Workshop Purpose

Upper Mississippi federal and state natural resource agencies and non-governmental partners have been debating for decades about how to best manage the pool water levels to ensure a reliable 9-foot navigation channel and a healthy river ecosystem, including whether the benefits of holding down the river level merited the resource needs. Over time, various policies appeared to limit the feasibility of implementing water level management on a routine basis even within the operating band. Observations from the St. Louis District’s water level management efforts over the past few years have shown tremendous ecological responses while, at the same time, the St. Paul District appeared stymied with obstacles to implementing a planned drawdown. The Upper Mississippi River Restoration’s (UMRR’s) effort to quantify the river’s ecological resilience linked water level management to several key drivers impacting fish and wildlife habitat. Together, this highlighted a need for a comprehensive dialogue among the resource agencies regarding objectives for potentially operationalizing routine, systemic, large-scale water level management – what that would look like, the challenges to doing so, and recommendations for moving forward. The workshop’s purposes are two-fold: 1) reaching a common understanding of implementation mechanics and stakeholder perspectives and 2) reaching consensus on a suite of recommendations.

Partner Recommendations

Through facilitated exercises, participants identified and prioritized recommendations for the UMRBA Board and broad UMRS partnership to consider. In addition to the highest ranking actions (listed below), the need for public outreach and education and increased communication and coordination among partners and Districts was evident in nearly all discussed recommendations.

1) Employ water level management opportunistically – seize opportunities to manage pool levels at the lower end of the existing operating band to generate ecological benefits within the existing funding, staffing, and policy construct

2) Perform a cost-benefit analysis to determine merit – define and quantify the trade-offs to implementing water level management associated with the spectrum of effort

3) Address various policy and program implementation issues – gain a comprehensive understanding of the policy and programmatic constraints impeding implementation of water level management and determine the best ways to resolve them

4) Implement drawdowns in Pools 13 and 18 – execute drawdowns (below the standard operating band) and more routine water level management (within the operating band) in these pools, which have a high potential for implementation success and for generating substantial ecological benefits as well as learning opportunities (Pool 13 is an UMRR LTRM study reach and there has been substantial monitoring in Pool 18)

5) Seek and secure necessary funding – identify means to cover the costs of additional dredging and material placement (or river training structures), increase efficiencies and reduce unnecessary costs, and generate public support for investment

6) Gain a better understanding of how hydrology and hydraulics affect river management – research and develop models to better predict river flows and water levels and identify the appropriate conditions to trigger water level management (perhaps integrate with the UMRS watershed study)
Day 1 – April 4

Opening Remarks/Setting the Stage

Partner Perspectives

Representatives from each of the Upper Mississippi federal and state agencies and non-governmental partners present shared their perspectives on the opportunities and challenges surrounding the potential for managing pool water levels in ways that benefit the ecosystem and what they hope will be achieved during the workshop. Representatives who spoke include B.J. Murray, Levi Solomon, Mike Griffin, Megan Moore, Jim Fischer, Jessica Brooks, Sabrina Chandler, Tim Schlagenhaft, Olivia Dorothy, Gretchen Benjamin, Paul Rohde, Kevin Landwehr, Brian Johnson, and Steve Clark. Shared objectives included learning, reaching consensus surrounding recommendations, and fostering interagency, interdisciplinary relationships.

Multi-Purpose Management

Dru Buntin provided a historical context of the Corps’ dual purpose management of the river – the agreements that led to the Corps operating the dams (and pool water levels) to ensure a reliable 9-foot navigation system as well as a healthy ecosystem that supports fish and wildlife habitat. The states strongly hold that balanced management of the river allows for maximizing the broad suite of river uses and ensuring that the navigation system and ecosystem are sustained for future generations.

Ecosystem Resilience

Jeff Houser provided an overview of UMRR’s effort to define and quantify the resilience of the Upper Mississippi ecosystem – i.e., its capacity to absorb disturbances and sustain its fundamental ecological characteristics to support abundant and diverse habitat – and how water level management directly or indirectly affects various controlling variables to ecosystem health. These controlling variables include water depth and velocity, substrate, total suspended solids, hydraulic connectivity among aquatic areas, water level fluctuations, and flood inundation. Conceptual models of lentic, lotic, and floodplain forest subsystems within the UMRS ecosystem illustrate the influence of individual and cumulative relationships among watershed and in-river drivers. Next steps include identifying thresholds among these relationships when an ecosystem is likely to move to a different state – e.g., floods lasting about 40 percent of the growing season suffocate many of the hardwood trees and present understory from establishing and growing, resulting in uniformly low species diversity and a degraded floodplain forest state.

District Pool Operations

Each of the three UMRS Districts presented on the operational realities of managing pool water levels. [Note: Slides of these presentations are included at the end of this summary.]

St. Louis District (MVS)

Joan Stemler presented on the operations of MVS’s hinge-point control pools and the District’s ability to manage the pools in ways that benefit the ecosystem. Four of the five MVS locks are controlled by a hinge-point, which is very challenging to manage. The pools’ water level limits change with flows ranges and can require over a five-foot pool change in a 24-hour timeframe. The District issues instructions to lock personnel at least once per day and gate changes are made as necessary. Stemler showed visualizations illustrating the hinge-point operations and discussed the District’s dredging operations as well as rock pinnacle removal necessary to maintain the nine-foot navigation channel. Stemler discussed the District’s approaches to forecasts river flows in order to make daily adjustments to pool levels.
In 1988, resource managers began asking the Corps to lower pool water levels during the growing season to improve ecological conditions. They began by asking for 3-foot drawdowns for 120 days, which the Corps was unwilling to do. It was in 1994 that resource managers changed the request to a half-foot drawdown for at least 30 days; 10 more days than the Corps was already holding water levels down half a foot. With successful communication and collaboration between the Corps and resource managers in the field, it was found that managing water levels is feasible when tried. Since 1994, MVS has achieved environmental benefits annually through successful water level management.

In particular, 2016 was a very successful year for MVS’s environmental pool management (EPM). In February 2015, the Corps formed an interagency project delivery team for EPM that defined a suite of parameters for successful water level management. This includes initiating EPM around April 1 every year, continuing EPM from May 1 for at least 90 days or until hydrologic conditions require routine dam operations, and ending EPM with raising water levels less than 0.3 foot per day to allow vegetation to survive and continue to grow. In 2016, the Corps was able to hold water levels at L&D 24 for at least half a foot for 148 days, 1 foot for 97 days, and 2 feet for 30 days. At L&D 25, water levels were held at 1.5 feet for 143 days and 2.5 feet for 61 days. At Mel Price, water levels were held at 1 foot for 224 days and 2 feet for 110 days. Stemler explained that the Corps only actively managed the pools for 10-20 days within the entire season. Stemler provided an overview of the biological response, which included increased species richness including emergent perennials and structural diversity. The response included all native species, with no infestations by invasive species. Stemler also explained how the Corps’ outreach efforts helped to increase public understanding and support for its efforts to hold water levels low.

**Rock Island District (MVR)**

Kevin Landwehr presented MVR’s pool characteristics and water level management capabilities given its ability to manage the dams. MVR has operational control of L&Ds 11-14, 16-18, and 20-22; L&D 15 is operated by lock staff; and L&D 19 is privately-held and controlled by Ameren UE. All of MVR’s L&Ds are operated under dam point control, except for L&Ds 16 and 20, which are operated under primary-secondary-tertiary control where regulation occurs at multiple points along the length of the pool. Landwehr explained how the Corps manages the dam point and primary-secondary-tertiary L&Ds, including the operating limits and different gate settings. Ameren operates L&D 19 for the purposes of maximizing hydropower energy output. That has significant implications for Pools 20-22, making it virtually impossible to implement drawdowns in those pools.

During the non-navigation season (winter), the Corps historically employed drawdowns to maintain minimum desired depth at St. Louis. The Anti-Drawdown Law of 1934 and amended in 1946 and 1948 requires the Corps to operate and maintain the pools as though the navigation season was open year-round, limiting drawdowns north of L&D 15. However, Pools 16-18 were drawn down as needed to maintain depth at St. Louis. From 1970 to 1987, drawdowns were limited to one foot at all dams and, since 1988, the dams have been operated for a year-round navigation season.

Landwehr explained the Pool 13 drawdown event in 1998, which showed that a drawdown of 30 days or more could be accomplished once every three years. The Navigation and Ecosystem Sustainability Program’s 2004 Water Level Management Report included a suite of prioritized recommendations for implementing water level management. In MVR, Pools 11 and 13 are found to be most suitable to water level management with Pools 16 and 18 as secondary priorities. Landwehr asserted that drawdowns in hinge-point pools have less recreational impacts and less associated dredging requirements.

Landwehr recalled that MVR attempted to implement a drawdown in Pool 13 again in 2000-2003, but conditions did not make it feasible. Partners quit asking the District to implement a drawdown, and therefore the Corps has not attempted once since then.
Hank DeHaan provided a handout of graphs showing dredging volume trends since 1997 in all Mississippi River pools within MVR, acknowledging that volumes have been decreasing. Illinois pools have experienced stable dredging volume needs.

**St. Paul District (MVP)**

Steve Clark explained that MVP employed deeper drawdowns in the 1930s than today due to several factors, including concerns regarding impacts to commercial navigation, riverfront property, and conservation. The 1948 Anti-Drawdown Act targeted winter operations, requiring that dams be held to levels required for navigation. And, changes in channel maintenance practices in the early 1970s required reduced frequency of dredging. In 1995, the Corps adopted the water level management task force’s (WLMTF’s) recommendation to maintain winter operations on the high side of the operating band.

Dan Fasching explained that MVP operates L&Ds 2-6 and 8-9 under hinge point control, L&D 7 under primary-secondary control, and L&D 10 under primary-secondary-tertiary control. Fasching explained the day-to-day dam operations, including how gate instructions are issued and the relationship among dams as well as the challenges association with wind, power generation, shift changes, math and human error and so forth that affect daily fluctuations.

Jon Hendrickson explained MVP’s channel maintenance management requires, including dredging depth requirements and material placement. All dredged material must be placed in uplands except in emergency situations, increasing the cost and limiting the volume that can be accommodated from each dredge job. Hendrickson said factors affecting success of drawdowns include timeframe, duration, and depth of exposed areas. While in the 1990s partners sought optimum drawdown conditions targeting a 1.5 foot depth, more recent discussions have concluded that opportunistic drawdowns of shorter duration could have ecological benefits. Hendrickson explained the drawdown events that occurred in Pool 8 in 2001-2002 and then in Pool 5 in 2005-2006, including the biological responses measured and the associated channel maintenance. According to Hendrickson, planning for future drawdowns should consider constraints associated with additional dredging costs and recreational boating as well as opportunistic factors such as deferred dredging reaches, high tailwater at some dams, short-term change sin channel conditions, and risk of groundings. One consideration may be the construction of river training structures to reduce dredging needs.

