Special Publication SJ97-SP16

WATER SUPPLY NEEDS AND SOURCES ASSESSMENT ALTERNATIVE WATER SUPPLY STRATEGIES INVESTIGATION AQUIFER STORAGE AND RECOVERY UTILITY EVALUATIONS

by

CH2M Hill

St. Johns River Water Management District
Palatka, Florida

1997

EXECUTIVE SUMMARY

The public water supply within the St. Johns River Water Management District (SJRWMD) is generally provided by high quality ground water. Reliability, minimal cost and treatment requirements, and supply stability are several characteristics of SJRWMD's ground water resources that make potable ground water the best source for water supply. The District previously evaluated the potential impact of increased ground water withdrawal through the year 2010 (Vergara 1994). Increasing ground water usage without incurring unacceptable environmental impacts is unlikely. Therefore, the District is investigating the feasibility of alternative water supply strategies.

Whether the source of supply is ground water or surface water, variation in supply and demand has traditionally been addressed by tank or reservoir storage facilities or by increased treatment plant capacity. However, in recent years, aquifer storage recovery (ASR) has been developed as an alternative means of water storage. ASR consists of storing water in a suitable aquifer through a well during times when water is available, and recovering the water from the same well during times when it is needed (Pyne 1995). When the water supply exceeds demand, a ground water well serves as a recharge well. Water is recovered later from the same well during peak demand.

With the potential benefit of ASR as an alternative storage method and water management tool, it is valuable to have guidelines to evaluate the feasibility of ASR in a particular location. The first technical memorandum (TM) in this series, TM C.1.c (CH2M HILL 1996), provided such a tool to assist the District in determining if ASR would be a feasible alternative for helping utilities meet current or future water supply needs. This TM, the second in the ASR series, applies the ASR feasibility tool to selected sites within SJRWMD.

PROJECT OBJECTIVE

The primary objective of subtask C.2.a is to apply the ASR feasibility tool outlined in TM C.1.c to specific utilities within SJRWMD. The primary focus of this application is on potable water storage; however, during the review of utility data it became apparent that other ASR applications, such as raw surface and ground water storage and reclaimed water storage for eventual irrigation, could be applicable in some situations.

This evaluation addressed the feasibility of using ASR to satisfy potable water storage needs from technical, economic, and regulatory perspectives and to determine if ASR should be further considered by the selected utilities.

Evaluating ASR Feasibility

The typical procedure for implementing an ASR system consists of the following three phases: preliminary feasibility assessment and conceptual design, test well, and final design and construction. In the first phase, information is gathered to assess if ASR should be considered as a storage option. This phase includes assessing both storage needs and the hydrogeologic characteristics of potential storage zones. If conditions appear to be favorable, then a test well program is designed. Construction and testing of the ASR test well provide the data necessary to confirm the hydrogeologic feasibility of ASR. The test well phase also provides a basis of design for the full-scale ASR system. The final phase is the preparation of contract documents, construction, and implementation of the ASR system.

The screening tool presented in TM C.1.c and applied herein is designed to provide a methodology for preliminary evaluation of ASR. It is most applicable to the initial evaluation of the need for ASR and its overall hydrogeologic suitability. Application of the tool should provide a preliminary assessment of these important factors, as well as focus future investigations on areas associated with uncertainty or where information is missing.

Feasibility Screening Tool

The ASR screening tool is divided into the following four parts:

- Facility planning factors—which determine the need for ASR or other storage options.
- Hydrogeologic design and operational factors—which aid in determining if ASR is technically feasible and will satisfy the specific needs of the utility.
- Cost factors—which provide approximate order-of-magnitude costs for ASR systems for specific flow rates compared with other storage or expansion options.

- Regulatory factors—which provide the existing regulations that govern the ASR concept.

The screening tool incorporates a score report for each of these four parts (designated Parts A, B, C, and D on the report sheets). The scoring sheets are used to record the respective ranking scores for the different types of information contained in each of these parts and utility information relevant to ASR.

RESULTS OF THE ASR FEASIBILITY SCREENING PROCESS

In consultation with CH2M HILL, the District selected five utilities for trial application of the ASR screening tool: the City of Melbourne Water and Sewer Division; the City of New Smyrna Beach Utilities Commission; the City of Port Orange Public Utilities; the City of Titusville Water Resources Department; and the St. Johns County Utilities Department. Each of the utilities was visited by project staff, including a water resources engineer and hydrogeologist, between October 4 and October 29, 1996. The purpose of the site visits was to develop an understanding of the utilities' operations and needs, and to gather information required for application of the ASR screening tool. Site history, existing problems, water use projections, anticipated water supply development issues, and acquisition of available data were discussed during the visits.

In each case, it was found that ASR is technically feasible and potentially useful, based on currently available information. Neither cost nor regulatory aspects would affect the feasibility of using ASR at each utility. Summaries of the potential application of ASR at each of the utilities are presented below.

City of Melbourne

According to information provided by the utility, seasonal storage to optimize water quality and emergency storage are the primary potential uses of ASR in Melbourne. The City's reverse osmosis (RO) water treatment plant (WTP) can be run at a near constant rate and surface water WTP production could be increased to store raw water when water quality is most favorable. Also, emergency storage for the barrier island side of the distribution system would be a safeguard against destructive natural forces that could sever the barrier island from the mainland water supply.

Based on the screening process, there is a high confidence that a suitable ASR zone could be identified for these purposes. The logical next step in evaluating the application of ASR in Melbourne would be to implement a test well program that targets a storage zone and confirms the parameters of interest.

City of New Smyrna Beach

The ASR screening process identified seasonal storage as the primary potential use of ASR for the Utilities Commission, City of New Smyrna Beach (UCCNSB). This application of ASR would include pumping the wellfields at higher rates during the wet season and storing the unused water in a zone under one of the wellfields of a beachside ASR location. By doing so, wellfield withdrawal rates could be reduced during the dry season as ASR water would help meet demand. Using this operating scenario, secondary benefits related to upconing, wetland impacts, and emergency storage may also be achieved.

From a hydrogeologic perspective and based on available data, there is a moderate confidence in finding a suitable storage zone in New Smyrna Beach. Therefore, if ASR was to be further evaluated as a means of meeting water supply needs, a focused hydrogeologic investigation to better assess process parameters would be required as part of the test well program.

City of Port Orange

For the City of Port Orange, long-term storage and seasonal storage are the primary potential uses of ASR. Using a specific operating scenario, secondary benefits related to saltwater intrusion, wetland impacts, and emergency storage may also be achieved. This operation would involve pumping the Central Recharge Wellfield at a withdrawal rate higher than demand during the wet season and storing the excess treated water in an ASR well. By pumping during the rainy season, the higher drawdown would be offset by an adequate surface water supply for recharging the wetlands. The extra treated water could be stored in a beachside ASR location, which would provide emergency storage. The lower pumping rate in the Eastern Wellfield would buffer seawater intrusion.

Because Port Orange's hydrogeology is similar to that of New Symrna Beach, there is a moderate confidence for successful use of ASR. The City would also require a focused hydrogeologic study to obtain more specific confinement and transmissivity values if an ASR test well program was to be implemented.

City of Titusville

For the City of Titusville, ASR may provide benefits for meeting demand. At this time, an inadequate source makes water purchase from the City of Cocoa necessary. The ASR screening process indicates that long-term storage and seasonal storage could help solve the City's water supply problems. The primary application would be to delay the need for an RO WTP by storing the water currently purchased from the City of Cocoa. This storage mechanism could also be used to meet demand fluctuations, while avoiding the water shortage and temporary pressure problems that the City has experienced in the past. Secondary benefits may be achieved using one of the two following ASR scenarios:

- Provide a consistent water source for customers. (Use only one type of water instead of switching between City of Titusville and City of Cocoa water.)
- Blend City of Titusville water with City of Cocoa water to form a saltwater intrusion buffer and to address wetland impact issues at the current wellfields.

An upcoming water management issue for the City of Titusville is construction of an RO WTP to replace or supplement the water currently purchased from the City of Cocoa. The RO WTP would provide a demand base flow at a constant rate, with demand fluctuations met by the existing WTP. However, the wellfields could be pumped in excess of demand during the wet season and the unused portion stored in an ASR well to meet seasonal demand fluctuations. This solution would restrict the wellfield maximum drawdown to periods of adequate surface supply to adjacent wetlands. The extra water could be stored in a beachside ASR location, which would help buffer lateral saltwater intrusion while providing emergency storage.

Based on the moderate confidence hydrogeologic screening results and native aquifer water quality in the area, a focused study of hydrogeologic parameters and an extensive test well program to determine recovery efficiency would be required to further evaluate the feasibility of implementing ASR as one component of the City's water supply strategy.

St. Johns County

For St. Johns County, the ASR screening tool indicated a supply deficit as well as an opportunity for seasonal storage using ASR. If the consumptive use permit (CUP) were increased to equal the wellfield maximum yield, surplus water could be stored during periods of low demand. The second option for meeting the supply deficit is to use an alternative source, such as brackish ground water, an option currently being considered by St. Johns County.

County water use data suggest that if an adequate supply is available, an opportunity for seasonal storage exists. Using a specific operating scenario, secondary benefits related to wetland impacts and emergency storage may also be achieved. By pumping during the wet season, a higher drawdown would be offset by an adequate surface water supply for the wetlands. The extra water could be stored in a beachside ASR location, which would provide emergency storage.

County data indicate a moderate confidence using the ASR screening tool. A focused investigation on confinement, transmissivity, and native water quality would be essential elements of the test well program for the proposed site.

RECOMMENDATIONS

The screening evaluation identified several options for using ASR at the five utilities. Based on these results, CH2M HILL makes the following recommendations:

- Each utility should evaluate the possibility of incorporating ASR into its long-term plan. This evaluation will include goals specific to each utility in meeting future water demands.
- Before proceeding with additional hydrogeologic data collection, the use of ASR to address wetland impacts should be undertaken. If this evaluation demonstrates that ASR could effectively address wetland impacts, the District and the utilities may want to consider ASR in review of future CUP applications.
- Once a utility has decided that ASR warrants further investigation, an ASR test plan for the facility should be developed, launching the Phase II portion of the ASR implementation procedure.

CONTENTS

CONTENTS (CONTINUED)

FIGURES

TABLES

INTRODUCTION

Public water supply within the St. Johns River Water Management District (SJRWMD) is generally provided by high quality ground water. Several characteristics of SJRWMD's ground water resources make potable ground water the water supply source of choice. First, ground water is inherently reliable—an important attribute for public water supply. Second, treatment requirements and cost are often minimal because of the generally good quality of the raw ground water. Third, if the resource is developed and managed properly, the quality of the raw ground water remains stable.

To date, high quality, reliable, and inexpensive public ground water supplies have been developed within SJRWMD. However, the District is concerned that additional future public water supply needs may not be met by increasing the use of ground water resources without incurring unacceptable environmental impacts. Therefore, the District is investigating the feasibility of alternative water supply strategies.

PROJECT BACKGROUND

The District previously evaluated the potential impact of increased ground water withdrawal through the year 2010 (Vergara 1994). Based on this evaluation, areas where water supply problems are now critical or will become critical were identified. An increase in ground water withdrawal could adversely impact area water resources, affecting natural systems, ground water quality, and existing legal users.

The District is investigating the technical, environmental, and economic feasibility of using alternative water supply strategies as a means of preventing existing and projected adverse impacts. The program includes investigations conducted by SJRWMD staff and by several consultants, including CH2M HILL.

Figure 1 illustrates the water supply options being considered for SJRWMD, including increased supply, reduced demand, and increased system storage to better manage existing supplies. For areas of critical concern, increased supply options could include developing one or more of the following water supply sources:

130581.SJ.AS 11/96 GNV

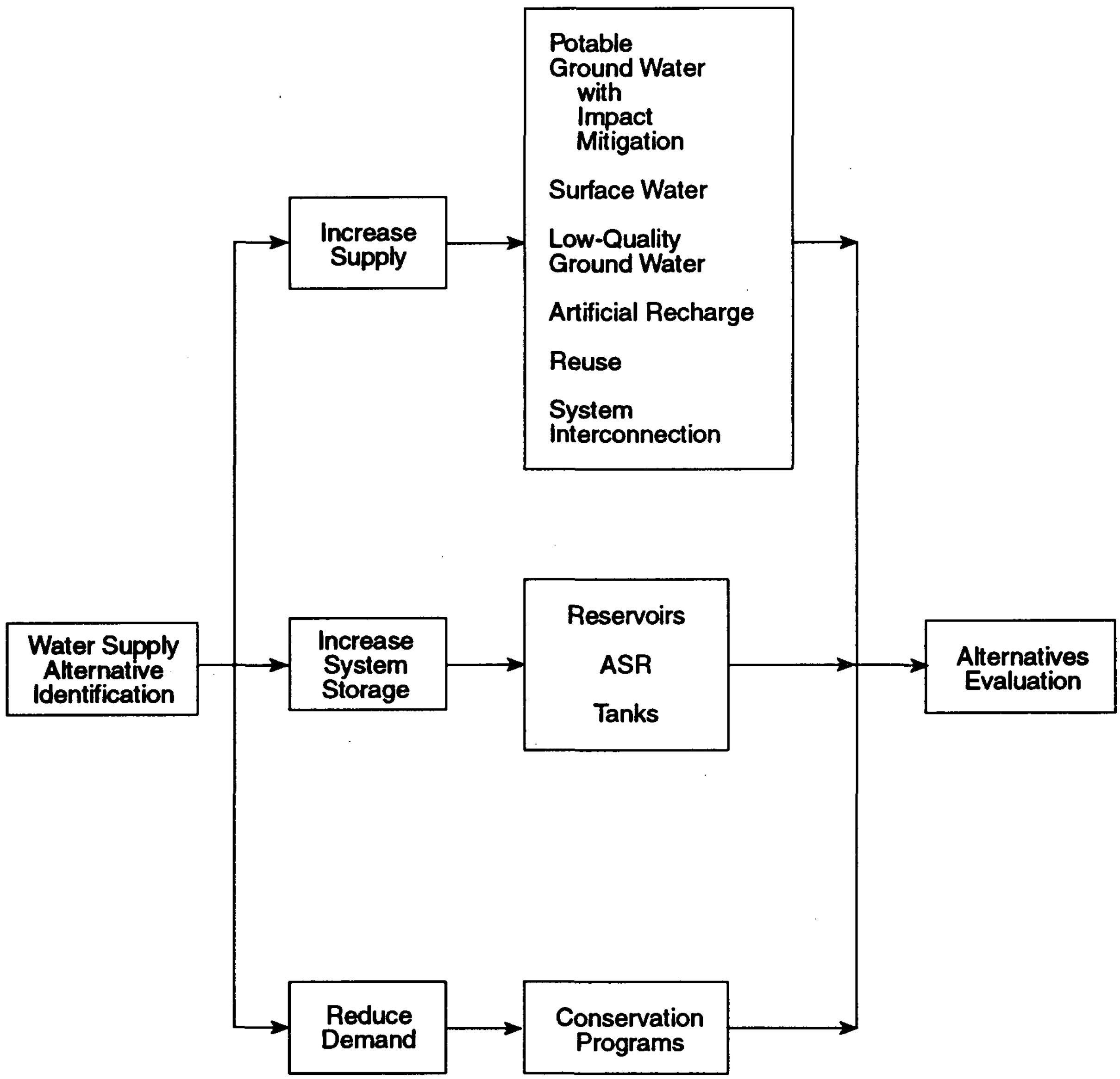


Figure 1. Water Supply Development Options for the SJRWMD.

- Potable ground water with mitigation of adverse impacts
- Surface water
- Brackish ground water
- Artificial recharge
- Reuse of reclaimed water
- Water supply systems interconnection
- Optimized ground water sources

Increased system storage could include the use of reservoirs, aquifer storage recovery (ASR) facilities, or ground storage tanks. Demand reduction may be achieved by implementing various water conservation initiatives. In many cases, a combination of increased supply, increased system storage, and reduced demand could provide the most environmentally acceptable, cost-effective future water supply systems.

This project is part of CH2M HILL's first phase of the required alternative water supply strategy investigation. The following water supply sources or water management techniques, collectively referred to as *alternative water supply strategies,* are included in the investigation:

- ASR
- Surface water supply development
- Development of brackish ground water sources
- Mitigation and avoidance of the impacts associated with ground water withdrawal

PURPOSE AND SCOPE

Although often the main focus, the water source is just one aspect of water supply planning. Whether the supply is ground water or surface water, variation in supply and demand has traditionally been addressed by tank or reservoir storage facilities or by increased treatment plant capacity. In recent years, ASR has been developed as an alternative means of water storage. Knowledge of ASR applications, related technical issues, and regulatory constraints provides a decision tool for assessing ASR feasibility at a particular site.

Pyne (1995) defines ASR as the storage of water in a suitable aquifer through a well during times when water is available, with recovery of the water from the same well when it is needed. When water supply exceeds demand, the well serves as a recharge well. Water is recovered later from the same well during peak demand.

In addition to providing conventional storage, ASR serves as a management tool that can be considered in utility planning. The technology offers the potential to store large volumes of water, which can be used as a strategic method of delaying or eliminating treatment plant expansion. The use of ASR has several advantages. First, the provision of increased storage can make it possible to address increases in peak demand. Second, ASR does not have large land requirements, such as tanks or surface reservoirs do. Third, ASR can reduce the required peak withdrawal rate. While the total volume of water removed would be the same, the reduced peak rate may decrease intrusion or the upconing of brackish water into the wellfield, as well as reduce wetland impacts.

With ASR's potential benefit as an alternative storage method and water management tool, guidelines for evaluating its feasibility at a particular utility are necessary. For this reason, the District contracted CH2M HILL to develop a tool to evaluate the initial feasibility of ASR. Subsequently, the District asked CH2M HILL to evaluate five candidate utilities using this tool. Development of the ASR evaluation tool and the outcomes of the test evaluations are presented in two technical memoranda (TMs)—TM C.1.c, completed in July 1996, and this memorandum, TM C.2.a, respectively.

TM C.1.c addressed the concept of ASR and its multiple applications in an existing water supply system exhibiting immediate or future storage needs (CH2M HILL 1996). TM C.1.c also presented the methodology to be used in the feasibility evaluation. After acceptance of the first TM, SJRWMD, in consultation with CH2M HILL, selected five candidate water supply utilities for quantitative evaluation of ASR feasibility using the ASR evaluation tool. This TM contains the results of that evaluation.

The subject utilities were selected on the basis of the following criteria:

- Geographical location within SJRWMD
- Limited or varying source quantity
- Limited or varying source quality
- Limited storage
- Known or potential saltwater intrusion impacts
- Known or potential wetlands impacts

The five utilities selected to participate in the study are as follows:

- City of Melbourne Water and Sewer Division
- City of New Smyrna Beach Utilities Commission
- City of Port Orange Public Utilities
- City of Titusville Water Resources Department
- St. Johns County Utilities Department

Figure 2 shows the location of each utility within SJRWMD. Individual utility evaluation reports are presented in separate appendixes (Appendixes A through E). The remaining sections of this report include a brief overview of the evaluation methodology, a discussion of the screening results for each utility, the conclusions drawn from the evaluation, and a list of references.

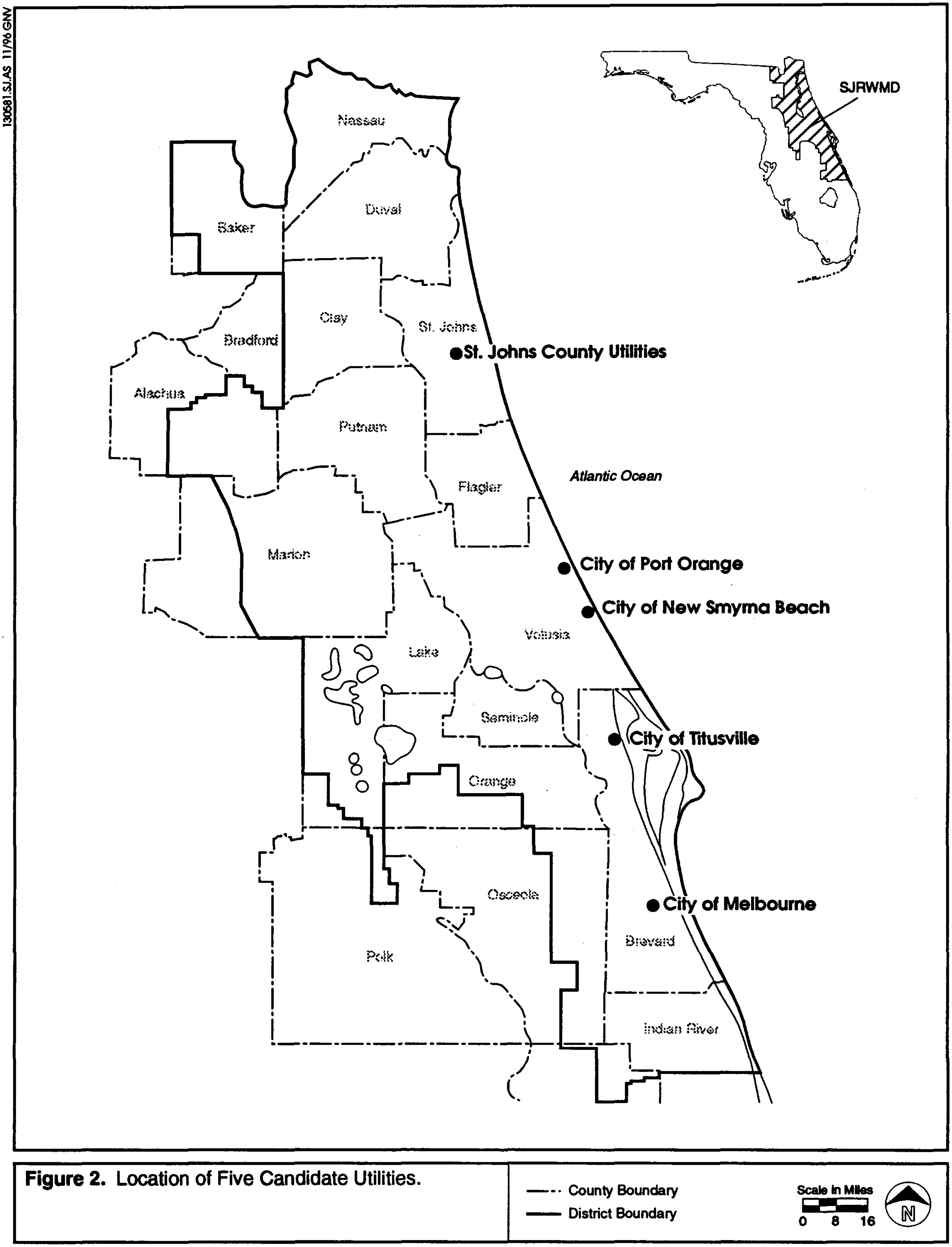


Figure 2. Location of Five Candidate Utilities.

METHODS

Evaluation of the feasibility of using ASR involves several levels of effort, or phases. Typically, the procedure for implementing an ASR system includes three broad phases. The first phase is the preliminary feasibility assessment and conceptual design. In this desktop study phase, initial information is gathered to assess if ASR should be considered as a storage option. If ASR is identified as being potentially desirable during the desktop effort, hydrogeological, economic, and regulatory issues are evaluated to determine if the technology is feasible for a specific water supplier.

The second phase includes an initial field investigation and permitting for a test ASR well. Detailed information is collected from the well and the feasibility of ASR is assessed. After the well has been completed, several tests are performed to define the parameters of the ASR system and determine the size needed to meet the water supplier's needs. The third phase includes expansion of the ASR system to meet projected needs of the utility.

The ASR screening tool aids in the first two phases of the ASR implementation procedure and can be used repeatedly throughout these phases. The first-time use of this tool, as in the desktop studies presented in this TM, enables the interested parties to determine if a particular ASR application could be incorporated into their existing water supply system. This first application of the tool also identifies missing information that could be important in assessing ASR.

DATA COLLECTION

Once the five utilities were selected, CH2M HILL began the two-step evaluation process that constitutes the first phase of the ASR investigation. First, data were collected during a site visit to each facility; then, the feasibility screening tool was applied to each utility.

The utilities were visited between October 4 and 29, 1996. Meetings at the sites followed a predetermined agenda that addressed the following topics:

- Site history
  - Water sources
  - Facility expansions
  - Water shortages

- Existing problems
  - Current system deficiencies
- Projections/anticipated issues
  - Population projections
  - Proposed future expansions
  - Wetlands mitigation
  - Land purchases for water supply storage
- Data acquisition
  - Water supply/demand volumes
  - Existing water treatment plant (WTP) capacities
  - Native ground water quality
  - Treated water quality
  - Existing hydrogeological reports
  - Existing and future environmental impacts
  - Existing interfering uses

In addition to supplying information and data, managers at each utility provided their perspectives on the usefulness of additional storage, ASR, and plant operations..

DESK-TOP EVALUATION

CH2M HILL then used these data and information to assess ASR feasibility at each location. The feasibility tool used in this evaluation had three main components:

- Technical feasibility factors--Provides the majority of the screening tool in two subsections: facility planning factors, which determine the benefits of ASR when compared with other storage options, and hydrogeologic, design and operational factors, which help determine if ASR will satisfy the specific needs of a utility.
- Cost factors—Provides approximate costs for ASR systems for specific flow rates and compares these costs with other options related to storage or expansion.
- Regulatory factors--Provides the existing regulations that govern the ASR concept.

The screening tool incorporates a scoring report for the following four sections: facility planning factors; hydrogeologic, design, and operational factors; order-of-magnitude costs; and regulatory requirements (Parts A, B, C, and D, respectively, on the report sheets). The scoring sheet was used to record the respective ranking scores for these types of information.

Part A, facility planning factors, was designed to use readily available utility data to determine if there were potential applications for ASR at the utility. Therefore, the supply and demand data collected at each utility was used to determine storage need. Because average annual data and one year of daily data were used in these calculations, the calculated storage need is a screening-level value. Diurnal storage for peak hour demands was not evaluated because of the short demand periods for these levels. Also, even with an ASR system, the existing tanks may be required for diurnal demands because of distribution capacities.

Part B scores the hydrogeologic, design, and operational factors used to determine the confidence in finding a suitable ASR storage zone. As for the facility planning procedures, this scoring tool was designed to provide a consistent evaluation of readily available data. The results indicate the level of additional effort required to locate an ASR storage zone before designing a test well program. The degree of confidence varies with the level of data available for this portion of the tool.

Part C is an order-of-magnitude cost comparison of ASR wells and other storage options. These annualized costs were based on the uniform criteria the District established for this series of alternative water supply source investigations. To achieve a consistent basis for comparison, pump stations and piping facilities were not included. Because this information would be site-specific, it could not be incorporated at the screening level. Instead, the cost of ASR wells with pumps was used to develop the ASR cost curves; the cost of tanks without pumping appurtenances was used to develop the tank cost curve; and the cost of reservoirs without pipelines was used to develop the reservoir cost curve. These cost curves provide the basis of the storage options comparisons.

For the facilities management options, the EPA cost curves were adapted to conform to SJRWMD parameters in 1996 dollars. By doing so, water treatment plant upgrades were accounted for without including distribution system work. As with the storage option comparison, distribution upgrades such as new pipelines or pump stations would be site-specific. Therefore, these items could not be incorporated into the screening-level tool. By making these assumptions, equivalent work could be compared for the management options.

Part D is a flow chart of regulatory requirements. This flow chart assumes current regulations, which readily support potable water ASR systems. In addition, permitting requirements for non-potable systems were considered.

DISCUSSION

The primary objective of this TM is to apply the ASR feasibility tool outlined in TM C.1.c to specific utilities within SJRWMD. The primary focus of ASR application is potable water storage. However, during the utility data investigations it became apparent that other ASR applications, such as raw surface and ground water storage and reclaimed water storage for irrigation supply, were potentially applicable.

The ASR screening tool is divided into the following four parts:

- Facility planning factors—which determine the need for ASR or other storage options.
- Hydrogeologic design and operational factors—which aid in determining if ASR is technically feasible and will satisfy the specific needs of the utility.
- Cost factors—which provide approximate costs for ASR systems for specific flow rates compared with other storage or expansion options.
- Regulatory factors—which provide the existing regulations that govern the ASR concept.

The screening tool incorporates a score report for each of the four parts (designated Parts A, B, C, and D on the report sheets). The scoring sheets were used to record the respective ranking scores for each subsection and utility information important to ASR. In each case, it was found that ASR is technically feasible and potentially useful based on currently available information.

The following subsections provide a summary of the results from each part of the ASR feasibility tool, as outlined in TM C.1.c, for each subject utility. The ASR application subsection summarizes where ASR can be incorporated within each utility to provide the highest benefit to the utility and its customers.

CITY OF MELBOURNE

The City of Melbourne has a large water utility with approximately 120,000 permanent potable water customers. The City's water supply system consists of two WTPs, a ground water and surface water supply, and several aboveground storage tanks, in addition to the water distribution system. The South WTP, treating surface water from Lake Washington, which is located on the main stem of the St. Johns River, has a current capacity rating of 20 million gallons per day (mgd). The South WTP operates within the permitted capacity of 16.5 mgd. Seasonal water quality fluctuations occur within the Lake Washington source. The second WTP, a reverse osmosis (RO) WTP treating a brackish ground water source, has a capacity of 6.5 mgd and operates at 5 mgd. If required, 1.5 mgd of raw well water can be blended with up to 5.0 mgd of RO product. This water is then combined with the surface water WTP finished water. Significant variations in the Floridan aquifer water quality and quantity do not occur. Appendix A provides detailed information and the completed ASR feasibility ranking tool for the City of Melbourne.

Part A. Facility Planning Factors

The application of ASR could potentially satisfy the City of Melbourne's different storage needs in the following ways:

Long-Term Storage Need. Because the current CUP capacity for the combined water source exceeds demand, long-term storage would not be driven by supply. Instead, storage may be related to seasonal fluctuations that allow a more consistent plant operation schedule, a reduction of surface water plant production, or emergency storage.

Seasonal Storage Need. Demand and supply values were plotted for 1 year (October 1, 1995, through September 30, 1996). These plots indicated a seasonal fluctuation. However, the CUP capacity is well in excess of demand for this period; therefore, the seasonal storage need is not based on quantity.

Instead, potential seasonal storage may be related to optimizing water quality from the Lake Washington source. Raw water quality varies for the surface water WTP. Rather than varying the treatment, a baseline of 5.5 mgd could be supplied by the existing RO plant, with the surface water plant operating at a higher rate when the raw water quality is better. The excess treated water would be stored in an ASR system and recovered to meet demand fluctuations. Also, if a problem with the raw water source occurred, the stored water could meet demand until plant operations were resumed. The average operating rate of the surface water plant would be about 12.5 to 13.0 mgd in this scenario. This seasonal storage could be used for raw surface water as well. When the raw water meets acceptable quality criteria, it could be stored in an ASR well. When recovered to meet demand, the ASR water would be treated and distributed. Therefore, the combined plant capacity would need to be able to meet the peak demand for raw water ASR. Considering this operation, 19.2 million gallons (MG) of seasonal water storage would be required. A 29-MG seasonal storage need was projected for 2010 (19.2 MG multiplied by the 2010 to 1995 average demand ratio, 19.5/13.9).

Other Storage Need. This category exists to address emergency storage capabilities. Emergencies include water main breaks, natural disasters, and environmental hazards with surface water supply. The storage need is simply the number of days of desired backup multiplied by the percentage of the average daily demand determined to be prudent. For the purposes of this study, a water main break for the supply to the barrier island was used to estimate a feasible emergency storage need. There are two crossings to the barrier island to provide a water supply loop. Assuming that approximately 30 percent of service would be disrupted for up to 5 days for a water main break to the barrier island, 29 MG of storage would be needed.

Thus, the storage need for the City of Melbourne would be based on seasonal source water quality and emergency needs, for a total of 58 MG.

Part B. Hydrogeologic, Design, and Operation Factors

The City of Melbourne's score for hydrogeologic, design, and operational factors is 166 points out of a total of 215 points (Appendix A). This score represents a high confidence for ASR feasibility and is related to the information available at the time of the site visit.

Part C. Cost Comparison Summary

ASR is a cost-effective solution for the City of Melbourne. Although the City is not limited by supply capacity, the quality of the surface water supply varies. Therefore, Melbourne could apply ASR to optimize the quality of surface water plant supply. Using ASR for seasonal storage is more economical than using tanks, with an equivalent annual cost of $23,000 versus $534,000, respectively. While ASR could be used to store either raw water or finished water, finished water would be more easily permitted. In addition to seasonal storage for water quality optimization, ASR can be used for emergency storage. Compared with the annual costs of storage tanks ($534,000 per year), ASR storage would be more economical ($226,000 per year).

Finished water ASR for emergency storage purposes could also serve as a seasonal storage mechanism at no additional cost. The annual cost to provide tanks for both purposes would be the sum of the seasonal and long-term storage tank costs ($1,068,000 per year). The final application performed during this evaluation is to use ASR ($249,000 per year) to delay the RO WTP expansion ($1,592,000 per year), which would be another cost-effective option.

Part D. Regulatory Summary

A SJRWMD CUP and a Florida Department of Environmental Protection (FDEP) Underground Injection Control (UIC) Class V Group 7 Permit are required for any ASR application. For the ASR options identified for the City of Melbourne, two permitting scenarios exist—one for potable water ASR and one for raw water ASR.

For potable water ASR, the injected water will meet all state and federal drinking water standards because the source is from the WTP. Therefore, no other permits are expected to be required beyond the CUP and UIC Class V Group 7 Permit. This permitting scenario appears to be feasible because potable ASR systems have been permitted throughout Florida.

Additional permitting requirements exist for raw water ASR and are based on raw water quality. For the City of Melbourne, the raw water would be from a surface source (Lake Washington) that is likely to exceed at least one state or federal drinking water standard. Where federal primary drinking water standards (PDWS), secondary drinking water standards (SDWS), and state minimum criteria are met but some state PDWS or SDWS are exceeded, a Water Quality Criteria Exemption from FDEP will be required. If the recharge water exceeds one or more federal standards, an Aquifer Exemption must be granted by FDEP.

Water Quality Criteria Exemptions and Aquifer Exemptions are more difficult permitting paths. Also, raw water from a surface source has not yet been permitted for ASR in Florida. Therefore, there is a risk that the exemption(s) will not be granted for a raw water ASR application.

Summary of ASR Application

SJRWMD considered demand variations and system pressure in the City of Melbourne's water system as problems that ASR might address. In contrast, the City views water quality and emergency storage as a potential application of this technology. As part of this study, CH2M HILL used the ASR screening tool and previous experience to determine both primary ASR applications and secondary benefits.

The ASR screening identified seasonal storage to optimize water quality and emergency storage as the primary potential uses of ASR for the City of Melbourne. Under a specific operating scenario, secondary benefits related to RO plant expansion may also be achieved. This scenario would involve operating the RO plant at a steady 5.5-mgd capacity to serve as the baseline water supply to the distribution system. The surface water plant operation would be increased when the water quality is better, more likely during the wet season, and excess water would be stored in the ASR well. If a treatment plant problem were to arise that reduced production capacity, the ASR water would be recovered until plant operations were resumed.

This method of water supply optimization could also occur using a raw water system. However, if a potable beachside ASR well stored finished water, it could provide emergency storage if a break occurred in the water main supplying the barrier island. Increased system pressure at the beach may also be achieved with this potable ASR application.

An ASR system could also be used to delay the RO plant expansion. An RO plant expansion will be required to meet peak demands; however, with an ASR system, the expansion could be delayed. In addition, the expansion may not need to be as large if an ASR system is in operation to help meet peak demands.

In conclusion, the initial results of the ASR screening evaluation indicate that ASR is a feasible technology for the City of Melbourne. In conjunction with the surface water plant capacity evaluation, the next logical step would be for the City of Melbourne to perform a more detailed analysis of incorporating an ASR system into facilities expansion plans. Once the master planning decisions are made, permits for a test well could be obtained and the well could be installed at the desired location.

CITY OF NEW SMYRNA BEACH

The Utilities Commission, City of New Smyrna Beach (UCCNSB) serves approximately 27,000 permanent potable water customers at this time. The UCCNSB water supply system consists of a water treatment plant, three wellfields, and several aboveground storage tanks, in addition to the water distribution system. The Glencoe WTP has a capacity of 10.4 mgd; however, the plant operates at approximately 5 mgd and uses existing storage to meet peak hour demands on the system. The three wellfields, Glencoe, Samsula, and S.R. 44, withdraw water from the Upper Floridan aquifer. Currently, the UCCNSB operates 6 wells on a rotation schedule (19 available wells in the 3 wellfields) to keep drawdowns and chlorides minimized. Appendix B provides detailed information and the completed ASR feasibility ranking tool for the City of New Smyrna Beach.

Part A. Facility Planning Factors

The usefulness of ASR in satisfying New Smyrna Beach's storage needs is summarized below:

- **Long-Term Storage Need.** Current CUP and plant capacities and projected demands indicate no significant benefit for long-term storage during the planning period.
- **Seasonal Storage Need.** Demand and supply values were plotted for 1 year (January October 1, 1995, through September 30, 1996). These plots indicate a seasonal fluctuation that would correspond to a storage need of 2.9 MG. However, if the plant had been operated at a constant 5 mgd throughout the year, a 6.2-MG storage need may be realized, with a savings in plant operations costs. Secondary benefits to the wetlands adjacent to the Samsula Wellfield may also be realized with a specific operation to address seasonal storage. This operation would involve pumping the Samsula and SR 44 wellfields at a rate higher than demand during the wet season and storing extra water in an ASR system. By pumping during rainy periods, the higher drawdown at the Samsula Wellfield could possibly be offset by an adequate surface water supply for the wetlands. A 7-MG seasonal storage need was projected for 2010 (6.2 MG multiplied by the 2010 to 1995 average demand ratio, 5.5/5.0).
- **Other Storage Need.** It is feasible for benefits to be derived from other storage needs, such as emergency storage. To illustrate how

this can be incorporated into a water plant operation, emergency storage needs will be assumed as 100 percent of the average daily flow for 3 days. This corresponds to an 17-MG storage need (100 percent of 5.5 mgd multiplied by 3 days).

The total storage need calculated for UCCNSB is 24 MG, a combination of seasonal and emergency storage needs.

Part B. Hydrogeologic, Design, and Operation Factors

UCCNSB's score for hydrogeologic, design, and operational factors is 148 points out of a total of 215 points (Appendix B). This score represents a moderate confidence for ASR feasibility and is related to the information available at the time of the site visit.

Part C. Cost Comparison Summary

UCCNSB provides an excellent example of the versatility of ASR in a water supply system and the issues that must be considered when evaluating ASR feasibility. The screening suggests that equivalent annual cost characteristics are favorable for ASR as a method of seasonal storage while operating the plant at a constant 5-mgd rate ($143,000 per year for tanks and $29,000 per year for ASR).

However, if ASR is considered as an emergency storage option, the annual cost of tanks and ASR is roughly comparable ($320,000 per year and $395,000 per year, respectively). This similarity in costs results from the higher emergency recovery rate, compared with the seasonal recovery rate. However, with the higher recovery rate, the ASR system could serve as both the seasonal storage and emergency storage option. The annual cost of using the tanks to serve both functions would be $479,000 (the sum of the seasonal and emergency tank costs), whereas the annual cost of ASR would be $395,000, which is the equivalent annual cost for emergency storage. In addition, some cost savings for operating the plant at a constant rate may not be factored into this calculation. Therefore, while ASR allows for more versatility, plant operating preferences for selecting ASR as a management solution remain.

Part D. Regulatory Summary

A SJRWMD CUP and an FDEP UIC Class V Group 7 Permit are required for ASR applications. Two permitting scenarios exist for the ASR options identified for UCCNSB—one for potable water ASR and one for raw water ASR.

For potable water ASR, the injected water will meet all state and federal drinking water standards because the source is from the WTP. Therefore, no other permits are expected to be required beyond the CUP and UIC Class V Group 7 Permit. This permitting scenario appears to be feasible because potable ASR systems have been permitted throughout Florida.

Additional permitting requirements will occur for raw water ASR, which would require an inter-aquifer transfer from the Upper Floridan aquifer at the Samsula Wellfield to the surficial aquifer at the Glencoe Wellfield. This arrangement would optimize pumping in the Samsula Wellfield during times when there is sufficient surface water supply to adjacent wetlands to offset any effects from increased drawdown. The storage zone may be in or just below the Glencoe production zone to meet demands. When federal PDWS and SDWS and state minimum criteria are met but some state PDWS or SDWS are exceeded, a Water Quality Criteria Exemption will be required from FDEP. If the recharge water exceeds one or more federal standards, then an Aquifer Exemption must be granted by FDEP.

Water Quality Criteria Exemptions and Aquifer Exemptions are more difficult permitting options. However, since the requested exemption would be for an inter-aquifer transfer from one drinking water source to another, it is probably obtainable with some additional risk when compared with the potable water scenario.

Summary of ASR Application

SJRWMD originally selected the UCCNSB based on concern for water quality in the Glencoe Wellfield and for adjacent wetland impacts at the Samsula Wellfield. However, based on its preliminary investigations in the area, the UCCNSB sees reclaimed water storage, not potable water, as the potential application of ASR.

The ASR screening process identified seasonal storage as the primary potential use of ASR. Using a specific operating scenario, secondary benefits related to upconing, wetland impacts, and emergency storage may also be achieved. This operation would involve pumping the Samsula and S.R. 44 wellfields at a rate higher than demand during the wet season and storing extra water in an ASR well. By pumping during the rainy season, the higher drawdown in the Samsula Wellfield could possibly be offset by an adequate surface water supply for the wetlands.

The excess water supply could be stored in a zone just below the Glencoe Wellfield pumping zone or at a beachside ASR system using potable water, or in both areas. Storage below the Glencoe Wellfield production zone could buffer the water quality problems experienced at higher pumping rates. Therefore, the reliability of Glencoe Wellfield pumping may be improved. A potable beachside ASR well would also provide emergency storage and increase pressure at varying demands for the City. ASR could also involve an inter-aquifer transfer of raw ground water from the Samsula Wellfield to the Glencoe production zone. This raw water ASR application would provide seasonal storage with secondary benefits related to upconing and wetland impacts, as discussed previously. Recovery from the system would be similar to that of the wellfields, in which water is pumped to the WTP prior to distribution.

Thus, based on the initial results of the ASR screening evaluation, ASR is a feasible technology for the City of New Smyrna Beach. The screening results show the flexibility achieved when using ASR as a component of the water supply system and the issues that must be addressed for successful implementation. However, the cost advantage of ASR compared with conventional storage may be small or nonexistent. Before proceeding with further hydrogeologic data collection, the effectiveness of ASR in addressing wetland impacts should be evaluated. If ASR proves to be beneficial for wetlands, UCCNSB could proceed with developing an ASR test plan for this facility.

CITY OF PORT ORANGE

The City of Port Orange is a growing coastal community with approximately 59,000 permanent potable water customers. The City water supply system consists of a WTP, two wellfields, and several aboveground storage tanks, in addition to the water distribution system. The City of Port Orange WTP has a capacity of 10 mgd. The plant currently operates at approximately 6 mgd and uses existing storage to meet peak hour demands on the system. The two wellfields, Eastern and Central Recharge, withdraw water from the Upper Floridan aquifer. In the past, the Eastern Wellfield has been affected by salt water intrusion (Stevens and Griffith, 1996). Appendix C provides detailed information and the completed ASR feasibility ranking tool for the City of Port Orange.

Part A. Facility Planning Factors

The usefulness of ASR in satisfying Port Orange's storage needs is summarized below:

- **Long-Term Storage Need.** Current CUP capacities and projected demands indicate that available supply capacity exists to provide long-term storage. Approximately 598 MG would be available for long-term storage to delay the plant upgrade from 2002 until 2006. This estimate is based on annual volumes and assumes that maximum demands can be met during the ASR process using the existing 5.5 MG of tank storage.

- **Seasonal Storage Need.** Demand and supply values were plotted for 1 year (January 1, 1995, through December 31, 1995). These plots and the average CUP withdrawal revealed a seasonal fluctuation that would correspond to a peak storage need of approximately 4.6 MG. An 8-MG seasonal storage need was projected for 2010 (4.6 multiplied by the 2010 to 1995 average demand ratio, 9.4/5.2). This storage need would add to the long-term storage need identified above.

Other storage needs were not specifically quantified for this site. However, it is feasible for additional benefits to be derived from ASR storage. First, the plant could be operated at a consistent level rather than varying operations based on demand. In addition, it would be feasible to incorporate an emergency water supply storage for the City of Port Orange.

Thus, the total storage need is 606 MG, a combination of long-term and seasonal storage needs.

Part B. Hydrogeologic, Design, and Operation Factors

The City of Port Orange's score for hydrogeologic, design, and operational factors is 153 points out of a total of 215 points (see Appendix C). This score represents a moderate confidence for ASR feasibility and is related to the available information at the time of the site visit.

Part C. Cost Comparison Summary

The screening results indicate that the annual cost comparisons are favorable for ASR. ASR would be more cost-effective than comparable storage techniques for long-term storage (annual cost of

$2,676,000 for reservoir versus $216,000 for ASR) and seasonal storage (annual cost of $164,000 for tank versus $79,000 for ASR), and would provide some savings by delaying plant expansion ($1,329,000 per year for a 5-mgd plant expansion versus $216,000 per year for an interim ASR system at the 2006 recovery rate). A factor not incorporated in this cost analysis is the smaller plant upgrade (less than 5 mgd) that would be required if ASR were implemented.

Although cost-effective, these applications raise timing, funding, and plant management questions. First, this screening evaluated an ASR system in operation in 1997 to calculate long-term storage. Realistically, it would take a year to get an ASR system permitted and operating effectively, reducing the volume available for storage unless an increase in average daily flow was obtained for the City's CUP. Meanwhile, the City of Port Orange has a contract in place for the WTP expansion. With monies already spent on the plant expansion, it may be more economical to continue with that project.

In addition to these timing issues, funding is also key. Funding is already in place for the plant expansion. Delaying the plant expansion while incorporating a new technology into the water system may not be viewed favorably by the public. Also, some public education on ASR may be required prior to its addition to the City of Port Orange water system. Finally, each individual utility has preferred operating procedures; thus, the ways in which ASR impacts plant operation must be considered by the City of Port Orange.

Regardless of the plant expansion status, it is cost-effective to implement ASR as a seasonal storage mechanism. The added benefit of emergency storage capabilities may be viewed as a worthwhile investment in addition to the plant expansion.

Part D. Regulatory Summary

A SJRWMD CUP and an FDEP UIC Class V Group 7 Permit are required for ASR applications. Two permitting scenarios exist for the ASR options identified for the City of Port Orange—one for potable water ASR and one for raw water ASR.

For potable water ASR, the injected water will meet all state and federal drinking water standards because the source is from the WTP. Therefore, no other permits are expected to be required beyond the CUP and UIC Class V Group 7 Permit. This permitting scenario is likely to be feasible because potable ASR systems have been permitted throughout Florida.

