REPORT OF
THE STATE WATER COMMISSION

WAYS TO MAKE OPTIMAL USE OF VIRGINIA'S WATER RESOURCES

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

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REPORT OF THE
STATE WATER COMMISSION
Pursuant to HJR 236 (1998)
to

The Honorable James Gilmore, Governor
and
the General Assembly of Virginia
Richmond, Virginia

I. INTRODUCTION AND AUTHORITY FOR STUDY

The State Water Commission is a permanent agency of the Commonwealth directed by statute to (i) study all qualitative and quantitative water supply and allocation problems in the Commonwealth, (ii) coordinate the legislative recommendations of other state entities responsible for water supply and allocation issues, and (iii) report annually its findings and recommendations to the Governor and the General Assembly (Va. Code § 9-145.8).

The 1998 Session of the General Assembly passed House Joint Resolution 236, patroned by Delegate George W. Grayson, requesting the State Water Commission to study ways to make the optimal use of Virginia's waters. The resolution specifically requested an examination of such water supply strategies as water recycling, desalination, wastewater treatment for reuse, and conservation.

II. PRESENTATIONS

At its December 7, 1998, meeting the Commission received a series of presentations on water supply strategies and associated technologies as requested by HJR 236. Presentations were received from Dr. Thomas J. Grizzard, Jr., Director of the Occoquan Lab of Virginia Polytechnic Institute and State University (VPISU) (on wastewater treatment for reuse); Mr. David L. Morris II, Planning and Program Manager, Newport News Waterworks (on desalination technology); and Mr. Calmet M. Sawyer, Director, Division of Wastewater Engineering and Mr. Robert W. Hicks, Director of Office of Environmental Health Services, both of the Virginia Department of Health, (on water reuse and recycling). Materials on water conservation were accumulated and provided to the Commission by the Hampton

Roads Planning District Commission and the Hampton Roads Water Efficiency Team (HRWET).

A. WASTEWATER TREATMENT FOR REUSE

Dr. Thomas J. Grizzard, Jr., Director of the Occoquan Lab of VPISU, briefed the members on wastewater treatment for reuse and provided the following definitions to orient the members to the topic:

Wastewater reclamation: the treatment or processing of wastewater to make it reusable in some beneficial manner. Dr. Grizzard described this as the application of " technology to achieve in less time and space what nature does to all wastewater discharges."

Wastewater recycling: the beneficial use of reclaimed water, generally involving only one use or user, such as an industrial plant.

Wastewater reuse: the beneficial use to which reclaimed water is put, often requiring a conveyance or distribution system.

Direct reuse: usage that occurs when a direct link exists between the reclaimed water system and the beneficial use. Dr. Grizzard noted that applications to drinking water are generally rare but uses in agricultural and urban irrigation, industrial applications and dual water systems are more common.

Indirect reuse: usage that occurs when reclaimed water is mixed or dispersed into an environment such as a stream, lake, reservoir, or groundwater aquifer prior to being withdrawn for reuse. This occurs in the Occoquan Reservoir system.

Non-potable reuse: the utilization of reclaimed water for any application other than drinking water, such as irrigation or industrial applications.

Potable water reuse: the use of highly treated reclaimed water to augment drinking water supplies. This occurs in the Occoquan Reservoir system.

Dr. Grizzard also provided the Commission with the policy statements on wastewater reuse of two major water supply and treatment organizations. The Water Environment Federation's (a wastewater treatment professionals organization) position is that "in those situations where water sources are insufficient to meet projected potable water demands, the Federation finds reclaimed water derived from municipal wastewaters should be considered a viable alternative to supplement a potable water source." The American Water Works Association's (a drinking water treatment professionals organization) statement reads in part "when raw water supply sources to an area are limited and reclaimed water is generally of equal or superior quality to other raw water supplies, AWWA does not oppose indirect reuse of wastewater whereby reclaimed water is a supplement to existing raw water sources receiving appropriate subsequent treatment."

Highlighting some of the major concerns in reuse systems, Dr. Grizzard cited microbial contamination (such as viruses and bacteria), chemical contamination (including inorganics such as heavy metals like copper and lead, and organics, such as synthetic organic chemicals) and potentially harmful by-products of the disinfection process. He noted that the dangers of microbial contamination have received heightened attention due to microbial contamination of the drinking water supply sickening over 400,000 people in the Milwaukee area in recent years.

1. Reservoir History

The Occoquan Reservoir was first impounded by the Alexandria Water Company in 1957, but ownership was transferred to the Fairfax County Water Authority in 1967. The reservoir is 14 miles long and has a storage capacity of 8.2 billion gallons. The annual average natural inflow of 550 cubic feet per second comes from a drainage area of 570 square miles. The watershed encompasses, in general terms, an area bounded by Dulles Airport on the north, Fairfax City on the east, Bull Run on the west and Quantico Marine Base on the south.

