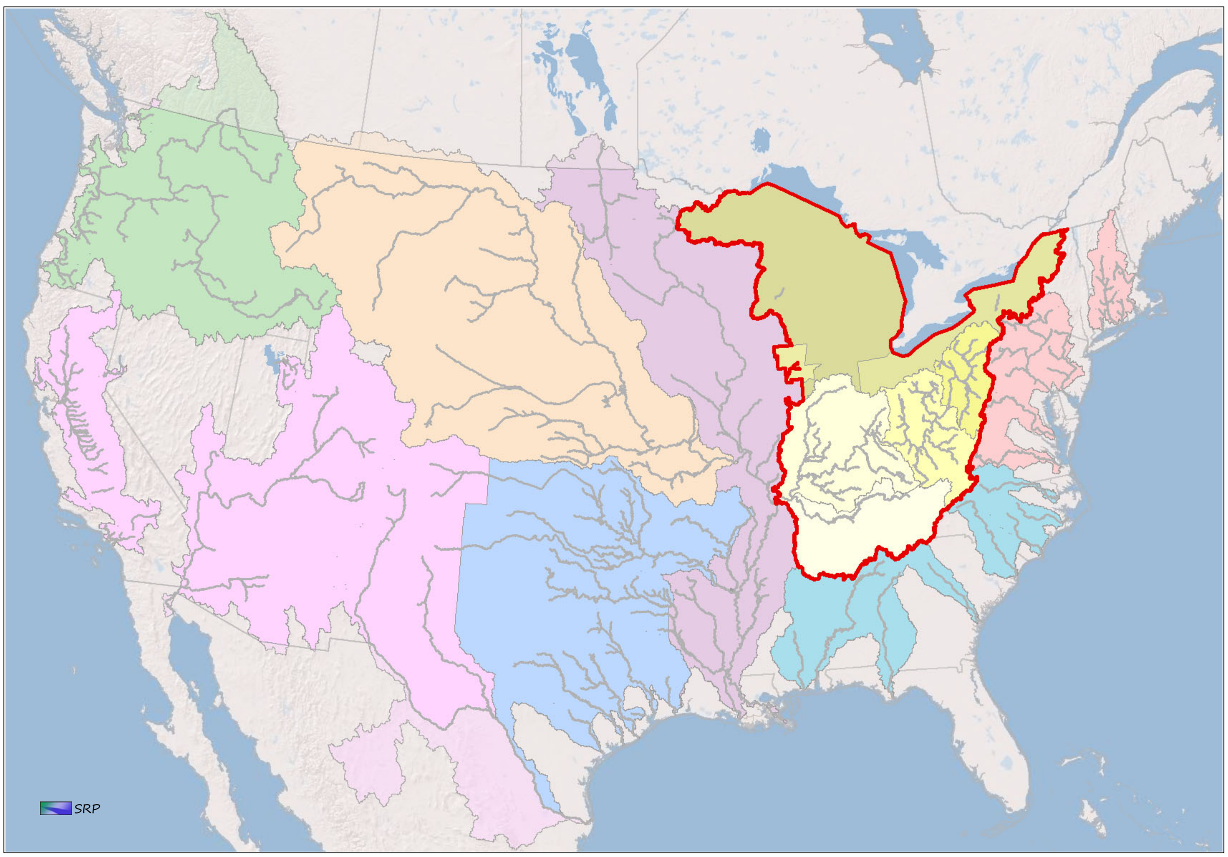
Sustainable Rivers Program

Environmental Opportunities for Rivers and Reservoirs in the Lakes and Rivers



Regional Operations and Water Management Meeting

Lakes and Rivers Division and Buffalo, Chicago, Detroit, Huntington, Louisville, Nashville, and Pittsburgh Districts

April 2024

Executive Summary

The Lakes and Rivers Operations and Water Management Meeting was held November 7-8, 2023. The purpose of the meeting was to identify environmental improvement opportunities at U.S. Army Corps of Engineers (Corps) involved reservoirs and related Civil Works water management infrastructure in the Lakes and Rivers region that are feasible to implement and are likely to provide compelling potential benefits. This report documents the meeting and the discussions held in plenary and breakout sessions. This is not a decision document; no specific recommendations are made. However, this report is intended for use by district and regional Corps staff considering opportunities and priorities for environmental improvement at water management infrastructure in the Lakes and Rivers region.

The Lakes and Rivers region is defined as the geographic area containing seven Corps Districts within Lakes and Rivers Division (LRD): Buffalo (LRB), Chicago (LRC), Detroit (LRE), Huntington (LRH), Louisville (LRL), Nashville (LRN), and Pittsburgh (LRP). Districts are responsible for Corps Civil Works water resource projects within a geographic area that encompasses the Ohio River basin and Great Lakes watershed areas within the United States of America (Figure 1). More than 79 reservoirs, affecting flows for 6,660 river miles within the region, were considered.

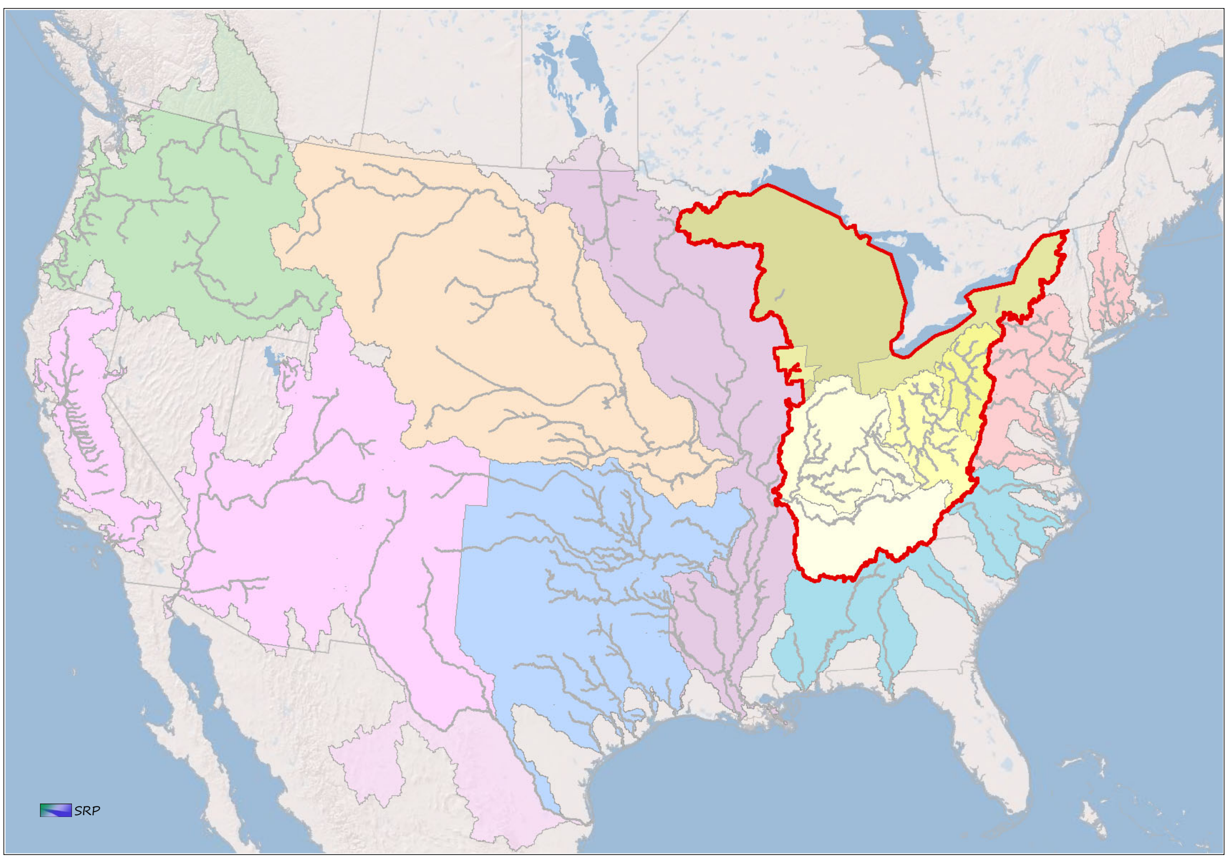


Figure 1. Geographic scope of the Lakes and Rivers Regional Meeting.

In formulating and evaluating environmental opportunities, location-based teams followed these steps:

1) list possible environmental improvement actions associated with reservoirs and water management infrastructure;
2) rate environmental potential of each action;
3) rate degree to which each action has been implemented;
4) select environmental actions with unrealized implementation; and,
5) rank reservoirs and water management infrastructure according to which are most promising for operational changes related to selected actions.

Identified actionable ideas, or combinations of environmental action and candidate reservoirs and water management infrastructure, are highlighted in the report and summarized in Table 1.

Table 1. Priority actionable ideas, Lakes and Rivers region.

Location-based team	Environmental Action	Reservoir(s)
Buffalo	Water Quality - Multiple variables	Black Rock Lock and Dam (L&D)
Buffalo	Debris management	Black Rock L&D, Mount Morris Dam
Buffalo	Physical habitat - Seasonal wetland creation (vernal pools / seasonal wetlands)	Mount Morris Dam
Buffalo	Invasive species control - native plant establishments	Mount Morris Dam
Buffalo	Upstream sediment management partnerships	Mount Morris Dam
Chicago	Water quality - Nutrients	Mississinewa Dam, J. Edward Roush Dam, Salamonie Dam
Chicago	Life stage support - Fisheries	Mississinewa Dam, J. Edward Roush Dam, Salamonie Dam
Chicago	Life stage support - Mussels	Mississinewa Dam, J. Edward Roush Dam, Salamonie Dam
Chicago	Water quality - Temperature	Mississinewa Dam
Detroit	Rate of flow change management to minimize fish stranding	Soo Locks
Detroit	Suppressing - Water level management for fisheries	Soo Locks
Detroit	Support - Water level management for fisheries	Soo Locks
Huntington	Geomorphic process support	Delaware Dam, R.D. Bailey Dam, Sutton Dam
Huntington	Floodplain connectivity	Alum Creek Dam, Delaware Dam, Senecaville Dam

Huntington	Life stage support - Mussels	Burnsville Dam, Paint Creek Dam, Sutton Dam
Huntington	Fish passage (locks and dams)	Captain Anthony Meldahl Locks and Dam
Huntington	Support - Water level management for water birds (migration period; dry dams)	Mohawk Dam
Louisville	Support - Water level management for fisheries	Nolin River Dam, Patoka Dam
Louisville	Floodplain connectivity	Barren River Dam, Patoka Dam, Taylorsville Dam
Louisville	Life stage support - Fisheries and mussels	Barren River Dam, Cave Run Dam, Green River Dam, Nolin River Dam, Taylorsville Dam
Louisville	Support - Water level management and life stage support - Shorebirds, gulls, other migrants	Patoka Dam
Louisville	Water quality - Temperature	Barren River Dam, Cave Run Dam, Taylorsville Dam
Louisville	Fish passage	Green River L&D 1, Green River L&D 2
Nashville	Life stage support - Fisheries	Center Hill Dam, Dale Hollow Dam, Wolf Creek Dam
Nashville	Support - Water level management for vegetation	Center Hill Dam, Dale Hollow Dam, Wolf Creek Dam
Nashville	Downstream Life stage support - Fisheries and benthics	Dale Hollow Dam, Wolf Creek Dam
Nashville	Water Quality – Temperature and Dissolved Oxygen	Dale Hollow Dam, J. Percy Priest Dam
Nashville	Fish passage	Cordell Hull L&D
Pittsburgh	Support - Water level management for fisheries	Berlin Dam, Kinzua Dam
Pittsburgh	Water quality - Temperature	Michael J. Kirwan Dam
Pittsburgh	Downstream E-flows – Life stage support - Fisheries	Berlin Dam, East Branch Dam, Michael J. Kirwan Dam, Mosquito Creek Dam
Pittsburgh	Fish passage	Braddock L&D, Dashields L&D, Emsworth L&D, Montgomery L&D
Pittsburgh	Physical habitat - Seasonal wetland creation (vernal pools / seasonal pools)	Union City Dam

Meeting participants (Appendix A) were comprised of staff from the seven participating Corps districts and The Nature Conservancy (TNC).

This report details content of the meeting and is structured to follow the meeting agenda (Appendix B).

The Lakes and Rivers meeting was the seventh in a series of regional Operations and Water Management meetings. Previous regional meetings were conducted in the Upper Midwest (involving Kansas City, Omaha, Rock Island, St. Paul, and St. Louis districts) in September 2019, South (involving New Orleans, Memphis, Vicksburg, Galveston, Little Rock, Fort Worth, and Tulsa districts) in September 2020, Pacific Northwest (involving Seattle, Portland, and Walla Walla districts) in November 2020, North Atlantic (involving Baltimore, New England, New York, Norfolk, and Philadelphia districts) in October 2021, South Atlantic (involving Charleston, Jacksonville, Mobile, Savannah, and Wilmington) in February 2023, and South Pacific (involving Albuquerque, Los Angeles, Sacramento, and San Francisco) in November 2023.

The intent of these regional meetings and associated reports is to identify and document environmental opportunities at water infrastructure that are feasible to implement with compelling potential benefits. It is acknowledged that full assessment and implementation of those opportunities would likely involve collaborations with partner and regulatory agencies and stakeholders. The actionable ideas in Table 1 - pairings of environmental action and water management infrastructure project with feasibility and anticipated environmental benefits - are simply ideas judged worthy of further consideration.

Introduction and Objective

The goal of the Lakes and Rivers Regional Operations and Water Management meeting was to identify environmental opportunities at Corps-involved reservoirs that are feasible to implement and are likely to provide compelling potential benefits.

By many measures (e.g., number of reservoirs, total storage, geographic distribution), the Corps is the largest water management organization in the nation. A reservoir survey completed in 2013 identified 465 reservoirs with federally authorized flood storage. The majority (356) of these reservoirs were owned and operated by the Corps. Additionally, the Corps has approximately 180 locks and dams on rivers nationwide. Considering environmental opportunities for all of these water bodies is daunting given differences in their size, location, and purpose(s).

Contemplating opportunities at finer spatial scales becomes more practical as similarities in hydrology, landscape, water bodies, and water resources management create a common context for sharing experiences and formulating alternative management strategies. Environmental opportunities and challenges also trend regionally, as considerations begin to focus on shared ecological community types, flyways, and habitats. The Lakes and Rivers Regional Operations and Water Management meeting was convened with this premise – that regional characteristics of water and ecological systems can underpin a productive dialogue about water management infrastructure operations for environmental benefits.

Meeting participants provided expertise in water management infrastructure operations, water management, water quality, natural resources management, environmental planning, and ecology. Collectively, the group began the formulation process by listing key environmental actions associated with water management infrastructure. Participants then split into location-based teams (based on geographical areas of responsibility of the seven participating Corps districts and experience). Each team scored the potential environmental benefits and current implementation feasibility level of each identified action (for all water management infrastructure, collectively). Teams then ranked specific actions with unrealized environmental benefits for individual projects within their area, according to which were the most promising candidates for operational changes and selected highest ranked actions to carry forward.

Sustainable Rivers Program

The Sustainable Rivers Program (SRP) is a national partnership between the Corps and TNC. The mission of SRP is to improve the health and life of rivers by changing water management infrastructure operations to restore and protect ecosystems, while maintaining or enhancing other authorized project purposes.

The SRP began in 1998 with an initial collaboration to improve the ecological condition of the Green River, Kentucky. The Program was formally established in 2002 and included eight river systems. As of 2023, the SRP includes more than 90 Corps water management infrastructure projects in 45 river systems influencing 12,183 river miles (Figure 2). It is the largest scale and most comprehensive program for implementing environmental flows below Corps reservoirs.

Figure 2. Status of rivers engaged in the Sustainable Rivers Program, 2023.

Environmental flows are defined as the quantity, timing, and quality of water flows required to sustain ecosystems. For water management infrastructure operators, environmental flows manifest as management decisions that manipulate water and land-water interactions to achieve ecological or environmental goals. The SRP process for environmental flows has three phases: (1) advance; (2) implement; and (3) incorporate. Advancing environmental flows involves engaging stakeholders in a science-based process to define the flow needs of riverine ecosystems. Implementation involves testing the effectiveness and feasibility of the defined flows. Incorporation involves formally including environmental flow strategies in reservoir operations policy (e.g., water control manual updates). Environmental flows were the founding objective of the SRP and remain the key focus. In recent years, the Program began exploring other water management infrastructure-oriented actions with potential to produce environmental benefits.

Importantly, this report and associated meeting are not about SRP. SRP has promoted the concept of regional meetings for several years with the intent of providing a venue for broad consideration of environmental actions at rivers and reservoirs. The Lakes and Rivers meeting was the seventh in a series of regional Operations and Water Management meetings sponsored by the SRP. Previous regional meetings were conducted in the Upper Midwest (involving Kansas City, Omaha, Rock Island, St. Paul, and St. Louis districts) in September 2019, South (involving New Orleans, Memphis, Vicksburg, Galveston, Little Rock, Fort Worth, and Tulsa districts) in September 2020, Pacific Northwest (involving Seattle, Portland, and Walla Walla districts) in November 2020, North Atlantic (involving Baltimore, New England, New York, Norfolk, and Philadelphia districts) in October 2021, South Atlantic (involving Charleston, Jacksonville, Mobile, Savannah, and Wilmington) in February 2023, and South Pacific (involving Albuquerque, Los Angeles, Sacramento, and San Francisco) in November 2023.

Lakes and Rivers Regional Rivers and Reservoirs

For the purposes of this meeting, the Lakes and Rivers region is comprised of the geographic areas of seven Corps Districts, Buffalo (LRB), Chicago (LRC), Detroit (LRE), Huntington (LRH), Louisville (LRL), Nashville (LRN), and Pittsburgh (LRP) Districts, which are part of the Corps' Lakes and Rivers Division (LRD). Collectively, the Districts are involved with 79 reservoirs with federally authorized flood space, all of which are owned and operated by the Corps (Figure 3). Six of the reservoirs are dry dams. Dry dams are typically smaller and more single-purpose than other reservoirs with federally authorized flood space. Most were constructed solely for flood risk management and many release water passively, storing water only when inflows exceed the physical capacity of always open outlets.

Based on the National Inventory of Dams (NID 2016), Corps-owned dams with federally authorized flood space contain 30.7 million acre-feet (MAF) of storage (excludes locks and dams), which is 34% of all surface water reservoir storage in the region. Table 2 provides a summary of the reservoirs.

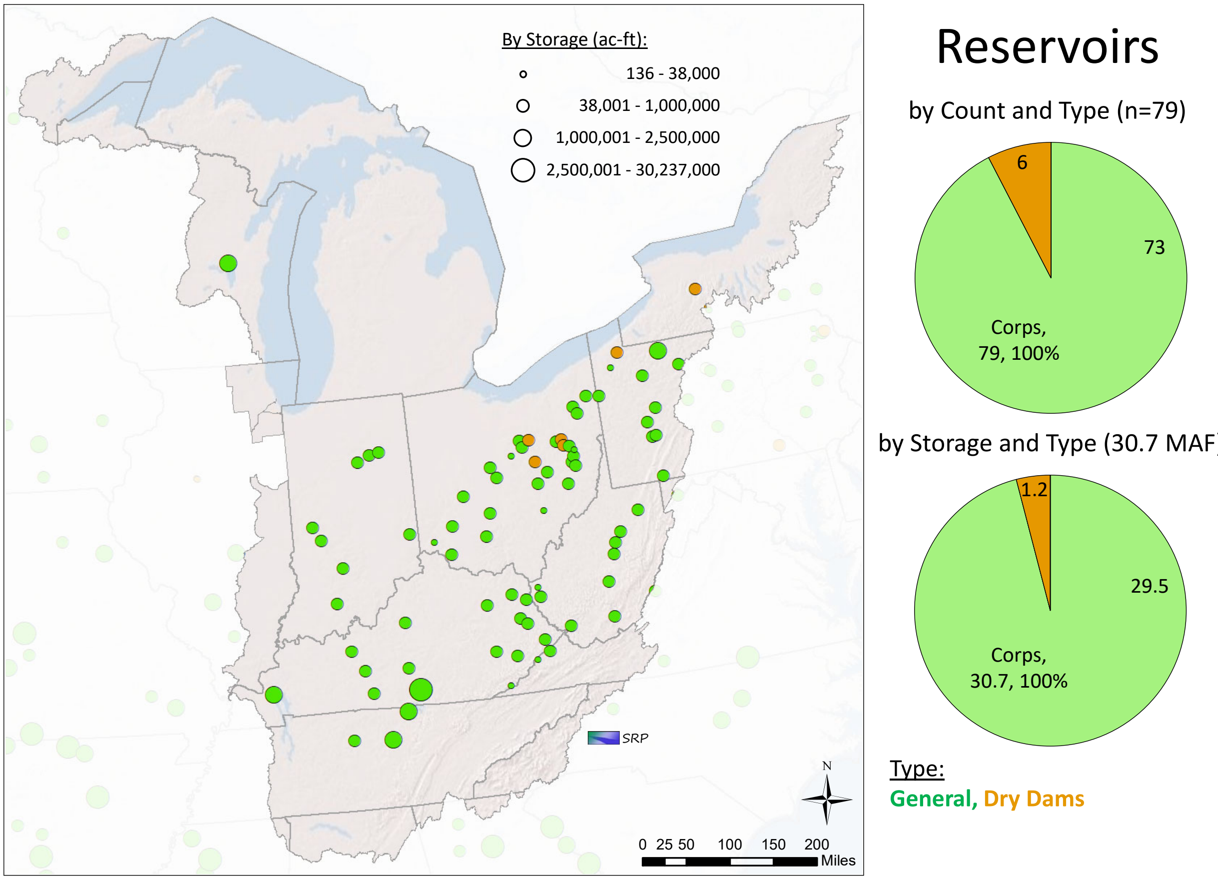
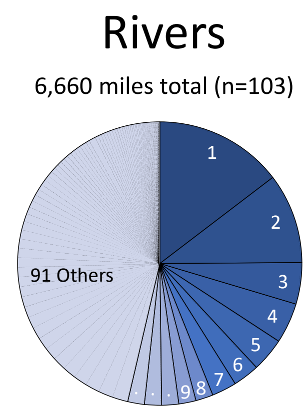


Figure 3. Corps-owned reservoirs with flood storage in the Lakes and Rivers region. Excludes Corps locks and dams.

Table 2. Lakes and Rivers region reservoir count and storage. Corps locks and dams are excluded from the "Corps - Count" and "Corps - Storage" tallies.

	Count			Storage (millions of acre-feet; MAF)		
	Corps		NID (all)	Corps		NID (all)
	General	Dry dams		General	Dry dams	
LRB	-	1	868	-	0.4	5.9
LRC	4	-	1,620	3.2	-	11.5
LRH	31	4	1,107	4.0	0.7	9.2
LRL	17	-	2,116	5.7	-	14.5
LRN	6	-	1,495	12.6	-	42.1
LRP	15	1	864	3.9	0.1	7.1
Total	73	6	8,070	29.5	1.2	90.3

The river network below the Corps-owned reservoirs with flood storage consists of 103 different named rivers. The Ohio is the longest with a total of 973 river miles from its start at the confluence of the Allegheny and Monongahela Rivers to its confluence with the Mississippi River. The Cumberland River has the second longest length within the region with the Green, Kentucky, Allegheny, Licking, Scioto, White, Patoka, Monongahela, and Little Kanawha Rivers completing the list of top twelve longest rivers. The combined lengths of blank or unlabeled reaches also fell in the top ten. Most unlabeled river miles within the region were for the Wabash River, which flows southwesterly from northern Indiana to its confluence with the Ohio River. Combining labeled (96 river miles) and unlabeled reaches of the Wabash would sum to just over 400 river miles, placing the Wabash as the third longest river in the region (Figure 4).



#	Name	Miles
1	Ohio River	973
2	Cumberland River	685
3		315
4	Green River	306
5	Kentucky River	258
6	Allegheny River	200
7	Licking River	187
8	Scioto River	132
9	White River	130
10	Patoka River	129
11	Monongahela River	129
12	Little Kanawha River	126
13…	91 Others	3,089
Total		6,660

Figure 4. Rivers below Corps-owned reservoirs with flood storage in the Lakes and Rivers region.

The total number of river miles in the region below Corps dams with flood storage is 6,660. Almost all (97%; 6,455 river miles) are below reservoirs that have an authorized purpose related to the environment (fish and wildlife, water quality, or recreation). Table 3 provides a summary of the rivers.

Table 3. River miles below Corps-owned dams. Tallies provided per ownership type and purpose.

