

# **2011 Drought Exercise Report**

## **Summary and Lessons Learned**

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## Introduction

The Washington, D.C., metropolitan area (WMA) relies on the Potomac River to supply approximately three quarters of the water it uses. The three major WMA water suppliers, Fairfax County Water Authority (Fairfax Water), the Washington Aqueduct Division of the U.S. Army Corps of Engineers (Aqueduct), and the Washington Suburban Sanitary Commission (WSSC), participate in a unique cooperative system of water supply management that is designed to optimize use of available resources and ensure that ample water is available during periods of drought. This system includes joint funding of water supply storage in reservoirs located upstream of the WMA intakes on the Potomac River and coordinated operations when flows in the river fall below certain specified thresholds. The Section for Cooperative Water Supply Operations on the Potomac (CO-OP) of the Interstate Commission on the Potomac River Basin (ICPRB) assists in the management of the system during droughts by coordinating WMA water supply withdrawals from the Potomac River and from off-river reservoirs and recommending releases from upstream reservoirs when forecasted flow in the Potomac River is not sufficient to meet expected WMA demands plus the environmental flow-by of 100 million gallons per day at the US Geological Survey's stream gage station near Washington, DC, at Little Falls dam.<sup>1</sup>

Each year when flows are at or above normal, CO-OP conducts a drought exercise. This ensures that during a severe drought all stakeholders are properly trained and not operating in an atmosphere of crisis. Participants in drought exercises include staff from:

- ICPRB's CO-OP Section,
- WMA water suppliers,
- U.S. Army Corps of Engineers (USACE), Baltimore District, and
- other regional stakeholders.

This report describes the 2011 drought exercise and reviews key areas of focus: load shifting, Jennings Randolph Reservoir release decision rule, and the development and improvement of operational tools and models.

Drought exercises provide CO-OP staff with an opportunity to practice using operational tools, make management decisions, and explore the effects of different assumptions that could be used during a real drought. It also allows ICPRB CO-OP and the other participants to practice and improve communication procedures among organizations.

CO-OP's 2011 drought exercise consisted of a kickoff workshop held on September 15 and six days of simulated drought operations, conducted from September 16 through 21. In addition to the components practiced in all exercises, this year's exercise was used to explore the real-time operational

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<sup>1</sup> A complete discussion of CO-OP drought operations can be found in the report, [2010 Washington Metropolitan Area Water Supply Reliability Study; Part 1: Demand and Resource Availability Forecast for the Year 2040](#), S.N. Ahmed, K.R. Bencala, and C.L. Schultz, ICPRB Report No. 10-01, May 2010, available at [www.potomacriver.org](http://www.potomacriver.org) under "Publications."

## *2011 CO-OP Drought Exercise*

capabilities of the OASIS (Operational Analysis and Simulation of Integrated Systems) model of the WMA water supply system.

OASIS is an integrated programming and database package, developed specifically for use in the water supply field by the firm, HydroLogics<sup>2</sup>. HydroLogics, under contract with ICPRB, completed the development of an OASIS model of the WMA system (“Potomac-OASIS”) in 2006. The model has recently been updated for use in a Water Research Foundation (WaterRF)–funded project, *Analysis of Reservoir Operations under Climate Change* (WRF Project number 4306). This project is being led by HydroLogics and uses the WMA water supply system as one of its case studies. The Potomac-OASIS model will be used in this study to provide long-term water supply forecasts. Potomac-OASIS is, in this respect, very similar to ICPRB’s Potomac River and Reservoir Simulation Model (PRRISM) which serves as CO-OP’s long-term water supply planning tool. OASIS models can also be configured as real-time decision-support tools for drought operations. HydroLogics recently provided CO-OP with such a version of the Potomac-OASIS model for use in the 2011 drought exercise.

## **Kickoff Workshop**

The first day of the 2011 exercise was devoted to a workshop held at ICPRB’s office in Rockville, Maryland. The purpose of the workshop was to provide a forum for exchanging information and discussing potential areas of future collaboration among the various agencies and organizations that CO-OP interacts with during a drought. Attendees included representatives from Fairfax Water, WSSC, Aqueduct, Loudoun Water, ICPRB, the Metropolitan Washington Council of Governments, the Baltimore/Washington office of the National Weather Service (NWS), the NWS’s Middle Atlantic River Forecast Center (MARFC), HydroLogics, and the Susquehanna River Basin Commission (SRBC). The workshop gave CO-OP staff an opportunity to familiarize these participants with the models and tools used by CO-OP to help make decisions during droughts. Also, a portion of the workshop was devoted to the WaterRF project. HydroLogics reported on recent updates made to the Potomac-OASIS model and obtained input from stakeholders on the system performance measures to be used for the WMA case study.

The workshop consisted of a series of focused discussions and presentations, which included:

- *Current flow and reservoir conditions and system operational constraints* - Discussion by ICPRB, Aqueduct, Fairfax Water, WSSC, and USACE staff on current flow and reservoir conditions and system operational constraints. This discussion has typically occurred at a “pre-exercise” meeting before previous drought exercises.
- *Overview of Washington Metropolitan Area Drought Exercises/Operations* - Cherie Schultz, ICPRB CO-OP
- *Performance of updated OASIS model* - Steve Nebiker, HydroLogics. Informal presentation showing OASIS model forecasts of WMA system reliability in the year 2030, compared to forecasts made by ICPRB’s PRRISM model.

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<sup>2</sup> For more on HydroLogics and OASIS, visit [www.hydrologics.net](http://www.hydrologics.net).

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- *WRF Project 4306: Analysis of Reservoir Operations Under Climate Change* - Megan Rivera, HydroLogics
- *WMA system performance measures* - Discussion led by Megan Rivera, HydroLogics. Suggestions and input were solicited from workshop participants on what performance measures should be included in the WMA case study in WaterRF Project 4306.
- *Current CO-OP Drought Operation Tools* - Sarah Ahmed, ICPRB CO-OP
- *Middle Atlantic River Forecast Center (MARFC)* - Ned Pryor, MARFC
- *NWS Low Flow & Drought Operations* - Jason Elliot, NWS
- *SRBC's coordination and management activities during droughts* - Informal presentation by Ben Pratt, SRBC

### **Workshop - Lessons Learned/Action Items**

Workshop participants provided CO-OP staff with a number of ideas for future information exchange and collaboration:

- 1) Ned Pryor of MARFC discussed the continuing efforts at the NWS to improve flow predictions during low flow periods using “bias correction”. CO-OP staff plan on contacting Pryor in the coming year to get an update on this topic.
- 2) Jason Elliot of the NWS showed examples from a pilot project which posts low flow information on NWS websites. Similar projects will be implemented nationwide in cases where partners express interest. CO-OP staff will discuss with WMA suppliers a request for important low-flow stage information in the WMA system.
- 3) Ben Pratt of SRBC discussed his organization’s use of the Susquehanna basin OASIS model as a decision-support tool during droughts. In a follow-up discussion, SRBC staff talked about challenges they have encountered in updating their OASIS model with real-time flow values. They suggested that more coding will be required to better configure the model for real-time use. SRBC and ICPRB staff agreed to keep each other updated on both progress made and roadblocks encountered in configuring and using OASIS as a real-time tool.
- 4) SRBC invited ICPRB to a one-day SRBC drought exercise scheduled for October 3, 2011, in Harrisburg, Pa. Two CO-OP staff members, Cherie Schultz and Sarah Ahmed, attended this exercise and observed the use of OASIS in “gaming mode”. Staff from HydroLogics conducted the exercise, which was attended by water suppliers and industrial users that rely on the Susquehanna River for water supply.

## **Simulated Drought Operations**

Simulated drought operations were conducted during the six-day period, Friday, September 16, through Wednesday, September 21. This included twice daily reports from CO-OP utilities on withdrawal rates and reservoir storage levels. Subsequently, CO-OP distributed twice daily updates on flow conditions, actual and estimated withdrawal rates, and operational recommendations for each utility and reservoir.

## 2011 CO-OP Drought Exercise

SRBC representatives observed the simulated operations on September 19. This provided them with a first-hand look at the data and tools used and the decisions made by CO-OP on a daily basis.

