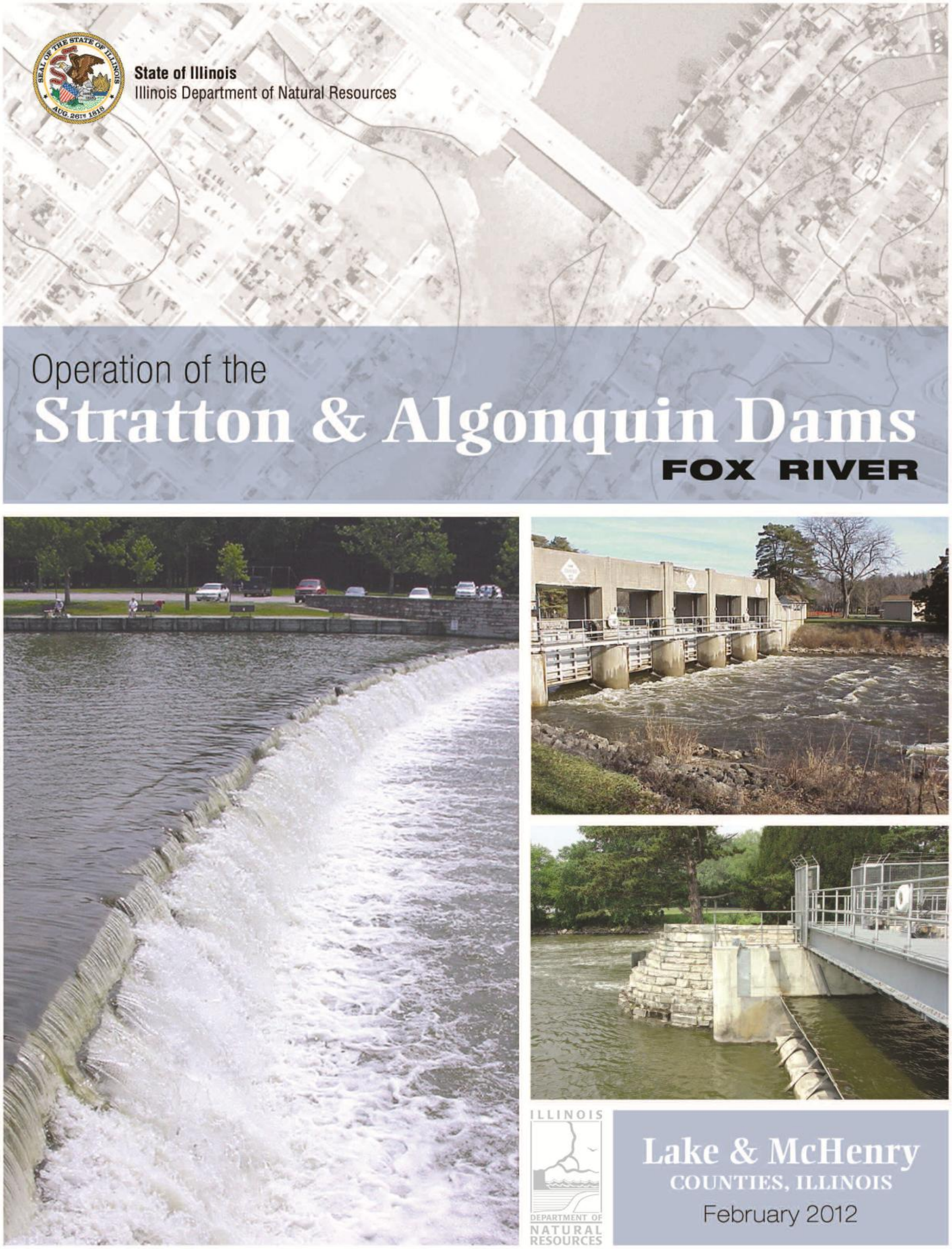
State of Illinois
Illinois Department of Natural Resources
Operation of the
Stratton & Algonquin Dams
FOX RIVER
ILLINOIS
DEPARTMENT OF NATURAL RESOURCES
Lake & McHenry
COUNTIES, ILLINOIS
February 2012

ABSTRACT

The Office of Water Resources has operated the gate control structure at Stratton Dam since 1939 and the Algonquin Dam control works since 2002. This report gives a description of the control works and outlines the operational plan.

The Office of Water Resources first developed and publicly discussed the operational plan for Stratton Lock and Dam in 1989. The 1989 plan was revised in 1991 to address the issue of ice jam flooding in Kane County downstream of Algonquin and since that time the plan has included a method of operation which would minimize the threat of ice jams. In 2002 the new gates at Stratton Lock and Dam and Algonquin Dam were completed, and a modified operational plan was developed and discussed publicly which incorporated operations of the gate at Algonquin Dam. That plan continues to be reevaluated as better information is made available.

Flooding is a natural phenomenon along the Chain of Lakes and the Fox River. While improvements to the operating plan can be made, there is no guarantee of substantial reductions in flood stages.

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HISTORY AND OWNERSHIP

STRATTON DAM

McHenry County was established on January 16, 1836. The government plat for Township 44 North, Range 8 East was signed December 17, 1839, and no dam at McHenry was indicated on this survey. Early in the 1900's a group of property owners and others organized the Fox River Navigable Waterway Association. In 1907, this association secured a Federal Permit and constructed a wooden dam across the Fox River to improve navigation for recreation in the Chain-O-Lakes. This dam deteriorated, and was replaced with a three foot steel sheet piling structure equipped with three foot high flash boards prior to 1915. This dam was constructed with a lock at the east end, on the opposite side of the present lock. This dam was indicated on a 1923 map prepared by the Division of Waterways and was similar to the 1915-16 River and Lakes Commission maps, covering the Fox River.

In 1923-24, the titles, rights and interest in the dam, lock and adjacent properties were conveyed to the State of Illinois after passage of the McHenry County Dam Act (615 ILCS 100). This act provides the Department of Natural Resources with the duty of maintaining the "*dam at a suitable height to properly provide a sufficient depth of water north of the dam in the Fox River and the lakes adjacent thereto and connected therewith to enable said waters to be navigable*." A November 9, 1936 survey of the dam site showed the crest length to be 210.7 feet. The dam crest was at elevation 733.6 with the top of the three foot flash boards at 735.6. On the date of the survey the pool elevation was 736.07 and the tailwater elevation was 732.50. Major damage occurred to the structure from the floods of November 1937 and July 1938.

In 1939, the State of Illinois Department of Public Works and Buildings, Division of Waterways (predecessor to the Office of Water Resources), under contract FR-14 constructed the present dam and gate control structure (Department of Public Works, 1938). Also in 1939, the State of Illinois made the initial land acquisition of 15 acres for McHenry Dam State Park, which became a part of Moraine Hills State Park, which is located on the east side of the Fox River.

The present boat lock was constructed in 1958-60 under Department of Public Works and Buildings contracts FR-109 and FR-113. The lock was opened for public use on June 1, 1960. A number of other contracts have been awarded and completed since 1939 to repair and maintain the existing dam, buildings and site area. None of these contracts has changed the hydraulic characteristics of the outlet works except for the installation of the hinged crest gate in 2002 by the United States Army Corps of Engineers.

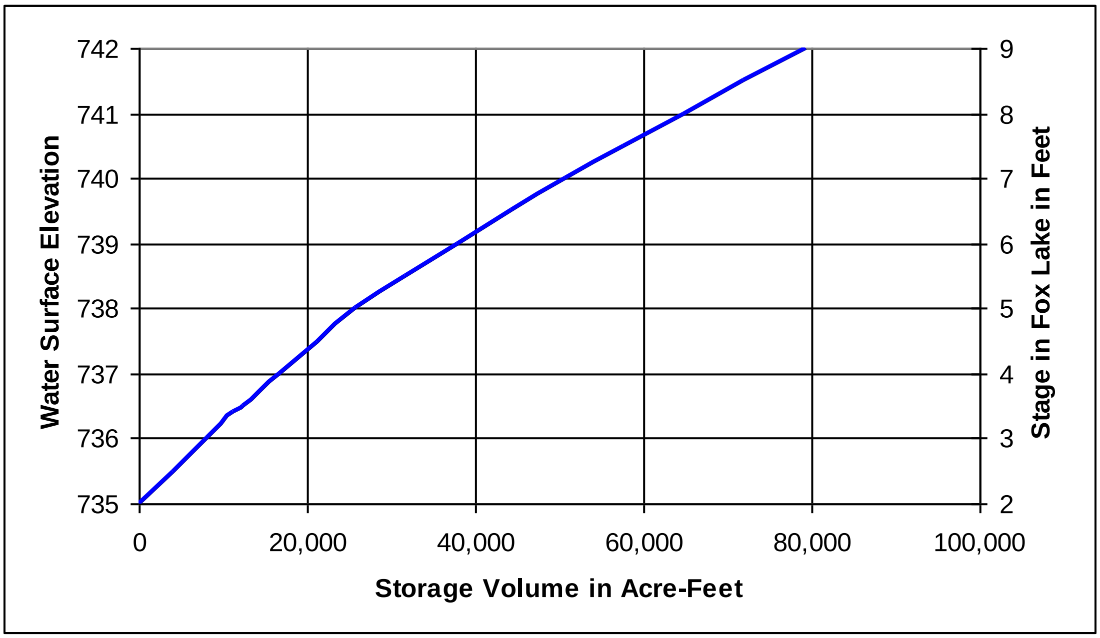
ALGONQUIN DAM

McHenry County was established January 16, 1836. The government Township 43 North, Range 8 East plat was signed on April 18, 1840. A ferry called Cornishers Ferry was indicated in the NW 1/4 of Section 34. The Village of Algonquin was formerly called Oceola. William Sloan was given authority to build a mill dam by an Act of Legislation approved February 11, 1853. A dam was built about 1854. In 1915 a dam existed along with a mill and a tail race on the east side of the river. On May 12, 1939 the State of Illinois acquired title by Quit Claim to the mill lot and dam from the Public Service Co. of Northern Illinois. In 1946-47 the State, Division of Waterways under contract PW-8 built the Algonquin Dam, a short distance south of the old dam and also removed the old dam. In 2002 the United States Army Corps of Engineers installed the hinged-the crest gate at Algonquin Dam.

DESCRIPTION OF CHAIN OF LAKES

The Chain of Lakes has a surface area of approximately 6,900 Acres (Kothandaramon, 1977) and is primarily used for recreation with some flood control benefits. There are approximately 1,250 square miles, or 800,000 acres, that drain to Stratton Lock and Dam. Between an elevation of 736.8 feet (low end of summer pool target range) and 737.2 feet (high end of summer pool target range) there is 3,000 acre-feet of storage in the Chain of Lakes; an average of 3/64 inch of runoff from the watershed upstream of the Chain of Lakes will fill the 3,000 acre-feet.

Figure 1: Storage in Chain of Lakes



DESCRIPTION OF STRATTON DAM

Stratton Dam is located at river mile 97.7 (Healy, 1979) on the Fox River and controls the outflow of water from the Fox Chain of Lakes in McHenry County. The drainage area at the dam is 1,250 square miles.

The dam control structures consist of a spillway, five sluice gates, a hinged crest gate, a navigation lock and a fish ladder. The specifics of the control works are given in Table 1 (Department of Transportation, 1976). Important note: the crest length of Stratton Dam before the placement of hinged-crest gates was 282 feet. None of the other dimensions and elevations of the dam have changed.

Table 1: Stratton Lock and Dam Control Works

Fixed Spillway Data	
Crest Length	221 ft.
Radius of Spillway Crest Curvature	419 ft.
Spillway Crest Average Elevation	736.76 ft. NGVD
Spillway Low Point Elevation	736.68 ft. NGVD
Approach Channel Bottom Elevation	729.5 ft. NGVD
Downstream Channel Bottom Elevation	725.1 ft. NGVD
Length of Fish Ladder Crest	4 ft.
Elevation of Fish Ladder Crest	Adjustable
Height of Spillway	6.5 ft.
Roughly Trapezoidal Cross Section with Broad Crest	

Vertical Lift Gates Data	
Number of Vertical Lift Gates	5
Width of Gate Opening	13.75 ft
Gate Sill Elevation	731.15 ft. NGVD
Maximum Gate Opening	9.0 ft.
Elevation of Downstream End Sill	731.65 ft. NGVD

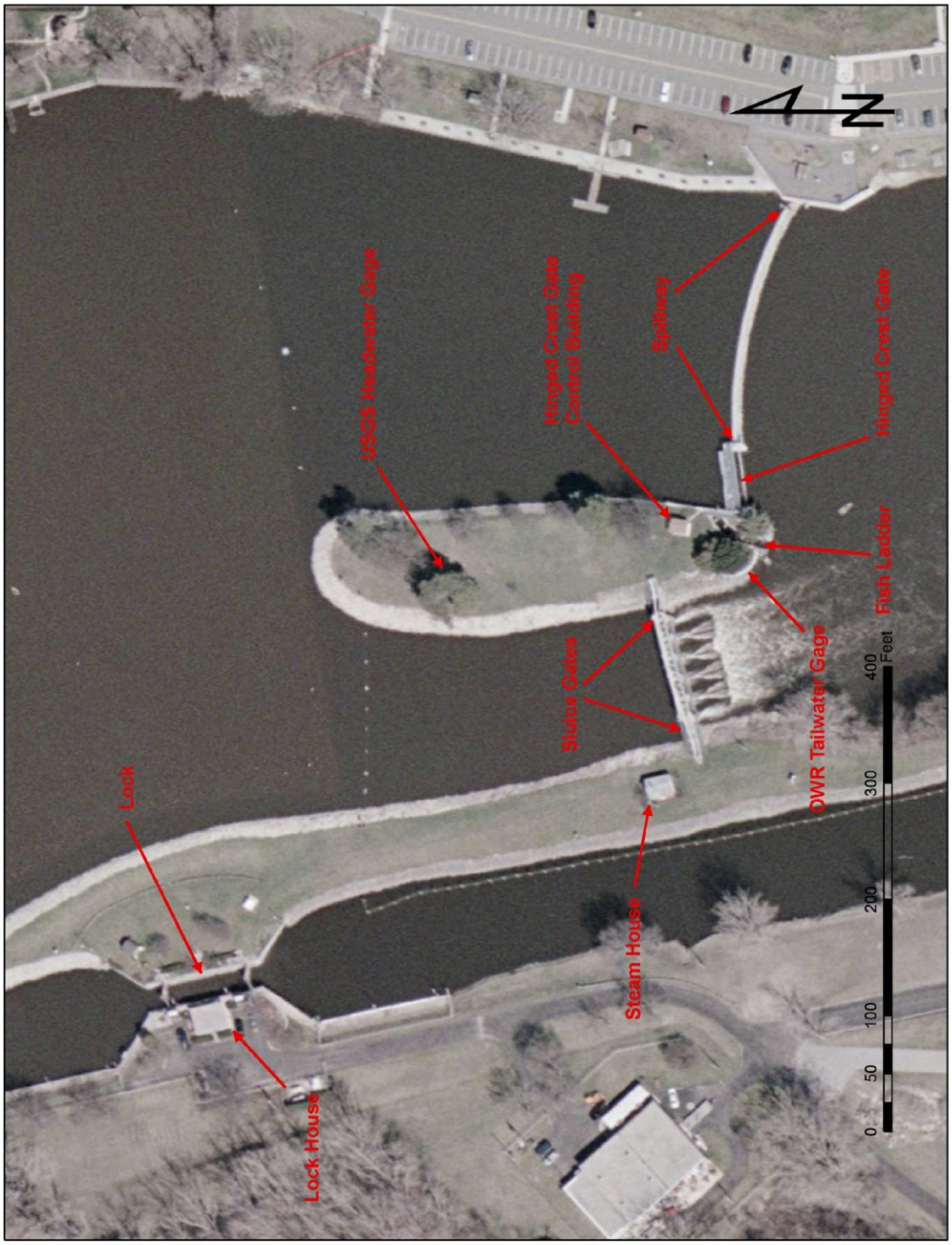
Hinged Crest Gate Data	
Width of Gate Opening	50 ft.
Top of Gate Closed (Upright)	737.20 ft. NGVD
Top of Gate Open (Flat)	730.50 ft. NGVD
Concrete Floor Elevation	730.083 NGVD
Top of Pier	742.0 NGVD

NGVD refers to the National Geodetic Vertical datum of 1929

0 stage of headwater gage = elevation 733.0 NGVD

0 stage of tailwater gage = elevation 730.15 NGVD

Figure 2: Plan View of Stratton Lock and Dam



Operation of Stratton and Algonquin dams

In 1988, the United States Geological Survey (USGS) completed a study under contract with the Division of Water Resources (DWR) to look at discharge ratings for the control structures at Stratton Dam (Fisk, 1988). Beginning in 2004 the USGS made additional flow measurements for various flow conditions and gate openings to update the earlier Fisk report and to develop a discharge rating for the hinged crest gate. Table 2 gives a summary of the hydraulic conditions and discharge equations derived for different flow regimes at the Stratton Dam control structures.

