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Desalination and Reclaimed Water -- Emerging Issues in Eastern Water Law

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Introduction

Rising population in the United States is straining freshwater resources. Increasing ground and surface withdrawals are causing adverse environmental effects, saline water intrusion and other negative resource impacts. This has caused many public water utilities to look towards alternative water supplies to existing and future water demands. Two of the most frequently discussed alternative water options are desalination of saline water and the reuse of reclaimed domestic wastewater. This paper will examine the opportunities, benefits, impediments, economics and legal issues associated with these two technologies. Since the State of Florida is at the forefront of these new developments, this paper will focus on this jurisdiction.

Desalination

"Water, Watery everywhere, / Nor any drop to drink" are lines from "The The Rime of the Ancient Mariner," by Samuel Taylor Coleridge. These lines have perhaps never been truer than now. Yet, while governments are struggling to come up with solutions to the ever increasing water demand there are vast oceans containing 97.3% of the earth's water right outside our doors.[1] While the idea of utilizing the endless supply of ocean water seems simple, there are many challenging technical, economic and legal issues associated with desalination.

Benefits

The primary benefit of desalination is that it is a drought-proof solution to water shortages. While some alternative water supplies are limited to non-potable uses, desalination also provides a relatively high quality potable water supply. Use of desalinated water reduces the demand for ground and surface water, provides diversity and reliability for sources of water supply, and provides additional potable water supply in areas were additional freshwater supplies are no longer available.[2] Desalination benefits also include minimal reliance on extended delivery systems and the opportunity for local control of water supplies.[3] Because there is a practically infinite supply of seawater available and brackish ground and surface waters are plentiful, desalinated water is relatively immune from price fluctuations caused by changes in supply and demand.[4]

Desalination Technologies in General

Desalination describes the process for removing dissolved minerals such as salts from brackish water or seawater to produce potable water. To accomplish the mineral removal, a desalination treatment technology such as distillation, reverse osmosis (RO) or electrodialysis reversal (ED) must be used.[5] Each method has its own separate advantages and disadvantages, often depending on local conditions.[6] What may be a major disadvantage in New England may not have much of an impact on a facility located in Florida. For example, desalination is often more difficult and costly in northern states due to higher energy costs associated with processing colder water.[7]

Distillation
Distillation is the oldest and most widely used desalination method.[8] This thermal process converts the seawater to water vapor which is then cooled and returned to liquid form.[9] The dissolved solids including salts remain in the un-vaporized portion of the seawater.[10] There are many different distillation technologies available. Among these technologies small-scale solar distillation is an optimal method because it avoids many problems associated with desalination such as discharge of reject concentrate and power costs.[11] However, because small-scale solar distillation relies entirely on sunlight to vaporize water, this form of technology is limited to very sunny areas located near a source of saltwater, which is frequently not the case in the Eastern United States.[12] Additionally, the amount of water produced is often too small for most applications and initial startup costs are high.[13]

The advantages of distillation are: it offers significant savings in operational and maintenance costs, it does not require the addition of chemicals or water softening agents to pretreat feed water, low temperature distillation plants are energy-efficient and cost-effective, many plants are fully automated and require a limited number of personnel to operate, it has minimal environmental impacts, the technology produces high-quality water, and co-location of facilities is a possibility.[14] Distillation treatment plants are often co-located with facilities employing industrial processes that are cooled by dissipating heat into water.[15] The heat is then used to distill fresh water from saline water.[16]

Like any process there are a variety of disadvantages associated with distillation as well. Because many plants are energy-intensive and the distillation process is expensive, cost is a major problem with distillation.[17] Additionally, distillation requires a high level of technical knowledge to design and operate, including special handling of chemical products.[18]

Electrodialysis
Electrodialysis is an electrochemical process that uses direct current to separate dissolved minerals in water, leaving pure water behind.[19] This process is typically used for brackish water with freshwater recovery rates ranging from 75-95 percent of the source water.[20] However, one major drawback to electrodialysis is that it is not suited to remove dissolved organic constituents and microorganisms, which are prevalent in seawater, brackish surface water and some forms of brackish groundwater under the influence of surface water.[21]

Reverse Osmosis
Reverse osmosis is a membrane process used in most major domestic coastal desalination plants including the Tampa Bay Desalination Plant, which is the largest desalination plant in North America.[22] In Florida alone reverse osmosis is used in nearly 200 water and wastewater treatment plants.[23] However, except for a small number of water bottling plants, reverse osmosis is rarely used in Northeastern states due to the high pumping costs associated with colder water.[24]

Unlike electrodialysis which uses direct current to separate minerals, the salt water in a reverse osmosis process is subjected to pressure and filtered through a semi-permeable membrane leaving behind a concentrated solution containing the majority of contaminants and minerals.[25] There are four major phases associated with reverse osmosis: pretreatment, pressurization, separation and stabilization.[26] The source water must first go through a pre-treatment phase to remove the fine particulates and suspended solids.[27] Then, the pressure is raised and the water is pumped through permeable membranes that prevent the passage of most dissolved salts.[28] As the water passes through the membranes it is separated into two streams: reject water (brine concentrate) and product water.[29] Finally, the product water is stabilized through pH adjustments and de-gasification before being acceptable for distribution.[30]

