. wetlands,
wildlife, invasives, etc.)
SPECIES OF SPECIAL CONCERN

WATER QUALITY

CHEMICAL PROPERTIES
PHYSICAL PROPERTIES
(i.e. temperature, turbidity)
PUBLIC HEALTH
REGULATORY TRIGGERS, i.e. TOTAL DAILY
MAXIMUM LOADS (TMDLs)

CONSTRUCTION

SEASONAL CONSTRUCTION LIMITS/WEATHER
CONSTRUCTION ACCESS
CONSTRUCTION SEQUENCE
WATER CONTROL
CONSTRUCTABILITY
EROSION & SEDIMENT CONTROL
WORKING IN WET VS DRY
CONSTRUCTION COST
PROTECTING UTILITIES
BONDING
INSPECTION & OVERSIGHT
PRESS & THE PUBLIC
UNKNOWNNS & MANAGING RISK

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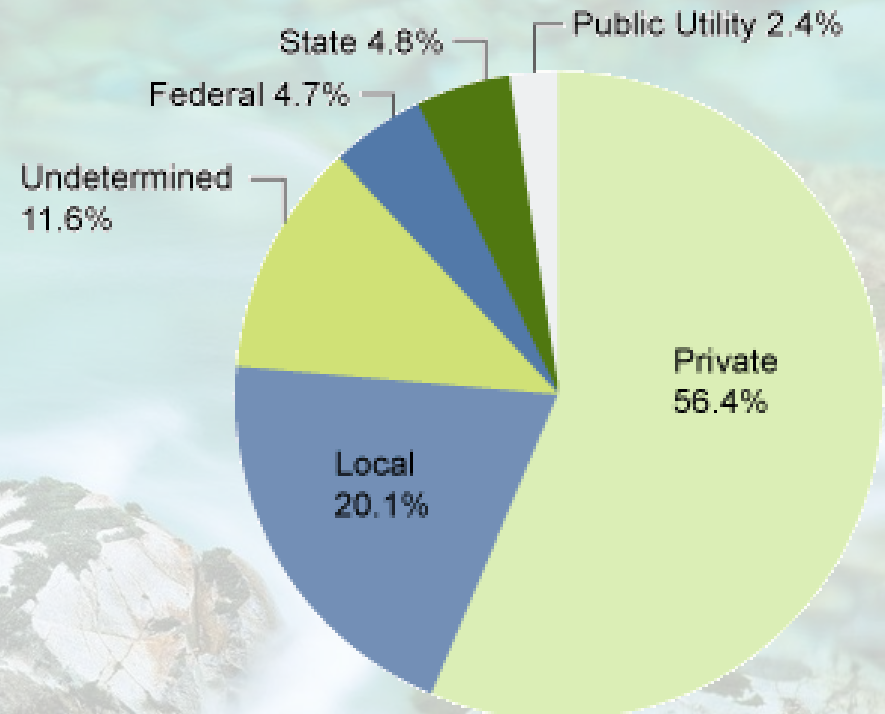
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PRESS & THE PUBLIC
UNKNOWNNS & MANAGING RISK

Existing Use / Ownership / Economics



*It is MY dam and I
can do what I damn
well please with it!*



Source: FEMA 2018

- The majority of dams (64%) in the US are privately owned (USACE, ASDSO)
- US Dam Safety Regulations require that most dams be maintained
- # of deficient dams in the US is increasing faster than repairs
- \$65 billion needed to repair dams (2016 ASDSO)

Source: Association of State Dam Safety Officials from *The Cost of Rehabilitating Our Nation's Dams: A Methodology, Estimate, and Proposed Funding Mechanism* and <http://www.infrastructurereportcard.org/dams/>

Impounded Sediment Quantity/Mobility

- Originally dredged impoundment
- Sediment filled impoundment now considered wetland
- Difficult permitting sediment relocation within former impoundment

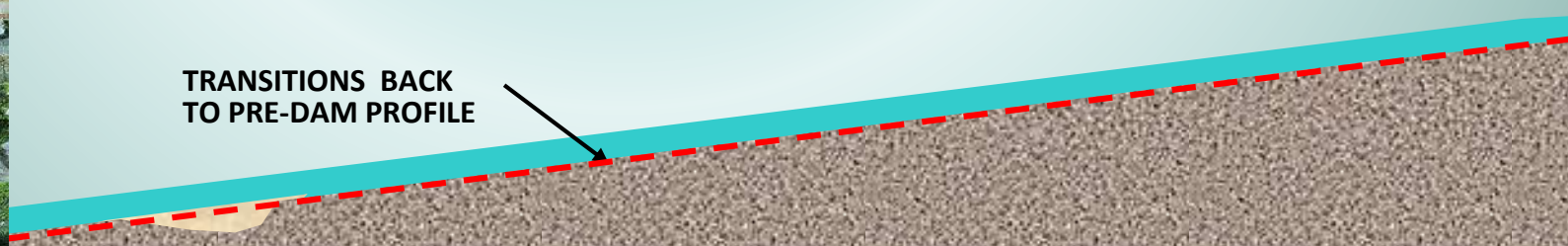
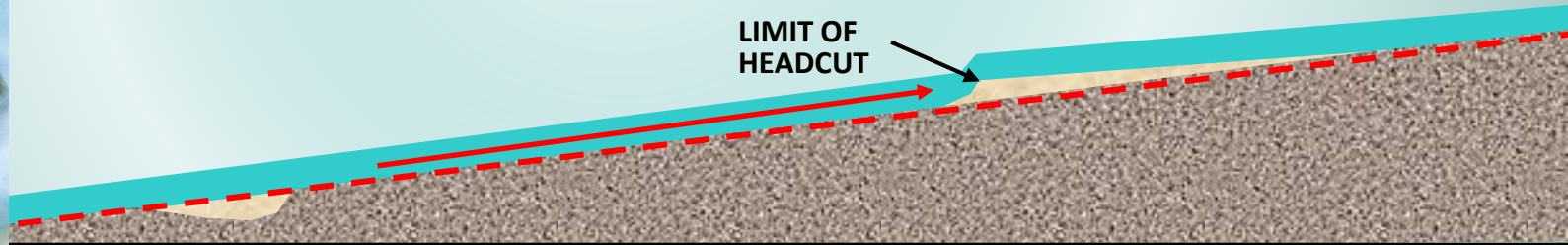
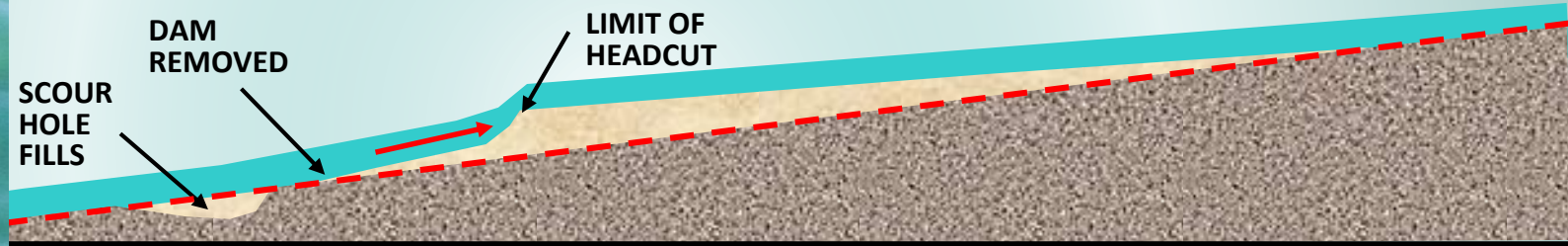
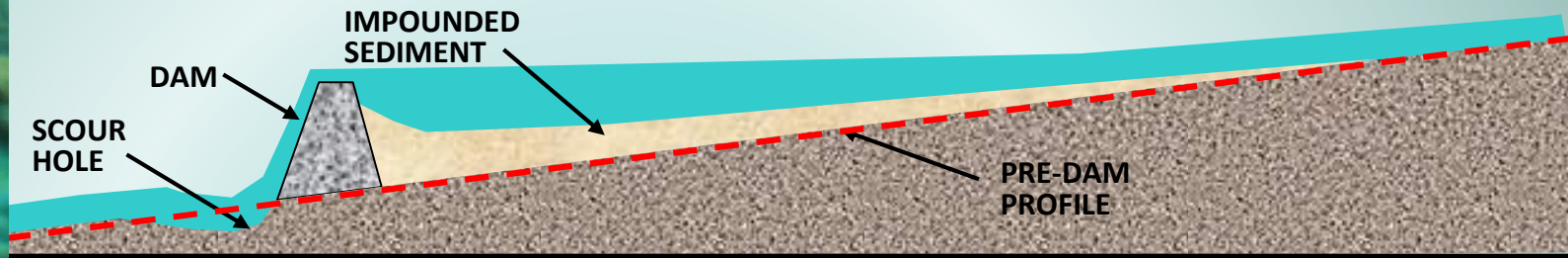


