Industrial Water Reuse – The Next Wave in Infrastructure Development

BY **GREG JOHNSON**

Industry, agriculture, and domestic water users are all competing for the most precious natural resource, water. With populations on the rise, water sources becoming stretched, and difficulty in expanding infrastructure capacity, increasing attention is being paid to how water is reused. As municipal infrastructure becomes more and more strained, it is inevitable that much of the burden will be shifted to commercial and industrial water users.

The American Water Works Association (AWWA) recently published an article titled "The Dawn of the Replacement Era". In the article, the AWWA estimates that of 20 utilities counted, there are projected expenditures of US$250 billion needed just to replace existing municipal water infrastructure. Much of the nation's infrastructure was installed during the late 1800s in response to a surge in population growth. There was another surge in infrastructure development during the great public works projects of the 1930s. A great deal of the country's critical infrastructure is nearing or has surpassed its design life span. Just dealing with needed retrofits will be challenging enough for the nation's water and wastewater districts. Increasing capacity and infrastructure to account for increased demand on top of the needed system replacements may prove to be too much.

Similarly, the Environmental Protection Agency's (EPA) Office of Water recently estimated the capital required over the next 20 years for both water and wastewater upgrades to be nearly US$500 billion. (EPA, The Clean Water and Drinking Water Gap Analysis, 2002). These estimates are not adjusted for inflation and use current value terms. The EPA attributes these costs to retrofitting treatment plants and infrastructure that are obsolete, more stringent drinking water and wastewater standards, and increasing expense and controversy associated with capital improvement projects.

During the 1970s and 1980s, the EPA provided more than US$60 billion for construction of public wastewater treatment projects through its Construction Grants Programme. The Clean Water Act, (CWA), of 1987 changed this programme and through an amendment to the CWA, the grant programme was terminated in 1990. Under the new procedure, the EPA initiated the State Revolving Fund, (SRF). With this programme, the EPA provides capitalisation seed money to the states, which in turn offer low interest loans to local communities for municipal projects. The net effect is that although local municipal districts receive low cost loans, they now must pay for 100% of capital improvement projects. Under the Construction Grants Programme, the EPA paid about one-half of these costs directly.

An example case is the 114,000-m^3/day water treatment plant installed in St. Joseph Missouri in 2000. The original treatment plant was aging and subject to flooding. The local Water Company spent US$30 million on the new treatment plant and a total of US$79 million on all improvements and upgrades to the existing infrastructure.

In just maintaining existing infrastructure, Toronto spent US$188 million on capital works programmes. This number is expected to double within four years. Faced with existing infrastructure problems, Toronto was also faced with expanding demand and water consumption near capacity. Rather than spending US$167 million to increase capacity, Toronto enacted its Water Efficiency Plan to encourage domestic and industrial consumers to reduce consumption. Serving about 450,000 water accounts, the Toronto infrastructure is made up of:

* 4 water treatment plants
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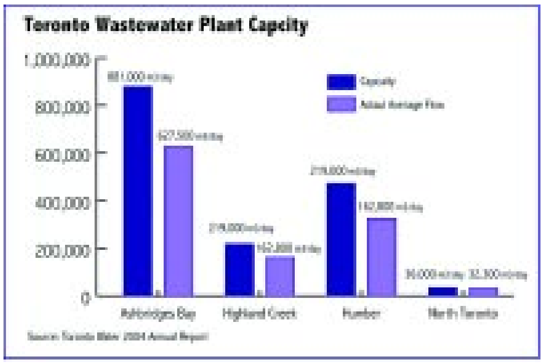
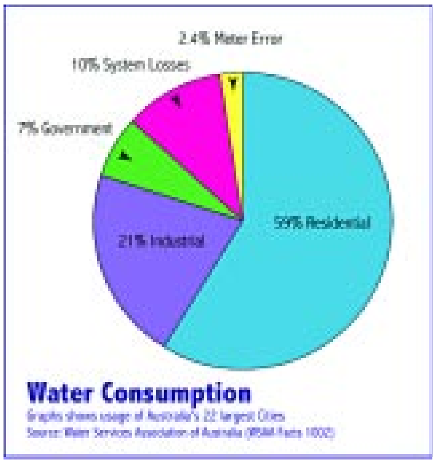
* 18 water pumping stations
* 74 wastewater pumping stations
* 4,396 km of sanitary sewers
* 1,302 km of combined sewers
* 4,305 km of storm sewers
* 5,015 km of distribution watermain
* 510 km of watermains

So, local water districts and wastewater treatment districts are faced with aging infrastructure, increasing demand in many cases, no matching funds from the Federal government or from many State Governments, and difficulty in raising prices to offset the needed addition capital. Maintaining existing infrastructure is the foremost priority and spending money to add capacity will come second, if at all. Water and wastewater districts are looking for other ways to free up capacity within the existing system.