Population increases and associated sewage discharge and runoff to the reservoir and its tributaries led to water quality problems by the late 1960s. Problems included algae blooms, low dissolved oxygen, fish kills, viruses in raw water, taste and odor problems, increased organic matter in the system and filter clogging, according to Dr. Grizzard. These occurrences led the State Water Control Board (SWCB) to prohibit new sewer connections until a solution could be found. A series of water quality studies soon followed.

A study directed by Dr. Clair N. Sawyer and conducted by the firm of Metcalf and Eddy during 1968 and 1969 found that point and nonpoint source pollution contributed to water quality degradation. Among the principal culprits was the discharge from 11 secondary sewage treatment plants in the reservoir's watershed. The study recommended in the following three alternatives for restoring the reservoir's water quality:

a. Export wastewater for treatment and discharge outside the Occoquan Watershed (the most common option at the time).

b. Provide the highest wastewater treatment technically achievable, contract with local jurisdictions to purchase the reclaimed water for direct reuse as drinking water, and limit watershed population to that which would use reclaimed water.

c. Provide the highest wastewater treatment technologically achievable, discharge the water to the Occoquan watershed for indirect reuse, and limit the basin's population to 100,000.

All three recommendations underwent extensive public review, after which the State Water Control Board proposed an in-basin solution sometimes referred to as the "Policy for Waste Treatment and Water Quality Management in the Occoquan Watershed" or the "Occoquan Policy." Dr. Grizzard identified three of this policy's major components. The first component called for a high-performance regional wastewater reclamation plant to replace existing sewage treatment plants. This state-of-the-art water reclamation plant would have to have (i) standby treatment units, (ii) emergency holding basins, and (iii) three independent electrical power sources. Accompanying this would be the creation of a new public service authority to manage the plant (now called the Upper Occoquan Service Authority or UOSA). The SWCB also called for independent monitoring of reservoir water quality. (A new lab would be created called the Occoquan Watershed Monitoring Laboratory, the lab where Dr. Grizzard now works). Finally, initial wastewater treatment plant capacity would be limited, and incremental increases in capacity would be allowed only to the extent that satisfactory reservoir water quality would be maintained.

Given these safeguards, the proposal was endorsed by the Fairfax County Water Authority, the Virginia Department of Health (VDH) and the United States Environmental Protection Agency. Today, the resulting system is a major component of the water supply serving over a million Northern Virginians.

2. The Reservoir Today

Dr. Grizzard also reviewed the extensive wastewater treatment processes used to deal with water quality before wastewater enters the Occoquan Reservoir. Among the many steps noted by Dr. Grizzard as being taken to treat the wastewater are solids separation and grit removal, biological treatment, including nitrification and de-nitrification, use of chemicals to cause unwanted materials to settle out, mixed media filtration, granular activated carbon adsorption, and chlorination and de-chlorination.

In 1998 UOSA discharged 20 million gallons per day (mgd) of reclaimed wastewater into the Occoquan Reservoir. This flow, coupled with the natural safe yield inflow to the reservoir of 65 mgd, produces a total yield of 85 mgd. By 2001, UOSA's discharge will be 38 mgd, bringing the total yield (natural flow plus discharge) to 103 mgd.

Dr. Grizzard advised the Commission that there is a proposal to expand UOSA's discharge to 54 mgd. He added that the Fairfax County Water Authority, the Virginia Departments of Health and Environmental Quality, the Occoquan Watershed Monitoring Subcommittee, and Systech, Inc., all endorse the expansion. Among the statements of support for the expansion are those that espouse UOSA as the most reliable source of high-quality water in the area and those that say the more effluent discharges, the better, because it substantially improves water quality in the Occoquan Reservoir, and that increased discharges by UOSA are essential to offset the increases in nonpoint source pollution from development. In fact, according to Dr. Grizzard, some advocate importation of wastewater from other watersheds for treatment by USOA so that additional high-quality reclaimed water will be available for withdrawal for drinking water supply purposes.

B. DESALINATION

Mr. David L. Morris II, Planning and Program Manager for Newport News Waterworks, explained the technology and challenges related to desalination. He explained that desalination (also called desalting and desalination) is the process of using technology to remove undesirable dissolved materials, especially salt compounds, from water.

Three basic types of technologies for desalination were described by Mr. Morris:

Pressure -- Reverse Osmosis: This process allows water to pass through a semi-permeable membrane when pressure is applied to the source "feed" water. The membrane acts as a filter restricting the flow of salts and other dissolved contaminants.