Hunters Pond Dam Example: Reservoir Infilling



GEOMORPHIC STABILITY

RIVERBED PROFILE: Simple Example

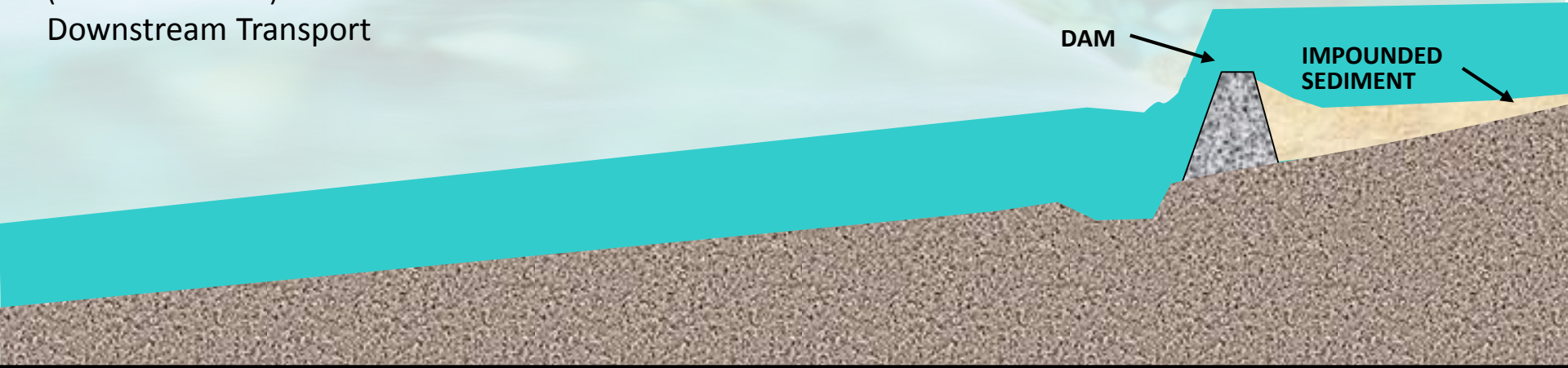


Impounded Sediment Quantity/Mobility

Diffuse Sediment Wave Model

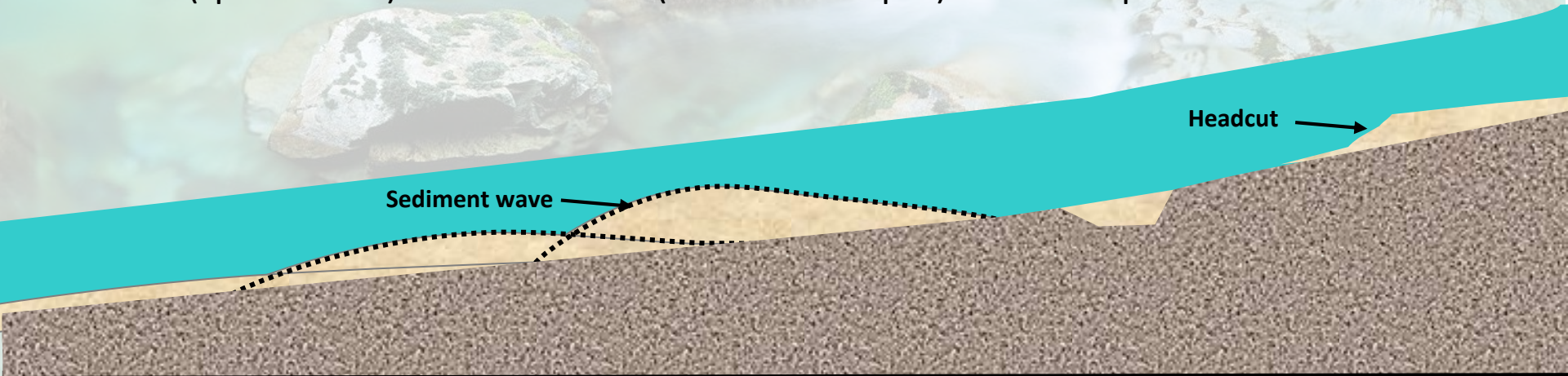
(Griemann - USBR)

Downstream Transport



Sediment Wave:

Diffuses (spreads out) and diminishes (reduces in depth) as it transports downstream



Impounded Sediment Quality

High
transport
capacity &
low d/s
sensitivity

Natural erosion
& deposition

Low
transport
capacity
&/or high
downstream
sensitivity

Contaminants
bioavailable?

Yes

Staged dam removal or
Cap/isolate sediment or
Partial sediment removal or
Full sediment removal

TESTING FOR:

- ▶ Grain size
- ▶ Organic Content
- ▶ Volatiles
- ▶ Cyanide
- ▶ Chromium
- ▶ PCBs
- ▶ Pesticides
- ▶ Herbicides
- ▶ Hydrocarbons
- ▶ Metals
- ▶ PAHs

SEDIMENT QUALITY CRITERIA

Screening

- ▶ Intentionally conservative

State Sediment Quality Guidelines

- ▶ Residential Reuse
- ▶ Commercial Reuse

Ecological Screening
Criteria - MacDonald D.D.,
C.G. Ingersoll, and T.A. Berger.
2000.

- ▶ Threshold Effects
- ▶ Probable Effects



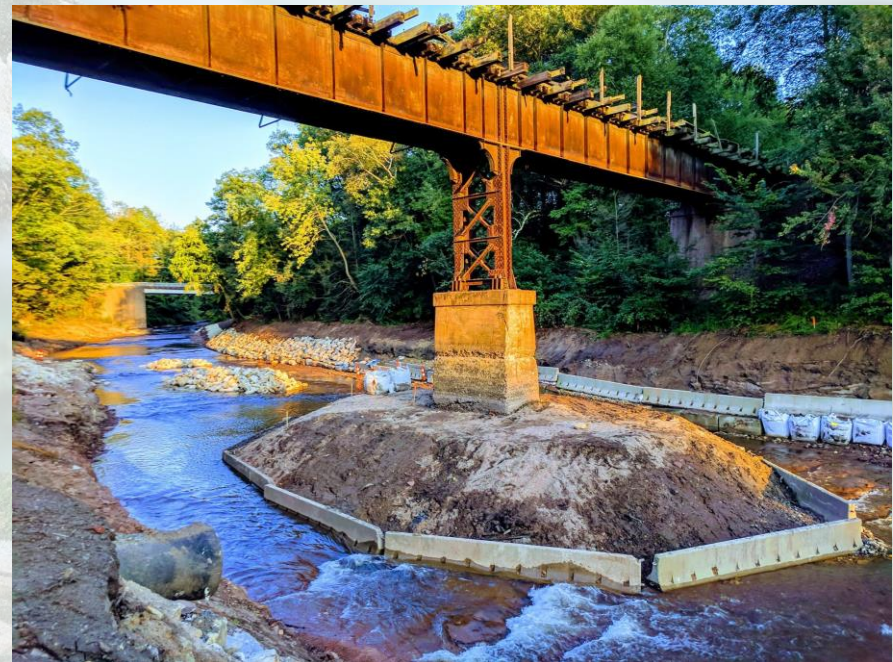
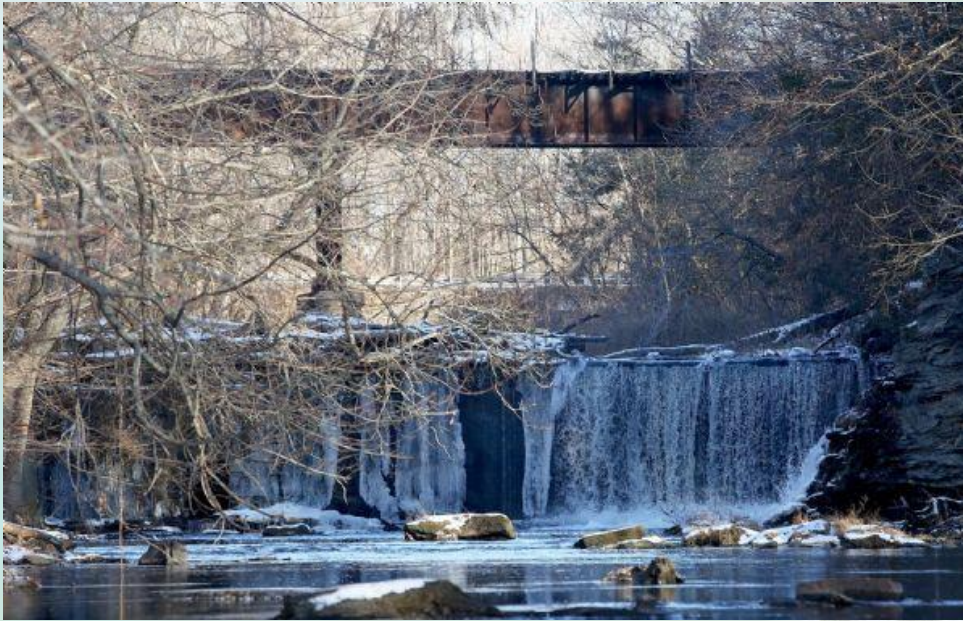
Infrastructure/Utilities



