Raising the Grade in the Upper Mississippi River & its Environs

CURRENT CONDITIONS, ONGOING ACTIVITIES, & FUTURE OPPORTUNITIES

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"Rivers run through our history and folklore, and link us as a people. They nourish and refresh us and provide a home for dazzling varieties of fish and wildlife and trees and plants of every sort. We are a nation rich in rivers."

— Charles Kuralt, On the Road With Charles Kuralt, 1995

Kuralt, Charles, (1995). On the Road with Charles Kuralt, New York : Fawcett Gold Medal, 363 pp.

Acknowledgments

In late March 2016, the collection and collation of information on major factors used to characterize the health of the Upper Mississippi River Basin seemed to be a substantial task, yet one that would be relatively straightforward. By early April, it became clear that this effort would be much more than "substantial" and anything other than "straightforward". However, we were fortunate to have tremendous support from volunteers who were willing to share their time and expertise to stimulate discussion and thought in advance of the Upper Mississippi River Raise the Grade Conference; this group includes the following:

Robin Bauerly, Western Illinois University Institute for Environmental Studies

Gretchen Benjamin, The Nature Conservancy

Dru Buntin, Upper Mississippi River Basin Association

Dave Hokanson, Upper Mississippi River Basin Association

Jordy Jordahl, America's Watershed Initiative

Heath Kelsey, University of Maryland, Center for Environmental Science

Kirsten Mickelsen, Upper Mississippi River Basin Association

Paul Osman, Illinois Department of Natural Resources and the Association of State Floodplain Managers

Rebecca Smith, The Nature Conservancy

While contributors held a range of converging and diverging opinions on key issues, each person was clearly dedicated to promoting practical steps that will have meaningful impacts on conditions across the Upper Mississippi River Basin. The authors also appreciate the research support provided by Jason Hunt, Victoria Livingston, Jennifer Sandrik-Rubio, and Terri Tobias, students in Western Illinois University's environmental science Ph.D. program.

Unlike other conference papers, this is a living document that will be revised to reflect the thoughts of conference work groups. We hope this document will serve as a baseline that will be used to judge the progress we collectively make in the future to raise the grade in the UMRB.

Kindest Regards,

Roger Viadero, Ph.D.
Professor and Director
Western Illinois University

Robert Sinkler
Water Infrastructure Director
The Nature Conservancy

Kathy Wine
Executive Director
River Action

WESTERN ILLINOIS UNIVERSITY

"Like Huckleberry Finn, the river itself has no beginning or end. In its beginning, it is not yet the river; in the end it is no longer the river. What we call the headwaters is only a selection from among the innumerable sources which flow together to compose it. At what point in its course does the Mississippi become what the Mississippi means?"

— T.S. Eliot, Introduction to The Adventures of Huckleberry Finn

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"Introduction" to The Adventures of Huckleberry Finn, by Samuel L. Clements, vii - xvi, London: Cressent Press, 1950.

Introduction

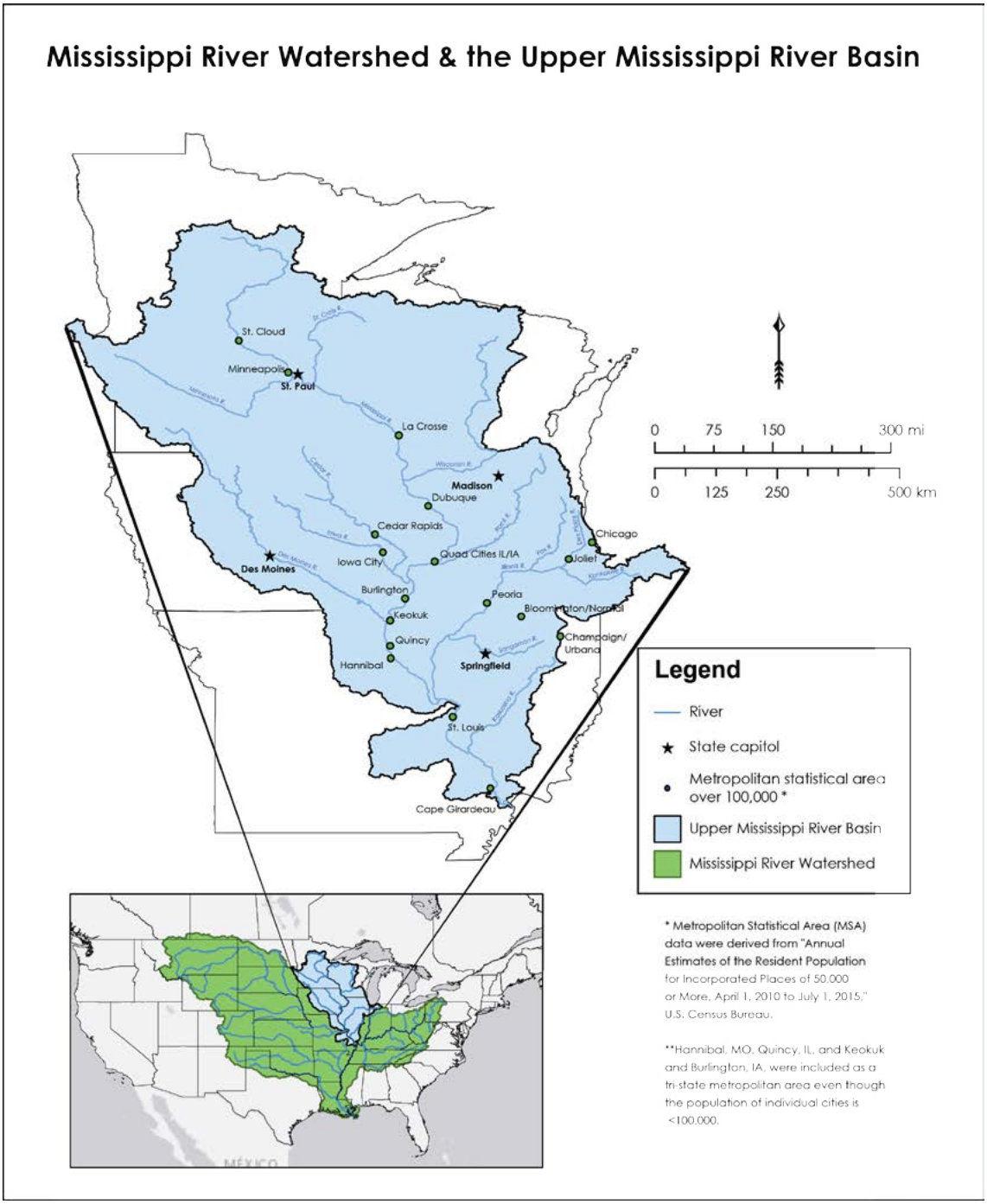
In October 2015, America's Watershed Initiative (AWI) released the Mississippi River Watershed Report Card to help stakeholders better understand current conditions and inspire collaborative efforts to improve the state of the basin. The watershed and each of its six sub basins were graded in six major areas that were selected to provide a common basis for comparison: (1) ecosystem health, (2) flood control and risk reduction, (3) transportation, (4) water supply, (5) the economy, and (6) recreation. Watershed-wide indicators included coastal wetland change and Gulf hypoxia. Overall, the Mississippi River Basin received a D+. As a sub watershed, the Upper Mississippi River Basin (UMRB) received a C. While this was the highest overall sub basin grade, significant room for improvement remains.

Due to the close relationship between the economy and energy production, the conference planning committee has combined both topics into a single session with a focus on energy. However, in this document, the AWI "economy" goal is used to maintain consistency with the Report Card. Regardless of where energy production is ultimately incorporated into a broad discussion of current and future conditions in the UMRB, most stakeholders will recognize that energy and economic issues are integrally related to every other "Raise the Grade" (RTG) goal.