**Facilitated Exercise**

Participants identified three opportunities and three challenges to water level management on sticky notes and placed them on the wall for a Day Two facilitation exercise – see below.

**Day 2 – April 5**

**Partner Perspectives**

Each participant provided an observation for the presentations on Day One and a desired outcome of Day Two’s discussion. Observations included:

- There are no show-stoppers, but rather each challenge can be overcome with an opportunity
- We can work better together to integrate water level management in annual dam operations
- Water level management presents a great opportunity for dialogue with the public
- There are policy constraints limiting the ability to employ water level management – identify and address the most pressing constraints
- The ecological impacts/trade-offs need to be better understood
• There exist opportunities to be opportunistic – identify triggers for employing and maintaining water level drawdowns on an annual basis; identify and prioritize opportunities
• Federal funds are silo-ed preventing available funds being used for water level management – secure adequate funding through appropriate channels and explore ways to work cross-programmatically
• In addition to maintaining lower water levels, water level management should consider restoring annual fluctuations
• Hold annual meetings to track progress and exchange information
• Hydrology in the river is changing and that will affect water level management – need to get a better understanding of watershed influences and acknowledge changing conditions
• Opportunities to automate gates with a hard-wired control located within the lock house may create substantial efficiencies and better enable water level management
• Consistent understandings of water level management terminology – low control pool, operating band, etc. – would be helpful to ensuring that all partners are on the same page
• There seems to be difference perspectives between Districts regarding hydraulics and how that affects water level management

Facilitated Exercise

Participants grouped the sticky notes of opportunities and challenges in similar thematic groups. Small groups formed to consider a series of questions that would ultimately result in recommendations for action. The instructions

- Define the opportunity or constraint (what)
- Explain why it is important (why)
- List actions that can be taken to address (how)
- Name who can take those actions (who)
- Identify what they would need in order to act (how)
- Explain whether UMRBA should do anything to support these actions (UMRBA)

A spokesperson for each small group presented on the results, which then all participants voted on their respective priorities. The recommended actions and their associated priorities are described below.

Opportunities

Opportunistic Management (28 votes)

- **What:** Employ water level management opportunistically with existing/readily available funding sources, policy framework, and working conditions
- **Why:** There are ecological benefits to managing water levels for ecological purposes that are feasible and at relatively low cost (partners are learning how to optimize)
- **How:**
  1. Be ready
  2. Continue to monitoring biological responses and collect data on operations when employing water level management
  3. Plan for opportunities following dredge operations; seek extended dredging activities if needed/feasible
(4) Allow for opportunistic allowances in dam operating manuals
(5) Partners continue to ask the Corps to operate the pool levels on an opportunistic basis; Corps staff discuss internally to instill the willingness
(6) Engage public to increase awareness, understanding, and buy-in
(7) Identify, own, and share the risk
   - **Who:** Federal and state agencies, river teams, non-governmental organizations
   - **UMRBA:**
     1. Engage agency leadership
     2. Facilitate the development of a UMRS environmental pool management manual

**Costs-Benefit Analysis (20 votes)**

- **What:** Define and quantify the benefits and costs associated with various levels of water level management
- **Why:** To rationalize the additional effort involved in managing pool water levels for the purposes of improving ecological health
- **How:**
  1. Complete a meta-analysis of information known
  2. Define the scope of a cost-benefit analysis
  3. Employ any additional studies necessary to accurately portray the costs and benefits associated with various scales of water level management
- **Who:** River teams, federal and state agencies, non-governmental organizations, universities, contractors (e.g., Earth Economics), Congress
- **UMRBA:**
  1. Support and facilitate the development of a cost-benefit analysis
  2. Pursue any necessary and desired legislative changes

**Pools 13 and 18 (17 votes)**

- **What:** Employ more routine, opportunistic water level management and drawdowns (below the standard operating band) in Pools 13 and 18
- **Why:**
  1. The pools represent feasible options to employ water level management that have a high potential to result in substantial ecological benefits
  2. These pools would “fill the gap” within MVR, creating a systemic link between MVS and MVP
  3. These pools offer tremendous learning opportunities given that Pool 13 is an LTRM study reach and there has been substantial monitoring in Pool 18
- **How:**
  1. Just do it! Ask for it!
  2. Determine whether NESP recommendations for water level management in these pools are still appropriate and feasible
  3. Inform the public through an outreach campaign
  4. Prepare the navigation channels (i.e., advanced dredging if needed)
- **Who:** Corps and federal and state resource managers
- **UMRBA:**
  1. Facilitate partners’ request for water level management in Pools 13 and 18
  2. Lead or support the public outreach campaign
Monitoring/Modeling/Learning (8 votes)

- **What:** Generate an information gradient associated with the range of water level management options
- **Why:** To obtain a better understanding of the biological responses to repeated implementation, benefits to natural resources more comprehensively, impacts to other river users, and implementation approaches – e.g., optimal depth and duration
- **How:**
  1. Immediate: continue learning from water level management in Pools 24-26
  2. Define and implement a desired monitoring protocol
  3. Prioritize learning needs
  4. Secure necessary resources – funding and staff – to make learning a priority
- **Who:** “Funded” or experienced staff at federal and state agencies and universities as well as other knowledgeable partners, with an appropriate mix of agencies and expertise
- **UMRBA:** Seek and secure necessary funding sources

Enabling Methodologies (7 votes)

- **What:** Determine ways to better manage sediment in the UMRS to make routine water level management more feasible– e.g., use of river training structures
- **Why:** To provide mechanisms by which Districts can operationalize water level management
- **How:**
  1. Evaluate the use of river training structures to minimize dredging costs
  2. Explore any new ways to handle dredge material that are more cost-effective, environmentally-acceptable
  3. Develop models to better manage sediment – e.g., 2-dimensional, Applied River Engineering Center models
  4. Acquire new, or increase capacity at existing, disposal sites for future drawdowns; integrate dredge needs with habitat restoration projects for disposal opportunities
- **Who:** Corps and federal and state resource agencies
- **UMRBA:**
  1. Seek and secure funding sources
  2. Pursue any necessary and desired policy and/or legislative changes

Improving Habitat (6 votes)

- **What/why:** Improve habitat for fish and wildlife through more routine, systemic water level management
- **How:**
  1. Educate policy makers, public, and key stakeholders within the basin about the potential of water level management for improving habitat; broaden support
  2. Quantify the benefits
  3. Implement pool-scale water level drawdowns through UMRR
  4. Explore all available authorities
- **Who:** Corps, federal and state resource agencies, and non-governmental partners
**Generic Opportunity (4 votes)**

- **What:** Follow through on the recommendations from today’s workshop
- **Why:** To ease constraints, operationalize, and realize benefits
- **How:** (1) Annual in-person meetings and other conference calls as needed
  (2) Enhance consistency and communication among partners
- **Who:** Corps, federal and state resource agencies, and non-governmental partners
- **UMRBA:** Provide accountability and momentum within the partnership

**Public Outreach (1 vote)**

- **What:** Outreach to the public to increase awareness and understanding
- **Why:** To gain support and ease concerns in advance of water level management events to dampen negative reactions
- **How:** (1) Hold public meetings
  (2) Install informative kiosks at boat landings
  (3) Distribute fliers at libraries, marinas, and other targeted locations
  (4) Employ a social media presence
  (5) Create consistent messages that are reviewed and accepted among the partnership
  (6) Task a communications specialist to create a strategy and materials
- **Who:** Federal and state resource agencies, non-governmental partners, water level management task force
- **UMRBA:** Provide leadership, facilitate logistics

**Constraints**

**Policy (26 votes)**

- **What:** Lack of a complete awareness/shared understanding of relevant policies and how they might be constraining (or facilitating) of water level management actions
- **Why:** Seemingly, existing policies are impeding routine water level management within and beyond the operating band whether they be perceived or real
- **How:** (1) Gain a comprehensive understanding of those policy constraints and determine the best ways to resolve them
  (2) Increase shared knowledge of the various authorities affecting water level management individually and cumulatively
- **Who:** Corps and federal and state resource managers
- **UMRBA:** Facilitate dialogue among partners about the policy issues and any action to resolve them

**Funding (15 votes)**

- **What:** Costs associated with water level management are expensive – dredging, material placement, monitoring, river training structures
- **Why:** Costs are an impeding factor
- **How:**
  1. Seek and secure necessary funding, including potential flexible funding sources within the Corps
  2. Advocate for desired policy changes to reduce unnecessary costs and increase efficiencies where possible
  3. Quantify ecological benefits and cost savings (over dredging for future years) to explain that costs are essentially off-set
  4. Generate public support for investment
- **Who:** Federal and state resource agencies, non-governmental partners, UMRBA
- **UMRBA:** Facilitate discussion about potential policy solutions and ways to minimize associated costs

*Hydrology & Hydraulics (10 votes)*

- **What:** The hydrology and hydraulics (H&H) of the river system are changing in ways that may be constraining
- **Why:** Successful implementation of water level management for environmental purposes is dependent on the H&H conditions – need to have a better understanding of how H&H affect drawdown implementation, including identifying the optimum conditions
- **How:**
  1. Pursue studies of sediment and water flow from the watershed, floodplain, and within the channel
  2. Update models to better predict H&H
  3. Integrate existing information from multiple sources
  4. Determine desired water level management effort to base results
  5. Secure public and agency support, funding, and expertise
  6. Define objectives and strategy to scope studies
- **Who:** Partners determine objectives; Corps, USGS, and other H&H technical experts develop the models and studies
- **UMRBA:**
  1. Obtain political support
  2. Facilitate collaboration and distribution of information

*Perceptions (8 votes)*

- **What:** There is a perception among some stakeholders that environmental pool management or drawdowns are not good/valuable
- **Why:** This becomes a impeding factor to being opportunistic or initiating plans for a larger drawdown
- **How:**
  1. Engage both the general public and targeted constituency groups such as Ducks Unlimited, etc.
  2. Define “triggering criteria” for the Corps to begin facilitating a planning process (to be opportunistic)
- **Who:** All partners have a roll
Risk (3 votes)

