Hotel Blackhawk
Davenport, Iowa

Upper Mississippi River Restoration Program Coordinating Committee

Quarterly Meeting

May 22, 2024

Agenda
with
Background
and
Supporting Materials

Blackhawk Hotel
Davenport, IA

Upper Mississippi River Restoration Program Coordinating Committee

May 22, 2024

Agenda

Tuesday, May 21 Partner Quarterly Pre-Meetings

3:30 – 4:45 p.m.	**Corps of Engineers**
3:30 – 4:45 p.m.	**Department of the Interior**
3:30 – 4:45 p.m.	**States**

Wednesday, May 22 UMRR Coordinating Committee Quarterly Meeting

Time	Attachment	Topic	Presenter
8:00 a.m.		**Welcome and Introductions**	***Sabrina Chandler**, USFWS*
8:05	**A1-15**	**Approval of Minutes of February 28, 2024 Meeting**	
8:10	**B1-25**	**Regional Management and Partnership Collaboration** ▪ FY 2024 Fiscal Update and FY 2025 Outlook ▪ HREP Selection ▪ UMRR Strategic Planning ▪ UMRR Restoration Workshop ▪ Report to Congress	***Marshall Plumley**, USACE*
9:10	**C1-5**	**Strategic Planning Update**	***Chrissa Waite**, USACE*
10:10		**Break**	
10:20	**D1-2**	**Communications** ▪ UMRR Communications Team ▪ External Communications and Outreach Events	 ***Rachel Perrine**, USACE* ***All***
10:50		**Program Reports** ▪ Habitat Rehabilitation and Enhancement Projects – District Reports	 ***Angela Deen, Julie Millhollin, Brian Markert**, USACE*
11:50 a.m.		**Lunch**	

(Continued on next page)

Wednesday, May 22   UMRR Coordinating Committee Quarterly Meeting
(Continued)

Time	Attachment	Topic	Presenter
1:00 p.m.		**Program Reports (Continued)**	
	E1-91	▪ Long Term Resource Monitoring and Science	
		– USACE LTRM Update	***Davi Michl**, USACE*
		– LTRM FY 2024 2nd Quarter Highlights	***Jeff Houser**, USGS*
		– LTRM Implementation Planning Update	
		– LCU Update	
		– FY 24 Science Proposals	
	E92-93	– A-Team Report	***Matt O'Hara**, IL DNR*
		– Consideration of Endorsement of Science Proposals	***Jeff Houser**, USGS*
2:00		**UMRR Showcase Presentations**	
		▪ Beaver Island HREP	***Steve Gustafson**, TBD*
		▪ Where do small fish originate from in the UMRS?	***Shaley Valentine**, INHS*
2:40		**Lower Mississippi River**	
		▪ Cape Girardeau Open House	
3:00 p.m.	**F1-8**	**Other Business**	
		▪ Future Meeting Schedule	***Sabrina Chandler**, USFWS*
3:10 p.m.		**Adjourn**	

ATTACHMENT A

Minutes of the February 28, 2024
UMRR Coordinating Committee Quarterly Meeting

(A-1 to A-15)

Minutes of the
Upper Mississippi River Restoration Program
Coordinating Committee

February 28, 2024
Quarterly Meeting

(Virtual)

Thatch Shepard (on behalf of Brian Chewning) of the U.S. Army Corps of Engineers called the meeting to order at 8:01 a.m. on February 28, 2024. UMRR Coordinating Committee members in attendance were Sabrina Chandler (USFWS), Chad Craycraft (IL DNR), Kirk Hansen (IA DNR), Vanessa Perry (MN DNR), Matt Vitello (MO DOC), Wade Strickland (WI DNR), Jeff Houser (USGS), and Rich Vaughn (NRCS). A complete list of attendees follows these minutes.

Shepard noted that the Corps plans to transition its appointment to the UMRR Coordinating Committee from Brian Chewning to Kelly Keefe who serves as USACE MVD Chief of Planning. Keefe has experience with the Everglades and other ecosystem-related programs. Andrew Stephenson expressed appreciation for Brian Chewning's dedication and contributions to the program during his tenure.

Minutes of the October 25, 2023 Meeting

Chad Craycraft moved, and Vanessa Perry seconded a motion to approve the draft minutes of the October 25, 2023 UMRR Coordinating Committee meeting as written. The motion carried unanimously.

Program Overview

FY 2024 Fiscal Update

On January 18, 2024, Congress enacted a continuing resolution extending current funding levels of the federal government until March 1, 2024. Marshall Plumley reported that the program has obligated $6,934,159 at the end of the first quarter. This is slightly less than usual because funds for LTRM base monitoring were not initially available for obligation in the first continuing resolution that expired November 17, 2023. The funds were made available for obligation in the second continuing resolution that expired January 19, 2024. As of February 1, 2024, obligations are at $9,504,461. This includes one contract awarded in the St. Louis District and the said funds allocated to USGS for LTRM. Obligations made by February 2024, including a fully funded LTRM, are approximately $12 million. Plumley said UMRR is executing as expected even with the constraints of the continuing resolutions.

Plumley explained that a few adjustments to projects are adjusting the implementation schedule for FY 2024. MVR, the construction contract award for Steamboat Island Stage 2 has been delayed due to adding verification requirements on bids. MVS has added plans to advance other habitat restoration projects given favorable bids received on its planned construction portfolio.

FY 2024 Fiscal Update

The current FY 2024 continuing resolution is scheduled to expire on March 1, 2024. Given that the FY 2024 President's budget and House and Senate Appropriations Committees have all allocated $55 million for UMRR, the Corps anticipates that funding level to be enacted.

Plumley reported that the FY 2025 President's budget is expected to be released on March 11, 2024. UMRR's annual authorized appropriation is $90 million. FY 2025 is the first fiscal year for which the Administration can budget for UMRR at that new authorized appropriation.

Support Letter for UMRR

Plumley reported that, on January 31, 2024, Senators from Tammy Baldwin, Tammy Duckworth, Richard Durbin, Tina Smith, and Amy Klobuchar sent a joint letter to ASA(CW) Michael Connor and the Office of Management and Budget (OMB) requesting $55 million for UMRR in FY 2025. Plumley said the active interest from Congress is very helpful in underscoring the value of making federal investments through UMRR.

UMRR Ten-Year Plan

Plumley reported on the following adjustments to habitat project schedules: Pool 10, Reno Bottoms, Green Island, Pool 12 Forestry, and West Alton. The Corps has added flood damage repair work at the Swan Lake habitat project to the 10-year plan. The Corps also anticipates completing feasibility planning for Meredosia Island habitat project next fiscal year and initiating planning on the Lower Pool 11 habitat project later this fiscal year.

HREP Selection

Plumley reported that UMRR will need approved fact sheets in FY 2025 to implement in FY 2026 – 2030. The UMRR Program Planning Team (PPT) provided updated guidance to Corps District-based river teams on topics related to overlapping boundaries with completed projects, environmental justice area identification and outreach, revisiting completed fact sheets, and cost estimation.

Plumley said it is important to consider the size and range of projects to build a balanced portfolio. The Corps has provided the river teams with a regional map viewer that will be used to capture restoration needs across the system. The river teams have initiated workshops to identify restoration needs, including one specific to the Illinois River.

In May 2024, the PPT will meet to share updates and reflect on the process to-date and to make any necessary adjustments to the process going forward. As currently scheduled, the PPT plans to review the collective draft project fact sheets in August 2024 and share the initial recommendations to the UMRR Coordinating Committee at its February 2025 quarterly meeting. Following a review in spring 2025, during its May 2025 quarterly meeting, the UMRR Coordinating Committee would consider endorsing the set of fact sheets to submit to MVD for review.

Strategic Planning

Plumley reported that the UMRR Coordinating Committee met on November 27 and December 11, 2023 to develop the strategic planning process overview document (as provided on pages B-7 to B-12 of the agenda packet. Chrissa Waite of the USACE Collaboration and Public Participation Center of Expertise is providing facilitation support services. Her biography is included on page B-13 of the agenda packet.

The strategic planning leadership team met on February 20, 2024 to craft the purpose, people, and process to develop the next strategic plan. No changes were made to previously approved content as the team talked only about sequence changes. Plumley noted that the strategic planning leadership team comprises Jim Fischer, Andrew Stephenson, Vanessa Perry, and Molly Sobotka. Davi Michl and Jeff Houser also took part in the leadership team meeting.

Implementation Issues

Plumley said that UMRR and partners have communicated to Congress and Corps leadership about concerns related to project partnership agreements (PPA). Changes in policy and law have resulted in changes to the previous process of executing an MOA for habitat projects located on federal lands managed by a state. The Corps (Headquarters, MVD, and Districts) internally agreed that a legislative fix is not needed and found that the Corps may to update its MOAs for O&M of UMRR habitat projects on these lands with states or, in certain cases, with other partners capable and willing to take on responsibilities.

A new model PPA is being drafted by Corps Headquarters. Bryan Hopkins noted that NESP can implement projects at 100 percent federal funding, but that there are places (e.g. Pool 19) where an NGO may be needed to consolidate real estate. Hopkins asked if there is a similar model that can be pursued under UMRR or if this is unique to NESP. Plumley said these are 100 percent federally-funded habitat projects managed by a state. Plumley said UMRR does not have any authorization language related to the ordinary high-water mark (OHWM). UMRR's MOAs would allow NGOs to participate.

UMRR Workshop

Plumley reported that UMRR will hold a workshop on May 7-9, 2024 in Bettendorf, Iowa. The last UMRR habitat-related workshop was held in 2019. Attendance is anticipated at 140 individuals from UMRR's partner governmental and nongovernmental entities. There will be a focus on programmatic matters, small group discussions on HREP planning and design, and conversations to advance LTRM/HREP integration. Plumley said important topics not included on the agenda will be pursued in other discussions.

Comprehensive Benefits

Plumley provided an overview of the ASA(CW)'s January 5, 2021, memo regarding Comprehensive Documentation of Benefits in Decision Documents. In UMRR, an ecosystem and science program, the benefits of projects are usually measured in habitat units and acres. The Corps recognizes that other benefits are accomplished with restoration projects. New steps when analyzing alternatives will include additional benefits categories.

The Memo directs the program to include a plan that maximizes net total benefits across all categories in the final array. For example, in the 2022 Report to Congress, economists considered jobs and economic development to quantify returns on investment in the program. The Quincy Bay HREP considers regional economic development and environmental justice values. Plumley wants to start tracking this information programmatically. Anshu Singh expressed appreciation for this approach and said it would help with economic development and legislative support.

In response to a question about the carbon sequestration potential of projects, Plumley said a new tool lets the Corps roughly evaluate this both for construction and resulting habitat improvements of projects. The Corps held an internal webinar last month to roll out the tool. Davi Michl shared that the Net Emissions Analysis Tool (NEAT) was developed by the USACE Air Quality and GHG Emissions Analysis Sub-Community of Practice (AQ/GHG Sub-CoP) to transition output data from publicly available air pollutant and GHG emissions models and integrate them all to compute net effects relevant to USACE civil works and regulatory projects. For more info, search "NEAT model" here: https://publibrary.planusace.us/#/home. Jeff Houser added that there is a science proposal to investigate the potential effects of restoration projects on ecosystem carbon cycling and retention.

Plumley said social effects have been included on feasibility reports, which may help partners communicate project impacts. Wade Strickland applauded the Corps' move in this direction because it relates to Environmental Justice and community engagement at the front end to get buy-in from communities. Vanessa Perry said she is keen to see other community social benefits, not only economic. She suggested making sure social and biological science staff work together. Plumley agreed and said it will be important to discuss further as the program develops the next strategic plan. This information is not currently in the HREP database to query, but Plumley would like to see that made available. Andrew Stephenson suggested another discussion with the Coordinating Committee on comprehensive benefits. Plumley agreed and proposed engaging Corps social scientists to present at a future quarterly meeting. Perry encouraged discussion of this topic in the strategic planning process. Plumley agreed and noted it will also be discussed at the upcoming UMRR workshop. Thatch Shepard added that Kelly Keefe is well versed in this work, so she will be a good addition to the team.

National Historic Preservation Act (NHPA) Section 106 Coordination

Plumley reported that the Corps has a draft agreement with states to clarify review procedures, improve consistency, consultation, and accountability to comply with NHPA Section 106. USACE can potentially execute this agreement as soon as May 2024. This will offer UMRR additional flexibility to defer steps until after the feasibility report. The preferred outcome is to have one agreement for both UMRR and NESP. Tribes asked to have 'invited signatory' status. Districts will carry out the agreement stipulations. Plumley said the previous approach with project-specific agreements was time intensive. This agreement will serve as an umbrella for all projects. The Corps will continued to do the compliance work necessary but will have a broader timeframe in which to do consultation with Tribes. This change is expected to improve efficiency and reduce burden on some partners.

SWOT Analysis

Chrissa Waite led the UMRR Coordinating Committee through an abbreviated SWOT analysis exercise to identify the strengths, weaknesses, opportunities, and threats for UMRR. She asked for input on ongoing activities to understand what is working well, what could improve, and how UMRR relates to other organizations.

Regarding strengths, Waite asked participants to consider what UMRR does that no-one else is doing. Vanessa Perry noted the way the program brings partners together with an intentional blending of science and restoration. Chat comments mentioned large scale, systemic, scientific work in a well-functioning partnership.

Waite asked participants to consider UMRR's available resources. Participants identified people, technical expertise, and consistent funding through congressional appropriation because of effective program implementation. Long-term monitoring stations provide extensive infrastructure and expertise. The program has access to state and federal programs and leaders as well as NGO expertise.

Waite then asked participants to identify weaknesses or vulnerabilities of UMRR. Marshall Plumley noted the challenge of accomplishing the work in a human-resource constrained environment. It is a great partnership comprised of people who have other responsibilities. Kirsten Wallace noted the complexity of communicating substantial but very technical knowledge and work across the partnership. PPAs and O&M in perpetuity pose onerous challenges to states and NGOs. Data sharing across agencies can be a challenge due to varying technical restrictions. Responding to emerging issues takes time and it can be challenging to respond to new problems. Funding constraints have impacted the program in the past. In the past, the program has struggled with communication between the two program elements. There are other authorizations or decisions impacting the system that can in turn impact UMRR, such as state permitting. The influence of actions in the watershed can affect the river while UMRR authority is bluff to bluff.

Waite asked participants to consider conditions and circumstances external to UMRR that may present opportunities. Participants identified climate change, flood resilience planning, including levee setbacks and wetland enhancement, and restoration or management initiatives in the uplands or watershed. Participants also noted Environmental Justice, community engagement, and policy changes that may present new opportunities for UMRR. Plumley said a Congressional authorization to look at the entire Mississippi River through a joint program office would be an opportunity to increase coordination across programs and agencies. Jeff Houser noted that increased media attention and outward communication efforts have boosted public awareness. These efforts include the publication of the Status and Trends Report with a partner coordinated press release, articles about the river by the Mississippi Ag and Water Desk that have resulted in regional and national media interest.

In response to a comment, Waite asked if there is any concern about overlap with NESP. Plumley said the programs are authorized to work in the same geographic area, but that NESP has ecosystem and navigation projects. The partnership is trying to communicate what is unique about NESP and UMRR and what each can accomplish. Matt Vitello noted a long-term concern about a shared program footprint and available areas to do projects. NESP has flexibility but over ten or more years, project availability will be reduced. Wallace added that appropriation requests for both programs is receiving more scrutiny. Wade Strickland said there is a strong partnership on UMRR and that he is hoping for a similar arrangement on NESP, but acknowledged the programs have different authorizing language.

Waite asked if there is anything to consider as a threat to UMRR's work. Participants identified that the partnership has discussed the capability of the program and of partners to support increased ecosystem restoration activities. For example, most 100 percent federal cost projects occur on USFWS lands, and the Service takes on significant O&M responsibility. Thatch Shepard added that projects have increased in size and cost. Shepard added that there is currently minimal oversight by Headquarters, but increased costs and project sizes could be bring greater attention. Perry agreed the program is receiving more attention, and suggested increased focus on establishing relevance to our communities, partners, and congressional supporters.

Waite asked what obstacles could prevent UMRR from doing its work. Participant responses included project costs increasing at an alarming rate, Continuing Resolutions, and PPAs. Plumley explained that UMRR has the budget authority to carry over funds carry over in the event of continuing resolutions. Over the last decade, UMRR has executed over 97 percent of its funding. Plumley noted, a change to this consistency would create challenges.

Waite expressed appreciation for all the comments shared during the exercise. Plumley said the strategic planning leadership team discussed reordering some activities for the strategic planning process. He outlined that Phase 1 will address the understanding of strategic issues, Phase 2 will develop strategic goals and objectives, Phase 3 will address strategies and actions, and Phase 4 includes a public review process. Perry thanked all who took part, notably public participants and those representing NGOs. Plumley added that any further thoughts should be shared with him or Waite.

Communications and Outreach Team

Marshall Plumley shared an outline of 2024 activities. He said the Communications and Outreach Team (COT) is providing ongoing support for the 2022 Report to Congress (RTC) release. COT members are sharing lessons learned from their own agencies and are working to put together a strategy for the RTC release in 2024. The COT has reviewed a draft brochure and story map for the RTC, which are being developed to help present its content. Other activities include a photo contest to engage with the public and partners and to collect materials for social media and other outreach campaigns. USACE Staff are inventorying interpretive centers and information kiosks that need updated materials on UMRR.

Future meetings of the COT will include discussions of Environmental Justice and the UMRR project selection process. In response to a question about partners experience, Wade Strickland said Wisconsin DNR Office of Great Waters holds an annual photo contest that results in a calendar. Strickland cautioned that as the photo contest has grown in popularity, it has taken more time to handle the entries. Andrew Stephenson clarified that for its first photo contest, the COT is leaning toward an internal, program-wide effort rather than a broader public effort. One reason the program is holding a photo contest is to collect images for use in UMRR outreach and communication materials. Strickland emphasized that it must be clear to entrants that submitting images is an authorization to use the photo for a wide range of purposes.

External Communications

Communication and outreach activities in the first quarter of FY 2024 include the following:

— Sabrina Chandler briefed Regional Director Will Meeks, who started in November 2023, on UMRR projects and he signed his first MOA for the Lower Pool 13 HREP. Meeks is strongly interested in the program and has shared updates with USFWS Headquarters.

— Chandler said the USFWS will celebrate the 100th anniversary of the UMR National Wildlife & Fish Refuge on June 7, 2024. Last week, Refuge staff, Wisconsin DNR, and Izaak Walton League staff and national president attended a meeting with a public talk with local river lore historian Steve Marking, in character as Will Dilg, to discuss what the program has meant to the river. This meeting also resulted in the La Crosse Chapter of the Izaak Walton League enrolling approximately 50 new members.

— Chandler said she continues to engage with the Congressional delegation to share information about UMRR, including LTRM. Pool 13 continues to be a spotlight and being able to use LTRM data to address questions in that pool has been extremely valuable.

— Kirsten Wallace said UMRBA has advocated for many priorities related to UMRR to be included in the next Water Resource Development Act (WRDA), including financial agreements to support states' participation in UMRR and increasing the annual authorized appropriation for LTRM.

— Vanessa Perry said Minnesota DNR has published its new Invasive Carp Action Plan, which was presented yesterday at the UMRBA quarterly meeting. The document can be found at https://www.dnr.state.mn.us/invasive-carp/index.html.

- Mark Gaikowski said USGS Regional Director Lacey will attend the Great Lakes Days and the Mississippi River Cities and Towns Initiative (MRCTI) annual Capitol meeting next week. This includes the partnership dinner between Great Lakes Cities and MRCTI. Director Lacey will have an opportunity to meet ASA(CW) Connor and BG Peeples at the event.

Showcase Presentations

Piasa & Eagles Nest Islands HREP

Ryan Swearingin provided an overview and update on Piasa and Eagles Nest Islands HREP, located near Alton, IL above Mel Price Lock & Dam at River Miles 207-211. This project has received considerable support from partners, stakeholders, local government, and the public. It is a rich recreational area with waterskiing, fishing, and hunting. Illinois DNR is the project sponsor and manager of the area. The islands, covering 1381 acres, are federal land and the project is federally funded. Before the locks and dams were built, the two islands were a mosaic. After dam construction, the side channel started silting in and the small islands vanished. Historical maps were influential in the process to initiate a project here and recreate an island mosaic like what existed previously. Pictures from before the current project show a very shallow chute. The opening to the backwaters in Piasa Island had closed. Problems identified were loss of depth and flow in Piasa Chute, a loss of backwater habitat, and loss of a diverse island mosaic. Project objectives include increasing side channel habitat, depth, and flow; increasing connected backwater habitat with diverse depth for fisheries; and restoring the diverse island mosaic. USACE used an extensive Adaptive Hydraulics Model to make sure the project would not impact navigation and it would end up with a self-sustaining side channel. The Corps developed a computing system at Engineer Research and Development Center (ERDC) to analyze flow processes. The Tentatively Selected Plan (TSP) had a 200-foot-wide braided channel, a reconnected backwater opening, a notched rock structure to connect the two main islands and would use dredged material to create small islands. Upon completion, the project will attain 430 Average Annual Habitat Units (AAHU).

Stage 1, completed in 2022, was all rock placement. Around 202,000 tons of rock were placed, costing $7.2 million. Stage 2 includes hydraulic dredging and island filling and has begun. A construction contract for $11 million was awarded in February 2023. The contractor will dredge 1.4 million CY of material from the braided channel between Piasa Island and the Illinois bank, to be placed directly into island sites. The contractor has so far placed around 500,000 cy in island sites using a 20” flexible pipe. High-visibility orange buoys are used to keep the pipe visible to river users.

The Corps held a naming contest for the new islands, reaching out to six local middle schools with 2,400 students. The winning middle schoolers were honored at a recreation festival. The names chosen are Canvasback Island in the main channel, and Powrie, Steamboat, and Moonlight Islands in the side channel. Recommended names were submitted to USGS, who is responsible for island names. Powrie is named after an influential woman who used to live on Piasa Island in the late 1800s. An interior least tern nest was found on the site. Its range has shrunk but now terns are appearing, and this nest was successful. The birds were delisted from the Endangered Species Act in 2021.

In response to a question, Swearingin explained that dredged material is not staged, it was pumped directly over the rock walls into the island containment rings. Monitoring for materials and nutrients is ongoing. Andrew Stephenson noted that beneficial use in MVS is uncommon and asked if this project will help the district reach its goal of 70 percent beneficial use of material, and when will it be factored into calculations. Swearingin was not sure how it will fold into calculations but noted that it is a substantial amount of material. Kirsten Wallace said Wisconsin DNR brought up the issue of using backwater material instead of main channel material in some habitat projects. Wallace suggested additional discussion on the topic in strategic planning.

Water Clarity in the UMR

In January, Alicia Carhart and colleagues published a study that sought to clarify roles of external inputs and internal feedbacks driving ecosystem processes related to water clarity in the UMR. Diverse aquatic habitats have various degrees of connectivity and thus different drivers. Research questions included:

- How has water clarity (total suspended solids (TSS)) changed across longitudinal and latitudinal gradients?
- To what degree were there shared temporal dynamics in TSS between off-channel areas of the river?
- Which environmental factors control inter-annual variation in TSS in off-channel areas in the UMRS, internal processes, external inputs, or both?

Researchers expected internal processes to be greater in the upstream area and external inputs greater downstream. The team evaluated 24 years of variables. Within each of six LTRM reaches, they chose off-channel areas with varied characteristics and two to ten areas for other variables. There was significant divergence of main and off-channel clarity over time. Intrinsic and extrinsic control of water clarity appeared to vary across the system. Connectivity, vegetation, and carp abundance were the main drivers of water clarity. However, covariates in the study showed limited impact, so other factors must be considered in the future. The study showed that rivers are influenced both by external and internal factors. Vegetation and fish communities affect clarity. TSS declines were due to a combination of processes. The findings are important for managing complex floodplain rivers, as managers can target underlying feedback mechanisms. For example, managers can prioritize aquatic vegetation or higher trophic levels. It is important to continue monitoring so future analyses can provide more data. Jeff Houser said this study is a great example of the amount of information that can be drawn from a long-term dataset. Data collected in many areas can be used to compare changes over time spatially. This study also demonstrates the extent of learning that can occur when we invest time and energy into sophisticated analysis.

Long Term Resource Monitoring and Science

FY 2024 1st Quarter Report

Jeff Houser reported that accomplishments of the first quarter of FY 2024 include publication of the following manuscripts and book chapter:

- *Establishing fluvial silicon regimes and their stability across the Northern Hemisphere*
- The book Resilience and Riverine Landscapes, edited by Thoms and Fuller, features the chapter *Resilience-based challenges and opportunities for fish management in Anthropocene rivers* by Jason DeBoer, Kristen Bouska, Christian Wolter, and Martin Thoms. All major rivers are impacted by human activity. This chapter looks at how a resilient space approach can be applied to the ecosystem. The UMR/ILWW system was a part of the study. Takeaways include:
    - Finding novel conditions and uncertain trajectories in these rivers
    - Factors governing fish populations are broad scale and beyond a manager's control
    - A resilience-based approach emphasizes increasing the capacity to deal with change
    - Changes in uses and values of the river system call for a common vision among different sectors to develop effective management strategies.

  Houser noted that these studies show how LTRM can be used in a global system.

UMRR Science Meeting

Houser reported that the UMRR science meeting was held at UMESC on January 16-18, 2024. It was attended by around 100 people from 3 federal agencies, 7 state agencies, and universities. The primary goal was to identify collaborative, relevant projects that improve our ability to restore the UMRS and lay groundwork for science proposals for consideration of funding in FY 2024. Other benefits included improved connections among participants and the transfer of institutional knowledge.

Houser described the organization of the meeting including plenary sessions on current modeling work and ecological responses to restoration actions as well as six working groups, which have become more interdisciplinary over time. The working groups and their focus are as follows:

- Work group 1 – How will climate change affect river flows, water quality, and aquatic vegetation on the UMRS? This builds off two previous projects that developed a historical hydrology dataset and a possible set of future projections. Group 1 considered SAV response to wind, waves, velocity, and shear stress, and understanding associations among hydrogeomorphology, water chemistry, and biota. This included aquatic areas of HNA, map of areas of conditions, to better understand the conditions identified based on water chemistry and distribution.

- Work Group 2 – Water quality responses to aquatic vegetation, carbon cycling, nutrients, and sedimentation with vegetation types.

- Work Group 3 – Look at how ice extent and duration is changing over time. There is satellite imagery to look at the river from 2016 to 2024. Research will look at how the spatial and temporal patterns in temperature are changing and the implication of river characteristics.

- Work Group 4 – Identify the abiotic drivers of fish population dynamics in upper aquatic trophic levels of the UMRS and assess a variety of attributes.

- Work Group 5 – Analyze floodplain ecology to better understand subsurface hydrology effects on vegetation over time, including how forests have responded to canopy mortality after 2019 flooding.

- Work Group 6 – Follow on to plenary session to lay groundwork for future studies by looking at smaller scale projects in the next few years to address four topics:
    - Strategic approach to identify HREP features that promote dense and diverse mussel assemblages
    - Estimate the influence of HREPs on river carbon dynamics
    - Look at backwater fish assemblages to understand how HREP measures to benefit backwaters impact fish communities.
    - Evaluate ecological responses to side channel rehabilitations in the middle Mississippi River

Houser thanked all who attended, notably working group leaders, Jim Fischer and Davi Michl, the LTRM Analysis Team, Randy Hines, and Lisa Hein for organizing the event.

LTRM Implementation planning

Houser reported on the partnership process to identify and prioritize information and management needs and develop a portfolio of actions to address those needs. The partnership identified opportunities to use additional funds from increased authorization to implement larger and potentially long-term projects and activities to address information needs if funding is sustained at a higher level. In 2023, LTRM funded the initiation of two information needs:

- Understanding geomorphic change within the UMRS
- Assessing gradients from Pool 14 to Pool 25.

If funding levels continue, two additional informational needs are anticipated to receive funds in FY24:

- Lower trophic levels: abundance, distribution and status of phytoplankton and zooplankton in the UMRS
- Floodplain ecology: vegetation change across the UMRS.

In response to a question from Andrew Stephenson asked if there is talk upcoming about more protocols for handling and marking turtles in fish data collection. Houser said that the fisheries component records basic measurements for turtle bycatch including length and weight. Houser added that one information needs identified an opportunity to mark turtles bycaught to gain insights on other population dynamics. Jim Fischer noted that to implement turtle marking in the 2024 field season, more detailed methods are needed. Field station team leads will meet on Friday to discuss implementation further. In response to a question about HREP impacts on river carbon dynamics, Houser said that work groups have looked at dynamics in the river. Models look at greenhouse gas emissions of the construction process, not river dynamics.

USACE LTRM Report
Davi Michl reported that LTRM FY 2024 budget allocation is $7 million ($5.5 million for base monitoring and $1.5 million for analysis under base) with an additional $6.85 million available for "science in support of restoration and management." The program has fully funded base monitoring this month. A draft SOW for science in support of restoration and management was received on February 16, 2024. Systemic topobathy acquisition has awarded three pilot projects. Pools 4 and 8 were selected for study. Preliminary results are expected in April 2024. Hydrosurvey acquisitions in support of developing the next UMRS systemic topobathy layer are anticipated to happen in spring 2024. Final deliverables from the three pilot projects are due in August. The pilot study purpose is to determine the best techniques and reduce costs associated with hydrosurveys. The PDT is evaluating study areas for 2024 acquisition. A Pool 13 pilot to leverage benefits to UMRR may be pursued. The spring forecast is looking favorable, but water levels do need to be high enough to collect effectively.

The LTRM budget is mostly unchanged since October. State carry-in funds could change when final numbers are provided. Michl anticipates funding analysis under base in March 2024. A pilot radio wave monitoring system is being made by USACE Detroit district for the Lower Pool 13 HARP. A mussel survey task order, Objective 4 under IDIQ, falls under an umbrella contract. The project biologist has been coordinating with USGS and expects to send to Contracting in March 2024. Monitors have been tasked to enter HREP monitoring data in the Environmental Monitoring and Management Application (EMMA). This will help track tasks, budgets, and schedules with a web-based database application. The focus is to enter data for active projects first, then go back in time to build the database with historical projects.

A-Team Report

Matt O'Hara said the A-team will hold its regular meeting in La Crosse on April 16, 2024, in conjunction with the Mississippi River Research Consortium (MRRC). The main goal is to rank project proposals. O'Hara will report on proposal rankings at the next quarterly meeting.

Habitat Restoration

Angela Deen said MVP has five active HREPs. PDTS are finalizing alternatives for Robinson Lake and Big Lake. Robinson Lake includes a unique sturgeon spawning reef feature using various cobble sizes. This is the first time a district has proposed such a feature. USACE Staff are addressing MVD comments on the Big Lake HREP to submit the final report this spring. MVP hired the same architectural engineer to design Reno Bottoms and Lower Pool 10. Borings for Reno Bottoms Stage 2 will determine if existing access roads can accommodate construction equipment. The 65 percent review is anticipated to occur in June. The Lower Pool 10 HREP will be advertised for construction in August or September. It is currently at the 95 percent review milestone. The PDT has bundled the islands into a base set of options. McGregor Lake is in the construction phase. The PDT is evaluating thin layer placement to look at how different materials settle, and findings will inform use and constructability of thin layer placement. Initial observations suggest sand settles near the pipe and fines settle further out. Extensive thin layer placement may need to be graded later. The Trempealeau Letter Report has been reviewed by partners. Deen expects to close out the report in the next few weeks. Reviewers recommended pursuing a new project at Trempealeau in the next selection process. MVP outreach included a science booth at a science fair for local high school students. Deen showed a drone video over McGregor Lake that was developed by the MVP GIS section and can be seen at https://www.youtube.com/watch?v=m6NQXuMorLg.

Julie Millhollin said MVR added Lower Pool 13 Phase 2 to the program schedule and began feasibility for Lower Pool 11. The Pool 12 Forestry PDT has identified a tentatively selected a plan and the report is in review. This is the first pool-wide project in MVR and the team is scheduling an open house for late-March. The Green Island PDT is finishing the policy and legal review on the TSP. The Lower Pool 13 Phase 1 report was approved in December and the project Finding of No Significant Impact (FONSI) was signed in January. Sabrina Chandler noted that USFWS has signed the MOA, and it is being routed to USACE now. Millhollin said the Lower Pool 13 Phase 2 District review on Chapters 1-3 was completed in December and an alternative formulation workshop was held on February 1, 2024. A Pool 18 forestry kickoff was held on November 30, 2023, during which POOCs and initial measures were set. The team is now drafting chapters 1-3 for District review. The Quincy Bay PDT held a public meeting on February 15, 2024, with over 350 people attending. Staff gave a project presentation and held a question-and-answer session. Public review is in progress until March 9, 2024. Design of Steamboat Island Stage 2 is complete and a construction contract has been advertised. Beaver Island is nearing construction completion. MVR projects in construction include Beaver Island, Steamboat Island Stage 1, Keithsburg Division Stages 1 and 2, and Huron Island Stage 3. The Steamboat Island Stage 1 contractor is on schedule to set riprap on the southeast island. The Keithsburg Stage 1 contractor is working on removing broken block mats for repair. The Stage 2 contractor is on site and waiting for fair weather to begin work. Huron Island Stage 3 will continue with plantings in June. Other activities include a multiple award task order contract (MATOC) at three sites including Steamboat Island, Lower Pool 13, and Spring Lake. PER site visits are scheduled for Big Timber, Rice Lake, Pleasant Creek, Princeton, and Lake Odessa. Lessons learned will be documented and shared. In response to a question, Millhollin said the Beaver Island ribbon cutting has not yet been scheduled but is anticipated to occur this summer.

Brian Markert said MVS received approval for the Yorkinut Slough feasibility report. The project will move into the design phase and a site visit with sponsors will be scheduled. Harlow Island Stage 2 design is advancing, and design of Stage 1 was completed last year. Harlow Island is the next projected anticipated to move into construction. The sediment deflection berm is a main feature to enhance the river side of the levee and the wetlands within the site. Corps real estate is working through the acquisition process at Crains Island. Both Harlow Island and Crains Island locations are designed to enhance and build complex soils over time. Sediment is deflected upstream but the site is left open at lower end so water backs in and drops fines. This builds up better soils that can support other vegetation types. In planning, West Alton Islands is in final DQC and public review is complete. The two project sponsors, MDC and USFWS, have their own areas of management in the project. The Gilead Slough and Red's Landing projects in Pool 25 are adjacent in a big complex. There is some synergy with team members, but the Corps will produce two separate reports with IL DNR and USFWS. Site visits occurred in autumn of 2023. Markert said the Corps is aiming to have projects designed and ready for construction pending the anticipated increase in funding. Construction of the exterior berm setback at Clarence Cannon was completed. USFWS has assumed management over a large part of the project area and is using the facilities, but Stage 5 has remaining items to complete, including a task order on reforestation. Colonel Andy Pannier, a biologist, visited the site and has taken interest in the program. The Swan Lake Flood Damage Rehabilitation limited scope letter was approved last year and the PDT is developing design packages to address repairs and add resiliency. The Corps applied more lenient standards for ecosystem projects than flood protection projects leading to favorable construction bids. Other activities include developing potential new projects on the UMR and ILWW, interpretive signage for Piasa and Eagles Nest Islands HREP, and collecting additional shallow water data for bathymetry. Staff are scoping the Ted Shanks PER. The Corps is scoping an Indefinite Delivery Indefinite Quantity (IDIQ) construction contract for UMRR. In response to a question regarding the sturgeon spawning reef, Markert said that MVS is working on substrate that is conducive to several species, tracking underwater substrate rock size, and flow orientation that attract different species. Angela Deen added that the Corps designed similar structures for centrarchids. Matt Vitello said the partnership has documented successful spawning below Dam 26 through the sustainable rivers program by altering discharge and that he would like to see this replicated at other locks and dams.

Other Business

Marshall Plumley noted that the MVR Change of Command ceremony is scheduled for May 23, 2024. Thatch Shepard expects MVD leadership to attend that week.

Upcoming quarterly meetings are as follows:

May 2024 – Quad Cities

- UMRBA quarterly meeting: May 21
- UMRR quarterly meeting: May 22

August 2024 – Minneapolis/Saint Paul Metro Area

- UMRBA quarterly meeting: August 6
- UMRR quarterly meeting: August 7

November 2024 – Saint Louis

- UMRBA quarterly meeting: November 19
- UMRR quarterly meeting: November 20

Bryan Hopkins expressed appreciation for the discussion on the importance of substrates for sturgeon to facilitate spawning, especially for species with extensive migration patterns. Noting other discussions exploring the idea of installing barriers to deter the spread of invasive species like carp, Hopkins highlighted a potential conflict between these two strategies and encouraged partners to address this perceived contradiction as a discussion topic prior to investing in projects that may work against each other.

With no further business, Wade Strickland moved and Vanessa Perry seconded a motion to adjourn the meeting. The motion carried unanimously. The meeting was adjourned at 2:55 p.m.

UMRR Coordinating Committee Attendance List

February 28, 2024

UMRR Coordinating Committee Members

Thatch Shepard (on behalf of Brian Chewning)	U.S. Army Corps of Engineers, MVD
Sabrina Chandler	U.S. Fish and Wildlife Service, Refuges
Jeff Houser	U.S. Geological Survey, UMESC
Richard Vaughn	U.S. Department of Agriculture, NRCS
Chad Craycraft	Illinois Department of Natural Resources
Kirk Hansen	Iowa Department of Natural Resources
Vanessa Perry	Minnesota Department of Natural Resources
Matt Vitello	Missouri Department of Conservation
Wade Strickland	Wisconsin Department of Natural Resources

Others in Attendance:

Karen Hagerty	U.S. Army Corps of Engineers (Retired)
Chrissa Waite	U.S. Army Corps of Engineers, Charleston District
LeeAnn Riggs	U.S. Army Corps of Engineers, MVD
Jim Lewis	U.S. Army Corps of Engineers, MVD
Samantha Thompson	U.S. Army Corps of Engineers, MVD
Nathan Wallerstedt	U.S. Army Corps of Engineers, MVP
Angela Deen	U.S. Army Corps of Engineers, MVP
Trevor Cyphers	U.S. Army Corps of Engineers, MVP
Davi Michl	U.S. Army Corps of Engineers, MVR
Julie Milhollin	U.S. Army Corps of Engineers, MVR
Kyle Bales	U.S. Army Corps of Engineers, MVR
Leo Keller	U.S. Army Corps of Engineers, MVR
Marshall Plumley	U.S. Army Corps of Engineers, MVR
Jessie Dunton	U.S. Army Corps of Engineers, MVR
Ryan Swearingin	U.S. Army Corps of Engineers, MVS
Brian Markert	U.S. Army Corps of Engineers, MVS
Jasen Brown	U.S. Army Corps of Engineers, MVS
Dane Boring	U.S. Environmental Protection Agency
John Winter	U.S. Fish and Wildlife Service, IIFO
Lauren Larson	U.S. Fish and Wildlife Service, IIFO
Charlie Deutsch	U.S. Fish and Wildlife Service, Refuges
Andy Casper	U.S. Geological Survey
Mark Gaikowski	U.S. Geological Survey
David Dupre	U.S. Geological Survey, CMWSC
Jennifer Dieck	U.S. Geological Survey, UMESC
Jim Fischer	U.S. Geological Survey, UMESC
Christopher Churchill	U.S. Geological Survey, UMESC
John Seitz	Illinois Department of Natural Resources
Matt O'Hara	Illinois Department of Natural Resources
Brian McCoy	Illinois Department of Transportation

Dave Bierman	Iowa Department of Natural Resources
Alicia Carhart	Wisconsin Department of Natural Resources
Sammi Boyd	Wisconsin Department of Natural Resources
Lindsay Brice	Audubon Society
Anshu Singh	Corn Belt Ports
Michael Anderson	Mississippi River Network
Bryan Hopkins	The Nature Conservancy
Doug Blodgett	The Nature Conservancy
Randy Smith	The Nature Conservancy
Mark Ellis	Upper Mississippi River Basin Association
Lauren Salvato	Upper Mississippi River Basin Association
Brian Stenquist	Upper Mississippi River Basin Association
Kirsten Wallace	Upper Mississippi River Basin Association
Andrew Stephenson	Upper Mississippi River Basin Association

ATTACHMENT B

Regional Management and Partnership Collaboration

- UMRR Quarterly Budget Reports (1/10/2024) *(B-1 to B-3)*
- UMRR 2024 Workshop Agenda (05/2024) *(B-4 to B-9)*
- UMRR 2022 Report to Congress Executive Summary, Implementation Issues, Conclusions and Recommendations (2022) *(B-10 to B-25)*

UMRR Quarterly Budget Report: St. Paul District

FY2024 Q2; Report Date: Thu May 02 2024

Habitat Projects

Project Name	Cost Estimates			FY2024 Financials			
	Non-Federal	Federal	Total	Carry In	Allocation	Funds Available	Actual Obligations
Lower Pool 10 Island and Backwater Complex	-	$32,428,000	$32,428,000	$78,068	$5,000,000	$5,078,068	$268,953
Lower Pool 4, Big Lake	-	$18,000,000	$18,000,000	$29,071	$250,000	$279,071	$155,026
Lower Pool 4, Robinson Lake, MN	-	$12,000,000	$12,000,000	$29,061	$550,000	$579,061	$158,163
McGregor Lake	-	$23,550,000	$23,550,000	$60,065	$350,000	$410,065	$98,035
Reno Bottoms	-	$38,965,000	$38,965,000	$21,379	$5,000,000	$5,021,379	$1,036,536
Total	-	$124,943,000	$124,943,000	$217,644	$11,150,000	$11,367,644	$1,716,713

Habitat Rehabilitation

Subcategory	FY2024 Financials			
	Carry In	Allocation	Funds Available	Obligations
District Program Management	-	-	-	$195,637
Total	-	-	-	$195,637

Regional Program Administration

Subcategory	FY2024 Financials			
	Carry In	Allocation	Funds Available	Obligations
Habitat Eval/Monitoring	-	$425,000	$425,000	$182,661
Total	-	$425,000	$425,000	$182,661

	Carry In	Allocation	Funds Available	Actual Obligations
St. Paul Total	$217,644	$11,575,000	$11,792,644	$2,095,011

UMRR Quarterly Budget Report: Rock Island District

FY2024 Q2; Report Date: Thu May 02 2024

Habitat Projects

Project Name	Cost Estimates			FY2024 Financials			
	Non-Federal	Federal	Total	Carry In	Allocation	Funds Available	Actual Obligations
Beaver Island	-	$25,288,000	$25,288,000	-	-	-	$48,848
Green Island, IA	-	$16,600,000	$16,600,000	$131,858	$1,900,000	$2,031,858	$391,078
Huron Island	-	$15,773,000	$15,773,000	$2,383	-	$2,383	$1,936
Keithsburg Division	-	$29,643,000	$29,643,000	$78,794	$500,000	$578,794	$206,687
Lower Pool 13	-	$25,288,000	$25,288,000	-	$550,000	$550,000	$12,243
Lower Pool 13 Phase II	-	-	-	$8,035	$600,000	$608,035	$172,606
Pool 12 (Forestry)	-	$9,000,000	$9,000,000	$45,550	$600,000	$645,550	$303,881
Pool 18 Forestry	-	$4,000,000	$4,000,000	-	$600,000	$600,000	$107,370
Quincy Bay, IL	-	$25,000,000	$25,000,000	$68,096	$700,000	$768,096	$345,817
Steamboat Island	-	$41,977,000	$41,977,000	$54,700	$8,200,000	$8,254,700	$6,400,769
Total	-	$217,569,000	$217,569,000	$389,416	$13,700,000	$14,089,416	$7,991,235

Habitat Rehabilitation

Subcategory	FY2024 Financials			
	Carry In	Allocation	Funds Available	Obligations
District Program Management	-	-	-	$80,453
Total	-	-	-	$80,453

Regional Program Administration

Subcategory	FY2024 Financials			
	Carry In	Allocation	Funds Available	Obligations
Adaptive Management	$2,828	$200,000	$202,828	$92,124
Habitat Eval/Monitoring	$118,857	$425,000	$543,857	$86,087
Model Certification/Regional HREP	-	$100,000	$100,000	$35,007
Public Outreach	-	$50,000	$50,000	$3,225
Regional Program Management	$162,211	$1,500,000	$1,662,211	$700,827
Regional Project Sequencing	-	$125,000	$125,000	$48,190
Total	$283,896	$2,400,000	$2,683,896	$965,460

Regional Science and Monitoring

Subcategory	FY2024 Financials			
	Carry In	Allocation	Funds Available	Obligations
Long Term Resource Monitoring	$174	$5,500,000	$5,500,174	$4,344,052
Science in Support of Restoration/Management	-	$8,350,000	$8,350,000	$1,630,391
Total	$174	$13,850,000	$13,850,174	$5,974,443

	Carry In	Allocation	Funds Available	Actual Obligations
Rock Island Total	$673,486	$29,950,000	$30,623,486	$15,011,591

UMRR Quarterly Budget Report: St. Louis District

FY2024 Q2; Report Date: Thu May 02 2024

Habitat Projects

Project Name	Cost Estimates			FY2024 Financials			
	Non-Federal	Federal	Total	Carry In	Allocation	Funds Available	Actual Obligations
Clarence Cannon	-	$29,800,000	$29,800,000	$51,513	$650,000	$701,513	$167,419
Crains Island	-	$36,562,000	$36,562,000	$3,340	$4,825,000	$4,828,340	$1,623,323
Gilead Slough	-	$11,000,000	$11,000,000	$2,454	$550,000	$552,454	$135,025
Harlow Island	-	$37,971,000	$37,971,000	-	$925,000	$925,000	$66,671
Oakwood Bottoms	-	$34,200,000	$34,200,000	-	$525,000	$525,000	$76,407
Piasa - Eagle's Nest Islands	-	$26,746,000	$26,746,000	-	$3,950,000	$3,950,000	$676,111
Red's Landing Wetlands	-	$16,573,680	$16,573,680	-	$475,000	$475,000	$146,115
West Alton Missouri Islands	-	$14,500,000	$14,500,000	-	$400,000	$400,000	$212,694
Yorkinut Slough, IL	-	$8,500,000	$8,500,000	$5,721	$750,000	$755,721	$208,055
Total	-	$215,852,680	$215,852,680	$63,028	$13,050,000	$13,113,028	$3,311,820

Habitat Rehabilitation

Subcategory	FY2024 Financials			
	Carry In	Allocation	Funds Available	Obligations
District Program Management	$46,864	-	$46,864	$261,653
Total	$46,864	-	$46,864	$261,653

Regional Program Administration

Subcategory	FY2024 Financials			
	Carry In	Allocation	Funds Available	Obligations
Habitat Eval/Monitoring	-	$425,000	$425,000	$85,380
Total	-	$425,000	$425,000	$85,380

	Carry In	Allocation	Funds Available	Actual Obligations
St. Louis Total	$109,892	$13,475,000	$13,584,892	$3,658,853

Upper Mississippi River Restoration Program
Workshop

May 7-9, 2024
Agenda

Participants are encouraged to view a series of recorded webinars in advance of the workshop, available at the following locations regarding:

- UMRR's primary functions and relevant efforts: https://www.mvr.usace.army.mil/Missions/Environmental-Stewardship/Upper-Mississippi-River-Restoration/Key-Initiatives/HREP-Workshops/HREP-2019/

- UMRR's science that supports its restoration strategies: https://www.mvr.usace.army.mil/Missions/Environmental-Stewardship/Upper-Mississippi-River-Restoration/Key-Initiatives/Workshops/

Get to know your fellow attendees by filling out a virtual business card.
Use the QR code below or the following link to access the Padlet platform:
https://padlet.com/umrbastaff/about-us-tzr8bit2uxq19zg4

Tuesday, May 7

Connection Information

- Web link: https://umrba.my.webex.com/umrba.my/j.php?MTID=m16f89dbab481c35fdf22711ba4cc4860
- Dial-in:
  - Phone number: 312-535-8110
  - Meeting number: 2555 635 2815
  - Passcode: 1234

Time	Topic	Presenter	Format
12:30 p.m.	**Welcome and Introductions**	***Marshall Plumley**, USACE*	
12:40	**UMRR Overview** ▪ Authorization Changes (Funding Levels) ▪ Project Sizes and Project Selection Process ▪ Risk Informed Planning ▪ Study Area, Project Areas, Phases, and Stages ▪ New Project Sponsors ▪ Changes to Review Processes ▪ Feasibility Report Template ▪ LTRM Implementation Planning	***Marshall Plumley**, USACE*	Large Group Presentation
1:15	**Partner Agency/Organization Priorities and Perspectives**	***UMRR Coordinating Committee***	Large Group Presentation
2:15	**Live Polling Exercise**	***All***	Large Group Facilitated Discussion
2:35	**Break**		
3:00	**UMRR Strategic Plan** ▪ A discussion of the most important issues for UMRR to consider over the next 10 years	***Marshall Plumley** and **Chrissa Waite**, USACE*	Small Group Table Top Discussion
3:45	**Climate Change** ▪ Live Polling Exercise ▪ Climate Change Analysis for HREPs ▪ UMRS Future Hydrology ▪ Building Knowledge to Support Equitable Climate Resilience in the UMR Basin ▪ Resist-Accept-Direct Framework	***All*** ***Lucie Sawyer**, USACE* ***Molly Van Appledorn and John Delaney**, USGS* ***Zac McEachran**, NOAA* ***Kristen Bouska**, USGS*	Large Group Learning and Facilitated Discussion
5:45	**Adjourn**		
6:30 p.m.	**An evening social will be held at Armored Gardens in Davenport, IA – 315 Pershing Ave**		

Wednesday, May 8

[Note: Connection information is available for the large group format only and not the small group formats.]

