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WATER SUPPLY NEEDS AND SOURCES ASSESSMENT ALTERNATIVE WATER SUPPLY STRATEGIES INVESTIGATION CONCEPTUAL DESIGN OF WETLAND AUGMENTATION SYSTEMS FOR RECOMMENDATIONS FOR PILOT AUGMENTATION PROJECTS

by

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EXECUTIVE SUMMARY

This technical memorandum (TM) is a part of the overall scope of Task E, which assesses the technical, environmental, and economic feasibility of mitigating or avoiding impacts to native wetland communities. These impacts could result from projected future (year 2010) ground water withdrawals in the Water Resource Caution Areas (WRCAs).

One approach to balancing impact and resource development is to compensate for altered hydrology by directly augmenting water levels in affected wetlands. Likewise, augmentation of water levels can be used as a means of avoiding impacts to wetlands for which there is concern regarding future impacts.

This TM develops conceptual designs for four types of wetland water level augmentation systems. The conceptual designs are developed using a previously developed methodology for designing, implementing, and costing wetland augmentation systems, which was the subject of TM E.2.d, *Methodology for Evaluating Wetland Augmentation Systems* (CH2M HILL 1997a). From interviews and site visits, which are summarized in TM E.2.d, five wellfield areas within the WRCAs were identified as candidate areas for implementing pilot wetland water augmentation projects. Six pilot project opportunities were identified by screening these five wellfield areas for application of one or more of the four conceptual augmentation systems.

The principle sections of this TM are as follows:

- Application of Methodology to Develop Conceptual Project Applications
- Development of Conceptual Designs for Augmentation Systems
- Screening of Pilot Projects
- Recommendations for Pilot Wetland Augmentation Systems
- Summary of Recommendations

APPLICATION OF METHODOLOGY TO DEVELOP CONCEPTUAL DESIGNS FOR WETLAND AUGMENTATION SYSTEMS

The previously developed methodology was applied to develop conceptual designs for different types of wetland augmentation systems. The methodology addresses the following factors affecting augmentation system design and selection:

- Wetland type
- Wetland water quality and quantity requirements
- Potential sources of water, which may include potable water, raw ground water, reclaimed water, surface water, and storm water
- Water storage and delivery systems
- Operation and maintenance of water level augmentation systems
- Cost estimating

The methodology is applied using the following steps:

1. Define wetland type, condition, and size.
2. Determine impacts to wetlands using the impact assessment methodology.
3. Identify biological and hydrological performance standards and success criteria.
4. Estimate water quality requirements.
5. Determine augmentation amounts and schedule of discharges.
6. Determine potentially available water sources.
7. Select water storage and delivery system.
8. Determine operation and maintenance needs.
9. Estimate costs.
10. Verify final selection.

For the purpose of developing conceptual designs, a standardized approach for applying the method was used.

CONCEPTUAL DESIGNS FOR WETLAND AUGMENTATION SYSTEMS

Conceptual designs for four wetland water level augmentation systems were developed. The four systems, which differ in either the source of water or type of discharge, are as follows:

- Direct discharge of raw ground water
- Diversion or retention of surface water
- Direct discharge of reclaimed water
- Indirect discharge of reclaimed water

Each conceptual design provides the following elements:

- Plan and profile schematic drawings of system components and configuration (ES-1)
- Description of augmentation system components
- Assessment of water quality issues
- General operation & maintenance (O&M) requirements for the system
- Estimate of cost
- Overview of project planning, permitting, design, and implementation

SCREENING FOR POTENTIAL PILOT PROJECTS IN WRCAS

A list of candidate wetland augmentation pilot projects within the WRCAs was developed from previously conducted site visits, interviews, and other information summarized in TM E.2.d. Screening criteria for identifying and selecting pilot projects were also developed in TM E.2.d and are listed below:

- The target wetland is likely to benefit in the long-term from hydrologic regime augmentation.

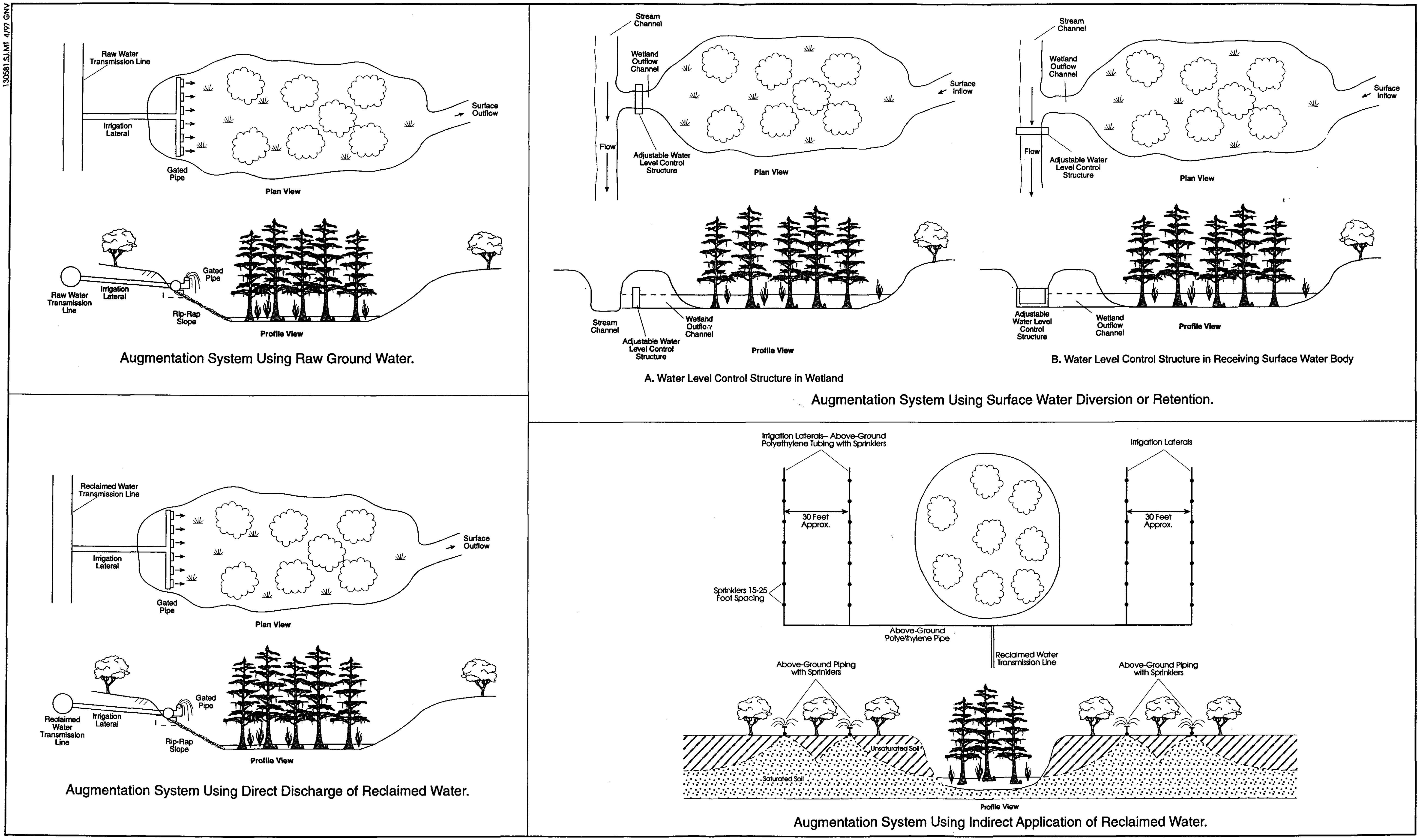

Figure ES-1. Conceptual Designs for Recommended Pilot Augmentation Systems.

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- A source of augmentation water is available.
- The utility or well field operator is a willing participant in the pilot program.
- Land ownership issues are favorable for project development and implementation.

Through the screening process, the potential to apply each of the four conceptual systems at the five candidate wellfield areas with the WRCAs was evaluated. The five wellfield areas are as follows:

- City of St. Augustine Wellfield, St. Johns County
- St. Johns County Utility's Tillman Ridge Wellfield
- City of Daytona Beach's Rima Ridge Wellfield, Volusia County
- City of Port Orange Wellfield, Volusia County
- City of Titusville Wellfields, Brevard County

Table ES-1 summarizes the pilot project screening process.

RECOMMENDED PILOT AUGMENTATION PROJECTS

As a result of the screening process, six pilot augmentation projects are recommended. Also, it is recommended that each pilot project be operated for at least 5 years to provide operational cost and performance data. Each of the six candidate pilot projects is based on one of the conceptual designs provided in the TM. One of the conceptual designs, indirect discharge of reclaimed water, is not recommended at this stage. However, application of this type of augmentation may prove to be appropriate after more detailed site investigations are completed.

The 5-year pilot program recommended includes a combination of projects, which, when implemented, will yield the operational cost and performance data needed to reliably identify the full cost of impact avoidance. The projects recommended will provide the following types of information critical to cost-effective planning, design, and implementation of ground water impact avoidance to wetlands:

- **Water balance**—How much water is required to maintain the target hydrologic regime?
- **Water application**—What is the most efficient means of applying water to a wetland, both in terms of spatial distribution and seasonality?

Table ES-1. Potential Augmentation Project Options at Locations Visited.

Candidate Location	Opportunity for Augmentation System Pilot Project			
	System 1 Raw Ground Water Diversion	System 2 Surface Water Retention or Diversion	System 3 Direct Discharge of Reclaimed Water	System 4 Indirect Discharge of Reclaimed Water
St. Johns County	Yes	No	No	No
City of St. Augustine	Yes	No	No	No
City of Daytona Beach	Yes	Yes[a]	No	No
City of Port Orange	Yes	No	Yes	Yes
City of Titusville	Yes	Yes	Yes	Yes

[a]Surface water retention in Bennett Swamp.

- **Ecological response**—What changes result that may provide early indications of vegetative recovery and animal population support? How are these changes comparable to unaltered regimes? What are the observed differences in wetland wildlife with and without the augmentation project?

- **Cost-benefit**—Which method provides the greatest ecological response for the investment? What is the net ecological response for the augmentation investment compared with a "no action" alternative? At what level of investment could a diminishing return be expected for the augmentation investment?

- **Operation and maintenance**—What is the simplest, most reliable system that can be demonstrated for the benefit of all water supply utilities potentially affected? What lessons can be learned that will minimize the operations and cost burden that utilities would bear on a full-scale application?

To assess the effects of seasonal, annual, and extra-annual rainfall variation, each pilot project should be operated and evaluated for at least 5 years, with the option to continue indefinitely. Project components will be designed and constructed for permanence, anticipating long-term operation.

The six projects are as follows:

- Project 1. Tillman Ridge Wellfield, St. Johns County—direct discharge of raw ground water
- Project 2. Bennett Swamp, Volusia County—surface water retention
- Project 3. City of Port Orange Wellfield, Volusia County—direct discharge of raw ground water
- Project 4. City of Port Orange Wellfield, Volusia County—direct discharge of reclaimed water
- Project 5. City of Titusville Wellfield, Brevard County—surface water diversion
- Project 6. City of Titusville Wellfield, Brevard County—direct discharge of reclaimed water

The general locations of the pilot projects are shown in Figure ES-2.

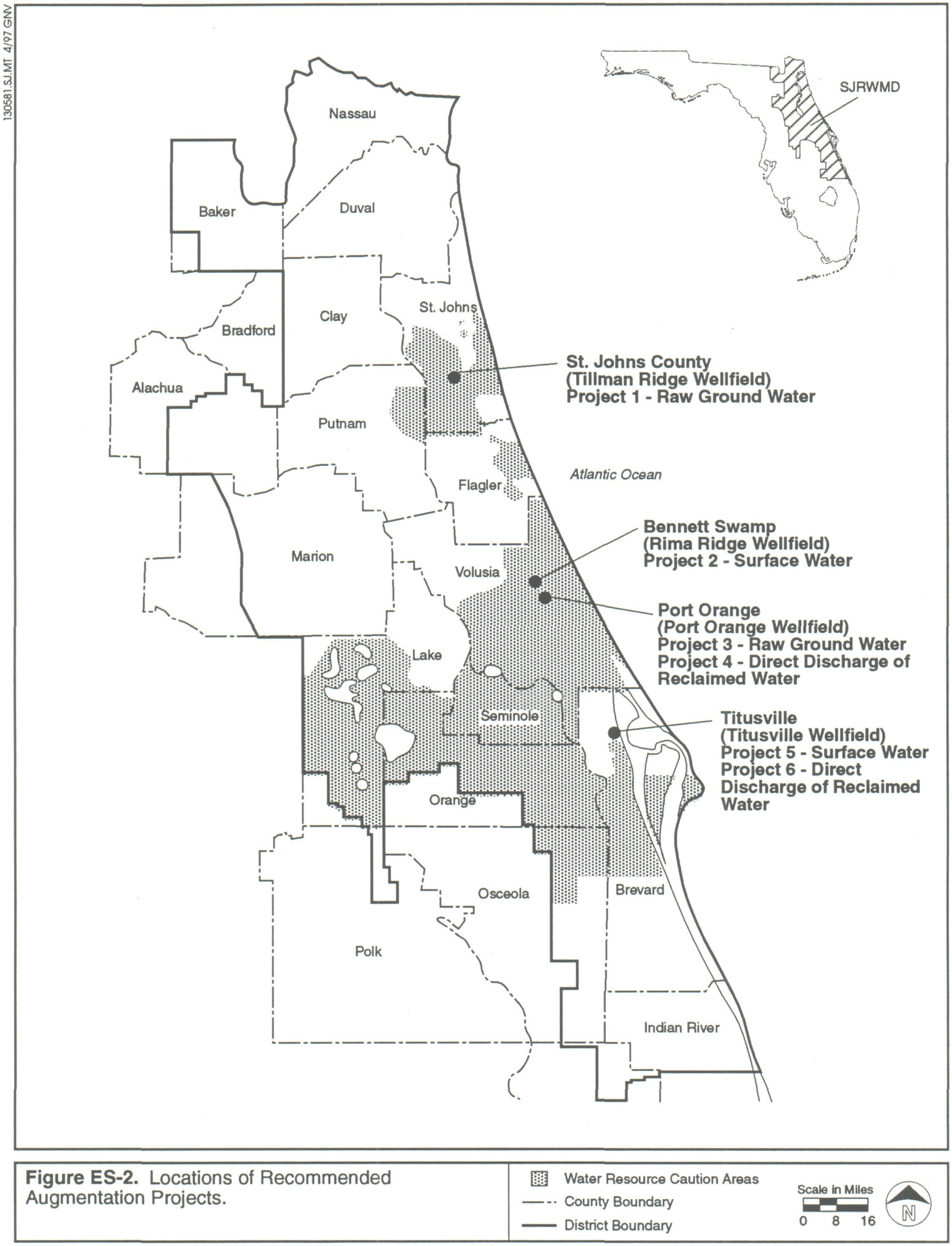

Figure ES-2. Locations of Recommended Augmentation Projects.

CONCLUSION

Six viable pilot project opportunities are identified and described in this TM. It is recommended that the St. Johns River Water Management District proceed to the next stage in augmentation project development, which will involve predesign investigations, preparation of detailed design, permitting, construction, and operation of the six augmentation systems.

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INTRODUCTION

Ground water, which is the primary source of municipal water supply in the St. Johns River Water Management District (SJRWMD), is an excellent water supply source because it is reliable, has minimal treatment costs because of its high quality, and is consistent in quality with proper development and management. However, while ground water has been generally a high-quality, reliable, inexpensive source of municipal supply in the SJRWMD, it is unlikely that it can meet all future public water supply needs without some level of ecological change in sensitive wetland and aquatic communities. For this reason, SJRWMD is investigating the feasibility of alternative water supply strategies.

One approach to balancing impact and resource development is to compensate for altered hydrology by directly supplementing or augmenting the hydrological regime in affected wetlands. This has been termed variously as wetland hydrological augmentation, irrigation, hydration, or rehydration. Technical Memorandum (TM) E.2.d, *A Methodology for Evaluating Wetland Augmentation Systems* (CH2M HILL 1997a), reviewed the needs and requirements of water level augmentation systems and addressed how impacts to native wetland communities in the Water Resource Caution Areas (WRCAs) can be avoided by augmenting water levels of potentially affected wetlands. TM E.2.d also presents a methodology for designing, implementing, and costing wetland water level augmentation systems, based in part on field visits to several wetland augmentation projects in Florida and to candidate augmentation sites at wellfields in the SJRWMD.

TM E.2.f is part of the overall scope of Task E, which assesses the technical, environmental, and economic feasibility of mitigating or avoiding impacts to native vegetative communities, especially wetland communities. These impacts could result from projected future (year 2010) ground water withdrawals in SJRWMD's WRCAs (Figure 1). This TM contains a planning-level application of the methodology in TM E.2.d to produce four conceptual designs for different types of augmentation systems, and then to develop specific applications with six recommended pilot projects in the WRCAs.