### Exercise Scenario

The scenario constructed for the exercise was loosely based on flow conditions experienced during September 2002, the most recent serious drought. The following description was used to set the stage for the exercise:

*Today's date: September 16, 2015*

*Since July, the Potomac River basin has been experiencing a period of hot and dry weather. These dry conditions have been exacerbated by low precipitation during the previous winter, which has resulted in low groundwater levels over the summer. Precipitation amounts have been particularly low in the Patuxent watershed and storage in these reservoirs is currently at only 25% capacity.*

*In mid-August, water supply releases began from Jennings Randolph Reservoir, with 20% matches provided by Savage Reservoir. These releases have decreased storage levels in both Jennings Randolph and Savage. Releases from Little Seneca Reservoir were also required during this period. Throughout this initial release period, ICPRB CO-OP's reservoir refill tools predicted that system reservoirs should refill by June 1, 2016.*

*Over the past two weeks, there has been negligible precipitation across the basin. Given the current dry period, it is expected that releases will be required over the next couple of days.*

*The Army Corps of Engineers is currently releasing water at a rate of 120 cubic feet per second (cfs) from Jennings Randolph and 55 cfs from Savage reservoirs.*

The very low amount of usable storage in WSSC's Patuxent reservoirs and reduced levels in the system's other reservoirs presented an additional challenge in this exercise given the need to preserve and balance storages across the system. The initial reservoir storage parameters used for the drought scenario are given in Table 1.

Table 1 - (Simulated) usable storage in system reservoirs on September 15, 2015, in billions of gallons (BG).

Facility	Percent Full	Current Storage (BG)	2015 Estimated Capacity (BG)
WSSC's Patuxent reservoirs	25%	2.5	9.9
Fairfax Water's Occoquan Reservoir	67%	5.1	7.6
Little Seneca Reservoir	92%	3.3	3.6
Jennings Randolph water supply	69%	8.2	11.8
Jennings Randolph water quality	73%	10.7	14.7
Savage Reservoir	56%	3.4	6.1

## *Load Shifting*

Load shifting, that is, the shifting of some portion of a supplier's withdrawal from one intake to another, requires close communication between ICPRB CO-OP and water supplier staff. Each of the WMA suppliers has two water supply intakes. Fairfax Water and WSSC both have one intake on the Potomac River and one off-Potomac intake (at the Occoquan and the Patuxent reservoirs, respectively). Aqueduct has two intakes on the Potomac River: one at Great Falls and one at Little Falls.

To estimate future Potomac withdrawals for input into flow prediction tools, CO-OP staff develops withdrawal scenarios for both the Potomac River and for the off-Potomac reservoirs. These scenarios may require future load shifts by the water suppliers. Scenarios are derived from water supplier-provided estimates of the current and next day's total demands, and historic averages of September demands for subsequent days.<sup>3</sup>

On the first day of the exercise, CO-OP requested that Fairfax Water simulate a limit on withdrawals from the Occoquan Reservoir to not exceed 90 MGD. A similar request was made to WSSC to simulate maintaining withdrawals from the Patuxent reservoirs as close to 30 MGD as possible. These requests were made in order to conserve storage in the reservoirs. All suppliers were requested, as a second priority, to keep Potomac River withdrawals as steady as possible to avoid unexpected drops in flow at Little Falls.

Because of the very low (simulated) flows in the Potomac River, CO-OP contacted Fairfax Water and WSSC staff to verify that (simulated) load shifts to their off-Potomac intakes could be made in the coming days if unexpected drops in Potomac River flow occurred. Joel Thompson of Fairfax Water was called to confirm that 90 MGD would be available from Occoquan Reservoir for the following nine days, and that shifts to Occoquan could be made over the weekend if necessary. Thompson said that load shifts to Occoquan of up to 20 MGD could probably be made with one day's notice. (Greg Prelewicz of Fairfax Water later added that a load shift of 10 MGD would be more comfortable.) Karen Wright of WSSC said that they had considerable flexibility in their use of the Patuxent reservoirs, since the Patuxent water treatment plant could be run at 30 MGD and be quickly ramped up to 60 or 65 MGD if necessary.

Thompson also mentioned that Fairfax Water's Corbalis water treatment plant on the Potomac has a "clear well" (finished water) with a capacity of 28 million gallons (MG). This could allow Fairfax Water Potomac withdrawals to be dropped by approximately 20 million gallons per day (MGD) on a temporary basis (for approximately one day) to allow enough time for a release from Little Seneca Reservoir to arrive at Little Falls.

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<sup>3</sup> However, for the 2011 drought exercise CO-OP flow prediction tools were loaded with 2002 withdrawal data for consistency with Potomac-OASIS model results.

### **Drought Scenario – Lessons Learned/Action Items**

- In future drought operations, CO-OP staff should request and confirm that storage in Fairfax Water’s Corbalis plant clear well is maintained at near capacity at all times for the duration of low flows.
- CO-OP staff should continue to discuss the potential constraints of the suppliers on load shifting and strategies for reducing variability in Potomac River withdrawals during drought operations.

### *Evaluation of Jennings Randolph Water Supply Release Decision Rule*

At the request of Washington Aqueduct’s General Manager, CO-OP staff experimented during the exercise with a minor alteration in the decision rule governing water supply releases from Jennings Randolph Reservoir (JRR). The objective of the rule change was to better conserve storage during the early days of a prolonged drought. Standard policy was to request a release from JRR water supply storage when a deficit was forecast in nine days time, that is, when forecasted Potomac River withdrawals, including environmental flow-by allowance, exceeded forecasted flow. In the 2011 drought exercise, staff used an altered decision rule which requested a (simulated) release only when the forecasted deficit was greater than or equal to 50 MGD. Thus, on the second and third day of the simulated drought, when the forecasted deficits were 38 and 42 MGD, respectively, no JRR releases were requested. A simulated JRR water supply release was initiated on the fourth day of the exercise, once the forecasted deficit had risen to 54 MGD.

One of the recommendations in CO-OP’s report on 2010 drought operations was to keep decision rules used during drought operations aligned with assumptions in CO-OP’s long-term planning tool, PRRISM. Therefore, the altered JRR water supply release decision rule was tested using PRRISM, for 2015, 2030, and 2040 “likely” demand scenarios. In all cases, the altered decision rule resulted in a small improvement in forecasted system performance. Minimum combined Little Seneca and JRR water supply storage and minimum combined Patuxent, Occoquan, Little Seneca and JRR water supply storage improved slightly for all three scenario years, and the probability of mandatory water restrictions in scenario year 2040 vanished. All of the results are summarized in Table 2.



Table 2 - PRRISM run results from the evaluation of the altered decision rule for JRR water supply releases.

Scenario Year	Reservoir(s)	Minimum Storages (BG)	
		Standard Decision Rule (JRR water supply release when deficit > 0 MDG)	Altered Decision Rule (JRR water supply release when deficit >= 50 MGD)
2015	Little Seneca	2.6	2.4
	JRR water supply (WS)	7.6	7.7
	Little Seneca + JRR WS	10.1	10.6
	Patuxent + Occoquan + Little Seneca +JRR WS	14.9	15.0
2030	Little Seneca	2	1.9
	JRR water supply (WS)	4.2	4.4
	Little Seneca + JRR WS	6.2	6.3
	Patuxent + Occoquan + Little Seneca +JRR WS	10.7	11.0
2040	Little Seneca	1.5	1.5
	JRR water supply (WS)	2.6	2.9
	Little Seneca + JRR WS	4.1	4.4
	Patuxent + Occoquan + Little Seneca +JRR WS	8.6	8.9

### **JRR Decision Rule – Lessons Learned/Action Items**

- The JRR water supply release decision rule in PRRISM will be changed so that JRR water supply releases will not be simulated unless the forecasted deficit is greater than or equal to an optimal amount. A series of model runs will be conducted to determine the optimal value. The results of this evaluation will also be discussed with participants in the WaterRF project. CO-OP will also suggest that similar types of changes in JRR release decision rules be explored further in that project.

### *Use of the Potomac-OASIS Model*

CO-OP staff spent time during the exercise becoming familiar with the real-time capabilities of the Potomac-OASIS model that was recently updated as part of the WaterRF-funded project on reservoir operations. HydroLogics provided ICPRB with a version of the model configured as an operations support tool for use in the exercise.

OASIS is an integrated programming and data management package for simulating the operations of water resource systems.<sup>4</sup> OASIS provides considerable flexibility to model complex systems by making available to the user an operations control language (OCL) to write non-standard constraints and

<sup>4</sup> See *User Manual for OASIS with OCL™*, October 14, 2008, HydroLogics

operating rules. It also provides conveniently pre-packaged scripts for incorporating standard processes, such as flow capacities and reservoir evaporation.

Like ICPRB's PRRISM model<sup>5</sup>, OASIS simulations are based on the period of record of hydrologic and meteorological data that determine water supply and demand. In the case of Potomac-OASIS, these data include natural daily flow in the Potomac River, daily inflows for system reservoirs, and daily temperature and precipitation data for the WMA area during the 78-year simulation period, October 1, 1929 through December 31, 2008. Like PRRISM, Potomac-OASIS simulates daily system demands based on a user selected forecast year and simulates daily system operations. Simulated operations include releases by the USACE from Jennings Randolph Reservoir water quality storage and from Savage Reservoir, CO-OP-requested releases from Jennings Randolph water supply storage and from Little Seneca Reservoir, and WMA supplier withdrawals from the Potomac River and from the Occoquan and Patuxent reservoirs.

