2006 Drought Exercise and Operations Guide

Prepared by

Erik R. Hagen
Mark A. Lorie
Cherie Schultz

May, 2007

The Section for Cooperative Water Supply Operations on the Potomac

Interstate Commission on the Potomac River Basin
51 Monroe St.
Suite PE-08
Rockville, Maryland 20850
Report No. 07-3

The Interstate Commission on the Potomac River Basin

This report was prepared by the Interstate Commission on the Potomac River Basin, Section for Cooperative Water Supply Operations on the Potomac. Funds were provided for this report by the Washington Suburban Sanitary Commission, the Washington Aqueduct Division of the U.S. Army Corps of Engineers, and the Fairfax County Water Authority.

Table of Contents

Table of Figures

Table of Tables

2006 Drought Exercise and Operations Guide

Prepared by Erik Hagen, Mark Lorie, Cherie Schultz
Section for Cooperative Water Supply Operations (CO-OP)
Interstate Commission on the Potomac River Basin (ICPRB)

Introduction

The three largest water suppliers in the Washington, D.C. metropolitan area (WMA) rely on the Potomac River and its reservoirs for water supply. These water suppliers cooperate on water supply operations in the Potomac, essentially operating as one entity in sharing water across the Potomac, Patuxent and Occoquan reservoir and riverine system during periods of low flow. The ICPRB's CO-OP section annually coordinates a week-long drought management exercise that simulates water management operations and decision-making under drought conditions for the WMA water suppliers. The exercise ensures that operational procedures are well practiced and understood, despite the possibility of many years between droughts. Annual simulation allows for the continual improvement of management tools and procedures, while training new personnel and refreshing procedures with veteran personnel.

The 2006 Drought Exercise took place September 20 through 28, 2006. Using simulated hourly flow data, CO-OP coordinated daily demands for water with available river flow, and determined virtual release rates from storage at Jennings Randolph Reservoir, Occoquan Reservoir, and the Patuxent reservoirs. In addition to the virtual releases, real releases were made from Little Seneca reservoir to test time of travel and to practice communications and operations. This report documents the findings and operational suggestions that resulted from the drought exercise. The report is organized into four sections, addressing background, communications, reservoir releases, and system management.

What's new

- A focus of this year's exercise was to practice shifting withdrawals from Great Falls to Little Falls.
- The hourly operational spreadsheet was modified to include explicit estimates of uncertainty in the Little Falls flow forecast.
- Useful information from prior drought exercises and from drought operations has been incorporated into this report, with the goal to provide a centralized repository for information that would otherwise be scattered among various reports. The report will be a useful resource for both utility personnel and CO-OP staff for next year's exercise or in the event of operations, and may be thought of as an evolving and continuously updated guide to operations.

Background

The majority (approximately 90 percent) of the WMA's population relies on water furnished by three water suppliers (collectively, Water Suppliers):

- The Washington Aqueduct Division of the U.S. Army Corps of Engineers (Aqueduct) serving the District of Columbia and portions of northern Virginia.
- Fairfax Water (FW) serving parts of northern Virginia.
- The Washington Suburban Sanitary Commission (WSSC) serving the Maryland suburbs

The Water Suppliers provide treated water either directly to customers or through wholesale suppliers to a total of approximately 4.1 million people (Kame'enui and Hagen, 2005). The Water Suppliers jointly own water storage in upstream Jennings Randolph and Little Seneca reservoirs that they have agreed to operate for their common benefit during droughts (Figure 1). In addition, WSSC and FW own and operate the Patuxent and Occoquan reservoirs, respectively, and have agreed to operate these reservoirs to improve regional water supply reliability during droughts.

Communications

Communication and coordination is a vital part of drought operations. This section of the report details the drought exercise pre-meeting, authorization for reservoir releases, web links, the daily drought updates, and coordination with the Metropolitan Washington Council of Governments (MWCOG).

Drought Exercise Pre-Meeting

A meeting of the CO-OP and the WMA Water Suppliers was held on September 6, 2006 in advance of the drought exercise. The purpose of the meeting was to:

- Share information about current maximum and minimum production capacity at each plant.
- Meet the other operational personnel from the other utilities.
- Discuss the drought exercise procedures.
- Update contact information.

Table 1 shows the production capacity information provided by the suppliers.

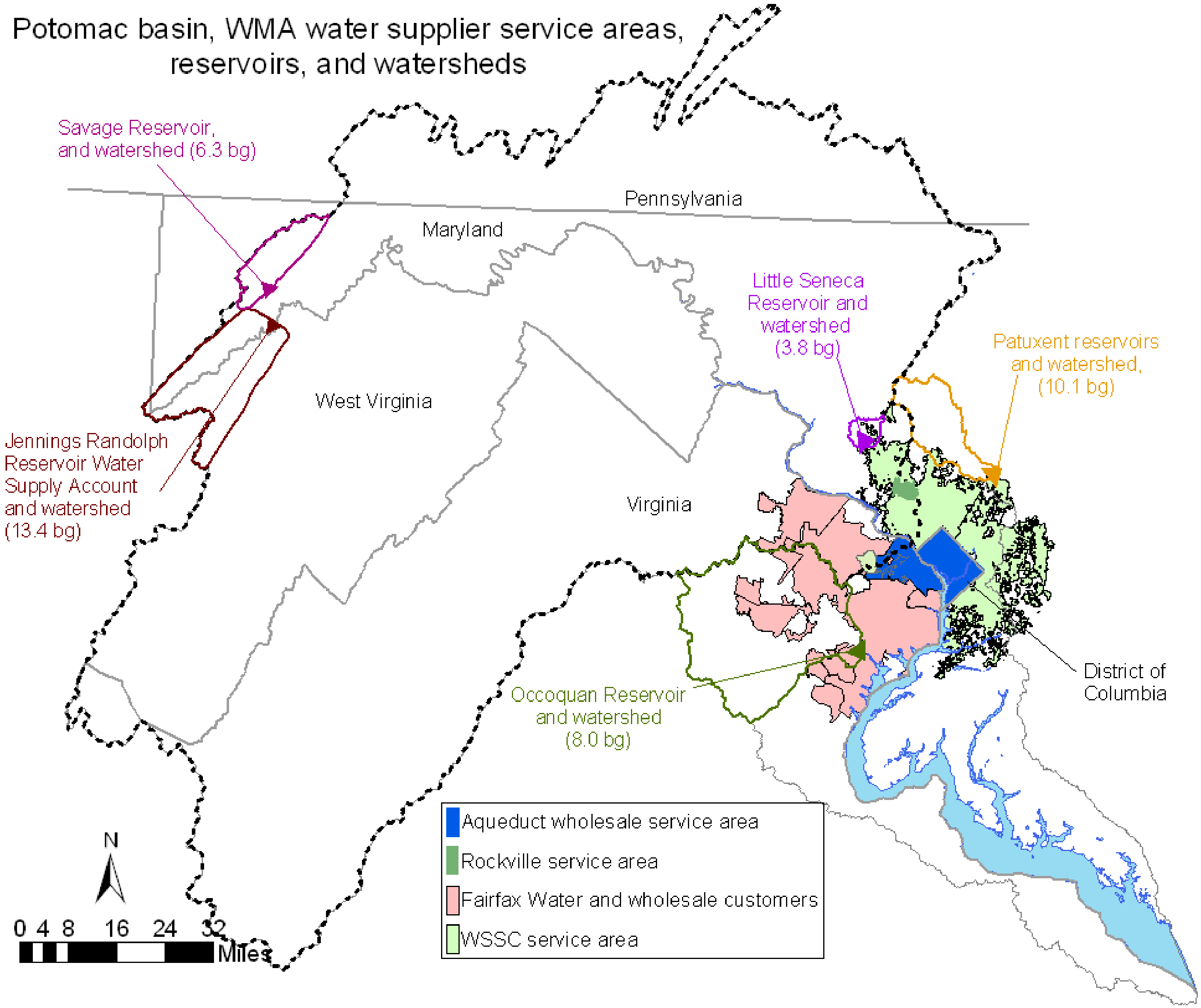

Figure 1: Potomac basin, Patuxent basin, basin states, water supply service area, and regional supply reservoirs

Table 1: WMA Water Suppliers Rated Production Capacities

Rated Production Capacity [MGD], max and min	
WSSC	
Potomac max	240[a]
Potomac min	100
Patuxent max	60 for a day or two, 50 continuously [b]
Patuxent min	45
FW	
Potomac max	150 (future: 225 with expansion, 2008 at the earliest)
Potomac min	50-60 MGD range, lower in the winter and higher in the summer [c]
Occoquan max	120
Occoquan min	Varies [d]
Aqueduct	
Dalecarlia max	200
Dalecarlia min	60
McMillan max	65-70 flat rate constrained by turbidity although short term can increase to 120 max.
McMillan min	63
TOTALS, maximum	
Total Potomac	**660 with short term increases possible**
Total System	**840 with short term increases possible**

[a]WSSC's Potomac plant, while rated at 285 MGD, cannot always move that volume of water. 240 MGD may be closer to the plant's current actual capacity.
[b]The Patuxent plant will be rated at a 72 MGD treatment rate with an emergency maximum of 120 MGD when the new plant is complete.
[c]The minimum current production from Potomac is a function of demand in the Potomac service area as well as pump capacities and the need to furnish part of Loudon County Sanitation Authority demand directly from Corbalis (Potomac) plant. Roughly, the minimum Potomac demand is the fraction of the total demand service by Potomac minus 35 MGD. (35 MGD is the maximum that can be transferred from the Occoquan service area, but note that approximately a 24-hour notice is required to configure yard piping at Pohick pumping station.)
[d]The minimum current production from Occoquan is a function of total demand in the Occoquan service area, and the maximum possible transfer from Potomac plant. The maximum transfer rate from Potomac plant to the Occoquan service area is 65 MGD, and minimal advance notice is required to effect this change. In addition to this constraint, there is also a hydraulic limitation requiring a minimum Occoquan withdrawal of 45 MGD. The minimum Occoquan demand is the greater of these two constraints. The fraction of demand that comes from the Potomac Service area is currently about 0.46, but will grow with time.