Figure 4: Stratton Dam Spillway

Figure 5: Downstream End of Stratton Dam Fish Ladder

Figure 6: Downstream Side of Stratton Dam Sluice Gates

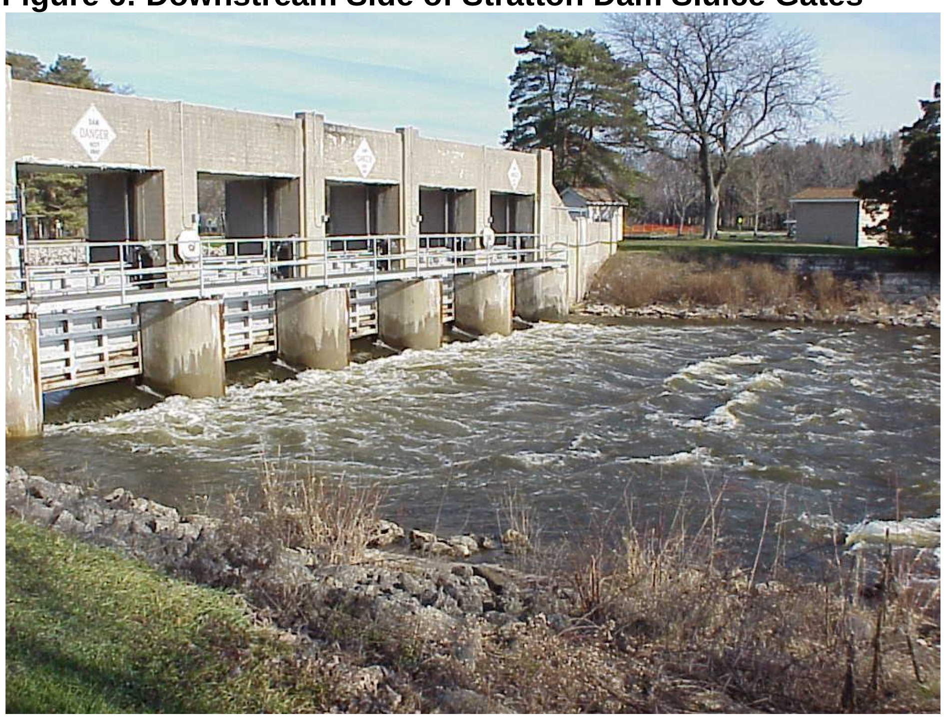


Figure 7: Stratton Dam Hinged Crest Gate

Table 2: Summary of Hydraulic Conditions and Discharge Equations for Different Flow Regimes at Stratton Dam Control Structures

Structure	Flow Regime	Hydraulic Conditions	Equations
Broad-Crested Weir	Free	$\frac{h_{3_{BCW}}}{h_{1_{BCW}}} \leq 0.60$	$Q_{BCW} = C_{BCW} B h_{1_{BCW}}^{1.5}$ $C_{BCW} = 2.94 h_1^{0.087}$ $B = 225\,ft$ $Q_{BCW} = 661.5 h_{1_{BCW}}^{1.59}$
Hinged-Crest Gate	Free	$\frac{h_{3_{HCG}}}{h_{1_{HCG}}} \leq 0.75$	$Q_{HCG} = C_{HCG} B h_{1_{HCG}}^{1.5}$ $C_{HCG} = 3.87 \left(\frac{h_{1_{HCG}}}{p_{HCG}} \right)^{-0.135}$ $B = 50\,ft$ $Q_{HCG} = 193.5 h_{1_{HCG}}^{1.365} p_{HCG}^{0.135}$
Hinged-Crest Gate	Submerged	$\frac{h_{3_{HCG}}}{h_{1_{HCG}}} > 0.75$	$Q_{HCG} = C_{HCG} C_{HCG-S} B h_{1_{HCG}}^{1.5}$ $C_{HCG-S} = 0.471 \left(\frac{h_{3_{HCG}}}{h_{1_{HCG}}} \right)^{-2.94}$ $Q_{HCG} = 91.14 h_{1_{HCG}}^{4.305} h_{3_{HCG}}^{-2.94} p_{HCG}^{0.135}$

Structure	Flow Regime	Hydraulic Conditions	Equations
Sluice Gate Weir	Free Weir	$\frac{h_{g_{SL}}}{h_{1_{SL}}} \geq 0.73$ **and** $\frac{h_{3_{SL}}}{h_{1_{SL}}} \leq 0.80$	$Q_{SL} = C_{SLW} B h_{1_{SL}}^{1.5}$ $C_{SLW} = 3.75 h_1^{-0.101}$ $B = 5 gates \times 13.75 ft = 68.8 ft$ $Q_{SL} = 258 h_{1_{SL}}^{1.40}$
Sluice Gate Weir	Submerged Weir	$\frac{h_{g_{SL}}}{h_{1_{SL}}} \geq 0.73$ **and** $\frac{h_{3_{SL}}}{h_{1_{SL}}} > 0.80$	$Q_{SL} = C_{SLW} C_{SLW-S} B h_{1_{SL}}^{1.5}$ $C_{SLW-S} = 0.750 \left(\frac{h_{3_{SL}}}{h_{1_{SL}}} \right)^{-1.33}$ $Q_{SL} = 193 h_{1_{SL}}^{2.73} h_{3_{SL}}^{-1.33}$
Sluice Gate Orifice	Free Orifice	$\frac{h_{g_{SL}}}{h_{1_{SL}}} < 0.73$ **and** $\frac{h_{3_{SL}}}{h_{g_{SL}}} < 1$ **or** $\frac{h_{3_{SL}}}{h_{1_{SL}}} \leq 0.70$	$Q_{SL} = C_{SLO} B h_{g_{SL}} (2 g h_{1_{SL}})^{0.5}$ $C_{SLO} = 0.271 h_1^{0.429} h_{g_{SL}}^{--0.062}$ $B = 5 gates \times 13.75 ft = 68.8 ft$ $g = 32.2 ft / s^2$ $Q_{SL} = 150 h_{1_{SL}}^{0.929} h_{g_{SL}}^{0.938}$
Sluice Gate Orifice	Submerged Orifice	$\frac{h_{g_{SL}}}{h_{1_{SL}}} < 0.73$ **and** $\frac{h_{3_{SL}}}{h_{g_{SL}}} \geq 1$ **and** $\frac{h_{3_{SL}}}{h_{1_{SL}}} > 0.70$	$Q_{SL} = C_{SLO} C_{SLO-S} B h_g (2 g h_{1_{SL}})^{0.5}$ $C_{SLO-S} = 0.325 \left(\frac{h_{3_{SL}}}{h_{1_{SL}}} \right)^{-3.17}$ $Q_{SL} = 48.6 h_{1_{SL}}^{4.10} h_{g_{SL}}^{0.938} h_{3_{SL}}^{-3.17}$

Figure 8: Cross Section of Stratton Dam Sluice Gate

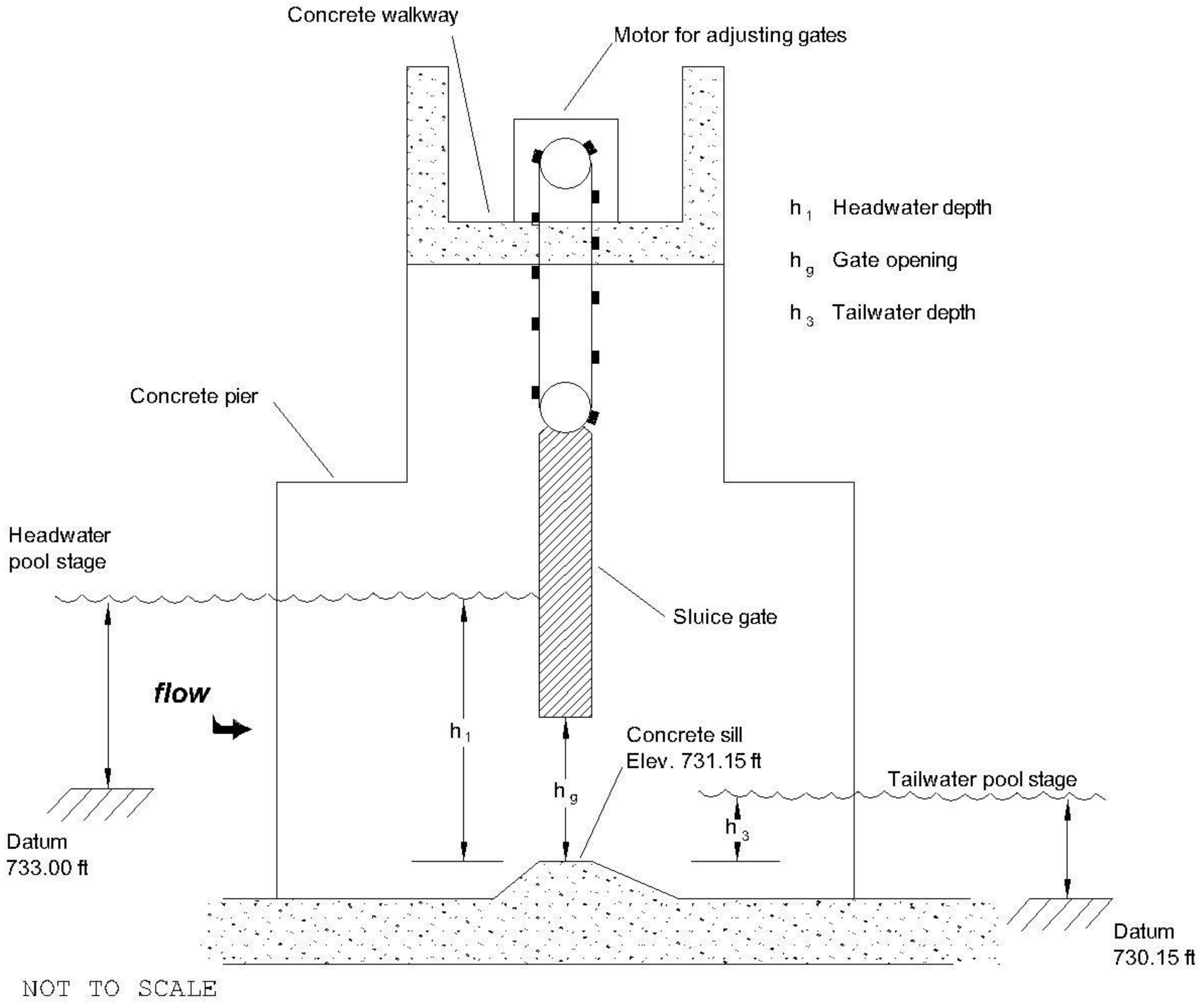


Figure 9: Cross Section of Stratton Hinged Crest Gate and Broad Crested Weir

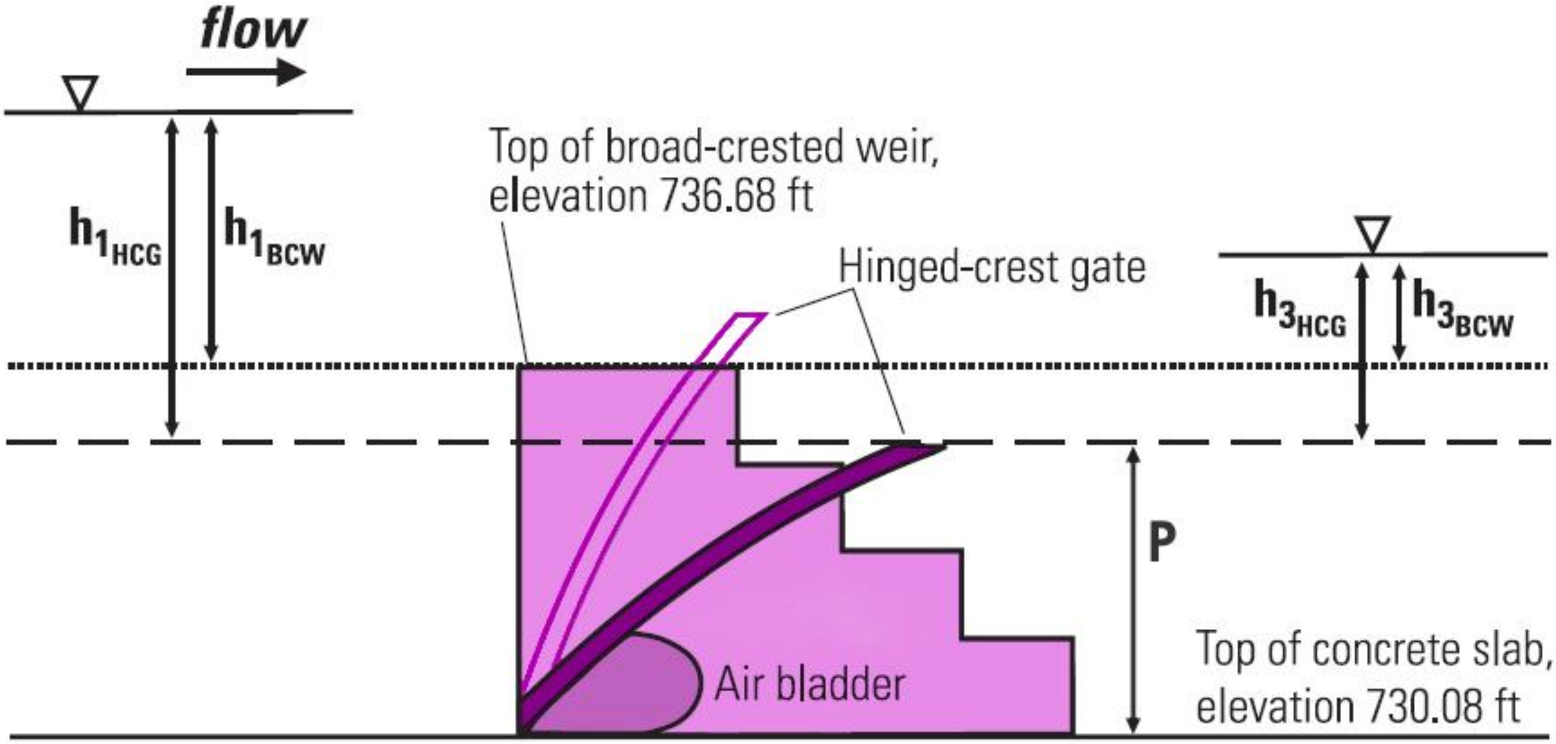
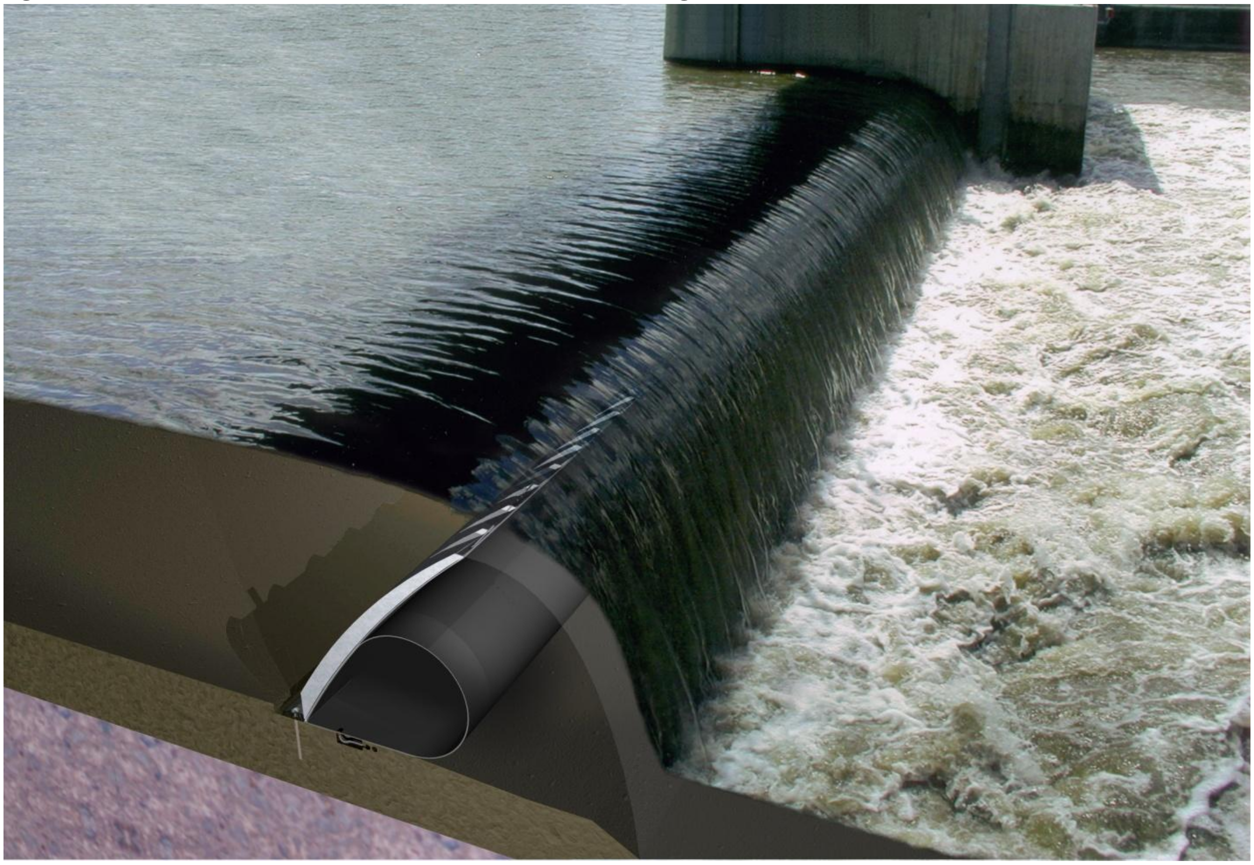


