An Innovative Opportunity for Water Reuse

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The city of Hollywood's program to ensure adequate drinking water for its residents illustrates issues and solutions unique to Florida and other coastal communities. Over the past 20 years, Hollywood has experienced rapid residential and commercial growth. Industrial activity also has increased, particularly in connection with nearby Port Everglades. While escalating demands on the city's drinking water system paralleled this growth, Hollywood's raw water withdrawal permit from SFWMD for the Biscayne aquifer was being reviewed because of encroaching saltwater.

The saltwater intrusion forced the city to identify supplementary water supplies and, eventually, to develop a new drinking water treatment system capable of handling the new water source. Membrane treatment technologies were chosen to treat two new supplies: brackish Floridan aquifer water and highly colored western Biscayne aquifer water.

Membrane processes create a concentrated byproduct. Key to the success of the new water supply system was the means of disposing of reject water in heavily populated and environmentally sensitive South Florida.

The disposal method pursued by Hollywood and Metcalf & Eddy achieves two goals. First, the disposal system meets all antidegradation policies set by EPA, DEP, and Broward County's Department of Natural Resources and Planning (BCDNRP). Second—and equally important from an environmental point of view—the reject water disposal system actually improves the quality of the effluent discharge from the city's nearby wastewater treatment plant through a shared ocean outfall.

Providing Drinking Water

As is true for many South Florida communities, Hollywood has relied on the shallow Biscayne aquifer for its drinking water supplies, which also serves as the primary drinking water supply for much of Southeast Florida. To protect the aquifer, SFWMD set strict withdrawal limits, mandatory withdrawal reductions, and wellfield protection restrictions on the region. The city had a withdrawal limit of 27.5 MGD; however, due to the encroaching saltwater, SFWMD reduced the city's allocation to 20.67 MGD for the Biscayne wellfield. As a result, a simple increase in the permitted withdrawal was not an option for Hollywood. Instead, the community was forced to initiate a search for alternative supplies.

Broward County was exploring western Biscayne water supplies, which contain highly colored organics. A brackish water supply is available in the Floridan aquifer beneath the city, but the water quality is substantially different from that of the existing Biscayne aquifer supplies. Hollywood's existing potable water treatment plant, which was slated for expansion to handle the increased raw water flow, would have been incapable of treating raw water from the Floridan aquifer.

In response, Hollywood's consultants, Metcalf & Eddy, designed an innovative, multi-component treatment system that subjected the two new raw water streams to discrete treatment trains. The first treatment train employs existing lime-softening equipment to treat water from the Biscayne aquifer. Three options for treatment allows the city to optimize the community's existing resources, ensuring consistent service and finished water quality during the construction of the other treatment trains. The second treatment train incorporates micron cartridge filters, membrane softening, and degassification for water from the Biscayne aquifer. The third treatment process uses reverse osmosis to achieve adequate water quality from the brackish Floridan supply. The use of multiple treatment trains maximizes Hollywood's use of existing equipment, allows lower-intensity treatment of higher-quality water, and reserves the more costly and intensive reverse osmosis treatment only for raw water requiring that level of treatment. Although each of these treatment technologies has been employed in Florida for water treatment, Hollywood's use of these three processes to provide simultaneous treatment within a single facility is the first of its kind.

Identifying Disposal Options

Based on characterization of the reject water, or concentrate, produced by the treatment trains, Hollywood initiated a search for acceptable discharge methods. The reject water produced by the membrane softening and reverse osmosis trains differed substantially. Reject water from the membrane-softened Biscayne aquifer produced higher concentrations of iron and mercury, while the Floridan water treated by reverse osmosis contained elevated concentrations of chloride, fluoride, and radionuclides. Both reject waters were slightly acidic and contained elevated concentrations of nutrients.