These augmentation projects represent a comprehensive, integrated program that will yield the operational cost and performance data needed to reliably identify the full cost of impact avoidance as a

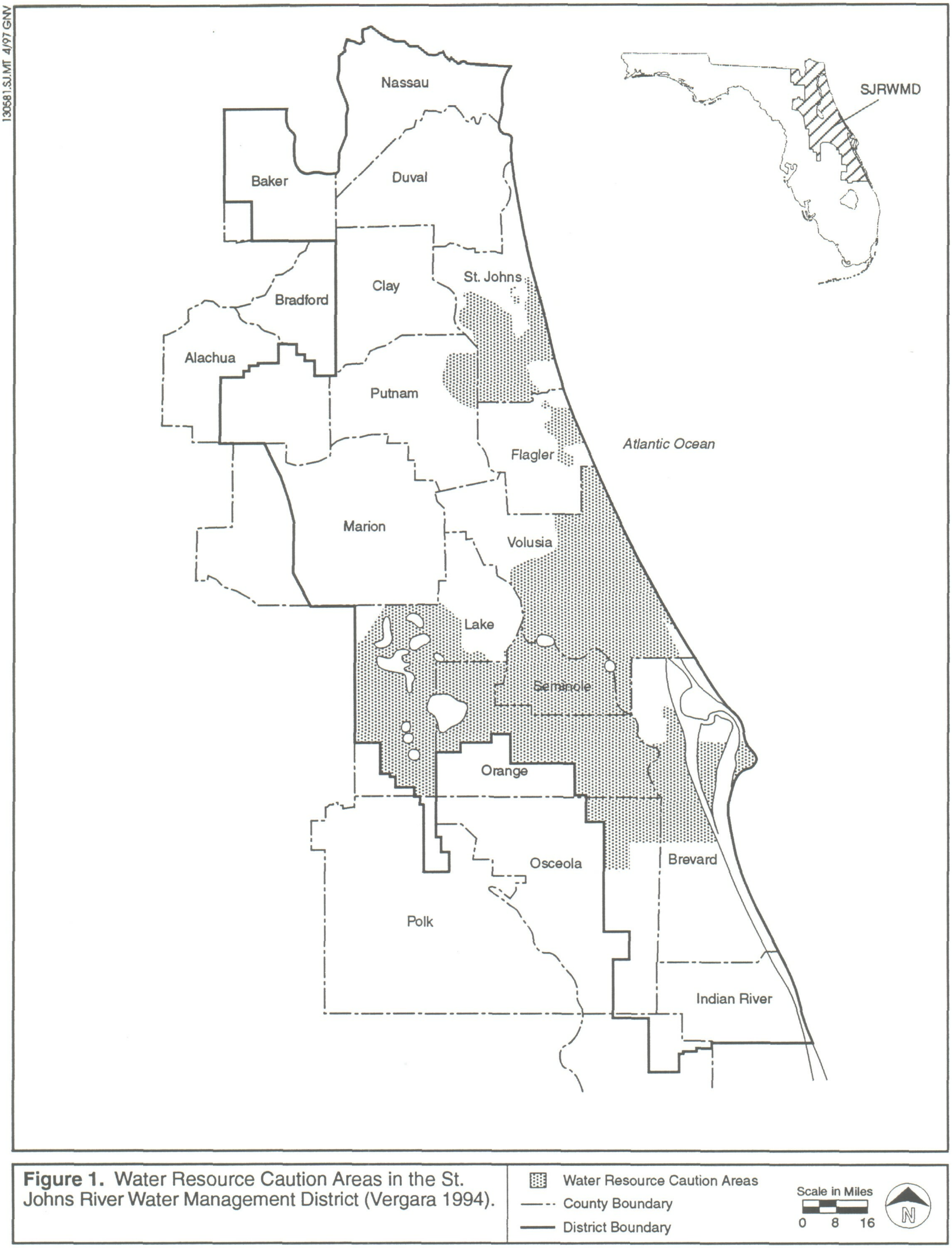

Figure 1. Water Resource Caution Areas in the St. Johns River Water Management District (Vergara 1994).

component of responsible water supply development. A separate attachment to this TM also provides staffing, schedule, and preliminary costs for performing the work associated with design and implementation of the pilot projects.

METHODS

As stated previously, TM E.2.f applies the methodology developed in TM E.2.d for the design of conceptual projects and the screening and identification of pilot projects within the WRCAs. In this section of the TM, an overview of the application of the methodology is presented.

APPLICATION OF METHODOLOGY FOR EVALUATING WETLAND AUGMENTATION SYSTEMS

TM E.2.d describes a ten-step methodology for screening, evaluating, and developing wetland augmentation systems. This method, which was used as guidance for developing the conceptual systems and proposed pilot projects, is as follows:

- Step 1—Define wetland type, condition, and size.
- Step 2—Determine impacts to wetlands using the impact assessment methodology.
- Step 3—Identify biological and hydrological performance standards and success criteria.
- Step 4—Estimate water quality requirements.
- Step 5—Determine augmentation amounts and schedule of discharges.
- Step 6—Determine potentially available water sources.
- Step 7—Select water storage and delivery system.
- Step 8—Determine operations and maintenance (O&M) needs.
- Step 9—Estimate costs.
- Step 10—Verify final selection.

IDENTIFICATION OF CONCEPTUAL PROJECT TYPES

In TM E.2.d, the needs and requirements of wetland augmentation systems were assessed. In that ecological and hydrological assessment, the following system components were reviewed: performance standards and success criteria, water source, water storage and delivery, water discharge and distribution, O&M, and cost estimating.

TM E.2.d also summarized the observations from the six trips to wellfields within the WRCAs and existing wetland augmentation projects in the northern Tampa Bay area. Conceptual project types were developed on the basis of type of source water and either direct or indirect discharge to the wetland. Potential combinations of source and discharge types were screened on the basis of the results of the site visits, yielding the following four types of conceptual augmentation projects:

- System 1. Direct discharge of raw ground water
- System 2. Surface water diversion
- System 3. Direct discharge of reclaimed water
- System 4. Indirect discharge of reclaimed water

APPLICATION OF METHODOLOGY AND GENERAL ASSUMPTIONS

The four conceptual designs were developed using the ten-step methodology presented in TM E.2.d and the previous section. Application of this methodology defines the general design elements common to all four augmentation systems, as well as the key assumptions needed to size facilities, determine levels of effort, and develop preliminary cost estimates.

Step 1. Define Wetland Type, Condition, and Size

At the conceptual design level, wetland type can be ignored because, for a given source, the same general design is applicable, regardless of wetland type. In regard to ecological condition, the project's purpose is to avoid future impacts caused by projected water table declines; therefore, for the purpose of developing non-site-specific design concepts, it is assumed that the hydrologic regime has not been significantly affected by water table decline. In actual application, as described in the following section on recommended pilot projects, augmentation can serve as both an avoidance and mitigation method.

Several additional assumptions are used to standardize the conceptual design approach. For the purpose of conceptual design, the size of the wetlands to be augmented is 10 acres, with the water budget and target hydroperiod determined from existing data or the best estimate from TM E.1.f, *Wetlands Impact, Mitigation, and Planning-Level Cost Estimating Procedure* (CH2M HILL 1997b).

Step 2. Determine Impacts to Wetlands Using Impact Assessment Methodology

The focus of this effort is on implementing impact avoidance strategies; therefore, candidate wetlands are assumed to exhibit signs of significant adverse impacts caused by reduced hydrologic regimes at some time in the future. For these conceptual designs, a conservative approach is to assume that, using the impact assessment methodology from TM E.1.f, the estimated degree of future ecological function loss will be 100 percent in the absence of augmentation. This assumption then dictates a robust design in regards to sizing water delivery, distribution, and control facilities.

For an actual detailed design of an augmentation system, this step would be used in conjunction with Steps 3 through 7 to determine water budgets, flow requirements, discharge schedule, and selection of conveyance and discharge facilities.

Step 3. Identify Biological and Hydrological Performance Standards and Success Criteria

A general discussion of performance standards and success criteria is provided in TM E.2.d. At the conceptual design level, the success criteria and ecological monitoring will be the same for all projects. Biological monitoring is required to determine the level of success of the hydration program and to provide data for adaptive management decisions. A 5-year monitoring program is anticipated for pilot augmentation projects. If pilot projects remain operational beyond the 5-year demonstration period, the annual monitoring program should be modified to track key components of the wetland system.

The long-term objective of all conceptual and pilot projects is to maintain or restore the historical hydrologic regime by augmenting the natural surface water or ground water, or both types of water, in the target wetland (Table 1). Biological monitoring is required to (1) define baseline conditions, (2) determine biological changes during the augmentation program, and (3) provide data for adaptive management decisions. The cost estimates developed for each augmentation system cover the annual monitoring associated with assessing the ecological and hydrological response of the wetland. Table 2 provides an outline for a monitoring program. A detailed, site-specific, 5-year monitoring plan will be developed for each pilot project as part of the implementation program.

Table 1. Typical Performance Standards and Hydrological and Biological Success Criteria for Pilot Wetland Augmentation Projects

Performance Standard	Function Category	Unit	Example Criteria	
			Year 1	Year 5
Achieve target hydrologic regimes in wetlands	Wetland hydroperiod			
	Cumulative hydroperiod	days/year	≥ 150	≥ 180
	Elevation of seasonal high water table	feet	1.5	1.5
	Hydric soil conditions	redox	reduced conditions	reduced conditions
Achieve target water quality regime in wetlands	Light penetration	Secchi depth/feet	1.0	1.0
	Nutrient concentration	mg/L	≤ 0.5 total phosphorus	≤ 0.5 total phosphorus
	Dissolved solids	mg/L	≤ 5	≤ 5
	Suspended solids	mg/L	≤ 5	≤ 5
	Dissolved oxygen	mg/L	≥ 5	≥ 5
Establish a vegetative cover characteristic of target wetlands	*Wetland community*			
	Vegetation density	stems/acre	Within 20% of reference condition	Within 20% of reference condition
	Height	feet	Within 20% of reference condition	Within 20% of reference condition
	Crown diameter	feet	Within 20% of reference condition	Within 20% of reference condition
	Canopy	percent cover	Within 20% of reference condition	Within 20% of reference condition
	Shrub	percent cover	Within 20% of reference condition	Within 20% of reference condition
	Ground	percent cover	Within 20% of reference condition	Within 20% of reference condition
	Exotic/nuisance species	percent cover	< 20	< 5
Restore habitats to support wildlife population equal to *reference areas in the* watershed	Wildlife usage	Observations	Greater than baseline	Greater than baseline and within 20% of reference condition

Table 2. Summary of Possible Monitoring Activities for Augmentation Project Sites

Monitoring Activity	Baseline	Operational	Frequency of Activity
Habitat			
Vegetation composition	✔	✔	Quarterly
Vegetation diversity	✔	✔	Annually
Plant survival		✔	Quarterly
Colonization by native species		✔	Annually
Exotic species control	✔	✔	Annually
Hydrology and Water Quality			
Water elevation hydrograph	✔	✔	Daily
Water quality	✔	✔	Quarterly
Light penetration	✔	✔	Quarterly
Turbidity	✔	✔	Quarterly
Nutrients	✔	✔	Quarterly
Dissolved oxygen	✔	✔	Quarterly
Specific conductance	✔	✔	Quarterly
Precipitation	✔	✔	Weekly
Wetland Substrate			
Organic accumulation		✔	Annually
Sediment accumulation		✔	Annually
Depth	✔	✔	Annually
Erosion	✔	✔	Annually
Wildlife Habitat			
Wildlife use	✔	✔	Quarterly
Invertebrate populations	✔	✔	Quarterly
Fish populations	✔	✔	Quarterly
Nuisance animals	✔	✔	Quarterly
Habitat structural diversity	✔	✔	Quarterly
Listed species	✔	✔	Quarterly
Photographic Record			
Panoramic views	✔	✔	Quarterly
Aerial photographs	✔	✔	Annually
Monitoring plots	✔	✔	Quarterly

Step 4. Estimate Water Quality Requirements

From a design standpoint, key water quality issues are dictated by the source waters for the four types of augmentation systems. These water quality issues are discussed in TM E.2.d. For the conceptual design, all source waters are assumed to be of a quality that meets state Class III surface water standards. Additional pretreatment systems are not included in the conceptual designs.

An issue to be considered when selecting a water source is the potential effect of regulatory compliance and associated permitting cost and schedule delays. In particular, the use of reclaimed water will require a permit under Florida Department of Environmental Protection (FDEP) regulations. This permitting requirement adds to the project cost and schedule and increases the number of parties in the approval process.

Step 5. Determine Augmentation Amounts and Schedule of Discharges

The water budget and target hydroperiod will be determined from existing data or the best estimate from TM E.1.f. The schedule and amount of a piped discharge will be determined on a case-by-case basis for specific project applications. For the purpose of sizing pipes and related structures and developing costs for conceptual designs, an estimate of an average maximum daily discharge rate is used. This value is conservatively estimated to be 30,000 gallons per acre per day (0.09 ft/day) and is based on the upper range for growing season discharge rates supplied by West Coast Regional Water Supply Authority (WCRWSA) for augmentation projects at its wellfields in Pasco County (CH2M HILL 1997a).

Step 6. Determine Potentially Available Water Source Alternatives

For the purpose of developing the conceptual projects, the source is pre-determined; each of the four design concepts uses a different water source. In actual application, more than one source may be available.

Step 7. Select Water Delivery and Storage System

General system components for each of the four project types will be developed using the following assumptions:

- The distance from the wetland to the water source is 1,000 feet.
- The water source is reliable and storage (e.g., pond, tank, ASR, artificial recharge) is not necessary.

- The delivery and conveyance system is a gravity fed pipeline or an already pressurized pipeline, so no additional pumping will be required.

Step 8. Determine O&M Needs

The general O&M needs for each augmentation system are similar (Table 3). Typical activities involve site infrastructure and monitoring of the ecological and hydrological response of wetland communities.

Step 9. Estimate Costs

The cost of an augmentation system includes study, design, permitting, construction, and O&M. Because there are only a few operational augmentation projects in the state, the costing data base is small. Some cost information is available through reports of existing projects. Additional information was obtained from WCRWSA and its consultants during the interview and field visits.

Detailed costs that are based on site-specific conditions and final design can be developed using the general costing tool provided in TM E.1.f. The general methodology for determining the overall project unit cost (cost per acre) includes the following activities:

1. Identifying the augmentation or restoration activity to be performed
2. Establishing a per unit cost for each activity or its components, including collection and conveyance of source water
3. Estimating costs for equipment, supplies, and land acquisition
4. Estimating O&M costs for implementation

The elements driving unit costs will also be based on cost estimating data and assumptions developed for SJRWMD's alternative water supply strategies program being performed by CH2M HILL and other consultants.

For pilot projects, there is typically an emphasis on establishing baseline conditions, defining specific project goals, and tracking project performance. Thus, the study and assessment components have higher costs than those for routine applications.

Table 3. Typical Operation and Maintenance Activities for Wetland Augmentation Systems

Activity	Requirements	Frequency
Site Infrastructure		
Roads	Maintain roads and associated swales and culverts	Inspect annually
Pipelines and conveyance structures	Maintain the design hydraulic capacity	Inspect annually
Pumps	Maintain to proper rated capacity	Inspect quarterly
Fences and gates	Maintain condition and function	Inspect annually
Wetland Areas		
Vegetation	Maintain biological criteria goals; check for signs of stress or change in species composition	Quarterly monitoring
Hydrology	Monitor stage relative to target condition	Continuous water level
Control Structures	Maintain design elevation and condition	Inspect quarterly
Substrate	Maintain integrity of wetland substrate; check for unwanted erosion or deposition	Check during monitoring events
Water Quality	Maintain water quality within design goals	Quarterly monitoring
Fauna	Maintain population levels	Quarterly monitoring

Step 10. Verify Final Selection

The verification step at the conceptual design level is an implicit process, confirming that practical, implementable augmentation systems have been developed. In this context, verification is achieved by finding site-specific applications for these design concepts.

SCREENING FOR RECOMMENDED PILOT PROJECTS

Screening for pilot project applications of the conceptual designs was conducted using the results of the site visits to wellfields within the WRCAs. From the site visits, a matrix of potential applications was developed, and from this matrix, the best opportunities were identified and recommended to SJRWMD for its review.

