Montana Association of Dam and Canal Systems

Is your Diversion Structure a "Drowning Machine"?

Actions you can take to Improve Safety

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Low Head Dam Definition

- "…a dam built across a stream to pass flows from upstream over all, or nearly all, of the width of the dam crest on a continual and uncontrolled basis…" Federal Register
- Purpose: to provide a stable upstream water level.

Other Low Head Dam Definitions

“a river-wide artificial barrier that generally spans a stream channel, blocking the waterway and creating a backup of water behind the barrier, with a drop off over the wall of not less than 6 inches and not more than 25 feet.” (33 U.S.C. § 467o)

“a dam or weir built across a stream to pass flows from upstream over all, or nearly all, of the width of the dam crest and does not have a separate spillway or spillway gates, but it may have an uncontrolled spillway. The dam crest is the top of the dam from left abutment to right abutment. A low-head dam may have been built for a range of purposes (e.g., check dam, mill dam, irrigation, water supply, recreation, hydroelectric, or cooling pond), but in all cases, it provides little or no storage function.” (USACE Nationwide Permit 53).

“a dam built across a stream to pass flows from upstream over all, or nearly all, of the width of the dam crest on a continual and uncontrolled basis” (Federal Register, 2017)

“a manmade in-channel structure in a watercourse that is capable of generating hazardous recirculating currents that pose a risk to public health and safety and causes the watercourse to have a vertical drop of twenty-five (25) feet or less” (Ind. Code Ann. § 14-27-7.3-2)

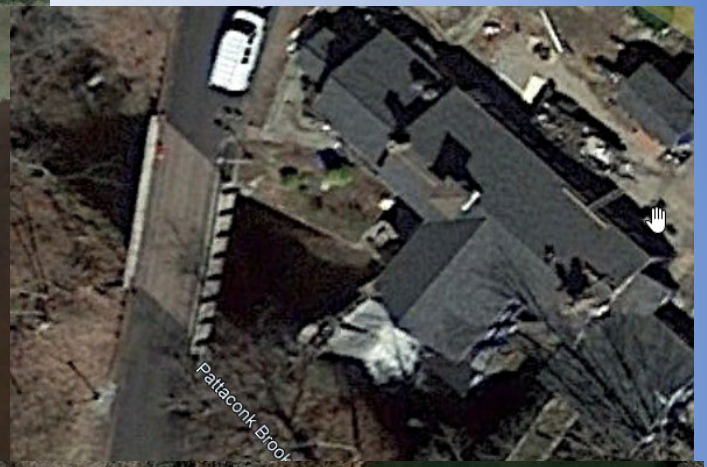
“a dam that is built across a river or stream for the purpose of impounding water where the impoundment, at normal flow levels, is completely within the banks, and all flow passes directly over the entire dam structure within the banks, excluding abutments, to a natural channel downstream” (Va. Code Ann. § 29.1-509A)

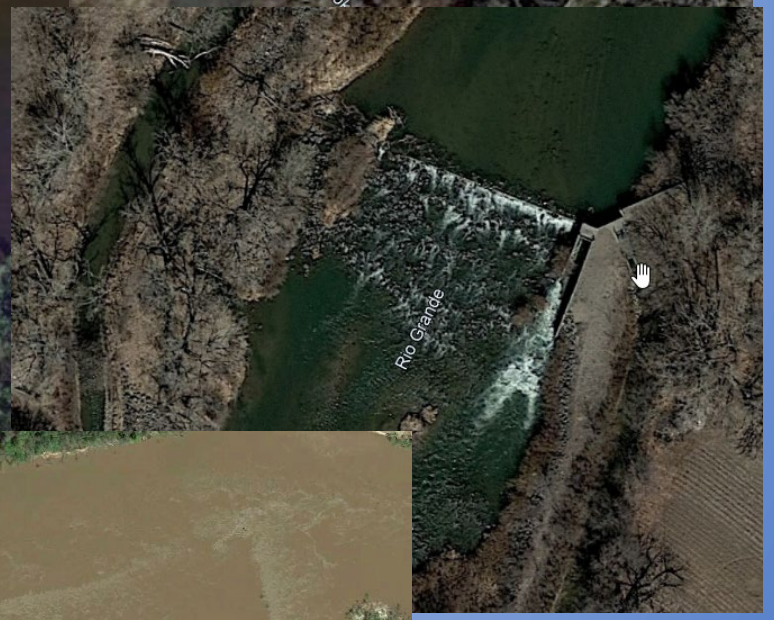
“a manmade structure which… (2) is built across a watercourse and certain flows pass over the entire dam structure, excluding abutments, to a natural channel downstream; and (3) the department determines to have hydraulic characteristics such that at certain flows persons may be caught in the hydraulic roller or boil immediately below the dam.” (30 Pa. Cons. Stat. § 3510(i))

“a manufactured structure, built in a river or stream channel, extending fully across the banks. A low-head dam is designed and built such that water flows continuously over the crest from bank to bank.” (American Society of Civil Engineers)

“a manmade structure spanning a river or stream channel in which water flows over the top of the dam.” (Low-head Dam Public Safety Awareness Month Proclamation)

Example Dams





Noticeable Features

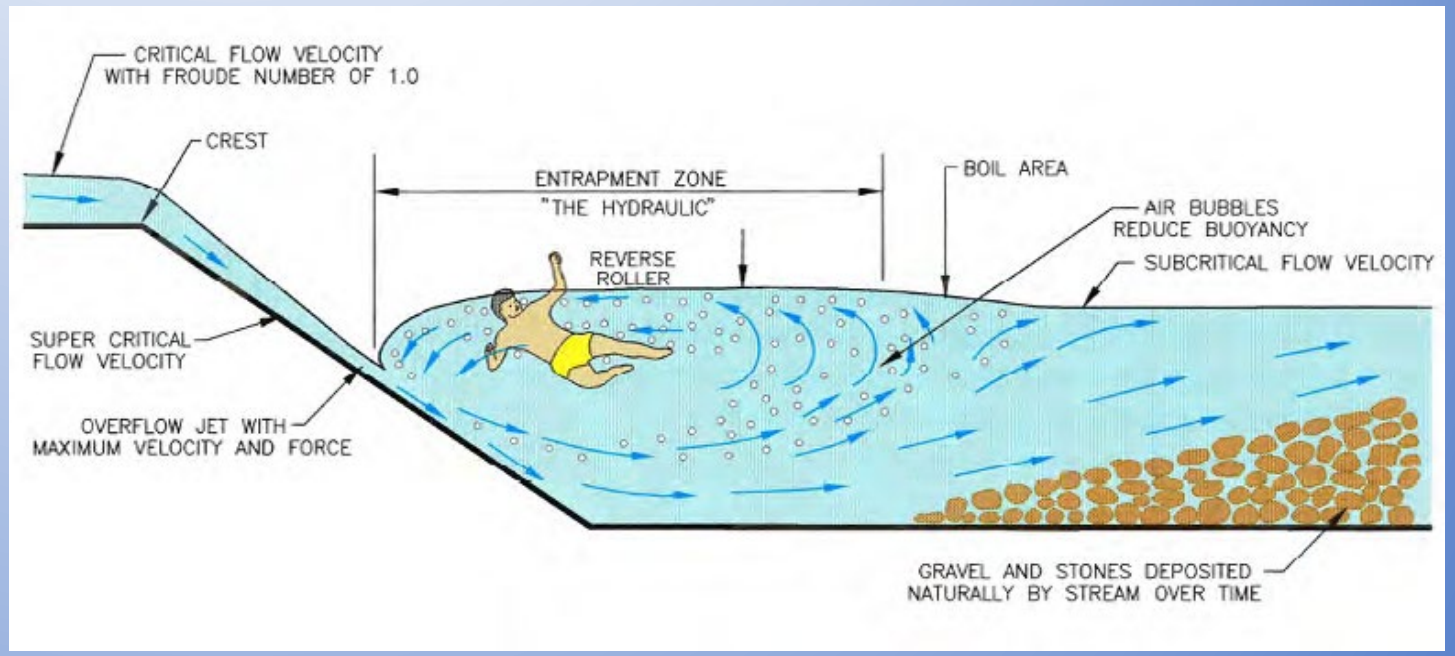
- There is often a noticeable drop in water elevation when not “flooded out”, although this drop may only be a few inches.
- Low Head Dams often have smooth water upstream of the dam.
- There is often a noticeable “boil” downstream of the dam.
- Under some hydraulic conditions, there is an aerated zone at the bottom of the dam.