Additional permitting requirements may occur for raw water ASR, which would require an aquifer transfer from the Upper Floridan aquifer at the Central Recharge Wellfield to the Upper Floridan at the Eastern Wellfield. The storage zone may be in or just below the Eastern Wellfield production zone. Although the receiving aquifer is the same as the source aquifer, the raw ground water may exceed state or federal drinking water standards. When federal PDWS and SDWS and state minimum criteria are met but state PDWS or SDWS are exceeded, a Water Quality Criteria Exemption is required from FDEP. If the recharge water exceeds one or more federal standards, an Aquifer Exemption must be granted by FDEP. Water Quality Criteria Exemptions and Aquifer Exemptions are more difficult permitting options. However, since the aquifer transfer occurs within the same drinking water source, it is probably achievable with minor additional risk over the potable scenario.

Summary of ASR Application

The City of Port Orange was originally selected by SJRWMD for this investigation because of concerns about Eastern Wellfield water quality and the impact of withdrawal from the Central Recharge Wellfield on adjacent wetlands. In contrast, the City of Port Orange views reclaimed water storage, not potable water, as the most attractive potential application of ASR.

The ASR screening process has identified long-term storage and seasonal storage as the primary potential uses of ASR for the City of Port Orange. Using a specific operating scenario, secondary benefits related to saltwater intrusion, wetland impacts, and emergency storage may also be achieved. This operation would involve pumping the Central Regional Wellfield at a rate higher than demand during the wet season and storing extra water in the ASR well. By pumping during the wet season, the higher drawdown would be offset by an adequate surface water supply for the wetlands.

The excess water could be stored in the Eastern Wellfield or a beachside ASR well, or both. Storage in the Eastern Wellfield would help prevent the water quality problems previously experienced from higher pumping rates because the recovery of stored water would account for the only increase in pumping from that wellfield. This scenario could include a potable ASR system or an aquifer transfer and storage of ground water. However, a potable beachside ASR site would also provide emergency storage and increase system pressure away from the plant.

The initial screening results support the conclusion that ASR is a feasible, cost-effective technology for the City of Port Orange. This site is an example of the flexibility of ASR when incorporating it into the water supply system and the different issues that must be considered during implementation. Area hydrogeology indicates a moderate confidence in finding a suitable ASR zone. Before proceeding with further hydrogeologic data collection for a potable water application, the use of ASR to address wetland impacts should be evaluated. If this evaluation demonstrates that ASR could effectively address wetland impacts, the City of Port Orange could proceed with developing an ASR test plan for this facility.

CITY OF TITUSVILLE

The City of Titusville is a coastal city whose population has varied because of fluctuations in the industries located in the area. The City's water supply system consists of a WTP, two wellfields, and several aboveground storage tanks, in addition to the water distribution system. The City of Titusville supplements its finished water supply with water purchased from the City of Cocoa. The City's WTP has a rated capacity of 16 mgd; however, the WTP is in need of repair and can sustain consistent maximum flows of only about 10 mgd at this time. Repairs are planned to bring the WTP up to the full 16-mgd capacity. Regardless of rated capacity, the plant operates at around 6 mgd and uses existing storage to meet peak hour demands. Appendix D provides detailed information and the completed ASR feasibility ranking tool for the City of Titusville.

The City's water supply is recovered from two wellfields, Area II Wellfield and Area III Wellfield, both completed in the surficial aquifer. The Area II Wellfield is located near the Titusville WTP and has 35 wells providing water to the City. Approximately 25 of these wells are producing simultaneously to minimize drawdowns. The Area III Wellfield has 35 wells providing water to the City. Approximately 10 to 15 of these wells are producing simultaneously to minimize drawdowns. In this area, the production rates have been lower and chloride concentrations higher than anticipated because of the vertical movement of brackish water.

The City of Titusville has been purchasing water from the City of Cocoa since the summer of 1995 to meet peak demands. In addition to the minimum purchase of 0.825-mgd, up to 3 mgd can be acquired to meet peak demands. The water from the City of Cocoa is not blended with the City's water.

Part A. Facility Planning Factors

ASR could potentially be used to satisfy the City of Titusville's following storage needs:

- **Long-Term Storage Need.** Current CUP capacities and projected demands indicate that available supply capacity exists using water purchased from the City of Cocoa to provide long-term storage. Approximately 529 MG would be available for ASR to delay the total water shortage from 2001 until 2004.

- **Seasonal Storage Need.** Demand and supply values were plotted for 1 year (October 1, 1995, through September 30, 1996). These plots and the average CUP withdrawal revealed a seasonal fluctuation corresponding to a peak storage need of approximately 1.4 MG. A 4-MG seasonal storage need was projected for 2010 (1.4 multiplied by the 2010 to 1995 demand ratio, 9.5/5.3). This storage need would add to the long-term storage need identified above.

Other storage needs were not specifically quantified for this site. However, it is feasible that additional benefits could be derived from ASR storage. For example, the plant could be operated at a constant level rather than varying operations based on demand. Also, additional emergency water supply storage could be provided. However, without an alternative water supply, there would be little supply to store for emergency purposes.

Thus, the total storage need for the City of Titusville is 533 MG, a combination of long-term and seasonal storage needs.

Part B. Hydrogeologic, Design, and Operation Factors

The City of Titusville's score for hydrogeologic, design, and operational factors is 136 points out of a total of 215 points (Appendix D). This score represents a moderate confidence for ASR feasibility and is related to the available information at the time of the site visit.

Part C. Cost Comparison Summary

The key issue for the City of Titusville is water supply. Limited by wellfield capacity, Titusville must purchase water from the City of Cocoa. Costs could be reduced by providing long-term storage for the purchased water (estimated annual cost of $2,444,000 for a reservoir versus $129,000 for ASR) as well as providing seasonal storage (annual cost of $89,000 for tanks versus $29,000 for ASR). The $129,000 annual investment in ASR for storing the water purchased from the City of Cocoa may also delay the addition of an RO plant ($1,740,000 annually) to meet 2010 demand and to replace the Cocoa supply. This delay in the RO plant expenditure could provide other savings to the City not addressed in this evaluation. Once the RO plant is installed, the ASR system could be used for seasonal storage at no additional cost. In conclusion, several cost-effective options exist for ASR within the Titusville water system. Most important, the critical issue for Titusville is to obtain additional water supply.

Part D. Regulatory Summary

A SJRWMD CUP and FDEP UIC Class V Group 7 Permit is required for ASR applications. A potable ASR system would be required for the options identified for the City. Because the source is from the WTP, the injected water will meet all state and federal drinking water standards. Therefore, no other permits are expected to be required beyond the CUP and UIC Class V Group 7 Permit. This permitting scenario appears to be feasible because potable ASR systems have been permitted throughout Florida.

Summary of ASR Application

Water purchased from the City of Cocoa and water supply and water quality problems with current wellfields were the factors SJRWMD considered when selecting the City of Titusville for this study. The City also recognizes its water supply issue as the key concern.

For the City of Titusville, an ASR system could help meet supply and demand, given the need to purchase water from the City of Cocoa. The results of the ASR screening indicate that long-term storage and seasonal storage could help solve the City's water supply problems. The primary benefit of ASR would be a short delay in constructing an RO plant by storing the water currently purchased from the City of Cocoa. This storage mechanism could also be used to meet demand fluctuations and avoid the water shortage and temporary pressure problems the City has experienced in the past. Secondary benefits may be achieved by following one of two ASR scenarios:

1. An ASR well could be used to provide a consistent water source for each customer. Waters from the City of Cocoa and City of Titusville have differences in taste and odor, which have elicited complaints. Customers consistently receiving City of Cocoa water had become accustomed to one taste and odor, which has caused problems when their potable water supply is switched daily or weekly between the two different types of waters. The ASR well would be located at a specific point in the distribution system, perhaps the potential site for the future RO plant. Specific service connections in the area would receive City of Cocoa water directly; excess would be stored in the ASR well. Recovery of the ASR water would be used to meet peak demands in the specified water supply area. The remainder of the service area would continue to receive City of Titusville water. Once an additional supply is developed, the ASR wells could provide emergency storage.

2. An ASR well could be located at the City of Titusville WTP to blend City of Cocoa water with Titusville water and to form a saltwater intrusion buffer and address wetland impact issues. In this scenario, City of Cocoa water would be routed directly to the WTP and placed in a storage zone beneath the current production zone of the wellfields. During low demand periods, finished City of Titusville water could also be stored in this zone. At peak demand periods, the blended water would be recovered, providing a more consistent product for customers while still meeting demand. With the location at the WTP, the option of retreatment to achieve required water quality and desired water aesthetics would be possible. Finally, if the increased pumping of the City 's wellfields was correlated with peak rainfall periods, the increased drawdown would be offset by an adequate surface water supply to the wetlands. This would also be of benefit in reducing upconing because peak pumping rates would be reduced.

Another water management issue for the City of Titusville is the construction an RO WTP to replace the water currently purchased from the City of Cocoa. A potential ASR application would still exist in that scenario. The RO WTP would provide the base flow at a constant rate. Demand fluctuations would be met by the existing WTP. The existing wellfields could be pumped in excess of demand, and during the wet season the unused portion could be stored in an

ASR well to meet seasonal demand fluctuations. Thus, the wellfield maximum drawdown would occur during periods of adequate surface water supply to adjacent wetlands.

In summary, water supply is a key issue in Titusville. There are three major options for incorporating ASR into the City's water supply system. The increased storage associated with ASR may not be sufficient to meet projected needs throughout the planning period. However, some cost-effective applications should be considered. The local hydrogeology supports a moderate confidence in finding a suitable ASR storage zone, with recovery efficiency remaining uncertain. Therefore, the City of Titusville may want to consider ASR applications only in addition to alternative water supply strategies for meeting future demands. The next step for the City would be at a master-planning level to address supply issues in addition to ASR feasibility.

ST. JOHNS COUNTY

St. Johns County Utilities Department, which provides water service for a large section of St. Johns County, serves approximately 30,000 permanent potable water customers. The County's water supply system consists of a WTP, two small package plants, a wellfield with surficial and Floridan aquifer wells, and several aboveground storage tanks, in addition to the water distribution system. Private utilities are also located throughout the county, particularly near Jacksonville. The St. Johns County Mainland WTP has a capacity of 7 mgd; however, the plant operates at about 3 mgd and uses existing storage to meet peak hour demands on the system. The two smaller package plants operate at 3,000 gpd. Appendix E provides detailed information and the completed ASR feasibility ranking tool for St. Johns County.

Part A. Facility Planning Factors

St. Johns County is characterized by the following types of storage needs:

- **Long-Term Storage Need.** Because the current CUP capacity is less than the demand, available supply capacity is insufficient to provide long-term storage. However, if the CUP capacity were upgraded to be consistent with the 7-mgd plant capacity, approximately 212 MG would be available for ASR, helping to delay the plant upgrade. Using the master plan projections from 1997 through 2010, this delay should extend from approximately year 2001 to year 2003.

- **Seasonal Storage Need.** Demand and supply values were plotted for 1 year (October 1, 1995, through September 30, 1996). This information indicated that the plant was operating in a 1.66- to 4.26-mgd range, with an average of about 3.33 mgd. Therefore, a seasonal fluctuation exists that may be addressed by operating the plant at a more consistent rate. Plant operation at a constant rate of 3.5 mgd would correspond to a peak storage need of approximately 13.3 MG. A 40-MG seasonal storage need was projected for the year 2010 (13.3 MG multiplied by the 2010 to 1995 average demand ratio, 9.45/3.33).

While other storage needs were not quantified for this site, additional benefits could be derived from ASR storage. First, the plant could be operated at a constant level rather than varying operations based on demand. In addition, an emergency water supply storage system could be implemented. Thus, the total storage need for St. Johns County is 252 MG, a combination of long-term and seasonal storage needs.

Part B. Hydrogeologic, Design, and Operation Factors

St. Johns County's score for hydrogeologic, design, and operational factors is 139 points out of a total of 215 points (Appendix E). This score represents a moderate confidence for ASR feasibility and is related to the available information at the time of the site visit.

Part C. Cost Comparison Summary

Results from the screening tool suggest that ASR is a potential option for use in St. Johns County. The annual cost comparisons are favorable for ASR on the basis of long-term storage options ($1,313,000 per year for a reservoir versus $367,000 per year for ASR) and seasonal storage options ($730,000 annually for a tank versus $43,000 annually for ASR). In addition, costs may be reduced by delaying plant expansions (annual cost of $1,960,000 for a plant expansion versus $367,000 for an interim ASR system at the 2003 recovery rate). If demand increases remain below projections for the next few years, a delay in plant expansion would make it even more economically attractive. In addition, use of ASR could result in the need for a smaller plant expansion, at an additional cost savings.

As demonstrated in this comparison, there are several ways to consider implementing ASR in St. Johns County. Although the estimates show lower costs for ASR, there may be other cost savings or benefits that are unique to the utility and not identified in the screening evaluation. The cost comparisons indicate that St. Johns County should consider ASR applications. However, additional supply and treatment capacity will be required prior to 2010.

Part D. Regulatory Summary

A SJRWMD CUP and FDEP UIC Class V Group 7 Permit are required for ASR applications. A potable ASR system would be required for the options identified for St. Johns County. Since the source is from the WTP, the injected water would meet all state and federal drinking water standards. Therefore, no permits except the CUP and UIC Class V Group 7 Permit should be required. This permitting scenario appears to be feasible because potable ASR systems have been permitted throughout Florida.

Summary of ASR Application

SJRWMD selected St. Johns County as a candidate for ASR because of the water quality problems that could occur if the County chooses to use the Upper Floridan aquifer as a primary source of potable water. As part of this study, CH2M HILL used the ASR screening tool and previous experience to determine the primary ASR application and secondary benefits.

The ASR screening process indicated a supply deficit in the planning period as well as the opportunity for seasonal storage. There are two options for alleviating the supply deficit. First, the CUP withdrawal limit could be increased to the estimated maximum yield of the current wellfield. Data provided by St. Johns County indicate that this value may be about 6 mgd. At this level, ASR could be implemented using the operational schedule below. The second option for reducing the supply deficit is using an alternative source, such as brackish ground water, an option currently being considered by St. Johns County.

According to data provided by the County, if an adequate supply is available, a seasonal storage opportunity exists. Using a specific operating scenario, secondary benefits related to wetland impacts and emergency storage could also be achieved. This operation would involve pumping at higher rates during the rainy season and storing extra water in the ASR well. By pumping during the wet season, the higher drawdown would be offset by an adequate surface water supply for the wetlands. The excess water supply could be stored in a beachside ASR well, which could provide emergency storage.

Thus, ASR could be implemented as part of St. Johns County Utility Department's water supply system. Achieving increased supply through an increased CUP or alternative water supply source would provide the potential for using ASR or optimizing existing wellfield pumping, or both of these options. The local hydrogeology supports a moderate confidence in finding a suitable ASR storage zone in this area. St. Johns County may want to consider incorporating ASR into its long-range master-planning goals. However, before proceeding with any further hydrogeologic data collection, the use of ASR in addressing wetland impacts should be studied. If this evaluation demonstrates that ASR could effectively address wetland impacts at the existing wellfield, St. Johns County could proceed with developing an ASR test plan for this facility.

CONCLUSIONS AND RECOMMENDATIONS

Current information indicates that ASR systems would be technically feasible and potentially useful for all the utilities investigated (Table 1). Cost comparisons for ASR and traditional storage solutions were generally favorable for the ASR applications. Also, permits would be easily obtainable for the potable water ASR applications identified for each utility. Although a raw surface water or ground water ASR is technically feasible for the Cities of Melbourne, New Smyrna Beach, and Port Orange, this option represents an additional risk as permit approval is uncertain.

UTILITY-SPECIFIC EVALUATIONS

A brief summary of the ASR evaluation and specific application of the ASR screening tool application for each utility is presented below.

City of Melbourne

With a surface water source providing most of the City of Melbourne water supply, raw water quality and vulnerability are the main concerns. An ASR system would allow the City to optimize the quality of raw water withdrawn. Another key application is emergency storage for the barrier island region. Hydrogeologic information indicates that locating a suitable storage zone in the Upper or Lower Floridan aquifers is highly likely, as indicated by the evaluation score of 161.

City of New Smyrna Beach

Water quantity optimization and seasonal storage needs may be met by ASR in the City of New Smyrna Beach. Under a specific operating scenario, ASR would have the following benefits: (1) reduce pumping rates and the associated upconing in the Glencoe Wellfield, (2) correlate peak pumping rates of the Samsula Wellfield with the wet season so that an adequate water supply to the adjacent wetland is maintained, and (3) provide emergency storage at peak demand centers. The calculated hydrogeologic score of 148 suggests a moderate level of confidence in finding a suitable storage zone in the Upper Floridan aquifer.

Table 1. Potential Uses of ASR for Specific Utilities

ASR Potential Application	City of Melbourne Water and Sewer Division	Utilities Commission, New Smyrna Beach	City of Port Orange Public Utilities	City of Titusville Water Resources Department	St. Johns County Utilities Department
Seasonal storage and recovery	✓	✓	✓	✓	✓
Deferred expansion of treatment facilities	✓		✓	✓	
Prevention of saltwater intrusion		✓	✓	✓	✓
Enhancement of wellfield production		✓	✓	✓	
Improvement of water quality	✓	✓	✓	✓	
Maintenance of distribution system pressure	✓	✓	✓	✓	
Maintenance of distribution system flow	✓	✓	✓	✓	
Long-term storage or **water banking**			✓	✓	
Emergency storage or strategic water storage	✓	✓	✓	✓	✓
Minimization of the maximum drawdown (to minimize wetlands impacts)		✓	✓	✓	✓

City of Port Orange

Seasonal storage to optimize water quantity is also the primary potential use of ASR for the City of Port Orange. Using the operating scenario described for the City of New Smyrna Beach, ASR may provide the benefits by reducing pumping rates and associated upconing in the Eastern Wellfield; correlating peak pumping rates of the Central Recharge Wellfield with the wet season to maintain adequate water supply; and providing emergency storage at peak demand centers. The utility's score of 148 suggests a moderate level of confidence in finding a suitable storage zone in the Upper Floridan aquifer.

City of Titusville

Providing additional water supply is the key issue for the City of Titusville. However, a potable ASR system may be incorporated into current operations to store the water purchased from the City of Cocoa or to optimize wellfield pumping, or for both of these options. ASR may be a cost-effective method to delay the construction of an RO plant, whereas seasonal storage for the optimized wet season pumping may be an effective solution to wetland impact problems. In either case, ASR could be used to provide a consistent water product for utility customers. Finding a suitable ASR storage zone seems probable, based on the hydrogeologic score of 136 (moderate-level confidence) from feasibility screening. The primary hydrogeologic concern is whether the water quality in the Upper Floridan aquifer will result in adequate recovery efficiency.

St. Johns County

An ASR system may be beneficial for the St. Johns County Utility Department once an adequate water supply is permitted. An increased supply from the existing source or alternative source provides the potential for ASR with, or without, optimizing existing wellfield pumping. Based on demand projections, ASR may only delay an RO plant by a few years. Also, optimizing pumping during the wet season could be an effective method of addressing wetland issues. The local hydrogeology also supports a moderate confidence in finding a suitable ASR storage zone in the Upper Floridan aquifer just below the current production zone. This confidence is reflected in the hydrogeologic score of 144 that was calculated as part of this investigation.

ASR Screening Tool Evaluation

The ASR screening tool was developed in four sections to address facility planning factors; hydrogeologic, design and operational factors; cost factors; and regulatory factors. The tool's purpose was to provide a consistent method of determining if an ASR system is warranted for future utility planning. In conjunction with providing examples of using this tool, evaluation of the five utilities served as a method of assessing the tool.

Overall the tool served its purpose. The figures developed in the text help illustrate how each of the alternative water source alternatives complement the use of ASR. The available data varied for the five utilities, but were considered representative of the data available at any of the utilities in SJRWMD. Storage need is determined from readily available data at the utility and is displayed by simple spreadsheet calculations and plots. These storage need calculations are screening-level values, not absolute operational volumes. The calculations are based on average daily flow and do not account for the storage required to meet peak hour demand.

The hydrogeologic scoring includes the full range of factors that affect development of an ASR system. The weighting was established to represent the key issues affecting implementation of ASR systems in SJRWMD. Because conditions are generally favorable for ASR in SJRWMD, confinement and transmissivity are the major components affecting selection of ASR storage zones, which was indicated by the higher weights. At a minimum, regional data are available on confinement and transmissivity for the aquifer systems, although some utilities have more specific data. However, experience with hydrogeology is also required when incorporating regional and site-specific data.

Appropriate ASR design can often address adverse conditions for the factors with lower weighting. For example, poor water quality can affect recovery efficiency; however, building a sufficient buffer during the test cycles may help improve recovery efficiencies. Therefore, if defaults are used for these parameters, there is no significant difference in the outcome. To understand how efficiently the ASR system may function, information should be obtained prior to or during the ASR test well program.

When screening-level data are missing, default values are used. The use of default values will not bias the results because default values are selected to represent expected average conditions. That is, in the absence of specific data, average conditions are assumed. This ensures that the results of the analysis will always be influenced by what is known, not by what is unknown. If the known factors are favorable, then application of the screening tool will indicate a potentially favorable ASR application. If the known factors are marginal or unfavorable, than application of the screening tool will indicate less favorable conditions.

The absence of screening-level data affects overall confidence in the results. The level of confidence is a function of the completeness of the screening data, as well as the relative importance of any missing factors. In the five case studies presented here, screening-level data were available for the most important ASR feasibility factors, including aquifer confinement and transmissivity. Default values were generally applied to less important factors, such as aquifer gradient and direction and physical chemical and design interactions.

In many situations, application of the screening tool identifies additional data that need to be collected. In all cases, regardless of the completeness of the screening data, ASR feasibility can only be fully confirmed in the second phase of the ASR planning and implementation procedure, which includes construction and evaluation of an ASR test well.

The costs provide a screening-level comparison and are annualized 20-year values in 1996 dollars. Assumptions were made to provide a comparison between similar conditions. For example, consider the ASR well location relative to the WTP. Pipeline costs between the plant and ASR well were not included because this will be site-specific. However, if a storage tank were added, the location may be remote from the WTP as well. This scenario would provide similar conditions for the cost comparison because the utility is likely to locate the storage along existing distribution lines. Also, changes in operational costs are not addressed in the cost comparison because they are beyond a screening-level review. Therefore, the screening-level cost comparison provides an overall sense of how ASR relates to traditional storage and management techniques.

Finally, the regulatory summary provides information about specific permit and exemption programs currently in place. As regulatory programs are constantly changing, for this section to remain effective, it will need to be updated as changes are made to the CUP and UIC programs.

RECOMMENDATIONS

As indicated above, several options for using ASR exist for the five utilities. Based on the foregoing conclusions, CH2M HILL makes the following recommendations to SJRWMD and the utilities:

- Each utility should evaluate the possibility of incorporating ASR into its long-term plan. This evaluation will include goals specific to each utility in meeting future water demands.
- Before proceeding with further hydrogeologic data collection, ASR should be evaluated for addressing wetland impacts. If this evaluation demonstrates that ASR could effectively address wetland impacts, the utilities and SJRWMD may want to consider ASR in review of future CUP applications.
- Once a utility has determined that ASR warrants further attention, an ASR test plan for the facility should be developed.

REFERENCES

CH2M HILL. *Aquifer Storage Recovery Feasibility. Alternative Water Supply Strategies in the St. Johns River Water Management District.* Technical Memorandum C.1.c. Prepared for SJRWMD. Gainesville, FL. CH2M HILL. 1996.

Pyne, R.D.G. *Ground Water Recharge and Wells. A Guide to Aquifer Storage Recovery.* Lewis Publishers. 1995.

Stevens, Randell, P.E., Public Utilities Director, and Fred W. Griffith, P.E., Public Utilities Engineer, City of Port Orange Public Utilities. Meeting with the authors, October 4, 1996.

Vergara, B. *Water Supply Needs and Sources Assessment, 1994.* Technical Publication SJ94-7. Palatka, FL. St. Johns River Water Management District. 1994.

Appendix A

ASR Feasibility Screening City of Melbourne

CONTENTS

ASR FEASIBILITY SCREENING—CITY OF MELBOURNE

FIGURES

TABLES

ASR FEASIBILITY SCREENING—CITY OF MELBOURNE

The City of Melbourne is located approximately 10 miles south of Satellite Beach on the eastern coast of Florida (see Figure A-1). The largest nearby city to the north is Cocoa, at a distance of approximately 20 miles; the largest nearby city to the south is Palm Bay, at a distance of approximately 4 miles.

Information about the City of Melbourne utility and specific water use data were provided by the City's Water and Sewer Division personnel during a site visit on October 29, 1996 (Mitskevich, 1996).

OVERVIEW

The City of Melbourne has a large water utility with approximately 120,000 permanent potable water customers. In addition, the City of Melbourne also supplies water retail sales to Melbourne Beach, Indiatlantic, Satellite Beach, Indian Harbor Beach, Palm Shores, and a portion of Brevard County, as well as wholesale water sales to Palm Bay and West Melbourne. Over the years, the utility has experienced steady growth corresponding to a steady increase in water demand. The October 1995 to September 1996 average daily water demand on the system was approximately 13.8 million gallons per day (mgd), with a maximum demand of approximately 16.2 mgd. An estimated 1 mgd of the potable water supply is used for irrigation purposes. The City of Melbourne's demand exhibits minor seasonal fluctuations relating to an influx of vacationers during the winter months (November to April). The tourist offseason is early spring to late fall. Water demands are projected to increase with the population growth and to experience continuing minor seasonal fluctuations.

Existing Facilities

The City of Melbourne water supply system consists of two water treatment plants (WTPs), ground water and surface water supply, and several aboveground storage tanks, in addition to the water distribution system.

Water Treatment Plants. The two City of Melbourne WTPs are located west of the city (Figure A-2). The South WTP, treating surface water, was first commissioned in 1959, with an initial capacity of 4 mgd. Since 1959, South WTP has been expanded five times, increasing capacity to the present rating of 20 mgd. The South WTP today operates within the permitted capacity of 16.5 mgd. Because of brackish ground water sources, a 6.5 mgd reverse osmosis (RO) WTP was built in 1995. Up to 6.5 mgd can be produced by blending raw well water with the finished RO WTP product. Blending operations are not currently conducted. A combination of both WTPs and storage easily meets today's maximum day demands. The waters from the treatment plants are blended prior to distribution; the combined water has chloride and total dissolved solids (TDS) concentrations of 60 milligrams per liter (mg/L) and 301 mg/L, respectively.

Water Supply. The City's water supply is recovered from two sources. Surface water is supplied from nearby Lake Washington and ground water is supplied from the Upper and Lower Floridan aquifers. Lake Washington and two wellfields are located northwest of the City of Melbourne, near the WTPs (Figure A-2). Surface water and ground water chloride concentrations are approximately 72 mg/L and 560 mg/L, respectively. The City has the ability to blend 1.5 mgd of raw well water with the 5 mgd of treated RO WTP water, if needed, prior to distribution. However, raw and treated waters are not currently mixed. All ground water wells for the RO WTP are powered by supplied electricity. One well has a standby generator, with two generators under construction that are to be completed in 1997.

Water Supply Storage. The City currently has approximately 14.5 million gallons (MG) of storage capacity in ground and aboveground tanks in nine locations. However, only approximately 13.5 MG is available for public supply. With 100 percent of the total storage available, the City's demands could be met for approximately 24 hours.

Future Facility Expansions

Water demand projections for the year 2010 average approximately 19.5 mgd, with a maximum demand of approximately 24.5 mgd. Based on the information available, it appears that the City of Melbourne has adequate water supply and treatment capacity to meet demand up to the year 2002 without any expansion of treatment capacity. If the actual population increases match the projections, then the WTPs will be 1.5 mgd short of meeting the year 2010 maximum day demands. Facility expansions are expected to meet the projected water demands.

Water Treatment Plants. An evaluation of the South WTP is currently in progress. This WTP will eventually undergo upgrades and possible expansions, which will increase the operation efficiency and eliminate constraints in the present WTP design to improve its production capabilities. An expansion project for the RO WTP is currently in the design stage. This expansion will double the RO WTP capacity to 13 mgd and is scheduled to be commissioned by the year 2000. This addition will increase the maximum treatment capacity to 29.5 mgd, which should meet maximum daily demands beyond the year 2020. The City currently does not need the expanded RO facility for supply reasons but will proceed with construction for water quality reasons.

Water Supply. The City of Melbourne owns two intake structures in Lake Washington that supply the South WTP. East of the lake, the City owns three 16-inch Floridan aquifer wells (Figure A-2). The City has added three new wells (currently 8-inch test wells) for the RO WTP expansion; however, these wells will not be used in the immediate future.

Water Supply Storage. The City is planning to decommission four elevated storage tanks in various locations around Melbourne. The total volume lost will be approximately 1 MG. This volume was not included in the 14.5 MG storage volume previously cited. However, because the pumping facilities are already in place, City staff identified these sites as potential ASR locations.

Water Supply System Restrictions

Wellfield Operations. The City's Consumptive Use Permit (CUP) dictates that 65 percent of the water production should come from Lake Washington. The remaining 35 percent is to be produced from the RO WTP wellfield.

Existing Lake Washington CUP Restrictions:

Maximum Annual Withdrawals		*Maximum Total Daily Withdrawals*	
5,439 MG	1996	16.5 mgd	1996
5,563 MG	1997	16.5 mgd	1997
2,859 MG	1998 (completion of RO WTP)	16.5 mgd	1998

Existing Floridan Aquifer CUP Restrictions:

Maximum Annual Withdrawals		*Maximum Total Daily Withdrawals*	
2,968.5 MG	1996	8.1 mgd	1996
2,968.5 MG	1997	8.1 mgd	1997
5,803.0 MG	1998	15.9 mgd	1998

Water Shortages. Water shortages have occurred in the past. The "Christmas Freeze" in 1989 broke many distribution lines in the system. At the same time, the highest peak day (19.9 MG) was experienced, with only the South WTP online. In 1992, a major fire in a 100-acre field occurred, requiring the City of Melbourne to open the interconnects to the Cities of Palm Bay and Cocoa. Water shortages can also occur because of electrical power outages because the wells for the RO WTP are not on emergency power. However, this deficiency is scheduled to be rectified.

The presence of hydrilla in Lake Washington is a cause of concern to the City of Melbourne. Hydrilla is a rooted aquatic plant that is often problematic during and just after the growing season. During the growing season, the plant spreads to encompass more lake area, which can interfere with the intake works for the WTP. After the growing season, the plant dies back, providing increased taste and odor components as the plant material decomposes in the lake. The decomposed plant material is no longer rooted; therefore, it can provide clogging problems at the intake screen. Also, the uprooting of hydrilla mats during large storm events in the upper basin has, in the past, created acute problems with taste, odor, and clogging.

Wetlands Monitoring. No requirements for monitoring wetlands have been established for the City of Melbourne area.

Environmental Impacts. The City of Melbourne currently operates a municipal effluent injection well approximately 9 miles southeast of the two WTPs (Figure A-3). This well is completed to a depth of 2,700 feet.

Other potential environmental impacts include accidental spills of fuel and chemicals from highway vehicles and railroad cars. One such spill occurred several years ago. The diesel fuel was contained near the US 192 accident site; however, booms were placed around the raw water intake as an added protection.

Interfering Uses. Nearby groundwater withdrawals may be interfering uses; therefore, this information was reviewed. Nearby ground water withdrawals include the City of Palm Bay and cattle farms. The City of Palm Bay operates a public supply wellfield approximately 10 to 15 miles south of the South and RO WTPs. This wellfield is completed in the shallow aquifer and should not interfere with ASR.

Other possible interfering uses in the area are cattle farms subject to CUPs. There appear to be no other major users in the area.

Other Issues

The City of Melbourne operates a reclaimed water distribution system that supplies residential, commercial, and governmental customers, including two golf courses in the area. This system has a production capacity of 2.5 mgd and currently supplies approximately 2 mgd for irrigation purposes.

ASR FEASIBILITY RANKING REPORT

As each section of the screening tool is reviewed, a score is determined that best represents the site-specific characteristics. At the end of the ranking process, each score is weighted as to its degree of importance and a final score is calculated. The magnitude of this score identifies a relative ASR feasibility for the site.

Part A. Facility Planning Factors

Step 1. List the Average Daily Demand.

Instructions: For Potable Use, if the ADD is greater than 1 mgd, proceed to Step 2. If the ADD is less than 1 mgd, another solution should be evaluated. For Agricultural Use, proceed to Step 2.

The City of Melbourne's average daily demand for 1995-1996 was 13.9 mgd. The projected average daily demand for the year 2010 is 19.5 mgd.

Step 2. List the Total Supply and Demand Volumes for the Planning Period.

Instructions: If the total supply volume is larger than the total demand volume, proceed to Step 3. If the demand is larger than the supply, investigate other supply increase and demand reduction solutions.

For the purposes of this study, the planning period is defined as 1997-2010, which corresponds to the end of the planning period used in the SJRWMD Needs and Sources Assessment. The CUP for the City of Melbourne extends to the year 1998, allowing 8,531.5 MG with a 24.6-mgd maximum in 1997 and 8,662 MG with a 32.4-mgd maximum in 1998. These numbers represent the combined water sources. The treatment capacities for the South and RO WTPs are 16.5 mgd and 6.5 mgd, respectively, with plans to expand the RO plant to 13 mgd in the near future. Therefore, the combined plant capacity (23 mgd) is comparable to the average CUP value at this time.

Carrying the 1998 annual value through 2010, the total supply would be 121,137.5 MG (8,531.5 MG multiplied by 1 year plus 8,662 MG multiplied by 13 years).

Demand data presented below for the City of Melbourne were taken from an unpublished draft public bulletin prepared by the City of Melbourne Water and Sewer Administration Water Conservation Department.

Year	AADF[1] [mgd]	Annual Volume[2] [MG]
1997	16.0	5840.0
1998	16.3	5949.5
1999	16.7	6095.5
2000	17.0	6205.0
2001	17.2	6278.0
2002	17.4	6351.0
2003	17.6	6424.0
2004	17.8	6497.0
2005	18.0	6570.0
2006	18.3	6679.5
2007	18.6	6789.0
2008	18.9	6898.5
2009	19.2	7008.0
2010	19.5	7117.5
Total		117,530

[1]Average Annual Daily Flow (AADF) data projections for 1997, 2000, 2005, and 2010 were determined from a graph prepared by the City of Melbourne. Linear interpolation used for values were not explicitly stated.

[2]16.0 mgd x (1 year x 365 days/year) = 5840.0 MG

Because the total demand volume, 90,702.5 MG, is less than the total supply volume, 121,137.5 MG, a sufficient quantity of water is expected during the planning period.

Step 3. List Storage Need Volumes Calculated as a Long-Term Volume, a Seasonal Volume, a Short-Term Volume, or Other.

Instructions: If the total volume is greater than 5 MG, proceed to Part B, below. If the total volume is less than 5 MG, investigate other storage options.

Long-Term Storage Need: Because the current CUP capacity for the combined water source exceeds demand, the long-term storage would not be driven by supply (see Figure A-4). Instead, storage may be related to seasonal fluctuations that allow a more consistent plant operation schedule, a reduction of surface water plant production, or emergency storage. Each situation is discussed below.

Seasonal Storage Need: Demand and supply values were plotted for 1 year (October 1, 1995, through September 30, 1996). These plots indicated a seasonal fluctuation. However, the CUP capacity is well in excess of demand for this period; therefore, the seasonal storage need is not based on quantity. (Refer to Figure A-5.)

Instead, potential seasonal storage may be related to optimizing water quality. A baseline of approximately 5 mgd could be supplied by the existing RO plant, with the surface water plant operating at a higher rate during the wet season when the raw water quality is better. The excess treated water would be stored in an ASR system and recovered to meet demand fluctuations. Also, if a problem with the water supply occurred, the stored water could meet demand until plant operations were resumed. The average operating rate of the surface water plant would be about 12.5 to 13.0 mgd in this scenario. This seasonal storage could be used for raw surface water as well. When raw water meets acceptable quality, it would be stored in an ASR system. Recovery would occur to meet demand. This would be based on sufficient WTP capacity available to meet peak demands. The capacity will be evaluated in the near future. Considering this water quality optimization, a 19.2 MG seasonal water quality storage need would be expected. (Refer to Figure A-6.) A 29-MG seasonal storage need was projected for 2010 (19.2 MG multiplied by the 2010 to 1995 average demand ratio, 19.5/13.9).

Other Storage Need: This category exists to address emergency storage capabilities. Emergencies include water main breaks, natural disasters, and environmental hazards with surface water supply. The storage need is simply the number of days of desired backup multiplied by the percentage of the average daily demand determined to be prudent. For the purposes of this study, a water main break for the supply to the barrier island was used to estimate a feasible emergency storage need. There are two crossings to the barrier island to provide a water supply loop. Assuming that approximately 30 percent of service would be disrupted for up to 5 days for a water main break to the barrier island, 29 MG of storage would be needed.

Thus, the storage need for the City of Melbourne would be based on seasonal water quality and emergency needs, for a total of 58 MG.

Part B. Hydrogeologic, Design, and Operation Factors

Area Hydrogeology

The hydrogeologic factors needed to evaluate the feasibility of ASR include the occurrence and depths of transmissive and confining intervals in the Upper and Lower Floridan aquifers. The characteristics of confining beds overlying the Floridan aquifer are also important in the evaluation of suitable zones. In Brevard County, the most probable ASR zones are expected to occur in the Upper Floridan aquifer. Deeper zones may be appropriate if high injection rates are desired, as needed for raw surface water storage.

Miller (1982) showed the top of the Floridan aquifer system in the Melbourne area to be between -200 and -300 feet mean sea level (msl). The Floridan aquifer was penetrated in the South Beaches injection well at 251 feet below land surface (bls). It was also penetrated in the Merritt Island injection well at 126 feet bls. At the City of Melbourne Grant Street injection well, the top of the Floridan aquifer system was penetrated at 273 feet bls. Cavernous and possibly fractured zones occurred in the Merritt Island and South Beaches wells within the lower dolomite sequences of the Oldsmar Limestone. Waters in excess of 10,000 TDS were penetrated in the South Beaches well at a depth of 1,253 feet bls, in the Merritt Island well at a depth of 950 feet bls, and in the City of Melbourne Grant Street well at a depth of approximately 1,250 feet bls (Smith and Gillespie, 1990).

The upper producing zone of the Floridan aquifer system extends from 240 to 550 feet bls. The Ocala Group and part of the Avon Park Limestone are the geologic units present within the zone. The conductivity and TDS concentrations of samples taken during reverse air drilling were consistent through the upper producing zone (Smith and Gillespie, 1990). The conductivities were about 2,250 micromhos per centimeter (µmhos/cm) and TDS concentrations were approximately 1,150 mg/L. Chlorides ranged between 430 mg/L and 615 mg/L. Estimates of transmissivity from aquifer tests ranged between 69,000 and 973,700 gallons per day per foot (gpd/ft). Storativity values range between 2.89 X 10^{-2} and 7.98 x 10^{-4}.

The middle semi-confining zone of the Floridan aquifer system extends from 550 feet to 680 feet bls. The zone is contained within the lower sequence of the Avon Park Limestone.

The lower producing zone of the Floridan aquifer system is contained within the Lake City Limestone. It extends from the base of the middle confining zone at 680 feet to a depth of 864 feet bls. When an aquifer test was performed on a test well near Lake Washington at the total depth of 850 feet, the well produced 2,450 gallons per minute (gpm), with only about 9 feet of *drawdown. The conductivity of the water from this zone was consistently about 2,300 µmhos/cm.*

The lower confining zone extends from 864 feet to at least 1,204 feet bls. The zone is composed of highly altered and dense dolomites from the Lake City Formation. The exact depth of the base of the lower confining zone is not known in this area. However, a test/injection well for the City of West Melbourne indicated that the base of the dolomite and limestone (very confining) sequence occurred at 1,450 feet bls.

The lower portion of the Floridan aquifer system in the Brevard County area can be delineated as upper producing zone, lower confining zone, and the Boulder Zone, which extends to the top of the sub-Floridan confining beds (Cedar Keys Formation).

Step 1. Storage Zone Confinement

Instructions: Use Table A-1 to rank the hydraulic conductivity and thickness of the vertical flow restrictive units (aquitard) above and below the storage zone. This data can be gathered from local wells in the same zone or from regional published information. Table 3 in Technical Memorandum (TM) C.1.c (CH2M HILL, 1996) presents an example ranking based on a 100-foot-thick confining unit, which shows how Figure A-2 (TM C.1.c) is used to determine the ranking.

Data from the existing RO supply and wastewater injection wells in Brevard County indicated that confining beds suitable for ASR exist in the Floridan aquifer. Suitable intervals, with hydraulic conductivity in the range of 1.0×10^{-4} to 1×10^{-5} feet per second(ft/sec), exist in the Upper Floridan aquifer. Hydrogeologic data indicated that confining beds 50 to 100 feet thick are probable in this area. Therefore, a rank of 3 was selected, using the middle values from Figure A-2 of the screening tool.

Table A-1. Storage Zone Confinement Ranking

Rank	Aquitard Hydraulic Conductivity	Aquitard Thickness
3	1×10^{-4} to 1×10^{-5}	50 to 100 feet

Step 2. Storage Zone Transmissivity

Instructions: Use Table A-2 to rank the target storage zone transmissivity. This data can be gathered from local wells in the same zone or from regional published information. Figure A-3 from the

TM C.1.c should be used in conjunction with Table A-2 to determine the ranking.

Hydrogeologic data from the existing RO supply and wastewater injection wells in Brevard County indicated that intervals exist in the Floridan aquifer with transmissivities between 40,000 and 70,000 gallons per day per foot (gpd/ft), close to the optimum range for potable water ASR. This data earned a rank of 5. This score also reflects local information from the City of Cocoa ASR investigations, which identified storage zone transmissivities in the range of 40,000 to 100,000 gpd/ft for wells completed at depths between 300 and 370 feet bls, as well as information from other ASR systems in Florida (at a variety of depths), whose transmissivities ranged from 17,000 to 300,000 gpd/ft. From this existing information, the common transmissivity is expected to range from approximately 40,000 gpd/ft to 70,000 gpd/ft. The possible ASR depth interval for the City of Melbourne area could be between 300 feet to 400 feet and 680 feet to 850 feet in the upper producing zones of the Floridan aquifer system.

Table A-2. Storage Zone Transmissivity Ranking

Rank	Transmissivity Criterion (gpd/ft)		Applicability
	Potable Water	Untreated Surface Water	
1	Less than 8,000	Less than 80,000	Limited
2	8,000 to 15,000	80,000 to 250,000	
3	15,001 to 40,000	250,001 to 400,000	
4	40,001 to 50,000	400,001 to 500,000	
5	**50,001 to 80,000**	500,001 to 1,000,000	Optimal
4	80,001 to 120,000	1,000,001 to 1,150,000	
3	120,001 to 200,000	1,150,001 to 1,400,000	
2	200,001 to 400,000	1,400,001 to 2,000,000	
1	Greater than 400,000	Greater than 2,000,000	Limited

Step 3. Aquifer Gradient and Direction

Instructions: Rank the local aquifer gradient and direction. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table A-3.

Table A-3. Local Aquifer Gradient/Direction Ranking

Rank	Aquitard Gradient (in same recharge zone)	Direction Criterion
1	Many strong influences exist	Extreme artificial gradient, reevaluate location of ASR system
2	Several strong influences	Exaggerated gradient, investigation needed
3 (default)	Multiple minor influences exist	Affected gradient worth investigating
4	Single minor influence or abnormal natural gradient	Minor investigation or existing data search
5	No influence	No influence

No detailed water-level information could be located during the course of this study. A default rank of 3 was selected in order to flag this criterion as needing site-specific information during the detailed investigation. The significance of local aquifer gradients would depend on the location of the ASR wells in relation to the City's RO supply wells and, to a lesser extent, injection wells.

Step 4. Recharge Water Quality

Instructions*:* Rank the recharge water quality using chloride or TDS concentrations of the water to be stored in the ASR zone. For potable water, this data can be obtained from the records of the WTP that will be supplying the source water. For raw water, this can be determined from published records or databases. If this information is not available, use the default value shown in Table A-4.

Treated water leaving the WTP for distribution has chloride and TDS concentrations of 60 mg/L and 301 mg/L, respectively. The concentration for chlorides was used, providing a rank of 4.

Table A-4. Recharge Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Compliance with SDW Standards
1	Greater than 200	or	Greater than 450	Just within SDW standards
2	200 to 171		450 to 351	
3	170 to 101		350 to 201	Moderately meets SDW standards
4	**100 to 50**		200 to 100	
5	Less than 50		Less than 100	Well within SDW standards

Step 5. Native Water Quality

Instructions: Rank the native water quality based on the chloride or TDS information of the native water in the target ASR zone. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table A-5.

There are three reports from the deep injection well projects that provide relevant information along with the City's data from the RO supply wells. Exploration in Brevard County found TDS around 1,500 to 2,000 mg/L at depths of 700 to 1,000 feet bls. Chloride wells in the same interval were less than 1,000 mg/L (Dames & Moore, no date (n.d.). Water quality samples in a shallow monitoring well (depth 1,205 ft bls) associated with Melbourne's David B. Lee wastewater injection well had levels at 6,810 mg/L for TDS and 4,600 mg/L for chlorides (Geraghty and Miller, 1988). The injection zones for the Merritt Island injection facility were in excess of 16,000 mg/L chlorides and 31,000 mg/L TDS (Geraghty and Miller, 1986). The final source of information was the aquifer testing for Melbourne's RO supply wells. During aquifer testing in the Lake Washington area in 1990, the native water quality for the most probable storage zone depth interval was as follows: conductivities were about 2,250 μmhos/cm, TDS was approximately 1,150 mg/L, and chlorides ranged between 430 mg/L and 615 mg/L. The average TDS concentration given in the City of Cocoa information is 1,325 mg/L. Therefore, a rank of 4 was selected based on the chloride levels for the RO supply wells and the Brevard County information.

Table A-5. Native Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Water Quality
1	Greater than 6,000	or	Greater than 10,000	Very brackish
2	6,000 to 3,001		10,000 to 5,001	
3	3,000 to 801		5,000 to 1,301	Slightly brackish
4	800 to 400		1,300 to 700	
5	Less than 400		Less than 700	Near fresh water

Step 6. Physical, Geochemical, and Design Interactions

Instructions: Rank the potential for physical, geochemical, or design interactions. This rank is based on the sum of the ranks from the sub-categories shown in the table below. If this information is not available, use the default value shown in Table A-6.