CONCEPTUAL DESIGNS FOR WETLAND AUGMENTATION SYSTEMS

Based on the wetland augmentation system information summarized in TM E.2.d, the following four types of conceptual augmentation projects are most applicable to candidate sites within the project area:

- Direct augmentation using raw ground water
- Direct augmentation using retained or diverted surface water
- Direct augmentation using reclaimed water
- Indirect augmentation using reclaimed water

OVERVIEW OF CONCEPTUAL DESIGNS

The conceptual augmentation systems are described below and the six suggested pilot projects are described on pages 34 through 48. A more detailed description of the components and requirements of wetland hydration projects in Florida is provided in TM E.2.d. Each conceptual design provides the following information:

- Description of the overall augmentation system with plan and profile schematic drawings
- Description of individual system components (water delivery, water discharge and distribution, and water level control)
- Water quality considerations
- General O&M considerations
- Preliminary cost estimate
- General outline of project planning, permitting, and implementation
- Additional assumptions

SYSTEM 1. DIRECT DISCHARGE OF RAW GROUND WATER

Plan and profile schematic drawings of System 1 are provided in Figure 2. Raw ground water is a convenient and commonly used water source for augmentation projects (CH2M HILL, 1997a). To use

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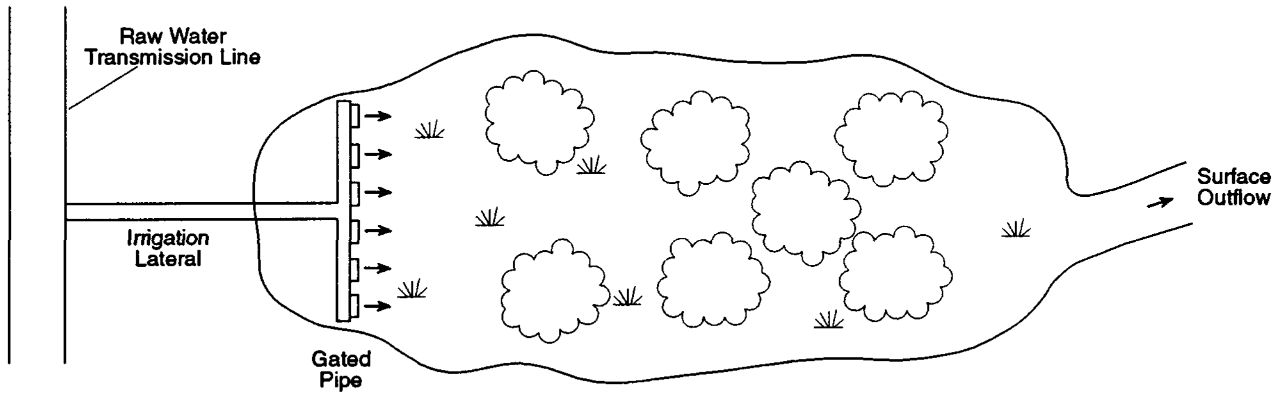
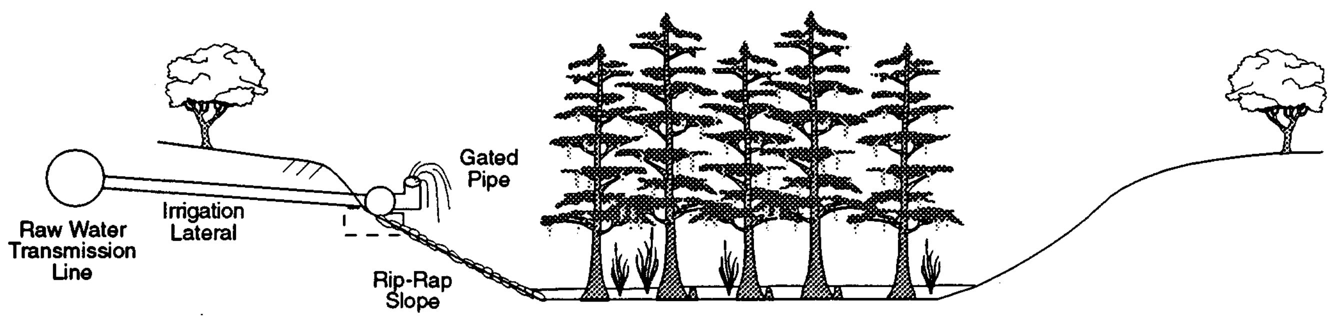


Plan View



Profile View

Note: Not to Scale

Figure 2. Conceptual Design for Augmentation System Using Raw Ground Water.

the resource, raw ground water must be available from a nearby wellhead or raw water transmission pipeline.

Augmentation System Components

Flow to the target wetland is conveyed through a horizontal pipe with a control valve. The conveyance pipe, which is buried in a shallow trench, connects to a horizontal gated distribution pipe that discharges water into the wetland. The distribution pipe is located along the upper edge of the wetland. The pipe is supported by simple braces or supports. Rip-rap is used to prevent soil erosion at the discharge points.

For a 10-acre wetland, it is assumed that multiple discharge points would best facilitate distribution of water within the target wetland. This assumption was confirmed during the field investigation. Gated distribution pipes either on boardwalks or on supports on the wetland surface are an effective means of distributing flow in large areas or over a long linear discharge zone (Figure 3). Other discharge configurations may be applicable, depending on site conditions. For example, point discharges can be used in wetlands with a high length-to-width ratio or in systems that are typically ponded. Single-point discharges are practical for bowl-shaped wetlands and long, narrow wetlands with a gradient. Spreader swales are effective for smaller wetlands, but are generally less practical for larger systems.

Water Quality Issues

Raw ground water differs in some aspects of quality from the surface water typically found in wetlands in the SJRWMD. These differences and potential effects were discussed in TM E.2.d. The information summarized in TM E.2.d indicates that the use of raw ground water as an augmentation source should not have unacceptable impacts on ecological function or species composition within the target wetland. Thus, no additional pretreatment of source water will be required.

General O&M Considerations

O&M activities include equipment replacement and repair, including piping and pipe supports, control valves, rip-rap, staff gage, piezometer, water level recorders, and other ecological monitoring equipment. If public use is encouraged, maintenance for signage, fencing, trails, or boardwalks may be required.

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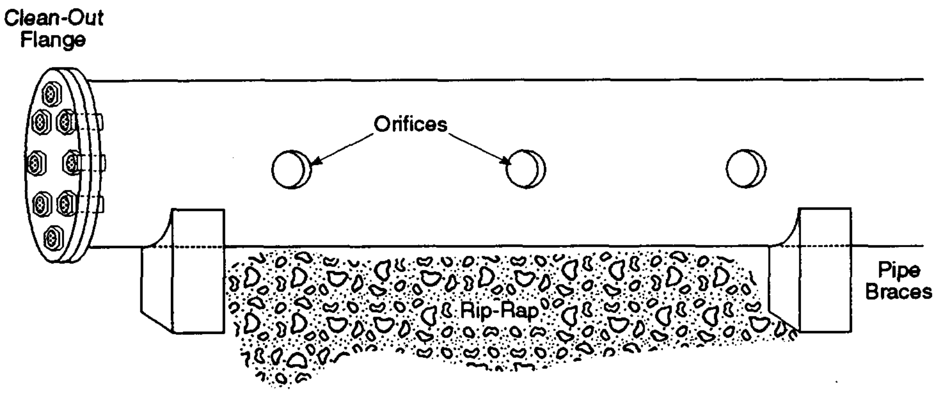

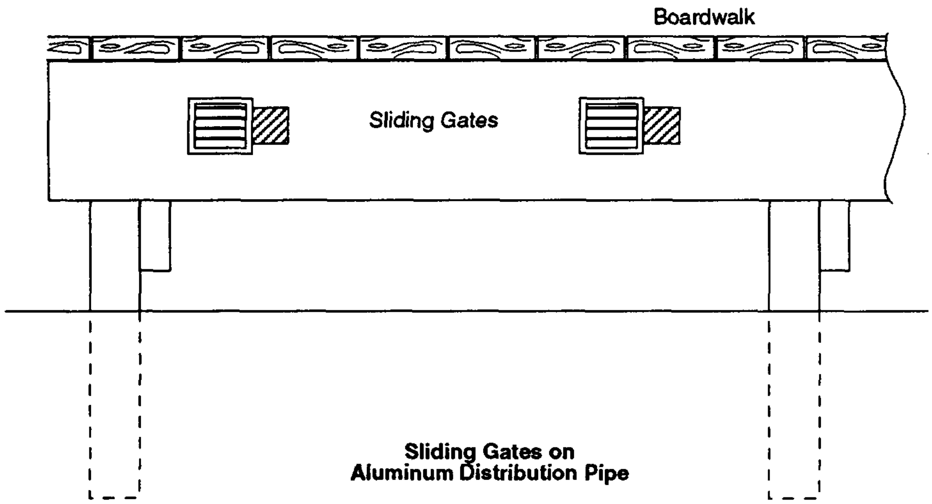

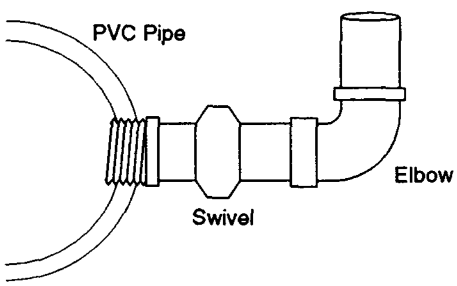

Figure 3. Alternative Gated Distribution Pipe Configurations.	Adapted from Kadlec and Knight 1996.

Preliminary Cost Estimate

A preliminary cost estimate for a conceptual 10-acre augmentation project using raw ground water is provided in Table 4. The cost estimate provides a summary of capital costs for construction and non-construction activities, recurring annual O&M costs, and an equivalent annual cost.

Project Planning, Permitting, Design, and Construction

General guidance for project planning, design, construction, and operation is provided by the Environmental Protection Agency (EPA) (1988), Water Pollution Control Federation (WPCF) (1990), Fesmire (1994), Berryman & Henigar (1995), Reed et al. (1995), and Kadlec and Knight (1996).

Success of the augmentation project can be assessed by monitoring ecological and hydrological conditions under both predischarge and operational regimes. Table 2 provides a checklist of possible activities for a monitoring plan.

Permits will be required for system construction; however, permitting issues for this type of discharge should not be significant. Use of ground water for augmentation may require SJRWMD's approval or, possibly, modification of an existing consumptive use permit (CUP). Construction of the conveyance and discharge system will probably require an environmental resource permit (ERP) from SJRWMD or a Section 404 dredge-and-fill permit from the U.S. Army Corps of Engineers (ACOE), or possibly both permits.

SYSTEM 2. SURFACE WATER DIVERSION OR RETENTION

Plan and profile schematic drawings of System 2 are provided in Figure 4. This system configuration adds a water control structure within or immediately downstream of the wetland, allowing either retention of water within the wetland or inducing backflooding by level control in the local drainage network. In areas where natural surface water runoff has been altered and diverted from the wetland, augmentation may also be accomplished by re-routing surface flow into the wetland.

Table 4. System 1—Wetland Augmentation Using Direct Discharge of Raw Ground Water Cost Estimate Summary

Item	Total Cost[a] ($)
Capital Costs	
Land[b]	21,875
Predesign Investigations	43,663
Design/Permitting	58,158
Construction[c]	64,566
Total Capital Costs	188,261
Operation & Maintenance Cost	23,228
Total Equivalent Annual Cost [d]	**36,335**

[a]Costs are in 1996 dollars.

[b]Previously established (Law Engineering, Inc., June 26, 1996) project costing protocols for land acquisition do not apply to wetlands. Therefore, land costing is based on comparable projects in Florida that ranged in acquisition cost from $0 (state-owned lands) to $15,000/acre (private lands); with an average cost of $1,000/acre for wetlands purchased. Land acquisition needs are assumed to be 10 acres of wetlands, plus an access easement through uplands. The uplands land cost is based on the previously established project costing protocol (Law Engineering, Inc., 1996). Assume 15-inch-wide pipeline easement through a new rural parcel for a length of 1,000 feet at $0.50/sq. ft.

[c]Augmentation rate is 300,000 gal/day for a 10-acre wetland. Pipe costs (Law Engineering, Inc., 1996) include complete installation, trenching, valves, and supports. PVC sprinklers are "impact sprinklers." Public access/restriction costs are not included. Road includes construction, removal, disposal, regrading, and seeding for a 1,000-foot-long by 12-foot-wide shell rock road.

[d]Equivalent annual cost is based on the previously established project costing protocol.

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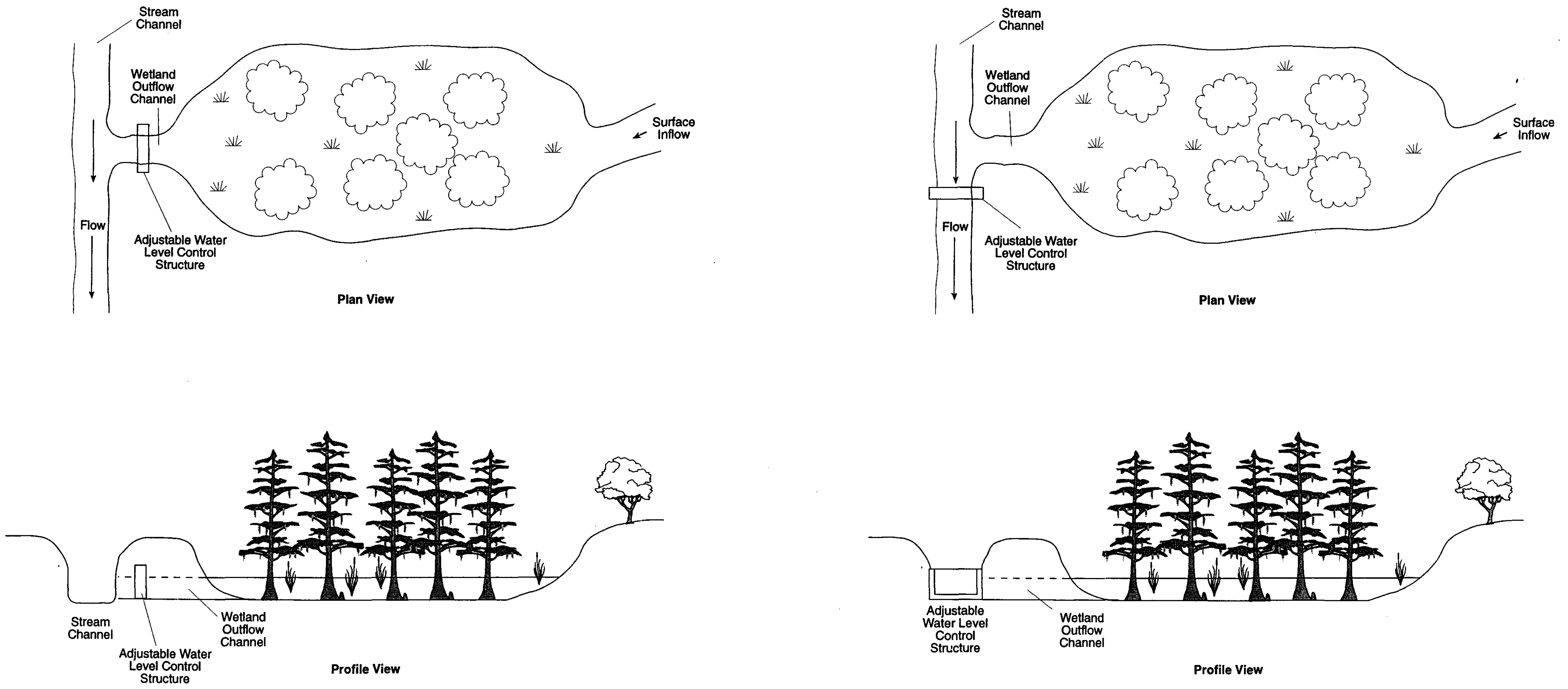

A. Water Level Control Structure in Wetland

B. Water Level Control Structure in Receiving Surface Water Body

NOTE: Not to Scale

Figure 4. Conceptual Design for Augmentation System Using Surface Water Diversion or Retention.

Augmentation System Components

Figure 4 depicts two project configurations. Figure 4A places a control structure in the outflow channel from the wetland. Figure 4B shows the control structure within the receiving stream and, in this case, upstream flow is conveyed toward the wetland through retention of flow in an open channel with control structures. The conveyance channel must be correctly sized to effectively distribute water within the wetland. Factors bearing on conveyance include slope, geometry, and flow path. Inflow is distributed by gravity flow.

Water Quality Issues

Water quality should not be an issue from either a regulatory or ecological effects standpoint. The source water for this project is the backflow from the local and regional surface drainage network, of which the target wetland is a component.

General O&M Considerations

O&M activities include equipment replacement and repairs, including control structures, rip-rap, staff gage, piezometer, and water level recorders (ecological monitoring equipment). Maintenance includes periodic clearing and mowing of open canals, swales, and berms to prevent obstruction of water flow. If public use is encouraged, maintenance may be required for signage, fencing, trails, or boardwalks.

Preliminary Cost Estimate

A preliminary cost estimate for a 10-acre augmentation project using surface water diversion or retention is provided in Table 5. The estimate assumes the use of a single control structure.

Project Planning, Permitting, Design, and Construction

Guidance for project planning, design, construction, and operation can be found in standard surface water and stormwater system design manuals and texts.

A monitoring program should be implemented to assess project success. The program should define baseline, predischarge conditions and then track the wetland through time under the augmentation regime. The monitoring program should characterize both hydrological and ecological conditions (Table 2).