Names for a Low Head Dam

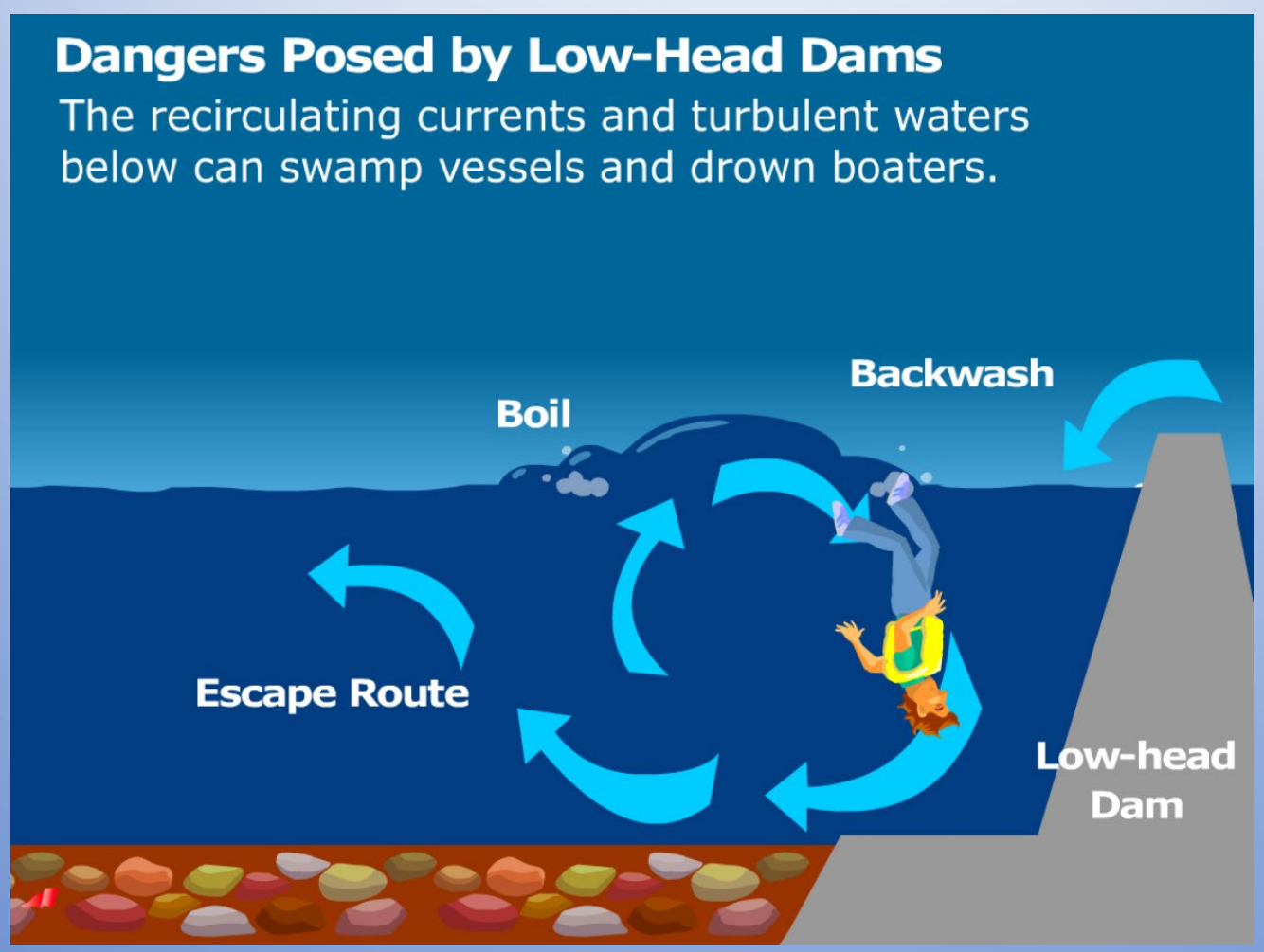
- Low Head Dam
- Diversion Dam
- Sill (common in the south)
- Weir
- Run of the River Dam (common in the east)
- Check Dam

Primary Danger: Submerged Hydraulic Jump

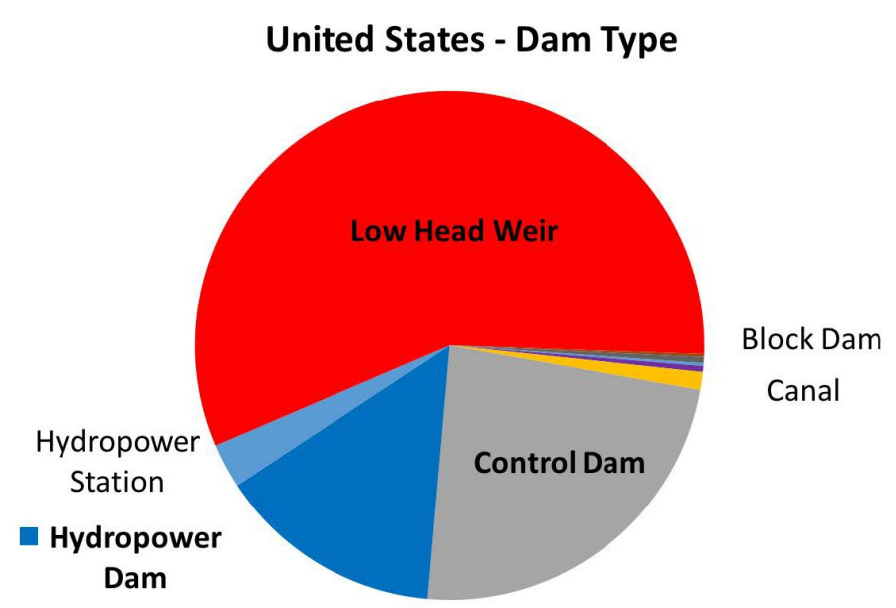
- When water level increases downstream it creates a submerged hydraulic jump and recirculation zone
- Approximately 1,000 people have drowned at LHDs
- Aka “Keeper”, “Hydraulic”, “Drowning Machine”

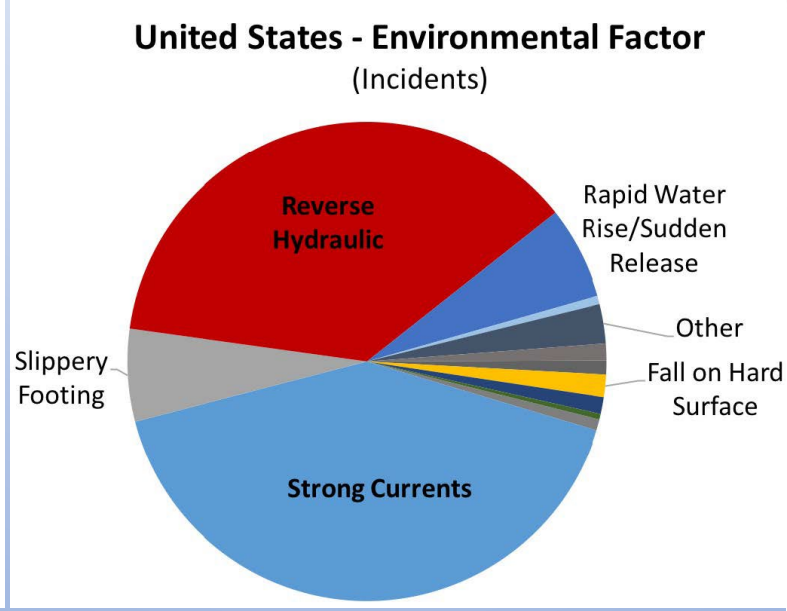


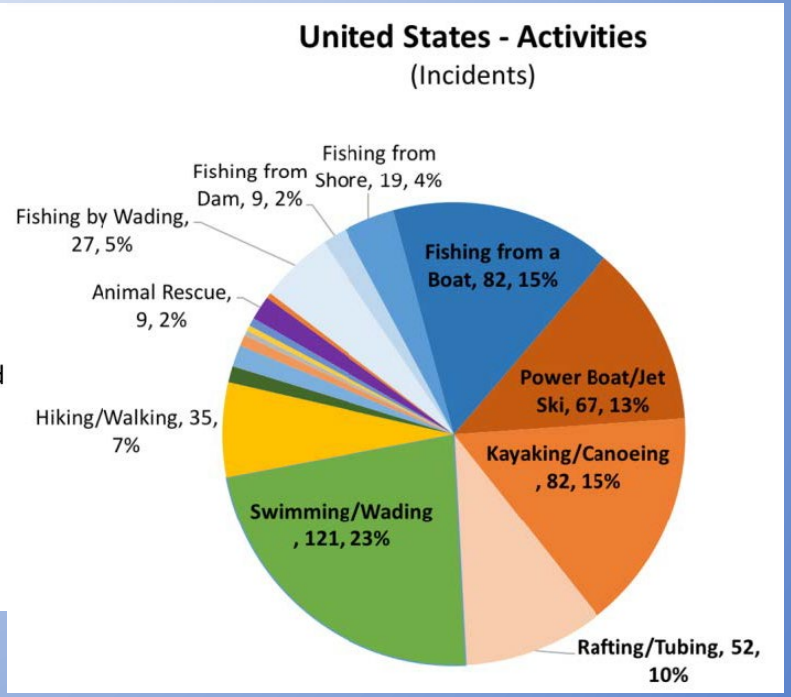
Danger of Submerged Jump (Hydraulic) at a Low Head Dam