- **What:** There is concern about associated risk – e.g., costs outweighing benefits, allocating risk for planning when not feasible, negative public reaction

- **Why:** Understanding risk is important for either accepting or mitigating and ultimately deciding whether to implement

- **How:**
  1. Identify risk and its certainty, impact, and options for addressing
  2. Communicate among partners the various risks involved in water level management and which are perceived and can be overcome immediately

- **Who:** UMRS regional partnership and public

- **UMRBA:**
  1. Facilitate public outreach and education
  2. Encourage forward movement

Operational (2 votes)

- **What:** The Corps 9-foot navigation channel authority cannot be impacted

- **Why:** Recognizing this authority allows planners to set boundaries and may require additional dredging to ensure the authority is met

- **How:**
  1. Define success
  2. Explore options for changing dredge operations and policies, including river training structures and automating gates
  3. Pursue any necessary federal and state policy changes
  4. Revise dam operations manuals and develop a water level management plan, enhancing consistency among Districts to the extent possible
  5. Make a shared commitment to invest in water level management
  6. Prioritize pools to employ water level management based on likelihood of success – implementation and desired biological responses
  7. Generate regional support – among agencies and the public – and funding

- **Who:** Federal and state agencies, non-governmental organizations, Congress

- **UMRBA:**
  1. Facilitate public outreach and education
  2. Encourage forward movement

Ecological Impact (0 votes)

- **What:** There are known negative impacts on mussel and fish populations that creates concern among some resource practitioners

- **Why:** Water level management may impact threatened and endangered species of mussels and fish

- **How:**
  1. Survey and assess mussel communities and relocate mussels from exposed areas
  2. Mitigate (or propagate) for mussel mortality
  3. Gradually alter water levels
  4. Only employ drawdowns within the operating band
  5. Time drawdowns to avoid spawning and rearing events

- **Who:** Corps and federal and state resource managers and scientists

- **UMRBA:** Facilitate multi-agency leadership in determining solutions to potential resources impacts
Partner Perspectives

Each participant provided an observation of the workshop discussion and outcomes, including:

- There was a lack of information in the Corps’ presentations about narrowing of the operating bands over time and just in-time dredging – would like to determine if the issues were perceived or whether future discussion is warranted about addressing those management issues
  - If the operating band was widened, there would be greater flexibility to be opportunistic
  - Environmental communities requested the Corps manage for a narrower operating band at higher levels to minimize dredging needs; it may be time to revisit that decision as it would require dredging deeper and increased associated costs or constructing river training structures
  - The tradeoff is that increased dredging may have a greater impact on the ecosystem than the benefit from doing water level management
- There might still be some misconception surrounding L&D operations
- The intent of the MVP WLMTF is to address these issues and prepare for a feasibility study
- Water level management presents a great opportunity for dialogue with the public
- The 9-foot navigation channel is the most significant constraint and the wide range of options for managing the system should be on the table
- In WRDA 2016, Congress asks the Corps to identify beneficial use projects that would disregard the federal low cost standard – the UMRS partnership could propose a project that includes dredging, a habitat restoration project (island), and a drawdown
- MVD has given the Districts a clear directive that an independent funding source is needed outside of O&M budget for any major drawdown beyond the operating band
- It may be worthwhile to do a modeling exercise to illustrate extent of exposed areas from various levels of drawdowns
Upper Mississippi River System
2017 Water Level Management Workshop

Attendance List

Levi Solomon Illinois Natural History Survey
B.J. Murray Illinois Department of Transportation
Kyle Bales Iowa Department of Natural Resources
Mike Griffin Iowa Department of Natural Resources
Kirk Hansen Iowa Department of Natural Resources
Dan Dieterman Minnesota Department of Natural Resources
Megan Moore Minnesota Department of Natural Resources
Brian Stenquist Minnesota Department of Natural Resources
Mike Griffin Iowa Department of Natural Resources
Kirk Hansen Iowa Department of Natural Resources
Dan Dieterman Minnesota Department of Natural Resources
Megan Moore Minnesota Department of Natural Resources
Brian Stenquist Minnesota Department of Natural Resources
Matt Vitello Missouri Department of Conservation
Deanne Drake Wisconsin Department of Natural Resources
Jim Fischer Wisconsin Department of Natural Resources
Brenda Kelly Wisconsin Department of Natural Resources
Jim Killian Wisconsin Department of Natural Resources
Kurt Rasmussen Wisconsin Department of Natural Resources
Jessica Brooks National Weather Service
Dave Busse U.S. Army Corps of Engineers
Steve Clark U.S. Army Corps of Engineers
Dan Cottrell U.S. Army Corps of Engineers
Hank DeHaan U.S. Army Corps of Engineers
Tim Eagan U.S. Army Corps of Engineers
Russell Errett U.S. Army Corps of Engineers
Dan Fasching U.S. Army Corps of Engineers
Jon Hendrickson U.S. Army Corps of Engineers
Toby Hunemuller U.S. Army Corps of Engineers
Shahin Khazrajafari U.S. Army Corps of Engineers
Brian Johnson U.S. Army Corps of Engineers
Kevin Landwehr U.S. Army Corps of Engineers
Ben McGuire U.S. Army Corps of Engineers
Davi Michl U.S. Army Corps of Engineers
Bre Popkin U.S. Army Corps of Engineers
Lane Richter U.S. Army Corps of Engineers
Joan Stemler U.S. Army Corps of Engineers
Chuck Theiling U.S. Army Corps of Engineers
Steve Tapp U.S. Army Corps of Engineers
Randy Urich U.S. Army Corps of Engineers
Sabrina Chandler U.S. Fish and Wildlife Service
Brandon Jones U.S. Fish and Wildlife Service
Mary Stęfąnski U.S. Fish and Wildlife Service
Tim Yager U.S. Fish and Wildlife Service
Jeff Houser U.S. Geological Survey
Kevin Kenow U.S. Geological Survey
Olivia Dorothy American Rivers
Tim Schlagenhaft Audubon
Gretchen Benjamin The Nature Conservancy
Doug Blodgett The Nature Conservancy
Paul Rohde Waterways Council, Inc.
Dru Buntin Upper Mississippi River Basin Association
Kirsten Mickelsen Upper Mississippi River Basin Association
Ecological resilience

- "...capacity of a system to absorb disturbance and...still retain essentially the same function, structure, identity and feedbacks" (Holling 1973, Walker et al. 2004)

- In other words – the ability of the system to cope with unexpected disturbances without losing its fundamental characteristics or identity

Resilience: main concepts

- Multiple states may be possible
- Thresholds small changes in some variables can lead to large, rapid changes in others
- Controlling variables of the ecosystem can interact resulting in positive or negative feedbacks
- Processes occurring at different scales interact

System changes: gradual, threshold, & hysteresis

Aquatic vegetation as example of resilience, lack of resilience, and why resilience isn’t always good.
Resilience assessment of the UMRS

What can we infer about the resilience of the UMRS from existing data?

- Describe the system
- Assess the system
  - General resilience: Capacity of a system to absorb disturbances of all kinds, including minor, unforeseen ones, so that all parts of the system keep functioning as they have in the past
  - Specific resilience: Resilience of some specified part of the system to a particular kind of disturbance
- Management implications

O’Connell et al. 2015. The resilience adaptation and transformation assessment framework: from theory to application. CSIRO, Australia

General Resilience

- Maintain diversity and redundancy
  - Geomorphic diversity
  - Biodiversity
- Manage connectivity
  - Off-channel areas
  - Floodplain
- Manage slow variables and feedbacks
  - Sediment/nutrient accumulation
  - Sediment characteristics
  - Changes in FP forest
  - Spread of invasive species


System Description

- Purpose:
  - Develop an agreed upon (more or less) simplification of the UMRS that clearly identifies the fundamental characteristics of the system.
  - Briefly describe the history of how the UMRS came to be what it is today.
  - Simplify a complex system to its most fundamental controlling variables.
    - Valued uses & ecosystem services
    - Major ecological resources needed to support those uses & services
    - Major controlling variables that affect those major resources

Major ecological resources identified during the UMRS resilience assessment

- Aesthetics, photography & sightseeing
- Biodiversity
- Bird-watching
- Boating, swimming & camping
- Cultural identity
- Drainage
- Flood risk reduction and storage
- Floodplain agriculture
- Hunting and trapping
- Hydropower
- Navigation
- Nutrient and sediment processing
- Recreational and commercial fishing
- Water supply

- Aquatic vegetation
- Birds
- Floodplain vegetation
- Native fish
- Native mussels
- Waterfowl
- Water quality

Three components of the UMRS conceptual model created during the UMRS Resilience Assessment

Lotic channels

Floodplains

Lentic areas

Lentic backwater lakes and impounded areas
Controlling variables that may be directly or indirectly affected by WLM

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lotic</th>
<th>Lentic</th>
<th>Floodplain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td></td>
<td></td>
<td>Water surface elevation - bed elevation + depth</td>
</tr>
<tr>
<td>Velocity</td>
<td></td>
<td></td>
<td>Complex effects on velocity depending on geomorphology</td>
</tr>
<tr>
<td>Substrate</td>
<td></td>
<td></td>
<td>Sediment drying/compaction can affect substrate characteristics</td>
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<tr>
<td>Total suspended solids</td>
<td></td>
<td></td>
<td>Sediment drying/compaction of exposed sediment may reduce resuspension when subsequently inundated</td>
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<tr>
<td>Connectivity b/t channels and OCAs</td>
<td></td>
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<td>Hydrologic connectivity among aquatic areas is affected by water surface elevation</td>
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<tr>
<td>Water level fluctuations</td>
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<td>Water surface elevation and its variability directly determined by WLM</td>
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<tr>
<td>Flood inundation</td>
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<td>Duration and extent of floodplain inundation directly determined by WLM</td>
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Potential thresholds relevant to WLM

- Inundation duration / frequency
- Duration/frequency of sediment exposure
- Sediment compaction
- Emergent plant germination/establishment

Summary

- Resilience perspective emphasizes:
  - Ability of an ecosystem to cope with unexpected disturbances without losing its fundamental characteristics or identity
  - Slowly changing variables and potential thresholds
  - Interactions among processes occurring at multiple scales
- Several of the controlling variables identified in the Resilience Assessment conceptual models can be directly or indirectly affected by WLM and a variety of other management and restoration actions (e.g., island construction, dredging, closing dam modifications...)