Authorization for water supply releases

During droughts, CO-OP provides operational recommendations to its Operations Committee, which has oversight per the Water Supply Coordination Agreement (1982). The Operations Committee is currently comprised of the Chief of the Washington Aqueduct, the Chief of Production for WSSC, and the General Manager of the FW. Communications between the CO-OP Operations Committee and CO-OP staff take place during droughts when water supply releases are imminent. The Operations Committee was contacted via email to authorize releases from Little Seneca Reservoir in specified amounts to take place as a part of this year's drought exercise.

Web links

Operators and others may be interested in the web links that ICPRB uses to evaluate precipitation forecasts and other weather related information as shown in **Table 2**.

Table 2: Websites and links for weather information

Description/ agency	**Website/directions**
Map showing quantitative forecast of precipitation, 1- and 2- days ahead. Middle Atlantic River Forecast Center (MARFC).	http://www.erh.noaa.gov/er/marfc/ Look for "Precipitation" heading on left margin, and click on "Forecasts."
Aerial map showing precipitation that has fallen in the region for the prior 24, 48 or 72 hours. MARFC.	http://www.erh.noaa.gov/er/marfc/ Look for "Precipitation" heading on left margin, and click on "Multisensor Obs."
Aerial map showing quantitative forecast of precipitation, 1 through 5 days ahead. National Weather Service's Hydrometeorological Prediction Center.	http://www.hpc.ncep.noaa.gov/qpf/qpf2.shtml Click on appropriate day's map. Days 1 through 5 show the total forecast.
Table showing daily average precipitation at each of the three regional airports. National Weather Service Forecast Office Baltimore/Washington.	http://www.weather.gov/climate/index.php?wfo=lwx This is an experimental site and may change in the near future.

Daily updates

Daily updates on evolving drought conditions and operations were sent out to the following distribution:

- WSSC: Tom Heikkinen, Karen Wright, John Kasprz, Todd Supple, Bill Staple, Roland Steiner.
- FW: Chuck Murray, Greg Prelewicz.
- Aqueduct: Tom Jacobus, Woody Peterson, Jay Nolan.
- Corps of Engineers, Baltimore District: Stan Brua.
- ICPRB: Joe Hoffman, Mark Lorie, Erik Hagen, Cherie Schultz.

Email address fields are as follows: To: Thomas.P.Jacobus@usace.army.mil, cMurray@fairfaxwater.org, theikki@wsscwater.com, gprelewicz@fairfaxwater.org, kwright@wsscwater.com, jKasprz@wsscwater.com, tsupple@wsscwater.com, wstaple@wsscwater.com, rsteine@wsscwater.com, John.W.Peterson@usace.army.mil, Leo.j.nolan@usace.army.mil CC: jhoffman@icprb, Stan.A.Brua@nab02.usace.army.mil, mlorie@icprb, cschultz@icprb.org, ehagen@icprb.org

Updates were written with a short summary at the top of the page, so readers could quickly identify new information. An example update is shown below:

EXERCISE
Today's Drought Exercise Summary (Tuesday 09/26/06)

Virtual flows continue to drop. VIRTUAL temperatures today and tomorrow are predicted to reach 105 deg. F, increasing forecasted virtual demands significantly. Therefore, we recommend 1) that the Aqueduct meet all demand from Little Falls and close the Great Falls conduits; 2) that WSSC load shift from the Potomac to the Patuxent (see below); and 3) that FW load shift from the Potomac to Occoquan (see below). Virtual releases from both Little Seneca and Jennings Randolph were initiated this morning.

NOTE: An ACTUAL Little Seneca release of 150 MGD was started this morning and will continue through tomorrow morning.

Gage Flow:
Little Falls flow 09/25: 1470 MGD
Little Falls flow 09/26: 1430 MGD (est.)
Point of Rocks flow 09/25: 1760 MGD
Point of Rocks flow 09/26: 1670 MGD (est.)

Net Production (09/25/06):
FW Corbalis raw water withdrawal (Potomac): 85 MGD
FW Occoquan raw water withdrawal: 89 MGD
WSSC Potomac Production: 128 MGD
WSSC Patuxent Production: 52 MGD
Aqueduct Great Falls withdrawal: 174 MGD
Aqueduct Little Falls withdrawal: 0 MGD
Total demand: 528 MGD
Potomac demand: 387 MGD

AM Predicted demands for Sep 26, Sep 27
FW predicted total raw water withdrawal: 176 MGD, 172 MGD
WSSC predicted total production: 175 MGD, 175 MGD
Aqueduct predicted total raw water withdrawal: 160 MGD, 160 MGD

PM Predicted demands for Sep 26, Sep 27
FW predicted total raw water withdrawal: MGD, 172 MGD
WSSC predicted total production: MGD, 175 MGD
Aqueduct predicted total raw water withdrawal: MGD, 160 MGD

ICPRB predicted demands for Sep 26, Sep 27
Predicted total raw water withdrawal for FW: 165 MGD, 160 MGD
Predicted total production for WSSC: 180 MGD, 179 MGD
Predicted total raw water withdrawal for the Aqueduct: 169 MGD, 169 MGD

9/26
A.M. Operations (The following is part of the 2006 Drought Exercise. Operational recommendations should not actually be implemented.)

Note: For virtual operations on this last day of the drought exercise, we assume that the predicted temperatures for today and tomorrow are 105 degrees, F. This leads to predicted virtual demands for today/tomorrow of WSSC: 194/204; FW: 181/185; WA: 175/194.

Fairfax Water: starting as soon as possible, and continuing until tomorrow morning
Simulated Occoquan withdrawal: 120 MGD (flexible)
Simulated Potomac withdrawal: 61 MGD (firm).

WSSC:
Simulated Patuxent withdrawal: 40 MGD until 7 PM this evening; 60 MGD from Sep 26 at 7 PM until at least Sep 27 at 4 AM.
Simulated Potomac withdrawal: 154 MGD until 7 PM this evening; 134 MGD from Sep 26 at 7 PM until at least Sep 27 at 4 AM.

Simulated Seneca: (release date, time, amount in MGD):
A VIRTUAL Little Seneca release of 60 MGD was initiated at 9 a.m.

Aqueduct:
Great Falls withdrawal target: 0 MGD
Great Falls New and Old conduit setting: closed
Little Falls: Withdrawal target: 175 MGD

Jennings Randolph release: A VIRTUAL water supply release from Jennings Randolph of 200 MGD was started this morning.

ACTUAL Reservoir Storage for Today			
Facility	Percent Full	Current usable storage, bg	Total usable storage, bg
WSSC's Patuxent reservoirs:	49	4.99	10.2
FCWA's Occoquan reservoir:	100	8.0	8.0
Little Seneca Reservoir	100	3.8	3.8
Jennings Randolph water supply acc	100	13.3	13.3
Jennings Randolph water quality acc	55	9.17	16.5
Savage Reservoir	53	3.3	6.2

Conference call, Drought Coordinating Technical Committee

A conference call of the regional Drought Coordinating Technical Committee (DCTC), coordinated by the MWCOG, took place on September 22, 2006 as a part of the drought exercise.

The simulated scenario for the conference call was developed by CO-OP and forwarded by MWCOG to the DCTC as follows:

Due to continued dry conditions in the Potomac Basin and recent information showing that the combined water storage in the Jennings Randolph and Little Seneca has now dropped below 60% as of this morning (September 20, 2006) we have scheduled a Drought Coordination Technical Committee conference call (agenda attached) for Friday, September 22, 2006 at 2 PM to discuss these ongoing conditions as well as consider a recommendation to move the region into the drought WARNING stage. Under the Metropolitan Washington Water Supply and Drought Response Plan a drought WARNING is triggered when the combined water supply storage at Jennings Randolph and Little Seneca reservoirs drops to 60% capacity for 5 consecutive days; or when there *is a 5% probability of not meeting unrestricted water supply demands over the next one to two months…*

As a matter of review, you are already aware that the Drought Coordination Committee declared a Drought WATCH for the region in late August, when 100% of the Potomac Basin entered D1 (moderate drought condition). Following that declaration, a press release was issued emphasizing that drinking water supplies were more than adequate to meet demand, that consumers were being asked to practice voluntary water conservation (referring them to the regional Water, Use it Wisely campaign for more information), and that we would continue to monitor these conditions.

.
The conference call agenda included:

- Roll call
- Overview of simulated regional drought conditions including: a review or regional drought conditions by MWCOG, status of the Drought Monitor and weather forecast by MWCOG, Summary of CO-OP system conditions and operations by ICPRB, water utility conditions by the suppliers, Maryland conditions by MDE, and a summary of VA conditions by VA DEQ
- Review of Drought Response Plan Guidance
- Discussion and Recommendations
- Next Steps

The DCTC provides technical recommendations to the Drought Coordinating Committee (DCC), composed primarily of the MWCOG Chief Administrative Officers. The DCC is responsible for declaring drought warnings and watches. Based on the simulated drought conditions described above, the DCTC unanimously recommended that no action be taken to move the region into a "Drought Watch" status. This conclusion was based on the time of the year (fall) with attendant cooling ambient temperatures, less evaporation and transpiration, and decreased consumer demand all expected in the near term.

CO-OP recommends including a similar conference call in coordination with MWCOG as part of future drought exercises.

Reservoir Releases and time of travel

Reservoir releases represent the mainstay of drought operations. This section of the report details the Little Seneca time-of-travel release and the Jennings Randolph and Savage reservoir release procedures and storage accounting.

Little Seneca release

As part of the drought exercise, a release was made from Little Seneca reservoir for the purpose of observing travel time and to exercise coordination with other agencies (Black Hills Regional Park via Maryland National Capital Park and Planning Commission [MNCPPC]) as well as the public through local elected officials. A press release was issued by CO-OP with the opportunity for input from MNCPPC (Appendix A). No newspapers picked up the story in this year's exercise, nor did they in last year's drought exercise despite a similar press release issued then. The Montgomery County Council and County Executive were given notification of the release in advance (Appendix B).