Figure 10: Cross Section View of Generic Hinged Crest Gate



This section view of a generic hinged crest gate shows how the inflation/deflation of the air bladder that is underneath the steel gate skin causes the steel gate skin to raise or lower

DESCRIPTION OF ALGONQUIN DAM

Algonquin Dam is located at river mile 81.6 on the Fox River. The drainage area at the dam is 1,403 square miles. An 849 acre reservoir is created by the dam which is primarily used for recreation. Table 3 shows the spillway data for Algonquin Dam (Department of Transportation, 1976). Important note: the crest length of Algonquin Dam before the placement of hinged-crest gates was 300 feet. None of the other dimensions and elevations of the dam have changed.

Table 3: Algonquin Dam Control Works

Fixed Spillway Data	
Crest length	242 ft
Spillway Crest Average Elevation	730.10 ft. NGVD
Spillway Low Point Elevation	730.10 ft. NGVD
Approach Bottom Elevation	722.2 ft. NGVD
Downstream Bottom Elevation	723.4 ft. NGVD
Height of Spillway	9.0 ft
0gee Shaped Spillway	

Hinged Crest Gate Data	
Width of Gate Opening	50 ft
Top of Gate Closed (Upright)	730.60 ft. NGVD
Top of Gate Open (flat)	724.00 ft. NGVD
Concrete Floor Elevation	723.583 ft. NGVD
Top of Pier	735.00 ft. NGVD

0 stage on Algonquin headwater gage = elevation 729.48 NGVD
0 stage on Algonquin tailwater gage = elevation 719.48 NGVD
0 stage on Algonquin downstream tailwater gage = elevation 719.48 NGVD

Table 4: Summary of Hydraulic Conditions and Discharge Equations for Different Flow Regimes at Algonquin Dam Control Structures

Structure	Flow Regime	Hydraulic Conditions	Equation of Flow
Ogee Spillway (Hinged-Crest Gate Closed[1])	Free	$\frac{h_{3_{OS}}}{h_{1_{OS}}} < 0.60$	$Q_{OS} = C_{OS} B h_{1_{OS}}^{1.5}$
Ogee Spillway (Hinged-Crest Gate Open[2])	Free	$\frac{h_{3_{OS}}}{h_{1_{OS}}} < -5.0$ **or**	$C_{OS} = 2.67 h_{1_{OS}}^{0.363}$ $B = 242\ ft$ $Q_{OS} = 646.1 h_{1_{OS}}^{1.863}$
Ogee and Spillway and Hinged Crest (Hinged Crest Gate At Spillway Elevation)	Free	$\frac{h_{3_{OS}}}{h_{1_{OS}}} < 0.60$	$Q_S = C_S B h_{1_{OS}}^{1.5}$ $C_{OS} = 2.34 h_{1_{OS}}^{0.546}$ $B = 292\ ft$ $Q_{OS} = 683.3 h_{1_{OS}}^{2.046}$
Ogee Spillway (Hinged-Crest Gate Open)	Affected	$-5.0 < \frac{h_{3_{OS}}}{h_{1_{OS}}} < 1$	$Q_{OS} = C_{OS} C_{OS-A} B h_{1_{OS}}^{1.5}$ $C_{OS-A} = 0.442\, p_{HCG}^{0.149} \left(\frac{h_{1_{OS}} - h_{3_{OS}}}{h_{1_{OS}}} \right)^{0.930} \left(\frac{h_{1_{HCG}} - h_{3_{HCG}}}{h_{1_{HCG}}} \right)^{-0.905}$ $Q_{OS} = 285.5 h_{1_{OS}}^{0.930} p_{HCG}^{0.149} (h_{1_{OS}} - h_{3_{OS}})^{0.930} \left(\frac{h_{1_{HCG}} - h_{3_{HCG}}}{h_{1_{HCG}}} \right)^{-0.905}$

OPERATION OF STRATTON AND ALGONQUIN DAMS

Structure	Flow Regime	Hydraulic Conditions	Equation of Flow
Hinged-Crest Gate	Free	$\frac{h_{3_{HCG}}}{h_{1_{HCG}}} \leq 0.77$	$Q_{HCG} = C_{HCG} B h_{1_{HCG}}^{1.5}$ $C_{HCG} = 3.33\left(\frac{h_{1_{HCG}}}{p_{HCG}}\right)^{-0.152}$ $B = 50\,ft$ $Q_{HCG} = 166.5 h_{1_{HCG}}^{1.348} p_{HCG}^{0.152}$
Hinged-Crest Gate	Submerged	$\frac{h_{3_{HCG}}}{h_{1_{HCG}}} > 0.76$	$Q_{HCG} = C_{HCG} C_{HCG-S} B h_{1_{HCG}}^{1.5}$ $C_{HCG-S} = 0.882\left(\frac{h_{3_{HCG}}}{h_{1_{HCG}}}\right)^{-0.472}$ $Q_{HCG} = 146.9 h_{1_{HCG}}^{1.820} h_{3_{HCG}}^{-0.472} p_{HCG}^{0.152}$

Figure 11: Cross Section of Algonquin Hinged Crest Gate and Ogee Spillway

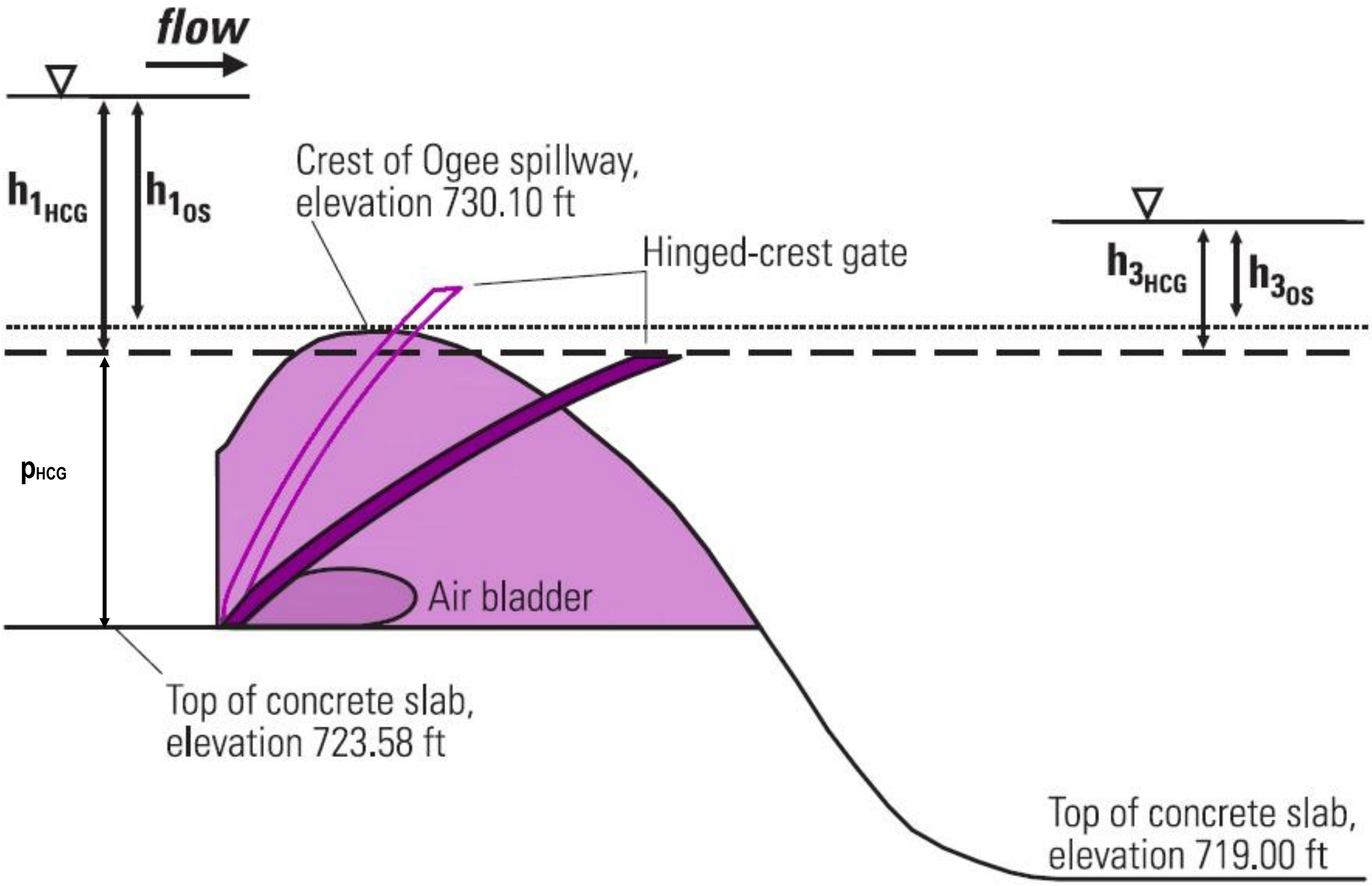
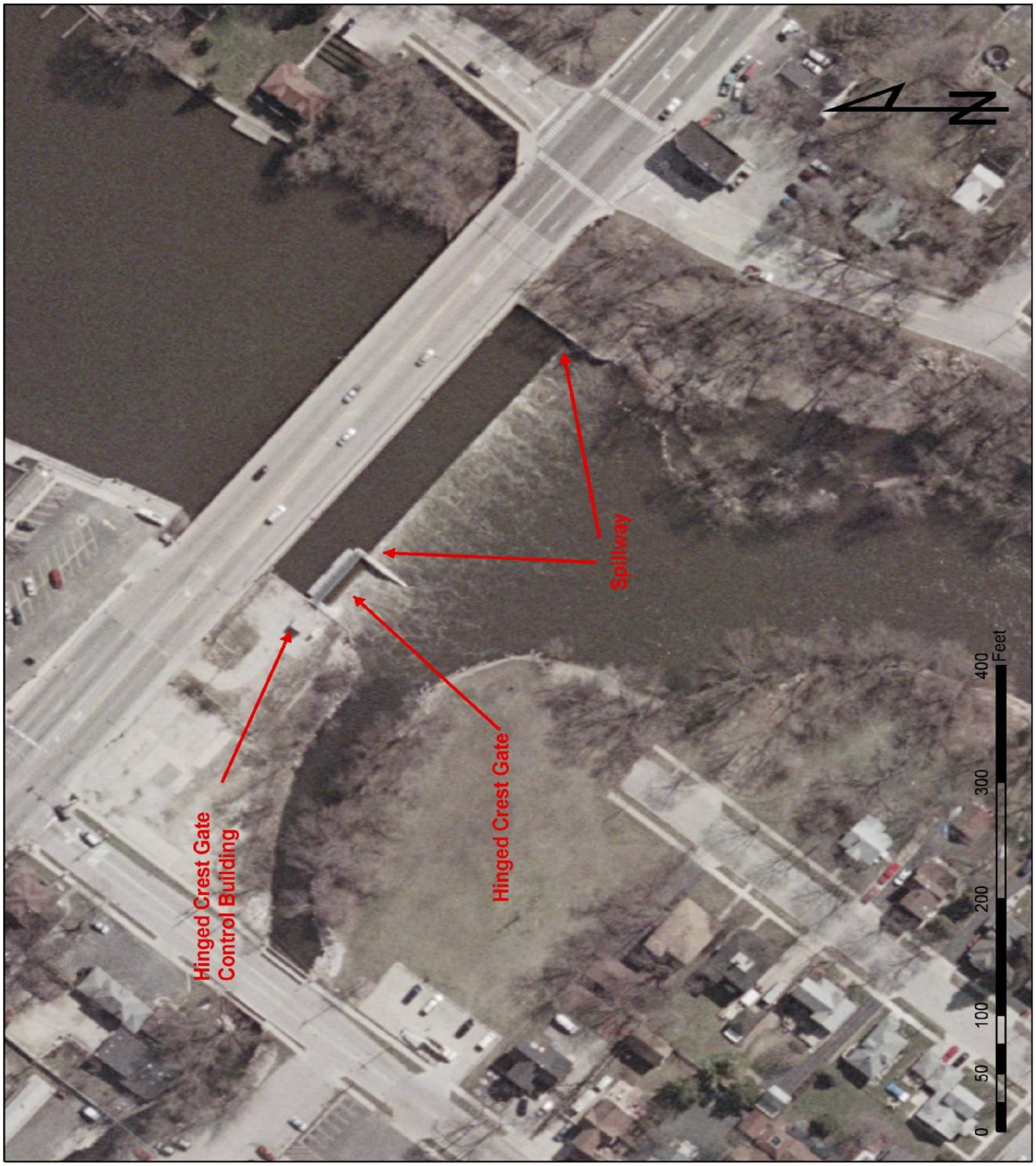


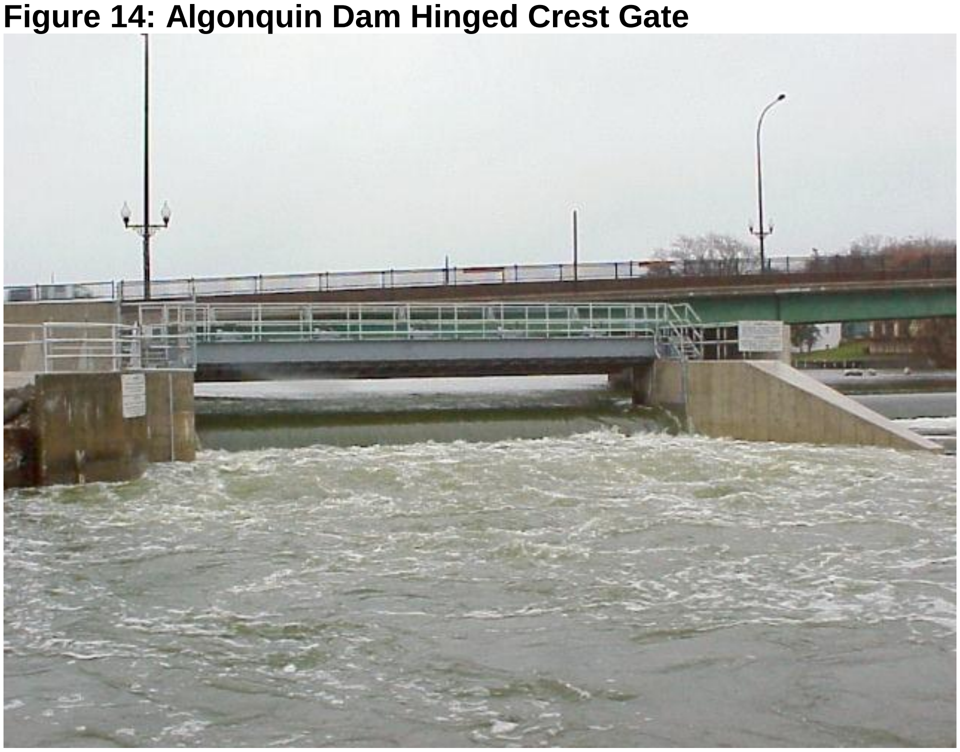
Figure 12: Plan View of Algonquin Dam



OPERATION OF STRATTON AND ALGONQUIN DAMS

Figure 13: Algonquin Dam Spillway

Figure 14: Algonquin Dam Hinged Crest Gate



OPERATION OBJECTIVES

Daily operations at Stratton Lock and Dam and Algonquin Dam are managed by collecting data, evaluating conditions, and determining operational adjustments to affect the resulting system performance.