There are a variety of advantages to using reverse osmosis over thermal processes such as distillation and electrodialysis. Because reverse osmosis relies on pressure instead of heat, it is typically less energy-intensive than thermal technologies.[31] This is important because energy can represent over half of the cost of desalination.[32] The cost effectiveness of reverse osmosis as compared to thermal desalination increases with saltier source water and minimal supplies of fossil fuels.[33] Additionally, warmer discharge water associated with thermal processes creates potential for adverse environmental impacts on the receiving waters.[34] Finally, the physical size of reverse osmosis plants is smaller than thermal plants making it less invasive to the area where it is located.[35]

Costs

High costs are the most significant impediment to the widespread use of desalination facilities. "The production cost of water is a function of the type of distillation process used, the plant capacity, the salinity in the feed water (seawater or brackish water), and the level of familiarity with the distillation process that exists in the region."[36] Initial start up costs associated with building the facility deters many prospective governments and companies. Additionally, rising energy costs drive up the cost of operation. Similarly, in areas where the coastal elevation is low, higher energy costs are incurred due to the process of lifting the product water uphill to consumers.[37]

Aside from capital costs, costs of electricity, membrane replacement, and labor make up the most significant costs associated with reverse osmosis plants[38] Although the energy costs associated with reverse osmosis plants are typically much less than those associated with distillation plants, desalination facility energy costs are still higher than those using conventional treatment technologies.[39]

Reject Concentrate Disposal

All desalination processes involve three liquid streams: the saline feed water (brackish water or seawater), a low-salinity product water, and a very saline concentrate.[40] The saline feed water is separated by the desalination process into two output streams: the low salinity product water and very saline concentrate streams (brine or reject water).[41] Disposal of the brine reject water represents a significant technical and legal impediment to desalination.

Because concentrate is characterized as an industrial waste by regulatory agencies,[42] disposal must comply with the applicable rules and statutes. There are a variety of concentrate disposal options available in the Eastern United States including deep well injection, direct and indirect ocean and surface water outfalls, discharges to publicly owned treatment works ("POTW"), and blending with freshwater for irrigation purposes. In other, more arid regions of the United States, options such as evaporation ponds may also be available.

The impact of discharging de-mineralized concentrate on a receiving water body can vary depending on volume, flow, depth, temperature, chemical composition, and degree of variability of the receiving water, and the volume, flow, temperature and chemical composition of the concentrate. The chemical composition of the concentrate can be significantly affected by the constituents in the source water. Demineralization concentrate is basically a concentrated form of the raw source water. There are typically few chemicals added during the process, but any such additives can occasionally present problems with meeting state water quality standards. Typically, the suitability of a receiving water body for discharge is made through comparison of receiving water quality standards (dependent on the classification of the receiving water) and the water quality of the effluent. Where water quality standards cannot be met at the point of discharge, regulatory relief in the form of a mixing zone may be granted by the regulatory agency. A permit authorizing a mixing zone will require that certain standards be met at the edge of the mixing zone.

Open Ocean Discharge

Open ocean discharge is a legally available option for disposal of demineralization concentrate, but it is not widely used in the United States. In situations where the concentrate is being disposed of into the ocean, there are many issues concerning water quality impacts and benthic toxicity. This disposal option is a subcategory of surface water discharge, with similar permitting requirements under Clean Water Act (CWA) Section 403 and 40 C.F.R. Subpart M. EPA Region IV views the additional requirements in CWA Section 403 and 40 C.F.R. Subpart M to be additional criteria, over and above any other requirements for a discharge to a water of the United States. An open ocean outfall was investigated as a concentrate disposal option for the Tampa Bay Seawater Desalination Plant. In that instance, the EPA Region IV indicated that open ocean outfalls were disfavored wastewater disposal options and that EPA was in the process of finding ways to eliminate the existing open ocean outfalls in South Florida.

In recent years, the federal government has sought to further limit open ocean outfalls. In May 2000, Executive Order No. 13158 was issued, which required EPA to use its existing authority under the Clean Water Act to further protect ocean waters. As a result, EPA drafted new ocean discharge criteria for the first time since 1980. The EPA draft rule is nearing completion and it appears to contain new criteria governing ocean discharge criteria such as ocean water quality standards.[43]

Additional approvals may be required from the U.S. Coast Guard and U.S. Army Corps of Engineers for impacts to navigable waterways and waters of the United States. Federal, state, and local coastal and ocean protection agencies may also have regulatory jurisdiction. For instance, the National Marine Fisheries Service may need to be consulted regarding impacts to commercial fisheries or endangered species that live in the marine environment.

Even considering the additional regulatory hurdles, the less stringent water quality requirements, when compared to other types of surface discharges and the ability to discharge large quantities of concentrate could make open ocean discharge an attractive alternative for large drinking water demineralization facilities. In an effort to avoid federal regulation, some utilities have investigated extending discharge pipes outside of United States territorial waters.