Table A-6. Overall Physical, Geochemical, and Design Interaction Ranking for the City of Melbourne

Sub-Category	Rank	Recharge Water and Criterion	Selected Rank
Physical Interactions from Suspended Solids			
TSS	1 2 3	TSS>2.0 mg/L 2.0 mg/L>TSS>0.05 mg/L **(default)** TSS<0.05 mg/L	2
Biological Growth and Geochemical Interactions			
pH	**1** 2 3	**7.8<pH< 8.6** (default) pH>8.6 pH<7.8	1 (7.88)
Total Phosphorous	1 2 3	P>0.1 mg/L 0.1 mg/L>P>0.05 mg/L **(default)** P<0.05 mg/L	3 (<0.05)
Nitrate as N	1 2 3	N>1 mg/L 1 mg/L>N>0.5 mg/L **(default)** N<0.5 mg/L	3 (0.26)
Dissolved Organic Carbon (DOC)	1 2 3	DOC>5 mg/L 5 mg/L>DOC>2.5 mg/L **(default)** DOC <2.5 mg/L	2
Total Iron (Fe)	1 2 **3**	Fe>1 mg/L 1 mg/L>Fe>0.3 mg/L (default) **Fe<0.3 mg/L**	3 (0.10)
Dissolved Oxygen (DO) of Recharge Water	1 2 3	DO>3 mg/L 3 mg/L>DO>1.5 mg/L **(default)** DO<1.5 mg/L	3 (<1.0)
Point Totals			17
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**4**

Note: Use the default value if data for any parameter is unavailable. Determine the overall rank from the following point totals:

Rank	Physical, geochemical, and design criteria (total of above points)	
1	7-10 points	Higher potential for plugging
2	11-12 points	
3	13-16 points	Moderate potential for plugging
4	**17-18 points**	
5	19-21 points	Low potential for plugging

Some parameters included in the ranking tool are not ordinarily included in the routine water quality analysis performed on the treated water. In cases where parameter values were missing, default ranks were incorporated that flag these parameters as needing further analysis. The water quality values for the treated water of the City of Melbourne are provided in parentheses next to the selected rank in Table A-6.

Step 7. Interfering Uses and Impacts

Rank the interfering uses and impacts which can exist or have the possibility to exist in the vicinity of a proposed ASR site. Information can be gathered from visual surveys, aerial photographs, topographic maps, and public records/information. This rank is determined from the sum of two sub-ranks shown in Table A-7. If this information is not available, use the default value shown.

Table A-7. Interfering Uses and Impacts Ranking

Sub-Category	Rank and Criterion		Selected Rank
Interfering Uses			
Distance to Potable Wells	1	0.10 mile<Wells<0.25 mile	2
	2	**0.26 mile<Wells<5 miles (default)**	
	3	Wells>5 miles	
Interfering Impacts			
Distance to Contamination Source	1	0.10 mile<Source<0.25 mile	2
	2	**0.26 mile<Source<1 mile (default)**	
	3	Source>1 mile	
Point Total			4
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**3**

Overall Interfering Uses and Impacts Rank determined from the following point totals:

Rank	Interfering Use and/or Impact Criteria (possibility of impact)	
1	2 points	High use or impact
2	**3 points**	
3	4 points	Moderate use or impact
4	5 points	
5	6 points	Low use or impact

An inventory of wells within a 5-mile radius of the RO wellfield revealed the following existing wells in the area:

Number of Wells	Well Size (inches)	Well Use
78	4, 6, 8	aquaculture, sod, livestock, pasture, citrus
7	16	public supply
2	6	fire protection
12	6	commercial/industrial

Interfering Uses: The City of Melbourne operates an RO supply wellfield at the WTPs. This information would earn a sub-rank of 1 if the ASR wells *were located at the WTP. If the ASR well were located at the beach, a sub-rank of 3 would apply. For this screening, we assigned a sub-rank of 2.*

Interfering Impacts: The City currently operates one injection well approximately 9 miles away from the WTPs. Also, potential accidental spills from the highway and railroads in the area cause potential impact concerns. This information earned a sub-rank of 2.

The results of the hydrogeologic, design, and operational factors scoring are interpreted as shown in Table A-8.

Table A-8. ASR Feasibility Score for Hydrogeologic, Design, and Operational Factors

Score	Feasibility Level	Type of Study Recommended
160 - 215	**High Confidence**	**General—confirm assumptions**
100 - 159	Moderate Confidence	Focused—investigate specific factors
43 - 99	Limited Confidence	Detailed—evaluate impact of critical factors

The City of Melbourne hydrogeologic, design, and operational factors score is 166 points out of a total of 215 points (see scoring sheet at the end of this appendix). This score represents a high confidence for ASR feasibility. Detailed site-specific information will likely change the feasibility score to better reflect actual conditions at the proposed ASR location.

Part C. Cost Comparison Summary

Instructions: The annual cost figures (Figures A-4 through A-10 in TM C.1.c) were developed as a means of comparing alternative water storage and treatment options. Use the tables to complete the Cost Comparison Summary Sheet provided in TM C.1.c. On this sheet, a comparison is made between ASR, other storage options and plant upgrades, which will provide the needed water for immediate peak demand or future demands.

Costs need to be evaluated on three levels for the City of Melbourne:

1. *Storage Option Comparison for Seasonal Storage Need in a Tank or ASR:*
   - a. *The seasonal storage need of 28.6 MG was projected for the City of Melbourne for the year 2010. The cost associated with providing a tank to meet this storage need is calculated as follows:*

Annual Cost = 17,787 X + 18,088, where X is the storage volume in MG

*Annual Cost = 17,787 * 29 + 18,088*

Annual Cost = $534,000

b. *For the ASR calculation, the recovery rate is required. Recovery would be taken over approximately 66 days. The peak factor is the ratio of maximum day to average day, which was calculated as 1.3 using plant records. Therefore, the peak recovery rate would be 28.6 MG * 1.3 / 66 = 0.6 mgd for a potential ASR system. For the purpose of this screening tool, a recovery of 0.5 mgd per well was used. The storage zone is likely to be in the same zone as the RO production, at the most remote location possible from the RO plant. As the well production for the plant is just under 2 mgd per well, the 1 mgd per well value was used to provide an indication of cost differences. The corresponding ASR cost is calculated as follows:*

Annual Cost = 38,295 X, where X is the recovery rate in mgd

*Annual Cost = 38,295 * 0.6*

Annual Cost = $23,000

2. *Storage Option Comparison for Emergency Storage Need in a Tank or ASR:*

a. *The City of Melbourne identified emergency storage as a potential application of ASR, based on the vulnerability of the surface water supply quality due to hydrilla and hazardous spills and the water main crossing to the barrier island. For this evaluation, the water main to the barrier island was used to calculate an emergency storage need of 29.3 MG. This is based on 30 percent of the supply interrupted if this main was out of service and up to 5 days to restore service. The cost associated with a tank to meet this storage need is as follows:*

Annual Cost = 17,787 X + 18,088, where X is the storage volume in MG

*Annual Cost = 17,787 * 29 + 18,088*

Annual Cost = $534,000

b. *For the ASR calculation, the recovery rate would need to be the capacity desired for peak recovery rate from the ASR well. The* *recovery rate would need to be 30 percent of the 2010 projected average day demand (19.5 mgd) if the supply to the barrier island were severed, approximately 5.9 mgd. The corresponding ASR cost is calculated as follows:*

Annual Cost = 38,295 X, where X is the recovery rate in mgd

*Annual Cost = 38,295 * 5.9*

Annual Cost = $226,000

3. *Management Option Comparison for ASR to delay plant expansion:*

   a. *The City of Melbourne is currently planning a 6.5-mgd upgrade to its RO plant to meet the 2010 peak demands. The cost associated with this upgrade would be calculated based on this rate, as follows, assuming lime softening plant upgrades are comparable in cost to RO plant upgrades:*

   Annual Cost = 440,000 $Q^{0.687}$, where Q is the capacity increase in mgd

   Annual Cost = 440,000 $(6.5)^{0.687}$

   Annual Cost = $1,592,000

   b. *For the ASR calculation, the recovery rate is required. This rate would need to be consistent with the difference in the peak demand in 2010 and the plant capacity, since the system is not limited by CUP or supply quantity. The projected peak day in 2010 is approximately 29.5 mgd, whereas the capacity for the two plants totals approximately 23 mgd at this time. Therefore, the peak recovery rate would be 6.5 mgd for a potential ASR system. The corresponding ASR cost is calculated as follows:*

   Annual Cost = 38,295 X, where X is the recovery rate in mgd

   *Annual Cost = 38,295 * 6.5*

   Annual Cost = $249,000

A cost summary sheet (Feasibility Screening Report Parts C and D) is included after all figures at the end of this appendix.

Part D. Regulatory Summary

Instructions: Part D presents the regulatory requirements for the different types of water quality. Place an "X" under the category of *YES* or *NO* to best describe the quality of the water to be stored.

Figure A-7 provides the regulatory permits or exemptions needed for the different water quality groups.

Figure A-7 is a flowchart showing the permits and approvals needed for specific water qualities to be stored in an ASR system. A SJRWMD CUP and a Florida Department of Environmental Protection (FDEP) Underground Injection Control (UIC) Class V Group 7 Permit will be required for any ASR application. For the ASR options identified for the City of Melbourne, two permitting scenarios exist—one for potable water ASR and one for raw water ASR.

For potable water ASR, the injected water will meet all state and federal drinking water standards, since the source is from the WTP. Therefore, no other permits are expected to be required beyond the CUP and UIC Class V Group 7 Permit. This permitting scenario appears to be feasible, since potable ASR systems have been permitted throughout Florida.

Additional permitting requirements will occur for raw water ASR based on the raw water quality. For the City of Melbourne, the raw water would be from a surface source (Lake Washington) that is likely to exceed at least one state or federal drinking water standard. Where federal primary drinking water standards (PDWS) and secondary drinking water standards (SDWS) and state minimum criteria are met, but some state PDWS or SDWS are exceeded, a Water Quality Criteria Exemption will be needed from FDEP. If the recharge water exceeds one or more federal standards, an Aquifer Exemption must be granted by FDEP.

Water Quality Criteria Exemptions and Aquifer Exemptions are more difficult permitting paths. Also, raw water from a surface source has not been permitted for ASR in Florida to date. Therefore, there is a risk that the exemption(s) will not be granted for a raw water ASR application.

CONCLUSIONS

SJRWMD considered demand variations and system pressure problems as the problems in the City of Melbourne's water system that ASR may address. In contrast, the City of Melbourne views water quality and emergency storage as a potential application of this technology. As part of this study, CH2M HILL used the ASR screening tool and previous experience to determine both primary ASR applications and any secondary benefits, to compare costs with traditional solutions, and to evaluate the regulatory requirements.

The ASR screening identified seasonal storage to optimize water quality and emergency storage as the primary potential uses of ASR for the City of Melbourne. Under a specific operating scenario, secondary benefits related to RO plant expansion may also be achieved. This scenario would be to operate the RO plant at a steady 5.0-mgd capacity to serve as the baseline water supply to the distribution system. The surface water plant operation would be increased when the water quality is better, with excess water stored in the ASR well.

If a treatment plant problem were to arise that reduced production capacity, the ASR water would be recovered until plant operations were resumed. This optimization could also occur using a raw water system. However, a potable beachside ASR could also provide emergency storage in the event of a break in the water main supplying the barrier island if the ASR system stored finished water. Increased system pressure at the beach may also be achieved with this potable ASR application. Using ASR to meet peak demands may delay the necessity of an RO WTP expansion. The driving force in the RO expansion would be peak demands and water quality. Using ASR to meet peak demands may delay the need to expand the plant. In addition, the size of the expansion may be reduced as the surface water supplied through ASR would provide a mechanism for meeting part of the peak demand.

Both potable and raw water ASR applications are achievable from a hydrogeologic perspective. For a potable ASR, the production aquifer for the RO plant may be the target storage depth at an ASR site remote from the RO plant. This distance is recommended to avoid interference with the RO plant operations. Of course, using a deeper aquifer zone to store potable water would be feasible but also more expensive. As potable water storage is the most likely scenario for including ASR at the City of Melbourne utility, the scoring was based on this target storage zone. A raw water application would target a deeper zone because it would be located at the plant site. Lower zones are more transmissive in this region, a capability required for injecting and recovering raw surface water. However, since there is a potential for decreased benefits and increased costs for the raw water ASR, a hydrogeologic score was not determined for that scenario. For the potable water ASR application discussed above, the hydrogeologic score was 166, indicating a high-level of confidence in ASR feasibility from a hydrogeologic perspective.

In addition to the technical feasibility of incorporating ASR into the water supply system demonstrated by the hydrogeologic evaluation, the cost comparison method developed for the ASR screening tool indicated ASR to be a cost-effective solution for the City of Melbourne. Although not limited by supply capacity, the City of Melbourne could apply ASR to optimize the quality of surface water plant supply. Using ASR for seasonal storage is more economical than using tanks, at an equivalent annual cost of $23,000 versus $534,000, respectively. Although technically the ASR could store either raw water or finished water, the finished water would be more easily permitted. In addition to seasonal storage for water quality optimization, ASR can be used for emergency storage. Compared to storage tanks annual cost ($534,000 per year), ASR would be more economical ($226,000 per year). It should be noted that this finished-water ASR for emergency storage could also serve as a seasonal storage mechanism at no additional cost. The annual cost to provide tanks for both purposes would be the sum of the seasonal and long-term storage tank costs, $1,068,000 per year.

The final application for ASR identified in this evaluation is to use ASR ($249,000 per year) to delay the RO expansion ($1,592,000 per year), another cost-effective option. In addition, the ultimate RO expansion may be scaled down owing to the ASR system capacity, a consideration that was not factored into this cost comparison. Again, it should be recognized that using the ASR system to delay plant expansions could easily provide seasonal and emergency storage benefits at no additional cost. Based on this screening, each application of ASR in the City of Melbourne is a potentially cost-effective solution for seasonal water quality and emergency storage requirements.

Given these potential benefits of using ASR, regulatory feasibility becomes important. Because the most likely application of ASR is the storage of potable water, permitting is expected to be readily achieved under current regulations. For this ASR scenario, only the SJRWMD CUP and the FDEP UIC Class V Group 7 Permit would be required. Raw water ASR would be a more difficult permitting path because a Water Quality Criteria Exemption and/or Aquifer Exemption may be required.

In conclusion, the initial results of the ASR screening evaluation indicate that ASR is a feasible technology for the City of Melbourne. In conjunction with the surface water plant capacity evaluation, the next step for the City of Melbourne would be to perform a more detailed analysis of incorporating an ASR system into facilities expansion plans. Once the master planning decisions are made, a test well would be installed at the desired location.

REFERENCES

CH2M HILL. *Aquifer Storage Recovery Feasibility. Alternative Water Supply Strategies in the St. Johns River Water Management District.* Technical Memorandum C.1.c. Prepared for SJRWMD. Gainesville, FL. CH2M HILL. 1996.

City of Melbourne/Water and Sewer Administration/Water Conservation Department. *Clear Facts about Melbourne's Water Supply and Treatment Facilities.* Public Bulletin (draft).

Consumptive Use Permit for the City of Melbourne. Issued by St. Johns River Water Management District.

Dames & Moore. Deep Exploratory/Test Injection Well South Beaches Wastewater Treatment Plant for Brevard County, Florida. (Date not available.)

Geraghty and Miller, Inc. Construction and Testing of an Injection Well David B. Lee Wastewater Treatment Plant. August 1988.

Geraghty and Miller, Inc. Construction and Testing of the Merritt Island Injection Wells. November 1986.

Miller, J.A. *Geology and Configuration of the Top of the Tertiary Limestone Aquifer System, Southeastern United States.* U.S. Geological Survey Open-File Reports 81-1178, 81-1124, and 81-1176. 1982.

Mitskevich, Geoffrey, P.E., Assistant Administrator, City of Melbourne Water and Sewer Division. Meeting with the authors, October 29, 1996.

Smith and Gillespie Engineers, Inc. *Floridan Aquifer Wellfield Study Data Collection and Evaluation Report.* May 1990.

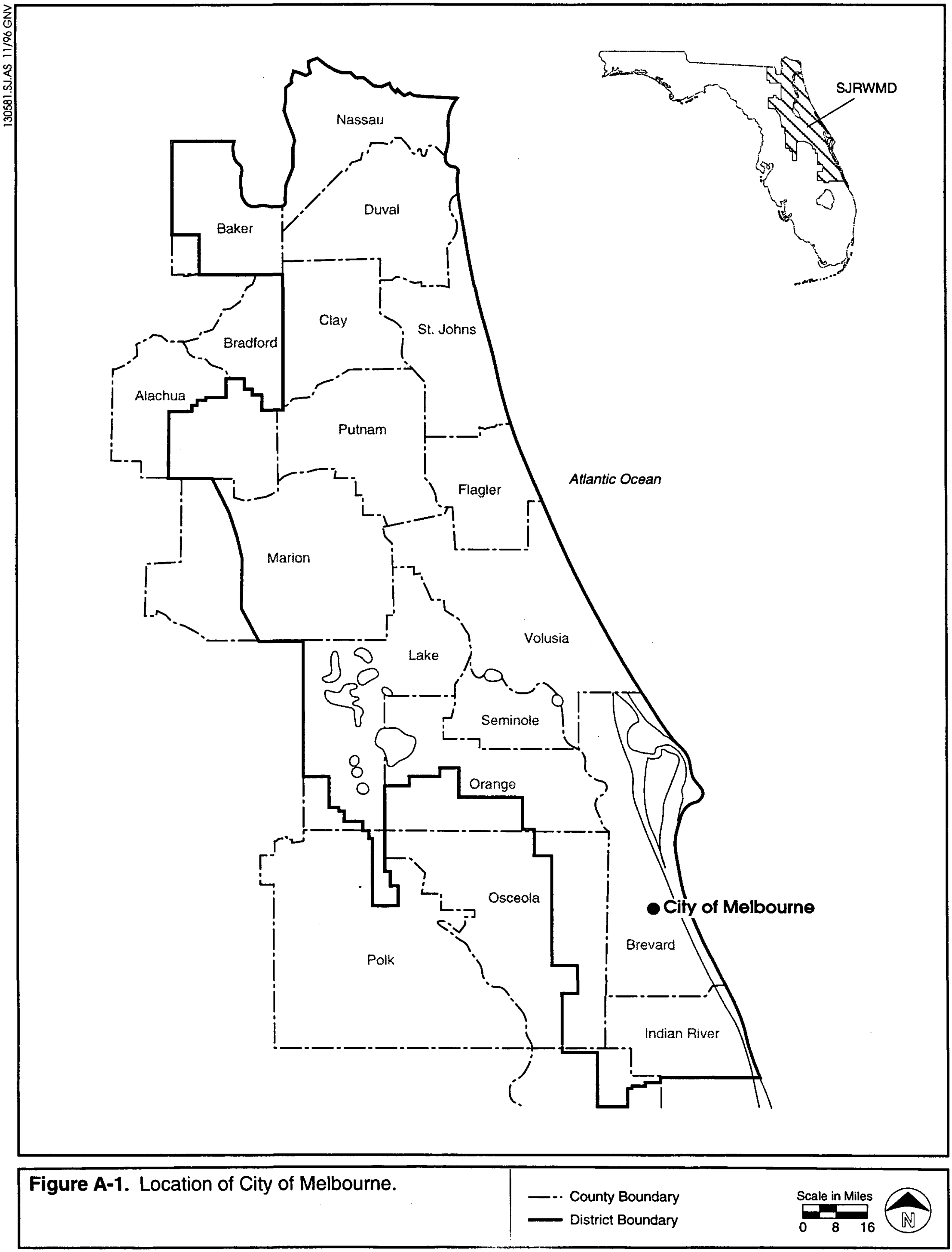


Figure A-1. Location of City of Melbourne.

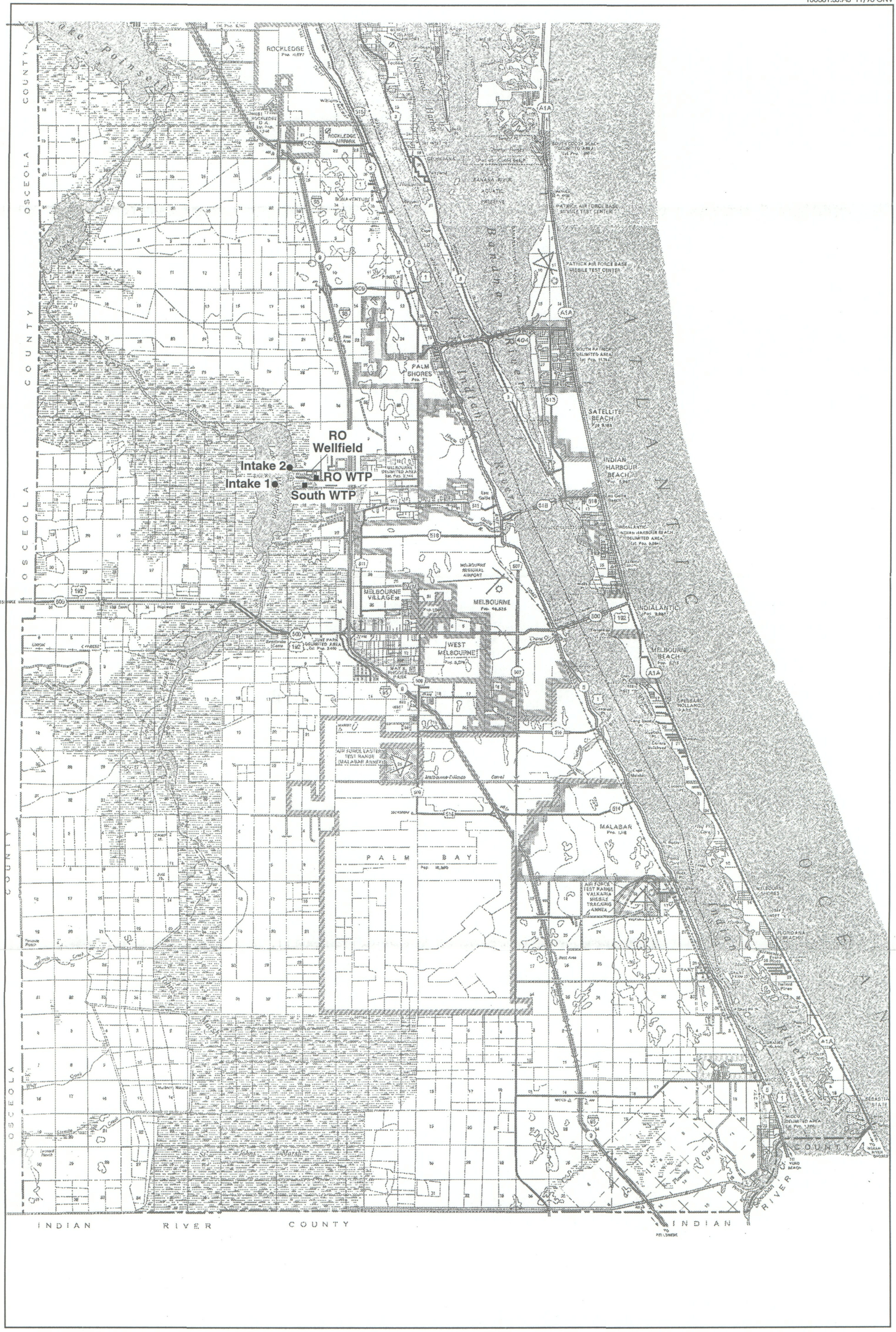


Figure A-2. City of Melbourne Water Treatment Plant and Wellfield Locations.

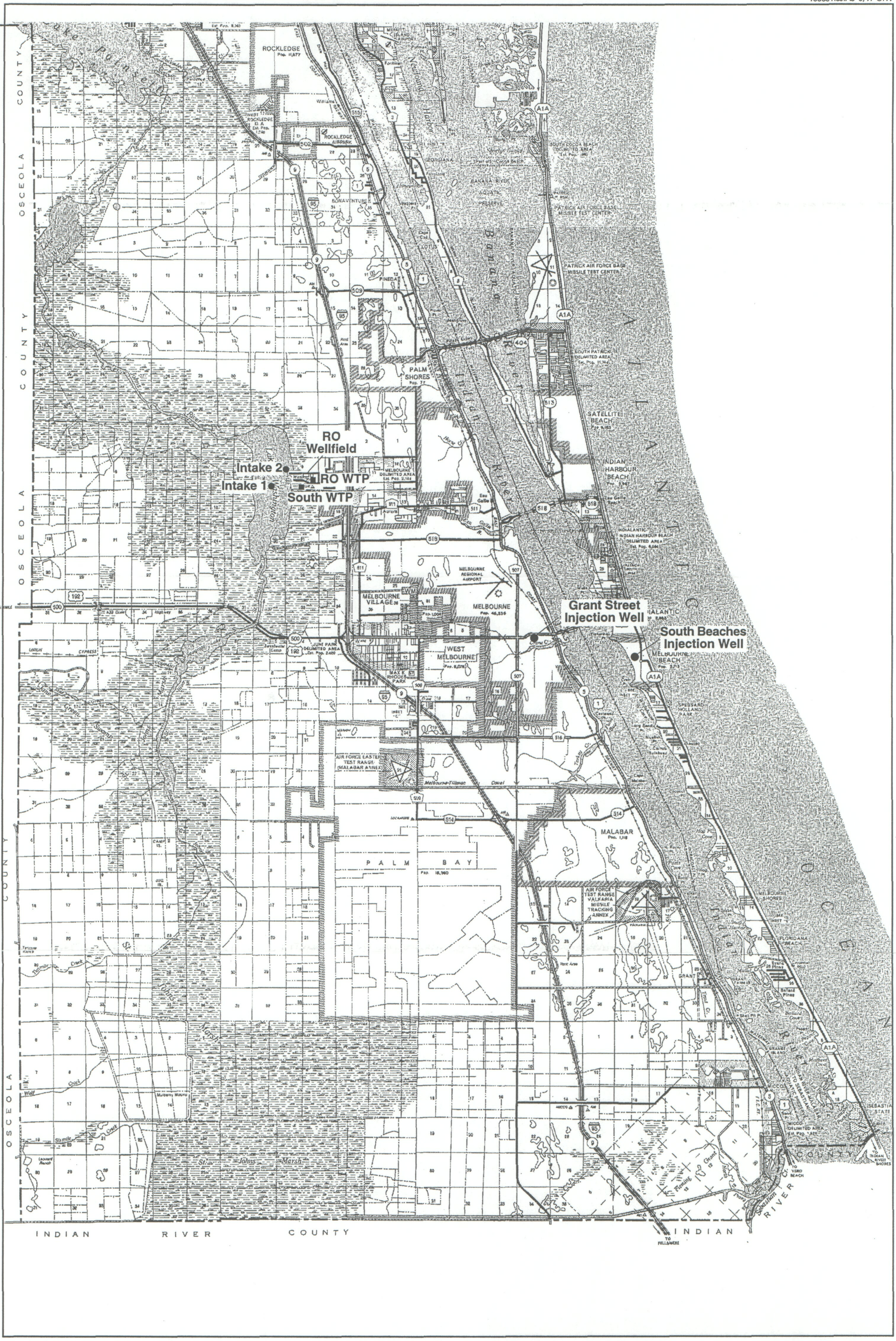


Figure A-3. City of Melbourne Interfering Uses and Impacts.

N

Approximate
Scale in Miles
0 1 2

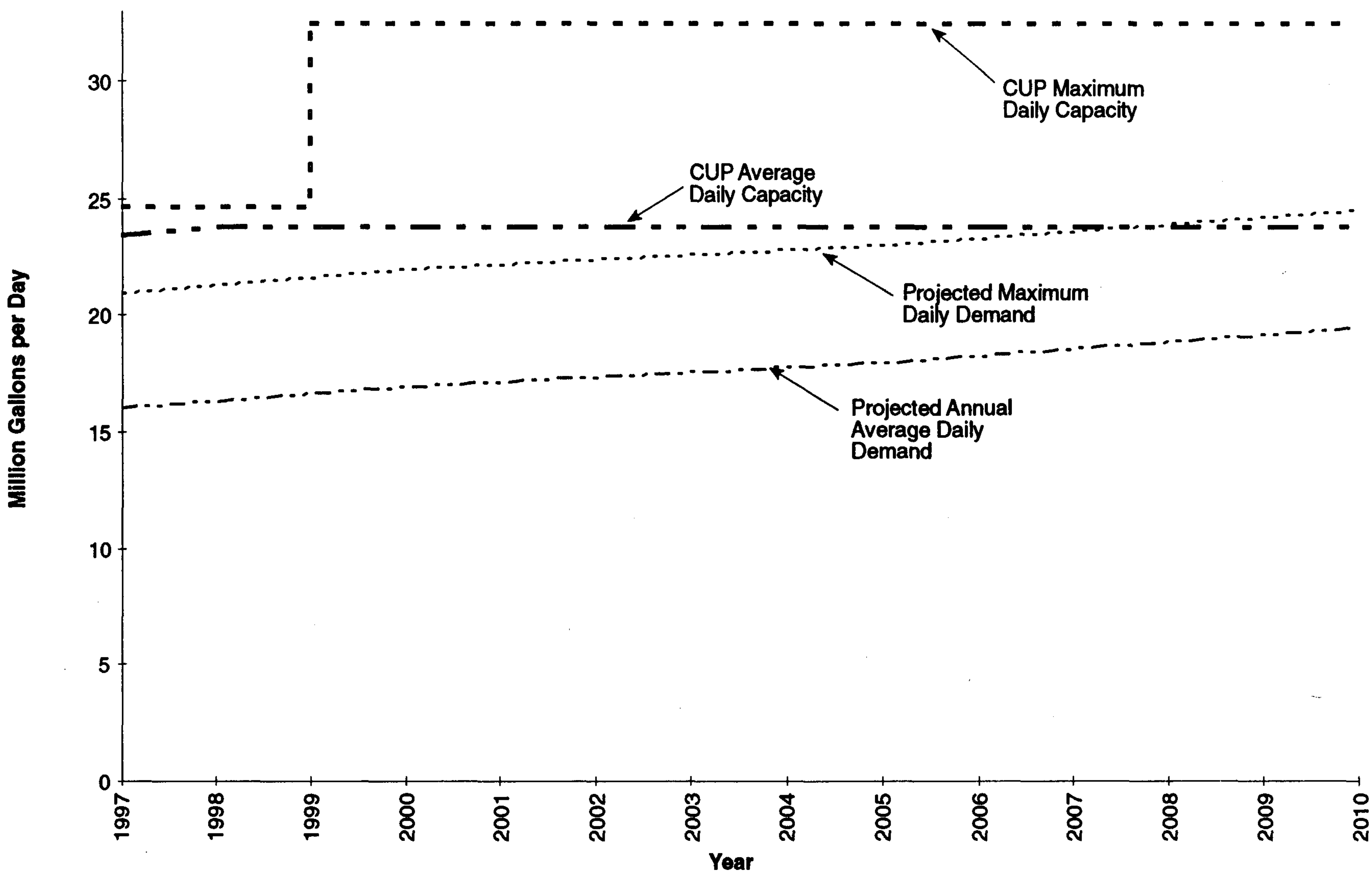


Figure A-4. City of Melbourne Long-Term Storage Need.

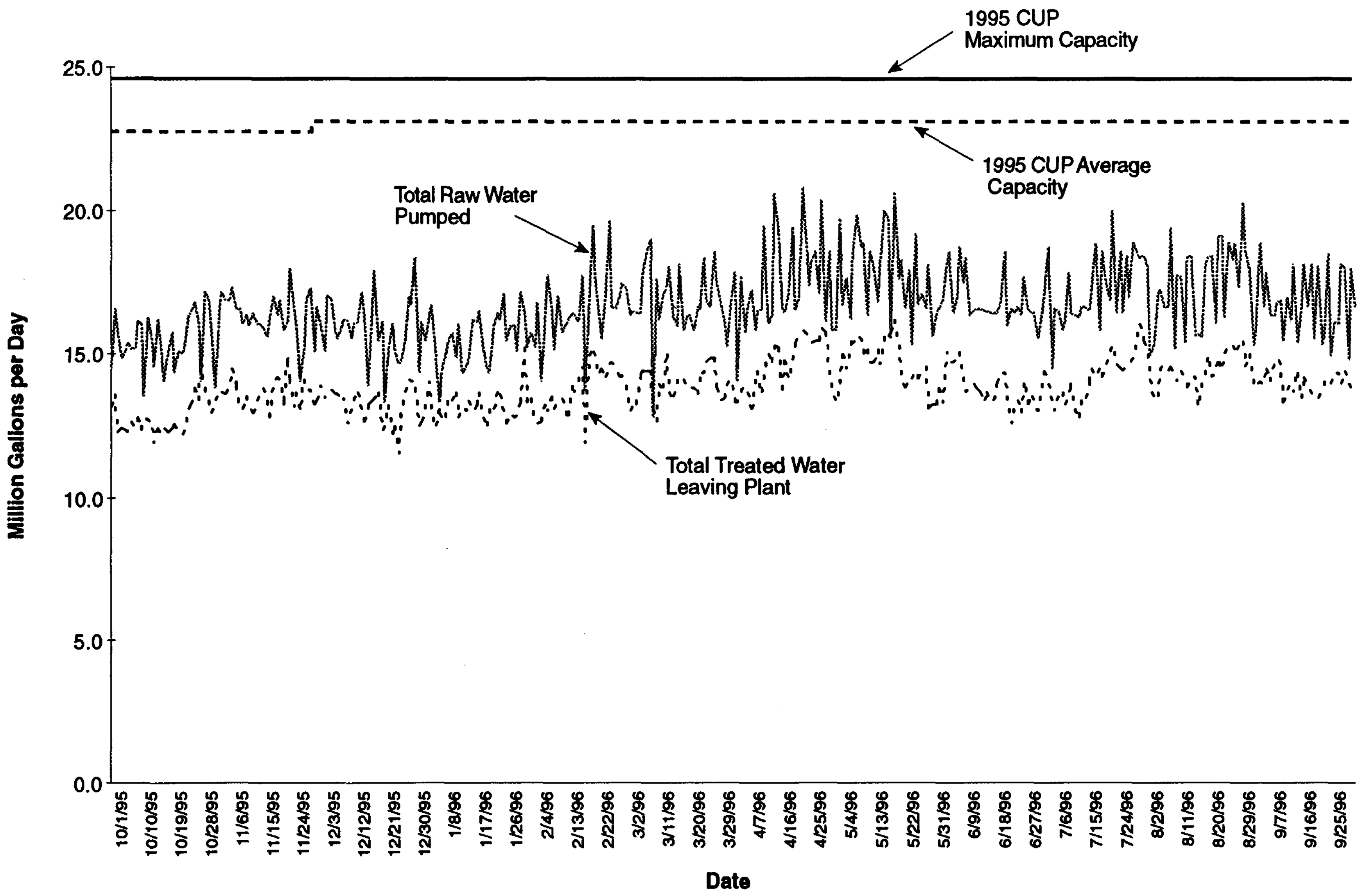


Figure A-5. City of Melbourne Seasonal Storage Need for Water Quantity.

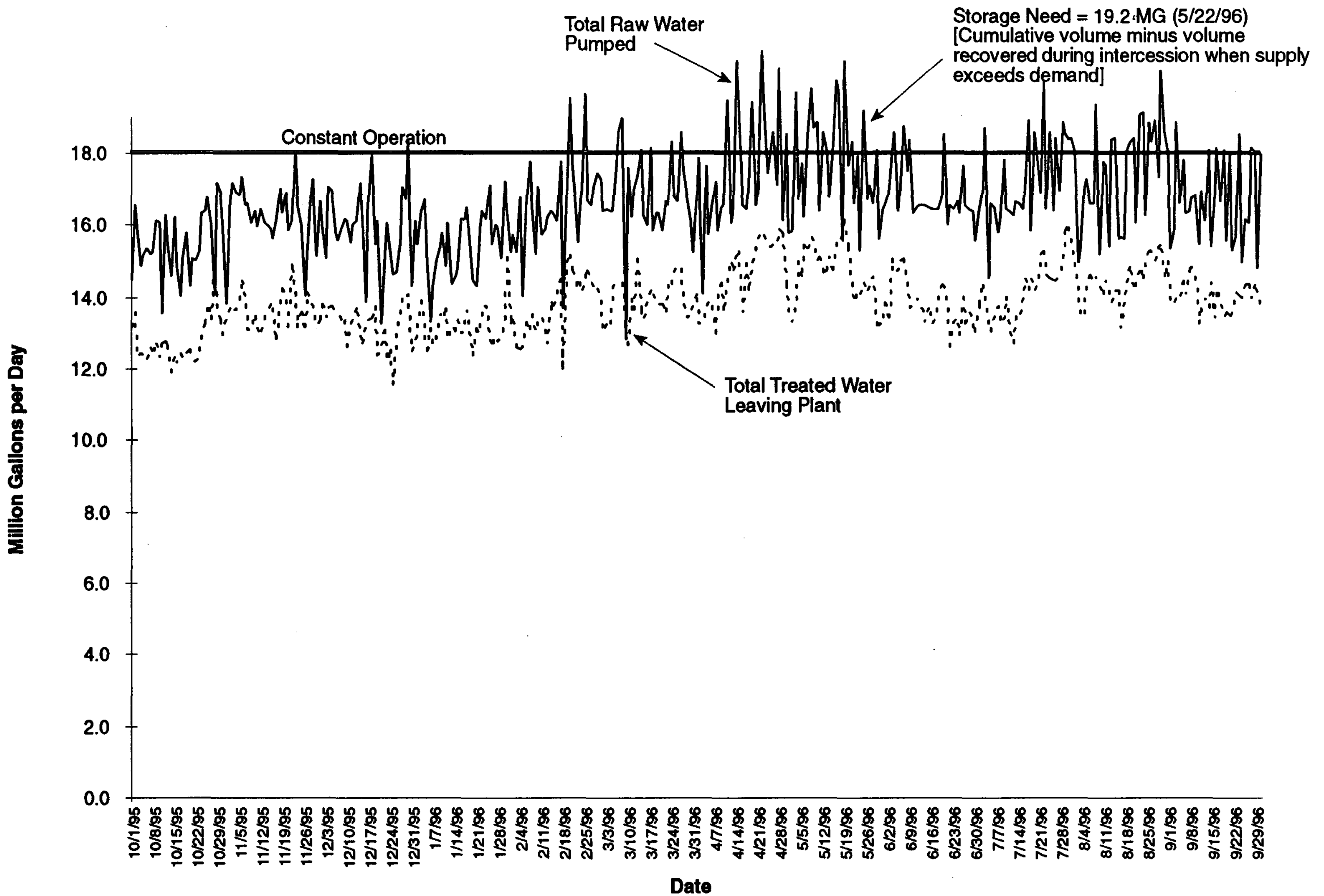
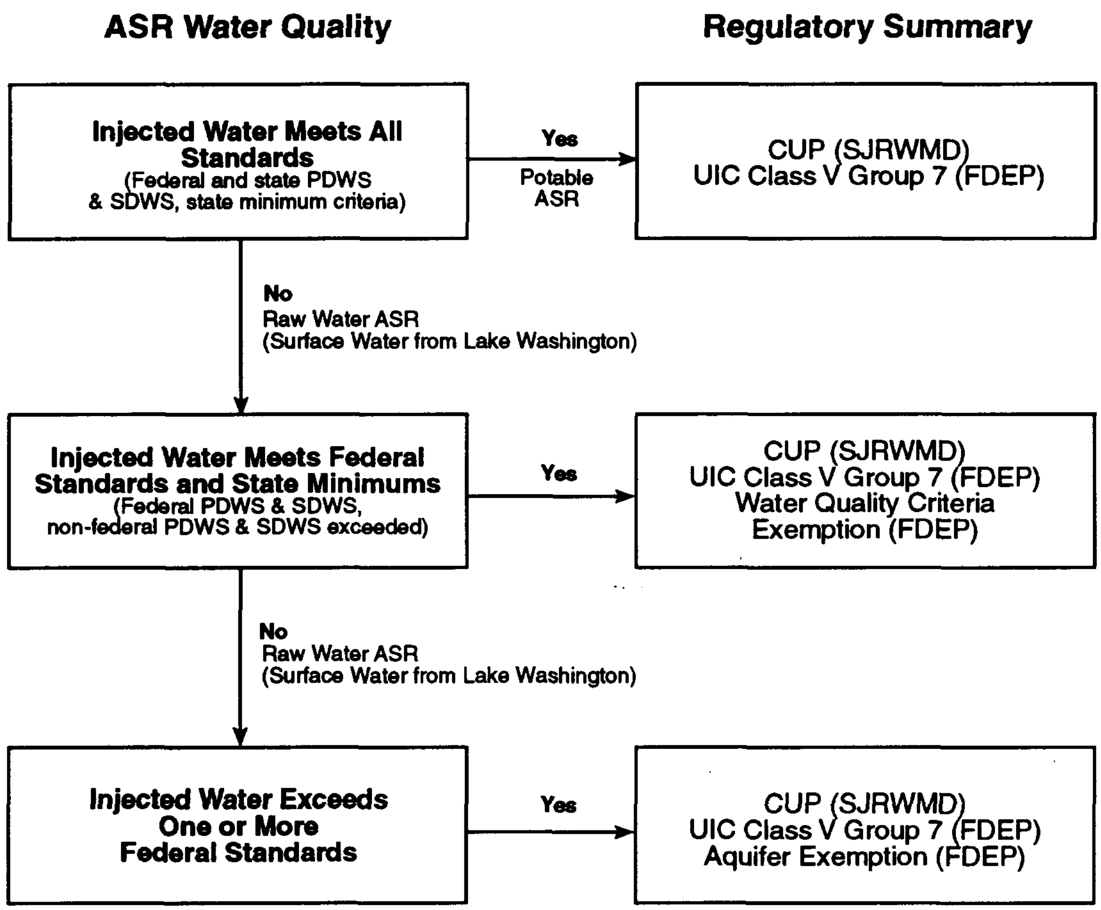


Figure A-6. City of Melbourne Seasonal Storage Need for Water Quality with Constant Operation at 18 mgd.

130581.SJ.AS 11/96 GNV



Note: Injected water can be either treated or raw.

Figure A-7. Possible ASR Regulatory Requirements for the City of Melbourne.

Feasibility Screening Report
Parts A and B

Facility Designation City of Melbourne

Water Source Surface Water, Ground Water (Floridan)

Date 12/2/96

Facility Director Geoffrey Mitskevitch, P.E.

Intended Use Potable Supply

Water Management District St. Johns River Water Management District

Date

District Officer

PART A FACILITY PLANNING FACTORS

1	Average Daily Demand (End of Planning Period):	19.5 mgd	Is ADD Greater Than 1 mgd?	X YES	NO
2	a. Total Supply Volume for Planning Period:	121,137.5 MG	Is the Supply Volume Greater Than Demand Volume?	X YES	NO
	b. Total Demand Volume for Planning Period:	90,702.5 MG			
3	List Storage Need Volumes Calculated:				
	a. Long Term Volume:	N/A MG			
	b. Seasonal Volume (For Quantity and Quality):	29 MG	Are any of the Volumes Greater Than 5 MG ?	X YES	NO
	c. Short Term Volume:	29 MG			
	d. Other (Emergency, Plant Operations, etc):	MG			
	e. Total a. through d., above	58 MG			

PART B HYDROGEOLOGIC, DESIGN, AND OPERATION FACTORS

ASR Hydrogeologic, Design and Operation Factor Scores

Section Points	1 Storage Zone Confinement	2 Storage Zone Transmissivity	3 Local Aquifer Gradient/Direction	4 Recharge Water Quality	5 Native Water Quality	6 Physical, Geochemical Interactions	7 Interfering Uses and/or Impacts	
5		5						High Feasibility Zone
4				4	4	4		High Feasibility Zone
3	3		3				3	Further Investigations Needed Zone
2								Further Investigations Needed Zone
1								Further Investigations Needed Zone
Weight Factor	X 10	X 10	X 1	X 2	X 10	X 5	X 5	
Score	30	50	3	8	40	20	15	Total Score 166

Score	Feasibility Level	Type of Study Recommended
160-215	High Confidence	General – Confirm Assumptions
100-159	Moderate Confidence	Focused – Investigate Specific Factors
43-99	Low Confidence	Detailed – Evaluate Impact of Critical Factors

Feasibility Screening Report
Parts C and D

Facility Designation: City of Melbourne — Date: 12/2/96

Facility Director: Geoffrey Mitskevitch, P.E.

Water Management District: St. Johns River Water Management District — Date: ____

District Officer: ____

PART C COST COMPARISON SUMMARY

Cost Comparison for Storage Options

Storage Need (SN): Emergency: 29.3 MG; Seasonal: 28.6 MG

ASR Recovery Rate = 5.5 mgd

Peak Factor (PF): 1.3

Recovery Duration (RD): 66 days

ASR Recovery Rate $\frac{PF + SN}{RD}$ = 0.6 mgd

Equivalent Annual Costs

	Seasonal		
Tank	$ 534,000	*(Figure A-5)*	$ 534,000
Reservoir	$ N/A	*(Figure A-5)*	$ –
ASR	$ 23,000	*(Figure A-5)*	$ 226,000

69

Cost Comparison for Management Options

Plant Rate Increase: 6.5 mgd

Equivalent Annual Costs

Plant Upgrades	Base Cost	Option 1	Option 2	Option 3	Option 4
Lime Softening and	1,592,000				
Sulfide Reduction by	Tray Aeration *(Figure A-8)*				
	Packing Tower *(Figure A-9)*				
	Ozonation *(Figure A-10)*				
TOTAL	1,592,000				

Equivalent Annual Cost for Options

Plant Upgrade: $ 1,592,000 (total cost from option selected from the table above)

ASR: $ 249,000 *(Figure A-4)*

PART D REGULATORY SUMMARY

	YES	NO	
Injected water meets all standards	X		(refer to Figure A2 for regulatory requirements)
Injected water meets federal standards and state minimums	X		(refer to Figure A2 for regulatory requirements)
Injected water exceedes one or more federal standards		X	(refer to Figure A2 for regulatory requirements)

Appendix B

ASR Feasibility Screening City of New Smyrna Beach

CONTENTS

ASR FEASIBILITY SCREENING—CITY OF NEW SMYRNA BEACH

FIGURES

TABLES

ASR FEASIBILITY SCREENING— CITY OF NEW SMYRNA BEACH

The City of New Smyrna Beach is located approximately 11 miles south of South Daytona on the eastern coast of Florida (see Figure B-1). The largest nearby city to the north is Daytona Beach, at a distance of approximately 14 miles. The largest nearby city to the south is Edgewater, at a distance of approximately 4 miles.

Information about the City of New Smyrna Beach utility and specific water use data were provided by Utilities Commission personnel during a site visit on October 16, 1996 (Korelich et al., 1996).

OVERVIEW

The City of New Smyrna Beach is a popular weekend tourist location in Florida. The Utilities Commission, City of New Smyrna Beach (UCCNSB) serves approximately 27,000 permanent potable water customers at this time. This demand reflects a 52 percent growth rate in the City of New Smyrna Beach during the 1980s. Contrasting data indicate that the City has been experiencing a stagnant growth rate in the 1990s. However, this information is difficult to estimate due to the fluctuating populations of vacationing visitors. The October 1995 to September 1996 average daily water demand on the UCCNSB system was approximately 4.3 million gallons per day (mgd), with a maximum demand of approximately 6.2 mgd. The demand exhibits seasonal fluctuations relating to an influx of vacationers from early spring until fall. Water demands are projected to increase with the population growth and to experience continuing seasonal fluctuations.

Existing Facilities

The UCCNSB water supply system consists of a water treatment plant (WTP), three wellfields, and several aboveground storage tanks, in addition to the water distribution system.

Water Treatment Plant. The UCCNSB WTP is located west of the city (Figure B-2). The WTP was built in 1975, with an initial capacity of 6.2 mgd. In 1991, the plant was expanded to a capacity of 10.4 mgd. However, the plant operates at approximately 5 mgd. Treated water leaving the WTP for distribution has chloride and total dissolved solids (TDS) concentrations of 46 milligrams per liter (mg/L) and 160 mg/L, respectively.

