

Developing a Rating for a Newly Installed Gated Structure on the Fox River to be used in Forecasting and Managing Reservoir Pool Levels

Marian Domanski, PE

Hydrologist Central Midwest Water Science Center mdomanski@usgs.gov

Charlie Cigrand

Physical Scientist Central Midwest Water Science Center ccigrand@usgs.gov



U.S. Department of the Interior U.S. Geological Survey

Fox River Watershed

- Fox River drainage area 2,657 mi²
- Drainage area in Wisconsin 934 mi²
- Drainage area at Stratton Lock and Dam 1,250 mi²





Study Area

- Aerial imagery of the study area and Chain of Lakes
- Location of real-time streamflow gaging station, stage-only gaging stations, and National Weather Service (NWS) stations





William G. Stratton Lock and Dam





Looking downstream at the William G. Stratton Lock and Dam

Stratton Lock and Dam Location

FOX RIVER AT JOHNSBURG, IL

Reservoir outlet

Stratton Lock and Dam

McCullom Lake

4FOX RIVER AT MILLER BRIDGE NEAR MCHENRY, IL

FOX RIVER (TAILWATER) NEAR MCHENRY, IL FOX RIVER NEAR MCHENRY, IL Google Earth



Johnsburg Chute

- Stratton Lock and Dam is the control structure for the Chain of Lakes
- The Chain of Lakes outlet and Stratton Lock and Dam are separated by the Johnsburg Chute

Johnsburg Chute





Previous studies: Structure Rating

- Sluice gate, hinge crested gate, broad-crested weir
- Measured headwater and tailwater stage with streamflow at a wide range of flows at different gate operations
- Used standard control-rating techniques: Chow (1959), Collins (1977), Roberston and others (1998)



In cooperation with the Illinois Department of Natural Resources-Office of Water Resources

Control-Structure Ratings on the Fox River at McHenry and Algonquin, Illinois



Scientific Investigations Report 2009-5186

U.S. Department of the Interior U.S. Geological Survey



Previous studies: HEC-ResSim Model

 A Reservoir System Simulation (HEC-ResSim) model was developed to integrate Illinois Department of Natural Resources (IDNR) dam operations with NWS forecast flows

 A stage-fall-flow relation was developed to model the head loss through the Johnsburg Chute



Prepared in cooperation with the Illinois Department of Natural Resources and the National Weather Service

Development and Evaluation of a Reservoir Model for the Chain of Lakes in Illinois



Scientific Investigations Report 2016–5155

U.S. Department of the Interior U.S. Geological Survey



Previous studies: HEC-ResSim Model



- F, water-surface elevation fall between Fox Lake near Lake Villa, Illinois (05547500) and Fox River near McHenry, Illinois (05549500)
- G_{LV}, gage height at Fox Lake near Lake Villa, Illinois (05547500)
- *G_{HW}*, gage height (headwater) at Fox River near McHenry, Illinois (05549500)
- *G_{TW}*, gage height (tailwater) at Fox River near McHenry, Illinois (05549501)



Previous studies: Integration into NWS Community Hydrologic Prediction System (CHPS)





Stratton Lock and Dam Renovations

- Sluice gate removal/torque tube gate installation
- Lock extended to increase capacity
- Need for developing new torque tube gate rating





Torque Tube Gates

- 5 sluice gates removed
- 3 torque tube gates installed





Current Study

- Install an index velocity gage near McHenry, Illinois
- Develop gate ratings for the three newly installed torque-tube gates
- Improve the operational model by developing a 2D hydraulic model of the Johnsburg Chute



Index Velocity Gage

USGS 05549400 FOX RIVER AT MILLER BRIDGE NEAR MCHENRY, IL

Index velocity gage

Fox R

USGS 05549500 FOX RIVER NEAR MCHENRY, IL USGS 05549501 FOX RIVER (TAILWATER) NEAR MCHENRY, IL Google Earth



Gate Rating

Torque-tube gate ratings will be developed using

- Discharge measurements taken for the index velocity gage rating
- Structure ratings from the previous study



- $h_{1_{TTG}}$, headwater depth above the torque-tube gate crest
- $h_{3_{TTG}}$, tailwater depth above the torque-tube gate crest
- $h_{g_{TTG}}$, torque-tube gate opening referenced to the elevation at the fully-closed position
- P_{TTG} , height of torque-tube gate crest above approach invert



Hydraulic Model

Previous reservoir model used a conservation of mass approach

• Hydrologic Engineering Center River Analysis System (HEC-RAS) 2D model for unsteady-flow conditions and a conservation of mass and momentum approach to account for:

- Hydrodynamics
- Lag times associated with wave propagation
 Alignment of Stratton Dam structures

• Model to include the Chain of Lakes and the Fox River 1.8 miles downstream from the Stratton Dam





Hydraulic Model Development

- HEC-RAS model geometry
- 2D Mesh
- NWS hydrologic inputs converted to HEC-Data Storage System Visual Utility Engine (DSSVue) format
- Stratton Lock and Dam Gate Operations









Hydraulic Model Calibration

Calibration data

- 7 USGS streamgages
- Discrete flow measurements for calibration event(s)

Calibration events

- High and lower flow events to develop
- gate rating

≊USGS



U.S. Geological Survey Streamgage	Gage Type	Dates of Operation
USGS 05549400 FOX RIVER AT MILLER BRIDGE NEAR MCHENRY, IL	Stage, discharge	24Sep2020 to present
USGS 05548500 FOX RIVER AT JOHNSBURG, IL	Stage	1Jan1987 to present
USGS 05547000 CHANNEL LAKE NEAR ANTIOCH, IL	Stage	10ct1993 to present
USGS 05547500 FOX LAKE NEAR LAKE VILLA, IL	Stage	20Oct1993 to present
USGS 05548000 NIPPERSINK LAKE AT FOX LAKE, IL	Stage	10ct1993 to present
USGS 05549500 FOX RIVER NEAR MCHENRY, IL	Stage	10ct1987 to present
USGS 05549501 FOX RIVER (TAILWATER) NEAR MCHENRY, IL	Stage	30Sep2002 to present





- Renovations of Stratton Lock and Dam with torque tube gates
- Current study
 - Index velocity gage
 - Torque-tube gate rating
 - 2D Hydraulic model
- Inter-agency communication
 - IDNR for water level management
 - NWS for their river forecasts



References Cited

Chow, V.T., 1959, Open channel hydraulics: New York, McGraw-Hill, 680 p.

Collins, D.L., 1977, Computation of records of streamflow at control structures: U.S. Geological Survey Water-Resources Investigation Report 77–8, 57 p.

Domanski, M.M., 2017, Development and evaluation of a reservoir model for the Chain of Lakes in Illinois: U.S. Geological Survey Scientific Investigations Report 2016–5155, 21 p., https://doi.org/10.3133/sir20165155.

Roberson, J.A., Cassidy, J.J., and Chaudhry, M.H., 1998, Hydraulic engineering (2d ed.): New York, Wiley, 653 p.

Straub, T.D., Johnson, G.P., Hortness, J.E., and Parker, J.R., 2009, Control-structure ratings on the Fox River at McHenry and Algonquin, Illinois: U.S. Geological Survey Scientific Investigations Report 2009–5186, 61 p., https://doi.org/10.3133/sir20095186.