Connection Information

- Web link: https://umrba.my.webex.com/umrba.my/j.php?MTID=m1bb4ff1aeb8b3545d08e7623e6cee1ec
- Dial-in:
  - Phone number: 312-535-8110
  - Meeting number: 2550 754 9008
  - Passcode: 1234

Time	Topic	Presenter	Format
8:00 a.m.	**Welcome and Day 1 Recap**	***Marshall Plumley**, USACE*	
8:15	**HREP Design and Construction: Lessons Learned**		Large Group Presentation
	▪ Beaver Island Mussel Habitat	***Dan Kelner**, USACE*	
	▪ Harpers Slough Design Recommendations	***Kacie Grupa**, USACE*	
	▪ Huron Island Submersed Aquatic Vegetation	***Collin Moratz**, USACE*	
	▪ Crains Island Passive O&M	***Jasen Brown**, USACE*	
9:00	**Live Polling Exercise**	***All***	Large Group Facilitated Discussion
9:15	**Break**		
9:30	**HREP Design Handbook Breakouts**		Small Group Interactive Learning Sessions
	▪ Overview and Instructions	***Kara Mitvalsky**, USACE*	
9:45	▪ Six rotating stations – Dredging – Islands – Shoreline and River Bank Protection and Aquatic Structure for Habitat – Training Structures and Channel Modifications – Forestry and Floodplain Restoration – Localized Water Level Management	***All***	
11:15	▪ Preferred station debrief update discussion		
12:00 noon	**Lunch***		
1:00	**Resilience Based Goals and Objectives for HREPs: UMRR's Rosetta Stone for Science, Habitat and Engineering**	***Jeff Janvrin**, WI DNR*	Large Group Presentation and Learning
1:30	**Linking Restoration Actions to Biotic Responses**	***Kristen Bouska**, USGS*	Small Group Interactive Learning Sessions
2:30	**Break**		

(May 8 Continued)

2:50	**HREP Monitoring** ▪ The Future of HREP Monitoring ▪ Environmental Monitoring and Management Application (EMMA)	 ***Marshall Plumley, USACE*** ***Mike Dougherty***, *USACE*	Large Group Presentation, Small Group Breakout, and Facilitated Discussion
4:10	**Modeling for Decision Making** ▪ Habitat Modeling Applied to HREPs ▪ Large Scale and System Model Applications	 ***Collin Moratz***, *USACE* ***Nathan De Jager***, *USGS*	Large Group Learning and Facilitated Discussion
4:50	**Day Two Reflection**	***All***	Large Group Facilitated Discussion
5:00 p.m.	**Adjourn**		

*Boxed lunches were made available for purchase for $25 (see RSVP).
Refreshments will be available for attendees during the workshop for a requested donation of $5.
Both are payable to UMRBA by cash or Venmo. Use the QR code below to link to
UMRBA's Venmo account (associated with phone number ending in 6447):

The UMRR Apparel Store is open for two weeks only!
Place your orders by May 19. Orders will be ready by June 10.
https://stores.inksoft.com/upper_mississippi_river

Thursday, May 9

[Note: Connection information is available for the large group format only and not the small group formats.]

Connection Information:

- Web link: https://umrba.my.webex.com/umrba.my/j.php?MTID=m82a2bc29ece400d951243f0dca3100c0
- Dial-in:
  - Phone number: 312-535-8110
  - Meeting number: 2554 383 8448
  - Passcode: 1234

Time	Topic	Presenter	Format
8:00 a.m.	**Welcome and Day 2 Recap**	***Marshall Plumley**, USACE*	
8:15	**Science and Restoration Integration Panel** ▪ Evaluations of Aquatic Vegetation Response at Pool 8 Islands using LTRM SRS Data ▪ Lower Pool 13 Project Development Team (PDT) Lessons Learned ▪ Lower Pool 13 HREP-Associated Research Project (HARP) ▪ Lower Pool 4 – Big Lake PDT	 ***Jeff Janvrin**, WI DNR* ***Ed Britton**, USFWS* ***Jeff Houser**, USGS* ***Elliot Stefanik**, USACE*	Large Group Learning and Facilitated Discussion
9:45	**Break**		
10:00	**Program Areas of Focus** ▪ UMRR Communications and Outreach Team ▪ Live Polling Exercise ▪ Comprehensive Benefits for HREPs & Quincy Bay Environmental Justice Example ▪ Live Polling Exercise	 ***Rachel Perrine**, USACE* ***All*** ***Marshall Plumley and Rachel Perrine**, USACE* ***All***	Large Group Learning and Facilitated Discussion
11:30	**Day Three Reflection**	***All***	Large Group Facilitated Discussion
12:30 p.m.	**Adjourn**		

Thank you to the planning committee!

Marshall Plumley	U.S. Army Corps of Engineers
Kara Mitvalsky	U.S. Army Corps of Engineers
Brian Markert	U.S. Army Corps of Engineers
Lane Richter	U.S. Army Corps of Engineers
Elisa Royce	U.S. Army Corps of Engineers
Angela Deen	U.S. Army Corps of Engineers
Kacie Grupa	U.S. Army Corps of Engineers
Julie Millhollin	U.S. Army Corps of Engineers
Davi Michl	U.S. Army Corps of Engineers
Sara Schmuecker	U.S. Fish and Wildlife Service
Sharonne Baylor	U.S. Fish and Wildlife Service
Jeff Houser	U.S. Geological Survey
Jim Fischer	U.S. Geological Survey
Kirk Hansen	Iowa Department of Natural Resources
Ryan Hupfeld	Iowa Department of Natural Resources
Vanessa Perry	Minnesota Department of Natural Resources
Nicole Ward	Minnesota Department of Natural Resources
Matt Vitello	Missouri Department of Conservation
Jeff Janvrin	Wisconsin Department of Natural Resources
Brenda Kelly	Wisconsin Department of Natural Resources
Andrew Stephenson	Upper Mississippi River Basin Association

Upper Mississippi River Restoration

Leading · Innovating · Partnering

2022 Report to CONGRESS

US Army Corps of Engineers®

Executive Summary

2022 Upper Mississippi River Restoration Program Report to Congress

The 2022 Upper Mississippi River Restoration (UMRR) program Report to Congress provides an evaluation of the UMRR program's Habitat Rehabilitation and Enhancement Projects (HREPs) and Long Term Resource Monitoring (LTRM) elements (Executive Summary Figure 1) since the previous Report to Congress in 2016. Additionally, this Report to Congress provides information about the Habitat Needs of the Upper Mississippi River System (UMRS) as well as conclusions and recommendations necessary to continue and improve implementation of the UMRR program. This fifth Report to Congress addresses the successes of the UMRR program leading, innovating, and partnering to successfully deliver habitat restoration, monitoring, and science to better understand the UMRS, and to achieve the programs vision of a healthier and more resilient Upper Mississippi River ecosystem that sustains the rivers multiple uses.

The following goals have been achieved from 2017 - 2022:

Leading

- Implemented the UMRR program as outlined in the adopted Joint Charter and the goals and objectives of the 2015-2025 Strategic Plan
- Provided critical insight and understanding of the UMRS through monitoring, research, and modeling to inform management of the UMRS
- Promoted a common vision, sense of purpose, transparency, and accountability among the program partners

Innovating

- Assessed and detected changes in the fundamental health and resilience of the UMRS
- Defined ecological resilience and appropriate indicators to measure status and trends in the UMRS
- Renewed UMRR's Habitat Needs Assessment and identified the suite of habitat projects to improve UMRS ecosystem health and resilience
- Addressed key ecological needs at various spatial scales
- Formulated and constructed 7 habitat restoration projects benefiting approximately 15,400 acres of nationally significant aquatic, wetland, forest, island, side channel and backwater habitats.

Partnering

- Actively exchanged information with UMRS watershed, national, and international partners
- Evaluated and learned from constructed habitat restoration projects
- Applied adaptive management principles to address risk and uncertainty
- Collaborated with partners to further inform issues related to project partnership agreements

Executive Summary Figure 1 Upper Mississippi River Ecosystem Floodplain Reaches, Habitat Projects, and Long-Term Monitoring Stations.

The 2022 UMRR Report to Congress has six parts

- **History and Background**
- **Chapter 1** – Strategic Partnership and Vision
- **Chapter 2** – Enhancing Habitat
- **Chapter 3**– Advancing River Science in Support of Restoration
- **Chapter 4**– Implementation Issues
- **Chapter 5** – Conclusions and Recommendations

These parts are summarized as follows:

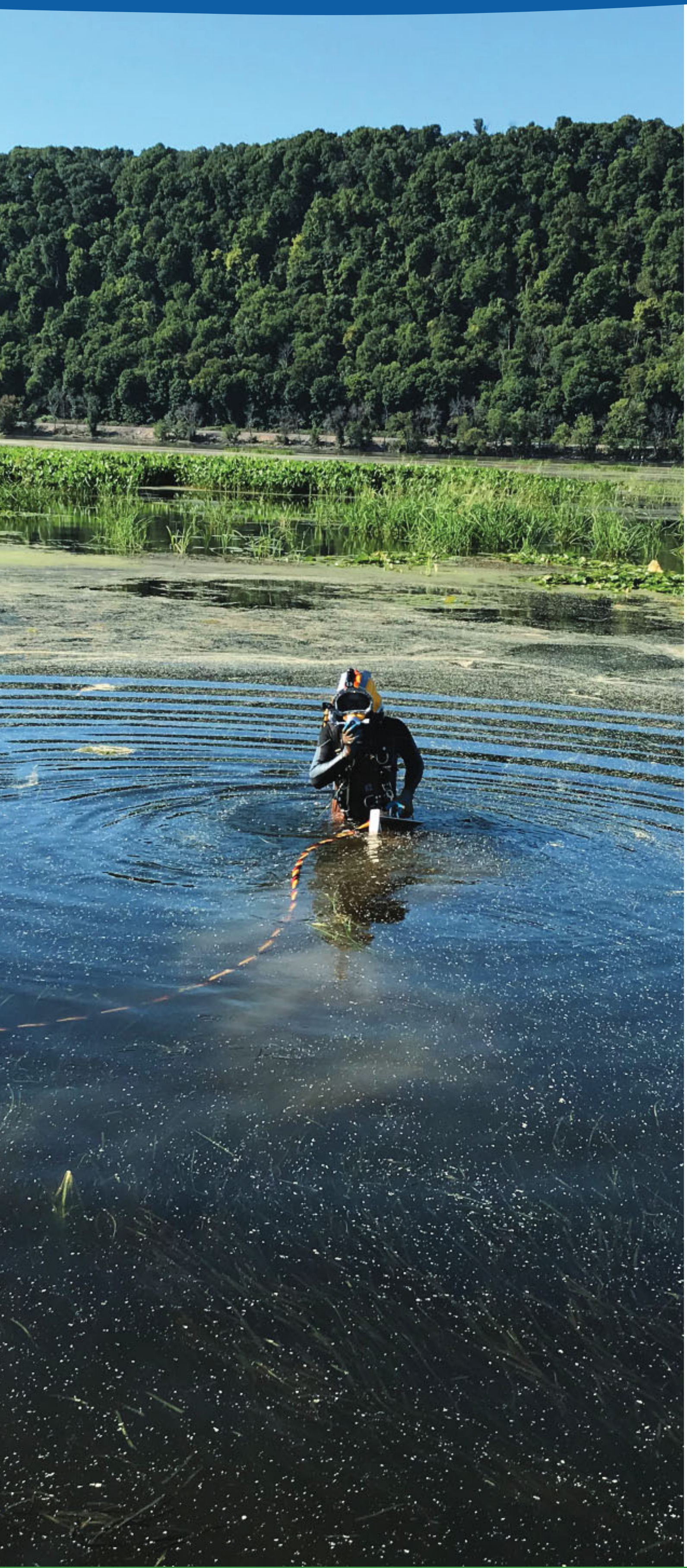
HISTORY AND BACKGROUND – The History and Background portion of the 2022 Report to Congress provides an overview of the national significance of the UMRS, the origins and evolution the UMRR program, changes to the authorization, and benefits of the UMRR program.

In a Nation endowed with magnificent water resources, the UMRS stands as a premier example of multi-purpose river management in the United States (US). The UMRS is the commercially navigable portions of the Mississippi River north of Cairo, Illinois, and the Minnesota, Black, St. Croix, Illinois, and Kaskaskia Rivers. Past and present day, people have used the resources provided by the UMRS for shelter, travel, food, commerce, and culture. While transformed in many ways, the UMRS retains many essential river functions and processes. Within the context of a modified river system, the Upper Mississippi River Restoration (UMRR) program seeks to expand upon and restore habitat and increase the resilience of a nationally-significant ecosystem.

In 1986, Congress recognized the UMRS as a nationally significant ecosystem and commercial navigation system in the Water Resource Development Action (WRDA) of that same year. The UMRS provides a 1,200-mile commercially navigable river network with a total of twenty-nine locks and dams on the Mississippi River and an additional eight on the Illinois River. The river network links five states to the Great Lakes and the Gulf Coast and supports a complex web of life in its mosaic of diverse and varied terrestrial and aquatic habitats. The UMRS is home to a diverse array of fish and wildlife that find habitat in its channels, backwaters, sloughs, wetlands, floodplain forests, and adjacent uplands. To preserve parts of the ecosystem and support the various fish and wildlife species, five National Wildlife and Fish Refuges (NWFRs) have been established covering over 300,000 acres of wooded islands, water, and wetlands along the UMRS. The Upper Mississippi River NWFR and adjacent State-owned wetlands are designated as a Wetland of International Importance, meeting the criteria established by the international Ramsar Convention on Wetlands. The Wetlands of International Importance in the UMRS meet these criteria because they contain representative, rare, and unique examples of natural or near-natural wetland types found within North America. Multiple Globally Important Bird Areas are also located on and along the UMRS due to the presence of globally threatened species.

To address the impacts of commercial and recreational navigation and rehabilitate degraded habitat, Congress authorized the UMRR program, initially known as the Environmental Management Program (EMP), in WRDA of 1986, making it the first large river ecosystem restoration, science, and monitoring program in the US. For the past 35 years, the UMRR program has successfully enhanced multiple uses of the river and leveraged partnership-led management for ecosystem science and restoration. Consistent funding and support from Congress and the Administration influence the ability of the UMRR program to deliver habitat restoration benefits and world class monitoring and science, contributing to the viability of the UMRS's diverse and significant fish and wildlife resources.

Congress has appropriated $703.82M to the UMRR program since its inception in 1986 through FY 21. In the previous 5 fiscal years (FY 2017-2021), Congress appropriated $165.85M to the UMRR program – nearly one-fourth of its historical funding. During this time, Congress had fully funded the UMRR program to levels matching the full authorized annual amount of $33.17M (Figure 2). This increase in funding consistently for five federal fiscal years helped the UMRR program achieve successes that would not have been attainable had funding remained at the historical average before FY 2017. This includes advancing ecosystem habitat projects effectively and efficiently (see Chapter 2) and making



substantial scientific advancements in large riverine ecosystem science (see Chapter 3).

Financial investment in protecting and restoring the UMRS provides economic, ecological, and infrastructure benefits. The UMRS is a treasured ecosystem abundant with fish and wildlife and a multi-billion-dollar economic engine. It plays a major role in local, regional, state, and national economies, both directly and indirectly. The UMRR program supports jobs and economic growth throughout the UMRS region. For every $10 million spent on habitat project construction, the UMRR program supports a total of 306 full-time equivalent jobs in manufacturing, agriculture, tourism, recreation, freight and passenger transportation, and energy sectors among others and $26,426,000 in economic output in the Nation. The UMRS supports critical infrastructure and ecosystem services for local communities and the region, including energy and drinking water systems. The UMRR programs work towards a healthier more resilient ecosystem that supports these systems.

The UMRR program is a successful partnership among federal and state agencies, non-governmental organizations, and the public. This systemic program provides a well-balanced combination of habitat restoration activities, monitoring, and science, pioneering many new and innovative engineering and planning techniques for ecosystem restoration in large river systems. The science element of the UMRR program showcases state-of-the-art and standardized techniques to monitor and conduct research on the river, which have substantially improved the ecological understanding of the UMRS and informed the restoration of the UMRS and other large-floodplain rivers. The UMRR scientific monitoring, engineering design, and environmental modeling techniques have been shared throughout the US and in more than five countries. As of December 2021, the UMRR program partnership completed 59 habitat restoration projects improving approximately 112,000 acres of fish and wildlife habitats in Illinois, Iowa, Minnesota, Missouri, and Wisconsin (Executive Summary Figure 1). By December 2022, the UMRR program anticipates completion of 4 additional habitat restoration projects bringing the total of 121,000 acres restored.

CHAPTER 1 – Strategic Partnership and Vision. Chapter 1 highlights the successful partnership among federal and state agencies, non-governmental organizations, and the public that is a cornerstone of the UMRR program.

Through interagency consultative and coordination bodies, the UMRR program's partnership considers and addresses a range of program policy and budget issues, defines program priorities and direction, and raises and resolves technical questions. HREPs are selected, planned, and designed in a collaborative manner among project planners, engineers, habitat managers, and scientists. LTRM is implemented in coordination with UMRR program partners from USGS and the five UMRS States.

The UMRR program's 2015-2025 Strategic Plan articulates the partnership's vision for the UMRS, charting a 10-year plan for program implementation. The strategic plan fosters UMRR program's longstanding commitment to cooperative action among its implementing partners and to external engagement and collaboration among the many organizations and individuals working for a better UMRS. The UMRR program benefits from a deeply rooted history of interagency and interdisciplinary partnerships. Through 2025, the UMRR Coordinating Committee (UMRR CC) will prioritize its focus on the following three initiatives:

1. Implement adaptive management in more deliberative ways and track biological responses to restoration
2. Apply ecosystem resilience concepts to UMRR's restoration and science
3. Refine communication to target the most pressing challenges for sustaining a healthy UMR ecosystem

In 2025, UMRR partnership will review the strategic plan and identify ways to further improve and continue the UMRR program's success in the next 10-years of enhancing restoration and knowledge of the UMRS.

The UMRR program has undertaken creative and intentional efforts to integrate the UMRR's primary elements: building HREPs and implementing LTRM and scientific research. Since 2016, several efforts have built bridges across those elements, resulting in seamless program delivery. With more stable and robust funding for the UMRR program, came the ability to strategically plan for science efforts to support restoration and management activities. These focused engagements bring together the best scientific, engineering, and natural resource management expertise from across the partnership. This fosters a collaborative approach to research and analysis that effectively leverages the strengths of both the LTRM and HREP program elements. In 2018, UMRR completed its second Habitat Needs Assessment (HNA-II) to identify long-term habitat restoration goals, objectives at multiple scales, and to identify areas and types of future restoration projects. In 2019, the UMRR program brought together expertise from across the partnership that plan, design, build, operate, maintain, and monitor HREP projects. This effort brought practitioners together to exchange lessons learned, collaborate on the future direction of HREPs, and initiate the identification, planning and sequencing of the next generation of HREPs. In 2020, UMRR partnership undertook a dialog to reassess the significance of the UMRS to better position the program in delivering value to the nation and help accomplish its vision of a healthier and more resilient UMR ecosystem that sustains the rivers' multiple uses. Finally, in support of ongoing ecosystem restoration and management efforts, the broad partnership has made significant progress in completing and applying the resilience assessment of the UMRS.

Through leadership, partnership, and innovation, the UMRR program continues to substantially improve knowledge of the UMRS. To advance restoration goals and objectives, the UMRR program works in collaboration with other programs and partners within the watershed and beyond to maximize the value of river restoration knowledge to the region and nation. This collaboration includes partnering with the USGS Next Generation Water Observation System (NGWOS), utilizing LTRM expertise and methods to monitor unique conditions present during the 2020 consolidated lock closures on the Illinois River, and the beneficial use of dredged material from navigation channel maintenance activities to enhance habitat at the McGregor Lake HREP.

CHAPTER 2- Enhancing Habitat. Chapter 2 is focused on the UMRR HREP element and the achievements in improving the ecological health and resilience of UMRS habitats.

Habitat restoration projects designed and funded under the HREP element aim to restore habitats and processes that have been degraded as a result of UMRS alter-ations (including river channelization or modifications, locks and dams construction, flood risk management projects, and floodplain development). As of December 2021, the UMRR program partnership has completed 59 habitat restoration projects improving approximately 112,000 acres of fish and wildlife habitats in Illinois, Iowa, Minnesota, Missouri, and Wisconsin. By December 2022, the UMRR program anticipates completion of four additional habitat restoration projects bringing the total of 121,000 acres restored. Currently, the UMRR program has 12 HREPs in planning or design and seven under construction. Upon construction completion of these UMRR HREPs, the UMRR program will enhance nearly 77,000 additional acres.

Understanding how the ecosystem responds to various restoration techniques and approaches used in HREP projects has always been a top priority for UMRR. Since 2016, the UMRR program evaluated the effectiveness of 36 completed UMRR HREPs by comparing pre and post project monitoring information with other research and knowledge of the ecological conditions. This effort improved the UMRR program's knowledge about the river system, restoration designs, construction techniques, and enhanced monitoring capabilities to detect direct and indirect physical, chemical, and biological responses to UMRR HREPs.

CHAPTER 3 – **Advancing River Science in Support of Restoration.** The accomplishments of the large-scale scientific research and monitoring effort of the LTRM element is the basis of Chapter 3.

Since its inception, the LTRM element has been at the forefront of collecting, providing public access to, and using scientifically based information to better understand how this large floodplain river system functions and to improve river management and restoration. The UMRR LTRM element fills a critical need for the standardized collection, integration, analysis, and reporting of scientific information to UMRS resource managers and decision makers. Since the last Report to Congress, two key publications have significantly advanced the science and understanding of the Upper Mississippi River System. In 2018, the UMRR program completed the Second Habitat Needs Assessment (HNA-II). Using HNA-II data, the UMRR program establishes a technically sound, objective, and consensus-based framework integrating best available data with partner agency management perspectives for restoration and management actions in the UMRS. The 2022 Ecological Status and Trends Report summarized analyses of two and a half decades of long-term monitoring, allowing UMRR staff and partners an incomparable ability to detect long-term trends, understand variation over time, and observe complex patterns in the river ecosystem. These data provide critical information on ecosystem dynamics relevant to the management and restoration of the river system.

CHAPTER 4 – **Implementation Issues.** Chapter 4 covers the issues could potentially affect UMRR program implementation efficiency.

From 2021 to 2022, the UMRR CC facilitated development and dialog about those issues with the goal of UMRR program partner consensus on recommendations to guide future implementation of the program. Topics for ongoing dialog among the partnership include: project partnership agreements (PPA), floodplain regulations, engaging nontraditional sponsors, water level management, land acquisition, watershed input and climate change, external communications, and federal easement lands. Specifically related to the PPA issue, the Corps is hearing from most non-federal sponsors (states, counties, municipalities, and non-profit entities) that some of the statutory requirements make it challenging for them to execute.

CHAPTER 5 – **Conclusions and Recommendations.** The 2022 Report to Congress concludes with a summary of the UMRR program's leadership, innovation, and partnership efforts of the past six years and identifies recommendations for future UMRR program implementation.

The UMRR program effectively uses federal appropriations by advancing its authorized purposes and improving the ecological condition and knowledge of the UMRS. An assessment of future capabilities indicates that the UMRR program has the capability to effectively use appropriations levels at the fully authorized annual amount of $55 million. The UMRR program has routinely executed more than 98 percent of its appropriated funds, including when funding levels were near or at its previously full annual authorized amount of $33.17 million. A consistent flow of funding allows the UMRR program to manage risk and uncertainty to achieve a high level of planning and construction capability and execute an aggressive schedule.

Financial investment in protecting and restoring the UMRS provides economic, ecological, and infrastructure benefits. The UMRS is a treasured ecosystem abundant with fish and wildlife and a multi-billion-dollar economic engine. It plays a major role in local, regional, state, and national economies, both directly and indirectly. The UMRR program supports jobs and economic growth throughout the UMRS region.

There are four recommendations in this Report's concluding chapter but no recommendations for Congress for modifications to policy or legislation to improve implementation. Briefly, the four recommendations conclude that the UMRR program should: (1) continue to work collaboratively to continue to implement action to achieve the goals and objectives of the 2015-2025 UMRR Program Strategic Plan to help drive the UMRS toward a healthier and more resilient state, (2) continue to take a proactive approach to ensure an adequate flow of projects in the planning, design, and construction phases, (3) remain fully functional and continue to serve ecosystem restoration and resource monitoring needs on the UMRS at its full authorized level of funding ($55 million), and (4) work to further inform issues related to execution of project partnership agreements.

cost-share sponsors could substantially increase the UMRR program's restoration opportunities, particularly in the unimpounded reach of the Upper Mississippi River and Illinois River reaches where there is a considerably higher proportion of private land and therefore fewer options for USFWS and the states to sponsor projects. Additionally, the UMRR Coordinating Committee recognizes that engaging nontraditional sponsors throughout various aspects of the UMRR program's implementation, including the habitat restoration project identification and selection process, can improve the UMRR program's ability to meet its mission.

Water Level Management

The Upper Mississippi River System federal and state resource agencies have expressed a priority to promote the management of water levels for ecosystem benefits throughout the river system through the coordination and implementation of policies and activities across Districts, the partnership, public, and stakeholders. The UMRR program currently has a habitat restoration project to implement pool-wide water level management in Upper Mississippi River Navigation Pool 13 in feasibility that would provide context for addressing these issues. Opportunities exist to explore these types of projects on a more systemic basis.

Land Acquisition

Acquisition of real estate interests from willing sellers (hereafter referred to as land acquisition) can be a valuable tool for the UMRR program, expanding restoration opportunities along the entire UMRS. For a variety of reasons, the UMRR program has rarely advanced habitat projects with substantial land acquisition components. The UMRR program is exploring opportunities to communicate with potential sponsors and landowners about restoration needs.

Watershed Input and Climate Change

Conditions of the UMRS result from a combination of tributary inputs from the watershed, natural and man-made structures within the river corridor, and management of river flow. The influences of climate change on the watershed, changes to the landscape,

to the water cycle, to the soil across the landscape, and other influential ecosystem processes has altered the hydrology, soil erosion, influxes of sediment and nutrients, and more, thereby significantly altering the rivers of the UMRS.

External Communications

Opportunities for the UMRR program and its partnership to work within a watershed context and create synergies with programs and projects that will affect the health and resilience of the UMRS are being explored. The UMRR program can aid other programs and projects that have influence on the UMR basin condition.

Federal Easement Lands

Some lands suitable for acquisition and restoration may be encumbered by easements (e.g., Wetland Reserve Program) that require coordination between the Corps and other Federal agencies to ensure compatibility.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

Thirty-five years ago, Congress recognized the UMRS as a nationally significant ecosystem and commercial navigation system. Through leadership, partnership, and innovation, the UMRR program continues to substantially improve knowledge on, and habitat in, the UMRS.

Overall Program

- The UMRR program substantially improves the ecological health, resilience, and understanding of the UMRS. At the end of 2022, through 63 habitat projects, the UMRR program increased and enhanced important fish and wildlife habitat, improved the river's floodplain structure and function, and counteracted factors degrading the river's ecological health. Constructing projects benefitted approximately 121,000 acres of nationally significant habitat. The UMRR program continuously demonstrates its ability to execute planning, design, and construction of habitat restoration projects effectively and efficiently.
- The UMRR program effectively uses federal appropriations by advancing its authorized purposes and improving the ecological condition and knowledge of the UMRS. An assessment of future capabilities indicates that the UMRR program has the capability to effectively use appropriations levels at the fully authorized annual amount of $55 million. The UMRR program routinely executed more than 98 percent of its appropriated funds, including when funding levels were near or at its full annual authorized amount. The relatively consistent flow of funding allows the UMRR program to manage risk and uncertainty to achieve a high level of planning and construction capability and execute an aggressive schedule. The 2015-2025 UMRR Strategic Plan provides a clear framework for decision-making about resource allocations and ensures the UMRR program remains fully accountable and transparent regarding federal investment.
- The UMRR program supports jobs and economic growth throughout the UMRS. For every $10 million spent on habitat restoration project construction, the UMRR program supports a total of 306 full-time equivalent jobs in manufacturing, agriculture, tourism, recreation, freight and passenger transportation, and energy sectors among others. In the local impact area, 139 of the 306 jobs result in $4,500,000 of labor income, $11,200,000 in the gross regional product, and $15,600,000 in economic output. More broadly, these expenditures support 167 of the 306 full-time equivalent jobs, $12,064,000 in labor income, $18,688,000 in the gross regional product, and $26,426,000 in economic output in the nation. 54.3% of these jobs are high-quality science, technology, engineering, and mathematics (STEM)-related jobs throughout the UMR region.
- The UMRR program is a pioneer in large river floodplain ecosystem restoration. When the UMRR program began, large river floodplain ecosystem restoration was essentially non-existent, making its first habitat project designs true experiments. With ongoing emphasis on learning and innovation, the UMRR program continually refines these techniques with data, modeling, and sophisticated engineering to create cost-effective and sustainable solutions to rehabilitate fish and wildlife habitat and restore complex riverine functions and processes. The UMRR program's standardized, multi-component and multi-habitat long term resource monitoring offers an innovative approach to assessing the overall river ecosystem under a wide range of conditions that has proven successful.

- The UMRR program generates critical knowledge about the Upper Mississippi River's ecological health and resilience, providing a solid foundation upon which to base management actions and policy. The UMRR program's scientific expertise, breadth of information, monitoring protocols, analytical capabilities, and data management and dissemination infrastructure create extensive possibilities to learn about the river's natural functions and processes, human influences, and opportunities to best address critical restoration needs. Continued long term monitoring and science will be imperative to understanding and managing ecosystem resilience to ongoing and future stressors.
- The UMRR program, is a highly-integrated program, effectively combining ecosystem restoration with scientific monitoring and scientific research to improve the ecological health and resilience of the UMRS. This involves research and monitoring informing restoration and management efforts and ensuring that restoration efforts are readily available for scientific use as a basis for learning. The UMRR program informs river management through integrated environmental monitoring, research, and modeling, as well as data management and dissemination.
- The UMRR program is a dedicated partner in improving the UMRS in an integrated, multi-purpose collaborative management context. The UMRS is a large, complex, and dynamic ecosystem that supports a uniquely complex set of human uses. A wide range of interests work collaboratively to ensure the sustainability of the river's many economic, ecosystem, and social values. While the UMRR program's resources remain directly focused on restoring and better understanding the river's main stem ecological health, those resources will be optimized only by working under the context of integrated watershed management. The UMRR program is rooted in a strong, collaborative interagency partnership. The UMRS benefits from a deeply-rooted history of interagency and interdisciplinary partnership that transcends traditional geopolitical boundaries and is responsible for the UMRR program's primary concept, initial authorization and subsequent permanent continuing authority, and maturation into a well-respected, effective restoration and science program. The ongoing commitment from all partners is fundamental to the UMRR program's longstanding success. This includes the involvement of nonprofits in programmatic implementation and public outreach.

Improving the Ecosystem

- The UMRR program has a proven record of success in building habitat projects that are innovative, durable, and effective in advancing systemic ecological goals and project objectives. The UMRR program develops feasibility reports for each individual habitat project that ensures accountability to the Corps' overall policy direction and to demonstrate the intended cause-and-effect relationship of providing ecological benefits.
- The UMRR program strives to use the best available knowledge to define and pursue restoration opportunities, evaluating the use of new technology, research findings, and other information as they emerge. Since the 2016 Report to Congress, the UMRR program has invested strategically in enhancing existing and new analytical tools. Scientific investigations have yielded considerable knowledge about the river's complex and dynamic ecosystem. Individually and collectively, these knowledge gains are invaluable in targeting restoration needs and placement, designing projects to improve site-specific habitat needs and broader ecological processes, and evaluating success in implementing restoration techniques and approaches.
- The UMRR program continually improves its restoration techniques through adaptive management. The UMRR program enhances restoration effectiveness and efficiency, learning from its long-term systemic monitoring, project-specific monitoring, project performance evaluation and focused research. Since the 2016 Report to Congress, the UMRR program routinely updates the Environmental Design Handbook to communicate insights gained regarding biological responses to project designs, new information about innovative restoration tools, and connections among system, floodplain reach, and site-specific ecological objectives, project criteria, and management objectives.

- The UMRR program is committed to focusing on the goals of the 2015-2025 UMRR Program Strategic Plan by taking a more deliberate and explicit approach to implementing adaptive management. This will be accomplished by:
    - Answer broad questions about the Upper Mississippi River ecosystem and its management, beyond the project-level.
    - Identify restoration needs that would be best addressed through new restoration techniques.
    - Enhance communication and understanding related to project performance and uncertainties in ecosystem management.
    - Learn from past and current efforts to inform future restoration.
    - Improve the overall effectiveness and efficiency of restoration techniques.
    - Inform long-term UMRS management.
    - Guide and optimize the UMRR program's investment in habitat restoration – e.g., determine at what point there are diminishing returns from investing in certain areas.

Advancing Knowledge and Understanding

- The UMRR program evaluates the fundamental health and resilience of the UMRS with scientific certainty and provides early detection and assesses impacts of in-river and watershed influences including invasive species. As the database builds and its diversity of monitored ecological conditions expands, scientific certainty increases regarding the causes and consequences of annual variability, long term changes in the structure and function of the river, and effects of gradual changes in the river ecosystems, as well as rare events, which can only be detected with long term data.
- The UMRR program's scientific investigations provide critical insights and understanding regarding a range of key ecological questions. Through a combination of monitoring, additional research, and modeling, the UMRR program informs management and restoration of the UMRS by answering questions related to existing and future conditions, ecological patterns and interactions, factors controlling dynamics, fish and wildlife habitat needs, and biological responses to restoration techniques and approaches.
- The UMRR program scientific information is easily useable and publicly accessible. The amount of information that the UMRR program has been able to collect, learn, and capture regarding the UMRS is abundant. To make sure that the information is relevant and used to its fullest extent, the UMRR program has created many models, analytical tools, and interactive web-based browsers to make the datasets useful to a variety of audiences including teachers, nonprofit organizations, and the general public.
- The 2015-2025 UMRR Program Strategic Plan makes a commitment to defining and applying the concepts of ecosystem resilience to the program's restoration and science efforts. In the next few years, the UMRR program's scientists and restoration practitioners will work together to:
    - Apply the recently developed definitions of ecological resilience for the UMRS to science and management activities.
    - Use established conceptual models of resilience to evaluate the factors contributing to the resilience of the UMRS, identify where the UMRS is in a desirable state and what management actions can contribute to maintenance or an increase in resilience. Likewise, identify which areas are in a less desirable state and how management actions might overcome those conditions will be identified.
    - Evaluate the potential effects of the UMRR program's habitat restoration projects on resilience both conceptually and through leveraging of UMRR LTRM data and UMRR HREPs.
    - Inform and improve the UMRR program's future restoration activities to better manage resilience through closer collaboration between scientists and managers.

Engaging and Collaborating

- The UMRR program builds a united effort with other, related in-river and watershed initiatives to work towards a healthier and more resilient UMRS more robustly and coherently. Enhanced coordination with targeted in-river and watershed efforts leverages resources and talents to improve overall knowledge and ecological conditions of the river system.
- The UMRR program remains accountable and transparent to Congress, the Administration, and general public by ensuring it continues to communicate relevant information in a timely manner. The UMRR program supplies key messages regarding plans, progress, and accomplishments of its various programmatic efforts to elected officials, agency leadership, nonprofits, and the interested public in various ways. This builds important relationships with river constituencies who benefit directly and indirectly from the UMRR program implementation.
- The UMRR program learns and shares information with other similar large river restoration and monitoring efforts. The UMRR program continues to serve as a leader in restoration, monitoring, and science, nationally and internationally, since the 2016 Report to Congress, and at the same time, learns from other large river programs in various exchanges. Many benefits result from these interactions, including cost efficiencies in the UMRR program implementation and insights not otherwise available.

Interagency Partnership

The UMRR program has a strong foundation of interagency partnership that is vital to program's success. As prescribed in its authorization, a suite of federal and state agencies is directly responsible for the UMRR program's implementation and have worked together to build and refine the program since its inception. The UMRR program is the only available systemic program for constructing habitat improvements, monitoring critical systemic information, and scientific analysis of the UMRS, creating a common unifying point collaboration for which agencies continue to come together and contribute in-kind and cost-share resources and expertise. Since the 2016 Report to Congress, the agencies have worked to continuously improve the UMRR program's implementation, transparency, accountability, and organizing and maintaining institutional knowledge.

Recommendations

- The Corps, implementing partners, and interested Tribal governments and the public work collaboratively to continue to implement action to achieve the goals and objectives of the 2015-2025 UMRR Program Strategic Plan to help drive the UMRS toward a healthier and more resilient state that supports the river's multiple uses.
- The UMRR program takes a proactive approach to ensure an adequate flow of projects in the planning, design, and construction phase that has been instrumental to the UMRR program's ability to execute annual appropriations consistently at 98 percent. Focusing implementation on continuing to achieve the 2015-2025 UMRR Program Strategic Plan vision for the river in a healthier and more resilient state, the UMRR program should pursue the following measures:
    - Advance the 2015-2025 UMRR Strategic and Operational Plans' guidance for programmatic implementation regarding the four goals for 1) enhancing restoration, 2) advancing knowledge, 3) engaging and collaborating with other key individuals and organizations, and 4) facilitating a strong, unified interagency partnership.
    - Apply defined ecological resilience concepts to the UMRS, including developing quantifiable indicators of ecosystem resilience to measure the status and trends of various resilience attributes.
    - Apply the HNA-II (2018) to identification and evaluation of future restoration efforts.
    - Continue to identify habitat projects that improve the health and resilience of the UMRS, reflecting insights gained from the HNA-II (2018).
    - Formulate and construct the identified suite of habitat projects.
    - Evaluate and learn from constructed habitat projects to inform future restoration and management of the UMRS.

- Continue to evaluate the UMRR program's progress in advancing the *2015-2025 UMRR Program Strategic Plan* and continue to learn and improve as a program and in implementing restoration and science techniques.
- Engage the partnership in 2024 in preparing the next *UMRR Program Strategic Plan*

- The UMRR program should remain fully functional and continue to serve ecosystem restoration and resource monitoring needs on the UMRS. The UMRR program provides significant benefits to the UMRS and the Nation by delivering high-quality habitat restoration and science projects, products, and services, and is fully capability of executing an effective, efficient program at its full authorized level of funding (i.e., $55 million). Specifically, the UMRR program should continue to:
  - Address key ecological needs at various spatial scales through habitat projects that reflect best available knowledge and advance UMRR's vision for a healthier and more resilient UMRS.
  - Apply adaptive management principles to address risk and uncertainty, and continually enhance restoration and knowledge of the UMRS.
  - Assess, and detect changes in, the fundamental health and resilience of the UMRS by continuing to monitor and evaluate its key ecological components of aquatic vegetation, bathymetry, fish, land use/land cover, and water quality. The UMRR program's standardized, multi-component and multihabitat long term resource monitoring offers an innovative approach to assessing the overall river ecosystem under a wide range of conditions that has proven successful at generating critical knowledge about the river's ecological health and resilience. This information provides a solid foundation upon which to base management actions and policy.
  - Provide critical insights and understanding regarding a range of key ecological questions through a combination of monitoring, additional research, and modeling to inform and improve management and restoration of the UMRS.
  - Work with key organizations and individuals in the Upper Mississippi River watershed; provide information to organizations and individuals whose actions and decisions affect the UMRS; and exchange knowledge with other organizations and individuals nationally and internationally.
  - Promote a common vision and sense of purpose, transparency, and accountability among the UMRR program's implementing partner agencies.
  - Implement the UMRR program as outlined in the adopted Joint Charter for the UMRR Coordinating Committee, Analysis Team, Habitat Planning and Sequencing Framework Teams (2021), and the 2015-2025 UMRR Program Strategic Plan.

- The Corps and non-federal sponsors should continue to work together to further inform issues related to execution of project partnership agreements.

ATTACHMENT C

UMRR Strengths Weaknesses Opportunities Threats Analysis

(2/28/2024) *(C-1 to C-5)*

UMRR Strengths, Weaknesses, Opportunities and Threats

The following tables capture the discussion and views expressed by some of the UMRR Coordinating Committee (CC) members and meeting participants at the February 28, 2024, UMRR Coordinating Committee during the Strategic Planning portion of the agenda. These tables represent initial information gathering related to the UMRR Program's next strategic plan and will be supplemented with additional information from various sources and partners over the coming months. This information will be used to identify common themes for further discussion by the UMRR CC, partners, and stakeholders. The statements within the following tables do not reflect the position of the UMRR Program.

Internal Strengths of UMRR

PARTNERSHIP	SCALE	LONG-TERM	CONSISTENTLY FUNDED	PROGRAMMATIC APPROACH
Bringing partnership together in upper basin	Large complex rehabilitation projects, long-term monitoring	Long term resource mentoring	continued support – in P. Bud – allows us to do continued work through CRA –	Blending of science and restoration; intentional pairing
Critical mass of river scientists and expertise for developing innovative methods for learning from the data collected by those field station staff.	Long term, spatially extensive monitoring, detailed biological monitoring of the UMRS. 6 study reaches spanning 1100 mi of Upper Miss and Il River. All data publicly available. Extensive analysis of this data has provided a diversity of insights into the structure and function of the UMRS that inform its restoration and management.	Long term, spatially extensive monitoring, detailed biological monitoring of the UMRS. 6 study reaches spanning 1100 mi of Upper Miss and Il River. All data publicly available. Extensive analysis of this data has provided a diversity of insights into the structure and function of the UMRS that inform its restoration and management.	program is in P. Bud, House and Senate measures – sustained support for program across leadership is important and unique.	Programmatic implementation (not piecemeal)
PEOPLE! people across a vast geography, multiple jurisdictions, etc.	Science-based monitoring at the system scale.	longest resource monitoring dataset in the country; first of its kind	Bipartisan support (Congressionally) of the program	lessons from project implementation over 30 years
100% the people.	Restoration planning and implementation at the system scale.	Network of 6 long term monitoring field stations that provide extensive infrastructure and expertise for improving our understanding of the river and informing its management.	program is in P. Bud, House and Senate measures – sustained support for program across leadership is important and unique.	
Access to state and federal agency programs and leaders as well as nonprofit entities' expertise and resources	Basin scale science, monitoring, and restoration.	Phenomenal long-term datasets.	Consistent funding	
collaboration and partnership with agencies like USGS, Fish and wild life services, DNR's etc.	Understanding resilience of large river ecosystems and how to manage resilience and sustainability of large river ecosystems	lessons from project implementation over 30 years	Congressional appropriations. Program has strong track record. In president's budget, house budget, senate budget. Support across spectrum	
number of agencies involved in UMRR making it a success.	Large scale big river restoration projects	deep history	$55M	
Strong, well functioning and well established partnership.				

Internal Weaknesses of UMRR

RESOURCE CONSTRAINTS	COMMUNICATION CHALLENGES	LACK OF INTEGRATION OF 2 MISSION AREAS	ORGANIZATIONAL CONSTRAINTS
Great partnership, but people have a lot of demands placed on their time.	Communicating the substantial but very technical knowledge and work	Integration of program elements – not the best communication between the 2 elements of the program; not moving toward the same goals. Better now.	have long established processes and bureaucracies – challenging to fit new issues into existing framework and structure. Can be challenging to disrupt establishment with emerging needs and approaches.
Human resources constrained environment.	The extensive partnership is a strength, but a related challenge is effectively communicating across the entire partnership effectively, but not excessively	two elements were not always moving toward the same goals	Responding to emerging issues
Accomplishing the work we have before us	Data sharing across agencies with individual restrictions	Integration of program elements	Changing policies, rules, agency goals/objectives
Staff turnover, loss of institutional knowledge	Difficulties finding a platform that all partners can access for group work on documents etc.	I think we've made significant strides in recent years with respect to integration (LTRM and HREP) and the program is poised to lean forward on this	How the program grows to respond to increased authorizations. Be flexible when future budgets are not as generous.
Finding the right people for some of our future priorities.	Sharing data online is something LTRM is very good at. Finding a platform that everyone can edit documents etc is an issue		Many other authorizations/decisions about the system that impact UMRR. EX: State permitting – RR of the Corps in applying for state permitting. Decisions made outside UMRR that impact us.
Hiring process takes a long time--impacts ability to be flexible	Struggle to collaborate/communicate with other efforts taking place in the basin		aligning partner priorities
Perhaps, the ever increasing demands on the time of all of us stakeholders. This is an example of a potential threat.			historically funding constraints did impact program.
			PPAs – PPAs – multiple challenges that make it onerous for states and NGOs to participate – O&M in perpetuity. condemnation as well. Hope to address those in the next several years.