Discharge to POTWs

The need for an individual permit for disposal of demineralization concentrate can be avoided if it can be discharged through a sewer system to a POTW. If demineralization concentrate is discharged to a POTW that discharges to surface waters, the concentrate may be required to meet certain pretreatment standards. A POTW may have trouble meeting its surface water permit conditions if the concentration of pollutants discharged into the treatment plant is too high. Consequently, discharging to a POTW may avoid the need for a separate permit, but the demineralization concentrate will still be subject to regulation.

The CWA also requires USEPA to develop national pretreatment standards to control industrial discharges to POTWs. The standards include categorical pretreatment standards and prohibited discharge standards, both of which restrict the level of certain industrial wastewater pollutants discharged to POTWs. This is generally done through a contract between the owner of the POTW and the discharger. The categorical pretreatment standards and prohibited discharge standards typically do not limit discharges of demineralization concentrate to POTWs. However, the POTW will typically have an National Pollutant Discharge Elimination System (NPDES) permit that regulates the concentration of conventional pollutants, such as total suspended solids ("TSS"), total dissolved solids ("TDS"), chlorides, and occasionally calcium, that can be discharged by the POTW. The salinity and other characteristics of the demineralization concentrate may cause a POTW discharge to exceed its effluent limitations. Thus, discharges to POTWs may be limited by the capacity of the POTW and the impact of the demineralization concentrate discharge on the POTW's ability to comply with its effluent limitations.

Deep Well Injection

For many projects located in areas with a suitable hydrogeology, deep well injection represents an extremely cost-effective option for reject concentrate disposal. Deep well injection is a disposal option in which liquid wastes are injected into permeable underground rock formations. Depths of the disposal wells typically range from 1,000 to 8,000 feet below land surface, because problems can arise if the concentrate reaches drinking water aquifers.

The Safe Drinking Water Act ("SDWA"), initially enacted in 1974, contains provisions for the protection of underground sources of drinking water ("USDW"). In 1984, USEPA defined a USDW as underground water with less than 10,000 mg/l TDS. 40 C.F.R. §144.3. Pursuant to Subtitle C of the SDWA, EPA administers the Underground Injection Control ("UIC") program and the sole source aquifer protection program. The UIC program directs EPA to establish minimum requirements for regulation of injection into USDWs. This program regulates deep well injection of demineralization concentrate.

The primary requirement of the SDWA for deep well injection is that the design and operation of an injection well does not allow movement of wastes into or between underground sources of drinking water. This disposal option is based on the concept that very slow fluid movement in the injection zone will allow the injected wastes to remain in the injection zone indefinitely.

Injection wells are divided into Classes I-V. Class I wells are wells used by municipal and industrial discharges to dispose of waste materials below the lowermost formation containing a USDW. Classes II through V include wells for many specific uses and different fluids. Demineralization concentrate disposal wells are typically required to be Class I wells. The largest and most numerous domestic Class I injection wells are located in southern Florida, where the favorable hydrogeology makes the use of the wells for subsurface injection of wastes an attractive option.

Irrigation

Finally, another disposal option involves using concentrate for irrigation or groundwater recharge. Irrigation is typically only an option for lower salinity reject water.[44] The vegetation and habitat in the areas where irrigation will be used must be saline tolerant. If run-off from the irrigation is possible, an NPDES permit must be obtained.

Toxicity Concerns

Toxicity is a major concern with all methods of concentrate disposal. Ion imbalance, pH, and TDS are the three parameters associated with toxicity.[45] Low pH results from the addition of acid to prevent scaling of calcium carbonate.[46] Typically, reject water contains concentrate that is approximately double the normal marine concentration of total dissolved solids of 36 parts per thousand (ppt).[47] High total dissolved solids can be toxic to marine organisms as well as terrestrial grasses, crops, and landscaping.[48]

Ionic constituents within the reject water concentrate may also pose a problem because membranes remove the majority of ions within the water resulting in a disproportionate ion concentration when compared to the receiving water body.[49] This ion imbalance, particularly calcium, fluoride, and potassium, is acutely toxic to freshwater and marine organisms.[50]

Toxicity problems arise with all forms of concentrate disposal with the possible exception of deep well injection.[51] The problems with pH can be easily resolved through existing technology and protocols involving chemical reactions.[52] Unfortunately, the remaining problems of toxicity and density are not as easily solved.[53] Multiple chemical treatments are required in order to reduce the toxicity.[54] Even after the toxicity problem is solved, the solution density must be changed via engineering solutions to reflect consistency with the seawater.[55]