Deaths and Incidents at Low Head Dams

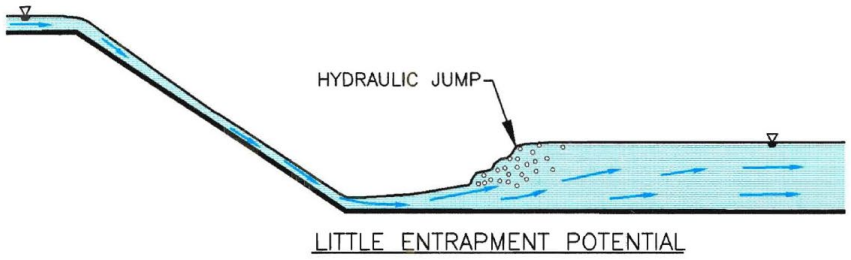






Research, analysis, and graphics courtesy of Tony Bennett of the Canadian Dam Association and International Commission on Large Dams.

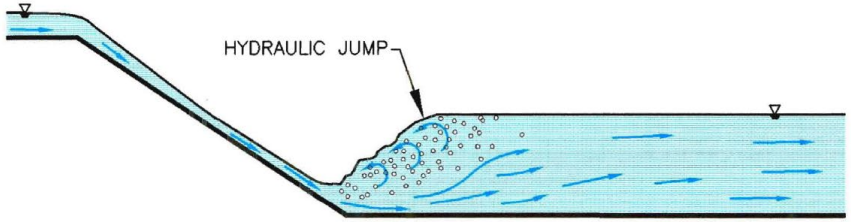
Various Hydraulic Conditions can Occur at Low Head Dams at Different Times



LITTLE ENTRAPMENT POTENTIAL

CASE I

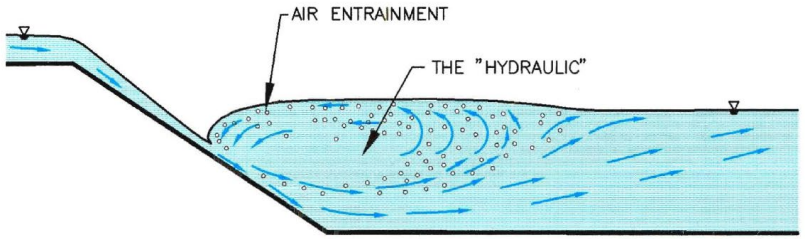
- LOW TAILWATER WITH SWEPT–OUT JUMP
- PERSONS WILL USUALLY BE SWEPT DOWNSTREAM



MODEST ENTRAPMENT POTENTIAL

CASE II

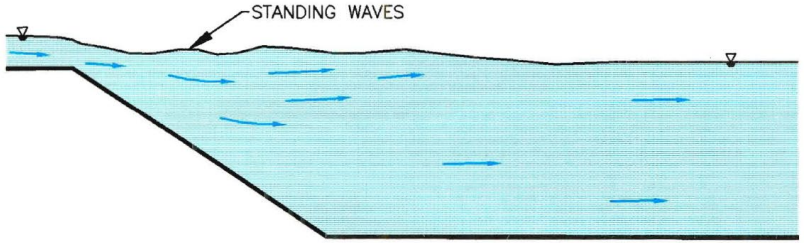
- NORMAL TAILWATER WITH OPTIMUM JUMP.
- MODEST ENTRAPMENT FOR PERSONS, ALTHOUGH LOGS AND SIDEWAYS CANOES CAN GET TRAPPED IN SMALL "HOLE".



HIGH ENTRAPMENT POTENTIAL
EXTREME HAZARD WITH TRANQUIL APPEARENCE

CASE III

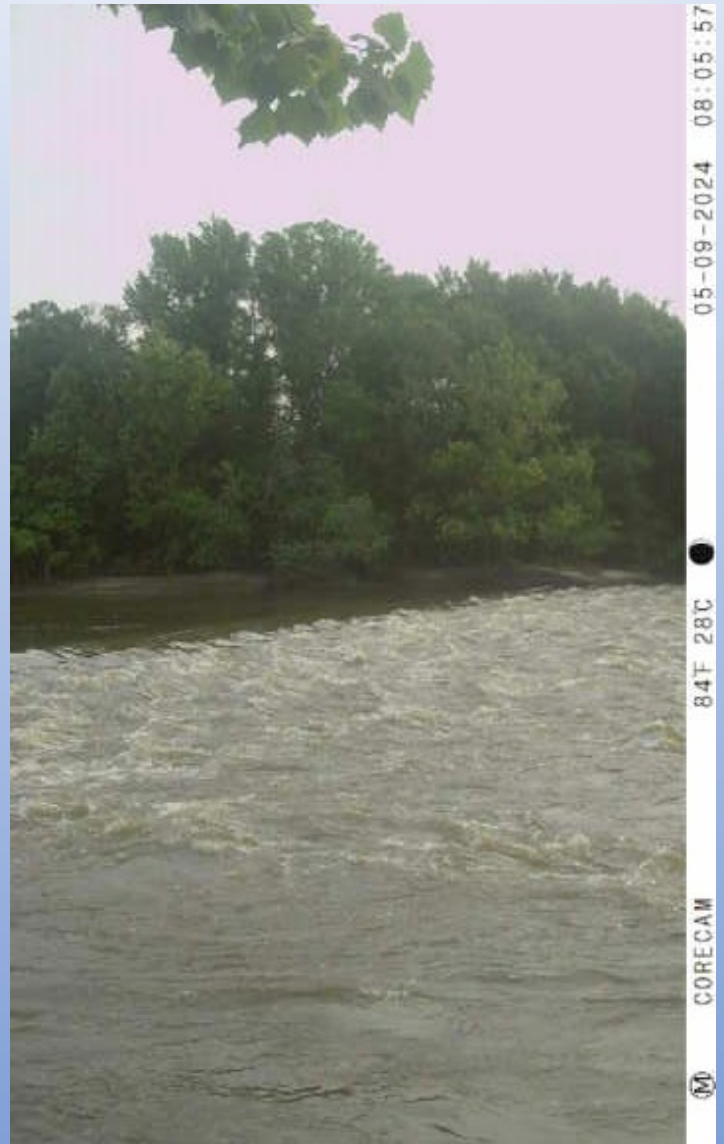
- HIGH TAILWATER WITH SUBMERGED HYDRAULIC JUMP
- THE RESULTING "HYDRAULIC" WILL TRAP A PERSON IN THE REVERSE ROLLING CURRENT
- RESCUE BOATS WILL BE "SUCKED" TOWARDS FALLING JET
- DIVING TO THE BOTTOM MAY CAUSE THE PERSON TO BE CARRIED DOWNSTREAM