As a next step forward, stakeholders from across the UMRB are using findings from the AWI Report Card as a tool to identify the intersection of needs and opportunities that transcend the traditional "stovepipe" interests of individual groups and develop concrete steps to put the report card into action. Ideally, these efforts will inspire and inform those in other sub-basins who share the vision of a Mississippi River basin with clean water, sustainable ecosystems, economic vitality, and world class recreational opportunities.

To help attendees make the most of the 2016 Upper Mississippi River Conference (UMRC), this document contains a goal-by-goal summary of the Upper Mississippi River Basin grades, key background information with sources of additional information, a list of actions that might be taken to Raise the Grade in the UMRB, and representative examples of ongoing activities. Since local actions taken in the UMRB and other sub basins have direct impacts on down stream communities, coastal wetland change and Gulf hypoxia are also included as watershed-wide indicators of environmental conditions. At the conclusion of the 2016 UMRC, recommendations developed at the working sessions will be incorporated into a final document that will be shared with conference attendees and other interested parties.

For those reading this document on a smart phone, tablet, or computer, please follow the links by clicking on blue, underlined, typeface to obtain additional detailed information on issues, opportunities, and stakeholders.



Map of the Mississippi River Watershed and the UMRB.

Goal 1. Support and enhance healthy and productive ecosystems

Conserve, enhance, and restore ecosystems within the Mississippi River Watershed to support natural habitats and the fish and wildlife resources that depend upon them. The ecosystem grade is a composite of scores received in four indicator areas:

1. Living resources, the condition of aquatic animal communities ..... C-
2. Streamside habitats, condition of stream and river habitat..... B
3. Water quality, nitrogen and phosphorus levels in rivers and streams ..... D+
4. Wetland change, % change in wetland area from 2006 to 2011..... D

UMRB ECOSYSTEM GRADE .....C-

Overview

Extending approximately 1,200 miles (~1900 km) from its ankle-deep headwaters at Lake Itasca, MN, the Upper Mississippi River (UMR) flows through lakes and forests into a landscape dominated by production agriculture. Ultimately, the UMR confluences with the Ohio River to form the broad alluvial floodplain of the Lower Mississippi River, below Cairo, IL. The 190,000 sq. mi. (~490,000 sq. km) of the Upper Mississippi River Basin (UMRB) is home to an exceptional variety of habitats including one of the world's largest river channels, small streams and sloughs, floodplain forests, wetlands and marshes, and backwater lakes.

The significance of UMRB habitats is recognized and valued by local, regional, national, and international stakeholders. For example, 300,000 acres (~122,000 ha) of UMRB wetlands are recognized as Wetlands of International Importance by the Ramsar Convention on Wetlands. As points of reference, other Ramsar sites in the western hemisphere include the Chesapeake Bay Estuarian Complex and the Pantanal floodplain in Brazil and Bolivia. In the UMRB, federal, state, and non-governmental organizations have cooperated to protect and preserve critical habitats - this includes the Upper Mississippi National Wildlife Refuge which covers nearly 200,000 acres (~81,000 ha) in Minnesota, Wisconsin, Iowa, and Illinois and the Trempealeau National Wildlife Refuge.[1]

Collectively, UMRB habitats support a diverse assemblage of aquatic and terrestrial wildlife comprised of more than 50 mammal, 150 fish, 37 freshwater mussel, and 45 amphibian and reptile species. Well known aquatic inhabitants of the UMRB include the paddlefish and the smooth soft-shell turtle. Similarly, the UMRB serves as a flyway for 40% of migrating waterfowl, shorebirds, and songbirds in North America. The UMRB is also a noted breeding and overwintering site for Bald Eagles.

The flora and fauna that occupy the UMRB are joined by approximately 30 million people who rely on the river and its tributaries as a source of drinking water, a venue for recreation, and a major artery for commerce. Along its course, the UMR pools behind a series of 29 locks and dams which were constructed to facilitate the river navigation. While these structures are considered to be among the most significant civil works projects constructed in North America, they have resulted in changes to the basin's hydrology, geomorphology, and ultimately, its biology. Representative changes range from an increase in the frequency and magnitude of flooding to the loss of shallow, vegetated habitats that provide food and shelter for fish and wildlife while simultaneously reducing water velocities, slowing the movement of sediments, and permitting the uptake of nutrients from the water column.

A less obvious, yet possibly more significant consequence of these landscape changes is the marked decrease in biological connectivity longitudinally, between river pools. This can increase competition between native and invasive fish species, promote the formation of localized areas of poor water quality, and reduce the genetic diversity of breeding stock in individual pools. Similarly, decreases in lateral connectivity have isolated the river channel from its floodplain. This has

[1] Ramsar Sites Information Service, https://rsis.ramsar.org

adversely impacted the exchange of water, sediment, organic matter, nutrients, and organisms that are necessary to maintain a healthy floodplain ecosystem. Further, it is worthwhile to note that actions taken in the UMRB will necessarily have impacts that can extend to the Gulf of Mexico and beyond.[2]

Many of the preceding changes are subtle and provide strong support for continual scientific monitoring by a multidisciplinary team of investigators.

Raising the Ecosystem Health and Productivity Grade in the UMRB

While debate continues over the relative costs and benefits of work to support ecosystem health and productivity, major stakeholders in the UMRB actively support the need to:

1. **Fully fund the Upper Mississippi River Restoration (UMRR) program.**

   For 30 years, broad-based ecosystem monitoring and restoration efforts in the UMRB have been catalyzed and coordinated through the Upper Mississippi River Restoration (UMRR) program. While measurable enhancements to ecosystem health have been realized, there are significant opportunities to advance these efforts even further. For instance, ecosystem health across the UMRB would benefit from the reconnection of side channels and backwater streams with the main river channel. Similarly, the development implementation of effective and inexpensive fish passage mechanisms can have measurable positive impacts on biological connectivity between UMR pools.

2. **Support the implementation and coordination of state nutrient loss reduction (NLR) strategies.**

   Currently, individual states are responsible for establishing individual performance standards and best management practices for nutrient loss reduction. Accordingly, individual states are at varying stages in the development of NLR plans. To reduce the cumulative adverse effects of nitrogen and phosphorus loading on downstream receptors - including hypoxia in the Gulf of Mexico - coordinated efforts are needed to manage nutrients in local waters, prior to being discharged into the waterways of the UMRB. The positive benefits realized by intervening close to the source of nutrient discharges ultimately yields a corresponding reduction in downstream nutrient loading. For example, USGS and USDA scientists recently demonstrated that on-farm conservation efforts applied in the UMRB can be used to maintain yields while reducing off-farm nitrogen and phosphorus discharges by as much as 34% and 10%, respectively.[3]

   While individual strategies are state-specific, all stakeholders can benefit by sharing information on successes and challenges.

3. **Strengthen basin-wide decision making by filling gaps in long term monitoring data.**

   The strength of decision making is directly related to the quality and relevance of the data that are used to inform the understanding of stakeholders. While existing long term resource monitoring efforts have resulted in substantial insights into UMRB ecology, there is a significant lack of systematic ecological data collected in the Lower Impounded Reach (LIR) of the UMR which covers approximately 280 river miles between Pools 13 and 26.[4]

A responsible path forward for the UMRB and downstream communities must include input and engagement from stakeholders with a wide range of perspectives. When informed by decisions that are based in quality science, meaningful steps can be taken to understand, protect, and preserve the health and function of ecosystems in the Upper Mississippi River.