Unlike ICPRB's PRRISM model, OASIS simulates the routing of water using linear optimization methods, with each operating rule expressed as either a goal or a constraint. OASIS requires that constraints be strictly enforced, but the set of system goals, which are typically in competition with one another and not completely consistent, are optimized at each model time step based on assigned weights. Despite this difference, Potomac-OASIS results for reservoir storage levels and other system performance measures match PRRISM results quite well over the simulation period.

OASIS models can be configured for use in three different operational modes:

- 1) Simulation mode: OASIS is most typically configured to operate in simulation mode to serve as a long-term planning tool. In simulation mode, OASIS can evaluate system performance under hydrologic conditions that have occurred over the period of record and given forecasted demands for the user-selected scenario year. The Potomac-OASIS model simulations of reservoir storage levels and other system performance measures are very similar to results from PRRISM.
- 2) Position Analysis mode: OASIS can be configured to operate in position analysis mode to function as an operations support tool. In position analysis mode the user provides OASIS with information on the system's current state and OASIS will provide probabilities that the system will be in various states at a future time. For example, HydroLogics provided ICPRB with a version of Potomac-OASIS configured in position analysis mode for use in the 2011 drought exercise. As described in more detail below, ICPRB staff input values for usable storage in system reservoirs on the simulation date, September 19, 2015, per the exercise scenario. Potomac-OASIS then provided probability plots of usable storage for each system reservoir for a variety of forecast periods ranging from four to 32 weeks.
- 3) Gaming mode: HydroLogics can configure OASIS in gaming mode for interactive table-top drought exercises. Participants can step day-by-day through several weeks of a simulated drought, making daily operational decisions and then observing OASIS's simulation of the

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<sup>5</sup> Ibid. 4.

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system's response on the following day. In this way, participants can see the impact of their decisions over the course of an extended drought.

During the drought exercise, CO-OP staff tested use of Potomac-OASIS in position analysis mode as an operational tool, with assistance from Steve Nebiker of HydroLogics. The model was loaded with the simulated time series of natural Potomac River flows and reservoir inflows constructed for the exercise by ICPRB, for the time period June, 1, 2015 through September 30, 2015.

In order to generate probabilities in position analysis mode, OASIS does a series of runs, or "traces", each beginning on the same day of the year. This start date is specified by the user as the current date. The run continues for a user-specified length of time. For CO-OP's drought exercise, Potomac-OASIS had been set up to generate 78 runs each 365 days in length. Each of these runs was based on a different set of inflow and evaporation time series for the reservoirs and on a Potomac River flow time series that had been synthetically generated by OASIS to reflect current and recent conditions.<sup>6</sup> Potomac-OASIS constructed the synthetic input time series for the exercise based on the following user inputs:

- The (simulated) current day - September 15, 2015.
- The drought exercise time series of the current day's and past days' reservoir inflows, evaporation rates, and Potomac River flows. These were contained in the model's time series data base.
- The current day's storage levels in the Occoquan, Patuxent, Savage, Little Seneca, and Jennings Randolph reservoirs – entered by the user in a model input table.

Each of the 78 position analysis runs reflect the daily system operational decisions, as simulated by Potomac-OASIS, that would be made in response to the run's set of input time series. Each run results in a different daily time series for storage in each system reservoir. After the 78 reservoir storage traces were generated, each was assumed to have an equal probability (i.e., 1/78) of occurring.

OASIS used the sets of reservoir storage traces to generate plots of cumulative probability distributions of future storage for each system reservoir. These plots, shown in Figure 1 through Figure 4, give the probabilities that reservoir storage will fall below the plotted level at various times in the future. For example, the plots in Figure 4 indicate that, four weeks after the run's start date of September 15, 2015, that is, on October 13, usable storage in the Patuxent reservoir has an approximately 70% probability of being below 20% of usable capacity (but a probability of only about 5% of being below 15% of usable capacity). Thirty-two weeks after the run's starting date, on approximately April 26<sup>th</sup> of the following year, the Patuxent reservoir has a probability of approximately 45% of being below 90% of usable capacity. Figures 1, 2, and 3 show that the Potomac-OASIS predicts that usable storage in Occoquan Reservoir, Little Seneca Reservoir, and the water supply storage in Jennings Randolph Reservoir, all have less than a 5% chance of being below 90% of usable capacity after 32 weeks, that is, by late April of the following year.

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<sup>6</sup> See Stochastic Hydrologic Model for Drought Management, R. M. Hirsch, J Water Resour. Planning and Management, ASCE, Vol 107, pp 303-313, October 1981.

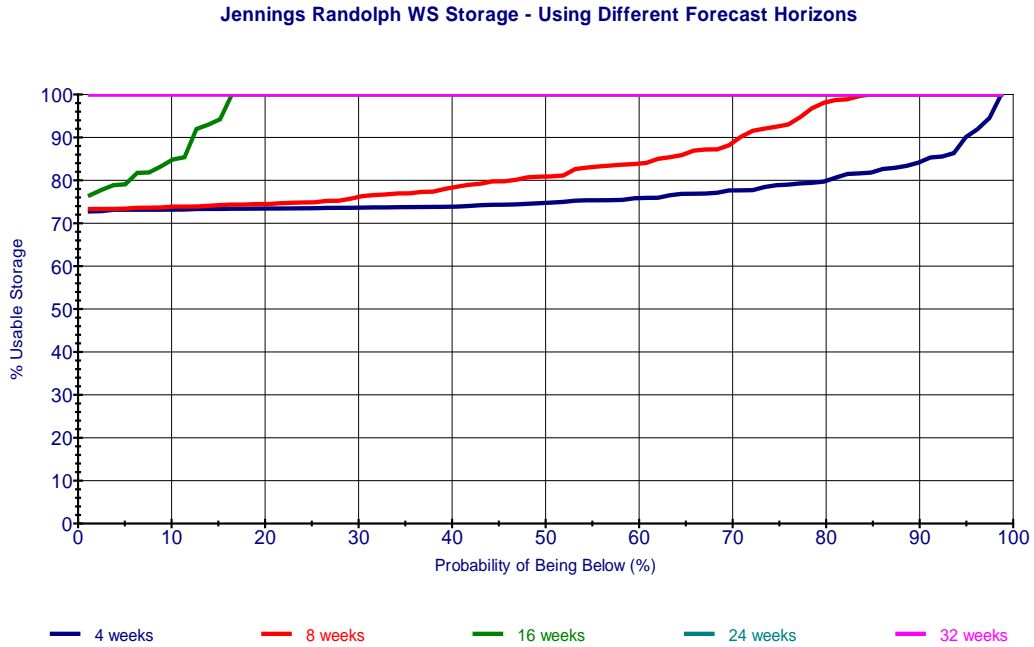


Figure 1 – Potomac-OASIS probabilistic estimates of future usable storage in Jennings Randolph water supply account.

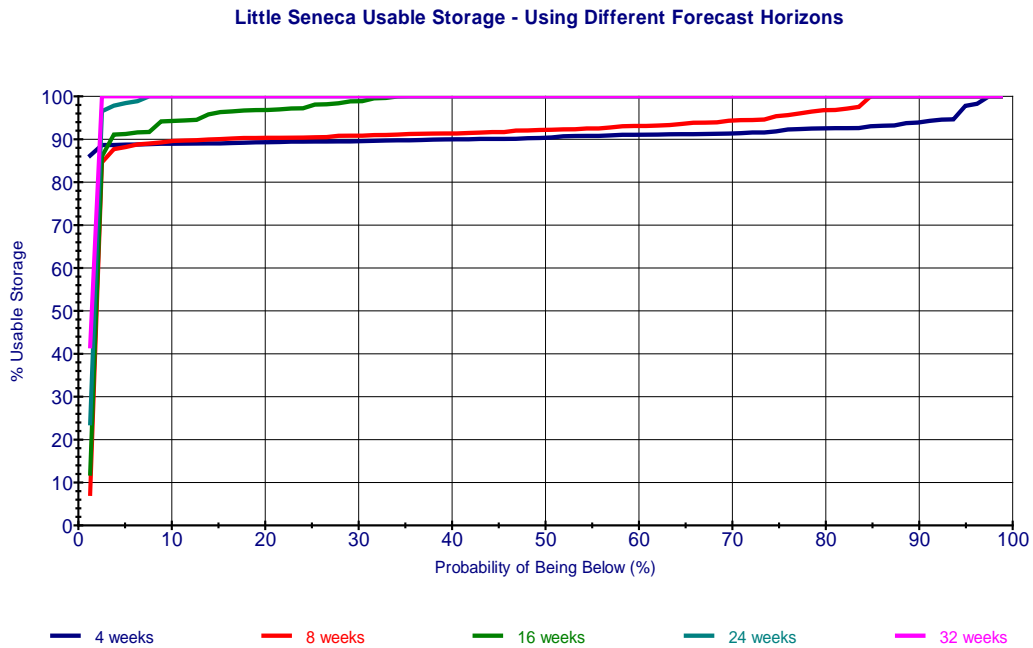


Figure 2 - Potomac-OASIS probabilistic estimates of future usable storage in Little Seneca Reservoir.