	River Miles by Ownership			River Miles by Purpose				
	Corps	Section 7	Both	Enviro	Hydro	Both	Neither	Total
LRB	69	0	0	0	0	0	69	69
LRC	148	0	0	107	41	0	0	148
LRH	1,975	0	0	1,502	0	442	31	1,975
LRL	2,689	0	0	2,132	0	539	18	2,689
LRN	742	0	0	245	0	497	0	742
LRP	1,038	0	0	540	0	452	46	1,038
Total	6,660	0	0	4,525	41	1,930	164	6,660

Reservoir-centric Environmental Efforts within the Lakes and Rivers Region

This section provides a summary of presentations from the seven participating districts about ongoing reservoir-centric environmental efforts in the region.

Buffalo District (LRB)

The Black Rock Channel extends from Buffalo Harbor to the Black Rock Lock. It is three and one-half miles in length. The Federal navigation channel has a minimum width of 200 feet. Pleasure craft are required to yield the right-of-way to commercial vessels due to the confined waters of the channel. The Black Rock Lock (Figure 5) and the Black Rock Channel provide safe passage for vessels to travel between Buffalo Harbor and Tonawanda Harbor around the reefs, rapids and fast currents that exist in the upstream portion of the Niagara River.

Figure 5. Photo of Black Rock Lock (USACE photo).

In combination with the New York Erie Canal, the Black Rock Lock and Black Rock Channel provide an inland water route between Lake Erie and the Atlantic Ocean. Branch canals in the New York State Canal System provide vessels access to Lake Erie and Lake Champlain.

The Black Rock Lock and the Black Rock Channel are located where Lake Erie drains into the Niagara River (Figure 6). The lock and channel permit pleasure craft and commercial vessels to travel between Buffalo Harbor and Tonawanda Harbor. In combination with the New York Erie Canal, they provide pleasure craft and canal-draft vessels an inland water route between Lake Erie and the Atlantic Ocean. Branch canals in the New York State canal system also provide boaters access to Lake Erie and to Lake Champlain.

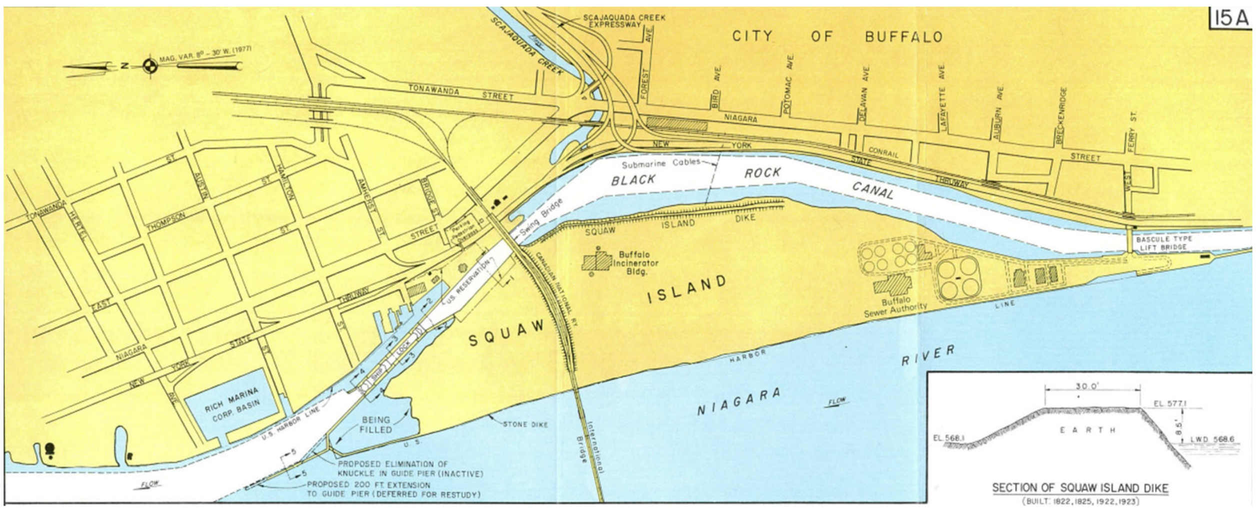


Figure 6. Black Rock Canal project location map.

Mount Morris Dam is located approximately 67 river miles above the mouth of the Genesee River, Livingston County, New York, and is approximately 3.5 miles from the town of Mount Morris (Figure 7). The William B. Hoyt II Visitor Center is located immediately southeast of the dam's overlook on the southeast side of the river.

Mount Morris Dam (Figure 8) was authorized by Section 10 of the Flood Control Act, 78th Congress, 2nd Session (House document #615), approved 22 December 1944 enacted by Public Law No. 534. Construction of Mount Morris Dam began in March 1948. Regulation of the Genesee River for flood control began on 24 November 1950. The dam was completed on 16 May 1952 and dedicated on 27 July 1952. The primary mission of Mount Morris Dam is to reduce the risk of catastrophic flooding in areas downstream including farmlands, residential areas, industrial and commercial development in the lower Genesee River Valley and Lake Ontario especially in the Rochester metropolitan area. The William B. Hoyt II Visitor Center was authorized under the existing USACE operation and maintenance authority. Legislation to name the facility was included in the Water Resources Development Act (WRDA) of 1992. The Visitor Center opened to the public in 1998 and was dedicated on June 18, 1999.

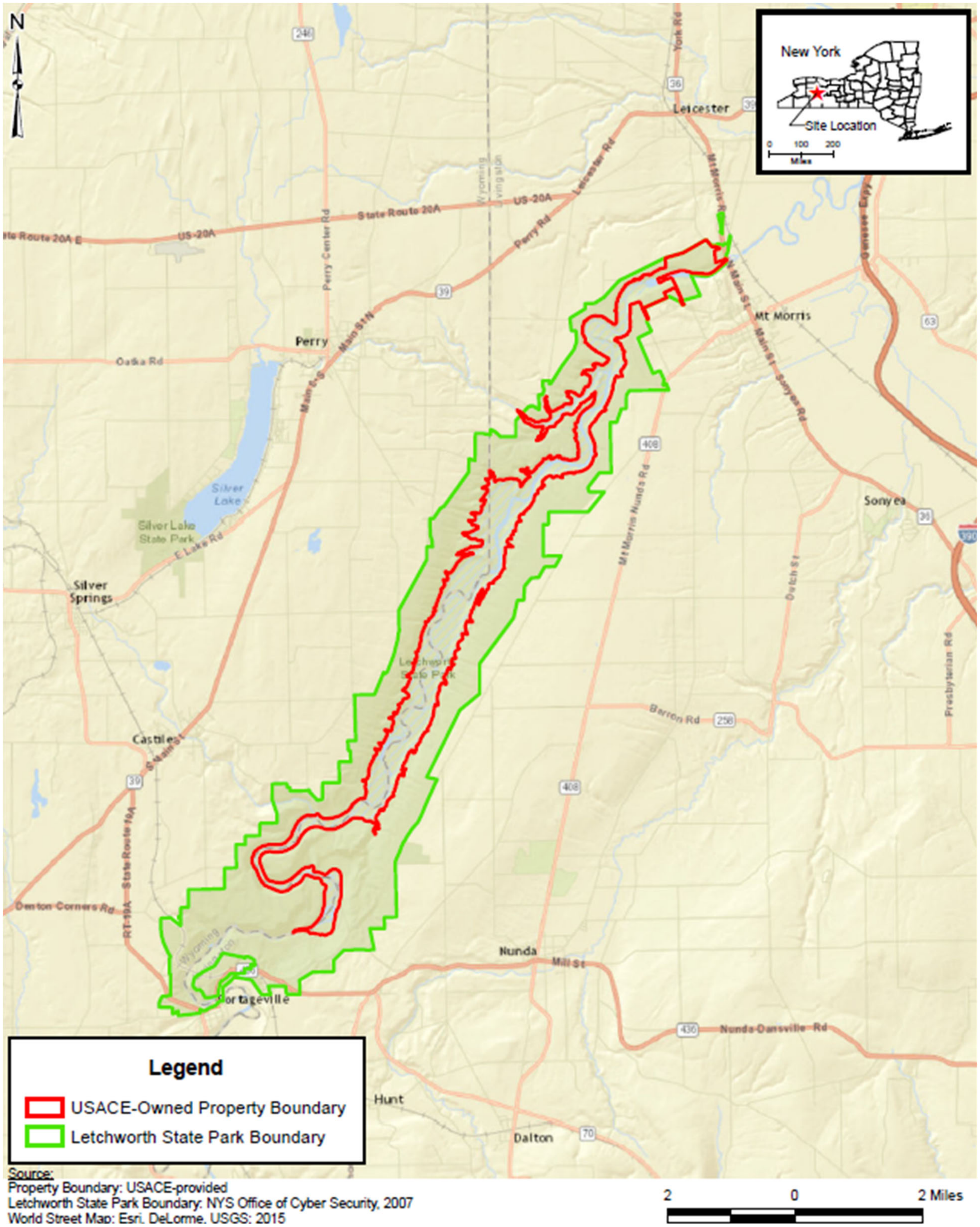


Figure 7. Location map of USACE area of responsibility for the Mount Morris Dam Project.

Figure 8. Photo of Mount Morris Dam (photo by Bob Oswald, USACE).

Chicago District (LRC)

Chicago District is responsible for water resources development in the Chicago metropolitan area, Upper Illinois River watershed, Lake Michigan watershed in Wisconsin, and the Upper Wabash River watershed in Indiana – an area of about 31,500 square miles (mi^2). LRC operates 12 lock and dams, 4 reservoirs (impounded by Menasha, J. Edward Roush, Salamonie, and Mississinewa dams), and maintains 21 federal harbors including channels and confined disposal facilities for dredged sediments (Figure 9).

Fox River

The Fox River extends approximately 40 miles from Lake Winnebago to Green Bay. The project includes 9 federal dams and 17 locks that are maintained for flood control, water supply, and power generation.

The Lower Fox River begins at the north end of Lake Winnebago and flows through Neenah, Menasha, Appleton and Green Bay to Lake Michigan. The Lower Fox River drains 6,349 mi^2 at an average flow of 4,390 cubic feet per second (cfs).

Federal dams operate with four private dams on the Lower Fox River, which are for hydropower generation and management of Lake Winnebago. Two of the dams, a private dam at Neenah and a federal dam at Menasha, serve as outlet controls for Lake Winnebago (Figure 10). The dams at Neenah and Menasha are operated in the interest of flood control, wetlands preservation, fish and wildlife enhancement, hydropower, boating, municipal water supply and occasional low flow augmentation for Lower Fox River water quality purposes. There are also numerous privately-owned and operated dams in the watershed above Lake Winnebago.

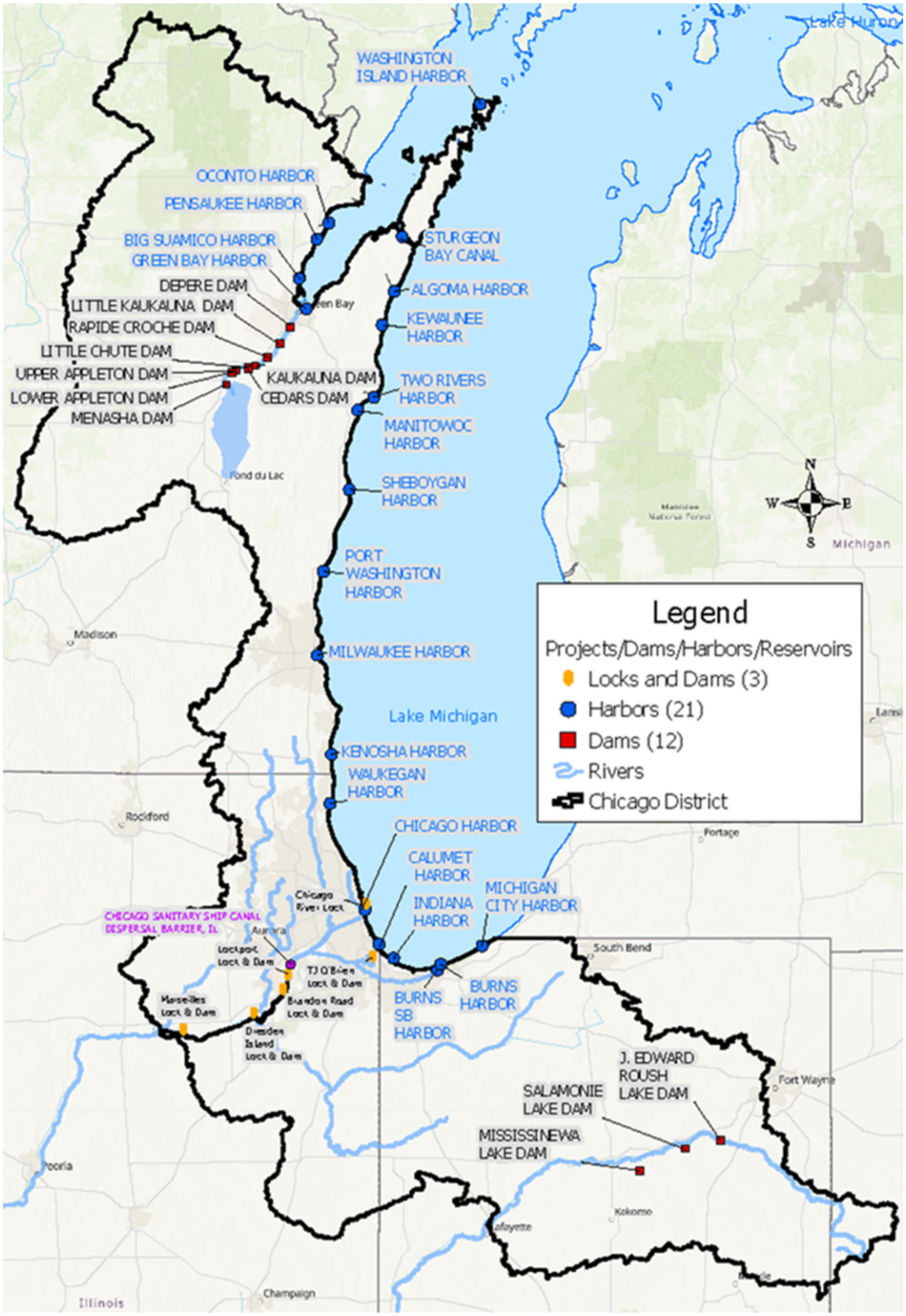


Figure 9. Water resources infrastructure related to dams and harbors managed by Chicago District.

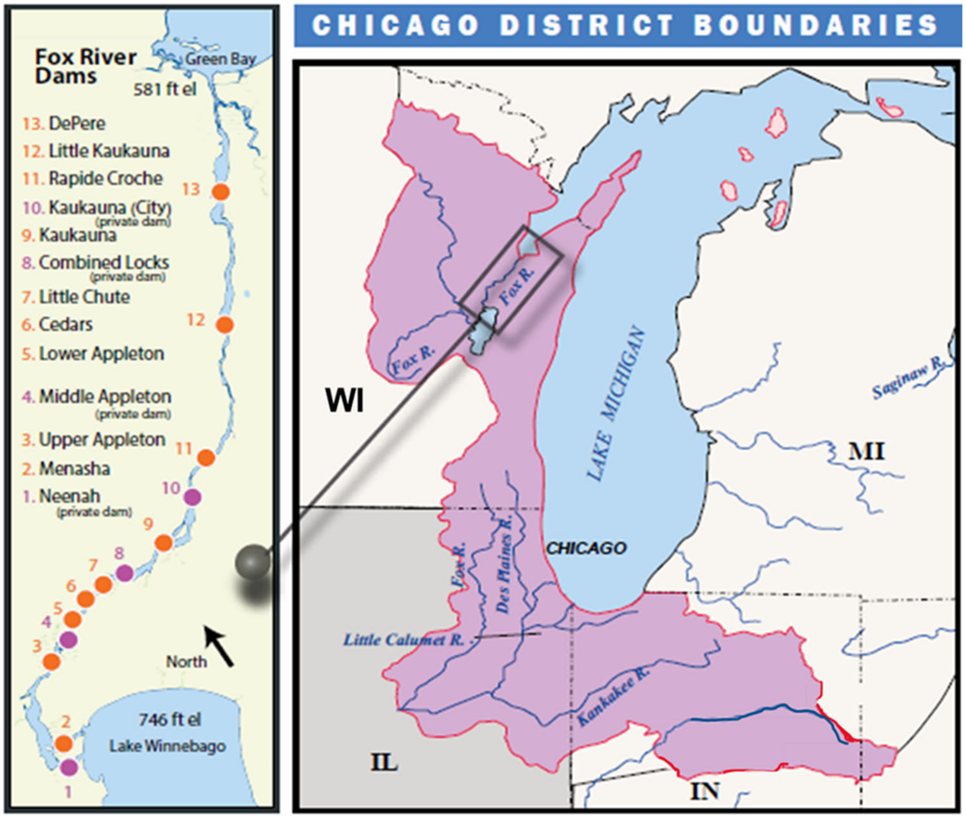


Figure 10. Rivers within Chicago District and locations of dams on the Fox River.

Chicago Area Waterway System (CAWS)

The CAWS is a network of canals and channelized rivers in northeastern Illinois and northwestern Indiana. It is a complex, multipurpose waterway with many uses and users that developed as the City of Chicago expanded. The CAWS is operated by the Metropolitan Water Reclamation District of Greater Chicago primarily to transport stormwater and wastewater treatment plant discharges. USACE maintains the CAWS for commercial and recreational navigation.

Nearly half of the CAWS is excavated, man-made channels. The rest is made up of formerly natural streams that have been highly altered and no longer resemble their original condition. Flow of water through the CAWS in Illinois is generally from north to south and from east to west. The system slowly drains away from Chicago and Lake Michigan into the Mississippi basin and down toward Lockport.

Much of the water in the CAWS comes indirectly from Lake Michigan. Water intakes located offshore in Lake Michigan supply water that is treated and then used in homes, offices, and industry. That water eventually makes its way to wastewater treatment plants. There are five wastewater treatment plants, called “water reclamation plants” (WRPs), in the CAWS. About 70 percent of the total annual flow out of the CAWS at Lockport is treated wastewater discharged from the WRPs in Illinois.

The CAWS is the only continuous connection between the Great Lakes and Mississippi River basins and poses a risk for the transfer of aquatic nuisance species, specifically invasive carp. The Corps operates the electric dispersal barrier on the Chicago Sanitary and Ship Canal to deter passage of invasive carp into the Great Lakes (Figure 11). Operations of the fish barrier were not considered during this meeting.

Figure 11. Map of the Chicago Area Waterway System and location of fish barrier.

Upper Wabash

The Upper Wabash River is located in north central Indiana and drains water from an approximately 2000 mi^2 watershed that reaches into western Ohio. The watershed is heavily agricultural with relatively flat fertile lands supporting highly productive grain fields. The small towns and local economies of the region are strongly connected to agriculture. Larger cities in the area have significant manufacturing and commercial activities, many of which are also related to agriculture.

The Upper Wabash lakes were created to reduce the impacts of flooding along the Wabash River. The dams at J.E. Roush, Salamonie, and Mississinewa lakes store precipitation from storms and winter snow melt and work in coordination to release stored waters to manage flood risk for the downstream communities of Huntington, Wabash, Peru, Logansport, and Lafayette, Indiana (Figure 12). Together, these projects manage about 73 percent of the water flowing through Wabash and 56 percent through

Logansport. In 2019, the projects provided an estimated $85 million in flood risk reduction benefits. These benefits include savings to communities, municipalities, landowners, and farmers. Since these 3 lakes were constructed, they have provided an estimated $1.6 billion in flood risk reduction benefits. Although flood risk management is the primary mission for the Upper Wabash Reservoirs, they also have secondary missions for fish and wildlife and recreation.

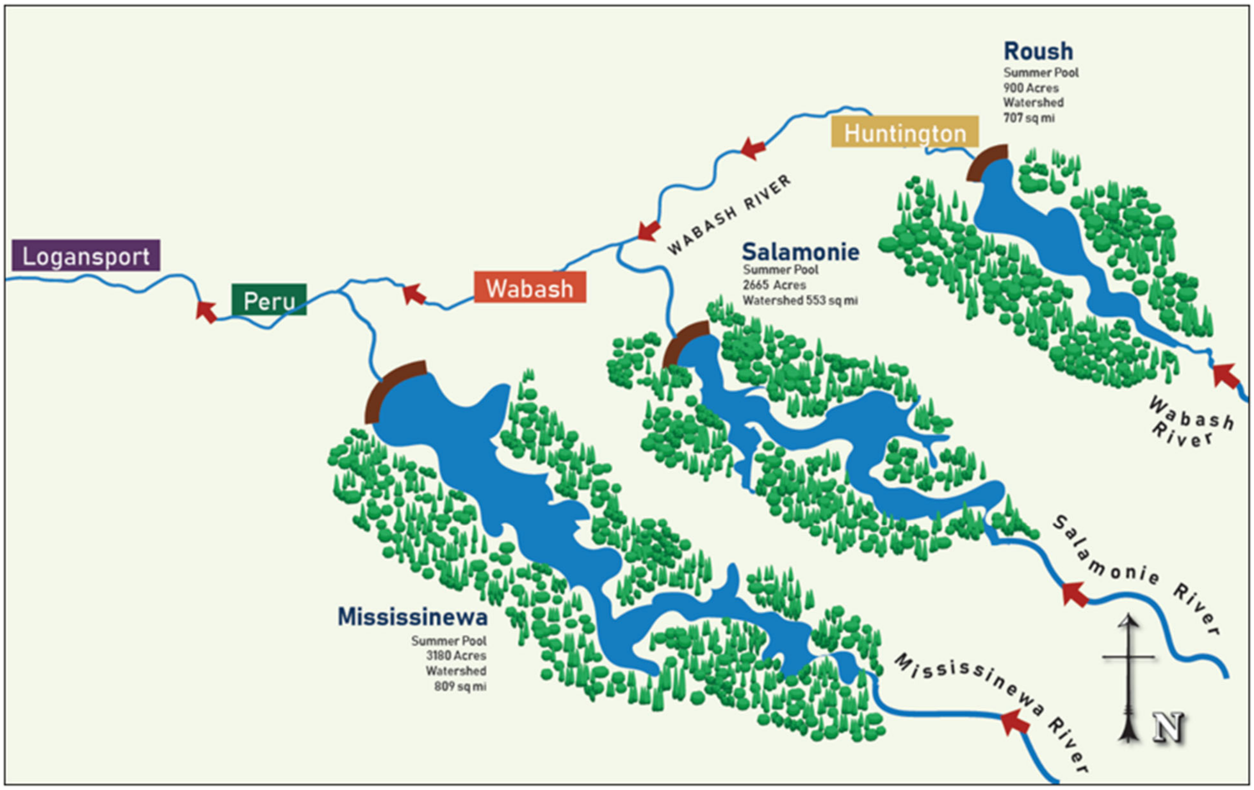


Figure 12. Reservoirs, rivers, and communities of the Upper Wabash River.

The three Upper Wabash dams are also participating in SRP. The Wabash River is home to many fish and mussel species and habitats. Aside from the three Corps-owned dams in the upstream reaches, the Wabash River remains relatively intact and maintains hydrologic connectivity down to the confluence with the Ohio River. For this reason, the Wabash River was added to the SRP in 2022 to evaluate environmental flow (e-flow) opportunities. LRC, in partnership with The Nature Conservancy (TNC), hosted an environmental flows (e-flows) workshop in July 2023 as part of this effort to identify flow recommendations for fishes, mussels, and riverine processes in the tailwaters of the dams. Subject matter experts from state and federal agencies, non-governmental organizations, and academic institutions were invited to participate.

The resulting flow recommendations were similar for each of the three tailwater reaches. Overall recommendations can be summarized as increasing hydrograph variability through low, moderate, and high flow pulses. Low flow periods are important for fish, mussels, and riverine processes, but low flows are already occurring as a result of low flows coming into the reservoirs and the need to maintain pool depth throughout the summer. Low and moderate pulses would be beneficial for both fish and mussel communities during wet, normal, and dry years, though the number and magnitude of the pulses would increase for wet years and decrease for dry years.