Questions?
Overview

- St. Louis District Overview/Background
- Lock & Dam Operations
- Dredging Operations
- Environmental Pool Management
- Questions

District Overview

- 5 Flood Control Reservoirs Projects
  - Lake Shelbyville, Carlyle Lake, Rend Lake, Mark Twain Lake, and Wappapello Lake
- 5 Lock and Dam Projects
  - L&D 24, L&D 25, Mel Price L&D, L&D 27, and Kaskaskia L&D
- 9 Watersheds draining into the Mississippi River within the St. Louis District
  - Salt, Cuivre, Lower Missouri, Meramec, Upper St. Francis, Castor, Lower Illinois, Kaskaskia, and Big Muddy Rivers

Critical Link

- Mississippi River @ L&D 22
- Illinois River @ Meredosia
- Missouri River @ Hermann
- Mississippi River @ St. Louis

St. Louis District

- 5 Flood Control Reservoirs Projects
  - Lake Shelbyville, Carlyle Lake, Rend Lake, Mark Twain Lake, and Wappapello Lake
- 5 Lock and Dam Projects
  - L&D 24, L&D 25, Mel Price L&D, L&D 27, and Kaskaskia L&D
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Locks and Dams

- L&D 24
- L&D 25
- Melvin Price Locks & Dam
- Locks 27
- Kaskaskia L&D
- Dam 27
HISTORY OF THE ST. LOUIS GAGE

- Lowest recorded stage = -6.2 feet (1940)
- Highest recorded stage = 49.6 feet (1993)
- Over a 55 foot range
- Average stage (11.3 feet)
- 2012-2013
  - Low ~ -4.6 (JAN 2013)
  - High ~ 40.5 (JUN 2013)
- Range in flows
  - -3.2’ (LWRP) approx. 6,300/foot
  - 30.0’ (Flood) approx. 22,000/foot

Coordination

- USACE
  - Mississippi Valley Division
    - St. Paul District
    - Rock Island District
    - Memphis District
  - Northwestern Division
  - Lakes and River Division
- NWS River Forecast Centers
  - North Central RFC (handoff at Chester, IL)
  - Missouri Basin RFC (handoff at Hermann, MO)
  - Lower Mississippi RFC (starting at Cape Girardeau)

Coordination

- USGS
  - Illinois
  - Missouri
- Coast Guard
  - Sector Upper Mississippi River
    - Upper Mississippi down to UMR mile 109.9 (Chester, IL)
  - Sector Lower Mississippi River
    - Lower Mississippi starting at UMR mile 109.9 (Chester, IL)
- River Industry Action Committee (RIAC)

Hinge Point Operation

- Difficult!! Operate by using two control points. One at dam and one mid-point in pool
- Range limits change with flow ranges
- Change in flows can require over a 5 ft pool change in a 24-hour timeframe
- Pool elevation instructions are issued to lock personnel (minimum daily) and gate changes are made as necessary
- Daily instructions +/- tenth

Hinge Point Operation

- Lock and Dam 24
  - Pool Limits: 445.5 - 449.0
  - Hinge Point Limits, Louisiana: 11.5 - 12.2 (May be exceeded if at maximum drawdown)
- Lock and Dam 25
  - Pool Limits: 429.7 - 434.0
  - Hinge Point Limits, Mosier Landing: 434.0 - 437.0 (May be exceeded if at maximum drawdown)
- Melvin Price Locks and Dam
  - Pool Limits: 412.5 - 419.0 Alton Lower Limit: 414.0
  - Hinge Point Limits, Grafton: 14.2 - 16.2 (May be exceeded if at maximum drawdown, or Alton at 414.0)
- Kaskaskia Lock and Dam
  - Pool Limits: 363.0 - 368.8
  - Hinge Point, Red Bud: 368.0 - 370.0
**Melvin Price Locks and Dam**

**Hinge Point Limits**, Grafton:
- 14.2 - 16.2
  - May be exceeded if at maximum drawdown or Alton at RM 414.0
- Alton Lower Limit: 414.0
- Pool Limits: 412.5 - 419.0

**Low Flow / Flat Pool Flow**

**Government Owned Flowage Easements**

**Hinge Point Operation**

**Environmental Pool Management Zone**

**Visualizing L&D Hinge Point Operating Limits**
Pool 27, UMR

Jobs: 3
CY: 185,499

Dredge Potter, 146k CY
1-5 Jul
Mel Price Lower, 203.3
Moline Island, 198.0

Dredge Goetz, 39.5k CY
17-22 Oct
Upper Chain of Rocks Canal, 194.0

Standby High Water – 15 days

Open River

Jobs: 11
CY: 2,155 MCY

Dredge Potter
20 Aug – 28 Dec 2016
Riverway, 173.0
*Cliff Cave, 167.0
*Notre Dame, 171.0
*Reidy, 175.0
*Lower Canal, 184.0
Riverway, 173.0
Cliff Cave, 167.0
JB Lower, 166.5
Vandall Threash, 67.0
Malkenes, 103.0
Service Base, 177.0

Standby High Water – 82 days
6 Jul – 8 Aug
1 – 8 Sep
13 Sep – 22 Oct

* Flex Pipe

Illinois Waterway 0 - 80

Jobs: 8
CY: 77,377

Dredge Goetz
26 Aug – 30 Sep
Wing Island, 40.8
Old La Grange Lock Lower, 77.0
Old La Grange Lock, 77.5
Moline Island, 76.7 & 76.4
Old La Grange Lock Upper, 78.0
Indian Creek, 78.8
Kamp Creek, 74.0
Mississippi Terr, 63.0

Standby High Water - 19.5 days

Rock Removal

- Remnants of the 1988-1989 rock removal
  - Grand Tower Reach (RM 78.9 to 80.0)
  - Thebes Reach (RM 38.5 to 46.0)

Bumpings/Groundings

- In our pools we generally have may a few bumpings, say 3 to 5 per season, but generally those issues are related to buoys off station or if it is an area that is shoaling. We can delay dredging by pulling buoys in with the Pathfinder
- We have also temporarily re-aligned the channel to avoid shallow water until a dredge is available
- We also provide survey data to industry to help them find the best available water
- Hard groundings per year, hopefully none that are directly in the channel
### Extended River Forecast

*(issued late November)*

- **Currently St. Louis is at -0.7 ft**
  - 7,000 cfs/ft
- **Upper Mississippi River Flow Forecast**
  - Currently ~ 39,200 cfs
  - 28 days ~ 21,500 cfs (~17,700 cfs)
- **Missouri River Flow Forecast**
  - Currently ~ 48,700 cfs
  - 28 days ~ 24,000 cfs (~24,700 cfs)
- **St. Louis 28 day Forecast**
  - Loss of 42,400 cfs ~ loss of 6 ft ~ -6.7 ft at St. Louis

### Accounting for Forecast Errors

- **Assuming St. Louis Low of -5.1 ft** *(i.e., no Mel Price operation)*
  - 6,000 cfs/ft
- **Upper Mississippi River Flow Forecast**
  - Error ~ -1,140 cfs
- **Illinois River**
  - Error ~ -3,000 to -6,000 cfs
- **Missouri River Flow Forecast**
  - Error ~ -3,300 cfs
- **St. Louis Low:**
  - Loss of 7,440 to 10,440 cfs ~ -6.3 ft to -6.8 ft

### Environmental Pool Management

**In St. Louis District**

**EPM – The Beginning**

Agency request (~1988)- “We want a 3 foot drawdown for 120 days!”

**Corps response – “Nope!”**

“It will impact navigation, dredging, we don’t have the mission, it costs too much, blah, blah, blah…..”
EPM – The Beginning
- 1994 NR agencies – “Can you at least give us a 1/2 ft for at least 30 days?”
- Corps “Yea we will try it.”
  ▶ Reality was the Corps was doing it for ~20 days already, so really only talking 10 days or so
  ▶ Environmental benefit was hard for the Corps to see, but we went along
- Corps “If we do it, you need to tell us if it worked.”
  ▶ They did, and it turns out it worked.

Environmental Pool Management
- Adaptively managing pools within the St. Louis District since 1994!
- Optimize water levels to maximize environmental benefits

1994 Annual Spring Coordination Meeting

Environmental Pool Management
- Since 1994 we have been able to achieve yearly environmental benefits
- There have been a few years when the process was abbreviated due to channel conditions (2008, 2010, 2013)
- 2014 River Resources Action Team (RRAT) TNC and USACE met after a 2014 EPM results presentation

Creation of Environmental Pool Management PDT
- Feb 2015 - Initial face-to-face meeting with multiple stakeholders/agencies to discuss current operations and development of PDT.
  ▶ Reviewed team members
  ▶ Seasonal bi-weekly/weekly conference calls
  ▶ Annual face-to-face meeting to review current year operations
- “Can you do 90 days?”

Environmental Pool Management Goals
Utilize the following parameters as general guidelines:
- Begin EPM around April 1st
  ▶ Before the majority of fish spawn begins
  ▶ Reduces likelihood of fish being stranded.
- Continue EPM from May 1st for at least 90 days or until hydrologic conditions require routine dam operations
  ▶ the period most suitable for vegetative growth and seed production.
- At the end of EPM, allow the pool to rise at a rate <0.3 foot per day or a rate recommended by the EPM Coordination Team
  ▶ Slow rise allows vegetation to survive and continue to grow

Environmental Pool Management Imperative
Continue to provide a safe and dependable navigation channel.
Environmental Pool Management Requirement

Close coordination with resource managers in the field

- Environmental conditions will vary from year to year
  - Time of year, temp, and precipitation all have an effect
- Field managers provide valuable insight into actual conditions
- Provide significant suggestions relative to needed adjustments.

2016 achieved 0.5ft drawdown for 148 Days

2016 achieved 1.5ft drawdown for 143 Days

2016 achieved 2.0ft drawdown for 110 days and 1.0ft drawdown for 224 days

Environmental Pool Management

2016 Operations

Lock & Dam 24
Species Richness by Pool

Questions

Rock Island District – Water Control

Kevin Landwehr, P.E., D.WRE
Chief, Hydrology and Hydraulics Branch
Rock Island District, USACE

78,000 sq. mi. Drainage Area
20 Navigation Locks and Dams
3 Multi-Purpose Flood Control Reservoirs
Centralized 24/7 System Operation
Daily coordination with the USGS and NWS

Mississippi River
Rock Island District operates and maintains 314 miles of the Upper Mississippi River: Dam 10 tailwater to Dam 22 tailwater.
MVR Water Control regulates Dams 11-14, 16-18, and 20-22.
Dam 15 normally operated by L&D personnel. (Dam 14 instructions and pool limits are emailed)
Dam 19 Hydroelectric Plant in Keokuk, IA is operated by Ameren UE. (Dam 18 three day forecast is called in daily)
The Dams are regulated as a system.
Each L&D is provided with daily operation instructions.
Daily flow forecasts are provided to the NCRFC, MVS, MVP, MVD, and other MVR internal stakeholders.