In the drought exercise of 2003, the Little Seneca release of 140 million gallons reduced the reservoir by 11.3 inches from full pool. Concern was raised by managers at Black Hills Regional Park that downstream fisherman would be washed out by the release. For the 2006 drought exercise,WSSC personnel ramped up the release relatively slowly to mitigate this concern, and it was seen that a release rate of 140 MGD increased the stage at Dawsonville by 0.7 feet.

Little Seneca release time of travel

Given background flow rates of 1,450 MGD, it appears that this year's release took about 14 to 15 hours to begin arriving at Little Falls (Table 3). Travel time is slower for lower river flows and is also a function of the size of the Seneca release rate. Table 3 shows the estimated travel times at several locations on various historical release dates. A release from Little Seneca during the extremely low flow conditions of 1999 and 2002 was not distinctly observed at Little Falls, as releases were obscured by variations in the hydrograph.

Table 3: Flow, release rates, and travel times from Little Seneca Reservoir to various locations

Date	Flow at Little Falls, MGD	Seneca release rate, MGD	Travel time to mouth of Seneca Creek on the Potomac, hours	Travel time to Little Falls intake, hours
September 26, 2006	1,450	150	Monitor not operational	14 to 15
September 27, 2005	700	145	7	20-23
September 30, 2005	650	75	9	20-24
October 3, 2005	700	75	8	20-23
September 8, 2004	1,500	140	Obscured by rain	NA
September 9, 2002	270	125	12 to 13	NA
April 25, 1989	3,800	310	5 to 6	NA
1986 (exact date unavailable)	NA	NA	10	NA

Versar, Inc collected stage data in the Potomac River during summer 2002 as part of a data collection program for reevaluation of the environmental flow recommendation. The travel time from the mouth of Seneca on the Potomac to Great Falls was not directly measured, but ICPRB estimated this travel time as approximately 6 to 7 hours during low flow periods, as based on Versar data for nearby monitoring locations (Kiang, 2003). The Versar data shows that the travel time between Great Falls to Little Falls is approximately 9 to 10 hours. Assuming a travel time of 12 to 13 hours from Little Seneca Reservoir to the mouth of Seneca Creek on the Potomac, the total travel time of a Little Seneca Reservoir release to Little Falls is thus calculated as 12 to 13 hours, plus 6 to7 hours for a release to travel from the mouth of Seneca Creek to Great Falls, plus 9 to 10 hours to travel from Great Falls to Little Falls, for **a total of approximately 27-30 hours during extreme low flows**.

Travel time from Edwards Ferry to Little Falls

ICRPB analyzed the real-time stage data from Edwards Ferry (see section on ICPRB river level monitors below) and Little Falls to determine travel time between these two points. Travel time was calculated by comparing identifiable points on each hydrograph, and varied as a function of river stage (Figure 2). The equation shown in Figure 2 can be used to predict travel time as a function of Little Falls river stage.

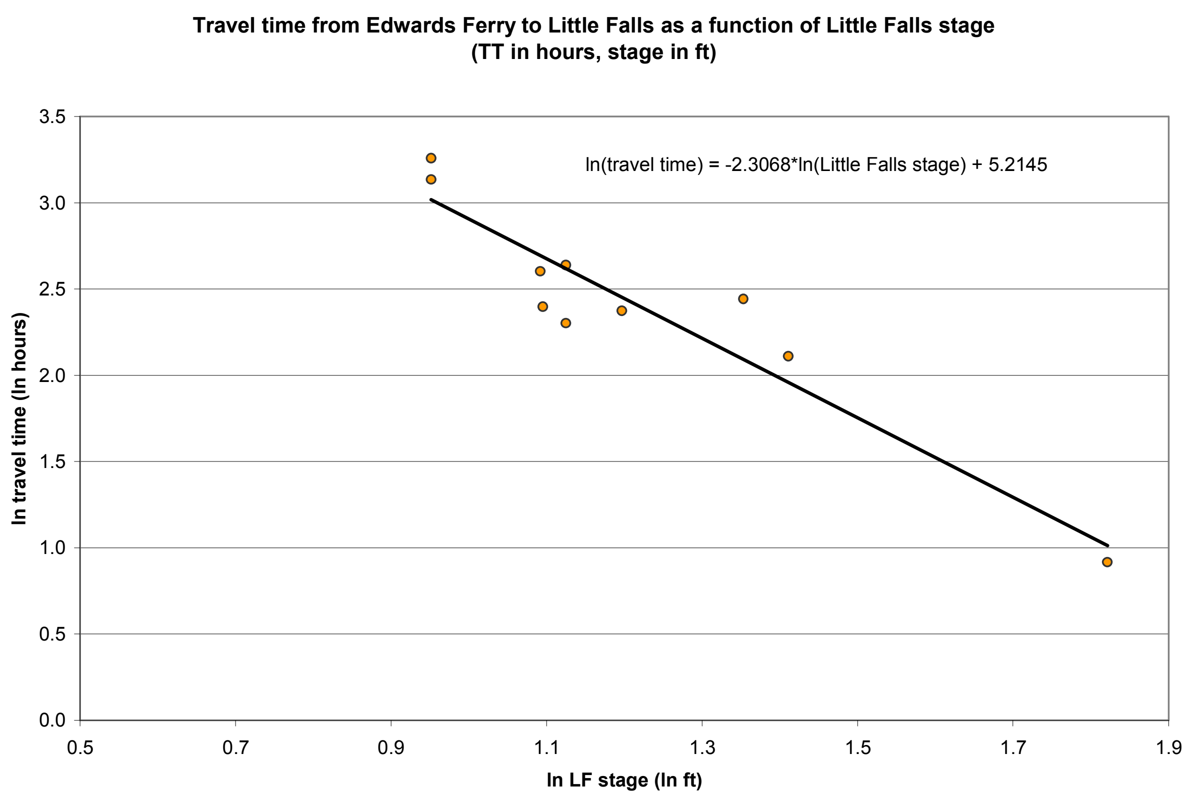

Figure 2: Travel time from Edwards Ferry to Little Falls as a function of Little Falls stage

Travel time of Jennings Randolph releases

Travel times of Jennings Randolph releases were observed for actual releases made in 2005 during a low flow period. These releases are documented in detail in ICPRB report 06-03. Travel times are summarized in Table 4.

Table 4: Travel time of Jennings Randolph releases

	Travel time from Luke (days) Release of 300 cfs, Point of Rocks flow of 1,400 cfs 9/27/2005	Travel time from Luke (days) Release of 700 cfs, Point of Rocks flow of 1,400 cfs 10/1/2005
Luke	0	0
Pinto	0.50	0.37
Cumberland	0.67	0.58
Paw Paw	1.40	1.27
Hancock	2.56	2.27
Point of Rocks	4.66	4.37
Little Falls	6.18	Not available

A factor which affects the travel time is the magnitude of the release. Larger releases travel faster. This is consistent with what would be expected from solitary wave travel theory which suggests that the travel time of the wave is a function of its magnitude (Dodd et al., 1984).

The magnitude of river flow also affects the travel time of the release, with quicker travel times associated with higher flows. During the lower flows experienced in the drought years of 1999 and 2002, when Point of Rocks flow was approximately 700 to 800 cfs, releases from Jennings Randolph took about 9 days to reach Little Falls (Kiang and Hagen, 2003).

Travel times assumed in operational model

Key travel times to Little Falls intake assumed in the hourly operational model are summarized in Table 5.

Table 5: Travel time assumed in operational spreadsheet model

From:	To: Little Falls intake (hours)
Little Seneca Reservoir	28
Fairfax Water intake	15
WSSC intake	9.6
Great Falls intake, river	9
Great Falls intake, aqueduct	4

Jennings Randolph and Savage release procedure and storage accounting

The Water Control Section of the Baltimore District of the U.S. Army Corps of Engineers (Baltimore COE) implements water supply releases from the North Branch system, which includes Jennings Randolph Reservoir and Savage Reservoir. Releases are made at the request of the CO-OP. Operational requests for reservoir releases are conveyed by 10:00 A.M. each morning by CO-OP staff, as would be the case during actual drought operations. Reservoir release rates from the North Branch system are modified daily. Given the estimate of a 9-day travel time to Little Falls, more frequent updates would most likely be unnecessary in most situations. For after-hours or weekend communications, CO-OP staff refer to the after hours call router and the "Priority Call List" (respectively) maintained internally by Baltimore COE staff. The list provides home contact information for Baltimore COE staff and prioritizes the call order. Both the call router and priority call list were tested during the exercise.

When releases are needed from the North Branch system for water supply, ICPRB determines a flow target just downstream of Jennings Randolph and Savage Reservoirs at Luke, Maryland and conveys this information to the Baltimore COE. This flow target is known as the "Luke target." (This target should be given to the Baltimore COE in cubic feet per second.)

Next, the COE determines how much water quality release they will make. The relevant agreement specifying COE operations is the *Agreement for Future Water Supply Storage Space in the Bloomington Reservoir*[1]*, Maryland and West Virginia*. Reservoir releases are made given the following criteria:

"The Government will make releases from Bloomington Lake to enhance water quality based upon the following considerations:

1. *Satisfaction of the requirements in the authorizing legislation (the Flood Control Act of 1962, Public Law 89-874.*
2. *The need for flow-by in the Potomac River,*
3. *The optimum overall quality of the Potomac River for all project purposes and for the benefit of all users downstream from Bloomington Lake.*

The Government may adjust any water quality releases upon a determination that such adjustment is in the public interest."

For this year's simulated water supply release, the COE credited 20 percent of the Jennings Randolph total release from the Savage Reservoir account. This policy, which initially was codified in the 1985 Master Manual for Reservoir Regulation, North Branch Potomac River Basin (COE, 1986), was effected during drought operations in the summer of 2002 and was supported in a letter dated May 2, 2003 written by James Taylor of the Upper Potomac River Basin Commission to Richard Olin of the Baltimore COE. This policy effectively provides a 20% credit to the water supply account at Jennings Randolph. The exact percentage used for the allocation is a function of the release rate from Jennings Randolph and is given on page L-6 (COE, 1986).