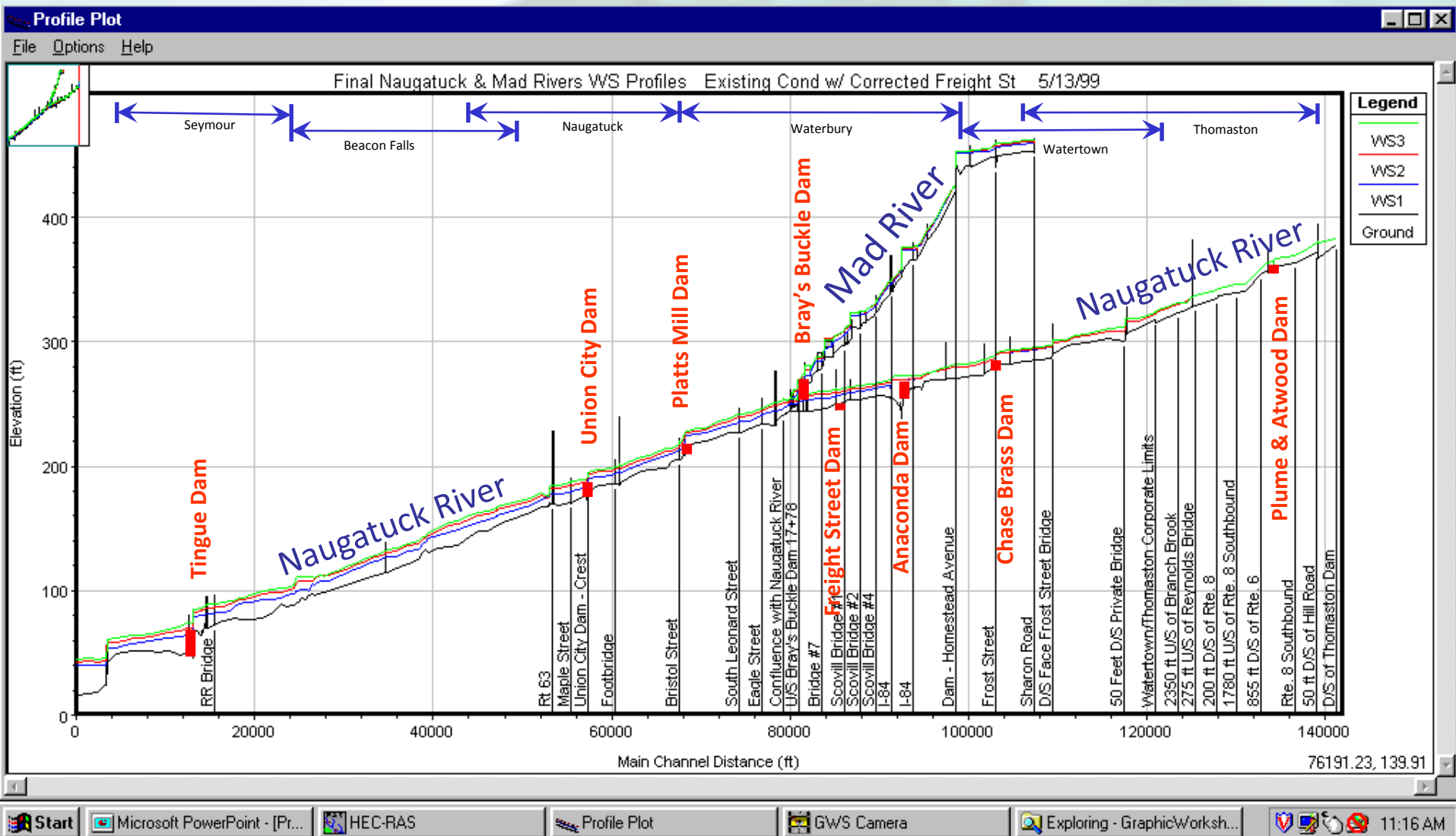
Pipe exposed when lake was drained

Infrastructure/Utilities

Springborn Dam, CT

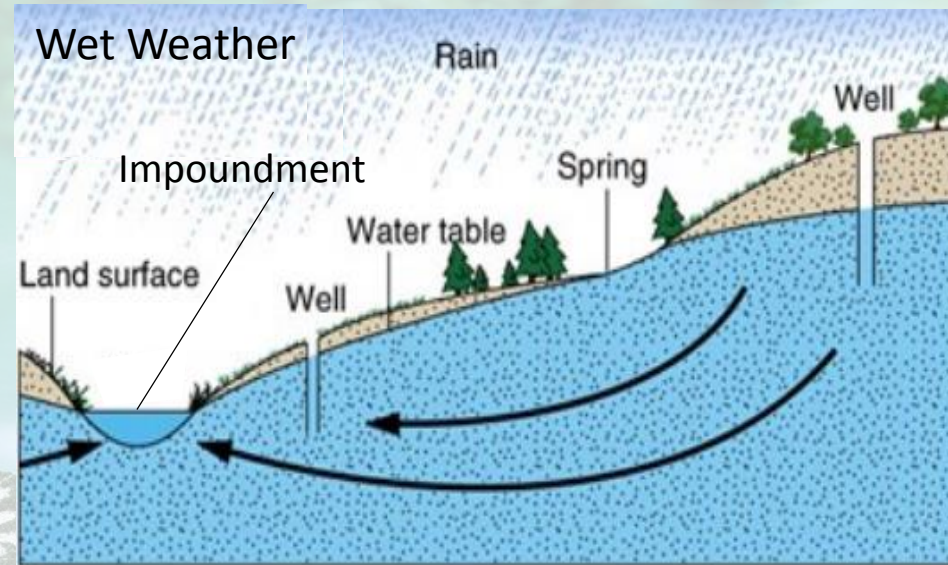


Hydrology & Hydraulics (i.e. Water Surface Elevation, Fish Passage, Scour, etc.)

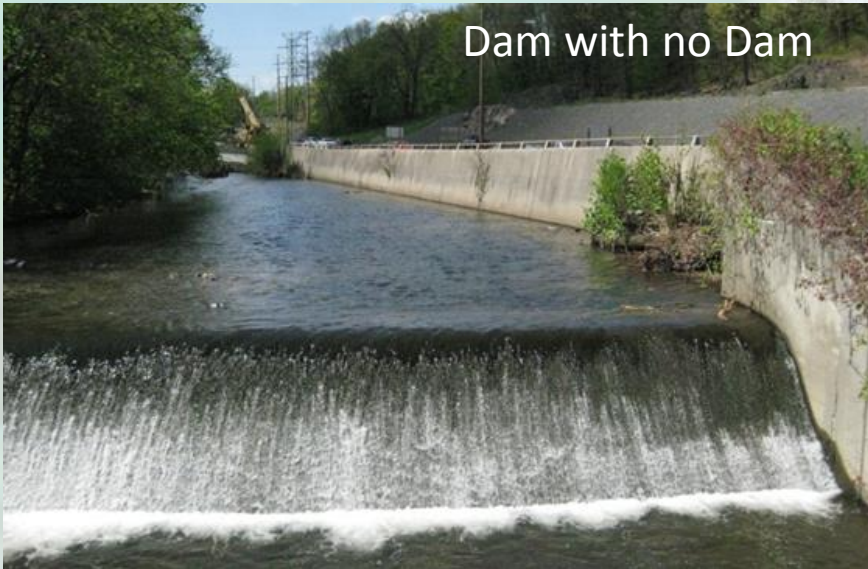


Hydrology & Hydraulics (i.e. flooding, well impacts, etc.)

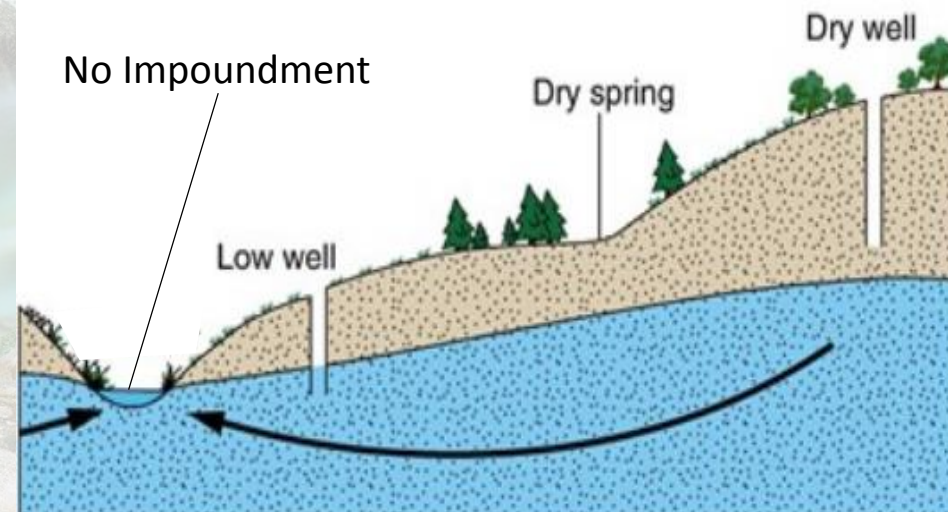
Flood Control Dam



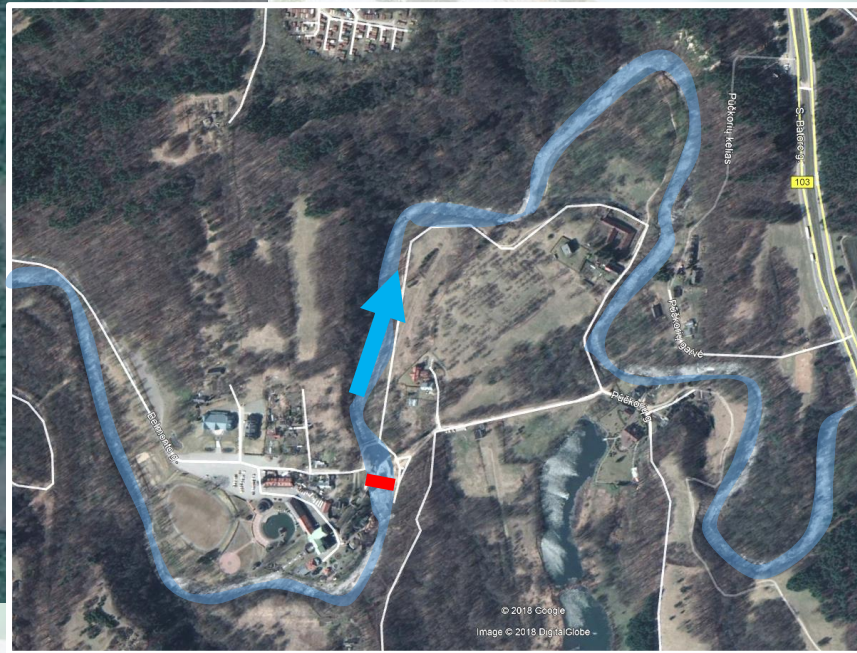
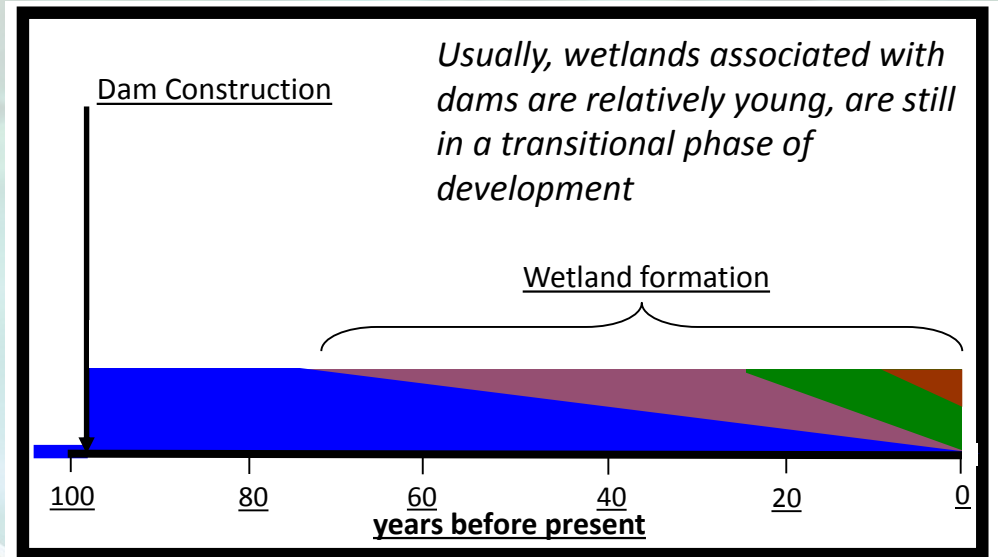
Dam with no Dam