Raising prices for some commodities can affect demand. Raising prices for basic necessities like sanitation, cleaning, and cooking would have little if any effect on the usage rates. 60% of domestic water is used for sanitation. A very small percentage is used for discre-





tionary water usage for things like landscape irrigation, car washing, and swimming pools.

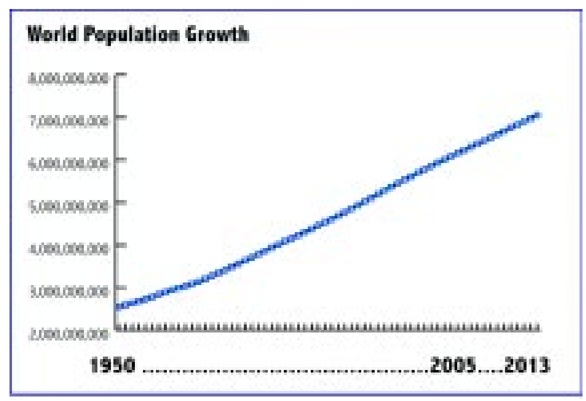
The analysis done on raising prices on water and sewer fees for domestic usage shows that this would have minimal impact on reducing demand. The EPA's report titled Water and Wastewater Pricing states that water policy analyst, Janice Beecher, found a 10% price increase for domestic use would result in a 2 to 4 percent decrease in consumption. In addition, a 10% price increase for industrial use would result in a 5 to 8 percent decrease in demand. (EPA 832-F-03-027)

One thing that does help is having all water users on accurate meters and having water rates tied to consumption. Another way to free up capacity is to reduce system losses that can be as high as 10%. This can be done during the process of retrofitting aging infrastructure.

Almost all water districts offer promotions and incentives for conservation. This benefits the water district and coincidentally the wastewater treatment district. The primary incentives have been for low flow showerheads and low volume toilets. Many other ideas are promoted including catching your own rainwater and rebates for general water conservation. Even ideas liking catching fog are being discussed.

In areas other than domestic usage, "reclaimed" water or recycled water from municipal wastewater is becoming more common for public irrigation projects. Recycling municipal water and introducing it indirectly into the drinking water supply by blending it into reservoirs or aquifers has been done on a limited basis. Singapore has installed a dual membrane system and recycles a significant amount of municipal waster as potable water, which is

blended with reservoir water. Orange County in California has done the same.



Drought conditions can also create water capacity problems. On September 20, 2005, the level of Falls Lake, Raleigh's water supply, was dropping due to drought conditions. On that day, the city of Raleigh enacted legislation calling for a voluntary reduction of 10% by households and businesses. The City Council also authorised the City Manager to implement mandatory conservation measures if the lake level continued to drop and voluntary measures were ineffective. Recommendations included points like not running water while brushing your teeth, how much water you should use in a bathtub, and using hand held landscape-watering devices only between the hours of midnight and 5:00 AM.

In other areas of the world, water shortage is just as extreme. Australia is the world's driest continent and is currently in the midst of a seven-year drought that is the worst since European settlement. Australia is very urbanised and people live in concentrated areas with limited resources of water. Its population in urban areas has continued to increase in spite of fixed levels of water supply. The situation in the city of Sydney is especially urgent and even the high cost of water is not able to stem the imbalance between need and supply. Sydney Water is currently working on programmes to encourage water reuse, especially for industrial users. The Gold Coast area south of Brisbane is also experiencing water shortage problems. This area has been recently developed and is rapidly growing, faster than the infrastructure can support.

Probably the freeing up of capacity in water supply and wastewater discharged will occur with the industrial water consumer. According to the U.S. Geological Survey, in 1995 American industry used an average of about 27 billion gallons per day of water for processing and manufacturing products. Governments have implemented permit programmes that regulate industries and prescribe how much water they can use and what quality of water they can discharge. As municipal infrastructure becomes more and more strained, it is inevitable that much of the burden will be shifted to commercial and industrial water users.