Mississippi River Pool Regulation

Types of Pool Regulation
- Dam Point Control – The pool is regulated based on a target pool stage located at the dam itself.
  - Dams 11 – 15, 17 – 19, and 21 - 22
- Primary-Secondary-Tertiary Control – pool is regulated based on control stages at multiple points along the length of the pool.
  - Dams 16 and 20

Why differences?
- 1930s pool operation studies
- In MVR, all were originally P-S-T, however, MVR petitioned for authority to acquire additional real estate interests to allow for dam point control.
  - Higher Cost vs. ease of operation
  - Pools 16 and 20 remained P-S-T for site specific reasons
    - Pool 16 – perceived impacts to infrastructure???, land required???
    - Pool 20 – power generation at Dam 19

Pool Regulation – Dam Point Control

Maximum Regulated Condition
Increasing flow
Flat Pool
Swellhead, typically ~ 0.5-0.7 ft (when out of operation)
Mississippi River Pool Regulation

Dam Point Control – Operating Limits

<table>
<thead>
<tr>
<th>Top of Regulation</th>
<th>0.4 ft</th>
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<tr>
<td>Flat Pool</td>
<td>0.1 Ft</td>
</tr>
<tr>
<td>Bottom of Regulation</td>
<td>0.4 Ft</td>
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</table>

- To smooth out the system we will occasionally deviate from these limits but will avoid running water over spillways. Dams 12, 13, 17, 18, 21 & 22 have non-overflow spillways that are 0.2 - 0.5 above flat pool.
- Winter (non-navigation) operating limits expand to one foot, however at request from USFWS, the pools are regulated as if navigation continues year round.

Primary-Secondary-Tertiary Control

- Utilizes multiple control points
- Active control point at any time is a function of river stage/flow

Lock and Dam 16

- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)

Low Flow / Flat Pool

Lock and Dam 16

- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)

Flow 30,000 cfs

Lock and Dam 16

- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)

Flow 60,000 cfs

Lock and Dam 16

- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)

Flow 100,000 cfs (max drawdown)
Lock and Dam 16

- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)

Lock and Dam 20

- Utilizes 3 control points depending upon flow conditions.
  - Low flows – maintain minimum stage of 2.6 feet at LD19 tailwater, until
  - Gregory Landing stage falls to 6.3 feet, then maintain this stage, at a minimum, until
  - Maximum drawdown at Lock and Dam 20 occurs (7.0 feet), maintain this as minimum pool stage until open river conditions exist.

120,000 cfs (out of operation)
BUILDING STRONG®

Mississippi River – Forecasting Challenges – Dam 19

• Run-of-the-river structure, 38 feet of head (2nd highest on the Upper Mississippi).
• 15 turbines and 119 crest gates.
• When inflow is at or above 62,000 cfs, water is passed through the turbines with crest gates being opened as necessary to maintain authorized pool.
• At inflows below 62,000 cfs, pool and tailwater fluctuate diurnally (cycling) as turbine units are brought on and off-line to achieve most economical operation of the power plant.
• During cycling, outflows can vary as much as 40,000 cfs.
• Dam 20 is authorized to operate within a sliding band of pool limits to dampen the effects of the fluctuations induced by the hydropower generation and provide sufficient depth below Dam 19.

Nuances

► LD 14 and 15 drawdown as go to open river
► Ice Effects
► Positive vs. negative gate settings
  ➢ Not all sites have submersible gates
► Hydropower
  ➢ LD15
  ➢ LD19

Dam 15 Hydropower

BUILDING STRONG®
USACE has oversight authority related to maintenance of the navigation channel.

Unscheduled gate operations performed by Ameren without knowledge of the duty forecaster.

A recent development is unexpected transmission or generation outages and heavy wind power production causing power grid congestion. This can cause negative pricing and unscheduled flow changes. During these scenarios Ameren will avoid operating the crest gates during inclement weather due to personnel safety concerns.

Pools 20-22 have very little storage area, as a result travel times are extremely short (six hours from Dam 19 to Dam 22).

Mississippi River – Forecasting Challenges – Dam 19

Regulation Changes Over Time

Navigation Season – No major changes

Non-Navigation Season

- Historical changes to limits
  - World War II – complete drawdowns of pools (as high as LD 2) to maintain minimum desired depth at St. Louis.
  - Post World War II – mid 1950s – drawdowns of pool 16-18 as need to maintain depth at St. Louis; above LD15, drawdowns limited by law***.
  - Mid 1950s-late 1960s – limited drawdown of pools 16-18 to 3-4 feet.
  - 1970-1987 – limited drawdown to 1 foot at all dams.
  - Since 1988 – operated during winter as if navigation continued year-round.

***“Anti-Drawdown Law.” Dated March 10, 1934, and as amended by Public Law 732 on August 14, 1946, and again by Public Law 897 on June 16, 1948. The law directs that the Corps shall generally operate and maintain pool levels as though navigation were carried on throughout the year.

Daily Operations

- Daily gate instructions are sent to each project, typically one setting per day but more if needed. Some restrictions in winter/holidays on timing.
- Specifies gate openings to be set at the dam – Total feet of Tainter and roller gate openings.
- Specifies pool limits.
- If operating band limits are exceeded, the project contacts the forecaster on duty for new gate setting.

Project Regulation - Mississippi River

- Gate changes are a function of:
  - Rising or falling pool
  - Location in operating band
  - Upstream changes in flow
  - Local tributary flow changes
  - Wind
  - Ice

Impact of Dam Operations on Water Levels

LD 18
Previous Drawdowns in MVR

- Lock and Dam 13 (1998)
- NESP Water Level Management Opportunities Report
- Lock and Dam 18 Planning under NESP

1998 Pool 13 Drawdown

- Goal was to conduct a 1 foot drawdown to elevation 582.0, occurring between June 15 and August 15.
- The drawdown would be a drawdown of opportunity occurring any time during the period that the flow is within and forecast to remain within the specified flow constraints (50,000 to 110,000 cfs).

Based on the available hydrologic record it appeared that a drawdown of 30 days or more could be accomplished, on average, once every 3 years.
NESP Water Level Management Report (Environmental Report 53)

- Each District prioritized actions – Appendices B-D
- MVR prioritization of pool-wide drawdowns based on screening of pools considering benefits, potential, and conflicts/impacts.
- Most suitable – Pools 11 and 13
- Second tier – Pools 16 and 18

Where we’ve been:

2005
- Aquatic Veg Survey
- Data Collection
- Existing Conditions
- Public Scoping Meetings

2006
- Alternative Formulation and Analysis
- Coordination on Recreational Access
- Shallow-Water Mussel Recon

2007
- Coordination of Shallow-Water Mussel Recon
- Coordination of potential thalweg disposal sites
- Mussel survey for population estimate and site-specific impacts

2008
- Coordination of potential mussel impacts
- Shallow-Water Mussel Survey

2-Foot Hinged Alternative
2-Foot drawdown at the dam, with secondary control point at Keithsburg of 528.0 ft
- Allows for full drawdown of 2 feet at the dam (primary control point) if flow is greater than ~ 40,000 cfs. Below 40,000 cfs, maintain elevation at Keithsburg of 528.0 (secondary control point).
Benefits of “Hinged” Drawdown

- Provides majority of benefits of “full” drawdown
- Reduced recreational impacts
- Reduced dredging requirements (cost)

Where we’ve been:

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- Aquatic Veg Survey
- Data Collection
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MVR – Mississippi River Dredging

Dredging Volume over Time (Pools 11-24)
Downward Trend Over Last 50 Years
Upward Trend Since 1998

MVR – Illinois Waterway Dredging

Dredging Volume over Time
Slight Downward Trend Since 1998
Slight Upward trend Over Last 50 Years

Number of Vessel Groundings – Miss.

Rock island District

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### Number of Vessel Groundings – IWW

<table>
<thead>
<tr>
<th>Rock Island District</th>
<th>5 yr Reported Groundings by Pool - Illinois Waterway</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E11</td>
</tr>
<tr>
<td>Scagge</td>
<td>3</td>
</tr>
<tr>
<td>Freema</td>
<td></td>
</tr>
<tr>
<td>Galena Rock</td>
<td>2</td>
</tr>
<tr>
<td>Monelco</td>
<td>1</td>
</tr>
<tr>
<td>Breakwater</td>
<td>0</td>
</tr>
<tr>
<td>Lockport</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>52</td>
</tr>
</tbody>
</table>

*Critical and Non-Critical Groundings reported directly to Channel Maintenance Section

**NEAR** - When a vessel is grounded or was approached the channel is not limited to the other vessels, period safety laps. This also not on critical grounding where the hazardous under runs region is a relatively short time period and traffic resumes without further incident.

**NEAR** - Critical and non-critical report to channel in the channel is not resumed and other vessels can safely pass. This category includes antagonist’s restriction caused by the vessel returning to yard.

### MVR - Available Dredging Placement

![MVR - Available Dredging Placement Diagram]

### Dredging Volumes by Pool

![Dredging Volumes by Pool Chart]

### Questions?
Nuts and Bolts of Large-Scale Water Level Management on the UMR, St. Paul District

For the UMRBA Water Level Management Workshop, April 4-5, Dubuque IA

Stakeholders
- Wisconsin DNR
- Minnesota DNR and PCA
- Iowa DNR
- U.S. Fish and Wildlife Service
- National Park Service
- U.S. Geological Survey
- TNC, Audubon, other NGO’s
- General Public

General Dam Operation
- General Control-Point operation explanation
- Operating Limits according to their Water Control Plans
- Have these changed over time and if so, how and why?