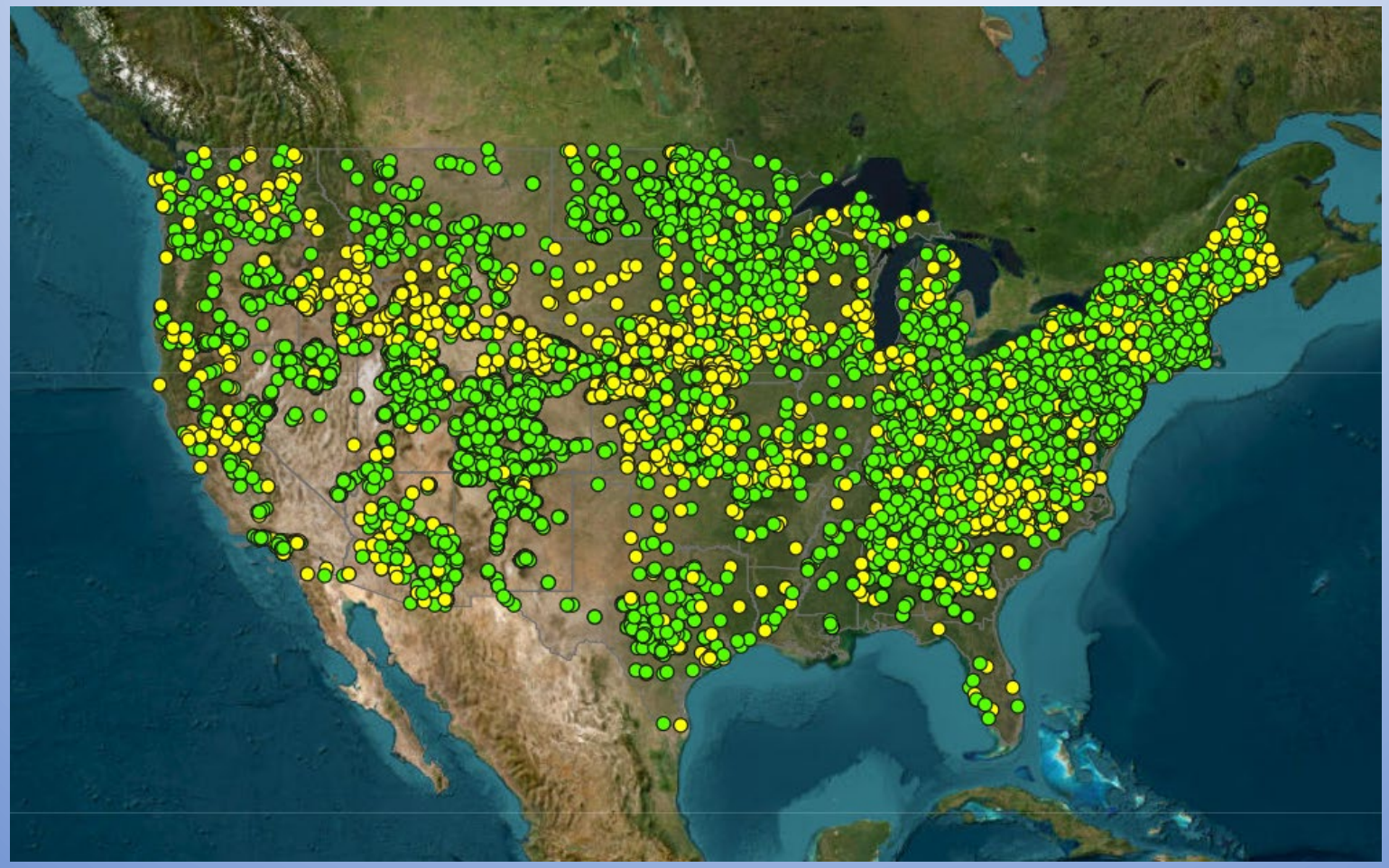
CASE IV

- VERY HIGH TAILWATER ASSOCIATED WITH HIGH FLOWS INUNDATES THE DROP STRUCTURE
- NO HYDRAULIC JUMP OCCURS
- NO UNUSUAL HAZARD TO PERSONS OR BOATS

Various Hydraulic Conditions can Occur at Low Head Dams At Different Times



National Inventory of Low-head Dams (2023)



National Inventory of Lowhead Dams (arcgis.com)

Task Force to Create a National Inventory

- Most LHDs are ‘non-jurisdicitonal’
  - Not part of the National Inventory of Dams
  - Not part of most State dam inventories
  - Not inspected or recognized
- Task Force organized in 2020
- “Alpha” version completed in 2023
- “Beta” version will be complete in 2025
- “USACE” version possibly available 2026/2027?

Photo courtesy of Bruce Rogers

2014 ASDSO Low Head Dam Survey

State	Confid. Level (%)	Est. LH dams (low end of range)	Est. LH dams (high end of range)	Actual Inventory reported
AK	5	1	50	
*AL				
AR	75	1	50	
AZ		Do not know		
CA		None known - no inventory or jurisdiction		
CO	25	200	300	
CT	75	1	50	
DE	100			30
FL	100			3
*GA				
HI	25	1	10	
IA	100			246
ID		dozens	hundreds	
IL	90	200	300	
IN	20	100	200	
KS	75	50	100	
KY	100			16
LA		Numbers not available		
*MA				
MD	50	100	200	
ME	50	0	0	
*MI				
MN	100			50
MO	80	50	100	

State	Confid. Level (%)	Est. LH dams (low end of range)	Est. LH dams (high end of range)	Actual Inventory reported
MS	50	1	50	
MT	10	500	500	
*NC				
ND	100			64
NE	50	1	50	
NH	100			244
NJ	75	100	200	
NM	50	1	50	
NV	30	100	200	
NY	10	200	300	
OH	75	100	200	
*OK				
OR	50	1	100	
PA	100			253
RI	N/A			
*SC				
SD	80	1	50	
TN	90	1	50	
TX	25	100	200	
UT		Several but no inventory		
VA	50	1	50	
*VT				
WA	10	1	50	

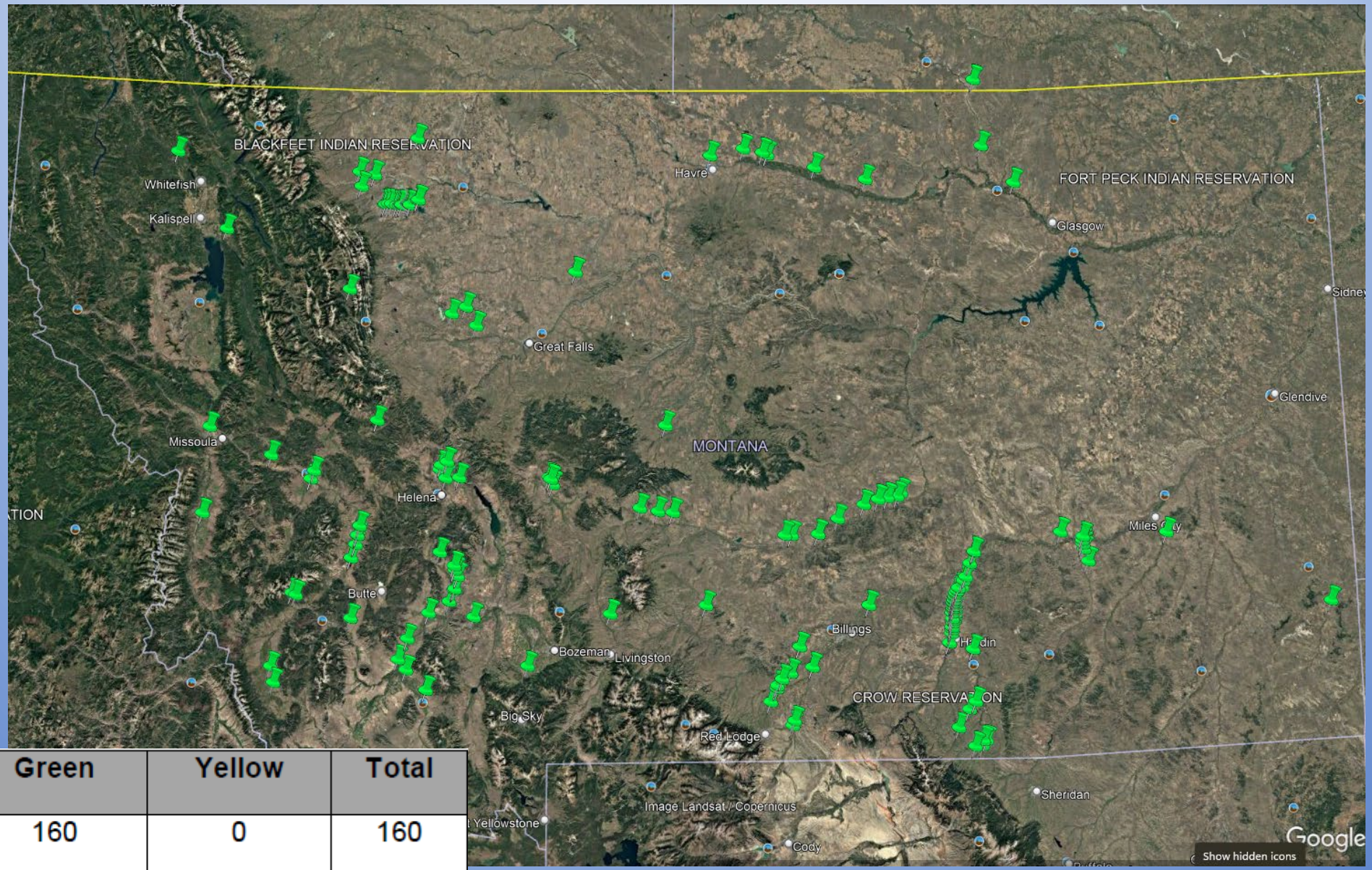
State (cont)	Confid. Level (%)	Est. LH dams (low end of range)	Est. LH dams (high end of range)	Actual Inventory reported
TOTALS		1814	3510	916

