THE RATIONALE FOR RESERVOIRS

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Abstract. Reservoir construction should be avoided, if there is a better alternative. However, in many cases, reservoirs are the only practical alternative for sustaining public water supplies during a drought. Water system managers must understand the environmental impacts of a reservoir but environmentalists must appreciate the need for reliable water supplies for the public. Water supply planning must consider all alternatives and any non-structural alternatives must be realistic. Where reservoirs must be built, effective mitigation programs should be a condition of the reservoir permit.

INTRODUCTION

Water supply reservoirs should not be built unless they are needed and there is no better alternative. However, it must be acknowledged that reservoirs have been needed in the past to assure adequate public water supplies and additional reservoirs may be required in the future to accommodate population growth. It must also be emphasized that reservoirs impose serious impacts on the environment. The loss of a free flowing stream should never be taken lightly and the construction of reservoirs should be avoided if there is another practical alternative.

The River Basin Science and Policy Center at the University of Georgia recently published a paper entitled “Reservoirs in Georgia: Meeting Water Supply Needs While Minimizing Impacts” (hereafter referred to as UGA Whitepaper). The UGA Whitepaper presents a comprehensive discussion of the environmental impacts of reservoirs and should be required reading for water system managers considering construction of a reservoir. The UGA Whitepaper also includes a paragraph describing the value of reservoirs for water systems. The fact remains that reservoirs provide a critically important function to insure the viability of many public water systems.

FUNCTIONS OF RESERVOIRS

The primary function of a reservoir can be described in one word – storage. Engineers tend to have a basic understanding of the importance of storage in a dynamic system. Where inputs and outputs are not constantly equal, storage must be utilized. Analog electronic circuits require capacitors, the sole purpose of which is storage of electric charge. Computers cannot function without data storage. Warehouses store inventory to allow for variations between supply and demand of a product. Detention ponds utilize storage to reduce peak flows from storm events. Elevated tanks store water so that water distribution system pressures will remain relatively constant in spite of short term variances in supply and demand. In a water supply system dependent on surface water, storage from raw water reservoirs is used to supply water to the system during periods of low stream flow.

Storage Requirements

In general, a water supply reservoir in northern Georgia will store something on the order of 100 to 200 days of system demand to supply water needs during a drought. Reservoirs on larger streams will typically require less storage than reservoirs on smaller streams where refill through natural inflow may occur over a period of several years. Increasing the level of protected streamflow will increase the amount of storage needed. In many cases the most efficient configuration is to locate a reservoir on a small stream but use pumped flow from a large stream for reservoir refill and non-drought water supply withdrawals.

The first treatise on sizing water supply reservoirs was published by Rippl in 1883. This analysis is performed graphically (Fig. 1) by plotting cumulative stream flow over time and superimposing straight lines with a slope equal to system demand. The greatest distance between the demand line and the cumulative flow curve is the required storage. Modern techniques for reservoir sizing use detailed computer simulations of the system operation including proposed reservoir configurations and can include other variables in the analysis. Trial and error simulations are run until the point of system failure is determined. These analysis techniques use historic stream flow records and

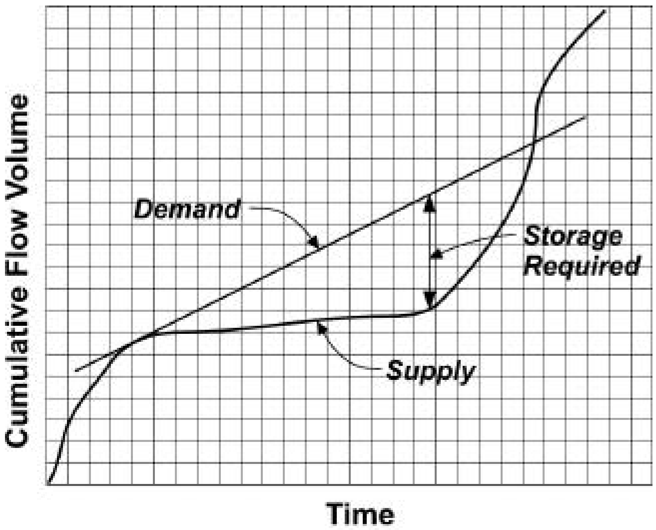

Figure 1. Analysis for Required Reservoir Storage.

simulate the system operation during droughts of record. This is accepted methodology by the Georgia EPD. However, there is concern that a future drought may occur that is worse than what has been recorded during the period of historic stream flow records. Droughts already may be occurring at an increasing frequency. Droughts in Georgia occurred during the 1920's, 1950's and 1980's – roughly 30 year intervals. However, the recent drought occurred less than 15 years after the 1986-1988 drought.