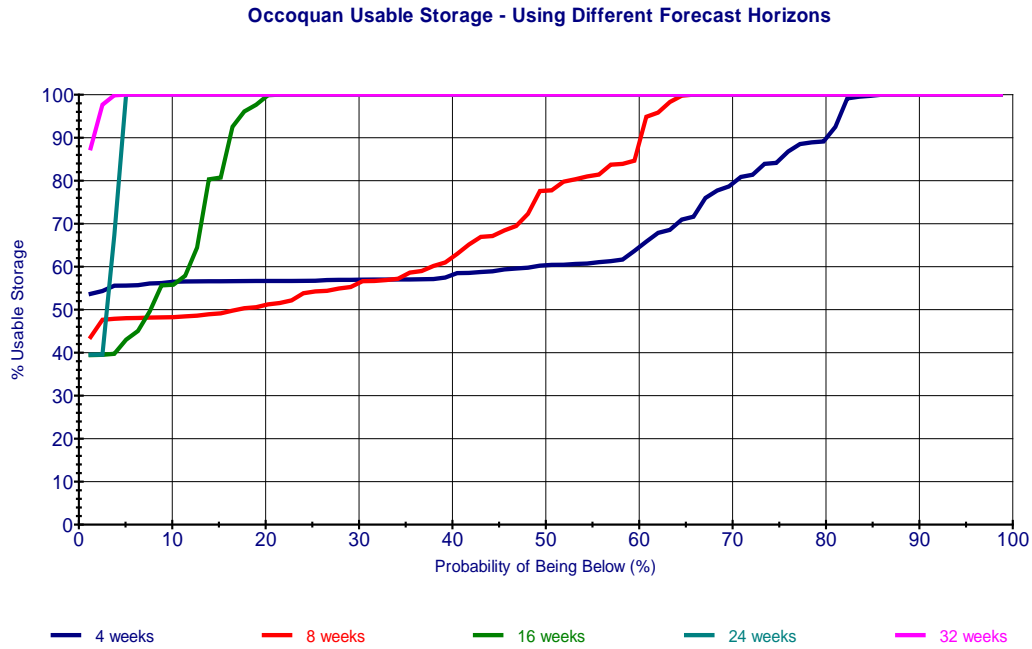


Figure 3 - Potomac-OASIS probabilistic estimates of future usable storage in the Occoquan Reservoir.

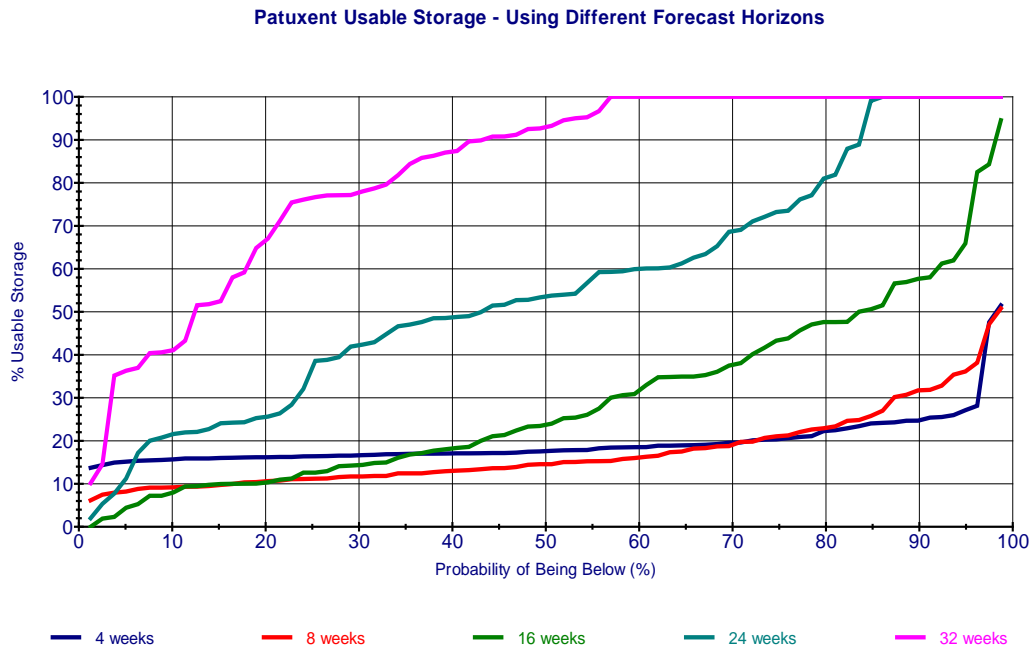


Figure 4 - Potomac-OASIS probabilistic estimates of future usable storage in the Patuxent reservoirs.

## **OASIS – Lessons Learned/Action Items**

The Potomac-OASIS model is a promising tool for CO-OP's real-time drought operations because it provides, on any given day, probabilistic estimates of future storage resulting from simulations of CO-OP system operations. Assuming that these models reflect actual system decision rules with reasonable accuracy, these predictions provide drought operations staff with valuable information. In particular, the 32-week reservoir storage plots give predictions of storage for the following spring. This gives an indication of whether or not one of CO-OP's key objectives will be met - that system reservoirs have less than a 5% probability of storage being below 90% of capacity on June 1 of the following year. CO-OP has its own set of reservoir refill prediction tools, which can be used for similar purposes, as described in its report on 2010 drought operations.<sup>7</sup>

Each of these models has complimentary advantages and disadvantages. The Potomac-OASIS model constructs future withdrawal scenarios from a systems perspective, based on the operating rules programmed into the long-term planning tools, whereas the CO-OP reservoir refill tools allow the user to input a future withdrawal scenario for each individual system reservoir. This may be advantageous, for example, in situations when unforeseen events require temporary changes in operational decision rules.

Potomac-OASIS is not yet optimally configured for real-time use in CO-OP operations. It is suggested that CO-OP staff take the following steps in the coming year to increase their familiarity with the model and to investigate possible model upgrades:

- CO-OP staff will program Potomac-OASIS to include a probabilistic prediction of reservoir storage on June 1 of the following year. This is likely a reasonably easy task that would help CO-OP staff to become more familiar with the OASIS OCL programming language, and slightly improve model functionality.
- According to HydroLogics, the Potomac-OASIS model could also be used to evaluate potential operating scenarios for several days or weeks in the future. CO-OP staff will talk to HydroLogics staff to learn more about this potential use of the model. The cost of configuring the positional analysis user interface to better support this use of the model will be determined in either CO-OP staff time or in a dollar amount for HydroLogics staff time.

## *CO-OP Drought Operations Tools*

CO-OP's current set of drought operations tools, developed using Microsoft Excel, are described in the 2010 drought operations report. These tools evolve from year to year as CO-OP staff identify and implement changes and upgrades to add new capabilities and to improve user interfaces. Drought exercises provide an excellent opportunity for staff to think about and discuss possible improvements to these tools.

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<sup>7</sup> 2010 Washington Metropolitan Area Drought Operations - Summary and Lessons Learned, S.N. Ahmed, K.R. Bencala and C.L. Schultz, Interstate Commission on the Potomac River Basin, Rockville, Maryland, 2011, ICPRB Report No. 11-04.