Table 5. System 2—Wetland Augmentation Using Retention of Surface Water Cost Estimate Summary

Item	Total Cost[a] ($)
Capital Costs	
Land[b]	21,875
Predesign Investigations	43,663
Design/Permitting	62,658
Construction[c]	35,525
Total Capital Costs	163,720
Operation & Maintenance Cost	21,776
Total Equivalent Annual Cost[d]	**34,292**

[a]Costs are in 1996 dollars.

[b]Previously established (Law Engineering, Inc., June 26, 1996) project costing protocols for land acquisition do not apply to wetlands. Therefore, land costing is based on comparable projects in Florida that ranged in acquisition cost from $0 (state-owned lands) to $15,000/acre (private lands); with an average cost of $1,000/acre for wetlands purchased. Land acquisition needs are assumed to be 10 acres of wetlands, plus an access easement through uplands. The uplands land cost is based on the previously established project costing protocol (Law Engineering, Inc., 1996). Assume 15-inch-wide pipeline easement through a new rural parcel for a length of 1,000 feet at $0.50/sq. ft.

[c]Pipe costs (Law Engineering, Inc., 1996) include complete installation, trenching, valves, and supports. PVC sprinklers are "impact sprinklers." Public access/restriction costs are not included. Road includes construction, removal, disposal, regrading, and seeding for a 500-foot-long by 12-foot-wide shell rock road.

[d]Equivalent annual cost is based on the previously established project costing protocol.

Permits will be required for construction of the water control structure; however, overall permitting issues should not be significant. Construction of a control structure will typically require an ERP from SJRWMD and a Section 404 dredge-and-fill from ACOE.

SYSTEM 3. DIRECT DISCHARGE OF RECLAIMED WATER

Plan and profile schematic drawings of System 3 are provided in Figure 5. Direct discharge of reclaimed water will require more extensive and complicated permitting, higher costs, and longer schedules than System 1, the raw ground water system, because of state and federal water quality requirements. Aside from these permitting differences, this system would use the same general facility design configuration and components as System 1.

Augmentation System Components

Reclaimed water is assumed to be available from a nearby, buried distribution pipeline. Inflow to the target wetland will be distributed by either pressurized or gravity flow through a horizontal pipe with a control valve. The horizontal inflow pipe will connect to a horizontal gated pipe that discharges the water into the wetland. Rip-rap will be used to prevent soil erosion at the discharge points at the wetland edge.

Water Quality Issues

Reclaimed water differs in some aspects of quality from the surface water typically found in wetlands in the SJRWMD. Differences and potential effects were discussed in TM E.2.d. This application assumes that the reclaimed source has received advanced secondary treatment and that the wetland will be functioning as a receiving wetland under the permitting criteria of Chapter 62-611 of the Florida Administrative Code (FAC).

Water discharge into, and any surface outflow, are presumed to meet applicable state and federal surface water criteria. Consequently, the conceptual design does not include an additional pretreatment system. It is assumed, however, that a water quality based effluent limit study will be required as part of the permitting effort.

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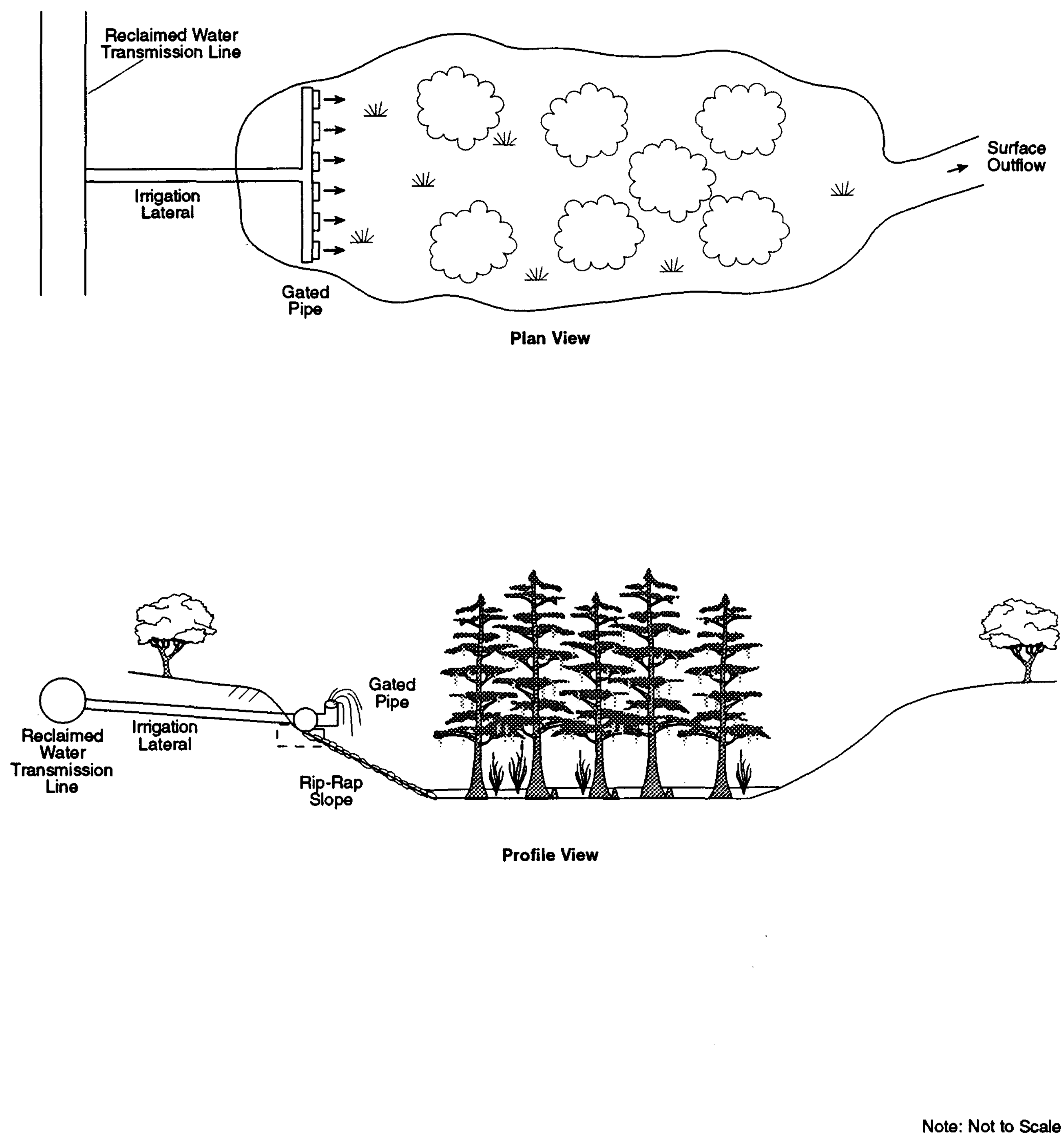

Figure 5. Conceptual Design for Augmentation System Using Direct Discharge of Reclaimed Water.

General O&M Considerations

O&M activities include equipment replacement and repairs, including piping, valves, discharge structures, rip-rap, staff gage, piezometers, water level recorders, and other monitoring equipment. If public use is encouraged, maintenance may be required for signage, fencing, trails, or boardwalks.

Preliminary Cost Estimate

A summary of the preliminary cost estimate for a 10-acre augmentation project using a direct discharge of reclaimed water is provided in Table 6. A more detailed breakdown of costs is provided in Appendix A.

Project Planning, Permitting, Design and Construction

General guidance for project planning, design, construction, and operation of receiving wetland systems can be found in EPA (1988), WPCF (1990), Reed et al. (1995), and Kadlec and Knight (1996).

Both predischarge baseline monitoring and operational monitoring of hydrological and ecological conditions will be required to determine a project's success (Table 2). This monitoring will also be required under permitting criteria of Chapter 62-611, FAC.

A direct discharge of reclaimed water to a receiving wetland will require a permit from FDEP under Chapter 62-611, FAC. Additional permits may be required for system construction. Construction of a conveyance and discharge system will probably require an ERP from SJRWMD or a Section 404 permit from ACOE.

SYSTEM 4. INDIRECT DISCHARGE OF RECLAIMED WATER

Plan and profile schematic drawings of System 4 are provided in Figure 6. Upland reuse systems can provide an indirect method of wetland water level augmentation through the recharge of surficial water tables on uplands adjacent to a wetland. Depending on the design and operation, some fraction of treated water recharges the shallow ground water, providing an alternative water source for augmenting the localized water table adjacent to wetlands.

Table 6. System 3—Wetland Augmentation Using Direct Discharge of Reclaimed Water Cost Estimate Summary

Item	Total Cost[a] ($)
Capital Costs	
Land[b]	21,875
Predesign Investigations	43,663
Design/Permitting	62,353
Construction[c]	64,566
Total Capital Costs	192,456
Operation & Maintenance Cost	23,228
Total Equivalent Annual Cost[d]	**38,181**

[a]Costs are in 1996 dollars.

[b]Previously established (Law Engineering, Inc., June 26, 1996) project costing protocols for land acquisition do not apply to wetlands. Therefore, land costing is based on comparable projects in Florida that ranged in acquisition cost from $0 (state-owned lands) to $15,000/acre (private lands); with an average cost of $1,000/acre for wetlands purchased. Land acquisition needs are assumed to be 10 acres of wetlands, plus an access easement through uplands. The uplands land cost is based on the previously established project costing protocol (Law Engineering, Inc., 1996). Assume 15-inch-wide pipeline easement through a new rural parcel for a length of 1,000 feet at $0.50/sq. ft.

[c]Augmentation rate is 300,000 gal/day for a 10-acre wetland. Pipe costs (Law Engineering, Inc., 1996) include complete installation, trenching, valves, and supports. PVC sprinklers are "impact sprinklers." Public access/restriction costs are not included. Road includes construction, removal, disposal, regrading, and seeding for a 1,000-foot-long by 12-foot-wide shell rock road.

[d]Equivalent annual cost is based on the previously established project costing protocol.

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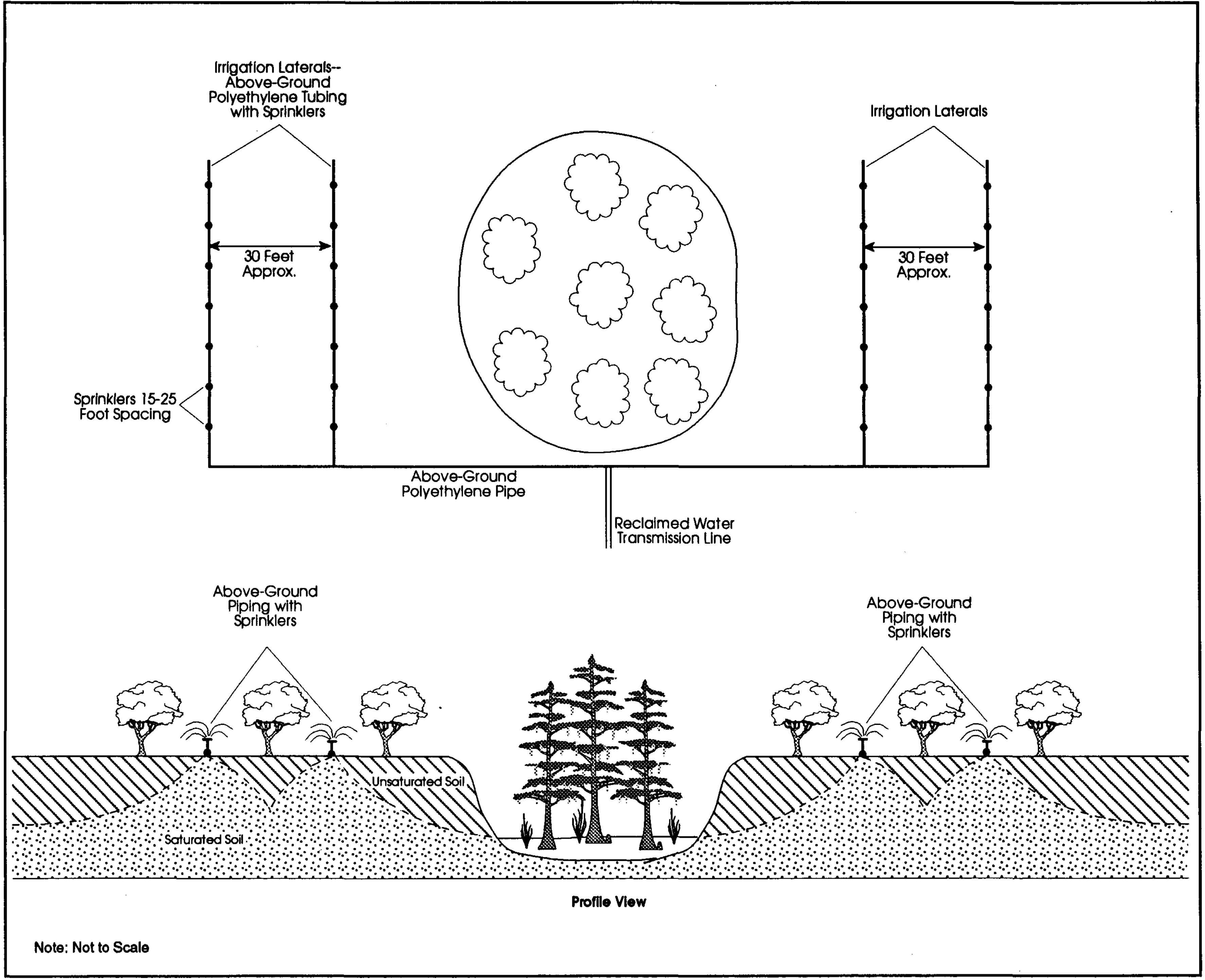

Figure 6. Conceptual Design for Augmentation System Using Indirect Application of Reclaimed Water.

Augmentation System Components

Reclaimed water is assumed to be available from a nearby distribution pipeline. Distribution laterals of buried polyvinyl chloride (PVC) pipe will convey water from the main distribution line to the irrigation laterals. Two linear sets of laterals will flank each side of the wetland. Aboveground piping is specified for the irrigation system to provide the flexibility needed for installation in a forested area, as typically exists at the candidate sites visited. The design approach precludes the need for significant disturbance to a site and adjacent areas. The design can be modified to accommodate buried irrigation pipe if that configuration best meets the project goals.

Low-pressure sprinklers spaced 10 to 20 feet on center will be used to apply water to uplands. Application rates will be sufficient to induce a flow gradient toward the wetland in the shallow water table.

Water Quality Issues

Waters discharging from a land application system differ in some aspects of quality from the surface water typically found in wetlands in the SJRWMD. These differences and their potential effects were discussed in TM E.2.d.

General O&M Considerations

O&M activities include equipment replacement and repairs, including pipes, pipe supports, pumps, valves, sprinklers, staff gages, piezometer, and water level recorders (ecological monitoring equipment). Maintenance includes periodic selective clearing and mowing of upland areas to prevent the obstruction of sprinkler action. If public use is encouraged, maintenance for signage, fencing, trails, or boardwalks may be required.

Preliminary Cost Estimate

A preliminary cost estimate for a 10-acre augmentation project using indirect discharge of reclaimed water is provided in Table 7.

Project Planning, Permitting, Design and Construction

Guidance for project planning, design, construction, and operation of land application systems is provided by EPA (1981, 1992), WPCF (1990), Reed et al. (1995), and Metcalf & Eddy (1989).

Table 7. System 4—Wetland Augmentation Using Indirect Discharge of Reclaimed Water Cost Estimate Summary

Item	Total Cost[a] ($)
Capital Costs	
Land[b]	21,875
Predesign Investigations	43,663
Design/Permitting	58,158
Construction[c]	132,760
Total Capital Costs	256,455
Operation & Maintenance Cost	26,638
Total Equivalent Annual Cost[d]	**47,052**

[a] Costs are in 1996 dollars.

[b] Previously established (Law Engineering, Inc., June 26, 1996) project costing protocols for land acquisition do not apply to wetlands. Therefore, land costing is based on comparable projects in Florida that ranged in acquisition cost from $0 (state-owned lands) to $15,000/acre (private lands); with an average cost of $1,000/acre for wetlands purchased. Land acquisition needs are assumed to be 10 acres of wetlands, plus an access easement through uplands. The uplands land cost is based on the previously established project costing protocol (Law Engineering, Inc., 1996). Assume 15-foot-wide pipeline easement through a new rural parcel, for a length of 1,000 feet at $0.50/sq. ft.

[c] The augmentation rate is 600,000 gal/day for a 10-acre wetland, which is double the rate for System 1 to allow for evapo-transpiration from upland vegetation. Pipe costs (Law Engineering, Inc., 1996) include complete installation, trenching, valves, and supports. PVC sprinklers are "impact sprinklers." Public access/restriction costs are not included. Road includes construction, removal, disposal, regrading, and seeding for a 1,000-foot-long by 12-foot-wide shell rock road.

[d] Equivalent annual cost is based on the previously established project costing protocol.

As with the other conceptual designs, monitoring of hydrological and ecological conditions under predischarge and operational regimes will be essential to tracking the success of the project.

The upland reuse system will probably require a permit from FDEP under Chapter 62-610, FAC.