System Viability Concerns

Failures of a public water system can have drastic effects. Short term failures cause depressurization of the distribution system, which can result in negative pressures in some areas of the system. Negative pressures create the potential for contamination of the water distribution system. After an occurrence of system depressurization, customers are told to boil any water used for drinking. Longer term failures have major impacts on public health, safety and quality of life. It is not likely that the public will accept long-term (more than two or three days) failure of the water system, even during droughts.

SUPPLY SIDE ALTERNATIVES TO RESERVOIRS

Upland Storage Lagoons

It may be possible to construct upland storage lagoons to provide required water storage. These would not directly impact a stream and might be more acceptable from an environmental perspective. This alternative should be investigated in an alternatives analysis. Unfortunately, the terrain in the Georgia piedmont is not very conducive to locating an upland lagoon having adequate volume without impacting a stream. Such a structure would require very large amounts of earth moving and likely require much rock excavation. Control of seepage would be expensive.

Groundwater

The option of using groundwater for a portion of needs should be considered. Unfortunately, groundwater is probably not a viable source for larger water system needs in the piedmont region of Georgia. Groundwater can be used for some peak shaving purposes as is being done by the Cobb County Marietta Water Authority but this mainly solves water treatment plant capacity needs rather than raw water supply needs. On an average annual basis the amount Cobb County uses from wells is very small.

The problems that might exist with long term continuous pumping of large quantities of groundwater in the Georgia piedmont (assuming that high yielding wells can be located) have not been fully examined. There is no huge quantity of aquifer storage as exists in South Georgia. In the natural system, water enters the groundwater in recharge areas and leaves at lower elevations through springs and stream interflow. As water is removed from the limited underground storage, inflows (recharge) must increase and/or outflows (springs and stream interflow) must decrease. This removes water from surface streams. Also, as water is pumped continuously on a long term basis, the underground passageways may tend to become clogged and well yields begin dropping.

Wastewater Reuse

Reuse of wastewater for potable water supplies is probably the most promising solution for increasing supply in the future. Wastewater treatment technology is becoming more advanced and more reliable. However, it is not likely that direct potable reuse, which means pumping treated wastewater directly to the water treatment facility, will be accepted in the near future. The best option is indirect potable reuse with the reclaimed water being applied to the upper end of a water supply reservoir. The detention time in the reservoir allows for die-off of pathogens and release of volatile organics. If an existing reservoir is available, its water supply yield could be increased by utilizing reclaimed wastewater. In studies being prepared for the Metropolitan North Georgia Water Planning District, indirect potable reuse to Lake Lanier is included in all of the evaluated alternatives for future water supply in the metropolitan area.

CASE STUDIES

Since the drought of the 1980's, 17 reservoirs have been built in the northern half of Georgia. Since reservoirs have clearly been necessary in the past, it is not unreasonable to assume that additional reservoirs may be necessary in the future to assure adequate public water supplies. Two case studies of reservoirs are presented here.

Newton County

In the mid 1980's almost all water used by public water systems in Newton County was supplied by the City of Covington. The City had a 4.0 MGD withdrawal permit from the Alcovy River. Significant growth was occurring in Newton County and the City knew that water supplies must be expanded but they were awaiting the completion of a four year regional water resources study before proceeding with a project. In 1986, the flow in the Alcovy River dropped to below 4.0 MGD. Even though the City's permit had no protected flow requirement and the full flow of the river was being withdrawn, sufficient water was not available to maintain the level in the small reservoir that fed the water treatment plant. The public water system came perilously close to failure. A permit was received to construct a reservoir in 1988 and the project began operation in 1992. Since that time the number of customers on public water systems in the County has more than doubled. The reservoir also provides a substantial portion of the water supply for Walton County.

Athens Area

Until recently, when the Bear Creek reservoir came on line, Athens-Clarke County supplied water for much of the area through its withdrawal from the North Oconee River. Athens-Clarke County had a pre-1977 permit with no requirement for low flow protection. Not only did this create a dangerous condition for reliability of supply but the reduced streamflow caused serious problems for wastewater assimilation downstream. Now that raw water is available from the Bear Creek reservoir, Athens no longer has to remove water from the river during low flow periods.

The Athens-Clarke area served by the Bear Creek project includes four counties that are expected to grow significantly in the next few decades. Water supply for this growth would not be available without the reservoir.

