Executive summary

Introduction

Twenty-five years ago, the Washington metropolitan area was faced with a looming water supply shortage. Area water suppliers developed a plan embodied in the Water Supply Coordination Agreement signed in 1982 to address water supply adequacy for the foreseeable future. This study provides a renewed assessment of the reliability of the Washington metropolitan area (WMA) supply. The study concludes that the water supply system is highly reliable and will be adequate to meet growing demand through the next 20 years.

The Low Flow Allocation Agreement, signed by the United States, Maryland, Virginia, the District of Columbia, the Washington Suburban Sanitary Commission (WSSC) and Fairfax Water in 1978, requires that "In April 1990 and in April of each fifth year thereafter ... the [WMA water suppliers and the District of Columbia] shall evaluate the adequacy of the then available water supplies to meet the water demand in the Washington Metropolitan Area which may then be expected to occur during the succeeding twenty year period." This report was prepared pursuant to that Agreement and is the fourth such report prepared by the Interstate Commission on the Potomac River Basin (ICPRB) Section for Cooperative Water Supply Operations on the Potomac (CO-OP).

Demand forecasting is critical to water resources planning. The time required to build new resources or implement demand management strategies is lengthy, and forecasts of future demand help managers and municipalities to plan for the future. Rather than providing a predetermined view of future demand, these forecasts provide supply managers with the tools to understand both the quantity of demand and factors that influence demand on water resources (Osborn et al., 1986). This study is primarily intended as an aid to long-range planning.

The study incorporates several changes to the prior studies. These include:

- improved system operations made possible by increases in treatment capacities at Patuxent and Occoquan reservoirs,
- an assessment of more-severe droughts than documented in the historical record,
- demand reduction percentages based on regional experience,
- water supply demand modeled as a function of weather and other variables,
- scenarios addressing impacts of potential regional climate change,
- an enhanced model of the North Branch water quality operations, and
- modified operations at Savage Reservoir.

Background

The majority of the WMA's population relies on water furnished by three water suppliers (collectively, WMA 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, serving portions of northern Virginia.
- The Washington Suburban Sanitary Commission (WSSC) serving primarily the Maryland suburbs in Prince George's and Montgomery counties.

The WMA water suppliers provide treated water either directly to customers or through wholesale suppliers. In periods of low flow, the WMA water suppliers essentially operate as one entity, sharing water across the Potomac, Patuxent and Occoquan basins. This cooperative work is coordinated by ICPRB's CO-OP section.

The study focus includes the WMA water suppliers and their wholesale customers, including the Loudoun County Sanitation Authority, Prince William County Service Authority, Virginia American Water Company, Vienna Dept. of Public Works, D.C. Water and Sewer Authority, Arlington County Department of Public Works, and the Falls Church Department of Environmental Services/Public Works. In addition, the City of Rockville's demand was estimated.

The natural flow in the Potomac River supplies approximately 75 percent of the water demand in the WMA, with the remainder supplied by Fairfax Water's Occoquan Reservoir and WSSC's Patuxent reservoirs. All three suppliers continue to contribute to the cost of Jennings Randolph and Little Seneca reservoirs in the Potomac basin that augment Potomac flows during droughts.

Demand projections

The estimate of future demand is based on three types of water uses, namely single family household use, multi-family (apartment) water use, and employee water use. All governmental, industrial and other commercial water use is lumped into the "employee" category of water use. Projections of numbers of households and employees are based on the most recent Metropolitan Washington Council of Governments (MWCOG) projections, which were collaboratively developed by MWCOG and local government planners. Forecasts of growth for population, employees, and households show significant growth, as shown in Table ES-1.

Table ES-1: Net increase in demographics by service areas from 2005 to 2025.

Service area	# Household increase, percent		# Population increase, percent		# Employee increase, percent	
Fairfax Water retail and wholesale	142,006	27%	366,518	26%	302,945	42%
Aqueduct wholesale service area	67,636	16%	146,981	15%	196,553	19%
WSSC service area	130,389	22%	273,835	17%	310,374	40%
Totals (plus Rockville)	**343,092**	**22%**	**792,524**	**19%**	**831,919**	**32%**

Coefficients were developed for each jurisdiction in the WMA to describe average daily water use by each type of water user. Demand estimates were developed by multiplying forecasts of the number of each type of water user by the coefficients describing average water use for each jurisdiction. In addition, unmetered water use was estimated for each jurisdiction. Per household water use is assumed to be lower in the future than it is today as a result of the *Energy Policy Act of 1992* (102D Congress, 2d session, 1992).