2020-2023 LHD INVENTORY
13,453 DAMS

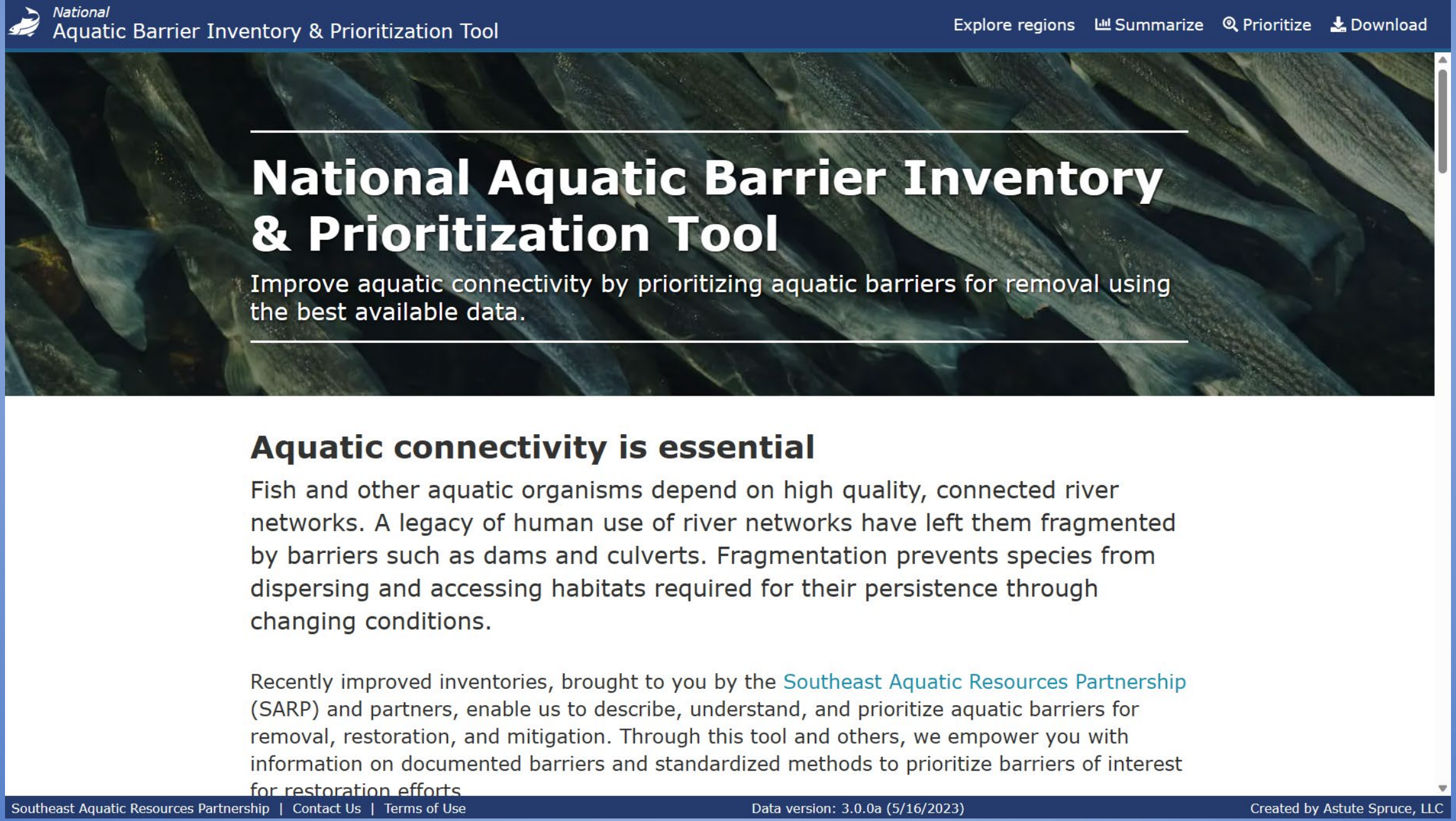
Counts By State

State: OH	Count: 183	State: SC	Count: 31
State: PA	Count: 484	State: RI	Count: 53
State: MD	Count: 92	State: DE	Count: 72
State: WV	Count: 67	State: OK	Count: 20
State: MO	Count: 104	State: VT	Count: 299
State: MI	Count: 142	State: NH	Count: 363
State: IN	Count: 148	State: NY	Count: 585
State: MN	Count: 377	State: UT	Count: 503
State: None	Count: 10	State: TN	Count: 127
State: ND	Count: 115	State: VA	Count: 151
State: WI	Count: 74	State: WY	Count: 325
State: ID	Count: 584	State: IA	Count: 370
State: ME	Count: 550	State: GA	Count: 108
State: LA	Count: 11	State: CO	Count: 1107
State: KY	Count: 275	State: AR	Count: 21
State: KS	Count: 291	State: TX	Count: 237
State: MT	Count: 160	State: OR	Count: 226
State: MS	Count: 23	State: WA	Count: 135
State: NV	Count: 714	State: MA	Count: 508
State: CA	Count: 317	State: AZ	Count: 205
State: NE	Count: 1626	State: FL	Count: 12
State: SD	Count: 50	State: AL	Count: 63
State: NM	Count: 736	State: CT	Count: 340
State: NC	Count: 187	State: NJ	Count: 212
		State: IL	Count: 60

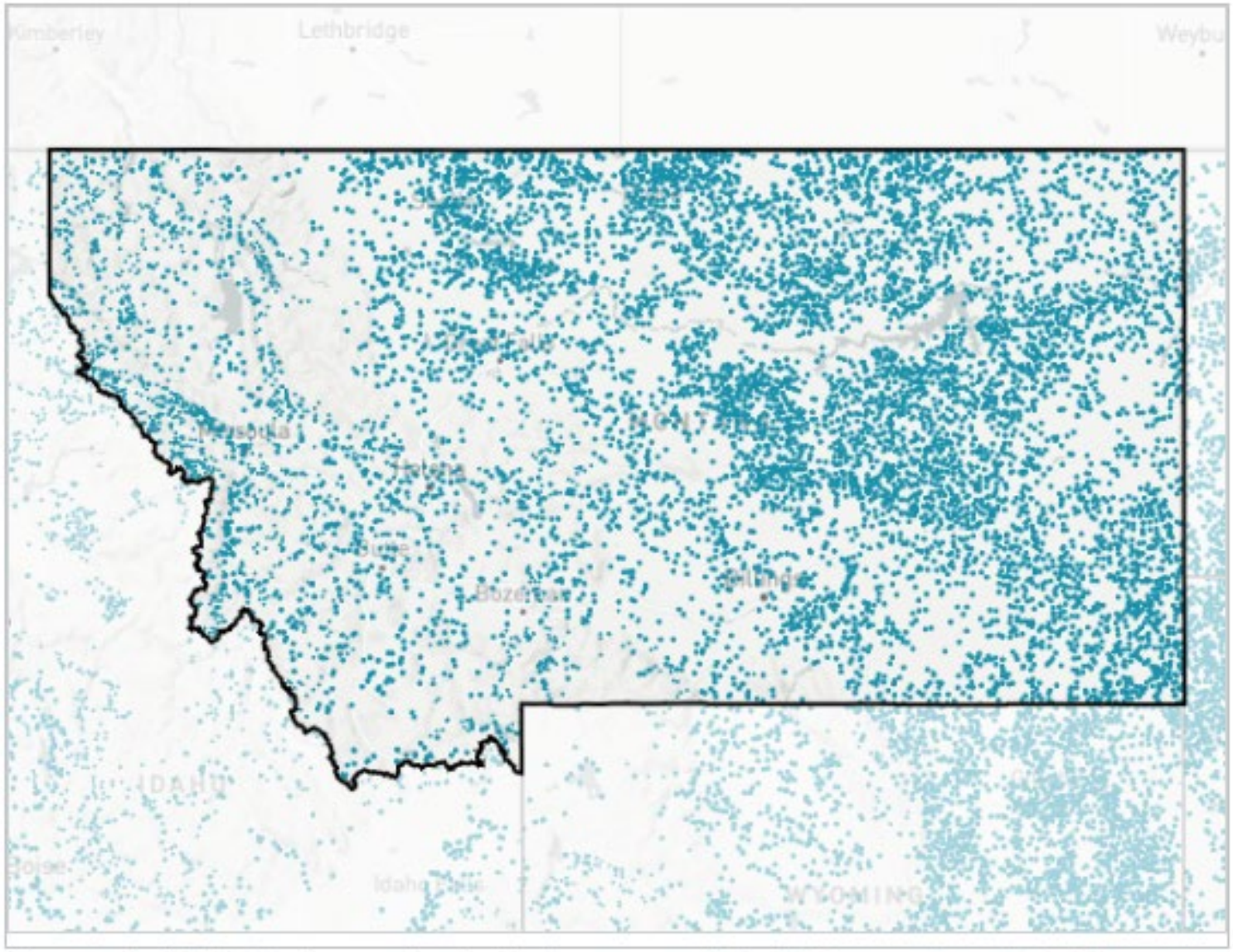
Montana Low Head Dams in “Alpha” Inventory



State	Green	Yellow	Total
Montana	160	0	160



Aquaticbarriers.org



Map of 15,982 inventoried dams and 3,649 road-related barriers likely to impact aquatic organisms in Montana.