Water Supply. The UCCNSB's water supply is withdrawn from three wellfields: Glencoe Wellfield, Samsula Wellfield, and S.R. 44 Wellfield, all completed in the Upper Floridan aquifer (Figure B-2). These wellfields are permitted to provide up to 7.6 mgd to the UCCNSB. Currently, the UCCNSB operates 6 wells on a rotation schedule (out of 19 available in the 3 wellfields) to minimize the drawdowns and the chlorides.

The Glencoe Wellfield was constructed in 1955 near the WTP. Currently, seven wells in this wellfield provide water to the UCCNSB. These wells have high production rates; however, if not closely monitored and rotated, the water quality of these wells can slowly degrade over time due to saltwater intrusion from upconing. Previously, eight wells provided water from this wellfield; however, one well was abandoned due to high chloride concentrations.

The Samsula Wellfield was constructed in 1986. Currently, six wells in this wellfield provide water to the UCCNSB. These wells have lower production rates than the Glencoe Wellfield, as well as good water quality, with chloride concentrations of approximately 15 mg/L. This wellfield, located approximately 5.5 miles west of the Glencoe Wellfield, was constructed as a result of increasing chloride levels in the Glencoe Wellfield and land availability west of the city. Since the installation of the Samsula Wellfield, the Glencoe Wellfield has experienced decreased pumping rates that, over time, have lowered the chloride concentrations to the initial levels.

The S.R. 44 Wellfield was constructed in 1991. Currently, six wells in this wellfield provide water to the UCCNSB. These wells have low production rates and exhibit high drawdowns. The chloride concentrations in water withdrawn from these wells are about 40 mg/L. This wellfield, located approximately 2 miles west of the Samsula Wellfield, was constructed to further decrease the demand on the Glencoe Wellfield and to make use of available land west of the city.

Water Supply Storage. The UCCNSB currently has approximately 6.1 million gallons (MG) of storage capacity in aboveground tanks in six locations. However, only 5.4 MG is available for public supply; the remaining 0.7 MG is used at the Glencoe WTP. With 100 percent of the total storage available, the UCCNSB demands could be met for approximately 24 hours.

Future Facility Expansions

By the year 2010, the average daily demand is expected to be around 5.5 mgd, with a maximum demand of 7.86 mgd. However, facility expansions are not planned to meet the projected water demands.

Water Treatment Plant. The WTP was upgraded in 1991; therefore, no expansions are planned in the near future.

Water Supply. No plans exist to add any additional wells to the current system. However, when additional supply is needed, the UCCNSB will have to purchase new land west of the S.R. 44 Wellfield.

The UCCNSB has a potable water interconnect with the City of Edgewater. Before upgrade of the City of Edgewater's WTP approximately 10 years ago, the UCCNSB supplied potable water to Edgewater to supplement that city's water supply.

Water Supply Storage. No plans exist to add any additional storage tanks to the current system.

Water Supply System Restrictions

Wellfield Operations. The UCCNSB's Consumptive Use Permit (CUP) dictates that 40 percent of the water production should come from the Glencoe Wellfield, located in the vicinity of the WTP. Approximately 30 percent is to be produced from the Samsula Wellfield and the remaining 30 percent from the S.R. 44 Wellfield.

Existing CUP Restrictions:

Average Annual Withdrawals		*Maximum Total Daily Withdrawals*	
5.290 mgd	1996	7.380 mgd	1996
5.290 mgd	1997	7.620 mgd	1997
5.290 mgd	1998	7.620 mgd	1998

Water Shortages. Water shortages have occurred in the past due to drought conditions in the area. When drought conditions exist, the water levels decline and the drawdowns in the supply wells increase, requiring the withdrawal rate to be reduced to keep drawdowns from becoming excessive.

Wetlands Monitoring. The UCCNSB is currently monitoring wetlands for vegetative impacts due to wellfield production. This monitoring is associated with the conditions of the CUP to determine the effects of pumping on the wetlands and minimize any impacts.

Environmental Impacts. The Volusia County Tomoka Landfill is located approximately 12 miles north of the Glencoe Wellfield. Volusia County currently operates a ground water monitoring system along the western area of the landfill that consists of shallow aquifer wells and an Upper Floridan aquifer monitoring well (see Figure B-3).

Interfering Uses. The City of Port Orange operates two water supply wellfields in the area. The Port Orange Eastern Wellfield is located 10 miles north of the Glencoe Wellfield. The Port Orange Central Recharge Wellfield is located approximately 7 miles north of the Samsula Wellfield (Figure B-3).

The City of Edgewater operates two wellfields, the Thomas and Western Wellfields, approximately 3 miles south of the Glencoe Wellfield (Figure B-3).

Kirkland Sod Farm is located west of the Glencoe and Samsula Wellfields. This farm operates a water supply wellfield under CUP restrictions and is located east of the S.R. 44 Wellfield (see Figure B-3).

Other Issues

The UCCNSB uses a reclaimed-water system for irrigation purposes. This system currently serves three golf courses and approximately 160 residential and commercial service connections. The City has pursued initial investigations into an ASR well designed to store excess reclaimed water during the wet season for irrigation in the dry season. A 900-foot test well was constructed to evaluate the hydrogeology for suitable ASR zones. However, there has been no recent activity due to permitting issues for reclaimed-water ASR.

ASR FEASIBILITY RANKING REPORT

As each section of the screening tool is reviewed, a score is determined that best represents the site-specific characteristics. At the end of the ranking process, each score is weighted as to its degree of importance and a final score is calculated. The magnitude of this score identifies a relative ASR feasibility for the site.

Part A. Facility Planning Factors

Step 1. List the Average Daily Demand.

Instructions: For Potable Use, if the ADD is greater than 1 mgd, proceed to Step 2. If the ADD is less than 1 mgd, another solution should be evaluated. For Agricultural Use, proceed to Step 2.

The *UCCNSB's average daily demand for October 1995 to September 1996 was 4.3 mgd. The projected demand for 2010 is approximately 5.5 mgd.*

Step 2. List the Total Supply and Demand Volumes for the Planning Period.

Instructions: If the total supply volume is larger than the total demand volume, proceed to Step 3. If the demand is larger than the supply, investigate other supply increase and demand reduction solutions.

For the purposes of this study, the planning period is defined as 1997-2010, which corresponds to the end of the planning period used in the SJRWMD 1994 Water Supply Needs and Sources Assessment. The CUP for the City of New Smyrna Beach extends to the year 1998, allowing a 5.29-mgd (1,930.85-MG) average and a 7.62-mgd maximum withdrawal. The treatment capacity for the WTP is 10.4 mgd. Therefore, the CUP value is the limiting condition. Carrying the 1998 annual value through 2010, the total supply would be 27,031.9 MG (1,930.85 MG multiplied by 14 years).

Demand data are presented below for the City of New Smyrna Beach. Recent projections established by UCCNSB were used to calculate the total demand volume for the 1997-2010 planning period.

Year	AADF[1] [mgd]	Annual Volume[2] [MG]
1997	4.330	1,580.0
1998	4.380	1,598.7
1999	4.440	1,620.6
2000	4.500	1,642.5
2001	4.560	1,664.4
2002	4.650	1,697.3
2003	4.740	1,730.1
2004	4.840	1,766.6
2005	4.930	1,799.5
2006	5.030	1,836.0
2007	5.130	1,872.5

Year	AADF[1] [mgd]	Annual Volume[2] [MG]
2008	5.240	1,912.6
2009	5.340	1,949.1
2010	5.450	1,989.3
Total		24,659.4

[1]Average Annual Daily Flow (AADF) data projected by UCCNSB.

[2]4.330 mgd x (1 year x 365 days/year) = 1580.5 *MG*

Since the total demand volume, 24,659.2 MG, is less than the total supply volume, 27,031.9 MG, a sufficient quantity of water is expected during the planning period (assuming that CUP capacities are maintained).

Step 3. List Storage Need Volumes Calculated as a Long-Term Volume, a Seasonal Volume, a Short-Term Volume, or Other.

Instructions: If the total volume is greater than 5 MG, proceed to Part B, below. If the total volume is less than 5 MG, investigate other storage options.

Long-Term Storage Need: Current CUP and plant capacities and the projected demands defined in Step 2 indicated no significant benefit from long-term storage within the planning period (refer to Figure B-4).

Seasonal Storage Need: Demand and supply values were plotted for 1 year (January October 1, 1995, through September 30, 1996). These plots indicated a seasonal fluctuation that would correspond to a storage need of 2.9 MG. However, if the plant had been operated at a constant 5 mgd throughout the year, a 6.2-MG storage need may be utilized, with a savings in plant operations costs. (Refer to Figure B-5.) A 7-MG seasonal storage need is projected for 2010 (6.2 MG multiplied by the year 2010 to 1995 average demand ratio, 5.5/5.0).

Other Storage Need: It is feasible for benefits to be derived from other storage, such as emergency storage. To illustrate how this can be incorporated into a water plant operation, emergency storage needs will be assumed as 100 percent of the average daily flow for 3 days. This corresponds to a 17-MG storage need (100 percent of 5.5 mgd multiplied by 3 days).

The total storage need calculated for UCCNSB is 24 MG, a combination of seasonal and emergency storage needs.

Part B. Hydrogeologic, Design, and Operation Factors

Area Hydrogeology

The hydrogeologic factors needed to evaluate the feasibility of ASR include the occurrence and depths of transmissive and confining intervals in the Upper and Lower Floridan aquifers. The characteristics of confining beds overlying the Floridan aquifer are also important in the evaluation of suitable zones. In Volusia County, the most probable ASR zones are expected to occur in the Upper Floridan aquifer.

The surficial aquifer system in Volusia County varies in thickness with the depth to the top of the Hawthorn Group. The surficial aquifer is from 0 to 100 ft thick.

The Hawthorn Group acts as a semi-confining unit between the surficial deposits and the Upper Floridan aquifer. Although the Hawthorn Group has low permeability, recharge occurs between the surficial aquifer and the Floridan aquifer because the confinement is thin or non-existent (Miller, 1986). Although the Hawthorn Group is absent in parts of Volusia County, well logs at the Glencoe Wellfield included a Hawthorn layer (Hartman, 1995).

The Floridan aquifer consists of the Ocala Group and Avon Park Formation geologic units, which are mostly limestones, dolomite, and some sand, to a depth of approximately 2,300 feet bls in Volusia County. The Ocala Group is found at a depth of approximately 100 feet in eastern Volusia County, but is not present in the western portion due to extensive erosion. The Ocala Group is composed of off-white, white, and gray limestone, and can be slightly dolomitized in Volusia County (Miller, 1986). Beneath the Glencoe Wellfield, the bottom of the Ocala Group is marked by a more dense dolomitic limestone. This layer also marks the change between the Ocala Group and the Avon Park Limestone.

The Avon Park Formation extends from approximately 200 to 1,200 feet bls. This is a highly fossiliferous limestone, with intervals composed of crystalline dolomite. This formation varies greatly in color and hardness. There are interbedded layers of soft white-chalky limestones, light brown or gray limestones, and brown dolomites (Miller, 1986).

Suitable ASR zones are expected to occur in the Upper Floridan aquifer between 250 and 400 feet bls and in the Lower Floridan aquifer between 500 and 900 feet bls.

Step 1. Storage Zone Confinement

Instructions: Use Table B-1 to rank the hydraulic conductivity and thickness of the vertical flow restrictive units (aquitard) above and below the storage zone. This data can be gathered from local wells in the same zone or from regional published information. Table 3 from the Technical Memorandum (TM) C.1.c (CH2M HILL, 1996) presents an example ranking based on a 100-foot-thick confining unit, which shows how Figure A-2 (TM C.1.c) is used to determine the ranking.

Data obtained from the City of New Smyrna Beach reclaimed water ASR test well indicated that good confining beds are likely to exist within the Upper and Lower Floridan aquifers. Therefore, a rank of 5 was selected.

Table B-1. Storage Zone Confinement Ranking

Rank	Aquitard Hydraulic Conductivity	Aquitard Thickness
5	1.0×10^{-5}	100 feet

Step 2. Storage Zone Transmissivity

Instructions: Use Table B-2 to rank the target storage zone transmissivity. This data can be gathered from local wells in the same zone or from regional published information. Figure A-3 (TM C.1.c) should be used in conjunction with Table B-2 to determine the ranking.

The transmissivity of the Upper Floridan aquifer has been tested in the Glencoe production wells. The results were transmissivities of 51,400 and 141,000 gpd/ft (Dyer, Riddle, Mills and Precort, Inc., n.d.). An average value of 50,000 to 300,000 gallons per day per foot (gpd/ft) is noted in a regional publication (Tibbals, 1990). The Lower Floridan aquifer has not been extensively evaluated in the area. The reclaimed water ASR test well at New Smyrna Beach was pump tested at depths between 700 and 900 feet. A transmissivity of 38,000 gpd/ft was calculated. Although the wellfield and regional data have higher estimated values for transmissivity, for the purposes of this evaluation, an estimated storage zone transmissivity of 15,000 to 40,000 gpd/ft was used, resulting in a rank of 3.

Table B-2. Storage Zone Transmissivity Ranking

Rank	Transmissivity Criterion (gpd/ft)		Applicability
	Potable Water	Untreated Surface Water	
1	Less than 8,000	Less than 80,000	Limited
2	8,000 to 15,000	80,000 to 250,000	
3	**15,001 to 40,000**	250,001 to 400,000	
4	40,001 to 50,000	400,001 to 500,000	
5	50,001 to 80,000	500,001 to 1,000,000	Optimal
4	80,001 to 120,000	1,000,001 to 1,150,000	
3	120,001 to 200,000	1,150,001 to 1,400,000	
2	200,001 to 400,000	1,400,001 to 2,000,000	
1	Greater than 400,000	Greater than 2,000,000	Limited

Step 3. Aquifer Gradient and Direction

Instructions: Rank the local aquifer gradient and direction. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table B-3.

A rank of 3 was selected because two wellfields exist in the areas around UCCNSB's Glencoe WTP and Wellfield. Depending on the depth of the ASR storage zone, these wellfields could influence the movement of the stored water of the ASR system.

Table B-3. Local Aquifer Gradient/Direction Ranking

Rank	Aquitard Gradient (in same recharge zone)	Direction Criterion
1	Many strong influences exist	Extreme artificial gradient, reevaluate location of ASR system
2	Several strong influences	Exaggerated gradient, investigation needed
3 (default)	Multiple minor influences exist	Affected gradient worth investigating
4	Single minor influence or abnormal natural gradient	Minor investigation or existing data search
5	No influence	No influence

Step 4. Recharge Water Quality

Instructions: Rank the recharge water quality using chloride or TDS concentrations of the water to be stored in the ASR zone. For potable water, this data can be obtained from the records of the WTP that will be supplying the source water. For raw water, this can be determined from published records or databases. If this information is not available, use the default value shown in Table B-4.

Treated water leaving the WTP for distribution has chloride and TDS concentrations of 46 mg/L and 160 mg/L, respectively. The concentration for chlorides was used, providing a rank of 5.

Table B-4. Recharge Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Compliance with SDW Standards
1	Greater than 200	or	Greater than 450	Just within SDW standards
2	200 to 171		450 to 351	
3	170 to 101		350 to 201	Moderately meets SDW standards
4	100 to 50		200 to 100	
5	**Less than 50**		Less than 100	Well within SDW standards

Step 5. Native Water Quality

Instructions: Rank the native water quality based on the chloride or TDS information of the native water in the target ASR zone. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table B-5.

The water quality of the Upper Floridan aquifer rapidly becomes non-potable below the wellfield production zone. Between the depths of 250 and 400 feet, TDS concentrations are expected to range from 1,000 to 5,000 mg/L. The reclaimed water ASR test well at New Smyrna Beach had TDS concentrations greater than 30,000 mg/L between 700 and 900 feet. For this evaluation, a rank of 2 was used to reflect the generally poor native water quality.

Table B-5. Native Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Water Quality
1	Greater than 6,000	or	Greater than 10,000	Very brackish
2	**6,000 to 3,001**		**10,000 to 5,001**	
3	3,000 to 801		5,000 to 1,301	Slightly brackish
4	800 to 400		1,300 to 700	
5	Less than 400		Less than 700	Near fresh water

Step 6. Physical, Geochemical, and Design Interactions

Instructions: Rank the potential for physical, geochemical, or design interactions. This rank is based on the sum of the ranks from the sub-categories shown in the table below. If this information is not available, use the default value shown in Table B-6.

The water quality values for the treated water of the UCCNSB are provided in parentheses next to the selected rank in Table B-6. When no value in parentheses exists, no information was available. Therefore, the default rank was selected.

Table B-6. Overall Physical, Geochemical, and Design Interaction Ranking for the City of New Symrna Beach

Sub-Category	Rank	Recharge Water and Criterion	Selected Rank
Physical Interactions from Suspended Solids			
TSS	1	TSS>2.0 mg/L	2
	2	2.0 mg/L>TSS>0.05 mg/L **(default)**	
	3	TSS<0.05 mg/L	
Biological Growth and Geochemical Interactions			
pH	**1**	**7.8<pH< 8.6** (default)	1 (8.12)
	2	pH>8.6	
	3	pH<7.8	
Total Phosphorous	1	P>0.1 mg/L	2
	2	0.1 mg/L>P>0.05 mg/L **(default)**	
	3	P<0.05 mg/L	
Nitrate as N	1	N>1 mg/L	3
	2	1 mg/L>N>0.5 mg/L (default)	
	3	**N<0.5 mg/L**	
Dissolved Organic Carbon (DOC)	1	DOC>5 mg/L	2
	2	5 mg/L>DOC>2.5 mg/L **(default)**	
	3	DOC <2.5 mg/L	

Sub-Category	Rank	Recharge Water and Criterion	Selected Rank
Total Iron (Fe)	1 2 3	Fe>1 mg/L 1 mg/L>Fe>0.3 mg/L (default) **Fe<0.3 mg/L**	3 (0.071)
Dissolved Oxygen (DO) of Recharge Water	1 2 3	DO>3 mg/L 3 mg/L>DO>1.5 mg/L **(default)** DO<1.5 mg/L	2
Point Totals			15
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**3**

Note: Use the default value if data for any parameter is unavailable. Determine the overall rank from the following point totals:

Rank	Physical, geochemical, and design criteria (total of above points)	
1	7-10 points	Higher potential for plugging
2	11-12 points	
3	**13-16 points**	Moderate potential for plugging
4	17-18 points	
5	19-21 points	Low potential for plugging

Step 7. Interfering Uses and Impacts

Rank the interfering uses and impacts which can exist or have the possibility to exist in the vicinity of a proposed ASR site. Information can be gathered from visual surveys, aerial photographs, topographic maps, and public records/information. This rank is determined from the sum of two sub-ranks shown in Table B-7. If this information is not available, use the default value shown.

An inventory of wells within a 5-mile radius of the Glencoe WTP and Wellfield revealed the following existing wells in the area:

Number of Wells	Well Size (inches)	Well Use
9	2, 5, 8, 12, 16	sod, livestock
15	16	public supply
3	6	fire protection
7	4, 10	golf course irrigation
3	2, 16	industrial

Interfering Uses: The Port Orange Eastern Wellfield is located 10 miles north of the Glencoe WTP and Wellfield. The City of Edgewater operates two wellfields approximately 3 miles south of the Glencoe WTP and Wellfield. This information earned a sub-rank of 2.

Interfering Impacts: The Volusia County Tomoka Landfill is located approximately 12 miles north of the Glencoe Wellfield. This information earned a sub-rank of 3.

Table B-7. Interfering Uses and Impacts Ranking

Sub-Category	Rank and Criterion	Selected Rank
Interfering Uses		
Distance to Potable Wells	1 0.10 mile<Wells<0.25 mile **2 0.26 mile<Wells<5 miles** (default) 3 Wells>5 miles	2 (3 miles)
Interfering Impacts		
Distance to Contamination Source	1 0.10 mile<Source<0.25 mile 2 0.26 mile<Source<1 mile (default) **3 Source>1 mile**	3 (12 miles)
Point Total		5
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)		**4**

Overall Interfering Uses and Impacts Rank determined from the following point totals:

Rank	Interfering Use and/or Impact Criteria (possibility of impact)	
1	2 points	High use or impact
2	3 points	
3	4 points	Moderate use or impact
4	**5 points**	
5	6 points	Low use or impact

The results of the hydrogeologic, design, and operational factors scoring are interpreted as shown in Table B-8.

The UCCNSB hydrogeologic, design, and operational factors score is 148 points out of a total of 215 points (see scoring sheet at the end of this appendix). This score represents a moderate confidence for ASR feasibility. Detailed site-specific information will likely change the feasibility score to better reflect actual conditions at the proposed ASR location.

Table B-8. ASR Feasibility Score for Hydrogeologic, Design, and Operational Factors

Score	Feasibility Level	Type of Study Recommended
160 - 215	High Confidence	General—confirm assumptions
100 - 159	**Moderate Confidence**	**Focused—investigate specific factors**
43 - 99	Limited Confidence	Detailed—evaluate impact of critical factors

Part C. Cost Comparison Summary

Instructions: The annual cost figures (Figures A-4 through A-10 in TM C.1.c) were developed as a means of comparing alternative water storage and treatment options. Use the tables to complete the Cost Comparison Summary Sheet provided in TM C.1.c. On this sheet, a comparison is made between ASR, other storage options and plant upgrades, which will provide the needed water for immediate peak demand or future demands.

Costs need to be evaluated on two levels for the City of New Smyrna Beach.

1. *Storage Option Comparison for Seasonal Storage Need in a Tank or ASR:*

   a. *The seasonal storage need of 6.8 MG was projected for the City of New Smyrna Beach in 2010 using a consistent plant operation level of 5 mgd. The cost associated with providing a tank to meet this storage need is as follows:*

   Annual Cost = 17,787 X + 18,088, where X is the storage volume in MG

   *Annual Cost = 17,787 * 7 + 18,088*

   Annual Cost = $143,000

   b. *For the ASR calculation, the recovery rate is required. Recovery would take place over approximately 28 days. The peak factor is the ratio of maximum day to average day, which was calculated to be 1.5 from the plant records. Therefore, the peak recovery rate would be 6.8 MG * 1.5 / 28 = 0.4 mgd for a potential ASR system. For the purpose of this screening tool, a recovery of 0.5 mgd per well was used. Our experience in this area indicates that 0.5 to 1.0 mgd per well recovery is likely. Therefore, the more conservative 0.5 mgd per well value was used to provide a measure* *of cost differences. The corresponding ASR cost is calculated as follows:*

Annual Cost = 71,897 X, where X is the recovery rate in mgd

*Annual Cost = 71,897 * 0.4*

Annual Cost = $29,000

2. *Storage Option Comparison for Emergency Storage Need in a Tank or ASR:*

   a. *The emergency storage need of 18.1 MG was calculated for the City of New Smyrna Beach to provide 3 days of emergency supply for a projected average day demand in the year 2010. The cost associated with providing a tank to meet this storage need is as follows:*

   Annual Cost = 17,787 X + 18,088, where X is the storage volume in MG

   *Annual Cost = 17,787 * 17 + 18,088*

   Annual Cost = $320,000

   b. *For the ASR calculation, the recovery rate would need to be the capacity desired for peak recovery rate from the ASR well. For the purposes of this evaluation, it was assumed that a recovery at the projected 2010 average day demand, 5.5 mgd, would be desired. The corresponding ASR cost is calculated as follows:*

   Annual Cost = 71,897 X, where X is the recovery rate in mgd

   *Annual Cost = 71,897 * 5.5*

   Annual Cost = $395,000

A cost summary sheet (Feasibility Screening Report Parts C and D) is included after all figures at the end of this appendix.

Part D. Regulatory Summary

Instructions: Part D presents the regulatory requirements for the different types of water quality. Place an "X" under the category of *YES* or *NO* to best describe the quality of the water to be stored. Figure B-6 provides the regulatory permits or exemptions needed for the different water quality groups.

Figure B-6 is a flowchart showing the permits and approvals needed for specific water qualities to be stored in the ASR well. A SJRWMD CUP and a Florida Department of Environmental Protection (FDEP) Underground Injection Control (UIC) Class V Group 7 Permit will be required for any ASR application. Two permitting scenarios exist for the ASR options identified for the UCCNSB—one for potable water ASR and one for raw water ASR.

For potable water ASR, the injected water will meet all state and federal drinking water standards, since the source is from the WTP. Therefore, no other permits are expected to be required beyond the CUP and UIC Class V Group 7 Permit. This permitting scenario appears to be feasible, since potable ASR systems have been permitted throughout Florida.

Additional permitting requirements will occur for raw water ASR, which would require an inter-aquifer transfer from the Upper Floridan aquifer at the Samsula Wellfield to the surficial aquifer at the Glencoe Wellfield. The storage zone may be in or just below the Glencoe production zone. Where federal primary drinking water standards (PDWS) and secondary drinking water standards (SDWS) and state minimum criteria are met, but some state PDWS or SDWS are exceeded, a Water Quality Criteria Exemption will be needed from FDEP. If the recharge water exceeds one or more federal standards, then an Aquifer Exemption must be granted by the FDEP.

Water Quality Criteria Exemptions and Aquifer Exemptions are more difficult permitting paths. However, since the requested exemption would be for an inter-aquifer transfer from one drinking water source to another, it is probably obtainable with some added risk compared to the potable water scenario.

CONCLUSIONS

SJRWMD originally selected the UCCNSB based on concern for water quality in the Glencoe Wellfield and for adjacent wetland impacts at the Samsula Wellfield. However, the UCCNSB saw reclaimed-water storage, not potable water, as the potential application of ASR, based on its preliminary investigations in this area. As part of this study, CH2M HILL used the ASR screening tool and previous experience to determine the primary ASR application and any secondary benefits, to compare costs with traditional solutions, and to evaluate the regulatory requirements.

The ASR screening process identified seasonal storage as the primary potential use of ASR. Using a specific operating scenario, secondary benefits related to upconing, wetland impacts, and emergency storage may also be achieved. This operation would be to pump the Samsula and S.R. 44 Wellfields at a rate higher than demand during the wet season and to store extra water in ASR. By pumping during the rainy season, the higher drawdown in the Samsula Wellfield could perhaps be offset by an adequate surface water supply for the wetlands.

The excess water supply could be stored in a zone just below the Glencoe Wellfield pumping zone and/or a beachside ASR. Storage below the Wellfield Glencoe production zone could perhaps buffer the water-quality problems experienced at higher pumping rates. This application could be either a potable ASR or an inter-aquifer transfer of raw ground water. However, a potable beachside ASR would also provide emergency storage at a varying demand center for the City.

Increased pressure may also be feasible with this increased potable water storage. UCCNSB provides an excellent example of the versatility of ASR in a water supply system and the issues to compare in making the decision to use ASR.

Either implementation of ASR appears to be feasible from a general hydrogeologic perspective. Suitable zones with similar characteristics are expected in the Upper and Lower Floridan aquifers, based on data available in this area. The hydrogeologic score of 148 for the potable water or raw ground water ASR applications discussed above indicates a moderate-level confidence in ASR feasibility.

The screening suggests that the equivalent annual cost characteristics are favorable for ASR as a seasonal storage solution in order to operate the plant at a constant 5-mgd rate ($143,000 per year for tanks and $29,000 per year for ASR). However, if ASR is considered as an emergency storage option, the annual costs of tanks and ASR are roughly comparable (at $320,000 per year and $395,000 per year, respectively). This similarity in cost results from the higher emergency recovery rate, compared to the seasonal recovery rate. However, with the higher recovery rate, the ASR system could serve as both the seasonal storage and emergency storage option. The annual cost of using the tanks to serve both functions would be $463,000 (the sum of the seasonal and emergency tank costs), whereas the annual cost of the ASR would be $395,000. In addition, some cost savings for operating the plant at a constant rate may not be factored in to this calculation. Therefore, while ASR allows for more versatility, plant operating and expenditure preferences in selecting ASR as a management solution remain.

Permitting requirements will factor into the decision as well. A Water Quality Criteria Exemption or Aquifer Exemption would be required for inter-aquifer transfer of raw ground water to the Glencoe Wellfield, in addition to the SJRWMD CUP and the FDEP UIC Class V Group 7 Permit required for all ASR systems. Since potable ASRs have been permitted throughout Florida, this permitting scenario is likely to be achievable. Raw water ASR may have less success, and thus represents an additional permitting risk.

In conclusion, ASR is a feasible technology for the City of New Smyrna Beach based on the initial results of the ASR screening evaluation. The results show the flexibility of applying the ASR technology and the issues to consider to determine the application of an ASR system. Before proceeding with any further hydrogeologic data collection, an evaluation of the use of ASR to address wetland impacts would be valuable. If this evaluation demonstrates that ASR could effectively address wetland impacts, UCCNSB could proceed with developing an ASR test plan for this facility.

REFERENCES

CH2M HILL. *Aquifer Storage Recovery Feasibility. Alternative Water Supply Strategies in the St. Johns River Water Management District.* Technical Memorandum C.1.c. Prepared for SJRWMD. Gainesville, FL. CH2M HILL. 1996.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *Glencoe Wellfield Management Study.* April 1987.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *S.R. 44 Wellfield Expansion.* December 1990.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *Water Supply Master Plan, Volusia City-County Water Supply Cooperative.* January 1991.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *Water Supply Master Plan, Update and Expansion, Volusia City-County Water Supply Cooperative.* March 1994.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *Glencoe Wellfield Safe Yield Analyses, Initial Findings,* n.d.

Hartman & Associates, Inc. *Draft Exploratory Reuse ASR Well.* August 1995.

Hartman & Associates, Inc. Utilities Commission City of New Symrna Beach Exploratory Reuse Well. August 1995.

Korelich, Peter A., P.E., Chief Engineer, UCCNSB; David B. Hoover, Treatment Operations Division Chief, UCCNSB; and Steve Zimmerman, Superintendent of Water Production, UCCNSB. Meeting with the authors. October 16, 1996.

Miller, James A. Hydrologic Framework of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina. USGS Professional Paper 1403-B. 1986.

Utilities Commission, City of New Smyrna Beach (UCCUSB). Water & Pollution Control Department Operational Summary - FY 1995. 1995.

Utilities Commission, City of New Smyrna Beach (UCCUSB). Water & Pollution Control Department Operational Summary - FY 1989. 1989.

130581.SJ.AS 11/96 GNV

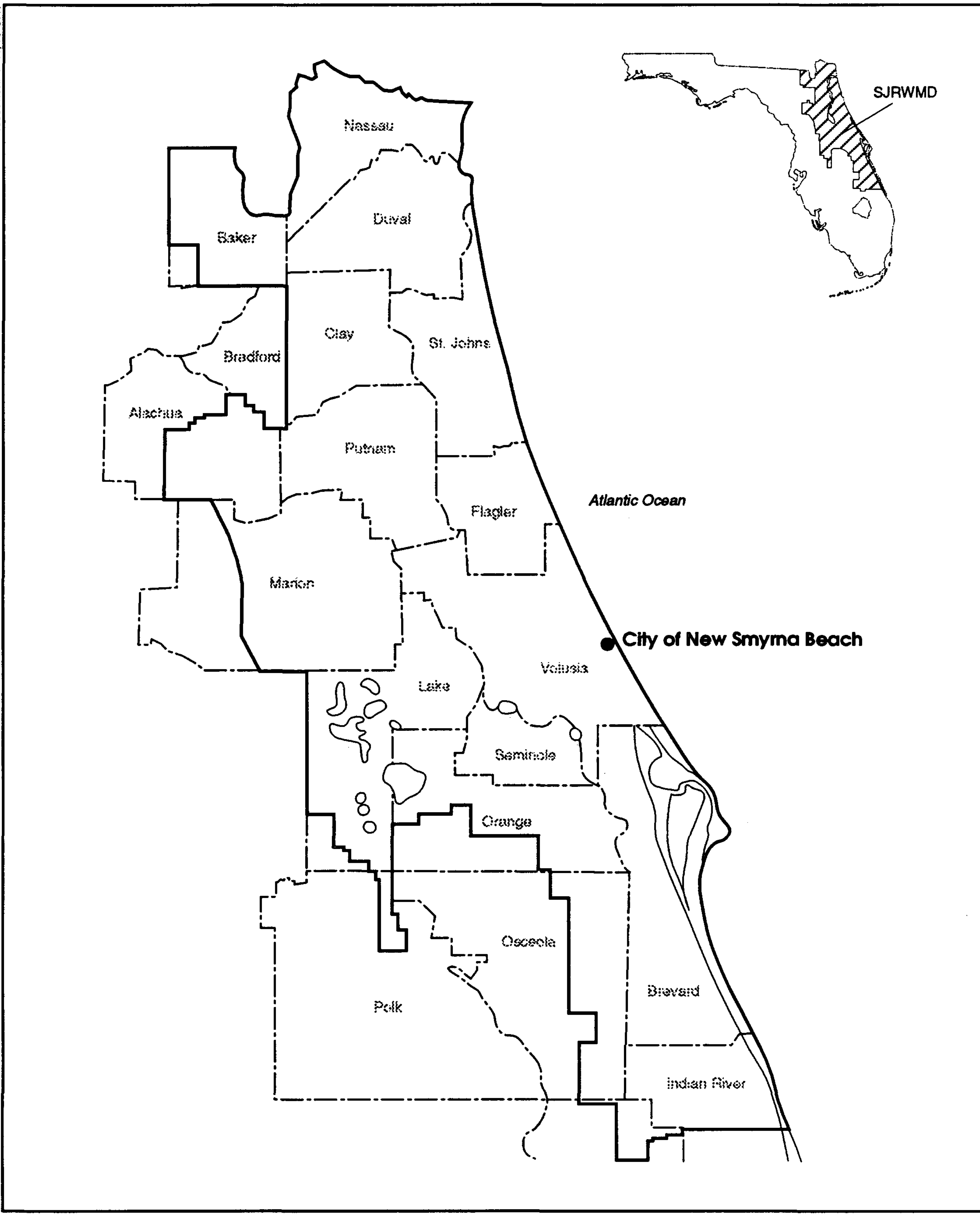


Figure B-1. Location of City of New Smyrna Beach.

County Boundary
District Boundary
Scale in Miles
0 8 16
N

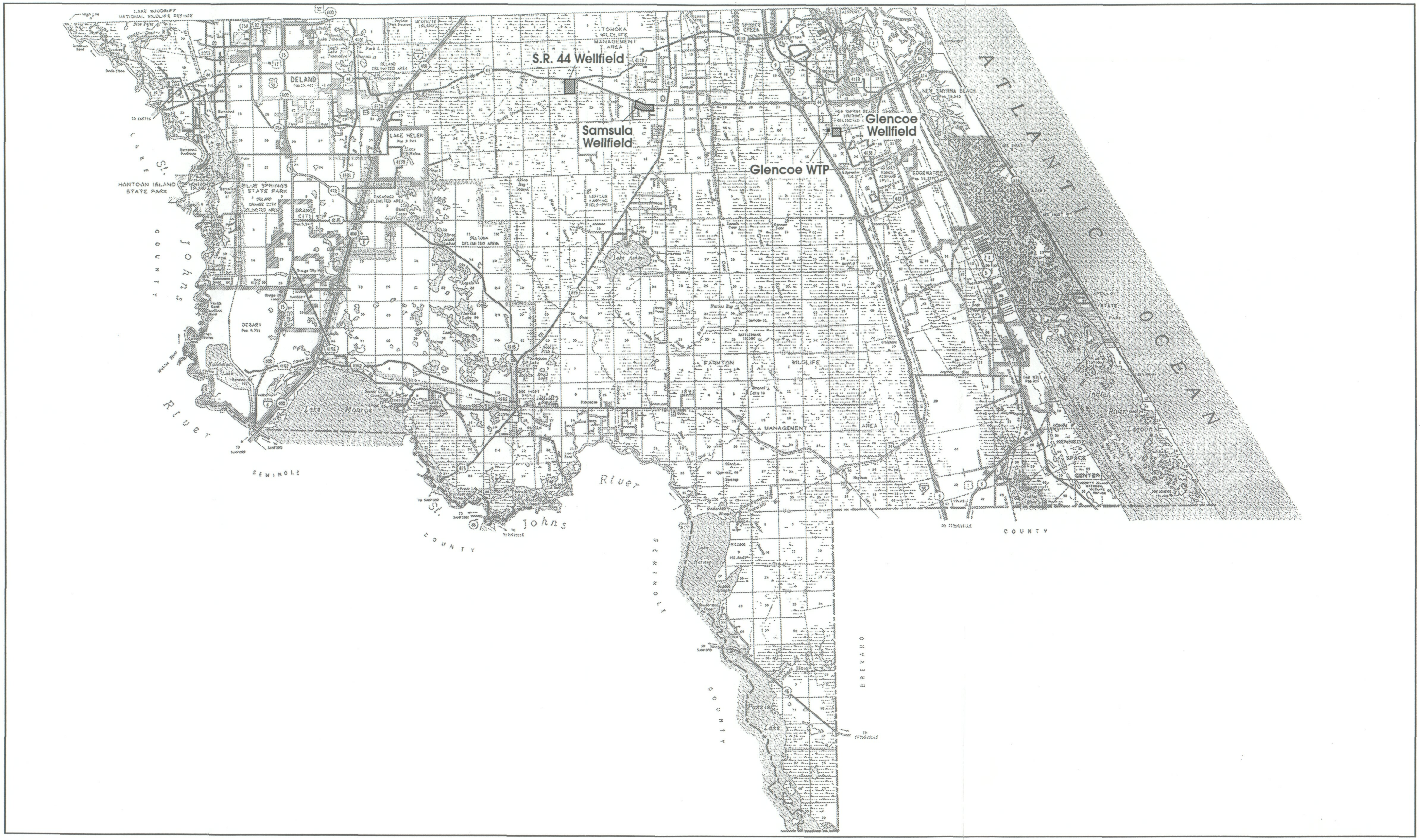


Figure B-2. UCCNSB Water Treatment Plant and Wellfield Locations.

Approximate Scale in Miles
0 2 4

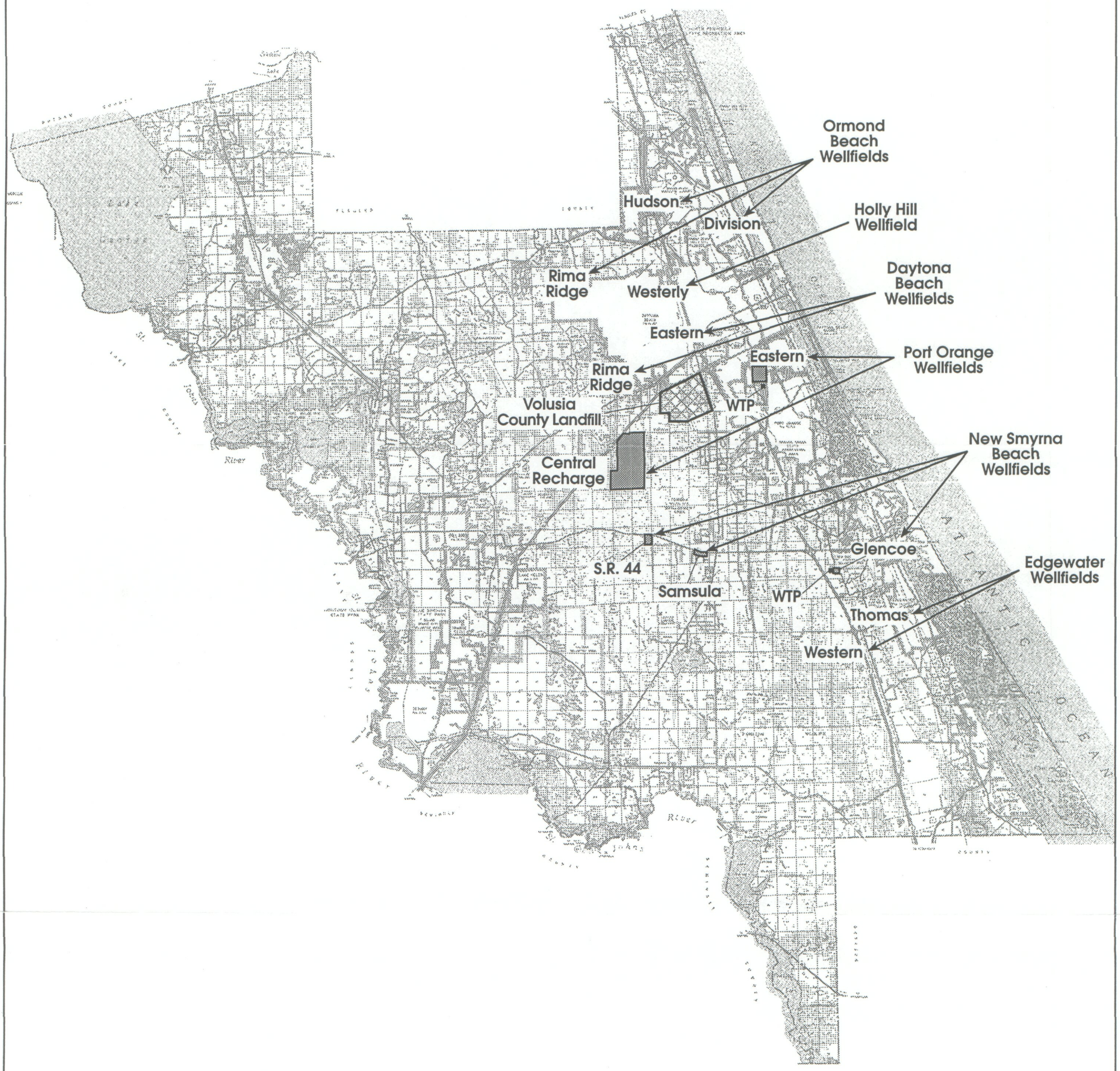


Figure B-3. UCCNSB Interfering Uses and Impacts.

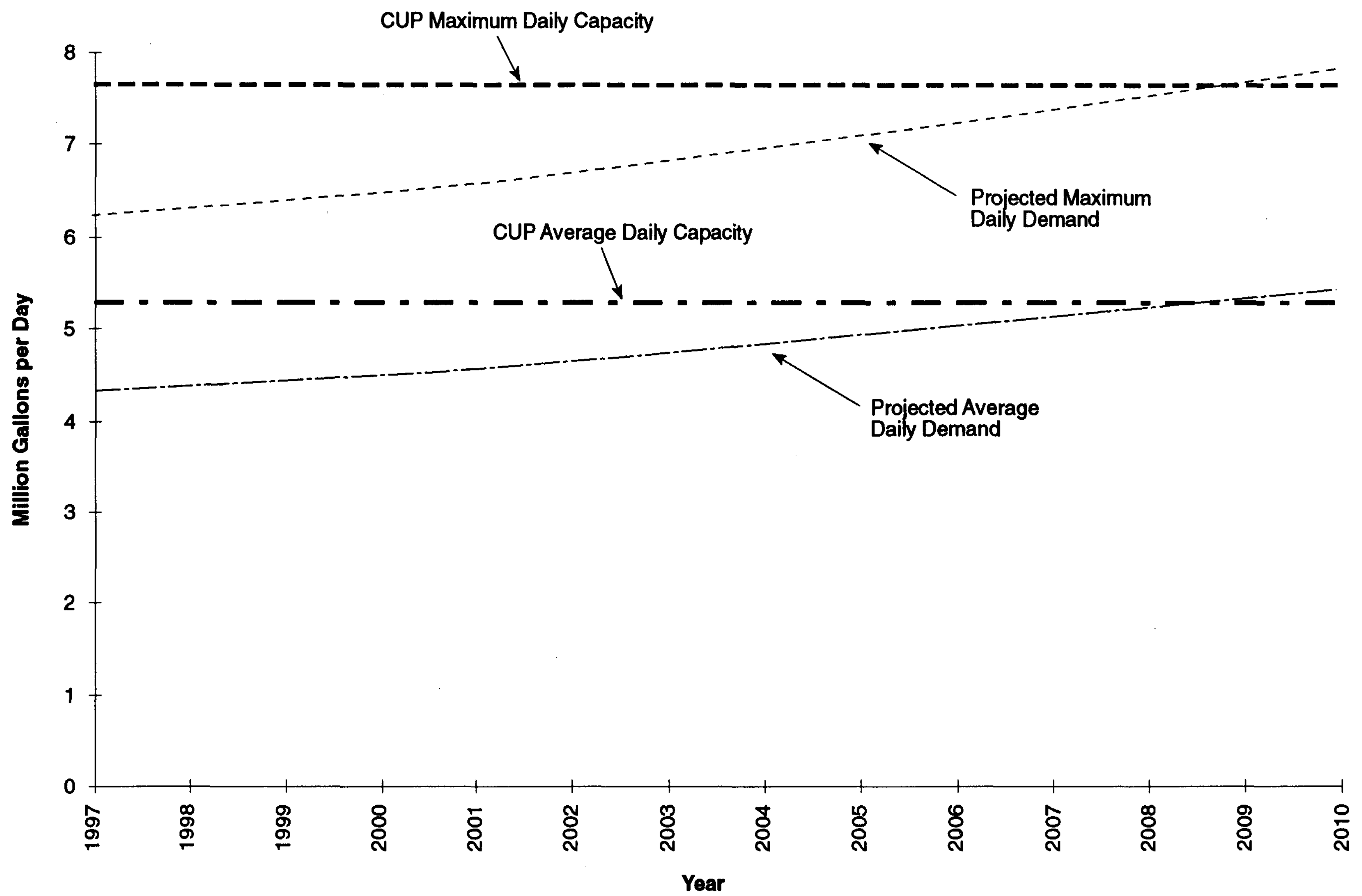


Figure B-4. UCCNSB Long-Term Storage Need.