Sewer discharge fees based on volume and contaminant levels are already in place and are increasing in many areas. In addition new quality regulations have been imposed on many specific industries such as metal plating and centralised waste treatment plants. As the cost for incoming plant water increases and the cost and quality of discharge are ratcheted up, it is becoming more and more compulsory to recycle process water to reduce or eliminate wastewater discharge. In many cases, not only is the water reused, the solids in the wastewater are utilised and some value is extracted. Most industries have already undertaken close scrutiny of their water circuit and have economised water usage to the greatest extent possible. The next logical step is to work on an end of pipe or point source wastewater recycling plan.

Eliminating discharge, or having a "closed loop" has been the trend in the pulp and paper industry for many years. According to Pulp & Paper International, today it takes about 5 gallons (15.9 litres) of water to manufacture one-pound of paper. 25 years ago that number was about 12 gallons of fresh water consumption for every pound of paper. According to the Confederation of European Paper Industries (CEPI) production of paper is up to 100 million US tons in Europe. Production of this much paper in today's terms would consume about 800 billion gallons of water, even after significant improvements and tightening of the water circuit. In Europe, the pulp and paper industry is the 2nd largest water user next to agriculture. Over the past few years, significant progress has been made to recycle plant water.

Some paper companies have even been able to achieve 100% closed loop processes. Papierfabrik Palm, a 600,000-tonne/yr containerboard mill was constructed as a new plant in Worth Germany and designed to be completely closed loop. Selling the new plant as closed loop made the permitting process much easier. Papierfabrik Palm uses biological treatment, followed by sand filtration and finally membrane filtration for its recycled water.

Advanced treatment using membranes for water reuse is becoming more popular. Process water that is reused must have specific quality requirements. Membranes are uniquely capable of precise control of contaminant levels. A variety of membranes including microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO), can be used depending on the need. MF and UF can be used to remove oil and suspended solids leaving a filtrate stream that can be reused as rinse water or cooling water. NF and RO can be used to remove various degrees of dissolved solids. This water can be used as make up water, boiler feed water, and any other clean water used for processing.

Most membranes used today are made of polymeric materials including polyamide, polysulfone, regenerated cellulose, PVDF, and PTFE or Teflon®. The pores on most polymer membranes are so small they can not be seen even with a scanning electron microscope. The pore sizes are determined by how well the membrane rejects particles of known size. The membrane itself allows water to pass through the physical pores or through the matrix of the polymer and does not allow larger molecules or suspended solids to pass. Selection of the proper membrane depends on the separation that is needed. For example, RO must be used to hold back dissolved Chromium in metal plating wastewater. UF can be used to hold back small colloids such as grease, free oil, and fat in laundry wastewater.

Another method of wastewater treatment for reuse is flocculation followed by clarification or coarse media filtration. In this case, chemicals are added such as Aluminum Sulfate (Alum) to precipitate and also bind smaller solids that can then more easily be filtered

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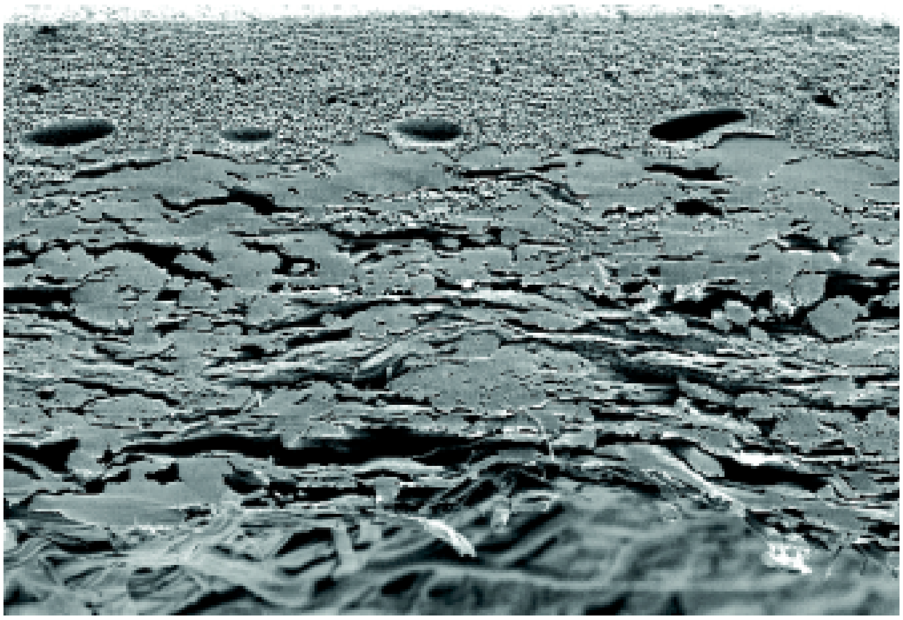