Desalination Case Study - Tampa Bay Seawater Desalination Plant

The Tampa Bay Seawater Desalination Plant ("TBD") is the largest seawater desalination facility in North America. It is designed to produce up to 25 million gallons per day, and can accommodate an expansion to produce up to 35 mgd in the future.[56] The Plant uses reverse osmosis to produce drinking water from seawater.[57] It is a co-location plant that uses approximately 44 million gallons a day (mgd) of the 1.4 billion gallons a day of warm seawater discharged from Tampa Electric's Big Bend Power Station.[58] TBD's high pressure pumps push the source water through the reverse osmosis membranes which separate the stream into drinking water and reject water, which is twice as salty as seawater.[59] As a cost and energy saving measure that also boosts pump horse power by as much as 40 percent, the pumps have energy recovery units.[60] As a result of the reverse osmosis process, approximately 25 mgd of purified water will be produced for delivery to Tampa Bay Water.[61] The reject water is returned to Big Bend Power Station's cooling water stream where it is blended and diluted.[62] The point of injection of the desalination discharge is located approximately 72 feet upstream of the point of discharge to the discharge canal, which provides reasonable assurance that complete mixing of the desalination concentrate with Tampa Electric's cooling water.[63] When TBD is producing 25 mgd of finished water, the approximate dilution ration of the desalination concentrate with Tampa Electric's cooling water is 70:1.[64] Historical data indicates a dilution rate of greater than 20:1 will occur 99.6 percent of the time and greater than 28:1 will occur 95 percent of the time. The salinity levels after dilution are approximately 1.0 to 1.5 percent higher than water in Tampa Bay, which is within normal seasonal fluctuations.[65]

The facility has faced a number of problems in reaching operational status. Construction and operations of TBD and pipeline required 18 separate permits and the permit review process was long and expensive taking approximately 2 years to complete.[66] Following issuance, the permits were challenged administratively by a not-for-profit corporation, Save Our Bays, Airs, and Canals Inc. ("SOBAC"), whose stated goal was to protect the environmental quality of the bays, canals, and waterways of the Tampa Bay area, and to ensure drinking water for SOBAC members in the Tampa Bay area.[67] SOBAC raised the following concerns in their permit challenge: increased salinity due to TBD discharge; alleged decreased dissolved oxygen ("DO") from higher salinity; impacts of higher salinity and alleged decreased DO on marine plants and animals; alleged release of metals from sediments due to higher salinity and alleged lower DO, and the effects on marine plants and animals; alleged monitoring deficiencies; alleged failure to utilize available technologies to lower salinity and raise DO; alleged deficient financial assurances; and various alleged resulting Florida Department of Environmental Protection (FDEP) rule violations.[68] As a result, the following two issues were presented in the case:

> (1) whether Tampa Bay Desal, LLC ("TBD") provided reasonable assurances that its permit application to discharge wastewater from a proposed seawater desalination plant, National Pollutant Discharge Elimination System ("NPDES") Permit Application No. FL0186813-001-IWIS, meets all applicable state permitting standards for industrial wastewater facilities; and (2) whether Tampa Electric Company, Inc. (TEC) provided reasonable assurances that its proposed modification to an existing industrial wastewater facility permit, NPDES Permit Modification No. FL0000817-003-IWIS, meets all applicable state permitting standards.[69]

After a protracted administrative hearing, the Administrative Law Judge determined that TBD had provided reasonable assurance that the proposed project met all applicable criteria outlined in the Florida Administrative Code and any other applicable Federal and State laws.[70] Thereafter, the permit was granted.[71]

Permitting was finally completed in the Spring 2001 and construction began in August 2001.[72] Final operating permits were obtained in November 2002 with initial start-up scheduled to begin in March 2003.[73] After a short period of operation from March 2003 to May 2005, deficiencies in TBD design required Tampa Bay Water to shut down the plant in June 2005 and hire a contractor to correct these errors.[74] The remediation construction began in November 2005 with completion scheduled for later in 2007.[75] Modifications include overhauling the pretreatment process to correct inadequate screening and filtration as well as deficiencies in the reverse osmosis and post-treatment processes.[76] While it is believed the plant will ultimately become operational, the construction and operation costs have more than tripled as a result of the legal and technological challenges encountered by this project.

Desalination Case Study - Tropical Farms Project

A somewhat less ambitious, but more successful desalination project is the Tropical Farms project located in Martin County. The project involves a surficial aquifer freshwater wellfield and treatment plant, a Floridan aquifer brackish water wellfield and treatment plant, and a deep injection well system. The plant is a hybrid desalination plant blending brackish groundwater with non-potable fresh water and is designed to produce about 8 mgd of drinking water. Because the plant uses brackish groundwater rather than seawater and is blended with non-potable fresh water, it produces a much lower salinity level reject water. Because of the high quality of the reject concentrate and the deep well injection disposal technology, the project was permitted without legal challenge in a relatively short time. Also, the dual use of fresh, non-potable water and brackish water dramatically reduced the capital and operational cost of this facility. Planning for the project began in 2001 and the plant is scheduled to be completed in 2007. It illustrates a cost-effective means of developing moderate amounts of desalinated water in an expeditious fashion.

Reclaimed Water Reuse

Florida Administrative Code Chapter 62-610, defines reclaimed water as wastewater that has received at least secondary treatment and is reused after flowing out of a wastewater treatment plant. Reuse is the deliberate application of reclaimed water for a beneficial purpose.[77] Landscape irrigation, agricultural irrigation, aesthetic uses, groundwater recharge, industrial uses, environmental enhancement, and fire protection are al considered types of reuse.