Dry Weather



Regulated Resources (i.e. wetlands)



- open water
- floating-leaf vegetation
- emergent vegetation
- floodplain vegetation

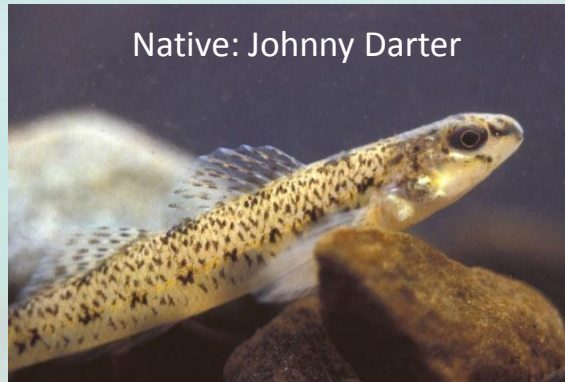
Two examples of different types of impoundments in Lithuania

Regulated Resources (i.e. threatened and endangered species, invasive species, etc.)



Invasive: Round Goby

Rouge River Dam, MI:
Invasive species
outcompetes native
species



Native: Johnny Darter



Threatened & Endangered
Species Restoration –
Salmon, etc.

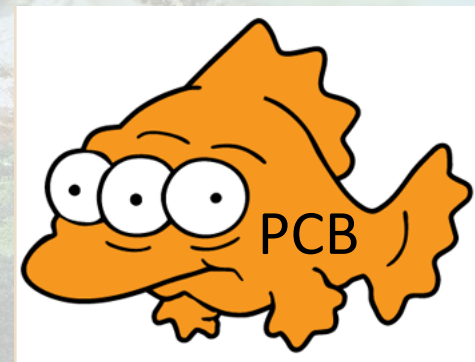
1st Barriers on the Great Lake Tributaries

(the need to exclude
lamprey makes dam
removal challenging)



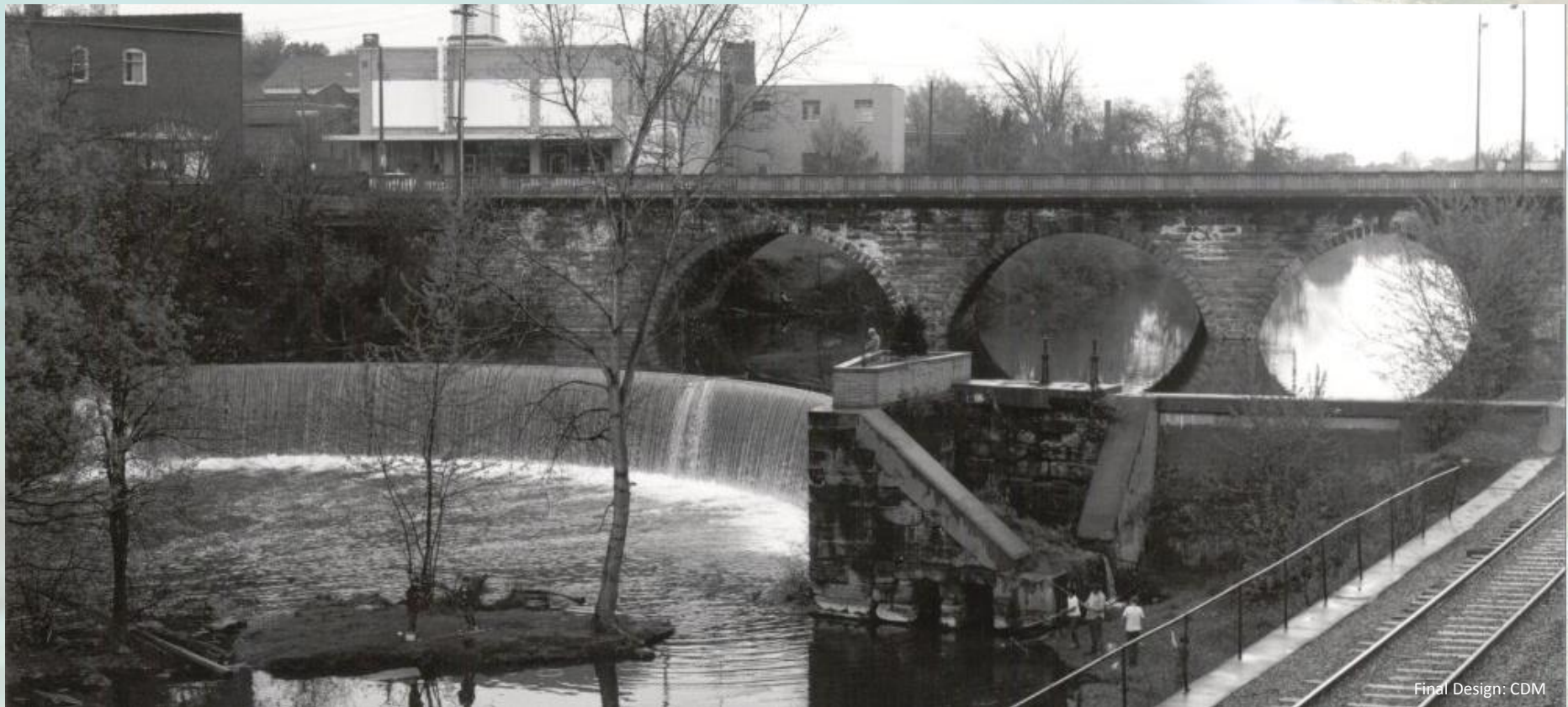
Government Mill Dam #6 E. Branch Housatonic River

(most downstream dam in a
series of dams acts as a barrier
to PCB contaminated fish)



Historic Resources

- **Historic Site: Kent Dam, Ohio**
- **Creative Solution: portion of dam retained to create falling water aesthetic**

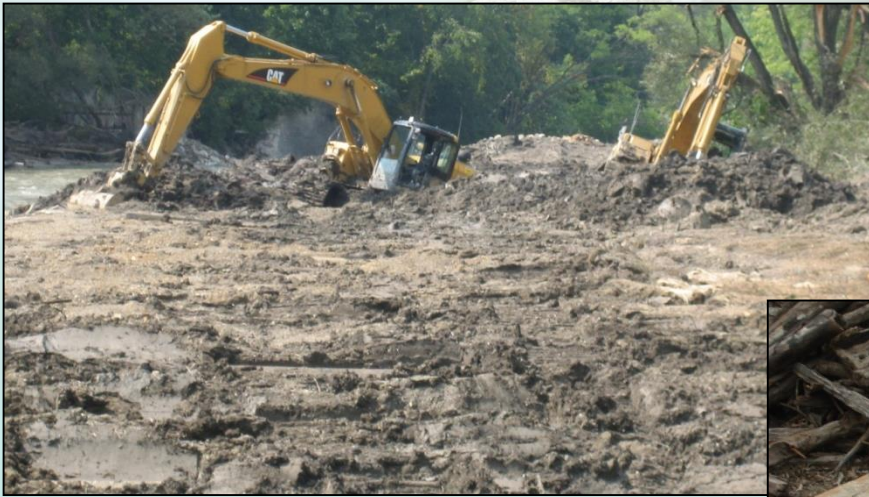


Historic Resources

- **Historic Site: Kent Dam, Ohio**
- **Creative Solution: portion of dam retained to create falling water aesthetic**