Some of these data collected include the following:

Forecasted peak flows from National Weather Service
Lake Stages as measured at Channel Lake, Nippersink Lake, and Fox Lake
River flows as computed for the Fox River at New Munster, Wisconsin and Nippersink Creek at Spring Grove
River stages at Johnsburg, Algonquin and Elgin

These two dams affect the flows and stages in four distinct reaches of the Fox River:

Reach 1 - State line to outlet of Pistakee Lake
Reach 2 - Pistakee Lake outlet to Stratton Lock and Dam
Reach 3 - Stratton Lock and Dam to Algonquin Dam
Reach 4 - Fox River downstream from Algonquin

Primary flow control is achieved at Stratton Lock and Dam. The operation of this structure can affect the outflow from the lakes and river above Stratton Lock and Dam and the inflow to Reach 3. Gate adjustments at Algonquin affect the stages through Reach 3 but have little effect on flows passing downstream. There are no operational controls in Reach 1 or Reach 4.

Operational Objectives:

1. During summer normal flow conditions, the dams are operated to maintain the recreational pools in Reach 1, Reach 2 and Reach 3. The objective stage upstream of Algonquin dam is 1.8 feet. Normal summer pool in the Chain of Lakes is in the range of 3.8 to 4.2 feet.
2. When summer flood flows occur, the sluice gates at Stratton Lock and Dam are utilized to pass flood waters downstream with the following constraints and/or conditions:
   - Flood stages in Reach 1,Reach 2, Reach 3 or Reach 4
   - Observed rainfall and projected total inflows to the Chain of Lakes
   - Forecast rainfall over the Fox River watershed
   - Hinged Crest gate not operated until flows or stages are expected that would indicate substantial flooding upstream and downstream
   - Volume of available storage in the Chain of Lakes

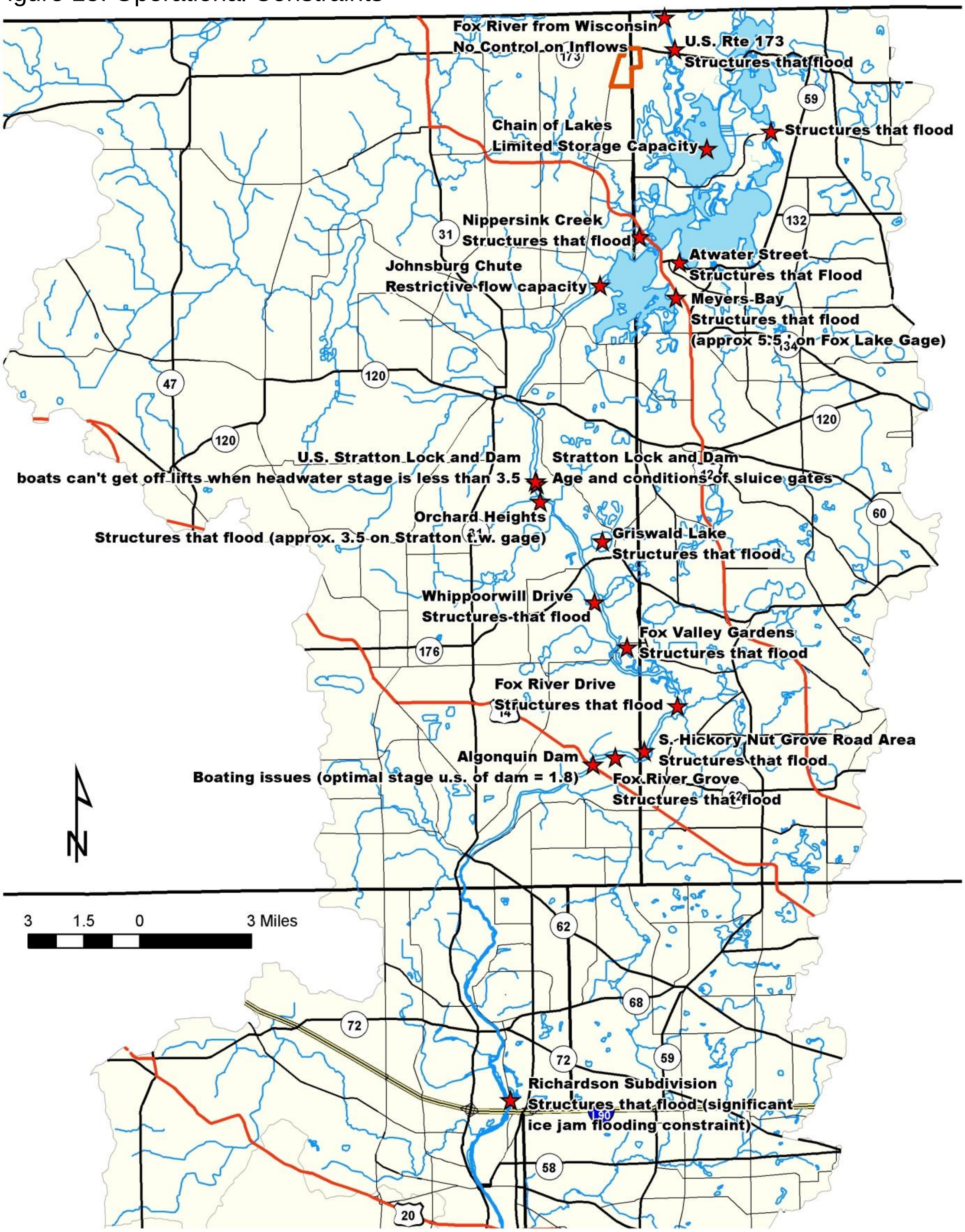
   There is not enough storage in the Chain of Lakes, nor capacity in the downstream river, to eliminate flooding. Flooding occurs due to large or extended periods of rainfall, or due to snow melt, or combinations of such events.

OPERATION OF STRATTON AND ALGONQUIN DAMS

3. During winter ice jam events the sluice gates at Stratton Lock and Dam are utilized to restrict flows downstream to 1100 cfs if possible with the following constraints and/or conditions:
    - An accumulation of 60 degree-freezing days
    - Very cold temperatures (daily high temperature < 20 degrees)

Operating the system based on anticipated conditions has been occurring for the past several years. This office regularly monitors inflow points at New Munster, Wisconsin and Nippersink Creek in Illinois to verify inflows to the system, and monitors rainfall records to estimate additional runoff which the system will receive in the near future. Forecasted and predicted conditions are then reviewed and the best operational procedure is determined from the operating plan. Those operational decisions consider all impacts, upstream as well as downstream of Stratton Lock and Dam. Frequently, flows are restricted to allow downstream tributaries to peak before releases are increased, or in winter time periods, to minimize ice related conditions. At other times, flows are increased early to minimize the peak flows which might otherwise be passed downstream and to minimize rises in the lakes. Figure 16 identifies some of the operational constraints that must be considered during the operation of Stratton and Algonquin Dams.

Figure 15: Operational Constraints



GAGING

Stream gaging plays a major role in the operation of Stratton Dam. Table 5 lists the telemetry stations used in the daily operations, and Figures 17 and 18 shows the location of these gages. The telemetry equipment is an electrical apparatus that measures water stage and transmits it by telephone or satellite to a receiving station. At the receiving station the water stage is then recorded. Twice daily and more frequently during major storm events each of these stations are contacted and readings are taken. In addition, wind speed and direction, precipitation, current temperature, and maximum and minimum daily temperature are recorded at Stratton Dam.

Numerous web sites identify present conditions as well as forecast conditions. Some of those web sites are listed here for public access:

Daily Fox River Stages
http://waterdata.usgs.gov/nwis/current?multiple_site_no=05545750%0D%0A05547000%0D%0A05547500%0D%0A05548000%0D%0A05548280%0D%0A05548500%0D%0A05549500%0D%0A05549501%0D%0A05550000%0D%0A05550001%0D%0A05551000%0D%0A05551001&search_site_no_match_type=exact&index_pmcode_STATION_NM=1&index_pmcode_DATETIME=2&index_pmcode_00065=3&index_pmcode_00060=4&index_pmcode_MEAN=&index_pmcode_MEDIAN=&index_pmcode_00055=&index_pmcode_72019=&index_pmcode_00045=&sort_key=site_no&group_key=NONE&sitefile_output_format=html_table&column_name=agency_cd&column_name=site_no&column_name=station_nm&format=html_table&html_table_sort_key=site_no&html_table_group_key=NONE&rdb_compression=file&list_of_search_criteria=multiple_site_no%2Crealtime_parameter_selection

Real Time Precipitation Data
http://il.water.usgs.gov/nwis-w/IL/datasum.components/precip.cgi

Quantitative Precipitation Forecasts
http://www.hpc.ncep.noaa.gov/qpf/qpf2.shtml

National Weather Service – Chicago, Illinois
http://www.crh.noaa.gov/lot/

USGS Real Time Water Data for Illinois
http://waterdata.usgs.gov/il/nwis/rt

Table 5: Fox River Stream Gaging Stations (Current)

Station Name	Gage #	Years of Record	Area (mi^2)
Gages Used for Daily Operations			
Fox River at New Munster, WI (Wilmot)	05545750	1939-present	811.0
Channel Lake near Antioch	05547000	1939-present	
Fox Lake near Lake Villa	05547500	1939-present	
Nippersink Lake at Fox Lake	05548000	1939-present	
Nippersink Creek near Spring Grove	05548280	1966-present	192.0
Fox River at Johnsburg	05548500	1939-present	1205.0
Fox River at McHenry	05549500	1941-present	1250.0
Fox River at Stratton Dam (TW)	05549501	1987-present	1250.0
Fox River at Algonquin (HW)	05550000	1915-present	1403.0
Fox River at Algonquin (TW)	05550001	2002-present	1403.0
Downstream Tailwater at Foot bridge		2009-present	
Additional USGS Continuous Recording Gages (Current and Historical)			
Fox River at Waukesha, WI	05543830	1963-present	126.0
Mukwonago River at Mukwonago, WI	05544200	1973-present	74.1
Poplar Creek at Elgin	05550500	1951-present	35.2
Fox River at South Elgin	05555100	1989-present	1556.0
Ferson Creek near St. Charles	05551200	1960-present	5.7
Fox River near Montgomery	05551540	2002-present	1732.0
Blackberry Creek near Yorkville	05551700	1960-present	70.2
Fox River at Dayton	05552500	1914-present	2642.0
Additional OWR Gages (Current and Historical)			
Fox River at Geneva	SGO3707	1962-present	1652.0
Fox River at Yorkville	SGO3705	1962-present	1804.0

Table 6: Fox River Stream Gaging Stations (Historical)

Station Name	Gage #	Years of Record	Area (mi^2)
USGS Continuous Recording Gages (Historical)			
White River near Burlington, WI	05535300	1973-1982	97.5
Squaw Creek at Round Lake	05547755	1989-2005	17.2
Nippersink Creek above Wonder Lake	05548105	1994-1997	84.5
Nippersink Creek below Wonder Lake	05548110	1994-1997	97.3
Boone Creek near McHenry	05549000	1948-1982	15.5
OWR Gages (Historical)			
Grass Lake	Staff Gage	1965-1994	
Cary Rawson Bridge	Staff Gage	1987-1994	
Fox River Grove Bridge U.S.	Staff Gage	1965-1994	
Fox River at Route 173 Bridge	SGO3708	1961-1993	871.0
Fox River at Stratton Dam	SGO3738	1962-1989	1250.0
Fox River at South Elgin Dam	SGO3704	1962-1989	1556.0
Fox River near Aurora	SGO3740	1947-1979	1706.0
Fox River at Montgomery	SGO3706	1969-2002	1732.0
Nippersink Creek near Solon Mills	SGO3735	1962-1966	185.0
Nippersink Creek at Spring Grove	SGO3736	1952-1960	199.0
Blackberry Creek near Elburn	SGO3741	1965-1969	6.0
Blackberry Creek near Sugar Grove	SGO3742	1965-1979	29.6

Table 7: Stage/Elevation Relationship for Various Gages

	Fox River at New Munster	Channel Lake near Antioch	Fox Lake near Lake Villa	Nippersink Lake at Fox Lake	Nippersink Creek near Spring Grove	Fox River at Johnsburg	Fox River at Stratton Dam (HW)	Fox River at Stratton Dam (TW)	Fox River at Algonquin Dam (HW)	Fox River at Algonquin Dam (TW)	Fox River at South Elgin
Gage Datum	735.72	733.00	733.00	733.00	746.00	733.00	733.00	730.15	729.48	719.48	687.95
Gage Stage	**Gage Elevation**										
0.0	735.72	733.00	733.00	733.00	746.00	733.00	733.00	730.15	729.48	719.48	687.95
0.2	735.92	733.20	733.20	733.20	746.20	733.20	733.20	730.35	729.68	719.68	688.15
0.4	736.12	733.40	733.40	733.40	746.40	733.40	733.40	730.55	729.88	719.88	688.35
0.6	736.32	733.60	733.60	733.60	746.60	733.60	733.60	730.75	730.08	720.08	688.55
0.8	736.52	733.80	733.80	733.80	746.80	733.80	733.80	730.95	730.28	720.28	688.75
1.0	736.72	734.00	734.00	734.00	747.00	734.00	734.00	731.15	730.48	720.48	688.95
1.2	736.92	734.20	734.20	734.20	747.20	734.20	734.20	731.35	730.68	720.68	689.15
1.4	737.12	734.40	734.40	734.40	747.40	734.40	734.40	731.55	730.88	720.88	689.35
1.6	737.32	734.60	734.60	734.60	747.60	734.60	734.60	731.75	731.08	721.08	689.55
1.8	737.52	734.80	734.80	734.80	747.80	734.80	734.80	731.95	731.28	721.28	689.75
2.0	737.72	735.00	735.00	735.00	748.00	735.00	735.00	732.15	731.48	721.48	689.95
2.2	737.92	735.20	735.20	735.20	748.20	735.20	735.20	732.35	731.68	721.68	690.15
2.4	738.12	735.40	735.40	735.40	748.40	735.40	735.40	732.55	731.88	721.88	690.35
2.6	738.32	735.60	735.60	735.60	748.60	735.60	735.60	732.75	732.08	722.08	690.55
2.8	738.52	735.80	735.80	735.80	748.80	735.80	735.80	732.95	732.28	722.28	690.75
3.0	738.72	736.00	736.00	736.00	749.00	736.00	736.00	733.15	732.48	722.48	690.95
3.2	738.92	736.20	736.20	736.20	749.20	736.20	736.20	733.35	732.68	722.68	691.15
3.4	739.12	736.40	736.40	736.40	749.40	736.40	736.40	733.55	732.88	722.88	691.35
3.6	739.32	736.60	736.60	736.60	749.60	736.60	736.60	733.75	733.08	723.08	691.55
3.8	739.52	736.80	736.80	736.80	749.80	736.80	736.80	733.95	733.28	723.28	691.75
4.0	739.72	737.00	737.00	737.00	750.00	737.00	737.00	734.15	733.48	723.48	691.95
4.2	739.92	737.20	737.20	737.20	750.20	737.20	737.20	734.35	733.68	723.68	692.15
4.4	740.12	737.40	737.40	737.40	750.40	737.40	737.40	734.55	733.88	723.88	692.35
4.6	740.32	737.60	737.60	737.60	750.60	737.60	737.60	734.75	734.08	724.08	692.55
4.8	740.52	737.80	737.80	737.80	750.80	737.80	737.80	734.95	734.28	724.28	692.75
5.0	740.72	738.00	738.00	738.00	751.00	738.00	738.00	735.15	734.48	724.48	692.95
5.2	740.92	738.20	738.20	738.20	751.20	738.20	738.20	735.35	734.68	724.68	693.15
5.4	741.12	738.40	738.40	738.40	751.40	738.40	738.40	735.55	734.88	724.88	693.35
5.6	741.32	738.60	738.60	738.60	751.60	738.60	738.60	735.75	735.08	725.08	693.55
5.8	741.52	738.80	738.80	738.80	751.80	738.80	738.80	735.95	735.28	725.28	693.75
6.0	741.72	739.00	739.00	739.00	752.00	739.00	739.00	736.15	735.48	725.48	693.95
6.2	741.92	739.20	739.20	739.20	752.20	739.20	739.20	736.35	735.68	725.68	694.15
6.4	742.12	739.40	739.40	739.40	752.40	739.40	739.40	736.55	735.88	725.88	694.35
6.6	742.32	739.60	739.60	739.60	752.60	739.60	739.60	736.75	736.08	726.08	694.55
6.8	742.52	739.80	739.80	739.80	752.80	739.80	739.80	736.95	736.28	726.28	694.75
7.0	742.72	740.00	740.00	740.00	753.00	740.00	740.00	737.15	736.48	726.48	694.95
7.2	742.92	740.20	740.20	740.20	753.20	740.20	740.20	737.35	736.68	726.68	695.15