Benefits

While it is possible for reclaimed water to be treated to meet potable water standards and serve as an alternative drinking water supply, this is not a common use. However, there are several benefits that may result from using reclaimed water for nonpotable water needs including:

- postponement or elimination of construction of additional water supply wells;
- reduction in the size of the potable water distribution lines;
- reduction in monthly water;
- guaranteed source of water;
- reduced demand on ground- or surface-water resources;
- exemptions from water shortage /restriction requirements;
- reduced application of commercial fertilizers since reclaimed water contains nutrients;
- more water available and reduced demands during water shortages for the regional water supplier

- groundwater recharge
- satisfaction of anti-degradation requirement for expansion of a surface water disposal facility
- exemptions from permitting requirements[78]

The use of reclaimed water for large-scale irrigation, particularly golf course irrigation, is one of the predominant methods for which it is being used. In Florida, there are approximately 346 golf courses utilizing reclaimed water for irrigation.[79] Additional large-scale and/or green space irrigation sites include schools, activity fields, parks, retail nurseries, median strips, cemeteries, commercial landscapes, and common areas.[80]

Up to 50 percent of the potable water delivered to single family homes is utilized for outdoor uses.[81] Use of reclaimed water for residential outdoor nonpotable use could amount to substantial savings of potable groundwater.[82] Utilizing lesser amounts of groundwater could prevent the need for expansion of existing water treatment facilities, drilling of new wells, or construction of new facilities.[83] The savings could then be passed on in the form of lowered monthly water bills and exclusion from water restrictions.[84]

Agricultural irrigation of food, fiber, fodder and seed crops, wholesale nurseries, sod farms and pastures are also another great option for reclaimed water usage.[85] While many state regulations prohibit direct contact of reclaimed water with edible crops that will not be peeled, skinned, cooked, or thermally processed before human consumption, indirect reclaimed water usage is sometimes allowed.[86] One such agricultural reclamation facility is the CONSERV II Water Reclamation Facility, located in Orange County, Florida. This facility has the capacity to irrigate 15,000 acres and dispose of 50 mgd of reclaimed water.[87]

Additional uses of reclaimed water include: industrial use of reclaimed water for cooling, process and wash waters; environmental enhancement in restoration of hydrologically altered wetlands; rapid rate land application to a series of percolation ponds or subsurface absorption systems; and groundwater recharge in areas of saltwater intrusion. [88]

State Regulations - the Florida Experience

Florida has developed a comprehensive reuse program aimed at promoting and encouraging water conservation and reuse of reclaimed water. As part of the plan, Florida implemented the Water Resource Implementation Rule in Florida Administrative Code Chapter 62-40, Section 403.064, F.S., the FDEP's Anti-degradation Policy, and "Reuse of Reclaimed Water and Land Applications" in Florida Administrative Code Chapter 62-610.[89]

The Water Implementation Rule requires water management districts to designate areas that have existing water resource problems or in which water resource problems are projected to develop during the next 20 years. These are often referred to as water resource caution areas. Applicants in these areas are required to make use of a reclaimed water source unless the applicant can demonstrate that the use is not economically, environmentally, or technologically feasible.[90] Section 403.064, Florida Statutes requires all applicants for domestic wastewater permits for facilities located in water resource caution areas to evaluate the feasibility of reuse as part of their permit application.

The FDEP Anti-degradation Policy contained in Florida Administrative Code Chapters 62-4, "Permits," and Chapter 62-302, "Surface Water Quality Standards" must be complied with prior to issuance of a permit for surface water discharge. "The anti-degradation policy requires a utility proposing to construct a new discharge or expand an existing discharge, to demonstrate that an alternative disposal method such as reuse is not feasible in lieu of a discharge to surface water, and that such a discharge is clearly in the public interest."[91]

Florida Administrative Code Chapter 62-600, entitled “Domestic Wastewater Facilities,” contains requirements for construction, operation, and permitting of domestic wastewater treatment facilities. Treatment and disinfection requirements for reuse of reclaimed water are established in Florida Administrative Code Rules 62-600.530 and 62-600.440. Domestic wastewater must meet, at a minimum, a treatment standard of secondary treatment, basic disinfection and pH control in order to be reused as reclaimed water.[92]

The specific reuse and land application requirements are set forth in Florida Administrative Code Chapter 62-610, “Reuse of Reclaimed Water and Land Application.” Reclaimed water used to augment supplies in Class I surface waters is a form of indirect potable reuse and is addressed in Part V of Chapter 62-610. Part V also regulates injection of some reclaimed waters. Rapid-rate land application systems may be use to recharge groundwaters and are regulated by Part IV.

Impediments

Along with the numerous benefits of reclaimed water, there are a few impediments. First, many people have a psychological barrier against utilizing reclaimed water. Changing public perception is often one of the most difficult obstacles affecting reclaimed water reuse. This concern may be overcome with a vigorous public information campaign. “Health risks associated with reclaimed water are relative to the degree of human contact and adequacy/reliability of the treatment processes that produce the reclaimed water.”[93] Problems such as those associated with micro-constituents can be minimized or avoided so long as the water has been properly treated. In areas of the country where reclaimed water has only received basic treatment, it is possible for hormones and estrogens to be picked up by grazing animals. In order to provide safe water, the FDEP has developed numerous regulations requiring extensive treatment and disinfection to ensure that public health and environmental quality are protected.[94]

Compliance with the strict water quality standards may also be viewed as an impediment to reclaimed water usage. Many states still view reclaimed water as treated wastewater and reuse as a disposal option, which leads to difficult water quality issues. Fortunately, in Florida, FDEP rules, such as the ones contained in Chapter 62-610, make it easier to permit public access reuse irrigation, agricultural reuse irrigation, and industrial reuse. In Florida, wastewater permitting is conducted by the FDEP and certain delegated local programs.[95] Individual permits include permit requirements and conditions tailored to the specific wastewater treatment and disposal systems regulated in the permit. These permits “generally contain requirements depending on the type of treatment facility and the disposal means.[96] Further discussion of water quality standards is contained below in the “regulatory requirements” section below.