### **CO-OP Tools – Lessons Learned/Action Items**

Below is a list of improvements, identified during the drought exercise, to be addressed in the coming year:

- Add estimate of Great Falls flow to daily flow forecasting tool. (Currently, this estimate is only available in the hourly tool.)
- Construct a Little Seneca Reservoir refill prediction tool to help inform decisions related to the balancing of Jennings Randolph and Little Seneca reservoirs. At the time of the drought exercise, reservoir refill prediction tools were for all system reservoirs but Little Seneca. [*This task was completed in October 2011.*]
- Improve performance and reliability of the hourly flow forecasting tool, which currently requires more than one minute of Excel calculation time when new input values are entered into the spreadsheet.
- Improve organization of the “GraphDaily” page of the daily flow forecasting tool. This page, which is crowded and difficult to navigate, contains cells where users can enter future withdrawal and reservoir release scenarios and view resulting changes in future Potomac River flow on a graph. It also contains cells where the user can change key model inputs, such as lag times and area adjustment factors, as well as a table showing error statistics of observed versus predicted flows at various points on the Potomac main stem. Experiment with moving some of this functionality to a separate page.
- Change calculations of future Potomac River withdrawals in the flow forecasting tools so that future off-Potomac reservoir withdrawals by Fairfax Water and WSSC are entered by the user, rather than the future Potomac withdrawals of these suppliers (which required a side calculation). [*This change was implemented in the daily forecast tool in October 2011.*]
- Improve the user interface of the page, “Reservoirs,” in the daily flow forecasting tool where the current day reservoir storages are input. Add the capability to track the impact of the user-entered future reservoir release scenarios on future storage.
- Change spreadsheet calculation of the Little Falls recession equation to account for the impact of a Little Seneca release in the calculation of natural flow at Little Falls.

## **Appendix – 2011 Exercise Monitoring Updates**

### **Current drought monitoring status: Drought exercise completed**

The 2011 CO-OP drought exercise started on Friday, September 16 and ran through Wednesday, September 21, and included updates over the weekend. Below you will find the scenario of drought conditions created for the exercise and an archive of the twice-daily e-mail updates that were sent to participating members.

The goal of the drought exercise is to practice using CO-OP's drought tools, familiarize ICPRB staff with the Potomac OASIS model, and conduct communications as if we were in a real drought. All operational recommendations discussed in our e-mail updates refer to simulated operations and did not actually occur during the exercise period.

Note that in the drought exercise e-mails simulated data appear with 2015 scenario dates and actual data appear with actual dates.

### *2011 Drought Exercise Scenario*

#### **Today's date: September 16, 2015**

Since July, the Potomac River basin has been experiencing a long period of hot and dry weather. These dry conditions have been exacerbated by low precipitation levels during the previous winter, which has led to low groundwater levels over the summer. Precipitation amounts have been particularly low in the Patuxent watershed and storage in these reservoirs is currently at only 25% capacity.

In mid-August, water supply releases were made from Jennings Randolph, with 20% matches provided by Savage Reservoir. This decreased storage levels in both Jennings Randolph and Savage. Releases from Little Seneca Reservoir were also required during this period. Throughout this initial release period, ICPRB CO-OP's reservoir refill tools predicted that system reservoirs should refill by June 1, 2016.

Over the past two weeks, there has been negligible accumulated precipitation across the basin. Given the current dry period, it is expected that releases will be required over the next couple of days.

The Army Corps of Engineers is currently releasing water at a rate of 120 cfs from Jennings Randolph and 55 cfs from Savage.



## *2011 CO-OP Drought Exercise*

### *Drought Exercise Updates*

#### **DROUGHT EXERCISE - Afternoon Potomac flow and demand update (Wednesday 09/21/2011)**

This update concludes the 2011 CO-OP Drought Exercise.

The following (SIMULATED) releases have been requested today: a Little Seneca water supply release of 30 MGD (total target of 66 cfs); a Jennings Randolph release with a Luke target flow of 350 cfs (226 MGD).

#### (SIMULATED) Daily Flows:

Little Falls gage flow 09/20/15: 162 MGD (250 cfs)

Little Falls gage flow 09/21/15: 154 MGD (est., based on most recently available real time data) (238 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/20/15: 500 MGD (780 cfs)

Point of Rocks flow 09/21/15: 660 MGD (est., based on recently available real time data) (1020 cfs)

#### (ACTUAL) Today's estimated demand (09/21/11) P.M.:

WSSC P.M. estimated demand: 170 MGD

FW P.M. estimated demand: 150 MGD

Aqueduct P.M. estimated demand: 145 MGD

Total P.M. estimated demand: 465 MGD

#### (ACTUAL) Tomorrow's estimated demand (09/22/11):

WSSC estimated demand: 170 MGD

FW estimated demand: 155 MGD

Aqueduct estimated demand: 145 MGD

Total estimated demand: 470 MGD

#### SIMULATED operations for today (09/21/15):

##### Fairfax Water (SIMULATED):

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.

Priority 2: maintain Potomac withdrawal as steady as possible.

Up to a 20 MGD load shift may be requested in the next day or two.

##### WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

A load shift may be requested for a short period if absolutely necessary.

##### Seneca (SIMULATED release date, time, amount in MGD):

Continue the 30 MGD water supply release from Little Seneca as requested, for a target flow of 66 cfs.

##### Aqueduct (SIMULATED):

Little Falls: continue use of 50 and 100 MGD pumps (assuming 185 MGD withdrawal).

Great Falls: per operational preference, but keep gate settings as steady as possible.

##### North Branch Reservoirs (SIMULATED):

The water supply release with a Luke target of 350 cfs (226 MGD) continues.

**2011 CO-OP Drought Exercise**

(SIMULATED) Reservoirs - Usable Storage (BG)

Facility	%Full	Current*	2015 Estimated Capacity*
WSSC's Patuxent reservoirs:	23%	2.32	9.9
Fairfax Water's Occoquan reservoir:	60%	4.57	7.6
Little Seneca Reservoir:	87%	3.13	3.6
Jennings Randolph water supply**:	66%	7.82	11.8
Jennings Randolph water quality**:	70%	10.36	14.7
Savage Reservoir:	53%	3.24	6.1

\*Storage and capacities for Occoquan, Patuxent and Little Seneca reservoirs are provided by Washington metropolitan area water utilities, and based on best available information. Storage and capacities for Jennings Randolph and Savage reservoirs are based on observed water levels and available US ACE water level/storage tables from 1998. ICPRB estimates that sedimentation has resulted in a loss of total available storage in Jennings Randolph Reservoir of 1.6 BG in recent years, and this loss is not reflected in the numbers above.

\*\* ICPRB's initial estimate. Final accounting of Jennings Randolph water supply versus water quality storage will be provided at a later date by the US ACE.

**DROUGHT EXERCISE - Morning Potomac flow and demand update (Wednesday 09/21/2011)**

There has been no significant rainfall in the basin over the past 24 hours. The National Weather Service forecasts indicate that a trace amount of precipitation may fall over the next 48 hours. Observed Little Falls flow appears to be steady for the time being. The following (SIMULATED) releases will continue until further notice: a Little Seneca water supply release of 30 MGD (total target of 66 cfs); a Jennings Randolph release with a Luke target flow of 350 cfs (226 MGD).

(SIMULATED) Daily Flows:

Little Falls gage flow 09/20/15: 162 MGD (251 cfs)

Little Falls gage flow 09/21/15: 154 MGD (est., based on most recently available real time data) (238 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/20/15: 500 MGD (780 cfs)

Point of Rocks flow 09/21/15: 660 MGD (est., based on recently available real time data) (1020 cfs)

(ACTUAL) Yesterday's Net Potomac Production (09/20/11):

FW Corbalis raw water withdrawal (Potomac): 93 MGD

WSSC Potomac Production: 116 MGD

Aqueduct withdrawal: 147 MGD

Total Potomac demand: 356 MGD

(ACTUAL) Yesterday's Patuxent, Occoquan, and Net Total System Production (09/20/11):

WSSC Patuxent withdrawal: 63 MGD

FW Occoquan raw water withdrawal: 64 MGD

Total System demand: 483 MGD

(ACTUAL) Today's estimated demand (09/21/11) A.M.:

WSSC A.M. estimated demand: 175 MGD

FW A.M. estimated demand: 150 MGD

Aqueduct A.M. estimated demand: 150 MGD

Total A.M. estimated demand: 475 MGD

(ACTUAL) Tomorrow's estimated demand (09/22/11):

WSSC estimated demand: 170 MGD

FW estimated demand: 155 MGD

Aqueduct estimated demand: 150 MGD

## **2011 CO-OP Drought Exercise**

Total estimated demand: 475 MGD

SIMULATED operations for today (09/21/15):

Fairfax Water (SIMULATED):

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.

Priority 2: maintain Potomac withdrawal as steady as possible.

If flows drop unexpectedly, a load shift of up to 20 MGD may be requested in the next day or two.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

If flows drop unexpectedly, a load shift may be requested for a short period if absolutely necessary in the next day or two.

Seneca (SIMULATED release date, time, amount in MGD):

Continue the 30 MGD water supply release from Little Seneca as requested, for a target flow of 66 cfs.

Aqueduct (SIMULATED):

Little Falls: continue use of 50 and 100 MGD pumps (assuming 185 MGD withdrawal).

