Estabrook Dam Improvements

IAFSM Annual Conference
March 9, 2017
Estabrook Dam

- Milwaukee River, Milwaukee County
- Owner: Milwaukee Metropolitan Sewerage District
- Low Hazard Dam
- Constructed 1930s
- Impoundment Size: 200 acre-feet
- Structural Height: 15 feet
- Spillway Capacity: 25,800 cfs
Estabrook Dam – Pertinent Information

- Ice Breakers
- Milwaukee River (shallow impoundment)
- Gated Spillway (Secondary)
- Estabrook Park
- Estabrook Island

Fixed Crest Spillway (Primary)

Dam Features – Left to Right:
- Left Fixed Crest Weir
- 10 Sluice Gates
- Right Fixed Crest Weir
- Estabrook Island
- Fixed Crest Serpentine Spillway
WDNR Administrative Order - 2009

- June 2008 Midwest Floods
  - IL, IN, IA, MI, MN, MO, WI
  - 30 Counties in WI – Declared State of Emergency
  - Lake Delton Failure – June 9, 2008
  - Increased Dam Safety Awareness Across the State

- 2009 the WDNR Inspected the Dam
  - WDNR Noted dam safety deficiencies
    - Upgrade Sluice Gates / Ice Breakers
    - Remove trees near the Dam
    - Remove woody debris upstream of dam
    - Perform a structural analysis of dam
  - July 28, 2009 – WDNR Administrative Order to the Dam Owner (Milwaukee County) to drawdown the impoundment until either repaired or abandoned
  - Summer 2009 – Milwaukee County opened sluice gates
  - Spring 2010 – Milwaukee County Hired AECOM
    - Inspect the Dam
    - Construction Drawings / Technical Specifications and Permitting Documents to repair the dam
Ice Breaker Repairs
• Concrete repairs to ice breakers
• Restore missing ice breaker

Gated Spillway Repairs
• Concrete repairs to piers
• Concrete repair to walkway above gates
• Repair / Replace / Refurbish Sluice Gates
• Concrete repairs to fixed crest
Fixed Crest Spillway
• Remove woody debris upstream of fixed crest spillway
AECOM prepared structural analysis and design of concrete repairs

- Design Drawings / Technical Specifications included:
  - Ice Breaker Repair
  - Gated Spillway / Sluice Gate Repair
  - Fixed Crest Spillway Concrete / Flashboard Repair
  - Shoreline Restoration

- Contractor Bidding Documents issued late 2010
Project is Delayed Until Further Notice

– Late 2010 – Project is Delayed....
  • Project was determined to require an environmental assessment, causing a delay to 2015

Fast Forward to 2015

2009
  WDNR Inspection

Estabrook Dam Drawdown

AECOM Inspection

2010
  AECOM Dam Repair Bid Documents

2011 - 2013
  AECOM Environmental Assessment

2014
  Milwaukee River Dredging Project

2015
  AECOM Feasibility Study

Milwaukee County decides to repair dam

2015 – AECOM authorized by Milwaukee County to repair dam and integrate fish passage
AECOM – 2016 Design

- 2015 to 2016 – AECOM hired by Milwaukee County to repair dam and integrate fish passage

- Update 2010 Construction Drawings / Technical Specifications

- WDNR & USACE Permitting

- Hydraulic Analysis for Fish Passage and Dam Modifications

- Primary Spillway (Formally Fixed Crest)
  - Fish Passage
  - 6 Remaining Sluice Gates

- Secondary Spillway (Formally Gates)
  - Fixed Crest Spillway
Fish Passage Design

- Fish Passage Design
  - Reconnection Rivers: Natural Channel Design in Dam Removal and Fish Passage – Luther Aadland
  - Worked directly with WDNR – Will Wawrzyn to determine design criteria for Northern Pike migration during spring runoff
  - 10% of Milwaukee River flow during Spring Runoff (1,250 cfs) is routed through fish passage
  - Velocity in rock ramp limited to 1 – 3 ft./sec
  - Flow depth ~ 1.5 feet
AECOM – Hydraulic Analysis

– Hydraulic Analysis for Fish Passage Design
  • To Permit the proposed fish passage through the WDNR Floodplain and Dam Safety Programs the hydraulic analysis must demonstrate the configuration of fish passage, along with necessary dam modifications:
    o Results in no net change to the Regulatory Base Flood Elevation (BFE)
    o Provides no reduction in spillway capacity for the Spillway Design Flood (SDF) = 100 year storm
    o Provides Fish Migration Gate Operation Plan to dictate flow rates, velocities to promote Northern Pike migration
    o Provides Normal Gate Operation Plan for Milwaukee River Storm Events
AECOM – Hydraulic Analysis