Many states limit the discharge of reclaimed water to either surface waters or the aquifer system because of water quality concerns. Failure to include the alternative disposal options such as irrigation and industrial reuse severely restricts the effectiveness of reclaimed water as a viable alternative water supply source.

Storage is perhaps one of the greatest issues with reclaimed water. Most systems deliver water to a pond at the customer site for use in their irrigation system. Others operate a pressurized irrigation system, which requires no customer storage and is usually distributed to individual house sites. Some of the storage options include: retaining everything at one location, storing at various sites, one main storage location with overflow contained at various areas, segregating reuse from storm water, blending reuse with storm water, overflows to waters of the state.

Additional concerns have also been expressed by end users in regards to reclaimed water for irrigation.[97] Water softening by homeowners and commercial users, high-pressure wash bays using sodium-phosphate detergents to remove road salt, soil, grease and solids, and property waste can add substantial amounts of sodium chloride to the water supply.[98] Typically, the wastewater treatment process does not reduce total salinity or the sodium content of the water, which may cause problems for golf courses in particular.[99] Golf courses that utilize reclaimed water with high salinity may find severe cases of black layer on irrigated greens, soggy turf conditions resulting from extra irrigation to leach out salts, or the need to change turf species.[100]

As always, there are costs associated with developing alternative water supplies. In addition to costs for transmission and distribution system installation, reclaimed water capital costs typically include upgrading wastewater treatment facilities to advanced secondary treatment by adding filtration and high-level disinfection. Additional upgrades to "advanced wastewater treatment," which reduce nitrogen and phosphorous, may be needed if re-hydration or wellfield recharge projects are contemplated.[101] Typically, utilities in growth areas find these costs easier to bear, when required as part of new construction, than mature utilities, which must retro-fit an existing service area.

Case Study
The town of Cary, North Carolina, has implemented a reclaimed water program.[102] The town advertises that reclaimed water users will pay a reduced rate for reclaimed water and will not be charged a sewage disposal fee. The reclaimed water costs $3.28 per thousand gallons, which is currently about $2.05 less than water from an irrigation connection (depending on whether the customer was using a dedicated irrigation meter or a standard household meter connection – note this cost is subject to annual review).[103] However, the town warns that the water is not treated to potable water standards and should not be used for any purposes where discharge from the water may run to the street or drainage pipes.[104] Therefore, the use is limited to landscape irrigation and other similar means, but not for washing cars or cleaning the outside of a house.[105] Additionally, State regulations require that a 25-foot buffer be maintained between an area sprayed with reclaimed water and any surface water. [106] Similar examples can be found throughout the Eastern United States.

Federal and State Regulations

Economic Incentives
The Water Desalination Act of 1996 ("Act")was enacted by Congress to authorize research to determine the most cost-effective and technologically efficient means by which usable water can be produced from saline water or water that has otherwise been contaminated. Under the Act, the Secretary of the Interior is authorized to award grants up to the amount of $5,000,000 and to enter into contracts to conduct, encourage and assist in the financing of research to develop processes for desalination.Appropriations of up to $25,000,000 were also authorized for desalination demonstration and related activities. However, these appropriations were only for fiscal years 1997 through 2002. Bills providing additional desalination energy assistance funds were brought before both the 108th and 109th Congress, but none became law.[107] H.R. 664 to amend the Water Desalination Act of 1996 to authorize the Secretary of the Interior to assist in research and development, environmental and feasibility studies, and preliminary engineering for the Municipal Water District of Orange County, California, Dana Point Desalination Project was referred committees on January 24, 2007. At the end of the 109th Congress, the House had passed a bill with the same name. The introduction of this bill indicates some continued limited federal interest in funding desalination research.

Funding for alternative water supply development is much more prevalent at the state and local level. For example, in Florida,. Section 170.01, Florida Statutes, provides that any municipality may "order the construction or reconstruction of water mains, water laterals, alternative water supply systems, including, but not limited to, reclaimed water, aquifer storage and recovery, and desalination systems, and other water distribution facilities, including the necessary appurtenances thereto." This section further provides that the municipality is able to finance these improvements by levying and collecting special assessments on the benefited property. Additionally, under Section 125.01, Florida Statutes, the county's governing body has the power to establish municipal service taxing or benefit units for any part or the entire unincorporated area of the county which may be provided alternative water supplies, including, but not limited to reclaimed water and water from aquifer storage and recovery and desalination systems.