	Fox River at New Munster	Channel Lake near Antioch	Fox Lake near Lake Villa	Nippersink Lake at Fox Lake	Nippersink Creek near Spring Grove	Fox River at Johnsburg	Fox River at Stratton Dam (HW)	Fox River at Stratton Dam (TW)	Fox River at Algonquin Dam (HW)	Fox River at Algonquin Dam (TW)	Fox River at South Elgin
Gage Datum	735.72	733.00	733.00	733.00	746.00	733.00	733.00	730.15	729.48	719.48	687.95
Gage Stage					**Gage Elevation**						
7.4	743.12	740.40	740.40	740.40	753.40	740.40	740.40	737.55	736.88	726.88	695.35
7.6	743.32	740.60	740.60	740.60	753.60	740.60	740.60	737.75	737.08	727.08	695.55
7.8	743.52	740.80	740.80	740.80	753.80	740.80	740.80	737.95	737.28	727.28	695.75
8.0	743.72	741.00	741.00	741.00	754.00	741.00	741.00	738.15	737.48	727.48	695.95
8.2	743.92	741.20	741.20	741.20	754.20	741.20	741.20	738.35	737.68	727.68	696.15
8.4	744.12	741.40	741.40	741.40	754.40	741.40	741.40	738.55	737.88	727.88	696.35
8.6	744.32	741.60	741.60	741.60	754.60	741.60	741.60	738.75	738.08	728.08	696.55
8.8	744.52	741.80	741.80	741.80	754.80	741.80	741.80	738.95	738.28	728.28	696.75
9.0	744.72	742.00	742.00	742.00	755.00	742.00	742.00	739.15	738.48	728.48	696.95
9.2	744.92	742.20	742.20	742.20	755.20	742.20	742.20	739.35	738.68	728.68	697.15
9.4	745.12	742.40	742.40	742.40	755.40	742.40	742.40	739.55	738.88	728.88	697.35
9.6	745.32	742.60	742.60	742.60	755.60	742.60	742.60	739.75	739.08	729.08	697.55
9.8	745.52	742.80	742.80	742.80	755.80	742.80	742.80	739.95	739.28	729.28	697.75
10.0	745.72	743.00	743.00	743.00	756.00	743.00	743.00	740.15	739.48	729.48	697.95
10.2	745.92	743.20	743.20	743.20	756.20	743.20	743.20	740.35	739.68	729.68	698.15
10.4	746.12	743.40	743.40	743.40	756.40	743.40	743.40	740.55	739.88	729.88	698.35
10.6	746.32	743.60	743.60	743.60	756.60	743.60	743.60	740.75	740.08	730.08	698.55
10.8	746.52	743.80	743.80	743.80	756.80	743.80	743.80	740.95	740.28	730.28	698.75
11.0	746.72	744.00	744.00	744.00	757.00	744.00	744.00	741.15	740.48	730.48	698.95
11.2	746.92	744.20	744.20	744.20	757.20	744.20	744.20	741.35	740.68	730.68	699.15
11.4	747.12	744.40	744.40	744.40	757.40	744.40	744.40	741.55	740.88	730.88	699.35
11.6	747.32	744.60	744.60	744.60	757.60	744.60	744.60	741.75	741.08	731.08	699.55
11.8	747.52	744.80	744.80	744.80	757.80	744.80	744.80	741.95	741.28	731.28	699.75
12.0	747.72	745.00	745.00	745.00	758.00	745.00	745.00	742.15	741.48	731.48	699.95
12.2	747.92	745.20	745.20	745.20	758.20	745.20	745.20	742.35	741.68	731.68	700.15
12.4	748.12	745.40	745.40	745.40	758.40	745.40	745.40	742.55	741.88	731.88	700.35
12.6	748.32	745.60	745.60	745.60	758.60	745.60	745.60	742.75	742.08	732.08	700.55
12.8	748.52	745.80	745.80	745.80	758.80	745.80	745.80	742.95	742.28	732.28	700.75
13.0	748.72	746.00	746.00	746.00	759.00	746.00	746.00	743.15	742.48	732.48	700.95

Figure 16: Gaging In Southern Portion of Watershed

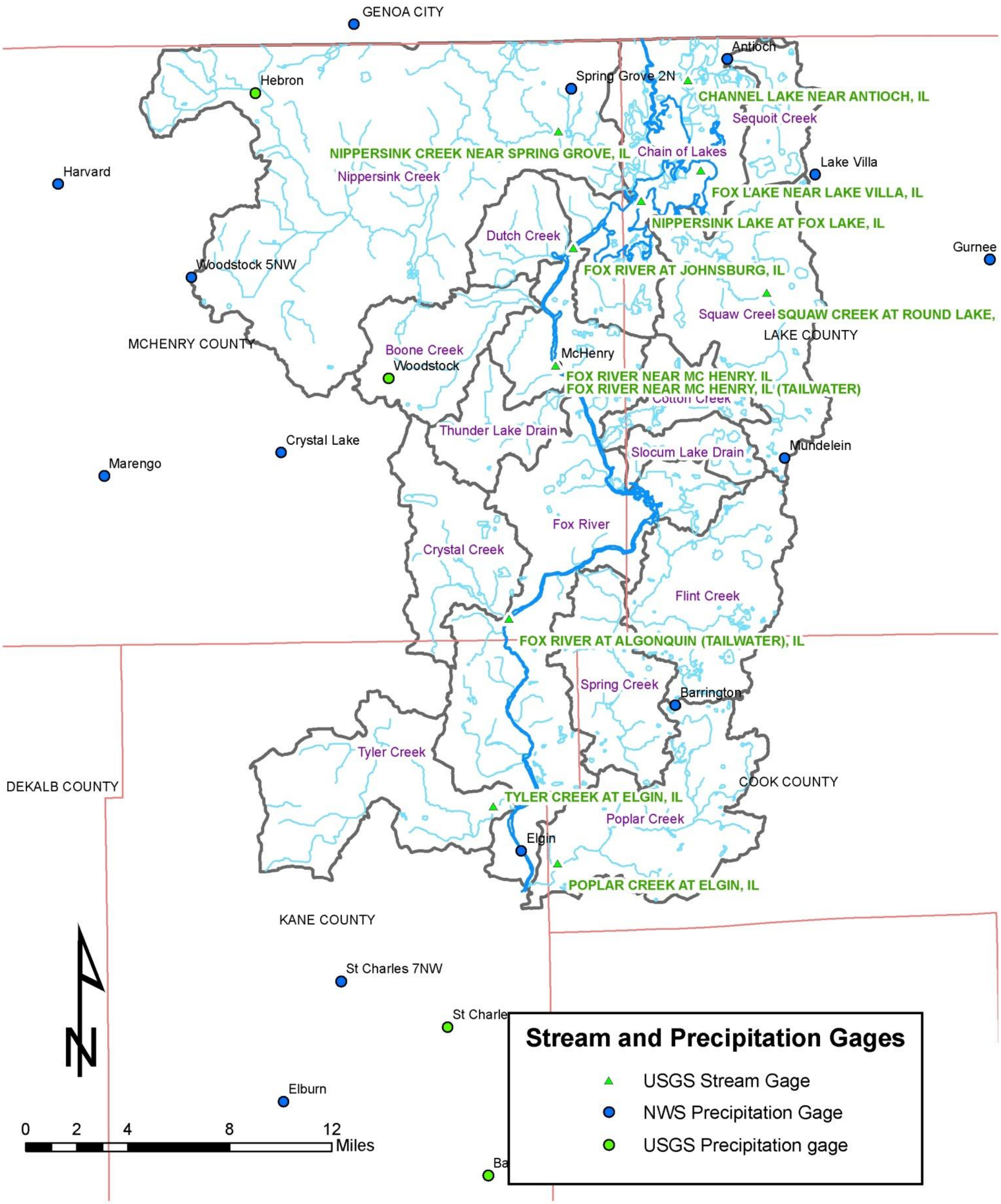
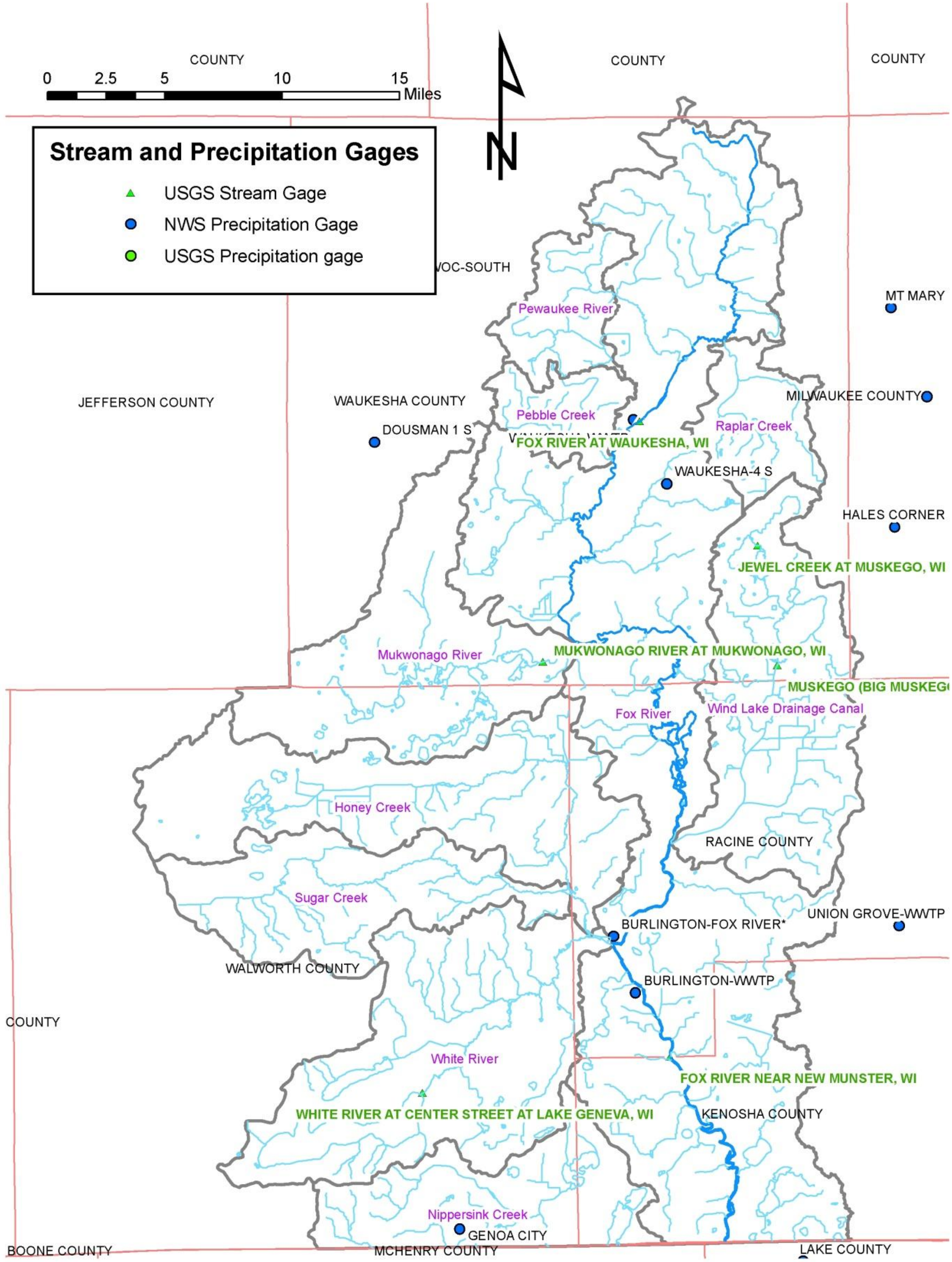


Figure 17: Gaging in Northern Portion of Watershed



STRATTON AND ALGONQUIN OPERATIONS

Operations at Stratton Dam and Algonquin Dam are divided into four operational periods: low flow, normal flow, flood warning, and flood flow. Figure 19 shows each of the periods on flow duration curves for the Nippersink, New Munster, McHenry and Algonquin gages.

Below an inflow of 390 cfs (known as Q_{75} - 75 percent flow duration) operations are considered to be low flow. From Q_{75} to Q_{25} (25 percent flow duration) operations are considered to be normal flow. During periods of normal flow the operations at Stratton Dam maintain outflow equal to inflow. This range of inflows is from 390 cfs to 960 cfs.

Inflows greater than 960 cfs are considered to be flood flows. There are three different types of flood events at Stratton Dam. These are: 1) rainfall-snowmelt events when at winter pool, 2) winter ice jams, and 3) rainfall events when at summer pool. Each of these event types is outlined in the following text.

Important information to consider in flood operations is rainfall and runoff frequency distributions. Listed in Table 8 are the 2 thru 100 year discharges for the Algonquin, New Munster and Nippersink stream gages using the annual maximum series of recorded discharges regardless of the season in which the discharge occurred.

