A PERSPECTIVE ON THE WASHINGTON METROPOLITAN AREA WATER SUPPLY PROBLEM

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by

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This paper will demonstrate that sufficient water can be impounded in existing reservoirs of the Washington Metropolitan Area to effectively eliminate water shortages until the Year 2000, and possibly beyond. The paper will discuss the additional beneficial effects that completion of Bloomington Dam and Reservoir will have on the area's water supply problem, including the potential for significant cost savings. Coordinated reservoir management techniques and additional physical facilities required to use existing storage facilities effectively will be described, along with the possibilities they may create for water quality management and flood control.

Finally, a proposed study of management techniques applied to the Washington Area will be described. The study would determine alternative combinations of management techniques and additional physical facilities which could best satisfy varying combinations of cost, water supply, and other water resources management objectives. The study is to be performed by the Johns Hopkins University Department of Geography and Environmental Engineering in cooperation with the Interstate Commission on the Potomac River Basin (ICPRB) and the United States Geological Survey (USGS). Funding is to be provided by the State of Maryland, the Commonwealth of Virginia, ICPRB, and the Department of Interior's Office of Water Research and Technology (OWRT). The OWRT funding is to be provided through a grant administered by the University of Maryland's Water Resources Research Center.

AVAILABILITY OF ADEQUATE WATER SUPPLY STORAGE

To demonstrate that sufficient water can be impounded in existing reservoirs, it is necessary to compare the total amount of water required by the region during a drought with the total amount of water available to the region from the Potomac River. For water demand purposes, a figure of 750 mgd will be used. According to the U.S. Army Corps of Engineers North East Water Supply Study (NEWS), the regional water requirement will reach this figure around the Year 2000 (see Table 1). Estimates of water available in the Potomac River will be taken from low flows and recurrence frequencies derived from U.S. Geological Survey flow records at Point of Rocks for the period April 1895 through March 1967 (see Table 2).

The total water deficit, the amount of additional water required to meet estimated water supply demands over and above what is available in the Potomac, can be derived for each drought duration and recurrence frequency listed in Table 2. The total water required is the product of the demand (750 mgd) and the drought duration (7-day, 14-day, 30-day, 60-day, 90-day, or 120-day). The total water available in the river is the product of the duration and the flow listed in Table 2 for the appropriate recurrence interval. The difference between the water required and the water available is the water deficit. Water deficits for all droughts listed in Table 2 are given in Table 3.

The maximum deficit in Table 3 is 15.3 billion gallons, and occurs for a drought of 90 days duration with a 50-year recurrence interval. There is only a two percent chance of incurring a deficit that large in any given year. This deficit can be compared to the storage capacities of the reservoirs which now exist in the Metropolitan Area, as shown in Table 4. The total capacity of these reservoirs is about 20 billion gallons. If these reservoirs were full at the beginning of a drought, and the water in the reservoirs was available to Potomac water users, the Washington Metropolitan Area would come through the worst drought in Table 3 with 5 billion gallons of water to spare.

Therein lies both the opportunity and the problem: While sufficient raw water storage capacity is already available, under present operating procedures that storage is to be significantly reduced at the beginning of a drought. The operation of existing reservoirs would have to be changed to ensure that existing reservoirs are sufficiently full at the beginning of a drought to provide water throughout the drought. Instead of using the reservoirs to provide water during all periods, dry and wet, at a more or less constant rate equal to their safe yields--65 mgd for the Occoquan and 35 mgd for the Patuxent--the reservoirs would have to be operated to provide less water during wet periods when Potomac water is available. As a result, the water would be available during drought periods. Additionally, new transmission facilities for either raw water, or finished water, or both, would probably be required to implement this new mode of operation. The kinds of facilities which might be necessary are discussed below.

Changing the operation of the reservoirs as suggested above would not require abandoning the Patuxent and Occoquan Treatment Plants nor would it require that nearly all the water treated by those plants be pumped from the Potomac. At a minimum, the daily inflow to the reservoirs up to the capacity of the treatment plants could be treated at the plants without Potomac pumping while maintaining full reservoirs. The average inflow to the reservoirs exceed the safe yields. Implementation of coordinated reservoir operation could further increase the amount of reservoirs water available to the reservoir treatment plants.

Changing the operation of the reservoirs as suggested here would make it unneccessary to use the Estuary Emergency Pumping Station for any drought listed in Table 3. Any health risks which might occur from the use of estuary water would therefore be minimized. Any connections constructed to coordinate operation of the reservoirs would have the additional benefit of reducing dependence on a single source of raw water. This would also reduce the consequences of equipment failure or raw water supply contamination. In addition, the suggested reservoir operation would result in higher storage levels in the reservoirs, increasing their recreational utility.

On the other hand, the frequency of extreme low flows in the Potomac would be increased by additional water withdrawals from the river. If major aqueduct withdrawals were made at the Little Falls intake rather than the Great Falls intake, the effects of the additional low flows could be entirely confined to the very short stretch of free flowing river (less than 1000 ft.) directly below Little Falls, and to the upper estuary. Recent water quality model runs made by the COG Water Resources Planning Board staff indicate that the water quality effects on the Estuary will be small.