---

[1] Jennings Randolph Reservoir was formerly known as Bloomington Lake or Bloomington Reservoir

The example below illustrates the release and accounting procedures followed by the COE:

- A Luke flow target of 370 cfs is provided to Baltimore COE by ICPRB.
- Baltimore COE subtracts local inflow, in this example 10 cfs, to account for inflow between the reservoirs and the gage at Luke (370 cfs – 10 cfs = 360 cfs).
- The remaining flow (360 cfs) must be allocated between Jennings Randolph and Savage Reservoir. Eighty percent (288 cfs) is released from Jennings Randolph and twenty percent is released from Savage Reservoir (72 cfs).
- The water released from Jennings Randolph—in this example, 288 cfs—must be allocated between the water supply and water quality accounts. The net water quality release from Jennings Randolph in the drought exercise was 100 cfs.
- The net water supply release from Jennings Randolph is the difference between the total Jennings Randolph release of 288 cfs and the water quality release of 100 (288 cfs – 100 cfs = 188 cfs).
- Inflow greater than 50 cfs is distributed between water supply and water quality accounts. The first 50 cfs of inflow is passed through the reservoir as part of a water quality release. Inflow to the water supply account is allocated as a ratio of water supply storage to the total allocated capacity, 46.5% (per *Agreement for Future Water Supply Storage Space in the Bloomington Reservoir, Maryland and West Virginia*, 1982).

Table 6 provides the COE accounting of the water supply releases called for by CO-OP during this year's drought exercise.

Table 6: Jennings Randolph storage accounting spreadsheet provided by COE for Drought Exercise 2006

DATE mm/dd/yy	CURRENT RESERVOIR STATUS: ELEV @ 1000 HRS (FT NGVD)	CURRENT RESERVOIR STATUS: WATER SUPPLY STORAGE @ 1000 HRS (40,995 ac-ft Total) (AC-FT)	WATER SUPPLY STORAGE (%)	CURRENT RESERVOIR STATUS: WATER QUALITY STORAGE @ 1000 HRS (47,181 ac-ft Total) (AC-FT)	WATER QUALITY STORAGE (%)	LUKE: WS TARGET (CFS)	LUKE: EST. OBS. (CFS)	LUKE: EST. LOCAL (CFS)	AVERAGE RELEASES FOR LAST 24 HOURS: TOTAL SAVAGE (CFS)	AVERAGE RELEASES: TOTAL J.RAND (CFS)	AVERAGE RELEASES: J.RAND WQ (CFS)	AVERAGE RELEASES: J.RAND WS (CFS)	FLOW NEEDED TO REFILL WS STORAGE (CFS)	COMPUTED PROJECT INFLOW (CFS)	J.RANDOLPH INFLOW DISTRIBUTION: BASE INFLOW CREDITED TO WQ (first 50) (CFS)	J.RANDOLPH INFLOW DISTRIBUTION: EXCESS INFLOW Inflow>50) (CFS)	J.RANDOLPH INFLOW DISTRIBUTION: MAXIMUM. INFLOW TO WS (CFS)	J.RANDOLPH INFLOW DISTRIBUTION: USABLE INFLOW TO WS (CFS)	J.RANDOLPH INFLOW DISTRIBUTION: BALANCE OF INFLOW TO WQ (CFS)	CHANGE IN STORAGE DURING CURRENT DAY: WATER SUPPLY (AC-FT)	CHANGE IN STORAGE DURING CURRENT DAY: WATER QUALITY (AC-FT)
25-Sep-06	1440.6	40,995	100.0%	26,310	55.8%		235	0	50	200	200	0	0	35	35	0	0	0	35	0	-327
26-Sep-06		40,995	100.0%	25,983	55.1%	540	540	0	90	450	100	350	350	40	40	0	0	0	40	-693	-119
27-Sep-06		40,302	98.3%	25,865	54.8%		240	0	50	200	200	0	350	45	45	0	0	0	45	0	-307
28-Sep-06		40,302	98.3%	25,558	54.2%		250	0	50	200	200	0	350	45	45	0	0	0	45	0	-307
29-Sep-06		40,302	98.3%	25,251	53.5%		250	0	50	200	200	0	350	44	44	0	0	0	44	0	-309
30-Sep-06		40,302	98.3%	24,942	52.9%		250	0	50	200	200	0	350	36	36	0	0	0	36	0	-325
1-Oct-06		40,302	98.3%	24,617	52.2%		250	0	50	200	200	0	350	38	38	0	0	0	38	0	-321
2-Oct-06		40,302	98.3%	24,296	51.5%		250	5	50	200	200	0	350	60	50	10	5	5	55	9	-286
3-Oct-06		40,311	98.3%	24,010	50.9%		245	5	50	190	190	0	345	55	50	5	2	2	53	5	-272
4-Oct-06		40,316	98.3%	23,738	50.3%		245	5	50	190	190	0	343	50	50	0	0	0	50	0	-277
5-Oct-06		40,316	98.3%	23,461	49.7%		255	5	55	195	195	0	343	60	50	10	5	5	55	9	-277
6-Oct-06		40,325	98.4%	23,184	49.1%		250	10	60	180	180	0	338	250	50	200	93	93	157	184	-46
7-Oct-06		40,509	98.8%	23,139	49.0%		245	10	50	185	185	0	245	310	50	260	121	121	189	239	8
8-Oct-06		40,749	99.4%	23,147	49.1%		245	10	50	185	185	0	124	400	50	350	163	124	276	246	179
9-Oct-06		40,995	100.0%	23,326	49.4%		245	10	50	185	185	0	0	340	50	290	135	0	340	0	307

System Management

The operational procedures and technical tools that were a focus of this year's drought exercise are described in this section.

Daily Operational procedures for 2006 operations

Daily operations are:

7:30 am CO-OP:

1. Obtain latest USGS gage flows for Potomac River at Point of Rocks and Little Falls, and ICPRB gage levels. Estimate flow at Little Falls in 24 hours.

7:30 am Aqueduct, FW and WSSC:

1. Provide operator forms to CO-OP by email or by phone if arranged ahead of time. Please mail to coop@icprb.org or call 301 984 1908 x138 and leave a message.

7:45 am CO-OP:

1. Check to see if all water use, forecast, and storage data has been received by email or phone at CO-OP. If not, call the designated staff contact at their office phone number or alternate contact number if it is the weekend. If contact cannot be made, call the appropriate operations control center.

8:00 am CO-OP:

1. Determine the sustainable safe withdrawal from the Occoquan and Patuxent reservoirs, and estimate Potomac flow withdrawal rates.
2. Determine the appropriate Little Seneca and Jennings Randolph reservoir release rates, and withdrawal rates for the Aqueduct at Great Falls and Little Falls.

10:00 am CO-OP:

1. Provide email Potomac withdrawal rates to FW and WSSC (remainder of demand to be met from Occoquan and Patuxent) (MGD). Follow up with verbal contact.
2. Provide Little Seneca Reservoir release rate to WSSC (MGD).
3. Provide withdrawal rates for the Aqueduct at Great Falls and Little Falls (MGD).
4. Provide upstream release target for Jennings Randolph to the Baltimore District of the Corps of Engineers (cfs and MGD).

1:00 pm Aqueduct, FW and WSSC:

1. Update operator forms. Provide operator forms to CO-OP by email or by phone if arranged ahead of time. Please mail to coop@icprb.org or call 301 984 1908 x138 and leave a message.

1:15 pm CO-OP:

1. Check to see if all operator forms have been received by email or phone at CO-OP. If not, call the designated staff contact at their office phone number or alternate contact number if it is the weekend. If contact cannot be made, call the appropriate operations control center.
2. Update flows. Advise WSSC of any needed change in the release rate for Little Seneca Reservoir.
3. Advise FW and WSSC if any adjustments are necessary for off-Potomac reservoirs.

4:00 pm CO-OP

1. Calculate tomorrow's recommended withdrawal targets for Great Falls and Little Falls.
2. Provide the withdrawal rates to the Aqueduct.
3. Update website with a summary of the day's operations.

Anytime: Update Little Seneca release rate as necessary. Contact WSSC control center directly.

Demand forecasting tool

CO-OP uses a demand forecasting tool that can predict daily demand at each utility, based on stepwise multivariate linear regression (backwards stepping) combined with an autoregressive moving average model (ARMA). Independent variables as inputs for estimating the current day's and next day's demand include:

- the number of consecutive days rainfall is less than 0.15 inches
- the prior day's demand
- the day-of-week
- soil moisture (Palmer drought severity index)
- today's estimated maximum temperature
- tomorrow's forecast maximum temperature
- today's estimated rainfall
- tomorrow's forecast rainfall
- prior days' maximum temperature (up to 2 days)
- prior days' rainfall (up to 5 days)

Demand forecasting contest - Results

Operators competed with each other in the third "*ICPRB CO-OP Annual Demand Forecast Competition.*" The winner of this year's contest was Fairfax Water. Last year's winner was the Washington Aqueduct.

Operator estimates were consistently better than the CO-OP model for the current day's demand for all three suppliers (Table 7).

Table 7: Demand forecasts and results for 2006 drought exercise.