Detroit District (LRE)

Background

The St. Marys River connects Lake Superior to Lake Huron and generally flows in a southeast direction (Figure 13). The discharge in this approximately 62 mile long connecting channel is controlled at various structures near Sault Sainte Marie, Michigan, and its twin city, Sault Sainte Marie, Ontario. This natural international border between the United States and Canada also serves as an important ecological corridor, facilitating animal migration, as well as providing critical habitat for submerged aquatic vegetation, fish and other ecological communities. The river further plays an important role as a waterway for commerce, hydropower, water supply and recreational fishing. Originally, due to the natural 23-foot drop in elevation in an area known as the St. Marys Rapids (Figure 13), navigation between the lakes was cumbersome, if not impossible. Since the construction of the locks at Sault Sainte Marie and completion of the flow control infrastructure early in the 20th century, the St. Marys outflow is completely regulated and overseen by the Lake Superior Board of Control.

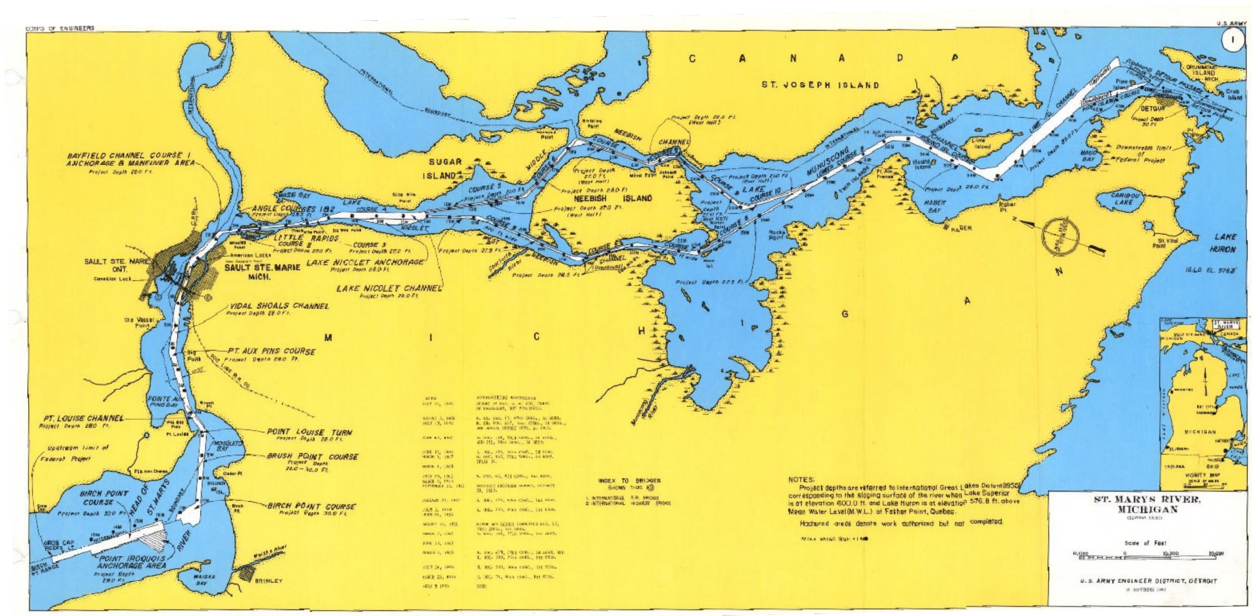


Figure 13. Detroit District project location map.

The USACE, along with Environment Climate Change Canada through authorities granted by the International Lake Superior Board of Control and the International Joint Commission regulate the discharge from Lake Superior. Regulation is largely accomplished through changes in hydropower allocation and changes to the Compensating Works (the furthest west boundary of the yellow outlined area in Figure 14).

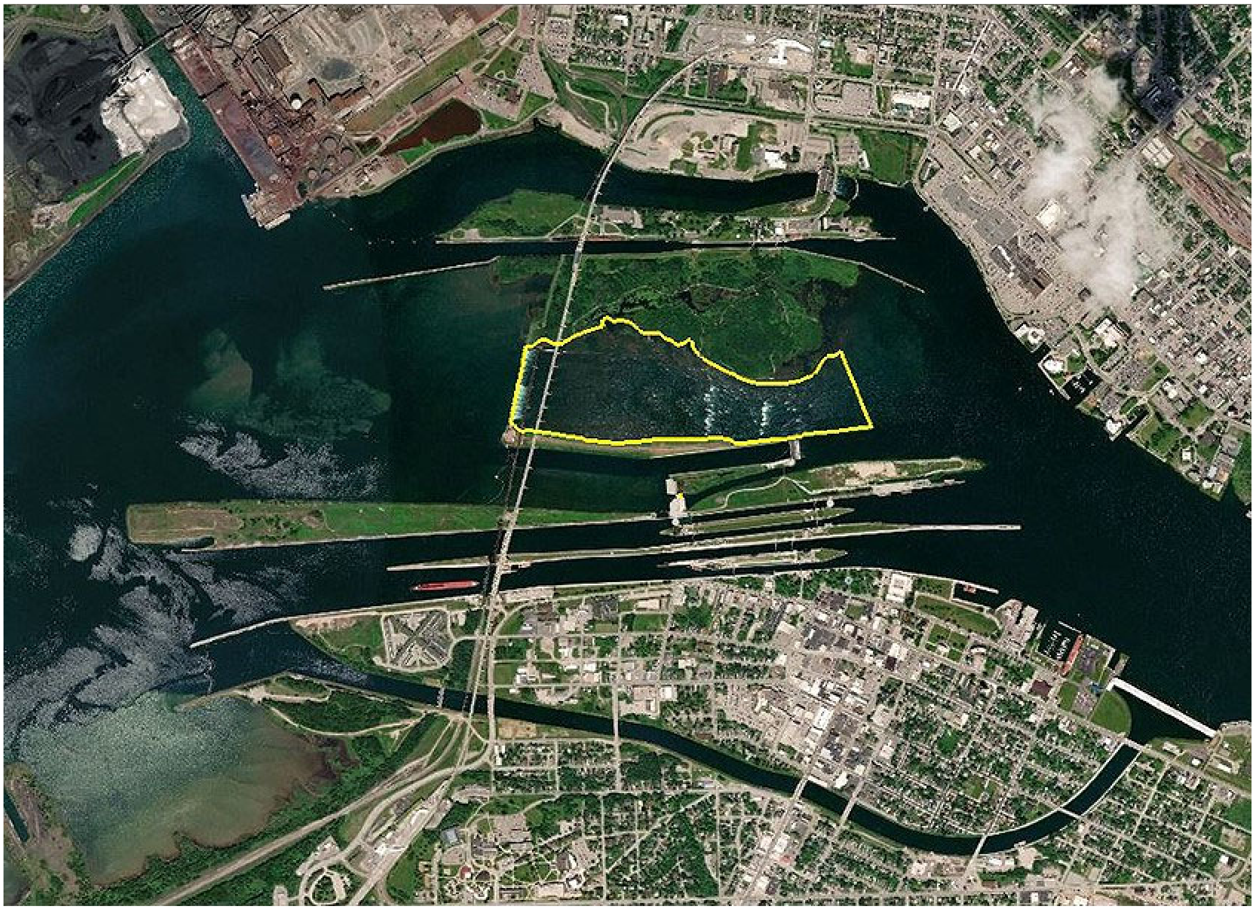


Figure 14. Aerial map from Google Earth of the Soo Locks and St. Marys Rapids (area outlined in yellow).

The Compensating Works is a 16-gate, low-head dam bisected by the United States – Canada border. It passes a minimum environmental discharge and larger volumes when the regulated outflow from Lake Superior exceeds hydropower capacity. The Compensating Works continually passes a minimum discharge of approximately 530 cfs through Gate 1 (the most northern gate). Flow from this gate is partially contained with a lateral dike along the north side of the St. Marys Rapids and the remainder of the minimum environmental discharge is passed through four central gates in the structure. Historically, operations required symmetric opening around the central gates. Since the implementation of Regulation Plan 2012, gate operations have become more flexible, however, gate configuration for a given discharge is determined largely by operational convenience while maintaining some flow symmetry across the border.

Historically, operating the gates was a largely manual process. Two of the gates on the US side still open by physically turning a crank, while the remaining six US gates have been upgraded so they can be electronically operated either remotely or from the structure, depending on the gate. All eight of the Canadian gates still require manual operation. The remotely operable gates can be set to open and close very slowly and are preferentially used when gate changes are required. The ability to control the pace of movement is more limited for the manually operated gates and the rate tends to be quicker than what can be accomplished using the remotely operated gates. The slow operation of the automated gates can help limit the water level rate of change in the St. Marys Rapids around environmentally sensitive times while juvenile fish are still present. Slow water level changes prevent these juveniles from becoming stranded in a disconnected pool adjacent to the rapids (Bain, 2007).

Ongoing work

Extensive modification of the Neebish Rapids for navigation began in 1904 and in several iterations thereafter that resulted in the present channel (Neebish Rapids are located on the west side of Neebish Island in Figure 13). Rapids, or at least areas with velocities greater than 0.33 to 0.66 feet per second (ft/s), serve as an important habitat for many Great Lakes fish species. Because of navigation improvements and subsequent channel modification the prevalence of higher velocity areas has been reduced. A recent study completed in the nearby Little Rapids demonstrated that an increase in water velocity results in an ecological community change from lentic towards lotic species assemblages (Molina-Moctezuma et al., 2021).

Current, ongoing research is being conducted to characterize the historic habitat associated with the West Neebish Rapids and use that new information to help define a new conceptual engineered channel that would run in parallel on Neebish Island. The new channel would be investigated to determine if a channel can be designed to not impact water levels in the navigation channel, provide potential spawning habitat to several different Great Lakes fishes (lake sturgeon, walleye, etc.) and be aesthetically integrated into the landscape so that the channel is a valuable landscape feature that people like to see and visit. This project will explore ideas about new channel development intended to serve as an increased water velocity habitat.

Huntington District (LRH)

Huntington District encompasses 45,000 mi^2 in parts of five states, which includes West Virginia, Ohio, Kentucky, Virginia, and North Carolina. LRH is responsible for 311 navigable miles along the Ohio River and 98 navigable miles on the Kanawha River and includes the Nation's second largest inland waterway port, the Port of Huntington.

LRH responsibilities include operation and maintenance of 9 locks and dams on the Ohio and Kanawha Rivers and 35 reservoirs with a flood risk management purpose that have prevented $21.6 billion in damages and dredging on the Ohio, Big Sandy, and Kanawha Rivers (Figure 15). In the most recent year of data available, over 55.7 million tons of commodities valued at more than $7.9 billion passed through LRH locks and dams on the Ohio and Kanawha Rivers amounting to more than 26,000 commercial lockages.

Sutton Lake is a 1,520-acre reservoir on the Elk River in Braxton and Webster counties, West Virginia. Sutton Lake was authorized by the U.S. Congress in the Flood Control Act of 1938; construction was completed in June 1960 and manages flows from a drainage area of 537 mi^2. Project purposes are flood risk management, fish and wildlife conservation, recreation, and enhanced recreation. Land includes 13,154 fee acres and 208 easement acres. There are ten recreation areas on the project, including Corps operated campgrounds and day use areas.

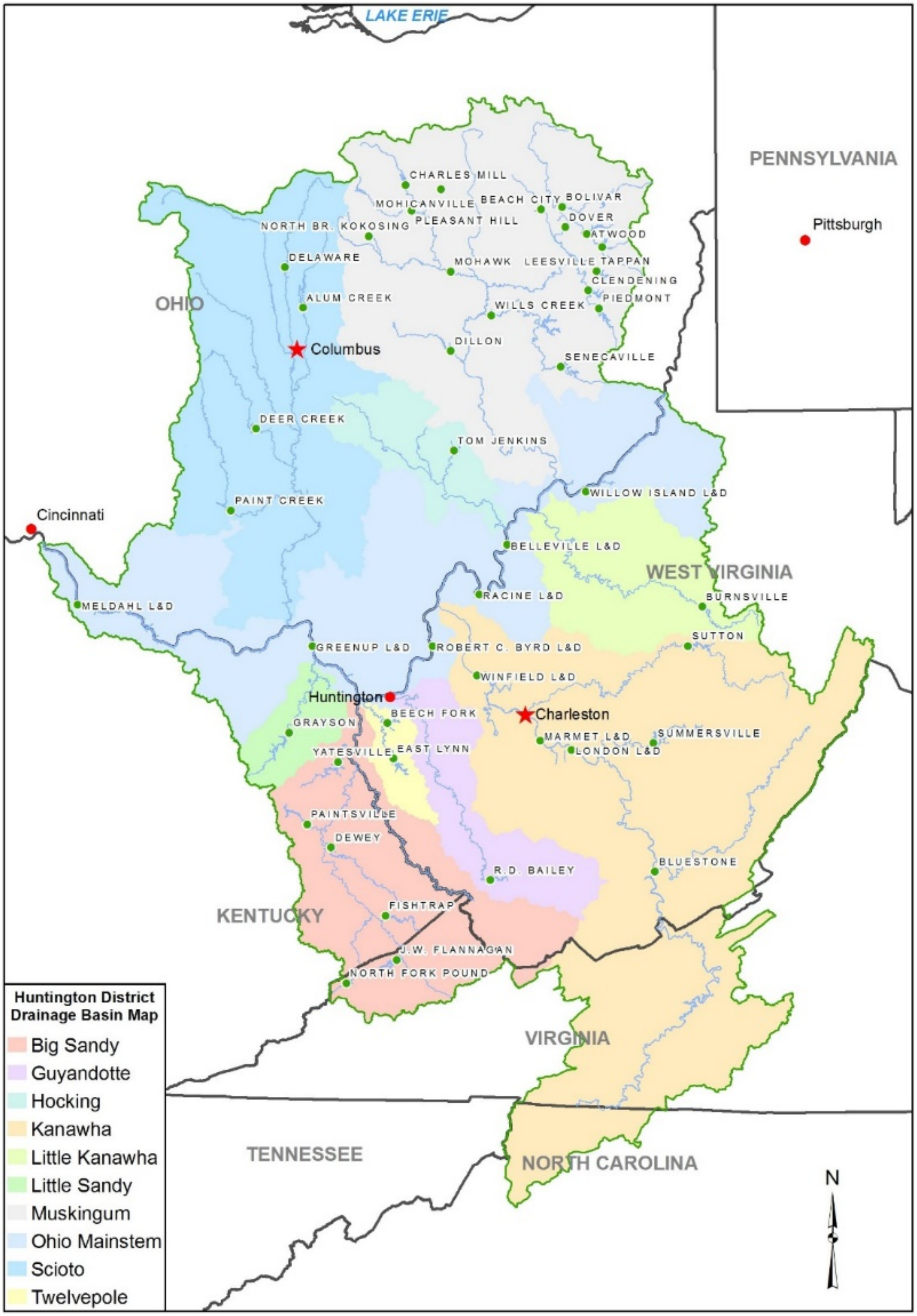


Figure 15. The Huntington District encompasses areas within North Carolina, Virginia, Kentucky, West Virginia, and Ohio.

Delaware Lake is part of a system of dams that reduce flood stages in the Olentangy, Scioto, and Ohio River Basins, benefiting communities and agricultural lands between Delaware and the Gulf of Mexico. Delaware Dam and Reservoir is located 32 miles above the mouth of the scenic Olentangy River, a tributary of the Scioto River, near Delaware Ohio. Authorized by the Flood Control Act of 1938 for the purposes of flood reduction, low-flow control for pollution reduction and water supply, recreation and fish and wildlife management. The project was constructed and is operated by the Huntington District. The Dam is a rolled earth fill type with a concrete gated spillway section. At a length of 3.5 miles and a height of 92 feet, Delaware Dam manages flows from a drainage area of 386 mi^2 through the use of five gated sluices and six 25-foot by 32-foot tainter/radial gates.

R.D. Bailey Lake is located in Wyoming and Mingo Counties of West Virginia. Its project purposes are flood risk management, water quality and recreation. The dam was completed in 1980 and manages flows from a drainage area of 540 mi^2. The lake is impounded by a rock and random-fill dam with a concrete face and an uncontrolled broad-crested saddle spillway. The outlet works include an intake structure with two sluices controlled by hydraulically operated slide gates which discharge through a circular tunnel through the left abutment of the dam. Five intake gates at four different elevations discharge into a sluice for selective withdrawal.

Alum Creek Lake is in Delaware County, Ohio, north of Columbus between I-71 and US 23. Alum Creek flows south joining Big Walnut Creek, near Groveport in southeast Columbus, which joins the Scioto River. Alum Creek Lake was built by the Corps to reduce the flood hazard along Alum and Big Walnut Creeks, the Scioto River, and along the Ohio River. The City of Columbus shared part of the additional project cost for water supply for the metropolitan area. Other benefits of the lake project are recreation, fish and wildlife management, and downstream water quality.

Senecaville Lake, located in southeastern Guernsey County and northeastern Noble County, Ohio, is one of a system of projects designed to provide flood control and water conservation in the Muskingum watershed in southeastern Ohio. The project is 1.4 miles upstream of the town of Senecaville and 21 miles upstream of Cambridge, Ohio. Senecaville Lake (Figure 16) forms a conservation pool for flood control, recreation, fish and wildlife, and for the maintenance of normal downstream flows during dry periods. Maximum height of the embankment is 49 feet. Total crest length is 2,350 feet.

Figure 16. Senecaville Lake in central Ohio (USACE photo).

The Captain Anthony Meldahl Lock and Dam project (Figure 17) includes a non-navigable, high-lift, 1,756 feet long gated dam including a 372-foot fixed weir with a 310-foot open crest. Twelve tainter gates span 100 feet between 14-foot intermediate piers and 15-foot end piers. The dam has two types of gates, submergible and non-submergible ogee sill units. There are two parallel locks. The main lock is 110 feet by 1,200 feet and the auxiliary lock is 110 feet by 600 feet, both with miter service gates and vertical-lift emergency gates. American Municipal Power (AMP) operates a hydropower electric plant on the Kentucky abutment of the dam. The plant includes three turbines with a total capacity of 105,000 kilowatts. Commercial operation of the hydropower plant began in April 2016.

Figure 17. Captain Anthony Meldahl Locks and Dam on the Ohio River (USACE photo).

Mohawk Dam is located in Coshocton County, Ohio, on the Walhonding River (Figure 18), a tributary of the Muskingum River. The dam is located 17.4 miles above the mouth of the Walhonding River and approximately 129.8 miles above the mouth of the Muskingum River. The town located the nearest to Mohawk Dam is Nellie, Ohio. The population of Nellie Village is 134. The floodplain between Mohawk Dam and the more populus downstream communities of Coshocton and Zanesville can generally be described as consisting of broad, gently sloping valleys. Development is sparse downstream of the dam, and is comprised primarily of small towns, some light industrial sites and farmland.

Figure 18. Mohawk Dam, located in central Ohio (USACE photo).

Louisville District (LRL)

Louisville District operates and manages 17 flood risk management projects across nine subbasins that drain into the Ohio River. Eight projects are located in Kentucky (Cave Run, Carr Creek, Buckhorn, Taylorsville, Green River, Nolin River, Barren River, and Rough River reservoirs), five in Indiana (C.M. Harden, Cagles Mill, Monroe, Patoka, and Brookville reservoirs), and four in Ohio (C.J. Brown, Caesar Creek, West Fork, W.H. Harsha reservoirs). Of these projects, most have some amount of selected withdrawal capability for temperature control. The projects with limited selective withdrawal capability (those with no, or only one, multilevel inlet) are Buckhorn, C.M. Harden, Cagles Mill, Rough River, and West Fork Reservoirs. The projects with the most capability for selective withdrawal include Taylorsville and Green River Reservoirs. All but one of the reservoirs have at least one authorization related to environmental actions (Figure 19; Table 4).

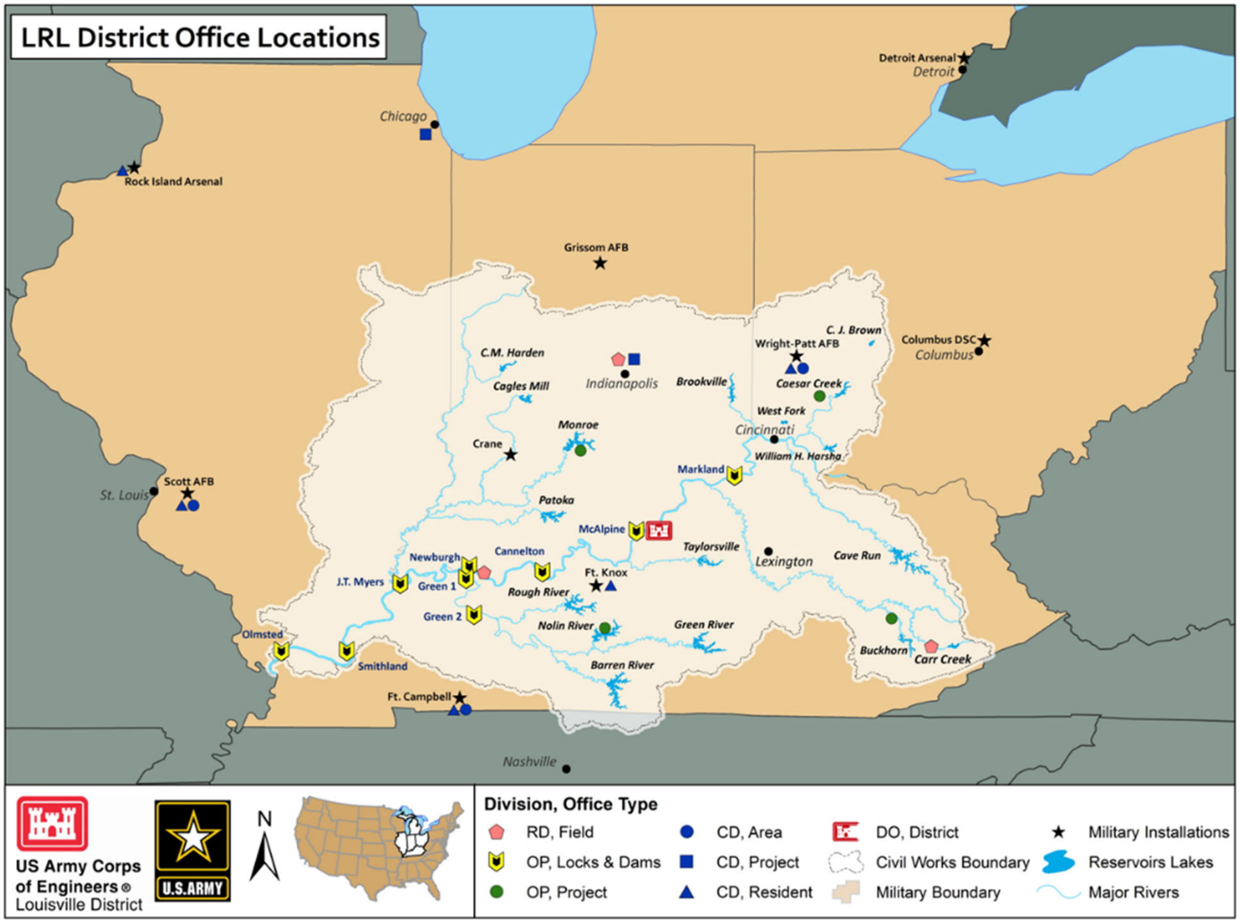


Figure 19. Office and reservoir locations of Louisville District.

Table 4. Louisville District reservoir basins, names, locations, drainage areas, and purposes.

Water Resource Projects within the Louisville District				
Basin	Lake	Location	Drainage Area (sq. mi.)	Authorized Purposes
Licking River	Cave Run	Morehead, KY	826	Flood Control, Recreation, Water Quality
Kentucky River	Buckhorn	Buckhorn, KY	408	Flood Control, Recreation, Water Quality
Kentucky River	Carr Creek	Sassafras, KY	58.2	Flood Control, Recreation, Water Quality
Salt River	Taylorsville	Taylorsville, KY	353	Flood Control, Recreation, Water Quality, Fish/Wildlife
Green River	Green River	Campbellsville, KY	682	Flood Control, Water Quality, Recreation, Water Supply
Green River	Barren River	Glasglow, KY	940	Flood Control, Water Quality, Recreation, Water Supply
Green River	Nolin River	Bee Spring, KY	703	Flood Control, Water Quality, Recreation, Water Supply
Green River	Rough River	Falls of Rough, KY	454	Flood Control, Water Quality, Recreation, Water Supply
Wabash Rver	C.M. Harden	Rockville, IN	216	Flood Control, Recreation, Water Quality
Wabash Rver	Cagles Mill	Poland, IN	295	Flood Control, Recreation, Water Quality
Wabash Rver	Monroe	Bloomington, IN	441	Recreation, Flood Control, Water Supply
Wabash River	Patoka	Dubois, IN	168	Flood Control, Water Quality, Recreation, Water Supply
Whitewater River	Brookville	Brookville, IN	379	Flood Control, Water Quality, Recreation, Water Supply
Miami River	C.J. Brown	Springfield, OH	82	Flood Control, Recreation, Water Quality
Miami River	West Fork	Cincinnati, OH	29.5	Flood Control, Recreation
Little Miami River	Caesar Creek	Waynesville, OH	237	Flood Control, Water Quality, Recreation, Water Supply
Little Miami River	W.H. Harsha	Batavia, OH	342	Flood Control, Water Quality, Recreation, Water Supply

LRL also has 9 locks and dams, seven along the mainstem Ohio (Markland, McAlpine, Cannelton, Newburgh, J.T. Meyer, Smithland, and Olmstead) and two in the lower Green River (Green River L&D 1, Green River L&D 2). All L&Ds within the district are solely authorized for navigation. Four of the mainstem Ohio River L&Ds have non-Federal hydropower generation (Markland, McAlpine, Cannelton, and Smithland) which have agreements with the District to meet minimum dissolved oxygen standards when generating. The two L&Ds on the lower Green River receive much less traffic than the Ohio River L&Ds due largely to the decline in coal mining and conversion of the Paradise power plant from coal to natural gas.