A full range of disposal alternatives was examined, including water reuse for agriculture or landscaping, deep-well injection, discharge to nearby surface waters, discharge to the Atlantic Intracoastal Waterway, and ocean disposal. Hollywood's initial screening of alternative disposal methods produced the following results:

Water reuse for ornamental, landscape, or agricultural irrigation is a desirable alternative in Florida, particularly since water containing high concentrations of total dissolved solids has the potential for reuse in the irrigation of salt-tolerant turfgrass species common to the region. Unfortunately, the projected ion concentrations for the reject water from either treatment train was considered too high for irrigation. A particular issue involved the salinity of the reject water. In addition, more than 70% by weight of the Biscayne reject water's salts represent calcium and carbonate. Studies indicated that the use of this water could not be used in less than ideal circumstances without additional treatment or dilution with higher-quality water.

Discharge to a nearby drainage canal was eliminated due to the presence of the Florida manatee, an endangered species. Similarly, discharge to the Atlantic Intercoastal Waterway was dismissed in part because of the presence of the manatee. Additional concerns centered on the uncertain environmental effects of the reject water on a large new mangrove wetlands mitigation bank established adjacent to the waterway by Hollywood. After spending considerable time and effort to establish the mitigation bank, Hollywood was unwilling to consider disposal options that could potentially have negative effects on the vitality of the wetlands area.

Deep-well injection for the reject water would have required tube and packer well designs as well as back-up wells, imposing a significant capital cost. When combined with the technical difficulty of adequately monitoring discharges to deep aquifers, the potential for public opposition to deep-well injection, the uncertainty of environmental impacts because of the absence of an ability to monitor effectively, and the anticipated costs of the technique eliminated it from consideration.

Ocean discharge through an existing ocean outfall that serves Hollywood's wastewater treatment facility was considered an option that met several objectives. First, sharing the existing infrastructure with the wastewater treatment plant appealed to Hollywood's desire to optimize its existing infrastructure whenever possible. Second, the use of an existing outfall would significantly minimize construction costs and potential delays. Third, preliminary investigations suggested that mixing the two waste streams could produce beneficial environmental results by actually improving the water quality of the combined discharge. Discussions with regulatory authorities indicated that the technique held high potential for compliance with the regulatory policies set by federal, state, and local agencies. Given that backdrop, Hollywood proceeded with the testing required to determine the permitting and environmental feasibility of the proposal.

Regulatory Parameters

The Clean Water Act requires that all states develop statewide antidegradation policies to protect water quality of each state's natural resources. Florida's Antidegradation Policy for Surface Water Quality applies to all new discharges or increases of existing discharges that potentially could reduce the quality of the receiving water.

Two major provisions of Florida's antidegradation policy held particular significance for Hollywood. First, if DEP finds that a new or existing discharge will reduce the quality of the receiving waters below the classification established for them, or violate any department rule or standard, it shall refuse to permit the discharge. Second, if DEP finds that a proposed new discharge or expansion of an existing discharge will not reduce the quality of the receiving waters it shall permit the discharge *if such degradation is necessary or desirable under federal standards and under circumstances which are clearly in the public interest, and if all other department requirements are met.* In other words, the discharge will be permitted only if it can be shown to be necessary or desirable and is in the public interest, which is determined through a balancing test of identified considerations.

Demonstrating the project's ability to comply with Florida's antidegradation policy was only one aspect of the challenge facing Hollywood and Metcalf & Eddy. A number of other issues required investigation and compliance including effluent limitations set by the Florida Administrative Code and the Broward County Code, surface water quality standards and criteria set by both state and county rules, toxicological standards set by DEP and EPA, discharge flowrates stipulated by DEP, and ambient water quality at the discharge point set by federal and local agencies and contained in Hollywood's existing NPDES permit.

Characterizing the Flow

The first step in the investigation focused on characterizing the reject water from the water treatment plant, the effluent carried by the outfall from the wastewater treatment plant, and the combined flow.

Effluent standards are set by the Florida Administrative Code and the Broward County Code for "end-of-the-pipe" concentrations prior to discharge. Chemical characterization of the reject water produced by the membrane treatment system indicated that all parameters satisfied effluent standards prior to discharge, with the exception of pH and radium 226. Although radium 226 levels for the reject waters exceeded both federal and state regulatory standards, the treatment system was designed to provide a 10 to 20-fold dilution of the effluent produced by the reverse osmosis train prior to its discharge to surface waters. Similarly, the slight acidity shown by the reject water was neutralized by the addition of the wastewater effluent prior to discharge through the outfall. In addition, the tremendous buffering capacity of the ocean further mollified any concerns regarding pH.