Drought Exercise 2006: Demand Forecasting Contest Results	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep	25-Sep	26-Sep	*Average Absolute Error for Operator Forecasts*	*Average Absolute Error for ICPRB's Forecast Model*
FAIRFAX WATER OPERATOR FORECASTS									
A.M. estimate of today's Raw Water Use, MGD	176	172	170	166	172	170	176		
P.M. estimate of today's Raw Water Use, MGD	176	172	174	166	172	178	176		
Tomorrow's estimated Raw Water Use, MGD	172	168	170	168	170	172	172		
Actual Raw Water Use, MGD	178	167	176	167	180	174	180		
Error, A.M. Estimate	-2	5	-6	-1	-8	-4	-4	**4.3**	**14.1**
Error, P.M. Estimate	-2	5	-2	-1	-8	4	-4	**3.7**	**14.1**
Error, Tomorrow's Estimate	5	-8	3	-12	-4	-8	-5	**6.4**	**10.7**
WASHINGTON AQUEDUCT OPERATOR FORECASTS									
A.M. estimate of today's withdrawal, MGD	160	160	155	145	145	160	160		
P.M. estimate of today's withdrawal, MGD	160	160	150	145	145	160	160		
Tomorrow's estimated withdrawal, MGD	160	160	150	145	155	160	160		
Actual withdrawal MGD	148	181.9	151	146	159	174	155		
Error, A.M. Estimate	12	-21.9	4	-1	-14	-14	5	**10.3**	**14.8**
Error, P.M. Estimate	12	-21.9	-1	-1	-14	-14	5	**9.8**	**14.8**
Error, Tomorrow's Estimate	-21.9	9	4	-14	-19	5	-2	**10.7**	**14.1**
WSSC OPERATOR FORECASTS									
A.M. estimate of today's production, MGD	165	170	170	170	180	180	175		
P.M. estimate of today's production, MGD	170	170	170	170	190	180	175		
Tomorrow's estimated production, MGD	170	170	180	180	170	175	175		
Actual production, MGD	173	165	176	166	185	180	185		
Error, A.M. Estimate	-8	5	-6	4	-5	0	-10	**5.4**	**8.6**
Error, P.M. Estimate	-3	5	-6	4	5	0	-10	**4.7**	**8.6**
Error, Tomorrow's Estimate	5	-6	14	-5	-10	-10	-9	**8.4**	**8.1**

Shifting demand from Great Falls to Little Falls

One of the objectives of the 2006 drought exercise was to practice shifting the Aqueduct withdrawals from Great Falls to Little Falls, i.e., "load shifting." *Load shifting from Great Falls to Little Falls can cause significant dips in flow at Little Falls, lowering flows by a margin greater than the value of the quantity of water shifted.* This issue was first encountered in operations during the drought of 1999. In 2002, the same problem occurred and operators observed that the problem correlated with a decrease in withdrawals at the upstream Great Falls intake combined with an increase in withdrawals at Little Falls intake. River flow at Little Falls was observed to drop by more than the quantity of water pumped from the river at that intake. As the drought of 2002 progressed, and operators observed the phenomena in more detail, it became clear that shifting withdrawals from Great Falls to Little Falls intakes can lower flows by a margin greater than the value of the quantity of water shifted. **This consequence is very important for current (and any future) CO-OP staff to understand, otherwise their actions could cause the instantaneous flow to drop below desired levels.**

In 2002, CO-OP staff linked the variability issue to differences in travel time between Great Falls intake to the Dalecarlia treatment plant via the aqueduct, and the travel time from Great Falls intake to Little Falls intakes via the Potomac River. This phenomenon can be explained as follows. Withdrawals at Great Falls take 4 hours to travel through the aqueduct and reach Dalecarlia water treatment plant near Little Falls (Woody Peterson, personal communication, 2003), however travel time of flow in the river from Great Falls to Little Falls is about 9 to 10 hours (Kiang and Hagen, 2003). When Great Falls withdrawals are reduced or stopped, it takes about 4 hours for the change in operations to be reflected at the end of the aqueduct at Dalecarlia. At this time, pumping must begin at Little Falls to make up for the reduced flow in the conduit. However, the pumps are withdrawing from flow in the river that has already experienced the full withdrawal from Great Falls. For five hours, the pumps will be withdrawing water from flow that has already been reduced by withdrawals at Great Falls. Therefore, shifting x amount of demand from Great Falls to Little Falls can result in a flow reduction that is twice the amount of the load shifted, i.e., $2x$, which lasts for a period of about 5 hours.

The 2003 drought exercise addressed the issue of flow variability through the incorporation of an hourly operational model. The ability to view simulated effects of water supply operations on flow was an important improvement. The consequences of operational decisions, good or bad, were reflected in subsequent flow, lending more realism to the drought exercise and thus creating better opportunities to refine decision making procedures.

In the drought exercise of 2004, simulated flows at Little Falls rose and fell precipitously (Figure 3), just as they did during actual drought operations in 1999 and in 2002. Of particular note, the simulated flow rates in the drought exercise dropped well below the minimum recommended flow of 100 MGD for portions of the day. This occurred because too big of a shift was made from Great Falls to Little Falls when flow was too close to 100 MGD at Little Falls.

This result illustrated the importance of using the spreadsheet tool to model operational changes ahead of their implementation, and to practice shifting withdrawals from Great Falls to Little Falls. Therefore, a major focus of this year's drought exercise was to practice the operational shifting from Great Falls to Little Falls, and to use the available information from the Edwards Ferry gage to do so.

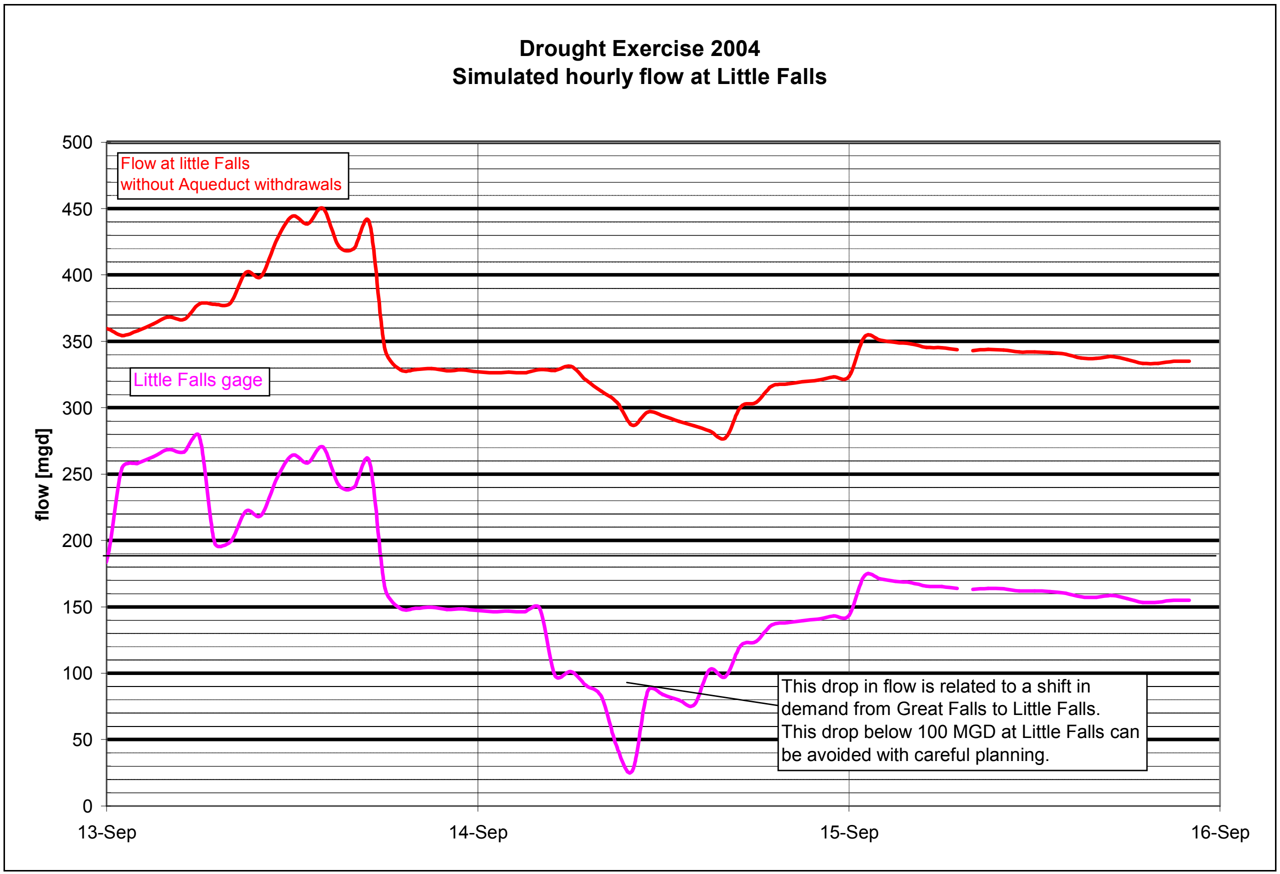

Figure 3: Simulated hourly flow at Little Falls, illustrating the flow variability at Little Falls gage after shifting withdrawals from Great Falls to Little Falls from Drought Exercise of 2004

Potomac withdrawals and pumping operations

Variations in Potomac withdrawals affect flow downstream at Little Falls. Without careful management, flow variability can affect the ability of ICRPB staff to measure and calculate how much water is in the river. This information is critical for calculating the amount to release from Little Seneca and other operational requirements, and is used as input to the hourly operational spreadsheet model.

CO-OP staff tracked the hourly operations for:

- WSSC Potomac plant.
- FW Potomac plant.
- Aqueduct's Great Falls gate settings and Little Falls pumping.

Operator forms are given to each utility at the beginning of the drought exercise to document exactly what information is needed (See Appendices C, D, and E). These forms are updated during the drought exercise at 7:30 AM and at 1:00 PM each day. The tracking went very smoothly. CO-OP staff recommend that the same operator forms and procedures be used for the next exercise and future operations.

During extreme low flows, CO-OP asks WSSC and FW to maintain a steady withdrawal from the Potomac as much as possible. This allows CO-OP staff to predict flow rates downstream at Little Falls, and allows CO-OP staff to maintain the flow while it is near minimum levels.

WSSC has a large storage capacity in water tanks relative to their withdrawal and relative to their Potomac demand, and the stored water is used to reduce the peak withdrawals. The tanks are refilled during lower demand periods, and the net result is a fairly steady withdrawal rate from the Potomac during low flows. FW currently has less storage relative to their Potomac withdrawal and has a more limited ability to keep the Potomac withdrawal steady. WSSC and FW hourly withdrawals are shown in Figure 4 as reported during this year's drought exercise. This graph illustrates the variability of withdrawals from these plants.