Lock & Dam Regulation
- Three Types of Regulation
  - Hinge Point
    - Dams 2 – 6 and Dams 8 – 9
    - Primary control (mid pool)
    - Secondary control at the Dam
    - Less flowage easements
  - Control at the Dam
    - Lock and Dam 7 Only
    - Secondary Only (Primary control point would be in the structure of Lock 6)
  - Primary @ Dam – Secondary mid pool – Tertiary @ Dam
    - Lock and Dam 10 Only (Designed by MVR)
Daily Dam Operation

- How are gate instructions issued?
  - Water on the ground
  - Upstream inflow
  - Gate balance
  - Conditions at the Dam (wind, maintenance)
- Gate change frequency
  - Usually once per day, at higher flows more regulation is needed

Daily Regulation Sheet

- Orders routinely sent before 8 AM
- Afternoon orders are needed when
  - Greater flows
  - Significant rain events
  - Minor adjustments can also be made
- Lock and Dam Operators can make a 20% change in flow without orders

Sending the Orders

Regulation Frequency

Fluctuations occur and the Math isn’t Perfect
Daily Fluctuations
- Wind - can change the pool 0.1 ft per 10mph
- Power generation – WI River, LD 2
- Shift changes and staffing
- Math and human error

Dam Operation Effects on Water Levels
- Typical fluctuations and ranges during the growing season (not open river conditions)
- Graphics depicting 10 years of daily water levels May-August for select dams

Lock & Dam forecast
http://155.76.213.89/docs/mvd2.html

Lock & Dam 10 - 2015 5 Day Forecasted Flows
Flows fell faster and climb faster than forecast
**Channel Maintenance**

- **Dredging depths**
  - St. Paul District dredges to 12’ below LCP with the goal of maintaining a > 9’ channel until the next navigation season.
  - Dredge material placement: All placement in the St. Paul District is upland except in Emergency situations – this increases cost and limits volume that can be accommodated from every dredge job.

**Channel Maintenance (Cont.)**

<table>
<thead>
<tr>
<th>Pool</th>
<th>Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>142,931</td>
</tr>
<tr>
<td>3</td>
<td>48,229</td>
</tr>
<tr>
<td>4</td>
<td>293,370</td>
</tr>
<tr>
<td>5</td>
<td>115,408</td>
</tr>
<tr>
<td>5A</td>
<td>47,708</td>
</tr>
<tr>
<td>6</td>
<td>25,795</td>
</tr>
<tr>
<td>7</td>
<td>52,462</td>
</tr>
<tr>
<td>8</td>
<td>75,796</td>
</tr>
<tr>
<td>9</td>
<td>15,852</td>
</tr>
<tr>
<td>10</td>
<td>24,190</td>
</tr>
<tr>
<td>Total</td>
<td>835,266</td>
</tr>
</tbody>
</table>

**Routine Pool Management, Hinge Pool**

- Routine Dredging Conducted to lowest controlled pool elevation
- Low Pool level tolerance at MVP dams very small (+/- 0.2 ft)
- Low tolerance minimizes overall dredging needs, but doesn’t support routine drawdowns

**Drawdowns, Hinge Pool**

- **Drawdown Cost** = Additional dredging prior to drawdown to maintain adequate depth for navigation
- This deeper dredging can result in reduced dredging needs for several years.
- The sediment trap efficiency is increased, which has resulted in overall increased dredging associated with drawdowns.
Channel Performance
• Number of groundings/complaints per year per pool

<table>
<thead>
<tr>
<th>Pool</th>
<th>Number of Groundings/Complaints by Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-10</td>
<td>1990: 4, 25, 52, 2, 14, 4, 4</td>
</tr>
<tr>
<td>10-20</td>
<td>1992: 4, 9, 4, 3, 2, 4, 3</td>
</tr>
<tr>
<td>20-30</td>
<td>1994: 4, 1, 2, 6, 2, 3, 0</td>
</tr>
<tr>
<td>30-40</td>
<td>1996: 0, 7, 2, 6, 4, 2, 4</td>
</tr>
</tbody>
</table>
| 40-50| 1998: 4, 3, 1, 1, 9, 2, 3 | 1999: 2, 1, 3, 2, 1, 0 |}

Totals: 124, 95, 93, 80, 79, 37, 151, 82, 58, 72, 871

Avg. Per Yr: 4.6, 3.5, 3.4, 3.0, 2.9, 1.4, 5.6, 3.0, 2.1, 2.7

Drawdowns – Defining Success
• Time frame
• Duration
• Depth of exposed acres

Early documents (1990s) – "The probability of having optimum drawdown conditions was defined as the probability for river discharge to allow a drawdown to the target depth (1.5') during the June through September growing season, with no more than two re-flooding events of less than one week duration."

Recent Discussions (2016 – 2017) – Opportunistic shorter duration smaller drawdowns could have ecological benefits.

Past Drawdown Examples

<table>
<thead>
<tr>
<th>Years</th>
<th>Pool 8</th>
<th>Pool 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005-06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawdown Initiated</td>
<td>June 16, 2001</td>
<td>June 13, 2005</td>
</tr>
<tr>
<td>June 15, 2002</td>
<td>June 12, 2006</td>
<td></td>
</tr>
<tr>
<td>Maximum DD Duration</td>
<td>1.5' (06 Jul - 14 Aug 2001)</td>
<td>1.5' (29 Jun - 31 Jul 2006)</td>
</tr>
<tr>
<td>1.5' (03 Jul - 16 Sep 2002)</td>
<td>1.5' (26 Jun - 29 Jun 2006)</td>
<td></td>
</tr>
<tr>
<td>Acres Exposed</td>
<td>1950 (Both years)</td>
<td>1000 (in 2005)</td>
</tr>
</tbody>
</table>

Annual Dredging in Pool 8

- 209,000 cubic yards dredged in 2001
- Reduced dredging for several years after this
- 26% increase in dredging for the 5 year time period 2001 – 2005 compared to the 1981 to 2000 time period

Past Drawdown Examples

<table>
<thead>
<tr>
<th>Vegetation Response</th>
<th>Fish</th>
<th>Mussels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift from annuals to perennials from 1st to 2nd year</td>
<td>No measurable effect? Potential for stranding and adverse effects to spawning areas</td>
<td>At least 28% of mussels died in shallow water areas in Pool 5. The mussel population in Pool 5 was estimated at 189 million</td>
</tr>
</tbody>
</table>

- 209,000 cubic yards dredged in 2001
- Reduced dredging for several years after this
- 26% increase in dredging for the 5 year time period 2001 – 2005 compared to the 1981 to 2000 time period
**Future Drawdowns**

- Constraints – Additional dredging costs, recreational boating
- Opportunistic DD factors:
  - Deferred (marginal) dredging reaches
  - High tailwater at some dams
  - Short-term changes in channel conditions (i.e., what condition is first cut in, when final cut is finished)
  - Risk of groundings

**Questions?**
Overview

- St. Louis District Overview/Background
- Lock & Dam Operations
- Dredging Operations
- Environmental Pool Management
- Questions

St. Louis District

- 5 Flood Control Reservoirs Projects
  - Lake Shelbyville, Carlyle Lake, Rend Lake, Mark Twain Lake, and Wappapello Lake
- 5 Lock and Dam Projects
  - L&D 24, L&D 25, Mel Price L&D, L&D 27, and Kaskaskia L&D
- 9 Watersheds draining into the Mississippi River within the St. Louis District
  - Salt, Cuivre, Lower Missouri, Meramec, Upper St. Francis, Castor, Lower Illinois, Kaskaskia, and Big Muddy Rivers

District Overview

St. Louis District

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Critical Link

- Mississippi River @ L&D 22
- Illinois River @ Meredosia
- Critical Link
- Missouri River @ Hermann
- Mississippi River @ St. Louis
HISTORY OF THE ST. LOUIS GAGE
- Lowest recorded stage = -6.2 feet (1940)
- Highest recorded stage = 49.6 feet (1993)
- Over a 55 foot range
- Average stage (11.3 feet)
- 2012-2013
  - Low ~ -4.6 (JAN 2013)
  - High ~ 40.5 (JUN 2013)
- Range in flows
  - 3.2' (LWRP) approx. 6,300/foot
  - 30.0' (Flood) approx. 22,000/foot

Coordination
- USACE
  - Mississippi Valley Division
    - St. Paul District
    - Rock Island District
    - Memphis District
  - Northwestern Division
  - Lakes and River Division
- NWS River Forecast Centers
  - North Central RFC (handoff at Chester, IL)
  - Missouri Basin RFC (handoff at Hermann, MO)
  - Lower Mississippi RFC (starting at Cape Girardeau, MO)

Hinge Point Operation
- Difficult!! Operate by using two control points. One at dam and one mid-point in pool
- Range limits change with flow ranges
- Change in flows can require over a 5 ft pool change in a 24-hour timeframe
- Pool elevation instructions are issued to lock personnel (minimum daily) and gate changes are made as necessary
- Daily instructions +/- tenth

Hinge Point Limits
- Lock and Dam 24
  - Pool Limits: 445.5 - 449.0
  - Hinge Point Limits, Louisiana: 11.5 - 12.2 (May be exceeded if at maximum drawdown)
- Lock and Dam 25
  - Pool Limits: 429.7 - 434.0
  - Hinge Point Limits, Mosier Landing: 434.0 - 437.0 (May be exceeded if at maximum drawdown)
- Melvin Price Locks and Dam
  - Pool Limits: 412.5 - 419.0 Alton Lower Limit: 414.0
  - Hinge Point Limits, Grafton: 14.2 - 16.2 (May be exceeded if at maximum drawdown, or Alton at 414.0)
- Kaskaskia Lock and Dam
  - Pool Limits: 363.0 - 368.8
  - Hinge Point, Red Bud: 368.0 - 370.0

Locks and Dams
- Melvin Price Locks & Dam
- Rock Island Locks & Dam
- Kaskaskia Lock & Dam
- Grafton Lock & Dam
- Alton Lock & Dam
- East St. Louis Lock & Dam
- East St. Louis Lock & Dam
- East St. Louis Lock & Dam
- East St. Louis Lock & Dam
Hinge Point Operation

Melvin Price Locks and Dam

- Hinge Point Limits, Grafton: 14.2 - 16.2
  - May be exceeded if at maximum drawdown or Alton at 414.0
- Alton Lower Limit: 414.0
- Pool Limits: 412.5 - 419.0

Flowage Easements

Environmental Pool Management Zone

Low Flow / Flat Pool

Max Flow

Open River

Increasing / Decreasing Flow

Visualizing L&D Hinge Point Operating Limits
Dredging Operations

Pool 24

Jobs: 1
CY: 5k
Mile 289
MVR – Mech
11 - 13 Jul 2016

Pool 25

Jobs: 8
CY: 565,829

Dredge Potter
10-23 Jun
Lock 25 Upper, 242.0
Wesport Island, 205.5
Cass Island, 258.0
Caroll Island, 270.0
Caroll Island, 271.3

