Integrated Urban Water Management in Dunedin, Florida, USA: Sustainable Practices from a Small Coastal City in the Gulf of Mexico

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Abstract

With increased urbanization and diminishing resources, many cities are struggling to provide basic services to their residents. One basic service expected to be provided by local municipalities is clean water supplied in sufficient quantities to meet the particular needs of the community. Water scarcity is becoming commonplace even in the most modern of cities. Stressed water sources and climate variability make it difficult for water managers to find reliable solutions to this issue. Coastal cities face additional challenges such as salt water intrusion.

The City of Dunedin (FL – USA), recently recognized as a SWITCH Associate City, has an innovative approach to urban water management. Key elements of Dunedin's success can benefit other cities, especially those in coastal regions with vulnerable water supplies. Strategies adopted by Dunedin include careful management and protection of its urban well field, water conservation using a wireless AMR (Automated Meter Reading) system, and its 'near closed loop' urban water cycle with extensive use of recycled wastewater – one of the ultimate goals for integrated water management in an urban setting.

1. Background

The City of Dunedin, FL (USA) is a coastal city in the Tampa Bay region of West Central Florida, located on the Gulf of Mexico. It is located in Pinellas County, the most densely populated county in Florida with more than 3,000 people per mile^2 in 2005 (1,158

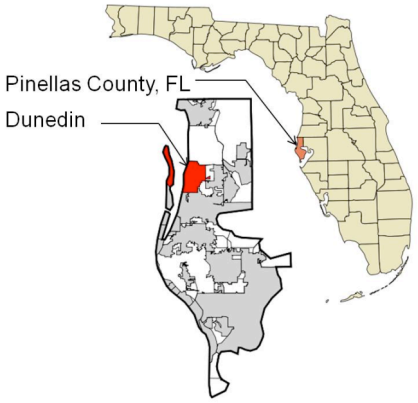


Figure 6 - Location Map

people per km^2). Dunedin is nearly 100% developed. The City itself is quite small (about 10 $miles^2$ or just under 26 km^2) and has a population of about 35,000.

The climate in West Central Florida is subtropical and humid, with an average annual precipitation of 52 inches (132 cm), most of which coming in the summer through heavy rain storms. However, significant quantities are lost to evapotranspiration and stormwater runoff. The largest single water demand in the region is lawn irrigation. Periodically, the demand exceeds supply, resulting in water shortages and irrigation restrictions.

2. Overview of water infrastructure

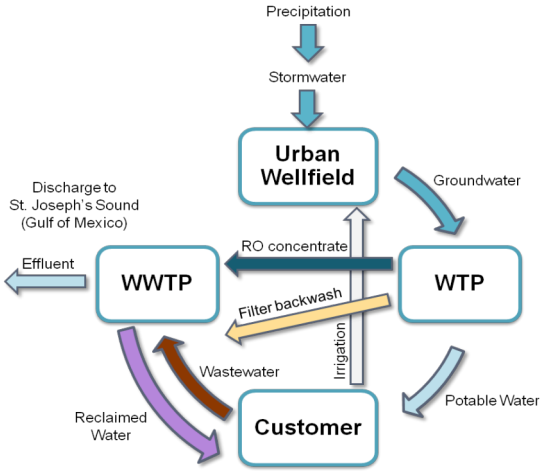
While most of the region depends on Tampa Bay Water (the region's wholesale water supply authority that provides water to several cities and counties including Pinellas County) for its drinking water, Dunedin is water independent, relying completely on its own drinking water source (with emergency connection to the County's system). Twenty-two freshwater bodies exist within the City's planning area, yet few would be appropriate sources for drinking water supply. Private ownership, water quality and environmental issues prevent the City from withdrawing from these surface water sources. The City's only water source is groundwater, extracted from twenty-six production wells uniquely located in an urban environment. These wells have the capacity of providing its residents with an average of 3.2 MGD (million gallons per day/12,100 m^3/d) and a capacity of up to 9.5 MGD (about 35,960 m^3/d).