External Opportunities

BETTER COORDINATION WITH NESP	INCREASED AWARENESS OF UMRR	CONNECT TO RELATED EFFORTS/PRIORITIES	COMMUNITY ENGAGEMENT	POLICIES AND PRIORITIES
Coordination/synergy with NESP and channel maintenance activities.	increasing interest in and awareness of the Mississippi and Illinois Rivers. Increasing press attention.	Interest in flood resilience planning (levee setbacks, wetland enhancements, etc)	Community engagement throughout the watershed	USACE policy changes on assessing comprehensive benefits of projects.
Navigation and Ecosystem Sustainability Program (NESP) – more coordination.	stressors on the system seem to be bringing more attention to UMRR - opportunity to leverage	Tie UMRR into watershed based efforts - e.g., state nutrient reduction strategies	Mississippi Ag and Water Desk	New Administrative priorities such as environmental justice, climate change.
Authorized to work in the same footprint. Have been trying to differentiate and articulate what each is uniquely qualified to accomplish.	should say increasing media attention	Restoration or management initiatives in the uplands/watershed		
Concerns in the long term with shared project footprint. Available areas to do projects in. NESP authorities have flexibility, but after 10+ years, project availability will get smaller.	Increasing media attention – 2022 Status and Trends Report. Upper MS Basin Ag and water desk – regularly writing articles about aspects of the MS river. Getting picked up by newspapers, NPR	Need to connect with organizations/efforts in the surrounding watershed, outside of UMRR authority		
Authorizing language – partnership isn't treated the same or formalized in the authorizing language. UMRR has strong partnership, but NESP lacks clarity on partnership.	Mississippi Ag and Water Desk	MRR&RI – Mississippi River Restoration and Resilience Initiative if authorized and funded. Proposal before congress now to provide authorization to EPA that looks at entire Mississippi River – focused on restoration and resilience. Provides opportunity to increase coordination across a number of efforts and agencies.		
Coordination/synergy with NESP and channel maintenance activities		NRCS MRBI - ID priority watersheds within basin - how can we build on and connect to these programs?		
Appropriations – asking for large sums of money for both programs				

External Threats

PROJECT COST	PARTNER ABILITY TO SUPPORT	FUNDING	SIMILAR ORGANIZATIONS	LACKING RELEVANCY	CLIMATE CHANGE	INCREASED OVERSITE, DESCREASED EFFICIENCY	INFLUENCES IN SURROUNDING WATERSHED
UMRR started out as small projects – but project size has increased and costs have increased.	What is the capability of UMRR to construct projects? What is the capability of partners to support the program? Can we use UMRR funding for partners to help support? If we get more $, will partners have the ability to contribute more support	Continuing resolution	NESP	If we're not doing work that feels relevant to partners, congressional reps, etc, they will not want to fund us. Need to show how we are positively impacting relevant issues.	Climate change and not building resilient enough projects to withstand impacts.	We don't currently have oversight of HQ. They have not been involved in UMRR – delegated to MVD – but as projects increase in size, they may want to pay more attention to us. May create more challenges. Could impact some of our current efficiencies.	Influence of actions in the watershed. UMRR's authority is bluff to bluff, so can't influence things outside that area of authority
Costs of projects increasing at an alarming rate.	it's hard for partners to expand capacity to keep up with the expanding program(s).			Not effectively responding to emerging issues.			influence of watershed
				not being able to show sufficient relevancy - i.e. not effectively responding to emerging issues			

ATTACHMENT D

UMRR Photo Contest Process Document
(5/1/2024) *(D1-D2)*

Revised May 1, 2024

UMRR Photo Contest Process Document

Purpose: To bolster UMRR's program materials and communication efforts.

> **"Empowering Conservation Through Vision: Capturing the Upper Mississippi River's Essence"**
> Our photo contest aims to gather stunning visual narratives that showcase the beauty, diversity, environmental significance, and successful ecological restoration of the Upper Mississippi River System. Your submissions will be integral in bolstering the Upper Mississippi River Restoration (UMRR) program's materials and communication efforts, as well as amplifying awareness and fostering appreciation for this vital ecosystem restoration and monitoring program. Join us in celebrating and safeguarding the Upper Mississippi River through the lens of your creativity.

Participants: UMRR Partners

Permission form: Will need to include specific language regarding:

- Purpose (inviting people to participate to support the purpose – inspire greater care, connecting people and resources, etc.)
- Photos will be used for UMRR materials
- Photo credits are included with photo end product

Duration of Submission Period: August 1, 2024 to October 31, 2024.

Promotion of the Contest: Structured around UMRR quarterly meetings:

- Announce contest at May 7-9 UMRR Workshop and May 22 UMRR quarterly meeting
- Email announcement on August 1 regarding open submissions portal/email address.
  - UMRR CC distribution list and UMRR program distribution list
- Email on October 1 regarding remaining time to submit photos.
  - UMRR CC distribution list and UMRR program distribution list

Submission Methods: A submission form on the UMRR web for UMRR partners to submit photos.

Submissions must include:

- Photographer name
- Email address
- Phone number
- Photo title
- Location photo was taken
- Entry category

Categories:

- Before/After, Construction, or Benefits of HREPs (Before/After photos not subject to resolution restrictions)
- Connecting People with Nature, Human Use, or Public Interaction
- Natural Features, Scenic Views, or Landscapes
- Cultural or Historic Features
- LTRM – Monitoring in Action

Organization and Storage of Photos: [Tentative] USACE to create SharePoint folder for organizing and storing photos with a companion participant information spreadsheet.

Judging Process: Two rounds of judging

- First: [UMRR COT volunteers] Review submitted photos November 1 – November 8. Announce five finalists for each category at November 20 UMRR QM.
- Second: Broader electronic voting process for finalists from November 20 through December 12. Winners shipped or presented with prizes at February QM

Prizes: UMRR gear or framed photos (if under $20) and "Our Mississippi" highlight in Spring 2025.

Feedback and Evaluation: Following selection of winners - send an email to all participants to help with post-event evaluation. Send additional request to Field Station Team Leads to see if anyone was precluded from submitting photos for any reason and therefore would note in the list of participants.
[UMRR COT should develop this process over the next few months.]

ATTACHMENT E

Program Reports

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Developing and Applying Indicators of Ecosystem Resilience to the UMRS						
2024R1	Updates provided at quarterly UMRR CC meeting and A team meeting	Various				Bouska, Houser
2024R2	Coordination of HARP data collection (see HARP SOW for additional milestones)	30-Sep-24				Bouska
2024R3	Submit draft Research Framework for Linking restoration actions and ecological responses	30-Sep-24				Bouska
On-Going						
2021R3	Submit resilience assessment synthesis manuscript for peer review publication	30-Mar-2021	30-Sep-2024		Delayed due to work on Pool 13 HARP proposal and LTRM Implementation planning group	Bouska
2021R4	Submit resilience assessment synthesis fact sheet for USGS peer review	30-Sep-2021	30-Sep-2024		Delayed due to work on Pool 13 HARP proposal and LTRM Implementation planning group	Bouska
2022R2	Submit manuscript that investigates associations between general and specified resilience for peer review publication	30-Sep-2022	30-Sep-2024		Delayed due to work on Pool 13 HARP proposal and LTRM Implementation planning group	Bouska
Landscape Pattern Research and Application						
2024LP1	Map Set: UMRS Contiguous Forest Areas (Pools 9, 12, OR2, LaG, 1, 2, 3, 7, 11, 10, Stc, Alt, 17, 22, 6, 5A, 5, 24, 25)	30-Sep-2024				Rohweder and De Jager
2024LP2	Map Set: Aquatic Areas (Pools 1, 2, 3, 7, 10, 11, 17, 22, Alt, 5, 5a, 6).	30-Sep-2024				Rusher, Rohweder, De Jager
2024LP3	Map Set: Attributes of 2010-2020 forest loss areas (Pools 4, 8, 13, 26, 9, 12, OR2, LaG, 1, 2, 3, 7, 11, 10, Stc, Alt, 17, 22, 6, 5A, 5, 24, 25)	30-Sep-2024				Rohweder and De Jager
2024LP4	Story Map: Land Cover Change (1989-2000-2010-2020)	30-Sep-2024				Rohweder and De Jager
2024LP5	Data Analysis: Effects of management actions and hydrological changes on forest succession at Reno Bottoms	30-Sep-2024				Trumper, De Jager, Van Appledorn

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
On-Going						
2023LP1	Draft Report: 2020 Land Cover Change	30-Sep-2023	30 sep 204		Initial rough draft is being revised. 2020 Landcover results delayed because of staff departures.	Rohweder and De Jager
2023LP2	Data Analysis: Thresholds analysis of Reed canary grass habitat suitability.	30-Sep-2023	30 sep 20224		Data analysis has taken longer than anticipated. Partially completed.	Delaney and Rohweder
2023LP3	Draft Report: Thresholds analysis of Reed canary grass habitat suitability	30-Sep-2023	30-Sep-24		We have started writing a rough draft for this report	Delaney, De Jager, Van Appledorn, Bouska, Rohweder
2023LP4	Data Analysis: Detecting decadal changes in RCG dominance in wet meadows	30-Sep-2023	30-Sep-24		Data analysis is well underway but has taken longer than expected. We will be working on identifying additional data needs and summarizing results for a report or manuscript.	Delaney, De Jager, Van Appledorn, Bouska, Rohweder
2016LP3	Draft Manuscript: Review of Landscape Ecology on the UMR	NA	30-Sep-24			De Jager
Intended for distribution (see "Published" section for completed products)						
2023LP3 Manuscript: Delaney, J.T., Van Appledorn, M., De Jager, N.R., Bouska, K.L., Rohweder, J.J. Draft. Predicting Phalaris arundinacea (reed canarygrass) invasion in forest understories of the Upper Mississippi River floodplain. Draft complete, At Ecosphere.						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Eco-hydrologic Research						
2024EH1	Analysis of groundwater levels on floodplain forest experimental plots	30-Sep-2024				Van Appledorn
2024EH2	Draft manuscript of underplanting growth and survival and relation to groundwater levels, surface flooding, and other environmental variables	30-Sep-2025				Van Appledorn
On-Going						
2023EH1	Draft report of backwater sedimentation patterns through time to support vulnerability modeling effort	30-Sep-2023	31-July-2024		Delayed due to parental leave	Van Appledorn, Rohweder, DeJager, Kalas
2023EH2	Draft manuscript of reed canary grass, wood nettle, and silver maple seedling distributions and persistence in the UMR floodplain across environmental gradients	30-Sep-2023	31-July_2024		Delayed due to Kirsch retirement; R. Burner is now working will Van Appledorn to complete	Van Appledorn, Kirsch
2020EH02	Submit manuscript of temporal patterns in UMRS inundation regimes for peer review	30-Sep-2021	31-Dec-2024		Delayed due to change in priorities	Van Appledorn, De Jager, Rohweder
2021EH02	Draft manuscript of UMRS floodplain forest classification	30-Sep-2021	30-Sep-2024		Delayed due to change in priorities	Van Appledorn, De Jager
Intended for distribution						
Development of UMRS inundation model query tool; Van Appledorn, Fox, Rohweder, De Jager; 2019EH03. Other products have replaced this tool.						
Manuscript: 2021EH01 Draft manuscript of Temporal and spatial trends of large wood in the UMRS and potential eco-hydrologic drivers. In review at journal. IP-156995						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Acquisition and Interpretation of Imagery for Production of 2020 UMRS Land Cover/Land Use Data and Pool-Based Orthomosaics						
2024LCU4	Image processing, stereo model development, orthorectification, pool-based mosaicking, image interpretation, automation, QA/QC, and serving of 2020 LCU datasets for Pools 5-6, 17, and 22-25.	30-Sep-2024				Dieck, Strassman
Intended for Distribution						
Aquatic Vegetation, Fisheries, and Water Quality Research, Statistical Evaluation						
On-Going						
Manuscript: Evidence of functionally defined non-random fish community responses over 25 years in a large river system (Ickes; 2019B13 replacing 2015B17 and 2016B17; Resubmitted to Hydrobiologia, IP-118040)						
Manuscript: A synthesis on river floodplain connectivity and lateral fish passage in the Upper Mississippi River, (Ickes; Submitted River Research and Applications, IP-123678)						
Statistical Evaluation						
Intended for distribution						
Manuscript: Inferring decreases in among-backwater heterogeneity in large rivers using among-backwater variation in limnological variables (2010E1; IP-027392; Gray; in journal review as " Temporal changes in water movement within and among floodplain lakes, by Brian R. Gray, Jim Rogala, Jon S. Hendrickson. and Jennifer Cochran Biederman")						
Pool 12 Overwintering HREP Adaptive Management Fisheries Response Monitoring						
2024P13d	Age determination of bluegills	1-Feb-2024		1-Feb-2024		Keuter
2024P13e	In-house databases updated	31-Mar-2024		31-Mar-2024		Keuter
2024P13f	Made available to program partners via Iowa Fish Mgmt. State Report	30-Jun-2024				Keuter

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
FY18 Funded Science in Support of Restoration and Management						
Conceptual Model and Hierarchical Classification of Hydrogeomorphic Settings in the UMRS						
2019CM6	Submit Final LTRM Completion report on hydrogeomorphic conceptual model and hierarchical classification system	30-Jun-2020	30-Jun-2024		Sent to SPN (USGS publishing hub). JNH updated modified target data from 30 Dec 2022 to June 2024	Fitzpatrick, Hendrickson, Sawyer, Strange
Water Exchange Rates and Change in UMRS Channels and Backwaters, 1980 to Present						
2019WE4	Submit Final LTRM Completion Report	30-Mar-2020	30-Dec-2023		Draft report complete. Lead author retired and next steps are TBD.	Hendrickson
Intrinsic and extrinsic regulation of water clarity over a 950-km longitudinal gradient of the UMRS						
Intended for distribution						
Systemic analysis of hydrogeomorphic influences on native freshwater mussels						
2019FM9	Final LTRM completion report (changed to manuscript)	30-Jan-2023	TBD		Both MS are in review by co-authors. Lead PI took a different job in Sep 2022 without completing the MS	Teresa Newton
Using dendrochronology to understand historical forest growth, stand development, and gap dynamics						
2022DD1	Draft manuscript: Floodplain forest structure and the recent decline of Carya illinoinensis (Wangenh.) K. Koch (northern pecan); Part 2	30-May-2022	TBD	brief update received from BV 12/26/23. Follow up query regarding modified target date sent to BV 01/25/24		Grant Harley (U Idaho), Ben Vandermyde(USACE contact)
Forest canopy gap dynamics: quantifying forest gaps and understanding gap – level forest regeneration						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Investigating vital rate drivers of UMRS fishes to support management and restoration						
2019VR8	Data set complete (data delivered to Ben Schlifer, physical structures delivered to BRWFS)	30-Sep-2021	31-Dec-24		Initial age estimates have been provided by MSU for all species. Otoliths have been transferred to IRBS, where further otolith processing has been occurring, species by species, for biochronology purposes. Any age differences between MSU and IRBS will be re-evaluated. Final age dataset will be delayed until all otoliths are processed and discrepancies re-evaluated.	Quinton Phelps
On-Going						
2019VR10	Submit draft manuscript (Drivers of vital rates)	31-Dec-2021	31-Dec-24		Thesis chapter completed. Submission as a journal article has been delayed due to age discrepancies among otolith readers.	Quinton Phelps, Kristen Bouska
Intended for distribution						

Manuscript 2019VR11: Valentine, S. A., K. L. Bouska, and G. W. Whitledge. In review. Network connectivity contributes to native small-bodied fish assemblages in the Upper Mississippi River System. Journal of Freshwater Biology. IP-148246.

Muehler et al. Latitudinal trends in population dynamics of Upper Mississippi River System Fishes--these results will now be incorporated into the Bouska et al. Vital Rates final report.

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
FY19 Funded Science in Support of Restoration and Management						
Reforesting UMRS forest canopy openings occupied by invasive species						
2019ref3	Draft LTRM Completion (changed to draft MS)	30-Apr-2021	30-Apr-24	Delayed. Intent now is to submit to journal rather than completion report. 1/23/24 comm w/LG		Guyon and Cosgriff
2019ref4	Final LTRM Completion (changed to journal submission)	30-Sep-2021	30-Sep-2024	Delayed. Intent now is to submit to journal rather than completion report		Guyon and Cosgriff
A year of zooplankton community data from the habitats and pools of the UMR						
2019zoo2	Draft LTRM Completion report on utility of zooplankton community monitoring for HREP assessment	30-Dec-2020	TBD		Sample collection delayed because of Covid-19 state protocols; zooplankton ID delayed; Fulgoni took new position. Discussion needed about value of completing 2019zoo2 and to determine next steps.	Sobotka
2019zoo3	Final LTRM Completion report on utility of zooplankton community monitoring for HREP assessment	30-Jun-2021	TBD			Sobotka
2019zoo4	Draft LTRM Completion report on detailing differences between pools and habitats. Report will also investigate the potential investigate the potential impacts of Asian carp on the zooplankton community.	30-Dec-2020	TBD			Sobotka
2019zoo5	Final LTRM Completion report detailing differences between pools and habitats and investigating potential impacts of Asian carp on zooplankton community.	30-Jun-2021	30-Jun-2024			Sobotka
FY19 Funded Illinois Waterway 2020 Lock Closure						
Intended for distribution						
2022FSH1 - Spear et al. Reduction of large vessel traffic improves water quality and alters fish habitat-use throughout a large river. Accepted May 2024 . Requires final BAO approval.						
2023IWW Pre- and Post-Maintenance Aerial Imagery for Illinois River's Alton through Brandon Lock and Dams, 2019-2021. 1 Dec 2022. Final Completion Report. LTRMP-2019AERZ **2022FSH1** Draft Manuscript: Fisheries and WQ. Submitted to IPDS (IP-159446) for review 11/7/2023. Currently in review at journal						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
FY20 Funded Science in Support of Restoration and Management						
Mapping Potential Sensitivity to Hydrogeomorphic Change in the UMRS Riverscape and Development of Supporting GIS Database and Query Tool						
2021HG7	Submit Final LTRM Completion report on hydrogeomorphic change GIS database and query tool.	30-Mar-2022	30-Jun-2023		Update 5/5/23: Reconciling peer review comments Update 12/22/23: Submitted to BAO for approval, but was sent back b/c data product needs to be released simultaneiously. Data product is currently undergoing peer review	Vaughan, Strange, Fitzpatrick, Van Appledorn, USACE core team
Improving our understanding of historic, contemporary, and future UMRS hydrology by improving workflows, reducing redundancies, and setting a blueprint for modelling potential future						
2021HH1	Historic and Contemporary Hydrologic Database Release and Documentation	30-Sep-2021	30-Sep-2024		Delayed due to issues of data acquisition from USACE; expected submission of data and metadata to USGS Fundamental Science Practices by 31-Jan-2024	M. Van Appledorn, L. Sawyer
2021HH2	Draft LTRM Completion Report: document database and documentation development steps, database capabilities, and quantitative summaries of the hydrologic regime through time.	30-Dec-2021	31-Jul-2024		Postponed due to delays in data acquisition from USACE	M. Van Appledorn, L. Sawyer
2021HH3	Final LTRM Completion Report: document database and documentation development steps, database capabilities, and quantitative summaries of the hydrologic regime through time	31-Mar-2022	30-Sep-2024		Postponed due to delays in data acquisition from USACE	M. Van Appledorn, L. Sawyer
Intended for distirbution						
2021HH6 Final LTRM Completion Report (Scenarios): This report will serve as the blueprint for modeling future hydrology to be undertaken with future funding						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Understanding physical and ecological differences among side channels of the Upper Mississippi River System						
2021SC4	Final report on UMRR management implications submitted for USGS review	30-Sep-2022	TBD		TBD. Delayed by McCain departure and results provided insufficient information to support this report. A similar item could be moved to the new Learning from HREPS group or removed.	Sobotka & McCain
2021SC5	Manuscript on benthic invertebrate associations with side channel characteristics submitted for USGS and peer review	30-May-2023	30-Dec-24		Delayed due to macroinvertebrate processing time required. Graduate student making steady progress towards manuscript.	Sobotka & Vander Vorste

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Refining our Upper Mississippi River's ecosystem states framework						
Intended for Distribution						
Delaney, J. T., and D. M. Larson. 2023. Using explainable machine learning methods to evaluate vulnerability and restoration potential of ecosystem state transitions. Conservation						
Tool: Submersed aquatic vegetation vulnerability evaluation application (SAVVEA); (**Completed**, 2021SS10; Delaney and Larson, IP-142969)						
Augmenting the UMRR fish vital rates project with greater species representation for genetics and otolith microchemistry						
2021VR3	Submit draft manuscript (genetics)	31-Dec-2022	31-Dec-24		Multiple delays occurred including the need for additional samples (frozen samples were low quality) and ensuring consistent methods with phase I genetics. Initial analyses have been completed with a few samples requiring re-sequencing.	Davis, Tan, Lamer
2021VR4	Submit draft manuscript (genetics - mimic/channel)	31-Dec-2022	31-Dec-24		Multiple delays occurred including the need for additional samples (frozen samples were low quality) and ensuring consistent methods with phase I genetics. Initial analyses have been completed with a few samples requiring re-sequencing.	Davis, Tan, Lamer
2021VR5	Submit draft manuscript (constructing management units)	31-Dec-2022	31-Dec-24		Delays in each individual component (vital rate, genetics, microchemistry) have pushed this	Bartels, Bouska, Davis, Lamer, Larson, Phelps, Tan, Whitledge
Functional UMRS fish community responses and their environmental associations in the face of a changing river: hydrologic variability, biological invasions, and habitat rehabilitation						
2021FF2	Draft manuscript: "Has large scale ecosystem rehabilitation altered functional fish community	30-Sep-2021	30-Jun-2024		Gatto departed for another position. Analyses complete manuscript in prep	Ickes and Gatto
2021FF3	Draft Manuscript: "Why aren't bigheaded carps (*Hypophthalmichthys* sp.) everywhere in the Upper Mississippi River System?"	30-Sep-2021	30-Jun-2024			Ickes and Gatto

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Understanding landscape-scale patterns in winter conditions in the Upper Mississippi River System						
2021WL1	System wide spatial layers of habitat conditions	30-Sep-2022	30-Jun-2024		Lead author was on family leave and moved to a new job; Manuscript and dataset very close to submission.	Mooney, Dugan, Magee
2021WL2	Draft manuscript: Landscape scale controls on overwintering habitat in a large river	30-Sep-2022	30-Jun-2024		Lead author was on family leave and moved to a new job; Manuscript and dataset very close to submission	Mooney, Dugan, Jankowski, Magee
2021WL3	Draft manuscript: Response of oxygen dynamics to ice and snow phenology in backwater lakes	30-Sep-2023	30-Dec-24		Analysis in progress; final data collection occurred May 2023.	Jankowski, Dugan, Burdis, Kalas, Kueter
2021WL4	Draft Manuscript: Patterns in sediment characteristics and oxygen demand across a winter riverine landscape	30-Sep-2023	30-Dec-24		MS Thesis in process of publication; manuscript in progress but lead author has taken another job. Kreiling and Jankowski working to move it ahead with his help.	Perner, Kreiling, Jankowski, Giblin
Forest Response to Multiple Large-Scale Inundation Events						
2021FR3	Technical Report	1-Jun-2022	30-Sep-24		Delayed due to staffing shortages, hiring of new staff at NGREEC; modifying from technical report to manuscript. Shelby has a paper in revision.	Cosgriff, Guyon, De Jager

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
FY22 Funded Science in Support of Restoration and Management						
Assessing Forest Development Processes and Pathways in Floodplain Forests along the Upper Mississippi River using Dendrochronology						
2023dendro3	Coordination and scheduling for three to five virtual meetings; Meetings will address current objectives outlined in Activity 3 and future directions	1 March – 31 May 2024		first virtual meeting held 11-Sep-2023. Subsequent meetings are planned		Windmuller-Campione and Van Appledorn
2023dendro4	Draft manuscript – Age data of floodplain forests of the Upper Mississippi River	30-May-2024				Windmuller-Campione and Van Appledorn
2023dendro5	Draft Manuscript – Growth dynamics of silver maple of the Upper Mississippi River	30-Sep-2024				Windmuller-Campione and Van Appledorn
2023dendro6	Final report writing, edits on manuscript, and completion of all data storage	30-Nov-2024				Windmuller-Campione and Van Appledorn
Evaluating the LOCA-VIC-mizuRoute hydrology data products for scientific and management applications in the UMRS						
2023Hydro3	ECB 2018-14 compliance completion	30-Sep-2023	30-Sep-24		USACE work prioirty shift. Modified target date to accommodate	Sawyer and Van Appledorn
2023Hydro4	Annual update: Year 1	31-Dec-2023	16-Jan-24	16-Jan-24	Oral update to UMRR planned for UMRR Science Meeting in mid-January; date modified to align with UMRR Science Meeting dates	Sawyer and Van Appledorn
2023Hydro5	UMRS projected hydrology data and documentation release	30-Sep-2024			No data and documentation release anticipated, as LOCA-VIC-mizuRoute products were found to be unreliable for UMRS per evaluation results	Sawyer and Van Appledorn
2023Hydro6	UMRR webinar on UMRS projected hydrology data release	31-Dec-2024			No data and documentation release anticipated, as LOCA-VIC-mizuRoute products were found to be unreliable for UMRS per evaluation results	Sawyer and Van Appledorn

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
2023Hydro7	Virtual workshop or LTRM project team update for red pathway outcomes	31-Mar-2024	10-May-24		Update to UMRR planned for UMRR Workshop on May 7-9, 2024	Sawyer and Van Appledorn
2023Hydro8	Draft LTRM completion report	30-Sep-2024			In progress with goal of submitting to IPDS by 31-May-24 as a USGS SIR	Sawyer and Van Appledorn
2023Hydro9	Final LTRM completion report	30-Dec-2025				Sawyer and Van Appledorn
Putting LTRM's long-term phytoplankton archive to work to understand ecosystem transitions and improve methodological approaches						
2023Phyto1	System-wide phytoplankton community dataset	30-Sep-2023	30-May-24		Sample identification completed Dec 1, 2023 by contractor. In progress of completing dataset compilation	Jankowski
2023Phyto2	Draft Manuscript: Phytoplankton community composition over the past 20 years in the Upper Mississippi River: distribution of harmful taxa and relationships with environmental trends	30-May-2024				Jankowski and others
2023Phyto3	Draft Manuscript: Relating phytoplankton communities to distinct vegetation recovery trajectories in Pools 4 and 13	30-May-2024				Jankowski and others
2023Phyto4	Report: Assessment of FloCam for use on archived and fresh phytoplankton samples for LTRM sampling	30-Mar-2024				Larson, James
2023Phyto5	Draft Manuscript: Comparison of trends captured by microscopy and FlowCam phytoplankton community analysis	30-May-2024				Larson, James

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Assessing long term changes and spatial patterns in macroinvertebrates through standardized long-term monitoring						
2023inv2	Laboratory identification of macroinvertebrates	30-Aug-2023	30-Sep-24		Delayed by large sample processing and ID workload	Manisha Pant
2023inv3	Screening level mayfly tissue analysis	30-Sep-2023	30-Jun-24		Samples shipped to AXYS for analysis. UI working with AXYS to resolve contract language issues. Once resolved, anticipate results in about 20 weeks.	Giblin, Pant
2023inv4	Annual summary	31-Dec-2023	30-Sep-24			Lamer
2023inv5	Complete data entry and QA/QC of 2023 data; 1250 observations.				2023inv2 delayed by large sample processing and ID workload	
	a. Data entry completed and submission of data to USGS (Includes contaminant data)	31-Jan-2024	30-Sep-24			State field station staff, Giblin
	b. Data loaded on level 2 browsers; QA/QC scripts run and data corrections sent to Field Stations	15-Feb-2024	30-Sep-24			Lamer, Schlifer
	c. Field Station and contaminant QA/QC with corrections to USGS	15-Mar-2024	30-Sep-24			State field station staff, Giblin
	d. Corrections made and data moved to public Web Browser	30-Mar-2024	30-Sep-24			Lamer, Schlifer
2023inv6	Field collection of macroinvertebrates	14-Jun-2024				State field station staff
2023inv7	Laboratory identification of macroinvertebrates	30-Aug-2024				TBD
2023inv8	Screening level mayfly tissue analysis	30-Sep-2024				Giblin

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
2023inv9	Annual summary	31-Dec-2024				Lamer
2023inv10						
	a. Data entry completed and submission of data to USGS (Includes contaminant data)	31-Jan-2025				State field station staff, Giblin
	b. Data loaded on level 2 browsers; QA/QC scripts run and data corrections sent to Field Stations	15-Feb-2025				Lamer, Schlifer
	c. Field Station and contaminant QA/QC with corrections to USGS	15-Mar-2025				State field station staff, Giblin
	d. Corrections made and data moved to public Web Browser	30-Mar-2025				Lamer, Schlifer
2023inv11	Draft LTRM Completion report or manuscript on contaminant sampling	30-Sep-2025				Giblin
2023inv12	Field collection of macroinvertebrates	14-Jun-2025				State field station staff
2023inv13	Laboratory identification of macroinvertebrates	30-Aug-2025				TBD
2023inv14	Annual summary	31-Dec-2025				Lamer
2023inv15						
	a. Data entry completed and submission of data to USGS (Includes contaminant data)	31-Jan-2026				State field station staff, Giblin
	b. Data loaded on level 2 browsers; QA/QC scripts run and data corrections sent to Field Stations	15-Feb-2026				Lamer, Schlifer
	c. Field Station and contaminant QA/QC with corrections to USGS	15-Mar-2026				State field station staff, Giblin
	d. Corrections made and data moved to public Web Browser	30-Mar-2026				Lamer, Schlifer
2023inv16	Draft LTRM Completion report or manuscript on macroinvertebrate sampling, trends, etc.	30-Sep-2026				Lamer

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Published FY24						
2021LP3	De Jager et al. 2024. Identifying conditions where reed canarygrass (Phalaris arundinacea) functions as a driver of forest loss in the Upper Mississippi River floodplain under different hydrological scenarios 10.1007/s11273-023-09969-6 : De Jager et al. 2024. Identifying conditions where reed canarygrass (Phalaris arundinacea) functions as a driver of forest loss in the Upper Mississippi River floodplain under different hydrological scenarios 10.1007/s11273-023-09969-6					
2023LP5	**Cooperator Report**: Rohweder, J., De Jager, N., 2023, Attributes of Upper Mississippi River System contiguous forest areas. Cooperator report prepared for the U.S. Army Corps of Engineers' Upper Mississippi River Restoration – Long Term Resource Monitoring element. 29 p. https://www.usgs.gov/centers/upper-midwest-environmental-sciences-center/science/attributes-upper-mississippi-river					
2023LP5	**Data Sets**: Rohweder, J.J., and DeJager, N.R., 2023, Attributes of Upper Mississippi River System contiguous forest areas: U.S. Geological Survey data release, https://doi.org/10.5066/P9JM2AYX.					
2023LP6	**Data Sets.** Ruhser, J., 2023, 2020 Aquatic Areas - Upper Mississippi River System (Pools 4, 8, 9, 12, 13, 26, Open River 2 and La Grange). 2020 Aquatic Areas - Upper Mississippi River System - ScienceBase-Catalog. U.S. Geological Survey data release, https://doi.org/10.5066/P9X3UT0T					
	Van Appledorn, M., N. R. De Jager, and J. J. Rohweder. 2023. Low-complexity floodplain inundation model performs well for ecological and management applications in a large river ecosystem. Journal of the American Water Resources Association, https://doi.org/10.1111/1752-1688.13152					
2023LCU3	Image processing, stereo model development, orthorectification, pool-based mosaicking, image interpretation, automation, QA/QC, and serving of 2020 LCU datasets for Pools 1-3, 7, 11, and 50% of Pool 10, the St. Croix and lower Minnesota Rivers, and the Alton Pool of the Illinois River.- ScienceBase-Catalog https://www.sciencebase.gov/catalog/item/6102cbf7d34ef8d7055e7971					
2019IE3	Carhart, A.M., D. Drake, J. Fischer, J.N. Houser, K.J. Jankowski, J. Kalas, and E. Lund. 2024. Intrinsic and extrinsic regulation of water clarity in a large, floodplain-river ecosystem. Ecosystems. https://doi.org/10.1007/s10021-023-00895-5.					
2019FG5	Manuscript : IP-150741 Guyon, L., Strassman, A., Oines, A., Meier, A., Thomsen, M., Sattler, S., DeJager, N., Hoy, E., Vandermyde, B., and Cosgriff, R., 2023, Forest canopy gap dynamics: quantifying forest gaps and understanding gap – level forest regeneration in Upper Mississippi River floodplain forests. Associated data release: U.S. Geological Survey data release, https://doi.org/10.5066/P9Q5EKU1					

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Aquatic Vegetation Component						
2024A1	Complete data entry and QA/QC of 2023 data; 1250 observations.					
	a. Data entry completed and submission of data to USGS	30-Nov-2023		30-Nov_2023		Lund, Carhart, Fopma
	b. Data loaded on level 2 browsers	15-Dec-2023		1-Mar-2024		Schlifer
	c. QA/QC scripts run and data corrections sent to Field Stations	28-Dec-2023		1-Mar-2024		Sauer, Schlifer
	d. Field Station QA/QC with corrections to USGS	15-Jan-2024		1-Mar-2024		Lund, Carhart, Fopma
	e. Corrections made and data moved to public Web Browser	30-Jan-2024		1-Mar-2024		Larson, Schlifer, Caucutt
2024A2	Web-based: Creating surface distribution maps for aquatic plant species in Pools 4, 8, and 13; 2023 data	31-Jul-2024				Larson, Schlifer
2024A3	Wisconsin DNR annual summary report 2023 that combines current year observations from LTRM with previous years' data, for the fish, aquatic vegetation, and water quality components.	30-Sep-2024				Bartels, Kalas, Carhart
2024A4	Complete aquatic vegetation sampling for Pools 4, 8, and 13 (Table 1)	31-Aug-2024				Lund, Carhart, Fopma
2024A5	Pool 4: Graphical summary and maps of aquatic vegetation current status and long-term trends.	30-Dec-2024				Lund
2024A6	Pool 8: Graphical summary and maps of aquatic vegetation current status and long-term trends.	30-Dec-2024				Carhart
2024A7	Pool 13: Graphical summary and maps of aquatic vegetation current status and long-term trends.	30-Dec-2024				Fopma
2024A8	Aquatic Vegetation Sampling Protocol Update	30-Sep-2024				Larson, Lund, Carhart, Fopma
Intended for distribution						
Manuscript and data release: Sherman J, St. Clair K, Gray B, Larson DM (in revision) Predicting a continuous causal variable given ordinal outcomes and structural zeroes with application to submersed aquatic vegetation biomass. In revision at USGS and Environmental and Ecological Statistics since December 2022. Reviewed again March 2023. IP-149488.						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Fisheries Component						
2024B1	Complete data entry, QA/QC of 2023 fish data; ~1,590 observations					
	a. Data entry completed and submission of data to USGS	31-Jan-2024		31-Jan-2024		DeLain, Dawald, Bartels, Hine, Kueter, Gittinger, West, Solomon, Maxson
	b. Data loaded on level 2 browsers; QA/QC scripts run and data corrections sent to Field Stations	15-Feb-2024		1-Mar-2024		Ickes, Schlifer
	c. Field Station QA/QC with corrections to USGS	15-Mar-2024		15-Mar-2024		DeLain, Dawald, Bartels, Kueter, Hine, Gittinger, West, Solomon, Maxson
	d. Corrections made and data moved to public Web Browser	30-Mar-2024		30-Mar-2024		Ickes and Schlifer
2024B2	Update Graphical Browser with 2023 data on Public Web Server.	31-May-2024				Ickes and Schlifer
2024B3	Complete fisheries sampling for Pools 4, 8, 13, 26, the Open River Reach, and La Grange Pool (Table 1)	31-Oct-2024				DeLain, Dawald, Bartels, Kueter, Hine, Gittinger, West, Solomon, Maxson
2024B4	Sample collection and database increment on invasive carp age and growth: collection of cleithral bones	31-Jan-2024				Solomon, Maxson
2024B5	IDNR Fisheries Management State Report: Fisheries Monitoring in Pool 13, Upper Mississippi River, 202;. Includes Pool 12 Overwintering HREP Adaptive Management Fisheries Response Monitoring	30-Sep-2024				Kueter
2024B8(D)	Database increment: Stratified random day electrofishing samples collected in Pools 9–11	30-Sep-2024				Kueter
2024B9(D)	Database increment: Stratified random day electrofishing samples collected in Pools 16–18	30-Sep-2024				Kueter
Intended for distribution						
Manuscript: A synthesis on river floodplain connectivity and lateral fish passage in the Upper Mississippi River (2021B11; Journal Promised a finding and set of reviews in 6 weeks. Revised distribution to June 2024; IP-123678)						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Water Quality Component						
2024D1	Complete calendar year 2023 fixed-site and SRS water quality sampling	31-Dec-2023		31-Dec-23		Jankowski, Burdis, Kalas, Johnson, L. Gittinger, Sawicki, Sobotka
2024D2	Complete laboratory sample analysis of 2023 fixed site and SRS data; Laboratory data loaded to Oracle data base.	15-Mar-2024		1-Feb-2024		Yuan, Schlifer
2024D3	1st Quarter of laboratory sample analysis (~12,600)	30-Dec-2023		30-Dec-2023		Yuan, Manier, Burdis, Kalas, Johnson, L. Gittinger, Sobotka
2024D4	2nd Quarter of laboratory sample analysis (~12,600)	30-Mar-2024		30-Mar-2024		Yuan, Manier, Burdis, Kalas, Johnson, L. Gittinger, Sawicki, Sobotka
2024D5	3rd Quarter of laboratory sample analysis (~12,600)	29-Jun-2024				Yuan, Manier, Burdis, Kalas, Johnson, L. Gittinger, Sawicki, Sobotka
2024D6	4th Quarter of laboratory sample analysis (~12,600)	28-Sep-2024				Yuan, Manier, Burdis, Kalas, Johnson, L. Gittinger, Sawicki, Sobotka
2024D7	Complete QA/QC of calendar year 2023 fixed-site and SRS data.					
	a. Data loaded on level 2 browsers; QA/QC scripts run; SAS QA/QC programs updated and sent to Field Stations with data.	30-Mar-2024		30-Mar-2024		Schlifer, Jankowski
	b. Field Station QA/QC; USGS QA/QC.	15-Apr-2024				Jankowski, Burdis, Kalas, Johnson, L. Gittinger, Sawicki, Sobotka
	c. Corrections made and data moved to public Web Browser	30-Apr-2024				Schlifer, Jankowski
2024D8	Complete FY2024 fixed site and SRS sampling for Pools 4, 8, 13, 26, Open River Reach, and La Grange Pool	30-Sep-2024				Jankowski, Burdis, Kalas, Johnson, L. Gittinger, Sawicki, Sobotka
2024D9	WEB-based annual Water Quality Component Update w/2023 data on Server.	30-May-2024				Schlifer, Jankowski

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
2024D10	Operational Support to the UMRR LTRM Element. Serve as in-house Field Station for USGS for consultation and support on various LTRM-wide topics	30-Sep-2024				Bartels, Carhart, Kalas, Patschull
2024D11	Phytoplankton dataset updated	30-Dec-2024				Jankowski
2024D12	Carp, phosphorus, and winter conditions influence summer phytoplankton community dynamics across lotic-lentic gradient of a large, eutrophic river	30-Dec-2024				Jankowski, J. Larson
On-Going						
2019D12	Draft LTRM Completion Report: Assessment of Phytoplankton Samples collected by the Upper Mississippi River Restoration Program-Long Term Resource Monitoring Water Quality Component	30-Dec-2019	30-Sep-2024		Lead (Fulgoni) took new position, plan for completion is TBD	TBD and Jankowski
2020D12	Final LTRM Completion Report: Assessment of Phytoplankton Samples collected by the Upper Mississippi River Restoration Program-Long Term Resource Monitoring Water Quality Component	30-Mar-2021	30-Sep-2024		Lead (Fulgoni) took new position, plan for completion is TBD	TBD and Jankowski
Intended for distribution						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Spatial Data Component						
2024SD1	Orthorectification of scanned photos (St. Louis District Mississippi River pools and Open River Reach, and the Illinois River pools)	30-Sep-2024				Schoen, Strassman
2024SD2	Pilot dataset and report of Real-Time Kinematic GNSS for use in remote or inaccessible vegetation locations	31-Dec-2023	30-Sep-24		Data in review. Delayed due to personnel changes.	TBD
2024SD3	Dataset of Applied UAS based ground penetrating radar to assist topobathy data collection	30-Sep-2024				TBD
2024SD4	Pilot dataset and report of material volumetrics using three methods	30-Jun-2024				TBD
2024SD5	Report on conducting surveys over existing backwater sediment transects using ground penetrating radar during ice cover	30-Sep-2024				TBD
2024SD6	Maintenance ArcGIS server	30-Sep-2024				Rohweder
2024SD7	Data Set: Land Cover Change in the UMRS for newly developed pools: Stc, Alt, 17, 22, 6, 5, 5a, 24, 25.	30-Sep-2024				De Jager
2024SD8	Draft Report: Land Cover Change in the UMRS Key Pools	30-Sep-2024				De Jager
On-Going						
2022SD7	Draft LTRM Completion Report: Pattern of Wild Rice Colonization (2022SD7)	30-Sep-2024				De Jager
2023SD9	Draft Report: Spatial Data Component Review and Future Objectives	30-Sep-2024				De Jager
Intended for distribution						
2021SD7 Topobathy 2023 For the Upper Mississippi River System. SOW/Strategic Planning Document available upon request.						

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Data Management						
2024M1	Update vegetation, fisheries, and water quality component field data entry and correction applications.	30-May-2024				Schlifer
2024M2	Load 2023 component sampling data into Database tables and make data available on Level 2 browsers for field stations to QA/QC.	30-Jun-2024				Schlifer
2024M3	Assist LTRM Staff with development and review of metadata and databases in conjunction with publishing of reports and manuscripts	On-going				Schlifer
UMRR Science Meeting						
2024SM1	2024 Science Meeting in La Crosse, wI	30-Jan-2024		18-Jan-2024		
2024SM2	Proposals distributed for review	4-Apr-2024				
2024SM3	Proposals submitted as UMRR CC quarterly mtg read ahead	3-May-2024				
2024SM3	Proposal recommendations presented to UMRR CC	22-May-24				
Status and Trends 3rd edition						
2022ST4	Draft S&T3 Fact Sheet	1-Mar-24	30-Sep-2024		Info Needs planning & implementation is a higher priority	Authors
2022ST5	Final S&T3 Fact Sheet	30-Sep-2024	FY25			Authors
Published FY24						
2021SD10 (2021LP3): De Jager et al. 2024. Identifying conditions where reed canarygrass (Phalaris arundinacea) functions as a driver of forest loss in the Upper Mississippi River floodplain under different hydrological scenarios. Wetlands Ecology and Management. 10.1007/s11273-023-09969-6 .						

5/3/2024

FY2024 UMRR Science Proposals Recommended for Funding

Listed below are eight proposals recommended by the UMRR LTRM management team for FY2024 Science in Support of Restoration and Management funding. Note that only the first year of funding is included for the proposal entitled “Generating future hydrology and water temperature projection for the UMRS using hybrid deep learning”.

These recommendations are based on assessments of the proposals by the A-Team (representatives of MN, WI, IA, IL, MO, and USFWS), USGS UMESC, and USACE. There were a total of 13 proposals developed following the FY24 UMRR Science Meeting. The criteria used to assess the proposals are provided at the end of this document.

Proposals not funded in FY2024 may be reconsidered in FY2025 pending an assessment of current information needs, available funding, and adequate revisions to address any questions and concerns raised during the 2024 review process.

Understanding, quantifying and forecasting associations among hydrogeomorphology, water chemistry, and the distribution and abundance of biota in the upper Mississippi river under climate change

Previous LTRM project:
UMRR Landscape Patterns Research and Application
UMRR Base Monitoring for water quality, aquatic vegetation, fish
UMRR Freshwater Mussel pool-wide surveys

Name of Principal Investigator(s):
Mark A. Kaemingk, University of North Dakota, mark.kaemingk@und.edu (Assistant Professor of Aquatic Ecology and PhD co-advisor, responsible for supervising and assisting Julia Hampton)
Julia R. Hampton, University of North Dakota, julia.hampton@und.edu (PhD graduate student, responsible for data wrangling, data analysis, report and manuscript writing)
Nathan R. De Jager, USGS-UMESC, ndejager@usgs.gov (Research Ecologist, responsible for project oversight, data management, assistance with report writing)
John C. Chick, Great Rivers Field Station, Illinois Natural History Survey, Prairie Research Institute, University of Urbana-Champaign, chick@illinois.edu (Field Station Director, responsible for project oversight, assistance with report writing)
Jason A. DeBoer, Illinois River Biological Station, Illinois Natural History Survey, Prairie Research Institute, University of Urbana-Champaign, jadeboer@illinois.edu (Large River Scientist and PhD co-advisor, responsible for supervising and assisting Julia Hampton, project oversight and assistance with report writing)

Collaborators (Who else is involved in completing the project):
KathiJo Jankowski, USGS-UMESC, kjankowski@usgs.gov (assistance with water quality data and analyses)
Brian Ickes, USGS-UMESC, bickes@usgs.gov (assistance with fisheries data and analyses)
Teresa Newton, USGS-UMESC, tnewton@usgs.gov (assistance with mussel data and analyses)
Danelle Larson, USGS-UMESC, dmlarson@usgs.gov (assistance with aquatic vegetation data and analyses).

Introduction/Background:

Climate, land use and other regional to global-scale changes have been and are expected to continue to shape the physical template of the Upper Mississippi River System (UMRS) in ways that influence water quality and the abundance and diversity of biotic communities. The Upper Mississippi River Restoration (UMRR) program uses a variety of restoration techniques to also shape the physical template of the river system to influence water quality and various biotic communities. One of the primary sources of information that UMRR uses to identify places for restoration is an aquatic areas GIS database (De Jager et al. 2018). This database consists of mapped areas that differ in physical attributes such as water depth, connection to channel environments, and presence of river training and other structures (Table 1). UMRR has recently invested significant resources into understanding ongoing hydrological and geomorphic change in the UMRS and in developing methods and tools for projecting such changes into the future under different climate change and management scenarios – information that will be useful for projecting changes in the future distribution and attributes of aquatic areas. The UMRR also provides Long-Term Resource Monitoring (LTRM) data, which supplies critical information regarding spatial and temporal patterns in water quality, aquatic vegetation, and fish communities. Similar navigation pool-wide data sets now exist for freshwater mussels. We currently still lack a basic understanding of the associations between hydrogeomorphic conditions, biogeochemistry, and riverine biota as they relate to aquatic areas and how ongoing and projected future hydrogeomorphic changes are likely to affect the river system as a whole. There remains a need for studies that complement, and can be combined with, existing LTRM data to improve our understanding of the broad scale patterns observed in the data and the implications for future restoration projects. This project will examine associations between aquatic areas, the physical attributes that define them, river water quality, and aquatic vegetation, fish, and mussel communities. What associations can be detected between aquatic areas and available abiotic and biotic data? What do these associations suggest regarding the overall physical, chemical, and biological characteristics of different aquatic areas? What changes in the distribution and abundance of aquatic areas are we likely to observe in the river system under climate-driven changes and how may those changes influence water quality and aquatic communities?