RECOMMENDED PILOT WETLAND AUGMENTATION PROJECTS

SCREENING PROCESS

A list of candidate wetland augmentation pilot projects within the WRCAs was developed from site visits, interviews, and other information summarized in TM E.2.d. Screening criteria for selecting pilot projects were also developed in TM E.2.d and are listed below:

- The wetland is likely to benefit in the long-term from hydrologic augmentation.
- A source of augmentation water is available.
- The utility or well field operator is a willing participant in the pilot program.
- Land ownership issues are favorable for project development and implementation.

As part of the initial screening process, brief site visits were made to the following candidate areas within SJRWMD's designated WRCAs:

- City of St. Augustine Wellfield
- St. Johns County Utility's Tillman Ridge Wellfield
- City of Daytona Beach's Rima Ridge Wellfield
- City of Port Orange Wellfield
- City of Titusville Wellfield

Summaries of the site visits are presented in Appendix A of TM E.2.d. Site visit documentation included background information, site characteristics, interview notes, an assessment of the potential for implementing augmentation, and photographs of key site features.

RECOMMENDED PROJECTS

Based on the results of the screening process, six potential augmentation projects are recommended for SJRWMD's consideration (Figure 7). Also, it is recommended that the pilot projects be operated for at least 5 years to assess ecological success, system operation, and costs. These pilot project opportunities, which are summarized in

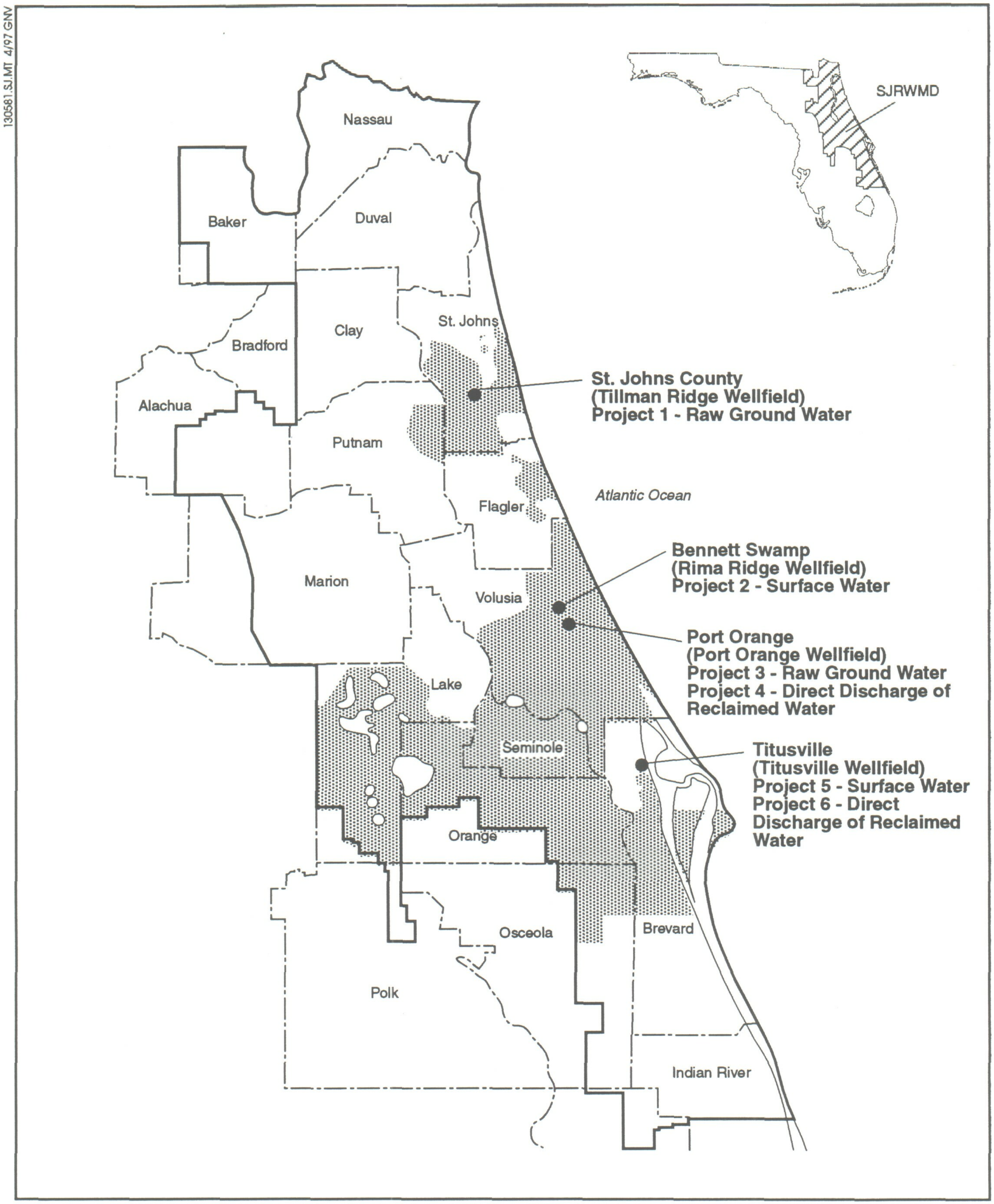

Figure 7. Locations of Recommended Augmentation Projects.

Water Resource Caution Areas
County Boundary
District Boundary

Scale in Miles
0 8 16
N

Table 8 and listed below, satisfy the four screening criteria discussed previously:

- Project 1. St. Johns County Wellfield—augmentation using raw ground water
- Project 2. Bennett Swamp, Volusia County—augmentation using surface water retention
- Project 3. City of Port Orange Wellfield—augmentation using raw ground water
- Project 4. City of Port Orange Wellfield—augmentation using direct discharge of reclaimed water
- Project 5. City of Titusville—augmentation using surface water diversion
- Project 6. City of Titusville—augmentation using direct discharge of reclaimed water

Descriptions of these pilot projects follow. Each of the six candidate pilot projects is an application of one of the conceptual designs provided in the previous section of this TM. One of the conceptual designs, an indirect discharge of reclaimed water, is not recommended as a pilot project at this stage. Application of this type of augmentation may, however, prove to be appropriate after more detailed site investigations are completed.

The recommended 5-year pilot program includes a combination of projects, which, when implemented, will yield the operational cost and performance data needed to reliably identify the full cost of impact avoidance. The recommended projects will provide the following types of information critical to cost-effective planning, design, and implementation of ground water impact avoidance to wetlands:

- **Water balance**—How much water is required to maintain the desired hydrologic regime?
- **Water application**—What is the most efficient means of applying water to a wetland, both in terms of spatial distribution and seasonality?
- **Ecological response**—What changes result that may provide early indications of vegetative recovery and animal population support? How are these changes comparable to unaltered regimes? What

Table 8. Potential Augmentation Project Options at Locations Visited.

Candidate Location	Opportunity for Augmentation System Pilot Project			
	System 1 Raw Ground Water Diversion	System 2 Surface Water Retention or Diversion	System 3 Direct Discharge of Reclaimed Water	System 4 Indirect Discharge of Reclaimed Water
St. Johns County	Yes	No	No	No
City of St. Augustine	Yes	No	No	No
City of Daytona Beach	Yes	Yes[a]	No	No
City of Port Orange	Yes	No	Yes	Yes
City of Titusville	Yes	Yes	Yes	Yes

[a]Surface water retention in Bennett Swamp.

are the observed differences in wetland wildlife with and without the augmentation project?

- **Cost-benefit**—Which method provides the greatest ecological response for the investment? What is the net ecological response for the augmentation investment, compared to a "no action" alternative? At what level of investment could we expect a diminishing return for the augmentation investment?

- **Operation and maintenance**—What is the simplest, most reliable system that can be demonstrated for the benefit of all water supply utilities potentially affected? What lessons can be learned that will minimize the operations and cost burden that utilities would bear on a full-scale application?

To assess the effects of seasonal, annual, and extra-annual rainfall variation, each pilot project should be operated and evaluated for at least 5 years, with the option to continue indefinitely. Project components will be designed and constructed for permanence, anticipating long-term operation.

A preliminary cost estimate, staffing plan, and implementation schedule for the each of the six pilot projects are provided in a separate attachment to this TM.

Project 1. St. Johns County Wellfield—Augmentation Using Raw Groundwater

Conceptual Plan

Augmentation using raw ground water is recommended for this wellfield pilot project. Raw ground water is the only readily available source of augmentation water at the wellfield. This project is an application of the conceptual design for System 1. The simplest design for conveyance and delivery of water to the wetland is through a horizontal pipeline tapped off a nearby well or raw water transmission line. A separate pump will not be required as it is assumed that more than sufficient pressure will be present in the raw water line. The conveyance line will be buried in a shallow trench. The conveyance pipe, with a control valve, will connect to a horizontal gated pipe that discharges the water onto a rip-rapped slope at the wetland's edge. Figure 2 presents a schematic, profile views, and details of this simple conceptual design.

Hydrologic Conditions

The St. Johns County Tillman Ridge Wellfield contains a mixture of wetlands and managed pinelands. Several wetland types (cypress, hardwood swamp, marsh, and ponds) are found among the clear-cut and planted pines. Some of the wellfield's wetlands show signs of altered hydrologic conditions, including leaning and fallen trees, exposed roots, encroachment of upland species, lack of standing water, and drying and fissuring of organic soils. Several of the wetlands are shallow systems, which quickly reflect changes in water table elevations.

SJRWMD and CDM, one of the County's consultants, have assessed the condition of the wetlands within the wellfield. Based on this assessment, a conceptual impact avoidance/mitigation plan has been developed by CDM and is included in Appendix B.

Utility Cooperation

St. Johns County Utilities (SJCU) appears willing to participate in the pilot augmentation program, although the details of a partnership with SJRWMD have not been formally developed.

Land Ownership

Land ownership is a concern because the county owns only the individual well sites. An easement arrangement with the property owners for conveyance pipeline, discharge pipe, ancillary structures, and site access for investigations and monitoring will be necessary. However, several of the wells and their associated raw water transmission lines are adjacent to wetlands, which could simplify project design issues and minimize adverse effects on current or future land uses.

Site Selection

The wetland(s) to be included in the pilot program should be selected jointly by SJCU and SJRWMD. Much of the information needed for site selection has already been compiled. SJCU's consultant has completed an inventory and impact assessment of wetlands in the vicinity of the wellfield. The summary tables in CDM's wetland assessment (Appendix B) provide inventories of wetland conditions, characterization of the nature and degree of hydrologic impacts, wetland sizes and community types, and distances to the nearest wells.

Interior views of two of these candidate wetlands are shown in Figure 8.

Projects 2. Bennett Swamp, Volusia County—Augmentation Using Surface Water Retention

Bennett Swamp lies to the east of the City of Daytona Beach's Rima Ridge Wellfield. The swamp, which is several thousand acres, is part of a larger complex of wetlands known as Tiger Bay.

Conceptual Plan

The hydrologic regime within Bennett Swamp will be augmented by controlling water levels within the swamp. This will be accomplished by constructing a water level control structure, such as an adjustable weir, within a channelized section of the main flow-way of the swamp. The actual location of the structure will be determined through additional field evaluations and hydrologic modeling to be conducted as part of the baseline and feasibility study. A previous study (CDM 1996) conducted on behalf of Volusia County and SJRWMD evaluated four weir locations within the regional Tiger Bay watershed, one within the western end of Bennett Swamp along Tiger Bay Canal.

As part of the Bennett Swamp project, a predesign investigation will be undertaken that will involve the following tasks (1) review of existing information, (2) field reconnaissance, (3) estimation of existing and historic hydrologic regimes, and (4) inventory risk assessment. The study will develop baseline wetland community characterization for the swamp. The results of the study will be used as input for more detailed studies to determine the final location, design, and effect that the proposed retention facility would have on enhancing the retention of surface water within the swamp, improving the existing hydrologic regime and reducing or avoiding the effects of future ground water withdrawals.

Hydrologic Conditions

Bennett Swamp is a large, forested wetland system consisting of approximately 2,200 acres, within a larger complex of wetlands in an uplands known as Tiger Bay in central Volusia County. Sections of Bennett Swamp show effects of reduced hydrologic regime (Figure 9). The City of Daytona's Rima Ridge wellfield lies on the western border of the swamp and several other wellfields operate in the vicinity. In addition, the surface water inflow and outflow system for the swamp has been altered by excavation of the Tiger Bay and Thayer canals, respectively. SJRWMD's ground water modeling efforts indicate

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Wetland No. 18/21. Trunk of Cypress Tree Showing Exposed Roots.

Wetland No. 23/38. Marc Minno Beside Pond Cypress Trunk with Exposed Roots.

Figure 8. Candidate Augmentation Sites for Project 1, Tillman Ridge Wellfield, St. Johns County

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Well House No. 21, Canopy of Cypress-Mixed Hardwood Forest of Western Bennett Swamp in Background.

Slough in Western Bennett Swamp, Trunks of Cypress Trees with Exposed Roots.

Figure 9. Candidate Augmentation Site for Project 2 at Bennett Swamp, Volusia County.

that, because of the cumulative effect of adjacent wellfields, the hydrology of the swamp may be significantly affected by presently planned pumping for the year 2010. These modeling efforts project that long-term ground water levels will decline if current future water supply plans are implemented and that these projected declines will probably result in unacceptable impacts to native vegetation.

Utility and Stakeholder Cooperation

Cooperative partners on this proposed project may include the City of Daytona Beach, the Volusian Water Alliance, and Volusia County. The City of Daytona Beach's Rima Ridge Wellfield borders the western edge of Bennett Swamp.

Land Ownership

Most of Bennett Swamp is privately owned by the Consolidated Tomoka Corporation. Thus, pilot project development will have to be done with the support and agreement of the landowner. Also, restoration activities within Bennett Swamp may have direct or indirect effects on other properties or land uses. These effects will be evaluated as part of the pilot project feasibility analysis.

Site Selection

The project area is already specified as Bennett Swamp. The location of the water control structure or structures will be determined from the additional investigation and analysis outlined above.

Projects 3. City of Port Orange Wellfield—Augmentation Using Raw Groundwater

Conceptual Plan

Augmentation using raw ground water is recommended as one of the pilot projects at the Port Orange Wellfield. This project is an application of the conceptual design for System 1. The conveyance and delivery of water to the wetland is through a horizontal pipeline tapped off a nearby raw water transmission line. A separate pump will not be required as more than sufficient pressure should be present in the raw water line. The conveyance line will be buried in a shallow trench. The horizontal pipe, with a control valve, will connect to a horizontal gated pipe that discharges the water onto a rip-rapped slope at the wetland's edge. Monitoring and control devices will also be installed. Either a manual or automated control device will regulate flow to the wetland according to desired water levels. Desired water levels will be set as a target hydrologic regime. Monitoring of the wetland's hydrologic response will be achieved with water level recorders, piezometers, and staff gauges. Figure 2 presents a schematic plan, profile views, and details of this simple conceptual design.

Hydrologic Conditions

The Port Orange Wellfield in Volusia County is characterized by a mixture of wetlands and managed pinelands. Several wetland types (cypress, hardwood swamp, bayhead, marsh, wet prairie) are found among the planted and natural pine communities. According to reviews by SJRWMD staff, many of the wetlands in the vicinity of the wellfield are in relatively good ecological condition. However, existing monitoring data indicate that some of the wetlands have a slightly altered hydrologic regime. From their review of monitoring data, SJRWMD staff have concluded that some wetlands within the wellfield are being impacted by water table declines related to wellfield pumpage.

None of the wetland sites visited on August 19, 1996, had standing water. At some sites, the water table was 1 foot below ground surface. Several of these wetlands are shallow systems, which quickly reflect changes in water table elevations. Because of these initial indicators of an altered hydrologic regime, the wellfield offers several opportunities for using wetland augmentation to avoid further hydrological alterations and to overcome observed alterations.

Utility Cooperation

Initial discussions with Mr. Randy Stevens, the City's Director of Utilities, regarding pilot augmentation were favorable. Apparently, the City would be a willing participant in augmentation projects using either raw ground water or reclaimed water as sources.

Land Ownership

Land ownership is not a concern on this wellfield because the City owns the land. The ownership of both wetland and upland areas provides the flexibility needed for project planning and implementation.

Site Selection

The wetlands included in the current monitoring program (Figure 10) are candidate wetlands to be used in a pilot augmentation project. Site

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Well House for Well No. 11, Edge of Wetland 11E in Background.

Wetland No. 11E. Interior Zone Adjacent to Well No. 11.

Figure 10. Candidate Augmentation Site for Project 3, Port Orange Wellfield, Volusia County.

selection will be done after a more detailed field review and after further discussions with City and SJRWMD staff.

Project 4. City of Port Orange Wellfield—Augmentation Using Direct Discharge of Reclaimed Water

Conceptual Plan

Augmentation using reclaimed water is recommended as one of two pilot projects on this wellfield. This pilot project is an application of the conceptual design for System 3. Although the source of water is different, this project will use the same general facility configuration and components as Project 3. Water conveyance to the wetland is through a horizontal pipeline tapped from a reclaimed water distribution line. The horizontal pipe, with a control valve, will connect to a horizontal gated pipe that discharges the water onto a rip-rapped slope at the wetland's edge. Monitoring and water level control devices will be the same as those described for Project 3. Figure 5 presents a schematic, profile views, and details of this simple conceptual design.