The City has invested in modern and innovative infrastructure. In 1992, it started operating a reverse osmosis (RO) water treatment plant (WTP) that treats the raw well water pumped from its urban well field. The facility uses greensand filtration as pretreatment for the RO stage. This combination of water treatment provides high quality water to its customers, allowing the City to have flexibility in the treatment of a range of water quality types, now and into the future. The WTP has the flexibility to produce and store water during off-peak hours, reducing the high cost of electricity bills to the water utility. Backup power generators at the water plant provide the city a great benefit. Resiliency of water supply is improved during emergency situations, such as during extreme weather events and hurricanes when power outages have been known to occur. Citizens would be able to receive much needed water with this source of temporary power. Provisional power by generators for utilities is not common practice in the industry.

The City's wastewater treatment plant (WWTP) is an advanced biological nutrient removal (A^2O) facility. This process achieves high levels of nutrient removal, resulting in effluent that can be safely discharged into the Gulf of Mexico or reused for irrigation of residential landscapes, golf courses and for industrial uses. Dunedin's strategic management of potable water, via demand offset with reclaimed water, has given the city recognition as having one of the best reclaimed water systems in the State.

In Dunedin, the water and wastewater plants are intimately connected. The RO plant's process creates two byproduct streams: concentrate and filter backwash (Figure 2). These streams are pumped directly to the WWTP for renovation. The dissolved solids in these waste streams coupled with the sensitivity of the micro-organisms at the WWTP requires careful coordination between the plants. In essence, the city's ability to provide drinking water is not only dependant on source water but also on the WWTP's ability to absorb WTP byproducts.

3. Water supply and careful management of urban well field



Due to the karst geology, West Central Florida is an area with high incidence of "sink holes," which can be exacerbated by overpumping of groundwater. Dunedin carefully manages its urban well field to protect the groundwater from salt water intrusion and avoid sink hole formation. Though there is no anticipated significant growth in Dunedin, the City plans to increase the number of wells. The strategy is to distribute wells more evenly throughout the city, while pumping at a lower rate (what has been terms the "sippy straw" approach). In addition to sink hole avoidance, another benefit to increasing the number of wells is the extraction of consistent and improved water quality, while reducing the potential of chloride migration and the contamination of the wells. A significant improvement in water quality from the shallower wells has been noted at approximately the 200 ft (61m) depth. A program for backfilling some of the deeper wells (some of which are as deep as 300 ft/91m) is currently underway. Raw water extraction from shallower wells improves the resiliency of Dunedin's water supply by improving protection against salt water intrusion, which is a real threat in the face of climate change and sea level rise.

4. 'Near Closed Loop' Water Cycle

Dunedin's urban water cycle can be described as "near closed loop," operated with great efficiency (Figure 2). Emphasis is placed on infiltrating stormwater to encourage aquifer recharge. Also, most of the water that is extracted from the aquifer for use eventually ends up recharging the aquifer again. The City employs a "fit for purpose" dual distribution system (blue and purple) for its water supply. The treated well water is distributed throughout the city for potable and fire fighting purposes (blue pipes). Once used, the wastewater is conveyed via sewer to the WWTP for treatment and recycling. The wastewater is treated to produce up to 3.5 MGD (13,250 m^3/d) of recycled wastewater (reclaimed water). The reclaimed water is redelivered to individual households through the City's extensive reclaimed water distribution system (purple pipes) and used for irrigation. Any unused water from the wastewater treatment plant is discharged into St. Joseph's Sound (on Gulf of Mexico). During the dry season when irrigation demand is high (Figure 3), 100% of the recycled wastewater is used for reclaimed water, resulting in zero discharge at the WWTP, an amazing feat. Because the irrigation demand often exceeds the availability of reclaimed water during the dry season, the City has implemented an irrigation schedule that takes reclaimed water

Figure 2 - Dunedin's urban water cycle

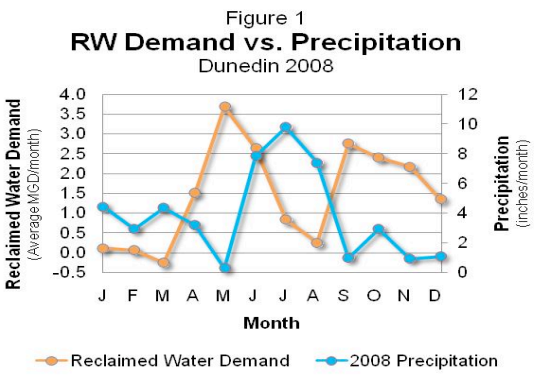


Figure 3 - Reclaimed Water Demand vs. Precipitation (2008)

availability offline for one day during the week to allow time to replenish supplies in the water towers. If necessary on occasions, the City also blends raw groundwater with reclaimed water to meet peak demand, in order to expand the reclaimed water customer base and achieve overall net decrease in groundwater withdraw.