Electrical -- Electrodialysis Reversal (EDR): This process uses an electric current to attract charged ions (the salts) toward the oppositely charged electrode. Charged membranes can be used to trap these ions. The process also creates two layers of water, one layer where the ions are concentrated and one from which they are being drawn. This latter portion of the water may be drawn off as desalted water.

Thermal -- Energy (Heat) Distillation. In this process, water is heated to vaporize it. Pure water and salt water condense at different temperatures. This difference allows salt-free water to condense and be drawn off in one area of the distillation equipment, leaving behind salt water. There are a number of different distillation methods, including those called "multiple state flash distillation," "mechanical vapor compression" and, the most commonly used, "multi-effect distillation."

Mr. Morris noted that desalination is being conducted primarily in two situations: (i) where there are no other options such as in desert countries and on islands and ships, and (ii) where the technology is relatively affordable because other options are not available or are more costly, such as in coastal communities in Florida and California.

Mr. Morris described for the Commission how the option of sea water desalination has been investigated for the Newport News communities. The inquiry found that:

(i) Two 60-inch intake pipes would have to extend two miles seaward from Cape Charles to reach a relatively stable source of sea water;

(ii) The two pipes would have to draw in 90 mgd to provide the same reliability as the surface water options being considered by Peninsula communities to meet a 27 mgd average demand;[1]

(iii) The sea water would need additional "stabilization," including removal of solids, pH adjustment and temperature control prior to the desalting procedures;

(iv) The resulting highly concentrated brine would have to be discharged back into the ocean at a different location than the intake through a single 72-inch pipe;

(v) A 25-mile treated water transmission pipeline would then be needed to get the water to the Peninsula; and

(vi) There would be a $500 million cost for construction, with an operating cost of $6 per 1000 gallons of produced water.

Mr. Morris noted that sea water desalting cost is so high because of the capital facilities, operating and maintenance costs and high energy needs (about 10 times the energy required for conventional fresh water treatment processes).

Sea water desalination has limited use (about 13 mgd total) in the United States. Some examples, provided by Mr. Morris, of sea water desalination facilities in the United States include a 0.6 mgd facility in Moro Bay, California, producing water at a cost of $5.37 per 1,000 gallons; a 0.75 mgd facility in a Santa Barbara, California, producing water at a cost of $5.89 per 1,000 gallons; and a Santa Catalina, California, 0.13 mgd facility costing $6.14 per 1,000 gallons of water. Key West, Florida, has a 3.0 mgd facility that was dedicated to it by the Navy but which is not in use. It was found that a 90-mile pipeline would cost less than operation of the Key West facility. Examples of foreign locations provided by Mr. Morris where sea water desalination occurs include Aruba, Israel, Saudi Arabia, and Guantanamo Bay, Cuba.

Virginia water sources for desalination contain varying degrees of dissolved solids. This is a very important consideration, according to Mr. Morris, because the more dissolved solids, the greater the time and expense for treatment and the greater the brine discharge. Mr. Morris noted that ocean water contains 35,000 parts per million (ppm) total dissolved solids, and that the Chesapeake Bay and its tributaries contain 7,500 to 35,000 ppm, while brackish groundwater contains 7,500 ppm. The stability of the water sources was stressed by Mr. Morris as extremely important to the efficient and economical operation and maintenance of desalting facilities and to the quality of the finished product.

[1] According to Mr. Morris, this is the planned amount to come from the proposed Mattaponi reservoir. The maximum daily demand for the Newport News area is 1.45 times the average or 40 mgd.

A number of Virginia localities are using a variety of desalting techniques. Mr. Morris noted that the City of Suffolk is using electrodialysis reversal of groundwater, and that Charles City County and the City of Newport News both use reverse osmosis of groundwater. The City of Chesapeake has a complicated reverse osmosis combined surface and ground water system under construction. The system is complicated in that the North River will be used when salinity is low, reverse osmosis will be used when the river is "slightly" salty, and ground water will be used when the river is too salty for the efficient use of reverse osmosis. The new Newport News brackish groundwater reverse osmosis facility has a yield capacity of 5.7 mgd and is the largest desalting facility north of Florida.

In addition to those already mentioned, Mr. Morris pointed out other factors to consider in making water desalting decisions. One particularly relevant to the southeastern Virginia ground water management area is the limits on the availability of brackish ground water. Another issue, and one particularly relevant to an estuary system, is the continually changing salinity, turbididty and temperature of these types of surface waters. Disposal of brine is an issue in all systems and more so with increasing salinity of the feed water supply.

