Tampa's Integrated ASR Program: Optimization of Supply to Meet Demand

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Abstract

The Tampa Water Department provides potable water to a large service area in west-central Florida. In contrast to the nearly 55 inches of rainfall that the Tampa area receives over an average year, the area is extremely drought sensitive and water resources are becoming increasingly more difficult to develop. The City of Tampa's primary source of water is the Hillsborough River Reservoir system. Given the flat topography, the seasonal fluctuation in rainfall, and the fact that the Hillsborough River reservoir system is extremely shallow, the City has difficulty sustaining a storage volume that can adequately supply the approximately 70 million gallons per day (mgd) demand that Tampa must provide to its customers all year long. Alternative water supplies must be developed to minimize the extent that Tampa relies on regional groundwater supplies during peak demand (dry season) periods.

Two distinct Aquifer Storage Recovery (ASR) programs are under development by the City of Tampa Water Department. A 10 mgd treated drinking water ASR program is under construction at a remote location west of the Hillsborough River Water Treatment Plant (WTP). This program is designed to store excess treated water during periods when supplies and treatment plant capacity exceed system demands. Additionally, a 30 mgd untreated to partially treated surface water ASR program is under development to store excess water available from the Hillsborough River during high flow events. This program will help provide a sustainable source of water for the Hillsborough River WTP during low flow periods in the river by developing a "reservoir under the reservoir". Once fully permitted and operational, this integrated ASR program should allow the City to meets its dry season peak demands entirely through water from the Hillsborough River Reservoir system, without relying on the stressed groundwater resources in the Tampa Bay area.

Tampa Water Department Supply and Demand

The City of Tampa Water Department supplies water to approximately 120,000 customers at an average daily rate of approximately 75 million gallons per day (mgd). These demands are expected to increase to approximately 87 mgd by year 2020. Because of the dramatic climatological changes between the rainy season, when the Tampa area experiences nearly two-

thirds of its approximately 55 inches of annual rainfall, and the dry season, the City experiences an average day to peak day peaking factor of approximately 1.4. During the dry season (March 15th through June 15th), demands are typically 1.1 times higher than the average annual demand.. The peak day water demand historically for the City has been up to 104 mgd.

Since 1925, the City's primary source of potable water has been the Hillsborough River (Figure 1). The City operates a state-of-the-art surface water WTP which primarily includes color removal and disinfection. The current capacity of the Hillsborough River WTP is 80 mgd, with an expansion to 100 mgd presently underway. Past peaking capacity was available from the City's Morris Bridge WTP, which treated high quality groundwater available from the City's Morris Bridge Wellfield. The City recently sold the Morris Bridge Wellfield to the regional water supply authority, Tampa Bay Water, to provide additional regional capacity to its system. Thus, the Tampa Water Department must develop alternative peaking supplies or look to the regional system for support during the dry season.

The Hillsborough River Reservoir system includes a shallow reservoir with approximately 2 billion gallons (bg) of storage. Since the City's water demands during a typical dry season often exceed the flow in the Hillsborough River, substantial periods have been reported when there has been no flow over the dam. Even with supplemental sources to augment the flow to the reservoir system, namely the Tampa Bypass Canal and Sulphur Springs, insufficient supply is available to carry the City through an extended dry season. Regional groundwater sources have been required to meet these demands.

Figure 2 shows a flow duration curve of the average flow in the Hillsborough River during the 15-year period of 1984 through 1998. This figure shows that on an average year, the City has sufficient supply available to meet customer demands up to its permitted 82 mgd average daily flow. However, Figure 3 shows that during drier years, such as Water Year 1997, there was only approximately 62 mgd available from the river which requires seasonal storage to make up the deficit in supply relative to the system demands. This water could be harvested during wetter years such as Water Year 1998 (Figure 4) when over 1 billion gallons per day flowed over the dam for approximately 4 months out of the year. Storing a very small percentage of this flow during periods such as this to provide a drought-tolerant future water supply is a primary goal for the City's ASR program.