LRL has been involved with SRP beginning with the initiation of the first SRP project at Green River Reservoir in 1998. After completion of this initial project, LRL has conducted SRP work on the Barren River Reservoir with an evaluation of operational constrains and opportunities in 2017 and has also been involved in the Ohio River SRP project along the mainstem Ohio River in recent years. In August of 2023, LRL hosted a Green River Basin SRP Workshop to identify potential opportunities for basin-wide management measures. This effort included extensive stakeholder engagement and coordination to determine ecological needs present in the basin.

In FY24, LRL had three SRP proposals accepted:

1. Licking River and Salt River temperature studies. With this project, LRL hopes to answer the following questions about the Licking and Salt rivers:

   1) How far downstream do dam releases at Taylorsville and Cave Run Lakes influence temperature?
   2) How do current tailwater temperature guide curves for Taylorsville and Cave Run Lakes compare to the thermal regime of their respective rivers in a natural, unimpounded state?

   This study includes study design and planning, collection and analysis of existing relevant temperature datasets, literature review of similar studies, acquisition and deployment of data loggers upstream and downstream of the reservoir, and retrieval of data loggers and collected data. From those efforts, LRL will determine the extent of thermal influence downstream from the reservoirs and compare temperature data from upstream sites with the current reservoir temperature guide curves to determine if any changes to the curves are needed.

2. Green River Basin environmental flows workshops. As a follow-up to the Green River Basin SRP Workshop hosted by LRL in FY23, LRL will coordinate and conduct a series of workgroups with stakeholders to identify ecosystem problems and opportunities present within the basin and to work towards establishing and refining opportunities for e-flows from the reservoirs within the basin. This effort is expected to produce an Adaptive Management and Monitoring Plan that would be used and updated in subsequent e-flow workshops and implementation processes. E-flow workshops are planned at Barren, Nolin, and Rough River lakes in FY25.

3. Licking River stakeholder engagement and environmental flows workshop. LRL plans to conduct a three-day technical workshop in Spring 2024 with representatives from TNC, USFWS, USFS, state agencies, biologists, ecologists, and other interested stakeholders in the Licking River Basin. The workshop's primary purpose will be to gather information on the ecological and environmental state of the basin, with the immediate goal of evaluating opportunities to develop e-flows that can be implemented at Cave Run Lake, the only LRL reservoir in the Licking River Basin.

Additionally, LRL has conducted other environmental opportunity prioritizations in previous years. In 2014, there was LRD-wide effort to prioritize e-flows for reservoirs across districts. LRL identified Barren River, Cave Run, and Salamonie and Mississinewa (note that Salamonie and Mississinewa are now LRC reservoirs) as good potential candidates for e-flows. Following this effort, an e-flows summary was written in 2016 detailing modifications that had been considered or were identified as having high potential. This included discussion of the actions at Green River Reservoir from the initial SRP project, evaluation of releases from Barren River Lake, adaptive management measures at Nolin River Reservoir for a maternity cave for the endangered Gray Bat, minor changes to Rough River timing and release rates at fall drawdown, delay of fall drawdowns at Buckhorn and Cave Run Lakes, and actions for recreation at CJ Brown Reservoir following a series of low head dam removals by the City of Springfield, Ohio. Additionally, a series of dam removals on the Green River and Barren River have taken place in recent years. Green River L&D 6 was removed in 2017, removal of Green River L&D 5 is ongoing, and Barren River L&D 1 was removed in 2022. Green River L&D 4 failed in the 1960's and has remained in place but is mostly free flowing through the failed dam section. Green River L&D 3 has been turned over to support local water supply needs.

In 2021, the LRL Water Quality Team, working with District water managers, began prioritizing tailwater temperature management (i.e., following the established temperature guide curves) at all reservoir projects. This process includes reviewing relevant in-lake and downstream data and determining operational changes (i.e., utilizing selective withdrawal capabilities) to maintain target tailwater temperatures. Since prioritizing this effort, the district has added U.S. Geological Survey (USGS) temperature gages to some tailwaters that did not already have them and has elevated the status of the USGS data collected for the District to publishable to ensure high data quality. Also, the Water Management Team created a Tailwater Temperature Dashboard, which pulls various information (USGS gage temperature data, temperature guide curve targets, latest in-lake profile information, and tower/outlet information) to facilitate decision-making regarding operation changes that benefit tailwater temperatures. Future work includes evaluation and verification of each project's temperature guide curves and determinations for the extent of impact downstream of each project.

Nashville District (LRN)

The Cumberland River watershed drains approximately 18,000 mi^2 of southern Kentucky and north-central Tennessee. The Cumberland River flows generally west from its source in the Appalachian Mountains to its confluence with the Ohio River.

The headwaters of the Cumberland River are comprised of three separate forks that begin in Kentucky and converge near Harlan, Kentucky. Near the confluences of the Laurel and Rockcastle Rivers, the Cumberland is impounded by Wolf Creek Dam, forming Lake Cumberland, a Corps multipurpose reservoir and one of the largest artificial lakes in the eastern United States.

The Cumberland River flows into Tennessee near Celina and several large rivers converge before being impounded near Nashville by Cordell Hull and Old Hickory Dams. After picking up the Stones River and Harpeth River, the river is impounded by Cheatham Lock and Dam. Flowing north and northwest toward Clarksville, Tennessee, the Cumberland River picks up Red River and is later impounded in Kentucky by Barkley Dam before reaching its confluence with the Ohio River.

Traveling approximately 688 river miles, the Cumberland River is one of the most important waterways in the southeastern United States economically, ecologically, and recreationally. Historically considered one of the most biologically diverse watersheds in North America, the Cumberland River once hosted more than 70 endemic mussel species. Construction of 10 dams (Figure 20) along the Cumberland River brought resilient commercial navigation, hydropower generation, and flood control, which were critical for the region, but have impacted aquatic ecosystem and species diversity.

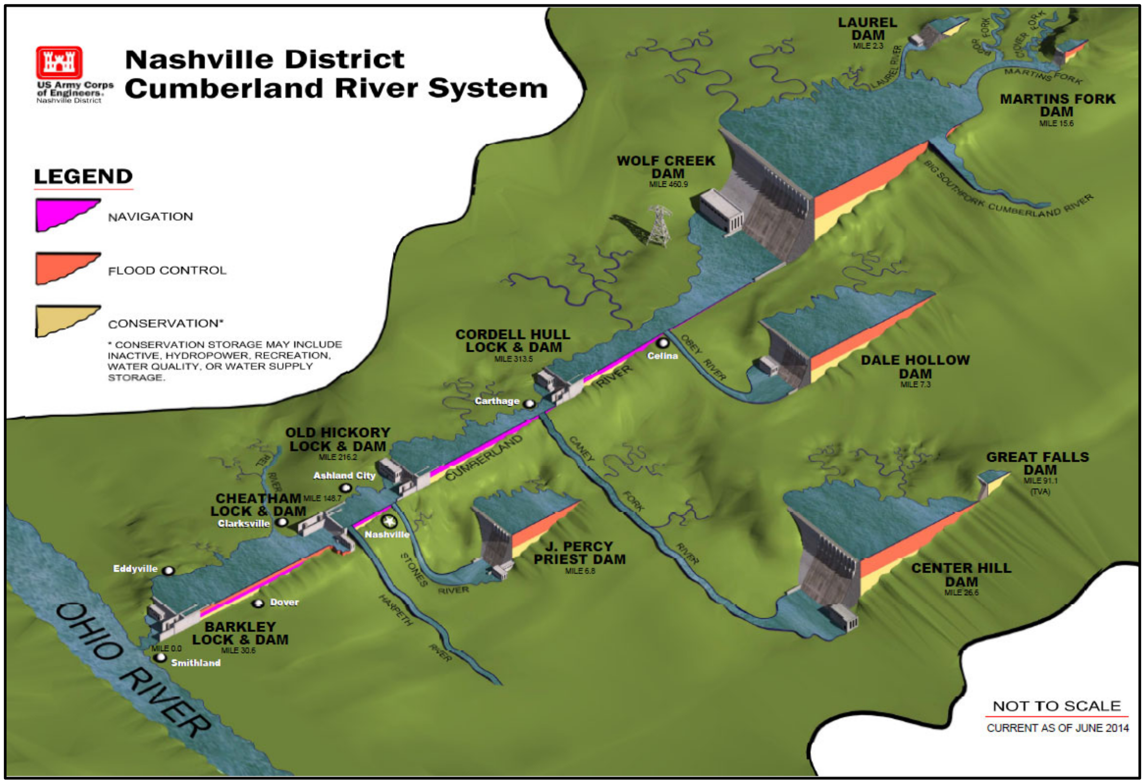


Figure 20. The Cumberland River system.

Pittsburgh District (LRP)

The Pittsburgh District includes the upper 127 miles of the Ohio River and the headwaters of the Allegheny and Monongahela rivers, which confluence in Pittsburgh to form the Ohio River. LRP encompasses 26,000 mi^2 and includes portions of western Pennsylvania, northern West Virginia, eastern Ohio, western Maryland, and southwestern New York. Multiple civil works missions are implemented in the areas of navigation, flood risk management, recreation, environmental restoration, hydropower, storm-damage reduction, regulatory, water supply and emergency response. Infrastructure includes more than 328 miles of navigable waterways, 23 navigation locks and dams, 16 multi-purpose / flood-damage reduction reservoirs, 42 local-flood damage-reduction projects and other projects to protect and enhance water resources and wetlands (Figure 21).

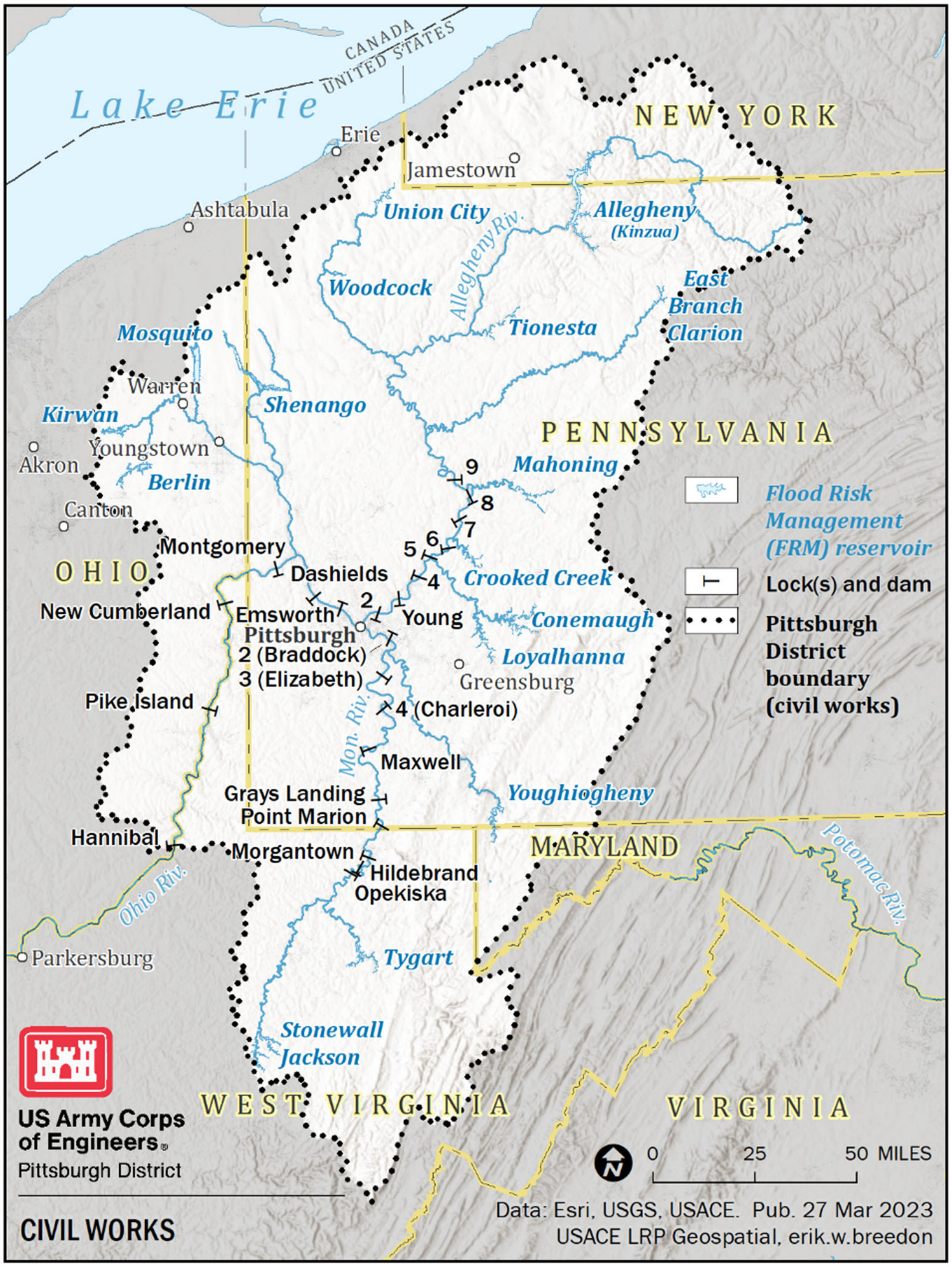


Figure 21. Boundaries and key infrastructure of Pittsburgh District.

Ongoing SRP efforts that are taking place within LRP include:

1. Upper Allegheny River: The goal of this project was to define and implement e-flows from the Kinzua Dam to benefit habitat and aquatic species. This project includes an examination of mussel species and habitat (partners include USGS, WPC, ANF, and ERDC). A successful spring pulse was implemented in 2023 and another pulse is planned for 2024 depending on water levels. Coordination with the Seneca Nation of Indians on the timing of potential spring pulses is ongoing. A mussel survey and geospatial work is planned for the summer of 2024.

2. Upper Allegheny River Navigation System: The goal of this project was to inventory existing and historic ecological conditions and prioritize environmental opportunities within the Upper Allegheny River Navigation System. This project has been completed and the results of it led to new SRP proposals in 2024.
3. Ohio River systems analysis and stakeholder engagement: The goal of this project was to identify environmental opportunities and develop implementation plans for L&Ds on the Ohio River (Pittsburgh, Louisville, and Huntington District collaboration). This project has been completed and results have led to new SRP proposals in LRP in 2024.
4. Flow recommendations for Youghiogheny River Lake: The goal of this project was to improve streamflow conditions, and availability and quality of habitat for riverine and floodplain species by restoring key components of the flow regime on the Youghiogheny River. Flow prescriptions have been developed and LRP is in ongoing collaboration with TNC.
5. Union City Dry Dam pothole wetlands: The goal of this project was to restore wetlands, create vernal pools, and establish native species along the French Creek West Branch at the Union City Dry Dam. This project is permitted and currently in contracting.

Allegheny Reservoir (Figure 22), impounded by Kinzua Dam, spans the New York-Pennsylvania border. This project, in conjunction with other flood control projects in the District, substantially reduces flooding in the Allegheny and upper Ohio River valleys. The reservoir provides water to be released during dry periods and helps to maintain navigable depths for commercial traffic on the Allegheny and upper Ohio Rivers. Hydroelectric power is an additional benefit provided by this reservoir. Current SRP efforts have resulted in e-flow prescriptions for the river stretch downstream of the dam with the aim of restoring seasonal hydrograph fluctuations, improving habitat for fish and mussel species in the area. Successful implementation of a spring pulse at this reservoir has been a highlight of SRP projects in the District and has helped the discussion and planning of future efforts to advance and implement into other rivers across the District.

Figure 22. Kinzua Dam and Allegheny Reservoir (USACE photo).

Environmental Opportunity Matrix and Ongoing Environmental Work

The Environmental Opportunity Matrix was initially developed for use in the Upper Midwest Regional Operations and Water Management meeting. Its intended use is to help identify priority environmental actions and opportunities effectively and comprehensively for the region. The matrix evolved through the subsequent South, Pacific Northwest, North Atlantic, South Atlantic, South Pacific, and now Lakes and Rivers regional meetings. Meeting participants were provided a copy of the matrix prior to the meeting and asked to review the list of potential environmental actions and objectives and identify any unlisted actions pertinent to Corps water resource infrastructure in the Lakes and Rivers region. At the end of the first plenary session, the matrix was reviewed again by the entire group.

During the first breakout session, each team was asked to use the matrix to consider environmental actions associated with Corps water resource infrastructure in their respective areas of responsibility. Each action was scored based on potential and implementation. Scores are per team; values reflect status for each team's entire portfolio of projects (per reservoir type).

Potential ("Pot.") is a measure of the degree to which an action is likely to produce benefits. Implementation ("Imp.") is a measure of how much of that potential has already been realized. Both measures are reported as either: 0 (none), 1 (low), 2 (moderate), or 3 (high). For potential, a "0" ranking is an activity that has no potential for providing environmental benefits even if it were implemented. For implementation, a "0" ranking means there has been no implementation. In interpreting the scoring, a "3-2" would be a very promising action with moderate fulfillment; a "1-3" would characterize an action with limited possibilities that has already been highly achieved. An implementation value less than 3 indicates that there are unrealized environmental benefits.

Table 5a addresses environmental opportunity at general reservoirs with multiple purpose storage while Table 5b addresses locks and dams and dry dam reservoirs. Green highlighting identifies actions selected by each team for consideration during the next breakout session.

Table 5a. Potential and implementation of environmental actions per location-based team (general reservoirs).

Potential (Pot.) is a measure of the degree to which an action is likely to produce benefits.
Implementation (Imp.) is a measure of how much of that potential has been realized.

Both measures are reported as either: 0 (none), 1 (low), 2 (medium), 3 (high), or not applicable (n.a.).

Values are per office. In other words, measures of potential and implementation are reported for each office's entire portfolio of projects.

(yellow) Denotes environmental flow actions and objectives--traditional focus of SRP
(green) Denotes environmental actions selected by location-based teams for per project consideration

Reservoir Project Types		Environmental Action/Objectives	LRB		LRC		LRE		LRH		LRL		LRN		LRP	
			Pot.	Imp.	Pot.	Imp.	Pot.	Imp.	Pot.	Imp.	Pot.	Imp.	Pot.	Imp.	Pot.	Imp.
General	In pool	Support - Water Level management for fisheries	n.a.	n.a.	1	0	n.a.	n.a.	1	2	2	1	2	1	3	2
		Support - Water level management for mussels	n.a.	n.a.	0	0	n.a.	n.a.	0	0	1	0	0	0	0	0
		Support - Water level management for overwinter biota	n.a.	n.a.	1	0	n.a.	n.a.	1	0	1	0	0	0	0	0
		Support - Water level management for vegetation (riparian)	n.a.	n.a.	3	0	n.a.	n.a.	2	1	2	1	3	0	1	0
		Support - Water level management for vegetation (wetlands)	n.a.	n.a.	0	0	n.a.	n.a.	0	0	2	1	3	0	1	0
		Support - Water level management for waterfowl	n.a.	n.a.	1	0	n.a.	n.a.	2	1	2	0	1	0	3	0
		Support - Water level management for shorebirds, gulls, other migrants	n.a.	n.a.	1	0	n.a.	n.a.	0	0	2	0	1	0	3	0
		Suppress - Level management for fisheries	n.a.	n.a.	0	0	n.a.	n.a.	0	0	0	0	0	0	0	0
		Suppress - Level management for mussels	n.a.	n.a.	0	0	n.a.	n.a.	0	0	2	1	0	0	1	0
		Suppress - Level management for overwinter biota	n.a.	n.a.	0	0	n.a.	n.a.	0	0	0	0	0	0	0	0
		Suppress - Level management for vegetation	n.a.	n.a.	0	0	n.a.	n.a.	2	1	2	1	0	0	3	0
		Suppress - Level management for waterfowl	n.a.	n.a.	0	0	n.a.	n.a.	0	0	1	0	0	0	1	0
		Suppress - Water level management for shorebirds, gulls, other migrants	n.a.	n.a.	0	0	n.a.	n.a.	0	0	0	0	0	0	0	0
		Pool rate of change management for bank integrity (WQ considerations)	n.a.	n.a.	3	3	n.a.	n.a.	1	3	0	3	1	0	2	0
		Water Quality - Pathogens	n.a.	n.a.	3	0	n.a.	n.a.	0	0	0	0	0	0	2	0
		Water Quality - Nutrients	n.a.	n.a.	3	0	n.a.	n.a.	0	0	1	2	1	0	2	0
		Water Quality - Temperature	n.a.	n.a.	1	0	n.a.	n.a.	0	0	0	0	2	0	3	1
		Water Quality - Management of harmful algal blooms	n.a.	n.a.	3	0	n.a.	n.a.	0	0	1	0	2	0	3	0
	Connect Up and Down	Manage distribution of depositing sediments (encourage sediment flux)	n.a.	n.a.	1	0	n.a.	n.a.	1	3	1	0	0	0	2	1
		Reallocations	n.a.	n.a.	0	0	n.a.	n.a.	0	0	2	1	0	0	1	1
		Sediment management - bed and bank	n.a.	n.a.	1	0	n.a.	n.a.	1	3	1	0	1	1	2	1
		Restrict passage of invasives	n.a.	n.a.	0	0	n.a.	n.a.	0	0	1	0	0	0	1	0
		Water Quality - Temperature	n.a.	n.a.	0	0	n.a.	n.a.	0	0	2	2	0	0	0	0
		Debris management	n.a.	n.a.	2	1	n.a.	n.a.	2	1	0	0	2	1	1	0
	Ecological	Geomorphic process support	n.a.	n.a.	3	0	n.a.	n.a.	2	2	3	0	2	0	3	1
	.	Floodplain connectivity	n.a.	n.a.	1	0	n.a.	n.a.	2	2	3	1	0	0	3	1
	.	Riparian management	n.a.	n.a.	2	0	n.a.	n.a.	0	0	3	1	2	1	3	1
	.	Wetland management	n.a.	n.a.	2	0	n.a.	n.a.	0	0	3	1	0	0	3	1
		Life stage support - Fisheries	n.a.	n.a.	3	0	n.a.	n.a.	1	0	3	1	3	2	3	1
		Life stage support - Benthics	n.a.	n.a.	3	0	n.a.	n.a.	1	0	3	1	3	1	3	1
	.	Life stage support - Mussels	n.a.	n.a.	3	0	n.a.	n.a.	2	1	3	1	3	1	3	2
	.	Life stage support - Waterfowl	n.a.	n.a.	1	0	n.a.	n.a.	1	0	3	0	1	0	1	0
	.	Life stage support - Shorebirds, Gulls, other migrants	n.a.	n.a.	1	0	n.a.	n.a.	1	0	3	0	1	0	1	0
	Ecological	Life stage support - Herps	n.a.	n.a.	1	0	n.a.	n.a.	1	0	3	0	1	0	1	0
	Downstream	Rate of change management for bank integrity (WQ considerations)	n.a.	n.a.	3	3	n.a.	n.a.	1	3	3	2	2	1	3	1
		Physical habitat creation (use of dredged material, oxbows/floodplain restoration)	n.a.	n.a.	1	0	n.a.	n.a.	0	0	0	0	1	0	3	2
		Recreation	n.a.	n.a.	2	2	n.a.	n.a.	2	3	2	3	3	2	3	2
		Water Quality - Dissolved Gas (management of gas bubble trauma)	n.a.	n.a.	0	0	n.a.	n.a.	2	2	0	0	0	0	1	1
		Water Quality - Nutrients	n.a.	n.a.	1	0	n.a.	n.a.	2	2	3	0	1	0	1	1
		Water Quality - Temperature	n.a.	n.a.	2	0	n.a.	n.a.	2	2	3	2	3	1	1	1
		Water Quality - Turbidity	n.a.	n.a.	1	0	n.a.	n.a.	2	2	0	0	1	0	1	1
		Water Quality - Dissolved Oxygen	n.a.	n.a.	1	0	n.a.	n.a.	2	2	2	2	3	2	1	3

Table 5b. Potential and implementation of environmental actions per location-based team (locks and dams and dry dams).