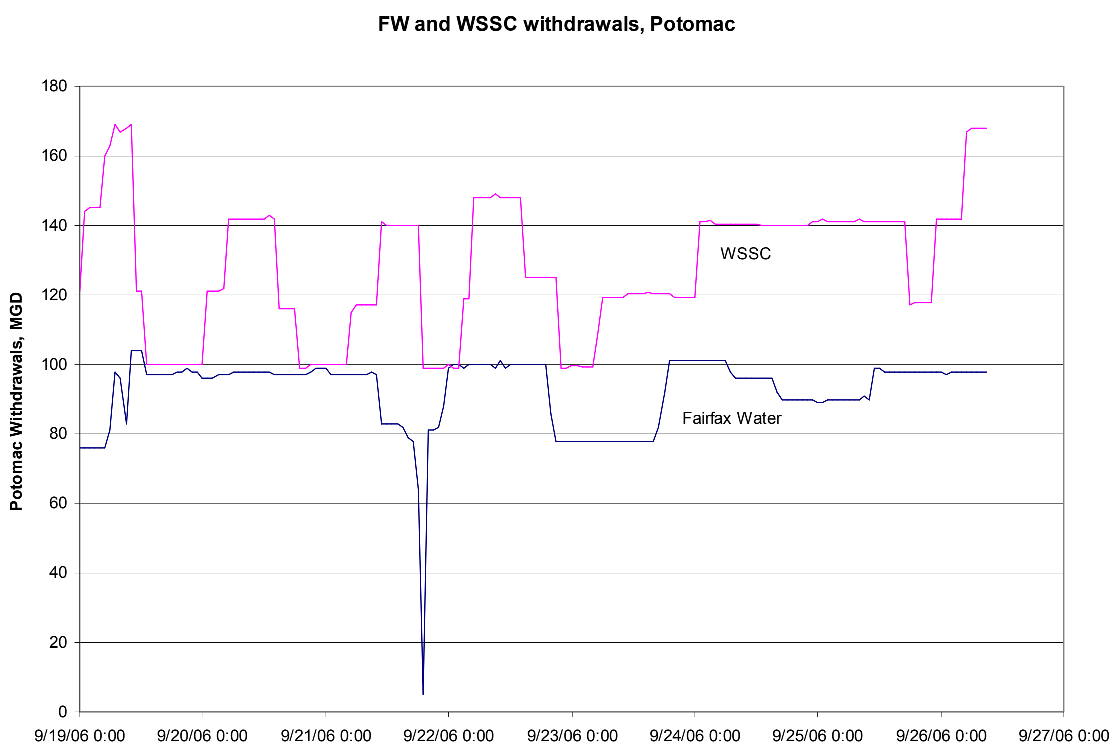

Figure 4: FW and WSSC raw water withdrawals/production during drought exercise

The ability to fine tune withdrawals from the Potomac is limited by the size of the WSSC raw water pumps. The approximate capacities of WSSC's raw pumps on the Potomac are as follows:

WSSC Pumps:	Capacity:
R1, R2, R5, R6	50 MGD
R7, R8, R9, R10, R11, R13	55 MGD
R3, R4	25 MGD

There are ranges, such as below 100 mgd, where rate changes would have to be as much as 25 mgd. Above 100 mgd WSSC can change the withdrawal rate by as little as 5 mgd with various combinations of pumps, but there are some gaps where the jumps would be higher.

<Is there a similar issue with FW pump sizes?>

The Aqueduct takes all of its water from Little Falls when flows are near the minimum flow recommendation. Withdrawals are usually maintained at a fairly steady rate. The Aqueduct has about a half-days worth of storage, and can reduce a withdrawal in the short term if needed. Changes to withdrawal rates by the Aqueduct have an immediate effect on Little Falls flow.

Figure 5 below shows the pump numbers and associated ratings in MGD for the Little Falls pumping station.

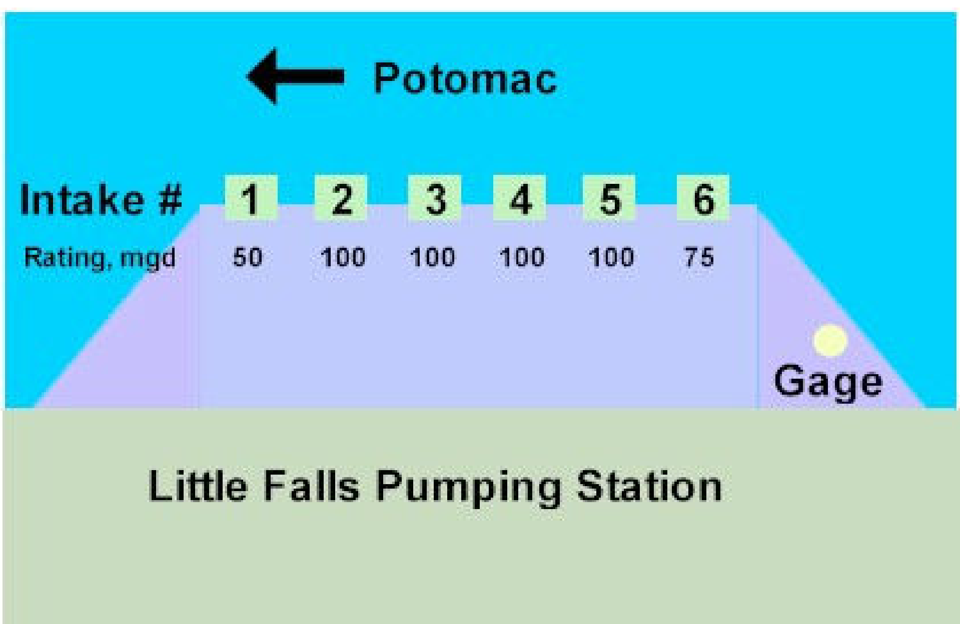

Figure 5: Aqueduct Little Falls pumping station, rated pump capacity

Great Falls gate settings were tracked to see if a withdrawal rate could be determined as a function of Great Falls gate settings and Potomac flow rate. Unfortunately, it is very difficult to keep the gates at one setting for a 24-hour period and no clear relationship could be determined from the data collected in 2006. The best available information was collected during the drought of 2002 and is provided in Table 8.

Table 8: Estimated withdrawal at Great Falls for various gate settings during the drought of 2002. The estimated flow upstream of Great Falls was between 400 – 500 mgd on each day.

	Gate Setting, ft	Great Falls withdrawal, mgd
9/15/02	1.25 - 1.50 *	110
9/16/02	1.25 - 1.50 *	130
8/16/02	1.00	106
9/20/02	1.00	103
9/21/02	1.00	106
9/22/02	1.00	121
9/23/02	1.00	107
9/13/02	0.75	90
9/14/02	0.75	73
7/13/02	0.50	32

* New conduit gate was set at 1.25 feet, old conduit gate was set at 1.50 feet.

:

ICPRB Potomac River level monitors

Two Potomac River level monitors were operational for the drought exercise. The Edwards Ferry monitor is maintained year round, and an additional monitor was deployed on the Potomac River near the mouth of Seneca Creek as a part of the drought exercise. The Seneca gage site is prone to flooding, so it is only deployed during summers. The Edwards Ferry gage is used to provide an advance prediction of river flows in order to monitor and improve the efficiency of water supply releases (Table 9). The monitor at the mouth of Seneca Creek is also valuable for drought operations, both as a backup for predicting Little Falls flow and for monitoring the arrival of the Jennings Randolph and Little Seneca Reservoir releases.

The simulated data for the Edwards Ferry monitor was extremely useful for determining how much water to release from Little Seneca Reservoir during the drought exercise. The travel time from Little Seneca Reservoir to Little Falls is approximately the same as it is from Edwards Ferry to Little Falls during low-flow periods, so it can be used to synchronize releases from Little Seneca Reservoir in order to meet flow targets at Little Falls. ICPRB report 06-02 provides a summary of the pilot 2005 Potomac water level monitoring program, including data analysis, a plot of the stage-discharge relationship between Edwards Ferry stage and adjusted Little Falls flow, and recommendations and conclusions.

Edwards Ferry gage was deployed in October of 2005, and stage information from this monitor was updated to the Internet in real-time starting in mid-December of 2005 through the present. A link to the website is available at www.potomacriver.org. (Go through the "Water Supply" link and select "Edwards Ferry.")

Table 9: Rating curve for Edwards Ferry stage monitor, showing predicted Little Falls flow as a function of Edwards Ferry stage, based on data collected in 2005.