Constructability



Stuck In the mud w/out mats



Timber mats



Metal swamp mats



Access from crest of dam



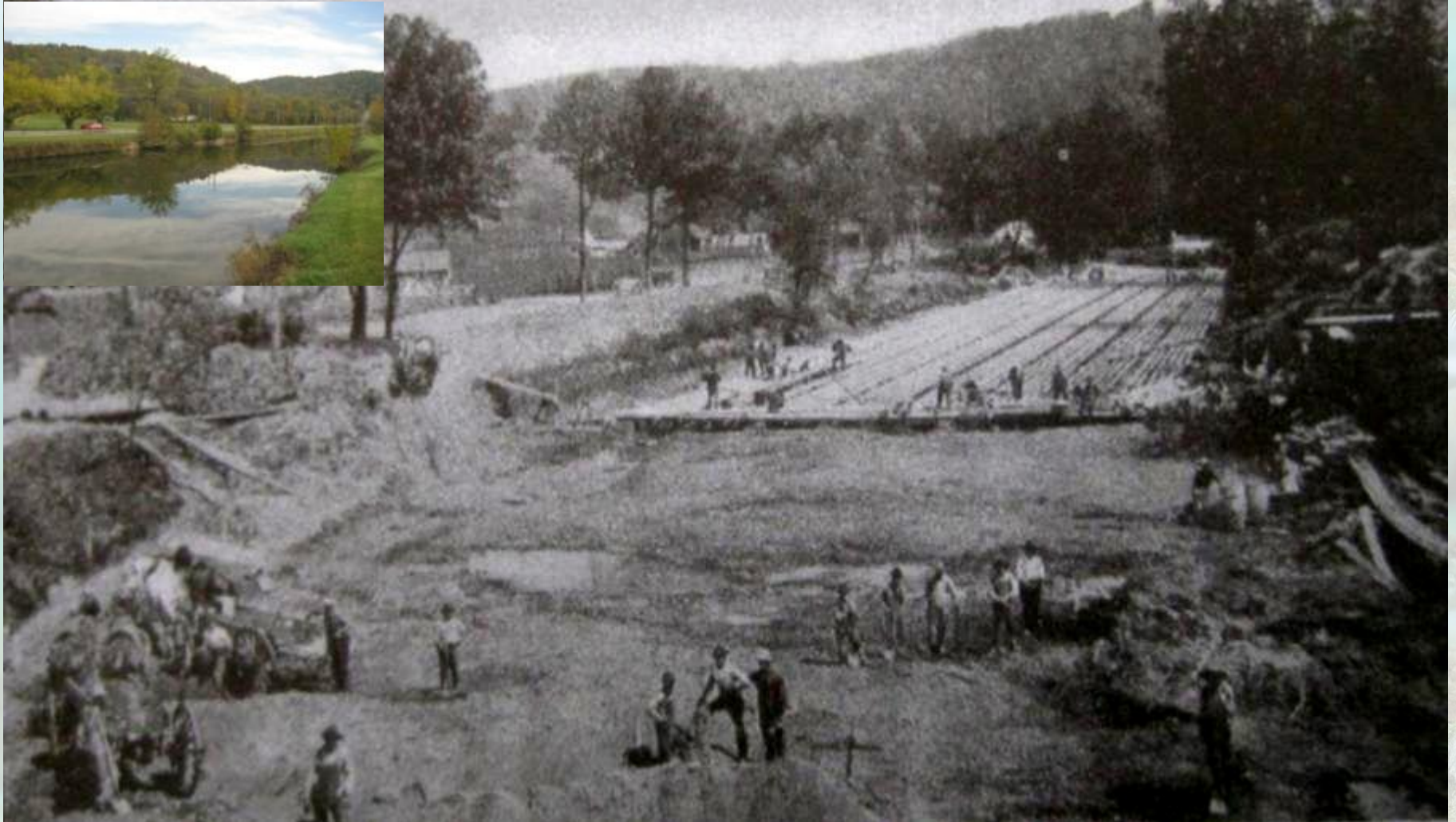
Thumb attachment for timber



Use of explosives

Unknowns / Managing Risk

A typical impoundment?



Dunkard Creek Dam, PA - Turn of the century cooling systems for a gas pumping station

Unknowns / Managing Risk

~~A typical impoundment?~~ No, the worlds largest radiator!



Site Restoration: Less is More

Tannery Dam
Removal, NH



Site Restoration: Less is More

Tannery Dam
Removal, NH



Site Restoration: Less is More

Tannery Dam
Removal, NH

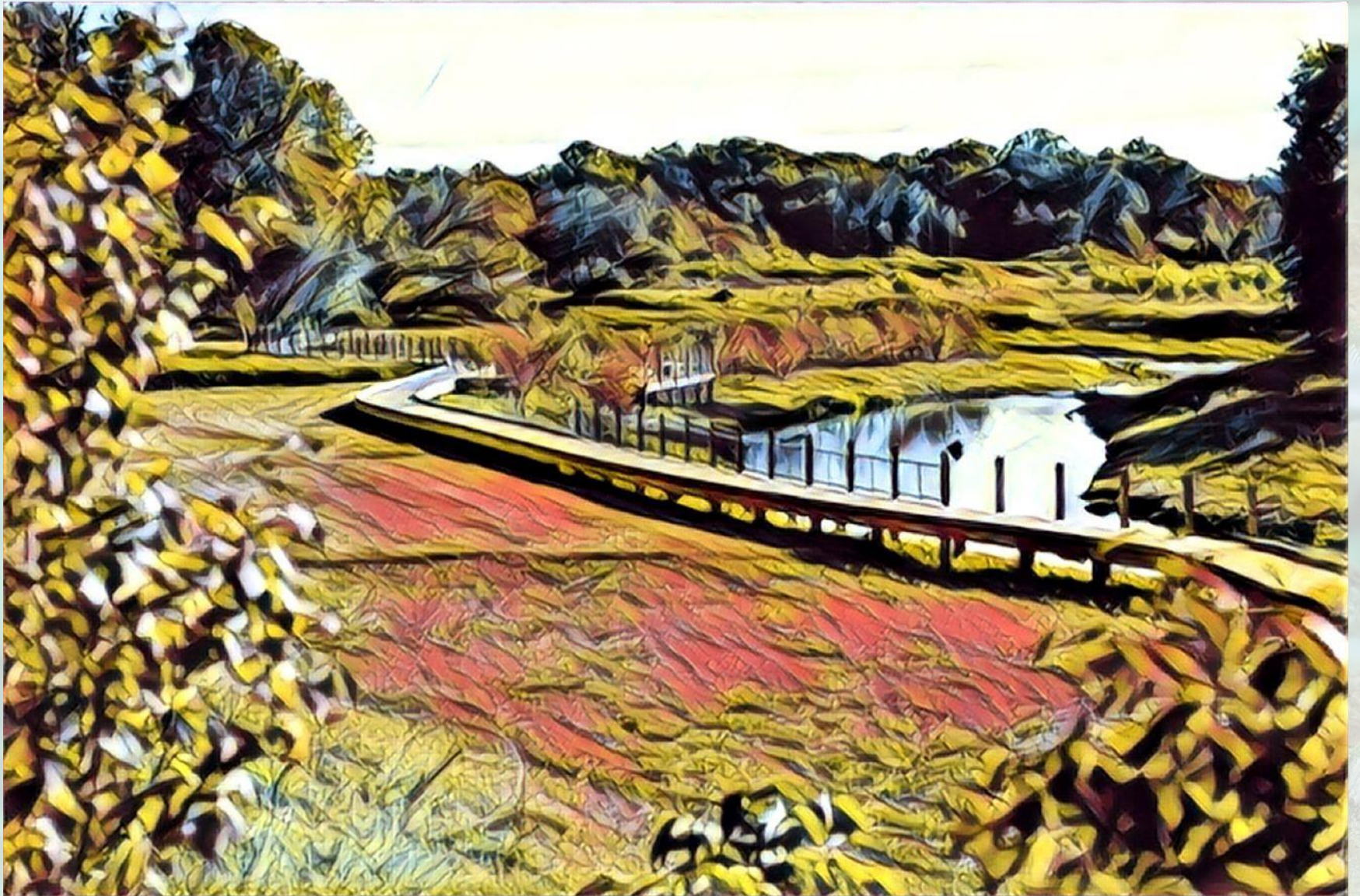


Connecting Communities to Rivers



Dexters Mill Creek Dam Removal & Park Creation, MI

Connecting Communities to Rivers



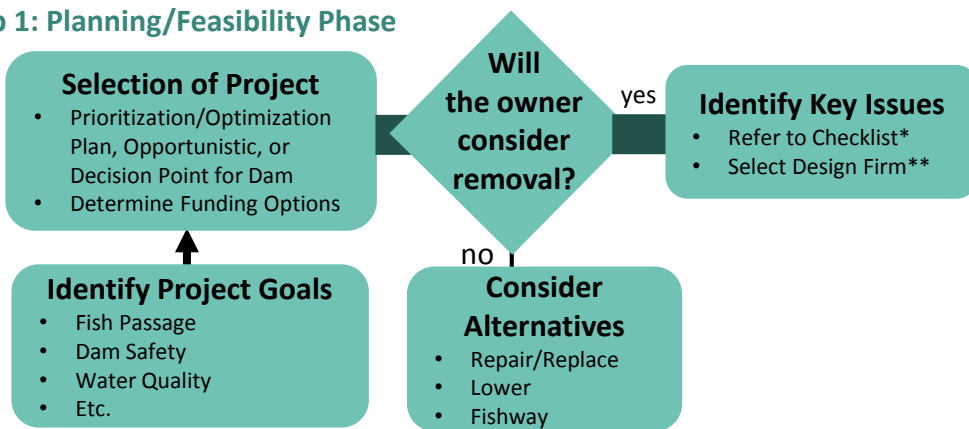
Dexters Mill Creek Dam Removal & Park Creation, MI



ANALYZING DAMS FOR REMOVAL

Step 1: Planning/Feasibility Phase

START

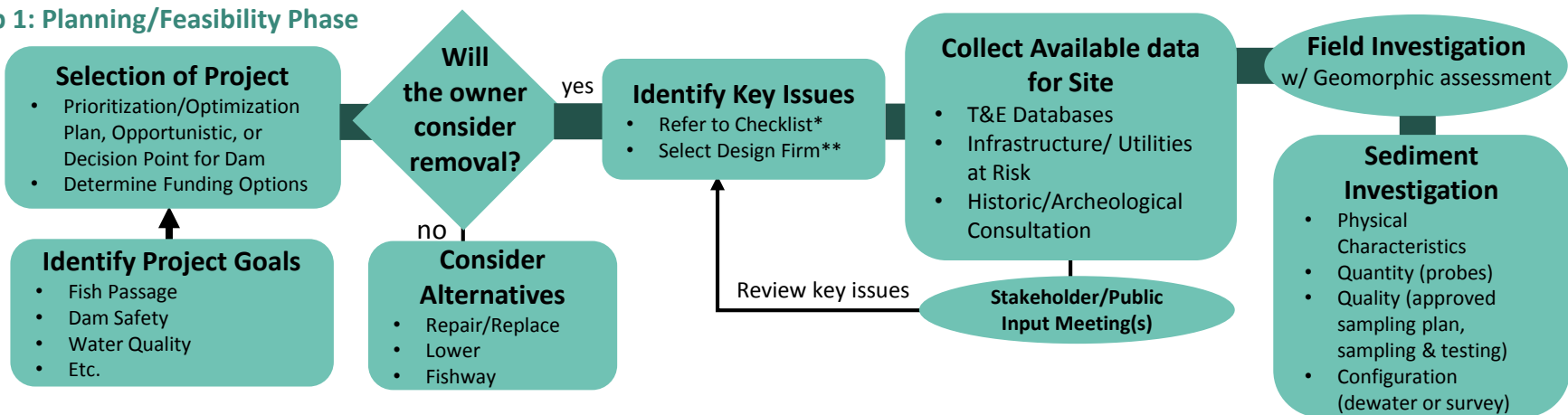


Top Key Issues:

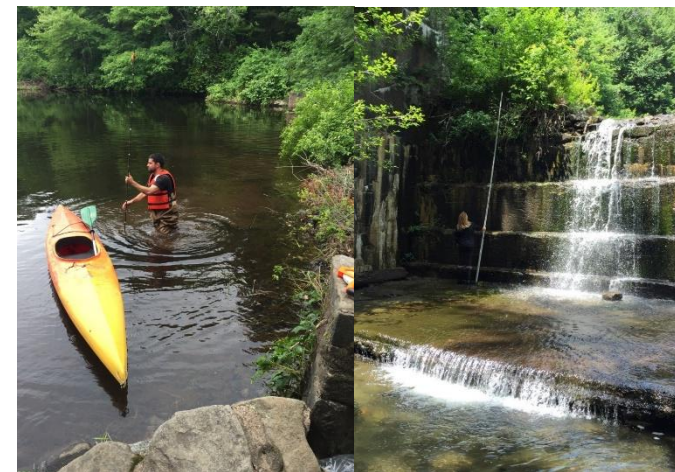
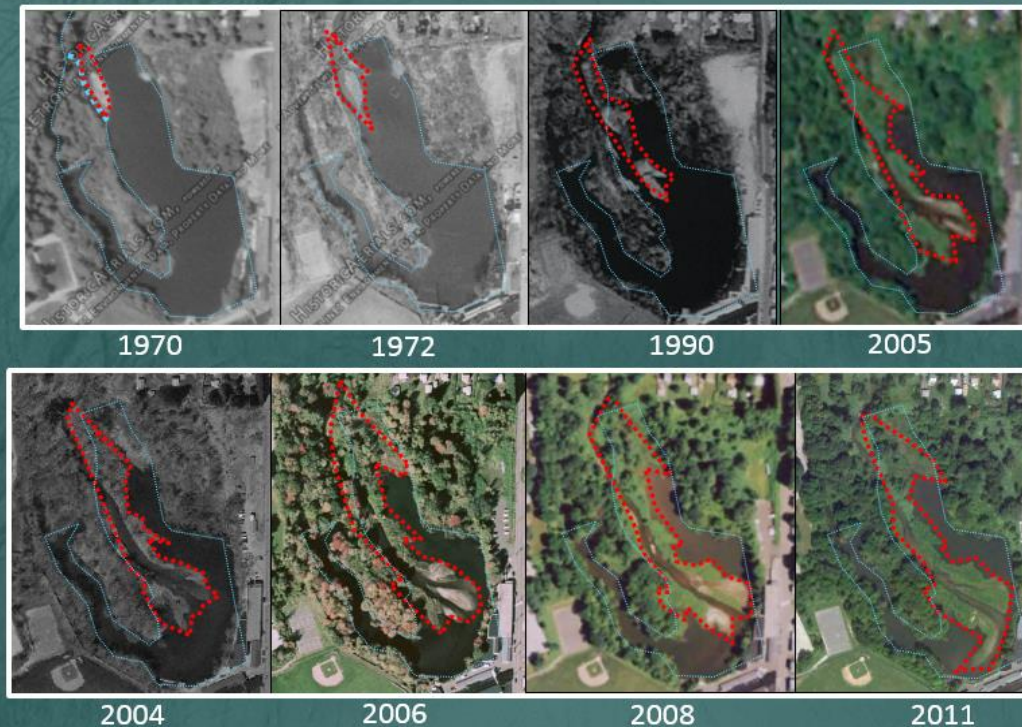
- *Sediment*
- *Infrastructure/utility impacts*
- *Current use (& economic value of dam)*
- *Environmental concerns & benefits*
- *Geomorphic equilibrium*
- *Public health & safety*
- *Flooding & hydrologic impacts*
- *Aesthetic & sentimental value*
- *Historic/archeological*
- *Community concerns*
- *Sensitive or invasive species*
- *Water rights*
- *Cost & funding availability*