Table 8: Annual Discharge Frequency Distributions for Select Gages

Gaging Station	**Frequency (years)**					
	2	5	10	25	50	100
	Discharge (cfs)					
Algonquin (1916-2007)	3268	4528	5307	6236	6891	7518
New Munster (1940-2007)*	2727	3906	4703	5729	6508	7301
Nippersink Creek (1960-2007)	1221	2002	2523	3168	3634	4086

* Gage at Wilmot until 1993

Figure 18: Flow Duration Curves

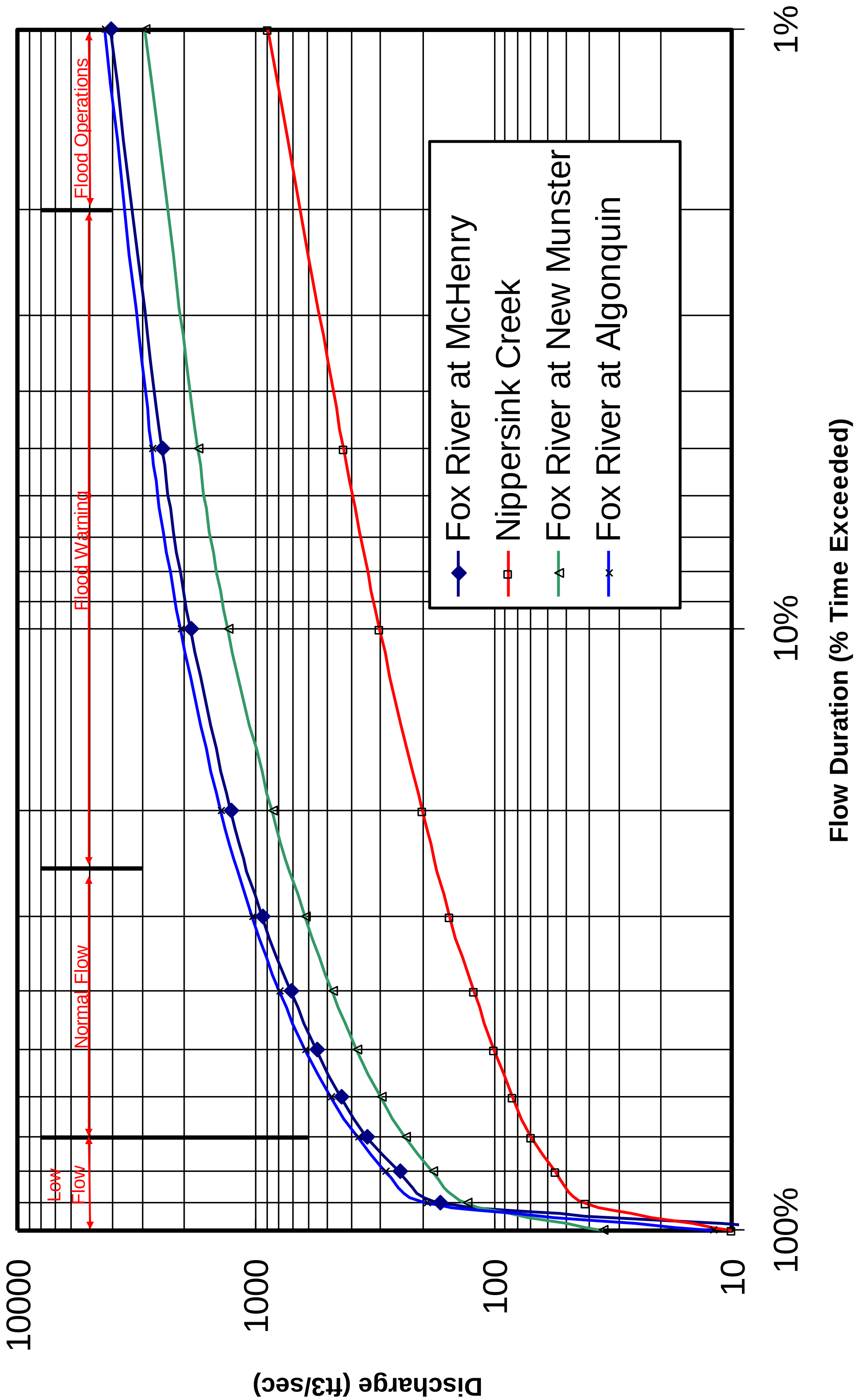


Table 9 shows the seasonal rainfall frequency distributions for the 24-hour storm period, for the northeast zone of Illinois (Huff, 1989). It is important to note the seasonal difference in the rainfall amounts. The seasonal values are based on 1/4 of the total statistical base and are therefore smaller than the annual values.

Table 9 Season Precipitation Frequency Distributions for 24-Hour Storm Period and Recurrence Intervals of 2 to 100 Years

Season	Frequency (years)					
	2	5	10	25	50	100
	Rainfall (inches)					
Winter	1.09	1.44	1.79	2.26	2.65	3.18
Spring	1.92	2.39	2.82	3.53	4.13	4.85
Fall	1.92	2.55	3.12	4.04	4.80	5.74
Summer	2.61	3.34	4.07	5.18	6.20	7.43
Annual	3.04	3.80	4.47	5.51	6.46	7.58

RAINFALL SNOWMELT EVENTS AT WINTER POOL

The majority of the flooding events in the Fox watershed occur in the March, April, May (spring) time period. Table 10 lists the months in which floods have occurred at the Algonquin stream gaging station (1916-2010). Of the 119 storm events since 1916 that have been greater than the two year event (3270 cfs) or the annual peak event if less than two year event, 79 have occurred during the spring.

Table 10: Months in which Flood Events have Occurred at the Algonquin Gage (1916-2012)

Month	Number of Events	Percent	Greatest Peak
January	2	1.7%	3650
February	10	8.4%	5160
March	42	35.3%	5750
April	26	21.8%	6610
May	11	9.2%	6020
June	10	8.4%	6030
July	4	3.4%	5630
August	3	2.5%	6690
September	5	4.2%	4700
October	3	2.5%	6170
November(1)	1	0.8%	1090
December	2	1.7%	5230
	119	100.0%	6690

(1) No peaks occurred greater than 3000 cfs so the highest monthly peak was used

Figure 19: Partial Duration Series for Algonquin Gage

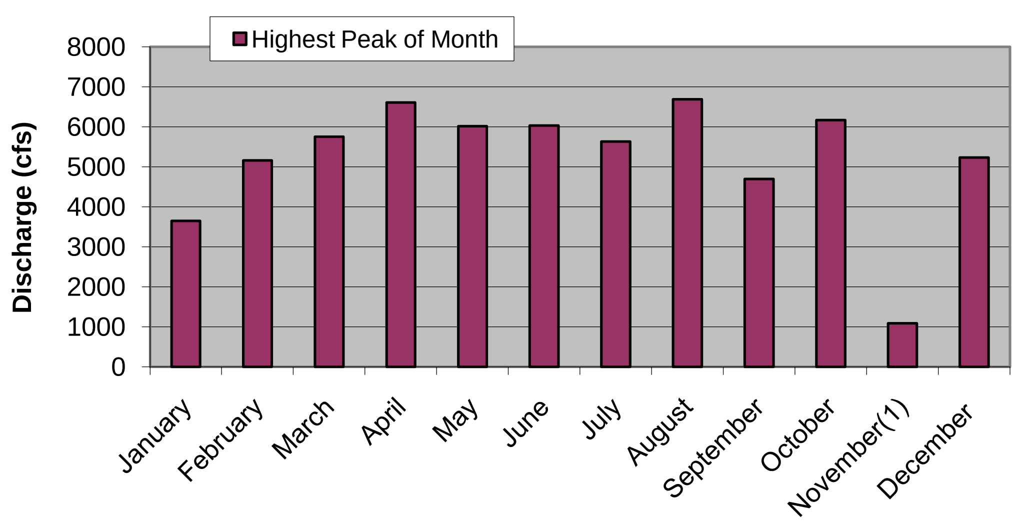
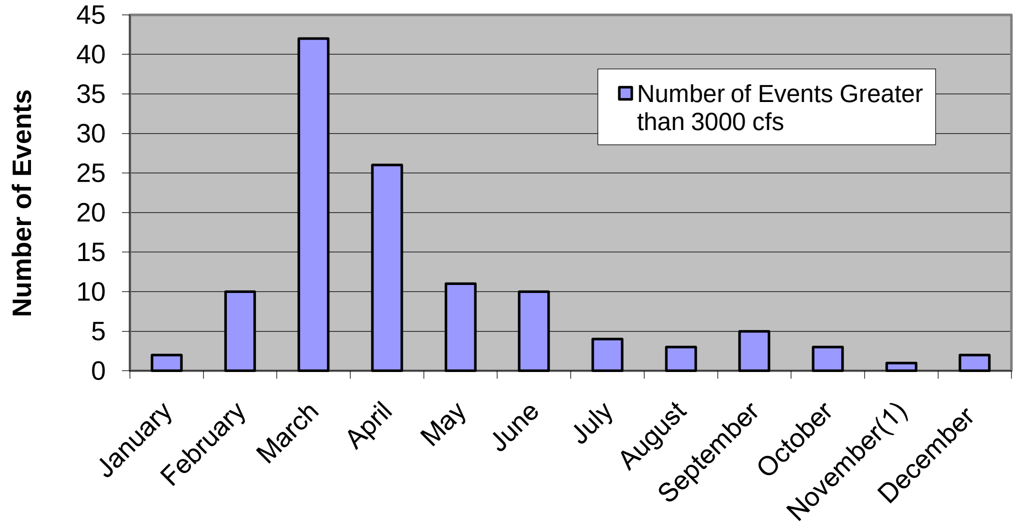


Figure 20: Partial Duration Series for Algonquin Gage (1916-2012)



(1) No peaks occurred greater than 3000 cfs so highest monthly peak was used

Most of the major events occur when the lakes are at a winter pool elevation of 735.5 feet (Fox Lake stage of 2.5 feet). At this elevation the maximum discharge at the dam if the sluice gates are completely open is approximately 1650 cfs. This discharge is less than the bankfull discharge of 2700 cfs and the no structural damage discharge of 3490 cfs. The hinged-crest gates at Stratton and Algonquin are most useful under these conditions, because the storage both upstream and downstream of these two dams can be optimized so the flood conditions upstream of these two dams can be lessened. An additional 1200 cfs can be passed if the hinged crest gate at Stratton Dam is completely open; this is a combined discharge of 2,850 cfs which is slightly higher than the bankfull discharge of 2700 cfs.

WINTER OPERATIONS/ICE JAMS

At approximately the 2 year discharge of 3200 cfs, out-of-bank flooding begins in Richardson Subdivision (Elevation 712.5) for open water conditions. With ice jams, this stage is usually reached at a flow of 1100 cfs. The ice jams form during the first major cold period of the winter before an ice cover on the river has formed. Ice jams also occur after a warming trend has broken up the ice cover and an extreme cold period again generates ice. The jam usually occurs when temperatures are below 20°F for several days. As these temperatures occur, Figure 22 can be used with known Algonquin discharges to estimate the flood stages at East Dundee. Daily communications, to monitor river stages, will be made with Kane County during these freeze up periods.

When degree-freezing days accumulate to 60 or more, flows from Stratton and Algonquin Dams are typically limited to approximately 1,000 cubic feet per second. For example, if the daily average of the minimum and maximum temperature is 20°F., the degree freezing days are 12 ($32^o – 20^o = 12$). This operational criterion was developed from an engineering study performed by the U. S. Army Corps of Engineers, Cold Regions Research Laboratory. The mean discharge at East Dundee for the winter months of December, January, and February is 853 cfs, 723 cfs and 843 cfs respectively (Knapp, 1988). Since that report was published in 1990, this office has operated the Stratton Lock and Dam and Algonquin Dam by following the criteria to minimize ice conditions on the lower river. This office has also worked with East and West Dundee, the Kane County Forest Preserve District, Kane County, and the residents of Richardson Subdivision to operate two ice booms for ten years to further mitigate those ice conditions. The Carpentersville Ice Boom was first installed, February 1, 1993. The East Dundee Ice Boom was first installed January 25, 1995. Presently, the ice booms are not in operation. Increased ice jam hazards now exist and the operation of Stratton Lock and Dam and Algonquin Dam cannot completely mitigate the ice conditions.

Fluctuating the pool within the Chain of Lakes during winter conditions causes impacts beyond the flood mitigation it provides. Ice forms at the level of the lakes, and as the lake level rises and falls, shoreline stress is created. This impacts local shoreline owners and the ecological habitat of the shorelines. Structural damage can occur to steel shoreline walls and to docks as flows fluctuate. Perched ice increases the hazards for recreational users of the Chain of Lakes. The void between the ice and water poses danger to ice fishermen and snowmobilers. Also, local stormwater drainage is inhibited when ice level is above normal summer pool.

<u>Example of winter operations:</u>
The weather conditions in early December of 2007 created high inflows to the Chain of Lakes. Cold weather created conditions conducive to ice formation. After December 6, 2007, restricted outflows from Stratton Lock and Dam helped to minimize the threat of ice jam flooding. On December 22, 2007, warm weather resulted in snow melt and the Chain of Lakes received additional inflow and lake stages rose. Due to forecasts for the return of cold weather, the outflows from Stratton Dam were restricted to those that could be safely released considering possible ice conditions. The outflows were less than the inflows and lake levels rose over 0.5 feet due to these conditions. Degree freezing days accumulated to over 70 as of Jan. 3, 2008, and cold weather continued. Flows at Algonquin were estimated at less than 1,100 cfs, the result of operations which restricted outflows during cold weather. With predicted warm weather and resulting increased runoff into the lakes, the lake levels were predicted to rise unless outflows were increased; these increased outflows could have resulted in greater risks downstream if cold weather returned. These conditions would have benefited from the

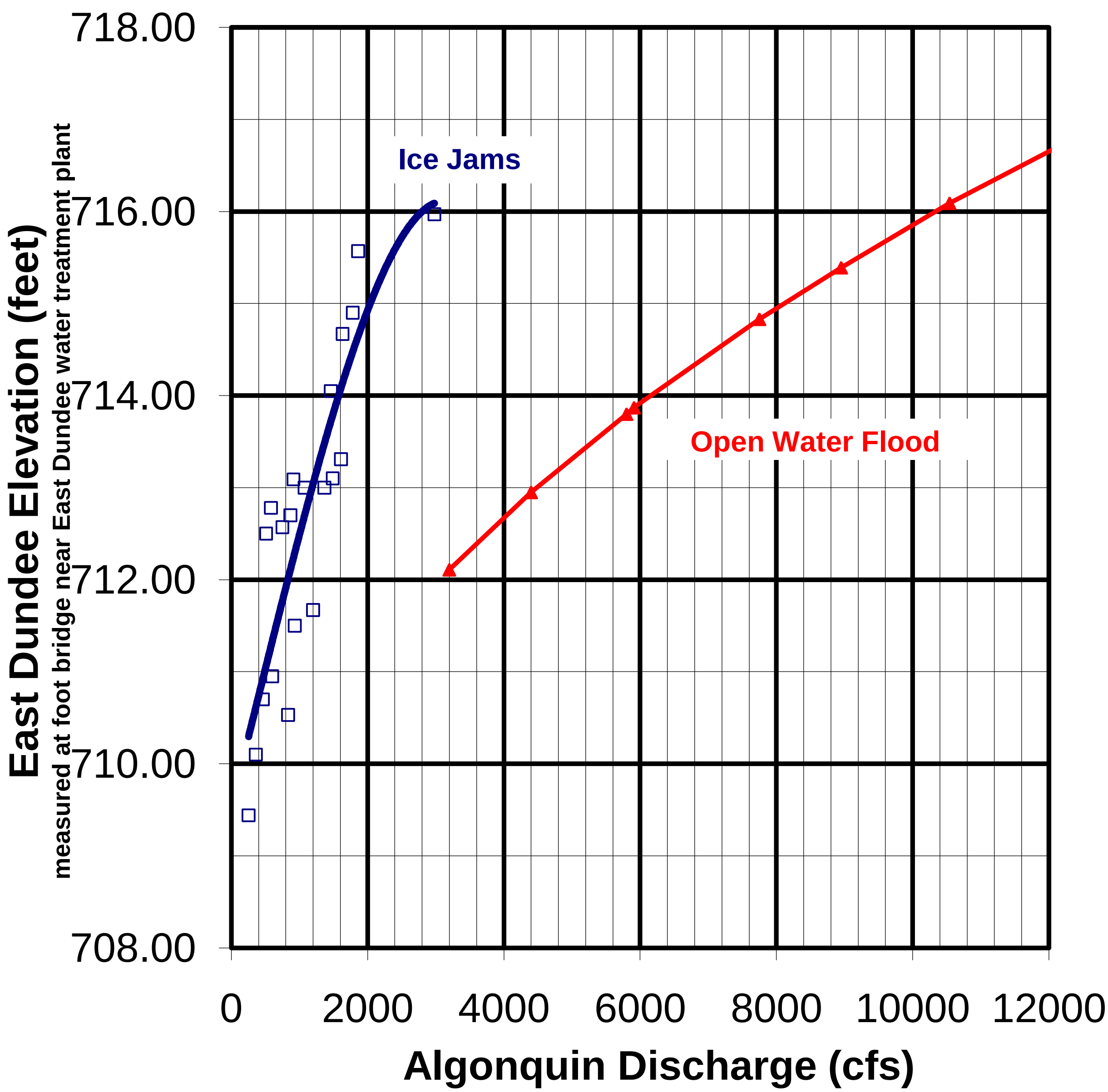
ice booms which could have reduced the ice accumulation at the I-90 bridge and would have extended the protection to Richardson Subdivision,

Table 11: Ice Jams and Flood Flows

Water Year	Date or Frequency	Algonquin Discharge (cfs)	East Dundee Elevation with Ice jam	East Dundee Elevation with Ice Boom	East Dundee Elevation with Open Water
963	12/5/1962	253	709.44		
1990	12/14/1989	359	710.10		
1989	12/17/1988	464	710.70		
1989	2/5/1989	510	712.50		
1965	1/17/1965	582	712.78		
1980	12/17/1979	600	710.95		
1982	12/18/1981	750	712.57		
1978	12/21/1977	834	710.53		
1962	12/15/1961	868	712.70		
1979	12/13/1978	912	713.09		
1961	12/13/1960	932	711.50		
1993	12/24/1992	1073	713.00		
1975	1/17/1975	1200	711.67		
1991	12/24/1990	1366	713.00		
1981	12/20/1980	1460	714.05		
1992	12/6/1990	1487	713.10		
1984	12/18/1983	1610	713.31		
1988	1/4/1988	1632	714.67		
2010	1/4/2010	1780[e]	714.9		
1985	1/3/1985	1860	715.57		
2009	1/9/2009	2267	n/a		
1988	2/7/1988	2981	715.97		
1994	12/28/1993	642		711.00	
1995	12/12/1996	894		712.00	
1995	1/29/1995	1100		711.70	
1996	1/30/1996	1171		713.00	
1998	1/14/1998	1920		712.60	
1983	12/12/1982	3850			712.77
	1 yr	3200			712.11
	2 yr	4400			712.95
	5 yr	5800			713.80
	10 yr	5910			713.87
	25 yr	7750			714.83
	50 yr	8950			715.39
	100 yr	10540			716.09
	500 yr	13475			717.22

e – Estimated Flow
Carpentersville Ice Boom Installed February 1, 1993 thru November 2005
East Dundee Ice Boom Installed January 25, 1995 thru November 2005

Figure 21: Ice Jams and Flood Flows



RAINFALL EVENTS AT SUMMER POOL

Since the construction of the existing dam and gate structure at McHenry in 1939, 17 events greater than the 2 year flood have occurred while at summer pool. These events are listed in Table 12.