Potable Water ASR System

A 10 mgd potable water ASR system is under development by the City of Tampa at the Rome Avenue Park (Figure 1). The purpose of this ASR system is to treat excess water during periods of high flow in the Hillsborough River and low demand in the system, and store it in a suitable aquifer for subsequent use. A test

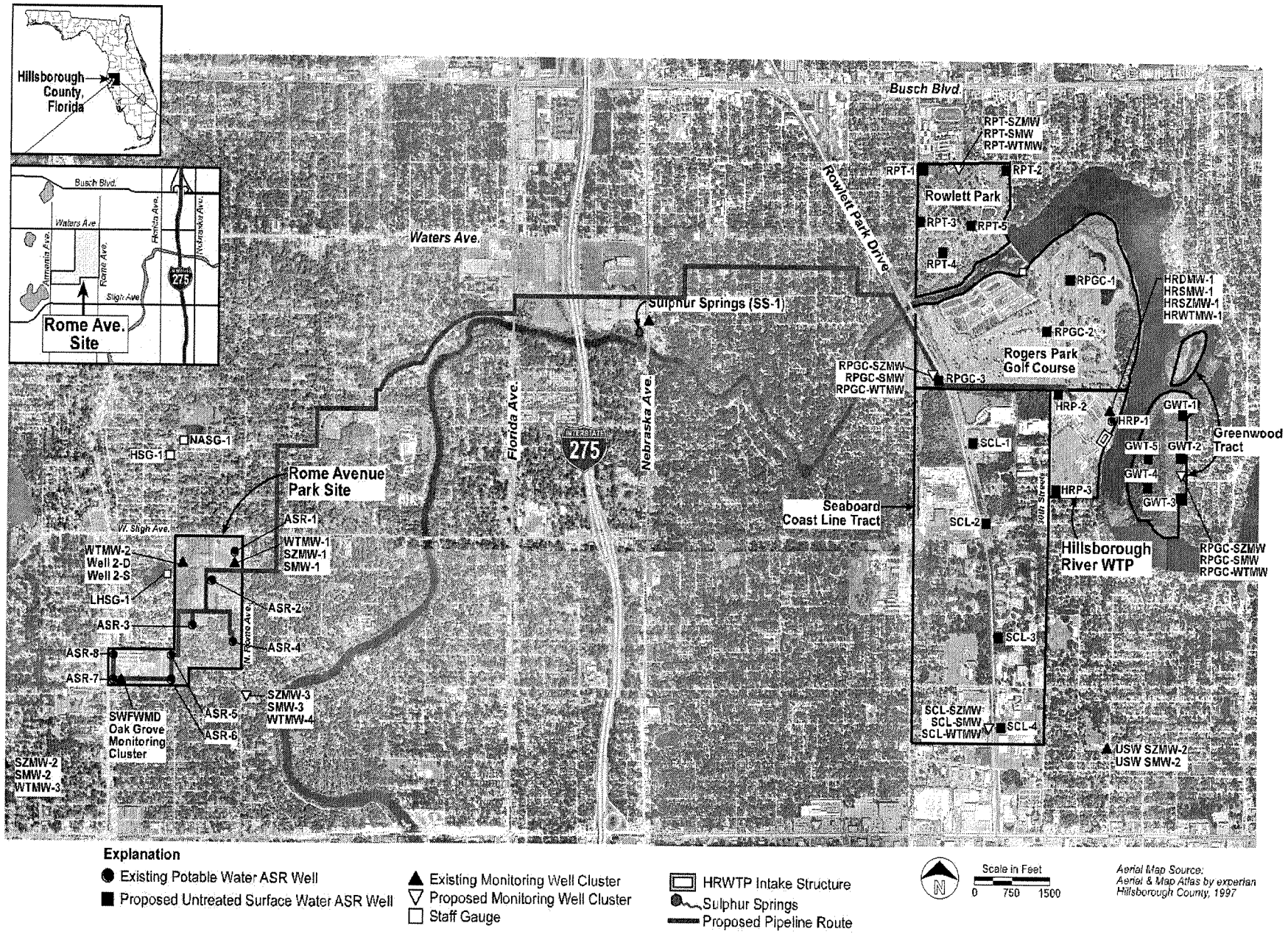

FIGURE 1
ASR Programs and Proposed Pipeline Route