Potential (Pot.) is a measure of the degree to which an action is likely to produce benefits.
Implementation (Imp.) is a measure of how much of that potential has been realized.

Both measures are reported as either: 0 (none), 1 (low), 2 (medium), 3 (high), or not applicable (n.a.).

Values are per office. In other words, measures of potential and implementation are reported for each office's entire portfolio of projects.

[green] Denotes environmental actions selected by location-based teams for per project consideration

Reservoir Project Types		Environmental Action/Objectives	LRB		LRC		LRE		LRH		LRL		LRN		LRP	
			Pot.	Imp.	Pot.	Imp.	Pot.	Imp.	Pot.	Imp.	Pot.	Imp.	Pot.	Imp.	Pot.	Imp.
L&D	In pool	Level management for fisheries	1	0	1	0	0	0	1	0	2	1	3	1	2	0
		Level management for mussels	0	0	1	0	0	0	1	0	2	1	3	1	2	0
		Level management for overwinter biota	0	0	1	0	0	0	1	0	2	1	1	0	2	0
		Level management for vegetation (riparian, woody, pioneer trees)	1	0	1	0	0	0	1	0	2	1	2	0	2	0
		Level management for veg (wetland emergent)	0	0	0	0	0	0	1	0	2	1	3	0	2	0
		Level management for waterfowl	0	0	1	0	0	0	1	0	2	1	1	0	2	0
		Level management for shorebirds, gulls, other migrants	0	0	0	0	0	0	1	0	2	1	1	0	2	0
		Water Quality - Nutrients	1	0	0	0	0	0	0	0	2	1	1	0	1	0
		Water Quality - Temperature	0	0	0	0	0	0	0	0	0	0	3	1	1	0
		Water Quality - Total Dissolved Gas	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		Water Quality - Turbidity	1	0	0	0	0	0	0	0	2	0	1	0	1	0
		Water Quality - Dissolved Oxygen	1	0	1	3	0	0	0	0	2	1	3	1	2	1
		Fish Passage Operations	1	0	2	2	0	0	1	0	3	1	1	0	2	1
		Managing Sediment	0	0	0	0	0	0	0	0	2	1	0	0	1	1
		Debris management	1	0	0	0	0	0	0	0	0	0	1	0	1	1
	Connect Up and Down	Fish Passage	1	0	1	1	3	0	2	0	3	1	3	1	3	1
		Rate of flow change management to minimize fish stranding	0	0	0	0	2	3	0	0	0	0	0	0	0	0
		Supressing - Water level management for fisheries	0	0	0	0	3	3	0	0	0	0	0	0	0	0
		Supressing - Water level management for vegetation	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		Support - Water level management for fisheries	0	0	0	0	3	1	0	0	0	0	0	0	0	0
		Sediment management - bed and bank	0	0	0	0	1	2	0	0	2	1	0	0	1	1
Dry Dams	In Pool	Physical habitat - Subimpoundment creation or restoration (ponds work)	1	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a..	n.a.	3	2
		Physical habitat - Riffle creation or restoration (stream work)	2	2	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Physical habitat - Permanent wetland creation (water quality / habitat improvements)	1	2	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Physical habitat - Seasonal wetland creation (vernal pools / seasonal wetlands)	2	2	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	3	1
		Invasive species control - native plant establishments	2	1	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	3	0
		Support - Water level management for amphibians	2	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Support - Water level management for fisheries	1	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Support - Water level management for water birds	2	0	n.a	n.a.	n.a	n.a.	2	0	n.a.	n.a.	n.a.	n.a.	0	0
		Support - Water level management for vegetation	2	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Suppress - Water level management for vegetation	3	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Recreation	1	1	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	3	0
	Connect Up and Down	Upstream sediment management partnerships	2	1	n.a	n.a.	n.a	n.a.	2	0	n.a.	n.a.	n.a.	n.a.	0	0
		Manage distribution of depositing sediments	1	1	n.a	n.a.	n.a	n.a.	0	0	n.a.	n.a.	n.a.	n.a.	0	0
		Sediment management - bed and banks	1	1	n.a	n.a.	n.a	n.a.	0	0	n.a.	n.a.	n.a.	n.a.	0	0
		Debris management	2	1	n.a	n.a.	n.a	n.a.	0	0	n.a.	n.a.	n.a.	n.a.	0	0
		Fish Passage	1	2	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Groundwater recharge for downstream ecological benefits	0	0	n.a	n.a.	n.a	n.a.	0	0	n.a.	n.a.	n.a.	n.a.	0	0
	Downstream	Riparian management for habitat conditions	1	3	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Subimpoundment creation or restoration (ponds work)	0	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	1	0
		Riffle creation or restoration (stream work)	0	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Permanent wetland creation - water quality / habitat improvements	0	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Seasonal wetland creation - vernal pools / seasonal wetlands	1	3	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Ecological flow targets (especially herps and vegetation)	2	1	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0
		Water quality for ecological purposes	1	0	n.a	n.a.	n.a	n.a.	1	0	n.a.	n.a.	n.a.	n.a.	0	0

Illustration of Reservoir Review

As background and information for the next focus session, a national review of environmental flow potential for reservoirs was presented. The review involved three questions, with each culminating in rankings of all 465 reservoirs with federally authorized flood space. The three questions were: 1) how influential could the reservoir be, 2) in terms of hydrologic alteration, what is the reservoir actually doing, and 3) what is the reservoir able to do? Each of these questions involved a different assessment. All were designed to sort the whole portfolio of reservoirs according to their relative promise as a candidate for environmental flow operations.

The "potential to influence" investigation involved a GIS exercise based on the storage volume of each reservoir and its corresponding mean annual flow at the dam and at points placed along the stream network below the dam. A value of storage divided by mean annual flow was computed at each point. Computed values decreased with distance from dam because the corresponding watershed area and associated mean annual flows increased. Computed values were multiplied by corresponding river reach lengths and summed for the full flow path, from dam to receiving lentic water body. Summed values were then sorted, ranked, and categorized as high, middle, and lower thirds within the region for display purposes (Figure 23).

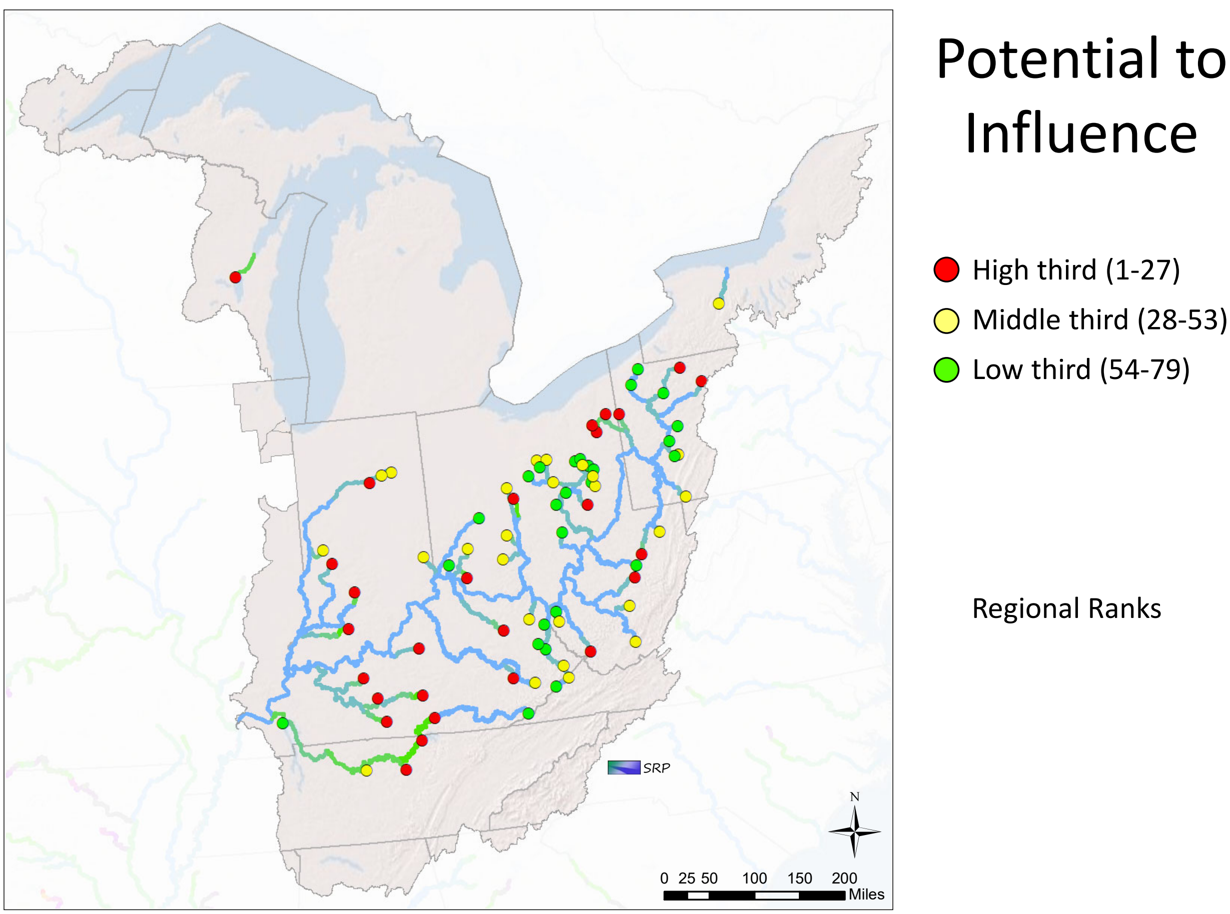


Figure 23. Results of the potential to influence assessment for the Lakes and Rivers region. Categories are based on regional rankings.

The "hydrologic alteration" assessment involved a statistical comparison of reservoir inflows and outflows. Differences in low flows, high flows, monthly volumes, and variability were all computed, expressed as a scale between 0 and 10 and then summed for the four metrics. The resulting sums were sorted, ranked, and categorized as high, middle, and lower thirds for display purposes (Figure 24).

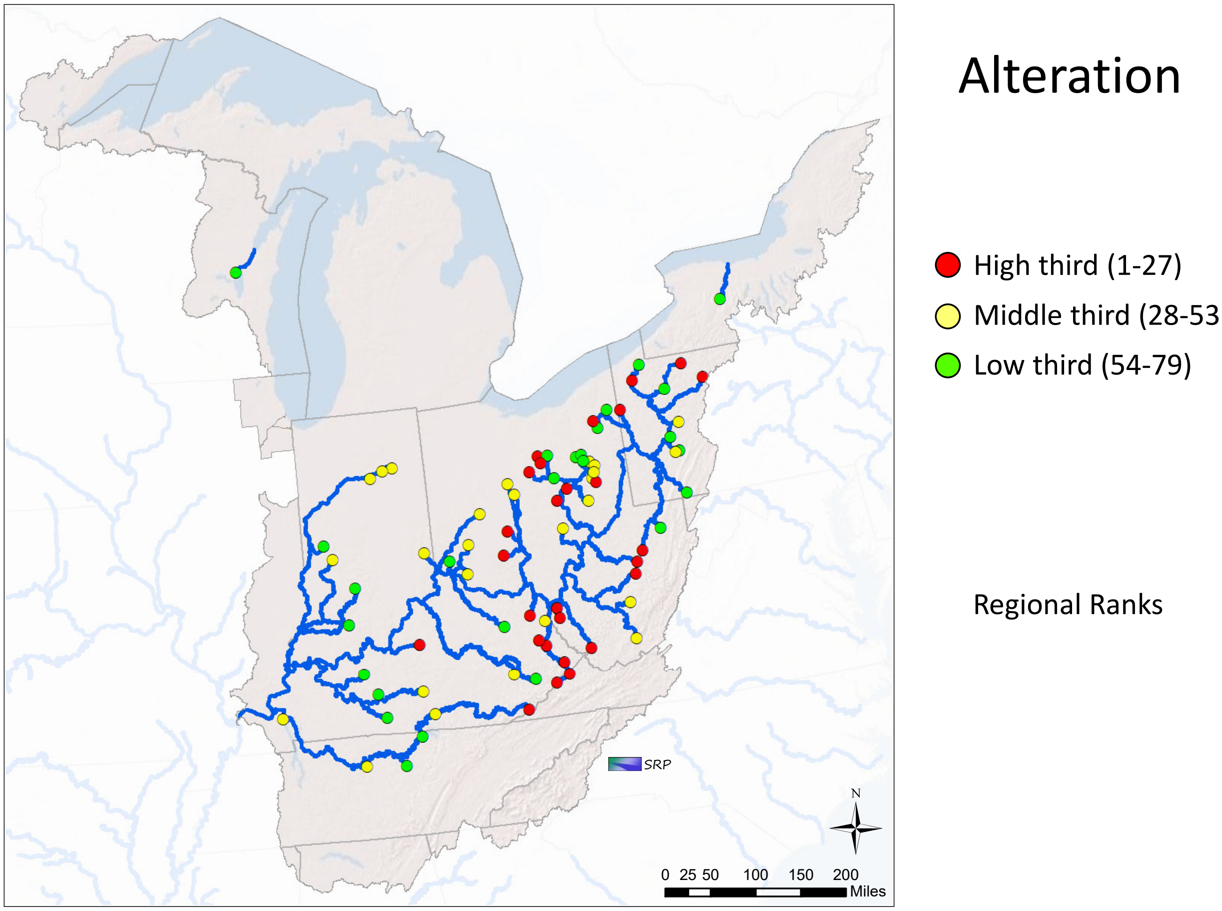


Figure 24. Results of the hydrologic alteration assessment for the Lakes and Rivers region. Categories are based on regional rankings.

The "characteristics" assessment considered each reservoir's authorities, operational flexibility, temperature management, fish passage, and channel condition. Reservoirs with federally authorized flood space have an average of 4 and as many as 8 authorized purposes per reservoir. Each authority accrued points for the reservoir (fish and wildlife +5, water quality +2.5, recreation +2.5, and all others -2 each). The total of the points was used as the score for the authorities portion of the assessment. Operational flexibility was estimated by computing the percentage of each reservoirs outflow that occurred between 0 and 20% of flood space encroached and then placing the percentage for each reservoir on a 0 to 10 scale. A reservoir's ability to manage outflow temperatures was scored on a scale from 0 to 10 with 0 being no ability, 5 being limited ability, and 10 being able to operate for water temperature with no expressed limitations. A reservoir's ability to pass fish was scored on a scale from 0 to 10 based on reported effectiveness, with 10 being free passage. Channel condition involved a comparison of a reservoir's objective flow (high flow limit) and its maximum non-damaging flow. When objective flow was equal to the maximum non-damaging flow a score of 0 was assigned. When objective flow was less than the maximum non-damaging flow the percent difference between the two values increased to a maximum of 10 when maximum non-damaging flow doubled the objective flow (differences greater than double were capped at a score of 10). When objective flow was greater than the maximum non-damaging flow the percent difference between the two values decreased to 0 as the maximum non-damaging flow decreased to 0. Scores for each of the five metrics were summed. Scores for the authorities and operational flexibility metrics were judged to be more important than the other metrics and given two shares each (added twice). The resulting sums were sorted, ranked, and categorized as high, middle, and lower thirds for display purposes (Figure 25).

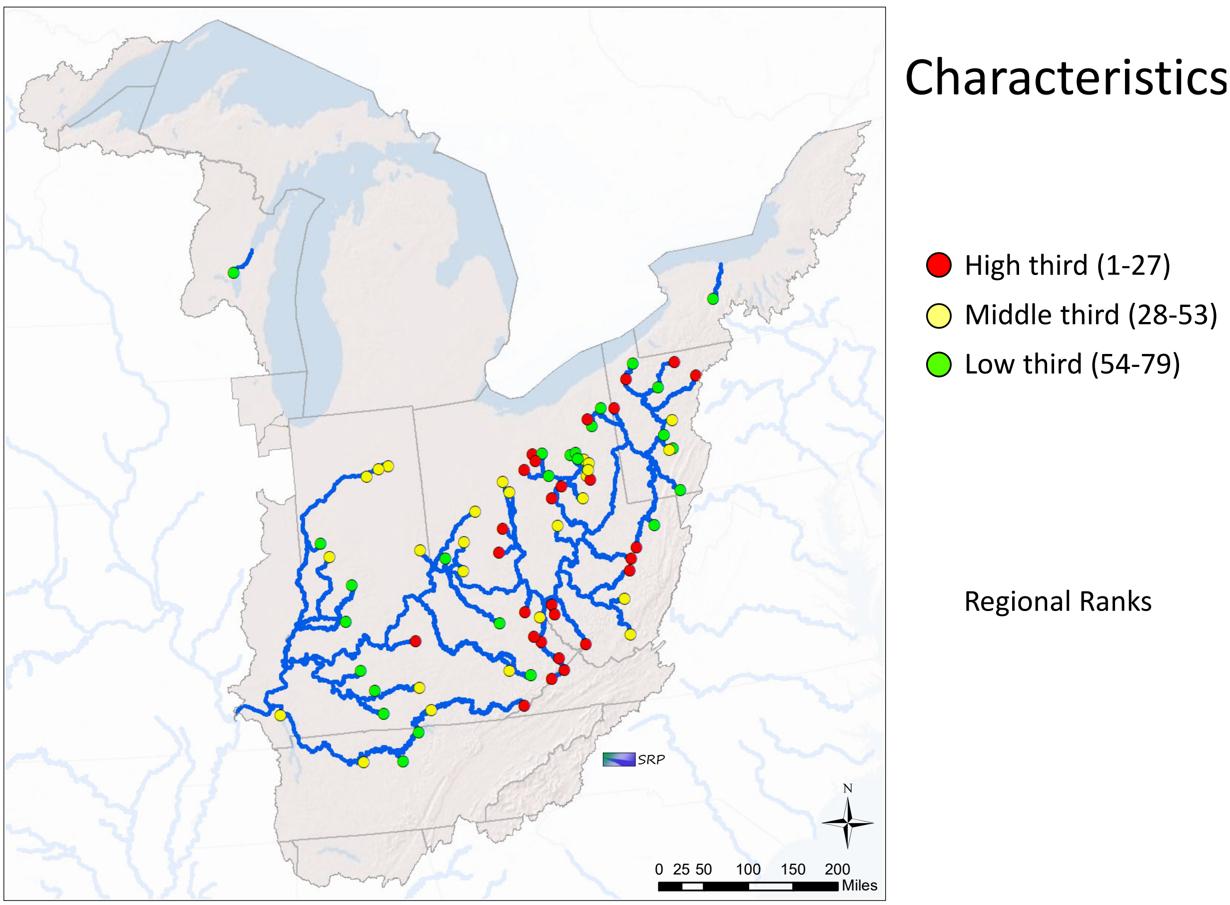


Figure 25. Results of the characteristics assessment for the Lakes and Rivers region. Categories are based on regional rankings.

Prioritization of Reservoirs

Location-based teams were provided with information from the national review of environmental flow potential and tasked with prioritizing infrastructure within their area of responsibility. Each team selected 3 to 7 environmental actions from Tables 5a and 5b, including "General (Reservoirs) – Downstream – Environmental flows", which was required. Other environmental actions were selected by the teams that have unrealized environmental benefits or were of importance to note.

Teams were tasked with prioritizing reservoirs within their area of responsibility for each selected environmental action. Results for each team are detailed below. Green highlighting shows the priority actionable ideas that are summarized in Table 1.

<u>Buffalo District (LRB)</u>

The following environmental actions were selected for prioritization:

1. Level management for fisheries (L&Ds, in pool)
2. Water Quality – Nutrients, turbidity, dissolved oxygen (L&Ds, in pool)
3. Debris management (L&Ds, in pool)
4. Physical habitat - Seasonal wetland creation (vernal pools/seasonal wetlands; dry dams, in pool)
5. Invasive species control – Multiple methods (dry dams, in pool)
6. Upstream sediment management partnerships (dry dams, connect up and down)
7. Debris management (dry dams, connect up and down)

Infrastructure projects were prioritized for each of these actions based on a combination of restoration need and potential ecological benefit (Table 6).

Table 6. Reservoir prioritization for LRB. Green highlighting indicates actionable ideas.

	Environmental Opportunities						
Project name	Level management for fisheries (Pot. 1; Imp. 0)	Water Quality - Multiple variables (Pot. 1; Imp. 0)	Debris management (Pot. 1; Imp. 0)	Physical habitat - Seasonal wetland creation (vernal pools / seasonal wetlands) (Pot. 2; Imp. 2)	Invasive species control - native plant establishments* (Pot. 3; Imp. 1)	Upstream sediment management partnerships (Pot. 2; Imp. 1)	Debris management (Pot. 2; Imp. 1)
Black Rock L&D	1	1	1				
Mount Morris Dam				1	1	1	1

* Combines both Invasive species control - native plant establishments and Suppress - Water level management for vegetation into one action

<u>Chicago District (LRC)</u>

The following environmental actions were selected for prioritization:

1. Water management for nutrient levels (general reservoirs, in pool)
2. Ecological flows opportunities to support fisheries and mussels (general reservoirs, downstream)
3. Environmental opportunities to manage water temperature (general reservoirs, downstream)

Reservoirs were prioritized based on the potential to realize environmental benefits (Table 7).

Table 7. Reservoir prioritization for LRC. Green highlighting indicates actionable ideas.

Project name	Environmental Opportunities Water Quality - Nutrients (Pot. 3; Imp. 0)	Life stage support - Fisheries (Pot. 3; Imp. 0)	Life stage support - Mussels (Pot. 3; Imp. 0)	Water Quality - Temperature (Pot. 2; Imp. 0)	Fish Passage (Pot. 2; Imp. 2)
Mississinewa Dam	1	1	1	1	
J. Edward Roush Dam	3	3	3	3	
Salamonie Dam	2	2	2	2	
Lockport Lock and Controlling Works					
Chicago River and Harbor Controlling Works					
Thomas J. O'Brien Lock and Controlling Works					
Cedars Lock and Dam	7				
Depere Lock and Dam	12	4			
Lower Appleton Locks and Dam	6				
Little Kaukauna Lock and Dam	11				
Little Chute Locks and Dam	8				
Menasha Lock and Dam	4				
Upper Appleton Locks and Dam	5				
Rapide Croche Lock and Dam	10				
Kaukauna Locks and Dam	9				
Indiana Harbor Canal Confined Disposal Facility					

Detroit District (LRE)

The following environmental actions were selected for prioritization:

1. Rate of flow change management to minimize fish stranding (L&D, connect up and down)
2. Suppressing - Water level management for fisheries (L&D, connect up and down)
3. Support - Water level management for fisheries (L&D, connect up and down)

Reservoirs were prioritized based on the potential to realize environmental benefits (Table 8).

Table 8. Reservoir prioritization for LRE. Green highlighting indicates actionable ideas.

Project name	Environmental Opportunites Rate of flow change management to minimize fish stranding (Pot. 2; Imp. 3)	Suppressing - Water level management for fisheries (Pot. 3; Imp. 3)	Support - Water level management for fisheries (Pot. 3; Imp. 1)
Soo Locks	1	1	1

Huntington District (LRH)

The following environmental actions were selected for prioritization:

1. Geomorphic process support (general reservoirs, downstream)
2. Floodplain connectivity (general reservoirs, downstream)
3. Life stage support - Mussels (general reservoirs, downstream)
4. Fish passage (L&Ds, connect up and down)
5. Support - Water level management for water birds (dry dams, in pool)

Reservoirs were prioritized based on the potential to realize environmental benefits (Table 9).

Table 9. Reservoir prioritization for LRH. Green highlighting indicates actionable ideas.