Alternative Conceptual Plan

An alternative pilot project using an indirect discharge of reclaimed water may be available at the Port Orange Wellfield. During preliminary discussions, Mr. Stevens indicated an interest in using reclaimed water to irrigate managed pinelands on the wellfield property. Such a land application system could be used to indirectly augment water levels in wetlands adjacent to the irrigated area. Mr. Stevens stated that the City has an existing reclaimed water distribution system that could be extended to the vicinity of the wellfield. However, an indirect discharge system would require more detailed field investigations to determine if land application of effluent would provide sufficient water table baseflow to the target wetland to meet project needs.

For the indirect discharge of reclaimed water, use of either a slow-rate or rapid-rate system may be possible. The initial design concept discussed with Mr. Stevens was to use a spray irrigation system on upland areas; however, the use of rapid infiltration basins located on the periphery of the wetland should also be evaluated.

Figure 6 presents a schematic plan, profile views, and details of a spray irrigation project design.

Utility Cooperation

As already noted, initial discussions with the City's Director of Utilities regarding implementation of pilot augmentation projects were favorable.

Land Ownership

Land ownership is not a concern on this wellfield because the City owns the land. The ownership of both wetland and upland areas provides the flexibility needed for project planning and implementation.

Site Selection

Site selection will be done after a more detailed field review and after further discussions with City and SJRWMD staff.

Project 5. City of Titusville—Augmentation Using Surface Water Diversion

Conceptual Plan

Project 5 will use diverted surface water to augment water levels in the Parkland Wetland, which is adjacent to the City's Area 2 Wellfield. This project has already been proposed by the City's Water Resources Department (Appendix C). This pilot project is an application of conceptual design of System 2.

The Parkland Wetland consists of approximately 50 acres. The wetland lies within the wellfield and is adjacent to residential areas with a defined surface water drainage system. This landscape configuration offers an opportunity to use surface water and stormwater diversion as an impact avoidance tool. The City proposes placement of an adjustable water level control structure in the outfall canal on the north side of the wetland (Figure 11). This structure would increase the potential for storing diverted surface water. Monitoring and control devices will also be installed. Either a manual or automated control mechanism will regulate the structure's control elevation on the basis of the desired hydrologic regime. Desired water levels will be set as the target hydrologic regime in the wetland. Monitoring of the wetland's hydrologic response will be accomplished with the use of water level recorders, piezometers, and staff gauges.

Pine/Wet Prairie Transition Adjacent to Well No. 19; Wetland No. C-19 in the Background.

Wetland No. C-19. Plot 1, Adjacent to Well No. 19; Open Stand of Cypress with Scattered Pine and Herbaceous Ground Cover.

Figure 11. Candidate Augmentation Site for Project 4, Port Orange Wellfield, Volusia County.

Figure 4B presents a schematic plan, profile views, and details of this conceptual design.

Hydrologic Conditions

The City of Titusville Area II Wellfield is located within the Florida coastal dune region. Within the wellfield, upland ridges of longleaf pine or sand pine scrub are interspersed with depressional areas of willow and maple swamp, sawgrass marsh, and hardwood slough.

The Parkland Wetland is a 50-acre scrub-shrub thicket dominated by low stature willow and maple. The swamp is adjacent to residential areas and Astronaut High School. Outflow from the wetland discharges to a canal on the north end.

The City has proposed the project because anticipated effects of future withdrawals from the wellfield indicate more than 10 feet of drawdown because of the absence of a continuous confining layer in the area. The City has proposed this surface water diversion as an impact avoidance strategy.

Utility Cooperation

The City of Titusville Utilities Department has been approached informally about participating in a cooperative pilot augmentation project. Initial discussions with the City indicate that the prospects for developing two types of potential projects are favorable: augmentation using either diverted surface water or stormwater runoff and augmentation using reclaimed water (Project 6).

Land Ownership

The land ownership issue appears to be manageable because the City is evaluating placement of a diversion structure within the existing drainage canal at its point of confluence with the wetlands outflow canal (Figure 12).

Site Selection

The City has already proposed a location for the control structure in the receiving drainage canal downstream of the wetland (Figure 12) (Appendix D). As part of the initial engineering evaluations, the effectiveness of a structure at the proposed location will be evaluated.

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Parkland Wetland, Outflow Canal at "T" Junction with Regional Drainage Canal.

Southwest Corner of Parkland Wetland, Scrub/Scrub Thicket of Willow and Red Maple.

Figure 12. Candidate Augmentation Site for Project 5, City of Titusville, Brevard County.

Project 6. City of Titusville—Augmentation Using Direct Discharge of Reclaimed Water

Conceptual Plan

Augmentation using reclaimed water is recommended for two pilot projects for the City's Area III Wellfield. As is the case at the Port Orange Wellfield, the Area III Wellfield presents a good opportunity to use direct discharge, and a less certain possibility to use indirect discharge. The technical feasibility of indirect discharge will be contingent on confirmation that land-applied water will provide an effective augmentation source through induced baseflow. Because the direct discharge system is more feasible at this time, it is more highly recommended. An indirect discharge using either slow-rate or rapid-rate land application will require further technical evaluation.

A direct discharge of reclaimed water is an application of the conceptual design for System 3. The same design configuration and components have been described for Projects 1, 3, and 4. The design for conveyance and delivery of water to the wetland will be through a new, buried conveyance line tapped from one of the City's existing reclaimed water distribution lines. The conveyance pipe, which will have a control valve, will connect to a horizontal, gated distribution pipe that discharges the water onto a rip-rapped slope at the wetland's edge. Monitoring and control devices will be installed as described for Projects 1, 3, and 4. Figure 5 presents a schematic, profile views, and details of this simple conceptual design.

During preliminary discussions, Mr. Brian Hunter of the City indicated an interest in using reclaimed water as an augmentation source for affected areas in the vicinity of the Area III Wellfield. The City already has a reuse system in the area, so the reclaimed water would be brought to the project site through a pipeline tapped off the nearest reclaimed water line. Also, the City already operates a wetland treatment system so staff have experience with operating and maintaining this type of wetland discharge.

For the indirect discharge of reclaimed water, use of either a slow-rate or rapid-rate system may be possible. Additional evaluations, however, are required to determine if indirect discharge by land application of reclaimed water would be an effective and efficient means of augmenting water levels in target wetlands.

A candidate wetland in the Wellfield III area is depicted in Figure 13.

Hydrologic Conditions

Project 6 is the second of two pilot wetland augmentation projects recommended for implementation at the City of Titusville Area III Wellfield, located within the Florida coastal dune region. In Area III, the wetland communities include sawgrass/willow marsh, maple/ slough, and maple swamp. Adjacent upland sand ridges are dominated by long leaf pine, sand pine, live oak, and scrub oaks.

There have been some concerns regarding projected effects of future pumping on wetlands adjacent to the Area III Wellfield. SJRWMD has projected that there is reasonable likelihood that impacts to wetlands within and adjacent to the wellfield would result if currently planned year 2010 water supply plans are implemented.

Utility Cooperation

The City of Titusville Water Resources Department has been approached informally about participating in the cooperative pilot augmentation project. Initial discussions with the City indicate that two types of potential projects are favorable: augmentation using either diverted surface water or stormwater runoff and augmentation using reclaimed water.

Land Ownership

The land ownership issue appears to be manageable because the City owns several lots near the wetland. City ownership of both wetland and upland areas provides the flexibility needed for project planning and implementation.

Site Selection

The City and SJRWMD have identified several wetlands in the vicinity of the Area III Wellfield that may be candidates for augmentation. These wetlands will be further evaluated in the next phase of the project, which will involve field evaluations and additional input from City and SJRWMD staff.

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Southwest Wetland to the West of Area III Wellfield; Looking Back to the Upland Edge from Interior Sawgrass Zone.

Upland Ridge on East Side of Southwest Wetland, Area III Wellfield; View from Xeric Oak Community Looking Back Toward Wetland.

Figure 13. Candidate Augmentation Site for Project 6, City of Titusville Area III Wellfield, Brevard County.

SUMMARY OF RECOMMENDATIONS

This TM is a part of the overall scope of Task E, which assesses the technical, environmental, and economic feasibility of mitigating or avoiding impacts to native wetland communities. One approach to balancing impact and resource development is to compensate for altered hydrology by directly augmenting water levels in affected wetlands. Likewise, augmentation of water levels can be used as a means of avoiding impacts to wetlands for which there is concern regarding future impacts.

Through the screening process, six projects are recommended for the following four sites:

- St. Johns County Utility's Tillman Ridge Wellfield
- City of Daytona Beach's Rima Ridge Wellfield
- City of Port Orange's Wellfield
- City of Titusville's Wellfield

The following recommendations are provided for SJRWMD's consideration:

1. Develop applications using conceptual designs for the following four types of augmentation systems:
   - System 1. Direct Discharge of Raw Ground water
   - System 2. Diversion or Retention of Surface Water
   - System 3. Direct Discharge of Reclaimed Water
   - System 4. Indirect Discharge of Reclaimed Water
2. Confirm the feasibility of implementing the following six 5-year pilot augmentation projects:
   - Project 1. Tillman Ridge Wellfield, St. Johns County--direct discharge of raw ground water
   - Project 2. Bennett Swamp, Volusia County--surface water retention
   - Project 3. City of Port Orange Wellfield, Volusia County--direct discharge of raw ground water
   - Project 4. City of Port Orange Wellfield, Volusia County--direct discharge of reclaimed water

   - Project 5. City of Titusville Wellfield, Brevard County—surface water diversion
   - Project 6. City of Titusville Wellfield, Brevard County—direct discharge of reclaimed water

3. Move to next stage in the pilot project evaluation process to develop detailed designs for the pilot augmentation projects. The tasks in this process include:

- Select specific candidate wetland sites for each of the six projects.
- Conduct predesign investigations.
- Select water sources.
- Secure commitment from the respective utilities or municipalities to participate in a 5-year pilot project program with SJRWMD.
- Develop and execute a plan for resolving land ownership issues.
- Prepare preliminary designs with cost estimates and schedules.

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APPENDIX A
DETAILED COST ESTIMATES
FOR CONCEPTUAL AUGMENTATION PROJECTS

Table A-1. Cost Estimate Summary, System 1 - Wetland Augmentation Using Direct Discharge of Raw Groundwater

Item		Quantity	Units	Unit Cost	Total Cost [1]
Capital Costs					
Land Cost[2] (wetlands)		10	AC	$1,000	$10,000
Land Cost (access easement 1000' x 15')		15,000	sq ft	$0.50	$7,500
Land Subtotal					$17,500
Land Acquisition (25% of land cost)					$4,375
	Land[2]				$21,875
Predesign investigations					
	Baseline Monitoring Components (installed):				
	Rain Gauge	1	EA	$700	$700
	Water level recorder	1	EA	$3,000	$3,000
	Staff Gauge	1	EA	$530	$530
	Piezometer	4	EA	$175	$700
	Plot markers: PVC, rebar	10	set/ac	$600	$6,000
	One year of data collection (monthly)	12	EA	$2,000	$24,000
Subtotal predesign/monitoring					$34,930
Contingencies (25% of predesign/monitoring)		1	LS		$8,733
	Predesign Investigations				$43,663
Design		1	LS	cost curve	$30,938
Permitting		1	LS	cost curve	$11,188
Survey	Property survey for easement	2,000	LF	$1	$2,000
	Wetland delineation	2,400	LF	$1	$2,400
	Ditch cross section	0	XS	$600	$0
Survey subtotal					$4,400
Design/Permitting Subtotal					$46,526
Contingencies (25% of design/permitting)		1	LS		$11,632
	Design/Permitting				$58,158
Construction[3]					
	Temporary access road	444	Sq Yd	$22	$9,778
	Site Preparation	0.5	AC	$3,500	$1,750
	Excavation/Earthwork	208	CY	$10	$2,083
	Rip-Rap / erosion control	208	CY	$28.50	$5,938
Piping	PVC connection to main	1	EA	$350	$350
	PVC pipe (1.5" sch 80)	0	LF	$12.45	$0
	PVC pipe (4" sch 80)	1,750	LF	$17.23	$30,153
	PVC pipe (6" sch 80)	0	LF	$21.38	$0
	Sprinklers & Riser assembly	0	EA	$28	$0
Control Structure	Flashboards	0	EA	$300	$0
	Guiderails	0	LS	$1,500	$0
	Sod at weir site	0	Sq Yd	$3	$0
Construction Subtotal					$50,051
Mobilization /demobilization (4% of construction cost)		1	LS		$2,002
Contingencies (25% of construction cost)		1	LS		$12,513
	Construction[3]				$64,566
Total Capital Costs					$188,261

Table A-1. Cost Estimate Summary System 1 - Wetland Augmentation Using Direct Discharge of Raw Groundwater

Item	Quantity	Units	Unit Cost	Total Cost [1]
Operation & Maintenance (5% of Construction cost)	1	LS		$3,228
Annual Ecological Monitoring[5] 10 ac Forested system	1	EA	$16,000	$16,000
Annual Exotic/nuisance sp. control	1	EA	$4,000	$4,000
Operation & Maintenance Cost				$23,228
Equivalent Annual Cost - PREDESIGN	$43,663		0.07501	$3,275
Equivalent Annual Cost - DESIGN	$58,158		0.07501	$4,362
Equivalent Annual Cost - CONSTRUCTION	$64,566		0.0847	$5,469
Equivalent Annual Cost - O&M	$23,228			$23,228
Total Equivalent Annual Cost[4]				**$36,335**

AC = acre, CY = cubic yard, EA = each, LF = linear feet, LS = lump sum, set/ac = set per acre, Sq Yd = square yard, XS = cross section

1 Costs are in 1996 dollars.

2 Previously established (LAW June 26, 1996) project costing protocols for land acquisition do not apply to wetlands. Therefore, land costing is based on comparable projects in Florida which ranged in acquisition cost from $0 (State owned lands) to $15,000/ac (private lands); with an average cost of $1,000/ac for wetlands purchased. Land acquisition needs are assumed to be 10 ac of wetlands, plus an access easement through uplands. The uplands land cost are based on the previously established project costing protocol (LAW 1996). Assume 15' wide pipeline easement through a new rural parcel for a length of 1000' @ $0.50/sq. ft.

3 Augmentation rate is 300,000 gal/day for a 10-acre wetland. Pipe costs (LAW 1996) include complete *installation, trenching, values and supports. PVC sprinklers are "impact sprinklers". Public* access/restriction costs are not included. Road includes construction, removal, disposal, regrading, and seeding for a 1000' long x 12' wide shell rock road.

4 Equivalent annual cost is based on the previously established project costing protocol.

5 Assume 2 people, 40 hrs.each, $50/hr, quarterly events per year.

Table A-2. Cost Estimate Summary, System 2 - Wetland Augmentation Using Diversion or Retention of Surface Water

Item		Quantity	Units	Unit Cost	Total Cost[1]
Capital Costs					
Land Cost[2] (wetlands)		10	AC	$1,000	$10,000
Land Cost (access easement 1000' x 15')		15,000	sq ft	$0.50	$7,500
Land Subtotal					$17,500
Land Acquisition (25% of land cost)		1	LS		$4,375
	Land[2]				$21,875
Predesign investigations					
	Baseline Monitoring Components (installed):				
	Rain Gauge	1	EA	$700	$700
	Water level recorder	1	EA	$3,000	$3,000
	Staff Gauge	1	EA	$530	$530
	Piezometer	4	EA	$175	$700
	Plot markers: PVC, rebar	10	set/ac	$600	$6,000
	One year of data collection (monthly)	12	EA	$2,000	$24,000
Subtotal predesign/monitoring					$34,930
Contingencies (25% of predesign/monitoring)		1	LS		$8,733
	Predesign Investigations				$43,663
Design		1	LS	cost curve	$30,938
Permitting		1	LS	cost curve	$11,188
Survey	Property survey for easement	2,000	LF	$1	$2,000
	Wetland delineation	2,400	LF	$1	$2,400
	Ditch cross section	6	XS	$600	$3,600
Survey subtotal					$8,000
Design/Permitting Subtotal					$50,126
Contingencies (25% of design/permitting)		1	LS		$12,532
	Design/Permitting				$62,658
Construction[3]					
	Temporary access road	222	Sq Yd	$22	$4,889
	Site Preparation	0.3	AC	$3,500	$1,050
	Excavation/Earthwork	300	CY	$10	$3,000
	Rip-Rap / erosion control	200	CY	$28.50	$5,700
Piping	PVC connection to main	0	EA	$350	$0
	PVC pipe (1.5" sch 80)	0	LF	$12.45	$0
	PVC pipe (4" sch 80)	0	LF	$17.23	$0
	PVC pipe (6" sch 80)	0	LF	$21.38	$0
	Sprinklers & Riser assembly	0	EA	$28	$0
Control Structure	Flashboards	32	EA	$300	$9,600
	Guiderails	1	LS	$1,500	$1,500
	Sod at weir site	600	Sq Yd	$3	$1,800
Construction Subtotal					$27,539
Mobilization /demobilization (4% of construction cost)		1	LS		$1,102
Contingencies (25% of construction cost)		1	LS		$6,885
	Construction[3]				$35,525
Total Capital Costs					$163,720

Table A-2. Cost Estimate Summary, System 2 - Wetland Augmentation Using Diversion or Retention of Surface Water

Item	Quantity	Units	Unit Cost	Total Cost[1]
Operation & Maintenance (5% of Construction cost)	1	LS		$1,776
Annual Ecological Monitoring[5] 10 ac Forested system	1	EA	$16,000	$16,000
Annual Exotic/nuisance sp. control	1	EA	$4,000	$4,000
Operation & Maintenance Cost				$21,776
Equivalent Annual Cost - LAND	$21,875		0.07	$1,531
Equivalent Annual Cost - PREDESIGN	$43,663		0.07501	$3,275
Equivalent Annual Cost - DESIGN	$62,658		0.07501	$4,700
Equivalent Annual Cost - CONSTRUCTION	$35,525		0.0847	$3,009
Equivalent Annual Cost - O&M	$21,776			$21,776
Total Equivalent Annual Cost[4]				**$34,292**

AC = acre, CY = cubic yard, EA = each, LF = linear feet, LS = lump sum, set/ac = set per acre, Sq Yd = square yard, XS = cross section

1 Costs are in 1996 dollars.

2 Previously established (LAW June 26, 1996) project costing protocols for land acquisition do not apply to wetlands. Therefore, land costing is based on comparable projects in Florida which ranged in acquisition cost from $0 (State owned lands) to $15,000/ac (private lands); with an average cost of $1,000/ac for wetlands purchased. Land acquisition needs are assumed to be 10 ac of wetlands, plus an access easement through uplands. The uplands land cost are based on the previously established project costing protocol (LAW 1996). Assume 15' wide pipeline easement through a new rural parcel for a length of 1000' @ $0.50/sq. ft.