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[2] Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (2004). A Science Strategy to Support Management Decisions Related to Hypoxia in the Northern Gulf of Mexico and Excess Nutrients in the Mississippi River Basin, U.S. Geological Survey Circular 1270, 58 pp.

[3] García, A., Alexander, R., Arnold, J., Norfleet, L., White, M., Robertson, D., and G. Schwarz (2016). Regional Effects of Agricultural Conservation Practices on Nutrient Transport in the Upper Mississippi River Basin, Environmental Science & Technology, 50 (13), 6991-7000. DOI: http://dx.doi.org/10.1021/acs.est.5b03543

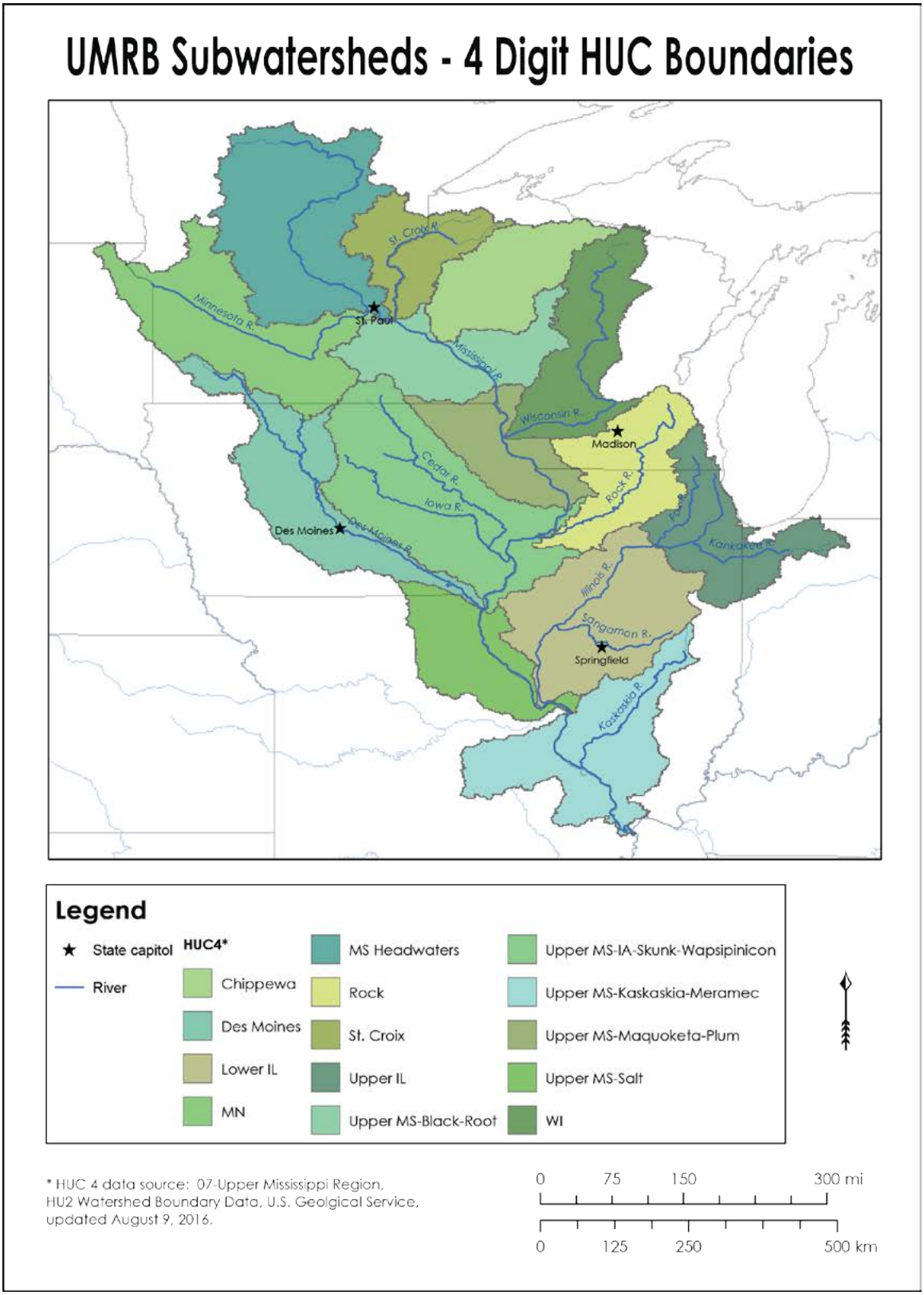
[4] http://www.umesc.usgs.gov/ltrmp.html

Photo by R. Bauerly, August 2009.

Shovelnose sturgeon, Mississippi River Pool 20.

Ongoing Activities to Raise the Ecosystem Grade in the UMRB

- UMRR restoration and science programs - http://www.mvr.usace.army.mil/Missions/Environmental-Protection-and-Restoration/Upper-Mississippi-River-Restoration/
- USACE Navigation and Ecosystem Sustainability Program (NESP; http://www.mvr.usace.army.mil/Missions/Navigation/NESP) - an integrated plan to ensure the environmental and economic sustainability of the UMRS.
- State nutrient loss reduction strategies
  - https://www.agr.state.il.us/nlrs
  - http://www.nutrientstrategy.iastate.edu/
  - https://www.pca.state.mn.us/water/nutrient-reduction-strategy
  - http://dnr.wi.gov/topic/surfacewater/nutrientstrategy.html
  - https://dnr.mo.gov/env/wpp/mnrsc/
- State Clean Water Act (CWA) programs
  - http://www.epa.illinois.gov/topics/water-quality/watershed-management/nonpoint-sources/section-319/index
- State and federal conservation programs
  - http://www.dnr.illinois.gov/conservation/Pages/default.aspx
  - http://www.mda.state.mn.us/conservationfundingguide
  - http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/
- U.S. Geological Survey monitoring programs and continuous monitoring initiative - http://www.umesc.usgs.gov/ltrmp.html
- National Great Rivers Research and Education Center (NGRREC) Great Lakes to Gulf data compilation - http://gltg.ncsa.illinois.edu/
- Upper Mississippi River Clean Water Act pilot monitoring program - http://www.umrba.org/wq/cwa-monitoring-strategy-flyer-3-14.pdf
- Lower Mississippi River Conservation Committee (LMRCC) resource assessment - http://www.lmrcc.org/



Map of UMRB Subwatersheds with 4 digit HUC boundaries.

Goal 2. Provide reliable flood control and risk reduction

Provide reliable flood protection and risk reduction through well managed and maintained infrastructure, including appropriate floodplain connections for water conveyance and ecosystem benefits, and management of surface and storm water runoff to better protect life, property, and economies. The flood control and risk reduction grade is a composite of scores received in three indicator areas:

1. Floodplain population change..... F
2. Levee condition..... C
3. Building elevation ..... B-

UMRB FLOOD CONTROL AND RISK REDUCTION GRADE .....D

Overview

Flood control and risk assessment efforts in the UMRB are complicated by the geographic scale of the region and the number of authorities with jurisdiction over the management and regulation of flood control and protection structures and practices. For decades, a wide range of constituents have formulated policies that are used to manage flood control and response across the UMRB. A direct consequence of this approach is an inconsistent patchwork of regulations that when followed can lead to unintended delays and last minute decisions that adversely impact the time sensitive response to flooding.