Great Falls: per operational preference, but keep gate settings as steady as possible.

North Branch Reservoirs (SIMULATED):

The water supply release with a Luke target of 350 cfs (226 MGD) continues

### **DROUGHT EXERCISE - Afternoon Potomac flow and demand update (Tuesday 09/20/2011)**

A Little Seneca water supply release of 30 MGD (total target of 66 cfs) was requested 9/18/2015 and will continue until further notice. The Jennings Randolph release was increased to reflect a Luke target flow of 350 cfs (226 MGD).

(SIMULATED) Daily Flows:

Little Falls gage flow 09/19/15: 164 MGD (254 cfs)

Little Falls gage flow 09/20/15: 162 MGD (est., based on most recently available real time data) (251 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/19/15: 510 MGD (790 cfs)

Point of Rocks flow 09/20/15: 500 MGD (est., based on recently available real time data) (780 cfs)

(ACTUAL) Today's estimated demand (09/20/11) P.M.:

WSSC P.M. estimated demand: 170 MGD

FW P.M. estimated demand: 160 MGD

Aqueduct P.M. estimated demand: 155 MGD

Total P.M. estimated demand: 485 MGD

(ACTUAL) Tomorrow's estimated demand (09/21/11):

WSSC estimated demand: 170 MGD

FW estimated demand: 165 MGD

Aqueduct estimated demand: 155 MGD

Total estimated demand: 490 MGD

SIMULATED operations for today (09/20/15):

Fairfax Water (SIMULATED):

## ***2011 CO-OP Drought Exercise***

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.

Priority 2: maintain Potomac withdrawal as steady as possible.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

Seneca (SIMULATED release date, time, amount in MGD):

Continue the 30 MGD water supply release from Little Seneca as requested, for a target flow of 66 cfs.

Aqueduct (SIMULATED):

Little Falls: continue use of 50 and 100 MGD pumps (assuming 185 MGD withdrawal).

Great Falls: per operational preference, but keep gate settings as steady as possible.

North Branch Reservoirs (SIMULATED):

A water supply release with a Luke target of 350 cfs (226 MGD) was requested on the morning of September 20, 2015.

### **DROUGHT EXERCISE - Morning Potomac flow and demand update (Tuesday 09/20/2011)**

There has been no significant (SIMULATED) rainfall in the basin over the past 24 hours. The National Weather Service quantitative precipitation forecasts indicate that there will be accumulations of up to a tenth of an inch in the area of the North Branch reservoirs over the next 48 hours. A (SIMULATED) Little Seneca water supply release of 30 MGD (total target of 66 cfs) was requested on 9/18/2015 and will continue until further notice. The (SIMULATED) Jennings Randolph release was increased to reflect a Luke target flow of 350 cfs (226 MGD).

(SIMULATED) Daily Flows:

Little Falls gage flow 09/19/15: 164 MGD (254 cfs)

Little Falls gage flow 09/20/15: 162 MGD (est., based on most recently available real time data) (251 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/19/15: 510 MGD (790 cfs)

Point of Rocks flow 09/20/15: 500 MGD (est., based on recently available real time data) (780 cfs)

(ACTUAL) Yesterday's Net Potomac Production (09/19/11):

FW Corbalis raw water withdrawal (Potomac): 96 MGD

WSSC Potomac Production: 118 MGD

Aqueduct withdrawal: 153 MGD

Total Potomac demand: 367 MGD

(ACTUAL) Yesterday's Patuxent, Occoquan, and Net Total System Production (09/19/11):

WSSC Patuxent withdrawal: 61 MGD

FW Occoquan raw water withdrawal: 64 MGD

Total System demand: 492 MGD

(ACTUAL) Today's estimated demand (09/20/11) A.M.:

WSSC A.M. estimated demand: 170 MGD

FW A.M. estimated demand: 160 MGD

Aqueduct A.M. estimated demand: 155 MGD

Total A.M. estimated demand: 485 MGD

(ACTUAL) Tomorrow's estimated demand (09/21/11):

WSSC estimated demand: 170 MGD

FW estimated demand: 165 MGD

Aqueduct estimated demand: 155 MGD

## 2011 CO-OP Drought Exercise

Total estimated demand: 490 MGD

SIMULATED operations for today (09/20/15):

Fairfax Water (SIMULATED):

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.

Priority 2: maintain Potomac withdrawal as steady as possible.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

Seneca (SIMULATED release date, time, amount in MGD):

Continue the 30 MGD water supply release from Little Seneca as requested, for a target flow of 66 cfs (units corrected from previous updates, correct units used in analysis).

Aqueduct (SIMULATED):

Little Falls: continue use of 50 and 100 MGD pumps (assuming 185 MGD withdrawal).

Great Falls: per operational preference, but keep gate settings as steady as possible.

North Branch Reservoirs (SIMULATED):

A water supply release with a Luke target of 350 cfs (226 MGD) was requested on the morning of September 20, 2015.

(SIMULATED) Reservoirs - Usable Storage (BG):

Facility	%Full	Current	2015 Estimated Capacity
WSSC's Patuxent reservoirs:	24%	2.35	9.9
Fairfax Water's Occoquan reservoir:	61%	4.66	7.6
Little Seneca Reservoir:	88%	3.17	3.6
Jennings Randolph water supply:	68%	7.97	11.8
Jennings Randolph water quality:	71%	10.39	14.7
Savage Reservoir:	54%	3.28	6.1

### **DROUGHT EXERCISE - Afternoon Potomac flow and demand update (Monday 09/19/2011)**

(SIMULATED) Little Seneca and Jennings Randolph water supply releases continue. We will watch flows closely to determine the on-going need and magnitude of the releases.

(SIMULATED) Daily Flows:

Little Falls gage flow 09/18/15: 160 MGD (250 cfs)

Little Falls gage flow 09/19/15: 164 MGD (est., based on most recently available real time data) (208 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/18/15: 500 MGD (780 cfs)

Point of Rocks flow 09/19/15: 510 MGD (est., based on recently available real time data) (790 cfs)

(ACTUAL) Today's estimated demand (09/19/11) P.M.:

WSSC P.M. estimated demand: 170 MGD

FW P.M. estimated demand: 162 MGD

Aqueduct P.M. estimated demand: 150 MGD

Total P.M. estimated demand: 482 MGD

(ACTUAL) Tomorrow's estimated demand (09/20/11):

WSSC estimated demand: 170 MGD

## **2011 CO-OP Drought Exercise**

FW estimated demand: 160 MGD  
Aqueduct estimated demand: 150 MGD  
Total estimated demand: 480 MGD

SIMULATED operations for today (09/19/15):

Fairfax Water (SIMULATED):

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.

Priority 2: maintain Potomac withdrawal as steady as possible.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

Seneca (SIMULATED release date, time, amount in MGD):

Continue the 30 MGD water supply release from Little Seneca as requested, for a target flow of 66 MGD.

Aqueduct (SIMULATED):

Little Falls: continue use of 50 and 100 MGD pumps (assuming 185 MGD withdrawal).

Great Falls: per operational preference, but keep gate settings as steady as possible.

North Branch Reservoirs (SIMULATED):

A water supply release with a Luke target of 255 cfs (165 MGD) was requested on the morning of September 19, 2015.

### **DROUGHT EXERCISE - Morning Potomac flow and demand update (Monday 09/19/2011)**

There has been no significant rainfall in the basin over the past 24 hours. The National Weather Service quantitative precipitation forecasts indicate that there will be accumulations of up to 0.75 inches in the area of the North Branch reservoirs over the next 48 hours. A (SIMULATED) Little Seneca water supply release of 30 MGD (total target of 66 MGD) was requested yesterday morning and will continue until further notice. We observed the arrival of the Little Seneca release this morning and it appears to have stabilized flows at Little Falls for the time being.

For this drought exercise we are using a 50 MGD deficit threshold at Little Falls for initiation of a Jennings Randolph water supply release. This threshold is only considered for the first day of the release. Today's 9-day forecasted deficit is above this threshold. Therefore, a (SIMULATED) Jennings Randolph water supply release was requested with a Luke target flow of 255 cfs (165 MGD). According to the COE's accounting rules this request will result in a water supply release of approximately 134 cfs (86 MGD). This week we will test the impact of this operational change over the entire historical record using our planning tool PRRISM.

We will watch flows closely to determine the on-going need and magnitude of the releases.