Current average annual water use for the WMA water suppliers during normal years is approximately 488 MGD and is projected to be 572 MGD in 2025. Demand during a hot and dry year in 2025 is projected to be approximately 587 MGD. The 2005 CO-OP forecast of annual average demand for 2020 is approximately 28 MGD less than the level forecast by the 2000 study (Figure ES-1). The lower forecast in this study is due primarily to updated demographic forecasts and lower calculated unit use rates. Population growth has increased at a faster rate than water demand in recent years.

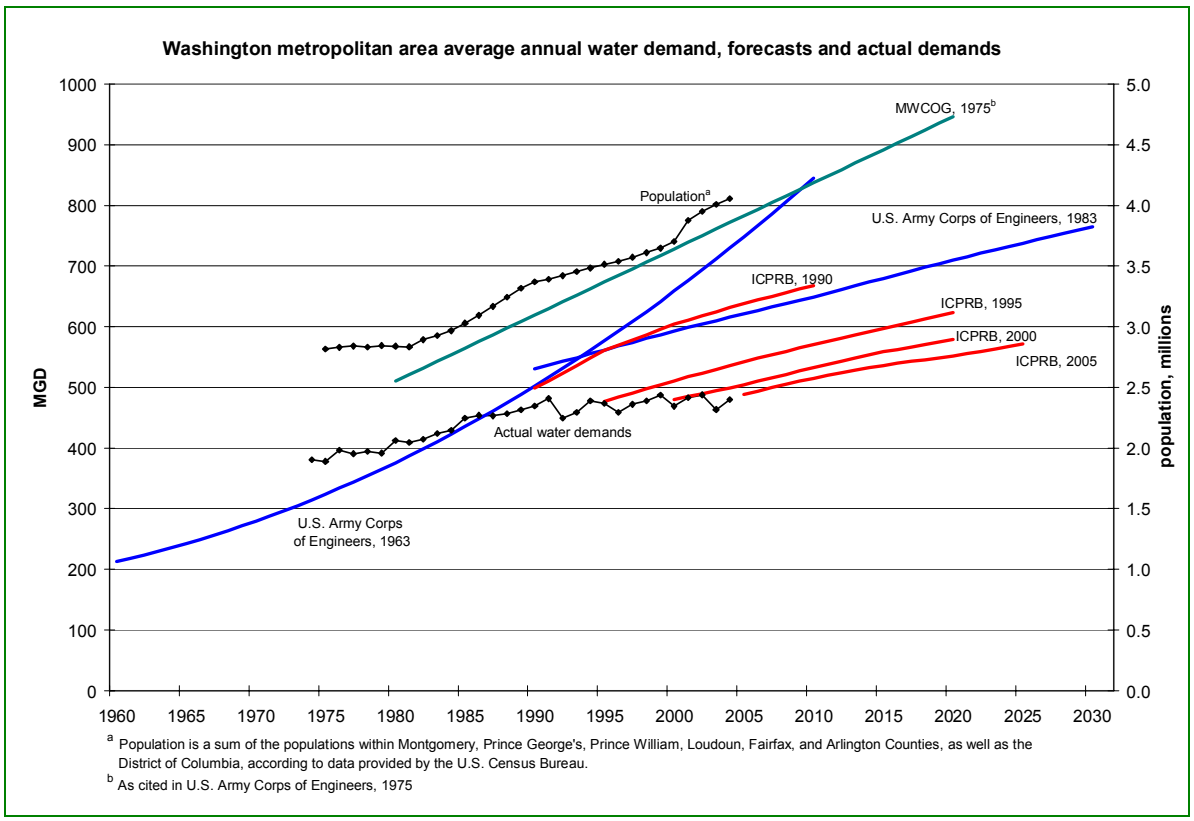

Figure ES-1: Comparison with forecasts from earlier studies for CO-OP Suppliers.

Resource analysis

The resource analysis examines the existing water system's ability to meet forecasts of future demand. The operation of the water resource system is modeled such that the Occoquan and Patuxent reservoirs are managed as part of a regional water supply system with Jennings Randolph and Little Seneca reservoirs, in order to maximize the reliability of the overall system.