5. Conservation

The City of Dunedin has implemented many programs for water conservation. Some traditional methods include watering restrictions, an inverted rate structure and offering free 'water saver kits' which have shown a reduction of 15.6% for residential use. More innovative methods include the City's investment in wireless AMR (automatic meter reading). By metering both water and reclaimed water customers, AMR assists in finding elusive water leaks which would otherwise be difficult to detect. Secondly, a 'meter magnet' for refrigerators is provided to customers, which makes it convenient for them to monitor their water usage from within their home. Finally, AMR serves as a deterrent to those who violate water restrictions, since their usage would clearly show the date and time of irrigation. As a result of both conservation and potable water offset with reclaimed water, while population has held steady, the city's demand for potable water production has steadily decreased over the years (Figure 4).

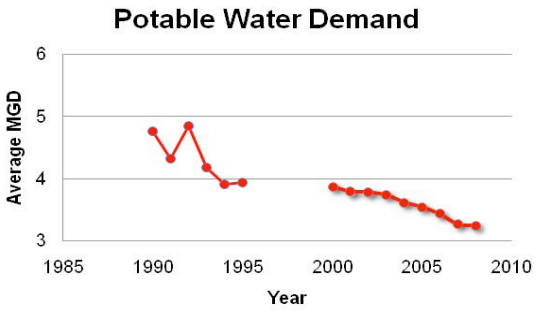


Figure 4 - Dunedin's Historical Potable Water Demand

6. Stormwater management

Dunedin's stormwater system is separate from the wastewater collection system. Stormwater collected in roadways is generally routed by roadside gutters or swales, and through an underground piping system to outfall to stormwater ponds within the drainage basin. Onsite stormwater is collected and allowed to infiltrate in individual stormwater retention or detention ponds. This latter practice allows water to percolate and ultimately recharge the aquifer.

Since Dunedin has relatively flat terrain, stormwater management is a challenge. Rain events, even during brief periods, can be quite intense and can cause significant flooding, especially in low lying areas. Possible solutions to flooding issues can include a more extensive use of LIDs (low impact development) or SUDs (sustainable urban drainage system). Among other things, these include the installation of green roofs or rainwater harvesting systems, which are known to mitigate the effects of flooding.

7. Institutional Framework

Dunedin's success in providing its citizens with adequate water supply is no accident. The City's achievements are a direct result of the support from its leaders and citizens. It's commitment to sustainable practices has been recognized by State agencies and other organizations. The City promotes green building practices (through staff accreditation and building certifications) and has received recognition as a Green Local Government by the Florida Green Building Coalition. Further, both the WTP and WWTP have received the Florida Department of Environmental Protection's Plant Operations Excellence Award, given in recognition of waste reduction, pollution prevention, and other special achievements recognized by this agency.

The City continues to work towards improving its water management through extended partnerships. The University of South Florida (USF) has worked closely with Dunedin for a number of years to study many aspects of its water treatment practices, providing innovative engineering solutions. In 2010, through the SWITCH network, the city began a collaboration with the University of Birmingham (UK) and USF to study the city's water cycle with the CityWater Balance model.

8. Future Challenges

Many challenges still lie ahead for Dunedin. According to the United States Global Change Research Program, anticipated changes in climate to coastal communities include air and water temperature increases, changes in levels and distribution of rainfall, increased storm intensity, sea level rise, and changes in coastal and ocean characteristics. Each one of these issues affects Dunedin directly. If no protection measures are taken, sea level rise could affect their water supply. The City continues to protect its wellfield from salt water intrusion by further reducing demand, seeking innovative strategies to combat coastal flooding and storm surge, and managing its water infrastructure, making it more resilient to the challenges of the future.

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