130581.SJ.AS 11/96 GNV

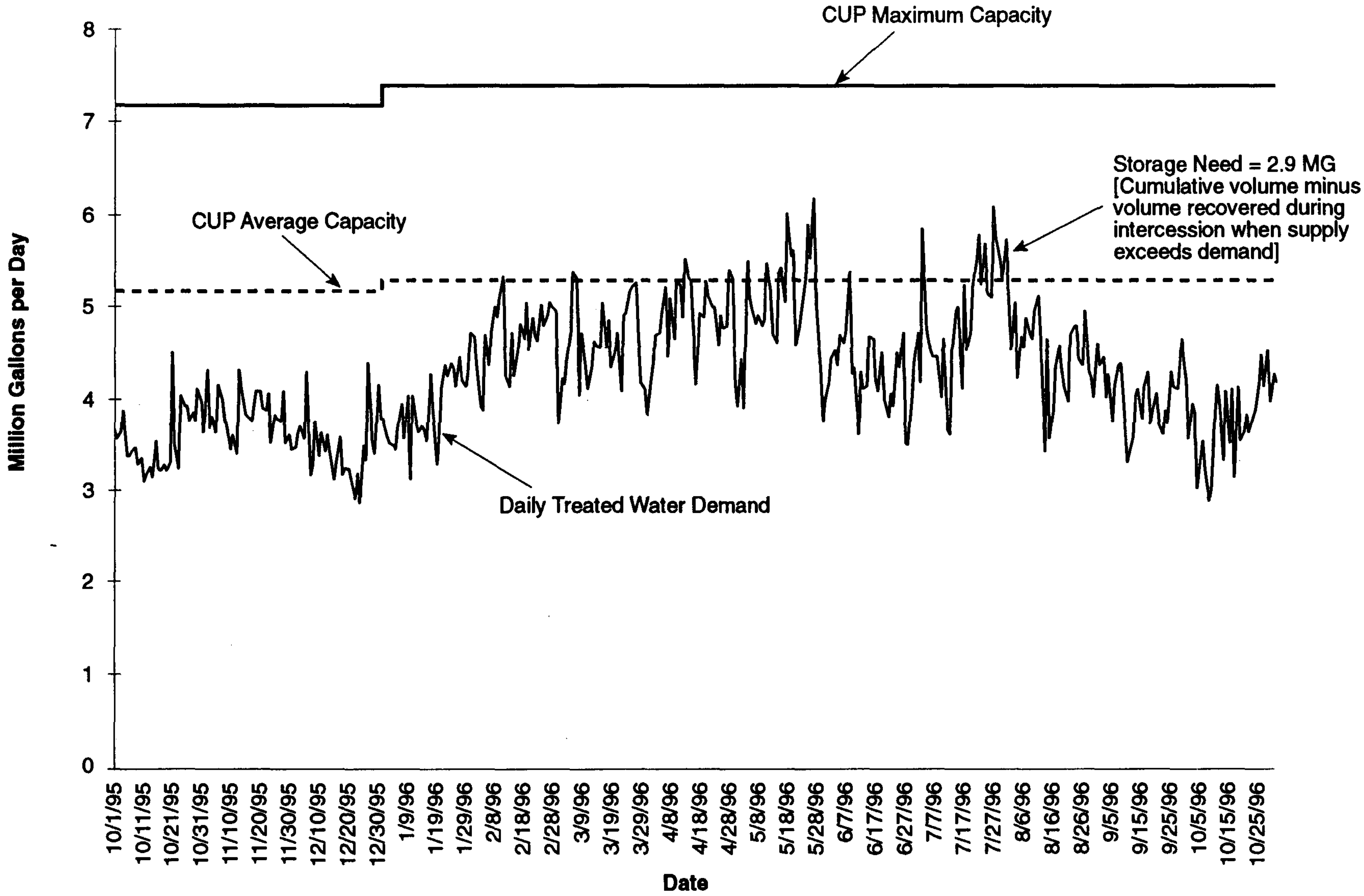
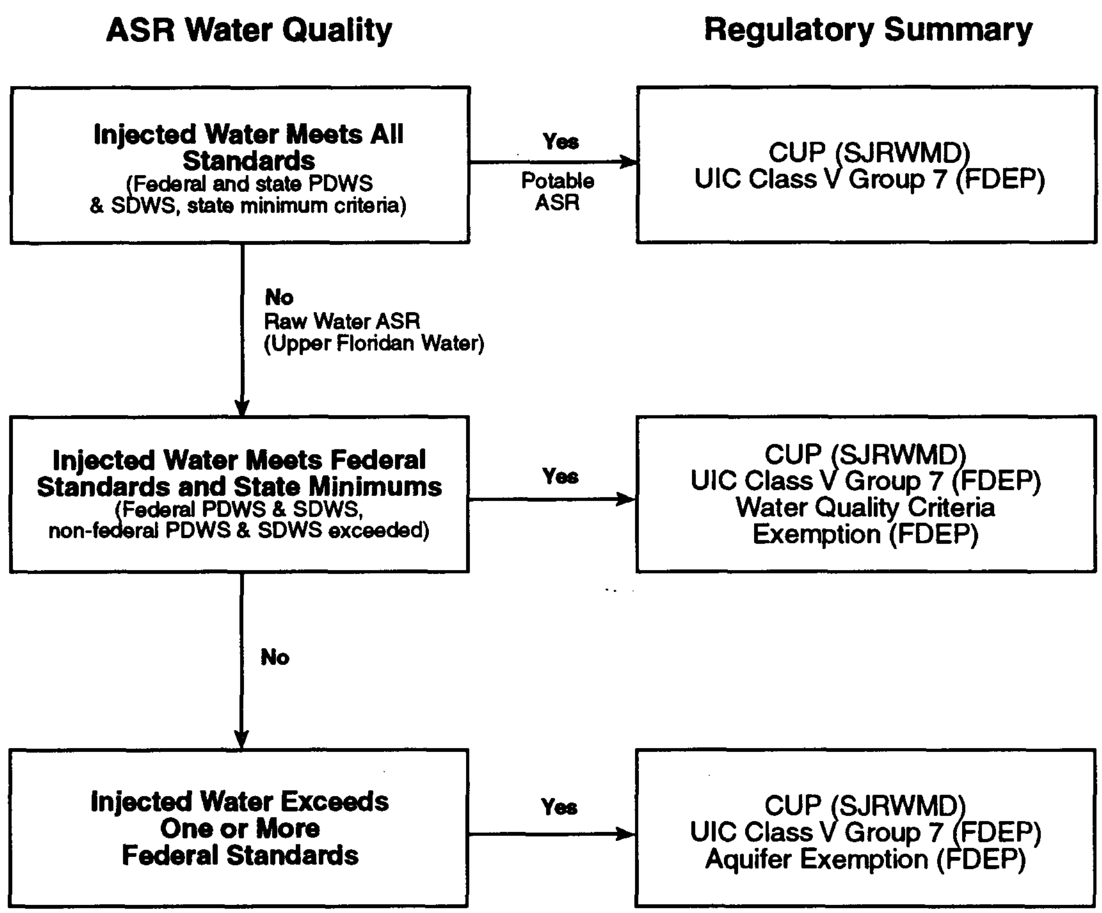


Figure B-5. UCCNSB Seasonal Storage Need for Water Quantity.

130581.SJ.AS 11/96 GNV



Note: Injected water can be either treated or raw.

Figure B-6. Possible ASR Regulatory Requirements for UCCNSB.

Feasibility Screening Report
Parts A and B

Facility Designation: Utilities Commission, City of New Smyrna Beach — Water Source: Upper Floridan Ground Water — Date: 12/2/96

Facility Director: Peter A. Korelich, P.E. — Intended Use: Potable Supply

Water Management District: St. Johns River Water Management District — Date: ______

District Officer: ______

PART A FACILITY PLANNING FACTORS

1	Average Daily Demand (End of Planning Period):	5.5	mgd	Is ADD Greater Than 1 mgd?	X YES ___ NO
2	a. Total Supply Volume for Planning Period:	27,031.9	MG	Is the Supply Volume Greater Than Demand Volume?	X YES ___ NO
	b. Total Demand Volume for Planning Period:	24,659.4	MG		
3	List Storage Need Volumes Calculated:				
	a. Long Term Volume:	0	MG		
	b. Seasonal Volume (For Quantity and Quality):	7	MG		
	c. Short Term Volume:	-	MG	Are any of the Volumes Greater Than 5 MG ?	X YES ___ NO
	d. Other (Emergency, Plant Operations, etc):	18	MG		
	e. Total a. through d., above	25	MG		

PART B HYDROGEOLOGIC, DESIGN, AND OPERATION FACTORS

	ASR Hydrogeologic, Design and Operation Factor Scores							
	1	2	3	4	5	6	7	
Section Points	Storage Zone Confinement	Storage Zone Transmissivity	Local Aquifer Gradient/Direction	Recharge Water Quality	Native Water Quality	Physical, Geochemical Interactions	Interfering Uses and/or Impacts	
5	5			5				High Feasibility Zone
4							4	High Feasibility Zone
3		3	3			3		Further Investigations Needed Zone
2					2			Further Investigations Needed Zone
1								Further Investigations Needed Zone
Weight Factor	X 10	X 10	X 1	X 2	X 10	X 5	X 5	Total Score
Score	50	30	3	10	20	15	20	148

Score	Feasibility Level	Type of Study Recommended
160-215	High Confidence	General – Confirm Assumptions
100-159	Moderate Confidence	Focused – Investigate Specific Factors
43-99	Low Confidence	Detailed – Evaluate Impact of Critical Factors

Feasibility Screening Report
Parts C and D

Facility Designation: Utilities Commission, City of New Smyrna Beach — Date: 12/2/96

Facility Director: Peter A. Korelich, P.E.

Water Management District: St. Johns River Water Management District — Date: ______

District Officer: ______

PART C COST COMPARISON SUMMARY

Cost Comparison for Storage Options

Storage Need (SN): Emergency: 18.1 MG; Seasonal: 6.8 MG

ASR Recovery Rate = 5.5 mgd

Peak Factor (PF): 1.5

Recovery Duration (RD): 28 days

ASR Recovery Rate $\frac{PF + SN}{RD}$ = 0.4 mgd

Equivalent Annual Costs

	Seasonal		Emergency
Tank	$ 143,000	*(Figure A-5)*	$ 338,000
Reservoir	$ N/A	*(Figure A-5)*	$ N/A
ASR	$ 29,000	*(Figure A-5)*	$ 395,000

Cost Comparison for Management Options

Plant Rate Increase: N/A mgd (Planned upgrade to meet 2010 demand)

Equivalent Annual Costs

Plant Upgrades	Base Cost	Option 1	Option 2	Option 3	Option 4
Lime Softening and					
Sulfide Reduction by	Tray Aeration *(Figure A-8)*				
	Packing Tower *(Figure A-9)*				
	Ozonation *(Figure A-10)*				
TOTAL					

Equivalent Annual Cost for Options

Plant Upgrade $ ______ (total cost from option selected from the table above)

ASR $ ______ *(Figure A-4)*

PART D REGULATORY SUMMARY

	YES	NO	
Injected water meets all standards	X		(refer to Figure A2 for regulatory requirements)
Injected water meets federal standards and state minimums	X		(refer to Figure A2 for regulatory requirements)
Injected water exceedes one or more federal standards		X	(refer to Figure A2 for regulatory requirements)

Appendix C

ASR Feasibility Screening City of Port Orange

CONTENTS

ASR FEASIBILITY SCREENING—CITY OF PORT ORANGE

FIGURES

TABLES

ASR FEASIBILITY SCREENING — CITY OF PORT ORANGE

The City of Port Orange is located approximately 2.5 miles south of South Daytona on the eastern coast of Florida (Figure C-1). The largest nearby city to the north is Daytona Beach, at a distance of approximately 6 miles. The largest nearby city to the south is New Smyrna Beach, at a distance of approximately 10 miles.

Information about the City of Port Orange utility and specific water use data were provided by Public Utilities personnel during a site visit on October 4, 1996 (Stevens and Griffith, 1996).

OVERVIEW

The City of Port Orange is a growing coastal community with approximately 59,000 permanent potable water customers. During the 1980s, the City of Port Orange experienced 100 percent growth. To date in the 1990s, the City has experienced growth of approximately 50 percent. The 1995 average daily water demand was approximately 5.2 million gallons per day (mgd), with a maximum demand of approximately 7.8 mgd. The City experiences seasonal high fluctuations owing to an influx of vacationers during Bike Week, Race Week, and Spring Break. However, the year's daily data suggests higher demands throughout the summer months. Therefore, the City's peak season is from early spring until late fall. Water demands are projected to increase with the population growth and to experience continuing seasonal fluctuations.

Existing Facilities

The City of Port Orange water supply system consists of a water treatment plant (WTP), two wellfields, and several aboveground storage tanks, in addition to the water distribution system.

Water Treatment Plant. Originally built in 1980, the City of Port Orange WTP is located west of the city (Figure C-2). In 1986, this lime-softening facility was expanded from the original 5-mgd capacity to 10-mgd capacity. According to the utility staff, the plant currently operates at approximately 6 mgd range. Treated water leaving the WTP for distribution has chloride and total dissolved solids (TDS) concentrations of 45 mg/L and 210 mg/L, respectively.

Water Supply. The City's water supply is recovered from two wellfields, the Eastern Wellfield (EW) and the Central Recharge Wellfield (CRW), both completed in the Upper Floridan aquifer (Figure C-2).

The EW was constructed in 1972 near the Port Orange WTP. Thirteen wells currently provide water to the City. The water quality of these wells slowly degraded over time from an initial chloride concentration of 80 milligrams per liter (mg/L) to a concentration of 180 mg/L, which may be due to saltwater intrusion. The wells in this wellfield were mechanically rehabilitated in 1991 and are now in good condition. All of the EW wells are powered by supplied electricity and eight wells have emergency diesel backup.

The CRW was constructed in 1987. With the expansion in 1987, the CRW currently includes 21 wells providing water to the City of Port Orange. This wellfield, located approximately 6.5 miles southwest of the EW, was constructed due to land constraints in the EW and increasing chloride levels in the EW. It is also beyond the County designated buffer line established to avoid exacerbation of chloride movement west, and is a known recharge area. In addition, the land was available for purchase to control adjacent development. The 21 wells in the CRW are powered by supplied electricity. The newer six wells are also equipped with emergency diesel power in the event of a power outage.

Since installation of the CRW, the EW has experienced reduced pumping rates that, over time, have lowered the chloride levels. The wellfields now exhibit chloride levels at around 38 mg/L (EW) and 107 mg/L (CRW).

Water Supply Storage. The City currently has 5.5 million gallons (MG) of storage capacity in aboveground tanks in four locations. However, only 4.5 MG is available for public supply; the remaining 1 MG is used at the WTP. With 100 percent of the total storage available, the City's demands could be met for approximately 20 hours.

Future Facility Expansions

By the year 2010, the average daily demand is expected to be over 9.4 mgd, with a maximum demand of approximately 15 mgd. Facility expansions are planned to meet the projected water demands.

Water Treatment Plant. An expansion of the Port Orange WTP is currently in the design process. This addition will increase the maximum treatment capacity to 15 mgd. The City plans to complete construction in 1998. However, the City will not apply for a Consumptive Use Permit (CUP) modification until the additional capacity is needed.

Water Supply. The City of Port Orange currently co-owns 5,800 acres with Daytona Beach and Volusia County. The City of Daytona Beach operates a wellfield directly north of the CRW. The City of Port Orange has plans to add 10 new wells. However, construction is not scheduled in the immediate future.

Water Supply Storage. An additional 4-MG aboveground tank is proposed for construction if the Florida Disinfection Rule is passed. This addition would increase the public storage volume to 8.5 MG and allow the City water demands to be met for approximately 40 hours.

Water Supply System Restrictions

Wellfield Operations. The City's CUP dictates that 70 percent of the water production should come from the CRW. The remaining 30 percent is to be produced from the EW.

Existing CUP Restrictions:

Maximum Annual Withdrawals		*Maximum Total Daily Withdrawals*	
2,390.7 MG	1997	9.93 mgd	1997
2,478.4 MG	1998	10.18 mgd	1998
2,562.3 MG	1999	10.21 mgd	1999
2,631.7 MG	2000	10.25 mgd	2000

Water Shortages. Water shortages and withdrawal constraints have occurred in the past due to drought conditions in the area. When drought conditions exist, the water levels decline and the drawdowns in the supply wells increase, requiring the withdrawal rate to be reduced to keep drawdowns from becoming excessive. Water shortages have also occurred due to electrical power outages. Eight wells in the EW and six wells in the CRW have emergency diesel power that will temporarily support the system until power can be restored.

Wetlands Monitoring. The City is in the third year of monitoring wetlands around the wellfields. This monitoring is associated with the conditions of the CUP to minimize or determine the effects of pumping on the wetlands.

Environmental Impacts. The Volusia County Tomoka Landfill is located approximately 2.5 miles northeast of the CRW (Figure C-3). Volusia County currently operates a ground water monitoring system along the western area of the landfill. The City of Port Orange also installed its own ground water monitoring well cluster approximately 2 miles away. That cluster consists of a shallow aquifer well and three Upper Floridan aquifer monitoring wells.

Interfering Uses. The City of Daytona Beach operates two public supply wellfields in the area: Rima Ridge Wellfield, located approximately 3 miles north of the CRW and 7 miles from the EW; and their own Eastern Wellfield, located approximately 5.5 miles from both the CRW and the City of Port Orange's EW. These wellfields are completed in the Upper Floridan aquifer (Figure C-3).

The City of New Smyrna Beach Utilities Commission operates three nearby public supply wellfields: Glencoe Wellfield, located 10 miles south of EW and 12.5 miles southeast of CRW; Samsula Wellfield, located 7 miles southeast of CRW and 9 miles southwest of EW; and the S.R. 44 Wellfield, located 5.5 miles southwest of the CRW and 10 miles southwest of EW. These wellfields are also completed in the Upper Floridan aquifer (see Figure C-3).

Other Issues

The City of Port Orange uses an extensive reclaimed water system for irrigation purposes. Approximately 1,400 of the 3,800 service locations are currently used. Projections show a shortage of reclaimed water in the future. Currently, 1,400 connections are using approximately half of the water supply. Due to the desire to have zero wastewater treatment plant effluent discharge to the Halifax River by 1990, this reclaimed water program was initiated voluntarily by the City with a pilot system in 1985. The reclaimed water distribution system supplies golf courses, City-owned land, and several new and existing residential communities in the area. This system presently supplies approximately 2 mgd for irrigation purposes.

ASR FEASIBILITY RANKING REPORT

As each section of the screening tool is reviewed, a score is determined that best represents the site-specific characteristics. At the end of the ranking process, each score is weighted as to its degree of importance and a final score is calculated. The magnitude of this score identifies a relative ASR feasibility for the site.

Part A. Facility Planning Factors

Step 1. List the Average Daily Demand.

Instructions: For Potable Use, if the ADD is greater than 1 mgd, proceed to Step 2. If the ADD is less than 1 mgd, another solution should be evaluated. For Agricultural Use, proceed to Step 2.

The City of Port Orange's average daily demand for 1995 was 5.2 mgd. The projected daily average demand for the year 2010 is 9.4 mgd.

Step 2. List the Total Supply and Demand Volumes for the Planning Period.

Instructions: If the total supply volume is larger than the total demand volume, proceed to Step 3. If the demand is larger than the supply, investigate other supply increase and demand reduction solutions.

For the purposes of this study, the planning period is defined as 1997-2010, which corresponds to the end of the planning period used in the SJRWMD Needs and Sources study. The CUP for the City of Port Orange extends to the year 2000, allowing 2,390.7 MG with a 9.93-mgd maximum for 1997; 2,478.4 MG with a 10.18-mgd maximum in 1998; 2,562.3 MG with a 10.21-mgd maximum in 1999; and 2,631.7 MG with a 10.25-mgd maximum in 2000. Carrying the year 2000 annual value through 2010, the total supply would be 36,380.1 MG (the sum of 2,390.7 MG, 2,478.4 MG, and 2,562.3 MG multiplied by 1 year plus 2,631.7 MG multiplied by 11 years). The treatment capacity for the WTP is 10 mgd. The City plans to expand capacity to 15 mgd in the near future. Therefore, the CUP value is the limiting condition.

Demand data are presented below for the City of Port Orange. Projected flow data from the Volusia City-County Water Supply Cooperative's Water Supply Master Plan, Update and Expansion *(Dyer, Riddle, Mills, and Precourt [DRMP], 1994) were used to calculate the total demand volume for the 1997-2010 planning period.*

Since the total demand volume, 38,970.3 MG, is greater than the total supply volume, 36,380.1 MG, a water supply problem can be anticipated unless a CUP increase is obtained prior to the end of the planning period. As a CUP renewal will be required in a few years, CH2M HILL proceeded with this screening tool, assuming that the minor increase in CUP quantity needed for this preliminary screening level would be met.

Year	AADF[1] [mgd]	Annual Volume [2] [MG]
1997	6.074	2217.0
1998	6.306	2301.7
1999	6.538	2386.4
2000	6.770	2471.1
2001	6.986	2546.9
2002	7.202	2628.7
2003	7.418	2707.6
2004	7.634	2786.4
2005	7.850	2865.3
2006	8.166	2980.6
2007	8.482	3095.9
2008	8.798	3211.3
2009	9.114	3326.6
2010	9.430	3442.0
Total		38,970.3

[1]Average Annual Daily Flow (AADF) data were projected in the *Water Supply Master Plan, Update and Expansion* (DRMP, 1994). Linear interpolation used for values were not explicitly stated in the report.

[2]6,074 mgd x (1 year x 365 days/year) = 2217.0 MG.

Step 3. List Storage Need Volumes Calculated as a Long-Term Volume, a Seasonal Volume, a Short-Term Volume, or Other.

Instructions: If the total volume is greater than 5 MG, proceed to Part B, below. If the total volume is less than 5 MG, investigate other storage options.

Long-Term Storage Need: The current CUP capacities and the projected demands defined in Step 2 indicated that available supply capacity exists to *provide long-term storage. Approximately 598 MG would be available for long-term storage to delay the plant upgrade from 2002 until 2006. This estimate is based upon annual volumes and assumes that maximum demands can be met during the banking process using the existing 5.5 MG of tank storage.*

Seasonal Storage Need: Demand and supply values were plotted for 1 year (January 1, 1995, through December 31, 1995). These plots and the average CUP withdrawal revealed a seasonal fluctuation that would correspond to a peak storage need of approximately 4.6 MG (refer to Figure C-5). An 8-MG seasonal storage need was projected for 2010 (4.6 multiplied by the 2010 to 1995 average demand ratio, 9.4/5.2). (See Figure C-4.) This storage need would add to the long-term storage need identified above.

Other storage needs were not specifically quantified for this site. However, it is feasible for additional benefits to be derived from ASR storage. First, the plant could be operated at a consistent level rather than varying the operations based on demand. In addition, it would be feasible to incorporate an emergency water supply storage for the City of Port Orange.

Thus, the total storage need for the City is 606 MG, the combination of the long-term and seasonal storage needs.

Part B. Hydrogeologic, Design, and Operation Factors

Area Hydrogeology

The hydrogeologic factors needed to evaluate the feasibility of ASR include the occurrence and depths of transmissive and confining intervals in the Upper and Lower Floridan aquifers. The characteristics of confining beds overlying the Floridan aquifer are also important in the evaluation of suitable zones. In Volusia County, the most probable ASR zones are expected to occur in the Upper Floridan aquifer.

The surficial aquifer system in Volusia County varies in thickness with the depth to the top of the Hawthorn Group. The surficial aquifer is from 0 to 100 ft thick.

The Hawthorn Group acts as a semi-confining unit between the surficial deposits and the Upper Floridan aquifer. Although the Hawthorn Group has low permeability, recharge occurs between the surficial aquifer and the Floridan aquifer, because the confinement is thin or non-existent (Miller, 1986). Although the Hawthorn Group is absent in parts of Volusia County, well logs at the City of New Smyrna Beach Glencoe Wellfield included a Hawthorn layer (Hartman, 1995). City of Port Orange well logs were not reviewed to determine the presence of the Hawthorn.

The Floridan aquifer consists of the Ocala Group and Avon Park Formation geologic units, which are mostly limestones, dolomite, and some sand, to a depth of approximately 2,300 feet bls in Volusia County. The Ocala Group is found at a depth of approximately 100 feet in eastern Volusia County, but is not present in the western portion due to extensive erosion. The Ocala Group is composed of off-white, white, and gray limestone, and can be slightly dolomitized in Volusia County (Miller, 1986). Beneath the City of New Smyrna Beach Glencoe Wellfield, the bottom of the Ocala Group is marked by a more dense dolomitic limestone. This layer also marks the change between the Ocala Group and the Avon Park Limestone.

The Avon Park Formation extends from approximately 200 to 1,200 feet bls. This is a highly fossiliferous limestone, with intervals composed of crystalline dolomite. This formation varies greatly in color and hardness. There are interbedded layers of soft white-chalky limestones, light brown or gray limestones, and brown dolomites (Miller, 1986).

Suitable ASR zones are expected to occur in the Upper Floridan aquifer between 250 and 400 feet bls and in the Lower Floridan aquifer between 500 and 900 feet bls.

Step 1. Storage Zone Confinement

Instructions: Use Table C-1 to rank the hydraulic conductivity and thickness of the vertical flow restrictive units (aquitard) above and below the storage zone. This data can be gathered from local wells in the same zone or from regional published information. Table 3 from Technical Memorandum (TM) C.1.c (CH2M HILL, 1996) presents an example ranking based on a 100-foot-thick confining unit, which shows how Figure A-2 (TM C.1.c) is used to determine the ranking.

Data obtained from the City of New Smyrna Beach reclaimed water ASR test well indicated that good confining beds are likely to exist within the Upper and Lower Floridan aquifers. Because the City of Port Orange and the City of New Smyrna Beach have a similar hydrogeological makeup, the test well data were also used for Port Orange. Therefore, a rank of 5 was selected.

Table C-1. Storage Zone Confinement Ranking

Rank	Aquitard Hydraulic Conductivity	Aquitard Thickness
5	1.0×10^{-5}	100 feet

Step 2. Storage Zone Transmissivity

Instructions: Use Table C-2 to rank the target storage zone transmissivity. This data can be gathered from local wells in the same zone or from regional published information. Figure A-3 (TM C.1.c) should be used in conjunction with Table C-2 to determine the ranking.

Average transmissivity of the Upper Floridan aquifer has been noted in a regional publication as 50,000 to 300,000 gallons per day per foot (gpd/ft) (Tibbals, 1990). The Lower Floridan aquifer has not been extensively evaluated in the area. The reclaimed water ASR test well at New Smyrna Beach was pump tested at depths between 700 and 900 feet. A transmissivity of 38,000 gpd/ft was calculated. Although the regional data have higher estimated values for transmissivity, for the purposes of this evaluation, an estimated storage zone transmissivity of 15,000 to 40,000 gpd/ft was used, resulting in a rank of 3.

Table C-2. Storage Zone Transmissivity Ranking

Rank	Transmissivity Criterion (gpd/ft)		Applicability
	Potable Water	Untreated Surface Water	
1	Less than 8,000	Less than 80,000	Limited
2	8,000 to 15,000	80,000 to 250,000	
3	**15,001 to 40,000**	250,001 to 400,000	
4	40,001 to 50,000	400,001 to 500,000	
5	50,001 to 80,000	500,001 to 1,000,000	Optimal
4	80,001 to 120,000	1,000,001 to 1,150,000	
3	120,001 to 200,000	1,150,001 to 1,400,000	
2	200,001 to 400,000	1,400,001 to 2,000,000	
1	Greater than 400,000	Greater than 2,000,000	Limited

Step 3. Aquifer Gradient and Direction

Instructions: Rank the local aquifer gradient and direction. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table C-3.

A rank of 3 was selected because numerous wellfields exist in the area north and south of the City's wellfields. Depending on the depth of the ASR *storage zone, these wellfields could influence the movement of the stored water of the ASR system.*

Table C-3. Local Aquifer Gradient/Direction Ranking

Rank	Aquifer Gradient (in same recharge zone)	Direction Criterion
1	Many strong influences exist	Extreme artificial gradient, reevaluate location of ASR system
2	Several strong influences	Exaggerated gradient, investigation needed
3 (default)	Multiple minor influences exist	Affected gradient worth investigating
4	Single minor influence or abnormal natural gradient	Minor investigation or existing data search
5	No influence	No influence

Step 4. Recharge Water Quality

Instructions: Rank the recharge water quality using chloride or TDS concentrations of the water to be stored in the ASR zone. For potable water, this data can be obtained from the records of the WTP that will be supplying the source water. For raw water, this can be determined from published records or databases. If this information is not available, use the default value shown in Table C-4.

Treated water leaving the WTP for distribution has chloride and TDS concentrations of 45 mg/L and 210 mg/L, respectively. The concentration for chlorides was used, providing a rank of 5.

Table C-4. Recharge Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Compliance with SDW Standards
1	Greater than 200	or	Greater than 450	Just within SDW standards
2	200 to 171		450 to 351	
3	170 to 101		350 to 201	Moderately meets SDW standards
4	100 to 50		200 to 100	
5	**Less than 50**		Less than 100	Well within SDW standards

Step 5. Native Water Quality

Instructions: Rank the native water quality based on the chloride or TDS information of the native water in the target ASR zone. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table C-5.

The water quality of the Upper Floridan aquifer rapidly becomes nonpotable below the wellfield production zone. Between the depths of 250 and 400 feet, TDS concentrations are expected to range from 1,000 to 5,000 mg/L. The reclaimed water ASR test well at New Smyrna Beach had TDS concentrations greater than 30,000 mg/L between 700 and 900 feet. For this evaluation, a rank of 2 was used to reflect the generally poor native water quality.

Table C-5. Native Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Water Quality
1	Greater than 6,000	or	Greater than 10,000	Very brackish
2	**6,000 to 3,001**		**10,000 to 5,001**	
3	3,000 to 801		5,000 to 1,301	Slightly brackish
4	800 to 400		1,300 to 700	
5	Less than 400		Less than 700	Near fresh water

Step 6. Physical, Geochemical, and Design Interactions

Instructions: Rank the potential for physical, geochemical, or design interactions. This rank is based on the sum of the ranks from the sub-categories shown in the table below. If this information is not available, use the default value shown in Table C-6.

Some parameters included in the ranking tool are not ordinarily included in the routine water quality analysis performed on the treated water. In cases where parameter values were missing, default ranks were incorporated that flag these parameters as needing further analysis. The water quality value for the treated water of the City of Port Orange is provided in parentheses after the selected rank in Table C-6.

Table C-6. Overall Physical, Geochemical, and Design Interaction Ranking for SJRWMD

Sub-Category	Rank	Recharge Water and Criterion	Selected Rank
Physical Interactions from Suspended Solids			
TSS	1 2 3	TSS>2.0 mg/L 2.0 mg/L>TSS>0.05 mg/L **(default)** TSS<0.05 mg/L	2
Biological Growth and Geochemical Interactions			
pH	**1** 2 3	**7.8<pH< 8.6** (default) pH>8.6 pH<7.8	1 (8.4)
Total Phosphorous	1 2 3	P>0.1 mg/L 0.1 mg/L>P>0.05 mg/L **(default)** P<0.05 mg/L	2
Nitrate as N	1 2 3	N>1 mg/L 1 mg/L>N>0.5 mg/L **(default)** N<0.5 mg/L	2
Dissolved Organic Carbon (DOC)	1 2 3	DOC>5 mg/L 5 mg/L>DOC>2.5 mg/L **(default)** DOC <2.5 mg/L	2
Total Iron (Fe)	1 2 **3**	Fe>1 mg/L 1 mg/L>Fe>0.3 mg/L (default) **Fe<0.3 mg/L**	3
Dissolved Oxygen (DO) of Recharge Water	1 2 3	DO>3 mg/L 3 mg/L>DO>1.5 mg/L **(default)** DO<1.5 mg/L	2
Point Totals			14
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**3**

Note: Use the default value if data for any parameter is unavailable. Determine the overall rank from the following point totals:

Rank	Physical, geochemical, and design criteria (total of above points)	
1	7-10 points	Higher potential for plugging
2	11-12 points	
3	**13-16 points**	*Moderate potential for plugging*
4	17-18 points	
5	19-21 points	Low potential for plugging

Step 7. Interfering Uses and Impacts

Rank the interfering uses and impacts which can exist or have the possibility to exist in the vicinity of a proposed ASR site. Information can be gathered from visual surveys, aerial photographs, topographic maps, and public records/information. This rank is determined from the sum of two sub-ranks shown in Table C-7. If this information is not available, use the default value shown.

An inventory of wells within a 5-mile radius of the Eastern WTP and Wellfield revealed the following existing wells in the area:

Number of Wells	Well Size (inches)	Well Use
17	8, 10, 12, 16	public supply
19	4, 6, 8	landscape
36	4, 6	golf course irrigation
1	8	commercial/industrial

Interfering Uses: The City of Daytona Beach Utilities operates two wellfields within a 7-mile radius of the City of Port Orange's wellfields. The City of New Smyrna Beach Utilities Commission operates three wellfields located 5.5 and 12.5 miles from the City of Port Orange's wellfields. This information earned a sub-rank of 3.

Interfering Impacts: The Volusia County Tomoka Landfill is located approximately 2.5 miles north of the CRW. This information earned a sub-rank of 3.

Table C-7. Interfering Uses and Impacts Ranking

Sub-Category	Rank and Criterion		Selected Rank
Interfering Uses			
Distance to Potable Wells	1 **2** 3	0.10 mile<Wells<0.25 mile **0.26 mile<Wells<5 miles** (default) Wells>5 miles	3 (5.5 miles)
Interfering Impacts			
Distance to Contamination Source	1 2 **3**	0.10 mile<Source<0.25 mile 0.26 mile<Source<1 mile (default) **Source>1 mile**	3 (2.5 miles)
Point Total			6
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**5**

Overall Interfering Uses and Impacts Rank determined from the following point totals:

Rank	Interfering Use and/or Impact Criteria (possibility of impact)	
1	2 points	High use or impact
2	3 points	
3	4 points	Moderate use or impact
4	5 points	
5	6 points	Low use or impact

The results of the hydrogeologic, design, and operational factors scoring are interpreted as shown in Table C-8.

The City of Port Orange Public Utilities hydrogeologic, design, and operational factors score is 153 points out of a total of 215 points (see scoring sheet at the end of this appendix). This score represents a moderate confidence for ASR feasibility. Detailed site-specific information will likely change the feasibility score to better reflect actual conditions at the proposed ASR location.

Table C-8. ASR Feasibility Score for Hydrogeologic, Design, and Operational Factors

Score	Feasibility Level	Type of Study Recommended
160 - 215	High Confidence	General—confirm assumptions
100 - 159	**Moderate Confidence**	**Focused—investigate specific factors**
43 - 99	Limited Confidence	Detailed—evaluate impact of critical factors

Part C. Cost Comparison Summary

Instructions: The annual cost figures (Figures A-4 through A-10 in TM C.1.c) were developed as a means of comparing alternative water storage and treatment options. Use the tables to complete the Cost Comparison Summary Sheet provided in TM C.1.c. On this sheet, a comparison is made between ASR, other storage options and plant upgrades, which will provide the needed water for immediate peak demand or future demands.

Costs need to be evaluated on three levels for the City of Port Orange:

1. *Storage Option Comparison for Long-Term Storage Need in a Reservoir or ASR:*

   a. *The long-term storage need of 598.1 MG was calculated for the City of Port Orange to delay plant expansion until approximately 2006. The cost associated with providing a reservoir would be calculated based on this volume as follows:*

   Annual Cost = 381,000 + 8,855$V_s^{0.8692}$, where V_s is the storage volume in MG

   *Annual Cost = 381,000 + 8,855 * (598) $^{0.8692}$*

   Annual Cost = $2,676,000

b. *For the ASR calculation, the recovery rate is required. Recovery would be for 4 years to offset supply deficits. The recovery rate would need to be consistent with the difference in the peak day demand in 2006 and the current plant capacity. The projected peak day in 2006 is approximately 13 MG, whereas the plant capacity is approximately 10 mgd at this time. Therefore, the peak recovery rate would be 3 mgd for a potential ASR system. For the purpose of this screening tool, a recovery of 0.5 mgd per well was used. Our experience in this area indicates that a recovery of 0.5 to 1.0 mgd per well is likely. Therefore, the more conservative 0.5 mgd per well value was used to provide a comparison of cost differences. The corresponding ASR cost is calculated as follows:*

Annual Cost = 71,897 X, where X is the recovery rate in mgd

*Annual Cost = 71,897 * 3.0*

Annual Cost = $216,000

2. *Storage Option Comparison for Seasonal Storage Need in a Tank or ASR:*

a. *The seasonal storage need of 8.2 MG was projected for the City of Port Orange in 2010. The cost associated with a tank to meet this storage need is calculated as follows:*

Annual Cost = 17,787 X + 18,088, where X is the storage volume in MG

*Annual Cost = 17,787 * 8 + 18,088*

Annual Cost = $160,000

b. *For the ASR calculation, the recovery rate is required. Recovery would be over approximately an 11-day period. The peak factor is the ratio of maximum day to average day, which was calculated as 1.5 using the plant records. Therefore, the peak recovery rate would be 8.2 MG * 1.5 / 11 = 1.1 mgd for a potential ASR system. The corresponding ASR cost is calculated as follows:*

Annual Cost = 71,897 X, where X is the recovery rate in mgd

*Annual Cost = 71,897 * 1.1*

Annual Cost = $79,000

3. *Management Option Comparison for ASR to Delay Plant Expansion:*

   a. *The City of Port Orange is currently planning a 5-mgd upgrade to meet 2010 peak demands. The cost associated with this upgrade would be calculated based on this rate as follows:*

   Annual Cost = 440,000 $Q^{0.687}$, where Q is the capacity increase in mgd

   *Annual Cost = 440,000 * $(5.0)^{0.687}$*

   Annual Cost = $1,329,000

The ASR cost would be the same as the storage calculation in Item 1.b, since the supply would not be available to delay the plant beyond the planning period. However, the ASR cost may be offset by the savings created by delaying the plant expansion. In addition to delaying the need for plant expansion, ASR storage may reduce the size of the required expansion. Used in conjunction with ASR, a 3-mgd plant expansion may be sufficient to meet demands. The current plan is to upgrade the plant by 5 mgd.

A cost summary sheet (Feasibility Screening Report Parts C and D) is included after all figures at the end of this appendix.

Part D. Regulatory Summary

Instructions: Part D presents the regulatory requirements for the different types of water quality. Place an "X" under the category of *YES* or *NO* to best describe the quality of the water to be stored. Figure C-6 provides the regulatory permits or exemptions needed for the different water quality groups.

Figure C-6 is a flowchart showing the permits and approvals needed for specific water qualities to be stored in the ASR well. A SJRWMD CUP and a Florida Department of Environmental Protection (FDEP) UIC Class V Group 7 Permit will be required for any ASR application. Two permitting scenarios exist for the ASR options identified for the City of Port Orange—one for potable water ASR and one for raw water ASR.

For potable water ASR, the injected water will meet all state and federal drinking water standards, since the source is from the WTP. Therefore, no other permits are expected to be required beyond the CUP and UIC Class V Group 7 Permit. This permitting scenario is likely to be feasible, since potable ASR systems have been permitted throughout Florida.

Additional permitting requirements may occur for raw water ASR, which would require an aquifer transfer from the Upper Floridan aquifer at the

CRW to the Upper Floridan at the EW. The storage zone may be in or just below the EW production zone. Although the receiving aquifer is the same as the source aquifer, the raw ground water may exceed state or federal drinking water standards. Where federal primary drinking water standards (PDWS) and secondary drinking water standards (SDWS) and state minimum criteria are met, but state PDWS or SDWS are exceeded, a Water Quality Criteria Exemption is required from FDEP. If the recharge water exceeds one or more federal standards, an Aquifer Exemption must be granted by the FDEP. Water Quality Criteria Exemptions and Aquifer Exemptions are more difficult permitting paths. However, since the aquifer transfer occurs within the same drinking water source, it is probably achievable with minor additional risk over the potable scenario.

CONCLUSIONS

The City of Port Orange was originally selected for this investigation based on concerns about EW effects on lateral saltwater intrusion and CRW withdrawal impact on the adjacent wetlands. In contrast, the City of Port Orange viewed reclaimed water storage, not potable water, as the potential application of ASR. As part of this study, CH2M HILL used the ASR screening tool and previous experience to determine potential primary ASR application and secondary benefits for potable water, to compare costs with traditional solutions, and to evaluate the regulatory requirements.

The ASR screening process identified long-term storage and seasonal storage as the primary potential uses of ASR for the City of Port Orange. Using a specific operating scenario, secondary benefits related to saltwater intrusion, wetland impacts, and emergency storage may also be achieved. This operation would be to pump the CRW at a rate higher than demand during the wet season and to store extra water in the ASR well. By pumping during the wet season, the higher drawdown would be offset by an adequate surface water supply for the wetlands.

The excess water could be stored in the EW and/or a beachside ASR. Storage in the EW would help buffer the water quality problems previously experienced by higher pumping rates, since the recovery of stored water would be the only increase in pumping from that wellfield. This scenario could include a potable ASR system or an aquifer transfer and storage of ground water. However, a potable beachside ASR would also provide emergency storage and increase system pressure away from the plant. Clearly, there is flexibility in the ASR applications and issues to consider at this utility.

The potential ASR applications are feasible from a general hydrogeologic perspective. Suitable zones with similar characteristics are expected in the Upper and Lower Floridan aquifers, based on available data. The hydrogeologic score of 153 for the potable or raw ground water ARS applications discussed above indicates a moderate-level confidence in ASR feasibility.

The screening results indicate that the annual cost comparisons are favorable for ASR. ASR would be more cost-effective than comparable storage techniques for long-term (annual cost of $2,676,000 for reservoir versus $216,000 for ASR) and seasonal storage (annual cost of $164,000 for tank versus $79,000 for ASR) and would provide some savings by delaying plant expansion ($1,329,000 per year for a 5-mgd plant expansion versus $216,000 per year for an interim ASR at the 2006 recovery rate). A factor not incorporated in this cost analysis is the reduced scale of the plant upgrade after the delay. In conjunction with ASR, a plant upgrade of less than 5 mgd may be anticipated.

Although cost-effective, these applications involve timing, funding, and plant management questions. First, this screening tool evaluated an ASR in operation in 1997 to calculate the long-term storage. Realistically, it would take a year to get an ASR permitted and operating effectively, reducing the volume available for storage unless an average daily flow increase was obtained for the City's CUP. Meanwhile, the City of Port Orange is in contract for the WTP expansion. With monies already spent on the plant expansion, it may be more economical to continue with that project.

In addition to these timing issues, funding is also key. The funding is obviously in place for the plant expansion. Delaying the plant expansion while incorporating a new technology into the water system may not be viewed favorably by the public. Some public education may be required for ASR prior to application at the City of Port Orange water system. Finally, each individual utility has preferred operating procedures; thus, the ways in which ASR impacts plant operation must be considered by the City of Port Orange. Regardless of the plant expansion status, it is cost-effective to implement ASR as a seasonal storage mechanism. The added benefit of emergency storage capabilities may be viewed as a worthwhile investment in addition to the plant expansion.

Permitting requirements will factor into the decision as well. A Water Quality Criteria Exemption or Aquifer Exemption would be required for inter-aquifer transfer of raw ground water to the EW in addition to the SJRWMD CUP and the FDEP UIC Class V Group 7 Permit required for all ASR systems. Since potable ASRs have been permitted throughout Florida, this permitting scenario is likely to be accomplished. Raw water ASR may have less success, and thus represents an additional permitting risk.

The initial screening results support the conclusion that ASR is a feasible technology for the City of Port Orange. This site is an example of the flexibility of applying the ASR technology and forefronts the issues to consider in determining the application of an ASR system. The area hydrogeology indicates that a suitable ASR zone may be found. However, before proceeding with any further hydrogeologic data collection for a potable water application, an evaluation of the use of ASR to address wetland impacts would be valuable. If this evaluation demonstrates that ASR could effectively address wetland impacts, the City of Port Orange could proceed with developing an ASR test plan for this facility.

REFERENCES

CH2M HILL. *Aquifer Storage Recovery Feasibility. Alternative Water Supply Strategies in the St. Johns River Water Management District.* Technical Memorandum C.1.c. Prepared for SJRWMD. Gainesville, FL. CH2M HILL. 1996.

Consumptive Use Permit for the City of Port Orange. Issued by St. Johns River Water Management District.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *Glencoe Wellfield Management Study.* April 1987.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *Water Supply Master Plan, Volusia City-County Water Supply Cooperative.* January 1991.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *Water Supply Master Plan, Update and Expansion, Volusia City-County Water Supply Cooperative.* March 1994.

Stevens, Randell, P.E., Public Utilities Director, and Fred W. Griffith, P.E., Public Utilities Engineer, City of Port Orange Public Utilities. Meeting with the authors, October 4, 1996.

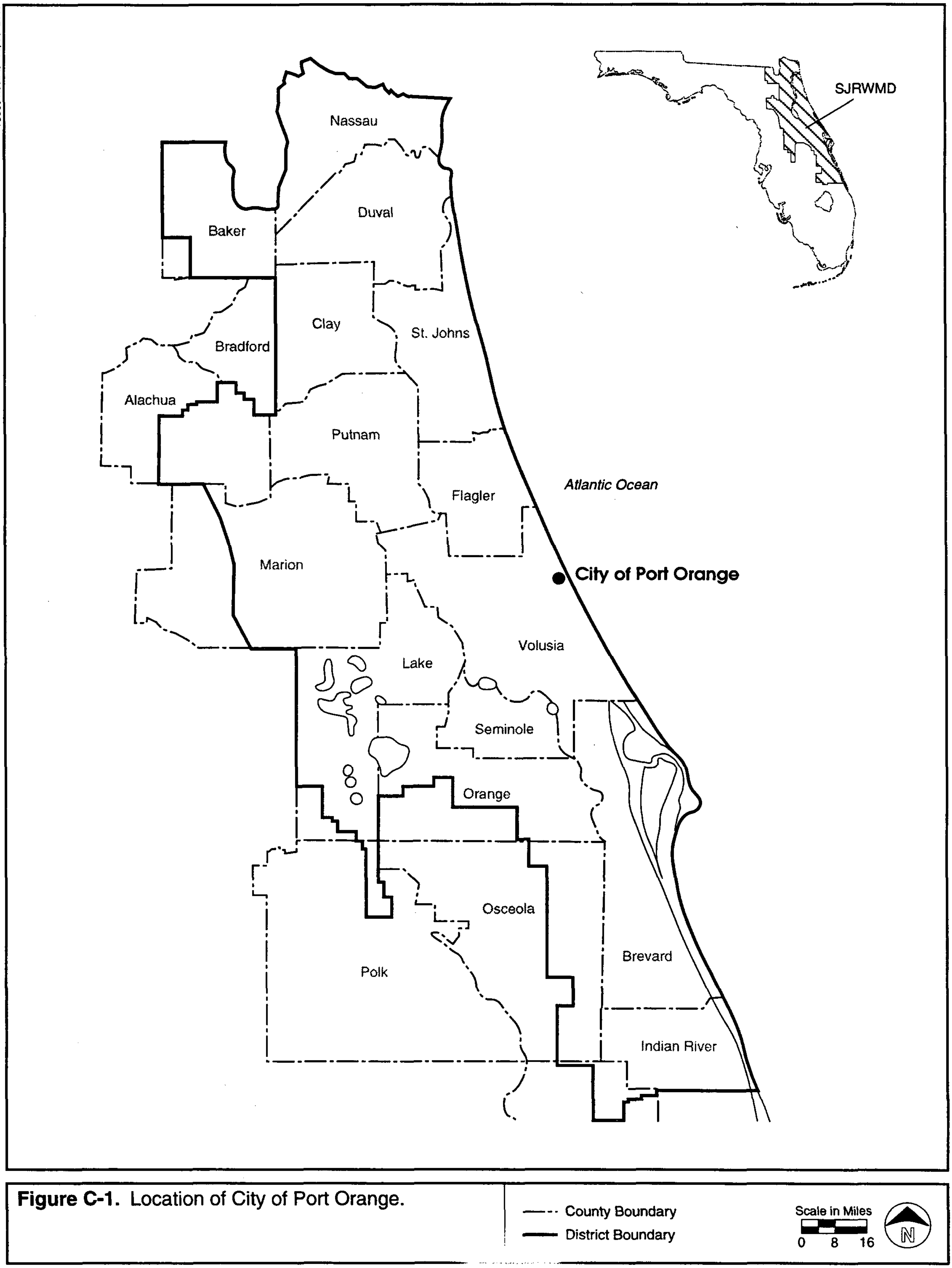


Figure C-1. Location of City of Port Orange.