(SIMULATED) Daily Flows:

Little Falls gage flow 09/18/15: 160 MGD (250 cfs)

Little Falls gage flow 09/19/15: 164 MGD (est., based on most recently available real time data) (253 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/18/15: 500 MGD (780 cfs)

Point of Rocks flow 09/19/15: 510 MGD (est., based on recently available real time data) (790 cfs)

(ACTUAL) Yesterday's Net Potomac Production (09/18/11):

FW Corbalis raw water withdrawal (Potomac): 89 MGD

WSSC Potomac Production: 118 MGD

**2011 CO-OP Drought Exercise**

Aqueduct withdrawal: 139 MGD  
 Total Potomac demand: 346 MGD

(ACTUAL) Yesterday's Patuxent, Occoquan, and Net Total System Production (09/18/11):

WSSC Patuxent withdrawal: 46 MGD  
 FW Occoquan raw water withdrawal: 67 MGD  
 Total System demand: 459 MGD

(ACTUAL) Today's estimated demand (09/19/11) A.M.:

WSSC A.M. estimated demand: 170 MGD  
 FW A.M. estimated demand: 170 MGD  
 Aqueduct A.M. estimated demand: 150 MGD  
 Total A.M. estimated demand: 490 MGD

(ACTUAL) Tomorrow's estimated demand (09/20/11):

WSSC estimated demand: 170 MGD  
 FW estimated demand: 160 MGD  
 Aqueduct estimated demand: 150 MGD  
 Total estimated demand: 480 MGD

(SIMULATED) operations for today (09/19/15):

Fairfax Water (SIMULATED):

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.  
 Priority 2: maintain Potomac withdrawal as steady as possible.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.  
 Priority 2: keep Potomac withdrawals as steady as possible.

Seneca (SIMULATED release date, time, amount in MGD):

Continue the 30 MGD water supply release from Little Seneca as requested, for a target flow of 66 MGD.

Aqueduct (SIMULATED):

Little Falls: continue use of 50 and 100 MGD pumps (assuming 185 MGD withdrawal).  
 Great Falls: per operational preference, but keep gate settings as steady as possible.

North Branch Reservoirs (SIMULATED):

A water supply release with a Luke target of 255 cfs (165 MGD) was requested on the morning of September 19, 2015.

(SIMULATED) Reservoirs - Usable Storage (BG):

Facility	%Full	Current*	2015 Estimated Capacity
WSSC's Patuxent reservoirs:	24%	2.41	9.9
Fairfax Water's Occoquan reservoir:	64%	4.84	7.6
Little Seneca Reservoir:	91%	3.26	3.6
Jennings Randolph water supply:	69%	8.20	11.8
Jennings Randolph water quality:	71%	10.43	14.7
Savage Reservoir:	55%	3.34	6.1

*2011 CO-OP Drought Exercise*

**DROUGHT EXERCISE - Afternoon Potomac flow and demand update (Sunday 09/18/2011)**

There has been no significant rainfall in the basin over the past 24 hours. The National Weather Service quantitative precipitation forecasts indicate that there will be accumulations of up to 0.75 inches over much of the basin during the next five days.

A Little Seneca water supply release of 30 MGD (total target of 66 MGD) was requested this morning and will continue until further notice. We will watch flows closely to determine the on-going need and magnitude of the release.

(SIMULATED) Daily Flows:

Little Falls gage flow 09/17/15: 210 MGD (330 cfs)

Little Falls gage flow 09/18/15: 160 MGD (est., based on most recently available real time data) (250 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/17/15: 510 MGD (800 cfs)

Point of Rocks flow 09/18/15: 500 MGD (est., based on recently available real time data) (780 cfs)

(ACTUAL) Today's estimated demand (09/18/11) P.M.:

WSSC P.M. estimated demand: 170 MGD

FW P.M. estimated demand: 160 MGD

Aqueduct P.M. estimated demand: 138.5 MGD

Total P.M. estimated demand: 468.5 MGD

(ACTUAL) Tomorrow's estimated demand (09/19/11):

WSSC estimated demand: 175 MGD

FW estimated demand: 170 MGD

Aqueduct estimated demand: 152 MGD

Total estimated demand: 497 MGD

SIMULATED operations for today (09/18/15):

Fairfax Water (SIMULATED):

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.

Priority 2: maintain Potomac withdrawal as steady as possible.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

Seneca (SIMULATED release date, time, amount in MGD):

Continue the 30 MGD water supply release from Little Seneca as requested, for a target flow of 66 MGD.

Aqueduct (SIMULATED):

Little Falls: continue use of 50 and 100 MGD pumps (assuming 185 MGD withdrawal).

Great Falls: per operational preference, but keep gate settings as steady as possible.

North Branch Reservoirs (SIMULATED):

There are currently no releases from the North Branch reservoirs.



## *2011 CO-OP Drought Exercise*

### **DROUGHT EXERCISE - Morning Potomac flow and demand update (Sunday 09/18/2011)**

There has been no significant rainfall in the basin over the past 24 hours. The National Weather Service quantitative precipitation forecasts indicate that there will be accumulations of up to 0.75 inches over much of the basin during the next five days.

A Little Seneca water supply release of 30 MGD (total target of 66 MGD) has been requested to begin this morning. (SIMULATED)

(SIMULATED) Daily Flows:

Little Falls gage flow 09/17/15: 210 MGD (330 cfs)

Little Falls gage flow 09/18/15: 160 MGD (est., based on most recently available real time data) (250 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/17/15: 510 MGD (800 cfs)

Point of Rocks flow 09/18/15: 500 MGD (est., based on recently available real time data) (780 cfs)

(ACTUAL) Yesterday's Net Potomac Production (09/17/11):

FW Corbalis raw water withdrawal (Potomac): 93 MGD

WSSC Potomac Production: 119 MGD

Aqueduct withdrawal: 146 MGD

Total Potomac demand: 358 MGD

(ACTUAL) Yesterday's Patuxent, Occoquan, and Net Total System Production (09/17/11):

WSSC Patuxent withdrawal: 57 MGD

FW Occoquan raw water withdrawal: 70 MGD

Total System demand: 485 MGD

(ACTUAL) Today's estimated demand (09/18/11) A.M.:

WSSC A.M. estimated demand: 175 MGD

FW A.M. estimated demand: 160 MGD

Aqueduct A.M. estimated demand: 143 MGD

Total A.M. estimated demand: 478 MGD

(ACTUAL) Tomorrow's estimated demand (09/19/11):

WSSC estimated demand: 175 MGD

FW estimated demand: 170 MGD

Aqueduct estimated demand: 157 MGD

Total estimated demand: 502 MGD

SIMULATED operations for today (09/18/15):

Fairfax Water (SIMULATED):

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.

Priority 2: maintain Potomac withdrawal as steady as possible.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible to preserve storage.

Priority 2: keep Potomac withdrawals as steady as possible.

Seneca (SIMULATED release date, time, amount in MGD):

A 30 MGD water supply release from Little Seneca is requested, for a target flow of 66 MGD.

Aqueduct (SIMULATED):

## 2011 CO-OP Drought Exercise

Little Falls: continue use of 50 and 100 MGD pumps (assuming 185 MGD withdrawal).

Great Falls: per operational preference, but keep gate settings as steady as possible.

North Branch Reservoirs (SIMULATED):

There are currently no releases from the North Branch reservoirs.

(SIMULATED) Reservoirs - Usable Storage (BG) as of 9/18/15:

Facility	%Full	Current*	2015 Estimated Capacity
WSSC's Patuxent reservoirs:	25%	2.44	9.9
Fairfax Water's Occoquan reservoir:	65%	4.93	7.6
Little Seneca Reservoir:	92%	3.3	3.6
Jennings Randolph water supply:	69%	8.2	11.8
Jennings Randolph water quality:	72%	10.54	14.7
Savage Reservoir:	55%	3.36	6.1

A correction to yesterday's reported actual demands in the morning email has been made in the archived version below. Yesterday's analysis, however, did reflect the correct demand figures.

### **DROUGHT EXERCISE - Afternoon Potomac flow and demand update (Saturday 09/17/2011)**

There has been no significant rainfall in the basin over the past 24 hours. The National Weather Service quantitative precipitation forecasts indicate that there will be accumulations of up to 0.75 inches over much of the basin during the next five days.

(SIMULATED) Daily Flows:

Little Falls gage flow 09/16/15: 310 MGD (470 cfs)

Little Falls gage flow 09/17/15: 210 MGD (est., based on most recently available real time data) (327 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/16/15: 570 MGD (880 cfs)

Point of Rocks flow 09/17/15: 510 MGD (est., based on recently available real time data) (800 cfs)

(ACTUAL) Today's estimated demand (09/17/11) P.M.:

WSSC P.M. estimated demand: 175 MGD

FW P.M. estimated demand: 160 MGD

Aqueduct P.M. estimated demand: 140 MGD

Total P.M. estimated demand: 475 MGD

(ACTUAL) Tomorrow's estimated demand (09/18/11):

WSSC estimated demand: 175 MGD

FW estimated demand: 170 MGD

Aqueduct estimated demand: 132 MGD

Total estimated demand: 477 MGD

SIMULATED operations for today (09/17/15):

Fairfax Water (SIMULATED):

Priority 1: keep Occoquan withdrawals as close to 90 MGD as possible.