Raising the Flood Control and Risk Reduction Grade in the UMRB

1. **Strengthen resources used for watershed-based planning and decision making in the UMRB.**

   In light of the increased frequency and severity of flooding events, UMRB stakeholders recognize the need for a basin-wide decision making system that can be used to integrate information from multiple sources, across jurisdictional boundaries. Since the strength of any decision making system is directly related to the quality of the underlying data, methods, and interpretations, continued efforts are needed to develop practical tools, such as USACE's Hydrologic Engineering Center's River Analysis System (HEC-RAS) model that are based on a rigorous study of hydrology and hydraulics of the UMRB. Likewise, improved information sharing between stakeholders including National Weather Service (NWS) forecasting tools and FEMA response and recovery resources, would lead to a more integrated approach to the management of flood related risks.

   The outcomes of this action can also help others to Raise the Grade in related areas including ecosystems, transportation, and water supply.

2. **Support efforts to align the levee accreditation processes across agencies.**

   Although USACE and FEMA have developed a Memorandum of Understanding in response to the Biggert-Waters Flood Insurance Reform Act of 2012, meaningful steps are still required to make the levee accreditation process uniform and implementable.

3. **Develop a proactive watershed-wide approach to identify, acquire, and coordinate the necessary tools and information for more effective flood fighting in the UMRB.**

   An integrated study of structural and non-structural floodplain management measures in the UMRB would improve the overall effectiveness of the flood fighting across the entire basin. This effort would allow a better understanding of the relationships between land use, climate change, and the frequency and severity of flood events on the main stem of the [Upper] Mississippi River. Likewise, improved targeting of floodplain management efforts can help decrease inadvertent and unnecessary impacts that can occur during emergency responses to rising waters.

4. **Engage stakeholders in the development of plans to address aging flood control infrastructure in the UMRB.**

   As flood control infrastructure continues to age, it has become increasingly difficult to upgrade and maintain modern engineering standards. These challenges are further complicated by an increase in the frequency and severity of flooding events that result from climate fluctuations. This has significant implications for local levee owners, and state and federal regulators and the integrated flood risk management system that can benefit from input from a wide range of stakeholders.

Ongoing Activities to Raise the Flood Control and Risk Assessment Grade in the UMRB

- City of Dubuque, IA - Upper Bee Branch Creek Restoration. http://www.cityofdubuque.org/1546/Upper-Bee-Branch-Creek-Restoration
- Post Flood Insurance Rate Map (FIRM) construction yields substantial decreases in flood insurance premiums and total claims. http://www.fema.gov/flood-insurance-rate-map-firm
- Iowa Watersheds Project, Iowa Flood Center: http://iowafloodcenter.org/projects/watershed-projects/
- Meramec River, MO, Feasibility study: http://www.mvs.usace.army.mil/Missions/Programs-Project-Management/Plans-Reports/MeramecFeasibilityStudy/

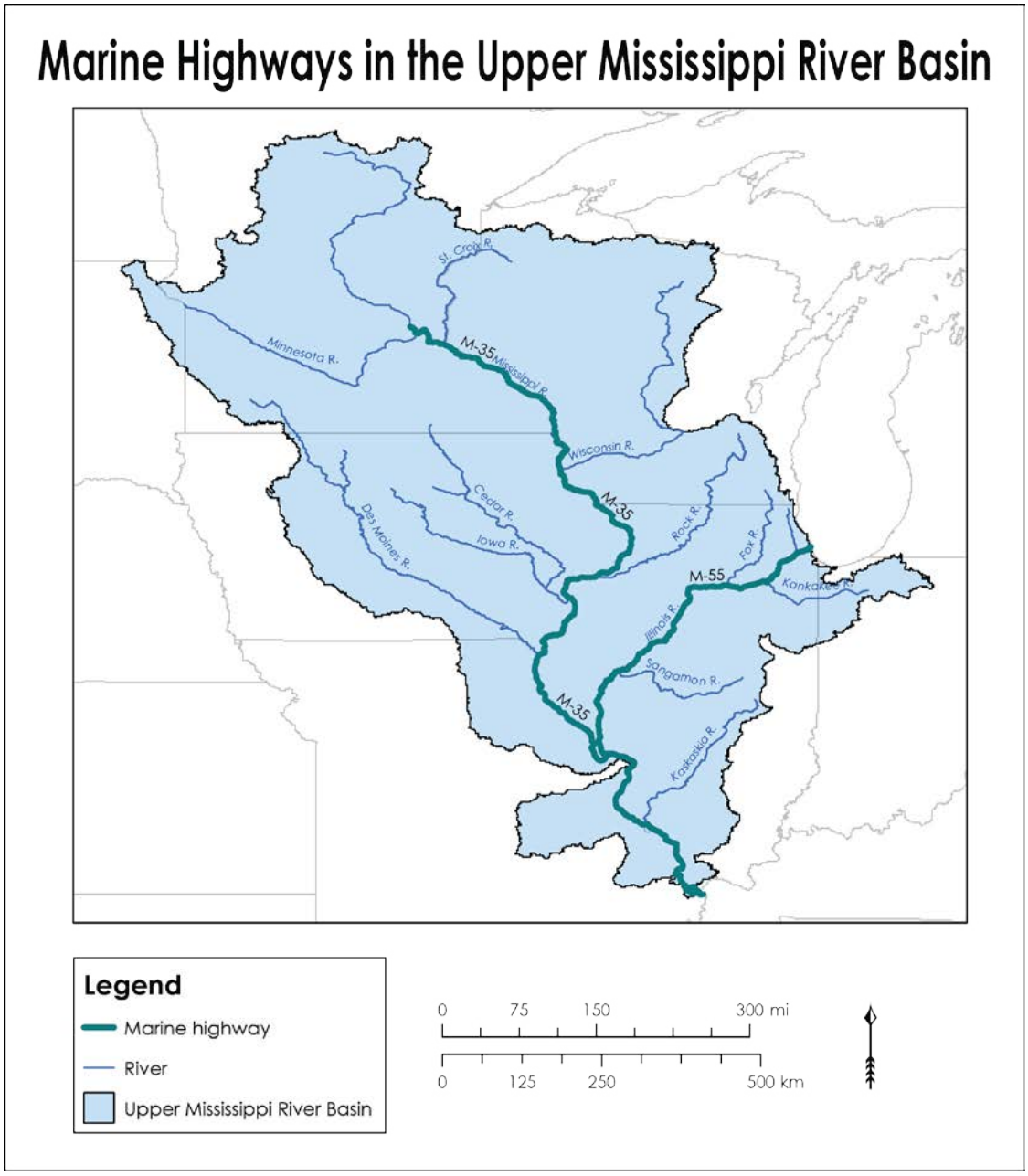
Photo by Barry Johnson, USGS, UMESC., June 27, 2008.

Flooding in the Upper Mississippi River Basin, June 2008.

- The Upper Des Plaines River and Tributaries Project, IL and WI. http://www.usace.army.mil/Portals/2/docs/civilworks/CWRB/upper_desplaines/upper_desplaines_rev2.pdf
- Floodplains by Design: Floodplain and ecosystem services mapping in the IA-Cedar Rivers Basin. http://www.aswm.org/pdf_lib/nffa_webinar/johnson_slaats.pdf
- Davenport, IA - America's largest city on a major river without a flood wall - continuing investment in riverfront green space and green infrastructure. http://cityofdavenportiowa.com/department/division.php?structureid=429
- Grafton, IL - After relocating the town on a 300' bluff, continued investments in tourism and community development yields measurable results. http://www.enjoygrafton.com/board-of-directors/
- Hannibal, MO - Strategic buyouts, investment in a city tree farm, a certified levee, and a flood wall protect property and draw citizens to the riverfront. http://www.hannibal-mo.gov/
- Prairie du Chien, WI -Investing in public ownership of riverfront property decreases risk and increases opportunities for recreational and historic/cultural activities. http://www.prairieduchien.info/
- St. Louis, MO - Riverfront Master Plan and the Bi-State River Ring reconnecting residents with the river while increasing flood storage capacity. http://greatriversgreenway.org/about-us/
- St. Paul, MN - Reconnecting citizens with the waterfront, improving flood forecasting capabilities, and enhancing public engagement/outreach. https://www.stpaul.gov/

U.S. Army Corps of Engineers, Rock Island District, August 8, 2014.