Using the deterministic continuous simulation model, the Potomac Reservoir and River Simulation Model (PRRISM), several scenarios were examined. These scenarios include the most recently available MWCOG estimate of growth (Round 6.4a), the most recently available MWCOG estimate of high growth (Round 6 high), a climate change scenario, a scenario assuming no demand reduction due to the effects of the *Energy Policy Act of 1992*, a simulation over a drought worse than the drought of record, and demand scenarios beyond (greater than) those for year 2025. (Although the study horizon is through 2025, the forecast was extended to 2045 by assuming similar rates of growth in order to assess the response of the system to higher demand.) Chapter 6 documents the assumptions made in the resource analysis, including the following:

- Voluntary and mandatory restrictions are assumed to reduce demand during extreme droughts.
- Reservoir storage is reduced over time to account for siltation.
- The current recommended environmental flow rate for Little Falls is modeled.
- Stream flow resources are reduced to account for increasing upstream consumptive demand.

Results/Conclusions

The current assessment of future water demand and water supply reliability for the metropolitan Washington area demonstrates that even with a high growth (MWCOG Round 6 high growth scenario), the water supply system developed twenty-five years ago is adequate to meet 2025 demand under a repeat of the worst meteorological and stream flow conditions in the historical record. Results of this analysis are shown in Table ES-2, below. *Furthermore, the system is able to meet estimated future water supply demand in 2045 given a repeat of the same drought conditions.*

Results of the current resource analysis show more storage remaining in system reservoirs under a repeat of the drought of record than those of the demand and resource study conducted five years ago. There are several reasons for this difference which are quantified in Table ES-3.

Estimates of future water demand are reduced in this study to account for water savings due to the Federal Energy Policy Act of 1992. An alternative scenario was developed to explore how resources would be affected if there was no such reduction in future unit use. Results showed that the water supply system is adequate to meet 2025 demand under a repeat of the worst meteorological and stream flow conditions on record.

Table ES-2: Results for most likely (Round 6.4a) and high (Round 6) growth scenarios

Results for MWCOG Round 6.4a and Round 6 high growth scenarios, 2025 demand	Round 6.4a	6.4a Std. deviation	Round 6 high	6 Std. deviation
Reliability				
Percentage of years with no Potomac deficits	100	0	100	0
Number of days in which Potomac deficits must be allocated	0	0	0	0
Number of Patuxent water supply shortfalls	0	0	0	0
Number of Occoquan water supply shortfalls	0	0	0	0
Percentage of years with restrictions				
Voluntary restrictions	4.1	0.0	5.5%	0.0%
Mandatory restrictions	0.0	0.0	0.1%	0.4%
Emergency restrictions	0.0	0.0	0.0	0.0
Minimum reservoir storage, BG, (percent full)				
Little Seneca Reservoir	2.9 (75)	0.11	2.6 (70)	0.15
Jennings Randolph water supply account	4.7 (36)	0.14	3.4 (26)	0.10
Jennings Randolph water quality account	1.5 (9)	0.00	1.3 (8)	0.00
storage in Patuxent Reservoir	2 (20)	0.04	1.8 (18)	0.08
storage in Occoquan Reservoir	1.6 (20)	0.02	1.6 (20)	0.01
storage in Savage Reservoir	0.7 (11)	0.00	0.7 (11)	0.00
Little Seneca Reservoir and Jennings Randolph water supply account, combined	7.6 (45)	0.25	6.2 (36)	0.17
Patuxent, Occoquan, and Little Seneca reservoirs and Jennings Randolph water supply, combined	12.2 (24)	0.24	10.5 (20)	0.28
Miscellaneous				
Number of years in simulation (10/1/1929 – 9/30/2002)	73	0	73	0
Average annual demand drought year (1930, MGD)	587	3	622	4
Minimum average flow				
Average minimum natural flow summer (1930), MGD	1,141	NA	1,141	NA
Average minimum natural flow fall (1930), MGD	606	NA	606	NA
Average minimum summer flow downstream of intakes (1930), MGD	574	5	556	6
Average minimum fall flow downstream of intakes (1930), MGD	252	5	225	8

Table ES-3: Differences between 2000 and 2005 Twenty-Year Demand Forecast and Resource Analyses.