C. WATER REUSE, RECYCLING AND RAIN CAPTURE

Two representatives of the Virginia Department of Health, Robert W. Hicks, Director of the Office of Environmental Health Services, and Calmet M. Sawyer, Director of the Division of Wastewater Engineering, provided the Commission with information on water reuse, recycling and rain capture. As an introduction they noted that the General Assembly directed VDH and the Department of Environmental Quality (DEQ), through HJR 587 (1997), to examine the potential for reuse of gray water and the use of rain water. That study resulted in House Document Number 93 (1998). The General Assembly then, during the 1998 Session, directed VDH to develop guidelines by January 1999 on the uses of gray and rain water describing the conditions under which these waters may be appropriately used and for what purposes. Through that legislation, VDH and DEQ were also directed to promote the use of gray and rain water as means to (i) reduce fresh water consumption, (ii) promote conservation, and (iii) ease demands on water and wastewater treatment works. House Document 93 (1998) provides background information on (i) the needs for water conservation measures in Virginia, (ii) gray water reuse and rainwater reuse and comparisons of the two, (iii) actions being undertaken in other states, and (iv) human health protection. The document may be consulted for more details.

"Gray water" was defined for the Commission as untreated water from bathtubs, showers, bathroom wash basins, washing machines and laundry tubs. Gray water does not include wastewater from toilets, kitchen sinks, or dishwashers, or laundry water from soiled diapers, all of which is classified as black water. The VDH officials noted that almost half of indoor water can be reused as gray water to irrigate and fertilize gardens and provide water for toilet flushing. Its use also reduces demands upon water supply and wastewater treatment plants which can have financial benefits by reducing the need for capital expansions.

Mr. Sawyer noted that rain water capture can provide a source of soft, high-quality water that can augment domestic water resources and reduce reliance on wells. In contrast to gray water, which is a fairly predictable and dependable source of water, rain water lacks dependability. Because of this, rain water storage facilities must be bigger than gray water storage facilities in order to compensate during low rain periods. House Document 93 notes that a rain water collection system on a 1,500 square foot household, with the average annual rainfall of Virginia (42 inches), could collect 35,393 gallons a year, providing a household with about 100 gallons of rain water a day. One hundred gallons is about a third of the what an average family of three uses daily in Virginia.

The VDH officials described State Board of Health policy as having the following three components: (i) use the best possible quality as the source of drinking water; (ii) encourage non-potable use of reclaimed or other non-potable water; and (iii) use reclaimed water to augment water supplies only where such reuse meets the Occoquan model standards.

Some potential non-potable water reuses noted by VDH include landscape irrigation, crop irrigation, dust suppression, toilet flushing, structure and equipment cleaning, fire protection augmenting, and industrial processing. Each of these uses requires precautions to protect the public health.

VDH expressed reclaimed wastewater use concerns similar to those noted by Dr. Grizzard. Issues mentioned by the VDH officials include micro-biological (pathogens) contamination, dissolved solids (salts), toxicity, and excess nutrients. VDH also noted that reclaimed wastewater treatment requirements may include advanced biological and chemical treatment; conventional filtration; other separation methods such as reverse osmosis, adequate storage; and proper operation and maintenance.

One factor noted by VDH as potentially inhibiting further use of gray and rain water is the current status of state regulations and building codes. State regulations currently include gray water in the definition of sewage, and it therefore must undergo the same treatment as sewage before it can be released to places where it may come into human contact. Building plumbing codes may also need to be updated to allow for separate plumbing for gray water so that it does not mix with water destined for potable uses.

D. WATER CONSERVATION

The Hampton Roads Planning District Commission and the Hampton Roads Water Efficiency Team provided a folder of information on water conservation measures. HRWET, founded in 1994, is made up of public utility and public information professionals who have banded together to create a regional water efficiency education program. Hampton Roads cities, counties and many military installations participate in HRWET, whose slogan is "Saving Today's Water for Tomorrow's Hampton Roads."

Included in the materials were detailed information booklets and check lists on such topics as development of water efficiency plans for businesses, home water use tips, and ways to save water in such diverse settings as cooling systems, commercial kitchens and cafeterias, hospitals and health-care facilities, and laundries. The materials also included information on basic steps in landscaping to achieve water efficiency.

A booklet entitled "A Consumer's Guide to Water Conservation" contained dozens of ways to save water. Included in the booklet are ways to save water, energy and money inside and outside the home. The booklet also discusses steps that can be taken by businesses, such as reuse. Efforts that may be taken at the community level are highlighted, as are educational resources in the final chapters of the booklet. These materials are on file with the Division of Legislative Services.

Respectfully submitted,

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