Example Montana Low Head Dam Incident

- Supply Ditch Headgate Diversion Dam on the Bitterroot River.
  - Pre 2011 – History of accidents at low head dam and frequent calls for help from Ravalli County Search and Rescue and Fire Departments; Some signs in place;
  - 2011 - High water caused that stretch of the Bitterroot to shift, sending the main river (and more boaters) through the eastern channel;
  - **June 23, 2013 - 6-Year-Old Girl Killed after her father's boat went over the dam and capsized;**
  - 2014 – Conservation District places signs at boat put-ins upstream from dam and near dam;
  - 2017 – Conservation District spent $500,000 to modify the structure to make it safer to boaters.
    - $300,000 from USACE,
    - $125,000 from DNRC RRGL Grant Program,
    - $40,000 from Montana FWP.

Example Montana Low Head Dam Incident

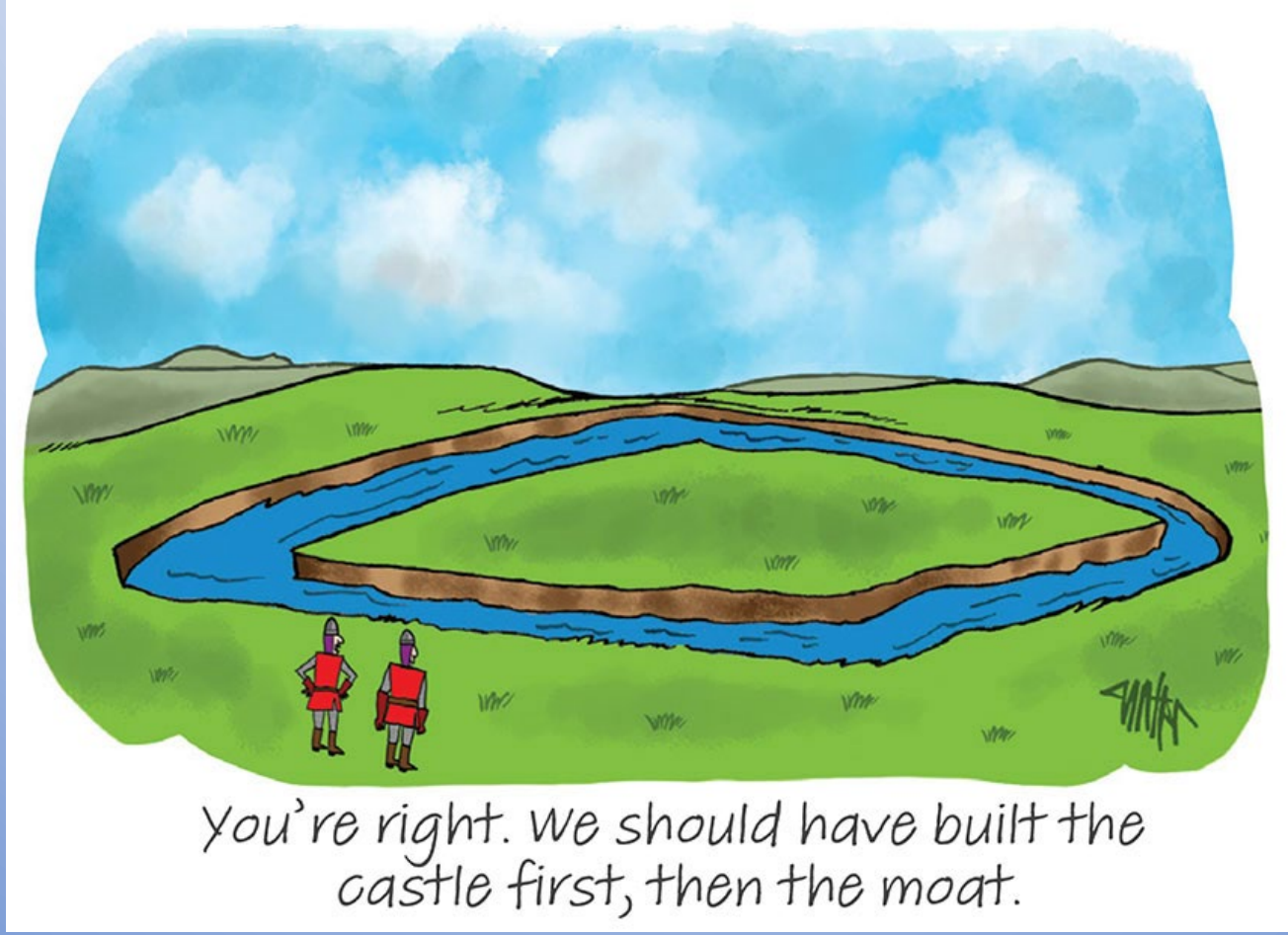
- Supply Ditch Headgate Diversion Dam on the Bitterroot River

Pre-Construction (2013)

Construction

Post-Construction

REHABILITATION

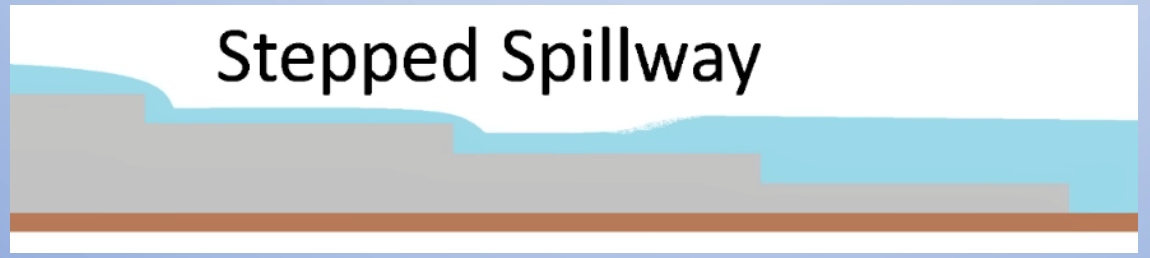


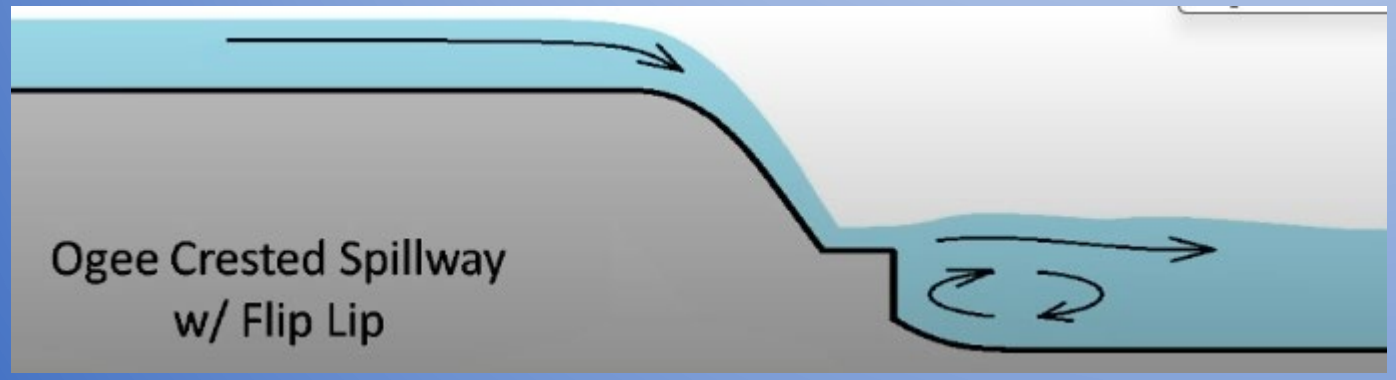
Design Considerations

- Is Structure Still Needed?
- Tailwater
- Frequency of Hydraulic
- Passage of People
- Scour and Deposition
- Passage of Debris
- Cost
- Fish Passage
- Passage of Ice
- Ownership
- Permits (404, 310, 401, 318, etc.)
- Partners?
- Risk
- Timing
- Maintenance
- Environmental Risks
- Water Rights

Rehabilitation Options, What can I do?