Many studies on the UMRS have sought to determine associations among fish, aquatic vegetation, mussels and physical characteristics such as water clarity, water depth, flow velocity, and dissolved oxygen. De Jager and Houser (2012) showed that water velocity, total nitrogen, and total phosphorous vary significantly across the surface of the UMRS, with patterns strongly related to aquatic area distributions. Aquatic macrophyte abundance and diversity has shown to be particularly strongly associated with water depth, various connectivity measures, wind fetch, and water clarity (Bouska et al. 2022, Carhart et al. 2023, Delaney and Larson 2023). Abiotic measurements such as total nitrogen and total phosphorous have also been shown to relate to fish community composition, and water velocity is considered a strong indicator of these communities as well (De Jager and Houser 2016). Regionalized efforts to quantify relationships between distribution of fish species in the UMRS and environmental variables have previously been conducted for numerous species (Ickes et al. 2014). Associations between the physical template of the river system and freshwater mussel distributions have been more difficult to establish, perhaps due to their dependence on fish hosts for dispersal, or because mussels respond to spatial variability at finer scales (Ries et al. 2016). However, experimental studies have suggested that hydrodynamics, namely water velocity play a crucial role in juvenile mussel dispersal (French and Ackerman 2014).

These previous studies suggest that several water quality attributes are related to aquatic area distributions, and that aquatic vegetation, mussel, and fish communities are related to spatial variability in aquatic areas and water quality attributes in different ways and over different spatial scales. However, these studies have almost universally taken a species or community centric view of the river, asking questions such as 'what factors influence the distribution and abundance of a given community'? We propose to take a fundamentally different approach to the study of physical-biological relationships on the UMRS. We seek to understand the landscape mosaic of the UMRS and address the question of 'what are the physical properties of the riverscape that we can model and map that are most important in structuring the biological communities of the UMRS?' This perspective acknowledges that biological communities vary over space and time, responding to both physical and biological factors, many of which are impossible to map over large spatial scales. Hence, the purpose of our study is not to understand the 'controls' on various biotic communities, but rather to identify and quantify aspects of the riverscape that play important roles in structuring biotic communities. Management agencies continue to manipulate physical variables to manage and restore various biotic communities. Furthermore, we anticipate changes in the abundance and distribution of mappable aquatic areas under future climate changes. What are the likely consequences of such changes to the biotic communities of the UMRS?

Goals and objectives:

Our primary goal is to develop a basic, quantifiable, and comprehensive understanding of how water quality attributes, aquatic vegetation, mussel, and fish communities are structured spatially and temporally across the UMRS and over the duration of long-term sampling; and to quantify associations with mappable, landscape-scale physical attributes (i.e., aquatic areas). Our secondary goal is to use the above information, along with outputs from Delaney et al. (future predictions of river discharge under climate change – project in process) to make informed predictions about the likely future distribution and abundance of aquatic areas and associated water quality and biotic community distributions.

Our specific objectives are to 1) compare putative differences in water quality, aquatic vegetation, mussel communities, and fish communities across aquatic areas within UMRS pools, 2) assess which aquatic areas are most similar or different among the abiotic and biotic components, 3) evaluate how differences in abiotic and biotic components have changed across aquatic areas through space (pools) and time (annual), and 4) use these results to make inferences on how future hydrological changes to aquatic areas will influence water quality, aquatic vegetation, mussel communities, and fish communities within the UMRS.

Expectations:

We expect to find differences among the abiotic (water quality) and biotic (aquatic vegetation, mussel, and fish communities) components across aquatic areas within each UMRS pool given the obvious differences in flow velocity and other habitat characteristics (sediment, temperature, nutrients) that typically govern water quality and aquatic communities (De Jager and Houser 2012, Carhart et al. 2023, Ickes et al. 2014, French and Ackerman 2014)(Figure 1, panel A). However, the strength of these differences and their associations or relatedness among aquatic areas is not well known (Figure 1, panel B). For example, do we expect communities in the main navigational channel to more closely resemble side channels or tributary channels? How similar are these patterns among the different abiotic and biotic components? We may also expect to see patterns where abiotic and biotic components are becoming more homogeneous among the aquatic areas through time (DeBoer et al. 2020), given changes in hydrology and land use (Figure 1, panel C). We may find significant changes in water quality that will influence our biotic components. Furthermore, our biotic components vary in life history strategies (size, dispersal, recruitment, age) that could lead to unique patterns in how they respond to changes in space and time. Compiling and collectively evaluating the response of our abiotic and biotic components will provide insight into how these factors and ecological communities are changing among aquatic areas, allowing us to predict which aquatic areas have been altered the most through time and which aquatic areas can be restored to achieve desirable management outcomes under different climate change scenarios.

Relevance of research to UMRR:
The UMRS is a highly modified, anthropogenic floodplain river system, and most rivers worldwide experience similar anthropogenic stressors, such as climate change, invasive species, and alterations to connectivity, water flow, and surrounding land-use (DeBoer et al. 2022), making large scale analyses conducted on the UMRS informative to large river science overall. Analyses that occur over large spatial and temporal scales, made possible by long-term monitoring programs, are crucial for understanding the mechanistic workings and future predictions of these types of systems. Our results will inform river restoration and management by quantifying how water quality attributes, aquatic vegetation, and mussel and fish communities are related to the aquatic areas database that is currently used in broad-scale UMRS restoration project planning. We will help river managers better forecast the effects of their actions on these biotic communities. Furthermore, we will help river managers better understand and forecast effects of climate change on these biotic communities as well. We seek to build a comprehensive understanding of how changes in the abundance and distribution of aquatic areas, whether due to climate change or management actions, are likely to shape the biological communities of the UMRS. Our research directly addresses Focal area 2.1 Assessing the associations between aquatic areas and biota and biogeochemistry using existing data and uses information from and builds upon Focal area 1.2 Future discharge, hydraulic connectivity, and water surface elevation (WSE) scenarios. Our study proposes analysis of 30 years of data across all LTRM sampling geographic regions, spanning many different aquatic habitat types (aquatic areas) and various biotic communities. Achieving detailed large spatial- and temporal- scale assessments at the pool-level has previously been difficult, but it is necessary to achieve a more specific, refined determination of these habitats. We believe it is vital to gain a deeper, more specific understanding of the relationships between aquatic areas and abiotic and biotic dependencies of the UMRS to inform management and restoration projects more sufficiently on the UMRS and large river systems worldwide.

Methods:

<u>Study Area</u>

The UMRS, comprised of the navigational portion of the Mississippi River north of Cairo, Illinois and the entire Illinois River (Bouska et al. 2019), is arguably one of the largest and most studied rivers in the world. Within these bounds, the UMRS is most often studied using four large zones (i.e., reaches): Upper Impounded Reach (Pools 1-13), Lower Impounded Reach (Pools 14-26, also described as “Middle Reach”), and the Unimpounded Reach (“Open River” pools) in the Mississippi River and the La Grange Pool on the Illinois River (consists of all Illinois River navigational pools). Unique characteristics pertaining to hydrology, geomorphology, habitat, and biota exist across these reaches, and more detailed reach descriptions can be found in De Jager et al. (2018). We will focus our analyses on Pools 3, 4, 5, 6, 8, and 13 in the Upper Impounded Reach, Pools 18 and 26 in the

Lower Impounded Reach, the southern open river reach (OR), and the La Grange (LG) reach of the Illinois River. Long-term water quality, vegetation, and fisheries data are available in Pools 4, 8, 13, 26, OR and LG). Pool-wide mussel surveys are available in Pools 3, 5, 6, 8, 13, and 18.

LTRM aquatic areas database

The UMRS contains various aquatic ecosystem types which exhibit a patch-work mosaic and range from lentic to lotic conditions. Building upon previous aquatic area classifications (Sternberg 1971, Wilcox 1993), De Jager et al. (2018) provides a more quantitative classification of aquatic areas found along the UMRS. This hierarchical classification of habitat patch types uses aerial imagery, bathymetry data, and physiochemical conditions to achieve a 3-level classification for the UMRS landscape during 1989 and 2010. Level 1 classification distinguishes the courses level of classification, utilizing aerial imagery to differentiate geomorphic and navigational structures. Classifications were delineated based on visual inspection of land-cover data (i.e., aerial imagery). The following classes were identified: Main Navigational Channel, Channel Border, Side Channel, Tributary Channel, Contiguous Floodplain Lake, Contiguous Floodplain Shallow Aquatic, Contiguous Impounded, Isolated Floodplain Lake, and No Coverage. Level 2 classifications provide a more fine-scale observation with the use of bathymetry and land-cover data and automated approaches. They consist of: Side Channel, Tertiary Channel, Contiguous Floodplain Lake, and Tributary Delta Lake. Level 3 classifications were developed to provide further descriptions of connectivity, depth, and structures of aquatic areas. Using the US Army Corps of Engineers Inland Electronic Navigation Chart, this classification level provides 2 classifications: Structured Channel Border and Unstructured Channel Border. Descriptions of all aquatic area classifications provided by De Jager et al. (2018) are outlined in Table 1.

LTRM water quality monitoring

Water quality indicators are regularly sampled in six study reaches of the UMRS: Pools 4, 8, 13, 26, OR, and LG (Soballe et al. 2004). A mixed sample design is used to assess Total Suspended Solids, Total Nitrogen, Total Phosphorous, Chlorophyll a, and Dissolved Oxygen. LTRM uses a mixed sampling design which incorporates fixed monitoring locations, which began in 1989, as well as Stratified Random Sampling (SRS), which began in 1993. Fixed sampling sites include tributary mouths and main channels, and sampling is conducted throughout most months except December and February. SRS is conducted in January, April, July, and October in the following stratum: main channels, side channels, contiguous backwaters, isolated backwaters, impounded areas, and two riverine lakes.

LTRM aquatic vegetation monitoring

Indicators of aquatic vegetation have been assessed throughout Pools 4, 8, 13, 26, LG for various years following methods detailed by Yin et al. (2000). Vegetation sampling has occurred consistently from 1998 to present in Pools 4, 8, and 13 and was previously sampled from 1998 to 2004 in Pools 26 and LG. Aquatic vegetation is sampled in main channel borders, side channels, impounded areas, contiguous backwaters, and isolated backwaters. Sampling of aquatic vegetation incorporates visual examinations, rake samples, and subsampling of the area surrounding the boat and is conducted in late summer. At each location water depth, substrate sediment type, and the presence of detritus are also recorded. When possible, plants are identified to species.

LTRM mussel monitoring

Systematic pool-wide sampling of mussel communities has been conducted periodically across the Mississippi River. Sampling was conducted in 2006/2007 for Pools 5, 6, and 18, 2013 for Pool 3, and 2019 for Pools 8 and 13. Data collection methods are described by Newton et al. (2011). Systematic sampling was chosen as it is an ideal method for sampling rare, spatially clustered populations. Aluminum quadrat frames were placed 10 m apart on the river bottom, and the top ~15 cm of substrate was excavated to extract specimens, which were identified, measured, and sexed (where possible).

LTRM fish monitoring

Fish monitoring has been conducted regularly from 1993 to present via SRS of all six study reaches of the UMRS: Pools 4, 8, 13, 26, OR, and LG. Additional minor fish monitoring efforts are conducted annually at fixed sites 1989 to present, and simple random sampling at wing dams along the UMRS from 1993 to present. Following standardized protocols (Gutreuter et al. 1995, Ratcliff et al. 2014), sites are seasonally sampled during 3 time periods (set in June-October). SRS of fish is conducted in main channel borders, side channel borders, impounded areas, and contiguous backwaters. Fixed sites are sampled at tributary mouths and tail waters. Engineered wing dam structures are located and sampled only on main channel borders. Environmental measurements are taken at each sampling site (e.g., specific conductivity, water velocity, presence/absence of structures). Specimens are identified to species, counted, and measured by length during all time periods.

<u>Goal one analyses (Objectives 1-3)</u>

We will use non-metric multidimensional scaling to compare dissimilarities (or relatedness) of each abiotic and biotic component across aquatic areas within UMRS pools. We will use the R package vegan and vegdist function to calculate Euclidian distances among the aquatic areas within each UMRS pool for each component (Objective 1). This approach will also allow us to compare relatedness among the different abiotic and biotic components. For example, we can use the Euclidian distance outputs and emerging patterns to assess whether water quality or fish communities are most dissimilar among aquatic areas (Objective 2).

To incorporate the influence of space and time (Objective 3), we will use trajectory analysis to describe, quantify, and analyze variation in our abiotic and biotic components across our aquatic areas through time (De Caceres et al. 2019). We will use the R packages vegclust and adespatial for this analysis. This approach has the benefit of examining potential pathways or trajectories, such as if communities are converging (i.e., becoming more homogenous) through time. We can also visualize these patterns in ordination space or create a trajectory map (showing patterns on a map of the UMRS). These visual aids could be beneficial for managers to identify areas for habitat rehabilitation or other spatial-related management decisions.

<u>Goal two analyses (Objective 4)</u>

Finally, information generated from the previous analyses will be used to predict how community-environmental relationships could be influenced by climate change (e.g., modifications to river discharge and temperature). We can take an "assemble and predict together" approach where community data and environmental predictors are simultaneously modelled to predict the distribution of community types among existing aquatic area types (Ferrier and Guisan 2006). Predicting climate change impacts could be accomplished using multivariate regression trees (De'ath 2002) or generalized dissimilarity modeling (Ferrier 2002).

Data management procedures:
Data are already publicly available.

Special needs/considerations, if any: NA

Budget: $247,403

Timeline (projected start date October 1, 2024):

Project Steps	Estimated Completion Date
Assemble Aquatic Areas GIS databases	Jan 2025
Assemble SRS and Mussel datasets	Mar 2025
Generate integrated data set with aquatic areas and aquatic area attributes associated with point locations	July 2025
Conduct goal one analyses	Jan 2026
Summarize goal one data analyses in report #1	Sept 2026
Summarize goal one data analyses in report #2	Jan 2027
Conduct goal two analyses	Jan 2027
Summarize goal two analyses in report #3	Sept 2027

Expected milestones and products (with completion dates):

Product	Estimated Completion Date
Publication 1: An assessment of differences in abiotic factors and ecological communities among aquatic areas within UMRS pools	Sept 2026
Publication 2: Trajectories of abiotic and ecological community change in UMRS aquatic areas	Jan 2027
Publication 3: Predicting climate-induced changes in aquatic areas of the UMRS and subsequent abiotic and biotic community responses	Sept 2027

References:

Bouska, K. L., Houser, J. N., De Jager, N. R., Van Appledorn, M., and Rogala, J. T., 2019. Applying concepts of general resilience to large river ecosystems: A case study from the Upper Mississippi and Illinois rivers. Ecological Indicators, 101, p.1094-1110.

Bouska, K.L., Larson, D.M., Drake, D.C., Lund, E.M., Carhart, A.M. and Bales, K.R., 2022. Aquatic vegetation dynamics in the Upper Mississippi River over 2 decades spanning vegetation recovery. Freshwater Science, 41(1), p.33-44.

Carhart, A.M., Rohweder, J.J. and Larson, D.M., 2023. 22 years of aquatic plant spatiotemporal dynamics in the upper Mississippi River. Diversity, 15(4), p.523.

De'Ath, G., 2002. Multivariate regression trees: a new technique for modeling species–environment relationships. Ecology, 83(4), p.1105-1117.

DeBoer, J.A., Thoms, M.C., Delong, M.D., Parsons, M.E. and Casper, A.F., 2020. Heterogeneity of ecosystem function in an “Anthropocene” river system. Anthropocene 31: 100252.

DeBoer, J.A., Thoms, M.C. and Delong, M.D., 2022. Ecosystem response through a resilience lens: Do differences in the Illinois River over 150 Y indicate regime shifts?. Journal of Geophysical Research: Biogeosciences, 127(1), p.e2021JG006553.

De Cáceres, M., Coll, L., Legendre, P., Allen, R.B., Wiser, S.K., Fortin, M.J., Condit, R. and Hubbell, S., 2019. Trajectory analysis in community ecology. Ecological Monographs, 89(2), p.e01350.

De Jager, N.R. and Houser, J.N., 2012. Variation in water-mediated connectivity influences patch distributions of total N, total P, and TN: TP ratios in the Upper Mississippi River, USA. Freshwater science, 31(4), p.1254-1272.

De Jager, N.R. and Houser, J.N., 2016. Patchiness in a large floodplain river: associations among hydrology, nutrients, and fish communities. River Research and Applications, 32(9), p.1915-1926.

De Jager, N.R., Rogala, J.T., Rohweder, J.J., Van Appledorn, M., Bouska, K.L., Houser, J.N. and Jankowski, K.J., 2018. Indicators of ecosystem structure and function for the Upper Mississippi River System (No. 2018-1143). US Geological Survey.

Delaney, J.T. and Larson, D.M., 2023. Using explainable machine learning methods to evaluate vulnerability and restoration potential of ecosystem state transitions. Conservation Biology, p.e14203.

Ferrier, S., 2002. Mapping spatial pattern in biodiversity for regional conservation planning: where to from here?. Systematic biology, *51*(2), p.331-363.

Ferrier, S. and Guisan, A., 2006. Spatial modelling of biodiversity at the community level. Journal of applied ecology, 43(3), p.393-404.

French, S.K. and Ackerman, J.D., 2014. Responses of newly settled juvenile mussels to bed shear stress: implications for dispersal. Freshwater Science, 33(1), p.46-55.

Gutreuter, S., Burkhardt, R. and Lubinski, K.S., 1995. Long term resource monitoring program procedures: fish monitoring. National Biological Survey, Environmental Management Technical Center. (LTRMP 95-P002-1. 42 pp. + Appendixes A-J.)

Ickes, B.S., Sauer, J.S., Richards, N., Bowler, M., and Schlifer, B., 2014, Spatially explicit habitat models for 28 fishes from the Upper Mississippi River System (AHAG 2.0) (ver. 1.1, July 2014): A technical report submitted to the U.S. Army Corps of Engineers' Upper Mississippi River Restoration-Environmental Management Program. (No. 2014–T002).

Newton, T.J., Zigler, S.J., Rogala, J.T., Gray, B.R. and Davis, M., 2011. Population assessment and potential functional roles of native mussels in the Upper Mississippi River. Aquatic Conservation: Marine and Freshwater Ecosystems, 21(2), p.122-131.

Ratcliff, E. N., Gittinger E. J., O'Hara T. M., and Ickes B. S., 2014. Long Term Resource Monitoring Program Procedures: Fish Monitoring, 2nd edition. A Program Report submitted to the U.S. Army Corps of Engineers' Upper Mississippi River Restoration-Environmental Management Program. (No. LTRMP 2014-P001.)

Ries, P., De Jager, N.R., Zigler, S.J. and Newton, T.J., 2016. Spatial patterns of native freshwater mussels in the Upper Mississippi River. Freshwater Science, 35(3), p.934-947.

Soballe, D. M., and Fischer J. R., 2004. Long Term Resource Monitoring Program Procedures: Water quality monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. (No. LTRMP 2004-T002-1) (Ref. 95-P002-5).

Sternberg, R.B., 1971. Upper Mississippi River habitat classification survey, Hastings, Minnesota, to Alton, Illinois. Upper Mississippi River Conservation Committee, Fish Technical Section.

Wilcox, D.B., 1993. An aquatic habitat classification system for the Upper Mississippi River System: U.S. Fish and Wildlife Service, Environmental Management Technical Center, Long Term Monitoring Program, Technical Report 93–T003, 9 p., 1 app.

Yin, Y., Winkelman J.S., and Langrehr H. A., 2000. Long Term Resource Monitoring Program Procedures: Aquatic Vegetation Monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. (No. LTRMP 95-P002).

Tables and Figures:

Table 1. Aquatic area descriptions and their associated levels described by De Jager et al. (2018).

Classification level	Aquatic area class name	Aquatic area class description
1	Main Navigational Channel	Designated navigation corridor, determined from navigational charts
1	Channel Border	Area between navigational channel and shorelines
1	Side Channel	Channels other than main channel
1	Tributary Channel	Tributaries entering river
1	Contiguous Floodplain Lake	Lakes connected by surface flow to channels
1	Contiguous Floodplain Shallow Aquatic	Inundated areas; mosaic area composed of open water, emergent and floating vegetation, and islands
1	Contiguous Impounded	Open water areas in downstream portions of navigation pools
1	Isolated Floodplain Lake	Floodplain lake with no surface water connections to channel
1	No Coverage	Areas with no photo coverage
2	Side Channel	Channels other than main channel
2	Tertiary Channel	Side channels not directly connect to main channel
2	Contiguous Floodplain Lake	Lakes connected by surface flow to channels
2	Tributary Delta Lake	Contiguous floodplain lake feature; Lake Pepin in navigational Pool 4
3	Structured Channel Border	Regions within channel border that contain river-training structures
3	Unstructured Channel Borders	Areas within channel border that do not contain river-training structures within 400 meters of region

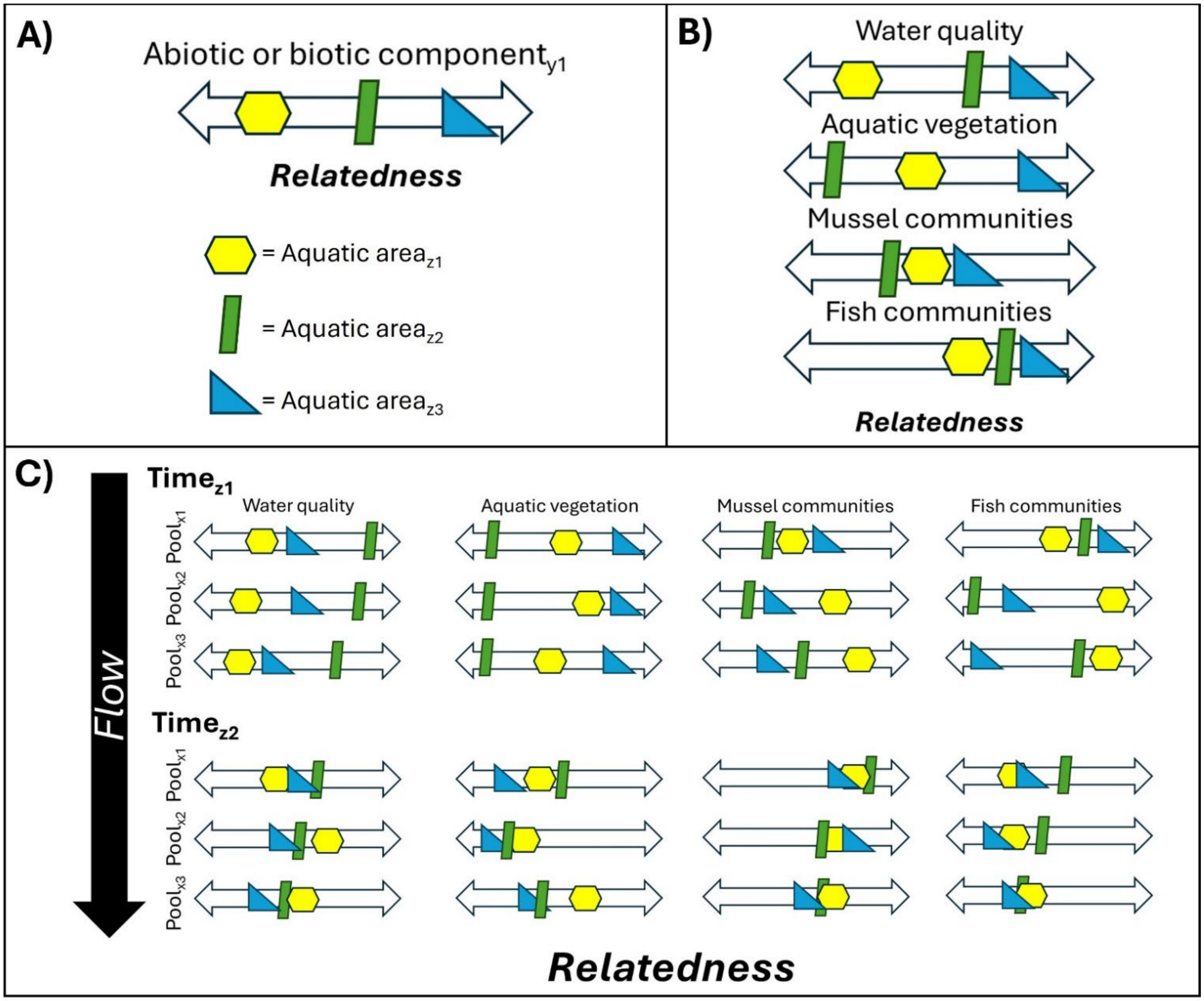


Figure 1. Conceptual model relating to objective 1 (panel A), objective 2 (panel B), and objective 3 (panel C). Panel A highlights anticipated differences among aquatic areas for each abiotic or biotic component within a UMRS pool. Each shape represents a type of aquatic area (e.g., main channel, side channel, tributary channel) and where they may exist along a habitat continuum for one particular abiotic or biotic variable (e.g., water quality, vegetation, mussel community, or fish community) within one UMRS pool. Panel B highlights potential variation in relatedness across the abiotic and biotic components in relation to the aquatic areas within a UMRS pool. Panel C compares how different components have responded across space (pools) and time (e.g., potentially becoming more homogenous).

Generating future hydrology and water temperature projections for the UMRS using hybrid deep learning (Funding for FY2025 only)

Previous LTRM project:
This work would build upon information gathered, lessons learned, datasets compiled, and future hydrology evaluation criteria developed during two previously UMRR funded proposals:

Improving our understanding of historic, contemporary, and future UMRS hydrology by improving workflows, reducing redundancies, and setting a blueprint for modelling potential future hydrology
Milestones: 2021HH4, 2021HH5, and 2021HH6
Van Appledorn, M., & Sawyer, L. (2023). Upper Mississippi River Restoration future hydrology meeting series (Completion Report LTRM-2021HH6; p. 35 pages + 10 appendices). Upper Mississippi River Restoration Program.

Evaluating the LOCA-VIC-mizuRoute hydrology data products for scientific and management applications in the UMRS
Milestones: 2023Hydro3, 2023Hydro4, 2023Hydro5, 2023Hydro6, 2023Hydro7, 2023Hydro8, 2023Hydro9. Final report in progress.

Name of Principal Investigator(s):
John Delaney, Biologist
USGS UMESC, La Crosse, WI | 608-781-6301, jdelaney@usgs.gov
Coordinate and oversee project; Coordinate and oversee data management & metadata development; oversee data visualization development; write reports

Matthew Trumper, Biologist
USGS UMESC, La Crosse, WI | 651-472-3379, mtrumper@contractor.usgs.gov
Coordinate database development for water temperature variables; oversee data management & metadata development; lead model development for water temperature; write reports

Collaborators (Who else is involved in completing the project):
Lucie Sawyer, Civil-Hydraulic Engineer
USACE Rock Island District (MVR), Rock Island, IL | 309-794-5836, lucie.m.sawyer@usace.army.mil
Coordinate and oversee project; write reports

Molly Van Appledorn, Research Ecologist
USGS UMESC, La Crosse, WI | 608-781-6323, mvanappledorn@usgs.gov
Coordinate and oversee project; write reports

Kristen Bouska, Research Ecologist
USGS UMESC, La Crosse, WI | 608-781-6344, kbouska@usgs.gov
Coordinate and oversee project; write reports

Nathan De Jager, Research Ecologist
USGS UMESC, La Crosse, WI | 608-781-6232, ndejager@usgs.gov
Coordinate and oversee project; write reports

Kathi Jo Jankowski, Research Ecologist
USGS UMESC, La Crosse, WI | 608-781-6242, kjankowski@usgs.gov
Coordinate and oversee project; write reports

Chanel Mueller, Senior Climate Change Policy Advisor
USACE Headquarters (HQ), Washington, D.C. | 651-666-0224, chanel.mueller@usace.army.mil
Consult on downscaled climate products, evaluation and data interpretation

Jason Rohweder, Biologist
USGS UMESC, La Crosse, WI | 608-781-6228, jrohweder@usgs.gov
Oversee GIS data development; write reports

Carl Schoenfield, Hydrologist
USACE Rock Island District (MVR), Rock Island, IL | 309-794-5307, carl.d.schoenfield@usace.army.mil
Assistance with temperature data and documentation acquisition

Samantha Oliver, Hydrologist
USGS Upper Midwest Water Sciences Center, Madison, WI | 608-821-3824, soliver@usgs.gov
Assistance with development, testing, and implementation of water temperature model

Jeremy Diaz, Machine Learning Specialist
USGS Water Mission Area, Reston, VA | 608-821-3820, jdiaz@usgs.gov
Assistance with development, testing, and implementation of water temperature model

Ben Schlifer, IT Specialist
USGS UMESC, La Crosse, WI | 608-781-6359, bschlifer@usgs.gov
Assistance with compiling water temperature information and integrating into existing workflows

Introduction/Background:
Projections of climate change over the 21st century in the Midwest indicate the potential for increasing average and extreme temperatures (Polasky et al., 2022), reduced snowpack (Demaria et al., 2016), wetter springs and drier summers (Grady et al., 2021; Zhou et al., 2021), along with increased intensity, variability, and more rapid transitions between wet and dry extremes (Chen & Ford, 2022). All of these factors are likely to alter the timing, intensity, and frequency of hydrologic events. However, there is still great uncertainty in how the climate will continue to change into the future due largely to the unknown trajectory in emissions driven by socioeconomic changes (IPCC, 2022). Due to this uncertainty, it is necessary to utilize the full range of projections to understand the potential future changes in climate and hydrology. A recent product was evaluated but was found unsuitable for conducting in-depth analyses of ecosystem function within the UMRS due to its inability to capture the seasonality (timing) or distribution of the basin's streamflow response over the climate models historical period simulations (Van Appledorn, Sawyer, et al. *in prep*). While other products may be on the horizon, it would be advantageous to develop a framework for modeling not only discharge but also other variables because we can ensure the products are at the resolution relevant to existing LTRM modeling frameworks, tailored to sufficiently capture management and decision relevant metrics, and can be easily updated as new global climate model projections and improved downscaled climate model products become available.

Hydrologic variables such as discharge, water surface elevation, and water temperature are important for structuring biological communities in large rivers (Junk et al. 1989, Poff et al. 1997), including the UMRS (Bouska et al 2018) where changes in these driving variables have been observed (Houser 2022). Recently, increases in average annual discharges, longer duration spring flood events and late season flood events have been observed but patterns vary by location across the UMRS (Van Appledorn et al. 2022). These shifts will have implications for biological communities adapted to a given annual flow regime, affect rates of primary productivity (Bernhardt et al. 2022), and alter the timing and magnitude of nutrient and sediment fluxes (Seybold et al. 2022). In addition, although trends in water temperature have not been well quantified in the UMRS, there is some evidence of increasing trends from national assessments (Kaushal et al. 2010) as well as a strong, nearly 1:1 relationship of water temperature with air temperature (Gray et al. 2018). Changing water temperatures have important implications for all aspects of river functioning and management including the availability of thermally suitable habitat for fish, rates of biogeochemical processes that control nutrient availability, and can even have implications for human health through increasing the frequency and extent of toxic cyanobacteria blooms (Paerl and Paul 2012). Water temperature is inherently linked to changes in discharge (Gray et al. 2018, Jankowski 2022) but not always directly, thus it is important to consider the effects of discharge and other controls in tandem when trying to project future changes.

Given the importance of discharge, water surface elevation, and temperature on organisms and ecosystems of the UMRS, it is not surprising that these variables are directly or indirectly incorporated in a multitude of modeling frameworks across the system. For instance, an inundation model driven by water surface elevation observations (Van Appledorn et al 2021; Van Appledorn et al. 2024) has been used to understand floodplain plant community distribution (De Jager et al. 2016), forest dynamics (De Jager et al. 2019), and reed canarygrass invasion (De Jager et al. 2024). Water temperature has been used to understand controls on algal biomass (Jankowski et al. 2021) and is a key variable included in fisheries habitat models (e.g., Sheehan et al. 1990, Knights et al. 1996, Laaker et al. 2020). Future projections of these driving variables will be invaluable for application to existing modeling frameworks, and the development of new ones, to understand how organisms and ecosystems of the UMRS may respond to future changes in climate.

Hydrologic modeling is an expansive and evolving field of study with multiple approaches for simulating hydrologic variables. Process based models rely on distributed data, require calibration of individual catchments, and are limited by our understanding and uncertainty of different processes. Within the broader field of artificial intelligence (AI), machine learning (ML) models are data driven models that learn complex relationships between the dependent variable and a selection of predictor variables, require many observations to train, and can outperform process based models. A data driven approach could be particularly useful in instances where information is limited or restricted to only a few variables such as climate change projections that often only include outputs of air temperature and precipitation. An additional advantage of AI/ML is that multiple catchments can be modeled simultaneously without the need to calibrate individual catchments like in a process model, and the AI/ML model benefits from the information gained by other catchments in the model (Kratzert et al. 2019). A common concern about AI/ML is the potential for a model to predict spurious outcomes because it does not apply any physical constraints; this can be of particular concern when observations of the predictor variables fall outside the range of values encountered during the training process. A wealth of approaches to incorporate process constraints have been developed which are often referred to as hybrid modeling approaches that can improve performance of data driven models (Jia et al. 2021; Appling et al. 2022, Sadler et al. 2022, Ng et al. 2023).

Objectives

The primary objective of this proposal is to generate future hydrology and water temperature projections for the UMRS. To achieve this objective, we will:

1. Use AI/ML and hybrid modeling techniques to develop robust, quantitative projections of discharge and water surface elevation (WSE) for USGS gage locations and USACE points of interest throughout the UMRS.
2. Develop a database of historic and contemporary water temperature that approximates the extent and resolution of the existing WSE database through collaboration between the USGS and USACE.
3. Apply the AI/ML and hybrid modeling framework developed for the future hydrology dataset to generate future projections of water temperature for gage locations throughout the UMRS.
4. Rigorously evaluate projections using model evaluation criteria for hydrology estimates based upon historical runs of climate models developed during a previously funded UMRR project.
5. Develop publications to describe model development and the datasets generated and disseminate the data and documentation through a publicly available website with features to help users visualize and acquire data.

Relevance of research to UMRR:
To best prepare for potential future changes in hydrology (Focal Area 1.2) and understand the ecological implications of such change (Focal Area 2.9), it is essential to estimate how critical variables such as discharge, water surface elevation, and water temperature may change across the UMRS (Van Appledorn and Sawyer 2023). We propose to utilize cutting edge deep learning (AI/ML) and hybrid modeling techniques to generate future projections of discharge, water surface elevation, and water temperature. This will be a highly collaborative effort that brings together managers, hydrologists, engineers, ecologists, and data scientists to develop an ensemble of future hydrologic projections for managers and researchers to incorporate into their work while ensuring best practices for the analysis and application of climate change information. For example, climate change projections could be used to refine HREP project selection, planning, design, and adaptive management by providing expected future water depth, floodplain inundation duration, and water temperature information. The result of this work has the potential to be broadly useful for applications in the UMRS by integrating with existing quantitative models of hydrologic-ecological relationships to explore how UMRS biota

may respond to a range of potential future conditions. This information will be critical to addressing ecological transformation through management as conditions continue to change (Ward et al. 2023). Additionally, this effort will focus on the construction of a model building pipeline that can be easily updated when new climate projections become available and can be adapted for additional variables beyond discharge, water surface elevation, and water temperature.

Methods:
Model development for discharge and water surface elevation

Global climate models simulate weather patterns using biogeochemical cycles and physical processes with changes in climate forcings (e.g., greenhouse gases, aerosols) observed in the past and projected into the future. Many institutions develop climate models which are released as an ensemble periodically through the Coupled Model Intercomparison Project (CMIP). CMIP standardizes the scenarios of future greenhouse gas emissions that will drive the climate models. The most recent release, CMIP6, consisted of eight emissions scenarios referred to as shared socio-economic pathways (SSPs). The simulated outputs from the global climate models can be too coarse to capture important weather patterns at local scales, thus a variety of methods for downscaling global climate models to better represent regional weather patterns have been developed. For our project, we have tentatively identified Localized Constructed Analogs version 2 (LOCA2; Pierce et al. 2023) as a candidate downscaling product that has been released recently and includes three SSPs: SSP 245, SSP 370, and SSP 585. These represent medium-low, medium, and high emissions scenarios with SSP 245 being equivalent to the previous representative concentration pathway (RCP) 4.5 and SSP 585 being equivalent to the previous RCP 8.5 scenarios from CMIP5. Including the 27 climate models available within LOCA2 along with the multiple scenarios and multiple experiments there are 329 total projections equating to 26,026 years of data (see Table 2 in Pierce et al. 2023). We recognize the sphere of climate information is ever changing with periodic updates to model ensembles and emissions scenarios through CMIP and the subsequent downscaling projects. We also acknowledge that each downscaling technique and the resulting datset has its own unique sources of potential error that are important to investigate and consider. Thus, we will be adaptive during the model building process and consider alternative downscaled climate products as they are released and focus our modeling framework in such a way that the model can be updated as new climate datasets are released or used to compare existing downscaled climate products.

Model development will be conducted in two phases with the first phase consisting of the construction of a base model utilizing a subset of gages for efficiency and the second phase using the full suite of gages once the processes and code have been developed and refined (Figure 1). The initial base model will be built using six gage locations across the UMRS including: Prescott, WI (05344500), Winona, MN (05378500), McGregor, IA (05389500), Keokuk, IA (05474500), Valley City, IL (05586100), and Grafton, IL (05587450). This base model will allow us to more efficiently test and iteratively refine our modeling approach before applying and evaluating the model on all gage locations across the UMRS. We anticipate starting with a long short-term memory (LSTM) network as the algorithm for predicting discharge. LSTM is a type of recurrent neural network that is capable of learning long-term time dependencies and is highly suited for time-series prediction (Hochreiter and Schmidhuber 1997). LSTM has been used in a number of discharge studies (Kratzert et al, 2019; Feng et al. 2020; Konapala et al 2020) as well as used to predict other hydrologic variables including water temperature (Rahmani et al. 2021a; Rahmani et al. 2021b).

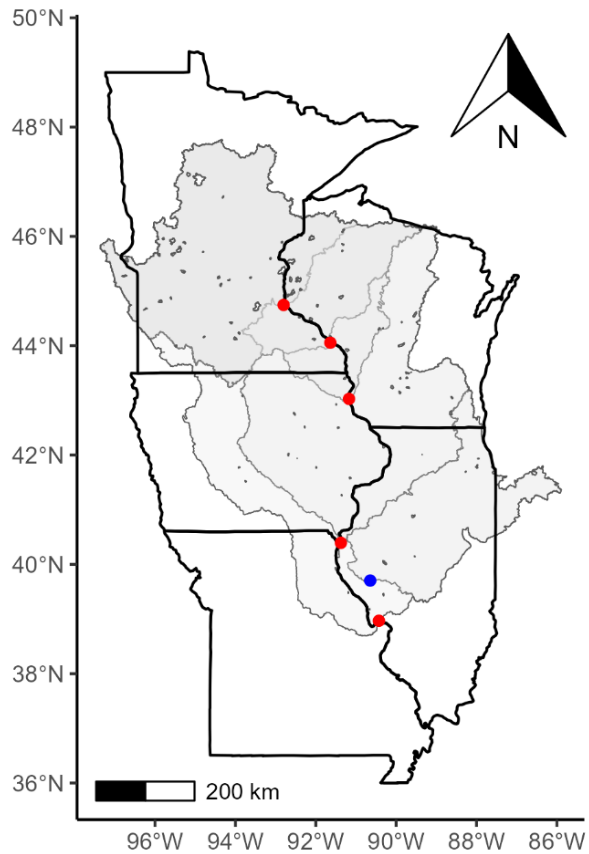


Figure 1: Map depicting gage locations and upstream catchment for the initial base model. Gage locations along the Upper Mississippi River are in red and the one gage on the Illinois River is in blue. Following the development of the initial base model at these locations, future discharge, WSE, and water temperature predictions will be developed for the full suite of USGS gage locations and USACE points of interest.

Discharge data will be compiled for each gage starting at 1940 (post L&D construction) and continuing through 2020 (80-years). Daily observations (1940-2020) of air temperature, precipitation, and the combination of the two will be summarized into commonly used metrics in climate studies (Table 1) for each upstream catchment of each gage. To ensure compatibility with future climate projections, we will use the same gridded air temperature and precipitation dataset used to downscale the global climate models. In the case of LOCA2, this dataset would be the "Unsplit-Livneh" dataset (Pierce et al. 2021). We will focus only on metrics that can be derived from daily temperature and precipitation estimates because these are the two outputs that will be available from downscaled climate products. During the model development and evaluation we will further refine the temperature and precipitation derived metrics and explore including indicators of antecedent conditions. Additionally, we will summarize catchment attributes (e.g., catchment area) for each catchment but those will not change over the timeseries. For each gage we will join the dataset consisting of daily discharge observations with the daily estimates of metrics derived from air temperature and precipitation observations along with the catchment attributes.

Table 1: Preliminary set of predictor variables derived from daily estimates of air temperature, precipitation, or the combination of the two.

Variable type	Variable name	Description
Temperature	tasmax	Daily maximum temperature
Temperature	tasmin	Daily minimum temperature
Temperature	tas	Daily average temperature (max + min)/2
Temperature	tasmin_30day	Average of minimum temperature over previous 30-day period
Temperature	tasmax_30day	Average of maximum temperature over previous 30-day period
Temperature	tasmin_90day	Average of minimum temperature over previous 90-day period
Temperature	tasmax_90day	Average of maximum temperature over previous 90-day period
Precipitation	pr	Total daily precipitation
Precipiation	pr_7day	Total precipitation over the previous 7-day period
Precipation	pr_30day	Total precipitation over the previous 30-day period
Precipation	pr_90day	Total precipitation over the previous 90-day period
Both	spei_1mo	1-month Standardized Precipitation-Evapotranspiration Index
Both	spei_3mo	3-month Standardized Precipitation-Evapotranspiration Index
Both	spei_6mo	6-month Standardized Precipitation-Evapotranspiration Index
Both	frac_snow	Fraction of precipitation falling when temperature is below 0°C

We will split the 80-year timeseries into two periods with the first 4/5 of the timeseries (1940-2003) serving as the training dataset and the last 1/5 (2004-2020) serving as the testing dataset. For model tuning and performance evaluation, the training period will be further split into cross validation folds using sliding period resampling. We will evaluate the performance of the model by comparing simulated and observed values using only data that the model has not seen during training (i.e., the testing dataset). Performance metrics will include those typical of hydrologic evaluations (Nash-Sutcliffe Efficiency, Kling-Gupta Efficiency, etc.). Our evaluation will focus on identifying potential deficiencies (e.g., underrepresenting high flows or not capturing important seasonal patterns) that could be improved by including estimates from a process based model. There are additional evaluations that could be performed including the comparison of different gridded weather data products and comparisons between purely process based models. These evaluations will determine the type of hybrid model, the appropriate gridded weather data products, and the process(es) to include if the evaluation warrants. Because our intention is to use the hydrologic model that is trained and developed using observed data to project to the end of the century using temperature and precipitation estimates from global climate models, we will tailor our evaluation to include a focus on both temperature and precipitation extremes. This could include holding out particularly warm, wet, and dry years as extreme testing sets, training the model on the more typical years and then evaluating performance under the extreme condition(s). This will give us greater confidence and understanding in how the models may perform with the estimates from the global climate models which do show more extreme temperatures and more variable precipitation patterns over the 21st century.

Each of the global climate models is run using observed levels of greenhouse gas concentrations over the historical period (1950-2014). It is important to note that the historical runs do not recreate the daily weather patterns and thus direct comparisons of daily simulated and observed values is not advisable. Only comparisons with metrics summarized over climatological periods (~30-years or more) can be made. To evaluate our hydrological model performance using the historical runs of the global climate models we will use a recently developed evaluation that is tailored specifically for evaluating performance of hydrologic models run with temperature and precipitation projections from historical climate model runs using metrics that are relevant to both researchers and mangers in the UMRS (Van Appledorn, Sawyer, et al. in prep). This evaluation will be conducted in consultation with the original team of USACE and USGS collaborators who developed the evaluation. Additionally, a detailed evaluation of how each individual model performs under the historical runs could be utilized by researchers in identifying which of the global climate models perform best in our region and could be used to develop weighting schemes when using future projections.

Once we have trained a model to predict discharge/WSE, evaluated its performance on both observed data and climate model historical runs, and have confidence that the model can adequately project discharge/WSE, we will be ready to apply the model to the future downscaled climate model projections. This will be a simple process of applying the model to the estimates of air temperature and precipitation from the downscaled climate model projections, but will require substantial computer storage and processing power. This highlights an added bonus of this effort, which is the gathering and synthesis of downscaled air temperature and precipitation projections that could be utilized in other research project within the basin. The estimates produced for both the historical and future climate model runs, along with the code, will be archived in ScienceBase. To facilitate access and communication of the projections we will develop an online dashboard that will allow users to visualize the projection across gages, scenarios, and time periods using best practices for the summarization and presentation of climate change information (Davis et al. 2020). An overview of the modeling process for discharge/WSE and associated products described above is outlined in Figure 2.