Project name	Geomorphic process support (Pot. 2; Imp. 2)	Floodplain connectivity (Pot. 2; Imp. 2)	Life stage support - Mussels (Pot. 2; Imp. 1)	Fish Passage (Locks and Dams) (Pot. 2; Imp. 0)	Support - Water level management for water birds (Migration Period) (Dry Dams) (Pot. 2; Imp. 0)
Alum Creek Dam	21	1	21		
Atwood Dam	19	14	31		
Beach City Dam	30	12	30		
Beech Fork Dam	31	31	20		
Bluestone Dam	22	20	7		
Burnsville Dam	7	18	2		
Charles Mill Dam	27	25	12		
Clendening Dam	17	11	29		
Deer Creek Dam	5	5	13		
Delaware Dam	3	3	8		
Dewey Dam	11	30	18		
Dillon Dam	9	9	16		
East Lynn Dam	26	23	10		
Fishtrap Dam	4	24	11		
Grayson Dam	24	17	9		
John W. Flannagan Dam	23	21	22		
Leesville Dam	16	10	27		
North Branch Kokosing Dam	20	15	19		
North Fork of Pound Dam	10	29	5		
Paint Creek Dam	6	7	3		
Paintsville Dam	29	28	28		
Piedmont Dam	13	4	23		
Pleasant Hill Dam	15	8	14		
R.D. Bailey Dam	2	19	4		
Senecaville Dam	12	2	6		
Summersville Dam	25	22	24		
Sutton Dam	1	16	1		
Tappan Dam	14	6	25		
Tom Jenkins Dam	28	27	26		
Wills Creek Dam	18	13	17		
Yatesville Dam	8	26	15		
Locks and Dams					
Belleville Locks and Dam				5	
Captain Anthony Meldahl Locks and Dam				1	
Greenup Locks and Dam				2	
Racine Locks and Dam				4	
Robert C. Byrd Locks and Dam				3	
Willow Island Locks and Dam				6	
London Locks and Dam				9	
Marmet Locks and Dam				8	
Winfield Locks and Dam				7	
Dry Dam					
Bolivar Dam					2
Dover Dam					5
Mohawk Dam					1
Mohicanville Dam					4
Beach City Dam*					3

*Also in general

Louisville District (LRL)

The following environmental actions were selected for prioritization, shaded in dark green below:

1. Support - Water level management for fisheries (general, in pool)
2. Floodplain connectivity (general, downstream)
3. Downstream life stage support - Fisheries and mussels (general, downstream)

4. Support - Water level management (general, in pool) and Life stage support (general, downstream) - Shorebirds, gulls, other migrants
5. Water quality – Temperature (general, downstream)
6. Fish passage (L&Ds, connect up and down)

While other opportunities were identified as feasible in Table 10, shaded in light green, data gaps exist that limit LRL's ability to determine if there is a need to investigate these opportunities further. This determination will require discussion with state natural resource agencies before identifying these opportunities as feasible or having potential positive impacts for each respective system. Other opportunities selected as feasible and implementable in the matrix are items that LRL has already identified as opportunities for improved implementation in the district and has taken steps to work towards environmental benefits that can be realized from these reservoirs. Unshaded items were not identified as actionable due to limitations in operation capability or limitations in authorized purposes.

Table 10. Reservoir prioritization for LRL. Green highlighting indicates actionable ideas. Bold indicates ideas described in the "Actionable Ideas and Discussion" section.

	Environmental Opportunities					
Project name	**Support - Water level management for fisheries (Pot. 2; Imp. 1)**	**Floodplain connectivity (Pot. 3; Imp. 1)**	**Life stage support - Fisheries and Mussels (Pot. 3; Imp. 1)**	**Support - Water level management and Life stage support - Shorebirds, Gulls, other migrants (Pot. 2,3; Imp. 0)**	**Water Quality - Temperature (Pot. 3; Imp. 2)**	**Fish Passage (Pot. 3; Imp. 1)**
Barren River Dam	4	1	2	1	2	
Brookville Dam	10	12	11	10	12	
Buckhorn Dam	5	16	16	5	16	
Caesar Creek Dam	11	7	8	11	11	
Cagles Mill Dam	12	14	12	12	15	
Carr Creek Dam	6	17	15	6	10	
Cave Run Dam	7	9	1	7	1	
Cecil M. Harden Dam	13	13	13	13	14	
Clarence J. Brown Dam	15	8	10	15	9	
Green River Dam	2	5	5	3	3	
Monroe Dam	16	11	9	16	8	
Nolin River Dam	**1**	4	4	2	5	
Patoka Dam	**14**	2	14	14	7	
Rough River Dam	3	3	6	4	17	
Taylorsville Dam	8	**10**	3	8	**4**	
West Fork of Mill Creek Dam	17	15	17	17	13	
William H. Harsha Dam	9	6	7	9	6	
Locks and Dams						
Cannelton Locks and Dam						3
Green River L&D 1						**1**
Green River L&D 2						**2**
John T. Myers Locks and Dam						4
Markland Locks and Dam						5
McAlpine Locks and Dam						6
Newburgh Locks and Dam						7
Olmsted Locks and Dam						8
Smithland Locks and Dam						9

Nashville District (LRN)

The following environmental actions were selected for prioritization:

1. Support - Water level management for fisheries (general, in pool)
2. Support - Water level management for riparian (general, in pool) and wetland (general, in pool) vegetation
3. Environmental flow targets – Life stage support for fisheries (general, downstream) and benthics (general, downstream)
4. Water management actions to improve water temperature (general, downstream) and dissolved oxygen (general, downstream)
5. Fish passage - Connectivity for fish via conservation locking (L&Ds, connect up and down)

Reservoirs were prioritized for each of these actions based on a combination of restoration need and potential ecological benefit (Table 11). Other environmental actions (i.e., not highlighted in Table 5 or listed above) were discussed during reservoir prioritization and are included in Table 11 for informational purposes, including level management for mussels (L&Ds, in pool), debris management (general and L&Ds, connect up and down), geomorphic process support (general, downstream), and life stage support for mussels (general downstream).

Table 11. Reservoir prioritization for LRN. Green highlighting indicates actionable ideas.

Project name	Environmental Opportunities In Pool Support - Water Level management for fisheries (Pot. 3; Imp. 1)	In Pool Level management for Mussels (Pot. 3; Imp. 1)	In Pool Support - Water level management for vegetation (Pot. 3; Imp. 0)	Debris Management (Pot. 2; Imp. 1)	Geomorphic Process Support (Pot. 2; Imp. 0)	Downstream Life Stage Support - Fisheries and Benthics (Pot. 3; Imp. 2)	Downstream Life Stage Support - Mussels (Pot. 3; Imp. 1)	Water Quality - Temp and DO (Pot. 3; Imp. 2)	Fish Passage (Pot. 3; Imp. 1)
Center Hill Dam	1		1	2	1	1	5	3	
Dale Hollow Dam	2		2	3	3	3	2	1	
J. Percy Priest Dam	6		6	4	2	4	1	2	
Laurel Dam	4		4	5	6	6	3	6	
Martins Fork Dam	5		5	6	5	5	4	5	
Wolf Creek Dam	3		3	1	4	2	6	4	
Locks and Dams									
Barkley Lock and Dam	3	3	3	1				4	4
Cheatham Lock and Dam	4	2	4	4				3	3
Cordell Hull Lock and Dam	2	4	2	2				2	1
Old Hickory Lock and Dam	1	1	1	3				1	2

Pittsburgh District (LRP)

The following environmental actions were selected for prioritization:

1. Reservoir pool level management for fisheries
2. Reservoir pool water quality - Temperature
3. Reservoir downstream e-flows - Life stage support - Fisheries
4. Locks and dams - Fish passage upstream and downstream using conservation lockages
5. Dry dams - Physical habitat - Seasonal wetland creation

A summary of the priority environmental opportunities at selected LRP projects is shown in Table 12 below.

Table 12. Reservoir prioritization for LRP. Green highlighting indicates ideas described in the “Actionable Ideas and Discussion” section.

	Environmental Opportunities				
Project name	Support - Water level management for fisheries (Pot. 3; Imp. 2)	Water Quality - Temperature (Pot. 3; Imp. 1)	Life stage support - Fisheries (Pot. 3; Imp. 1)	Fish Passage (Pot. 3; Imp. 1)	Physical habitat - Seasonal wetland creation (vernal pools / seasonal pools) (Pot. 3; Imp. 1)
Berlin Dam	1	5	4		
Conemaugh Dam	13	15	13		
Crooked Creek Dam	15	14	10		
East Branch Dam	10	2	1		
Kinzua Dam	2	7	5		
Loyalhanna Dam	14	12	15		
Mahoning Creek Dam	5	8	9		
Michael J. Kirwan Dam	6	1	3		
Mosquito Creek Dam	7	9	2		
Shenango Dam	8	4	11		
Stonewall Jackson Dam	9	3	8		
Tionesta Dam	12	13	14		
Tygart Dam	11	10	12		
Woodcock Creek Dam	4	6	7		
Youghiogheny Dam	3	11	6		
Dry Dams					
Union City Dam					1
Locks and Dams					
Allegheny River Lock and Dam 2				9	
Allegheny River Lock and Dam 4				11	
Allegheny River Lock and Dam 5				12	
Allegheny River Lock and Dam 6				13	
Allegheny River Lock and Dam 7				14	
Allegheny River Lock and Dam 8				15	
Allegheny River Lock and Dam 9				16	
Braddock Locks and Dam				4	
C.W. Bill Young Lock and Dam				10	
Charleroi Locks and Dam				5	
Dashields Locks and Dam				2	
Emsworth Locks and Dams				1	
Gray's Landing Lock and Dam				18	
Hannibal Locks and Dam				8	
Hildebrand Lock and Dam				19	
Maxwell Locks and Dam				20	
Monongahela River Locks and Dam 3				17	
Montgomery Locks and Dam				3	
Morgantown Lock and Dam				21	
New Cumberland Locks and Dam				6	
Opekiska Lock and Dam				22	
Pike Island Locks and Dam				7	
Point Marion Lock and Dam				23	

Actionable Ideas and Discussion

In the final breakout session, teams reconvened to further refine their prioritization of reservoirs. Each location-based team identified actionable ideas. An actionable idea is the pairing of a selected **Environmental action** and **Reservoir(s)** deemed to be compelling in accordance with potential environmental benefits and feasible to implement. This section details actionable ideas for each team.

Buffalo District (LRB)

The LRB team identified 7 actionable ideas (Table 6, green highlighting).

Level management for fisheries within the **Black Rock Canal** and Niagara River was scored as "Pot. 1; Imp. 0". The upper Niagara River has been impacted by a reduction in natural riparian habitat and hardening channel banks. Black Rock Lock is located adjacent to the upper Niagara River and operates to facilitate movement of commercial and recreational vessels past unpassable rapids along the river. Opportunities exist to operate the lock to facilitate the upstream migration of fish species (i.e., Emerald Shiner, Lake Sturgeon).

Water quality – Multiple variables. Modification to lock operations to benefit water quality was scored as "Pot. 1; Imp. 0." Scajaquada Creek flows into the Niagara River at the **Black Rock Canal**. Combined sewer overflows and urbanization contribute pollutants that impair water quality (i.e., excess nutrients, low dissolved oxygen, and high turbidity) in Scajaquada Creek. There may be potential to modify lock operations to flush water through Scajaquada Creek and Black Rock Canal to reduce residence time and pollutant concentrations in these waterbodies. The extent to which changes in operation will impact water quality in Scajaquada Creek and Black Rock Canal requires further investigation. Remediation of water quality and restoration of Scajaquada Creek are a priority for multiple stakeholders in the region, including Buffalo Niagara Waterkeeper and New York State Department of Environmental Conservation.

Debris management was scored as "Pot. 1; Imp. 0". Clearing and snagging contracts for debris management are currently utilized within **Black Rock Canal**. Further opportunities to utilize the debris was recognized as a way to provide additional ecological uplift outside of the Federal Navigation channel within the upper Niagara River.

Physical habitat improvement, such as seasonal wetland creation (vernal pools / seasonal wetlands) was scored as "Pot. 2; Imp. 2". The **Mount Morris** Dam is operated as a 'dry' dam and doesn't maintain a reservoir. Instead, the dam stores runoff during precipitation/runoff events that would otherwise risk flooding in downstream areas. When hydrologic conditions allow, the Mount Morris Dam is operated at 'run of river' flows, which attempts to mimic natural conditions. As a result, a vibrant and complex forest exists within the Letchworth Canyon upstream of the dam which is only periodically filled with water during large flood events. Seasonal riparian wetlands naturally exist along the Genesee River within the federal area of influence and are considered environmentally beneficial to various bird and amphibian species. Creating additional pothole pools in areas that are seasonally inundated could be accomplished concurrent with annual woody debris removal efforts at minimal additional effort (i.e., earth moving equipment is already mobilized for debris removal). It is likely that these potholes will fill with sediment over time, depending on the frequency and duration of pool storage. However, if the cost to install and maintain is minimal, the ecological benefits may be worth the investment.

Invasive species control and native plant re-establishment was scored as "Pot. 2; Imp. 1". The **Mount Morris** Dam and Recreation Area has been impacted by various invasive species to include tree-of-heaven, autumn olive, purple loosestrife, and Japanese knotweed to name a few. Mount Morris Dam sits on the Genesee River surrounded by New York State Parks lands and is operated as a dry dam. Upstream areas are mostly agricultural and can add invasive species seeds into the watershed. There are opportunities to reduce the number of invasive species and re-introduce native vegetation along riparian corridors. This can be accomplished through mechanical means or in limited areas by water management of the reservoir to enhance the riparian habitat.

Upstream sediment management partnerships was scored as "Pot. 2; Imp. 2". High sediment levels in the Genesee River are believed to be among the most significant detriments to water quality in the river, and there are already efforts underway to help address sediment concerns. Genesee River Wilds, the Genesee Valley Conservancy, and other non-profit groups already collaborate to help create riparian buffers and blueway recreation trails along the length of the Genesee with the goal of reducing sediment inputs and decreasing bank erosion. Any opportunities to reduce sediment in the Genesee would benefit river ecology and would be in the USACE interest in terms of reduced sedimentation upstream of **Mount Morris** Dam, and reduced need to dredge the federal channel near the mouth of the Genesee River.

Debris management was scored as "Pot. 2; Imp. 1". **Mount Morris** Dam sits on the Genesee River and operates as a dry dam. Extensive woody debris accumulates behind a trash boom across the river to keep debris from entering the gate structure areas and conduits. Some debris does make it past the boom and may make its way through the dam. Buffalo District awards a yearly contract to manage this debris for removal from the gorge by means of grinding into wood chips. There is a potential to look at alternative uses for the byproducts for the removal for ecological purposes or to look at alternate methods of removal and disposal.

Chicago District (LRC)

The LRC team identified 10 actionable ideas (Table 7, green highlighting).

Pool level management for water quality was scored as "Pot. 3; Imp. 0" and identified as actionable at **Mississinewa**, **Salamonie**, and **Roush** reservoirs. Relying on lake level management to interrupt or impede the life cycle of harmful algal blooms (HAB) within the pool may evolve to become the only feasible option to reduce these significant impacts. Research has shown decreasing water residency and increasing velocity in reservoirs can impact development of HABs. One option would be to hold seasonal pool higher in the operational band to accommodate higher intermittent releases.

Environmental flow opportunities - Life stage support for fish and mussels were scored as "Pot. 3; Imp. 0" and identified as actionable at **Mississinewa**, **Salamonie**, and **Roush** reservoirs. The Upper Wabash River was added to the Sustainable Rivers Program in 2022. After a successful subject matter expert orientation and environmental flows workshop, LRC is planning to gather baseline habitat and species presence data in the downstream reaches from which potential benefits from future implementation of e-flows can be measured. During the spring fill, project releases are set to minimum for approximately one month. With the proposed e-flows changes to operations, the spring fill would be initiated as early as February, allowing for increased stages in advance of typical operations. Pulsed releases would be effectuated, the duration and magnitude of which would be based on the availability of stored water, short-term weather forecasts, and the hydrologic outlook provided by the National Weather Service. These releases would allow for the mimicking of natural flow pulses, capturing some of the incoming seasonal flood pulses while continuing the fill the reservoir. To mimic small rain events, pools would be held above summer pool, allowing for dryer months to be augmented with small, short pulses. The frequency, magnitude and duration of the pulse would be dependent upon the hydrologic conditions at the time but would not be expected to exceed a two-day duration. During the winter drawdown, project releases would be pulsed rather than following a prescribed curve, allowing for tempering of the downstream waterway to thermal shock. Initially relatively smaller pulses would be released, gradually increasing over the drawdown period. Project releases would match inflows between the pulses, mimicking the natural flows of the waterway. The cumulative effect of the releases would be sufficient to allow the target dates and elevations to be matched.

Downstream water quality - Temperature was scored as "Pot. 2; Imp. 0". The **Mississinewa** Reservoir tower has multilevel outlets that allow water to be released from depths of 10 feet (727 feet above mean sea level - msl), 21 feet (716 feet msl), and 32 feet (705 feet msl). Summer target pool elevation is 737 feet msl. The maximum flow that can be released from the multilevel inlets is 188 cfs. Any flows above 188 cfs would be release through the main gates, which draw from the bottom of the reservoir, approximately 65 feet below the summer pool surface. Water released from the main gate is colder than incoming water, therefore temperatures in the downstream reach are artificially colder than they would naturally be. Multilevel release inlets can be used to temper water temperatures in the tailwater below the dam to promote fish spawning and mussel reproduction.

Detroit District (LRE)

The LRE team identified 3 actionable ideas, 2 of which are detailed below (Table 8, green highlighting).

Rate of flow change management to minimize fish stranding was scored as "Pot. 2; Imp. 3". The St. Marys Rapids are a productive ecosystem many species rely on to fulfill some portion of their lifecycle. Management of Lake Superior outflow alters conditions in the rapids and affects habitat quality. Work is being conducted to investigate various strategies associated with gate operation at the **Soo Compensating Works**, which are used to control the flow through the rapids. The Lake Superior Board of Control strives to keep water level rates of change to less than 0.33 foot per hour; however, very little is known about water level response to gate changes in the rapids. A two-dimensional model was constructed of the St. Marys River to help understand the water level response within the rapids. Preliminary results are used to develop general guidelines for use while more specific recommendations are developed. Results show water level rates of change are more sensitive during relatively low discharge and provide guidance on the duration of the gate movements to meet the 0.33 foot per hour water level rate of change. However, manual adjustments are labor intensive, do not fully accommodate recommended water level rates of change and expose staff to adverse environmental conditions. To date, a comprehensive evaluation of automation and its ecological benefits has not been completed. Preliminary surveys of the rapids while gates are closing have discovered fish stranding is still problematic, regardless of the additional of automated gates.

Support - Water level management for fisheries was scored as "Pot. 3; Imp. 1". Currently, optimization work is being conducted to shift the focus from operational efficiency of the **Soo Compensating Works**

to increasing beneficial fish habitat in the rapids. Various fish species require different water depths, velocities and substrate throughout their life cycle, changing the combination of gate openings to best accommodate various fish species throughout the year can be accomplished by directing discharge to various portions of the rapids and creating these favorable conditions. Through the coupling of physics-based hydrodynamic models with individual-based models of animal behavior, appropriate gate settings will be determined to achieve these conditions. The St. Marys Rapids Habitat Optimization Project represents a significant investment in the fusion of habitat restoration, navigational servitude and hydropower production. It can be a demonstration project for other hydropower and navigation infrastructure projects to enhance downstream habitat.

Huntington District (LRH)

The LRH team identified 11 actionable ideas (Table 9, green highlighting).

General Reservoirs

Life stage support - Mussels was scored as "Pot. 2; Imp. 1". LRH waterways are home to a diverse mussel community. Some of the lake tailwaters are host to more than 20 species of freshwater mussels. Ecological flow changes have been shown to benefit mussel communities within the district. **Sutton Lake** made changes to its augmentation operations in 2010 that coincided with the first demonstration of mussel recruitment in the Elk River in over 30 years. Similar actions could be taken at other projects within the district to limit cold water discharges, maintain minimum flows during critical low flow seasons, and continue to manage outflows for optimal water quality.

Burnsville Dam is located in Braxton County on the Little Kanawha River, 124 miles above its confluence with the Ohio River. It was developed to reduce flooding on the Little Kanawha River, which runs 167 miles and drains an area of 2,320 mi^2. Summer pool is maintained from April through October. In early November the pool is gradually lowered by 13 feet to the target winter pool. This winter pool elevation is maintained through March. A robust mussel community which includes Federally listed species, lies downstream of Burnsville Lake. A study of operations during the low flow season could provide opportunities to manage flows for mussel resource benefits.

Paint Creek Lake provides flood risk management for communities along Paint Creek. Additionally, Paint Creek provides water supply for Highland Water Company, increased flow downstream during low flow conditions, and recreational opportunities and wildlife habitat. Paint Creek Lake is operated for flow augmentation for the town of Bourneville, Ohio. The need for this augmentation has not been assessed recently. If feasible, decreasing augmentation flows from Paint Creek Lake could provide the low flow environment necessary for maximized reproduction and recruitment of native mussels in Paint Creek.

Spatial distribution of potential benefits related to life stage support for mussels is shown in Figure 26.

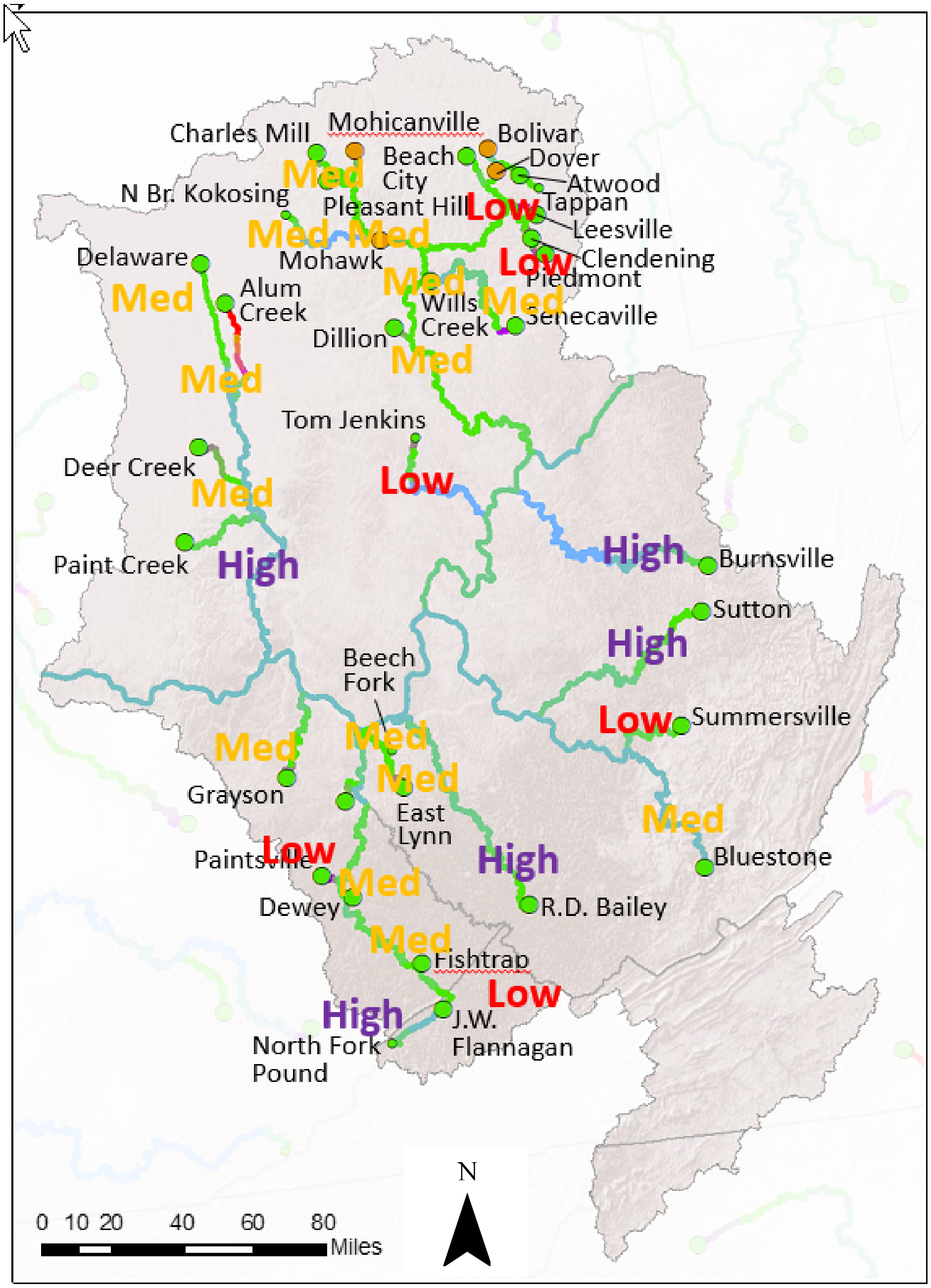


Figure 26. Map showing the relative potential for benefits related to life stage support operations for native mussels, Huntington District.