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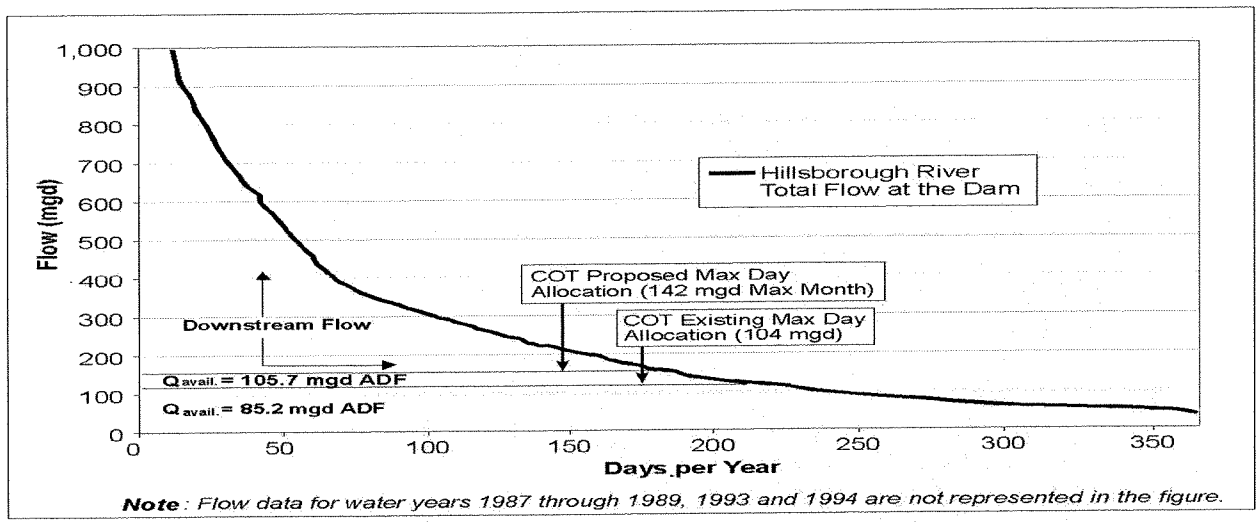

***Note**: Flow data for water years 1987 through 1989, 1993 and 1994 are not represented in the figure.*

FIGURE 2
Average Hillsborough River Dam Discharge
(Water Years 1984 through 1998)

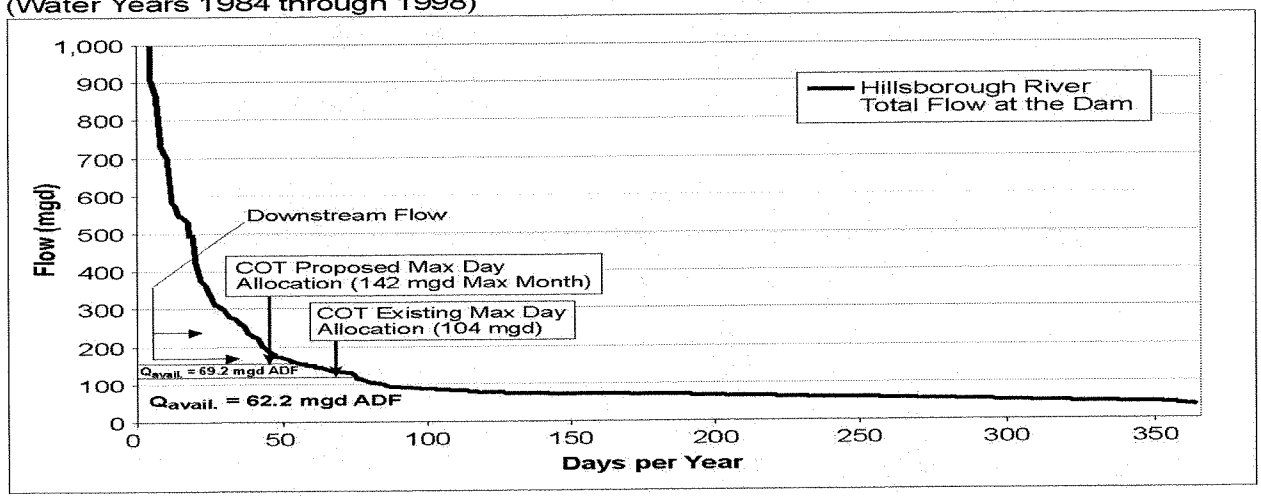

FIGURE 3
Hillsborough River Dam Discharge
Water Year 1997 (10/1/96 through 9/30/97)