- Effective HEC-RAS Model Southwestern Wisconsin Regional Planning Commission (SEWRPC) – 2014
Estabrook Dam Modeled as single Bridge Routine
AECOM – Hydraulic Analysis

- Corrected Effective HEC-RAS Model
  - Truncated to include only areas immediately upstream and downstream of Dam
  - Milwaukee River split into multiple “river reaches” for direct comparison to “Post Project Model”
  - Estabrook Dam (bridge routine) was replaced by inline structure with 10 gates
  - Ice-breakers added as HEC-RAS “obstructions”
  - Updated Survey Data
Corrected Effective HEC-RAS Configuration

- Corrected Effective HEC-RAS Model
  - Effective cross sections were split into multiple sections to represent geometry for individual reaches

![Diagram](image_url)
Corrected Effective HEC-RAS Split Flow

- Corrected Effective HEC-RAS Model
  - Total Flow is separated into multiple river reaches
  - Split flow optimized separately into each reach so upstream energy grade line in all split river reaches is within 0.01 feet

<table>
<thead>
<tr>
<th>Reach</th>
<th>Cross Section</th>
<th>Flow (cfs)</th>
<th>E.G. Elev. (feet)</th>
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<tr>
<td>Milwaukee River Lower Reach</td>
<td>6.928</td>
<td>14,800</td>
<td>620.91</td>
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<td>Junction - 1</td>
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<tr>
<td>Fish Passage</td>
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<td>620.64</td>
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<tr>
<td>Gated Spillway</td>
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<td>4,409</td>
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<tr>
<td>Fixed Crest</td>
<td>46.843 BI</td>
<td>7,384</td>
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<tr>
<td><strong>Total Flow (cfs) / Tolerance (feet)</strong></td>
<td><strong>14,800</strong></td>
<td><strong>(0.01)</strong></td>
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</table>
Effective vs. Corrected Effective

- Corrected Effective HEC-RAS Model Results
  - Upstream WSEL differences in the Effective to Corrected Effective were limited to (0.12) feet
    - Noted Changes in multiple river reaches and split flow
    - Gated Spillway vs. bridge routine

<table>
<thead>
<tr>
<th>Cross Section (River Mile)</th>
<th>100-year Peak Flow (cfs)</th>
<th>SEWRPC 2014 WS Elevation (feet)</th>
<th>Corrected Effective WS Elevation (feet)</th>
<th>Comparison Difference WS Elevation (feet)</th>
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<td>7.110 Port Washington Road</td>
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<tr>
<td>6.928</td>
<td>14,800</td>
<td>620.63</td>
<td>620.51</td>
<td>(0.12)</td>
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</table>
Post Project HEC-RAS Configuration

Estabrook Dam
Post Project Model Configuration

- Model Junction Point
- Fish Passage Structure
- FEMA Lettered Cross Section
- FEMA Cross Section
- SEWRPC Cross Section
- Fish Passage Cross Section
- 1% Annual Chance Floodway Boundary
- 1% Annual Chance Flood Boundary
- 0.2% Annual Chance Flood Boundary
- Model Reach
Post Project HEC-RAS Configuration

- Post Project HEC-RAS Model – Proposed Fish Passage Structure
  - Located on the left bank located upstream of sluice gates #1-4
  - Upstream Concrete Weir to direct flow through fish passage structure
  - Lateral Weir Wall that connects to existing dam pier for extreme flood events
  - Rock Ramp composed on 9 rock boulder weirs spaced approximately 16 feet apart with 0.8 feet drop resulting in 5% longitudinal slope
  - Remove Gates #1 through #4
Post Project HEC-RAS Configuration

- Post Project HEC-RAS Model – Proposed Fish Passage Structure – Inline and Lateral Weirs

In this diagram, we can see two types of fish passage structures: Inline Weir Structure and Lateral Weir Structure. The Inline Weir Structure is depicted on the left side of the diagram, while the Lateral Weir Structure is located on the right side. The proposed fishway is indicated with a stepped weir section, with elevations marked at ELV. 618.0 and ELV. 617.5. The stepped weir consists of a series of 14' steps with a total length of 65'. The layout includes detailed specifications and elevation coordinates for the proposed fishway design.
Post Project HEC-RAS Configuration

- Post Project HEC-RAS Model – Proposed Fish Passage Structure

- Dam Gates
- Flow through Fish Gates 5-10
- Lateral Weir Structure
- E.G.L. Match Upstream
- Inline Weir Structure
- Rock Ramp
- Flow through Fish Passage

E.G.L. Match Downstream

Proper fish passage and habitat enhancement measures are crucial for maintaining aquatic ecosystems. The proposed fish passage structure includes various components designed to facilitate fish migration and reduce hydraulic impacts. These components are carefully planned and designed to ensure the safety and wellbeing of the fish populations in the area.
- Post Project HEC-RAS Model Results