11-20 Aug
Lock 25 Upper, 243.0
Lock 25 Upper, 243.0

Pool 26, UMR

Jobs: 11
CY: 599,797

Dredge Potter
6-12 June
Sherwood, 219.0
Bolter Island, 227.0
Lock 25 Lower, 241.0

23 Jun – 1 Jul
Bolter Island, 227.0
Thomas Landing, 229.0
Parque Island, 233.0
Martin Towhead, 234.0
Squaw Island, 231.0
Atkin, 235.0

9-11 Aug
Royal Landing, 223.5
**BUILDING STRONG®**

**Pool 27, UMR**

- Jobs: 3
- CY: 185,499
- Dredge Potter, 146k CY
  - Mid July
  - Mel Price Lower, 203.3
  - Motile Island, 198.0
- Dredge Goetz, 39.5k CY
  - 17-22 Oct
  - Upper Chain of Rocks Canal, 194.0
- Standby High Water – 15 days

**Open River**

- Jobs: 11
- CY: 2,155 MCY
- Dredge Potter
  - 20 Aug – 28 Dec 2016
  - Riverway, 173.0
  - *Cliff Cave, 167.0
  - *Notre Dame, 171.0
  - *Reidy, 175.0
  - *Lower Canal, 184.0
  - *Roaring, 173.0
  - CJR area, 157.0
  - JB Lower, 166.5
  - Vancil Trench, 171.0
- Shovelton, 113.0
- Sandhill Base, 177.0
- Standby High Water – 82 days
  - 6 Jul – 8 Aug
  - 1 – 8 Sep
  - 13 Sep – 22 Oct
  - * Flex Pipe

**Illinois Waterway 0 - 80**

- Jobs: 8
- CY: 77,377
- Dredge Goetz
  - 26 Aug – 30 Sep
  - Wing Island, 40.0
  - Old La Grange Lock Lower, 77.0
  - Old La Grange Lock, 77.5
  - Morris Island, 76.7 & 76.4
  - Old La Grange Lock Upper, 78.0
  - Indian Creek, 78.8
  - Kamp Creek, 74.0
  - Macoupin Ferry, 63.0
- Standby High Water - 19.5 days

**Rock Removal**

- Remnants of the 1988-1989 rock removal
  - Grand Tower Reach (RM 78.9 to 80.0)
  - Thebes Reach (RM 38.5 to 46.0)

**Bumpings/Groundings**

- In our pools we generally may have a few bumpings, say 3 to 5 per season, but generally those issues are related to buoys off station or if it is an area that is shoaling. We can delay dredging by pulling buoys in with the Pathfinder.
- We have also temporarily re-aligned the channel to avoid shallow water until a dredge is available.
- We also provide survey data to industry to help them find the best available water.
- Hard groundings per year, hopefully none that are directly in the channel.
Extended River Forecast
(issued late November)
- Currently St. Louis is at -0.7 ft
  - 7,000 cfs/ft
- Upper Mississippi River Flow Forecast
  - Currently ~ 39,200 cfs
  - 28 days ~ 21,500 cfs (-17,700 cfs)
- Missouri River Flow Forecast
  - Currently ~ 48,700 cfs
  - 28 days ~ 24,000 cfs (-24,700 cfs)
- St. Louis 28 day Forecast
  - Loss of 42,400 cfs ~ loss of 6 ft ~ -6.7 ft at St. Louis

Accounting for Forecast Errors
- Assuming St. Louis Low of -5.1 ft (i.e. no Mel Price operation)
  - 6,000 cfs/ft
- Upper Mississippi River Flow Forecast
  - Error ~ -1,140 cfs
- Illinois River
  - Error ~ -3,000 to -6,000 cfs
- Missouri River Flow Forecast
  - Error ~ -3,300 cfs
- St. Louis Low:
  - Loss of 7,440 to 10,440 cfs ~ -6.3 ft to -6.8 ft

Environmental Pool Management is Adaptive Management

EPM – The Beginning
Agency request (~1988)-
“We want a 3 foot drawdown for 120 days!”

Corps response -“Nope!”
“It will impact navigation, dredging, we don’t have the mission, it costs too much, blah, blah, blah.....”
EPM – The Beginning

- 1994 NR agencies – “Can you at least give us a 1/2 ft for at least 30 days?”
- Corps “Yea we will try it.”
  - Reality was the Corps was doing it for ~ 20 days already, so really only talking 10 days or so
  - Environmental benefit was hard for the Corps to see, but we went along
- Corps “If we do it, you need to tell us if it worked.”
  - They did, and it turns out it worked....

Environmental Pool Management

- Adaptingly managing pools within the St. Louis District since 1994!
- Optimize water levels to maximize environmental benefits

1994 Annual Spring Coordination Meeting

Creation of Environmental Pool Management PDT

- Feb 2015 - Initial face-to-face meeting with multiple stakeholders/agencies to discuss current operations and development of PDT.
  - Reviewed team members
  - Seasonal bi-weekly/weekly conference calls
  - Annual face-to-face meeting to review current year operations
- “Can you do 90 days?”

Environmental Pool Management Goals

- Utilize the following parameters as general guidelines:
  - Begin EPM around April 1st
    - Before the majority of fish spawn begins
    - Reduces likelihood of fish being stranded.
  - Continue EPM from May 1st for at least 90 days or until hydrologic conditions require routine dam operations
    - the period most suitable for vegetative growth and seed production.
  - At the end of EPM, allow the pool to rise at a rate <0.3 foot per day or a rate recommended by the EPM Coordination Team
    - Slow rise allows vegetation to survive and continue to grow

Environmental Pool Management Imperative

Continue to provide a safe and dependable navigation channel.
Environmental Pool Management Requirement

Close coordination with resource managers in the field

- Environmental conditions will vary from year to year
  - Time of year, temp, and precipitation all have an effect
- Field managers provide valuable insight into actual conditions
- Provide significant suggestions relative to needed adjustments.

2016 achieved 0.5ft drawdown for 148 Days

2016 achieved 1.5ft drawdown for 143 Days

2016 achieved 2.0ft drawdown for 110 days and 1.0ft drawdown for 224 days

Environmental Pool Management 2016 Operations

Lock & Dam 24
L&D 24 Environmental Pool Management

- 1 Foot 148 Days
- 1 Foot 97 Days
- 1 Foot 30 Days

Active EPM

L&D 24 Environmental Pool Management

- 1/2 Foot 148 Days

Mel Price Lock & Dam

- 2.5 Foot 61 Days
- 1.5 Foot 143 Days

Active EPM

Mel Price Environmental Pool Management

- 1 Foot 224 Days
- 2 Foot 19 Days

Biological Response to EPM
Rock Island District – Water Control

Kevin Landwehr, P.E., D.WRE
Chief, Hydrology and Hydraulics Branch
Rock Island District, USACE

Rock Island District Water Management

- 78,000 sq. mi. Drainage Area
- 20 Navigation Locks and Dams
- 3 Multi-Purpose Flood Control Reservoirs
- Centralized 24/7 System Operation
- Daily coordination with the USGS and NWS

Mississippi River

- Rock Island District operates and maintains 314 miles of the Upper Mississippi River: Dam 10 tailwater to Dam 22 tailwater.
- MVR Water Control regulates Dams 11-14, 16-18, and 20-22.
- Dam 15 normally operated by L&D personnel. (Dam 14 instructions and pool limits are emailed)
- Dam 19 Hydroelectric Plant in Keokuk, IA is operated by Ameren UE. (Dam 18 three-day forecast is called in daily)
- The Dams are regulated as a system.
- Each L&D is provided with daily operation instructions.
- Daily flow forecasts are provided to the NCRFC, MVS, MVP, MVD, and other MVR internal stakeholders.

Mississippi River Pool Regulation

- Types of Pool Regulation
  - Dam Point Control – The pool is regulated based on a target pool stage located at the dam itself.
    - Dams 11 – 15, 17 – 19, and 21 - 22
  - Primary-Secondary-Tertiary Control – pool is regulated based on control stages at multiple points along the length of the pool.
    - Dams 16 and 20

Why differences?

- 1930s pool operation studies
- In MVR, all were originally P-S-T, however, MVR petitioned for authority to acquire additional real estate interests to allow for dam point control.
  - Higher Cost vs. ease of operation
  - Pools 16 and 20 remained P-S-T for site specific reasons
    - Pool 16 – perceived impacts to infrastructure???, land required???
    - Pool 20 – power generation at Dam 19

Pool Regulation – Dam Point Control

- Maximum Regulated Condition
- Increasing flow
- Flat Pool
- Swellhead, typically ~ 0.5-0.7 ft (when out of operation)
Mississippi River Pool Regulation

Dam Point Control – Operating Limits

<table>
<thead>
<tr>
<th>Top of Regulation</th>
<th>0.1 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Pool</td>
<td></td>
</tr>
<tr>
<td>Bottom of Regulation</td>
<td>0.4 ft</td>
</tr>
</tbody>
</table>

- To smooth out the system we will occasionally deviate from these limits but will avoid running water over spillways. Dams 12, 13, 17, 18, 21 & 22 have non-overflow spillways that are 0.2 - 0.5 above flat pool.
- Winter (non-navigation) operating limits expand to one foot, however at request from USFWS, the pools are regulated as if navigation continues year round.

Primary-Secondary-Tertiary Control

- Utilizes multiple control points
- Active control point at any time is a function of river stage/flow

Lock and Dam 16

- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)

Flow 30,000 cfs

Flow 60,000 cfs

Flow 100,000 cfs (max drawdown)
Lock and Dam 16
- Normal Pool Limits: 544.6-545.1 (11.0-11.5)
- Hinge Point Limit @ Fairport: 545.6 (10.4)

Lock and Dam 20
- Utilizes 3 control points depending upon flow conditions.
  - Low flows – maintain minimum stage of 2.6 feet at LD19 tailwater, until
  - Gregory Landing stage falls to 6.3 feet, then maintain this stage, at a minimum, until
  - Maximum drawdown at Lock and Dam 20 occurs (7.0 feet), maintain this as minimum pool stage until open river conditions exist.
Lock and Dam 20

- **Flow Increasing**

Nuances
- LD 14 and 15 drawdown as go to open river
- Ice Effects
- Positive vs. negative gate settings
  - Not all sites have submersible gates
- Hydropower
  - LD15
  - LD19

Mississippi River – Forecasting Challenges – Dam 19

- Run-of-the-river structure, 38 feet of head (2nd highest on the Upper Mississippi).
- 15 turbines and 119 crest gates.
- When inflow is at or above 62,000 cfs, water is passed through the turbines with crest gates being opened as necessary to maintain authorized pool.
- At inflows below 62,000 cfs, pool and tailwater fluctuate diurnally (cycling) as turbine units are brought on and off-line to achieve most economical operation of the power plant.
- During cycling, outflows can vary as much as 40,000 cfs.
- Dam 20 is authorized to operate within a sliding band of pool limits to dampen the effects of the fluctuations induced by the hydropower generation and provide sufficient depth below Dam 19.
Mississippi River – Forecasting Challenges – Dam 19

- USACE has oversight authority related to maintenance of the navigation channel.
- Unscheduled gate operations performed by Ameren without knowledge of the duty forecaster.
- A recent development is unexpected transmission or generation outages and heavy wind power production causing power grid congestion. This can cause negative pricing and unscheduled flow changes. During these scenarios Ameren will avoid operating the crest gates during inclement weather due to personnel safety concerns.
- Pools 20-22 have very little storage area, as a result travel times are extremely short (six hours from Dam 19 to Dam 22).