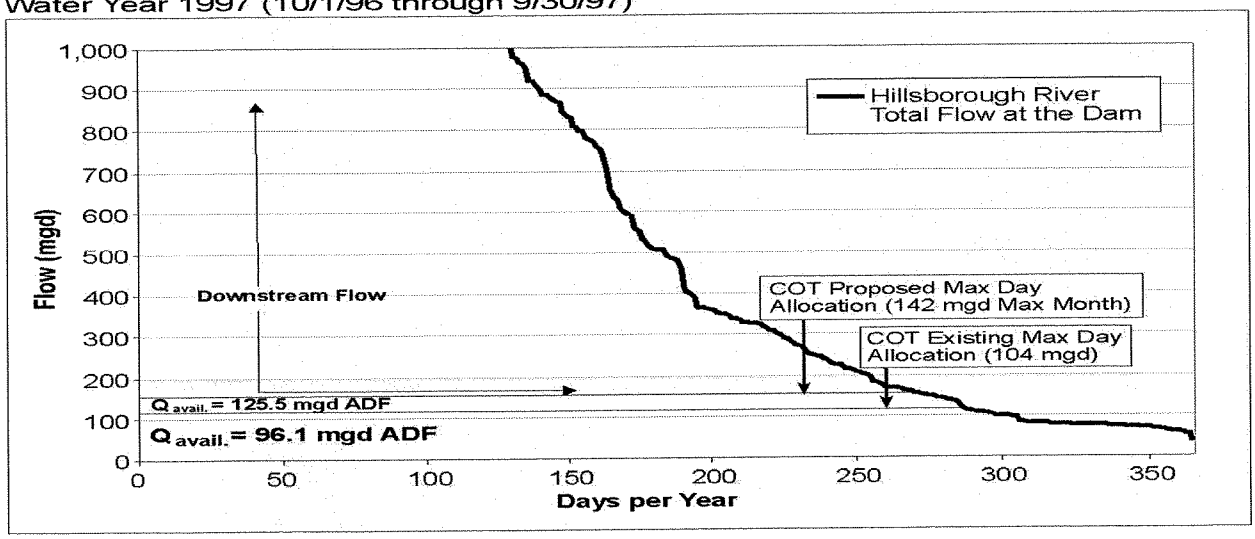

FIGURE 4
Hillsborough River Dam Discharge
Water Year 1998 (10/1/97 through 9/30/98)

well capable of storing and recovering approximately 1000 gallons per minute (gpm) was constructed and operational testing was conducted to demonstrate that 100 mg (approximately 1 mgd for 100 days) or more could be stored and successfully recovered at the initial site. Based on the successful completion of the test well program (which demonstrated 100 percent recovery of the treated drinking water on the initial long-term cycle test) the program is under expansion to the full 10 mgd with 8 ASR wells and an
associated monitoring well network (Figure 5). Public property was used to site each ASR well and monitoring well clusters; sites include a public park, a middle school, stormwater property, and the Tampa Police Athletic League. Several wells have been successfully completed within 100 feet or so from nearby residences. Once the potable water ASR system is operational, the City will have the ability to store and recover nearly 1 bg (10 mgd for 100 days) of treated drinking water from this site annually. This provides a significant emergency drinking water supply for the City's use in the event that the City's or the regional water system's ability to provide high quality drinking water is disrupted for any reason (e.g., a major hurricane moves through the area).

Rome Avenue Park is located adjacent to large diameter transmission piping on the City's distribution system. A primary factor in siting the initial ASR system at this location was to allow the City to divert and supplement the distribution system with up to 10 mgd of potable water at the ASR site. However, based on subtle differences in the water quality recovered from the ASR system relative to the treated drinking water available at the site, the City elected to construct a pipeline from the potable water ASR wellfield back to the Hillsborough River WTP to blend all drinking water and provide consistent water quality to its customers. In addition, to minimize the aesthetic disturbance in this residential area, ASR and monitoring well wellheads are being completed below grade in vaults which have zero impact to the neighborhood.