Debris build up at Lock and Dam 21 after 2014 flooding, Quincy, IL.



Map of Marine Highways in the Upper Mississippi River Basin.

Goal 3. Serve as the nation's most valuable river transportation corridor

Provide for safe, efficient, and dependable commercial navigation within the Mississippi River Watershed to ensure a competitive advantage for our goods in global markets. The transportation grade is a composite of scores received in three indicator areas:

1. Infrastructure condition..... D-
2. Infrastructure maintenance..... F
3. Lock delays ..... A

UMRB TRANSPORTATION GRADE .....D

Overview

The UMRB plays a key role in the movement of commodities including corn, soybeans, and coal from America's Heartland to consumers across the world. In the 1930s, a series of locks and dams were constructed to permit river traffic from Minneapolis, MN, to Cairo, IL. The design lifespan of these structures was approximately 50 years. To support commercial barge traffic, the navigation channel is maintained at a minimum depth of 9 ft (2.7 m) and a width of at least 400 ft (122 m). Contrary to popular belief, the lock and dam system in the UMRB is not operated to control flood levels. The AWI transportation grade for the UMRB was comparable to the D- given to the nation's inland waterways and the D given to characterize the condition of our dams by the American Society of Civil Engineers (ASCE) in 2013. Interestingly, the ASCE methodology was based on sixteen different indicators. While this is in some cases significantly more than the AWI considered, the general agreement in grades is indicative of the overall need to take decisive action to improve our nation's infrastructure.[5]

To ensure the future viability of waterborne commerce throughout the UMRB, there is a pressing need to repair and/or replace a significant fraction of the existing lock and dam infrastructure. For example, lock chambers that are 1,200 ft (366 m) are needed to accommodate modern towing practices and capabilities. Since barges move along the UMR from one pool to the next, the failure of a single structure could result in a system-wide shut down. Likewise, the increased frequency of drought conditions has had significant impacts on river navigation. In the summer of 2012, the Midwest experienced a prolonged drought that resulted in critically low water levels in the Upper Mississippi River and its tributaries. As a consequence, some docking locations became inaccessible. In other cases, barge companies had to reduce their payloads to avoid running aground.[6]

As the only inland river system designated as both a nationally significant ecosystem and a nationally significant navigation system, any changes to infrastructure, operation, and maintenance must be balanced against potential ecosystem impacts.[7]

Raising the Transportation Grade in the UMRB

1. **Develop a funding plan for UMRB infrastructure improvements that are able to meet current and future needs.**

   Despite the fact that authorizations have been made to modernize infrastructure in the UMRB, there has been a lack in the corresponding appropriations needed to conduct this work. Likewise, funding is needed to address the legacy of deferred maintenance at locks, harbors, and other related structures. Given the magnitude of infrastructure improvement needs, these efforts must include innovative approaches to infrastructure financing.

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5 http://www.infrastructurereportcard.org/a/#p/about-the-report-card/methodology

6 Sainz, Adrian. "Low Mississippi River levels to persist into fall." Peoria Journal Star, 22 August 2012.

7 Upper Mississippi River Management Act of 1986, 33 U.S.C. §652

2. **Continue full funding for America's Marine Highway Grant Program**

   In the U.S., marine transportation is one of the most underutilized modes of surface transportation. However, investments in marine transportation can help alleviate urban roadway congestion, decrease air pollution, and increase the economic efficiency of moving freight and passengers. Other related benefits include a reduction in wear and tear on roads and bridges. Continued full funding of the America's Marine Highway Program is needed to realize the significant positive outcomes that include the transportation/ infrastructure, economic, and ecosystem/environmental sectors.

3. **Continue to emphasize the UMRB's dual roles as a nationally significant ecosystem and a nationally significant navigation system.**

Ongoing Activities to Raise the Transportation Grade in the UMRB

- The Navigation and Ecosystem Sustainability Program: http://www.mvr.usace.army.mil/Missions/Navigation/NESP.aspx
- The designation of the Upper Mississippi River as the "M-35 Marine Highway Corridor" gives ports, terminals, and operators access to federal funding, technical support, and other resources to expand and/or develop new shipping services.
- Multi-Year Capital Investment Program: http://www.iwr.usace.army.mil/Portals/70/docs/IWUB/annual/IWUB_Annual_Report_2015_25Jan16_Final.pdf
- U.S. Army Corps of Engineers Asset Management Program: http://www.all-llc.com/SAME-Newsletters/SAME-09-Conf/Jose%20Sanchez%20-%20SAME%20Conference_3SEP09.pdf

Pamela Niebur, U.S. Army Corps of Engineers, St. Paul District, March 25, 2015.

M/V New Dawn locking through Lock and Dam 2, Hastings, MN.

Goal 4. Maintain a supply of abundant clean water

Ensure the quality and quantity of water in the Mississippi River Basin is adequate to support the economic, social, and environmental functions that are dependent on it. The water supply grade is a composite of scores received in two indicator areas:

1. Water treatment violations..... C
2. Water depletion..... B

UMRB WATER SUPPLY GRADE.....C+

Overview

From Minneapolis, MN, to Cairo, IL, the Upper Mississippi River and its tributaries serve as a source of drinking water to approximately 15 million people in over 50 major population centers.[8] These waters are also a key resource for commerce and recreation while simultaneously serving as a home to a diverse array of aquatic organisms as well as terrestrial and avian wildlife. These multiple uses have presented challenges for stakeholders seeking to make the most of this finite resource.

Using a similar "report card" approach, the American Society of Civil Engineers gave the nation's drinking water infrastructure a D, due largely to the age of key components.[9] ASCE also developed grades for key infrastructure (*e.g.*, bridges, roads, inland waterways, *etc.*) in many states. In IL, IA, and MO, the drinking water grade ranged from a C- to a C+.[10]

Other issues that affect water supplies in the UMR include hydrologic variability and nutrient loading. With the increased frequency of significant flood events and periods of prolonged drought, it has become difficult to predict the availability of water. Likewise, issues related to nutrient loading in UMR waters can have substantial impacts on the availability of water for human consumption as well as recreation. For example, elevated nutrient concentrations support the growth of algae which ultimately results in a decrease in dissolved oxygen in the water column. Algae blooms can also adversely affect native aquatic habitats and interfere with the operation of water treatment processes. In some cases, these nutrients aid the growth of non algal microorganisms that degrade organic matter in the water column and decrease DO.[11]

In 2000, the U.S. Geological Survey estimated that around 30,000 million gallons per day of fresh water was withdrawn from the five UMRB states.[12] This represented a 25% decrease in total water withdrawal when compared with water withdrawal in 2005. The most notable uses of water in the UMRB states in 2010 were thermoelectric power generation (87%), public water supply, (6%), and agriculture (2%). The remaining 5% was used in industrial and mining applications. In 2013, there were 96 power plants located in the UMR corridor.[13]

While total water use in the UMRB decreased between 2005 and 2010, there was an 18% increase in water used for thermoelectric power production.[14,15] The preceding fact lends insight into the growing importance of the water-energy nexus in the United States. In fact, when hydro-power generation is added to the water used in thermoelectric power generation, the integral relationship

8 Upper Mississippi River Conservation Committee (UMRCC, 2000). A River that Works and a Working River: A Strategy for the Natural Resources of the Upper Mississippi River System, Upper Mississippi River Conservation Committee, Rock Island, Illinois. 40 pp.