  Results show that the proposed dam modifications and fish passage cause no rise to the upstream BFE. - **Regulatory Floodplain Requirement Meet.**

  - Removal of Gates #1 through #4 required to provide necessary additional capacity to prevent upstream rise
Estabrook Dam Spillway Capacity Check

Meet Requirements of NR 333.07

Fish Passage Restricts Flow @ Lower Stages

Higher MKE River Stages, during more frequent recurrence interval storms
Fish Passage Gate Operation Plan

- Developed Fish Migration Gate Operation Plan (Spring)

  - From low flow to 400 cfs, gates #5 through #10 closed
  - > 400 cfs gate operations of #5 through #10 commence
  - One gate will have a minimum of four gate operating positions
    - Closed
    - Two feet open
    - Half open (3.8 feet)
    - Fully open (7.5 feet)
  - All other gates, fully open or fully closed
Normal Gate Operation Plan

- Developed Normal Gate Operation Plan (Summer - Winter)
  - Establish Normal Operating Band per WDNR – 616.6 +/- 6”
  - Considered range of flows from USGS Gages
  - During Normal Operations, Gates #5 – #10 are closed < 750 cfs
  - Starting at 750 cfs, Gates #5 - #10 commence

<table>
<thead>
<tr>
<th>Flow (cfs)</th>
<th>Gate Condition</th>
<th>WS El. (feet)</th>
<th>HEC-RAS Profile ID</th>
<th>Action</th>
<th>Flow (cfs)</th>
<th>Gate Condition</th>
<th>WS El. (feet)</th>
<th>HEC-RAS Profile ID</th>
<th>Action</th>
<th>Flow (cfs)</th>
<th>Gate Condition</th>
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<th>HEC-RAS Profile ID</th>
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<td>750</td>
<td>Gates Closed</td>
<td>617.2</td>
<td>750 Closed</td>
<td>Open</td>
<td>750</td>
<td>Gate 6 Halfway Open</td>
<td>616.8</td>
<td>750 G6 Half</td>
<td>Close</td>
<td>550</td>
<td>Gate 6 Halfway Open</td>
<td>616.3</td>
<td>550 G6 Half</td>
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<tr>
<td>1,250</td>
<td>G6 Halfway Open</td>
<td>617.2</td>
<td>1,250 G6 Half</td>
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<td>1,250</td>
<td>Gate 6 Open</td>
<td>617.0</td>
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<td>Gate 6 Open</td>
<td>616.2</td>
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<td>617.1</td>
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<td>Gate 6&amp;7 Open</td>
<td>616.6</td>
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<td>Gate 6&amp;7 Open</td>
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<td>1,250 G6 G7</td>
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<tr>
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<td>617.2</td>
<td>2,250 G6 G7 G8</td>
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<td>Gate 6,7&amp;8 Open</td>
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<td>3,500</td>
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<tr>
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<td>3,250</td>
<td>All Gates Open</td>
<td>616.0</td>
<td>3,250 All Gates</td>
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</tr>
</tbody>
</table>
Conclusion

- Project Satisfied Project Requirements
  - Results in no net change to the Regulatory Base Flood Elevation (BFE)
  - Provides no reduction in spillway capacity for the Spillway Design Flood (SDF) = 100 year storm
  - Provides Normal Gate Operation Plan for Milwaukee River Storm Events
  - Provides Fish Migration Gate Operation Plan to dictate flow rates, velocities to promote fish migration

- Received WDNR and USACE approval – Summer 2016

- Contractor Bidding – Summer 2016

- Low Contractor Bid ~ $4.1 Million

- Approved Milwaukee County Funding ~ $3.5 Million

- Approximately $600,000 Short

- Milwaukee County - December 31, 2016 deadline from WDNR

- Considerable Cost Savings to Remove Dam based on Environmental Assessment (Dam Removal Estimates Range from $1.7 to $2.5 Million)

- Strong Public and Local Government Support to remove dam due to cost savings and benefit to the environment
Estabrook Dam Next Steps

– End of 2016 – Milwaukee County sells ownership of approximately 4 acres at Estabrook Park to Milwaukee Metropolitan Sewerage District (MMSD) for $1.

– MMSD Hired AECOM in January 2017 to prepare **Dam Removal** Plans. Scope includes:
  – Hydraulic Analysis
  – Geomorphic Assessment
  – Environmental Services
  – Permitting
  – Dam Removal Plans & Specifications

– Estabrook Dam Removal ~ Possible Presentation Topic IAFSM 2018/ 2019 ~
Acknowledgements

– MMSD
  – Tom Chapman, P.E.

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– WDNR
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  – Will Wawrzyn
Questions?

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Project Manager
AECOM, Milwaukee WI

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