130581.SJ.AS 11/96 GNV

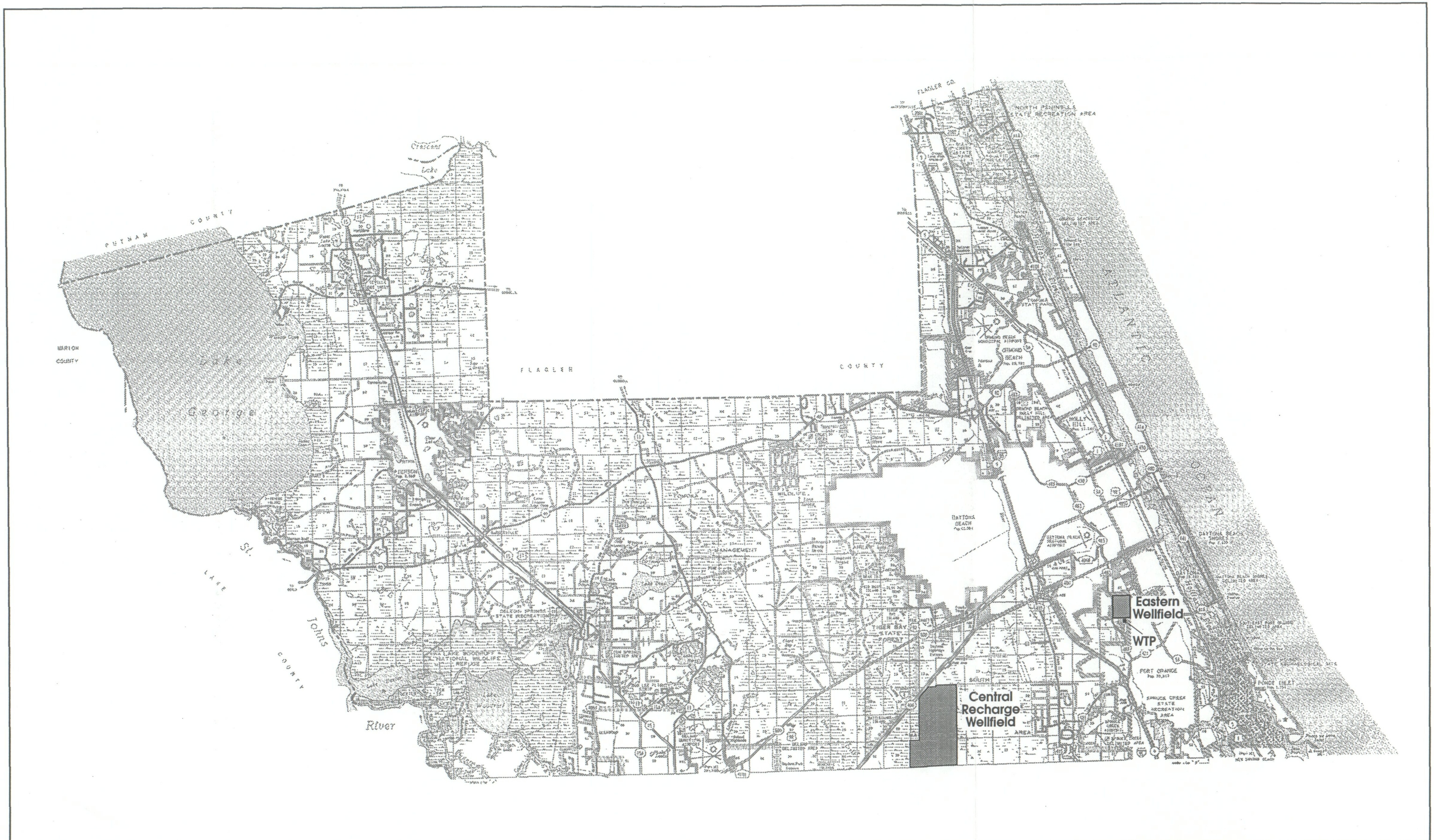


Figure C-2. City of Port Orange Water Treatment Plant and Wellfield Locations.

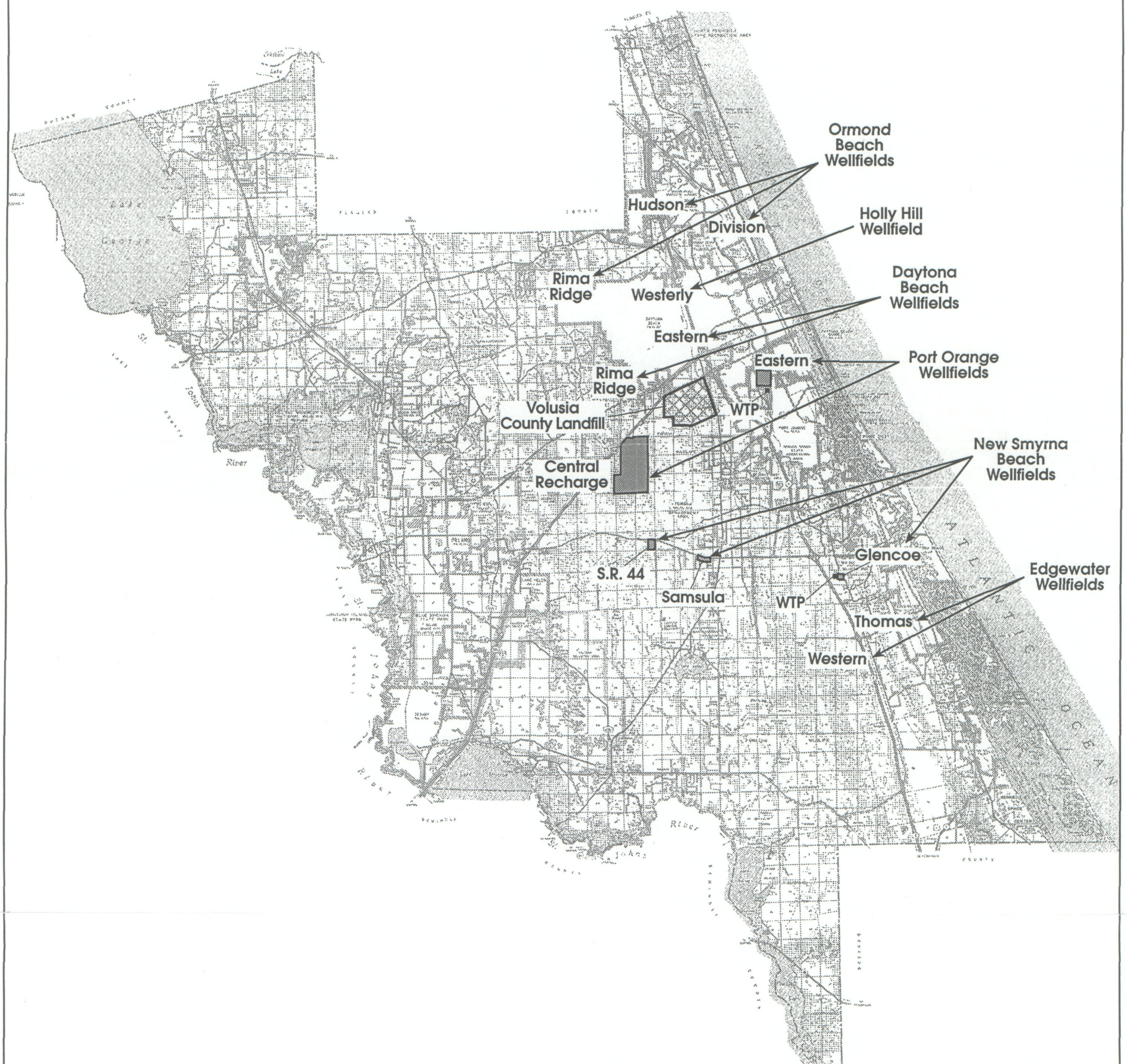


Figure C-3. City of Port Orange Interfering Uses and Impacts.

130581.SJ.AS 11/96 GNV

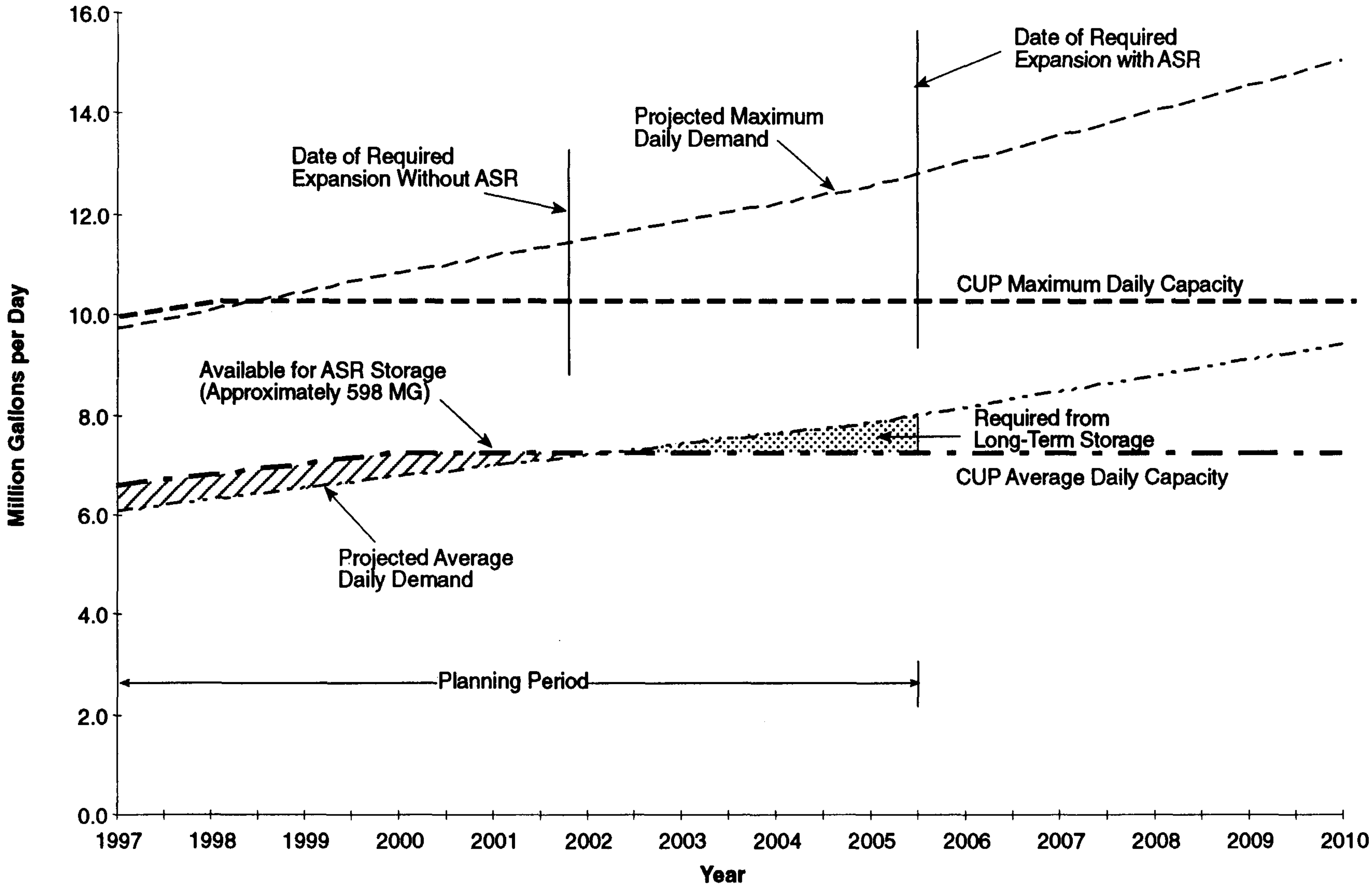


Figure C-4. City of Port Orange Long-Term Storage Need.

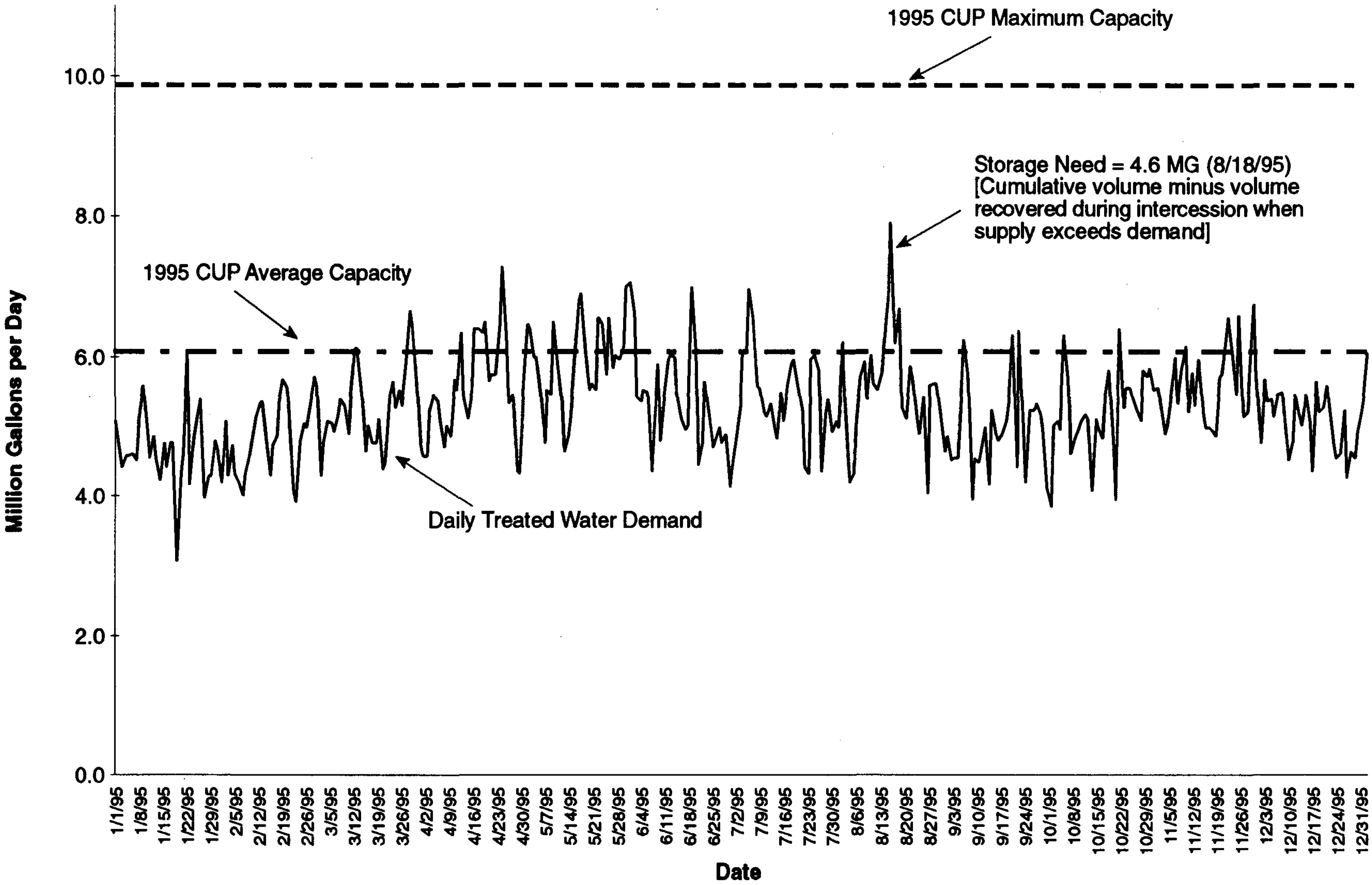
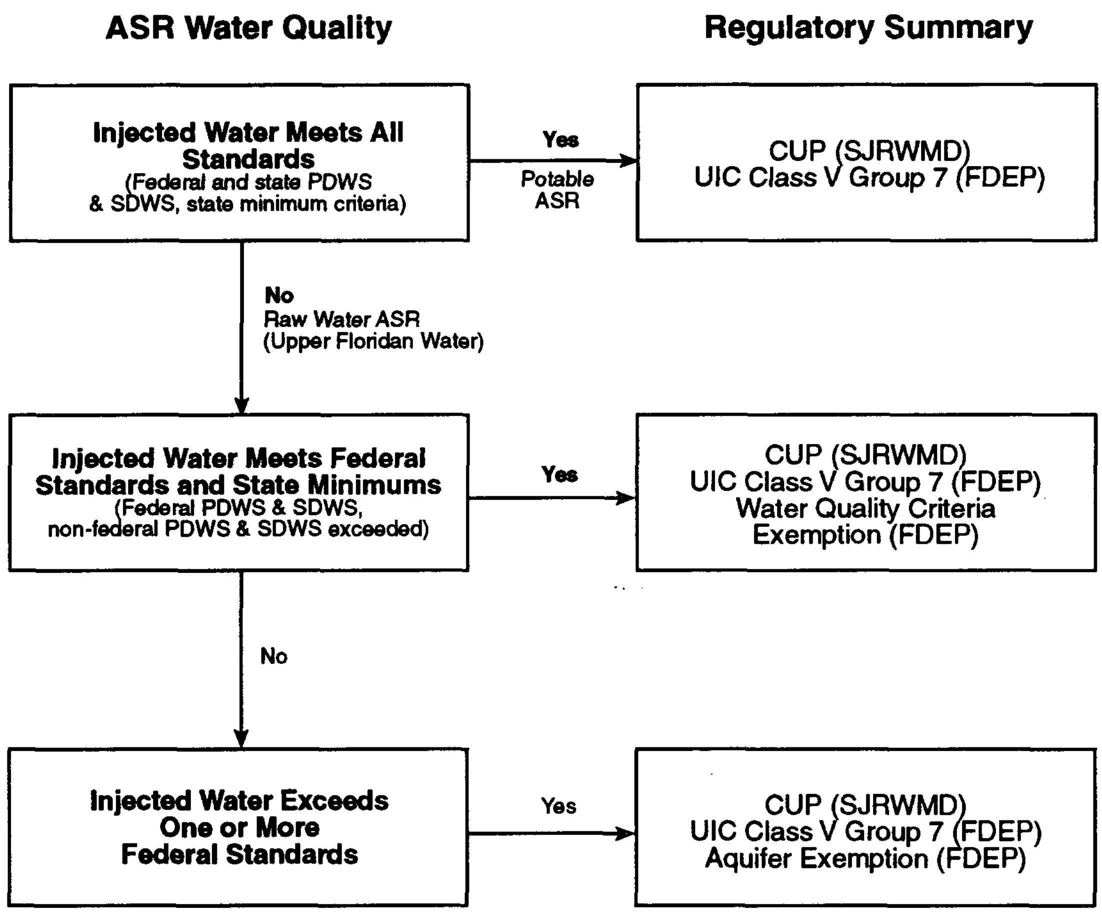


Figure C-5. City of Port Orange Seasonal Storage Need for Water Quantity.

130581.SJ.AS 11/96 GNV



Note: Injected water can be either treated or raw.

Figure C-6. Possible ASR Regulatory Requirements for the City of Port Orange.

Feasibility Screening Report
Parts A and B

Facility Designation City of Port Orange — Water Source Floridan Ground Water — Date 12/2/96

Facility Director Randell Stevens, P.E. — Intended Use Potable Supply

Water Management District St. Johns River Water Management District — Date ______

District Officer ______

PART A FACILITY PLANNING FACTORS

1	Average Daily Demand (End of Planning Period):	9.4	mgd	Is ADD Greater Than 1 mgd?	X YES ___ NO
2	a. Total Supply Volume for Planning Period:	36,380.1	MG	Is the Supply Volume Greater Than Demand Volume?	___ YES X NO
	b. Total Demand Volume for Planning Period:	38,970.3	MG		
3	List Storage Need Volumes Calculated:				CUP renewal expected in future therefore, proceed to 3
	a. Long Term Volume:	598	MG	Are any of the Volumes Greater Than 5 MG ?	X YES ___ NO
	b. Seasonal Volume (For Quantity and Quality):	8	MG (2010)		
	c. Short Term Volume:	-	MG		
	d. Other (Emergency, Plant Operations, etc):	-	MG		
	e. Total a. through d., above	606	MG		

127

PART B HYDROGEOLOGIC, DESIGN, AND OPERATION FACTORS

ASR Hydrogeologic, Design and Operation Factor Scores

Section Points	1 Storage Zone Confinement	2 Storage Zone Transmissivity	3 Local Aquifer Gradient/Direction	4 Recharge Water Quality	5 Native Water Quality	6 Physical, Geochemical Interactions	7 Interfering Uses and/or Impacts	
5	5			5			5	High Feasibility Zone
4								
3		3	3			3		Further Investigations Needed Zone
2					2			
1								
Weight Factor	X 10	X 10	X 1	X 2	X 10	X 5	X 5	Total Score
Score	50	30	3	10	20	15	25	153

Score	Feasibility Level	Type of Study Recommended
160-215	High Confidence	General – Confirm Assumptions
100-159	Moderate Confidence	Focused – Investigate Specific Factors
43-99	Low Confidence	Detailed – Evaluate Impact of Critical Factors

Feasibility Screening Report
Parts C and D

Facility Designation: City of Port Orange — Date: 12/2/96

Facility Director: Randell Stevens, P.E.

Water Management District: St. Johns River Water Management District — Date: ______

District Officer: ______

PART C COST COMPARISON SUMMARY

Cost Comparison for Storage Options

Storage Need (SN): Long-Term: 598.1 MG; Seasonal: 8.2 MG

ASR Recovery Rate = 3 mgd (Demand in excess of plant capacity in 2006)

Peak Factor (PF): 1.5 — Recovery Duration (RD): 11 days — ASR Recovery Rate $\frac{PF + SN}{RD}$ = 1.1 mgd

Equivalent Annual Costs

	Long-Term		Seasonal
Tank	$ N/A	*(Figure A-5)*	$ 164,000
Reservoir	$ 2,676,000	*(Figure A-5)*	$ N/A
ASR	$ 216,000	*(Figure A-5)*	$ 79,000

Cost Comparison for Management Options

Plant Rate Increase: 5 mgd (Planned upgrade to meet 2010 demand)

Equivalent Annual Costs

Plant Upgrades	Base Cost	Option 1	Option 2	Option 3	Option 4
Lime Softening and	1,329,000				
Sulfide Reduction by	Tray Aeration *(Figure A-8)*				
	Packing Tower *(Figure A-9)*				
	Ozonation *(Figure A-10)*				
TOTAL	1,329,000				

Equivalent Annual Cost for Options

Plant Upgrade $ 1,329,000 (total cost from option selected from the table above)

ASR $ 216,000 *(Figure A-4)*

PART D REGULATORY SUMMARY

	YES	NO	
Injected water meets all standards	X		(refer to Figure A2 for regulatory requirements)
Injected water meets federal standards and state minimums	X		(refer to Figure A2 for regulatory requirements)
Injected water exceedes one or more federal standards		X	(refer to Figure A2 for regulatory requirements)

Appendix D

ASR Feasibility Screening
City of Titusville

CONTENTS

ASR FEASIBILITY SCREENING—CITY OF TITUSVILLE

FIGURES

TABLES

ASR FEASIBILITY SCREENING—CITY OF TITUSVILLE

The City of Titusville is located approximately 30 miles south of New Smyrna Beach on the eastern coast of Florida (see Figure D-1). The largest nearby city to the south is the City of Cocoa, at a distance of approximately 20 miles.

Information about the City of Titusville utility and specific water use data were provided by the City's Water Resources Department personnel during a site visit on October 17, 1996 (Chaffee et al., 1996).

OVERVIEW

The City of Titusville is a coastal city whose population has varied due to fluctuations in the industries located in the area. During the 1980s, the City of Titusville experienced 26 percent population growth, with a corresponding water demand increase of 43 percent. To date in the 1990s, the City has experienced no growth, due to reduction in work forces by area industries. Currently, the City supplies approximately 50,000 permanent potable water customers. The 1995 average daily water demand was approximately 5.3 million gallons per day (mgd), with a maximum demand of approximately 7.9 mgd. Water demand exhibits seasonal fluctuations relating to an influx of vacationers during the winter months. The area's offseason is from spring to late fall.

Existing Facilities

The City of Titusville water supply system consists of a water treatment plant (WTP), two wellfields, and several aboveground storage tanks, in addition to the water distribution system. The City of Titusville supplements its finished water supply with water purchased from the City of Cocoa.

Water Treatment Plant. The City of Titusville operates a lime-softening WTP located near the northern city limits (Figure D-2). The WTP was originally built in 1954, with an initial capacity of 0.5 mgd. In 1964, the plant was expanded to a capacity of 6 mgd; in 1968, another expansion increased the capacity to the current 16-mgd level. However, the WTP is in need of repair and can sustain consistent maximum flows of only approximately 10 mgd at this time. Repairs are planned to bring the WTP up to the full 16-mgd capacity.

Regardless of rated capacity, the plant operates at around 6 mgd. Treated water leaving the WTP for distribution has chloride and total dissolved solids (TDS) concentrations of 75 milligrams per liter (mg/L) and 290 mg/L, respectively.

Water Supply. The City's water supply is recovered from two wellfields, Area II Wellfield and Area III Wellfield, both completed in the shallow surficial aquifer (Figure D-2). The Area II Wellfield was constructed in the 1960s near the Titusville WTP. The wellfield currently has 49 wells; however, only 35 wells provide water to the City due to drawdown problems with higher pumping rates. Approximately 25 of these wells are operating at one time to minimize drawdowns. These wells have been rehabilitated recently to minimize drawdowns within the wells in order to maintain an areal representative water quality of approximately 40 mg/L chloride concentration. All of the Area II wells are powered by supplied electricity with no emergency backup. The City owns the land under 4 of the 49 wells in the Area II Wellfield. All of the other wells are constructed in the City right-of-way. The original permitted withdrawal from this wellfield in the 1960s was 7.4 mgd; however, due to the increasing drawdowns, the permitted withdrawal rate has been reduced to 5.4 mgd.

The Area III Wellfield was constructed in the middle 1980s and currently has 35 wells providing water to the City. Approximately 10 to 15 of these wells are operating at one time to minimize drawdowns. In this area, the production rates have been lower and chloride concentrations higher than anticipated due to vertical movement of brackish water. The chloride levels are highest in the dry months, which are also the highest demand periods. The Area III Wellfield is located approximately 5 miles southeast of the Area II Wellfield. These wells are also powered by supplied electricity and are not equipped with emergency diesel power in the event of power outage. The City owns approximately 70 percent of the land in this wellfield. The other 30 percent of the land is undeveloped. The original permitted withdrawal from this wellfield in the 1980s was 2.2 mgd; however, due to the increasing chloride levels, the permitted withdrawal rate has been reduced to 1.1 mgd.

The City of Titusville has been purchasing water from the City of Cocoa since summer 1995 in order to meet peak demands. In addition to the 0.825-mgd minimum purchase quantity, up to 3 mgd can be acquired to meet peak demands. The water from the City of Cocoa is not blended with the City's water. There tends to be a substantial taste difference between the two water sources. The City has been receiving numerous complaints from the residents who periodically receive water from the two different sources.

Water Supply Storage. The City currently has a storage capacity of 6.7 million gallons (MG) in ground and aboveground tanks in several locations. However, only 5.7 MG is available for public supply; the remaining 1 MG is used at the WTP. With 100 percent of the total storage available, the City's demands could be met for approximately 20 hours.

Future Facility Expansions

Based on the information available, the City of Titusville has adequate water supply and abundant treatment capacity to meet demand for today's needs. However, if the actual population increases match the projections, then the water supply will not be adequate to satisfy demands beyond 1997. The recent stagnant population growth of the Titusville area has temporarily delayed the urgency of identifying additional water supply sources. The City of Titusville has been considering the options for additional or alternative water supplies in the area for the future, including using the brackish ground water supply. The average daily demand for the year 2010 is projected to be approximately 9.5 mgd, with a maximum demand of 16.6 mgd.

Water Treatment Plant. Repairs of the Titusville WTP are currently in the design phase. These modifications will restore the WTP capacity to its original treatment capacity of 16 mgd.

A reverse osmosis (RO) addition to the water treatment process is currently being considered—possibly to be constructed within the next 10 years. This addition will allow withdrawal from the Floridan aquifer and reduce dependency on the surficial aquifer for the City of Titusville water supply.

Water Supply. The existing wellfields cannot be expanded due to the limited resource. The Area II Wellfield reportedly will be able to provide 5 mgd consistently for a long period; however, Area III will continue to have problems with saltwater encroachment.

The City of Titusville currently is assessing alternate raw water supply options because the current surficial aquifer water supply is limited. Options include two brackish sources: Lake Harney and the Upper

Floridan aquifer in northwestern Brevard County; and ground water from the Volusia Floridan aquifer in southwest Volusia County.

Water Supply Storage. To date, there are no plans to expand the City of Titusville's storage capacity.

Water Supply System Restrictions

Wellfield Operations. The City's Consumptive Use Permit (CUP) dictates that 83 percent of the water production should come from the Area II Wellfield located in the vicinity of the WTP. The remaining 17 percent is to be produced from the Area III Wellfield.

Existing CUP Restrictions:	
Maximum Annual Withdrawals	***Maximum Total Daily Withdrawals***
2,372.5 MG in 1996	9.2 mgd in 1996
Average Annual Withdrawals	
Area II	Area III
1,971 MG in 1996	401.5 MG in 1996

Water Shortages. Water shortages have occurred in the past due to drought conditions in the area. The highest demands correspond to the dry times of the year. When drought conditions exist, the water levels decline and the drawdowns in the supply wells increase, requiring the wells to be pumped at reduced rates to keep drawdowns from becoming excessive. Excessive drawdowns result in water quality problems.

Wetlands Monitoring. A wetlands monitoring plan was started in 1993 in accordance with the CUP conditions. The City is currently monitoring wetlands for the third year. This monitoring is associated with the conditions of the CUP to minimize or determine the effects of pumping on the wetlands. Five sites are monitored in the Area II Wellfield for potential impacts, with one site used for reference. Five sites are monitored in the Area III Wellfield. One site is monitored for potential impacts, one site is used for reference, and three sites are considered impacted by SJRWMD.

Environmental Impacts. A construction landfill exists on the extreme southern limit of the city. The Interstate 95 right-of-way crosses the western edge of the Area II Wellfield, posing threats to the water supply in the event of petroleum or chemical spill resulting from a highway accident. No other environmental impacts appear to exist in the area.

Interfering Uses. Brevard County Utilities operates a water supply wellfield in the area (Figure D-3). This wellfield has six wells and is located approximately 2 miles north of the Area II Wellfield.

Other Issues

The City of Titusville has experienced pressure problems in the distribution lines within city limits in multilevel buildings and in the areas farthest away from the WTP.

ASR FEASIBILITY RANKING REPORT

As each section of the screening tool is reviewed, a score is determined that best represents the site-specific characteristics. At the end of the ranking process, each score is weighted as to its degree of importance and a final score is calculated. The magnitude of this score identifies a relative ASR feasibility for the site.

Part A. Facility Planning Factors

Step 1. List the Average Daily Demand.

Instructions: For Potable Use, if the ADD is greater than 1 mgd, proceed to Step 2. If the ADD is less than 1 mgd, another solution should be evaluated. For Agricultural Use, proceed to Step 2.

The City of Titusville's average daily demand for 1995 was 5.3 mgd. The projected average daily demand for the year 2010 is approximately 9.4 mgd.

Step 2. List the Total Supply and Demand Volumes for the Planning Period.

Instructions: If the total supply volume is larger than the total demand volume, proceed to Step 3. If the demand is larger than the supply, investigate other supply increase and demand reduction solutions.

For the purposes of this study, the planning period is defined as 1997-2010, which corresponds to the end of the planning period used in the SJRWMD Needs and Sources study. The City of Titusville is in the process of renewing its CUP. The 1996 value is 2,372.5 MG per year, with a 9.20-mgd maximum from the combined Area II and Area III wellfields. In addition, the City of Titusville has a contract with the City of Cocoa to purchase finished water. The minimum annual quantity is 0.825 mgd, with a 3.00-mgd *maximum purchase quantity. The operating capacity for the WTP is currently just over 10 mgd and will be restored to 16 mgd with scheduled capital improvements. Therefore, the CUP value is the limiting condition. Carrying the 1996 annual value through 2010, the total supply would be between 37,430.8 MG (2,372.5 MG plus the 301.1-MG contracted minimum annual purchase quantity from Cocoa multiplied by 14 years) and 48,545.0 MG (2,372.5 MG plus the 1,095.0-MG maximum contracted annual purchase quantity from Cocoa multiplied by 14 years).*

Demand data are presented below for the City of Titusville. Projected flow data from the City's Water Futures System Analysis *(Dyer, Riddle, Mills, and Precourt, Inc. [DRMP], 1993) were used to calculate the total demand volume for the 1997-2010 planning period.*

Year	AADF[1] [mgd]	Annual Volume[2] [MG]
1997	6.630	2420.0
1998	6.850	2500.3
1999	7.074	2582.0
2000	7.298	2663.8
2001	7.522	2745.5
2002	7.746	2827.3
2003	7.970	2909.0
2004	8.184	2987.2
2005	8.398	3065.3
2006	8.612	3143.4
2007	8.826	3221.5
2008	9.040	3299.6
2009	9.254	3377.7
2010	9.468	3455.8
Total		41,198.3

[1]Data projected in the City of Titusville *Water Futures System Analysis* (DRMP, 1993). Linear interpolation used for values not explicitly stated in the report.

[2]6.330 x (1 year x 365 days/year) = 2,420.0 MG.

*Since the total demand volume, 41,198.3 MG, is greater than the total minimum supply volume, 37,430.8 MG, and less than the maximum supply volume, 48,545.0 MG, the City of Titusville has a potential water supply problem. Without an alternate source, such as brackish ground water or an additional CUP allocation, the City of Titusville would have to purchase the maximum volume of water contracted from the City of Cocoa to meet the projected demands. In addition, the City of Titusville would have to "**water bank**" water purchased in excess of demand to meet future needs. Therefore, ASR should be incorporated with other water supply alternatives.*

Step 3. List Storage Need Volumes Calculated as a Long-Term Volume, a Seasonal Volume, a Short-Term Volume, or Other.

Instructions: If the total volume is greater than 5 MG, proceed to Part B, below. If the total volume is less than 5 MG, investigate other storage options.

*Long-Term Storage Need: Current CUP capacities and the projected demands defined in Step 2 indicated that available supply capacity exists (using water purchased from the City of Cocoa) to provide long-term storage. Approximately 529 MG would be available for "**water banking**" to delay the total water shortage from 2001 until 2004. (Refer to Figure D-4.)*

Seasonal Storage Need: Demand and supply values were plotted for 1 year (October 1, 1995, through September 30, 1996). These plots and the average CUP withdrawal revealed a seasonal fluctuation that would correspond to a peak storage need of approximately 1.4 MG. (Refer to Figure D-5.) A 4-MG seasonal storage need was projected for 2010 (1.4 multiplied by the 2010 to 1995 demand ratio, 9.5/5.3). This storage need would add to the long-term storage need identified above.

Other storage needs were not specifically quantified for this site. However, it is feasible for additional benefits to be derived from ASR storage. First, the plant could be operated at a consistent level rather than varying the operations based on demand. In addition, it would be feasible to incorporate an emergency water supply storage for the City of Titusville. However, without an alternate water supply, there would very little supply to store for emergency purposes.

Thus, the storage need calculated for the City of Titusville is 533 MG, a combination of the long-term and seasonal storage needs.

Part B. Hydrogeologic, Design, and Operation Factors

Area Hydrogeology

The hydrogeologic factors needed to evaluate the feasibility of ASR include the occurrence and depths of transmissive and confining intervals in the Upper and Lower Floridan aquifers. The characteristics of confining beds overlying the Floridan aquifer are also important in the evaluation of suitable zones. In Brevard County, the most probable ASR zones are expected to occur in the Upper Floridan aquifer.

Areas of fresh water (less than 250 mg/L chloride concentration) occur in the Upper Floridan aquifer in a few locations within Brevard County. One location is an elongated area in north Brevard near the City of Titusville, where recharge from local rainfall results in a thin and limited lens of fresh water. The other two freshwater areas are in southern Brevard County. Thus, the Floridan aquifer, though highly productive, cannot be used directly as a major source of fresh water within Brevard County without RO treatment technology.

The sediments that overlie the Floridan aquifer include the surficial (also called shallow) aquifer and areally extensive zones of lower-permeability clayey materials. Because the potentiometric surface of the Floridan aquifer is higher than the water table in the surficial aquifer in most of Brevard County, there is the potential for natural upward movement, or discharge, of salty water into the shallow aquifer. The degree of such upward movement is dependent on the relative permeability and continuity of confining beds that overlie the Floridan aquifer. The confining beds in northern Brevard County are thin or absent; therefore, saltwater upconing is a continuous concern in the City of Titusville area. The City of Titusville, in the north Brevard area, relies on a large number of wells in the surficial aquifer. These wells withdraw from a freshwater lens that occurs in the surficial aquifer overlying the Floridan aquifer.

The general water quality in the Upper Floridan aquifer in the Titusville area exhibits elevated chloride and TDS levels. The Upper Floridan aquifer occurs at a shallow depth (approximately 100 to 150 feet below land surface) in the Titusville area.

The upper producing zone of the Floridan aquifer system extends from about 100 to 500 feet bls. The Ocala Group and part of the Avon Park Limestone are the geologic units present within the zone. TDS concentrations are expected to exceed 5,000 mg/L in this interval. Estimates of transmissivity from aquifer tests range from 60,000 to 200,000 gallons per day per foot *(gpd/ft) based on data from the Cocoa Wellfield. Storativity values range between 2.89 X 10^{-2} and 7.98 x 10^{-4}.*

The middle semi-confining zone of the Floridan aquifer system extends from 550 feet to 680 feet bls. The zone is contained within the lower sequence of the Avon Park Limestone.

The lower producing zone of the Upper Floridan aquifer is contained within the Lake City Limestone. It extends from the base of the middle confining zone at 680 feet to a depth of about 900 feet bls. An aquifer test on a well near Lake Washington produced an estimated transmissivity of 500,000 gpd/ft.

Step 1. Storage Zone Confinement

Instructions: Use Table D-1 to rank the hydraulic conductivity and thickness of the vertical flow restrictive units (aquitard) above and below the storage zone. This data can be gathered from local wells in the same zone or from regional published information. Table 3A from Technical Memorandum (TM) C.1.c (CH2M HILL, 1996) presents an example ranking based on a 100-foot-thick confining unit, which shows how Figure A-2 (TM C.1.c) is used to determine the ranking.

Data from the existing RO supply and wastewater injection wells in Brevard County indicated that confining beds suitable for ASR exist in the Floridan aquifer. Suitable intervals, with hydraulic conductivity in the range of 1.0 x 10^{-4} to 10^{-5} feet per second exist in the Upper Floridan aquifer. This permeability would result in a generally good storage zone confinement ranking with thicknesses of 50 to 100 feet. Thus, a rank of 3 was selected.

Table D-1. Storage Zone Confinement Ranking

Rank	Aquitard Hydraulic Conductivity	Aquitard Thickness
3	1.0 x 10^{-3} to 1.0 x 10^{-6}	50 to 100 feet

Step 2. Storage Zone Transmissivity

Instructions: Use Table D-2 to rank the target storage zone transmissivity. This data can be gathered from local wells in the same zone or from regional published information. Figure A-3 (TM C.1.c) should be used in conjunction with Table D-2 to determine the ranking.

Hydrogeologic data from the existing RO supply and wastewater injection wells in Brevard County indicated that intervals exist in the Floridan aquifer *with transmissivities of between 40,000 to 70,000 gpd/ft, close to the optimum range for potable water ASR. Local information from the City of Cocoa ASR investigations indicated storage zone transmissivities in the range of 40,000 to 100,000 gpd/ft in wells completed between 300 and 370 feet bls. A deeper ASR zone would have a higher transmissivity. The Upper Floridan aquifer zone was used for this ranking, resulting in a rank of 5.*

Table D-2. Storage Zone Transmissivity Ranking

Rank	Transmissivity Criterion (gpd/ft)		Applicability
	Potable Water	Untreated Surface Water	
1	Less than 8,000	Less than 80,000	Limited
2	8,000 to 15,000	80,000 to 250,000	
3	15,001 to 40,000	250,001 to 400,000	
4	40,001 to 50,000	400,001 to 500,000	
5	**50,001 to 80,000**	**500,001 to 1,000,000**	**Optimal**
4	80,001 to 120,000	1,000,001 to 1,150,000	
3	120,001 to 200,000	1,150,001 to 1,400,000	
2	200,001 to 400,000	1,400,001 to 2,000,000	
1	Greater than 400,000	Greater than 2,000,000	Limited

Step 3. Aquifer Gradient and Direction

Instructions: Rank the local aquifer gradient and direction. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table D-3.

No detailed water-level information could be located during the course of this study. A default rank of 3 was selected in order to flag this criterion as needing site-specific information during the detailed investigation. The significance of local aquifer gradients would depend on the location of the ASR wells in relation to RO supply wells.

Table D-3. Local Aquifer Gradient/Direction Ranking

Rank	Aquifer Gradient (In same recharge zone)	Direction Criterion
1	Many strong influences exist	Extreme artificial gradient, reevaluate location of ASR system
2	Several strong influences	Exaggerated gradient, investigation needed
3 (default)	Multiple minor influences exist	Affected gradient worth investigating
4	Single minor influence or abnormal natural gradient	Minor investigation or existing data search
5	No influence	No influence

Step 4. Recharge Water Quality

Instructions: Rank the recharge water quality using chloride or TDS concentrations of the water to be stored in the ASR zone. For potable water, this data can be obtained from the records of the WTP that will be supplying the source water. For raw water, this can be determined from published records or databases. If this information is not available, use the default value shown in Table D-4.

Treated water leaving the WTP for distribution has chloride and TDS concentrations of 75 mg/L and 290 mg/L, respectively. The concentration for chlorides was used, providing a rank of 4.

Table D-4. Recharge Water Quality Ranking

Rank	Chloride (mg/L)		TDS	Compliance with SDW Standards
1	Greater than 200	or	Greater than 450	Just within SDW standards
2	200 to 171		450 to 351	
3	170 to 101		350 to 201	Moderately meets SDW standards
4	**100 to 50**		200 to 100	
5	Less than 50		Less than 100	Well within SDW standards

Step 5. Native Water Quality

Instructions: Rank the native water quality based on the chloride or TDS information of the native water in the target ASR zone. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table D-5.

No storage-zone investigation has been conducted to date. Therefore, no storage-zone-specific water quality information is available. A rank of 2 was used, since data from the County well inventories included TDS concentrations over 5,000 mg/L in the Upper Floridan aquifer around Titusville.

Table D-5. Native Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Water Quality
1	Greater than 6,000	or	Greater than 10,000	Very brackish
2	**6,000 to 3,001**		**10,000 to 5,001**	
3	3,000 to 801		5,000 to 1,301	Slightly brackish
4	800 to 400		1,300 to 700	
5	Less than 400		Less than 700	Near fresh water

Step 6. Physical, Geochemical, and Design Interactions

Instructions*:* Rank the potential for physical, geochemical, or design interactions. This rank is based on the sum of the ranks from the sub-categories shown in the table below. If this information is not available, use the default value shown in Table D-6.

Some parameters included in the ranking tool are not ordinarily included in the routine water quality analysis performed on the treated water. In cases where parameter values were missing, default ranks were incorporated that flag these parameters as needing further analysis. The water quality for the treated water of the City of Titusville is provided in Table D-6 in parentheses after the selected rank.

Table D-6. Overall Physical, Geochemical, and Design Interaction Ranking for SJRWMD

Sub-Category	Rank	Recharge Water and Criterion	Selected Rank
Physical Interactions from Suspended Solids			
TSS	1	TSS>2.0 mg/L	
	2	2.0 mg/L>TSS>0.05 mg/L **(default)**	2
	3	TSS<0.05 mg/L	
Biological Growth and Geochemical Interactions			
pH	1	7.8<pH< 8.6 (default)	
	2	**pH>8.6**	2 (8.81)
	3	pH<7.8	
Total Phosphorous	1	P>0.1 mg/L	
	2	0.1 mg/L>P>0.05 mg/L **(default)**	2
	3	P<0.05 mg/L	
Nitrate as N	1	N>1 mg/L	
	2	1 mg/L>N>0.5 mg/L **(default)**	2
	3	N<0.5 mg/L	
Dissolved Organic Carbon (DOC)	1	DOC>5 mg/L	
	2	5 mg/L>DOC>2.5 mg/L **(default)**	2
	3	DOC <2.5 mg/L	
Total Iron (Fe)	**1**	**Fe>1 mg/L**	
	2	1 mg/L>Fe>0.3 mg/L (default)	1 (2.4)
	3	Fe<0.3 mg/L	
Dissolved Oxygen (DO) of Recharge Water	1	DO>3 mg/L	
	2	3 mg/L>DO>1.5 mg/L **(default)**	2
	3	DO<1.5 mg/L	
Point Totals			13
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**3**

Note: Use the default value if data for any parameter is unavailable. Determine the overall rank from the following point totals:

Rank	Physical, geochemical, and design criteria (total of above points)	
1	7-10 points	Higher potential for plugging
2	11-12 points	
3	**13-16 points**	Moderate potential for plugging
4	17-18 points	
5	19-21 points	Low potential for plugging

Step 7. Interfering Uses and Impacts

Rank the interfering uses and impacts which can exist or have the possibility to exist in the vicinity of a proposed ASR site. Information can be gathered from visual surveys, aerial photographs, topographic maps, and public records/information. This rank is determined from the sum of two sub-ranks shown in Table D-7. If this information is not available, use the default value shown.

An inventory of wells within a 5-mile radius of the Area II Wellfield revealed the following existing wells in the area:

Number of Wells	Well Size (inches)	Well Use
3	1.5	dewatering
82	6, 8, 10, 12	public supply
20	2, 4, 6, 8, 12	golf course irrigation/ household
1	6	gasoline recovery
2	4, 6	commercial/industrial

Interfering Uses: The City of Titusville is considering developing an RO water supply and treatment facility to meet future demands. The location and producing zones of the RO wells could impact an ASR facility. A sub-rank of 2 was used in this evaluation since no specific locations have been identified.

Interfering Impacts: No interfering impacts are expected.

Table D-7. Interfering Uses and Impacts Ranking

Sub-Category	Rank	Criterion	Selected Rank
Interfering Uses			
Distance to Potable Wells	1	0.10 mile<Wells<0.25 mile	2 (5 miles)
	2	**0.26 mile<Wells<5 miles** (default)	
	3	Wells>5 miles	
Interfering Impacts			
Distance to Contamination Source	1	0.10 mile<Source<0.25 mile	3
	2	0.26 mile<Source<1 mile (default)	
	3	Source>1 mile	
Point Total			5
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**4**

Overall Interfering Uses and Impacts Rank determined from the following point totals:

Rank	Interfering Use and/or Impact Criteria (possibility of impact)	
1	2 points	High use or impact
2	**3 points**	
3	4 points	Moderate use or impact
4	5 points	
5	6 points	Low use or impact

The results of the hydrogeologic, design, and operational factors scoring is interpreted as shown in Table D-8.

The City of Titusville hydrogeologic, design, and operational factors score is 136 points out of a total of 215 points (see scoring sheet at the end of this appendix). This score represents a moderate confidence for ASR feasibility. Detailed site-specific information will likely change the feasibility score to better reflect actual conditions at the proposed ASR location.