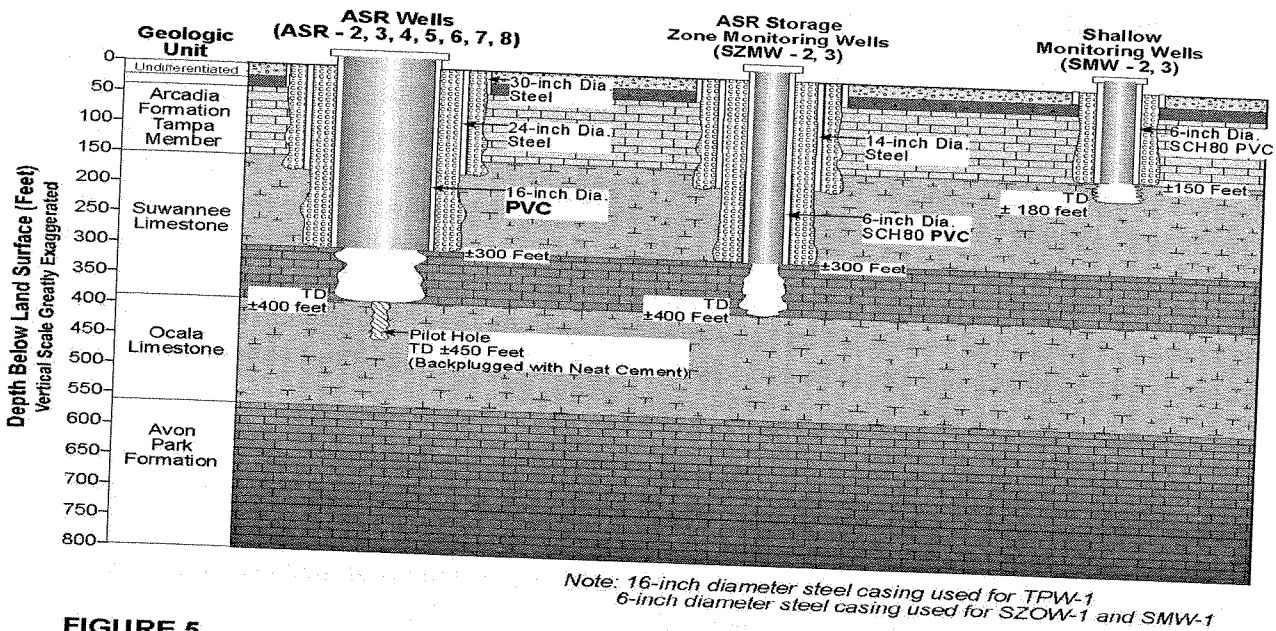

FIGURE 5
Generalized Potable Water ASR Artesian Well Construction Details

Since this ASR system is in a mature, highly urbanized area, significant residential groundwater use still exists in the area. The vast majority of these small-diameter wells are shallow irrigation wells. However, several domestic wells are present in the area which supply drinking water and water serving other uses inside the homes. Groundwater flow modeling and solute transport modeling have been used to define potential impacts to adjacent competing users so that domestic well owners can be successfully pre-mitigated (primarily through connection to the City's drinking water system) prior to full operation of the 10 mgd wellfield. The City has also offered to post-mitigate any non-domestic (e.g., irrigation) wells should an impact occur due to operation of the new ASR wellfield.

Once the potable water ASR system is online, coupled with the WTP expansion to 100 mgd, the City will be able to supply up to approximately 110 mgd to meet these peak demands. However, during typical peak demand periods the flow in the Hillsborough River is at its lowest rate of the year. This results in inadequate supply of raw surface water to treat at the plant. To optimize use of the full treatment capability even during severe drought events, the City must develop an alternative drought-resistant water supply to augment the WTP during low flow periods in the river. The harvesting and storage of surface water during peak river flows for subsequent treatment at the Hillsborough River WTP is one option to meet this objective.

Partially Treated Surface Water ASR System

A 30 mgd partially treated surface water ASR system is under development near the Hillsborough River WTP. Based on modeling performed on the City's reservoir system, this 30 mgd raw water supply, coupled with the 10 mgd potable water ASR system, will provide system reliability that will meet most drought conditions over about the next 20 years. Additional drought-resistant water supplies will be required beyond this period, either through ASR expansions or alternative sources.

Groundwater quality in the vicinity of the Hillsborough River WTP is poorer than at the Rome Avenue Park location. A test ASR system completed in the late 1980s at the WTP discovered native groundwater with Total Dissolved Solids (TDS) concentrations between approximately 3,500 and 6,000 mg/L beneath the plant in the potential ASR storage zones. This initial test ASR system was initially for potable ASR but upon discovering the poorer native groundwater in the vicinity of the WTP, the City realized that the area was promising for development of an ASR program that was not required to meet all drinking water standards in the recharge water. An exploratory monitoring well is under construction approximately 1 mile south of the WTP to better define local ambient groundwater quality in the target storage zones and to assist with the siting of the initial partially treated surface water ASR well.