Table 12: Summer Pool Flood Events since 1939

Peak Events greater than 2-year event (3270 cfs) that occurred between May 1 and October 15 and after 1939 (when dam was constructed)			
Year	Month	Day	Algonquin Dam Average Daily Discharge
1967	6	17	3960
1972	9	24	4700
1973	5	4	5730
1986	10	3	6170
1996	5	23	4570
1999	6	18	4710
2000	6	17	5060
2001	6	17	3450
2002	6	7	3780
2004	5	31	6020
2007	8	26	6690
2008	5	13	3680
2008	6	19	5760
2008	7	24	3670
2009	5	4	3680
2010	5	16	4250
2010	8	1	3680

FISH LADDER OPERATIONS

The fish weir should be “open” and operational from mid-March through mid-August. As water levels increase weir boards should be installed to maintain as smooth a transition between pools as possible. OWR staff at the Stratton Lock and Dam will oversee general operation and maintenance of the weir. IDNR Fisheries staff will assist with opening and closing procedures (as needed) and periodically investigate fish use.

1. Placement of weir boards should allow for an equal rise from the lowest pool (#1 near the tailwater) to highest pool (#7 near the headwater). Rise between each

pool should not exceed 6” to 8”.

2. Drain holes (also called turbulence holes) may need to be plugged during winter-pool flows so water can accumulate in pools 7, 6, 5, 4 and 3.

3. Weir boards need to be adjusted so flows are equalized as the Chain of Lakes fills toward summer pool.

4. At summer pool the “attractor tube” should be open to help draw fish toward the weir. Prior to summer pool, flows through the attractor tube may be too low to draw fish toward the weir. The attractor tube may be most functional when water is flowing over the low head dam to the east of the fish weir.

5. At winter pool shut down water flows via a weir board at the headwater between November and early March to reduce the likelihood of ice damage.

OPERATIONS MODELING

The Illinois State Water survey has completed three studies to help develop and evaluate a flood control management policy for Stratton Dam (Knapp 1991 and Knapp 1992) and Stratton and Algonquin Dams (Knapp 1997). Two models were developed for use in these evaluations: 1) a rainfall-runoff watershed model (PACE), and 2) an unsteady flow-routing model (FEQ) to simulate the hydraulics of both the lakes and the Fox River.

RAINFALL-RUNOFF MODEL

One of the major purposes of the rainfall-runoff model is for streamflow estimating using a near real-time mode. Near real-time modeling uses input data from precipitation events that have just recently occurred. The Fox River model typically uses rainfall information from storms that occurred earlier in the day or on the previous day to develop stream flow estimates. This is contrasted with real-time modeling, which simulates the hydrologic response to a precipitation event immediately after its occurrence.

Given the input of near real-time precipitation and temperature data, the model will estimate streamflow conditions the current day and for up to six days into the future. In addition to this near real-time estimating, the model can estimate future flows using a rainfall prognosis as model input. For example, if the short-term meteorological forecast calls for heavy rainfall over the watershed during the next 24 or 48 hours, the model can estimate the effects of this potential (or hypothetical) rainfall on the streamflow. Potential rainfall is used to assess potential impacts but gate operations are based on recorded rainfall only.

For the near real-time operation of the Fox River hydrologic model, the model user must first compile the data that lists the amount of precipitation and air temperatures over the watershed. Precipitation information can be obtained via the internet from the National Weather Service or the United States Geological Survey. Currently, 21 gages, in or near the Fox River watershed, provide this daily information. This information, along with temperature data is manually entered into the rainfall-runoff model for processing.

The timeliness of the available precipitation information does not significantly impact model accuracy, but it does determine how soon the streamflow can be estimated. This, in turn, determines how soon Stratton Dam operators react to approaching flood conditions, since the flow estimate provides the technical information needed for them to modify the gate settings.

Since the development of the PACE rainfall-runoff model the National Weather Service (NWS) has established a river forecast point for the Fox River at the New Munster, Wisconsin gage. The forecast that is developed for the Fox River at this location is the only river forecast point upstream of the Chain of Lakes. The forecast at this location and the PACE model prediction are both evaluated in the determination of the operations of the gates at Stratton Dam and Algonquin Dam.

UNSTEADY FLOW-ROUTING MODEL

In the simulation studies, the pool level is reduced by opening the gates to one of two target discharge levels: 1) 1800 cfs, which is the maximum discharge for which no-wake conditions can be maintained, and 2) up to 3000 cfs which is the maximum discharge without overbank flooding. At the recreational pool level (737.00 feet), the 1800 cfs discharge is achieved by opening the sluice gates to a setting of 2.5 feet. When the stage at Stratton Dam is more than one foot below the recreational pool level, a gate opening of 3.0 feet may be required. The second discharge level (3000 cfs) is achieved at normal pool (737.00) level when the sluice gates are opened wide.

The criterion for opening the gates to release 3000 cfs, described below, requires relatively certain knowledge that severe (overbank) flooding is approaching the Chain of Lakes. Releases from Stratton Dam are allowed to exceed the target discharges when high stages in the lakes cause increasing amounts of uncontrolled flow over the Stratton Dam spillway.

The following policy was chosen after analyzing: 1) the simulated impacts of using various operation alternatives, 2) expected relationships between the flow predictions and associated observed flows, and 3) the frequency at which the policy will be employed.

This flood control policy is designed so that the operation of the Stratton Dam gates does not directly induce flooding downstream except when the flow prediction model indicates the approach of extremely high flows (in which case the occurrence of downstream flooding is almost certain). For lesser events, the policy keeps Stratton Dam gate openings at a level (2.5 feet) that will allow unrestricted flow conditions to continue, until that time when increasing stages at Stratton Dam create sufficient uncontrolled flow over the spillway, thereby causing the total release to exceed the maximum no-wake flow.

The flow chart showing the criteria for operating both the sluice gates at Stratton Dam and hinged-crest gates at Stratton and Algonquin Dams is shown in Figure 23 (from Figure 17, Knapp 1998). This flow chart is used both during a flood event and after a flood event as a guide to operations. Additional information gathered during a flood event such as the likelihood of ice jams forming or the flow conditions of downstream tributaries may require deviations from the guidance of the flow chart in order to minimize the overall flood potential of the Fox River. All predictions refer to predicted inflows coming into the Chain of Lakes as calculated by the PACE model which include the Fox River, Nippersink Creek, and all the ungaged tributaries. The data needed to traverse the flow chart is a predicted value of the inflow to the Chain of Lakes from the PACE model and the stage of Fox Lake at the time that the PACE model was executed. The operation chart is not meant to be used with flow values from sources other than the PACE model.

Important note: The development of the operation plan restricted the position of the hinged crest gates to either closed or completely open. Additional flow measurements made since the time of the operation plan development allows for the use of incremental hinged crest gate openings to fine tune the performance of the system

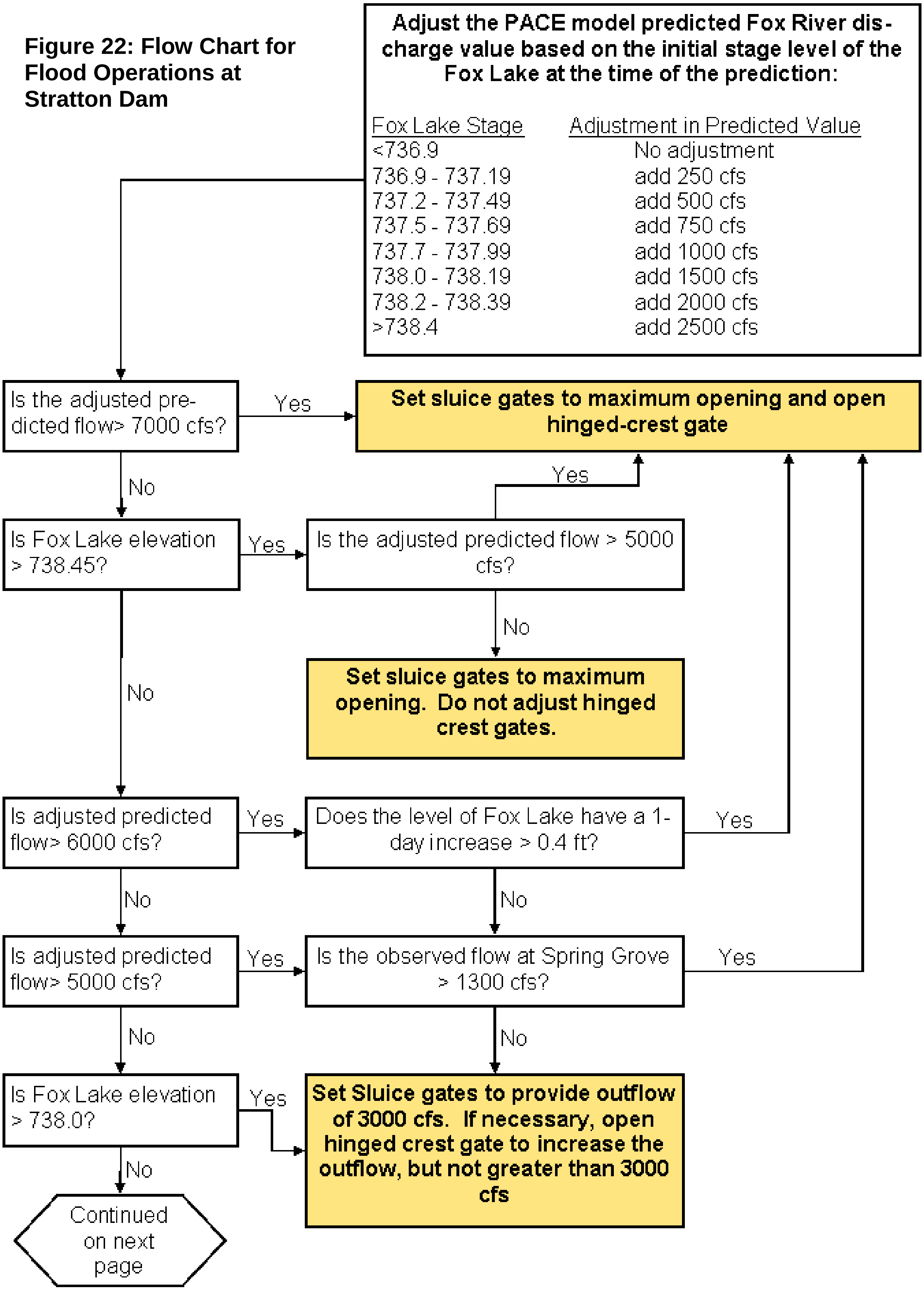
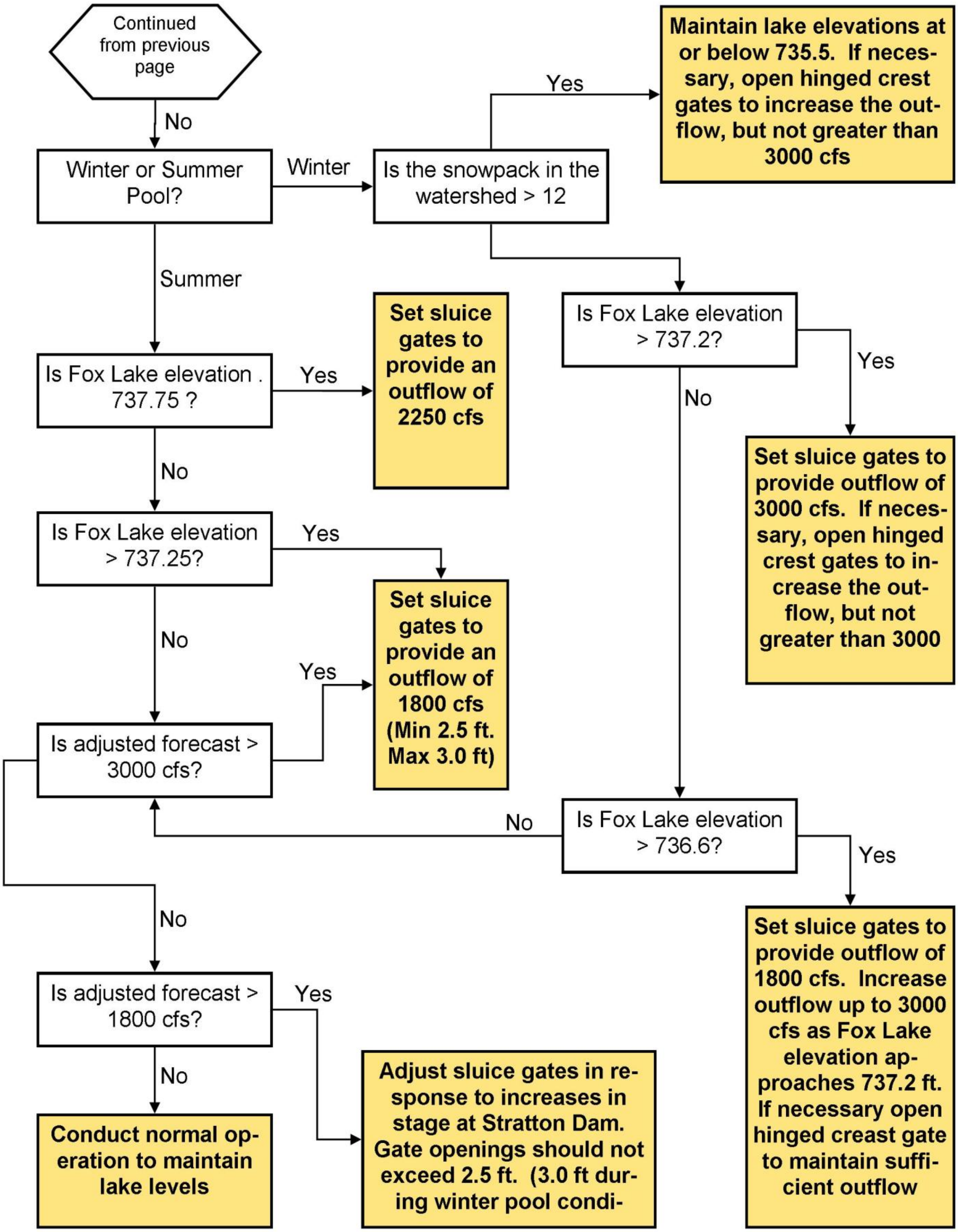


Figure 22: Flow Chart for Flood Operations at Stratton Dam

All predictions refer to predicted inflows coming into the Chain of Lakes as calculated by the PACE model


Continued from previous page
No
Winter or Summer Pool?
Winter
Is the snowpack in the watershed > 12
Yes
Maintain lake elevations at or below 735.5. If necessary, open hinged crest gates to increase the outflow, but not greater than 3000 cfs
Summer
Is Fox Lake elevation . 737.75 ?
Yes
Set sluice gates to provide an outflow of 2250 cfs
No
Is Fox Lake elevation > 737.25?
Yes
Set sluice gates to provide an outflow of 1800 cfs (Min 2.5 ft. Max 3.0 ft)
No
Is adjusted forecast > 3000 cfs?
Yes
No
Is adjusted forecast > 1800 cfs?
Yes
Adjust sluice gates in response to increases in stage at Stratton Dam. Gate openings should not exceed 2.5 ft. (3.0 ft during winter pool condi-
No
Conduct normal operation to maintain lake levels
Is Fox Lake elevation > 737.2?
Yes
Set sluice gates to provide outflow of 3000 cfs. If necessary, open hinged crest gates to increase the outflow, but not greater than 3000
No
Is Fox Lake elevation > 736.6?
No
Yes
Set sluice gates to provide outflow of 1800 cfs. Increase outflow up to 3000 cfs as Fox Lake elevation approaches 737.2 ft. If necessary open hinged creast gate to maintain sufficient outflow

FLOOD WARNING PLAN

Flood prediction is the means by which local officials can estimate the occurrence of a flood and foresee its impact on their community. This assessment of the potential impact of a flood defines the nature of the response activities to be used in protecting life and property. Once river stage predictions are available, local officials need to assess the impact of the predicted stage on their community.