Stage	Little Falls flow, adjusted, MGD	standard deviation	Stage	Little Falls flow, adjusted, MGD	standard deviation	Stage	Little Falls flow, adjusted, MGD	standard deviation
93.15	1,090	15	93.5	1,440	177	93.89	2,010	191
93.16	1,110	28	93.51	1,490	153	93.99	2,180	172
93.17	1,100	31	93.52	1,470	103	94.09	2,360	172
93.18	1,110	42	93.53	1,530	118	94.19	2,470	123
93.19	1,130	59	93.54	1,550	114	94.29	2,670	NA
93.2	1,140	68	93.55	1,570	125	94.39	2,800	NA
93.21	1,140	52	93.56	1,550	135	94.51	3,220	NA
93.22	1,170	74	93.57	1,560	136	94.61	3,170	NA
93.23	1,150	64	93.58	1,580	94	94.71	3,450	NA
93.24	1,150	71	93.59	1,590	111	94.81	3,680	NA
93.25	1,170	73	93.6	1,590	87	94.91	3,760	NA
93.26	1,170	78	93.61	1,600	69	95.01	4,010	NA
93.27	1,190	81	93.62	1,610	84	95.11	4,270	NA
93.28	1,190	70	93.63	1,620	76	95.21	4,640	NA
93.29	1,200	80	93.64	1,620	78	95.31	4,750	NA
93.3	1,180	66	93.65	1,630	82	95.41	5,110	NA
93.31	1,200	67	93.66	1,620	67	95.51	5,410	NA
93.32	1,190	75	93.67	1,600	82	95.61	5,720	NA
93.33	1,220	81	93.68	1,580	74	95.72	6,030	NA
93.34	1,240	78	93.69	1,630	87	95.82	6,330	NA
93.35	1,240	85	93.7	1,650	69	95.92	6,950	NA
93.36	1,220	76	93.71	1,680	54	96.02	7,330	NA
93.37	1,220	71	93.72	1,700	101	96.12	7,520	NA
93.38	1,230	92	93.73	1,680	58	96.22	7,810	NA
93.39	1,250	96	93.74	1,690	90	96.33	8,340	NA
93.4	1,270	103	93.75	1,700	92	96.56	9,250	NA
93.41	1,290	102	93.76	1,740	137	96.83	10,090	NA
93.42	1,260	94	93.77	1,730	111	97.07	11,000	NA
93.43	1,290	111	93.78	1,740	108	97.4	12,290	NA
93.44	1,290	114	93.79	1,780	160	97.68	13,780	NA
93.45	1,310	133	93.8	1,780	158	98.04	15,130	NA
93.46	1,410	117	93.81	1,890	204	98.5	16,880	NA
93.47	1,400	136	93.82	1,860	154	99.07	19,140	NA
93.48	1,380	144	93.83	1,940	188	99.48	21,850	NA
93.49	1,420	142	93.84	1,910	171			

The monitor near the mouth of Little Seneca was deployed in August, 2006, but communications could not be established in time for the exercise. This was due to a prolonged period of 6 weeks required by Verizon to activate the modem. The gage modem is now kept operational year round so that it can be deployed without going through the extended activation process with Verizon.

Determining withdrawals from Patuxent and Occoquan reservoirs

The Patuxent and Occoquan reservoirs in the Washington Metropolitan Area (WMA) are operated to meet a specific target: that they reach 90 percent full by June 1 of each year at a 95 percent reliability (i.e., 95 percent of the time), per agreement by the Water Supply Coordination Agreement of 1982 (WSCA, 1982).

In the late 1990s, ICPRB CO-OP developed an interactive graphical tool to help reservoir operators craft sustainable withdrawal strategies that met this reliability standard. This tool was based on conservative estimates of historical reservoir inflows. Specifically, the 5th percentile flow of the historical record for each month between the current time and the following May were strung together and used as the benchmark series of inflows. This series of flows represented a highly conservative approximation of the 5% probability event and, therefore, a safe benchmark for operations. In the early 2000s, this tool was augmented with an interactive spreadsheet visualization tool that used position analysis. Position analysis is a simulation of reservoir storage given the historical record of streamflows and conducted with an assumed starting storage and various assumptions about reservoir withdrawal rates. These spreadsheets were used in the Drought Exercise of 2006. More recent work has further refined these spreadsheet tools to incorporate flow forecasts into the calculation of reservoir refill probabilities.

Results

Practicing communications, conducting reservoir releases, and testing operating tools are a part of each year's drought exercise and generally are a valuable contribution to drought preparation and readiness. This year was no exception. In addition, annual exercises allow for ongoing improvements to drought operations and management. Some notable results are summarized here:

- New staff were trained on using the tools and conducting operations, and drought operations procedures have been reinforced for those who participated in prior exercises.

- The hourly operational spreadsheet for drought exercises and real operations was modified to incorporate the information available from the Edwards Ferry flow monitor, including an estimate of the uncertainty of the Little Falls flow prediction.

- Incorporating uncertainty into the forecast of Little Falls flow helped water managers in developing the release recommendations from Little Seneca Reservoir.

- The use of Edwards Ferry gage information in operational spreadsheets was very useful in shifting withdrawals from Great Falls to Little Falls. The simulated shift in withdrawals from Great Falls to Little Falls in this year's drought exercise was successful, without any fluctuations in instantaneous flow at Little Falls below the 100 MGD threshold.

- The conference call of MWCOG Drought Technical Coordinating Committee was a success. Call participants made a recommendation to the broader Drought Coordinating Committee that allowed for adaptive management of the drought plan, as modified by current conditions. The precedent of flexibility and adaptive management was firmly established. The increased flexibility in such a strategy avoids the pitfalls of automatic triggers.

- The use of software which allows CO-OP staff to share views of our computer screens remotely while teleconferencing proved very useful for sharing information.

- Outreach to agencies and elected officials in coordination with the Little Seneca and Jennings Randolph reservoir releases reinforced the message of water supply reliability and reservoir releases as a part of normal drought operations.

Conclusions and recommendations

CO-OP staff conclusions and recommendations are very practical and operational in nature, and reinforce the lessons learned of both prior drought exercises and drought operations. These include:

- Continue to conduct Little Seneca travel time releases during drought exercises or during periods of low flow, and conduct time of travel Jennings Randolph releases during low flows. These releases are important for determining travel time and for exercising public communication and coordination with other agencies.
- This year's coordination with a designated point of contact at the three utilities resulted in optimal operational management. Continue to implement this strategy.
- Maintain an hourly operational spreadsheet for drought exercises and real operations that incorporates the information available from the Edwards Ferry flow prediction and the uncertainty in the flow estimate explicitly.
- Designate a staff person to copy all files to a cd or portable drive at the end of each day in the event of a power shortage or an inability to connect to the ICPRB server.
- Distribute operator forms prior to the exercise or prior to drought operations.
- Ask utility operations personnel to include all CO-OP staff on email distribution.
- Continue to hold a pre-exercise meeting to establish minimum and maximum treatment capacity information and to update communication procedures.
- Given the increased demands on time and effort during droughts, continue to schedule at least three CO-OP staff persons during both drought exercises and for actual drought operations.
- Start on Wednesday, to allow 3 full days of operations before the weekend. Also, conduct a "dry-run" of the exercise the day before.

- Contact MWCOG in advance of the drought exercise and plan a scenario for them to implement in their role as regional coordinator of drought response plans. Continue to hold a Drought Technical Coordinating Committee meeting, in which the participants provide a recommendation to the broader Drought Coordinating Committee.
- Continue to copy all utility staff on all correspondence so that everyone is aware of changes in operations at other facilities. This provides more transparency in operations, as well as more redundancy.
- Review the 2006 drought operations report and the operations manual prior to the beginning of the 2007 exercise.
- Continue to refine and use the newly developed spreadsheet tools for determining sustainable withdrawal rates from Patuxent and Occoquan reservoirs.
- Maintain steady withdrawals at FW and WSSC as much as possible
- Consider holding a meeting similar to the proposed pre-exercise meeting if reservoir releases and active drought management appears likely.
- Continue research into methods for developing an improved forecast for Little Falls flow for 9-days into the future.
- Conduct next year's drought exercise in June or July to test the demand forecasting model developed by ICPRB as compared to operator forecasts. The demand forecast model may be better at predicting summertime demands.
- Consider conducting mini-drought exercises internally in the spring over a one or two day period.
- Continue to produce the annual drought exercise report as a guide to drought operations, and consider designating it as the official "Drought Operations Manual," which is an attachment to the Water Supply Coordination Agreement.
- Maintain the Seneca modem year round, given the difficulty in set up and Verizon's 6-week delay in activating the modem.
- Consider setting up a modem as a backup internet connection in the case of a power outage.

References:

Agreement for Future Water Supply Storage Space in the Bloomington Reservoir, Maryland and West Virginia, 1982. Signatories include: The U.S., the District of Columbia, the WSSC, and Fairfax Water.

COE, 1986. 1985 Master Manual for Reservoir Regulation, North Branch Potomac River Basin. Baltimore District U.S. Army Corps of Engineers. Baltimore, MD.

Dodd, R.K., J.C. Eilbeck, J.D. Gibbon, H.C. Morris, 1984. Solitons and Nonlinear Wave Equations. Academic Press, Inc. Harcourt Brace Jovanovich, Publishers. London.

Kame'enui, A., E.R. Hagen, 2005. Water Supply Reliability Forecast for the Washington Metropolitan Area,Year 2025. Interstate Commission on the Potomac River Basin, ICPRB 05-6, Rockville, Maryland.

Kiang, J.E., E.R.Hagen, 2003. 2002 Drought Operations Report and Lessons Learned, Washington Metropolitan Area.

MWCOG Board Task Force on Regional Water Supply Issues, 2000. Metropolitan Washington Water Supply and Drought Awareness Response Plan: Potomac River System. Metropolitan Washington Council of Governments, Publication number 20703. Washington, D.C.

Water Supply Coordination Agreement, 1982. Signatories include: The District Engineer Baltimore District COE for the U.S., the Chairman of Fairfax Water, the General Manager of the WSSC, The Mayor of the District of Columbia, Chairman of the Interstate Commission on the Potomac River Basin.

Appendices

A. Little Seneca Press Release
B. Letter to Montgomery County Council and Executive
C. Operator form for Washington Aqueduct
D. Operator form for WSSC
E. Operator form for FW

Appendix A. Little Seneca Press Release

Upstream Reservoir Release Bolsters Potomac Flow
Interstate Commission on the Potomac River Basin
For release September 26, 2006

Water stored by Washington-area water suppliers will be released from Little Seneca Reservoir near Germantown, Maryland, and from Jennings Randolph Reservoir located in the headwaters of the Potomac River basin during this year's annual Drought Exercise conducted by the Interstate Commission on the Potomac River Basin (ICPRB). ICPRB coordinates the drought exercise on behalf of the Washington metropolitan area water suppliers, including the Washington Suburban Sanitary Commission serving Montgomery and Prince George's counties, Fairfax Water serving Northern Virginia, and the Washington Aqueduct serving suppliers in the District of Columbia, Arlington County, and Falls Church. Cooperative use of Little Seneca and Jennings Randolph reservoirs by the independent water suppliers allows for the demands of each to be met during droughts.