3 Pipe costs (LAW 1996) include complete installation, trenching, values and supports. PVC sprinklers are "impact sprinklers". Public access/restriction costs are not included. Road includes construction, removal, disposal, regrading, and seeding for a 500' long x 12' wide shell rock road.

4 Equivalent annual cost is based on the previously established project costing protocol.

5 Assume 2 people, 40 hrs.each, $50/hr, quarterly events per year.

Table A-3. Cost Estimate Summary, System 3 - Wetland Augmentation Using Direct Discharge of Reclaimed Water

Item		Quantity	Units	Unit Cost	Total Cost [1]
Capital Costs					
Land Cost[2] (wetlands)		10	AC	$1,000	$10,000
Land Cost (access easement 1000' x 15')		15,000	sq ft	$0.50	$7,500
Land Subtotal					$17,500
Land Acquisition (25% of land cost)		1	LS		$4,375
	Land[2]				$21,875
Predesign Investigations					
	Baseline Monitoring Components (installed):				
	Rain Gauge	1	EA	$700	$700
	Water level recorder	1	EA	$3,000	$3,000
	Staff Gauge	1	EA	$530	$530
	Piezometer	4	EA	$175	$700
	Plot markers: PVC, rebar	10	set/ac	$600	$6,000
	One year of data collection (monthly)	12	EA	$2,000	$24,000
Subtotal predesign/monitoring					$34,930
Contingencies (25% of predesign/monitoring)		1	LS		$8,733
	Predesign Investigations				$43,663
Design		1	LS	cost curve	$30,938
Permitting (plus 30% for reclaimed water permitting)		1	LS	cost curve	$14,544
Survey	Property survey for easement	2,000	LF	$1	$2,000
	Wetland delineation	2,400	LF	$1	$2,400
	Ditch cross section	0	XS	$600	$0
Survey subtotal					$4,400
Design/Permitting Subtotal					$49,882
Contingencies (25% of design/permitting)		1	LS		$12,471
	Design/Permitting				$62,353
Construction[3]					
	Temporary access road	444	Sq Yd	$22	$9,778
	Site Preparation	0.5	AC	$3,500	$1,750
	Excavation/Earthwork	208	CY	$10	$2,083
	Rip-Rap / erosion control	208	CY	$28.50	$5,938
Piping	PVC connection to main	1	EA	$350	$350
	PVC pipe (1.5" sch 80)	0	LF	$12.45	$0
	PVC pipe (4" sch 80)	1,750	LF	$17.23	$30,153
	PVC pipe (6" sch 80)	0	LF	$21.38	$0
	Sprinklers & Riser assembly	0	EA	$28	$0
Control Structure	Flashboards	0	EA	$300	$0
	Guiderails	0	LS	$1,500	$0
	Sod at weir site	0	Sq Yd	$3	$0
Construction Subtotal					$50,051
Mobilization /demobilization (4% of construction cost)		1	LS		$2,002
Contingencies (25% of construction cost)		1	LS		$12,513
	Construction[3]				$64,566
Total Capital Costs					$192,456

Table A-3. Cost Estimate Summary, System 3 - Wetland Augmentation Using Direct Discharge of Reclaimed Water

Item	Quantity	Units	Unit Cost	Total Cost [1]
Operation & Maintenance (5% of Construction cost)	1	LS		$3,228
Annual Ecological Monitoring[5] 10 ac Forested system	1	EA	$16,000	$16,000
Annual Exotic/nuisance sp. control	1	EA	$4,000	$4,000
Operation & Maintenance Cost				$23,228
Equivalent Annual Cost - LAND	$21,875		0.07	$1,531
Equivalent Annual Cost - PREDESIGN	$43,663		0.07501	$3,275
Equivalent Annual Cost - DESIGN	$62,353		0.07501	$4,677
Equivalent Annual Cost - CONSTRUCTION	$64,566		0.0847	$5,469
Equivalent Annual Cost - O&M	$23,228			$23,228
Total Equivalent Annual Cost[4]				**$38,181**

AC = acre, CY = cubic yard, EA = each, LF = linear feet, LS = lump sum, set/ac = set per acre, Sq Yd = square yard, XS = cross section

1 Costs are in 1996 dollars.

2 Previously established (LAW June 26, 1996) project costing protocols for land acquisition do not apply to wetlands. Therefore, land costing is based on comparable projects in Florida which ranged in acquisition cost from $0 (State owned lands) to $15,000/ac (private lands); with an average cost of $1,000/ac for wetlands purchased. Land acquisition needs are assumed to be 10 ac of wetlands, plus an access easement through uplands. The uplands land cost are based on the previously established project costing protocol (LAW 1996). Assume 15' wide pipeline easement through a new rural parcel for a length of 1000' @ $0.50/sq. ft.

3 Augmentation rate is 300,000 gal/day for a 10-acre wetland. Pipe costs (LAW 1996) include complete installation, trenching, values and supports. PVC sprinklers are "impact sprinklers". Public access/restriction costs are not included. Road includes construction, removal, disposal, regrading, and seeding for a 1000' long x 12' wide shell rock road.

4 Equivalent annual cost is based on the previously established project costing protocol.

5 Assume 2 people, 40 hrs.each, $50/hr, quarterly events per year.

Table A-4. Cost Estimate Summary, System 4 - Wetland Augmentation Using Indirect Discharge of Reclaimed Water

Item		Quantity	Units	Unit Cost	Total Cost [1]
Capital Costs					
Land Cost[2] (wetlands)		10	AC	$1,000	$10,000
Land Cost (access easement 1000' x 15')		15,000	sq ft	$0.50	$7,500
Land Subtotal					$17,500
Land Acquisition (25% of land cost)		1	LS		$4,375
	Land [2]				$21,875
Predesign investigations					
	Baseline Monitoring Components (installed):				
	Rain Gauge	1	EA	$700	$700
	Water level recorder	1	EA	$3,000	$3,000
	Staff Gauge	1	EA	$530	$530
	Piezometer	4	EA	$175	$700
	Plot markers: PVC, rebar	10	set/ac	$600	$6,000
	One year of data collection (monthly)	12	EA	$2,000	$24,000
Subtotal predesign/monitoring					$34,930
Contingencies (25% of predesign/monitoring)		1	LS		$8,733
	Predesign Investigations				$43,663
Design		1	LS	cost curve	$30,938
Permitting		1	LS	cost curve	$11,188
Survey	Property survey for easement	2,000	LF	$1	$2,000
	Wetland delineation	2,400	LF	$1	$2,400
	Ditch cross section	0	XS	$600	$0
Survey subtotal					$4,400
Design/Permitting Subtotal					$46,526
Contingencies (25% of design/permitting)		1	LS		$11,632
	Design/Permitting				$58,158
Construction[3]					
	Temporary access road	444	Sq Yd	$22	$9,778
	Site Preparation	0.5	AC	$3,500	$1,750
	Excavation/Earthwork	0	CY	$10	$0
	Rip-Rap / erosion control	0	CY	$28.50	$0
Piping	PVC connection to main	1	EA	$350	$350
	PVC pipe (1.5" sch 80)	3,000	LF	$12.45	$37,350
	PVC pipe (4" sch 80)	900	LF	$17.23	$15,507
	PVC pipe (6" sch 80)	1,000	LF	$21.38	$21,380
	Sprinklers & Riser assembly	600	EA	$28	$16,800
Control Structure	Flashboards	0	EA	$300	$0
	Guiderails	0	LS	$1,500	$0
	Sod at weir site	0	Sq Yd	$3	$0
Construction Subtotal					$102,915
Mobilization /demobilization (4% of construction cost)		1	LS		$4,117
Contingencies (25% of construction cost)		1	LS		$25,729
	Construction [3]				$132,760
Total Capital Costs					$256,455

Table A-4. Cost Estimate Summary, System 4 - Wetland Augmentation Using Indirect Discharge of Reclaimed Water

Item	Quantity	Units	Unit Cost	Total Cost [1]
Operation & Maintenance (5% of Construction cost)	1	LS		$6,638
Annual Ecological Monitoring[5] 10 ac Forested system	1	EA	$16,000	$16,000
Annual Exotic/nuisance sp. control	1	EA	$4,000	$4,000
Operation & Maintenance Cost				$26,638
Equivalent Annual Cost - LAND	$21,875		0.07	$1,531
Equivalent Annual Cost - PREDESIGN	$43,663		0.07501	$3,275
Equivalent Annual Cost - DESIGN	$58,158		0.07501	$4,362
Equivalent Annual Cost - CONSTRUCTION	$132,760		0.0847	$11,245
Equivalent Annual Cost - O&M	$26,638			$26,638
Total Equivalent Annual Cost[4]				$47,052

AC = acre, CY = cubic yard, EA = each, LF = linear feet, LS = lump sum, set/ac = set per acre, Sq Yd = square yard, XS = cross section

1 Costs are in 1996 dollars.

2 Previously established (LAW June 26, 1996) project costing protocols for land acquisition do not apply to wetlands. Therefore, land costing is based on comparable projects in Florida which ranged in acquisition cost from $0 (State owned lands) to $15,000/ac (private lands); with an average cost of $1,000/ac for wetlands purchased. Land acquisition needs are assumed to be 10 ac of wetlands, plus an access easement through uplands. The uplands land cost are based on the previously established project costing protocol (LAW 1996). Assume 15' wide pipeline easement through a new rural parcel for a length of 1000' @ $0.50/sq. ft.

3 Augmentation rate is 600,000 gal/day for a 10-acre wetland. This is double the rate for System 1 to allow for evapo-transporation from upland vegetation. Pipe costs (LAW 1996) include complete installation, trenching, values and supports. PVC sprinklers are "impact sprinklers". Public access/restriction costs are not included. Road includes construction, removal, disposal, regrading, and seeding for a 1000' long x 12' wide shell rock road.

4 Equivalent annual cost is based on the previously established project costing protocol.

5 Assume 2 people, 40 hrs.each, $50/hr, quarterly events per year.

APPENDIX B
TILLMAN RIDGE WELLFIELD CONCEPTUAL AVOIDANCE/MITIGATION PLAN
PREPARED BY CAMP DRESSER AND MCKEE, INC.

Tillman Ridge Wellfield
Wetland Impacts
Conceptual Avoidance/Mitigation Plan

February 7, 1997

The purpose of this memorandum is to present the final determination of wetland impacts at the Tillman Ridge Wellfield as jointly established by CDM (Larry Schwartz and Jim Lee) and the SJRWMD (Bob Epting and Lisa Grant), and to propose a conceptual avoidance/mitigation plan to be incorporated into the wellfield consumptive use permit (CUP).

Wetland Impacts

The summary tables provided with this memorandum (and the map provided with a pervious memorandum) were prepared based on field visits performed on May 28 and 29, June 11 and 12, August 14, and September 13, 1996 with CDM and SJRWMD staff. The wetland delineations indicated on the map were based on the field visits and interpretation of 1983 and 1994 color infrared aerial photographs provided by the SJRWMD.

The final determination of wetland impacts at the Tillman Ridge Wellfield are presented in Table 1. Table 1 indicates that there were some wetlands that had no impact and there are five wetland impact categories (WIC), as follows; slight, slight/moderate, moderate, moderate/severe, and severe.

In order to determine avoidance/mitigation requirements the next step is to establish a weighting factor (WF) for each wetland impact category (WIC). The WFs for each WIC were determined based on specific qualitative indicators of wetland impact (IWI) as seen in the field as the WIC was iteratively established for each wetland. A polynomial was fitted to determine the WF as follows. Slight impacts require minimal avoidance/mitigation (WF = 0.01) because the observed impact (reduction of water level) is within the natural range of wetland conditions. Severe impacts require extensive avoidance/mitigation (WF = 0.9) as the observed impact includes a loss in the dominant vegetation but not a complete loss of ecosystem functions. Reasonable qualitative estimates were then made for the three other WICs (slight/moderate WF = 0.10, moderate WF = 0.25, moderate/severe WF = 0.50) and fitted to a second order polynomial (Figure 1). Table 2 presents the IWIs for each WIC. Table 3 summarizes the avoidance/mitigation requirements based on the area of wetland impact for each WIC. These results indicate that the avoidance/mitigation requirements at the Tillman Ridge Wellfield are 21.53 acres (approximately 22 acres).

Conceptual Avoidance/Mitigation Plan

Any conceptual avoidance/mitigation plan is evaluated pursuant to the environmental criteria for elimination or reduction of impacts (Section 12.0) presented in Part II of the Applicants Handbook for Management and Storage of Surface Waters. The authority and specific criteria are presented in Section 40C-4.301 and 302, FAC. The conceptual avoidance/mitigation plan for the Tillman Ridge Wellfield consists of wetland augmentation/rehydration in the near term, and offsite wetland restoration and wellfield management in the long term. Wellfield management may include reduction or cessation of withdrawals of specific existing wells for production, new well development, and subsequent wellfield pumpage rotation.

Wetland augmentation/rehydration offers great promise as a technique to eliminate existing and to avoid future impacts due to groundwater drawdown. But more information is needed to determine how to implement this alternative effectively. For this reason a wetland augmentation/rehydration program at the Tillman Ridge Wellfield will benefit both St. Johns County and the St. Johns River Water Management District.

Wetland augmentation/rehydration is proposed at two locations within the present wellfield. The first location is designated as #23/38 (Table 1) and is located adjacent to production well # 4. This is a 8.18 acre wetland with moderate impacts. The second location is designated as #19/39 (Table 1) and is located adjacent to production well # 13. Wetland #19/39 is part of a larger wetland. Parcel # 19 is a 4.79 acre wetland with slight impacts. Parcel #39 is a 9.22 acre wetland with moderate/severe impacts. Rehydration of these wetlands will serve to eliminate existing impacts and avoid future impacts. Valuable wetland habitat will exist in close proximity to isolated wetlands that have severe impact. A simple conveyance system can be designed such as a multiport distribution pipe tapped off of the individual wells with some material used for energy dissipation. The discharge volume and schedule will be established to maintain a natural hydroperiod in the wetland. Hydrologic monitoring of the wetland augmentation/rehydration sites should be performed in conjunction with hydrologic monitoring established by the Water Management District (WMD) for the wellfield as part of the existing cost-share agreement. Equitable vegetation monitoring should also be performed.

A wetland augmentation/rehydration program for the 22.19 acres (8.18 + 4.19 + 9.22) described above is proposed here to eliminate 16 acres of existing impacts. This is in recognition of the fact that there is some loss of function that can not be replaced. The offsite wetland restoration described below will serve to mitigate for the balance of the 22 acre avoidance/mitigation requirements, or 6 acres (22 - 16 = 6).