Table D-8. ASR Feasibility Score for Hydrogeologic, Design, and Operational Factors

Score	Feasibility Level	Type of Study Recommended
160 - 215	High Confidence	General—confirm assumptions
100 - 159	**Moderate Confidence**	**Focused—investigate specific factors**
43 - 99	Limited Confidence	Detailed—evaluate impact of critical factors

Part C. Cost Comparison Summary

Instructions: The annual cost figures (Figures A-4 through A-10 in TM C.1.c) were developed as a means of comparing alternative water storage and treatment options. Use the tables to complete the Cost Comparison Summary Sheet provided in TM C.1.c. On this sheet, a comparison is made between ASR, other storage options and plant upgrades, which will provide the needed water for immediate peak demand or future demands.

Costs need to be evaluated on three levels for the City of Titusville:

1. *Storage Option Comparison for Long-Term Storage Need in a Reservoir or ASR:*

   a. *The long-term storage need of 529 MG was calculated for the City of Titusville to delay plant expansion until approximately 2006. The cost associated with providing a reservoir would be calculated based on this volume as follows:*

   Annual Cost $= 381{,}000 + 8{,}855V_s^{0.8692}$, *where* V_s *is the storage volume in MG*

   Annual Cost $= 381{,}000 + 8{,}855 * 529^{0.8692}$

   Annual Cost = $2,444,000

b. *For the ASR calculation, the recovery rate is required. Recovery would be for 3 years to offset supply deficits. The recovery rate would need to be consistent with the difference in the peak demand in 2003 and the maximum supply capacity. The projected peak demand in 2003 is approximately 14 mgd, whereas the CUP capacity is a maximum withdrawal of 9.2 mgd plus a maximum of 3 mgd from the City of Cocoa at this time. Therefore, the peak recovery rate would be 1.8 mgd for a potential ASR system. For the purpose of this screening, a recovery of 0.5 mgd well was used. Our experience in this area indicates that a recovery of 0.5 mgd per well is likely in the surficial aquifer. Although higher rates may be achieved in the Floridan aquifer, the more conservative 0.5 mgd per well value was used to provide a more conservative comparison of the cost differences for this option. The corresponding ASR cost is calculated as follows:*

Annual Cost = 71,897 X, where X is the recovery rate in mgd

*Annual Cost = 71,897 * 1.8*

Annual Cost = $129,000

2. *Storage Option Comparison for Seasonal Storage Need in a Tank or ASR:*

a. *The seasonal storage need of 4 MG was projected for the City of Titusville in 2010. The cost associated with providing a tank to meet this storage need is calculated as follows:*

Annual Cost = 17,787 X + 18,088, where X is the storage volume in MG

*Annual Cost = 17,787 * 4 + 18,088*

Annual Cost = $89,000

b. *For the ASR calculation, the recovery rate is required. Recovery would be taken over approximately 17 days. The peak factor is the ratio of maximum day to average day, which was calculated as 1.5 using the plant records. Therefore, the peak recovery rate would be 4.3 MG * 1.5 / 17 = 0.4 mgd for a potential ASR system. The corresponding ASR cost is calculated as follows:*

Annual Cost = 71,897 X, where X is the recovery rate in mgd

*Annual Cost = 71,897 * 0.4*

Annual Cost = $29,000

3. *Management Option Comparison for ASR to Delay RO Plant:*

   a. *Although an upgrade has not been identified, the City of Titusville is considering an RO plant to meet the 2010 peak demands and to address water quality issues The projected maximum demand in 2010 is 16.6 mgd. Considering the peak CUP withdrawal of 9.2 mgd, a 7.4-mgd plant capacity would be required assuming the plant will replace the City of Cocoa water purchase once constructed. The cost associated with this upgrade is calculated using this rate, as follows, assuming lime-softening plant upgrades are comparable in cost to RO plant upgrades:*

      Annual Cost $= 440{,}000\ Q^{0.687}$, *where Q is the capacity increase in mgd*

      Annual Cost $= 440{,}000 * 7.4^{0.687}$

      Annual Cost = $1,740,000

   b. *The ASR cost would be $129,000, which is the same as calculated in Item 1.b. This is the investment needed to achieve a potential cost savings by delaying the RO plant construction by a few years and eventually eliminating water purchase from the City of Cocoa. Although this is another potential ASR application for Titusville, the key issue remains the supply.*

A cost summary sheet (Feasibility Screening Report Parts C and D) is included after all figures at the end of this appendix.

Part D. Regulatory Summary

Instructions: Part D presents the regulatory requirements for the different types of water quality. Place an "X" under the category of *YES* or *NO* to best describe the quality of the water to be stored. Figure D-6 provides the regulatory permits or exemptions needed for the different water quality groups.

Figure A-7 is a flowchart showing the permits and approvals need for specific water qualities to be stored in an ASR system. A SJRWMD CUP and a Florida Department of Environmental Protection (FDEP) Underground Injection Control (UIC) Class V Group 7 Permit will be required for any ASR application. A potable ASR system would be required for the options identified. Since the source is from the WTP, the injected water will meet all state and federal drinking water standards. Therefore, no other permits are expected to be required beyond the CUP and UIC Class V Group 7 Permit.

This permitting scenario appears to be feasible, since potable ASR systems have been permitted throughout Florida.

CONCLUSIONS

Water purchased from the City of Cocoa and water supply/quality problems with current wellfields were the factors SJRWMD considered when selecting the City of Titusville for this study. Similarly, the City of Titusville recognizes its water supply issue as the key concern and is looking at potential solutions. As part of this study, CH2M HILL used the ASR screening tool and previous experience to determine primary potential ASR applications and any secondary benefits, to compare annual costs with traditional solutions, and to evaluate the regulatory requirements.

For the City of Titusville, an ASR system may provide benefits for meeting supply and demand, given the need to purchase water from the City of Cocoa. The ASR screening indicated that long-term storage and seasonal storage may assist in solving the City's water supply problems. The primary application would be a short delay of the needed RO plant by storing the water currently purchased from the City of Cocoa. This storage mechanism could also be used to meet demand fluctuations and to avoid the water shortage and temporary pressure problems the City has experienced in the past. Secondary benefits may be achieved by following one of two ASR scenarios:

1. An ASR well could be used to provide a consistent water source to each customer. Water from the City of Cocoa and the City of Titusville have differences in taste and odor that have elicited complaints. Customer consistently receiving City of Cocoa water would become accustomed to one taste and odor, rather than being switched daily or weekly between the two potable waters. The ASR well location would be at a specific point in the distribution system, perhaps the potential site for a future RO plant. Specific service connections in the area would receive City of Cocoa water directly; excess would be stored in the ASR well. Recovery of the ASR water would be used to meet peak demands in the specified water supply area. The remainder of the service area would continue to receive City of Titusville water. Once an additional supply is developed, the ASR wells could provide emergency storage.

2. An ASR well could be located at the City of Titusville WTP to blend the City of Cocoa water with Titusville water, to form a saltwater intrusion buffer, and to address wetland impact issues. In this scenario, City of Cocoa water would be routed directly to the WTP and placed in a storage zone beneath the current production zone of the wellfields. During low demand periods, finished City of Titusville water could also be stored in this zone. At peak demand periods, the blended water would be recovered, providing a more consistent product for the customers while still meeting demand. With the location at the WTP, the option of retreatment to achieve required water quality and desired water aesthetics would be retained. Finally, if the increased pumping of the City 's wellfields were correlated with peak rainfall periods, the increased drawdown would be offset by an adequate surface water supply to the wetlands. This would also be of benefit to reduce upconing because peak pumping rates would be reduced.

Another issue in water management for the City of Titusville is the construction an RO WTP to replace the water currently purchased from the City of Cocoa. A potential ASR application would still exist in that scenario. The RO WTP would provide the base flow at a constant rate. The demand fluctuations would be met by the existing WTP. The existing wellfields could be pumped in excess of demand during the wet season and the unused portion could be stored in an ASR well to meet seasonal demand fluctuations. Thus, the wellfield maximum drawdown would occur during periods of adequate surface supply to the adjacent wetlands.

These applications of ASR are feasible from a hydrogeologic perspective as well. A zone in the brackish Upper Floridan aquifer would be targeted. For the potable water ASR application discussed above, the hydrogeologic score of 161 indicates a moderate-level confidence in ASR feasibility.

Using the cost comparisons from the ASR screening tool, it appears that costs may be reduced by providing long-term storage for the purchased water (estimated annual cost of $2,444,000 for a reservoir versus $129,000 for ASR) as well as providing seasonal storage (annual cost of $89,000 for tanks versus $29,000 for ASR). The $129,000 per year investment in ASR for storing the water purchased from the City of Cocoa may also delay the addition of an RO plant ($1,740,000 per year) to meet 2010 demand and to replace the City of Cocoa supply. This delay in the RO plant expenditure may provide other savings to the City not addressed here. Once the RO plant is installed, the ASR could be used for seasonal storage at no additional cost. In conclusion, several cost-effective options exist for ASR within the City of Titusville water system. The caution is not to lose sight of the critical issue at Titusville—additional water supply.

In combination with an alternate supply source and purchased water, ASR provides management options for the City of Titusville that are consistent with regulatory requirements. Because the applications identified are for a potable water ASR system, permitting should be relatively straightforward. The SJRWMD CUP and FDEP UIC Class V Group 7 Permit have been issued throughout Florida for similar projects.

In summary, water supply is a key issue at Titusville. There are three major options for incorporating an ASR system into the solution to the City of Titusville's water supply problem. The increased storage may not be sufficient to meet projected needs throughout the planning period. However, some cost-effective applications can be considered. The hydrogeology also supports a moderate confidence in finding a suitable ASR storage zone, with recovery efficiency remaining uncertain. Therefore, the City of Titusville may want to consider the applications of ASR only in addition to alternative water supplies to meet future demands. The next step for the City would be on a master-planning level: to address supply issues in addition to ASR feasibility.

REFERENCES

CH2M HILL. *Aquifer Storage Recovery Feasibility. Alternative Water Supply Strategies in the St. Johns River Water Management District.* Technical Memorandum C.1.c. Prepared for SJRWMD. Gainesville, FL. CH2M HILL. 1996.

Chaffee, James L., P.E., Water Resources Director; Walter L. Boughner, Chief Treatment Plant Operator; Gary L. Hendrix, Chemical Containment Inspector; and Brian M. Hunter, Water Plant Supervisor. Meeting with the authors, October 17, 1996.

Consumptive Use Permit for the City of Titusville. Issued by St. Johns River Water Management District.

Dyer, Riddle, Mills, and Precourt, Inc. (DRMP). *Water Futures System Analysis, City of Titusville.* 1993.

130581.SJ.AS 11/96 GNV

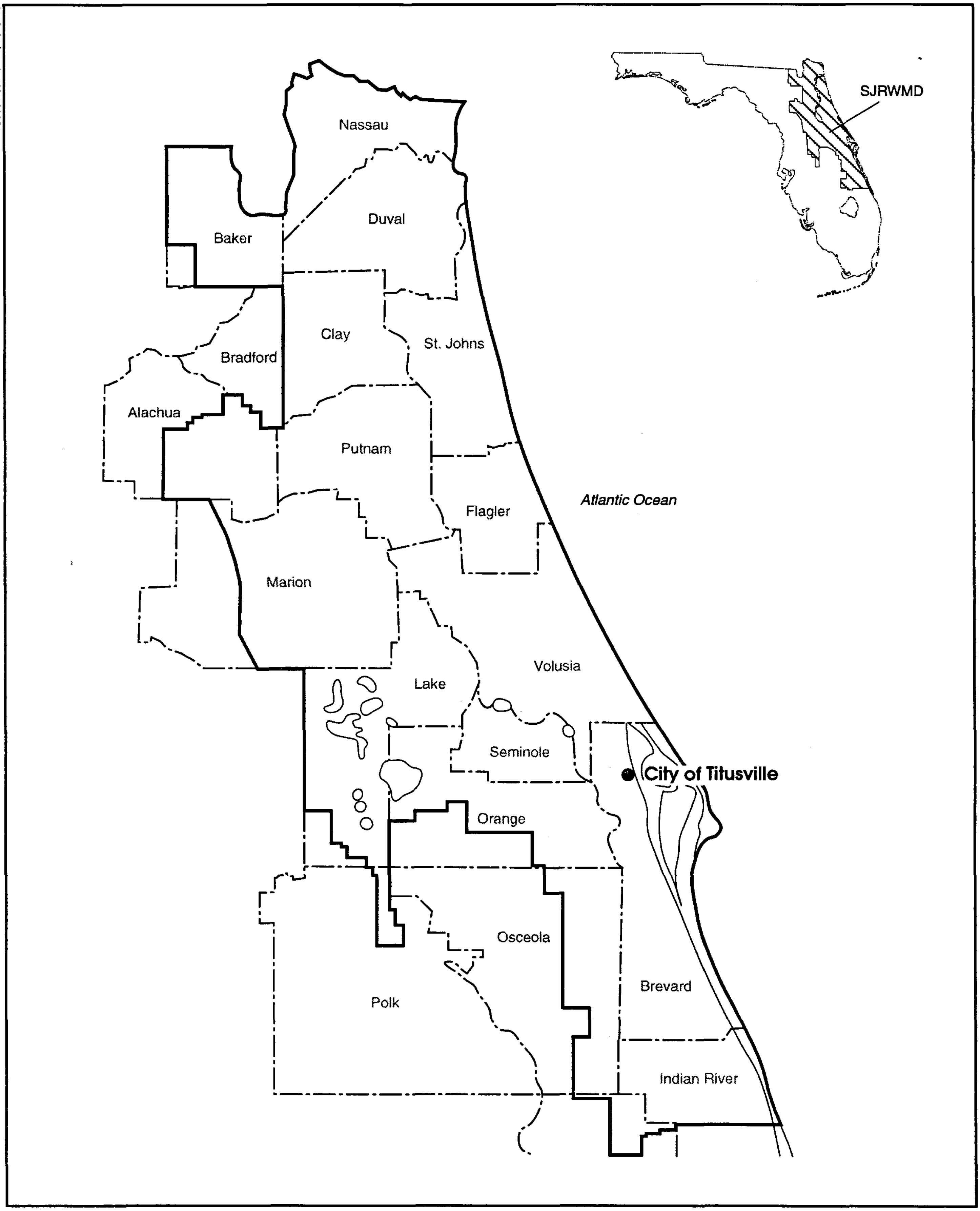


Figure D-1. Location of City of Titusville.

County Boundary
District Boundary
Scale in Miles
0 8 16
N

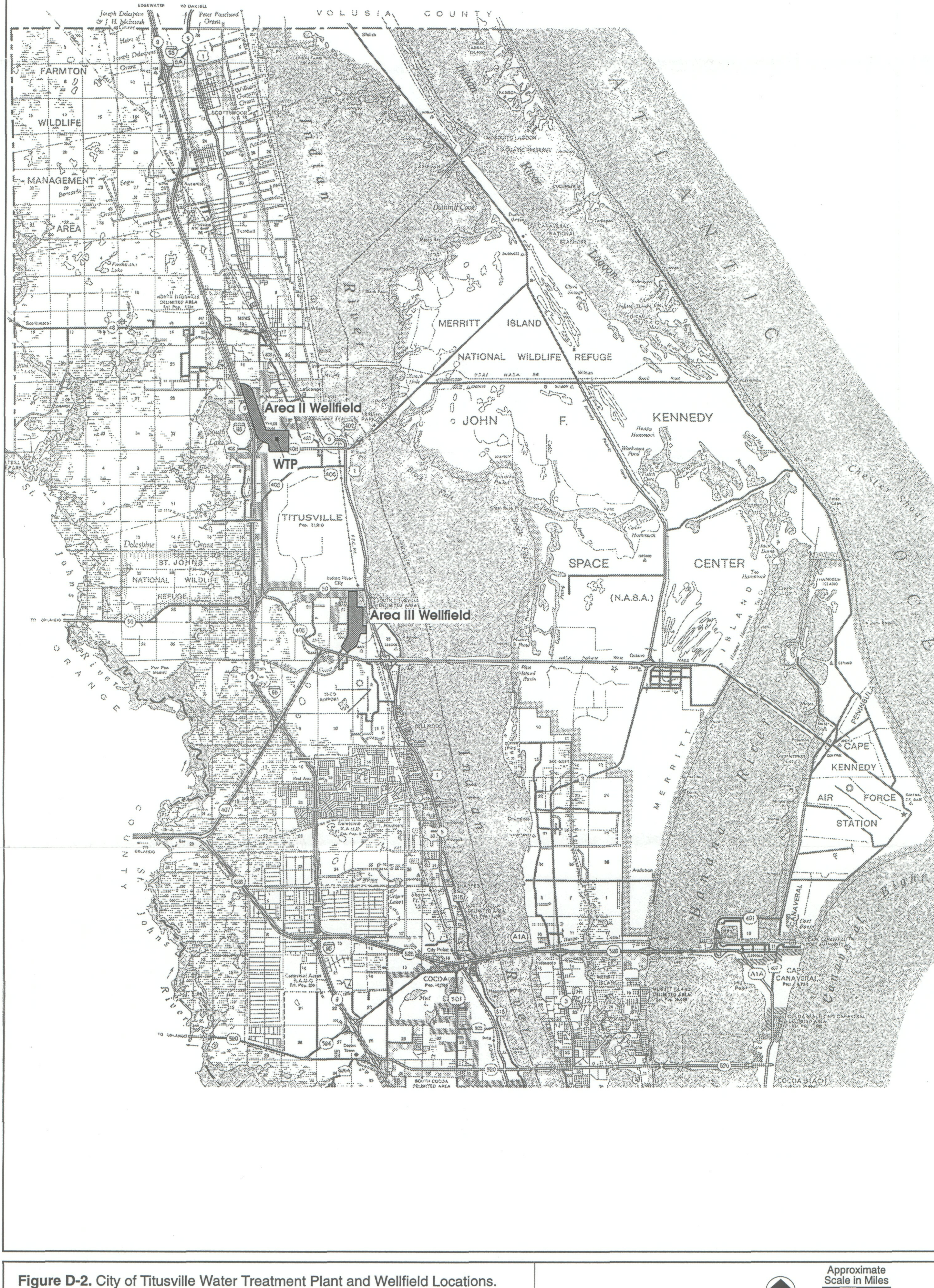


Figure D-2. City of Titusville Water Treatment Plant and Wellfield Locations.

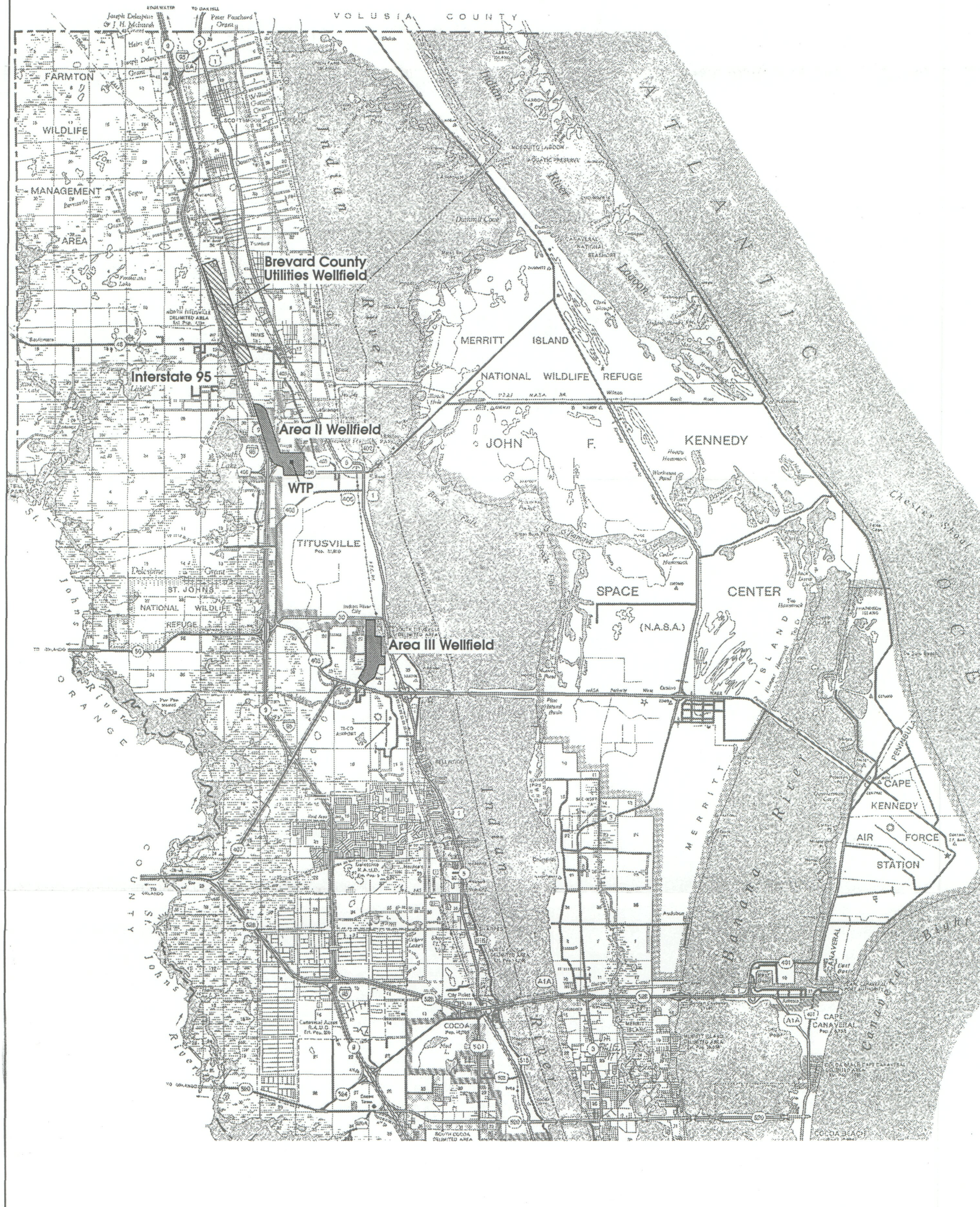


Figure D-3. City of Titusville Interfering Uses and Impacts.

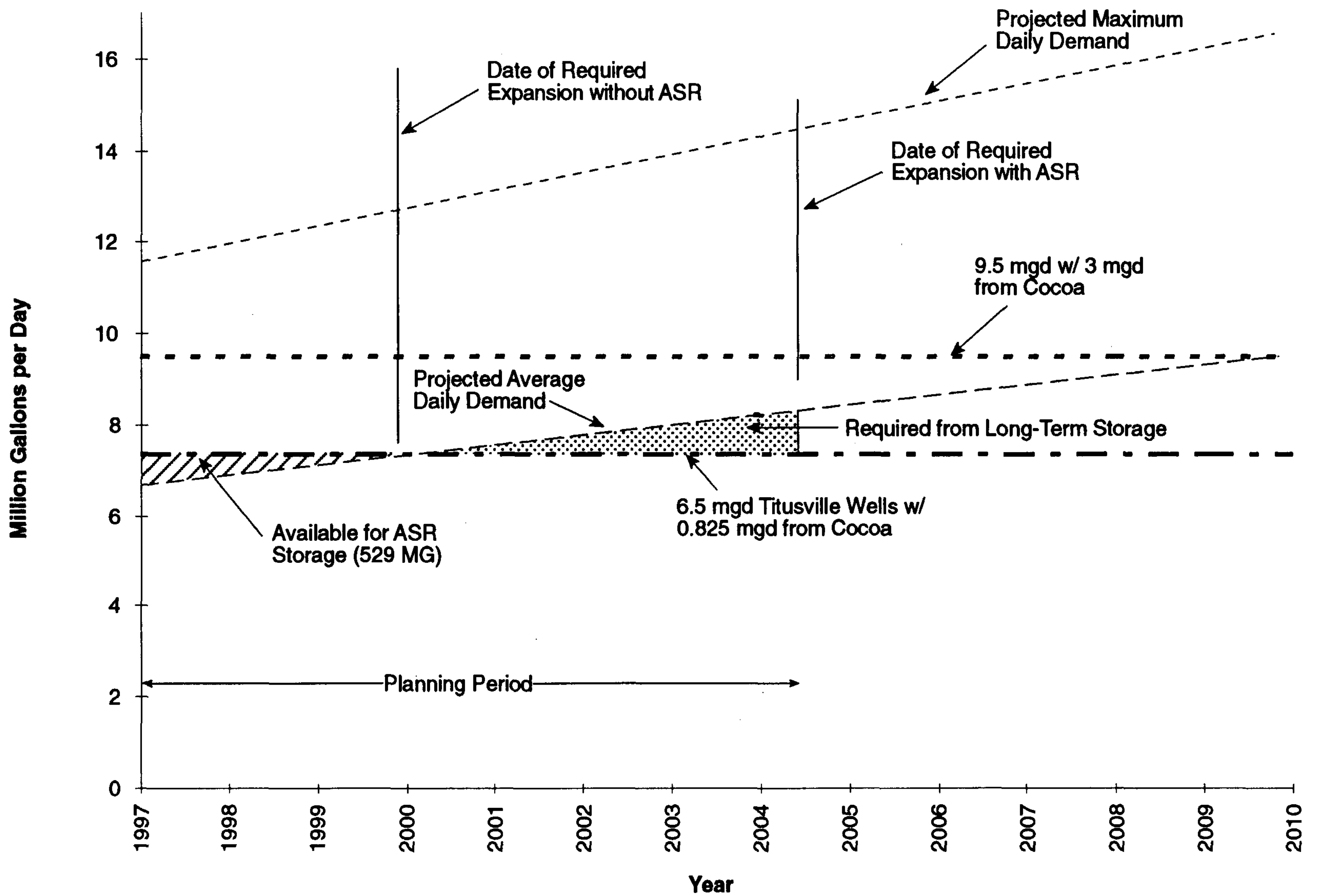


Figure D-4. City of Titusville Long-Term Storage Need.

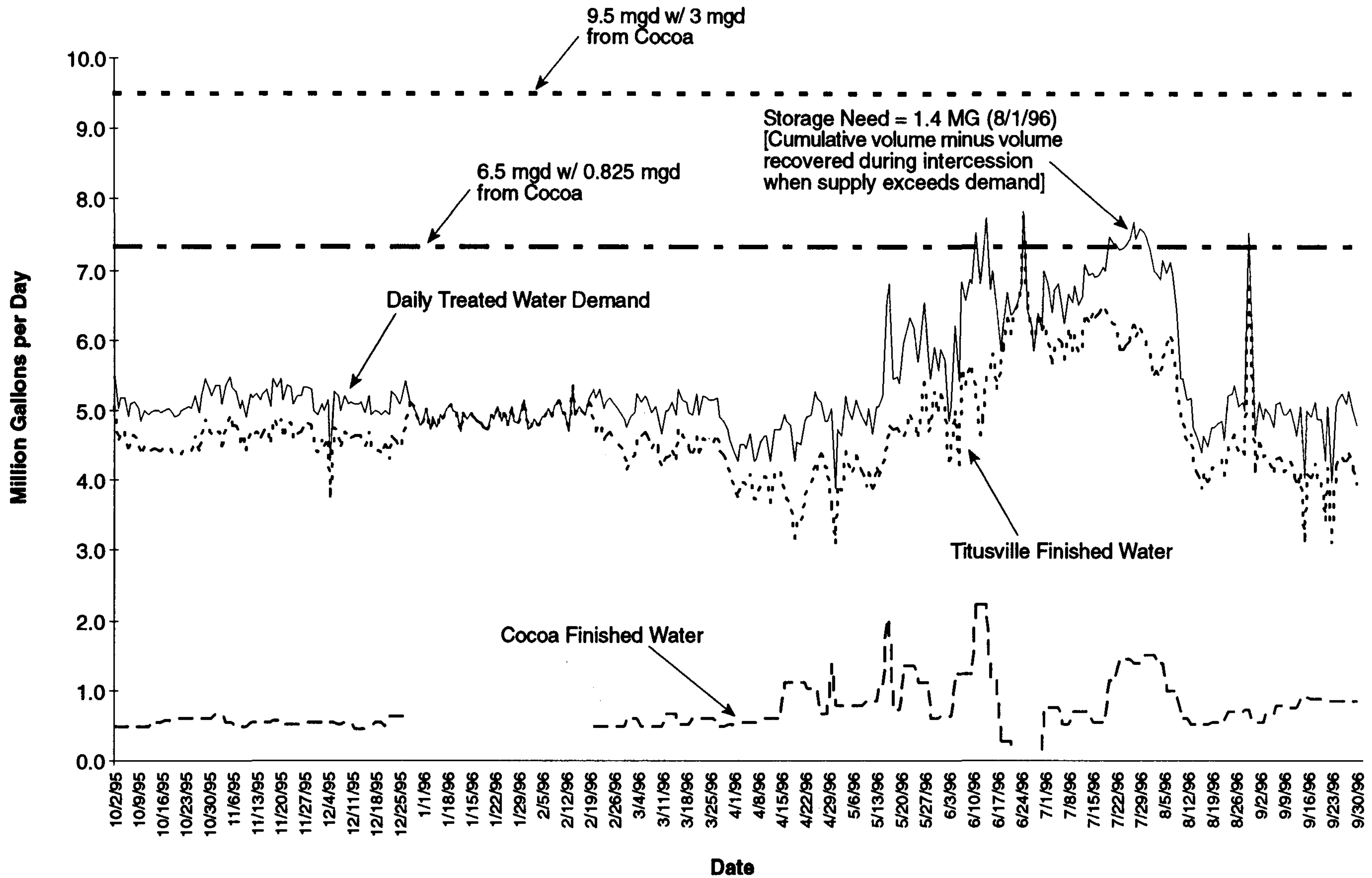
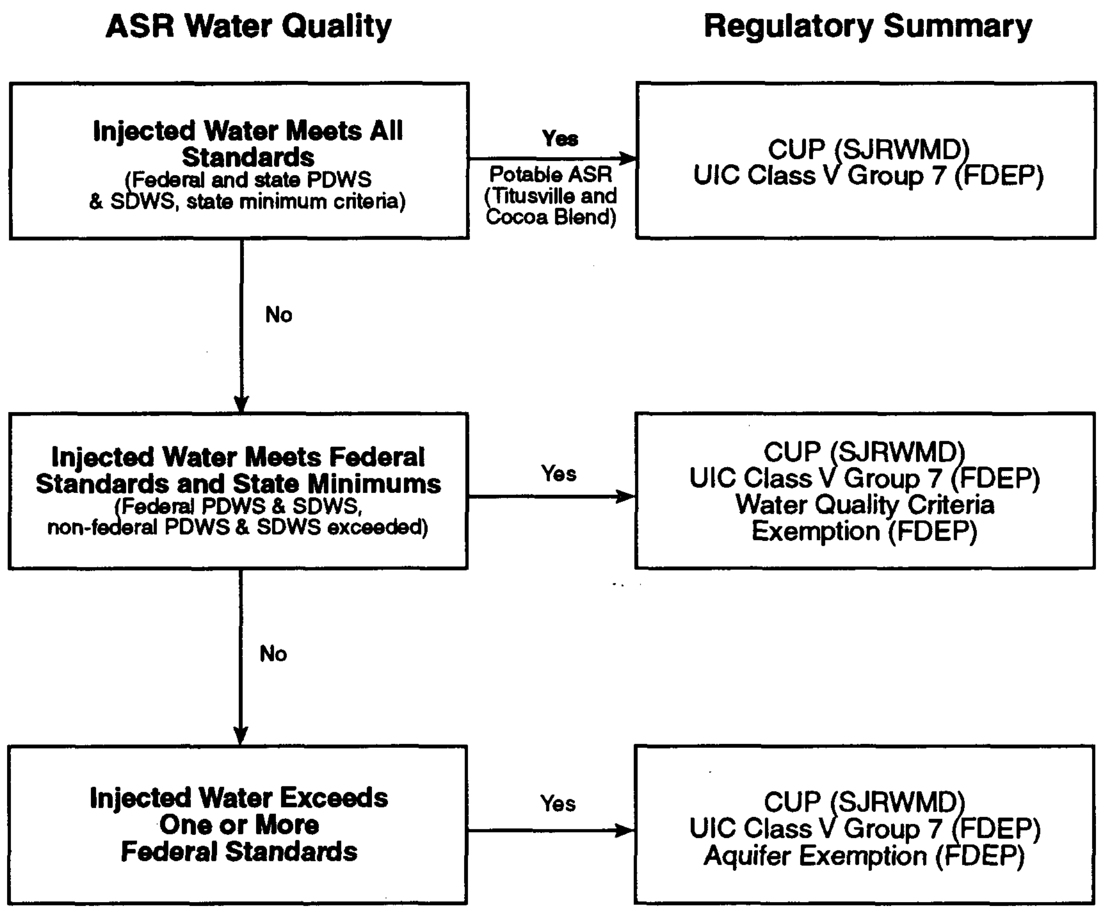


Figure D-5. City of Titusville Seasonal Storage Need for Water Quantity.



Note: Injected water can be either treated or raw.

Figure D-6. Possible ASR Regulatory Requirements for the City of Titusville.

Feasibility Screening Report
Parts A and B

Facility Designation City of Titusville Water Source Surficial Aquifer Ground Water Date 12/2/96

Facility Director James L. Chaffee Intended Use Potable Supply

Water Management District St. Johns River Water Management District Date

District Officer

PART A FACILITY PLANNING FACTORS

1 Average Daily Demand (End of Planning Period): 9.5 mgd — Is ADD Greater Than 1 mgd? X YES ___ NO

2 a. Total Supply Volume for Planning Period: 37,430.8 to 48,545.0 MG
b. Total Demand Volume for Planning Period: 41,198.3 MG — Is the Supply Volume Greater Than Demand Volume? X YES ___ NO

3 List Storage Need Volumes Calculated:
a. Long Term Volume: 529 MG
b. Seasonal Volume (For Quantity and Quality): 4 MG (2010)
c. Short Term Volume: - MG
d. Other (Emergency, Plant Operations, etc): - MG
e. Total a. through d., above 533 MG

Are any of the Volumes Greater Than 5 MG ? — If maximum purchase from Cocoa is made X YES ___ NO

PART B HYDROGEOLOGIC, DESIGN, AND OPERATION FACTORS

ASR Hydrogeologic, Design and Operation Factor Scores

Section Points	1 Storage Zone Confinement	2 Storage Zone Transmissivity	3 Local Aquifer Gradient/Direction	4 Recharge Water Quality	5 Native Water Quality	6 Physical, Geochemical Interactions	7 Interfering Uses and/or Impacts
5		5					
4				4			
3	3		3			3	
2					2		2
1							
Weight Factor	X 10	X 10	X 1	X 2	X 10	X 5	X 5
Score	30	50	3	8	20	15	10

Total Score 136

High Feasibility Zone (points 5–4)

Further Investigations Needed Zone (points 3–1)

Score	Feasibility Level	Type of Study Recommended
160-215	High Confidence	General – Confirm Assumptions
100-159	Moderate Confidence	Focused – Investigate Specific Factors
43-99	Low Confidence	Detailed – Evaluate Impact of Critical Factors

157

Feasibility Screening Report
Parts C and D

Facility Designation City of Titusville — Date 12/2/96

Facility Director James L. Chaffee

Water Management District St. Johns River Water Management District — Date ______

District Officer ______

PART C COST COMPARISON SUMMARY

Cost Comparison for Storage Options

Storage Need (SN) : Long-Term: 529 MG / Seasonal: 4 MG

ASR Recovery Rate = 1.8 mgd (Demand in excess of 6.5 mgd in 2006)

Peak Factor (PF): 1.5 — Recovery Duration (RD): 17 days — ASR Recovery Rate $\frac{PF + SN}{RD}$ = 0.4 mgd

Equivalent Annual Costs

	Long-Term		Seasonal
Tank	$ N/A	*(Figure A-5)*	$ 89,000
Reservoir	$ 2,444,000	*(Figure A-5)*	$ N/A
ASR	$ 129,000	*(Figure A-5)*	$ 29,000

Cost Comparison for Management Options

Plant Rate Increase: 7.4 mgd (Planned upgrade to meet 2010 demand)

Equivalent Annual Costs

Plant Upgrades	Base Cost	Option 1	Option 2	Option 3	Option 4
Lime Softening and					
Sulfide Reduction by	Tray Aeration *(Figure A-8)*				
	Packing Tower *(Figure A-9)*				
	Ozonation *(Figure A-10)*				
TOTAL					

Equivalent Annual Cost for Options

Plant Upgrade $ 1,740,000 (total cost from option selected from the table above)

ASR $ 129,000 *(Figure A-4)*

PART D REGULATORY SUMMARY

	YES	NO	
Injected water meets all standards			(refer to Figure A2 for regulatory requirements)
Injected water meets federal standards and state minimums			(refer to Figure A2 for regulatory requirements)
Injected water exceedes one or more federal standards			(refer to Figure A2 for regulatory requirements)

Appendix E

ASR Feasibility Screening St. Johns County

CONTENTS

ASR FEASIBILITY SCREENING—ST. JOHNS COUNTY

FIGURES

TABLES

ASR FEASIBILITY SCREENING— ST. JOHNS COUNTY

St. Johns County is located in the northeast portion of Florida, between Duval County and Flagler County (see Figure E-1). The nearest large city is St. Augustine, which is located on the eastern coast of Florida.

Information about the St. Johns County utility and specific water use data were provided by the County's Utilities Department personnel during a site visit on October 14, 1996 (Stewart and Young, 1996).

OVERVIEW

St. Johns County Utilities Department provides water service for a large section of St. Johns County. Currently serving 30,000 permanent potable water customers, the County anticipates expanding its Mainland Water Treatment Plant (WTP) service area to meet future needs in adjacent areas. During the 1980s, St. Johns County experienced 61 percent growth. Projected growth for the 1990s is 36 percent. The October 1995 to September 1996 average daily water demand was approximately 3.3 million gallons per day (mgd), with a maximum demand of approximately 4.4 mgd. This demand exhibits seasonal high fluctuations relating to an influx of vacationers during Spring Break to the Anastasia Island area. This seasonal increase corresponds to an overall demand increase between April and September. Continued growth is expected throughout St. Johns County, as detailed in the *Water and Wastewater Master Plan* (Camp, Dresser, and McKee, Inc. [CDM], 1994).

Existing Facilities

The St. Johns County water supply system consists of the Mainland WTP, two small package plants, a wellfield with surficial and Floridan aquifer wells, and several aboveground storage tanks, in addition to the water distribution system. Private utilities are also located throughout the county, particularly near Jacksonville.

Water Treatment Plants. St. Johns County Utilities Department operates the one large WTP and two smaller plants (3,000 gpd). The Mainland WTP is located west of I-95, just north of CR 214 (Figure E-2). Built in 1991, with an initial capacity of 7 mgd, the plant operates around 3 mgd. The County's two package plants were either acquired from previous owners or installed to supply water to residential communities outside of any existing service area. Only Mainland WTP and the nearby Tillman Ridge Wellfield were evaluated in this study. Treated water leaving the WTP for distribution has chloride and total dissolved solids (TDS) concentrations of 163 million gallons per liter (mg/L) and 330 mg/L, respectively.

Water Supply. The St. Johns County water supply is recovered from the Tillman Ridge Wellfield. The wellfield has seven wells completed mainly in the surficial aquifer and one well completed in the Upper Floridan aquifer. Blended prior to treatment, 55 percent of the raw water supply currently comes from the surficial aquifer and 45 percent from the Floridan aquifer.

The wellfield was constructed in 1981 near the Mainland WTP (Figure E-2). The shallow aquifer wells have the capacity to produce 350 gallons per minute (gpm); however, this pumping rate has reduced over time due to the deterioration of the wells. These wells are scheduled to be redeveloped, which should restore the original pumping rates.

The raw ground water has chloride concentrations of approximately 30 mg/L for the surficial aquifer and 180 mg/L for the Floridan aquifer. The raw ground water also has TDS concentrations of approximately 350 mg/L for the surficial aquifer and 1,000 mg/L for the Floridan aquifer. Therefore, the Floridan aquifer water is used as a blending source with the better-quality surficial aquifer water in order to meet the demand. The lime-softening treatment process currently cannot lower the Floridan aquifer water TDS to acceptable levels. Therefore, additional Floridan aquifer water cannot be introduced.

Water Supply Storage. The County currently has a storage capacity of 7.5 million gallons (MG) in ground and aboveground tanks located in several locations. However, only 6 MG is available for public supply; the remaining 1.5 MG is used at the WTP. With 100 percent of the total storage available, County demands could be met for approximately 43 hours.

Future Facility Expansions

The projected average demand for the year 2010 is 9.9 mgd, with a maximum demand of 15.8 mgd, for an expanded Mainland WTP service area. Facility expansions are planned to meet the projected water demands.

Water Treatment Plants. St. Johns County is considering a reverse osmosis (RO) addition to the water treatment process within the next 7 to 10 years. This addition will allow more withdrawal from the Floridan aquifer and reduce dependency on the surficial aquifer for the St. Johns County water supply.

Water Supply. The County plans to expand its surficial aquifer wellfield with four new wells in the next 2 years. These new wells will aid in maintaining the water supply while existing wells are redeveloped to restore current specific capacities to original levels. One additional Floridan aquifer well has been installed and mechanically equipped. This well will be put into service in the next few months. These expansions will increase the full wellfield capacity to 8.3 mgd. Future expansions will probably occur towards the east, in the direction of Tressle Bay Swamp.

Water Supply Storage. There are plans to add a 1.5-MG storage tank at the WTP in the next 2 to 3 years. The addition will bring the storage capacity to 7.5 MG.

Water Supply System Restrictions

Wellfield Operations. The County's Consumptive Use Permit (CUP) dictates the following restrictions on the water withdrawal:

Maximum Annual Withdrawals		Maximum Total Daily Withdrawals	
1,088.4 MG	1996	3.73 mgd	1996

The CUP is currently being modified for renewal. This modification includes acquisition of the Southern States Utility and the Northwest Utilities, which has its own water supply wells.

Water Shortages. Water shortages have occurred in the past due to drought conditions in the area. When drought conditions exist, the water levels drop and the drawdowns in the supply wells increase, requiring the wells to be pumped at lower rates to keep drawdowns from becoming excessive.

Wetlands Monitoring. The County is not currently monitoring its wetlands. If impacts to wetlands have occurred, wetlands monitoring or mitigation may be required in the future.

Environmental Impacts. There appear to be no industries or landfills in the area that could adversely impact the water source.

Interfering Uses. Within the geographical limits of St. Johns County, 24 individual utilities are currently in operation. Many of these utilities serve a small number of people from a one- or two-well supply system. Six substantial wellfields exist within St. Johns County, surrounding the Tillman Ridge Wellfield on three sides (Figure E-3). The wellfield farthest from the Mainland WTP and Tillman Ridge Wellfield is 23 miles northeast; the closest is 4.5 miles east. Approximately 120 agricultural wells are located in the western half of St. Johns County.

ASR FEASIBILITY RANKING REPORT

As each section of the screening tool is reviewed, a score is determined that best represents the site-specific characteristics. At the end of the ranking process, each score is weighted as to its degree of importance and a final score is calculated. The magnitude of this score identifies a relative ASR feasibility for the site.

Part A. Facility Planning Factors

Step 1. List the Average Daily Demand.

Instructions: For Potable Use, if the ADD is greater than 1 mgd, proceed to Step 2. If the ADD is less than 1 mgd, another solution should be evaluated. For Agricultural Use, proceed to Step 2.

The St. Johns County average daily demand for 1995-1996 was 3.2 mgd. The projected average daily demand for the year 2010 is 9.9 mgd.

Step 2. List the Total Supply and Demand Volumes for the Planning Period.

Instructions: If the total supply volume is larger than the total demand volume, proceed to Step 3. If the demand is larger than the supply, investigate other supply increase and demand reduction solutions.

For the purposes of this study, the planning period is defined as 1997-2010, which corresponds to the end of the planning period used in the SJRWMD Needs and Sources study. St. Johns County is in the process of renewing its CUP. The 1996 value is 1,088.4 MG per year, with a daily maximum of 3.73 mgd from the combined surficial and Floridan aquifer water supply. The treatment capacity for the WTP is 7 mgd. Therefore, the CUP value is the limiting condition. Carrying the 1996 annual value through 2010, the total supply would be 15,237.6 MG (1,088.4 MG multiplied by 14 years).

Demand data are presented below for the Mainland WTP. Projected flow data from the Water and Wastewater Master Plan *(CDM, 1994) were used to calculate the total demand volume for the 1997-2010 planning period. It should be noted that the actual demand is lower in 1996 than the CUP.*

Year	AADF[1] [mgd]	Annual Volume[2] [MG]
1997	6.539	2386.7
1998	6.700	2445.5
1999	6.800	2482.0
2000	6.919	2525.4
2001	7.200	2628.0
2002	7.400	2701.0
2003	7.700	2810.5
2004	7.900	2883.5
2005	8.140	2971.1
2006	8.500	3102.5
2007	8.900	3248.5
2008	9.200	3358.0
2009	9.600	3504.0
2010	9.946	3630.3
Total		46,677.1

[1]Average Annual Daily Flow (AADF) data projected in the *Water and Wastewater Master Plan* (CDM, 1994). Linear interpolation used for values not explicitly stated in the report.

[2]6.539 mgd x (1 year x 365 days/year) = 2386.7 MG.

Since the total demand volume, 40,677.1 MG, is greater than the total supply volume, 15,237.6 MG, a water supply problem is anticipated without a supply increase. Since the CUP renewal is in progress, we proceeded with this screening tool, assuming that the supply increase would be provided. Also, the Master Plan involves purchasing small utilities that would provide valid reasons for CUP increase throughout the planning period. The supply increase may be in CUP capacity or an alternate water supply.

Step 3. List Storage Need Volumes Calculated as a Long-Term Volume, a Seasonal Volume, a Short-Term Volume, or Other.

Instructions: If the total volume is greater than 5 MG, proceed to Part B, below. If the total volume is less than 5 MG, investigate other storage options.

Long-Term Storage Need: Since the current CUP capacity is less than the demand, available supply capacity is insufficient to provide long-term storage. However, if the CUP capacity were upgraded to be consistent with the 7-mgd plant capacity, approximately 212 MG would be available for ASR to delay the plant upgrade. Using the Master Plan projections from 1997 through 2010, we expect this delay to extend from approximately year 2001 to year 2003. Refer to Figure E-4.

Seasonal Storage Need: Demand and supply values were plotted for 1 year (October 1, 1995, through September 30, 1996). This information indicated that the plant was operating in a 1.66- to 4.26-mgd range, with an average around 3.33 mgd. Therefore, a seasonal fluctuation exists that may be addressed by operating the plant at a more consistent rate. Plant operation at a constant rate of 3.5 mgd would correspond to a peak storage need of approximately 13.3 MG. (Refer to Figure E-5.) A 40-MG seasonal storage need was projected for the year 2010 (13.3 MG multiplied by the 2010 to 1995 average demand ratio, 9.45/3.33).

Other storage needs were not specifically quantified for this site. However, it is feasible for additional benefits to be derived from ASR storage. First, the plant could be operated at a consistent level rather than varying the operations based on demand. In addition, it would be feasible to incorporate an emergency water supply storage for St. Johns County.

Thus, the storage need calculated for the County is 252 MG, a combination of the long-term and seasonal storage needs.

Part B. Hydrogeologic, Design, and Operation Factors

Area Hydrogeology

The hydrogeologic factors needed to evaluate the feasibility of ASR include the occurrence and depths of transmissive and confining intervals in the Upper and Lower Floridan aquifers. The characteristics of confining beds overlying the Floridan aquifer are also important in the evaluation of suitable zones. In St. Johns County, the most probable ASR zones are expected to occur in the Upper Floridan aquifer.