Step 1: Planning/Feasibility Phase

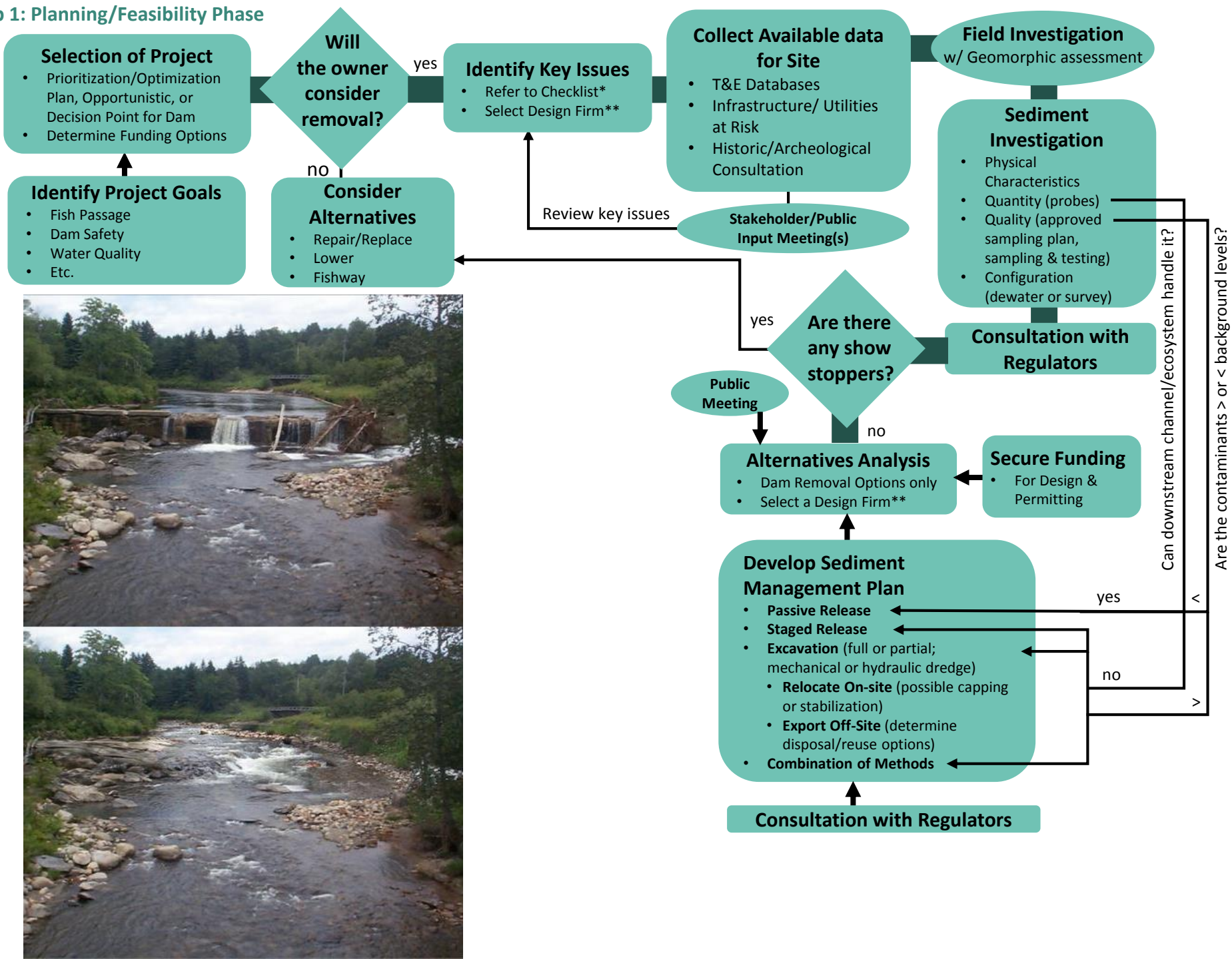
START



The Heminway Pond Transition From 1934 to 2011 Watertown, CT

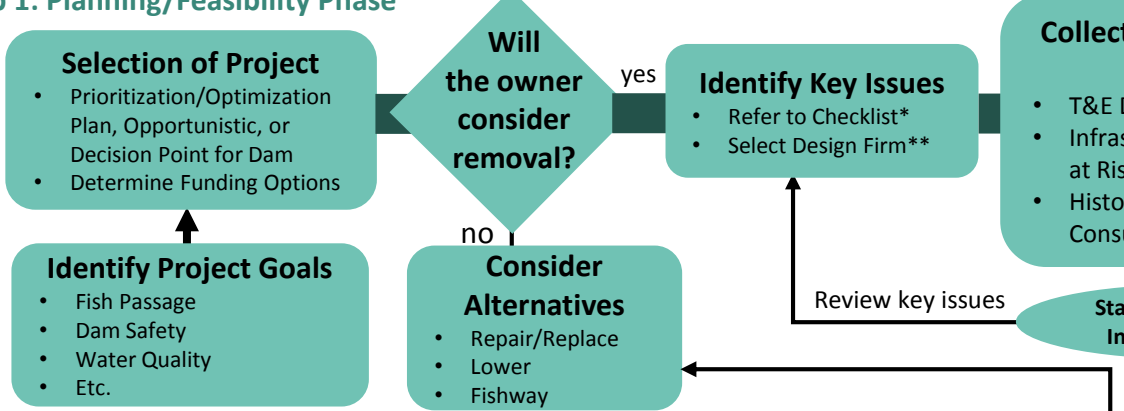


START

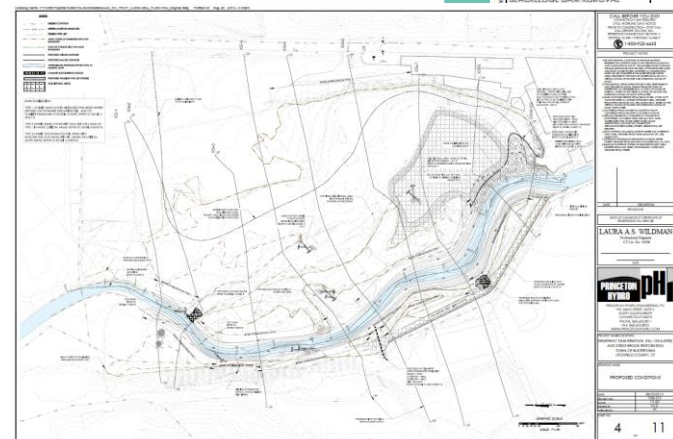
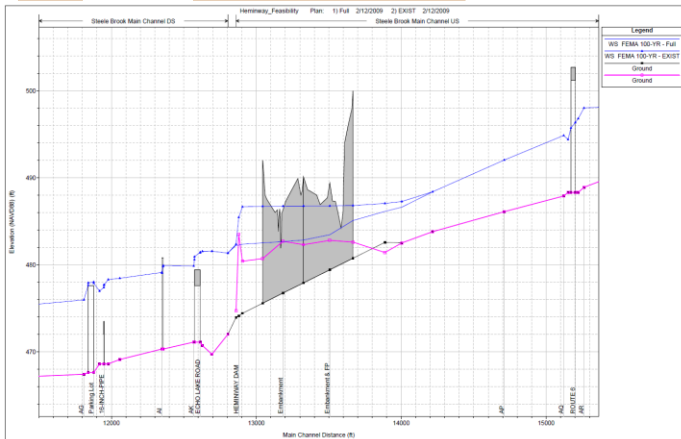
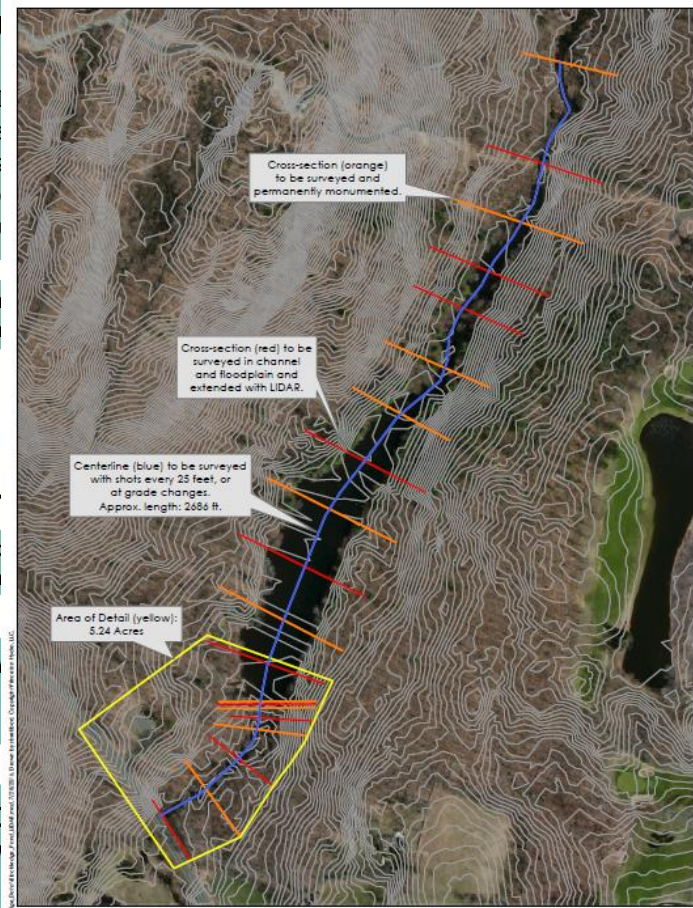
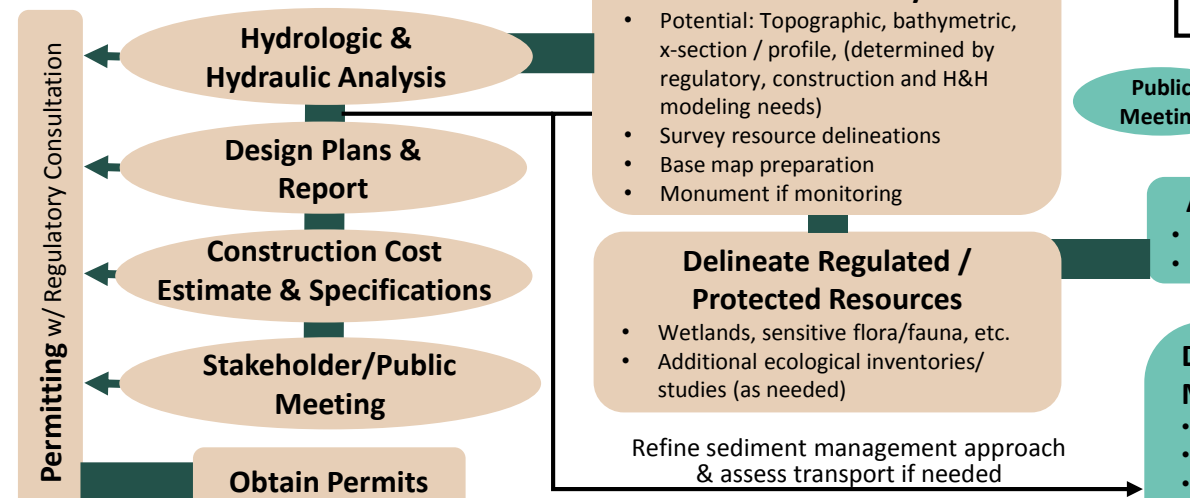


Step 1: Planning/Feasibility Phase

START



Step 2: Design & Permitting Phase

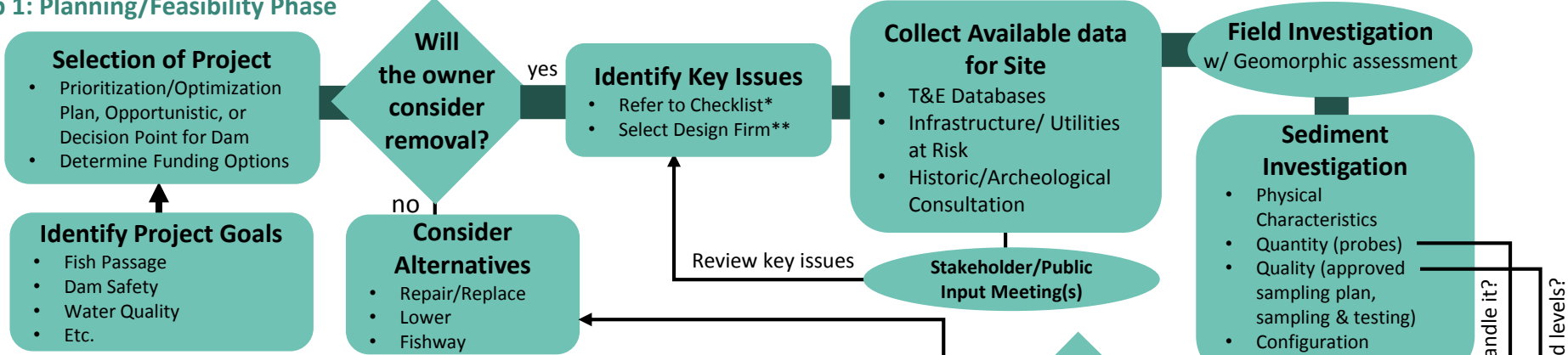


Methods
with Regulators

ARE THE CONTAMINANTS > OF < BACKGROUND LEVELS?