The assumptions made in this analysis are conservative. Flows at Great Falls, where much of the water is taken from the Potomac, are greater than the flows at Point of Rocks, on which the analysis is based. The water demand of 750 mgd for the Year 2000 is also conservative. It is significantly higher than the Year 2000 demands more recently projected by the Council of Governments and the consultant to the Bi-County Water Supply Task Force. Perhaps most important this analysis ignores the pending availability of approximately an additional 100 mgd of flow in the Potomac provided by the completion and operation of Bloomington Dam and Reservoir.

BENEFITS OF BLOOMINGTON DAM AND RESERVOIR

Assuming that Bloomington Dam and Reservoir would produce an increase in flow of 100 million gallons per day in the Potomac dramatically reduces the requirement for water in existing reservoirs at the start of a drought. Water deficits which would occur, given this assumption, are shown in Table 5. The maximum deficit drops from 15.3 billion gallons to 6.5 billion. Further, since 100 mgd additional flow would be available in the Potomac, the size of any required connections would be reduced by 100 mgd.

Further, if Bloomington were not operated as a constant release reservoir, but rather with an eye toward somewhat larger releases during particularly low flow periods, extreme one-day low flows could be substantially reduced. This would further reduce the size and thus the cost of any required connections, at the expense of requiring additional water in local reservoirs at the start of a drought.

Regardless, the existence of Bloomington, coupled with a coordinated reservoir management program and some raw or finished water supply connections, makes possible some "surplus" storage in local reservoirs. This could be used for water releases for water quality control or to provide flood control storage in the Patuxent and Occoquan reservoirs.

One other large additional benefit can be attributed to Bloomington. Since Bloomington will produce approximately 100 mgd, and regional water demand is projected by the NEWS study at about 12 mgd/year, construction of

Bloomington will allow a delay in the implementation of other future water supply projects by about eight years without an increase in risk of shortage (in addition to the risk which would have been incurred if Bloomington had not been built). An eight year delay in construction of future water supply projects would make it possible to fund other sorely needed capital improvements.

PHYSICAL FACILITIES AND MANAGEMENT PROCEDURES

Several of the management and physical alternatives which would make it possible to use existing storage facilities effectively have been mentioned earlier. The primary physical facilities are those which involve the connection of the Occoquan and Patuxent water supply systems with the Potomac River systems. Obviously, water in the reservoirs is of no use to the people dependent on the Potomac system unless there is a way to transmit water from the reservoirs to the Potomac system. Conversely, water in the reservoirs will be lower at the beginning of a drought unless it is possible to substitute sufficient Potomac water for reservoir water in the reservoir supply systems during wet periods. This can be done by raw water connections between the treatment plants or between the reservoirs and the River above the water supply intakes by finished water connections at key points in the system of water treatment capacity, or by some combination of the two.

It is possible to speculate on the size of the connections which would be necessary. Assuming the design criterion was to meet 750 mgd demand during a 7-day, 50-year drought, the design demand would be 750 mgd and the flow in the river would be 519 mgd (419 mgd from Table 2, plus 100 mgd from Bloomington). Therefore, the total water demand remaining would be 231 mgd to be supplied from the reservoirs. Existing capacity at the reservoir treatment plants already provides for the treatment and distribution of about 140 mgd. The difference, 91 mgd, is an estimate of the additional connections required. This estimate is probably substantially high, because the river flow estimates are low and the demand estimate is high, as discussed earlier. Optional operation of Bloomington Reservoir might reduce the requirement for connections to a very modest level.

The connections need not be interjurisdictional. Connections between the Washington Suburban Sanitary Commission's Potomac and Patuxent supply areas for finished water or raw water connections between the WSSC reservoirs and the WSSC treatment plants, or increased treatment and distribution capacity from the Fairfax County Water Authority's Occoquan Reservoir would be just as effective as interjurisdictional connections.

Major management alternatives involve coordination of releases from existing reservoirs, including Bloomington, at all times, not only during low flows. The major benefits of coordinated releases can be obtained not when the reservoirs are nearly empty, but when they are nearly full.

During low flow periods reservoirs are far from full, coordinated releases can achieve tradeoffs only between the duration and the severity of the drought. This is what was suggested earlier concerning the elimination of extreme low flow in the River using Bloomington. Extreme low flows can be eliminated only at the expense of increasing the duration of more moderate low flows in the River. Fortunately, with Bloomington in operation, this increase in duration could be compensated for by a small increase in the drought supply in the local reservoirs. It could, however, result in a considerable reduction in the size and thus the cost of required connections.

Difficult questions of allocation occur during low flow periods. It is important to realize, however, that during droughts, when allocations must occur, it is impossible to create more water, regardless of the allocation formula. In fact, the allocation, if described as a percentage of the available supply, need not affect even the duration or the severity of the shortage. Allocation issues do, however, affect the distribution of the cost of the required connections and of the water delivered from the Bloomington Reservoir. Any agreement concerning the coordinated operation of raw water supply sources will also require the resolution of these thorny issues between the states and the Army Corps of Engineers.