9 http://www.infrastructurereportcard.org/grades/

10 http://www.infrastructurereportcard.org/states/

11 Mallin, M., Johnson, V., Ensign, S., and T. MacPherson (2006). "Factors Contributing to Hypoxia in Rivers, Lakes, and Streams," Limnology and Oceanography, 51, 690-701.

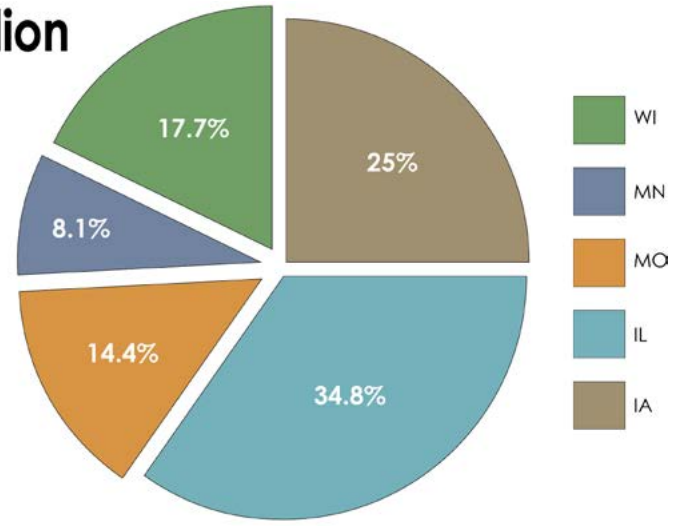
12 Maupin, M., Kenny, J., Hutson, S., Lovelace, J., Barber, N., and K. Linsey (2014). Estimated Use of Water in the United States in 2010, U.S. Geological Survey Circular 1405, 56 pp.

13 U.S. Fish and Wildlife Service, Upper Mississippi River Basin Association, and the Nature Conservancy (2015). Upper Mississippi River: A Vital Resource for Regional Economic Prosperity - Preliminary Results, http://www.umrba.org/umr-econ-profile.pdf.

14 Kenny, J., Barber, N., Hutson, S., Linsey, K., Lovelace, J., and M. Maupin (2009). Estimated Use of Water in the United States in 2005, U.S. Geological Survey Circular 1344, 52 pp.

15 Maupin, ***et al***. (2014).

In 2014, $789 million in funds were available for new projects in UMRB states through the Clean Water State Revolving Fund Program



between water and energy becomes even more significant. Comprehensive, detailed information on the challenges and opportunities presented by the water-energy nexus was developed by the U.S. Department of Energy in 2014.[16]

Raising the Water Supply Grade in the UMRB

1. **Improve our understanding of the relationship between water supply, energy, and the economy in the UMRB.**

   Any consideration of factors affecting water supply must be integrated with the corresponding implications for the regional and national economies. For example, data on water consumption as opposed to water withdrawal are needed to fully characterize the water-energy relationship. In thermoelectric power production, large volumes of water are withdrawn and used for cooling. However, a large fraction of this water is returned to the watershed and is a significant resource that can support other important activities further downstream.

2. **Maintain funding levels for key conservation and water pollution control programs in the UMRB.**

   Programs including the Mississippi River Basin Healthy Watersheds Initiative (MRBI) and the Regional Conservation Partnership Program (RCPP) as well as Section 319 Non-Point Source Water Pollution Control grants are key measures that help protect source water quality.

3. **Continue support for the Clean Water State Revolving Fund and the Drinking Water Revolving Fund.**

   CWSRF and DWRF programs provide loans to communities that can be used to fund publicly owned treatment works (POTWs), invest in green infrastructure, and control non-point sources of pollution.[17]

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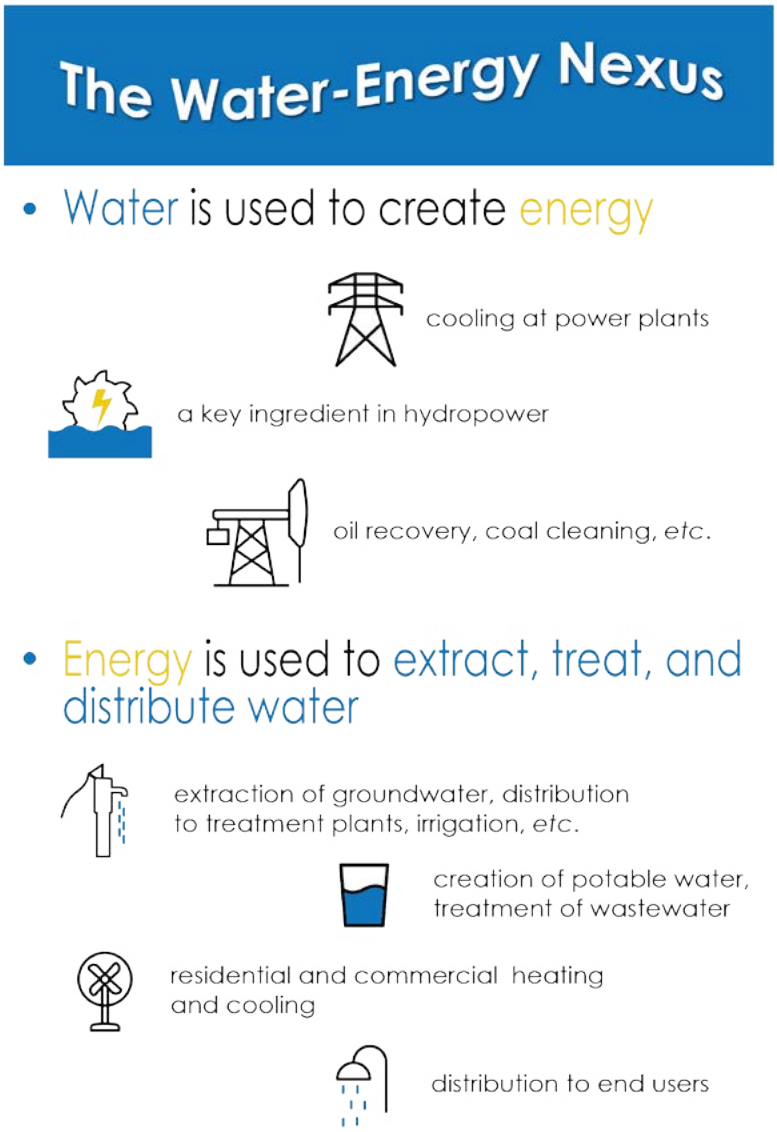
[16] Bauer, D., Philbrick, M., and B. Vallario (2014). The Water-Energy Nexus: Challenges and Opportunities, U.S. Department of Energy, Water-Energy Technology Team, 238 pp. http://www.energy.gov/sites/prod/files/2014/06/f16/Water%20Energy%20Nexus%20Report%20June%202014.pdf

[17] U.S. Environmental Protection Agency, Clean Water State Revolving Fund (CWSRF) National Information Management System Reports, 46 pp. https://www.epa.gov/cwsrf/clean-water-state-revolving-fund-cwsrf-national-information-management-system-reports



Key elements of the water-energy nexus.