- Signage
- Construction
  - Rock Ramp or Rapids
  - Concrete Stepped Spillway Drop
  - Dedicated Stilling Basin or Constructed Drop
  - Boat Chute
  - Flipped Lip



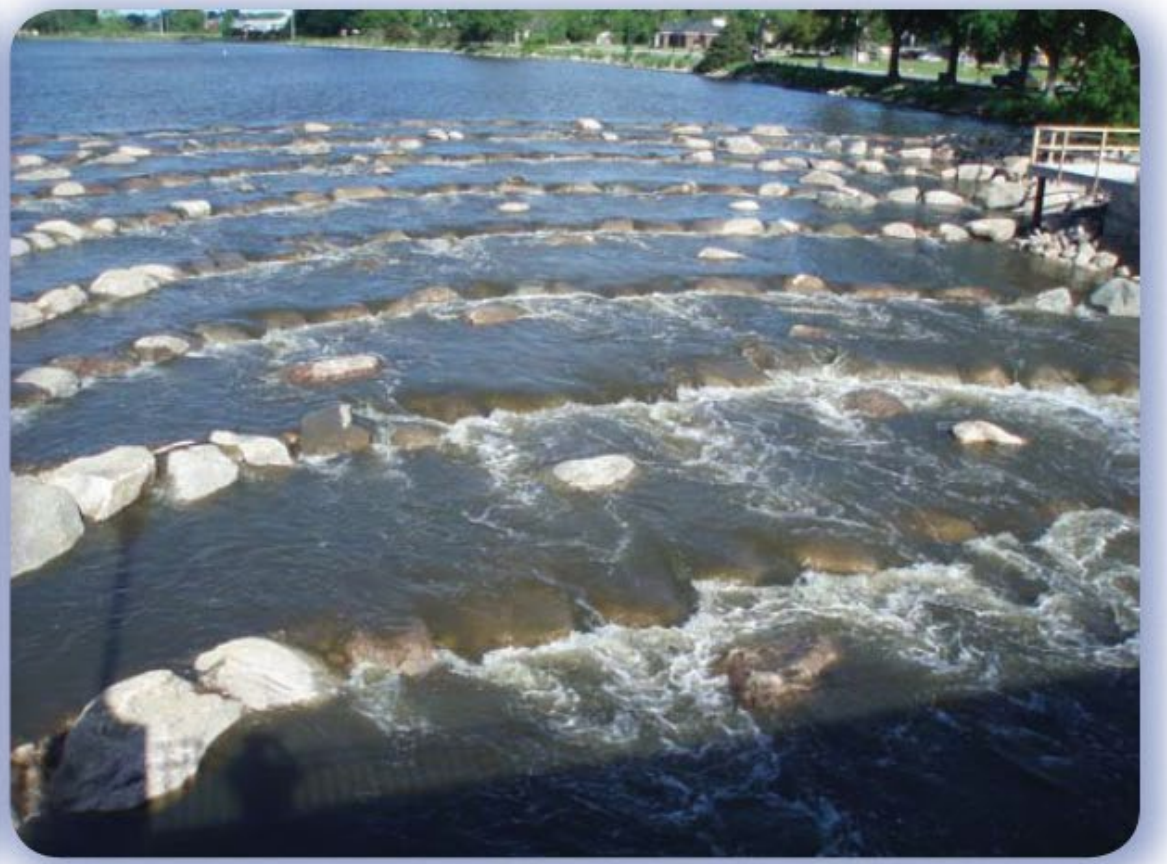


ROCK RAMP

Before

Upstream view of dam from right bank

After

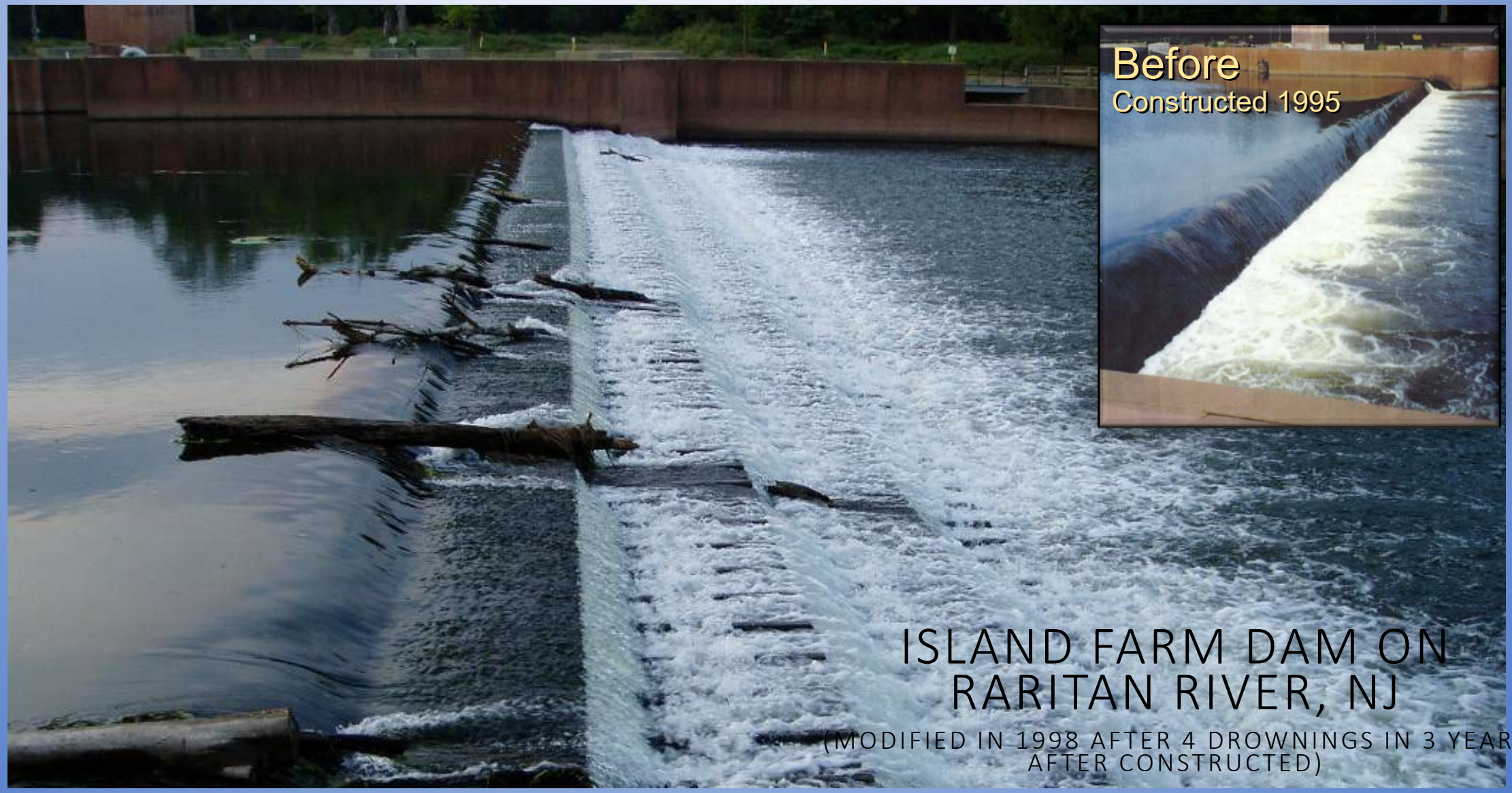


Upstream view of completed ramp

COURTESY OF MINNESOTA DNR – RECONNECTING RIVERS

COMPLEX STRUCTURAL MODIFICATION

After



ISLAND FARM DAM ON RARITAN RIVER, NJ

(MODIFIED IN 1998 AFTER 4 DROWNINGS IN 3 YEARS AFTER CONSTRUCTED)