Coordinated releases during higher flow periods, when the reservoirs are nearly full, can "create" additional water, and thus reduce both the number of shortages and the duration and inverity of those which do occur. This is done by operating to minimize the amount of water which is unintentionally spilled. To illustrate, consider a situation of two independent reservoirs being used to supply a common demand. One is full, the other nearly empty. It would be logical to take the entire demand from the full reservoir. When water is taken from the full reservoir, inflow to that reservoir can be captured to make up for the water released. If, on the other hand, the water is taken from the nearly empty reservoir, any inflow to the full reservoir will be lost over the dam. Since any inflow to the nearly empty reservoir is likely to be captured in either case, some additional water will be available for an impending drought if the water demand is satisfied from the full reservoir.

THE STUDY

A study to be cooperatively funded by the State of Maryland, the Commonwealth of Virginia, the Interstate Commission on the Potomac River Basin (ICPRB), and the Office of Water Research and Technology of the Department of the Interior through the Maryland Water Resources Research Center has been proposed by the Johns Hopkins University Department of Geography and Environmental Engineering. The study would be conducted in cooperation with ICPRB and the United States Geological Survey. It will primarily cover the benefits which could be derived by coordinated operation of reservoirs. Operating rules which are most effective in meeting water supply requirements for the Metropolitan Area will be identified by the study, and the frequency and severity of shortages resulting from attempting to meet varying water supply requirements with varying levels of connections between the reservoirs and river supply systems will be determined. The operating rules tested for Bloomington Reservoir will maintain the levels of upper Potomac basin water supply, flood control, and recreation directed in the legislation authorizing construction of the Bloomington Dam. The implications of providing water for water quality control in the Potomac and the Patuxent, and of providing flood control storage in the Patuxent will also be investigated.

The study will provide the basis for determining the costs of meeting Metropolitan Area water supply requirements with existing water storage facilities, and for operating existing facilities as effectively as possible.

An interstate advisory committee will be formed to help direct the study and discuss issues which must be resolved in order to implement coordinated water supply operation within the region.

CONCLUSIONS

Water supply shortages in the Washington Area can be all but eliminated to the Year 2000 through the effective use and management of existing water supply storage within the region. Raw or finished water connections between Potomac supplies and reservoir supplies will probably be needed to implement the necessary management techniques. The connections need be of only modest size (less than a total of 100 mgd), and need not be interjurisdictional. Optimal operation of Bloomington Dam could significantly reduce the size and cost of the required connections. Many additional benefits could be achieved by connections and coordinated management, including improved system reliability, improved water quality, and additional flood control in the Patuxent.

Difficult questions of allocating the flow in the Potomac and distributing the costs of connections need to be resolved before coordinated reservoir management techniques can be implemented.

TABLE 1

Water Demand Projection
Year 2000

NEWS Study Monthly Demands*

July	August	September	Average Summer
771	755	723	750 mgd

MWCCG Demand Projections**

Annual Average	Max Day
564	798

* From NEWS Study Report, U.S. Army COE NAD, 11/75 p. 31. Figures for Potomac Demand Corrected by adding back 130 mgd assumed from Patuxent and Occoquan Reservoirs and assuming additional 10 mgd (total of 14 mgd) from Goose Creek and Beaverdam Reservoirs.

** From Linear extrapolation of figures in Impact Assessment: 1980, 1990, 1995 Water Resources Implications of Growth Forecasts, MWCOG, 1976.

TABLE 2

Drought Flows, Durations and Recurrence Frequencies*

Drought Duration	Frequency of Recurrence 10 yr.	20 yr.	50 yr.
7 - Day	541	478	419
14 - Day	575	506	438
30 - Day	641	568	503
60 - Day	729	632	541
90 - Day	813	697	580
120 - Day	929	794	658

* Flows in mgd at Point of Rocks, Maryland.

Source: Walker, Patrick N., Flow Characteristics of Maryland Streams, Maryland Geological Survey, 1971, p. 113.

TABLE 3

Total Water Deficits (billions of gallons, assuming no flow augmentation from Bloomington)

Drought Duration	Frequency of Recurrence 10 yr.	20 yr.	50 yr.
7 - Day	1.4	1.9	2.3
14 - Day	2.5	3.4	4.4
30 - Day	3.3	5.5	7.4
60 - Day	1.2	7.1	12.5
90 - Day	0	4.8	15.3
120 - Day	0	0	11.0

TABLE 4

Storage Capacities of
Metropolitan Area Reservoirs

Reservoir	Storage*
Occoquan	9
Tridelphia	5
Duckett	5
Beaverdam (off Goose Creek)	1
Total	20

* Storage given in billion gallons, rounded down from working storage, and excluding flood control storage in Tridelphia and Duckett.

TABLE 5

Total Water Deficits (billions of gallons, assuming 100 mgd augmentation from Bloomington)

Drought Duration	Frequency of Recurrence 10 yr.	20 yr.	50 yr.
7 - Day	.7	1.2	1.6
14 - Day	1.1	2.0	3.0
30 - Day	.3	2.5	4.4
60 - Day	0	1.1	6.5
90 - Day	0	0	6.3
120 - Day	0	0	0