Ongoing Activities to Raise the Water Supply Grade in the UMRB

- USGS Continuous Water-Quality Monitoring - The ability to access real-time scientific data on water levels as well as key water quality parameters allows managers to more effectively manage water resources in the UMR.
- Clean Water and Drinking Water State Revolving Funds - These state-federal partnerships are a vital source of low-cost financing that are used to support water infrastructure improvements.
- Implementation of State Nutrient Loss Reduction Strategies - The reduction of nutrient loading helps to increase source water quality while reducing the need for the investment in additional treatment processes.

Goal 5. Support local, state, and national economies

Sustain a water use system to efficiently and effectively support agricultural, industrial, and energy productivity. The economy grade is a composite of scores received in three indicator areas:

1. River-dependent employment ..... C+
2. Median income C
3. GDP by sector C

UMRB ECONOMY GRADE ..... C+

Overview

The Upper Mississippi River Basin and its environs serve as a drive train for economic development in the region and the nation. Based on a recent report co-sponsored by the U.S. Fish and Wildlife Service, the Upper Mississippi River Basin Association (UMRBA), and The Nature Conservancy (TNC), the UMR is responsible for approximately $250 billion in annual revenue. This study was limited to the 60 counties immediately adjacent to the UMR.[18] As a result, annual basin-wide river-related revenue is likely to be even greater than reported.

The UMRB economy is dominated by manufacturing, tourism, and agriculture which collectively accounted for over 92% of both jobs and annual revenue. The relationships between the UMR economy, transportation, and ecosystem health are often simultaneously synergistic and antagonistic. However, most stakeholders agree that economic prosperity in the UMRB can result only from a balance between these factors. For example, many manufacturers in the UMRB rely on water borne transportation to deliver raw materials to plants and to ship finished goods to consumers.

When comparing current data with those reported in 1999, economic growth in the UMR region increased by $47 billion.[19] In contrast, the region experienced a decrease of almost 112,700 jobs.

Raising the Economy Grade in the UMRB

1. **Expand efforts to determine the basin-wide economic relevance of the Mississippi River.**

   Significant work has been done to quantify the economic importance of the Upper Mississippi River to the regional and national economies. However, previous and current studies have focused on those counties that are immediately adjacent to the Upper Mississippi River.[20] While expanding the geographic scope of this study may be a daunting challenge, the outcomes would provide stakeholders with a broader perspective of the UMR's economic importance.

2. **Incorporate the value of ecosystem services into economic studies/assessments.**

   In a region that is so rich in environmental assets, failure to account for their value in economic studies can result in a drastic underestimate of regional net worth. For example, waterfowl hunting and wildlife observation were reported to generate over $1 billion in revenue in 1999.[21] However, this estimate did not include any consideration of the intrinsic value of existing migratory bird habitat. Likewise, the absence of this information makes it difficult for stakeholders to weigh the costs and benefits of potential investments in environmental protection and/or restoration.

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[18] U.S. Fish and Wildlife Service, Upper Mississippi River Basin Association, and The Nature Conservancy (2015). Upper Mississippi River: A Vital Resource for Regional Economic Prosperity - Preliminary Results, http://www.umrba.org/umr-econ-profile.pdf.

[19] Black, R., McKenney, B., O'Connor, A., Gray, E., and R. Unsworth (1999). Economic Profile of the Upper Mississippi River Region, Industrial Economics, Inc., 108 pp.

[20] Black, ***et al***. (1999).

[21] Black, ***et al***. (1999).

3. **Promote collaboration between state Departments of Economic Development, metropolitan planning organizations, and local municipalities to ensure a clean water supply, sustainable transportation network, and economic security in the future.**

Ongoing Activities to Raise the Economy Grade in the UMRB

Based on the UMR's dual designation as a nationally significant ecosystem and transportation corridor, all ongoing efforts to Raise the Grade in ecosystem health, flood protection, transportation, water supply, and recreation directly support improvements in the region's economy. Particular attention should be given to the importance of the water-energy nexus (see Goal 4) that is likely to have increased economic significance as alternative energy sources are developed and water scarcity becomes more prevalent in the UMRB and beyond. Recently, the National Council on Science and the Environment (NCSE) suggested broadening this concept into an energy-water-food nexus.[22] Others have expanded this approach even further to include climate.[23]

Many stakeholders in the UMRB will recognize the inclusion of food in the water-energy nexus as an important step toward integrating transportation, the economy, the environment, and flood control into a comprehensive framework that better represents the synergistic and antagonistic relationships that exist between these key sectors. In fact, the U.S. Chamber of Commerce Foundation has articulated the importance of these broader relationships by including economic issues and risk management as elements of the food-water-energy nexus.[24]

Goal 6. Provide world-class recreation opportunities

Enrich the quality of life for people and recreation-based economies by maintaining and enhancing riverine, lake, and wetland-associated recreation within the basin. The recreation grade is a composite of scores received in two indicator areas:

1. Outdoor participation ..... C-
2. Hunting and fishing licenses ..... B

UMRB RECREATION GRADE ..... C+

Overview

The UMRB is home to a range of recreational activities that are as broad as the river is long. Among the many recreational uses of the UMR, fishing, boating, hiking, and sightseeing are among the most popular. These activities in the UMR are supported by three national wildlife refuges, 48 state parks, and more than 500 boat access points. These river recreation venues are connected by the Great River Road National Scenic Byway.

Assigning a value or relative importance to a specific activity or place can be difficult. However, most stakeholders recognize the important link between river recreation and the regional economy. To place the role of recreation in perspective, tourism supported around 140,000 jobs in the UMR in 1999.[25] In comparison, the tourism industry along the UMR was estimated to employ approximately 273,000 people in 2015.[26]

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22 https://thefoodenergywaternexus.wordpress.com/ncse/

23 World Economic Forum (2011). Water Security: The Water-Food-Energy-Climate-Nexus, Dominic Waughray, Ed., Island Press, Washington, 248 pp.

24 Lundy, J., and L. Bowdish (2013). The Energy-Water-Food Nexus, U.S. Chamber of Commerce Foundation. http://www.nasdaqomx.com/digitalAssets/92/92448_energy-water-food-nexus-research_1.pdf

25 Black, ***et al***. (1999).

26 U.S. Fish and Wildlife Service, ***et al.*** (2015).

Since activities such as boating and fishing account for a large fraction of river recreation in the UMRB, the link between recreation, the economy, and ecosystem is clear.[27] This preceding point is key to understanding the pressing need to consider RTG Goals as an integrated, interdependent system.

Raising the Recreation Grade in the UMRB

1. **Provide support for trails, byways, and bridges in the Fixing America's Surface Transportation (FAST) Act.**
2. **Encourage connections between cities and waterways.**
3. **Promote National Wildlife Refuges.**
4. **Improve and expand the network of water trails and integrated walking/hiking, biking, and canoeing trails that are maintained by private, state, and federal stakeholders across the UMRB.**

Ongoing Activities to Raise the Recreation Grade in the UMRB

- National Geographic's Mississippi River interactive travel guide http://mississippiriver.natgeotourism.com
- Great River Birding Trail http://experiencemississippiriver.com/activities-recreation/birding/birds-upper-mississippi
- Trails at USFWS National Wildlife Refuges
  - https://www.fws.gov/refuge/upper_mississippi_river/canoe_trails.html
  - https://www.fws.gov/refuge/upper_mississippi_river/plan_your_visit/walking-biking.html

[27] Black, ***et al***. (1999).

Photo by R. Viadero, June 2016.

Canoeing the waters of the Upper Mississippi River Basin.

Watershed-Wide Goals. Gulf Hypoxia and Coastal Wetland Change

Gulf hypoxia is a watershed-wide indicator that is used as a measure of the nutrient loading from the Mississippi River and its tributaries into the northern Gulf of Mexico. The Gulf Hypoxia grade is based on the size of the Gulf "dead zone".