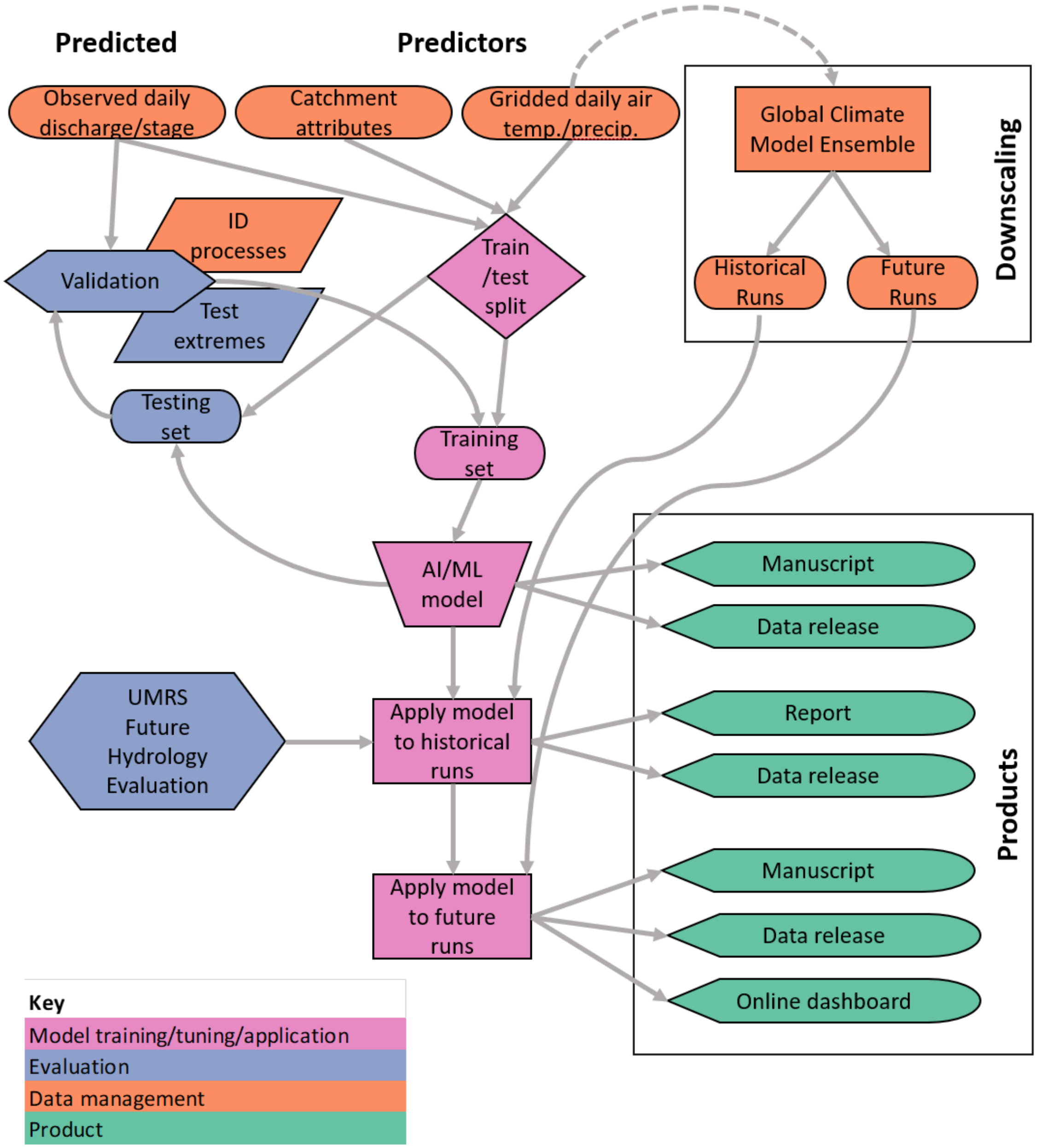


Figure 2: AI/ML modeling workflow. This workflow focuses on the discharge/water surface elevation model development, but water temperature will follow similar processes, use the same downscaled climate products (air temperature and precipitation), and incorporate the discharge estimates from the model depicted here. See Figure 3 for a timeline of this process as well as the timeline and steps for water temperature. Products for both discharge/water surface elevation and temperature are detailed in Table 2.

Database development for water temperature

The first step to developing future water temperature projections is to develop a comprehensive water temperature database from gage locations throughout the UMRS. The database development process for water temperature will leverage existing LTRM workflows that were created to streamline the process of acquiring hydrologic data from USACE points of interest. Briefly, the steps to develop these databases of historic and contemporary data will include the following actions:

1) The USACE will provide documentation to USGS UMESC on QA/QC methods that have been implemented for historic data. This documentation will be used to identify and understand existing data quality issues and how to address them.
2) USACE will develop its own .DSS databases of historic water temperature. Upon completion, the database will be transferred to USGS UMESC scientists who will review contents for QA/QC.
3) The LTRM database manager will update a front-end web application originally developed for the water surface elevation database to include the water temperature database, allowing for custom queries of the data. The historic data from USACE and the documentation will then be made available.
4) To keep the database current, USGS UMESC scientists will implement a semi-automated scripting process to extract contemporary water temperature data from the Corps Water Management System (CWMS) database, a repository of hydrologic data that has undergone a standard QA/QC process. These scripts were previously developed by the LTRM database manager to build the WSE database. Water temperature data will be extracted annually and integrated with the existing compiled data.

The outcome of these steps will be a central repository of current, standardized, and accessible water temperature data for the entire UMRS. This database will include daily hydrologic data and associated metadata for all gage locations.

Model development for water temperature

The modeling framework we employ for discharge/WSE projections will serve as a blueprint for generating projections of water temperature (Figure 2). Specifically, we will use the code, documentation, and insights gained from our initial modeling effort with discharge/WSE to inform each step in the model development process for water temperature variables.

Following the modeling approach described above, we will initially use the LSTM algorithm to predict water temperature. Recent studies have demonstrated the high accuracy of LSTM-based models in predicting stream water temperature (Rahmani et al. 2021a; Rahmani et al. 2021b). Given that discharge/WSE and water temperature are influenced by similar environmental factors (e.g., air temperature, precipitation, and catchment attributes), there will likely be considerable overlap in the inputs used for modeling water temperature. We expect this overlap to streamline the process of testing and refining water temperature models, as depicted by the shortened timeline for temperature modeling in Figure 3. Discharge observations from corresponding gage locations will also be added as an input to the model because discharge is a key driver of water temperature, consistent with the fact that discharge has been shown to be an important predictor in LSTM-based water temperature models (e.g., Rahmani et al. 2021a). Additional model inputs will be incorporated based on relevant literature and consultation with technical experts. Performance of the water temperature model will be evaluated on observations and historical climate model runs. After model evaluation, we will apply the model to future downscaled climate change projections of air temperature and precipitation, as well as future discharge projections generated from our LSTM hydrology model described above. The code and data products for the water temperature model will be archived in ScienceBase and the projections we develop will be added to the online dashboard.

Data management procedures: All data produced (hydrologic projections of discharge, water surface elevation, and water temperature) during this project, along with associated code, will be archived in ScienceBase and follow USGS Fundamental Science Practices (FSP) requirements for public release. The online dashboard will utilize data from the public ScienceBase releases and follow USGS FSP requirements for public-facing visualizations.

Special needs/considerations, if any: N/A

Budget: Total project cost is $725,275. However, given the sequential nature of the tasks and milestones that we have outlined, the project could be funded on an annual basis as follows: FY25: $221,510, FY26: $234,031, and FY27: $269,733.

Timeline: Project will initiate on October 1, 2024 (FY25) and continue for a duration of 3-years. See Figure 3 for a detailed project timeline that is broken into discharge/WSE and temperature components.

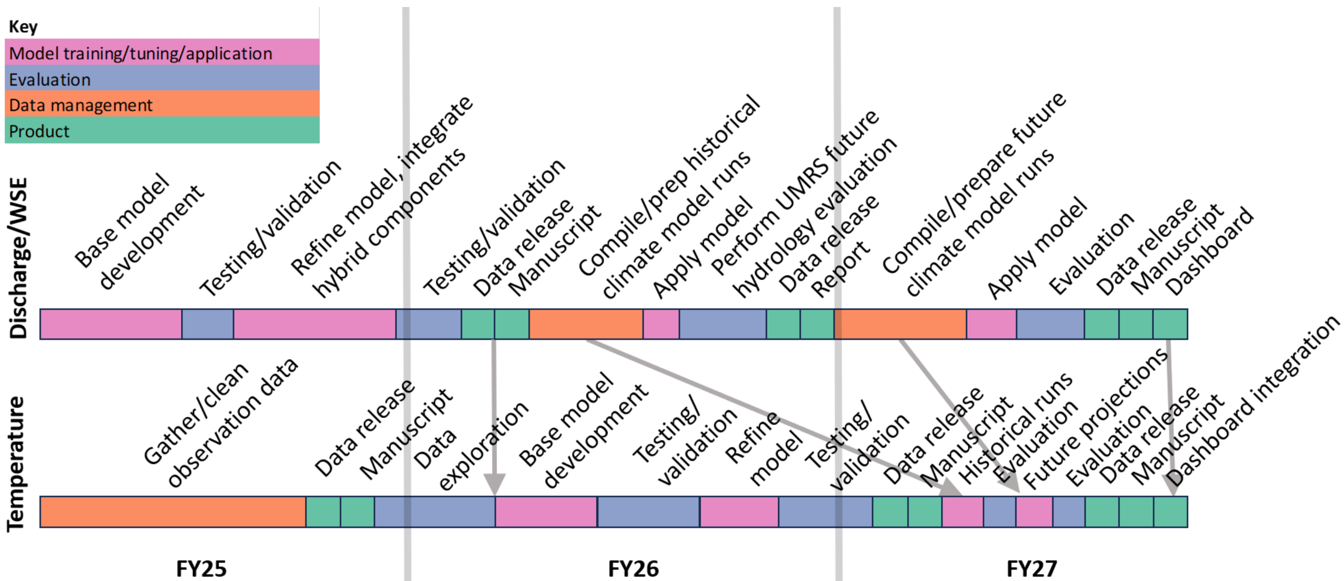


Figure 3: Project timeline for developing future discharge/WSE and water temperature projections. Bars are color coded to represent different project activities described in the methods. Gray vertical lines separate fiscal years and gray arrows show connections between the discharge/WSE and water temperature modeling efforts.

Expected milestones and products [with completion dates]:

Table 2: Expected milestones and products. Shading indicates the product type with discharge/WSE in blue, temperature in red, and both in purple.

Milestones and products	Fiscal Year	Date
Milestone: Initial Discharge/WSE model development and identification processes to add	FY25	31 Dec 2024
Annual update: Year 1	FY25	31 Dec 2024
Data release: Water temperature database submitted to IPDS	FY25	30 Jun 2025
Manuscript: Water temperature historical trends submitted to IPDS	FY25	30 Sept 2025
Data release: Discharge/WSE model code submitted to IPDS	FY26	31 Nov 2025
Manuscript: Discharge/WSE model performance replicating the observed record submitted to IPDS	FY26	31 Nov 2025
Annual update: Year 2	FY26	31 Dec 2025
Data release: Code and model outputs for historical climate model runs submitted to IPDS	FY26	30 Sept 2026
Report: Evaluation of historical climate model runs of Discharge/WSE submitted to IPDS	FY26	30 Sept 2026
Data release: Water temperature model code submitted to IPDS	FY27	30 Nov 2026
Manuscript: Water temperature model performance and evaluation submitted to IPDS	FY27	30 Nov 2026
Data release: Code and model outputs for future climate model runs submitted to IPDS	FY27	31 Jul 2027
Manuscript: Future discharge/WSE projections for the UMRS submitted to IPDS	FY27	31 Jul 2027

Data release: Future water temperature projections submitted to IPDS	FY27	30 Sept 2027
Manuscript: Water temperature model future projections submitted to IPDS	FY27	30 Sept 2027
Data release: Online dashboard that summarizes discharge/WSE and water temperature projections across the UMRS submitted to IPDS	FY27	30 Sept 2027

References

Appling, A. P., S. K. Oliver, J. S. Read, J. M. Sadler, and J. A. Zwart. 2022. Machine Learning for Understanding Inland Water Quantity, Quality, and Ecology. Pages 585–606 Encyclopedia of Inland Waters. Elsevier.

Bernhardt, E. S., P. Savoy, M. J. Vlah, A. P. Appling, L. E. Koenig, R. O. Hall, M. Arroita, J. R. Blaszczak, A. M. Carter, M. Cohen, J. W. Harvey, J. B. Heffernan, A. M. Helton, J. D. Hosen, L. Kirk, W. H. McDowell, E. H. Stanley, C. B. Yackulic, and N. B. Grimm. 2022. Light and flow regimes regulate the metabolism of rivers. Proceedings of the National Academy of Sciences 119:e2121976119.

Chen, L., and T. W. Ford. 2022. Future changes in the transitions of monthly-to-seasonal precipitation extremes over the Midwest in Coupled Model Intercomparison Project Phase 6 models. International Journal of Climatology:joc.7756.

Davis, C., H. Aldridge, R. Boyles, K. S. McNeal, L. Maudlin, and R. Atkins. 2020. Visually communicating future climate in a web environment. Weather, Climate, and Society 12:877–896.

De Jager, N. R., J. J. Rohweder, M. Van Appledorn, E. Hlavacek, and A. Meier. 2024. Identifying conditions where reed canarygrass (Phalaris arundinacea) functions as a driver of forest loss in the Upper Mississippi River floodplain under different hydrological scenarios. Wetlands Ecology and Management.

De Jager, N. R., J. J. Rohweder, Y. Yin, and E. Hoy. 2016. The Upper Mississippi River floodscape: Spatial patterns of flood inundation and associated plant community distributions. Applied Vegetation Science 19:164–172.

De Jager, N. R., M. Van Appledorn, T. J. Fox, J. J. Rohweder, L. J. Guyon, A. R. Meier, R. J. Cosgriff, and B. J. Vandermyde. 2019. Spatially explicit modelling of floodplain forest succession: interactions among flood inundation, forest successional processes, and other disturbances in the Upper Mississippi River floodplain, USA. Ecological Modelling 405:15–32.

Feng, D., Fang, K., & Shen, C. 2020. Enhancing Streamflow Forecast and Extracting Insights Using Long-Short Term Memory Networks With Data Integration at Continental Scales. Water Resources Research, 56(9).

Grady, K. A., L. Chen, and T. W. Ford. 2021. Projected Changes to Spring and Summer Precipitation in the Midwestern United States. Frontiers in Water 3:780333.

Gray, B. R., D. M. Robertson, and J. T. Rogala. 2018. Effects of air temperature and discharge on Upper Mississippi River summer water temperatures. River Research and Applications 34:506–515.

Hochreiter, S., and J. Schmidhuber. 1997. Long Short-Term Memory. Neural Computation 9:1735–1780.

Houser, J. N., ed. ,. 2022. Ecological status and trends of the Upper Mississippi and Illinois rivers: U.S. Geological Survey Open-File Report 2022-1039. Page 218.

IPCC. 2022. Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. First edition. Cambridge University Press.

Jankowski, K. J., J. N. Houser, M. D. Scheuerell, and A. P. Smits. 2021. Warmer winters increase the biomass of phytoplankton in a large floodplain river. Journal of Geophysical Research: Biogeosciences 126:e2020JG006135.

Jankowski, K. J. 2022. Water Quality Indicators, chap. E of Houser, J.N., ed., Ecological status and trends of the Upper Mississippi and Illinois Rivers: U.S. Geological Survey Open-File Report 2022-1039. Pages 38–54.

Jia, X., Zwart, J., Sadler, J., Appling, A., Oliver, S., Markstrom, S., Willard, J., Xu, S., Steinbach, M., Read, J., & Kumar, V. 2021. Physics-guided recurrent graph model for predicting flow and temperature in river networks. SIAM International Conference on Data Mining, SDM 2021.

Junk, W. J., Bayley, P. B., and Sparks, R. E. (1989). The flood pulse concept in river-floodplain systems. Can. Spec. Publ. Fish. Aquat. Sci. 106, 110–127.

Kaushal, S. S., G. E. Likens, N. A. Jaworski, M. L. Pace, A. M. Sides, D. Seekell, K. T. Belt, D. H. Secor, and R. L. Wingate. 2010. Rising stream and river temperatures in the United States. Frontiers in Ecology and the Environment 8:461–466.

Konapala, G., S.-C. Kao, S. L. Painter, and D. Lu. 2020. Machine learning assisted hybrid models can improve streamflow simulation in diverse catchments across the conterminous US. Environmental Research Letters 15:104022.

Kratzert, F., D. Klotz, G. Shalev, G. Klambauer, S. Hochreiter, and G. Nearing. 2019. Towards learning universal, regional, and local hydrological behaviors via machine learning applied to large-sample datasets. Hydrology and Earth System Sciences 23:5089–5110.

Ng, K. W., Y. F. Huang, C. H. Koo, K. L. Chong, A. El-Shafie, and A. Najah Ahmed. 2023. A review of hybrid deep learning applications for streamflow forecasting. Journal of Hydrology 625:130141.

Paerl, H. W., and V. J. Paul. 2012. Climate change: Links to global expansion of harmful cyanobacteria. Water Research 46:1349–1363.

Pierce, D. W., D. R. Cayan, D. R. Feldman, and M. D. Risser. 2023. Future Increases in North American Extreme Precipitation in CMIP6 Downscaled with LOCA. Journal of Hydrometeorology 24:951–975.

Pierce, D. W., L. Su, D. R. Cayan, M. D. Risser, B. Livneh, and D. P. Lettenmaier. 2021. An extreme-preserving long-term gridded daily precipitation data set for the conterminous United States. Journal of Hydrometeorology.

Poff, N. L., Allan, J. D., Bain, M. B., Karr, J. R., Prestegaard, K. L., Richter, B. D., Sparks, R. E., & Stromberg, J. (1997). The natural flow regime: A paradigm for river conservation and restoration. BioScience, 47(11), 769-784.

Polasky, A. D., J. L. Evans, J. D. Fuentes, and H. L. Hamilton. 2022. Statistical climate model downscaling for impact projections in the Midwest United States. International Journal of Climatology 42:3038–3055.

Rahmani, F., Lawson, K., Ouyang, W., Appling, A., Oliver, S., & Shen, C. 2021a. Exploring the exceptional performance of a deep learning stream temperature model and the value of streamflow data. Environmental Research Letters, 16(2).

Rahmani, F., Shen, C., Oliver, S., Lawson, K., & Appling, A. 2021b. Deep learning approaches for improving prediction of daily stream temperature in data-scarce, unmonitored, and dammed basins. Hydrological Processes, 35(11).

Sadler, J. M., A. P. Appling, J. S. Read, S. K. Oliver, X. Jia, J. A. Zwart, and V. Kumar. 2022. Multi-Task Deep Learning of Daily Streamflow and Water Temperature. Water Resources Research 58:e2021WR030138.

Seybold, E. C., R. Dwivedi, K. N. Musselman, D. W. Kincaid, A. W. Schroth, A. T. Classen, J. N. Perdrial, and E. C. Adair. 2022. Winter runoff events pose an unquantified continental-scale risk of high wintertime nutrient export. Environmental Research Letters 17:104044.

Sheehan, R., W. M. Lewis, and L. Bodensteiner. 1994. Winter habitat requirements and overwintering of riverine fishes. Reports. Paper 8.

Van Appledorn, M., N. R. De Jager, and J. J. Rohweder. 2021. Quantifying and mapping inundation regimes within a large river-floodplain ecosystem for ecological and management applications. River Research and Applications 37:241–255.

Van Appledorn, M. 2022. Hydrologic Indicators, chap. B of Houser, J.N., ed., Ecological status and trends of the Upper Mississippi and Illinois Rivers: U.S. Geological Survey Open-File Report 2022-1039. Pages 38–54.

Van Appledorn, M., & Sawyer, L. 2023. Upper Mississippi River Restoration future hydrology meeting series (Completion Report LTRM-2021HH6; p. 35 pages + 10 appendices). Upper Mississippi River Restoration Program.

Van Appledorn, M., N. R. De Jager, and J. J. Rohweder. 2024. Low-complexity floodplain inundation model performs well for ecological and management applications in a large river ecosystem. JAWRA Journal of the American Water Resources Association 60:9–26.

Van Appledorn, M., L. Sawyer, L. Youngblood, J. Harrell, J. T. Delaney, C. Mueller, B. Breaker, and C. Frans. in prep. Evaluating the LOCA-VIC-mizuRoute hydrology data products for scientific and management applications in the Upper Mississippi and Illinois Rivers. USGS Scientific Investigations Report.

Ward, N. K., A. J. Lynch, E. A. Beever, J. Booker, K. L. Bouska, H. Embke, J. N. Houser, J. F. Kocik, J. Kocik, D. J. Lawrence, M. G. Lemon, D. Limpinsel, M. R. Magee, B. M. Maitland, O. McKenna, A. Meier, J. M. Morton, J. D. Muehlbauer, R. Newman, D. C. Oliver, H. M. Rantala, G. G. Sass, A. Shultz, L. M. Thompson, and J. L. Wilkening. 2023. Reimagining large river management using the Resist–Accept–Direct (RAD) framework in the Upper Mississippi River. Ecological Processes 12:48.

Zhou, W., L. R. Leung, and J. Lu. 2021. Seasonally dependent future changes in the US Midwest hydroclimate and extremes. Journal of Climate:1–35.

Submersed plant responses to physical forces of wind, waves, velocity, and shear stress

Previous LTRM project:
Builds off the 2020 SSR 'Ecosystem States Framework' by Danelle Larson & team and our publications (Delaney and Larson 2023a, 2023b, Larson et al. 2023a, 2023c, 2023b, Carhart et al. 2023). The proposal also builds off recommendations of the Resilience Assessment and Habitat Needs Assessment-II (McCain et al. 2018, Bouska et al. 2019). Similar research questions are currently being addressed in the Lower Pool 13 HREP/HARP research area (led by K. Bouska), and our proposal expands those questions to explore the physical force and plant relationships at broader geographic scales and at other HREP areas. We are exploring these relationships and piloting our methods in the Pool 13 HARP area in spring and fall 2024.

Name of Principal Investigator(s):

Danelle Larson, U.S. Geological Survey, UMESC, LTRM Aquatic Vegetation Leadership
Phone: 608-781-6350; Email: dmlarson@usgs.gov
Danelle will be responsible for: project management (budgeting, execution, dissemination), leading response-driver analyses, writing 2 manuscripts, co-lead data management

Jenny Hanson, U.S. Geological Survey, UMESC
Phone: 608-781-6372; Email: jhanson@usgs.gov
Jenny will be responsible for conceptualizing study design, leading acoustic Doppler current profiler (ADCP) field measurements and data processing, and co-leading some data analysis and reports.

Collaborators (Who else is involved in completing the project):

Angus Vaughan, U.S. Geological Survey, UMESC
Email: aavaughan@usgs.gov
Angus will be responsible for conceptualizing study design, assist with ADCP field measurements, QA/QC of ADCP data, and co-leading some data analysis and reports

Jason Rohweder, U.S. Geological Survey, UMESC
Phone: 608-781-6228; Email: jrohweder@usgs.gov
Jason will help conceptualize the study design, model wind and waves, provide map outputs of models, assist with data management, coauthor manuscript.

Colleen Anderson, U.S. Geological Survey, UMESC
Email: canderson@usgs.gov
Colleen will assist with ADCP field measurements and post-processing of ADCP data.

Julia Cogan, U.S. Geological Survey, UMESC
Email: jcogan@usgs.gov
Julia will assist with ADCP field measurement and post-processing of ADCP data.

Nicole Manasco (USACE)
Phone:308-794-5558; Email: Nicole.M.Manasco@usace.army.mil
Nicole will share 2019 ADCP data from Lower Pool 13 study area, collecting ADCP in Pool 19, and connect results to restoration relevance.

Eric Lund, MN DNR, 651-299-4023, eric.lund@state.mn.us
Alicia Carhart, WI DNR, 608-781-6363, Alicia.Carhart@wisconsin.gov
Steph Szura, WI DNR, 608-781-6365, stephanie.szura@wisconsin.gov
Seth Fopma, IA DNR, 563-872-5495, seth.fopma@dnr.iowa.gov
LTRM aquatic vegetation component staff will help with conceptualization and plant data collections.

John Delaney, U.S. Geological Survey, UMESC
Phone: 608-781-6301; Email: jdelaney@usgs.gov
John will assist with data analyses for plant responses to physical forces and co-write manuscripts.

Kristen Bouska, U.S. Geological Survey, UMESC
Phone: 608-781-6344; Email: kbouska@usgs.gov
Kristen will coordinate with the Lower Pool 13 HARP project team and co-write manuscripts.

Introduction/Background:

Wild celery and other submersed aquatic vegetation (SAV) are two distinct, unique, and highly desirable vegetation community types in the UMRS (Devendorf 2013, Larson et al. 2023c). Wild celery is the only aquatic vegetation species that thrives in the open impounded areas upstream of lock and dams, which make up a significant area of canvasback habitat throughout the UMRS and thus is a common restoration focus.

We do not currently have firm understanding of how physical forces like velocity, wind, waves, and shear stress affect SAV and wild celery abundance and resilience. The UMRR has recently invested in addressing these relationships in the Lower Pool 13 HREP study area at the restoration scale and focused on wild celery (Bouska et al. FY24 funded 'HARP research'). Typically, we do not collect these physical variables in our traditional LTRM sampling schemes. Without this understanding, we lack the means to confidently restore SAV or wild celery, especially in desirable areas such as Pools 13–19 (Focal Areas 2.3.8 and 2.3.12). The UMRR-restoration practitioners routinely request quantitative targets for environmental drivers of SAV and wild celery (e.g., water velocity, wind fetch, and water quality) that they can manipulate with HREP design features.

Wild celery has been of long-standing focus on the UMRS, to which significant research and restoration has been devoted since the 1980's and continues today. There are ~15 published works on wild celery within the UMRS, and a few hundred papers outside this system. Research themes in the UMRS included: the quantification of wild celery winter buds as exceptionally important food for water birds like migrating canvasback ducks (Donnermeyer and Smart 1985), the importance of water clarity and light thresholds(Korschgen and Green 1988, Kimber et al. 1995, Kreiling et al. 2007), spatiotemporal changes since 1980 (Bouska et al. 2022, Carhart et al. 2023), and wild celery as a distinct ecological community (Bouska et al. 2022, Larson et al. 2023c). Collectively these studies revealed wild celery is highly valuable wildlife habitat, dynamic through time, responsive to the river environment, and occupies a unique ecological niche compared to the other SAV community type.

The knowledge gaps that cause uncertainties during conservation and HREP planning include the key environmental drivers affecting distribution and abundance of two key community types: SAV and wild celery. We hypothesize both plant community types are significantly affected by the impacts of HREP hydrogeomorphic features on the physical environment like connectivity, wind fetch, wave energy, velocity, and hydrodynamic wakes. Previous work showed wild celery responds to environmental factors such as sediment nitrogen concentrations, depth, light availability, and wind fetch (Kreiling et al. 2007), but we still lack data to address key uncertainties of hydrogeomorphic variables of HREP interest.

<u>Our overarching goal is to accurately identify environmental drivers and responses of submersed aquatic plants to physical forces like wind, waves, velocity, and shear stress.</u> These physical factors are not typically measured in close proximity (in space or time) to LTRM's aquatic plant samples, and so the relationships have not been well-quantified. Better quantification the effects of these environmental drivers on plant distribution and abundance will guide restoration at multiple scales, including at HREP sites, pools, and river reaches throughout the Upper Mississippi River System (UMRS). To accomplish this, we use existing LTRM data, and collect new field data in strategic places across the UMRS. **Our objectives, research questions and focal areas include:**

Objective 1: ***Identifying environmental responses & effects of aquatic plants.***

- What are the ecological responses of submersed aquatic vegetation (SAV) to environmental factors (e.g., velocity, shear stress, roughness, depth, wave and wind fetch), and are there nonlinear/threshold responses indicating management targets? [Focal Area 2.3.1, 2.3.4]
- Are there physical feedbacks that reinforce or undermine the persistence of aquatic vegetation? [Focal Area 2.3.5]

- How do we improve measuring and modeling velocity & shear stress to better associate hydraulic variables with aquatic plants to guide HREP selection, planning, design, and constructions? [Focal Area 2.3.3]
- What is the magnitude and spatial extent that aquatic plants create hydrodynamic wakes that alter velocity and trap sediment downstream of the plants, thereby creating new suitable habitat for aquatic plant bed expansion?

Objective 2: ***Transfer our gained information to places of greatest restoration needs for aquatic plants.***

- What can be learned about physical forces and plants from HREP projects at Big Lake/Robinson Lake (Pool 4) and Lower Pool 13? [Focal Area 2.3.7]
- What are the limitations to aquatic plants in Pools 13–19, and what restoration techniques could re-establish vegetation and increase biomass? Which places in the UMRS are close to thresholds where restoration is most effective? [Focal Area 2.3.12; also relates to Implementation Planning Information Needs "Aquatic Plant Distribution" and "River Gradients--Pool 14 to Pool 25"]

Relevance of research to UMRR:

Abundant SAV and wild celery are defined as foundational goals in the UMRR partnership and some HREPs (e.g., currently Lower Pool 13 HREP, Big Lake and Robinson Lake, Pool 4 HREPs). This study will identify the environmental drivers, feedbacks, and constraints of SAV and wild celery under a large gradient of environmental conditions in the UMRS. We will provide restoration practitioners the ability to learn about constraints at relevant management scales that they can use to prioritize areas for HREPs and address with HREPs. Then, our continued LTRM vegetation monitoring and future research can evaluate actions that expand wild celery abundance and resilience. Our results can guide managers through adaptive management to maintain high quality SAV and wild celery beds or redefine feasible restoration goals.

Describe how the research addresses one or more of the 2024 Focal Areas: This multi-disciplinary work encompasses five major focal area themes, including hydrogeomorphology, aquatic vegetation, water quality, wildlife habitat, and HREPs as learning opportunities (Focal Areas 2.1, 2.3, 2.5, 2.6, and 2.7). Our proposal will effectively cover >70% of the research questions for aquatic vegetation (Focal Area 2.3).

If work involves an HREP, name it: Understanding constraining thresholds and distributional extent of wild celery will be informative to HREP planning and design where goals and objectives involve or otherwise effect wild celery. Patches of SAV or wild celery within the Lower Pool 13 HREP, Phase 1 (Big Lake) and Phase 2 (Robinson Lake) HREPs (of the Lower Pool 4 HREP, and past island HREPs (Pool 8) will be included explicitly in field collection efforts. We are particularly interested in whether the abundant celery beds in Big Lake are affected by the HREP features. In addition, Robinson Lake has existing 2D HEC-RAS models that will allow us an opportunity to evaluate the differences with our proposed ACDP method's 1D velocity outputs. In addition, we will work in Pool 19, which is slated in FY25/26 to become a new, long-term monitoring field station through the LTRM Implementation Planning priorities.

Future Research Opportunities: With foundational information from this proposal, we can later address other priorities in future SSR funding cycles, like: How can we use predictive modeling to better understand where wild celery and SAV are likely to occur under various scenarios of climate, hydrology, and HREP actions (Focal Area 2.3.2)?

Methods:

Our study areas are strategically placed with methods crafted to achieve our two objectives. The study areas will cover two areas per pool, representing different environmental conditions. The study areas combined will average approximately 250 hectares. We will collect data in select areas in Pools 4, 8, and 19. While Pools 4 and 8 study areas will be located within or adjacent to HREPs, the Pool 19 study areas will be selected for areas known for SAV. Will we use the ADCP data collected in Pool 13 HARP project area in 2024 for further data analyses herein.

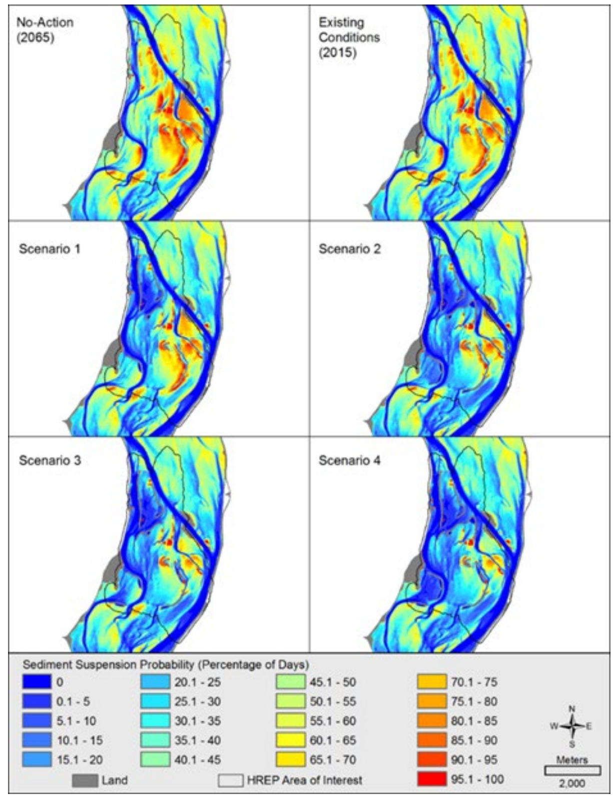


Figure 1. Example of the sediment suspension probability outputs calculated for the Harper's Slough HREP area

For wind and wave models: we will include Pools 4, 8, 13, and the understudied reach of Pool 19. Wind fetch outputs will be calculated for each pool at the pool scale in 10-degree increments (n=36) using the UMRR 2020 land cover data set as an input (see Figure 1 as example). This library of wind fetch measurements will then be used as input to the wave model. Maximum orbital wave velocities, and subsequently sediment suspension probability outputs will be calculated for specific areas of interest within each pool using several input data sources including wind fetch, maximum 2-min average wind speed direction data collected from the nearest National Oceanic and Atmospheric Administration, National Climatic Data Center and modeled water depth based upon UMRR topobathy data. Wind data used will be collected only during the growing seasons. In previous projects where wave characteristics were modeled a static water depth was used. For this project, we propose to modify the wave model tool to be able to generate water depths specific to each day's reported river stage as collected at U.S. Army Corps of Engineers (USACE) gage stations nearest to the specific area of interest. This will greatly increase the accuracy of the model by basing each daily sediment suspension probability output on that day's recorded river stage, and the maximum 2-minute average wind speed and direction recorded at the nearest climatic data collection location. This will allow us to more accurately model wave parameters using a dynamic water depth data source based upon real-time stage data. Previous iterations of this modeling exercise used a static water depth (75% exceedence), but here we are proposing to model water depth based upon the specific day being analyzed by using stage data collected from the nearest gaging station. Because the wave model does not incorporate current velocity into its calculations, only areas in more lentic aquatic area types will be modeled such as contiguous floodplain lake, contiguous floodplain shallow aquatic, contiguous impounded, and isolated floodplain lake. We will relate the LTRM aquatic plant data (including Pool 19 data collected by the LTRM Aquatic Vegetation Component) and the wind and wave data within identified areas of interest.

For the ADCP methods: we will conduct two field efforts to obtain direct measures of hydraulic conditions over the course of the 2025 growing season for each pool. The surveys will occur in early May 2025, prior to peak plant biomass and timed to capture higher flow conditions during plant germination and growth. The USGS will resurvey the same patches after the plants senesce/die back (autumn 2025) to capture different discharge conditions to detect changes in both near-bed velocities and hydrodynamic wakes after the growing season. Due to likely interference of dense leaves or dense SAV patches on ADCP measurements, analyses may reflect such interference.

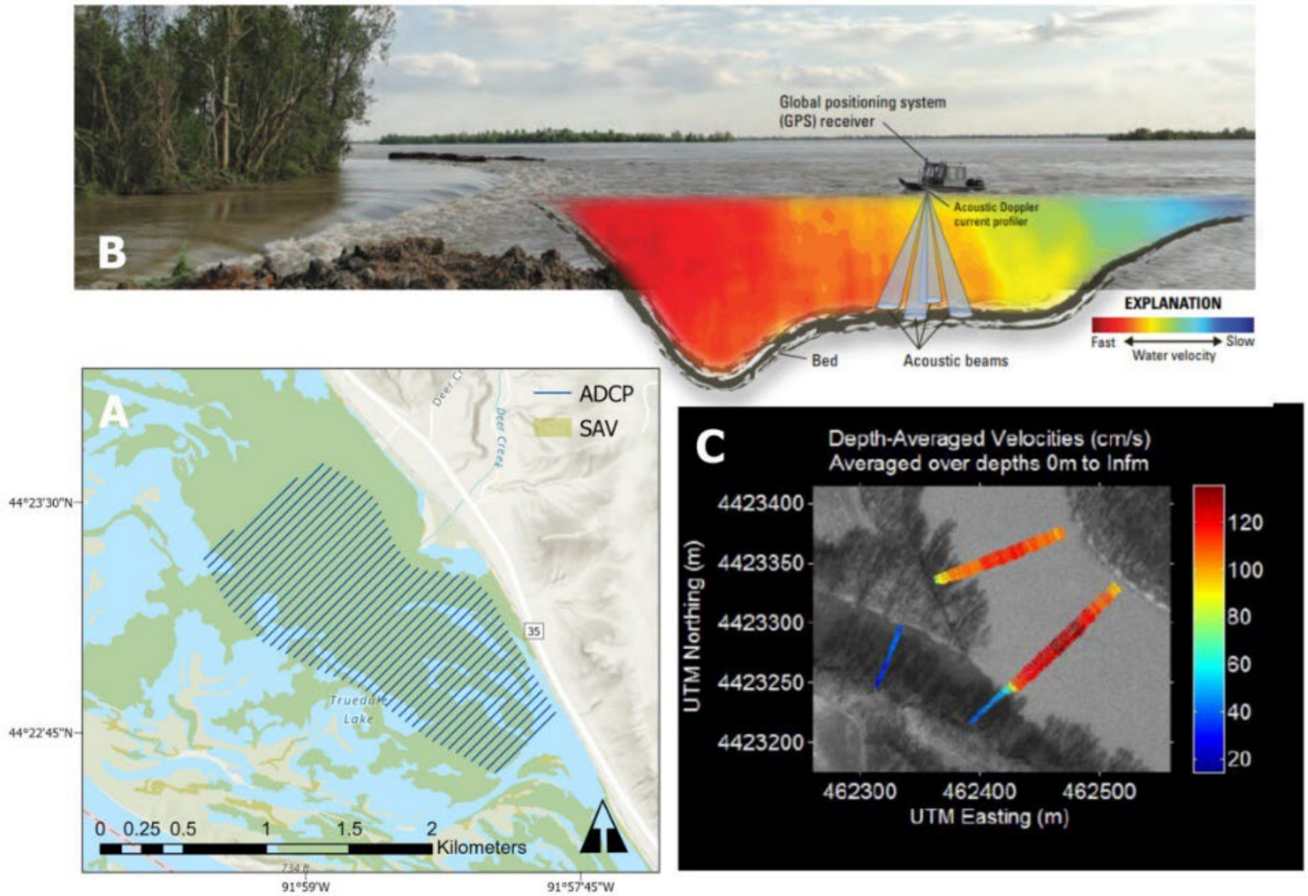


Fig. 2. Pool 4 Big Lake HREP example of 50-m spaced ADCP transects (A); Schematic of moving-boat ADCP measurement (credit: Jackson, 2013, B); Example of depth averaged velocities (credit: Engel and Jackson, 2017, C).

A SonTek M9 ADCP system designed to directly measure river discharge will be used to measure 3-dimensional water currents and depths from a moving watercraft for two targeted areas containing SAV patches in our study areas of Pools 4, 8, 13, and 19. Transects will be oriented perpendicular to flow and spaced ~ 50 m apart, encompassing the footprint of targeted SAV patches as well as additional distance upstream, laterally, and downstream. This sampling design will allow us to capture a gradient of hydraulic forces spanning suitable conditions in the SAV patches to potentially unsuitable conditions outside the patches and to estimate the hydrodynamic wake associated with each targeted patch (Fig. 2). The SonTek M9 has two sets of velocity measurement transducers – four 3.0-MHz transducers and four 1.0-MHz transducers, and a 0.5-MHz vertical acoustic beam for depth data, and is combined with RiverSurveyor®, a software package which selects the optimum processing configuration.

We will use the Velocity Mapping Toolbox to process and visualize the ADCP data obtained along our study transects. From the raw ADCP data, VMT can output vertical beam bed depth, backscatter strength, vertically averaged and near-bed velocity magnitudes, and estimates of shear velocity and roughness length from which bed shear stress can be computed.

For sampling aquatic plant and other habitat variables, we will sample plants following the first ADCP sampling period and during peak plant biomass in mid- to late August 2025. The LTRM aquatic vegetation component team will assess aquatic plant prevalence and species composition in each study area using the LTRM rake methods (Yin et al. 2000). In addition, we will record substrate type and turbidity as these are known environmental drivers of SAV and wild celery and can be used as model covariates to improve parameter estimates of the physical forces we are focused on (Delaney and Larson 2023a, Larson et al. 2023c).

For data analyses, we will run regressions and community distribution models. The modeling approach will focus on understanding the species (i.e., wild celery as this species is typically in monoculture; Larson et al. 2023c) and taxonomic (i.e., the rest of the SAV community) responses to environmental gradients that will include regression techniques that utilize best practices for understanding species environmental relationships such as Shapley values (e.g., Delaney and Larson 2023a, b), shape-constrained generalized additive models (e.g., Delaney et al. in prep), or others. The modeling approach will be determined by exploratory data analyses such as oridination techniques, density plots, and interaction analyses. We will test regression assumptions and correct if violations occur. We will report parameter estimates, magnitude of effects, *p*-values, and cross-reference existing literature for determining ecological significance (Wasserstein et al. 2019).

For the SAV community type, we will run two types of analyses: (1) a regression analysis with SAV as the sole response variable, with procedures described previously for wild celery; and an ecological community analysis; for example, a 'Threshold Indicator Taxa Analysis-TITAN' for community/multi-species distribution responses. We will use the community analysis to detect changes in many SAV species distributions across gradients including velocity, turbidity, and shear stress. We will also use TITAN to detect threshold responses of wild celery in context of other SAV species because this community-approach will approximate at what velocity conditions wild celery may become outcompeted by other SAV, like coontail, following island construction or other HREP features that affect velocity (Carhart and De Jager 2019).

To address the third point of objective 1 (improving measurement and modeling of hydraulic variables and their association with aquatic plants for guiding HREPs) we will evaluate two potential approaches for obtaining system-wide velocity estimates and compare them against our high-quality field ADCP measurements. The two approaches to be evaluated will be geospatial interpolations of velocity measurements obtained during LTRM sampling and modeled velocities from existing systemwide HEC-RAS hydrodynamic models developed by USACE.

For HEC-RAS models*:* USACE has recently developed existing conditions HEC-RAS hydrodynamic models throughout the UMRS (USACE 2020a, 2020b). The models are hybrid 1D-2D models, with higher resolution 2D representation in areas behind levees or with complex flow patterns. Flow simulations were developed for unsteady flow conditions during 3-4 historic flood events (2001, 2014, and 2019 for Pools 1-19 and additionally 2008 for Pools 11-19). These models estimate spatially explicit, vertically-averaged flow velocities throughout the UMRS across the range of flows observed during the modeled events, and therefore have the potential to provide estimates of SAV habitat suitability across a large spatial extent based on any potential velocity thresholds discovered in this study. However, the models were developed primarily for flood risk management rather than ecological studies, so it is unclear whether their spatial scale is fine enough to provide information suitable for predicting SAV habitat suitability, particularly in areas of 1D representation. Our ADCP transects in Robinson Lake, Pool 4, will overlap existing 2D modeled areas and therefore provide an opportunity for assessing the applicability of the existing HEC-RAS models for estimating velocity gradients relevant to aquatic habitat. We will compare ADCP-measured vertically-averaged flow velocities with modeled velocities at similar discharge conditions across our study transects, computing error at 5m point spacing across each transect. We will report error statistics stratified by high vs. low flow condition; 1D vs 2D model representation; and for 1D areas, by whether the ADCP transect coincides with a model cross-section or not. This analysis will enable us to make recommendations on whether, where, and under what conditions the existing hydrodynamic models may be appropriate for addressing ecological questions such as aquatic vegetation habitat suitability.

For velocity interpolation models: Previous velocity analyses exemplify the ongoing need for advanced, 2-dimensional surface maps of velocity and integration with wild celery data to better understand relationships to velocity and create HREP target conditions (Yin and Rogala unpub. LTRM Report 2013A8, Larson et al. 2023c). We will first construct interpolated velocity surface maps for select reaches within Pools 4, 8, and 13 using all velocity measured during LTRM sampling in those areas. We will model velocity at multiple levels of relative discharge (low, moderate, and high) using exceedance probabilities and sample size distributions. We will interpolate velocity using several robust methods available in the ArcGIS spatial analyst toolbox (e.g., inverse distance weighted, kriging, nearest neighbor, spline with and without land barriers) and using different combinations of potentially critical input parameters that are unique to each toolset (e.g., number of input sites, distance limitations, land barriers, and masking layers). Additionally, each of the velocity data sets collected by LTRM water quality, fish and aquatic vegetation sampling will necessarily be examined separately, owing to disparate resolution of sampling locations across the three components. The resulting output of the different ArcGIS tools and input parameters will be evaluated using the methods and analysis scripts developed by Larson et al. (2023b). We will report and map the top-performing method based on cross-validation and the smallest mean absolute error, as well as based on the smallest error relative to ADCP-measured velocities at similar discharge conditions. Finally, we will publish the methods and the output velocity surface maps of Pools 4, 8 and 13 (in GIS-compatabile vector or faster format) for public use and other UMRR applications, such as relationships of velocity to other plants, fish, hydrogeomorphic processes, and HREP planning.

Data management procedures: Our manipulated data files and analyses script will be shared via ScienceBase.

Special needs/considerations, if any: None but thank you.

Budget: ~ $267,822. Please see budget spreadsheet attached.

Timeline: We will begin the project in October 2024 (FY25). All data are planned for collection in 2025; however, we will finish data collection in 2026 if river discharge hinders safe field sampling in 2025. We will submit all products for internal review before or by 31 September 2027.

Task	Completion Date	Task Leads
Collect ACDP data, spring 2025	Spring 2025	Hanson & Team
Collect plant and other habitat data, summer 2025	Summer 2025	LTRM Aquatic Veg. Component
Collect ACDP data (repeated sampling), fall 2025	Fall 2025	Hanson & Team
Process ADCP data	Winter 2025	Hanson & Team
Wind model (Pools 4, 8, 13, and 19)	Winter 2025	Rohweder
Wave model (Pools 4, 8, 13, and 19)	Winter 2025	Rohweder
Velocity interpolations (Pools 4, 8 and 13)	Winter 2025	Lund
Velocity interpolation comparisons	Winter 2026	Lund
Velocity methods (1D vs 2D hydraulics) comparisons	Winter 2026	Vaughan
Data releases	Winter 2026	Larson, Rohweder, Vaughan, Lund, and Hanson
Manuscripts to IPDS for internal review	Fall 2027	Larson and coauthors

Expected milestones and products [with completion dates]:

*All our products will first be sent to the LTRM Science Director, and then undergo review through USGS per Fundamental Science Practices policy. All data will be preserved and publicly available through ScienceBase and the LTRM website.

- Data release: ACDP and plant data (Completion: Winter 2025)
- Data release: wind model (Completion: Winter 2025)
- Data release: wave model (Completion: Winter 2025)
- Data release: wind and wave base layers (Completion: Winter 2025)
- Spatial Data release: wind and wave base layer options for HREP's project databases for Pool 4 and Pool 13 (Completion: Winter 2025)
- Velocity interpolation surface maps (Completion: Winter 2026)
- Manuscript: relationships of plant communities to wind and waves (Completion: Fall 2026)
- Manuscript: relationships to plant communities to velocity, depth, and shear stress (Completion: Fall 2026)

Acknowledgements: We thank the participants at the UMRR2024 Science Meeting for inspiring ideas herein. We are very grateful to Davi Michl (USACE), Jeff Houser (USGS), and Marissa Borre (USGS) for providing thoughtful proposal comments.

References

Bouska, K. L., J. N. Houser, N. R. De Jager, M. Van Appledorn, and J. T. Rogala. 2019. Applying concepts of general resilience to large river ecosystems: A case study from the Upper Mississippi and Illinois rivers. Ecological Indicators 101:1094–1110.

Bouska, K. L., D. M. Larson, D. C. Drake, E. M. Lund, A. M. Carhart, and K. R. Bales. 2022. Aquatic vegetation dynamics in the Upper Mississippi River over 2 decades spanning vegetation recovery. Freshwater Science 41:33–44.

Carhart, A. M., and N. R. De Jager. 2019. Spatial and temporal changes in species composition of submersed aquatic vegetation reveal effects of river restoration. Restoration Ecology 27:672–682.