<u>Geomorphic process support</u> was scored as "Pot. 2; Imp. 2". **Sutton**, **R.D. Bailey**, and **Delaware** lakes all show potential for benefits related to operations for geomorphic process support. Pulsed flows from these lakes could allow re-sorting of river substrates and provide for better habitat. During normal low flow conditions, downstream reaches can become "armored" due to constant, unchanging flow regimes. This armoring limits available habitat for benthic macroinvertebrates and fish. Pulsed flows allow higher velocity water to reorganize the substrate material in the river bottom to maximize available habitat.

These three lakes have the potential to operate for pulsed flows. With high potential to influence values (Figure 23), pulses from these projects could benefit long reaches of tailwater downstream.

Spatial distribution of potential benefits related to geomorphic process support is shown in Figure 27.

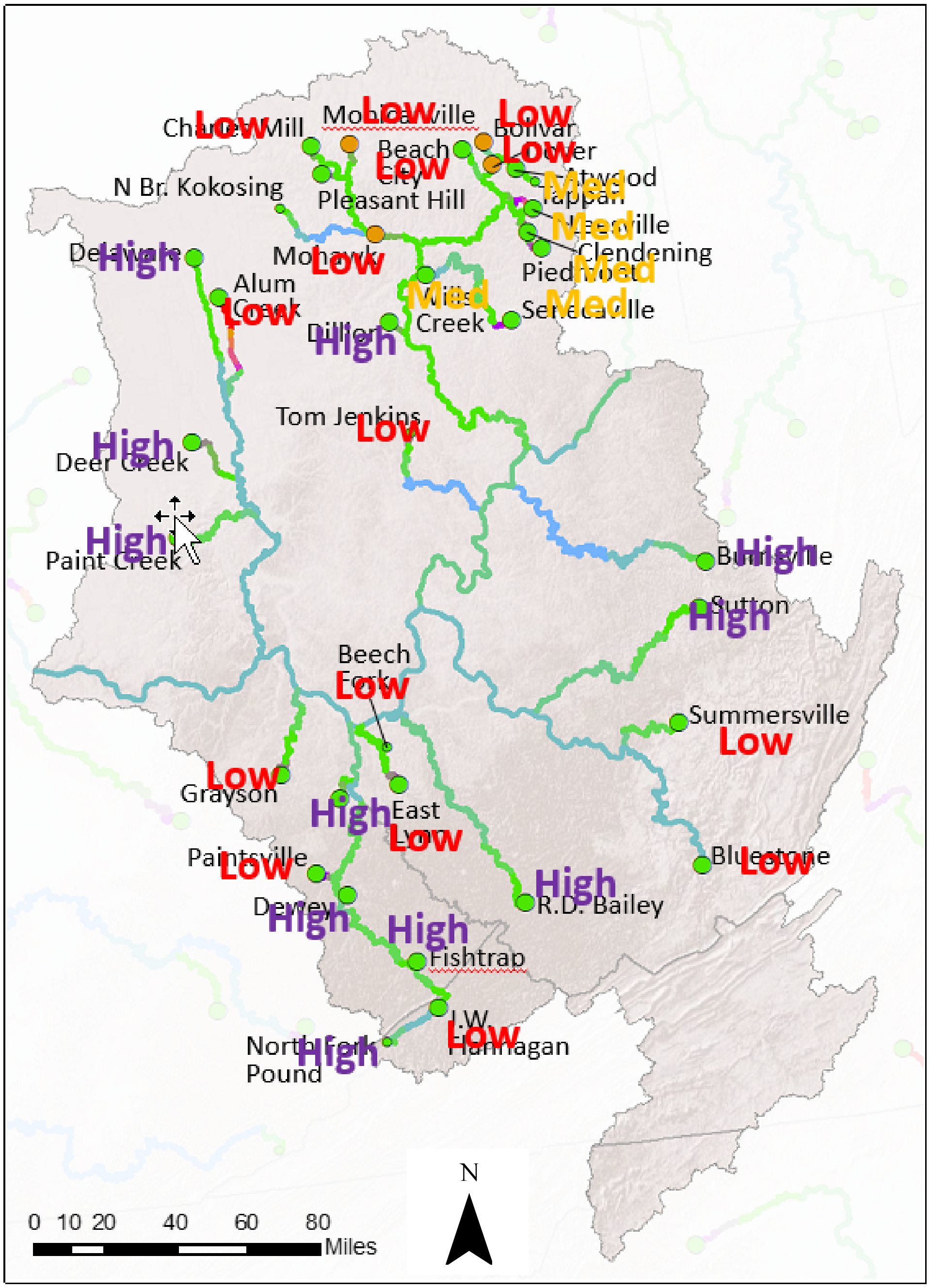


Figure 27. Map showing the relative potential for benefits related to geomorphic process support, Huntington District.

Floodplain connectivity was scored as “Pot. 2; Imp. 2". Potential was scored a 2 because existing floodplains below many LRH general reservoirs could be engaged by increasing outflows to inundate additional floodplain areas. Implementation was scored a 2 because many LRH reservoirs do not currently operate for floodplain connectivity but could do so in the future. The LRH projects where floodplain connectivity could be most ecologically beneficial are **Alum Creek**, **Senecaville**, and **Delaware**

dams. These three projects are located in Ohio where land elevation is considerably more level and connected than projects residing in the more mountainous areas of Kentucky and West Virginia. Operating outflows to reach the maximum control elevation downstream could provide for beneficial floodplain connectivity. Well-timed releases could connect stream channels to floodplains during critical ecological seasons while avoiding impacts to farmland. Initial assessments of these projects should include a determination of how often flood damage control elevations are reached downstream. This proposal is not recommending that control point elevations be raised for ecological purposes.

Spatial distribution of potential benefits related to floodplain connectivity is shown in Figure 28.

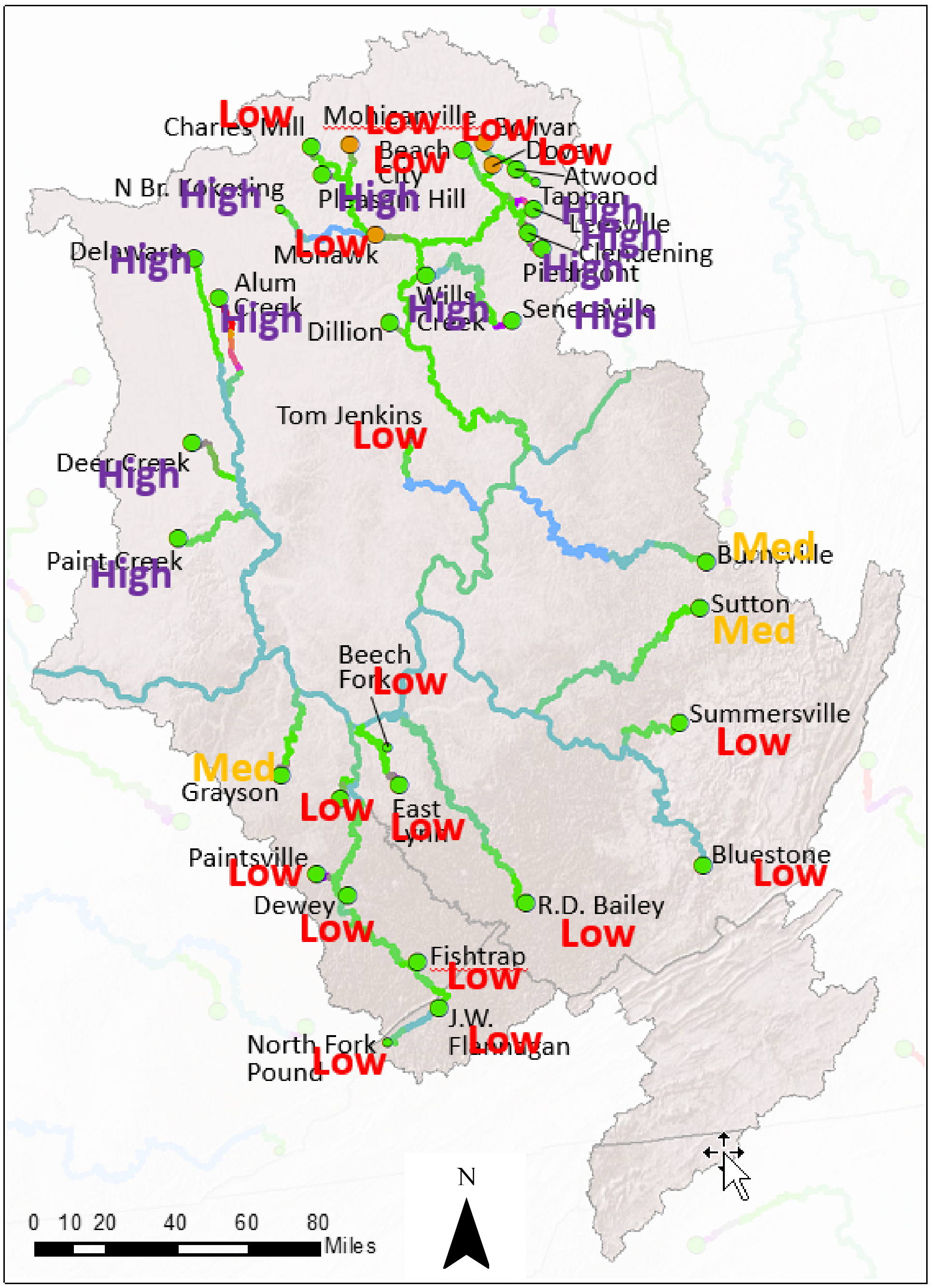


Figure 28. Map showing the relative potential for benefits related to floodplain connectivity, Huntington District.

Locks and Dams

<u>Fish Passage</u> was scored as "Pot. 2; Imp. 0". **Captain Anthony Meldahl Lock and Dam** is a navigation dam on the Ohio River at Ohio river mile 436 and is the furthest downstream lock and dam in LRH. The project also hosts an onsite non-federal hydropower project. The navigation pool impounded on the Ohio River is 95 miles long and bounded upstream by Greenup Lock and Dam at river mile 341. Corps Locks and Dams can be a significant barrier to migrating fish. The fish passage would be facilitated by utilizing the auxiliary lock chamber utilizing the following sequence:

1. Equalize the lock chamber to lower pool and open the downstream miter gates
2. Open filling valves to create a current out of the downstream end of the lock chamber
3. Leave the downstream miter gates open for two days
4. Shut the downstream miter gates
5. Equalize the lock chamber to upper pool
6. Open the upstream miter gates to allow the fish to pass and travel upstream in the Ohio River

This environmental flow could be beneficial any time of the year, however, performing this operation during the last week of May would maximize the value with regard to fish spawn. Efforts to minimize migration of non-native carp could impact the feasibility of these operations. The District should work with appropriate Federal and state resource agencies on this proposal.

Dry Dams

<u>Support - Water level management for water birds</u> was scored as "Pot. 2; Imp. 0". Huntington District operates four dry dams within the Muskingum River watershed. These dry dams could be used for the development of wading and dabbling bird habitat during the fall migration season (Figure 29). This migration season also occurs during the lower flow season which carries less risk for flooding. Consequently, it is possible to maintain a limited pool in the reservoir for ecological benefits while not significantly impacting the project's flood control mission. However, given the potential for some impact to the project's flood control mission, any proposed temporary impoundment behind the dam should be evaluated thoroughly for unacceptable risk to flood damage reduction operations.

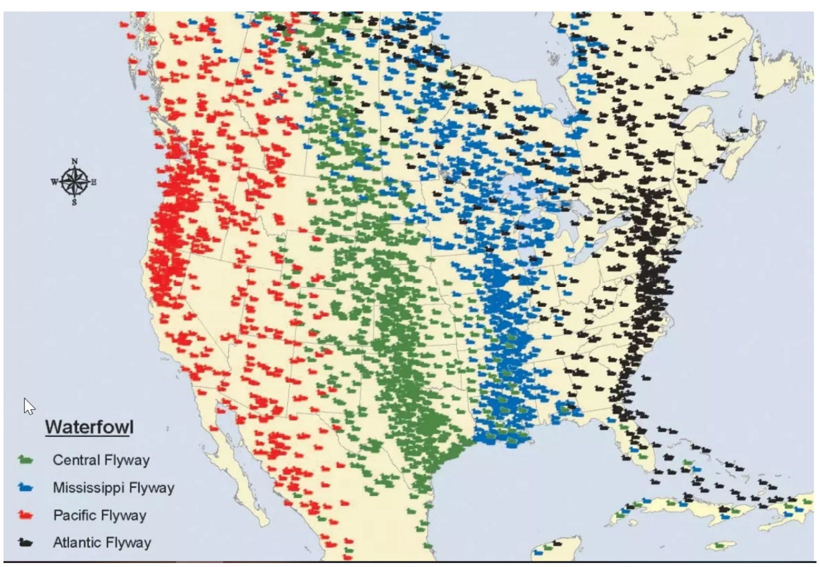


Figure 29. Major flyways of migratory birds in North America. Courtesy of U.S. Fish and Wildlife Service.

Of the four dry dam projects, **Mohawk** is likely to provide the largest benefit due to a drainage area of 821 mi^2 and over 8,000 acres of inundation at the flood control pool elevation. The goal of this operation would be to inundate habitat within the dry storage area with a depth of approximately 18 inches. This depth would be beneficial to migrating, dabbling waterfowl. However, the reservoir area of the Mohawk dry dam is also critical habitat for the Rabbitsfoot Mussel (*Quadrula cylindrica cylindrica*). Changes to operations and deviations from the Water Control Plan would require Section 7 Endangered Species Act coordination with the U.S. Fish and Wildlife Service.

Louisville District (LRL)

The LRL team identified 16 actionable ideas, 6 of which are detailed below (Table 10, green highlighting).

Support - Water level management for fisheries was scored as "Pot. 2, Imp. 1". **Nolin Reservoir** has the highest release capacity of the Louisville FRM projects, with a significant downstream channel capacity. Of all LRL projects, Nolin has the highest potential to minimize pool fluctuations and maintain pool elevations while balancing risk to the flood control mission. Kentucky Fish and Wildlife service has also expressed interest in potentially adjusting the target pool elevations to provide more benefit to the Nolin Reservoir fishery.

The fishery in **Patoka Reservoir** has significantly declined in the past several years. Decline in game fish population is due to suspected reduction in submerged vegetation following prolonged duration of high water in 2018 and 2019. The project has a 4-foot change from winter to summer pool. During a dry year, there may be the potential to target winter pool for one season allowing the reservoir rim to re-vegetate and re-establish. It is expected Indiana Department of Natural Resources would be very supportive of a one-year effort to reestablish vegetation to help reestablish and support a recovery of the fishery in Patoka Reservoir.

Floodplain connectivity was scored as "Pot. 3, Imp. 1". The topography below **Taylorsville Dam** may be conducive to releasing high enough flow rates to re-establish floodplain connectivity. The land use downstream of Taylorsville Dam is highly agricultural. During non-crop season releases, low lying bottom lands are frequently inundated. This allows higher releases to connect to the floodplain after small flood events that occur during non-crop season. Crop-season releases are lower, but Taylorsville has a unique tower configuration allowing for temperature control with releases up to about 2,000 cfs. Immediately after highwater events downstream, this crop season release capacity could allow a pulse to connect the river to the floodplain. This could potentially allow for floodplain connectivity to occur at any point in the year.

Water quality - Temperature was scored as "Pot. 3, Imp. 2". **Taylorsville Lake** has a unique tower configuration allowing for temperature control with releases up to about 2,000 cfs. There are also known state-listed mussels in the Salt River that would benefit from improved temperature management. The combination of high feasibility and good ecological benefit make Taylorsville Lake a good candidate for improving downstream temperature management.

Fish passage was scored as "Pot. 3, Imp. 1". **Green River Lock and Dams 1 and 2** were selected for fish passage improvements by modifying the operation schedule of the miter gates. Decreased navigation through these structures has reduced operation of the locks and consequently decreased potential for fish passage (Lock and Dam 2 has approximately 20 lockages per month that serves a single customer, per personal communication with the lockmaster). Green River is one of the most biodiverse systems in the country, especially for fishes and mussels, which would both benefit from increased passage. There may also be opportunity to utilize upstream FRM reservoirs to manage pool levels in Green River to increase fish passage opportunities at Rochester Dam, formerly Green River L&D 3. Rochester Dam was recently transferred from LRL to the city of Rochester, Kentucky, for water supply purposes. The lock has been filled in and is no longer functional, essentially making the structure a fixed weir dam. During high flows, water overtops the dam and allows for fish passage, however, LRL may be able to increase the frequency and/or duration of fish passage opportunities with pulses from the four upstream reservoirs.

Nashville District (LRN)

The LRN team identified and discussed 11 actionable ideas (Table 11, green highlighting).

In pool support - Water level management for fisheries was scored as "Pot. 3; Imp. 1". **In pool support - Water level management for vegetation** was scored as "Pot. 3; Imp. 0". **Dale Hollow, Center Hill,** and **Wolf Creek** dams are three of the LRN projects with the highest pool level fluctuations between winter and summer pools. These large changes in pool elevation can allow for seasonal growth of vegetation that can be beneficial for waterfowl species or fish species during the high winter pool. There are also fish species that benefit from consistent pool elevations during their spawning seasons. There is an opportunity to consider specific species needs for maintaining pool elevations during specific times or changing the drawdown and fill of the pool to benefit vegetation growth.

Life stage support - Fisheries and benthics was scored as "Pot. 3; Imp. 2". The Obey and Cumberland Rivers downstream from **Dale Hollow** and **Wolf Creek** dams, respectively, support valuable put and take cold-water trout fisheries. Both dams have initial, congressionally authorized project purposes for flood control and hydropower. They have generally authorized project purposes for water supply, water quality, fish and wildlife, and recreation.

State water quality standards for dissolved oxygen (DO) for cold-water fisheries is 6.0 milligrams per liter (mg/L) in Tennessee and 5.0 mg/L in Kentucky. DO levels in the tailwaters are influenced by reservoir condition and operation. Typically, releases are accomplished through turbine discharges for power production. As the reservoir thermally stratifies during the warm season, DO levels in the water column below the thermocline decrease since any source of reaeration is removed. Turbine discharge DO levels in the tailwater eventually fall below the state thresholds at varying times depending upon a complex set of factors, including weather, discharge patterns, phytoplankton activity, and reservoir elevation.

Minimum flow improvements increase minimum wetted perimeter (width of the streambed that is submerged at any given time) and minimum velocities in the tailwater. Increased wetted area produces increased area for growth of benthic organisms which provide food for fish populations, especially if the wetted area is sustained with minimal disruption. The primary metric used to assess habitat availability is weighted usable area (WUA). WUA is the wetted area of a stream weighted by its suitability for aquatic organisms or recreational activity.

There is an opportunity to study the extent to which different combinations of dam components lead to best fulfilment of authorized purposes for fish and wildlife while preserving the ability of the facilities to meet their initially authorized project purposes of flood control and hydropower.

Water quality - Temperature and dissolved oxygen were scored as "Pot. 3; Imp. 2". **Dale Hollow** has a cold-water discharge tailwater area that is popular for fishing and other recreation. The Obey River flows nearly 8 miles until the confluence with the Cumberland River. Currently, there are operational limits and considerations on the releases due to temperature concerns and low dissolved oxygen. There is potential to better optimize releases to improve downstream water quality to support aquatic life. **J. Percy Priest** was identified as a potential candidate for this environmental consideration. During the late summer and early fall, high concentrations of hydrogen sulfides in the bottom of the reservoir do not allow for turbine generation due to downstream water quality requirements at a water supply intake. As a result, a cone valve was added to the powerhouse to add a minimum flow to the Stones River without utilizing the spillway. The Water Control Manual currently requires winter drawdown to occur at the beginning of October when the pool is heavily stratified, and hydrogen sulfides continue to negatively impact downstream water quality needs. J. Percy Priest often experiences lake turnover at the beginning to middle of November, at which point the densely concentrated hydrogen sulfides are mixed and diluted allowing for hydropower generation. An opportunity exists to consider extending summer pool to mid-November, thereby benefiting fall spawning fish and other aquatic species in the pool, while also allowing for increased hydropower.

Fish passage (via conservation locking) was scored as "Pot. 2; Imp. 0". Conservation locking at **Cordell Hull L&D** was identified as a promising candidate for an ecological opportunity to facilitate the passage of the Lake Sturgeon (*Acipenser fulvescens*). Tennessee Department of Environment and Conservation's Natural Heritage Inventory Database shows multiple records of Lake Sturgeon at Cordell Hull Dam on the mainstem Cumberland, just upstream of its confluence with the Caney Fork River. Additionally, Tennessee Wildlife Resources Agency's (TWRA) Angler Reporting Program resulted in numerous reports of Lake Sturgeon in the Caney Fork River, up to Center Hill Dam. In May of 2023, a spawning aggregation of Lake Sturgeon was reported in the riprap on the left descending bank just downstream from the Center Hill Powerhouse. Lake Sturgeon are a state listed endangered species and will be up for review in 2024 for federal listing by the U.S. Fish and Wildlife Service. TWRA has stocked over 200,000 Lake Sturgeon in the Cumberland and Tennessee River basins since the year 2000, including in Old Hickory Lake. A critical factor contributing to the species' recovery is availability of suitable spawning habitat.

In addition to generating hydropower for local communities, Cordell Hull L&D was built to support navigation purposes to upstream industrial facilities. Over the past 50 years, river commerce upstream of Cordell Hull has declined significantly. Cordell Hull sees less than 10 lockages per year which creates a significant barrier to aquatic species passage through the mainstem Cumberland River. Studies conducted by Auburn University have investigated the efficacy of conservation lockages for aquatic species passage on the Alabama River, funded by the Sustainable Rivers Program and the Mobile District. Although studies are ongoing, conservation lockages in addition to attractor flows have proven to successfully support the migration of fish through the barrier.

Pittsburgh District (LRP)

The LRP team identified and discussed 12 actionable ideas (Table 12, green highlighting).

Support - Water level management for fisheries was scored as "Pot. 3; Imp. 2". Two reservoirs, the **Kinzua Dam** and the **Berlin Lake Dam**, were prioritized for this environmental action.

The Seneca Nation historically occupied territory throughout Central and Western New York, including along the Allegheny River. When **Kinzua Dam** was constructed and the river valley flooded, a large portion of the reservation land was either inundated or placed into an easement, with the result that the Seneca Nation lost the ability to use that land. The Seneca Nation has since built and maintains a walleye hatchery located on a tributary stream to the Allegheny River and Reservoir. The fishery raises and releases walleye, a species that the Seneca people traditionally relied on, into Allegheny Reservoir to mature and proliferate. A potential future effort to evaluate the lifecycle needs of hatchery-released walleye could help determine reservoir level management actions to provide ecological benefits for both the species and the Seneca Nation. The Seneca Nation would need to be a project partner for this effort to move forward.

Berlin Lake is classified as a moderately deep, eutrophic, mid-latitude, dimictic reservoir. Strong stratification in summer can lead to hypoxic areas by the dam, resulting in hydrogen sulfide releases in the outflow, reduced fish habitat in the deeper depths of the reservoir and increased dissolved metal concentrations at certain times. Fluctuations in water level often cause erosion and sedimentation. A decrease in water level can stimulate plant growth near shore, potentially stabilizing sediments and increasing water clarity, but it has the potential to harm fisheries by reducing spawning areas and raising water temperature. This environmental opportunity would allow the Pittsburgh District to review the conditions and stratification extents at Berlin Lake and determine what environmental benefits could be realized by altering lake water levels for fish populations, including survival, spawning, and availability of quality habitat.

Water quality - Temperature was scored as "Pot. 3; Imp. 1". **Michael J. Kirwan** is a multipurpose reservoir authorized for water quality control, fish and wildlife enhancement, recreation, and water supply. The reservoir stores water for release downstream during dry periods which improves both the quality and quantity of flow in the Mahoning River for domestic and industrial use, recreation, esthetics, and aquatic life. Discharge from Michael J. Kirwan Dam is controlled by three larger vertical lift gates with invert elevations of 938.3 feet and three smaller vertical lift gates with invert elevations of 938.3 feet, 955.3 feet, and 971.3 feet (Figure 30). The highest of the smaller gates can be used for release of warmer water and the lower two smaller gates for discharge of colder water during summer months.