SIGNS

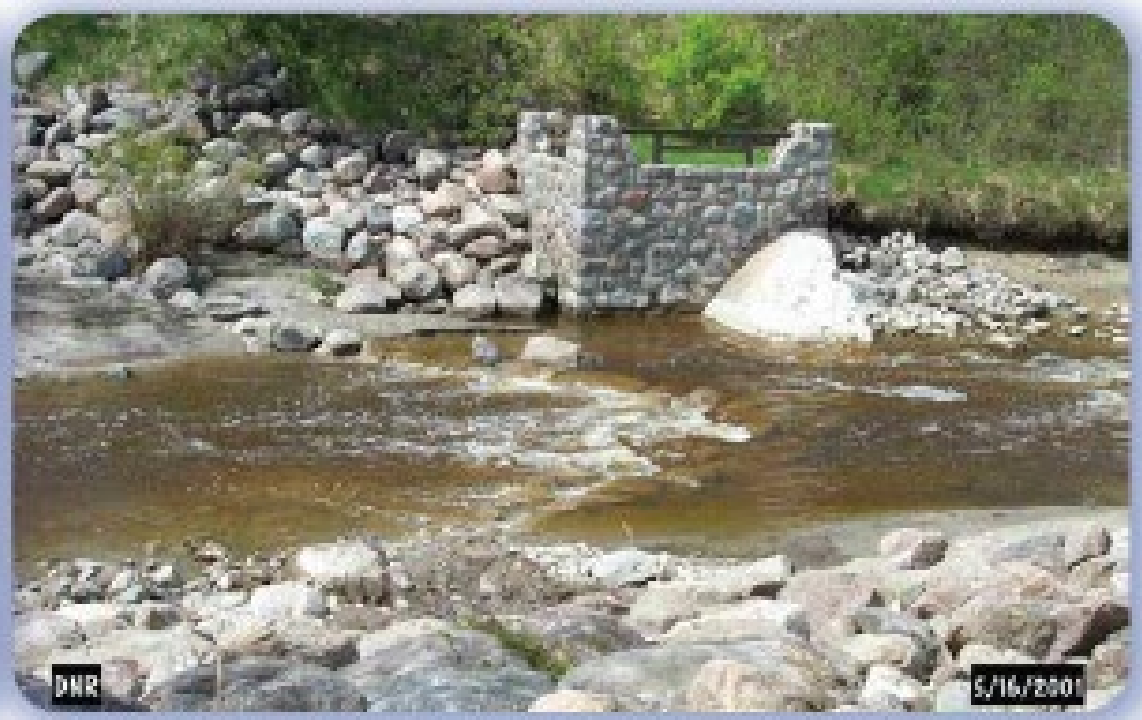
PHOTOS COURTESY OF COLORADO DNR AND CPW

REMOVAL

Before

Upstream view of dam during high flow

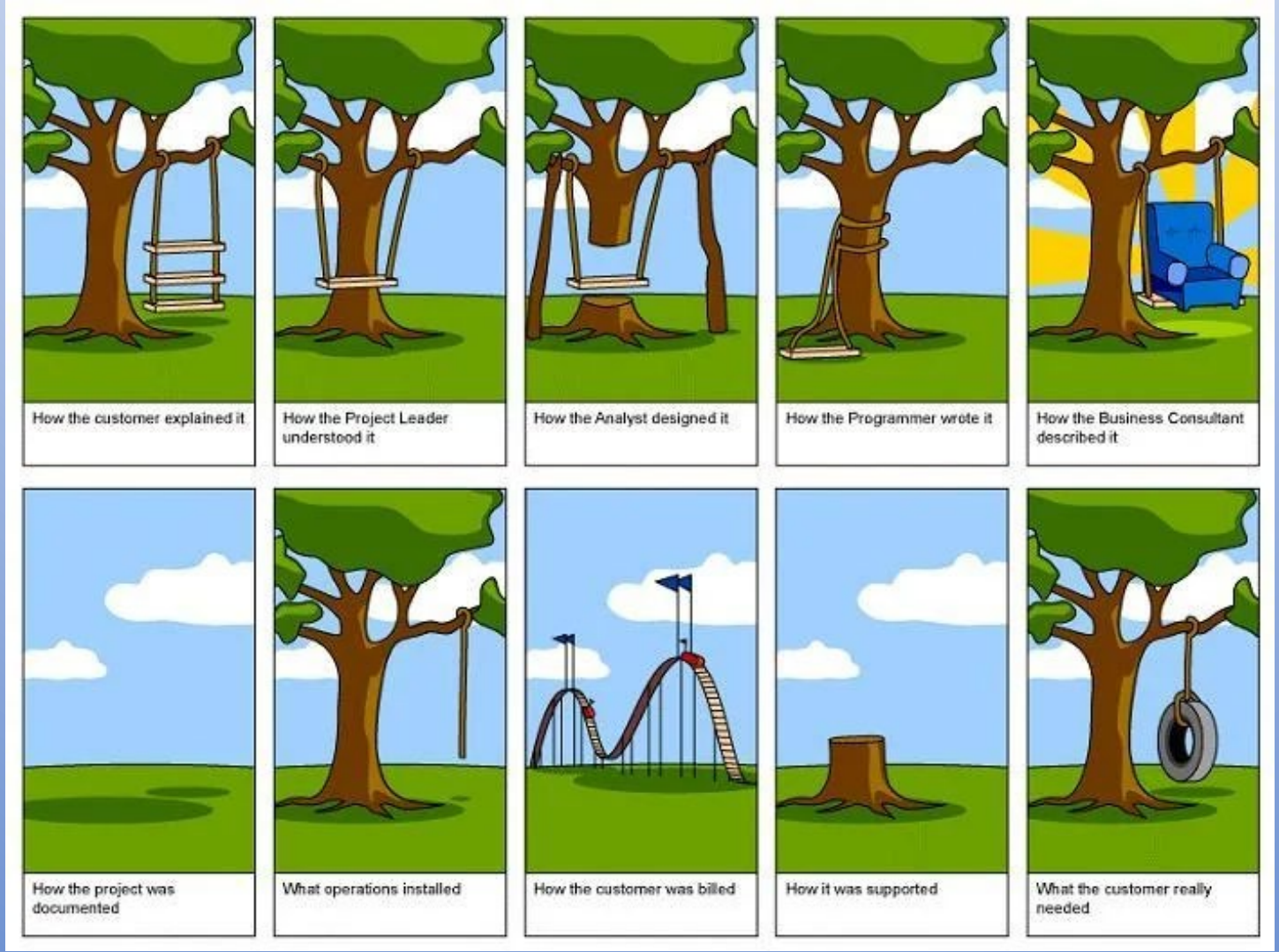
After



Upstream view of removed dam and constructed boulder weir

COURTESY OF MINNESOTA DNR – RECONNECTING RIVERS

WHAT OBSTACLES TO IMPROVING SAFETY ARE THERE AND HOW CAN THESE BE ADDRESSED?



CONSIDERATIONS

- OWNERSHIP
- FEAR OF LIABILITY
- FINANCING
- HISTORIC NATURE OF STRUCTURE
- RECREATION, FISHING AND AESTHETICS OF UPSTREAM POOL
- MICRO-HYDRO AND OTHER BUSINESS INTERESTS

OWNERSHIP

Possible Owners

- PRIVATE OWNERSHIP
- PUBLIC OWNERSHIP
- UNKNOWN OWNERSHIP
- SPLIT OWNERSHIP
  - OWNER OF LAND
  - OWNER OF WATER
  - OWNER OF STREAMBED

Ways to Identify Owners

- Public land ownership records (county assessor)
  - Montana Cadastral
- Public water rights records
- Facilities and organizations associated with the dam
- Water Systems, ditches, etc.
- State statutes

IDENTIFY AND ENGAGE OWNERS EARLY ON!

APPEARANCE OF LIABILITY AND RISK

The public safety surrounding the premises of the dam is usually assumed to be the responsibility of the owner, as they are responsible for the safety of the dam itself. (New Hampshire Department of Environmental Services [NHDES], 2011).

Dam owners and property owners potentially bear the risk of liability in the event of an accident whether signs are present or not. Furthermore, the installation of signs actually reduces the likelihood of an incident occurring and thereby reduces the owner's risk of liability.

Some states have recreational use statutes that allow for public use of privately owned land for recreational purposes and which shield private landowners from liability for people who are injured while recreating on their land (NPS, 2016).

By placing warning signs and reducing the risk of an incident, the dam or property owner is helping to protect themselves, as well as the public.

FINANCING

DEPENDING ON SCOPE, REHABILITATION MAY COST ANYWHERE FROM $5,000 TO $5,000,000.

SIGNS MAY ONLY COST $1,000 - $10,000.

MANY FUNDING SOURCES AVAILABLE

COST & RISK OF DOING NOTHING?

A RECENT LAWSUIT SETTLED FOR $2.5M/FATALITY

HISTORIC NATURE OF STRUCTURE

Weigh the benefits of keeping the dam versus the potential risk that it poses in terms of safety.

Can the historic portion (abutments, etc.) of the dam be saved while also improving public safety?

Would placement of historic signs allow for rehabilitation?

RECREATION, FISHING AND AESTHETICS

CAN UPSTREAM POOL BE MAINTAINED?

IS THE AREA A HEAVILY USED RECREATION CORRIDOR?

WOULD REMOVAL OR RETROFIT OF THE DAM IMPROVE FISH PASSAGE AND WATERWAY CONNECTIVITY?

WOULD REMOVAL OR RETROFIT OF THE DAM ELIMINATE AN INVASIVE FISH SPECIES BARRIER?

VISIT THE SITE, ENGAGE THE PUBLIC AND DISCUSS WITH STATE FISH AND WILDLIFE DEPARTMENT

MICRO-HYDRO AND OTHER BUSINESS INTERESTS

IS THE FACILITY REGULATED BY THE FERC?

REMOVAL MAY NOT BE AN OPTION, BUT REHABILITATION OR SIGNAGE?

OWNER HAS ACTIVE FINANCIAL INTEREST IN MAKING DAM SAFE.

QUESTIONS?

Contact Information

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