In 2005, the Florida became more active in funding alternative water supply development at the state level by appropriating $100 Million annually for a grant program administered by regional water management districts. Among the factors the districts are directed to consider in awarding grants are: whether the project prevents or limits adverse water impacts, reduces competition for water supplies, brings about replacement of traditional sources, utilizes reuse water as a major component, is part of a plan to implement two or more alternative water supply projects, is a subsequent phase of an alternative water supply, and the quantity of the water supplied as compared to the cost. During the past several years, the water management districts have made funding available from a variety of sources. Most water management districts implement some form of funding program to provide assistance to local governments, public or private entities, and other users for projects that develop alternative water supplies.[108]

Statutes and Regulations

In order for either reclaimed water or desalination facilities to succeed, the facility must comply with the applicable federal and state regulations and statutes. The reject concentrate water from the desalination process and the reclaimed water must comply with regulatory standards. The primary federal laws that generally govern desalination and reclamation facilities are the Safe Drinking Water Act, the Clean Water Act, the Endangered Species Act, the Rivers and Harbors Act and the related federal and state regulations.

Clean Water Act

The CWA was originally enacted in 1972 as the Federal Water Pollution Control Act. It regulates desalination and reclaimed water facilities in two ways: (1) regulation of construction activities in water of the United States; and (2) discharge of reject concentrate and reclaimed water into the waters of the United States, including open ocean outfalls, and publicly owned treatment works that ultimately discharge to waters of the United States.

The CWA regulates the discharge of pollutants to waters of the United States through the NPDES. CWA §402. Under this program, EPA, or delegated state programs issue permits for discharges of wastewater from point sources into waters of the United States, if the discharge meets applicable standards. These standards include effluent limitations, total waste load allocations, non-degradation requirements, toxic and pretreatment effluent standards. Additional standards apply to ocean discharges. NPDES facilities using beneficial reclaimed water are subject to additional permit requirements that are incorporated into their wastewater permit along with the NPDES permits.

CWA Section 404 regulates construction activities in waters of the United States and it is the statutory authority for the federal wetlands regulatory program. The CWA 404 program regulates and discharge of dredge or fill material released into waters of the United States, which include most wetlands and surface water bodies.

Safe Drinking Water Act

Under the the Safe Drinking Water Act ("SDWA"), EPA or delegated state agencies regulate the quality of public drinking water, including drinking water that comes from desalination of brackish groundwater or seawater. Some drinking water standards may impact how a desalination facility is designed or how desalinated brackish groundwater or seawater is used in public water systems. EPA has established primary and secondary drinking water standards. Primary standards are human health based limits that are typically set as maximum contaminant limits. Secondary drinking water standards are additional recommended guidelines that have been established by EPA, but are not based on human health effects. Some primary or secondary drinking water standards may impact the design of desalination facilities. For instance, the secondary standard for chloride is 250 mg/l. In addition, compliance with the primary drinking water standard for disinfection byproducts may become more difficult if desalinated water contains elevated levels of bromide. Compliance with drinking water standards may also need to be evaluated if desalinated water is to be blended with drinking water from other sources or if desalinated water is to be distributed through drinking water systems that have used other sources of water.

Generally, compliance with the primary and secondary drinking water standards under the SDWA is easily achieved in the design of a desalination facility. Compliance with most primary and secondary drinking water standards can be directly measured before the water produced by the demineralization facility is transported off site. Generally water purchase agreements only require compliance with drinking water standards at the point of sale, and do not address the impact of the purchased water in the water distribution system. If the source and composition of the purchased water is similar to the water sources used by the receiving public water system, the impact may be minimal. However, if the water chemistry of the purchased water is significantly different, there is potential for unforeseen water quality problems. Problems mixing ground water and surface water have been observed in public water systems. The City of Tucson may be the most widely reported instance of water quality problems caused by mixing source water. Since dematerialized water can have significantly different water chemistry than either ground water or surface water, there is potential for water quality problems in the public water system introducing dematerialized water into an existing system using other water sources.

Some relatively recent developments in drinking water regulation required compliance monitoring for certain contaminants at the point of use. For public water systems, the point of use is frequently the residential water faucet. When a public water utility develops its own desalination facility any impact on the public water system's compliance with drinking water standards can be addressed considering the entire system as a whole, but if water is provided to the public water system by an independent vendor or by another public water utility, issues concerning compliance with drinking water standards can become complex.

The lead and copper rule requires that drinking water meet the primary drinking water standard at the point of use. The most common source of lead and copper in public water systems is corrosion in the water distribution system. The corrosion control requirements in 40 C.F.R. §141.82 give direction to the state agencies on how to determine the proper corrosion control methods for large public water systems. The EPA rules envision that large facilities will conduct corrosion control studies to identify the optimal corrosion control treatment for that system: (i) alkalinity and pH adjustment; (ii) calcium hardness adjustment; and (iii) addition of a phosphate or silicate based corrosion inhibitor at a concentration sufficient to maintain an effective residual concentration in all test tap samples. 40 C.F.R. §141.82(c)(1). The water supplier must measure the following water quality parameters before and after any corrosion control tests: (i) lead; (ii) copper; (iii) pH; (iv) alkalinity; (v) calcium; (vi) conductivity; (vii) orthophosphate; (viii) silicate; and (ix) water temperature. 40 C.F.R. §141.82(c)(3).