The Drought Exercise is occurring from September 20 through September 26, 2006. A Little Seneca release will likely occur on the morning of September 26, 2006, unless weather conditions cause us to delay the release. The release is expected to lower the level of the reservoir by up to 12 inches. The release will amount to 150 million gallons per day (MGD) and will last for about 24 hours. The lake level should recover quickly. The releases are coordinated with staff from Washington metropolitan area water suppliers and the Maryland-National Capital Park and Planning Commission, which manages recreational facilities and conservation areas in Black Hill Regional Park at Little Seneca Reservoir. The releases from Jennings Randolph and Little Seneca will test operating procedures and document travel times to Little Falls, the site of the most downstream water supply intake.

Little Seneca Reservoir was constructed with funds provided by the Washington metropolitan area water suppliers. The reservoir was completed in 1981 and is used to augment Potomac River flow during droughts and along with Jennings Randolph Reservoir ensures a safe and reliable supply of water for 4.1 million residents of the Washington metropolitan area. Releases are a part of normal drought operations, and drought-related releases were made in 1999 and in 2002. Releases from Little Seneca were made during prior years' drought exercises in 2003, 2004, and in 2005 to test operating procedures.

The ICPRB annually coordinates a week-long drought management exercise that simulates operational procedures and decision-making under drought conditions. The test ensures that operational procedures are well practiced and understood, and keeps operations personnel familiar with drought operations. Annual simulation also helps all parties to continually improve and refine procedures.

"Announcement of these water releases is a testament to the level of planning, over several decades, that allows the Washington area the water it needs," noted ICPRB Executive Director Joseph Hoffman. "It is a testament to area governments, water suppliers, and ICPRB, which have worked cooperatively to create a regional solution to water concerns, and have left the Washington area able to withstand the effects of extended low-flow periods." If the drought of record (1930-1931) were to recur, water storage would be more than adequate to meet the needs of the Washington metropolitan area.

If combined water supply storage in Jennings Randolph and Little Seneca reservoirs dropped below 60% full, voluntary restrictions would possibly be implemented under regional agreements. Water supply storage in these two reservoirs currently is full. It is late in the reservoir release season. In the unlikely event that water supply releases are necessary this fall, the test release will have no detrimental impact on our ability to respond to actual drought conditions.

Hoffman noted that CO-OP, the utilities, and governments continue to assess water supply needs to ensure that the metropolitan area, as well as the entire Potomac basin, will meet future challenges to a safe and adequate water supply.

More information on current water supply status, the drought exercise, and the water supply system for the metropolitan area can be found on the ICPRB website at www.potomacriver.org. (Follow the appropriate links under "water supply.")

For more information contact Curtis Dalpra, Interstate Commission on the Potomac River Basin, 301 984 1908 x107

Appendix B. Letter to Montgomery County Council and County Executive

September 22, 2006

To: Phil Andrews, Howard Denis, Nancy Floreen, Mike Knapp, George Leventhal, Tom Perez, Marilyn Praisner, Steve Silverman, and Mike Subin
100 Maryland Avenue
Rockville, MD 20850

Dear Montgomery County Councilmember,

The Interstate Commission on the Potomac River Basin (ICPRB) coordinates an annual drought exercise on behalf of the Washington metropolitan area water suppliers including the Washington Suburban Sanitary Commission serving Montgomery and Prince George's counties, Fairfax Water serving Northern Virginia, and the Washington Aqueduct serving suppliers in the District of Columbia, Arlington County, and Falls Church. I am writing to give you background information about an upcoming water supply release planned for Little Seneca Reservoir. Water stored by the Washington-area water suppliers will be released from Little Seneca Reservoir near Germantown, Maryland, during this year's annual Drought Exercise conducted by ICPRB.

Little Seneca Reservoir was constructed with funds provided by the Washington metropolitan area water suppliers. The reservoir was completed in 1981 and is used to augment Potomac River flow during droughts to ensure a safe and reliable supply of water for 4.1 million residents of the Washington metropolitan area including the citizens of Montgomery County. Releases are an important part of normal drought operations, and drought-related releases were made in 1999 and in 2002. A release was made during the Drought Exercises of 2003, 2004, and 2005.

A Little Seneca release for this year's drought exercise will likely occur on the morning of September 26, 2006, unless weather conditions cause us to delay the release. This release is expected to lower the level of the reservoir by approximately 12 inches. The release is also an important part of our annul Drought Exercise, allowing ICPRB to collect information on time of travel of releases, which are affected by flow levels. An additional benefit is to practice drought operations as they would occur. In the unlikely event that water supply releases are necessary this fall, the releases will have no detrimental impact on our ability to respond to actual drought operations.

Please do not hesitate to write or call with questions, concerns, or comments.

Sincerely,

Erik Hagen
Director CO-OP Operations

Interstate Commission on the Potomac River Basin <address>

Appendix C: Operator form for Washington Aqueduct

Drought Operations/ Drought Exercise
ICPRB Operator Form for the Aqueduct
Please email to coop@icprb.org at 7:30 a.m. and at 1:00 p.m.

Date	
Time sent (7:30 or 1300)	
A.M. estimate of today's demand, MGD	
P.M. estimate of today's demand, MGD	
Tomorrow's estimated demand, MGD	
Yesterday's withdrawal from Great Falls (MGD)	
Yesterday's pumpage from Little Falls (MGD)	

Yesterday's pumping rates from Little Falls Pumping Station

NO. 1			NO. 2		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0			0.0
		0.0			0.0
		0.0			0.0
		0.0			0.0

NO. 3			NO. 4		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0			0.0
		0.0			0.0
		0.0			0.0
		0.0			0.0

NO. 5			NO. 6		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0			0.0
		0.0			0.0
		0.0			0.0
		0.0			0.0

Today's pumping rates from Little Falls Pumping Station

NO. 1			NO. 2		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0			0.0
		0.0			0.0
		0.0			0.0
		0.0			0.0

NO. 3			NO. 4		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0			0.0
		0.0			0.0
		0.0			0.0
		0.0			0.0

NO. 5			NO. 6		
TIME		HRS	TIME		HRS
ON	Through	RUN	ON	Through	RUN
		0.0			0.0
		0.0			0.0
		0.0			0.0
		0.0			0.0

Yesterday's Great Falls gate settings

HOUR	Old conduit	New conduit
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		

Today's Great Falls gate settings

HOUR	Old conduit	New conduit
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		

Appendix D: Operator form for WSSC

Drought Operations/ Drought Exercise
ICPRB Operator Form for WSSC
Please email to coop@icprb.org at 7:30 a.m. and at 1:00 p.m.

Date	
Time sent (7:30 or 1300)	
A.M. estimate of today's demand, MGD	
P.M. estimate of today's demand, MGD	
Tomorrow's estimated demand, MGD	
Storage in Triadelphia (bg)	
Storage in Duckett (bg)	
Storage in Little Seneca (bg)	
Yesterday's production from Potomac plant (MGD)	
Yesterday's production from Patuxent (MGD)	

Yesterday's production at Potomac Plant, MGD

	Production
12:00 AM	
1:00 AM	
2:00 AM	
3:00 AM	
4:00 AM	
5:00 AM	
6:00 AM	
7:00 AM	
8:00 AM	
9:00 AM	
10:00 AM	
11:00 AM	
12:00 PM	
1:00 PM	
2:00 PM	
3:00 PM	
4:00 PM	
5:00 PM	
6:00 PM	
7:00 PM	
8:00 PM	
9:00 PM	
10:00 PM	
11:00 PM	

Today's production at Potomac Plant, MGD

	Production
12:00 AM	
1:00 AM	
2:00 AM	
3:00 AM	
4:00 AM	
5:00 AM	
6:00 AM	
7:00 AM	
8:00 AM	
9:00 AM	
10:00 AM	
11:00 AM	
12:00 PM	
1:00 PM	
2:00 PM	
3:00 PM	
4:00 PM	
5:00 PM	
6:00 PM	
7:00 PM	
8:00 PM	
9:00 PM	
10:00 PM	
11:00 PM	

Appendix E: Operator form for FW

Drought Operations/ Drought Exercise					
ICPRB Operator Form for Fairfax Water					
Please email to coop@icprb.org at 7:30 a.m. and at 1:00 p.m.					
				Date	Sept-25
				Time sent (7:30 or 1300)	13:00
				A.M. estimate of today's RAW WATER USE, MGD	170
				P.M. estimate of today's RAW WATER USE, MGD	178
				Tomorrow's estimated RAW WATER USE, MGD	172
				Storage in Occoquan (bg)	8.3
				Yesterday's Raw Water w/d from Corbalis (MGD)	96
				Yesterday's Raw Water w/d from Occoquan (MGD)	84
				Yesterday's TOTAL Withdrawal (MGD)	180

Yesterday's RAW			Today's RAW WATER	
	Withdrawal			Withdrawal
12:00 AM	**101**		12:00 AM	**89**
1:00 AM	**101**		1:00 AM	**89**
2:00 AM	**101**		2:00 AM	**90**
3:00 AM	**101**		3:00 AM	**90**
4:00 AM	**101**		4:00 AM	**90**
5:00 AM	**101**		5:00 AM	**90**
6:00 AM	**101**		6:00 AM	**90**
7:00 AM	**98**		7:00 AM	**90**
8:00 AM	**96**		8:00 AM	**90**
9:00 AM	**96**		9:00 AM	**91**
10:00 AM	**96**		10:00 AM	**90**
11:00 AM	**96**		11:00 AM	**99**
12:00 PM	**96**		12:00 PM	**99**
1:00 PM	**96**		1:00 PM	
2:00 PM	**96**		2:00 PM	
3:00 PM	**96**		3:00 PM	
4:00 PM	**92**		4:00 PM	
5:00 PM	**90**		5:00 PM	
6:00 PM	**90**		6:00 PM	
7:00 PM	**90**		7:00 PM	
8:00 PM	**90**		8:00 PM	
9:00 PM	**90**		9:00 PM	
10:00 PM	**90**		10:00 PM	
11:00 PM	**90**		11:00 PM	