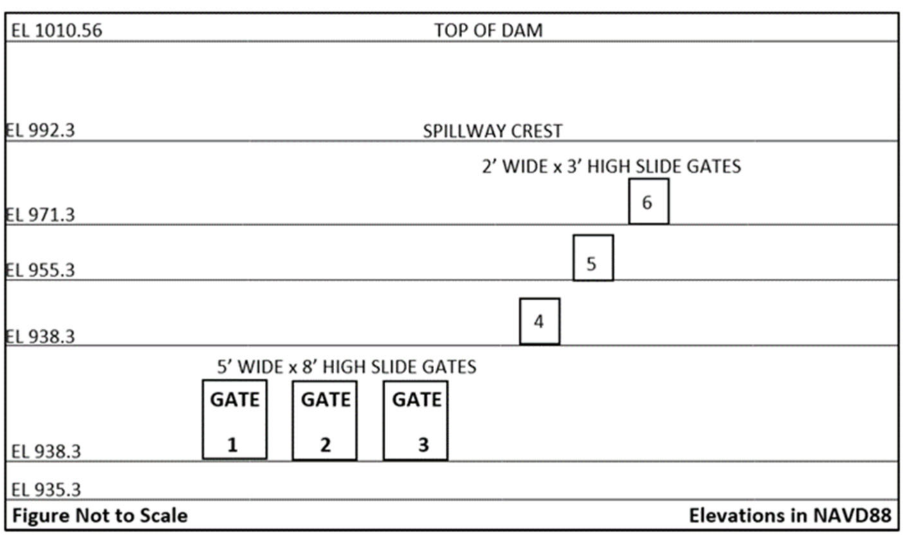


Figure 30. Michael J. Kirwan Dam gate schematic.

In-reservoir water temperature stratification is disrupted as water is pulled from the **Michael J. Kirwan reservoir**. Warmer water can become entrained at lower elevations which can stress aquatic species that require cooler temperatures. Team discussion revealed potential measures that could support maintaining reservoir temperature stratification at **Michael J. Kirwan Dam** by altering which sluice gates are used over summer and fall months. The opportunity would include monitoring of seasonal in-reservoir water temperature variation to determine stratification stability with changes in gate use. Pittsburgh District would then use this information to see what improvements could be made in day-to-day operations to support beneficial reservoir temperature stratification.

Downstream e-flow targets – Life stage support – Fisheries was scored as "Pot. 3; Imp. 1". Multiple reservoirs were prioritized for this environmental action, including the **East Branch Clarion River Lake, Mosquito Creek Lake, Michael J. Kirwan Reservoir**, and **Berlin Lake**.

East Branch Clarion River Lake is authorized for flood control, water quality control, fish and wildlife, and recreation. Controlled releases of water from the dam during dry summer months help improve water quality and quantity for industrial and domestic uses while supporting aquatic life and downstream recreational uses. The East Branch Clarion River downstream of the dam is designated as a high quality, cold-water fishery. **East Branch Clarion River Lake** is a deep reservoir with selective withdrawal capabilities. It has 4 gates at different elevations and can discharge from any of the gates or multiple gates to mix water to achieve downstream temperature requirements (Figure 31 and 32) as guided by a downstream temperature-flow schedule on the Clarion River at Johnsonburg.

Current operations have eliminated bankfull events, reduced the magnitude and frequency of high flow pulses, reduced the magnitude of spring baseflows, significantly elevated the magnitude of summer baseflows, and created winter flows that are lower than early fall flows. Team discussion revealed existing flow prescriptions developed in 2017 for **East Branch Clarion River Lake** could restore a more natural hydrograph to the East Branch and mainstem Clarion Rivers, support geomorphic processes, and support downstream high quality, cold-water fisheries. Next steps would be to review the existing flow prescriptions and determine which are feasible to implement while adhering to downstream flow and temperature requirements. This information would support implementation of select flow prescriptions and associated monitoring of the effects using downstream USGS gages and on-site data collection.

Alteration of streamflow in the Mahoning River due to the operation of upstream reservoirs was assessed using the Indicators of Hydrologic Alteration (IHA) software developed by The Nature Conservancy. The IHA is a free software program that provides useful information for those trying to understand the hydrologic impacts of human activities or trying to develop environmental flow recommendations for water managers. Results of this assessment were compiled into a Hydrologic Alteration Study in September 2020 which provided a summary of flow alterations upstream and downstream of **Michael J. Kirwan Dam**, **Mosquito Creek Dam**, and **Berlin Dam** for three reach segments along the Mahoning River.

In general, the study found that the three reservoirs primarily store water during the spring and release water during the summer and fall. Extreme low flows naturally present in summer months are no longer present. Reservoirs in the Mahoning River basin operate to retain high flow pulses and floods. Therefore, maximum flows and frequency of high pulses have reduced significantly under current conditions. Furthermore, there are no small or large floods and minimum flows are higher in current conditions. Similarly, the frequency of low pulses and extreme low flows have reduced significantly.

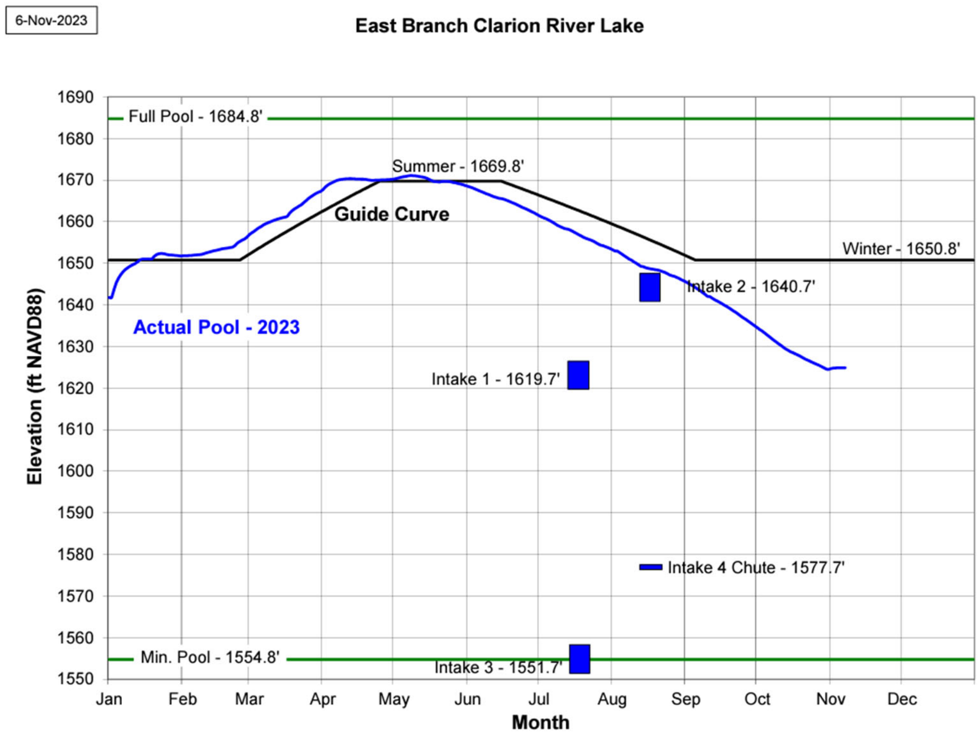


Figure 31. East Branch Clarion River Lake guide curve and intake elevations.

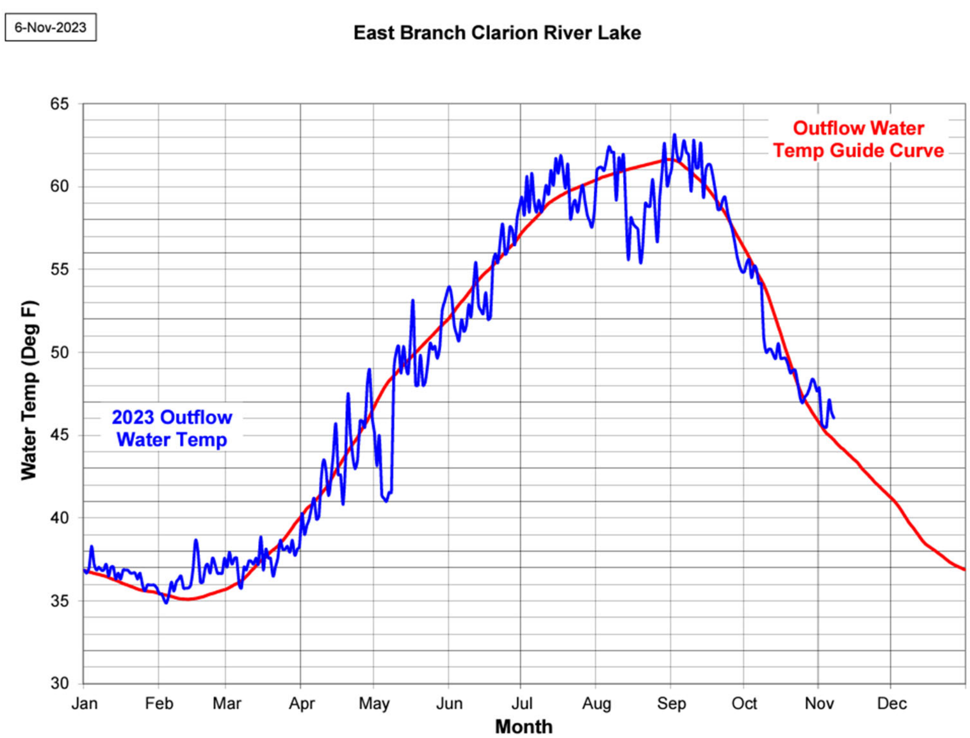


Figure 32. East Branch Clarion River Lake outflow temperature guide curve and 2023 outflow water temperature.

The study provided a limited assessment of alteration in the Mahoning River basin and is based solely on hydrologic data. It would be beneficial to quantify e-flow requirements for the Mahoning and to identify any potential incompatibilities between e-flow requirements and current operations. This could be done collectively for these three reservoirs leveraging information from other studies in the Upper Ohio River Basin. E-flow requirements would be considered for implementation feasibility within the authorized purposes and operational constraints of each reservoir.

Locks and Dams - Fish passage (via conservation locking) was scored as "Pot. 3; Imp. 1" for connectivity up and down. Multiple locks and dams were prioritized for this environmental action, including **Emsworth Locks and Dam, Dashield Locks and Dam, Montgomery Locks and Dam**, and **Braddock Locks and Dam**.

Emsworth, Dashields and Montgomery (Figure 33) are the first three locks and dams on the Ohio River downstream of Pittsburgh, Pennsylvania. Negative impacts to aquatic communities have occurred since the lock and dams were constructed due to habitat segmentation and lack of adequate passage through the lock and dam systems. Potential measures that could improve habitat connectivity for fish populations within the upper mainstem Ohio River include: 1) Creation of regional task force to define and recommend actions, monitor goals and measures of success with State and Federal Resource management agencies, Academia, and Nongovernmental stakeholders and 2) Enaction of a pilot effort related to conservation locking for aquatic habitat on the first 30 river miles of the Ohio River, which would be focused at **Emsworth** (river mile 6.2), **Dashields** (river mile 13.3), and **Montgomery** (river mile 31.7). The opportunity would engage Operations and create a standard operating procedure for the manipulation of operations at these locations to create attractant flows and flow regimes based on fish species seasonality of migration along with monitoring to quantify "success" of this means to lock fish to other pools and increase habitat connectivity.

Figure 33. Upper Ohio Navigation Project Locks and Dams (USACE photos).

Braddock Locks and Dam (Figure 34) is the first operating project located on the Monongahela River south from its confluence with the Allegheny River in Pittsburgh. Because this lock and dam is located downstream from the Elizabeth Locks and Dam, which is scheduled to be removed in 2024, it presents an opportunity to further increase fish passage through the Monongahela and Ohio River systems. There is a current SRP effort to engage stakeholders on the Upper Ohio River and carry out a pilot project performing conservation lockages for fish passage. This effort on the Monongahela River would leverage information and implementation plans created from that SRP project to plan and implement conservation lockages at the Braddock Locks and Dam, including review of existing information, creation of a conservation lockage plan, and implementation.

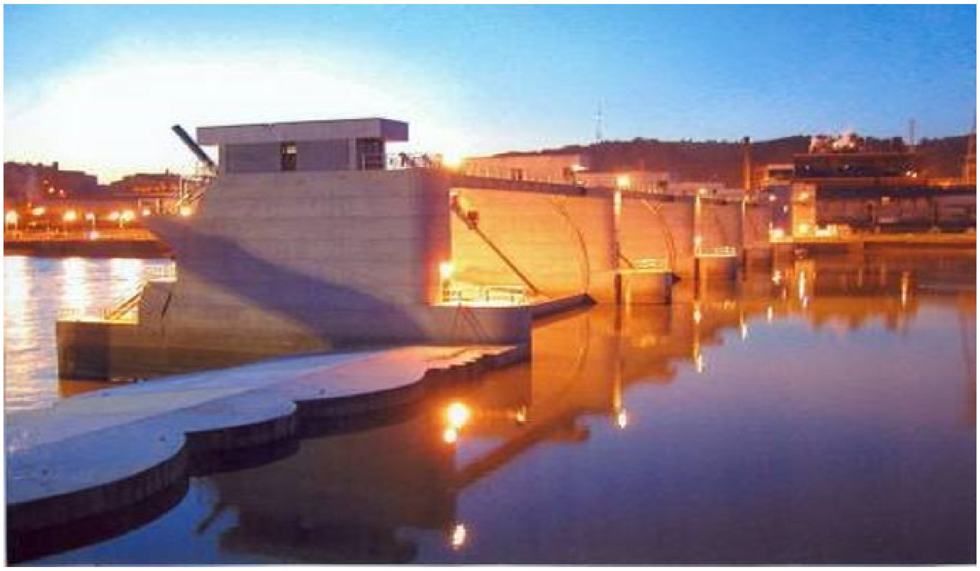


Figure 34. Braddock Locks and Dam (USACE photo).

Dry Dams - Physical habitat improvement - Seasonal wetland creation (vernal pools/seasonal wetlands) was scored as "Pot. 3; Imp. 1". **Union City Dam** was built in 1971 to control the frequently flooded French Creek. Current operations at Union City Dam are minimal and the reservoir does not maintain a permanent water pool (Figure 35). Instead, the dam retains excess water during rainy seasons and discharges it passively at a near constant rate. Temporary pools and inundated areas during rain provide varying habitats for fish and amphibians. French Creek contains 27 of Pennsylvania's 65 freshwater mussel species, four of which are federally endangered. There is an opportunity to construct onsite pothole wetlands to improve habitat diversity for wetland-dependent life. This biologically diverse area would benefit from further environmental actions, such as encouraging vernal pools or seasonal wetlands particularly in the upper reaches of the pool that are periodically inundated.

Figure 35. Photo of Union City Dam (photo by Carl Nim, USACE).

Conclusion

The Lakes and Rivers Regional Operations and Water Management Meeting was held November 7-8, 2023. The Lakes and Rivers region is defined as the geographic area containing seven Corps Districts within Lakes and Rivers Division (LRD): Buffalo (LRB), Chicago (LRC), Detroit (LRE), Huntington (LRH), Louisville (LRL), Nashville (LRN), and Pittsburgh (LRP). Teams for each District collaborated to determine environmental opportunities at water management infrastructure projects that are feasible to implement and are likely to provide compelling potential benefits. More than 79 reservoirs, affecting flows for over 6,660 river miles within the region, were considered.

In formulating and evaluating environmental opportunities, location-based teams followed these steps:

1. list possible environmental improvement actions associated with reservoirs and water management infrastructure;
2. rate environmental potential of each action;
3. rate degree to which each action has been implemented;
4. select environmental actions with potential and unrealized implementation; and,
5. rank reservoirs and water management infrastructure according to which projects are most promising for operational changes related to selected actions.

A key outcome of the meeting is the list of “actionable ideas”, each of which is a pairing of an environmental action with unrealized implementation possibilities at a water management infrastructure project with potential to enact related operational changes. There were 70 actionable ideas identified during the workshop involving 26 Corps reservoirs, 10 Corps locks and dams, and 2 Corps dry dams (Table 1).

This tally is worthy of reflection. In a day and a half, 40 participants identified 70 actionable ideas. In other words, Table 1 includes 70 potential ways to get more environmental benefits from already built, public, water management infrastructure - just do more of this (action) at this location (infrastructure). This does not mean making the changes would be easy or always generate the anticipated benefits. However, these actionable ideas do clearly connect water resources management to ecosystem management and illustrate the unrealized potential of infrastructure to be used as tools in the restoration and management of ecosystems.

It is hoped that the meeting outcomes can be used by district and Lakes and Rivers regional partners to initiate future implementation of as many of the identified actions as possible using the suite of environmental restoration and management tools and authorities at their disposal, including the Sustainable Rivers Program.

This was the seventh regional meeting supported by the Sustainable Rivers Program. From a Program perspective, the meeting was done to 1) identify environmental opportunities at reservoirs in the Lakes and Rivers and 2) cultivate a forum about environmental considerations at reservoirs. The Corps has several recurring meetings that focus on water management and involve multiple Districts. To the knowledge of SRP, none are specific to environmental considerations. SRP will continue to advance these regional meetings and help implement the resulting ideas with the overall goal of incorporating environmental strategies into the operations of Corps water management infrastructure.

References

Bain, M. (2007). Hydropower Operations and Environmental Conservation: St. Marys River, Ontario and Michigan Mark B. Bain Conseil international du lac Supérieur. http://www.ijc.org/conseil_board/superior_lake/en/superior_home_accueil.htmhttp://www.ijc.org/conseil_board/superior_lake/fr/superior_home_accueil.htm

Molina-Moctezuma, A., Ellis, E., Kapuscinski, K. L., Roseman, E. F., Heatlie, T., & Moerke, A. (2021). Restoration of rapids habitat in a Great Lakes connecting channel, the St. Marys River, Michigan. Restoration Ecology, 29(1). https://doi.org/10.1111/rec.13310

Appendix A - Lakes and Rivers Region - Operations and Water Management Meeting Participants

District	Name	Organization	Location-based Team
LRB**			
	Steve Winslow	Corps	Buffalo
	Jennie Brancho	Corps	Buffalo
	Thomas Wenzel	Corps	Buffalo
	Thomas Arcuri	Corps	Buffalo
	John Hickey*	Corps	Buffalo
LRC			
	Jared Mobley	Corps	Chicago
	Alex Hoxsie	Corps	Chicago
	Ryan Johnson	Corps	Chicago
	Jeff Fuller	Corps	Chicago
	Jared Blocher	Corps	Chicago
	John Hickey*	Corps	Chicago/Huntington
LRE**			
	Megan Royal	Corps	Detroit
	Timothy Calappi	Corps	Detroit
	Charles (Chuck) Sidick	Corps	Detroit
	Rheannon Hart*	Corps	Detroit
LRH			
	Sean Carter	Corps	Louisville
	Megan Wilburn	Corps	Louisville
	Andy Johnson	Corps	Louisville
	John Hickey*	Corps	Chicago/Huntington
LRL			
	Abbey Miglio	Corps	Louisville
	Adam Connelly	Corps	Louisville
	Zac Wolf	Corps	Louisville
	Steele Mcfadden	Corps	Louisville
	Joe Staigl	Corps	Louisville
	Kristin Berger	Corps	Louisville
	Clayton Mastin	Corps	Louisville
	Chris Boggs	Corps	Louisville
	Deryck Rodgers	Corps	Louisville
	Danna Baxley	TNC	Louisville
	Rheannon Hart*	Corps	Louisville

LRN			
	Daniel Clark	Corps	Nashville
	Ryan Wigner	Corps	Nashville
	Faye Valerio	Corps	Nashville
	Michael Rawetzki	Corps	Nashville
	Patrick Garner	Corps	Nashville
	Jim Howe*	TNC	Nashville
LRP			
	Marion Divers	Corps	Pittsburgh
	John Chopp	Corps	Pittsburgh
	Carl Nim	Corps	Pittsburgh
	Kyle Kraynak	Corps	Pittsburgh
	Kaitlyn Kiehart	Corps	Pittsburgh
	Andi Fitzgibbon	Corps	Pittsburgh
	Lane Richter*	Corps	Pittsburgh

*SRP Team Member
**Virtual Workshop

Appendix B - Lakes and Rivers Region - Operations and Water Management Meeting Agenda

NOVEMBER 7-8, 2023

LAKES AND RIVERS REGION - OPERATIONS AND WATER MANAGEMENT MEETING

Meeting goal is to identify environmental opportunities at water infrastructure that are feasible to implement with compelling potential benefits. Participants provide expertise in reservoir operations, water management, water quality, natural resources management, environmental planning, and ecology. Meeting provides a venue for consideration of environmental actions at rivers and water infrastructure of the Lakes and Rivers Region.

KEY EVENT DATES

SEPTEMBER
COORDINATION WITH PARTICIPANTS

OCTOBER
DISTRIBUTION OF MATERIALS

NOVEMBER 7-8
OPERATIONS AND WATER MANAGEMENT MEETING

MEETING LOCATION:
Admiral Room, Fourwinds Lakeside Inn & Marina, Bloomington, IN

OPERATIONS AND WATER MANAGEMENT MEETING - LAKES AND RIVERS REGION

Tuesday, November 7, 2023 – Admiral Room

9:00 am - 9:30 am

Introductions and Meeting Objectives. Session includes welcome, introductions, meeting overview, and meeting objectives.

9:30 am - 10:00 am

SRP Brief. History and status of the Sustainable Rivers Program (SRP). As of 2022, SRP has engaged 44 river systems and 90+ Corps reservoirs. SRP focuses on environmental flows (e-flows), including a process for advancing, implementing, and incorporating e-flows into reservoir operations, while exploring a broader set of strategies about environmental opportunities at water infrastructure.

10:00 am - 10:30 am

Regional Rivers and Reservoirs. Results from ongoing GIS analyses are used to summarize rivers and reservoir systems of the Lakes and Rivers Region. Details include number, volume, purposes, and potential influence of Corps reservoirs in region.

10:30 am - 10:45 am Break

10:45 am - 11:30 am

"Water Infrastructure"-centric Environmental Efforts within Region. SRP efforts in the Lakes and Rivers Region include work on the Upper Wabash, Green, Ohio, Upper Ohio, French Creek, and others. Session includes presentations about SRP and other environmental projects within region (perspectives from participating Districts).

11:30 am - 12:30 pm

Focus Session: Ongoing Environmental Work at Water Infrastructure Projects within Region. Interactive group exercise (with reporting to conclude session) related to current environmental activities. Three topics or questions will be explored:

1) Identify environmental opportunities at reservoirs. Define potential and implementation per office.
2) What opportunities are underrepresented and feasible?
3) What are limitations to implementation?

12:30 am - 1:30 pm Working Lunch (at the venue)

1:30 pm - 2:00 pm Continuation of Previous Focus Session

2:00 pm - 2:30 pm

National Reservoir Review. Review of project authorizations and basic capabilities of Corps reservoirs to operate for environmental purposes, including which reservoirs have fish and wildlife, water quality, and/or recreation as an authorized purpose.

2:30 pm - 4:00 pm

Focus Session: Prioritization of Water Infrastructure Projects within Region. Location-based teams will be provided with information from a national reservoir review and tasked with prioritizing candidate infrastructure projects within their area of interest/expertise. Prioritizations will be done for environmental flow potential and two or three of the most promising environmental activities identified in the previous Focus Session. Teams will also develop ideas about how data provided might be applied differently in support of environmental activities.

4:00 pm Wrap for day and details about tomorrow.

Wednesday, November 8, 2023 – Admiral Room

8:00 am - 8:15 am (start earlier)

Greeting and Revisit of Meeting Objectives. Session describes meeting goals and activities for the day.

8:15 am - 8:30 am

Review of Yesterday. Brief retrospective about yesterday's focus sessions for 1) environmental activities at water infrastructure projects and 2) project prioritizations.

8:30 am - 10:30 pm

Strategy Session to Integrate Information. Location-based teams reconvene to finalize thoughts and materials for report out and write up findings.

10:30 am - 11:00 am Break

11:00 pm - 12:00 pm

Reports from Location-based Teams. Teams will report to group on identified environmental opportunities and candidate infrastructure projects. Actionable ideas will be highlighted.

12:00 pm - 1:00 pm Working Lunch (at the venue)

1:00 pm - 1:30 pm

Group discussion. Open discussion about meeting products and actionable ideas. Follow-up tasks. Concluding thoughts.

1:30 pm - 2:00 pm

Review Regional Meeting Concept. This is the seventh regional meeting done via the Sustainable Rivers Program. Review overall agenda and revisit key components to discuss effectiveness and generate ideas for future meetings. Ideas about meeting goals, construct, and potential would be welcome. Discuss where the meetings outcomes can and should go and can these types of meetings be a platform for anything else.

2:00 pm Meeting Adjourned