Priority 2: maintain Potomac withdrawal as steady as possible.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

## ***2011 CO-OP Drought Exercise***

Seneca (SIMULATED release date, time, amount in MGD):  
No release from Little Seneca Reservoir is scheduled as of this afternoon.

Aqueduct (SIMULATED):  
Little Falls: implement an additional load shift by adding the 50 MGD pump; continue operating 100 MGD pump (resulting in an observed 185 MGD withdrawal).  
Great Falls: per operational preference if additional demand needs to be met.

North Branch Reservoirs (SIMULATED):  
There are currently no releases from the North Branch reservoirs.

### **DROUGHT EXERCISE - Morning Potomac flow and demand update (Saturday 09/17/2015)**

There has been no significant rainfall in the basin over the past 24 hours. The National Weather Service quantitative precipitation forecasts indicate that there will be accumulations of up to 0.75 inches over much of the basin during the next five days.

If flows continue to drop at Little Falls, we may request a Little Seneca release (SIMULATED) this afternoon.

(SIMULATED) Daily Flows:

Little Falls gage flow 09/16/15: 310 MGD (470 cfs)

Little Falls gage flow 09/17/15: 210 MGD (est., based on most recently available real time data) (327 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/16/15: 570 MGD (880 cfs)

Point of Rocks flow 09/17/15: 510 MGD (est., based on recently available real time data) (800 cfs)

(ACTUAL) Yesterday's Net Potomac Production (09/16/11):

FW Corbalis raw water withdrawal (Potomac): 81 MGD

WSSC Potomac Production: 124 MGD

Aqueduct withdrawal: 152 MGD

Total Potomac demand: 357 MGD

(ACTUAL) Yesterday's Patuxent, Occoquan, and Net Total System Production (09/16/11):

WSSC Patuxent withdrawal: 49 MGD

FW Occoquan raw water withdrawal: 69 MGD

Total System demand: 475 MGD

(ACTUAL) Today's estimated demand (09/17/11) A.M.:

WSSC A.M. estimated demand: 175 MGD

FW A.M. estimated demand: 160 MGD

Aqueduct A.M. estimated demand: 141 MGD

Total A.M. estimated demand: 496 MGD

(ACTUAL) Tomorrow's estimated demand (09/18/11):

WSSC estimated demand: 175 MGD

FW estimated demand: 170 MGD

Aqueduct estimated demand: 140 MGD

Total estimated demand: 495 MGD

## ***2011 CO-OP Drought Exercise***

SIMULATED operations for today (09/17/15):

Fairfax Water (SIMULATED):

Immediate load shift of 10 MGD to Occoquan (from 80 MGD to 90 MGD).

Maintain Potomac withdrawal as steady as possible.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

Seneca (SIMULATED release date, time, amount in MGD):

No release from Little Seneca Reservoir is scheduled as of this morning. This will be reconsidered later in the day.

Aqueduct (SIMULATED):

Little Falls: continue operating 100 MGD pump (assuming 125 MGD withdrawal).

Great Falls: Gate 1 at 0.7 and Gate 2 at 0.8.

North Branch Reservoirs (SIMULATED):

There are currently no releases from the North Branch reservoirs.

### **DROUGHT EXERCISE - Afternoon Potomac flow and demand update (Friday 09/16/2015)**

(SIMULATED) Daily Flows:

Little Falls gage flow 09/15/15: 210 MGD (320 cfs)

Little Falls gage flow 09/16/15: 310 MGD (est., based on most recently available real time data) (473 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/15/15: 610 MGD (940 cfs)

Point of Rocks flow 09/16/15: 570 MGD (est., based on recently available real time data) (880 cfs)

(ACTUAL) Today's estimated demand (09/16/11) P.M.:

WSSC P.M. estimated demand: 180 MGD

FW P.M. estimated demand: 160 MGD

Aqueduct P.M. estimated demand: 135 MGD

Total P.M. estimated demand: 475 MGD

(ACTUAL) Tomorrow's estimated demand (09/17/11):

WSSC estimated demand: 180 MGD

FW estimated demand: 160 MGD

Aqueduct estimated demand: 130 MGD

Total estimated demand: 470 MGD

SIMULATED operations for today (09/16/15): Same as morning requests.

Fairfax Water (SIMULATED):

Per operational preference

Be advised that a load shift of up to 20 MGD to Occoquan may be required on short notice.

WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible.

Priority 2: keep Potomac withdrawals as steady as possible.

Seneca (SIMULATED release date, time, amount in MGD):

No release from Little Seneca Reservoir is scheduled today.

## ***2011 CO-OP Drought Exercise***

### **Aqueduct (SIMULATED):**

Little Falls: continue with 100 MGD withdrawal

Great Falls: Gate 1 at 1.1 and Gate 2 at 1.1

### **North Branch Reservoirs (SIMULATED):**

There are currently no releases from the North Branch reservoirs.

### **DROUGHT EXERCISE - Morning Potomac flow and demand update (Friday 09/16/2015)**

There has been no significant rainfall in the basin over the past 24 hours. The National Weather Service quantitative precipitation forecasts indicate that there will be accumulations of approximately 0.5 inches over much of the basin during the next five days.

Be advised that because of the low flow conditions at Little Falls, releases from Jennings Randolph and Little Seneca reservoirs may be resumed in the coming days. A separate e-mail will be sent today to the CO-OP supplier general managers to request concurrence for possible releases over the weekend.

### **(SIMULATED) Daily Flows:**

Little Falls gage flow 09/15: 210 MGD (320 cfs)

Little Falls gage flow 09/16: 310 MGD (est., based on most recently available real time data) (473 cfs)

Note: Gage flow at Little Falls is measured after water supply withdrawals.

Point of Rocks flow 09/15: 610 MGD (940 cfs)

Point of Rocks flow 09/16: 570 MGD (est., based on recently available real time data) (880 cfs)

### **(ACTUAL) Net Potomac Production (09/15/11):**

FW Corbalis raw water withdrawal (Potomac): 86 MGD

WSSC Potomac Production: 126 MGD

Aqueduct withdrawal: 146 MGD

Total Potomac demand: 358 MGD

### **(ACTUAL) Patuxent, Occoquan, and Net Total System Production (09/15/11):**

WSSC Patuxent withdrawal: 57 MGD

FW Occoquan raw water withdrawal: 69 MGD

Total System demand: 484 MGD

### **(ACTUAL) Today's estimated demand (09/16/11) A.M.:**

WSSC A.M. estimated demand: 180 MGD

FW A.M. estimated demand: 160 MGD

Aqueduct A.M. estimated demand: 135 MGD

Total A.M. estimated demand: 475 MGD

### **(ACTUAL) Tomorrow's estimated demand (09/17/11):**

WSSC estimated demand: 180 MGD

FW estimated demand: 160 MGD

Aqueduct estimated demand: 130 MGD

Total estimated demand: 470 MGD

### **SIMULATED operations for today (09/16/15):**

#### **Fairfax Water (SIMULATED):**

Please keep Potomac withdrawals as steady as possible.

Keep Occoquan withdrawals below 90 MGD to conserve storage.

## 2011 CO-OP Drought Exercise

Be advised that a load shift of up to 20 MGD to Occoquan may be required on short notice.

### WSSC (SIMULATED):

Priority 1: keep Patuxent withdrawals as close to 30 MGD as possible to conserve storage.

Priority 2: keep Potomac withdrawals as steady as possible.

### Seneca - (SIMULATED) (release date, time, amount in MGD):

No release from Little Seneca Reservoir is scheduled today.

### Aqueduct (SIMULATED):

Little Falls: continue with 100 MGD withdrawal

Great Falls: Gate 1 at 1.1 and Gate 2 at 1.1

### North Branch Reservoirs (SIMULATED):

There are currently no releases from the North Branch reservoirs.

### (SIMULATED) Reservoirs - Usable Storage (BG):

Facility	%Full	Current	2015 Estimated Capacity
WSSC's Patuxent reservoirs:	25%	2.5	9.9
Fairfax Water's Occoquan reservoir:	67%	5.1	7.6
Little Seneca Reservoir:	92%	3.3	3.6
Jennings Randolph water supply:	69%	8.2	11.8
Jennings Randolph water quality:	73%	10.7	14.7
Savage Reservoir:	56%	3.4	6.1