Four warning levels will be used along the Fox River. Each warning level is tied into a river stage elevation which in turn corresponds to some expected degree of flooding in a community.

Table 13: Flood Warning Stages along the Fox River

Location	Bank Full		Minor Flood		Mobilization		Major Flood	
	Elev.	Dis.	Elev.	Dis.	Elev.	Dis.	Elev.	Dis.
New Munster	741.0	3200	742.5	4700	743.0	5500	743.5	6200
Fox Lake	737.5		738.5		739.5		740.5	
Johnsburg	737.0		738.0		739.0		740.0	
Stratton Pool	737.0	3000	737.5	5200	738.0	5900	739.0	7500
Stratton Tailwater	735.0	2900	736.0	4200	737.0	5500	738.0	6900
Algonquin	732.0	2500	733.0	6000	733.5	7100	734.0	8300
Carpentersville	722.5	2700	723.0	4200	723.5	5600	724.0	7400
East Dundee	712.0	2800	712.5	3600	713.0	4400	714.0	6200

The four warning levels will be identified as bank full stage, minor flood stage, mobilization stage, and major flood stage.

LEVEL 1 WARNING LEVEL

Bank full stage is defined as the river stage which equals the lowest riverbank elevation. Initial flooding will occur in areas adjacent to the river, but will not result in damages to property or a risk to the safety of residents.

LEVEL 2 WARNING LEVEL

Minor flood stage is defined as the river stage which results in the flooding of low-lying agricultural and park lands, roads, and basements. Bank erosion may also occur as may some minor damages.

LEVEL 3 WARNING LEVEL

Mobilization stage is defined as the river stage which results in low-level flooding of homes and businesses. The problems caused by this flooding situation can be adequately handled by local authorities with minimal assistance from State and Federal agencies.

LEVEL 4 WARNING LEVEL

Major flood stage is defined as the river stage which results in significant flood damage to public and private property and an increased risk to the safety of residents. Evacuation of flooded areas is necessary under this level of flooding. Problems caused by this level of flooding often overtax local resources, and Federal and State assistance may become necessary.

LOW FLOW OPERATIONS

Low flow operations follow the instream flow criteria discussed in "Instream Flow Protection: A Planning Standard for Illinois Streams", developed by the State Water Plan in 1983. When inflow is above 390 cfs the minimum release at Stratton Dam is 240 cfs. As the inflow drops below 390 cfs the release is then calculated as inflow plus lowest flow expected for a 7-day period once in every ten years ($Q_{7,10}$ = 94 cfs) divided by 2. The lowest gate setting at Stratton Dam is 0.10 foot with a discharge of 90.0 cfs when the pool is at an elevation of 736.76 feet. In addition, during the summer months when the lock is in operation there is an additional 8 to 10 cfs average daily discharge downstream from lockage.

In equation form, the minimum outflow during low flows is:

$$Q_{OUT} = (Qin + Q_{7,10}) / 2$$

$$Q_{OUT} = (Qin + 94) / 2$$

Presently Aurora, Elgin and Fermi National Accelerator Laboratory are the major users of Fox River water. Table 14 lists the average rate of withdrawal for these water users.

Table 14: Fox River Water Withdrawals

User	Average Rate of Withdrawal (mgd)	Average Rate of Withdrawal (cfs)
Aurora	10.0	15.5
Elgin	14.0	21.7
Fermi Lab	1.0	1.5
Total	25.0	38.7

TRANSITION TO SUMMER POOL

Almost all (85%) of the annual peak flood events occur as a result of snowmelt and early spring rainfall. Historical streamflow data was reviewed from 1940 at Wilmot and from 1916 at Algonquin to develop an operational plan for the transition from winter to summer pool.

The first of May will remain the target date for summer pool (elevation 737) to coincide with the opening of the locks to navigation. The lakes may be brought to summer pool earlier if all the following criteria are met.

1. The inflow from the winter snow melt event has passed;

2. The inflow to the lakes has dropped below the annual mean inflow of 685 cfs as measured at the New Munster (544 cfs) and Nippersink (141 cfs) gaging stations;

3. When the mean inflow of 685 cfs is obtained, there must not be any precipitation indicated on the National Weather Service 48-hour quantitative precipitation forecast (QPF).

Once this criteria is met, transition to summer pool may proceed following the guidelines given in "Instream Flow Protection: A Planning Standard for Illinois Streams." (Illinois State Water Plan, 1983).

The inflow available for storage is the maximum value of either the streamflow minus the 75% duration flow (Q_{75}) or the difference of the streamflow minus the lowest flow expected for a 7-day period once in every ten years ($Q_{7,10}$), divided by two.

In equation form, the standard is:

$$Q_{available} = \text{Maximum of} \quad \begin{matrix} Q_{stream} - Q_{75} \\ \text{or} \\ (Q_{stream} - Q_{7,10})/2 \end{matrix}$$

The Q_{75} inflow is 268 cfs measured at New Munster (185 cfs) and Nippersink (51 cfs). The $Q_{7,10}$ inflow is 89 cfs measured again at New Munster (73 cfs) and Nippersink (16 cfs).

WINTER DRAWDOWN

Winter drawdown at Stratton Dam starts on November 1 and continues to December 1 of each year. The normal drawdown is two feet below the crest of the spillway (736.76 feet), to an elevation of 734.76 at Stratton Dam. The resulting drawdown in the lakes is normally about 18 inches as monitored at the lake stations with the lowest drawdown to be at 735.5. The winter drawdown gives an additional 14,400 acre-ft of storage for flood control in the Chain-O-Lakes as measured from a summer pool stage of 4.2 feet to a winter drawdown stage of 2.5 feet.

On September 11, 1986, the Flood Control Advisory Committee of the Chain-O-Lakes Fox River Waterway Management Agency, recommended that winter drawdown of the Lakes area commence on the 15th day of October and reach normal winter water level by the 15th day of November. It was the general opinion of the committee that this change would minimize damage to the lower river area. Prior to this time the drawdown ran from November first to December first. In 1992 at the request of the Chain-O-Lakes Fox River Waterway Management Agency the winter drawdown was returned to November first. Numerous complaints from people having problems navigating in the waterway led to this return to the original drawdown dates.

The winter drawdown was re-investigated in 2011. Numerous requests were made during the previous 5 years to change the winter drawdown, i.e. eliminate winter drawdown or increase winter drawdown. The construction of the hinged crest gates does not reduce the need for the winter drawdown. Winter drawdown provides flood damage reduction benefits to numerous structures on the Chain of Lakes and Fox River. Increasing the winter drawdown, lowering of the winter pool stage, would increase these flood damage reduction benefits. However, there are environmental impacts associated with winter drawdown.

Delaying winter drawdown has been requested several times. Climatological data for the winters of 2000 – 2010 was reviewed. The 60° freezing days, the indicator of potential ice jams where outflows from Stratton Dam should be reduced to 1000cfs to minimize flooding, are reached by December 10 over 70% of the time. Therefore, the reduction of stage in the Chain of Lakes needs to be accomplished before December 10. Shortening the time to accomplish winter drawdown risks the potential for shoreline erosion. If an ice cover forms on the lakes before winter pool stage is reached, potential damage to seawalls and piers could occur as the pool under the ice drops.

Inflows to the Chain of Lakes as measured at the Fox River near New Munster, Wisconsin and Nippersink Creek near Spring Grove will be monitored during November. Long range temperature and precipitation forecasts by the National Weather Service will also be monitored. If inflows are below normal; temperatures are forecasted to be above normal; and precipitation forecasted to be below normal delaying of the winter drawdown will be considered. The winter drawdown will be started on November 1 but the drawdown would be completed at a slower rate to extend the completion into December.

EMERGENCY OPERATIONS DAM BREACH

As part of the dam safety analysis conducted in 1998 for the proposed hinged-crest gates at Stratton and Algonquin Dams, a dam breach analysis was conducted for each of the dams. Results of the dam breach analysis indicate that a breach of the Stratton or Algonquin Dams will not increase the threat to life nor property damage. In the event of a breach at either structure the flow conditions of the river will require monitoring just as during any other flood period.

Both Stratton and Algonquin Dams are masonry (concrete) structures. Both structures are relatively low in height with small storage upstream. The dam breach analysis examined three different breach events: the Probable Maximum Precipitation (PMP), 100-Year, and Static (normal pool) event. A comparison was made between the natural condition and the breach condition for each of the three events to determine changes in the water surface elevations resulting from the breach. Table 15 shows the results of the comparison of the peak stages from the simulated breach alternatives.

For the PMP and 100-year events there is very little impact downstream of the dams as a result of the simulated breach. This can be explained by the fact that when the simulation of the breach occurs the river channel and overbank areas are already inundated by the flood waters and the river stage differential between the pool and tailwater at the dams are minimal. In this respect, there is no increased threat to life or substantial property damage.

Under the third scenario, each of the structures was breached at a normal pool stage. Under these conditions the maximum difference exists between the pool and tailwater stages. The simulated breaches cause increases in stage and discharge directly downstream of each structure as the pool areas is drained. When Stratton Dam is breached the change in the stage directly downstream was 1.43 feet. When Algonquin Dam was breached the change in the stage directly downstream was 2.25 feet. In both cases as the flood wave travels downstream its effects are attenuated. The increases in stages generated by the breaches, has been reduced to 0.34 and 0.78 feet, respectively by the time it reaches Carpentersville Dam.

The increase in maximum discharges from the simulated breaches under the normal pool conditions at Stratton and Algonquin Dams coincide with flow rate equivalent to the discharges which would be expected from between the normal two and five-year flood events. Neither of these flood events poses a serious threat to life nor a risk of substantial property damage. Conditions may warrant the restriction of boat traffic and the possible closing of the river.

Table 15: Dam Breach Analysis For Stratton And Algonquin Dams With Hinged Crest Gates - Peak Stage

Node	Channel Lake	Fox Lake	Nippersink Lake	Johnsburg	Stratton Dam		Rawson Bridge	Algonquin Dam		Carpenters-ville Dam	East Dundee
					US	DS		US	DS		
	F12	U18	U24	D33	D43	DU44	D53	D65	U66	D71	D75
PMP EVENT											
No Breach	754.04	753.07	753.06	751.19	749.44	749.43	748.74	743.73	743.63	736.87	730.55
Stratton Breach	754.04	753.06	753.06	751.19	749.43	749.42	748.73	743.72	743.63	736.82	730.5
Difference	0.00	-0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.00	-0.05	-0.05
Algonquin Breach	754.03	753.06	753.06	751.19	749.43	749.42	748.73	743.72	743.63	736.84	730.52
Difference	-0.01	-0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.00	-0.03	-0.03
100 YR. EVENT											
No Breach	741.87	741.68	741.68	740.87	739.17	738.69	737.37	734.03	732.9	724.31	715.23
Stratton Breach	741.84	741.65	741.65	740.83	739.06	738.71	737.39	734.04	732.92	724.32	715.25
Difference	-0.03	-0.03	-0.03	-0.04	-0.11	0.02	0.02	0.01	0.02	0.01	0.02
Algonquin Breach	741.86	741.67	741.67	740.86	739.13	738.64	737.28	733.7	732.9	724.31	715.23
Difference	-0.01	-0.01	-0.01	-0.01	-0.04	-0.05	-0.09	-0.33	0.00	0.00	0.00
STATIC EVENT											
No Breach	737.19	737.19	737.19	737.19	737.12	732.4	731.83	731.37	726.94	721.72	710.22
Stratton Breach	737.19	737.19	737.19	737.18	737.09	733.83	732.66	731.77	727.76	722.06	710.96
Difference	0.00	0.00	0.00	-0.01	-0.03	1.43	0.83	0.40	0.82	0.34	0.74
Algonquin Breach	737.19	737.19	737.19	737.18	737.12	732.3	731.67	731.15	729.11	722.5	711.61
Difference	0.00	0.00	0.00	-0.01	0.00	-0.10	-0.16	-0.22	2.17	0.78	1.39

LOCAL INPUT TO OPERATIONS

If a gate change is to be made, the Elgin Water Treatment Plant is contacted so that they can make any needed operational changes due to changing flow rates. When outflows from Stratton Dam are below 200 cfs Fermi National Accelerator Laboratory is contacted.

PERMITS AND APPROVALS

This operation plan incorporates regulatory authorities and comments exercised by the following:

Illinois Department of Natural Resources

- Office of Water Resources permit for construction of hinged crest gates
- Comprehensive Environmental Review Program

United States Army Corps of Engineers

- Environmental Assessment for Hinged Crest Gates
- Special Area Management Plan

Illinois Environmental Protection Agency

- 401 water quality review of hinged crest gates

RECENT IMPROVEMENTS TO OPERATIONS:

1. More frequent data from the New Munster gage in Wisconsin - we now collect data every four hours instead of the 12 hour data collected previously. (Completed in 2004)
2. The evaluation of radar estimates of rainfall over the watershed for use in modeling predicted flows has been unsatisfactory. Some over estimation of rainfall is currently being seen in the radar data. Incorporation of this information into our watershed models requires additional work. (Published in 2006)
3. Discharge measurements made by the USGS have been used to develop improved estimates of flow through the new Obermeyer gates. This gives us a better understanding of the ability to move water out of the lakes, and whether the downstream channel can handle the flow. (Published in 2009)
4. IDNR/OWR survey crews surveyed the depth of the river from Algonquin Dam to Burton's Bridge, and from Stratton Dam to the outlet of Pistakee Lake to determine if siltation in the river is contributing to less flow capacity and more

flooding, and how siltation may be affecting boating. A similar effort was conducted in portions of the Chain of Lakes. (Completed in 2004)

5. Final USGS report for the rating equations for the control structures at Stratton and Algonquin Dams published. The new equations were added to the database which records water stages and calculates flow values. (Completed in 2010)

WORK YET TO BE PERFORMED:

1. Recalibration of the Fox River Prediction Model. This model is currently calibrated based on old land use data compiled by Northeastern Illinois Planning Commission in 1979 and daily average rainfall amounts. Updating the land use, and incorporation of better measurements of actual rainfall will improve the model.
2. Economic Impact Assessment - The assessment of flood damages to residential and commercial structures, as well as an assessment of recreational use which is impacted due to boating restrictions, will help to measure the positive and negative effects of the present operating plan. This work is in-progress.
3. Winter Drawdown Analysis - This analysis has been requested by those who believe the winter drawdown is environmentally damaging to the ecosystem of the region. This includes impacts to shorelines, habitat, fisheries, and wetlands. Such an analysis has been under discussion for some time, and efforts to move the study along are hampered by the lack of staff and dollars. Additional considerations for greater drawdown as well as an earlier drawdown have also been requested.
4. Operational Plan Revisions - With improved data collection, improved models, a better understanding of the positive and negative impacts of the present operating plan, we can look to the development of a modified operating plan. Specific modifications that have been requested include more proactive use of the gates, re-looking at boating restrictions, and investigation of adjustments to boundary constraints (flood prone structures, river capacity, etc.)

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