Regulation Changes Over Time

**Navigation Season – No major changes**

**Non-Navigation Season**

- Historical changes to limits
  - World War II – complete drawdowns of pools (as high as LD 2) to maintain minimum desired depth at St. Louis.
  - Post World War II – mid 1950s – drawdowns of pool 16-18 as need to maintain depth at St. Louis; above LD15, drawdowns limited by law***.
  - Mid 1950s-late 1960s – limited drawdown of pools 16-18 to 3-4 feet.
  - 1970-1987 – limited drawdown to 1 foot at all dams.
  - Since 1988 – operated during winter as if navigation continued year-round.

---

**Daily Operations**

- Daily gate instructions are sent to each project, typically one setting per day but more if needed. Some restrictions in winter/holidays on timing.
- Specifies gate openings to be set at the dam – Total feet of Tainter and roller gate openings.
- Specifies pool limits.
- If operating band limits are exceeded, the project contacts the forecaster on duty for new gate setting.

**Project Regulation - Mississippi River**

- Gate changes are a function of:
  - Rising or falling pool
  - Location in operating band
  - Upstream changes in flow
  - Local tributary flow changes
  - Wind
  - Ice

---

**Impact of Dam Operations on Water Levels**

![Graph showing water levels impact of dam operations](image)

- (Graph details not transcribed)
Previous Drawdowns in MVR

- Lock and Dam 13 (1998)
- NESP Water Level Management Opportunities Report
- Lock and Dam 18 Planning under NESP

1998 Pool 13 Drawdown

- Goal was to conduct a 1 foot drawdown to elevation 582.0, occurring between June 15 and August 15
- The drawdown would be a drawdown of opportunity occurring any time during the period that the flow is within and forecast to remain within the specified flow constraints (50,000 to 110,000 cfs).

Based on the available hydrologic record it appeared that a drawdown of 30 days or more could be accomplished, on average, once every 3 years.
NESP Water Level Management Report
(Environmental Report 53)

- Each District prioritized actions – Appendices B-D
- MVR prioritization of pool-wide drawdowns based on screening of pools considering benefits potential and conflicts/impacts.
  - Most suitable – Pools 11 and 13
  - Second tier – Pools 16 and 18

Where we’ve been:

2005
- Aquatic Veg Survey
- Data Collection
- Existing Conditions
- Public Scoping Meetings

2006
- Alternative Formulation and Analysis
- Coordination on Recreational Access
- Shallow-Water Mussel Recon

2007
- Coordination of Shallow-Water Mussel Recon
- Coordination of potential thalweg disposal sites
- Mussel survey for population estimate and site-specific impacts

2008
- Coordination of potential mussel impacts
- Shallow-Water Mussel Survey

2-Foot Hinged Alternative
2-Foot drawdown at the dam, with secondary control point at Keithsburg of 528.0 ft
- Allows for full drawdown of 2 feet at the dam (primary control point) if flow is greater than ~ 40,000 cfs. Below 40,000 cfs, maintain elevation at Keithsburg of 528.0 (secondary control point).

Figure 7 - Computed Water Surface Profiles - Hinged Operation

Figure 8. Target Pool Elevation Under Hinged Operation
Benefits of “Hinged” Drawdown

- Provides majority of benefits of “full” drawdown
- Reduced recreational impacts
- Reduced dredging requirements (cost)

Where we’ve been:

2005
- Aquatic Veg Survey
- Data Collection
- Existing Conditions
- Public Scoping Meetings

2006
- Alternative Formulation and Analysis
- Coordination on Recreational Access
- Shallow-Water Mussel Recon

2007
- Coordination of Shallow-Water Mussel Recon
- Coordination of potential thalweg disposal sites
- Mussel survey for population estimate and site-specific impacts

2008
- Coordination of potential mussel impacts
- Shallow-Water Mussel Survey
Stakeholders

- Wisconsin DNR
- Minnesota DNR and PCA
- Iowa DNR
- U.S. Fish and Wildlife Service
- National Park Service
- U.S. Geological Survey
- TNC, Audubon, other NGO’s
- General Public

General Dam Operation

- General Control-Point operation explanation
- Operating Limits according to their Water Control Plans
- Have these changed over time and if so, how and why?

Lock & Dam Regulation

- Three Types of Regulation
  - Hinge Point
    - Dams 2 – 6 and Dams 8 – 9
    - Primary control (mid pool)
    - Secondary control at the Dam
    - Less flowage easements
  - Control at the Dam
    - Lock and Dam 7 Only
    - Secondary Only (Primary control point would be in the structure of Lock 6)
  - Primary @ Dam – Secondary mid pool – Tertiary @ Dam
    - Lock and Dam 10 Only (Designed by MVR)
Daily Dam Operation

- How are gate instructions issued?
  - Water on the ground
  - Upstream inflow
  - Gate balance
  - Conditions at the Dam (wind, maintenance)

- Gate change frequency
  - Usually once per day, at higher flows more regulation is needed

Daily Regulation Sheet

Regulation Frequency

- Orders routinely sent before 8 AM
- Afternoon orders are needed when
  - Greater flows
  - Significant rain events
  - Minor adjustments can also be made
- Lock and Dam Operators can make a 20% change in flow without orders

Sending the Orders

Fluctuations occur and the Math isn’t Perfect
Daily Fluctuations

- Wind - can change the pool 0.1 ft per 10mph
- Power generation – WI River, LD 2
- Shift changes and staffing
- Math and human error

Dam Operation Effects on Water Levels

- Typical fluctuations and ranges during the growing season (not open river conditions)
- Graphics depicting 10 years of daily water levels May-August for select dams

Lock & Dam forecast
http://155.76.213.69/docs/mvd2.html

Lock & Dam 10 - 2015 5 Day Forecasted Flows
Flows fall faster and climb faster than forecast

LD 8 Year Ave WSEL During Growing Season when in Secondary Control

<table>
<thead>
<tr>
<th>Year</th>
<th>Ave WSEL During Growing Season when in Secondary Control</th>
<th>Std. D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>630.09</td>
<td>0.1</td>
</tr>
<tr>
<td>2007</td>
<td>630.16</td>
<td>0.1</td>
</tr>
<tr>
<td>2008</td>
<td>630.14</td>
<td>0.2</td>
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<tr>
<td>2009</td>
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<td>0.1</td>
</tr>
<tr>
<td>2016</td>
<td>630.13</td>
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</tr>
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</table>

Primary Secondary Out of Control
22% 71% 7%

Inverse Operations of the pools
**Channel Maintenance**

- Dredging depths
  - St. Paul District dredges to 12' below LCP with the goal of maintaining a > 9' channel until the next navigation season.

- Dredge material placement: All placement in the St. Paul District is upland except in Emergency situations – this increases cost and limits volume that can be accommodated from every dredge job.

---

**Channel Maintenance (Cont.)**

**Annual Dredging Per Pool 1985 - 2016**

<table>
<thead>
<tr>
<th>Pool</th>
<th>Cubic Yards</th>
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<tr>
<td>2</td>
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<tr>
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<td>9</td>
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<tr>
<td>10</td>
<td>24,349</td>
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<tr>
<td>Total</td>
<td>835,266</td>
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MN River, Pool 1, USA, harbors not included.
**Channel Performance**
- Number of groundings/complaints per year per pool

<table>
<thead>
<tr>
<th>Year</th>
<th>Pool 2</th>
<th>Pool 3</th>
<th>Pool 4</th>
<th>Pool 5</th>
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<td>4</td>
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<td>2016</td>
<td>16</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
</tbody>
</table>

**Average Yr**
- 4.6
- 3.5
- 3.4
- 3.0
- 2.9
- 1.4
- 5.6
- 3.0
- 2.1
- 2.7

**Drawdowns – Defining Success**
- Time frame
- Duration
- Depth of exposed acres

**Early documents (1990s)** – “The probability of having optimum drawdown conditions was defined as the probability for river discharge to allow a drawdown to the target depth (1.5’) during the June through September growing season, with no more than two re-flooding events of less than one week duration.”

**Recent Discussions (2016 – 2017)** – Opportunistic shorter duration smaller drawdowns could have ecological benefits.

**Past Drawdown Examples**

<table>
<thead>
<tr>
<th>Years</th>
<th>Pool 8</th>
<th>Pool 5</th>
</tr>
</thead>
</table>

- **Vegetation Response**: Shift from annuals to perennials from 1st to 2nd year. Increase in emergent and submersed veg. But veg has been increasing in other pools.

- **Fish**
  - No measurable effect? Potential for stranding and adverse effects to spawning areas. Positive impacts from increased vegetation.

- **Mussels**
  - At least 28% of mussels died in shallow water areas in Pool 5. The mussel population in Pool 5 was estimated at 189 million

**Annual Dredging in Pool 8**
- 209,000 cubic yards dredged in 2001
- Reduced dredging for several years after this
- 26% increase in dredging for the 5 year time period 2001 – 2005 compared to the 1981 to 2000 time period
First page:

- 362,000 cubic yards dredged in 2005
- Reduced dredging for several years after this
- 44% increase in dredging for the 5 year time period 2005 – 2009 compared to the 1981 to 2004 time period
- Note – Additional dredging was done for island construction in 2005

Second page:

**Future Drawdowns**

- Constraints – Additional dredging costs, recreational boating
- Opportunistic DD factors:
  - Deferred (marginal) dredging reaches
  - High tailwater at some dams
  - Short-term changes in channel conditions (ie. what condition is first cut in, when final cut is finished)
  - Risk of groundings

**Questions?**