AVOIDING RESERVOIR CONSTRUCTION THROUGH DEMAND MANAGEMENT

It seems that most reservoir opponents are convinced that all future water supply needs can be met through demand management. Demand management is a tool that must be used as much as is practical to reduce the need for expanded water supplies but it is risky to assume that all water needs for future population growth can be met through reductions in usage by the existing population. Studies being prepared for the Metropolitan North Georgia Water Planning District are projecting a 12% reduction in 2030 water needs through demand management (JJ&G 2002) but population for the area is expected to increase by 60% to 85% in the next 30 years. Athens-Clarke County water officials have set an ambitious goal of reducing water demand 17% by 2050 and yet a 29% increase in water treatment capacity is currently planned to meet needs in the more immediate future.

The Georgia EPD requires all water systems applying for new or expanded withdrawal permits to have water conservation plans and water conservation should be an important component of water supply planning. Some components of water conservation programs are:

Efficient Plumbing Fixtures

Efficient plumbing fixtures have been required by building codes since 1992. All growth projections should assume that new users will be using efficient fixtures. Retrofit programs should be considered by water utilities. Rebates can be offered for the replacement of older toilets. Water systems can provide items like low flow showerheads and faucet aerators to their customers at no cost.

Outdoor Water Use Restrictions

Outdoor watering restrictions are becoming a fact of life. During drought periods these are mandated by the state.

Conservation Pricing

Conservation pricing structures can help reduce water demand but their degree of effectiveness is uncertain. In a report by the American Water Works Association Research Foundation, the price elasticity of normal indoor domestic water consumption was estimated to be -0.10. This means that a 50% increase in water rates will cause a 5% reduction in demand. Most conservation pricing programs now in effect in Georgia take the form of summer surcharges. For reducing demand during critical periods, outdoor watering restrictions may accomplish the same purpose.

The UGA Whitepaper cites the case of the City of LaGrange where water consumption decreased sharply after in increase in water rates. However, the case in LaGrange was not typical. Most of the reduction in LaGrange's water sales occurred due to one very large industrial customer that installed water recycling equipment.

Leak Reduction

Water losses from leaks should be reduced as much as is practical. Water systems typically report unaccounted-for water usage at figures around 10%. Some of this loss is from leaks but a substantial portion comes from inaccurate meters to customers. Other losses come from uses such as system flushing and fire protection. All water systems attempt to eliminate leaks wherever they can be found but it is not realistic to assume that leak reduction in water distribution systems will provide a significant portion of future water needs. Water audits for individual customers are a useful part of water conservation programs and are provided free by some water systems.

MINIMIZING RESERVOIR IMPACTS

Unless it is feasible to build an upland storage lagoon at a location that will not impact any streams, the construction of a raw water storage reservoir will result in an unavoidable loss of free flowing stream. There may also be some losses of wetlands, endangered species habitat and cultural resources. The alternatives analysis (including site selection) that is required by EPD and the approval agencies for a Section 404 permit must take these factors into account. It would not be appropriate here to present simplistic ideas regarding site selection. This is a complex process that must also include economic and social factors.

MITIGATION OF ENVIRONMENTAL IMPACTS

A permit for construction of a new reservoir cannot be obtained without a mitigation plan. The UGA Whitepaper concluded that many of the plans are not successfully implemented. Also, the loss of a free flowing stream cannot be mitigated by building a new stream at another location.

Streams are already undergoing stresses due to other human activities. It is not unreasonable to require governments that need water reservoirs to implement non-point source pollution prevention programs above and beyond that which might be required by stormwater regulations. Environmental monitoring and data acquisition programs will become more important in the future for managing human coexistence with the natural environment. These can be a condition of reservoir permits. With adequate data, the optimum location and sizing of stream buffers and greenways can be determined using data intensive models such as REMM (Wenger 1999). It may be acceptable to lose a small percentage of the free flowing streams in an area to assure the viability of public water supplies if other streams are protected to a higher level than would otherwise be the case.

CONCLUSION

Reservoirs impose serious impacts on the natural environment but in many cases they are the only practical alternative for assuring the reliability of public water supplies. Before embarking on a reservoir project, water system managers must be certain that alternatives to reservoirs have been fully investigated.

The construction of a reservoir means the loss of a segment of free flowing stream and it also has an effect on the upstream and downstream portions of the stream. If a reservoir is required, it should be located to minimize these effects as much as practical. Any local government that must build a reservoir should commit to a mitigation plan that aims to provide additional protection to other streams within its jurisdiction.

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