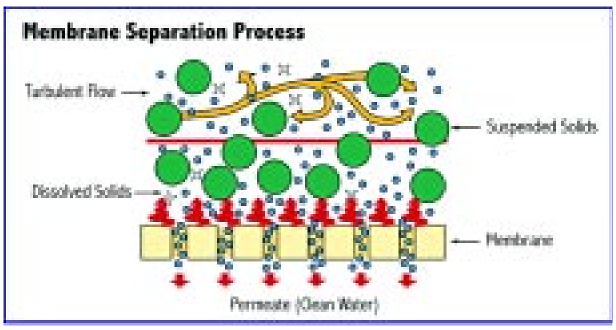

out using coarse filtration. Biological methods are also used where the solids present are destroyed by nutrient seeking bacteria. Both of these methods however, can remedy certain solids in the wastewater and have limitations on how clean the water can be made. Membranes up to RO allow the wastewater treatment operator to create almost pure water, or close to it.

As an example, metal plating wastewater has limits on nickel and chrome, in addition to other things, before it can be discharged. These regulations have recently been tightened from previous levels. Chemical precipitation can be used to reduce the levels of nickel and chrome and if done properly, the resulting effluent can be discharged. However, this process involves addition of large volumes of chemicals to the water and the sludge created is increased by addition of these chemicals. The metal plating plant is still buying new fresh water, discharging effluent, and generating a sludge waste. The plant is also susceptible to fines for effluent excursions and further regulation in the future. This represents an unknown liability and cost of doing business.

RO membranes can be used to close the water loop and remove the metal plating wastewater from the sewer discharge network. Since there is no liquid discharge, there is no liability or risk of penalties and additional regulation. RO membranes are capable of producing about 90% of the volume as clean water that can be reused for rinsing. As an additional benefit, this also reduces the need for fresh water consumed by the plant. Only a small amount is needed for make up. The remaining 10% volume of concentrated wastewater can be evaporated leaving a very small amount of dried solids. The result of closing the loop is 90% reduction in incoming water, no sewer discharge, no chemical consumption for precipitation, and a very small amount of waste solids, compared to flocculation/precipitation.

The Resource Conservation and Recovery Act requires metal plating plants to be permitted to operate a hazardous wastewater treatment process. These plants are exempt from this regulation if they conform to a closed loop permit under the Clean Water Act regulations. The National Metal Finishing Resource Center (NMFRC) reports that about 7.5% of metal plating plants are now closed loop. Many others are working towards that goal.

One of the challenges facing many industries is that their primary function has always been making their product. Through the years they have become experts in the manufacture of their own product and have very streamlined processes that keep them competitive. Just over the last 10-20 years, these same industries have also needed to become small wastewater treatment plant operators more than ever and learn how to do that in addition to making their product. Wastewater is generally seen as a necessary evil and many companies are reluctant to spend money on wastewater treatment when they would rather spend it on new equipment and processes for making their product better. Products bring revenue in, wastewater takes money out.

Companies now employ environmental engineers whose only job is to keep discharge in compliance. New laws also make individuals criminally liable for upsets. A company that makes cardboard boxes also needs to be an expert on wastewater treatment. This has resulted in major changes in industry over the last few decades. Companies are currently evaluating the best available technologies for treating wastewater and are learning in the process. The process of selecting and bringing online the right treatment process for a particular application is expensive and difficult. In many cases there is limited precedent for what practice is best.

As population and demand continue to grow and as environmental compliance becomes more stringent, and with little or no matching State or Federal funds for capital projects, local water and wastewater utilities are faced with a conundrum. It is quite predictable that much of this burden will be shifted to commercial and industrial water consumers. In an ever increasing global economy with new competitive pressures, industries that use a lot of water should work on developing plans for the future to conserve water and reuse as much as possible. ***AW***

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