DEP, which regulates discharge flowrates, had stipulated that the ocean discharge evaluation demonstrate the acceptability of the combined discharge under "... a worst-case scenario dependent on the city's existing and future domestic wastewater disposal/reuse volumes." The combination of the two waste streams produced a combined flowrate of 5.3 MGD based on peak discharge flowrates at build-out levels of the water treatment trains. This flowrate was in keeping with acceptable volumes.

Additional testing was required to identify concentrations of constituents in excess of receiving water quality standards. The combination of reject water and effluent indicated that the reject water would be diluted prior to its discharge to the ocean, thereby complying with applicable water quality standards for the majority of constituents in question. For those constituents in excess of acceptable standards after dilution, additional treatment would be required. Excess hydrogen sulfide, for example, would be addressed by chemical oxidation of the reject water prior to discharge from the water treatment plant with chlorine introduced at the end of the reverse-osmosis membrane skids.

Toxicological testing was required to evaluate the potential effects of the combined discharge on marine life. The sea urchin *Arbacia penctulata* was selected as the test species, with chronic toxicity to be determined by effects of the discharge flows on the organism's fertilization rates. When considered by itself, the reject water posed no toxicity threat; when added to the wastewater effluent, the reject water reduced the chronic toxicity of the treated wastewater effluent.

Finally, testing was required to determine the potential dilution associated with the combined discharge. Studies of the three phases of discharge dilution—initial dilution, surface dilution, and farfield dispersion—were conducted and matched to data produced by waste stream characterizations at points prior to discharge. The results concluded that what initially appeared to be potential problems were, in fact, not problems.

DEP standards for gross alpha activity and iron were exceeded in both the effluent and reject waters, which imposed dilution requirements of 1:1 and 2:5 respectively. Those dilutions were achieved and exceeded at the edge of the mixing zone.

Table 1 - Analytical Chemistry Results for Pilot Phase Reject Waters

Results (&g/Liter, unless noted)	Lowest Effluent Standard	Lowest Applicable Marine Standard or Criterion	FLORIDAN (R/O) Reject Water (6/2/92)	BISCAYNE (M/S) Reject Water (6/2/92)
pH	6.0-8.5 (a)	6.5-8.5 (c,d,e)	7.0	5.0
Total Hardness			4,800,000	2,100,000
Ammonia		≤340 (c,f)	2,600	5,600
Chloride		10% over ambient (d,g)	9,600,000	34,000
Fluoride		≤5,000 (d)	4,500	<200
Hydrogen Sulfide		≤2 (c)	<100	<100
Gross Alpha Activity (pCi/L)		≤15 (d)	0.0 (j)	25
Ra226 (pCi/L)	3 (a)	≤3 (e)	8.7	1.8
Ra228 (pCi/L)			1.2	0.3
Ra226 + 228 (pCi/L) (calculated)		≤5 (d)	9.9	2.1
Copper	500 (a)	≤2.9 (c,d)	<1.0	<1.0
Aluminum		≤1,500 (d)	<200	<200
Total Arsenic	50 (a)	≤50 (d,e)	<25	<25
Cadmium	100 (b)	≤0.3 (d)	<0.05	<0.05
Chromium (hexavalent) (k)	100 (a)	≤50 (c,d)	<25	<100 (j)
Chromium (trivalent) (k)		≤673 (d)	<25	<25
Iron (total)		≤300 (d)	310	2,400
Lead	300 (a)	≤5.6 (d,h)	<1.0	<1.0
Mercury	1.0 (a,b)	≤0.025 (c,d)	0.12	0.39
Zinc	1,000 (a)	≤86 (c,d)	<20	<20
Nitrate			<50	110
Nitrite			<50	<50
Total Phosphorus	10,000 (a)	≤50 (e)	<100 (j)	160
Orthophosphate			630	170
Total Nitrogen (all forms) (i)	30,000 (a)	≤1,500 (e)	2,600	5,710