1. Gulf "dead zone" size..... D-

GULF HYPOXIA GRADE.....D-

Overview

Water from the Mississippi River Basin carries nutrients (nitrogen and phosphorus) to the northern Gulf of Mexico. Sources of nutrients in the water include fertilizers applied to crops, effluent from wastewater treatment facilities, and storm water runoff.[28] Large algae blooms can result from high nutrient concentrations. After the algae die off and settle to the bottom of the Gulf, they are decomposed by microorganisms that consume oxygen. Since there is little to no mixing in deep water, the oxygen concentration in bottom waters can become too low to support life. In marine systems, organisms that are unable to migrate out of this hypoxia zone often die.[29]

In 1997, the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force; HTF), composed mainly of federal, tribal, and state agencies, began studying the causes and effects of hypoxia in the northern Gulf of Mexico. The HTF set specific goals that included a 20% reduction in loading by 2015 and a 45% reduction by 2035. The HTF also established a dead zone area of 5,000 km^2 as a goal. Since 1997, the hypoxia zone ranged in area from 4,400 km^2 (in 2010) to 22,000 (in 2002). During this time frame, the performance goal was met only one time - in 2010. The complete set of hypoxia zone data is available at http://www.gulfhypoxia.net. Comprehensive information of task force activities is available at https://www.epa.gov/ms-htf.

Raising the Gulf Hypoxia and Coastal Wetland Change Grade in the UMRB

1. **Reduce nutrient and sediment loading by preventing their entry into UMRB waterways or intercepting them before water is discharged into the Gulf of Mexico.**

   Meaningful steps toward meeting this goal can be reached by supporting the implementation and/or full funding of:

   a. State nutrient loss reduction (NLR) strategies
   b. The Mississippi River Basin Healthy Watersheds Initiative (MRBI)
   c. Regional Conservation Partnership Program (RCPP)

2. **Reconnect rivers to their floodplains.**

   When rivers are reconnected to their floodplains, the impacts of flooding are mitigated, soil erosion is reduced, and excess nutrients are filtered from the water.

3. **Support the use of green infrastructure and the inclusion of Green Project Reserves in the Clean Water State Revolving Fund and Drinking Water Revolving Fund.**

   Permeable pavement, bioswales, rain gardens, and green roofs are representative examples of cost-effective, resilient approaches to slowing water flow rates while filtering

[28] Goolsby D. (2000). Mississippi basin nitrogen flux believed to cause Gulf hypoxia, Transactions of the American Geophysical Union, 81, 325-327.

[29] Rabalais, N., Turner, R., and D. Scavia (2002). Beyond Science into Policy: Gulf of Mexico Hypoxia and the Mississippi River Nutrient Policy Development for the Mississippi River Watershed, BioScience, 52(2), 129-142.

out nutrients. Green Project Reserves are an important source of support for communities to develop and implement long-term green infrastructure solutions.

Ongoing Activities to Raise the Gulf Hypoxia and Coastal Wetland Change Grade in the UMRB

- State nutrient loss reduction strategies:
  - https://www.agr.state.il.us/nlrs
  - http://www.nutrientstrategy.iastate.edu/
  - https://www.pca.state.mn.us/water/nutrient-reduction-strategy
  - http://dnr.wi.gov/topic/surfacewater/nutrientstrategy.html
  - https://dnr.mo.gov/env/wpp/mnrsc/
- State Clean Water Act (CWA) programs
- Natural Resource Conservation Services-Regional Conservation Partnership Program
  - This program targets funding to areas that can make a significant difference in nutrient reduction.
- Monitoring and research by Universities, USGS, and commodity groups such as the Soybean Association and the Corn Growers Association
- State specific funding and policy programs such as:
  - Minnesota's Clean Water Legacy Fund http://www.legacy.leg.mn/funds/clean-water-fund
  - Missouri's Parks, Soils, and Water Tax https://mostateparks.com/page/55069/parks-soils-and-water-sales-tax
  - Wisconsin's Adaptive Management Program http://dnr.wi.gov/topic/surfacewater/adaptivemanagement.html
- Gulf Hypoxia Task Force https://www.epa.gov/ms-htf

Photo courtesy of P.J. Hahn, TKO Productions of New Orleans, Inc., (504) 669-8469, www.TKOProduction.com

Loss of wetlands along the Louisiana coast.

Glossary

A-F

ACEP ..... Agricultural Conservation Easement Program
ASCE ..... American Society of Civil Engineers
ASFPM ..... Association of State Floodplain Managers
AWI ..... America's Watershed Initiative
CFM ..... Certified Floodplain Manager
CSP ..... Conservation Stewardship Program
CWA ..... Clean Water Act
DO ..... Dissolved Oxygen
EPA ..... U.S. Environmental Protection Agency
EQIP ..... Environmental Quality Incentives Program

G-L

FAST Act ..... Fixing America's Surface Transportation Act
FEMA ..... Federal Emergency Management Agency
FIRM ..... Flood Insurance Rate Map
GDP ..... Gross Domestic Product
HEC-RAS ..... Hydrologic Engineering Center's River Analysis System
H and H ..... Hydrology and Hydraulics
HTF ..... Hypoxia Task Force
IAFSM ..... Illinois Association for Floodplain & Stormwater Management
IFSMA ..... Iowa Floodplain and Stormwater Management Association
IRPTA ..... Inland Rivers, Ports, & Terminals Association
IWTF ..... Inland Waterways Trust Fund
LIR ..... Lower Impounded Reach [of the Upper Mississippi River]
LMRCC ..... Lower Mississippi River Conservation Committee
LTRMP ..... Long Term Resource Monitoring Program

M-R

MFSMA ..... Missouri Floodplain & Stormwater Management Association
MnAFPM ..... Minnesota Association of Floodplain Managers
MRB ..... Mississippi River Basin
MRBI ..... Mississippi River Basin Healthy Watersheds Initiative
MRC ..... Mississippi River Collaborative
MRCTI ..... Mississippi River Cities & Towns Initiative
MRN ..... Mississippi River Network
MRS ..... Mississippi River System
NAI ..... No Adverse Impact
NCSE ..... National Council on Science & the Environment
NESP ..... Navigation and Ecosystem Sustainability Program

NGO ..... Nongovernmental Organization
NGRREC ..... National Great Rivers Research & Education Center
NLR ..... Nutrient Loading Reduction
NRCS ..... Natural Resource Conservation Service
NWC ..... National Waterways Council
NWQP ..... National Water Quality Program
NWS ..... National Weather Service
RCPP ..... Regional Conservation Partnership Program
RTG ..... Raise the Grade

S-Z

TNC ..... The Nature Conservancy
UMESC ..... Upper Midwest Environmental Sciences Center
UMIMRA ..... Upper Mississippi, Illinois, & Missouri River Association
UMR ..... Upper Mississippi River
UMRB ..... Upper Mississippi River Basin
UMRBA ..... Upper Mississippi River Basin Association
UMRC ..... Upper Mississippi River Conference
UMRCC ..... Upper Mississippi River Conservation Committee
UMRCP ..... Upper Mississippi River Comprehensive Plan
UMRR ..... Upper Mississippi River Restoration [Program]
USACE ..... U.S. Army Corps of Engineers
USDA ..... U.S. Department of Agriculture
USFWS ..... U.S. Fish & Wildlife Service
USGS ..... U.S. Geological Survey
WAFSCM ..... Wisconsin Assn. for Floodplain, Stormwater, & Coastal Mgmt.
WEF ..... World Economic Forum
WRDA ..... Water Resource Development Act
WRRDA ..... Water Resource Reform & Development Act

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