Carhart, A. M., J. J. Rohweder, and D. M. Larson. 2023. 22 Years of Aquatic Plant Spatiotemporal Dynamics in the Upper Mississippi River. Diversity 15.

Delaney, J. T., and D. M. Larson. 2023a. Using explainable machine learning methods to evaluate vulnerability and restoration potential of ecosystem state transitions. Conservation Biology 1–13.

Delaney, J. T., and D. M. Larson. 2023b. Online, interactive dashboard: Submersed plants vulnerability evaluation tool for assessing plant resilience, risk of loss, and high restoration potential. Https://rconnect.usgs.gov/SAVVEA/.

Devendorf, R. D. 2013. A migratory habitat model for diving ducks using the Upper Mississippi River. Pages 1–0. U.S. Army Corps of Engineers, St. Paul District.

Donnermeyer, G., and M. Smart. 1985. The biomass and nutritive potential of Vallisneria americana Michx in navigation pool 9 of the upper Mississippi river. Aquatic Botany 22:33–44.

Kimber, A., C. E. Korschgen, and A. G. Van Der Valk. 1995. The distribution of Vallisneria americana seeds and seedling light requirements in the Upper Mississippi River. Canadian Journal of Botany 73:1966–1973.

Korschgen, C., and W. Green. 1988. American wildcelery (Vallisneria Americana): Ecological considerations for restoration. Technical Report 19. U.S. Department of Interior, Fish and Wildlife Service, Washington, DC.

Kreiling, R. M., Y. Yin, and D. T. Gerber. 2007. Abiotic influences on the biomass of Vallisneria americana Michx. In the Upper Mississippi River. River Research and Applications 23:343–349.

Larson, D. M., W. Bungula, A. Lee, A. Stockdill, C. McKean, F. “Forrest” Miller, K. Davis, R. A. Erickson, and E. Hlavacek. 2023a. Reconstructing missing data by comparing interpolation techniques: Applications for long-term water quality data. Limnology and Oceanography: Methods 21:435–449.

Larson, D. M., W. Bungula, C. McKean, A. Stockdill, A. Lee, F. F. Miller, and K. Davis. 2023b. Quantifying ecosystem states and state transitions of the Upper Mississippi River System using topological data analysis. PLoS computational biology 19:e1011147.

Larson, D. M., A. Carhart, and E. Lund. 2023c. Aquatic vegetation types identified during early and late phases of vegetation recovery in the Upper Mississippi River. Ecosphere 14:e4468.

McCain, K., S. Schmueker, and N. De Jager. 2018. Habitat Needs Assessment - II : Linking Science to Management Perspectives. U.S. Army Corps of Engineers, Rock Island, IL.

USACE (U.S. Army Corps of Engineers). 2020a. Upper Mississippi River Phase II flood risk management existing conditions hydraulic model documentation report. 20 pp.

USACE (U.S. Army Corps of Engineers). 2020b. Upper Mississippi River Phase IV flood risk management existing conditions hydraulic model documentation report. 23 pp.

Wasserstein, R. L., A. L. Schirm, and N. A. Lazar. 2019. Moving to a World Beyond “p <0.05.” American Statistician 73:1–19.

Yin, Y., J. S. Winkelman, and H. A. Langrehr. 2000. Long Term Resource Monitoring Program Procedures: Aquatic vegetation monitoring. LTRMP 95-P002-7. Pages 1–8. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin.

In-depth characterization of phytoplankton communities and toxicity across connectivity gradients along 450 miles of the Upper Mississippi River System

Previous LTRM project:
This project will collect additional samples during summer 2024 associated with the "Filling in the gaps with FLAMe: Spatial patterns in water quality and cyanobacteria across connectivity gradients and flow regimes in the Lower Impounded Reach of the Upper Mississippi River"

This project provides additional information not included in but complementary to "Putting LTRM's long-term phytoplankton archive to work to understand ecosystem transitions and improve methodological approaches"

Name of Principal Investigator(s):
Luke Loken

- Hydrologist, USGS Upper Midwest Water Science Center; 1 Gifford Pinchot Drive, Madison, WI 53726, lloken@usgs.gov
- Project management, field coordination, data management and analysis

Rebecca Kreiling

- Research Ecologist, USGS Upper Midwest Environmental Sciences Center; 2630 Fanta Reed Rd, La Crosse, WI 54603, rkreiling@usgs.gov
- Project management, oversee budget, supervise support staff, writing, data analysis, assist with data management.

Kathi Jo Jankowski

- Research Ecologist, USGS Upper Midwest Environmental Sciences Center; 2630 Fanta Reed Rd, La Crosse, WI 54603, kjankowski@usgs.gov
- Coordinate sampling design, project management, communication/integration with LTRM/UMRR staff, writing, data analysis.

James Larson,

- Research Ecologist, USGS Upper Midwest Environmental Sciences Center 2630 Fanta Reed Rd, La Crosse, WI 54603; jhlarson@usgs.gov;
- Assist with interpretation and analysis of phytoplankton community data and methods comparison

Collaborators (Who else is involved in completing the project):

LTRM Lower Trophic Level Specialist; USGS UMESC; use data generated to evaluate methods and sampling design for phytoplankton analysis

Sophia Lafond-Hudson, USGS Upper Midwest Water Science Center; leading FLAMe project logistics and data analysis; collection of phytoplankton samples

Kenna Gierke, USGS UMESC: collection of water samples; processing FlowCam samples

Carrie Givens, USGS Upper Midwest Water Science Center; DNA analysis of phytoplankton and cyanobacteria communities; data analysis and writing.

Hayley Olds, USGS Upper Midwest Water Science Center; cyanotoxin analysis; data analysis and writing.

Leon Katona, USGS Upper Midwest Water Science Center; data interpretation, analysis and writing.

Introduction/Background: Phytoplankton community dynamics in river systems are complex, yet they are critical aspects of primary productivition and water quality, and they can be used as indicators of ecosystem response to change. In freshwaters experiencing perturbations, phytoplankton may play a disproportionately large and overlooked role for ecosystem stability and be an indicator of change, since they are a foundational link among trophic levels (Bertani et al. 2016). Climate change, invasions of novel species, and land use stressors interact to directly and indirectly alter phytoplankton communities and may promote increased frequency, severity, and toxicity of harmful algal blooms (HAB; Paerl and Huisman 2008; Michalak et al. 2013; Glibert 2017).

Previous work in the UMRS has shown that phytoplankton community composition varies longitudinally (Manier et al. 2021, Reavie et al. 2011) and across connectivity gradients (Manier et al. 2021, Decker et al. 2012, Giblin et al. 2022). While diatoms and green algae are relatively abundant throughout the main channel, backwater and impounded areas typically differ in algal composition (Manier et al. 2021). Cyanobacteria, including potentially toxic genera, appear to most abundant in off-channel areas (Giblin et al. 2022), but not always (Manier et al. 2021). In general, studies of phytoplankton community composition in rivers have often been limited in temporal, horizontal, and vertical scales. Studies in the UMRS have primarily focused on the upper impounded reach and broadly across aquatic areas categorized as “backwater” or “main channel,” which have not provided fine-scale information on how phytoplankton communities vary as a continuous function of their connection to the main channel. Further, community information has largely been collected upriver of major tributaries with elevated nutrient loads (e.g., Iowa, Des Moines, Illinois Rivers), and thus in locations less prone to HAB formation. While evidence supports multiple chemical and physical drivers promoting HAB formation (Burford et al. 2020), research on this topic is rapidly expanding given the increased awareness of HAB globally (Ho et al. 2019). Many phytoplankton communities associated with HAB events include potentially toxic species (Manier et al. 2021; Giblin et al. 2020, 2022), but our understanding of where, when, and under what conditions those species occur is limited.

As part of the previously UMRR-funded FLAMe project (Fast Limnological Automated Meaurements), we have an opportunity to gather additional information on phytoplankton communities, HAB potential, and cyanotoxins in areas of the UMRS where there is limited phytoplankton community data. Specifically, the project focuses on a gap in LTRM monitoring between Pools 13 and 26, where water quality and aspects of phytoplankton dynamics will be assessed longitudinally from Pools 10 to 26 and across ~50 connectivity gradients from the main channel to backwaters during summer 2024. This one-time sampling campaign provides us with a unique opportunity to build on our understanding of phytoplankton community dynamics and HAB formation in the UMRS across a vast, data-poor extent of the river. Detailed data on phytoplankton community assembles and cyanotoxins will be paired with high spatial resolution information on multiple dimensions of water quality (temperature, oxygen, nutrients, turbidity, etc) to provide a better understanding of physical and chemical drivers of HAB formation in the UMRS.

To date, LTRM phytoplankton community composition has primarily been generated using traditional microscopy methods (Giblin et al. 2020; Manier et al. 2021; Burdis et al, in prep). In recent years, there have been many developments in the methods used to assess phytoplankton communities. in recent years. While traditional microscopy provides valuable and reliable information, it can be time intensive and costly, making it difficult to assess the complexities of phytoplankton dynamics in complex systems. New analytical approaches include automated imaging techniques (e.g., FlowCam) and multiple molecular approaches providing valuable information on community assemblages, including characterization of the genetic diversity of phytoplankton and cyanobacteria communities and the potential to produce cyanotoxins. Further, there is increasing concern about the potential for harmful cyanotoxins to occur in river ecosystems, but there are limited data to assess and map the risks (Graham et al.2020, Giblin et al. 2022, UMRBA). The production of toxins is extremely variable in time and space and can vary among and within species. For instance, simply because species are present, does not necessarily translate into potential harm. Modern approaches using genetic analysis of cyanobacterial communities can not only identify the presence of toxic strains but also quantify the presence of toxin-producing genes in the community. Another challenge for monitoring HABs and cyanotoxins is that the occurrence of these compounds are often highly variable both spatially and temporally, not always persistent, and can be moved easily by wind- and flow-driven currents. Thus, discrete sampling alone can often result in missing or underestimating cyanotoxin presence. The use of Solid Phase Adsorption Toxin Tracking (SPATT) passive samplers helps address this issue by providing a temporally integrated, time-weighted average, estimate of dissolved cyanotoxin concentrations (Kudela, 2017; Roué et al., 2018). SPATT samplers are an innovative passive sampling device, often used as a complement to traditional discrete water sampling for measuring cyanotoxins. SPATT samplers have detected cyanotoxins when simultaneous discrete samples have failed to detect the same toxins, and exhibits more sensitivity compared with discrete samples (Lane et al., 2010; Kudela, 2011). Collectively these approaches provide in-depth understanding of drivers of phytoplankton community dyanamics, the potential for harmful species to occur, and toxin production.

Therefore, we propose to collect and analyze additional samples for microscopy, genetics, and cyanotoxins as part of an existing field campaign in summer 2024.

Relevance of research to UMRR:
Excessive nutrient inputs, eutrophication, and HABs are potential threats to the success of restoration projects, but there are gaps in our understanding of how they vary among and within reaches of the UMRS.

A need for further understanding of "lower trophic level" communities has been identified as part of the LTRM Implementation Planning process, which includes revisiting the design of how LTRM water quality teams collect phytoplankton information. This proposed work would provide useful information for that effort through collecting a high density of spatially resolved information on phytoplankton communities in areas of the river with limited sampling to date that are potentially prone to HAB formation due to elevated nutrient loads, proximity to tributary sources, and/or with increased water residence time. The proposed work will also provide information on the utility of data generated from multiple methods of phytoplankton characterization (chlorophyll, microscopy, qPCR, and cyanotoxin analysis). This information can inform future decisions on design and sample analysis for characterizing UMRS phytoplankton communities as well as provide multiple pieces of information regarding the toxin-production potential of phytoplankton communities and presence/extent of cyanotoxins across important environmental gradients in the UMRS. These data complement information that LTRM gains from existing funds for microscopic analysis of phytoplankton from archived samples in the following ways: 1) providing overlapping information from multiple techniques to validate and deepen our understanding of phytoplankton and cyanobacterial communities, and 2) generating novel and management-relevant information on the genetic potential for toxin-production as well as concentrations of the toxins themselves.

Focal Areas: Focal area 2.5 Consequences of river eutrophication and water quality for critical biogeochemical processing rates and habitat conditions; Focal area 2.7. Learning from Restoration; Focal area 2.8: River gradients – Pools 14 through 25

Methods:

<u>Snapshot of phytoplankton community composition during two-week boat survey</u>
As part of the LTRM-funded FLAMe research study, there will be a two-week boat survey from Pool 10 to Pool 26 during conditions favorable for elevated phytoplankton densities (July/Aug 2024). The boat and crew will be mapping water quality along this 450 river mile stretch and collecting samples at ~76 sites, comparing water quality among the main channel, tributaries, and off-channel habitats. By sampling broadly across the Mississippi River, off-channel areas will naturally vary in their input chemistry based on longitudinal variation in main channel chemistry. Off-channel areas will also vary in their connectivitiy to the main channel and proximity to tributary sources allowing us to evaluate how multiple physical and chemical drivers influence water quality. The crew will be measuring bulk chlorophyll and sensor-based measurements of chlorophyll and phycocyanin fluorescence to document variation in phytoplankton and cyanobacteria occurrence across river habitats. These metrics provide an understanding of total amount of phytoplankton, but do not provide information about which species are present, their relative abundances, and their potential toxicity.

Here, we propose to collect additional samples during this one-time sampling campaign for in-depth phytoplankton and cyanobacteria community characterization, comparison and assessment of cyanotoxin-production potential, and cyanotoxin analysis (Table 1). Additional samples will include multiple approaches to characterizing the phytoplankton community composition including phytoplankton community analysis based on FlowCam (analyzed at UMESC), community composition based on microscopy (analyzed by BSA Environmental). In addition, we will pair these with more direct, quantitative measurements for cyanobacterial relative abundance and toxin-production potential through doing qPCR analysis targeting the Cyanobacteria 16S rRNA and cyanotoxin-production genes for microcystin, cylindrospermopsin, and saxitoxin (*mcy*E, *cyr*A, and *sxt*A). Lastly, we will quantify concentrations of four cyanotoxins (microcystin, cylindrospermopsin, saxitoxin, and anatoxin-a) using discrete samples and SPATT passive samplers using enzyme-linked immunosorbant assays (ELISA; analyzed by USGS – Milwaukee). SPATTs will be integrated into the boat's continuous flow-through sampling system, allowing for an integrated water sample over space and time, allowing for lower detection levels and broader scale surveillence of potential toxicity across the river. Combining cyanobacteria cell abundance, quantification of cyanotoxin-genes, measured cyanotoxins, chlorophyll-*a*, and other environmental variables improves system understanding of the relation between the phytoplankton and cyanobacteria community composition ("who's there?", "how many?", and "how harmful") and respective community shifts with environmental variability and influence.

Phytoplankton characterization will be interpreted along with FLAMe data and nutrient analyses, to better understand the chemical and physical drivers associated with different communities of potentially harmful algae. The FLAMe project will be analyzing surface water samples for nutrient analyses to understand biogeochemical processes, which will aid in evaluating drivers of phytoplankton abundance. Rarely do studies have this extent of overlapping information on phytoplankton communities, toxins and environmental conditions, thus this provides a unique opportunity to greatly enhance our understanding of the potential for harmful and toxic blooms to occur in the UMRS.

Approach	Information generated	Proposal	Limitations	Advantages
Chlorophyll a – fluorescence	Continuous index of algal abundance	FLAMe	Environmental interference. Needs field veritifcation.	Continuous and instanteous data
Chlorophyll a – lab extraction	Discrete index of algal abundance	FLAMe	No information about community composition. Discrete sampling locations	Easy, standard lab method, inexpensive
Microscope ID	Visual-based assessment of community composition; abundance and biovolume	This proposal	Time and labor intensive; no picoplankton or strain information	Well-established; information about genus/species composition
FlowCam Imaging	Visual, but automated assessment of community composition; abundance and biovolume	FLAMe	Libraries in development; limited to visual characterization which makes identification challenging in some cases; turbidity and detritus interference	Fast, automated approach to identify communities; storage of data and imagery for future analysis
qPCR	Abundance of cyanobacteria identification and cyanotoxin producing genes	This proposal	Not full community analysis	Provides information on whether potential for toxin production exists in community
SPATT sampler and ELISA cyanotoxin analysis	Integrated sample of cyanotoxin concentration	This proposal	Cyanotoxin information not specific to a point location, rather an integrated sample across a pool. SPATT results are not directly comparable to water concentrations and are generally interpreted as prescence/absence of targeted cyanotoxins.	Integrated information on cyanotoxin concentration across a given spatial area. More representative look at the occurrence of cyanotoxins.
ELISA cyanotoxin analysis of discrete water samples	Cyanotoxin concentrations in water	This proposal	Discrete cyanotoxin water samples may fail to detect	Cyanotoxin concentrations in water can

			all cyanotoxins present in an area.	be compared to water quality standards to better assess potential health risk

Data management procedures:

All FlowCam imagery will be archived at UMESC. All phytoplankton community and cyanotoxin data will be published on USGS ScienceBase.

.

Special needs/considerations, if any: Samples will be collected during the FLAMe study starting in late July 2024, but no funds are currently allocated to processing the samples once collected.

Budget:

Boat survey, water quality and fluorescence analyses	($46,574 in kind)
USGS stafftime	($35,000, 360 hours in kind)
Phytoplankton FlowCam and microscopy	$66,049
qPCR for cyanotoxin genes	$38,328
Cyanotoxins at discrete sites and integrated across habitats	$131,933
Total need	**$236,310**

Timeline:

- Spatial survey of water quality — Jul – Aug 2024
- FlowCam phytoplankton sample processing and identification — Aug 2024 – May 2025
- Microscopic analysis samples — Jan 2025 – Dec 2025
- Genetic analysis of phytoplankton samples — Aug 2024 – Nov 2025
- Cyanotoxin analysis — Nov 2024 – Nov 2025
- Annual report — Oct 2025
- Data analysis and publication — Oct 2025 – Sep 2026

Expected milestones and products [with completion dates]:

- Data release with phytoplankton community and cyanotoxin data (Nov 2025)
- Data will be delivered to new LTRM hire for use in developing sampling plans and strategies (Nov 2025)
- Publication evaluating community change across connectivity gradients during peak-bloom conditions across 450 river miles of the Mississippi River (Sep 2026).

All draft reports, publications, and manuscripts should be submitted to the UMRR LTRM Science Director, Jeff Houser (jhouser@usgs.gov), before journal submission or USGS internal review (if applicable). Products with USGS authors must undergo formal USGS review including data review. LTRM Reports (Completion, Technical, Program) with non-USGS authors must undergo formal USGS review including data review.

References

Bertani, I., R. Primicerio, and G. Rossetti. 2016. Extreme Climatic Event Triggers a Lake Regime Shift that Propagates Across Multiple Trophic Levels. Ecosystems 19: 16–31. doi:10.1007/s10021-015-9914-5.

Burford, M.A., C.C Carey, D.P. Hamilton, J. Huisman, H.W Paerl, S.A Wood, A. Wulff. 2020. Advancing the research agenda for improving understanding of cyanobacteria in a future of global change. Harmful Algae 91.

Decker, J. K. 2012. Nutrient controls on phytoplankton composition and ecological functions among hydrologically distinct habitats in the upper Mississippi River. (Unpublished doctoral dissertation). Fordham University, New York, NY.

De Jager, N.R., J. T. Rogala, J. J. Rohweder, M. Van Appledorn, K. L. Bouska, J. N. Houser, and K. J. Jankowski. 2018. Indicators of ecosystem structure and function for the Upper Mississippi River System: U.S. Geological Survey Open-File Report 2018–1143, 115 p., https://doi.org/10.3133/ofr20181143

Giblin, S. M., and G. A. Gerrish. 2020. Environmental factors controlling phytoplankton dynamics in a large floodplain river with emphasis on cyanobacteria. River Res. Appl. 36: 1137-1150. Doi:10.1002/rra.3658.

Giblin, S. M., J. H. Larson, and J. D. King. 2022. Environmental drivers of cyanobacterial abundance and cyanotoxin production in backwaters of the Upper Mississippi River. River Res. Appl. 38: 1115-1128. Doi:10.1002/rra.3987

Glibert, P. M. 2017. Eutrophication, harmful algae and biodiversity — Challenging paradigms in a world of complex nutrient changes. Mar. Pollut. Bull. 124: 591–606. doi:10.1016/j.marpolbul.2017.04.027.

Graham et al., 2020, Cyanotoxin occurrence in large rivers of the United States, Inland Waters, 10:1, 109-117, DOI:10.1080/20442041.2019.1700749

Ho JC, Michalak AM, Pahlevan N (2019) Widespread global increase in intense lake phytoplankton blooms since the 1980s. Nature. doi: 10.1038/s41586-019-1648-7

Kudela, R. M. 2011. Characterization and deployment of Solid Phase Adsorption Toxin Tracking (SPATT) resin for monitoring of microcystins in fresh and saltwater. Harmful Algae 11, 117–125. doi: 10.1016/j.hal.2011.08.006.

Kudela, R. M. 2017. "Passive Sampling for Freshwater and Marine Algal Toxins," in Comprehensive Analytical Chemistry (Elsevier), 379–409. doi: 10.1016/bs.coac.2017.08.006.

Lane, J. Q., Roddam, C. M., Langlois, G. W., and Kudela, R. M. 2010. Application of Solid Phase Adsorption Toxin Tracking (SPATT) for field detection of the hydrophilic phycotoxins domoic acid and saxitoxin in coastal California: SPATT for field detection of domoic acid. Limnology and Oceanography: Methods 8, 645–660. doi: 10.4319/lom.2010.8.0645.

Manier, J. T., R. J. Haro, J. N. Houser, and E. A. Strauss. 2021. Spatial and temporal dynamics of phytoplankton assemblages in the upper Mississippi River. River Res. Appl. 37: 1451–1462. doi:10.1002/rra.3852.

Michalak, A. M., E. J. Anderson, D. Beletsky, and others. 2013. Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions. Proc. Natl. Acad. Sci. U. S. A. 110: 6448–52. Doi:10.1073/pnas.1216006110.

Paerl, H. W., and J. Huisman. 2008. Climate. Blooms like it hot. Science 320: 57–8. doi:10.1126/science.1155398.

Roué, M., Darius, H. T., and Chinain, M. 2018. Solid Phase Adsorption Toxin Tracking (SPATT) Technology for the Monitoring of Aquatic Toxins: A Review. *Toxins* 10, 167. doi: 10.3390/toxins10040167.

Hindcasting and forecasting abiotic drivers of UMRS fish populations and advancing management and research tools for non-game fishes

Previous LTRM project: This project will use data and draw inferences from previous science and support projects, including the vital rates of UMR fishes project, relying on ~20,000 age estimates and resulting indices of growth, recruitment, and mortality from 13 focal species representing unique trophic and reproductive guilds. A comprehensive report to synthesize the age estimates, otolith microchemistry, and population genomics is currently in development with completion expected in the next 6-12 months. The proposed project will also leverage age and length-based indices from complementary monitoring programs on the UMR and Illinois River (Multi-agency monitoring, IL Long-term electrofishing program, IA DNR standardized electrofishing).

Name of Principal Investigator(s):

Brian S. Ickes, USGS-UMESC, bickes@usgs.gov; co-PI, project management (all data responsibilities)
James T. Lamer, INHS-IRBS, lamer@illinois.edu; co-PI, project management

Collaborators (Who else is involved in completing the project):

Rebecca Krogman (rebecca.krogman@dnr.iowa,gov), Kris Maxson, INHS, Havana, kmaxs87@illinois.edu; Michael Spear, INHS, Havana, mspear2@illinois.edu, assisting with R Shiny app development; Andrew Glen, MDoC, andrew.glen@mdc.mo.gov; Charmayne Anderson, MDNR, charmayne.anderson@state.mn.us; Ben Patschull, WDNR, bpatschull@contractor.usgs.gov; Andy Bartels, WDNR, abartels@contractor.usgs.gov; Kristina Pechacek, WDNR,kristina.pechacek@wisconsin.gov; in kind proposal development, literature review, data assembly and Q/A, report and manuscript preparations. D*aniel Gibson-Reinemer, USGS-UMESC, dgibson-reinemer@usgs.gov; in kind abiotic data modeling, writing, and manuscript preparations. Lake City, MN and Alton, IL field station staff (various); in kind literature review and assembly. Kristen Bouska, USGS-UMESC, kbouska@usgs.gov; in kind assistance sharing R code for vital rates, abiotic hypothesis generation, and manuscript preparation.*

Introduction/Background:

The Upper Mississippi River System (UMRS) is a complex ecosystem encompassing a diverse array of habitats that support a rich assemblage of fish species. Therefore, the dynamic rate functions and fish community structure in the UMRS are likely influenced by a multitude of biotic and abiotic factors. Understanding the dynamics of these populations and their responses to environmental drivers is crucial for effective management and conservation efforts.

Abiotic factors such as hydrology, temperature, and geomorphology play pivotal roles in shaping fish habitat suitability, reproductive success, and overall population dynamics. For example, variations in river flow patterns can impact spawning cues, larval drift, and habitat connectivity for migratory species (Forsythe et al. 2012; Tornabene et al. 2020). Similarly, fluctuations in water temperature can influence growth rates, metabolic activity, and the distribution of thermally-sensitive species (Lemons and Crawshaw 1985; Johnson et al. 1998; Stocks et al. 2021; Hansen et al. 2023).

Over the past several decades, the UMRS has experienced significant alterations in its hydrological regime due to anthropogenic activities such as dam construction, channelization, and land-use changes (Houser et al. 2022). These alterations have led to shifts in flow patterns, sediment dynamics, and habitat availability, which can cause cascading effects on fish populations (Macnaughton et al., 2015). Additionally, the region is facing mounting pressures from climate change, including changes in precipitation patterns, increased frequency of extreme weather events, and rising temperatures (Winkler et al. 2014).

In response to these challenges, the Long Term Resource Monitoring (LTRM) program has been instrumental in monitoring and assessing the ecological health of the UMRS. Through systematic data collection and analysis, LTRM has generated valuable insights into the status and trends of fish populations, habitat conditions, and water quality parameters (Houser et al. 2022). However, gaps still exist in our understanding of how abiotic drivers influence key aspects of fish population dynamics, particularly for non-game species. Additionally, life history requirements and habitat preferences are poorly documented for many of these non-game species. The development of management tools tailored to non-game fish species is imperative for effective conservation planning and decision-making. Non-game species, often overlooked in traditional management approaches, play critical roles in ecosystem functioning and provide valuable indicators of overall ecosystem health. By focusing on these species, we can better understand the broader ecological dynamics of the UMRS and ensure the long-term sustainability of its fish communities. The first subproject seeks to address these knowledge gaps in two ways: 1) investigate the effects of water temperature and river stage on fish population fluctuations, and 2) identify potential management strategies to mitigate negative fish population responses to trending abiotic factors.

The second subproject will 1) leverage existing LTRM data alongside complementary datasets from partner agencies and research institutions to inform data gaps in non-game fishes, and 2) develop practical tools to support habitat management and conservation efforts. By integrating scientific research with stakeholder engagement and collaboration, we can work towards a more resilient and adaptive management framework for the UMRS, ensuring the continued health and vitality of its aquatic ecosystems.

.

Objectives:

1. Identify specific abiotic factors (e.g, mean monthly water temperature, winter severity, seasonal growing degree days) driving variations in fish populations and choose species, life stage, and biological functions to evaluate.
2. Develop hindcast models that retrospectively assess historical changes in abiotic conditions and their impacts on fish abundance, recruitment, growth, and survival across maximal LTRM spatial and temporal scales.
3. Generate forecast models that predict future trends in abiotic conditions and estimate their potential effects on fish populations under different climate change or management scenarios.
4. Develop and serve management and research tools tailored to non-game fish species, including an updated fisheries life history database, an R Shiny mapping application for species occurrence, and a sample size estimator for Habitat Rehabilitation and Enhancement Projects (HREPs) studies.

Relevance of research to UMRR:

The research proposed in this project is highly relevant to the information needs and management priorities of the Upper Mississippi River Restoration (UMRR) program and its partners. As a collaborative effort between federal agencies, state governments, and other stakeholders, UMRR aims to restore and maintain the ecological health, productivity, and sustainability of the Upper Mississippi River System (UMRS) while balancing economic and social interests.

Informing river restoration and management: The proposed research will provide critical insights into the ecological processes driving fish population dynamics within the UMRS. By deciphering the relationships between abiotic drivers and fish populations, we can identify key habitat requirements, migration corridors, and spawning areas essential for the long-term viability of fish communities. This information will inform targeted restoration efforts aimed at enhancing habitat quality, connectivity, and resilience to environmental stressors.

Furthermore, understanding how abiotic factors influence fish populations is essential for prioritizing restoration projects and allocating limited resources effectively. By identifying areas most susceptible to environmental change or habitat degradation, managers can focus restoration efforts where they will have the greatest impact on ecosystem health and function.

Contribution to Habitat Rehabilitation and Enhancement Projects (HREPs): HREPs are a cornerstone of UMRR's restoration efforts, aimed at improving habitat conditions for fish and wildlife while maintaining navigation and other human uses of the river. The proposed research will directly contribute to the selection, design, and monitoring of HREPs by providing scientific evidence on the habitat preferences and requirements of target fish species by designing and deploying a tool that uses LTRM fisheries data to design powerful effects studies in response to HREP restoration projects.

Specifically, by identifying the abiotic drivers influencing fish populations, we can design HREPs that mimic natural habitat conditions and promote the recruitment, growth, and survival of key fish species. Additionally, the development of management tools tailored to non-game fish species will ensure that HREPs address the needs of a diverse range of species, including those with conservation status or ecological significance.

In summary, the proposed research directly addresses the core objectives and priorities of UMRR by providing essential scientific information and fisheries tools to support habitat restoration, conservation, and sustainable management of the UMRS. By integrating scientific research with management practices, we can work towards a more resilient and adaptive approach to river restoration and conservation, benefiting both human communities and the natural environment.

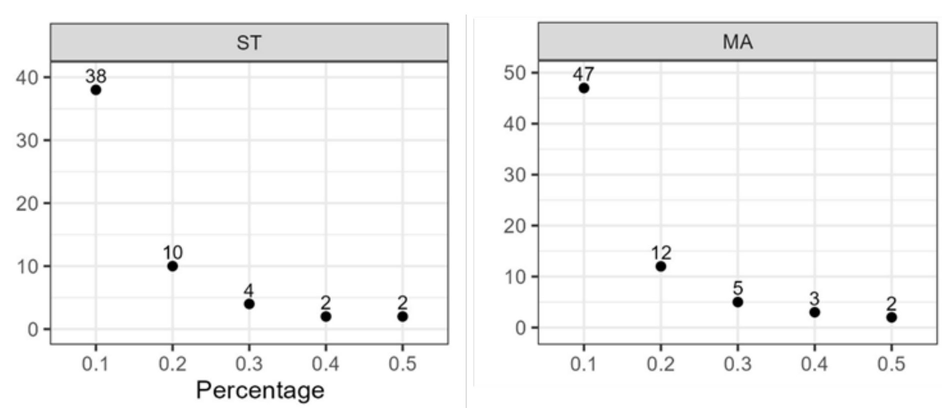
Methods:

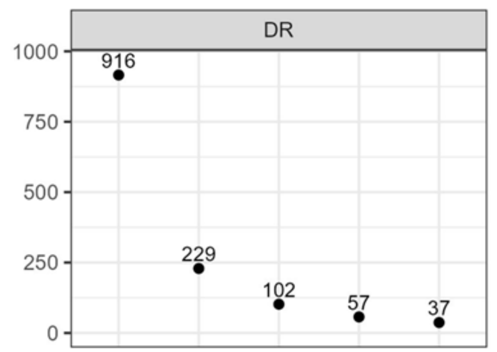
The proposed research will employ a multi-faceted approach to investigate the relationships between abiotic drivers and fish population dynamics in the UMRS. Leveraging existing LTRM data supplemented with additional datasets, we will utilize advanced statistical techniques to analyze the complex interactions between environmental variables and fish populations. The following detailed methods will be employed:

1. Data Collection and Compilation:
   -Existing LTRM fish monitoring data will serve as the primary source of biological information, providing comprehensive records of fish abundance, diversity, and habitat use across the UMRS.
   -Supplementary data from the Multi-agency Monitoring Program (MAM) program, the IL standardized Long-term electrofishing (LTEF) surveys, and IA outpool standardized fish sampling will be integrated to increase spatial coverage and resolution, particularly in areas with limited LTRM coverage.
   -Abiotic data, including hydrological, climatic, and geomorphological variables, will be obtained from various sources, including USGS stream gauges, weather stations, and remote sensing platforms. Weekly, monthly, seasonal, and annual summary variables will be generated, including calculated variables such as reversal magnitude, growing degree days, and winter severity.
2. Statistical Analysis:
   -Generalized Linear/Additive Modeling (GLM/GAM) will be employed to analyze the relationship between abiotic drivers and fish population dynamics. GLM allows for the incorporation of multiple predictor variables and can accommodate non-linear relationships and categorical predictors. Response variables will include measures of fish abundance, growth, recruitment, and mortality.
   -Initial exploratory analyses using tools like random forest and decision tree modeling will identify candidate predictor variables based on their biological relevance and statistical significance. Potential predictors may include flow regime metrics, water temperature, sediment characteristics, and geomorphic features.
   -Model selection procedures, such as Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC), will be used to identify the most parsimonious models that best explain variation in fish abundance, growth, recruitment, and survival.
   -Spatial and temporal autocorrelation will be accounted for in the analysis to ensure robust model inference and account for potential spatial and temporal dependencies in the data.
3. Hindcasting and Forecasting:
   -Historical abiotic data will be used for hindcasting, allowing us to assess how past changes in environmental conditions have influenced fish populations over time. This retrospective analysis will provide valuable insights into the long-term dynamics of fish populations and help identify key drivers of population fluctuations.
   -Forecasted abiotic data, obtained from climate and hydrological models, will be used for future projections. By incorporating climate change scenarios and predicting future trends in environmental conditions, we can assess the potential impacts of climate change on fish populations and inform adaptive management strategies.
4. Model Validation and Sensitivity Analysis:

-Model performance will be evaluated using appropriate validation techniques, such as cross-validation or bootstrapping, to assess predictive accuracy and reliability.
-Sensitivity analyses will be conducted to explore the robustness of model results to changes in model assumptions and input data, helping to identify sources of uncertainty and improve model interpretation.

5. HREP sample size estimator and interactive R Shiny application
-Sample sizes required to reliably detect change over time in fish metrics such as CPUE will be calculated using power analysis. Work will build on similar power analyses recently performed for assigning effort levels for the LTRM invertebrates component and Multi-Agency Monitoring program on the Illinois Waterway (Ickes, unpublished). This work will leverage historic LTRM data and data from partner agencies and projects (e.g. Multi-Agency Monitoring) to learn from past effort when allocating future effort. Estimations will be pool- and species-specific across the range of LTRM pools (and possibly other UMRS pools/reaches) and the range of historically captured LTRM fish species with a given minimum capture number. Analytical priority will be given to non-game species. Estimates will be based on the history of variability and uncertainty of our long-term data. Sample size estimations will be calculated across ranges of desired and/or expected magnitudes of change as well as ranges of statistical certainty with which we may reliably detect those magnitudes of change. This customization will allow for flexibility when designing "sufficient" sample sizes for a given inquiry or evaluation.
-Power analysis results will be stored in tables accessed by an interactive R Shiny application, allowing customized user inputs (e.g. check boxes, radio buttons, value sliders, etc.) for variables such as study pool(s), species for evaluation, magnitude of desired detected change, and statistical certainty in detecting that change. Output of the R Shiny app will include visualizations of sample size results plotted across certainty levels and/or magnitudes of change alongside current sample sizes of LTRM and other ongoing monitoring to compare planned effort levels to effort levels required to detect a given change. Output will also include downloadable tables of results. Underlying LTRM data will be available through the existing data portal. Any other data used for the power analyses (e.g. Multi-Agency Monitoring) will be publicly available and linked from the app's user interface. The R Shiny application will be deployed and hosted by UMESC through the USGS's Posit Connect platform in cooperation with UMESC staff (in-kind contributions) and USGS Cloud Hosting Solutions.
-This interactive application will help guide scientific questions by first answering whether customized questions can be reliably answered with a given effort level – and if not, where and by how much to increase current effort to meet required sample sizes. This tool may be especially useful for guiding HREP decision-makers in identifying areas and/or species where ongoing monitoring is already sufficient to detect potential HREP-mediated ecological change, or in allocating additional sampling effort to evaluate success of HREPs located in less comprehensively monitored areas.





Example figure of sample size required (y-axis) to detect percentage change in electrofishing CPUE of Silver carp (x-axis) at a given statistical certainty level for three pools of the Illinois Waterway, as calculated from Multi-Agency Monitoring data by Ickes et al. (unpublished). Pools with relatively low abundance of Silver carp (DR = Dresden Island) require relatively high sample sizes to detect small magnitudes of change as compared to pools with larger populations of silver carp (ST = Starved Rock; MA = Marseilles).

6. Interactive R Shiny mapping tool

-A major strength of LTRM data is its fine-scale spatial resolution over a broad geographic area. Displaying this wealth of spatial data can be challenging with static visualizations, but advancements in open-source tools for developing and hosting interactive maps allows us to interact with large data sets quickly and intuitively. By combining the reactive data handling of R Shiny with the customizable and interactive mapping of the Leaflet library, we plan to create an online, public-facing application for exploring the full extent of the data from the LTRM fish component and other UMRS projects.

-Making distributional data available at-a-glance will be valuable for practitioners. For example, when validating identifications of species that may be rare, the tool may be a reference for whether a given identification in that area is typical for the program or geographically noteworthy. The tool could also serve as a jumping-off-point for more in-depth analyses of species habitat associations, range expansions/contractions through time, or interspecific range overlaps/co-occurrences. Making the application online and public facing should drive engagement with the data among the public and other stakeholders.

-We will leverage existing codebase from IRBS staff for collating and mapping relevant UMRS fisheries datasets (LTRM, Long-Term Electrofishing, Multi-Agency Monitoring, etc.) in an R Shiny application that will display fish component at the sampling-site scale across the entire UMRS. The user interface will mostly consist of an interactive map with reactive selection criteria for displaying occurrence and/or abundance data of selected species from selected river systems, monitoring programs, timespans, hydrogeomorphic strata, gear types, etc. In addition, summary statistics, time-series figures, and other informative data visualizations can be calculated and displayed reactively from user selections alongside the map. Addition of complementary data layers can be added as available/useful, such as habitat quality, bathymetry, etc. Where data sharing policies dictate (e.g. for threatened and endangered species), precision of spatial coordinates can be reduced to protect against data misuse.

-Data collation and application development will be executed by the postdoc in conjunction with IRBS staff. Deployment and hosting of the application will be executed by the postdoc in conjunction with UMESC staff, leveraging the USGS's Posit Connect license. Ideally, this mapping tool of fish occurrence data will be deployed as a complementary "tab" of the same app displaying the HREP sample size estimator, providing a one-stop-shop for leveraging historic UMRS data for inference and planning.

7. Updated fisheries life history database

-The LTRM life history database (O'Hara et al. 2007) has been an important resource for processing and analyzing LTRM fish component data since its publication in 2007. It has supported analysis of fish data by functional groups, ontogeny, and other important life history characteristics to improve ecological inferences from the data. However, recent LTRM-funded projects have identified areas for improvement in

the existing LTRM life history database. Some fields of the database remain empty for species of increasing scientific and management relevancy (e.g. non-game species), and some quantitative fields (e.g. body length at maturity) fit poorly when mapped upon the growing body of LTRM fish component data.
-The current life history database was developed over 15 years ago, and many of its values were assigned using literature review or expert opinion. Given the growing collection of LTRM data over those 15 years, the LTRM data itself may now represent a more complete and accurate source of life history information when compared to the original sources for the database. An update to the life history database – driven by analysis of LTRM data itself, where possible – should improve future analyses of the LTRM data, especially in the context of non-game species.
-The current fields of the life history database are too numerous to list here, as are the analytical approaches for improving them. Many can be improved by reviews of literature generated in the 15 years since the database was first compiled. Analytical approaches that leverage existing LTRM data will be possible for quantitative variables. One such example would be maximum body length of juvenile individuals, for which classification techniques such as Mixture Modeling could identify cutoff values between subpopulations (i.e. juveniles and adults) by defining overlapping length-frequency distributions. Outputs from the Vital Rates project could be used to update growth-related values in the life history database. Logistic regression or occupancy modeling of species-specific occurrence data and co-collected site characteristics data can be used to fill-in or refine substrate preferences or other habitat related values for fishes with strong habitat associations in the LTRM data.

By integrating advanced statistical techniques with the comprehensive datasets available through LTRM/complementary programs and building fisheries tools to benefit management and research, we can advance our understanding of fish population dynamics in the Mississippi and Illinois rivers and support evidence-based decision-making for sustainable river management.

Data management procedures
Interactive R shiny applications (Mapping tool and HREP sample size estimator tool) will be hosted by UMESC or a UMRR partner agency and made publicly available. All project data will be stored at UMESC and data and metadata will be served publicly through ScienceBase.

Special needs/considerations, if any: (e.g., funding needs to be received by 30 May 2024)

Budget:
PhD level quantitative biologist – $178,291 (2 years salary and benefits (46.38%) at $60K salary) – Full project execution, data modeling, life history updates, R Shiny app development, writing, publication

Travel – $3K per year per principals (co-PIs and post-doc).

Publication costs: $5k over 2-years.

Total costs x 15% (IRBS IDC)

Total Budget: $258,126 (including USGS 3% pass through)

Timeline:
2 years

Time constraints (if any) for beginning project and expected completion date(s):
In kind data assembly, data Q/A and literature work can occur at time of proposal acceptance. Post-doc hire will be contingent on budget allocation timing.

Expected milestones and products [with completion dates]:
-An updated fisheries life history database including a GAP analysis of missing information for all non-game fishes, as well as a non-game fish compendium atlas similar to the earlier nonnative species atlas of Irons et al (2007).
-Development and design of a distributed R Shiny app that maps LTRM domain species occurrence, time series, ranked abundance, life history attributes, environmental associations, and species co-occurrences.
-A R Shiny sub app that estimates sample size requirements for HREP response studies using LTRM data at smaller spatial scales relevant for HREP.
-Publication on abiotic drivers of fish populations
-Additional publications on specific questions that arise from exploratory analysis may be pursued

References

Forsythe, P. S., K. T. Scribner, J. A. Crossman, A. Ragavendran, E. A. Baker, C. Davis, and K. K. Smith. 2012. Environmental and lunar cues are predictive of the timing of river entry and spawning-site arrival in lake sturgeon *Acipenser fulvescens*. Journal of Fish Biology 81(1):35–53.

Hansen, L. E., C. B. Yackulic, B. G. Dickson, B. R. Deemer, and R. J. Best. 2023. Linking ecosystem processes to consumer growth rates: gross primary productivity as a driver of freshwater fish somatic growth in a resource-limited river. Canadian Journal of Fisheries and Aquatic Sciences 80(9):1456–1469.

Houser, J. N., K. L. Bouska, N. R. De Jager, B. S. Ickes, K. J. Jankowski, D. M. Larson, M. V. Appledorn, and J. J. Rohweder. 2022. Introduction. Chap. A of Houser, J. N., ed. Ecological status and trends of the Upper Mississippi and Illinois Rivers (ver 1.1, July 2022): U.S. Geological Survey Open-File Report 2022-1039, 27 p.

Irons, K. S., S. A. DeLain, E. Gittinger, B. S. Ickes, C. S. Kolar, D. Ostendorf, E. N. Ratcliff, and A. J. Benson. 2007. Non-native fishes in the Upper Mississippi River System. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, May 2007. Long Term Resource Monitoring Program Completion Report 2005B8 submitted to the US Army Corps of Engineers, Rock Island, Illinois. 92 pp. (Unpublished)

Johnson, B. L., B. C. Knights, J. W. Barko, R. F. Gaugush, D. M. Soballe, and W. F. James. 1998. Estimating flow rates to optimize winter habitat for centrarchid fish in Mississippi River (USA) backwaters. Regulated Rivers: Research & Management 14(6):499–510.

Lemons, D. E., and L. I. Crawshaw. 1985. Behavioral and metabolic adjustments to low temperatures in the Largemouth Bass (*Micropterus salmoides*). Physiological Zoology 58(2):175–180.

Macnaughton, C. J., F. McLaughlin, G. Bourque, C. Senay, G. Lanthier, S. Harvey-Lavoie, P. Legendre, M. Lapointe, and D. Boisclair. 2017. The effects of regional hydrologic alteration on fish community structure in regulated rivers. River Research and Applications 33(2):249–257.

O'Hara, M., B. S. Ickes, E. Gittinger, S. DeLain, T. Dukerschein, M. Pegg, and J. Kalas 2007. Development of a life history database for Upper Mississippi River fishes. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. LTRMP 2007-T001. 10 pp. + Appendixes A–B. (NTIS ADA470170)

Stocks, J. R., S. Davis, M. J. Anderson, M. W. Asmus, K. J. M. Cheshire, D. E. Van Der Meulen, C. T. Walsh, and D. M. Gilligan. 2021. Fish and flows: Abiotic drivers influence the recruitment response of a freshwater fish community throughout a regulated lotic system of the Murray-Darling Basin, Australia. Aquatic Conservation: Marine and Freshwater Ecosystems 31(11):3228–3247.

Tornabene, B. J., T. W. Smith, A. E. Tews, R. P. Beattie, W. M. Gardner, and L. A. Eby. 2020. Trends in river discharge and water temperature cue spawning movements of Blue Sucker, *Cycleptus elongatus*, in an impounded Great Plains river. Copeia 108(1):151–162.

Winkler, J.A., Andresen, J.A., Hatfield, J.L., Bidwell, D., & Brown, D. (Eds.). (2014). Climate change in the Midwest: a synthesis report for the National Climate Assessment. Washington, DC: Island Press.

Using sUAS to monitor and survey regeneration and recruitment in areas of forest canopy loss

Previous LTRM project:
This project will build upon existing floodplain forest datasets, as possible, utilizing permanent LTRM forest research plots originally established in 1995 and revisited in 2021, to study forest regeneration and loss over the past decade. Additionally, this project will utilize data produced by the 2020 Systemic Land Cover (LCU2020) and ongoing work to map areas of floodplain forest canopy loss where project surveys will occur.

Name of Principal Investigator(s):
Andrew Strassman, USGS-UMESC, 608-781-6386, astrassman@usgs.gov: Andrew will be a project co-lead. He will assist with GIS data processing, interpretation, and publication, coordinate sUAS field crew deployment with district sUAS crew leads, provide expertise in GIS and aerial imagery interpretation, and report writing.
Dr. Lyle Guyon, NGRREC, 618-468-2870, lguyon@lc.edu: Lyle will be a project co-lead. He will assist with data collection and analysis, report writing, and project coordination in the southern reaches of the project.