(a) Broward County Effluent Standards - Discharge to Surface Waters (27.198)
(b) DEP Effluent Limitations (17-4.244 (3) (b) 5F.A.C.)
(c) EPA marine chronic criterion (USEPA, 1991)
(d) DEP Type III Marine Standard (17-302.560 F.A.C.)
(e) Broward County Marine WQ Standards (27-5.07)
(f) Site specific parameter, worst case value based on T=30%C, S=30 ppt, pH=8.2
(g) Minimum background (chloride) = 15.95 ppt based on minimum salinity of 29 ppt
(h) DEP WQ standard based on erroneous EPA marine chronic value of 5.6 ppb in Gold Book
(i) Calculated parameter = ammonia + nitrate = nitrite, does not include organic nitrogen regulated by Broward County Standard
(j) Matrix interference resulted in elevated detection limit
(k) Total chromium (hexavalent + trivalent) <50 by Broward County Marine Standard

Broward County's Marine Water Quality standards for phosphorous and nitrogen at the discharge point were exceeded, but dilution of these constituents was achieved within an area equivalent to a circle of 50 meters in radius—well below the 400-meter permissible mixing zone.

EPA's end-of-pipe ambient water chronic toxicity criterion for ammonia was exceeded, triggering a dilution requirement of 18:8, a value frequently achieved even before the plume reached the water surface. Under a worse-case scenario, when future flows might be accompanied by extremely low current speeds, models showed that the necessary dilution would be reached within an area equivalent to 50 meters in radius—also well below the allowable 400-meter mixing zone.

Conclusion

The reject water "disposal" program developed by Hollywood is slated to play a significant role in the city's environmental management program as well as in its public service activities. While complying with all federal, state, and local environmental regulations, Hollywood's reject water disposal method serves to improve the chemical and toxicological character of the discharge of treated wastewater flowing through its ocean outfall. The addition of reject water has reduced the overall toxicity of the wastewater effluent and raised the salinity of the discharged liquid to more closely match the water quality of the receiving ocean waters. Equally important from a financial perspective, Hollywood's use of existing infrastructure eliminates the need to construct—and pay for—entirely new disposal facilities. Other disposal alternatives, from deep-well injection to the construction of a new outfall, might have been expected to trigger public opposition or criticism. Instead, Hollywood has achieved a win-win situation for the city's ratepayers, for regulatory agencies, and for the environment.

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Water Conserv II: A Model of Cooperation and Communication

Dan Estow

Much has been written about the successful Water Conserv II water reuse project. But the operational side of the story—how the project has functioned day-in-and-day-out for nearly a decade serving the diverse needs of a broad constituency—has remained a quiet, behind-the-scenes story that has made the project's public success possible.

Water Conserv II is the largest water reuse project of its kind in the world. It is also the first reuse project in Florida permitted by DEP to irrigate crops produced for human consumption with reclaimed water. Jointly owned by the city of Orlando and Orange County, the project is now in its tenth year of operation and has been a success virtually from the start.

The project has received a host of environmental awards: most recently, FWEA's 1994 David W. York Reuse Award, which recognizes projects that excel in environmental quality management, system performance and benefits, and public education. Enough technical papers and articles have been written on the successful Water Conserv II project to fill the average library shelf. Less well known, however, is the operational side of the story—how the project has functioned day-in and day-out for nearly a decade, serving the diverse needs of a broad constituency. It is the quiet, behind-the-scenes story that makes this project's public success possible, a story of cooperation and communication among a host of governmental and private parties.

Background

As a result of a 1979 court decision, the city of Orlando and Orange County were ordered to cease wastewater discharge into Shingle Creek, which flows into Lake Tohopekaliga, by March 1988. After considerable research, it was determined that the most feasible alternative was to design and construct a water reuse project in west Orange and southeast Lake counties, along a high, dry, and sandy area known as the Lake Wales Ridge. The primary use of the reclaimed water would be for agricultural irrigation, principally in citrus groves, and any excess water would be distributed into a series of Rapid Infiltration Basins (RIBs) to recharge the Floridan aquifer.