The surficial aquifer system in St. Johns County varies in thickness with the depth to the top of the Hawthorn Group. The system is composed of the sands, shell beds, and sandy limestones of the Pliocene- and

Pleistocene-age sediments. The aquifer system is nonartesian and water levels are usually within 10 feet of land surface. The surficial aquifer system is approximately 100 feet thick.

The intermediate confining beds are generally associated with the Hawthorn Group in this area of Florida. The low-permeability silty and clayey sediments within this sequence effectively retard the vertical flow of water between the surficial aquifer system and the Floridan aquifer system. These confining beds are approximately 122 feet thick at the St. Johns County Tillman Ridge Wellfield, but could be as thick as 350 feet (Tibbals, 1990). The silts and clays within the Hawthorn Group are of very low permeability.

The Floridan aquifer system consists of the upper producing zone, the middle semi-confining zone, and the lower producing zones. The upper producing zone of the Floridan aquifer extends from approximately 140 feet (from Palm Coast Floridan aquifer well construction) to 700 feet (Tibbals, 1990) below land surface (bls). The Ocala Group and part of the Avon Park Limestone are the geologic units present within the zone. TDS and chloride concentrations in the Upper Floridan aquifer at Palm Coast average 500 mg/L and 135 mg/L, respectively. TDS and chloride concentrations of samples taken during drilling of the St. Johns County Floridan aquifer water supply wells were about 1,200 mg/L and 180 mg/L, respectively. The water is expected to degrade with increasing depth.

The middle semi-confining zone of the Floridan aquifer system extends from 700 feet to 800 feet bls (Tibbals, 1990). The zone is contained within the lower sequence of the Avon Park Limestone. The lower producing zone of the Floridan aquifer is contained within the Lake City Limestone. It extends from the base of the middle confining zone at 800 feet to a depth of approximately 2,000 feet bls. Transmissivity is expected to be higher in the lower producing zones.

Step 1. Storage Zone Confinement

Instructions: Use Table E-1 to rank the hydraulic conductivity and thickness of the vertical flow restrictive units (aquitard) above and below the storage zone. This data can be gathered from local wells in the same zone or from regional published information. Table 3A from Technical Memorandum (TM) C.1.c (CH2M HILL, 1996) presents an example ranking based on a 100-foot-thick confining unit, which shows how Figure A-2 (TM C.1.c) is used to determine the ranking.

Data from the Floridan aquifer supply wells in St. Johns County indicated that confining beds suitable for ASR exist in the Floridan aquifer. Suitable intervals, with hydraulic conductivity in the range of

1.0 x 10^{-4} to 10^{-5} feet per second, exist in the Upper Floridan aquifer. This permeability would result in a generally good storage zone confinement ranking, with thicknesses greater than 40 ft.

Table E-1. Storage Zone Confinement Ranking

Rank	Aquitard Hydraulic Conductivity	Aquitard Thickness
3	**1.0 x 10^{-4} to 1.0 x 10^{-5}**	**50 to 100 feet**

Step 2. Storage Zone Transmissivity

Instructions: Use Table E-2 to rank the target storage zone transmissivity. This data can be gathered from local wells in the same zone or from regional published information. Figure A-3 (TM C.1.c) should be used in conjunction with Table E-2 to determine the ranking.

Hydrogeologic data from the St. Johns County and Palm Coast Floridan aquifer supply wells indicated that intervals exist in the Upper Floridan aquifer between 140 and 700 feet, with transmissivities of between 100,000 and 200,000 gallons per day per foot (gpd/ft). This range is slightly less than optimum for potable water ASR and resulted in a rank of 3.

Table E-2. Storage Zone Transmissivity Ranking

Rank	Transmissivity Criterion (gpd/ft)		Applicability
	Potable Water	Untreated Surface Water	
1	Less than 8,000	Less than 80,000	Limited
2	8,000 to 15,000	80,000 to 250,000	
3	15,001 to 40,000	250,001 to 400,000	
4	40,001 to 50,000	400,001 to 500,000	
5	50,001 to 80,000	500,001 to 1,000,000	Optimal
4	80,001 to 120,000	1,000,001 to 1,150,000	
3	**120,001 to 200,000**	**1,150,001 to 1,400,000**	
2	200,001 to 400,000	1,400,001 to 2,000,000	
1	Greater than 400,000	Greater than 2,000,000	Limited

Step 3. Aquifer Gradient and Direction

Instructions: Rank the local aquifer gradient and direction. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table E-3.

The significance of local aquifer gradients would depend on the location of the ASR wells in relation to the County's Floridan aquifer supply wells. A default rank of 3 was selected in order to flag this criterion as needing site-specific information during the detailed investigation.

Table E-3. Local Aquifer Gradient/Direction Ranking

Rank	Aquifer Gradient (in same recharge zone)	Direction Criterion
1	Many strong influences exist	Extreme artificial gradient, reevaluate location of ASR system
2	Several strong influences	Exaggerated gradient, investigation needed
3 (default)	Multiple minor influences exist	Affected gradient worth investigating
4	Single minor influence or abnormal natural gradient	Minor investigation or existing data search
5	No influence	No influence

Step 4. Recharge Water Quality

Instructions: Rank the recharge water quality using chloride or TDS concentrations of the water to be stored in the ASR zone. For potable water, this data can be obtained from the records of the WTP that will be supplying the source water. For raw water, this can be determined from published records or databases. If this information is not available, use the default value shown in Table E-4.

Treated water leaving the WTP for distribution has chloride and TDS concentrations of 163 mg/L and 330 mg/L, respectively. The concentration for chlorides was used, providing a rank of 3.

Table E-4. Recharge Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Compliance with SDW Standards
1	Greater than 200	or	Greater than 450	Just within SDW standards
2	200 to 171		450 to 351	
3	**170 to 101**		350 to 201	Moderately meets SDW standards
4	100 to 50		200 to 100	
5	Less than 50		Less than 100	Well within SDW standards

Step 5. Native Water Quality

Instructions: Rank the native water quality based on the chloride or TDS information of the native water in the target ASR zone. This data can be gathered from local wells in the same zone or from regional published information. If this information is not available, use the default value shown in Table E-5.

The native water quality in the Upper Floridan aquifer can be expected to be similar to that found in the Floridan aquifer supply wells belonging to St. Johns County and Palm Coast. The chloride concentration ranges from 135 to 180 mg/L, and TDS from 500 to 1,200 mg/L. This good water quality resulted in a rank of 4.

Table E-5. Native Water Quality Ranking

Rank	Chloride	(mg/L)	TDS	Water Quality
1	Greater than 6,000	or	Greater than 10,000	Very brackish
2	6,000 to 3,001		10,000 to 5,001	
3	3,000 to 801		5,000 to 1,301	Slightly brackish
4	**800 to 400**		1,300 to 700	
5	Less than 400		Less than 700	Near fresh water

Step 6. Physical, Geochemical, and Design Interactions

Instructions: Rank the potential for physical, geochemical or design interactions. This rank is based on the sum of the ranks from the sub-categories shown in the table below. If this information is not available, use the default value shown in Table E-6.

Some parameters included in the ranking tool are not ordinarily included in the routine water quality analysis performed on the treated water. In *cases where parameter values were missing, default ranks were incorporated that flag these parameters as needing further analysis. The water quality for the treated water of the St. Johns County Mainland WTP is provided in parentheses next to the selected rank in Table E-6.*

Table E-6. Overall Physical, Geochemical, and Design Interaction Ranking for SJRWMD

Sub-Category	Rank	Recharge Water and Criterion	Selected Rank
Physical Interactions from Suspended Solids			
TSS	1	TSS>2.0 mg/L	
	2	2.0 mg/L>TSS>0.05 mg/L **(default)**	2
	3	TSS<0.05 mg/L	
Biological Growth and Geochemical Interactions			
pH	1	7.8<pH< 8.6 **(default)**	
	2	pH>8.6	1
	3	pH<7.8	
Total Phosphorous	1	P>0.1 mg/L	
	2	0.1 mg/L>P>0.05 mg/L **(default)**	2
	3	P<0.05 mg/L	
Nitrate as N	1	N>1 mg/L	
	2	1 mg/L>N>0.5 mg/L (default)	3
	3	**N<0.5 mg/L**	
Dissolved Organic Carbon (DOC)	1	DOC>5 mg/L	
	2	5 mg/L>DOC>2.5 mg/L **(default)**	2
	3	DOC <2.5 mg/L	
Total Iron (Fe)	1	Fe>1 mg/L	
	2	1 mg/L>Fe>0.3 mg/L (default)	3 (0.09)
	3	**Fe<0.3 mg/L**	
Dissolved Oxygen (DO) of Recharge Water	1	DO>3 mg/L	
	2	3 mg/L>DO>1.5 mg/L **(default)**	2
	3	DO<1.5 mg/L	
Point Totals			15
Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**3**

Note: Use the default value if data for any parameter is unavailable. Determine the overall rank from the following point totals:

Rank	Physical, geochemical, and design criteria (total of above points)	
1	7-10 points	Higher potential for plugging
2	11-12 points	
3	**13-16 points**	Moderate potential for plugging
4	17-18 points	
5	19-21 points	Low potential for plugging

Step 7. Interfering Uses and Impacts

Rank the interfering uses and impacts which can exist or have the possibility to exist in the vicinity of a proposed ASR site. Information can be gathered from visual surveys, aerial photographs, topographic maps, and public records/information.

This rank is determined from the sum of two sub-ranks shown in Table E-7. If this information is not available, use the default value shown.

An inventory of wells within a 5-mile radius of the Mainland WTP and Tillman Ridge Wellfield revealed the following existing wells in the area:

Number of Wells	Well Size (inches)	Well Use
20	4, 5, 6, 8	agriculture
27	6, 8, 10, 12	public supply
4	4, 6, 8	landscape
1	6	household
11	2, 4, 6, 8	commercial/industrial

Interfering Uses: Twenty-four individual utilities exist around the St. Johns County Mainland WTP and Tillman Ridge Wellfield that operate small water supply systems. Six wellfields exist within St. Johns County. The closest is approximately 4.5 miles from the WTP. Also, approximately 120 agricultural wells are located in the western half of St. Johns County. Due to the number of wells in the area, a rank of 1 was used for this evaluation.

Interfering Impacts: There is no known environmental impact. This information earned a sub-rank of 3.

Table E-7. Interfering Uses and Impacts Ranking

Sub-Category	Rank and Criterion	Selected Rank
Interfering Uses		
Distance to Potable Wells	**1 0.10 mile<Wells<0.25 mile** 2 0.26 mile<Wells<5 miles (default) 3 Wells>5 miles	2 (4.5 miles)
Interfering Impacts		
Distance to Contamination Source	1 0.10 mile<Source<0.25 mile 2 0.26 mile<Source<1 mile (default) **3 Source>1 mile**	3
Point Total		4

Overall Interfering Uses and Impacts Rank (Using rank and point totals listed below)			**3**
Overall Interfering Uses and Impacts Rank determined from the following point totals:			
Rank	Interfering Use and/or Impact Criteria (possibility of impact)		
1	2 points	High use or impact	
2	3 points		
3	**4 points**	**Moderate use or impact**	
4	5 points		
5	6 points	Low use or impact	

The results of the hydrogeologic, design, and operational factors scoring are interpreted as shown in Table E-8.

The St. Johns County hydrogeologic, design, and operational factors score is 139 points out of a total of 215 points (see scoring sheet at the end of this appendix). This score represents a moderate confidence for ASR feasibility. Detailed site-specific information will likely change the feasibility score to better reflect actual conditions at the proposed ASR location.

Table E-8. ASR Feasibility Score for Hydrogeologic, Design, and Operational Factors

Score	Feasibility Level	Type of Study Recommended
160 - 215	High Confidence	General—confirm assumptions
100 - 159	**Moderate Confidence**	**Focused—investigate specific factors**
43 - 99	Limited Confidence	Detailed—evaluate impact of critical factors

Part C. Cost Comparison Summary

Instructions: The annual cost figures (Figures A-4 through A-10 in TM C.1.c) were developed as a means of comparing alternative water storage and treatment options. Use the tables to complete the Cost Comparison Summary Sheet provided in TM C.1.c. On this sheet, a comparison is made between ASR, other storage options and plant upgrades, which will provide the needed water for immediate peak demand or future demands.

Costs need to be evaluated on two levels for St. Johns County.

1. *Storage Option Comparison for Long-Term Storage Need in a Reservoir or ASR:*

   a. *The long-term storage need of 380 MG was calculated for St. Johns County. The cost associated with providing a reservoir would be calculated based on this volume, as follows:*

   Annual Cost = $381{,}000 + 8{,}855V_s^{0.8692}$, *where* V_s *is the storage volume in MG*

   Annual Cost = $381{,}000 + 8{,}855\,(212)^{0.8692}$

   Annual Cost = $1,313,000

   b. *For the ASR calculation, the recovery rate is required. Recovery would be for 4 years to offset supply deficits. The recovery rate would need to be consistent with the difference in the plant peak day and the plant average day as a maximum. The projected peak day in 2003 is approximately 12.4 mgd, whereas the plant capacity is approximately 7 mgd at this time. Therefore the peak recovery rate would be 5.1 mgd for a potential ASR system. For the purpose of this screening tool, a recovery of 0.5 mgd per well was used. Our experience in this area indicates that a 0.5 mgd per well recovery is likely. Therefore, the 0.5 mgd per well value was used to provide an indication of cost differences. The corresponding ASR cost is calculated as follows:*

   Annual Cost = 71,897 X, where X is the recovery rate in mgd

   *Annual Cost = 71,897 * 5.1*

   Annual Cost = $367,000

2. *Storage Option Comparison for Seasonal Storage Need in a Tank or ASR:*

   a. *The seasonal storage need of 39.7 MG was projected for St. Johns County in 2010. The cost associated with a tank to meet this storage need is as follows:*

   Annual Cost = 17,787 X + 18,088, where X is the storage volume in MG

   *Annual Cost = 17,787 * 40 + 18,088*

   Annual Cost = $730,000

   b. *For the ASR calculation, the recovery rate is required. Recovery would be taken over approximately 92 days. The peak factor is the ratio of maximum day to average day, which* *was calculated to be 1.3 using the plant records. Therefore, the peak recovery rate would be 39.7 MG * 1.3 / 92 = 0.6 mgd for a potential ASR system. The corresponding ASR cost is calculated as follows:*

Annual Cost = 71,897 X, where X is the recovery rate in mgd

*Annual Cost = 71,897 * 0.6*

Annual Cost = $43,000

3. *Management Option Comparison for ASR to delay plant expansion:*

   St. Johns County is planning to add an RO plant in the next 7 to 10 years. Based on the planning data used for this tool, construction needs to occur in 2001. Since there is currently insufficient supply, the only savings will be to delay the RO plant for 2 years. Although calculating the benefit of delaying this plant was beyond the scope of this screening, delaying construction does appear to be a worthwhile consideration for the utility from a financial and planning perspective. Therefore, the cost of a lime-softening addition was calculated as an indication of the proposed RO plant cost. The projected peak demand in 2010 is 15.8 mgd. With the plant currently operating at 7 mgd, an 8.8-mgd upgrade is required.

   Annual Cost = 440,000 $Q^{0.687}$, where Q is the capacity increase in mgd

   Annual Cost = 440,000 $(8.8)^{0.687}$

   Annual Cost = $1,960,000

   The ASR cost would be the same as the storage calculation in Item 1.b, since the supply would not be available to delay the plant beyond the planning period. However, the ASR cost may be offset by the savings created by delaying the plant expansion.

A cost summary sheet (Feasibility Screening Report Parts C and D) is included after all figures at the end of this appendix.

Part D. Regulatory Summary

Instructions: Part D presents the regulatory requirements for the different types of water quality. Place an "X" under the category of *YES* or *NO* to best describe the quality of the water to be stored. Figure E-6 provides the regulatory permits or exemptions needed for the different water quality groups.

Figure A-7 is a flowchart showing the permits and approvals needed for specific water qualities to be stored in an ASR system. A SJRWMD CUP *and a Florida Department of Environmental Protection (FDEP) Underground Injection Control (UIC) Class V Group 7 Permit will be required for any ASR application. A potable ASR system would be required for the options identified. Since the source is from the WTP, the injected water will meet all state and federal drinking water standards. Therefore, no permits except the CUP and UIC Class V Group 7 Permit should be required. This permitting scenario appears to be feasible, since potable ASR systems have been permitted throughout Florida.*

CONCLUSIONS

The potential water quality problems associated with the Upper Floridan aquifer in this region provided the basis for SJRWMD selecting St. Johns County as a candidate ASR utility. As part of this study, CH2M HILL used the ASR screening tool and previous experience to determine primary ASR application and any secondary benefits.

The ASR screening process indicated a supply deficit in the planning period as well as an opportunity for seasonal storage using ASR. There are two options for alleviating the supply deficit. First, the CUP withdrawal limit can be increased to the estimated maximum yield of the current wellfield. Data provided by St. Johns County indicated that this value may be around 6 mgd. At this level, ASR may be achieved using the operational schedule discussed below. The second option for reducing the supply deficit is using an alternate source, such as brackish ground water—an option currently being considered by St. Johns County.

According to data provided by the County, if an adequate supply is available, a seasonal storage opportunity exists. Using a specific operating scenario, secondary benefits related to wetland impacts and emergency storage may also be achieved. This operation would be to pump at higher rates during the rainy season and to store extra water in ASR. By pumping during the wet season, the higher drawdown would be offset by an adequate surface water supply for the wetlands. The excess water supply could be stored in a beachside ASR, which could provide emergency storage.

These applications of ASR are feasible from a hydrogeologic perspective as well. A zone in the brackish Upper Floridan aquifer would be targeted, and the hydrogeologic score of 144 indicates a moderate-level confidence in ASR feasibility for potable water storage.

Results from the cost comparison evaluation also suggest that ASR is a possible option for use in St. Johns County. The annual cost comparisons are favorable for ASR, based on long-term storage options ($1,313,000 per year for a reservoir versus $367,000 per year for ASR) and seasonal storage options ($730,000 per year for a tank versus $43,000 per year for ASR). In addition, costs may be reduced by delaying plant expansions (annual cost of $1,960,000 for a plant expansion versus $367,000 for an interim ASR at the 2003 recovery rate). If demand increases remain below projections in the next few years, the plant expansion offset may become more economically attractive. In addition, an ASR system may reduce the plant upgrade requirements, a savings that was not factored into this cost comparison.

As seen in this comparison, there are several ways to consider ASR at the utility. Although the estimates show lower costs for ASR, there may be other perceived costs or benefits that are individual to the utility and not identified in the screening tool. While cost comparisons indicate that the utility could consider ASR applications, an additional supply and treatment capacity will be required prior to 2010.

Like the management and cost factors, regulatory requirements are favorable for ASR use in St. Johns County. Since potable ASR systems were the only applications identified, permits should be obtained without difficulty. The permits that correspond to a potable ASR are a SJRWMD CUP and a FDEP UIC Class V Group 7 Permit, which have been issued throughout Florida for similar projects.

In summary, potential applications for an ASR system exist for the St. Johns County Utility Department. An increased supply through a CUP increase or an alternate source provides the potential for long-term storage and/or optimizing existing wellfield pumping. The hydrogeology also supports a moderate confidence in finding a suitable ASR storage zone in this area. St. Johns County may want to consider incorporating ASR into its long-range master-planning goals. However, before proceeding with any further hydrogeologic data collection, an evaluation of the use of ASR to address wetland impacts would be valuable. If this evaluation demonstrates that ASR could effectively address wetland impacts identified at the existing wellfield, St. Johns County could proceed with developing an ASR test plan for this facility.

REFERENCES

Camp, Dresser, and McKee, Inc. (CDM). *Water and Wastewater Master Plan, St. Johns County*. October 1994.

CH2M HILL. *Aquifer Storage Recovery Feasibility. Alternative Water Supply Strategies in the St. Johns River Water Management District*. Technical Memorandum C.1.c. Prepared for SJRWMD. Gainesville, FL. CH2M HILL. 1996.

Consumptive User Permit for St. Johns County. Issued by the St. Johns River Water Management District.

Geraghty & Miller, Inc. *Potential for Deep Injection of Treated Sewage Effluent at Palm Coast, Hydrology Report for the City of Palm Coast*. August 1978.

Miller, J.A. *Geology and Configuration of the Top of the Tertiary Limestone Aquifer System, Southeastern United States*. U.S. Geological Survey Open-File Reports 81-1178, 81-1124, and 81-1176. 1982.

Stewart, Barry, Superintendent of Water Treatment, and Bill Young, Assistant Director of Utilities, St. Johns County Utilities Department. Meeting with the authors, October 14, 1996.

Tibbals, C.H. *Hydrology of the Floridan Aquifer System in East-Central Florida*. Regional Aquifer-System Analysis. U.S. Geological Survey Professional Paper 1403-E. 1990.

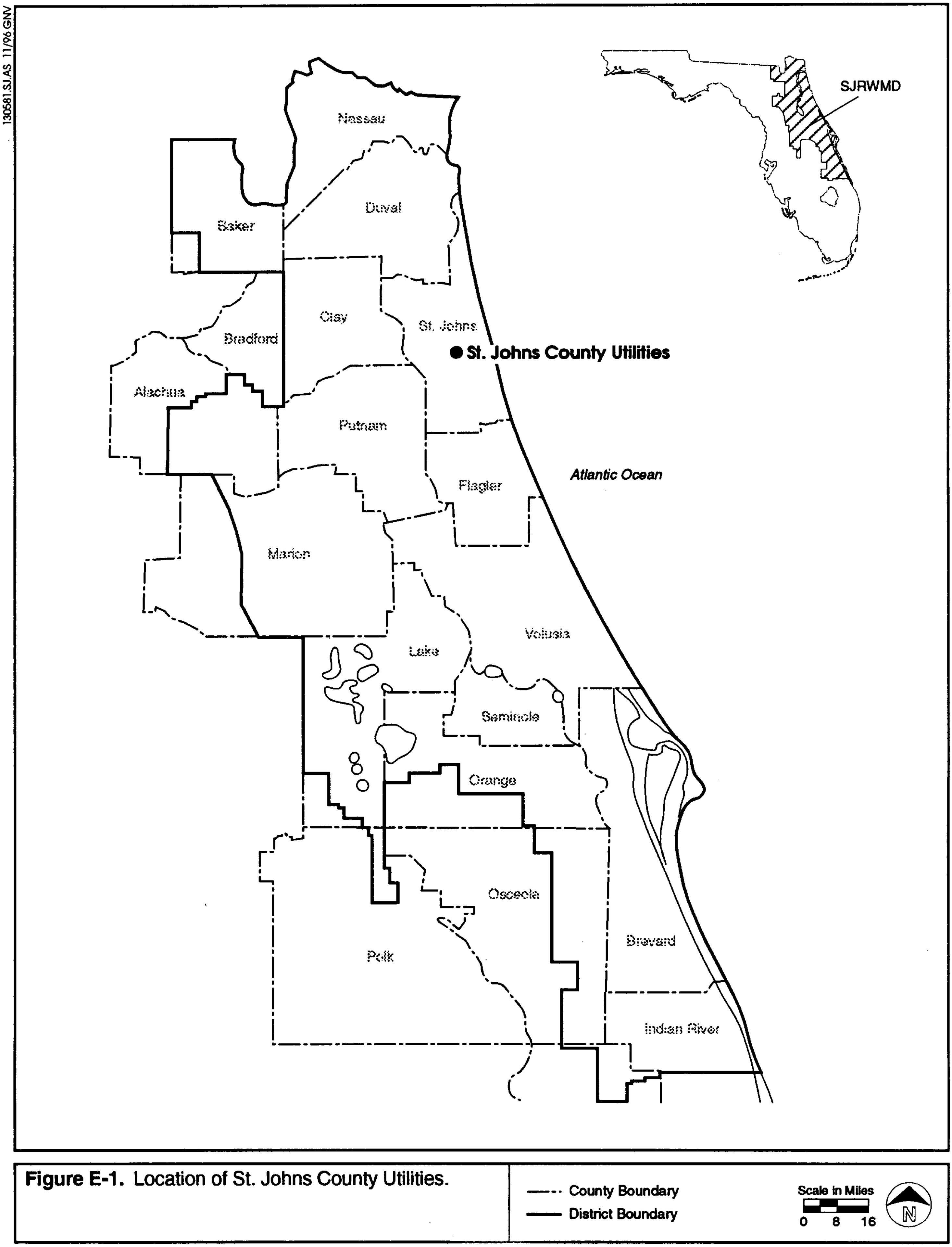


Figure E-1. Location of St. Johns County Utilities.

130581.SJ.AS 11/96 GNV

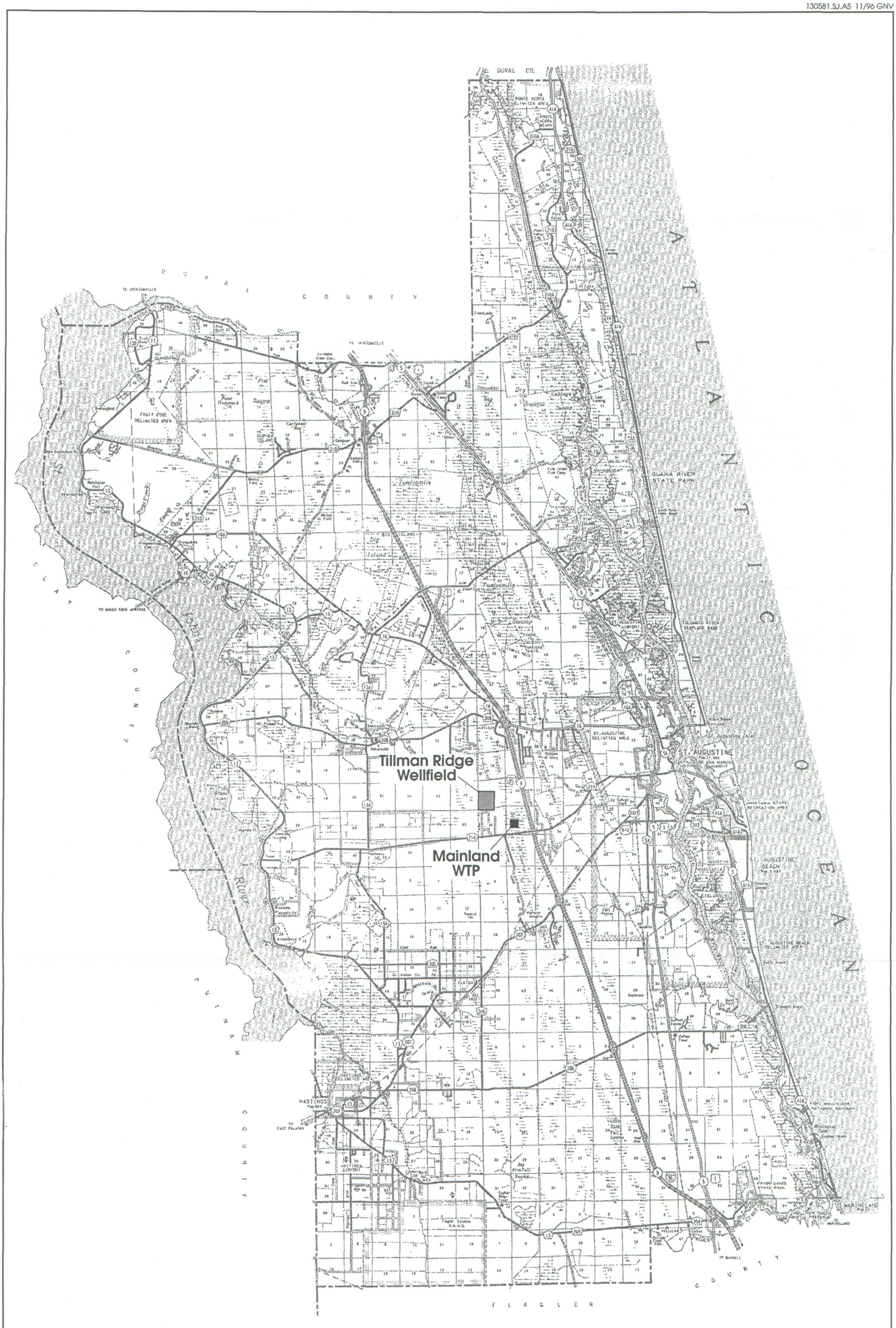


Figure E-2. St. Johns County Water Treatment Plant and Wellfield Locations.

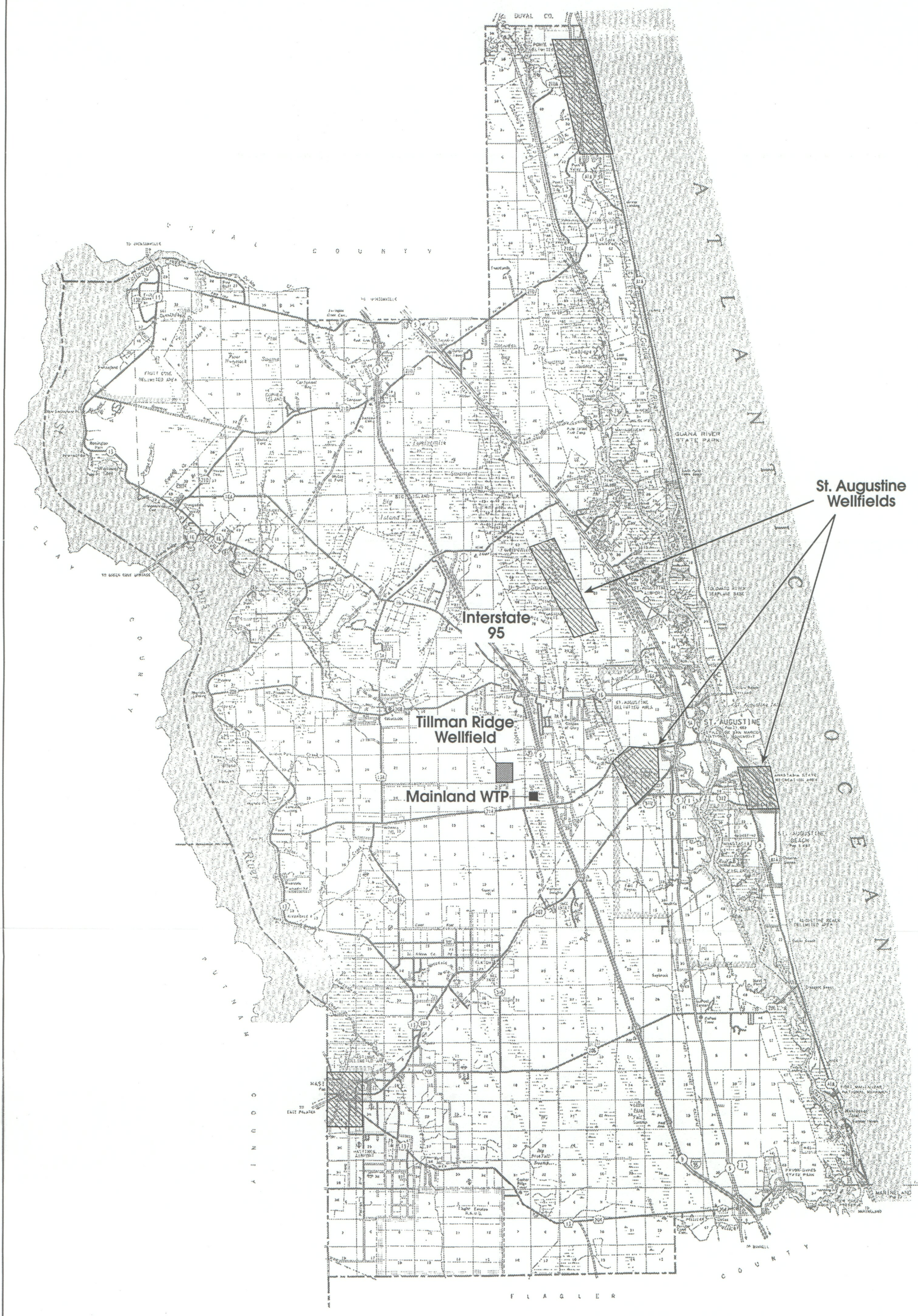


Figure E-3. St. Johns County Interfering Uses and Impacts.

Scale in Miles
0 4 8

130581.SJ.AS 11/96 GNV

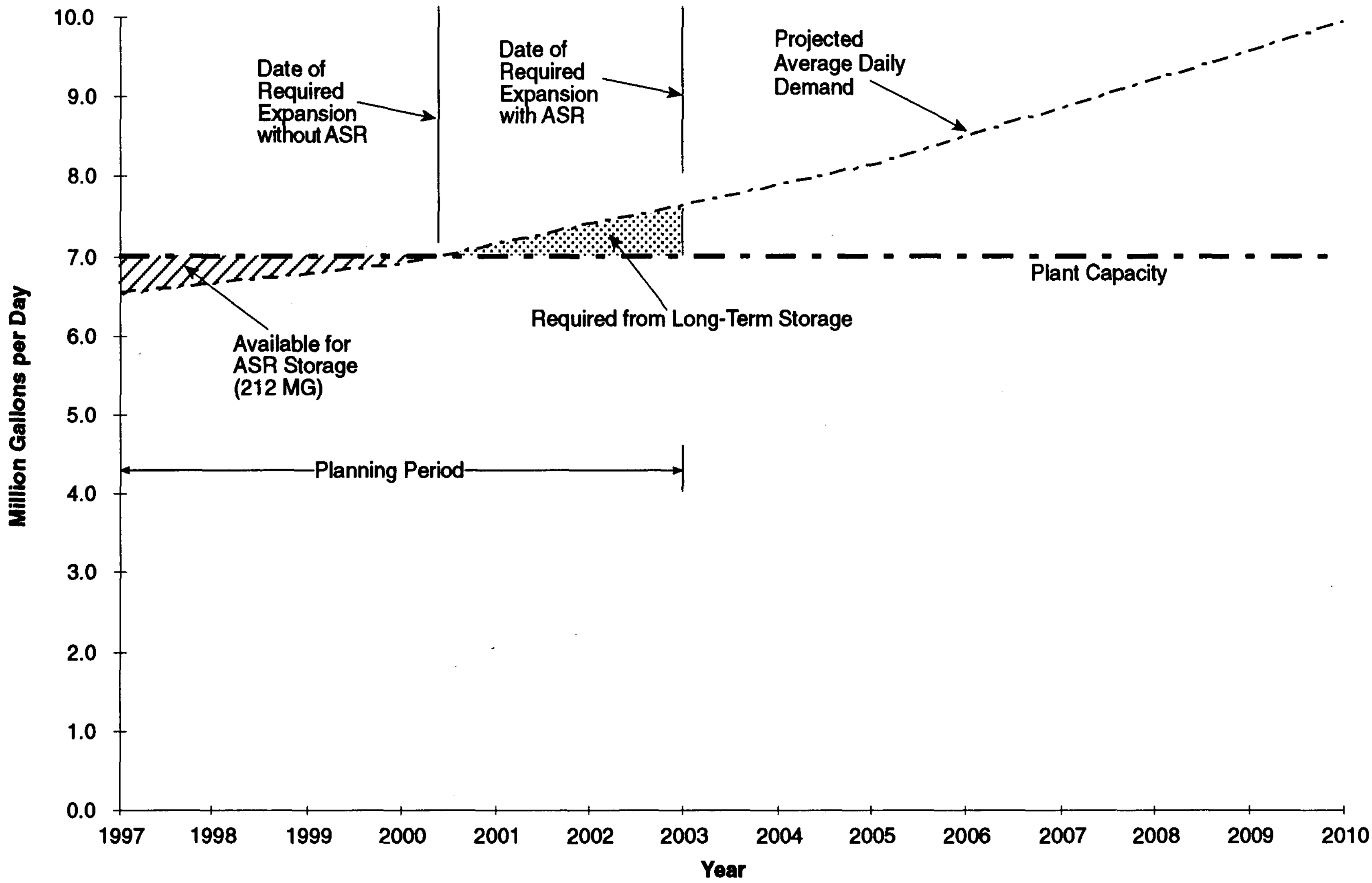


Figure E-4. St.Johns County Long-Term Storage Need.

130581.SJ.AS 11/96 GNV

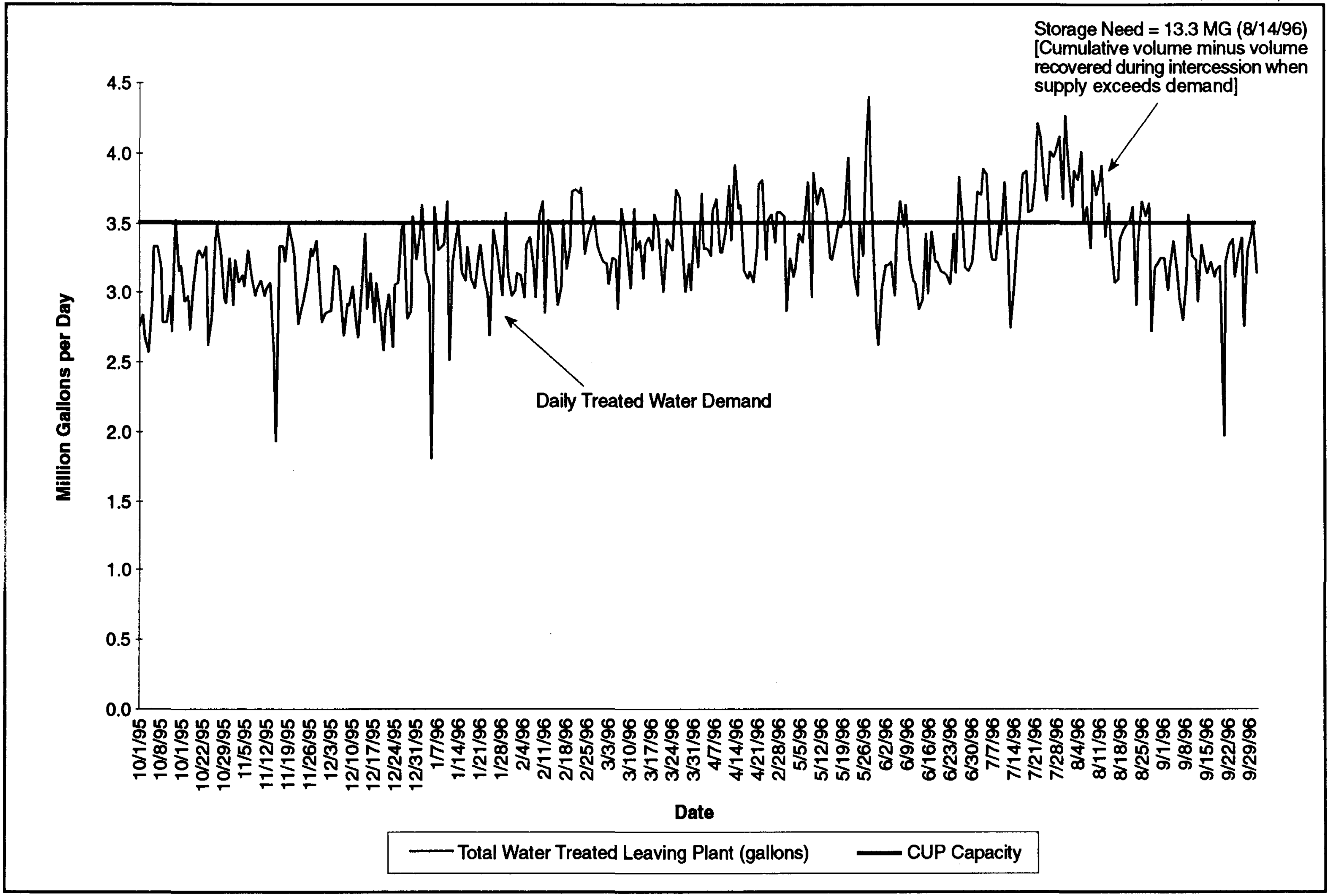
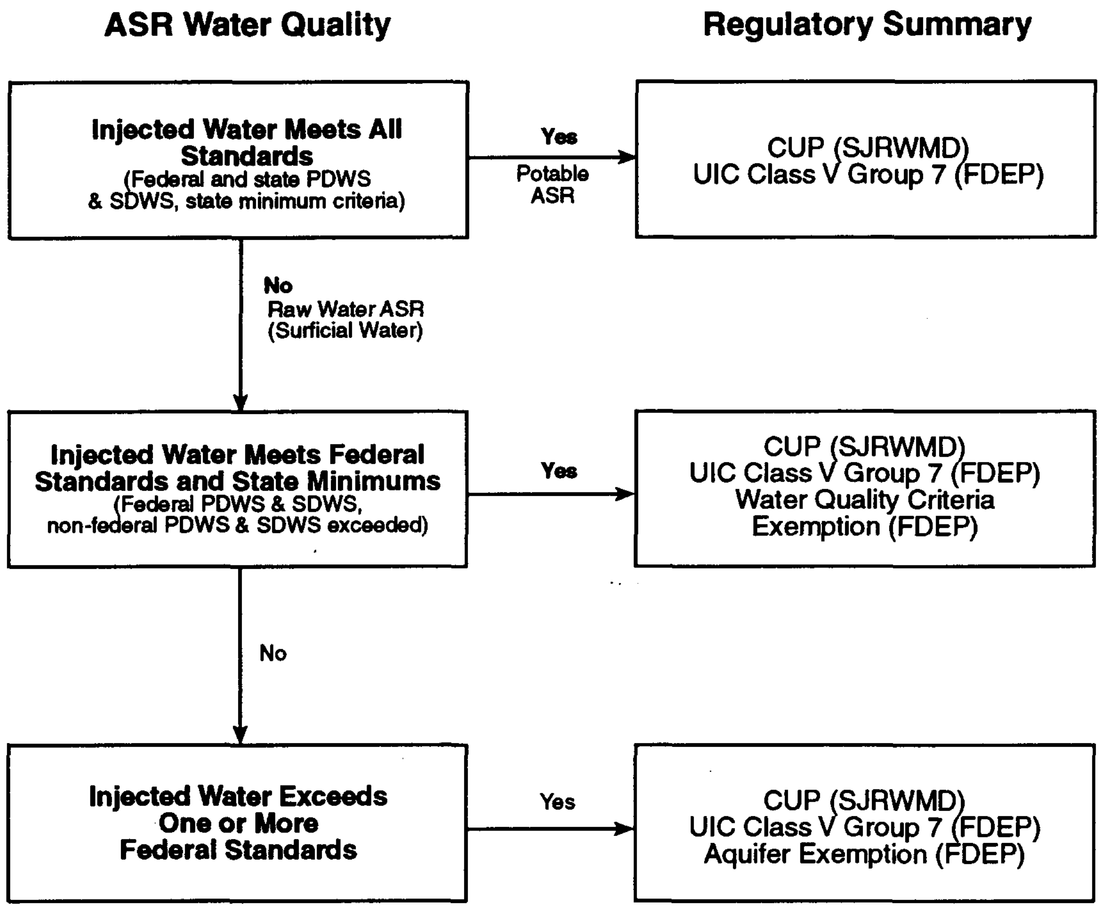


Figure E-5. St.Johns County Seasonal Storage Need for Water Quantity.

130581.SJ.AS 11/96 GNV



Note: Injected water can be either treated or raw.

Figure E-6. Possible ASR Regulatory Requirements for St Johns County.

Feasibility Screening Report
Parts A and B

Facility Designation St. Johns County Utilities   Water Source Surficial Aquifer Ground Water   Date 12/2/96

Facility Director Bill Young   Intended Use Potable Supply

Water Management District St. Johns River Water Management District   Date ______

District Officer ______

PART A FACILITY PLANNING FACTORS

1 Average Daily Demand (End of Planning Period): 9.9 mgd — Is ADD Greater Than 1 mgd? X YES ____ NO

2 a. Total Supply Volume for Planning Period: 15,237.6 MG
b. Total Demand Volume for Planning Period: 40,677.1 MG — Is the Supply Volume Greater Than Demand Volume? ____ YES X NO

3 List Storage Need Volumes Calculated:
a. Long Term Volume: 212 MG (Assuming supply at rate of plant)
b. Seasonal Volume (For Quantity and Quality): 40 MG (2010)
c. Short Term Volume: - MG
d. Other (Emergency, Plant Operations, etc): - MG
e. Total a. through d., above 252 MG

Are any of the Volumes Greater Than 5 MG ? X YES ____ NO

CUP removal expected in future therefore, proceed to 3

185

PART B HYDROGEOLOGIC, DESIGN, AND OPERATION FACTORS

ASR Hydrogeologic, Design and Operation Factor Scores

Section Points	1 Storage Zone Confinement	2 Storage Zone Transmissivity	3 Local Aquifer Gradient/Direction	4 Recharge Water Quality	5 Native Water Quality	6 Physical, Geochemical Interactions	7 Interfering Uses and/or Impacts	
5								High Feasibility Zone
4					4		4	
3	3	3	3	3		3		Further Investigations Needed Zone
2								
1								
Weight Factor	X 10	X 10	X 1	X 2	X 10	X 5	X 5	Total Score
Score	30	30	3	6	40	15	20	146

Score	Feasibility Level	Type of Study Recommended
160-215	High Confidence	General – Confirm Assumptions
100-159	Moderate Confidence	Focused – Investigate Specific Factors
43-99	Low Confidence	Detailed – Evaluate Impact of Critical Factors

Feasibility Screening Report
Parts C and D

Facility Designation: St. Johns County Utilities — Date: 12/2/96

Facility Director: Bill Young

Water Management District: St. Johns River Water Management District — Date: ______

District Officer: ______

PART C COST COMPARISON SUMMARY

Cost Comparison for Storage Options

Storage Need (SN): Long-Term: 212 MG; Seasonal: 40 MG

ASR Recovery Rate = 5.2 mgd (Demand in excess of plant capacity in 2003)

Peak Factor (PF): 1.3 — Recovery Duration (RD): 92 days — ASR Recovery Rate $\frac{PF + SN}{RD}$ = 0.6 mgd

Equivalent Annual Costs

	Long-Term		Seasonal
Tank	$ N/A	*(Figure A-5)*	$ 730,000
Reservoir	$ 1,313,000	*(Figure A-5)*	$ N/A
ASR	$ 367,000	*(Figure A-5)*	$ 43,000

Cost Comparison for Management Options

Plant Rate Increase: 8.8 mgd (Planned upgrade to meet 2010 demand)

Equivalent Annual Costs

Plant Upgrades	Base Cost	Option 1	Option 2	Option 3	Option 4
Lime Softening and	1,960,000				
Sulfide Reduction by	Tray Aeration *(Figure A-8)*				
	Packing Tower *(Figure A-9)*				
	Ozonation *(Figure A-10)*				
TOTAL					

Equivalent Annual Cost for Options

Plant Upgrade $ 1,960,000 (total cost from option selected from the table above) in 2001 or delayed to 2003 with ASR

ASR $ 367,000 (*Figure A-4*) pilot to 2001 with plant delayed until 2003

PART D REGULATORY SUMMARY

	YES	NO	
Injected water meets all standards	X		(refer to Figure A2 for regulatory requirements)
Injected water meets federal standards and state minimums	X		(refer to Figure A2 for regulatory requirements)
Injected water exceedes one or more federal standards		X	(refer to Figure A2 for regulatory requirements)