Collaborators (Who else is involved in completing the project):
Additional sUAS and vegetation field collaborators with be developed as project scope is determined.
Andrew Meier, USACE, 651-290-5899, andrew.r.meier@usace.army.mil: Andy will assist with interpretation of USACE forest plots data, understanding floodplain forest dynamics in the UMRS, and help with coordinating the potential for access to USACE sUAS resources in the St. Paul District.
Tate Sattler, USACE, 563-451-0335, tate.w.sattler@usace.army.mil: Tate will assist with interpretation of USACE forest plots data, understanding floodplain forest dynamics in the UMRS, and help with coordinating the potential for access to USACE sUAS resources in the Rock Island District.
Dr. Marcella Windmuller-Campione, Univ. of MN, 612-624-3400, mwind@umn.edu: Marcella will assist with fielding students (undergrad/grad) along with advising students on research associated with this project. She has expertise in vegetation dynamics and stand dynamics in the UMRS.
Dr. Shelby Weiss, NGRREC, 618-468-2834, saweiss@lc.edu: Shelby will assist with local coordination of field crews (near Alton), data analysis, and manuscript/report preparation.
Erin Hoy, USGS-UMESC, 608-781-6384, ehoy@usgs.gov: Erin will assist with imagery interpretation and analysis.

Introduction/Background:
We have lost thousands of hectares of floodplain forest canopy in the Upper Mississippi River System (UMRS) since 2019, but are we losing the forest? That is a question we need to answer: is the forest disappearing, just starting over in areas hit by extreme flooding, or is it more complicated? And what about the forests that should have died, but survived? Why were some areas resilient while others failed? Finally, is the forest regenerating across these areas equally and, if not, what can this tell us about where these landscapes are headed? We do know floodplain forests are in trouble in the UMRS, impacted by non-native invasive and weedy native species, changes in inundation patterns and flood regime, and a changing climate (De Jager 2012, De Jager et al. 2012, Guyon et al. 2012, Houser 2022). We also know regeneration patterns and regeneration success vary across the system (De Jager et al. 2019, Guyon et al. 2023, Windmuller-Campione et al. 2022). However, it is important not to understate that just because forest canopy trees die does not mean the forest itself is dead. Forests regenerate after disturbances on a regular basis and UMRS forests that recently experienced heavy mortality may just be starting over, but are they? There is a free, time-sensitive, natural experiment underway, the outcome of which will dictate the successional pathways of vast areas of the floodplain landscape for generations. Through this we can learn about the pathways these areas are following, where they may lead, and what factors may influence their direction. This knowledge can then inform Habitat Rehabilitation and Enhancement Projects (HREPs) that look to enhance or restore floodplain forests within the UMRS.

Between 2010 and 2020, pools 3 – 13 (exclusive of pools 5 – 6) lost a combined 6,303 hectares of forest to non-forested land cover (unpublished data, De Jager and Rohweder 2024, U.S. Army Corps of Engineers 2017, U.S. Army Corps of Engineers 2024). This trend, while not yet quantified for other pools using the LCU2020 data, has been observed across the UMRS. However, because of mapping resolution and map class definitions, it is impossible to tell from LCU2020 data whether these areas are in the initial stages of regeneration or converting long-term to a non-forest landcover.

What makes this forest canopy loss event special? Through an analysis of Landsat data, we can reveal the years the majority of canopy loss occurred (unpublished data, De Jager and Rohweder 2024). This analysis showed that the years of greatest canopy percent cover decline were centered on 2019 – 2021, likely due to tree mortality following the prolonged flooding of 2018 – 2019. In areas with high tree mortality, this prolonged flood event resulted in not just a reset of the forest canopy, but also impacted other terrestrial vegetation at these sites due in part to high levels of deposition that buried ground-layer vegetation and associated seedbanks.

A decline in early successional forest types has been observed within the UMRS and other regulated river systems (Yin et al. 1998; Johnson et al. 2012). Early successional species, such as cottonwood (*Populus deltoides*) and willows (*Salix* spp.), often establish in open canopy conditions with fresh sediment deposits. While large-scale flood events are thought to promote these conditions and provide new opportunities for early successional tree species to establish, in a previous comparably large-scale flood event in 1993, within an impounded reach of the UMRS, post-flood establishment of cottonwood and willow was relatively low, likely due to high herbaceous cover in the year following the flood and a maintained high water table (Cosgriff et al. 2007). In areas with high canopy loss following the 2019 flood, initial unplanned observations within the past year suggest that the vegetation in these areas is primarily composed of diverse, native floodplain grasses and forbs (Per comms., Hoy 8/9/2023 and Vandermyde 1/17/2024). But is this native herbaceous floodplain vegetation facilitating forest regeneration or competing with and/or possibly suppressing it? Are these areas now prone to colonization by invasive species such as reed canarygrass (*Phalaris arundinacea*)? Also, how do we capture this ephemeral data over large areas to learn how initial post-flood vegetation colonization and establishment patterns influence the transition to a forest that will not exist for a decade or two?

To address the need to capture these ephemeral conditions over large areas at a high resolution quickly, we plan to deploy small Uncrewed Aerial Systems (sUAS). These platforms can safely and quickly assess large areas with high-resolution sensors that can supplement, or potentially supplant, crewed ground surveys of vegetation. However, before we can migrate to collecting ground data from sUAS, we need to determine: if sUAS can collect vegetation data that reliably supplants traditional ground survey data collected by field personnel; if the collection of sUAS data in fact saves time and money; and if new UAS-collected data can be utilized to rapidly update and reassess select components of historical ground-collected datasets (e.g., in permanent forest monitoring plots).

The data this project collects and analyzes will be able to answer questions about survey rigor, provide researchers across the LTRM community with information on whether sUAS can be used to improve, supplement, or supplant their existing data streams, and assist in understanding the progression of this floodplain forest mass mortality event.

Relevance of research to UMRR:
The project will address three questions critical to UMRR partners, scientists, and landscape managers:

1) Are floodplain forests that recently experienced heavy canopy mortality regenerating?
2) What successional pathways are regenerating forests following?
3) Can sUAS supplement or supplant on-the-ground vegetation data collection?

The answer to the first question is critical to managers as it directly impacts a cascade of management decisions that are based upon landcover, erosion, and landscape succession. If these forests are naturally regenerating, then managers may simply need to monitor them for progress and problems. If forests are not regenerating, then managers need to determine if these areas should, or even can, be reforested. If they cannot be reforested, what does this mean? A cascade of downstream questions and decisions arise from what will be a large-scale landcover conversion. This conversion has further implications for habitat availability and landform stability as the processes formerly supported by the forest (erosion mitigation, evapotranspiration, carbon cycling, provisioning of habitat, and water filtration among others) change to those provided by herbaceous landcover. We believe this is a timely opportunity to assess forest regeneration following the 2019 event, given that the ensuing five to six years should have provided ample time for these areas to be recolonized by floodplain forest seedlings, saplings, and advance regeneration. If woody regeneration is not present, this could indicate a suspension of normal forest reestablishment and successional development patterns following periodic high magnitude flood disturbance events.

At sites where woody regeneration is present, understanding species composition of early post-flood vegetation communities (research question 2) will provide an indication of potential future forest trajectories across the different contexts where there was high canopy loss, and which (if any) of these contexts yielded the establishment of early successional species. We will also be able to leverage existing datasets to provide detail on species composition and regeneration across time.

The answer to the third question more directly impacts the future research and monitoring opportunities that can occur within the UMRS as we define the parameters under which sUAS can and should be deployed. This could directly impact any future research question that needs to collect field data. It could also directly impact how HREPs are monitored during and post construction. If sUAS can provide the data needed to determine if an HREP is meeting stated project goals, this could result in substantial decreases in financial costs and personnel risks for field deployment, resulting in a cost-effective way to increase monitoring efforts.

Methods:
The project will begin with a review of existing field vegetation plot data and its position on the landscape, particularly with respect to areas of known high canopy-tree mortality following the 2019 flood event. Ideally, we will be able to select a subset of the permanent plots established by Yin et al. in 1995 (Yin et al. 1998) and resampled in 2021 (post-2019 flood; Weiss et al. *In prep*) for continued study in this project. This will allow for the establishment of a historical baseline of forest conditions in plot areas, direct comparisons of plot-level canopy and regeneration data across time, and further refinement of our understanding of short-term regeneration dynamics following major disturbance events by utilizing regeneration data collected two- and six-years post-flood. To ensure a robust sampling effort in high canopy-tree mortality areas, we will also draw upon existing USACE Forest Resource Inventory plots and/or establish new vegetation monitoring plots if necessary. Once plots are selected, flight plans will be developed to collect imagery over the plots in an efficient manner. Imagery will be collected using a WingtraOne Gen II sUAS or similar platform collecting 1cm resolution true-color imagery, with the collection method designed for the creation of a digital 3D surfaces (either surface from motion [SfM] or stereoscopic). Absolute horizontal ground accuracy of the imagery will be better than 50cm. This platform can capture several 100 hectares of imagery per day with collection limited by conditions, battery life, and site redeployment times. A deployment to 2 days per pool surveyed is expected to be sufficient to collect the needed imagery data.

Concurrent with sUAS surveys, or as close to concurrent as practical, ground survey data will be collected. These collection methods will be adapted from several sources, including: a recent UMRR-funded study assessing floodplain forest response to multiple large-scale inundation events (Weiss et al. *In prep*); a preliminary Upper Mississippi River (UMR) Rapid Forest Mortality Assessment Protocol developed by foresters from the USACE and USFWS as a component of a pilot UMRCC study to assess the extent of new forest regeneration in areas of high forest mortality; and the USACE Phase II Forest Resources Inventory Protocol. Vegetation data will generally be collected following a nested plot design focused on three main components: overstory trees, understory saplings and seedlings (i.e., the regeneration layer), and ground layer vegetation including grasses, forbs, and trailing vines. Overstory tree data will include parameters such as species, dbh (diameter at breast height), and height collected on all live and dead trees greater than 12.7 cm (5 inch) dbh within a 10-meter fixed radius plot. Regeneration layer data will be collected from the same fixed radius plot, and will include species, height, and diameter of woody species between 2.5 and 12.7 cm dbh. The fixed radius plots will then be subsampled to record percent cover of grasses, herbaceous vegetation, trailing vines, and tree seedlings (< 2.5 cm dbh) using 0.25 m^2 quadrats. We propose focusing detailed ground vegetation data on two pools initially, one in the northern reaches (e.g., Pool 9 or 10) and one in the middle/southern reaches of the UMR (e.g., Pool 13 or 17). This may be further expanded as time allows. Vegetation data from the northern reach will be collected by a field crew from the University of Minnesota directed by Dr. Windmuller-Campione, and data from the southern reach will be collected by a field crew from NGRREC directed by Dr. Guyon. A deployment of 20-30 days per pool surveyed is expected to be sufficient to collect the needed ground vegetation plot data.

Following field data collection, imagery data will be processed and prepared for 1) use in GIS software and 2) delivery as a USGS data release. This will include orthorectification, mosaicking, and metadata creation. Field vegetation plot data will be collated into a central geodatabase to allow for final analysis and comparison with sUAS data.

After imagery processing, vegetation mappers with botanical experience will review the imagery and work to complete the same data sheet originally used at the existing site. The vegetation mapper will not have access to or knowledge of the results of the field vegetation survey, but will otherwise have access to similar materials as a field biologist would plus any additional resources that can be accessed via GIS.

Once both field and sUAS data has been collected and processed, it will be analyzed to determine general vegetation composition and structure, the extent to which natural regeneration is present (also compared to historical data as available), and the degree of similarity between ground and sUAS data. This last analysis will focus on differences in relative composition and diversity, percent cover, and density of detected species. The use of the same plots for the collection of both sUAS and ground vegetation survey data should allow for relatively straightforward pairwise comparisons of quantifiable metrics such as vegetation percent cover and density. Similarity indices (e.g., Jaccard and/or Sorenson) and/or multivariate techniques (e.g., non-metric multidimensional scaling [NMDS]) will be used to assess the degree to which sUAS sampling reflects ground survey species composition data. Where possible, historical structure and composition data will be referenced and compared to ground survey/sUAS data using multivariate ordination techniques to assess vegetation community change through time.

Additionally, a full-cost accounting and comparison of time requirements for each method will be presented to evaluate potential cost benefits associated with using sUAS compared to traditional field crew labor for field data collection efforts.

Following the completion of analysis, imagery and plot data collected as part of this project will be entered into the USGS FSP/IPDS process as a data release with a final repository of ScienceBase. A final project report will be created as either a USGS Open File Report (OFR) or a Scientific Investigations Report (SIR) with a final repository of the USGS Publication Warehouse. Following product completion, results will be presented to researchers at a UMRS-centered conference or meeting.

Data management procedures

Imagery data collected as part of this project will be collected per USGS QMS data standards, stored on USGS servers, have FGDC compliant metadata created, be reviewed under the USGS FSP/IPDS data release process, and be disseminated to the public via the USGS-managed ScienceBase data warehouse.

Vegetation data, both field and desktop generated, collected as part of this project will be collected per USGS QMS data standards, stored on USGS servers, have FGDC compliant metadata created, be reviewed under the USGS FSP/IPDS data release process, and be disseminated to the public via the USGS-managed ScienceBase data warehouse.

Special needs/considerations, if any:
We have been presented with a natural experiment that will not present itself again (hopefully!) at a systemic scale in the UMRS for many years. Failure to collect these ephemeral data will result in the loss of capacity to learn from these events, limit our ability to learn about how successional pathways progress in these converted landscapes in the UMRS, and decrease our access to toolsets for responding to floodplain forest regeneration needs in an increasingly perturbated system.

Budget:
See attached spreadsheet for details.

Category	Budget Request				
Fiscal Year	FY2024	FY2025	FY2026	FY2027	Subtotal
USGS-UMESC	$20,097	$56,976	$49,981	$2,554	$129,608
USACE - MVP	$803	$3,022	$3,113	$3,206	$10,144
USACE - MVR	$5,045	$5,045	$5,045	$5,045	$20,180
CESU-NGRREC	$0	$48,932	$0	$0	$48,932
CESU-UMN	$0	$0	$98,171	$0	$98,171
FY Subtotal	$25,945	$113,975	$156,310	$10,805	
Grand Total					$307,035

Timeline:
We expect this project to begin with field sUAS data collection in the summer of calendar year 2024, pending federal funding availability. The bulk of field sUAS and vegetation data collection will progress over the summer of 2025. Field data processing will occur in the fall of 2024 and 2025 with desktop analysis of field imagery data in the winter of 2025 and 2026. Final analysis of results will occur over the spring and summer of 2026 with final report and data creation starting fall 2026 and wrapping up in the spring of 2027 with product dissemination and presentation. All timeline events subject to funding availability and river condition.

Expected milestones and products [with completion dates]:
The final report will detail project methods, data, and results. These materials will be useful to researchers and managers in the UMRS who want to understand the potential successional pathways found in the areas of forest canopy loss. The report will also detail the ability of sUAS to supplement or supplant field-based ground surveys of vegetation along with the project costs associated with both ground-based and sUAS-based collection and analysis of these data. All milestones and final products are subject to funding availability and river condition.

- FY2024
  - Site data review and site selection (June 30, 2024)
  - Collection of ⅓ of field imagery (September 30, 2024)
- FY2025
  - Processing of FY2024 field imagery (December 31, 2024)
  - Creation of "desktop" plot data for FY2024 collected imagery (March 30, 2025)
  - Collection of remaining ⅔ of field imagery (September 30, 2025)
  - Collection of field plots data (September 30, 2025)

- FY2026
    - Processing of FY2025 field imagery (December 31, 2025)
    - Creation of “desktop” plot data for FY2024 collected imagery (March 30, 2026)
    - Analysis of data (July 31, 2026)
    - Drafting of final report and submission to UMRR LTRM Science Director, Jeff Houser, for review (September 30, 2026)
    - Creation of USGS data release products and entry into USGS FSP/IPDS (September 30, 2026)
- FY2027
    - Completion of USGS FSP/IPDS process and final public dissemination (December 30, 2026)
    - Presentation of final results at river-focused conference (September 30, 2027)

References

Cosgriff, R. J., J.C. Nelson, Y. Yin. 2007. Floodplain forest response to large-scale flood disturbance. Transactions of the Illinois State Academy of Science 100 (1): 47–70.

De Jager, N.R. 2012. Effects of flood frequency and duration on the allometry of community-level stem size-density distributions in a floodplain forest. American Journal of Botany 99:1572-1576.

De Jager, N.R., M. Thomsen and Y. Yin. 2012. Threshold effects of flood duration on the vegetation and soils of the Upper Mississippi River floodplain, USA. Forest Ecology and Management 270: 135-146.

De Jager, N.R., Van Appledorn, M., Fox, T.J., Rohweder, J.J., Guyon, L.J., Meier, A.W., Cosgriff, R.J., and Vandermyde, B.J. 2019. Spatially explicit modelling of floodplain forest succession: interactions among flood inundation, forest successional processes, and other disturbances in the Upper Mississippi River floodplain, USA. Ecological Modelling 405: 15-32.

Houser, J.N., ed., 2022, Ecological status and trends of the Upper Mississippi and Illinois Rivers (ver. 1.1, July 2022): U.S. Geological Survey Open-File Report 2022–1039, 199 p., .

Guyon, L., C. Deutsch, J. Lundh, and R. Urich. 2012. Upper Mississippi River Systemic Forest Stewardship Plan. U.S. Army Corps of Engineers. 124 pp.

Guyon, L., Strassman, A.C., Oines, A., Meier, A., Thomsen, M., Sattler, S., De Jager, N., Hoy, E., Vandermyde, B. and Cosgriff, R., 2023, Forest canopy gap dynamics: quantifying forest gaps and understanding gap – level forest regeneration in Upper Mississippi River floodplain forests. A completion report submitted to the U.S. Army Corps of Engineers’ Upper Mississippi River Restoration Program from the U.S. Geological Survey, LTRM Science in Support of Restoration - SOW2019FG5. 73 pp.

Johnson, W.C., M.D. Dixon, M.L. Scott, L. Rabbe, G. Larson, M. Volke, and B. Werner. 2012. Forty years of vegetation change on the Missouri River floodplain.” BioScience 62 (2): 123–35.

U.S. Army Corps of Engineers’ Upper Mississippi River Restoration (UMRR) Program Long Term Resource Monitoring (LTRM) element. 2024, 2020 Systemic Land Cover Data, Upper Mississippi River System (UMRS): U.S. Geological Survey data release, https://doi.org/10.5066/P9U46VQP.

U.S. Army Corps of Engineers’ Upper Mississippi River Restoration (UMRR) Program Long Term Resource Monitoring (LTRM) element. 2017, UMRR 2010 Land Cover Land Use: La Crosse, WI, https://doi.org/10.5066/F77942QN.

Van Appledorn, M., N. De Jager, and J. Rohweder. 2018. UMRS Floodplain Inundation Attribute Rasters: U.S. Geological Survey data release, https://doi.org/10.5066/F7VD6XRT.

Vaughan, A. A. Hydrogeomorphic Units and Catenae in the Upper Mississippi River System. In-press.

Windmuller-Campione, M.A., L. F. Reuling, M. Van Appledorn, D. M. Nielsen, and A. R. Meier. 2022. What is a stand? Assessing the variability of composition and structure in floodplain forest ecosystems across spatial scales in the Upper Mississippi River. Forest Ecology and Management, Volume 520, https://doi.org/10.1016/j.foreco.2022.120385.

Yin, Y. 1998. Flooding and Forest Succession in a Modified Stretch along the Mississippi River. *Regulated* Rivers: Research & Management 14: 217–25.

Yin, Y., Y. Wu, S.M. Bartell, and R. Cosgriff. 2009. Patterns of forest succession and impacts of flood in the Upper Mississippi River floodplain ecosystem. Ecological Complexity 6 (4): 463–72.

Understanding the role of surface-subsurface hydrology and soil characteristics on floodplain vegetation in the Upper Mississippi River System through space and time

Previous LTRM projects: This proposal builds on three prior UMRR-SSRM projects: "Conceptual Model and Hierarchical Classification of Hydrogeomorphic Settings in the UMRS" (2019CM1-6), "Mapping Potential Sensitivity to Hydrogeomorphic Change in the UMRS Riverscape and Development of Supporting GIS Database and Query Tool" (2021HG1-7) and "Assessing Forest Development Processes and Pathways in Floodplain forests along the Upper Mississippi River using Dendrochronology" (2023dendro). It is also informed by other LTRM projects including LTRM Ecohydrology Research and the UMRS Floodplain Inundation Model, as well as U.S. Army Corps of Engineers (USACE) supported forest inventories and investigations.

Names of Principal Investigators:
Marcella Windmuller-Campione, University of Minnesota, 612-624-3400, mwind@umn.edu; overall organization of the multi-state project, develop vegetation sampling with L. Guyon; lead field sampling and well installation for St. Paul district; lead overall data management and meta-data development and preservation.
Lyle Guyon, Ecologist, The National Great Rivers Research and Education Center, 618-468-2870, lguyon@lc.edu; develop vegetation and soil sampling; lead field sampling and well installation for St. Louis District.
Antonio Arenas, Iowa State University, 515-294-2410, aarenas@iastate.edu; lead hydrologic modeling, manuscript writing.
Molly Van Appledorn, Research Ecologist, USGS, 608-781-6323, mvanappledorn@usgs.gov; coordinate spatial analyses (hydrogeographic, hydrologic), lead UMRS floodplain inundation model evaluation, manuscript writing.

Collaborators (Who else is involved in completing the project):
Andrew Meier, Lead Forester, USACE, St. Paul District, 651-290-5899, Andrew.R.Meier@usace.army.mil, collaboration in site selection, review of outputs (in-kind support).
Ben Vandermyde, Lead Forester, USACE, Rock Island District, PO Box 534, Pleasant Valley, IA 52767, 309-794-4522, ben.j.vandermyde@usace.army.mil, collaboration in defining specific questions for analysis, providing context for future integration of MVR and MVS dendrochronology data, review of outputs (in-kind support).
Brian Stoff, Lead Forester, USACE, St. Louis District, 301 Riverlands Way, West Alton, MO 63386, 636-899-0064, brian.w.stoff@usace.army.mil, collaboration in defining specific questions for analysis, providing context for future integration of MVR and MVS dendrochronology data, review of outputs (in-kind support).
Shelby Weiss, Post-Doctoral Research Associate, NGRREC, 618-468-2834, saweiss@lc.edu; data analysis and modeling.
John Sloan, Watershed Scientist, NGRREC, 618-468-2820, jjsloan@lc.edu, soil sampling and analysis.
Angus Vaughan, Hydrologist, USGS, 608-781-6152, aavaughan@usgs.gov, hydrogeomorphic unit mapping and interpretation, sampling design, results interpretation (in-kind support).
Bruce Henry, Forest Ecology, US Fish and Wildlife Service, 608.518.7834, bruce_henry@fws.gov, collaboration in defining specific questions for analysis, providing context for future integration of MVR and MVS dendrochronology data, review of outputs (in-kind support).

Introduction/Background:

What's the issue or question?

There is a noticeable gap in our fundamental understanding of water-soil-forest processes in the UMRS that limits management decision-making. Water and soils are fundamental pieces of floodplain ecosystems, including those of the Upper Mississippi River System (UMRS) (Romano 2010). The availability of water –both above and below the ground's surface—is critical for the regeneration, establishment, and growth of woody vegetation (trees and shrubs) (Figure 1). Similarly, soils directly affect forest processes by modulating nutrient and water availability and role as a substrate for root anchoring via their texture and chemical characteristics. Floodplain hydrogeomorphic units (HGUs) are landform features often used as surrogates for suites of hydrologic and soils characteristics. Research from other floodplain ecosystems have documented repeated associations between HGUs and vegetation distributions, presumably because of the importance of water and soil on forest dynamics (e.g., Shelford 1954, Osterkamp & Hupp 1984, Hupp & Osterkamp 1985). However, such associations may not be reliable under shifting hydrologic conditions, invasive species pressures, and other rapid ecosystem changes because HGUs are approximations of important physical characteristics (Van Appledorn & Baker 2023). It is important, therefore, to develop process-based knowledge of how surface and subsurface water availability, soil conditions, and forest regeneration, establishment and growth relate to each other across HGUs in order to anticipate how forests may respond to changing conditions and develop appropriate management strategies.

Recent studies have begun to address gaps in foundational knowledge about UMRS floodplain forest ecology. For example, from 2018 to 2020 the UMRR funded studies addressing canopy gap dynamics, reforestation methods, invasive plant species, and effects of major floods on forest resources; and in 2022 funded two additional dendrochronology projects which had main goals of quantifying the age of trees within the floodplain to improve understanding of forest development process. These studies are representative of efforts to expand the set of basic and critical information that underlies floodplain forest management decisions. However, although there has been increased investment and research quantifying current forest dynamics, researchers and managers still have a very poor understanding of how surface water may interact with subsurface water on the floodplain, how these dynamics may vary across different soil conditions and topography, and what the consequences may be for floodplain vegetation (see Windmuller-Campione et al. 2022).

What do we already know about it (based on research within the UMRS or elsewhere)?
Floodplain forest dynamics (regeneration, growth, establishment) are a function of multiple abiotic and biotic drivers (Figure 1) (e.g., Hosner & Minkler 1963, Hughes et al. 2001). We have observed that patterns of floodplain forest composition, structure, and succession are correlated with patterns of inundation frequency, depth, and duration across the floodplain and are closely linked to the flood tolerances of individual species (Battaglia et al. 2002, Yin et al. 2009, Van Appledorn & Baker 2023). We also know that soil characteristics strongly influence nutrient and water exchange and have connections to species distributions as well (e.g., sandy vs. clay soils may support different vegetation communities) (De Jager et al. 2012). In addition, hydrogeomorphic setting may strongly influence patterns of soil development and water availability and therefore species distributions (e.g. Hughes 1997). However, how all these pieces fit together across the UMRS floodplain landscape is not well understood at this time. For example, a manager may know one or two pieces, so developing restoration efforts are more of a game of chance where you do not have all the rules or all the game pieces.

Initial efforts to establish linkages between HGUs and vegetation in the UMRS are encapsulated by the works of Heitmeyer (2007 and 2008) and Heitmeyer & Bartletti (2012). Although developed at relatively coarse scales, these hydrogeomorphic studies provided useful information for planning purposes (e.g., evaluating restoration options) and produced maps of geomorphic features across large portions of the UMRS floodplain. However, they are limited in their coarseness and ability to infer water-soil-vegetation processes in a consistent way across the system. Recently, Vaughan et al. (*in press*) mapped HGUs in a semi-automated way using fine-scale geospatial data inputs. The results have the potential to link fine-scale water-soil-forest processes and dynamics across broad geographic areas because they represent repeatable units defined by underlying hydro-geomorphic characteristics. Another tool is the UMRS Floodplain Inundation Model (FIM; Van Appledorn et al., 2021), a systemic model of surface-water dynamics that has been used to understand floodplain forest succession (De Jager et al., 2019). The FIM has only been used to describe surface water conditions, and its ability to capture subsurface hydrologic dynamics has not been tested. There remains a need, therefore, to

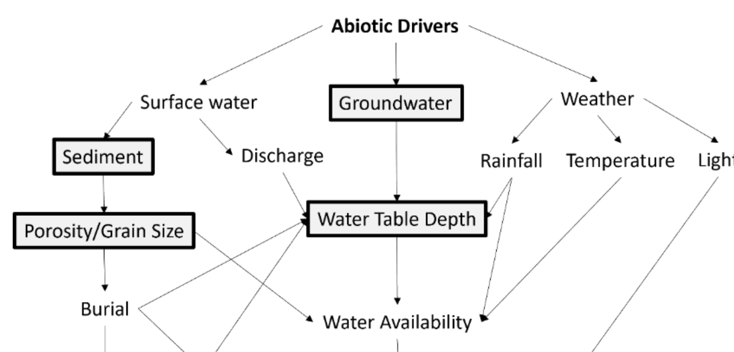


Figure 1. Conceptual model, adapted from Hughes et al. (2001), relating abiotic and biotic drivers to woody species regeneration, growth, and establishment through direct and indirect pathways. Abiotic drivers we will assess in this proposal are highlighted in grey: sediment porosity/grain size, groundwater dynamics, and water table depth. We will combine empirical and simulated data to describe these drivers with existing data on other abiotic drivers including surface water inundation and floodplain surface elevations as characterized by hydrogeomorphic units.

explicitly test and link these models in an integrative way to empirical measures of surface and subsurface water conditions, soil characteristics, and forest processes. Documenting how HGUs vary with respect to water and soil conditions and their relationships with forest processes in contrasting reaches of UMRS will greatly improve the interpretability and utility of the HGU model to forest management activities.

How will the proposed work improve our understanding of the UMRS?
Continued stresses on UMRS floodplain forests such as changing hydrology, pathogens, insects, herbivory, and invasive plant species have spurred increasing investment into floodplain forest management and restoration over time. Floodplain forest restoration activities have included tree plantings, direct seeding, and timber stand improvements (among other actions) to varying degrees of success. Unfortunately, survival rates can be low for planted seedlings (<50% survival), even when care is taken to provide the best possible growing environment by using tree tubes, scarifying the soil, and treating for reed canarygrass through chemical and mechanical means (Windmuller-Campione et al., 2022) – a phenomenon reported in other floodplain ecosystems (e.g., Pannill et al., 2001). Effects of invasive species competition and herbivory are likely to greatly reduce seedling survival, even when planting receive protection. However, it is almost always unknown why a particular planting or treatment may fail.

Newly germinant and planted seedlings are vulnerable to too much or too little water. Although we often think water as not being limiting within the UMRS, possibly because of increasing discharge patterns in recent decades (Van Appledorn 2022), we actually do not have a baseline understanding of a seedling's available water throughout the growing season and how that varies with soil condition. This limits the ability of managers to develop management plans that are best suited for a given site that contribute to increased survival, improved restoration outcomes, and greater potential for ecosystem resilience. In addition, soils and hydrologic processes are critical to HREP planning and design, including island building efforts, yet there are few investigations linking UMRS floodplain soils, hydrologic processes, and terrestrial vegetation dynamics – especially ones occurring in contrasting floodplain reaches. A current study funded through the Corps' Engineering Research and Development Center Ecosystem Management and Restoration Research Program is evaluating detailed soil characteristics of built and natural islands to assess physical, chemical, and biological characteristics of soils as they relate to vegetation success. However, temporal variation in soil moisture and site hydrology is a critical driver of vegetation survival and growth that is not captured in the current study, and which is a key focus of our proposed study. There is also uncertainty in how well existing spatial modeling tools like the HGU model and FIM capture important gradients in water and soil that can be used to prioritize restoration investments.

The proposed work will fill three critical knowledge gaps. First, it will improve our understanding of floodplain forest dynamics in the UMRS by establishing linkages between water, soil and forest dynamics across a gradient of HGUs and river reaches using an integrated approach that merges empirical and modeled datasets. In doing so, we will gain a detailed understanding of the complexities of groundwater-surface water interactions, soil conditions, and their effects on forest regeneration, growth and establishment in three study areas selected to represent dominant environmental conditions in contrasting physiographic regions of the UMRS. Second, it will assess the utility of an existing geospatial model of floodplain inundation (FIM) for characterizing groundwater dynamics. An understanding of where and how well the model can explain water level dynamics across the UMRS floodplain has the potential to expand its application and use as a management tool for prioritizing floodplain forest restoration activities. Third, this study will improve the interpretability of the Vaughan et al. (*in press*) HGU model for forest management applications. Characterizing the relationships among water, soils, and forest dynamics within and across HGUs will help ground the meaning of individual HGUs within contrasting river reaches of the UMRS and generate expectations of physical and forest conditions in places where empirical data are lacking.

What are the objective(s) or hypotheses?

The primary objective of this study is to define the linkages between surface-subsurface hydrology, hydrogeomorphic features, soils, and floodplain vegetation dynamics in the UMRS. Specifically, we will build upon previous efforts to document HGUs and surficial flooding conditions to describe soil characteristics, the spatial and temporal availability of ground and surface water, and their relationships with the growth, recruitment, composition, and structure of floodplain forests. This research will address the following questions in order to develop critical information to guide vegetation management in the UMRS:

1) How does the availability of surface vs. groundwater vary throughout the growing season and across HGUs?
2) How does soil texture and quality vary across a gradient of HGUs?
3) How do forest dynamics (recruitment, growth, etc.) relate to surface/subsurface water availability and soil patterns?

A secondary objective of this study is to assess the ability of the UMRS FIM to estimate groundwater dynamics. Here, we ask 1) How do FIM-derived predictions of groundwater levels compare to empirical measures and simulated results from a hydrodynamic numerical model? And 2) how does FIM performance vary across hydrogeomorphic unit and river reach? By comparing the existing systemic FIM to two alternative measures of groundwater dynamics we will be able to develop guidance on appropriate uses and interpretations of FIM estimates of groundwater levels in space and time, potentially increasing the utility of FIM for management applications throughout the UMRS.

Relevance of research to UMRR:
Over the last few years, floodplain forests have become a higher and higher priority for restoration across all agencies involved in UMRS management. Numerous HREPs have identified floodplain forest restoration and/or the creation of new islands as a top priority, including a number of active HREPs (Reno Bottoms, Pool 12 Forestry, Pool 13) and HREPs with approved fact sheets (Black River Bottoms, Pool 8 Forestry). An integrated understanding of how water, soil, and forest processes interact within and across HGUs in representative river reaches of the UMRS will provide fundamental knowledge of critical aspects of the floodplain ecosystem. As research that integrates physical and biological components of the UMRS ecosystem, this research will directly address Focal Area 2.6 “Understanding relationships among floodplain hydrogeomorphic patterns, vegetation and soil processes, and effects on wildlife habitat and nutrient export.”

Methods:
Our general approach balances the need to account for broad physiographic gradients within a large river system while gaining useful information about complex physical processes in a logistically feasible way. We will couple field sampling efforts with integrated surface-subsurface hydraulic models to produce a detailed understanding of the complex relationships between surface and subsurface water, soils, and vegetation. Our goal is to strategically capitalize on the natural physical gradients within the UMRS to generate process-based knowledge at a few locations that can be translated or adapted to other locations with similar physical characteristics. Although this sampling design will not capture the full range of potential conditions, descriptions of important processes and the contexts in which they operate produced for the representative locations will provide fundamental information to develop adaptive terrestrial forest management treatments and improve HREP design. Additionally, all PIs and collaborators see this work as a step toward long term investment that could continue to increase our understanding of floodplain ecosystems and improve management.

Study Area
The study area will span the USACE’s St. Paul, St. Louis, and Rock Island districts of the UMRS. Sampling and modeling will occur at one location per USACE district selected to represent 1) contrasting longitudinal gradients of river hydrology, basin physiography, and vegetation composition, 2) a typical range of finer-scale environmental heterogeneity as characterized by HGU distributions, and 3) typical forest conditions of each district. Location selection will be informed by expert opinion of forest managers within the USACE and FWS, systemic data products including HGM (Vaughan et al. *in press*) and FIM (Van Appledorn et al. 2021), and USACE

forest inventory data. Ideally, locations chosen for this study will have been the focus of previous or current research and/or management activities to capitalize on expert knowledge and existing resources. For example, Reno Bottoms in Pool 9 is an excellent candidate location given its status as an HREP location, high density of forest inventory plots, and availability of tree cores for growth analyses (Windmuller-Campione et al., 2022). Although the sampling design will not capture the full range of potential physical and forest conditions present in the UMRS, the three representative locations should provide fundamental information on important process that could be used to develop adaptive floodplain forest management treatments and greatly improve HREP design throughout the UMRS.

Objective 1: linkages between surface-subsurface hydrology, soils, and vegetation

Field Sampling

The overarching goal of the field sampling is to describe the range of hydrogeomorphic conditions and their relationships to vegetation at each location. To do this, we will follow a spatially nested sampling design at each location that is informed by the underlying hydrologic and geomorphic gradients and existing forest conditions. First, we will combine output from the HGM and FIM to identify floodplain landforms expected to exhibit similar hydrogeomorphic conditions (e.g., soils, hydrologic dynamics) within each location given their position in the landscape, surface morphology, and expected inundation regime. We will then overlay these landforms with USACE forest inventory data to create polygons of hydrogeomorphic-forest types. Next, we will choose two sets of three landform polygons per location that span the range of expected conditions. For example, two polygons that exhibit relatively low, flat morphologies and experience relatively frequent, deep inundation with *Salix* communities, two polygons that exhibit relatively high, sloped morphologies and experience relatively infrequent, shallow inundation with oak-hickory communities, and two polygons with intermediate hydrogeomorphic conditions and silver maple overstories. These polygon landforms will be used as strata for the field sampling effort. The USFWS will be consulted on the sampling design to avoid disrupting cultural resources and obtain proper permitting.

We will quantify groundwater and surface water hydrology, soil properties and chemistry, and the under and overstory vegetation for the six polygons. First, we will install shallow groundwater monitoring wells at the center or a representative location within each polygon. Although the wells will be purchased by the USGS, installation will leverage all partners along the river to reduce travel costs. Wells will be constructed using 5 cm slotted PVC to a depth of ~1-2 m using an auger of the same diameter. Onset HOBO Model U20-001-01 water level loggers will be deployed in each well to record water levels at 15 minute increments, a time step that can allow insight into evapotranspirative processes. Monitoring will commence ahead of the expected spring flood pulse and continue through the end of the growing season; pressure transducer deployment and retrieval will be coordinated through USACE lead forests of each district. Dry wells will also be installed to measure temperature-buffered barometric pressure for barometric pressure compensation during the calculation of water levels if no meteorological records are in the immediate vicinity (McLaughlin and Cohen, 2014). Data will be downloaded from the loggers annually and analyzed to develop a time series of water levels for each polygon landform. One tipping bucket rain gauge (HOBO Model RG3) per location will also be installed for the purposes of hydraulic model calibration (total = 3 gauges). Hydrologic data collection will occur each year of the study.

Once during the proposal period we will collect soil samples at a minimum of three plots that capture the environmental variability surrounding the groundwater wells and one additional plot located in close proximity to the well. Because the well location is selected to represent typical conditions on the HGU it is located, our soil sampling design is meant to capture the dominant soil conditions defining the HGU rather than capturing the full range of conditions. Soil samples will be collected from three depths of the mineral soil (0–15, 15–30, and 30–60 cm) at 5 points within each plot using a 10 cm-diameter auger and then composited by depth increment. In the field, bulk density will be estimated at the midpoint of each depth increment. In the lab, bulk density samples will be sieved to pass a 2 mm mesh following initial determination of the whole-soil (intact core) value. Then the mass of the sieved fine-fraction will be determined. Soil samples for chemical analysis will be air-dried and include only soils that have pass through the 2-mm mesh sieve. Chemical analysis will occur at the University of Minnesota Soils testing laboratory and will include pH, soluble salts (electrical conductivity), nitrate, ammonia, phosphorus, potassium, calcium, magnesium, sodium, iron, manganese, zinc, copper, molybdenum, and boron. A HydroSense II handheld soil moisture probe will be used in the field to rapidly document high-density spatial patterns of soil moisture within and across HGUs to complement the lower density sampling of soil columns and chemistry.

Nested fixed-radius vegetation plots will be established adjacent to the soil sampling area to quantify the overstory, regeneration layers, and percent cover of understory species. Circular 1/50th (radius of 7.98 m) and 1/500th (radius 2.52 m) hectare plots will be used to sample the overstory and seedling and sapling layers, respectively. Overstory trees are defined as any tree greater than 12.7 cm at diameter at breast height (dbh 1.3 m). In addition to standard forest inventory measurements (dbh, species, status), a tree core and height from every third tree will be taken to get a better understanding of age, as age-size relationships are unreliable in UMRS forests (Voth Rurup et al., *in prep*). Seedlings (1 m to 2.54 cm dbh) and saplings (2.55 to 12.6 cm dbh) will be tallied by species and status for all individuals less than 2.54 cm dbh. DBH measurements will occur on all individuals between 2.54 and 12.6 cm; every 3rd tree will also have height and a tree core taken. Within each of the regeneration plots, soil moisture probes will provide a within growing season measurement of soil moisture and an opportunity to quantify variability. Additional soil moisture measurements using soil moisture probes may occur during well installation and removal at the beginning and head of the growing season, respectfully. All other vegetation measurements will be completed once during the project's duration.

Hydrologic Modeling

We will use integrated spatially explicit, numerical surface-subsurface models to evaluate the dynamics and feedbacks between overland and groundwater flows in the three study locations (Figure 2). Such an approach is important for our study because existing models and tools do not capture the energetics of water flow (e.g., UMRS FIM), do not account for subsurface processes (e.g., UMRS Hydraulic Model; USACE 2018), or have neither of these qualities, limiting their applicability in our study. Models will be built for each study location using the HydroGeoSphere (HGS) platform that simulates 2D overland/surface flows using the diffusive wave approximation of the Saint-Venant equations. The movement of water in the subsurface (unsaturated and saturated) will be simulated using a 3D version of the Richards' equation (e.g. Therrien et al. 2010). For each study location, a model will be used to generate approximately a decade of continuously simulated hydrology. We expect that by simulating a 10-year time window, the model results will be able to capture the periods when the water dynamics in the floodplain are influenced mainly by 1D hydrologic processes during relatively dry periods (e.g., evapotranspiration) as well as the more dynamic behavior during flooding events. Model simulations will be forced using upstream hydrographs and precipitation time series; regional groundwater level information from long-term USGS monitoring locations will be used to determine a head boundary condition for the subsurface domain. The extent and spatial discretization (e.g., mesh resolution) of the models will be determined through an iterative process with the goals of achieving mesh-independent numerical results, minimizing the effect of the boundary conditions, and maintaining manageable computing times. The surface domains will be represented with a terrain-conforming 2D triangular irregular mesh that will be extended downwards to represent the 3D subsurface domain. Initial computational grids will include approximately 4-km upstream from the selected plots, will use a triangular mesh with an average edge of 10 m, and will include the first 20 meters of the soil column.

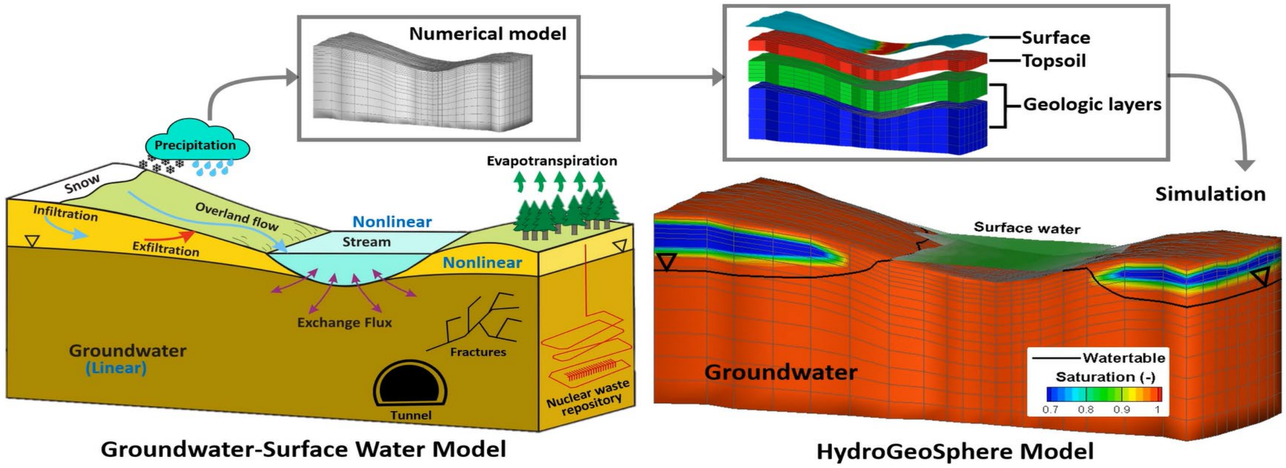


Figure 2. Conceptual model of the HydroGeoSphere modeling platform showing the components of the groundwater-surface water numerical model (left) and how the model is represented in a computational mesh to characterize saturation of the surface and topsoil by groundwater or surface water through space and time (right). Figure from the model developer (https://www.aquanty.com/hydrogeosphere/).

The models will produce sub-hourly and spatially distributed time series of inundation extent, water table depth, water velocities, and soil moisture levels across each study location. Model performance will be assessed using different datasets including satellite imagery for inundation extent and observed groundwater levels; model predictions of evapotranspiration will be compared against satellite-based estimations of that variable.

Data analysis

Our field methods will produce a time series of water level fluctuations for the duration of the sampling period for each polygon landform within our study locations. We will use the time series data to compute metrics of water availability for each landform that are relevant for understanding vegetation patterns. For example, the percentage of growing season during which water was within the top 10 cm of soil depth; frequency, depth, duration, and timing of surface water inundation; number of days inundated when the depth of water exceeded seedling height at a plot; etc. We will also compute similar metrics for each polygon landform using the 10-year simulated hydrology outputs from the numerical model. This is useful especially for characterizing hydrologic variability across the polygon landform that is not captured by point measurements from the groundwater wells. It is also valuable for understanding longer term dynamics (10 years) that may exhibit greater inter-annual variation than may be observed during a more limited study period. We will examine how distributions of both short- and long-term hydrologic metrics vary across locations and sites using first order summary statistics. We will also use multivariate ordinations (e.g., non-metric multidimensional scaling (NMDS), principal components or coordinate analysis) and cluster analyses to describe how suites of hydrologic metrics together can characterize surface/subsurface water availability vary throughout the growing season and across hydrogeomorphic units (**research question #1**).

We will also use multivariate analyses to assess how soil texture and quality vary across hydrogeomorphic units in the UMRS (**research question #2**). We will plot differences in bulk density and chemical composition using NMDS, and overlay results with hydrologic variables to understand covariates. Using both hydrologic and soil metrics in multivariate and cluster analyses together, along with HGU feature classes and descriptors within the HGU dataset and FIM metrics, will help identify 'hydrogeomorphic types' – repeated suites of physical conditions that may serve as translatable units across the UMRS more broadly. Ideally, these analyses would clarify the linkages between the HGU and FIM maps and expected soil characteristics and water availability dynamics. Creating such a reference typology will inform management decisions and HREP designs: if a HGU feature was encountered in a new location that had similar HGU and FIM characteristics as a hydrogeomorphic type described in our study, managers and planners may expect similar surface/subsurface water availability dynamics in the new feature compared to the studied feature.

Finally, we will relate water availability and soil characteristics to patterns of forest composition, recruitment, and growth to address **research question #3**. We will summarize patterns of over- and understory composition across sampled polygon landforms within and among study locations. We will use NMDS biplots to explore how composition correlates to water and soil characteristics and to identify what species do or do not track closely with certain physical conditions. We will use both short-term (from wells) and long-term (from numerical model) hydrologic metrics, soil texture and chemical status, HGU feature classes and descriptors within the HGU dataset, and FIM metrics in predictive machine learning (ML) or generalized linear mixed models to test hypotheses about surface/subsurface water availability, soil characteristics, and over- and understory vegetation composition patterns. Similar approaches will be used for recruitment variables as well. To test hypotheses about how physical conditions relate to growth patterns, we will develop tree ring chronologies of all sampled overstory individuals and measure relative and absolute annual growth rates using DendroElevator technologies (http://dendro.elevator.umn.edu). Annual rates of the past decade will be directly compared to annual descriptions of water availability extracted from the numerical hydrologic model. Based on our previous work showing a positive relationship between growth rates and river discharge (Griffin et al., *in prep*) in Pools 3 - 10, we expect that greater growth will occur in years when water is available in the rooting zone during the growing season. By integrating soil characteristics, we will be able to further refine the nature of the relationship between river discharge, surface inundation, groundwater availability, and growth rates, and how soil characteristics may interact with these relationships. The overall outcome of these analyses will be a rich description of the relationships among forest dynamics, water availability, and soil characteristics that may be used as context for interpreting inferring likely biophysical relationships on other floodplain landform features outside the study area. A second outcome of these analyses will be the development of a conceptual model of vegetation relationships with soil characteristics and water availability processes in different physiographic contexts of the UMRS.