Permitting and preliminary design are under way for the 30 mgd surface water ASR program. A Water Use Permit (WUP) has been requested from the Southwest Florida Water Management District (SWFWMD) to increase the City's peak day diversion from the Hillsborough River to 142 mgd to harvest some of the "surplus" wet weather flow. This is an increase of 38 mgd from the 104 mgd peak day withdrawal in the City's existing WUP. Due to the dual ASR system under development for the City, the City is able to maintain its current average day withdrawal at 82 mgd. A primary condition of holding the average annual withdrawal at 82 mgd is the use of a 7-year rolling average to determine the "average daily flow". Granting the rolling average will allow the City to not only store excess surface water and treated drinking water during a wet

season for use during the following dry season, but will also allow the City to store fully treated and partially treated surface water during a wet year, banking it for a full year or more for use during a subsequent drought year. This concept will allow the City to better optimize its ASR program and make better use of the significant ASR capital expenditures for its drinking water customers. This will also allow the City to store excess water early in the ASR program, when system demands are at their lowest levels, to build the freshwater "bubbles" required around each of the partially treated ASR wells to achieve higher recovery efficiencies in the future when the water is more desperately needed.

Permitting of the ASR wells is also under way with the Florida Department of Environmental Protection (FDEP). The FDEP is responsible for permitting the ASR wells under its Underground Injection Control (UIC) program, with the focus of this permitting surrounding standards for groundwater discharges. In essence, FDEP primarily regulates the quality of the water recharged into the ASR system, whereas the SWFWMD primarily regulates surface water diversion criteria and recovery operations of the ASR system. The Hillsborough County Department of Health also permits each ASR well as they are used as sources for the City's drinking water supplies.

An FDEP Class V Group 7 well construction permit application has been submitted for the construction of 19 additional surface water ASR wells. This permitting is currently under way, with an estimated completion date within 4 to 6 months. The permit application requests construction of these wells systematically over a 5-year period, with an initial ASR well constructed in each area first, followed by a 2 to 4 well expansion following successful completion of the initial well. To expedite the permitting and construction process, the wells will be cycle tested using treated drinking water initially. Following successful completion of the initial cycle testing using potable water, the City will take the necessary regulatory steps to conduct small-scale testing of the wells using untreated or partially treated surface water from the Hillsborough River. Since this surface water will not meet drinking water standards (total coliform, color, and possibly iron), a relief mechanism such as an aquifer exemption, a limited aquifer exemption, an extended Zone of Discharge or Zone of Recharge, or some other regulatory variance will be required to store and recover this lower quality water in the subsurface. State and federal regulations protect aquifers containing less than 10,000 mg/L TDS from injecting any water that does not meet all drinking water standards, to protect these aquifers for future drinking water supplies. The irony of this is that these very regulations are currently impeding on the City of Tampa and other municipalities' abilities to develop brackish aquifers for future drinking water supplies by storing partially treated surface water for future use. The FDEP and the United States Environmental Protection Agency (EPA) are working diligently to resolve this issue to allow projects such as the City of Tampa's to move forward if they benefit the water resources of the region.

The proposed storage zone for the surface water ASR program is the Avon Park Formation. This zone is a fractured, highly transmissive dolomite with brackish to saline water quality in the study area. The Avon Park Formation has very limited competing use south of the WTP, and is not likely to be developed in the future for brackish water supplies since saltwater intrusion would very likely occur. ASR wells operate much differently from brackish water supply wells, and regional saltwater intrusion may actually be better controlled in the future through freshening due to the operation of an ASR program such as this. ASR wells completed into this

permeable zone are expected to be capable of yielding 2 to 5 mgd from a single well. The City's 20-well surface water ASR wellfield should be capable of easily storing 3 bg (30 mgd for 100 days) or more during high-flow periods in the Hillsborough River. Recovery of this water will then allow the City to continue to operate its WTP near capacity, even when flows in the river are at 70 mgd or less. Without successful surface water ASR implementation for the City of Tampa, the City will continue to rely on the already stressed groundwater resources in the northern Tampa Bay area.

Summary and Conclusions

The City of Tampa is moving rapidly to develop a dual ASR program that will allow storage of high quality treated drinking water and storage of untreated or partially treated surface water to provide for the long-term water supply needs of its customers. While potable water ASR has proven successful in the Tampa area and worldwide, the concept of storing of untreated surface water is much younger and provides significant regulatory challenges prior to realizing the full benefit that such a program can have. Once successful, the dual ASR program will provide a sustainable, drought-resistant 82 mgd water supply for the City of Tampa customers. This will allow the City to remain self-reliant and allow the regional water suppliers to better serve the region without developing additional groundwater supplies or alternative water supplies to meet Tampa's growing water demands.

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