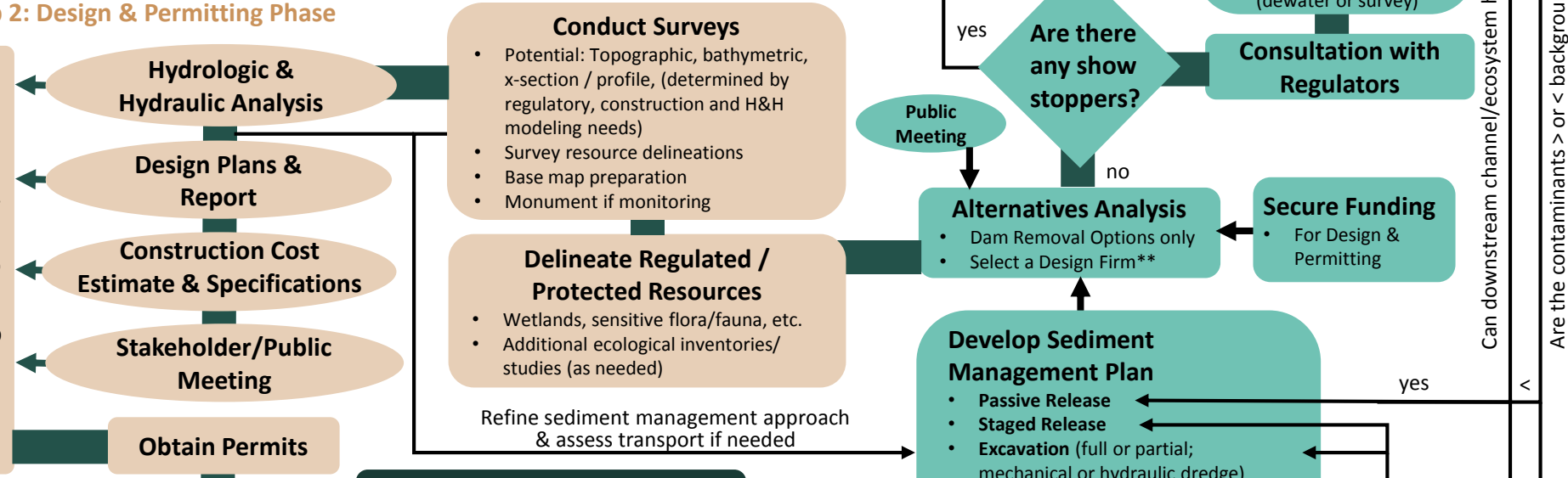
Step 1: Planning/Feasibility Phase

START



Step 2: Design & Permitting Phase

Permitting w/ Regulatory Consultation

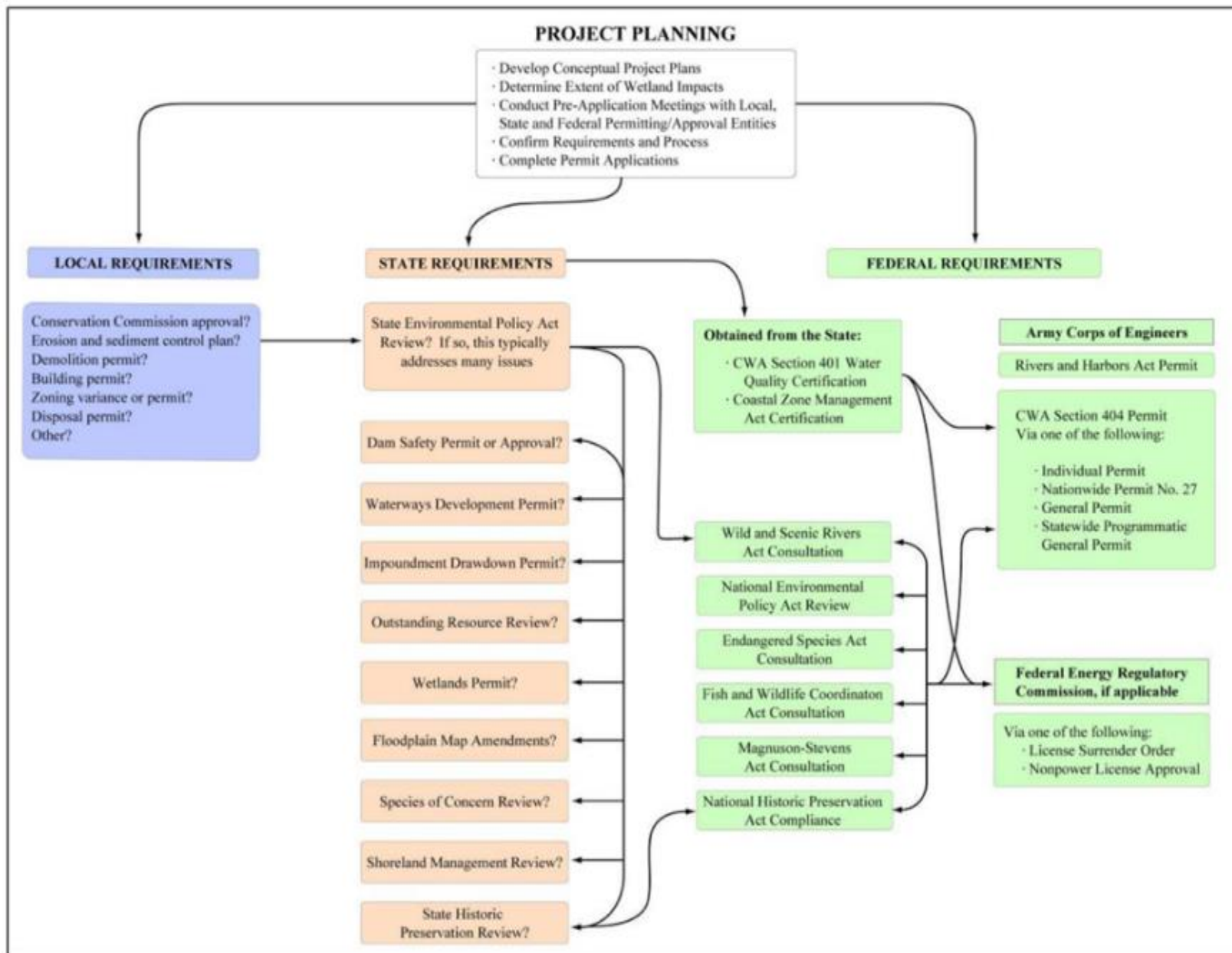


Step 3: Construction Phase

Step 4: Monitoring & Adaptive Management Phase

* Separate attachment
** Depends on how complicated the project is

Conceptual Permitting Flow Chart



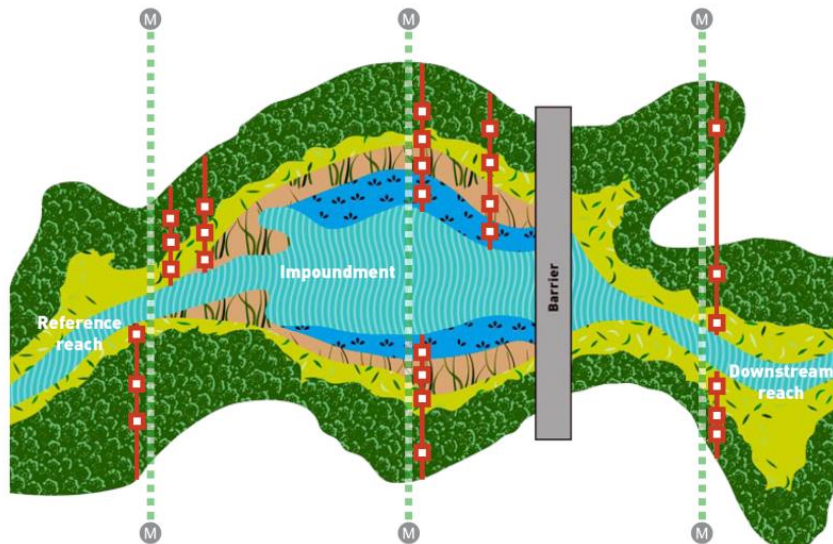


DATA FROM DESIGN CAN THEN BE USED AS THE PRE-REMOVAL DATA SETTING US UP FOR POST-REMOVAL MONITORING

DETAILED: When funds are available

RESOURCE MANAGEMENT FOCUSED: When funds are not available

STREAM BARRIER REMOVAL MONITORING GUIDE



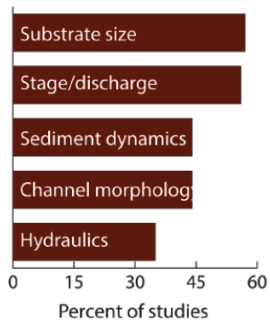
<http://www.gufofmaine.org/streambarrierremoval/>

USGS Powell Center: Review and Synthesis of Dam Removal Research in the US

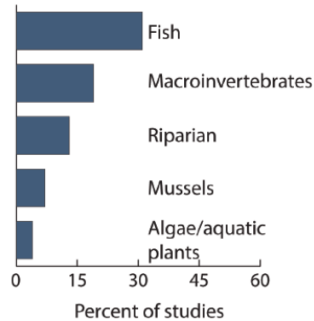
Gathered 600 dam removal studies – Analyzed 139 US studies with empirical data

Metrics Measured

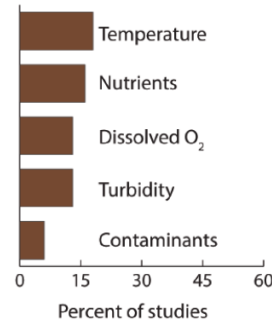
Physical



Biological

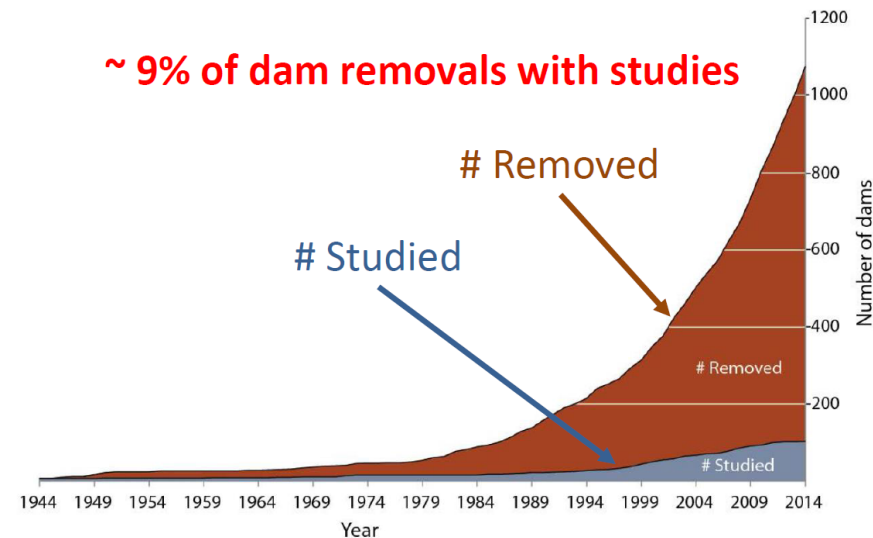


Water-quality



Bellmore et al. *In Review*

~ 9% of dam removals with studies



Bellmore et al. *In Review*

- This metadata was incorporated into a relational database, and published as a USGS data series

– Bellmore JR, Vittum KM, Duda JJ, and Greene SL. 2015. USGS Dam Removal Science Database. US Geological Survey.
<http://doi.org/10.5066/F7K935KT>.

- Can be accessed and downloaded on the web at: <http://doi.org/10.5066/F7K935KT>
 – Search for “USGS Dam Removal Science Database”

of Dams Removed





POTENTIAL DIFFERENCES BETWEEN USA & LITHUANIA REGARDING DAM REMOVALS

HOW KEY ISSUES MAY DIFFER IN LITHUANIA

- Different regulations that will define different “key” issues
- Longer history of infrastructure that could now be impacted with removal
- Different invasive species and water chemistry issues
- Stakeholders are at a different stage in the evolution of the concept of restoring river connectivity through dam removal



BEWARE: EUROPE HAS A HIGHER PERCENTAGE OF UNICORN HABITAT



Dam of Forest Kingdom/Les
Království, Czech rep.

A scenic photograph of a river flowing over mossy rocks. The water is a vibrant turquoise color, and the rocks are covered in green moss. The text "THANK YOU" is overlaid in the center in a large, white, sans-serif font.

THANK YOU

Laura Wildman, PE
w: 860-652-8911 c: 860-989-7966
lwildman@princetonhydro.com