Objective 2: UMRS Floodplain Inundation Model Evaluation
Output from the UMRS FIM will be compared to empirical measures of groundwater levels as sampled within the shallow groundwater wells and the simulated time series of water levels from the HGS numerical hydrologic model to assess FIM performance. We will simulate daily water depths at each sampling location for the duration of the study period (field sampling period for empirical data; 10-year period for simulated data) using the FIM model. The FIM model produces negative surface water depths that indicate predicted water levels are below the terrain surface; negative depth values were excluded from past analyses but are available as part of the complete model output (Van Appledorn et al., 2024).

To compare FIM to empirical measures of groundwater levels, groundwater levels will be coarsened to a daily time step and spatially interpolated across the floodplain surface. A set of points will be distributed across the study area surface in a spatially nested design following the HGU features using the GRTS framework (Brown et al., 2015); the total number of points will be dependent on the study area size and HGM complexity. We will then extract FIM results and interpolated groundwater level results at the point locations and compare using Root Mean Square Error (RMSE), first order descriptive statistics, and distributional comparisons using Pearson's correlation coefficient, Komolgorov-Smirnov tests, and others.

We will compare FIM results to results from the HGS model at each study location by extracting simulated HGS water level data at the same set of points described above. Simulated results will be temporally coarsened when necessary to arrive at a daily time step. Comparisons of time series data will include calculating RMSE and descriptive statistics, however, the longer time series (~10 years) will allow more detailed comparisons of FIM performance under varying hydrologic conditions such a high- vs low-water years, early- vs late-season high water events, and others. These comparisons may be accomplished by further subsetting the time series data into specific periods of interest and through additional statistical modeling.

The outcome of this evaluation will be an understanding of UMRS FIM model performance across nested gradients of environmental heterogeneity (e.g., longitudinal hydrologic gradients and within-site hydrogeomorphic units) and for a range of inter-annual flow conditions (e.g., high- vs low-flow years). Depending on FIM performance outcomes, correction factors for FIM outputs may be developed from the comparison results to account for particular aspects of environmental heterogeneity or hydrologic regime to improve systemic FIM groundwater level predictions in future applications.

Data management procedures

Vegetation data will be collected by field crews supervised by M. Windmuller-Campione and L. Guyon. Vegetation data, hydrologic files, and soil analysis output will be scanned, entered, or uploaded and shared through online platforms (e.g., Box, MS products). Soil samples will be collected and processed at the UMN soil laboratory. Physical storage will order in M. Windmuller-Campione lab and long-term storage will be coordinated with USACE. Long term data availability will be hosted through the University of Minnesota Data Repository (DRUM) (https://conservancy.umn.edu/handle/11299/166578) which we have previously used for long-term data storage and sharing for a previous CESU agreement.

Special needs/considerations, if any: none

Budget: $386,194

Timeline: Proposed project dates are October 1, 2024, through September 30, 2027. We expect no time constraints related to this project. Detailed timeline with activities, products and progress can be found in Table 1. Pending permitting and other constraints the project partners and collaboration team are expecting to continue data collection from wells outside of the 3-year funding proposal.

Expected milestones and products [with completion dates]:

Table 1: Expected milestones, status, and completion dates.

Activity	Status	Completion Date
Select 3 stands across St. Paul, St. Louis, and Rock Island Districts	Started	Oct 2024
Graduate student hired	Pending	Oct 2024
Collaborate with HGM modeling team on maps and delineations of the stands	Started	Nov 2024
Finalize terrestrial sampling design and methodology	Pending	Feb 2025
Obtain permits as needed, consult agencies, hire field crews, purchase equipment	Pending	Mar 2025
Hydrologic Model Mesh Generation	Pending	Mar 2025
Wells Installed	Pending	April 2025
Terrestrial vegetation and soils collected - year 1	Pending	Oct 2025
Hydrologic Model Calibration	Pending	Oct 2025
Soil preparation in laboratory and analysis - year 1	Pending	Mar2026
Initial hydrologic data cleaned for building and testing hydrologic model	Pending	Mar 2026
Terrestrial vegetation and soils collected - year 2	Pending	Oct 2026
Hydrologic Model Validation	Pending	Oct 2026
Soil preparation in laboratory and analysis - year 2	Pending	Mar 2027
Second year of hydrologic data cleaned and inputted into model	Pending	Mar 2027
Terrestrial vegetation and tree core data entered, cleaned, and analyzed	Pending	June 2027
Field meeting potentially in collaboration with regional forestry coordination meeting on results from models (note funding would be from individual organization to attend)	Pending	Aug 2027
Evaluation of UMRS FIM model performance	Pending	Sept 2027
Project data entered in the UMN DRUM for open access	Pending	Oct 2028
Publication of hydrologic model development	Pending	Oct 2027
Publication linking vegetation, soils, and hydrologic function	Pending	Oct 2028
Publication of UMRS FIM model performance	Pending	Oct 2028

* We expect to share our results through a minimum of 2 presentations in local, regional, or national conferences and meetings

References

Battaglia, L.L., Minchin, P.R., Pritchett. D.W. 2002. Sixteen Years of Old-Field Succession and Reestablishment of a Bottomland Hardwood Forest in the Lower Mississippi Alluvial Valley. Wetlands 22 (1): 1–17.

Brown, J.A., Robertson, B.L., & McDonald, T. 2015. Spatially balanced sampling: application to environmental surveys. Procedia Environmental Sciences 27:6-9.

De Jager, N. R., Thomsen, M., & Yin, Y. 2012. Threshold effects of flood duration on the vegetation and soils of the Upper Mississippi River floodplain, USA. Forest Ecology and Management, 270, 135-146.
De Jager, N.R., Rohweder, J.J., Yin, Y. & Hoy, E., 2016. The Upper Mississippi River floodscape: spatial patterns of flood inundation and associated plant community distributions. Applied Vegetation Science, 19(1), pp.164-172.
De Jager, N.R., Van Appledorn, M., Fox, T.J., Rohweder, J.J., Guyon, L.J., Meier, A.R., Cosgriff, R.J., Vandermyde, B.J. 2019. Spatially explicit modelling of floodplain forest succession: interactions among flood inundation, forest successional processes, and other disturbances in the Upper Mississippi River floodplain, USA. Ecological Modeling 405: 15-32.
Griffin, D., Voth Rurup, L., Tumper, M., Van Appledorn, M, Meier, M., Windmuller-Campione, M. *In Prep*. Climatic Drivers of Floodplain Forests of the Upper Mississippi River. Forest Ecology and Management
Guyon, L., Deutsch, C., Lundh, J. & Urich, R. 2012. Upper Mississippi River Systemic Forest Stewardship Plan. U.S. Army Corps of Engineers. 124 pp.
Heitmeyer, M.E. 2007. Feasibility Investigation: Hydrogeomorphic Modeling and Analyses – Upper Mississippi River System Floodplain. Greenbrier Wetland Services. Advance, MO.
Heitmeyer, M.E. 2008. An Evaluation of Ecosystem Restoration Options for the Middle Mississippi River Corridor. Greenbrier Wetland Services Report 08-02. Advance, MO.
Heitmeyer, M.E., & Bartletti, J.L. 2012. Hydrogeomorphic Evaluation of Ecosystem Restoration Options for the Quincy, Sny, and Columbia-American Bottoms Ecoregions of the Upper Mississippi River Floodplain. Greenbrier Wetland Services Report 12-03. Advance, MO.
Hosner, J. F., & Minckler, L. S. 1963. Bottomland hardwood forests of southern Illinois--regeneration and succession. Ecology, 44(1), 29-41.
Hughes, F.M., 1997. Floodplain biogeomorphology. Progress in Physical Geography 21(4): 501-529.
Hughes, F.M., Adams, W.M., Muller, E., Nilsson, C., Richards, K.S., Barsoum, N., Decamps, H., Foussadier, R., Girel, J., Guilloy, H. & Hayes, A., 2001. The importance of different scale processes for the restoration of floodplain woodlands. Regulated Rivers: Research & Management: An International Journal Devoted to River Research and Management, 17(4-5), pp.325-345.
Hupp, C.R. & Osterkamp, W.R. 1985. Bottomland vegetation distribution along Passage Creek, Virginia, in relation to fluvial landforms. Ecology 66(3): 670-681.
McLaughlin, D. L., & Cohen, M. J. 2014. Ecosystem specific yield for estimating evapotranspiration and groundwater exchange from diel surface water variation. Hydrological Processes, 28(3), 1495-1506.
Osterkamp, W.R., & Hupp, C.R. 1984. Geomorphic and vegetative characteristics along three northern Virginia streams. Geological Society of America Bulleting 95(9): 1093-1101.
Pannill, P.D., Hairson-Strang, A.B. & Bare, C.E., 2001. Riparian forest buffer survival and success in Maryland. Annapolis, MD: Maryland Department of Natural Resources Forest Service Research report DNR. FS-01-01. http://dnrweb. dnr. state. md. us/download/forests/rfb_survival. pdf.
Romano, S.P., 2010. Our current understanding of the Upper Mississippi River System floodplain forest. Hydrobiologia, 640(1), pp.115-124.
Shelford, V.E. 1959. Some Lower Mississippi Valley flood plain biotic communities: their age and elevation. Ecology 35(2) 126-142.
Theis, L. J., & Knox, J. C. 2003. Spatial and temporal variability in floodplain backwater sedimentation Pool Ten, Upper Mississippi River. Physical Geography, 24(4), 337-353.
Therrien, R., McLaren, R.G., Sudicky, E.A. & Panday, S.M., 2010. HydroGeoSphere: A three-dimensional numerical model describing fully-integrated subsurface and surface flow and solute transport. Groundwater Simulations Group, University of Waterloo, Waterloo, ON, 830.
Van Appledorn, M. 2022. Hydrologic indicators, chap. B of Houser, J.N., ed., Ecological status and trends of the Upper Mississippi and Illinois Rivers (ver. 1.1, July 2022): U.S. Geological Survey Open-File Report 2022–1039, 18 p.
Van Appledorn, M. & Baker, M.E. 2023. Flood Regimes Alter the Role of Landform and Topographic Constraint on Functional Diversity of Floodplain Forests. Ecography (3): e06519.
Van Appledorn, M., De Jager, N. R., & Rohweder, J. J. 2021. Quantifying and mapping inundation regimes within a large river-floodplain ecosystem for ecological and management applications. River Research and Applications, 37(2), 241-255.
Van Appledorn, M., Rohweder, J.J., and De Jager, N.R. 2024. Floodplain Inundation Model and Inundation Depths: Upper Mississippi and Illinois Rivers: U.S. Geological Survey data release, https://doi.org/10.5066/P13BRXXJ.
Vaughan, A., Fitzpatrick, F., Strange, J., and Van Appledorn, M. *In press*. Mapping potential sensitivity to hydrogeomorphic change in the UMRS riverscape. Upper Mississippi River Restoration Program Completion Report 2021HG1-7.
Voth Rurup, L., Tumper, M., Griffin, D., Van Appledorn, M., Meier, M., Windmuller-Campione, M. *In Prep.* Diameter Age Relationships of Floodplain Forest Trees of the Upper Mississippi River. Forest Science
Windmuller-Campione, M., Van Appledorn, M., Meier, A., & Reuling, L. (2022). Survival and growth of four floodplain forest species in an Upper Mississippi River underplanting. Tree Planters' Notes.
Windmuller-Campione, M.A., Reuling, L.F., Van Appledorn, M., Nielsen, D.M. and Meier, A.R., 2022. What is a stand? Assessing the variability of composition and structure in floodplain forest ecosystems across spatial scales in the Upper Mississippi River. Forest Ecology and Management, 520, p.120385.
Yin, Y., Wu, Y., Bartell, S.M., Cosgriff, R. 2009. Patterns of Forest Succession and Impacts of Flood in the Upper Mississippi River Floodplain Ecosystem. Ecological Complexity 6 (4): 463–72.

Strategic approach to identify HREP features that promote dense and diverse mussel assemblages

Previous LTRM project: NA

Name of Principal Investigators:

Kristen Bouska, USGS, Upper Midwest Environmental Sciences Center, La Crosse, WI, 608-781-6344, kbouska@usgs.gov. Role: project oversight and coordination, organize workshop, synthesize existing HREPs that have included mussel features, data management, and draft final products.

Traci DuBose (ESB New Hire), USGS, Upper Midwest Environmental Sciences Center, La Crosse, WI, 608-781-6___, tdubose@usgs.gov. Role: draft conceptual model for mussel habitat, synthesize existing hydrophysical information on habitat requirements for mussels, and draft final products.

Teresa Newton, USGS, Upper Midwest Environmental Sciences Center, La Crosse, WI, 608-781-6217, tnewton@usgs.gov. Role: technical oversight on mussel aspects, participate in workshop, and review products.

Collaborators:

Sara Schmuecker, USFWS, Rock Island Field Office, Moline, IL, 309-757-5800 ext 203, sara_schmuecker@fws.gov. Role: technical oversight on mussel aspects, participate in workshop, provide input into conceptual model, ensure the information in the guidelines document meets USFWS conservation and management objectives for mussels, and review final products.

Davi Michl, USACE, UMRR Science & Long Term Resource Monitoring, Rock Island District, Rock Island, IL, 309-794-5174, Davi.E.Warden-Michl@usace.army.mil. Role: participate in workshop, provide insight into how mussel benefits have been assessed in prior HREP planning efforts, and review final products.

Dan Kelner, USACE, St. Paul District, St. Paul, MN, 651-290-5277, daniel.e.kelner@usace.army.mil. Role: technical oversight on mussel aspects, participate in workshop, ensure the information on prior HREPs that included mussel features is adequately captured, and review final products.

Lucie Sawyer, USACE, Rock Island District, Rock Island, IL, 309-794-5836, Lucie.M.Sawyer@usace.army.mil. Role: technical oversight on hydrologic and hydraulic models, participate in workshop, and review final products.

Trevor Cyphers, USACE, St. Paul District, St. Paul, MN, 651-290-5031, Trevor.W.Cyphers@usace.army.mil. Role: technical oversight of HREP planning processes, participate in workshop, assist in generating a list of future HREPs that are amenable to addition of mussel features, and review final products.

Mike Dougherty, USACE, Rock Island District, Rock Island, IL, 309-794-5491, Michael.p.dougherty@usace.army.mil. Role: technical oversight on hydrologic models, participate in workshop, generate a list of future HREPs that are amenable to addition of mussel features, and review final products.

Kara Mitvalski, USACE, Rock Island District, Rock Island, IL, 309-794-5623, Kara.N.Mitvalsky@usace.army.mil. Role: technical oversight on HREPs that have potential to include mussel features, participate in workshop, and review final products.

State representatives, TBD, participate in workshop and review final products.

NGO representative, TBD, participate in workshop and review final products.

Introduction:

What's the issue or question? Hydrophysical conditions strongly influence aquatic communities in rivers (Statzner et al. 1988, Gore 1996). For benthic organisms, distributions are often responsive to heterogeneous physical and hydraulic conditions near the sediment-water interface that result from spatial and temporal variation in discharge and geomorphology (Rempel et al. 2000, Merigoux and Doledec 2004). Interest in understanding physical habitat variables that could drive the distribution and abundance of freshwater mussels has been increasing due to their precipitous decline throughout North America. Native freshwater mussels are a group of organisms that appear responsive to variation in hydrophysical conditions (Steuer et al. 2008, Zigler et al. 2008), but little is known about how to incorporate this knowledge into design features in habitat rehabilitation and enhancement projects (HREPs). Current approaches for incorporating mussel features into HREPs is largely opportunistic. Typically, resource managers add rounded river stone features in specific HREP areas in anticipation that these features will increase physical habitat diversity and thus promote mussel assemblages. While this approach has had some success (see next paragraph), a more strategic approach that identifies (1) the specific HREP features and locations that could support dense and diverse mussel assemblages, (2) the appropriate response metrics (e.g., density, diversity, recruitment), (3) the frequency and duration of monitoring, and (4) the next steps is warranted. This process would advance the information gaps associated with mussels and HREPs by developing a strategic approach that provides guidelines for incorporation of mussel features into HREPs.

What do we already know about it? In the past few years, resource managers have evaluated mussel features at three HREPs in the Upper Mississippi River (UMR). One of these was designed to evaluate mussel resources pre- and post-project and two evaluated mussels post-project only. The first project, Capoli Slough (Pool 9), was completed in 2014 and involved construction of bank stabilization features around a barrier island and the addition of cobble substrates in a secondary channel. Due to presence of the federally-listed species *Lampsilis higginsii* mussel the project was modified to avoid and minimize impacts to mussels by reducing access dredge cuts and relocating mussels from access cuts to a side channel. Pre- (2009) and post-construction (in 2020) monitoring indicated a four-fold increase in total mussel density (from 2.5/ m^2 to 10/m^2), increased *L. higginsii* density (from 0/ m^2 to 0.1/m^2) within the side channel, and documented recolonization of *L. higginsii* into adjacent access cuts (Kelner 2021). The second project, Bertom McCartney (Pool 11), was completed in 1991 and included increasing flows in a side channel (>3 ft/sec) and a gradation of substrate sizes to deter colonization by zebra mussels to the benefit of native mussels. Post-project monitoring in 2014 indicated low zebra mussel density but also low density (<5/m^2) and diversity (11 species) of native mussels (Kelner 2015). The third project, Beaver Island (Pool 14), constructed in 2020, included the addition of rock chevrons and bank protection to minimize erosion of Albany Island and the addition of rounded river stone along Albany Slough to enhance physical habitat diversity to benefit mussels. Post-construction monitoring (2023) found 15 live species and low, but similar densities (<0.5/m^2) at each of three sub-sites (Kelner 2024). Several additional projects that include mussel enhancement objectives have been proposed or are in planning stages (e.g., Pool 14 Steamboat Island, Pool 7 Mussel Habitat Enhancement). While these studies have provided useful information, this ad hoc approach has not been able to provide specific HREP features that might benefit mussels.

How will the proposed work improve our understanding of the UMRS? Prior studies to identify what constitutes physical habitat for mussel in rivers relied almost exclusively on variables such as depth, current velocity, and substrate type; these models had limited predictive power (e.g., Holland-Bartels 1990, Strayer and Ralley 1993, Brim Box et al. 2002). More recent studies have shown that mussel occurrence is related to complex hydraulic variables such as shear stress and relative substrate stability (Howard and Cuffey 2003, Newton et al. 2020). Studies in the UMR suggest that hydrophysical conditions account for a substantial portion of the variability in mussel distributions (Steuer et al. 2008, Zigler et al. 2008). For example, hydrophysical models used a suite of complex hydraulic and physical variables to successfully predict ~74% of presence and absence of mussels in Pool 8 (Zigler et al. 2008). Managers design HREPs to improve the overall health and resiliency of the UMRS ecosystem, and thus projects are often targeted to overlap with areas that contain species of conservation concern, threatened, and endangered species. Although HREPs are largely beneficial to protected species, this juxtaposition occasionally requires a delicate balance of trade-offs between short-term impacts protected species to achieve project objectives and long-term impacts to these populations that result from habitat improvements. The proposed research provides an approach to not only facilitate projects that could improve habitat to support dense and diverse mussel assemblages, but also supports the ability to further avoid and minimize potential impacts to achieve non-mussel habitat objectives. This strategic, data-driven approach will

(1) synthesize and identify specific habitat variables (and their ranges) that likely drive dense and diverse mussel assemblages and (2) identify upcoming HREPs that have the potential to meet these habitat criteria. This process could be used to prioritize HREPs where habitat features for mussels could be easily added.

<u>What are the objectives</u>?

1. Develop a conceptual model that describes what constitutes suitable habitat for mussels in the UMRS.
2. Summarize existing data on mussels and HREPs that includes lessons learned from prior HREPs with added mussel features, identify physical habitat variables (and their ranges) that appear to drive dense and diverse mussel assemblages, and identify those mussel metrics most suited to evaluate the success of a given HREP.
3. Summarize the results from the first two objectives into a guidance document that describes a conceptual approach for how to incorporate mussel features into HREPs.

Relevance of research to UMRR:

<u>How does this work relate to the information needs of UMRR partners</u>?

1. *How will the results inform river restoration and management?* There is currently substantial uncertainty in how to design HREPs to promote habitat features for mussels. Much of this uncertainty stems from our limited understanding of what constitutes suitable habitat for mussels in large rivers. The synthesis of existing information on habitat requirements for mussels is urgently needed by UMRS resource managers to facilitate leveraging opportunities with existing and proposed HREPs. Because mussels are a resource of concern to many state, federal, and NGO partners, there is considerable interest in how HREPs in the UMRS could be designed to support the conservation and recovery of mussels. In addition, the proposed research supports question 5b of the LTRM research framework on native mussels ("What are the effects of alternative habitat restoration activities on mussels in an adaptive management framework [in essence, using mussels as experiments]?) and output 2.2c ("Information generated from focused research agenda on setting management objectives and defining indicators, aquatic vegetation, mussels, floodplain connectivity, and landscape patterns") in the LTRM strategic plan (Newton et al. 2010).

2. *How will the proposed work contribute to, or improve, the selection or design of HREPs?* Completion of the guidelines document will facilitate a process that will allow future HREPs to be designed using the best available information with respect to identifying HREPs most amenable to modifications to support mussel features. The identification of stepwise guidelines will provide clarity in how HREPs can be used to benefit mussels and to identify the most appropriate HREPs to add mussel objectives.

3. *Describe how the research addresses one or more of the 2024 focal areas.* This research relates to Focal area 1.1: Macroinvertebrates and Focal area 2.7: Linking restoration actions and ecosystem responses.

4. *If work involves an HREP, name it*. This work will summarize mussel efforts at past HREPs and identify features in future HREPS that could support mussel objectives.

Methods:

The spatial scale of this project could include the entire UMRS. For ***objective one***, we will develop a conceptual model that describes what constitutes suitable habitat for mussels in the UMRS. This will be accomplished by convening a workshop with state, federal, and NGO partners to capture partner information and data needs regarding the conservation and management of mussels in the UMRS. The conceptual habitat model will focus on those habitat features that can be manipulated in HREPs.

For ***objective two***, we will summarize (1) existing hydrophysical models with mussels to identify those habitat variables (and their ranges) that have been shown to support dense and diverse mussel assemblages, (2) existing knowledge of where mussel features have been added to HREPs, and (3) mussel response metrics that are best suited to evaluate the success of a given HREP. For summarizing hydrophysical models, we will review and synthesize models focused on large rivers to identify fundamental habitat variables that most likely contribute to dense and diverse mussel assemblages. We will also identify ranges of those variables that support dense and diverse mussel assemblages (i.e., shear stress values of 1-3 dynes/cm support the most dense mussel assemblages). For summarizing prior HREPs with mussel features, we will review and synthesize existing reports where mussel features have been incorporated into HREPs (i.e., Capoli Slough, Beaver Island, Bertrom-McCartney). We will also identify physical features (i.e., rock size, rock placement, velocity gradients) that were designed to enhance habitat diversity and assess if the addition of these features enhanced mussel assemblages. For the mussel response metrics, we will summarize existing information and identify which response metrics are most suited for evaluation of HREPs and identify the frequency and duration of future monitoring projects. Because of the long lifespans of mussels and annual variability in hydrology, the effects of HREP design features on mussels may not be evident for decades. Thus, some response metrics (i.e., total density) may not be well suited to evaluate HREPs. Response metrics such as recruitment and variation in size and age demography may provide information on the success or failure of a given HREP over a shorter period of time. Once response metrics have been identified, guidelines for the frequency (i.e., once every 2 years pre- and post-construction) and duration (i.e., 2 years pre-construction and 5 years post-construction) of monitoring will be developed.

For ***objective three***, we will summarize the results of the first two objectives into a guidance document for best management practices for incorporating mussel features into HREPs. This document will (1) create a conceptual model that identifies those physical habitat features most likely to support dense and diverse mussel assemblages in the UMRS including a description of the mechanisms by which these variables might drive mussel assemblages; (2) summarize prior HREPs where mussel features have been incorporated and synthesize lessons learned; (3) summarize the ranges of those habitat variables that currently support dense and diverse mussel assemblages; (4) identify which mussel response metrics, at what scale, are best suited to evaluate HREPs; (5) identify the frequency and duration of mussel monitoring needed to evaluate the success of a given HREP; and (6) outline the existing knowledge gaps needed to refine design criteria for incorporating mussel features into future HREPs.

Data management procedures:
All data generated in this study will be recorded in bound notebooks, electronic files, or kept in file folders on UMESC servers that are routinely backed up. An electronic study file will be created on the UMESC server in consultation with IT and data management personnel. Syntheses of existing data will be compiled into synthetic reports, with input from all investigators and collaborators. Upon project completion, data, notebooks, and electronic files will be stored in the UMESC archives. Our intent is to use data that are already publicly available. In the event that we use data that is not already publicly available, we will create a Federal Geographic Data Committee compliant metadata file; data and metadata will be approved for release following the USGS Fundamental Science Practices and made publicly available through USGS ScienceBase.

Special needs/considerations: none

Budget:
Our total estimated cost for this project is approximately $66,000. This estimate includes salary for the project principal investigators as well as salary and travel support for 8 individuals (2 FWS, 6 USACE) and travel support for 6 individuals (5 State agency, 1 NGO) to participate in the proposed workshop. The workshop is tentatively planned to be at UMESC to minimize rental and travel costs.

Timeline:
Our anticipated start date is October 2024 and our expected completion date is December 2026.

Expected milestones and products:

In addition to the milestones identified below, our products include (1) quarterly conference calls with collaborators to seek input on specific milestones and provide updates on progress, (2) annual summaries to the USACE Upper Mississippi River Restoration LTRM Management Team, and (3) a guidelines document.

Milestone	Relevance	Anticipated completion
Workshop to develop a conceptual model	Develop a conceptual model of mussel habitat in the UMR to facilitate incorporation of mussel features into future HREPs	September 2025
Literature review of prior HREPs that have included mussel features	A synthesis of lessons learned in prior mussel HREPs; this will be used to develop new guidelines for sampling and monitoring mussels associated with HREPs	September 2025
Literature review of habitat characteristics that promote dense and diverse mussel assemblages in large rivers	A synthesis of which habitat variables and their ranges are important to mussels; this will be used to identify which future HREPs are amost amenable to mussel features	March 2026
Literature review of existing mussel response metrics	A synthesis of which mussel response metrics habitat variables and their ranges are important to mussels; this will be used to develop pre- and post-monitoring projects for mussels and HREPs	May 2026
Guidelines document	This document will include (1) a conceptual model of mussel habitat in UMR, (2) lessons learned from prior HREPs where mussel features have been incorporated, (3) a table of habitat variables, and their ranges, that support dense and diverse mussel assemblages, (4) identify which mussel response metrics are best suited to evaluate HREPs, (5) identify the frequency and duration of monitoring needed to evaluate the success of a given HREP, and (6) outline the existing knowledge gaps needed to refine design criteria for incorporating mussel features into future HREPs.	December 2026

References:

Brim Box, J., R.M. Dorazio, and W.D. Liddell. 2002. Relationships between streambed substrate characteristics and freshwater mussels (Bivalvia: Unionidae) in coastal plain streams. Journal of the North American Benthological Society 21:253–260.

Gore, J.A. 1996. Responses of aquatic biota to hydrological change. Pages 209–230 in Petts, G.E. and P. Calow (eds), River biota: diversity and dynamics. Blackwell Science, Oxford.

Holland-Bartels, L.E. 1990. Physical factors and their influence on the mussel fauna of a main channel border habitat of the upper Mississippi River. Journal of the North American Benthological Society 9:327–335.

Howard, J.K. and K.M. Cuffey. 2003. Freshwater mussels in a California North Coast Range river: occurrence, distribution, and controls. Journal of the North American Benthological Society 22:63–77.

Kelner, D. 2015. Mussel habitat enhancement monitoring, Upper Mississippi River Pool 11, Bertom and McCartney Lakes UMRR HREP.

Kelner, D. 2021. Section 7 Endangered Species Act Consultation, Capoli Slough UMRR HREP Six year post-construction mussel monitoring – 2020.

Kelner, D. 2024. Albany Slough mussel habitat enhancement monitoring, Upper Mississippi River Pool 14, Beaver Island Upper Mississippi River Restoration Program-Habitat Rehabilitation and Enhancement Project, three-year post-construction 2023.

Merigoux, S. and S. Doledec. 2004. Hydraulic requirements of stream communities: a case study on invertebrates. Freshwater Biology 49:600–613.

Newton, T.J., S.J. Zigler, W. Haag, J. Duyvejonck, and M. Davis. 2010. Scientific framework for research on unionid mussels in the Upper Mississippi River System. Prepared for the Upper Mississippi River Restoration Program. 7 pp.

Newton, T.J., S.J. Zigler, P.R. Schrank, M. Davis, and D.R. Smith. 2020. Estimation of vital rates to assess the relative health of mussel assemblages in the Upper Mississippi River. Freshwater Biology 65:1726-1739.

Rempel, L.L., J.S. Richardson, and M.C. Healey. 2000. Macroinvertebrate community structure along gradients of hydraulic and sedimentary conditions in a large gravel-bed river. Freshwater Biology 45:57–73.

Statzner, B., J.A. Gore, and V.H. Resh. 1988. Hydraulic stream ecology: observed patterns and potential applications. Journal of the North American Benthological Society 7:307–360.

Steuer, J.J., T.J. Newton, and S.J. Zigler. 2008. Use of complex hydraulic variables to predict the distribution and density of unionids in the Upper Mississippi River. Hydrobiologia 610:67–82.

Strayer, D.L. and J. Ralley. 1993. Microhabitat use by an assemblage of stream-dwelling unionaceans (Bivalvia), including two rare species of *Alasmidonta*. Journal of the North American Benthological Society 12:247–258.

Zigler, S.J., T.J. Newton, J.J. Steuer, M.R. Bartsch, and J. Sauer. 2008. Importance of physical and hydraulic characteristics to unionid mussels: a retrospective analysis in a large river reach. Hydrobiologia 598:343–360.

2024 UMRR Science Proposal Evaluation and Ranking Criteria

Note that score for first criterion is double the weight of the subsequent three. Use only whole numbers for scoring (no decimals).

Total Score (sum of Scores 1 – 4):________ (enter this number (or the avg of this number across reviewers in your agency) on the Scoring Spreadsheet)

[Note that the scoring range for criterion 4 was modified according to the conclusions reached during the October 2023 Analysis Team meeting.]

1. How important is the proposed activity to advancing knowledge and understanding needed for managing and restoring the UMRS**? Base your assessment of importance on how well the work address one or more 2024 Focal Areas and other supporting information provided in the proposal.** Raw score (0 to 9): ________ X 2 =total score (0 to 18) _________[**Score 1**].

0	Not important – unlikely to contribute to our understanding of any focal areas.
1 - 3	Somewhat Important –will likely make a small contribution to our understanding of at least one focal area.
4 – 6	Important but could be addressed at any time. Expected to make a significant contribution to our understanding of one or more 2024 Focal Areas.
7 - 9	Very Important and should be addressed now. Expected to make a substantial contribution to our understanding of one or more 2024 Focal Areas and is addressing an urgent need or taking advantage of an unusual opportunity.

2. Are the study objectives clear and realistically achievable? That is, has the problem or question to be addressed been clearly identified and are the research questions or hypotheses clearly stated. Score (0 to 9): ___ [**Score 2**]

0	Objectives (including questions or hypotheses to be addressed) are poorly described or unlikely to be achieved.
1 – 3	Objectives (including questions or hypotheses) are clearly identified but it is unclear the extent to which the proposed work will achieve them; little significant new information is likely to be obtained
4 – 6	Objectives (including questions or hypotheses) are clearly identified and are likely to be at least partially achieved, such that some significant new information is likely to be obtained.
7 – 9	Objectives (including questions or hypotheses) are clearly identified and likely to be fully achieved such that substantial new information is expected to be obtained.

3. Are the methods clearly described? Do the PIs and collaborators have the necessary expertise to conduct the work? Will the methods produce the data or information required to get effectively address project objectives?
Score (0 to 9): ____ [**Score 3**]

0	Methods are not clearly stated
1 – 3	Methods are clearly stated, but are not likely to produce needed data/information
4 – 6	Methods are clearly stated, but unclear how well the results will address specified objectives
7 – 9	Methods are clearly stated and likely to effectively address specified objectives

4. What is the scale of the problem (even if tested or applied at a local scale)? Score (0 to 6): _______ [**Score 4**]

0	Local problem only
1 –2	Local problem with reach-wide generality or application
3 –4	Reach-wide problem
5 – 6	Systemic problem, with great generality

UMRR Coordinating Committee Quarterly Meeting
A-Team Report
May 22, 2024
Matt O'Hara Illinois Department of Natural Resources- A-Team Chair

A-Team members assisted in the development of research projects by participating in workgroup discussions with USGS principal investigators at the 2024 UMRR Science meeting held at USGS Upper Midwest Sciences Center (UMESC) in La Crosse, Wisconsin January 16-18, 2024. On February 2, 2024, the A-Team received the science proposals and ranking sheet for agency review and scoring. The A-Team met on April 16, 2024, in La Crosse, Wisconsin, with the principal investigators present to discuss the thirteen science proposals and address any follow-up questions posed by A-Team members. A-Team final agency rankings were due by COB April 23, 2024. Along with review and discussion of the science proposals, approval of the October meeting notes was passed, agency updates were provided, and a July meeting was proposed to be held in the Havana, Illinois area with several potential meeting locations TBD. The A-Team convened via a virtual meeting on April 25, 2024, to discuss and review the thirteen ranked science proposals. These proposals were sorted by the highest to lowest total ranking score, the A-Team voted and unanimously approved the project rankings final list. Matt O'Hara, the IDNR A-Team Chair, met with the UMRR LTRM Management Team on May 2, 2024, to discuss final funding recommendations for science proposals. There was consensus on recommending eight project proposals (7 fully funded and 1 partially funded) to be funded. This recommendation was based upon the available FY 25 funding and the ability for project to be completed. To be able to fund the eight projects, the group recommended delaying full funding for “The Generating future hydrology and water temperature projections for the UMRS using hybrid deep learning” project (1 year fully funded, additional years TBD). Delayed funding will have no effect on the scientific products and outcomes of this project; however, this did allow funding of the “In-depth characterization of phytoplankton communities and toxicity across connectivity gradients along 450 miles of the Upper Mississippi River System” project, which the group identified as important to support a previously endorsed implementation planning information need. The LTRM Management Team also agreed that projects that were not funded in FY24 can be considered for funding in FY25 (assuming funding availability) and such funding will be based on their ranking position. The A-Team Chair Matt O’Hara recommends endorsement of funding for the eight Science proposals based on the A-team and LTRM Management Team recommendations.

ATTACHMENT F

Additional Items

- Future Meeting Schedule *(F-1)*
- Frequently Used Acronyms (4-29-2022) *(F-2 to F-8)*

Quarterly Meetings
Future Meeting Schedule

August 2024	
Minneapolis-St. Paul Metro	
August 6	UMRBA Quarterly Meeting
August 7	UMRR Coordinating Committee Quarterly Meeting

November 2024	
St. Louis, MO	
November 19	UMRBA Quarterly Meeting
November 20	UMRR Coordinating Committee Quarterly Meeting

Acronyms Frequently Used on the Upper Mississippi River System

AAR	After Action Report
A&E	Architecture and Engineering
ACRCC	Asian Carp Regional Coordinating Committee
AFB	Alternative Formulation Briefing
AHAG	Aquatic Habitat Appraisal Guide
AHRI	American Heritage Rivers Initiative
AIS	Aquatic Invasive Species
ALC	American Lands Conservancy
ALDU	Aquatic Life Designated Use(s)
AM	Adaptive Management
ANS	Aquatic Nuisance Species
AP	Advisory Panel
APE	Additional Program Element
ARRA	American Recovery and Reinvestment Act
ASA(CW)	Assistant Secretary of the Army for Civil Works
A-Team	Analysis Team
ATR	Agency Technical Review
AWI	America's Watershed Initiative
AWO	American Waterways Operators
AWQMN	Ambient Water Quality Monitoring Network
BA	Biological Assessment
BATIC	Build America Transportation Investment Center
BCOES	Bid-ability, Constructability, Operability, Environmental, Sustainability
BCR	Benefit-Cost Ratio
BMPs	Best Management Practices
BO	Biological Opinion
CAP	Continuing Authorities Program
CAWS	Chicago Area Waterways System
CCC	Commodity Credit Corporation
CCP	Comprehensive Conservation Plan
CEICA	Cost Effectiveness Incremental Cost Analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CFS	Cubic Feet Per Second
CG	Construction General
CIA	Computerized Inventory and Analysis
CMMP	Channel Maintenance Management Plan
COE	Corps of Engineers
COPT	Captain of the Port
CPUE	Catch Per Unit Effort
CRA	Continuing Resolution Authority
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program

CSP	Conservation Security Program
CUA	Cooperative Use Agreement
CWA	Clean Water Act
CY	Cubic Yards
DALS	Department of Agriculture and Land Stewardship
DED	Department of Economic Development
DEM	Digital Elevation Model
DET	District Ecological Team
DEWS	Drought Early Warning System
DMMP	Dredged Material Management Plan
DNR	Department of Natural Resources
DO	Dissolved Oxygen
DOA	Department of Agriculture
DOC	Department of Conservation
DOER	Dredging Operations and Environmental Research
DOT	Department of Transportation
DPR	Definite Project Report
DQC	District Quality Control/Quality Assurance
DSS	Decision Support System
EA	Environmental Assessment
ECC	Economics Coordinating Committee
EEC	Essential Ecosystem Characteristic
EIS	Environmental Impact Statement
EMAP	Environmental Monitoring and Assessment Program
EMAP-GRE	Environmental Monitoring and Assessment Program-Great Rivers Ecosystem
EMP	Environmental Management Program [Note: Former name of Upper Mississippi River Restoration Program.]
EMP-CC	Environmental Management Program Coordinating Committee
EO	Executive Order
EPA	Environmental Protection Agency
EPM	Environmental Pool Management
EPR	External Peer Review
EQIP	Environmental Quality Incentives Program
ER	Engineering Regulation
ERDC	Engineering Research & Development Center
ESA	Endangered Species Act
EWMN	Early Warning Monitoring Network
EWP	Emergency Watershed Protection Program
FACA	Federal Advisory Committee Act
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FDR	Flood Damage Reduction
FFS	Flow Frequency Study
FMG	Forest Management Geodatabase
FONSI	Finding of No Significant Impact
FRM	Flood Risk Management

FRST	Floodplain Restoration System Team
FSA	Farm Services Agency
FTE	Full Time Equivalent
FWCA	Fish & Wildlife Coordination Act
FWIC	Fish and Wildlife Interagency Committee
FWS	Fish and Wildlife Service
FWWG	Fish and Wildlife Work Group
FY	Fiscal Year
GAO	Government Accountability Office
GEIS	Generic Environmental Impact Statement
GI	General Investigations
GIS	Geographic Information System
GLC	Governors Liaison Committee
GLC	Great Lakes Commission
GLMRIS	Great Lakes and Mississippi River Interbasin Study
GPS	Global Positioning System
GREAT	Great River Environmental Action Team
GRP	Geographic Response Plan
H&H	Hydrology and Hydraulics
HAB	Harmful Algal Bloom
HEC-EFM	Hydrologic Engineering Center Ecosystems Function Model
HEC-RAS	Hydrologic Engineering Center River Analysis System
HEL	Highly Erodible Land
HEP	Habitat Evaluation Procedure
HNA	Habitat Needs Assessment
HPSF	HREP Planning and Sequencing Framework
HQUSACE	Headquarters, USACE
H.R.	House of Representatives
HREP	Habitat Rehabilitation and Enhancement Project
HSI	Habitat Suitability Index
HU	Habitat Unit
HUC	Hydrologic Unit Code
IBA	Important Bird Area
IBI	Index of Biological (Biotic) Integrity
IC	Incident Commander
ICS	Incident Command System
ICWP	Interstate Council on Water Policy
IDIQ	Indefinite Delivery/Indefinite Quantity
IEPR	Independent External Peer Review
IGE	Independent Government Estimate
IIA	Implementation Issues Assessment
IIFO	Illinois-Iowa Field Office (formerly RIFO - Rock Island Field Office)
ILP	Integrated License Process
IMTS	Inland Marine Transportation System
IPR	In-Progress Review
IRCC	Illinois River Coordinating Council

IRPT	Inland Rivers, Ports & Terminals
IRTC	Implementation Report to Congress
IRWG	Illinois River Work Group
ISA	Inland Sensitivity Atlas
IWR	Institute for Water Resources
IWRM	Integrated Water Resources Management
IWS	Integrated Water Science
IWTF	Inland Waterways Trust Fund
IWUB	Inland Waterways Users Board
IWW	Illinois Waterway
L&D	Lock(s) and Dam
LC/LU	Land Cover/Land Use
LDB	Left Descending Bank
LERRD	Lands, Easements, Rights-of-Way, Relocation of Utilities or Other Existing Structures, and Disposal Areas
LiDAR	Light Detection and Ranging
LMR	Lower Mississippi River
LMRCC	Lower Mississippi River Conservation Committee
LOI	Letter of Intent
LTRM	Long Term Resource Monitoring
M-35	Marine Highway 35
MAFC	Mid-America Freight Coalition
MARAD	U.S. Maritime Administration
MARC 2000	Midwest Area River Coalition 2000
MCAT	Mussel Community Assessment Tool
MICRA	Mississippi Interstate Cooperative Resource Association
MDM	Major subordinate command Decision Milestone
MIPR	Military Interdepartmental Purchase Request
MMR	Middle Mississippi River
MMRP	Middle Mississippi River Partnership
MNRG	Midwest Natural Resources Group
MOA	Memorandum of Agreement
MoRAST	Missouri River Association of States and Tribes
MOU	Memorandum of Understanding
MRAPS	Missouri River Authorized Purposes Study
MRBI	Mississippi River Basin (Healthy Watersheds) Initiative
MRC	Mississippi River Commission
MRCC	Mississippi River Connections Collaborative
MRCTI	Mississippi River Cities and Towns Initiative
MRRC	Mississippi River Research Consortium
MR&T	Mississippi River and Tributaries (project)
MSP	Minimum Sustainable Program
MVD	Mississippi Valley Division
MVP	St. Paul District
MVR	Rock Island District
MVS	St. Louis District

NAS	National Academies of Science
NAWQA	National Water Quality Assessment
NCP	National Contingency Plan
NIDIS	National Integrated Drought Information System (NOAA)
NEBA	Net Environmental Benefit Analysis
NECC	Navigation Environmental Coordination Committee
NED	National Economic Development
NEPA	National Environmental Policy Act
NESP	Navigation and Ecosystem Sustainability Program
NETS	Navigation Economic Technologies Program
NGO	Non-Governmental Organization
NGRREC	National Great Rivers Research and Education Center
NGWOS	Next Generation Water Observing System
NICC	Navigation Interests Coordinating Committee
NPDES	National Pollution Discharge Elimination System
NPS	Non-Point Source
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NRDAR	Natural Resources Damage Assessment and Restoration
NRT	National Response Team
NSIP	National Streamflow Information Program
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
O&M	Operation and Maintenance
OHWM	Ordinary High Water Mark
OMB	Office of Management and Budget
OMRR&R	Operation, Maintenance, Repair, Rehabilitation, and Replacement
OPA	Oil Pollution Act of 1990
ORSANCO	Ohio River Valley Water Sanitation Commission
OSC	On-Scene Coordinator
OSE	Other Social Effects
OSIT	On Site Inspection Team
P3	Public-Private Partnerships
PA	Programmatic Agreement
PAS	Planning Assistance to States
P&G	Principles and Guidelines
P&R	Principles and Requirements
P&S	Plans and Specifications
P&S	Principles and Standards
PCA	Pollution Control Agency
PCA	Project Cooperation Agreement
PCX	Planning Center of Expertise
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
PgMP	Program Management Plan

PILT	Payments In Lieu of Taxes
PIR	Project Implementation Report
PL	Public Law
PMP	Project Management Plan
PORT	Public Outreach Team
PPA	Project Partnership Agreement
PPT	Program Planning Team
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RCP	Regional Contingency Plan
RCPP	Regional Conservation Partnership Program
RDB	Right Descending Bank
RED	Regional Economic Development
RIFO	Rock Island Field Office (now IIFO - Illinois-Iowa Field Office)
RM	River Mile
RP	Responsible Party
RPEDN	Regional Planning and Environment Division North
RPT	Reach Planning Team
RRAT	River Resources Action Team
RRCT	River Resources Coordinating Team
RRF	River Resources Forum
RRT	Regional Response Team
RST	Regional Support Team
RTC	Report to Congress
S.	Senate
SAV	Submersed Aquatic Vegetation
SDWA	Safe Drinking Water Act
SEMA	State Emergency Management Agency
SET	System Ecological Team
SMART	Specific, Measurable, Attainable, Risk Informed, Timely
SONS	Spill of National Significance
SOW	Scope of Work
SRF	State Revolving Fund
SWCD	Soil and Water Conservation District
T&E	Threatened and Endangered
TEUs	twenty-foot equivalent units
TIGER	Transportation Investment Generating Economic Recovery
TLP	Traditional License Process
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TSP	Tentatively selected plan
TSS	Total Suspended Solids
TVA	Tennessee Valley Authority
TWG	Technical Work Group
UMESC	Upper Midwest Environmental Sciences Center

UMIMRA	Upper Mississippi, Illinois, and Missouri Rivers Association
UMR	Upper Mississippi River
UMRBA	Upper Mississippi River Basin Association
UMRBC	Upper Mississippi River Basin Commission
UMRCC	Upper Mississippi River Conservation Committee
UMRCP	Upper Mississippi River Comprehensive Plan
UMR-IWW	Upper Mississippi River-Illinois Waterway
UMRNWFR	Upper Mississippi River National Wildlife and Fish Refuge
UMRR	Upper Mississippi River Restoration Program [Note: Formerly known as Environmental Management Program.]
UMRR CC	Upper Mississippi River Restoration Program Coordinating Committee
UMRS	Upper Mississippi River System
UMWA	Upper Mississippi Waterway Association
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VTC	Video Teleconference
WCI	Waterways Council, Inc.
WES	Waterways Experiment Station (replaced by ERDC)
WHAG	Wildlife Habitat Appraisal Guide
WHIP	Wildlife Habitat Incentives Program
WIIN	Water Infrastructure Improvements for the Nation Act
WLM	Water Level Management
WLMTF	Water Level Management Task Force
WQ	Water Quality
WQEC	Water Quality Executive Committee
WQTF	Water Quality Task Force
WQS	Water Quality Standard
WRDA	Water Resources Development Act
WRP	Wetlands Reserve Program
WRRDA	Water Resources Reform and Development Act