Difference between two studies		Change in minimum storage in Jennings Randolph and Little Seneca Reservoirs
Changes in demand forecast	The 2000 forecast of 2020 demand is 597 MGD, and the 2005 forecast of 2025 demand is 572 MGD.	+0.4 BG
Water quality releases	More sophisticated modeling of Jennings Randolph/Savage water quality operations and releases.	+2.8 BG
Operational efficiency	Improved system operations made possible by increases in treatment capacity at Patuxent and Occoquan reservoirs.	+1.3 BG
Savage operations	A percentage of the Jennings Randolph Reservoir water supply release is matched by a concurrent water quality release from Savage Reservoir.	+0.6 BG

An assessment of potential impacts of climate change included the effects of potential changes to water demand due to forecasts of regional temperature changes, and a sensitivity analysis which reduced stream flow. The results suggest that the water supply system maintains a high degree of reliability over the 20-year forecast horizon of this study. It should be noted that the degree of uncertainty associated with the climate change analysis conducted for this study is high.

Results of simulations over a drought worse than the drought of record (i.e., over a 500-hundred year stream flow simulation) show that the system would be unable to meet all demand for approximately 6 days during one year of the 500-year simulation. The average shortfall over the six days was 41 MGD with an average total shortfall of 0.3 billion gallons and an average maximum shortfall of 90 MGD. Lower demand associated with 2020 was examined. In that case, the system would be adequate to meet 2020 demand without any supply shortfalls, although system storage would be significantly depleted. All demand cannot be met with available streamflow when Little Seneca Reservoir and Jennings Randolph reservoirs are empty. When the existing resources are insufficient to meet demand, the suppliers would use existing agreements to place restrictions on demand and allocate available resources. The results must be interpreted with caution, as there is some uncertainty associated with the method and actual events could exceed simulated drought conditions.

Flows are lower in the Potomac downstream of Little Falls as compared to natural conditions. Growth in demand over the next 20 years will not significantly change the frequency of low flows but will lower the magnitude of those flows that are already low. Reservoir releases increase flow in the 200-mile stretch of the Potomac River upstream of the water supply intakes during low flows as compared to natural conditions.

Per-household water use rates have changed significantly over the past 15 years, declining approximately 18 percent across single-family households from 1990 to 2000, and another 13 percent from 2000 to 2005. These declining water use rates may be due to several factors. A poll by a MWCOG study shows the region's residents support conservation, with 80-90 percent of respondents describing conservation as "very" or "somewhat important." Each of the suppliers has programs in place to encourage moderation in water use. For example, WSSC's rate structure and plumbing code are both credited with reducing recent growth in demand. In the near term, the WMA water suppliers are addressing demand management through participation in the regional Wise Water Use Campaign to encourage year-round conservation. How much of the change in water use is due to these conservation programs is unknown. Some changes may also be due to changes in plumbing codes, social attitudes towards water use, availability of low energy and water use appliances as required in the *Federal Energy Policy Act of 1992*, or other factors.

Water use rates and regional growth projections in the WMA may continue to change rapidly, suggesting that conducting the study regularly is of considerable value. The selection of the five-year interval for the current study provides multiple additional benefits. It allows regular updates and incorporation of recent demographic forecasts, and increases visibility and understanding of the adequacy of the region's water resources. It provides adequate time to conduct research on the physical system and incorporate modifications in subsequent studies. It allows for improvements in system operation to be explored and implemented as low-cost alternatives to construction of future resources.

The current study results suggest that there is time available to assess future water supply alternatives. Furthermore, the need for additional supplies may be delayed if further operational improvements are made and/or declines in unit use continue. For the longer term, structural and non-structural methods can be explored to meet forecast increases in population. Operational improvements show promise and can continue to be refined through annual drought exercises. Potential structural enhancements to supply include the use of large rock quarries that may be available in future years for water storage. While analysis of the structural measures has received some recent attention, the non-structural ideas are the main focus of ongoing and recent efforts.

Recommendations

- *The high degree of uncertainty associated with climate change research in the Potomac basin is high and can be addressed through more focused study.* The existing regional climate research is oriented towards changes in average conditions, when precisely what is needed is an assessment of changes in extreme conditions. Additional study can clarify the potential impact of climate change on extreme hydrologic events such as drought.

- *The model used to predict demand that is based on weather and other variables can be further improved for operational and planning applications.*

- *Refine operational procedures in order to maximize water supply reliability.* This will result in two benefits. One, operational drought readiness will be improved. Second, operational improvements can offset growth in demand, perhaps delaying the time that new resources are needed.

- *Refine estimates of consumptive use in the basin.* Estimates of upstream consumptive use are highly uncertain, so additional study is warranted to check the accuracy of these estimates.

- *Explore the effects of changing historical land use on hydrology.* The Potomac basin is significantly more forested now than it was during the drought of 1930. Additional study can explore how land use changes affect low flow hydrology.

The full report is available on the ICPRB website at
http://www.potomacriver.org/