Before the plan could move forward, however, it first needed the full support of area citrus growers—the intended "consumers" of the reclaimed water. Even though area growers were under pressure to find alternative water sources because surface and ground water withdrawals had become increasingly more difficult, their initial reception to the project was lukewarm at best.

According to Don Phillips, whose family has been growing citrus in Orange and Lake counties for the past 75 years, many of the growers were skeptical. There is a general mistrust of government, especially when it comes to its involvement in agriculture, and there was considerable government involvement in the project. The growers needed assurances that it was not going to have any adverse effects on them, that they were not going to just become a dumping ground for the city and county.

Justifiably, the growers expressed a "show-me attitude," insisting on seeing research conducted on the effects of reclaimed water on area citrus. They were impressed by the results, which demonstrated unequivocally that the reclaimed water would be beneficial to citrus production. Enough area growers signed up to get the project off the ground, and others joined shortly thereafter. Since the startup of Water Conserve II, more than 72 local growers agreed to accept the reclaimed water, which would be supplied to their properties free-of-charge for a 20-year period.

The growers agreeing to participate in the Water Conserv II project were still concerned over the subject of availability, however. Since they would be using the reclaimed water for freeze protection as well as for irrigation, it was doubly important that access to the reclaimed water supply be uninterrupted. Project organizers clearly realized that any disruption in service would bring serious problems to the somewhat uneasy early alliance that had been established.

Project Description

Water Conserv II came on line in December 1986, 15 months ahead of the court-ordered deadline. The project cost $180 million to build originally, with 55 percent of the funds coming from the federal government and the remainder split between the city and county.

The reclaimed water comes from two facilities: the city's McLeod Road Water Reclamation Facility and the county's South Water Reclamation Facility. The project is permitted to receive 44 MGD for reclamation. It has a design capacity of 50 MGD and can handle flows up to 75 MGD. The project currently averages 30 MGD. About 60 percent of the flow is directed to agricultural customers such as citrus growers and commercial nurseries. The remaining 40 percent is distributed to the various RIB sites.

Additional transmission lines have been added over the past ten years, adding about $40 million to the overall cost of the project. There are also plans on the drawing board to develop 550 area acres as public golf courses and a golf academy, using reclaimed water for grounds irrigation.

Making It Work

Since startup, the day-to-day operations, maintenance, and management of the Water Conserv II project have been carried out by a private firm. The city and county have long operated extensive water and wastewater systems and, with their experience and expertise, either entity (individually or jointly) could have managed the ongoing operation of the project. It made more sense, in terms of logistics, to bring in a professional operations firm to be responsible for this aspect of the project.

With city and county ownership, federal support, state oversight, and agricultural and commercial clients, the project was already unusually complicated; cross jurisdictional management would have added to that complexity. The city and county felt a professional operations firm, working under a renewable contract could provide responsive management and a single point of accountability for all parties involved.

For nearly a decade, Water Conserv II's private operator maintained and managed the more than 50 miles of water distributions lines and 20 miles of transmission mains that bring reclaimed water to the project's participants. The 28-person staff also maintained the project's 46 RIBs, four 5 mg water storage reservoirs and more than 200 monitor wells and piezometers.

Most importantly, the operator served as the day-to-day liaison with the recipients of the reclaimed water and viewed itself as having three clients: the city of Orlando, Orange County, and the growers and others who receive the water.

Communications Plays Key Role

Communication is the key to the success of the project. Growers, for example, are notified before any interruption of service. The results of testing and monitoring are also made available. Orange County Public Utilities has an absolute open policy and is happy to share its ten years of data, collected from 24-hour monitoring at more than 200 monitor wells and piezometers, with interested parties.

In addition, the non-profit Mid-Florida Citrus Foundation continues to research the effects of reclaimed water on citrus and alternative crops. Results from the foundation's controlled studies conclude that young citrus trees grow faster as more reclaimed water is applied; canopy volume, yield and pounds of juice per acre all increase significantly with greater reclaimed water application.

With a virtually unlimited supply of free water, growers have become more generous in their irrigation scheduling. Although there are minimum and maximum volumes per acre specified in the grower contract, this has not been an issue to date. Continuity and trust remain an essential ingredient in the project's success.

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