Demineralized water can be aggressive and contribute to corrosion in water distribution systems. The aggressiveness of the demineralized water can be controlled through stabilization prior to introduction of the water into the distribution system. Issues related to corrosion control and compliance with the lead and copper rule should be addressed in water purchase agreement where demineralized water is to be introduced into an existing public water distribution system. EPA has indicated in a number of guidance documents and opinion memos that interconnected systems can voluntarily allocate amongst the wholesale water suppliers and/or interconnected public water systems responsibility for compliance with the lead and copper rules through agreements. See, e.g., Memorandum from Jeff Cohen, Chief Lead Task Force Officer of Ground Water and Drinking Water to Regional Drinking Water Branch Chiefs (WSG 85A) January 10, 1992; U.S. Environmental Protection Agency Office of Water, Final State Reporting Guidance for LCRMR, (October 2001); Lead and Copper Monitoring and Reporting Guidance for Public Water Systems, U.S. Environmental Protection Agency Office of Water, EPA-816-R-02-009 (Feb. 2002) pg 37.

The disinfection byproduct rule is the other relevant EPA rule where compliance with drinking water standards is measured at the point of use. Disinfection byproducts can continue to form in the distribution system as the contact time between chlorine and the organic molecules in the water increases. Consequently, compliance monitoring for disinfection byproducts must be conducted throughout the public water system.` The regulatory indicator compound used to evaluate compliance with disinfection byproduct requirements is total trihalomethane maximum (TTHM). Compliance monitoring must be completed as outlined in 40 C.F.R. §141.30 in order to demonstrate compliance with the maximum contaminant level. Introduction of demineralized water into an existing public water system can have minor impact on compliance with the disinfection byproduct rule if the demineralized water has significantly higher concentrations of halide ions heaver than chloride, such as bromide. Heavier halide ions can substitute for chloride in the TTHMs and other indicator compounds measured under the disinfection byproduct rule. The regulatory levels for disinfection byproducts are relatively low mass-based concentrations, so if the heavier bromide ion is substituted in significant quantities the measured disinfection byproducts may also increase.

Endangered Species Act

The Endangered Species Act ("ESA") is the principal federal statute protecting fish and wildlife species that have deteriorated to the extent that the continued survival of the species is in question. The U.S. Fish and Wildlife Service ("USFWS") has primary jurisdiction to enforce the ESA. The National Marine Fisheries Service also has some authority to implement the ESA to protect endangered marine species.

Section 9 of the ESA and federal regulations prohibit the "take" of federally listed species. "Take" is defined under the ESA, in part, as killing, harming, or harassing such species. Under federal regulations, "take" is defined further to include modifying or degrading habitat so that essential behavioral patterns, including breeding, feeding, and sheltering are significantly impaired and lead to the death or injury to the wildlife. An incidental "take" permit is required under Section 10(a) and federal consultation is required under Section 7, if the development could affect a federally listed species.

Section 7 of the ESA requires that federal agencies, in consultation with the USFWS and NMFS, ensure that their actions do not jeopardize the continued existence of the species or habitat critical for the survival of that species. "Take" of a federally listed species may be allowed through Section 7 consultation between the USFWS and another federal agency if the proposed project is sponsored by or under another federal agency's jurisdiction. A federal agency initiates informal consultation with the USFWS. Prior to completion of a Biological Assessment, the USFWS determines if the proposed project would have "no effect" on the listed species or "may affect" the species. Should the USFWS render a "may affect" determination, formal consultation would be initiated between the USFWS and the federal lead agency via submittal of the Biological Assessment to the USFWS. A Biological Assessment evaluates the effects of a project on listed and proposed threatened and endangered species. The USFWS then prepares a Biological Opinion regarding whether or not the project would jeopardize the continued existence of the species.

The disposal of reject concentrate water and the application of reclaimed water may trigger the ESA, if habitat critical for the continued survival of an endangered or threatened species is impacted. This Act frequently comes into play when reject concentrate is discharged to estuarine or marine systems, where increased salinity may have an impact on species survival. The ESA was the major reason for rejecting desalination of the Indian River Lagoon near Cocoa Beach and Melbourne on Florida's east coast as a viable water supply option.

Rivers and Harbors Act
Section 10 of the Rivers and Harbors Act ("RHA") regulates obstructions to navigable waters. The Army Corps of Engineers has permitting authority under the RHA to regulate structures and work in or over navigable waters of the United States that may affect the course, location, condition, or capacity of navigable waters. Construction of piers, boat ramps, and pipeline crossings are typically regulated under this Act. This Act comes into play when constructing sub-aqueous crossings for reject concentrate disposal lines or for constructing reclaimed water lines to barrier islands.

Conclusion

While there are many obstacles standing in the way of effectively utilizing reclaimed water and desalination technologies, the benefits of preserving our ground and surface water sources and providing viable sources of water far outweigh any obstacles. It is important for all governments and utilities to work together in hopes of best achieving a sustainable water supply for years to come.

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