Offsite wetland restoration is proposed for wetlands located near the St. Johns County SR 207 Wastewater Treatment Plant (WWTP), Cypress Lakes Development, and the County owned golf course and stormwater management system within the development (Figure 2). The hydrology of these wetlands (designated as A1 and A2) has been altered via implementation of the stormwater management system and the wetlands will be restored with the application and reuse of reclaimed water from the SR 207 WWTP. Any mitigation requirements that are related to the implementation of the stormwater management system will be addressed prior to determination of the mitigation requirements available to mitigate for the balance (22 - 16 = 6 acres) of the avoidance/mitigation requirements for the Tillman Ridge wellfield. Wetland A1 has an area of 39 acres and wetland A2 has an area of 19 acres, for a total of 58 acres. Typical restoration mitigation ratios for forested wetlands are on the order of 2:1 to 5:1. Therefore, as a worse case scenario (58/5 = 11.6 acres), there appears to be enough wetland area available at this site for restoration to address mitigation requirements that are related to implementation of the stormwater management system as well as the balance (22 - 16 = 6) of the avoidance/mitigation requirements for the Tillman Ridge Wellfield.

Wellfield management could include reduction or cessation of withdrawals of specific existing wells for production, new well development, and subsequent wellfield pumpage rotation. The reduction or cessation of withdrawals wells #4 and #13 for production will serve to avoid future impacts, but this can not occur until new production wells are on line to address the current water demand. The development of new production wells is important to meet future water demand. These wells need to be located in areas where impacts to wetlands will be avoided or minimized. Based on the documented impacts to wetlands in the wellfield and the location of existing production wells in the wellfield it appears that new production wells could be located north of the wellfield just west of Trestle Bay Swamp. Further evaluation is necessary to determine the most appropriate location and number of new production wells. Additional augmentation/rehydration could also be considered to avoid or minimize wetland impacts. Subsequently, a wellfield pumpage rotation schedule can be established for existing and new production wells.

Summary

Wetland impacts at the Tillman Ridge Wellfield have been quantified and avoidance/mitigation requirements have been established. A conceptual avoidance/mitigation plan has been developed to eliminate some of the existing wetland impacts, mitigate for the loss of some wetland functions, and avoid future wetland impacts due to groundwater drawdown. Wetland augmentation/rehydration can be implemented with support from the WMD. An appropriate off-site restoration alternative is available as a component of the plan. The goal of the existing cost-share agreement is to provide data to refine and run the WMD's model. These activities must be completed in order for the WMD and the County to work cooperatively to locate new production wells, reduce or eliminate withdrawals of specific existing wells for production, and to subsequently develop a wellfield management pumpage rotation schedule. A cooperative approach can be used to develop a water supply plan that will avoid or minimize impacts to wetlands and meet future water demands. The County can be removed from the list of priority water resource caution areas and a long-term CUP can be issued.

TABLE 1
TILLMAN RIDGE WELLFIELD WETLAND EVALUATION

Site No.	SCS Soil Type	Depth to Water Table (inches)	Dominant Vegetation	Organics Condition/ (Historic - Present)	Degree of Impact	Distance to Well (feet)	Well No.	Area (acres)
1	Placid mucky fine sand	10	Black Gum, Chain Fern	Shallow/ forested-herbaceous	None	272	12	0.14
2	Placid mucky fine sand	8-10	Black Gum, Lyonia, Chain Fern	Shallow	none	590	12	0.74
3	Samsula muck	28	Slash Pine, Red Root	Intermediate/	Severe	1,126	12	0.23
4	Placid mucky fine sand, depressional	6-8	Cypress, Chain Fern	Shallow/ forested-forested	None	443	12	0.60
5	Samsula muck	28	Young Slash Pine, Blue Maidencane	Deep/ herb-herb	Severe	914	12	0.20
6	Samsula muck	At Surface	Red Root	Deep/ herb-herb	Severe	976	12	0.13
7	St. Johns fine sand	40	Cypress, Young Slash Pine, Maidencane	Deep/ forested-forested	Severe	1,040	5	0.69
8	Holopaw fine sand, depressional	50	Cypress, Maidencane	Deep/ herb-herb	Moderate	1,193	5	1.70
11	St. Johns fine sand	40	Slash Pine, Cypress, Chain Fern	Deep/ forested-forested	Moderate	504	11	0.82
12	Samsula muck, depressional	10	Young Slash Pine, Red Root	Deep/ herb-herb	Severe	554	11	0.28
13	St. Johns fine sand, depressional	55	Cypress, Loblolly Bay, Chain Fern	Shallow/ forested-forested	Moderate	485	11	1.23
14	Hontoon muck	24	Cypress, Holly, Loblolly Bay, Chain Fern	Deep/ forested-forested	Severe	95	11	0.83
15	Samsula muck	8	Red Root, Cactus	Deep/ herb-herb	Moderate	810	9	0.22
16	St. Johns fine sand	25	Black Gum, Cypress, Lyonia	Shallow/ forested-forested	Moderate/ Severe	1185	11	4.23

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TABLE 1
TILLMAN RIDGE WELLFIELD WETLAND EVALUATION

Site No.	SCS Soil Type	Depth to Water Table (inches)	Dominant Vegetation	Organics Condition/ (Historic - Present)	Degree of Impact	Distance to Well (feet)	Well No.	Area (acres)
17/37/40	Myakka fine sand, depressional	>80	Loblolly Bay, Saw Palmetto, Chain Fern	Shallow/ forested-forested	Slight/ Moderate	765	11	20.20
18/21	St. Johns mucky fine sand, depressional	65	Loblolly Bay, Cypress, Slash Pine, Lyonia, Chain Fern	Shallow/ forested-forested	Moderate/ Severe	425	4	6.39
19	St. Johns fine sand		Black Gum, Cypress, Slash Pine	Shallow/ forested-forested	Slight	25	11	4.79
20	St. Johns mucky fine sand	55	Red Bay, Chain Fern	Shallow/ forested-forested	Severe	469	5	1.30
23/38	Samsula muck	35	Black Gum, Cypress	Shallow/ forested-forested	Moderate	38	4	8.18
24	Samsula muck	8	Black Gum, Cypress	Shallow/ forested-forested	None			
25	St. Johns fine sand	16	Cypress, Loblolly Bay	Shallow/ forested-forested	None	6,014	12	0.92
26	St. Johns mucky fine sand	18	Cypress, Slash Pine, Chain Fern	Shallow/ forested-forested	None	3,394	12	0.90
27	Myakka fine sand, depressional	24	Slash Pine, Chain Fern	Shallow/ forested-forested	Slight	1,509	5	9.77
28	St. Johns fine sand	30	Black Gum, Myrtle-leaved Holly, Red Root	Shallow/ herb-forested	Severe	571	9	0.30
29	St. Johns fine sand	At Surface	Black Gum, Chain Fern, Red Root	Shallow/ forested-forested	Moderate	191	9	0.58
30	Myakka fine sand	>80	Red Bay, Red Root	Shallow/ herb-herb	Severe	938	9	0.24
31	Hontoon muck	65	Cypress, Black Gum, Loblolly Red Bay, Chain Fern	Shallow/ forested-forested	Severe	1,400	11	0.41

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TABLE 1
TILLMAN RIDGE WELLFIELD WETLAND EVALUATION

Site No.	SCS Soil Type	Depth to Water Table (inches)	Dominant Vegetation	Organics Condition/ (Historic - Present)	Degree of Impact	Distance to Well (feet)	Well No.	Area (acres)
32	St. Johns mucky fine sand	40	Loblolly Bay, Red Root, Chain Fern, Spartina Bakeri	Shallow/ herb	Slight	1,450	4	1.19
34	N/A	At Surface	Loblolly Bay, Red Root	Shallow/ forested-forested	None	700	9	0.72
35	N/A	At Surface	Loblolly Bay, Chain Fern, Red Root	Shallow/ forested-forested	None	591	9	1.23
36	St. Johns mucky fine sand	4	Black Gum, Chain Fern	Shallow/ forested	None	471	9	1.55
39	St. Johns fine sand		Black Gum, Cypress, Loblolly Bay	Shallow/ forested	Moderate/ Severe	159	11	9.22
41	Placid mucky fine sand			deep/ herb-herb	Severe	690	12	0.08
42	St. Johns fine sand		Black Gum, Cypress, Loblolly Bay, Slash Pine	Shallow/ forested	Slight/ Moderate	305	11	7.49
43	St. Johns fine sand		Black Gum, Cypress, Loblolly Bay, Slash Pine	Shallow/ forested	Slight/ Moderate	861	11	3.09

note: Site Numbers 9, 10, 22, and 33 were inspected and found not to be jurisdictional wetlands.

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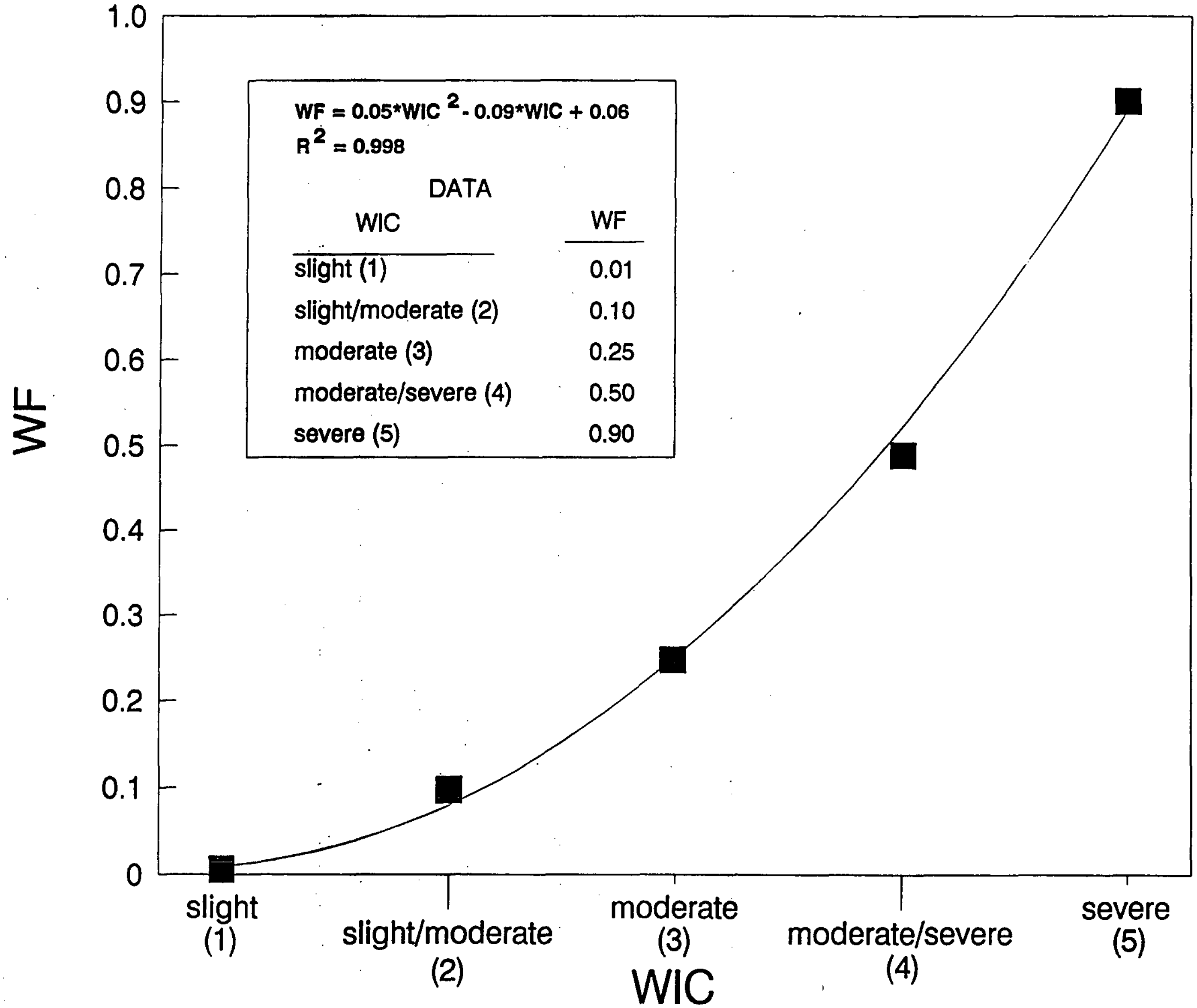

Figure 1. Weighting Factors (WF) for each Wetland Impact Category (WIC) at the Tillman Ridge Wellfield.

Table 2. Wetland Impact Categories (WICs) and corresponding Indicators of Wetland Impacts (IWIs) for the Tillman Ridge Wellfield.

Indicators of Wetland Impacts (IWIs)	**Wetland Impact Categories (WICs)**				
	Slight	**Slight/ Moderate**	**Moderate**	**Moderate (Severe)**	**Severe**
1) reduction of water level	X	X	X	X	X
2) soil oxidation and root exposure		X	X	X	X
3) some understory death		X	X	X	X
4) invasion of drier species			X	X	X
5) some tree fall			X	X	X
6) change in dominance				X	X
7) loss in dominant vegetation severe tree fall					X

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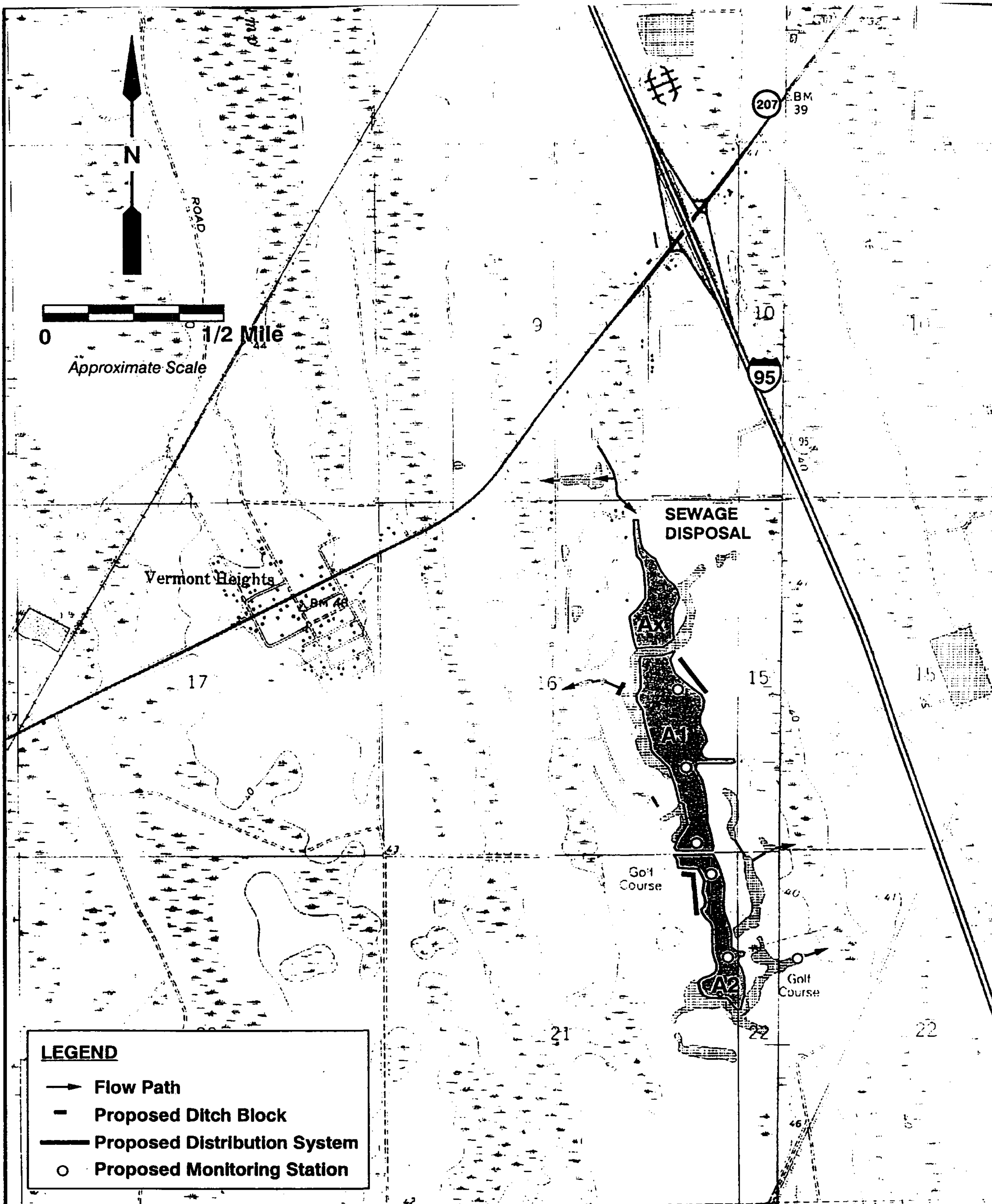
Table 3. Summary of mitigation requirements (area) for the Tillman Ridge Wellfield based on the area of wetland impact and the weighting factors (MWFs).

Wetland Impact Category (WIC)	Area of Impact (acres)	Avoidance/Mitigation Requirements (acres)
Slight	15.75	0.16
Slight/Moderate	30.78	3.08
Moderate	12.73	3.18
Moderate/Severe	15.61	7.08
Severe	8.92	8.03
Total		21.53



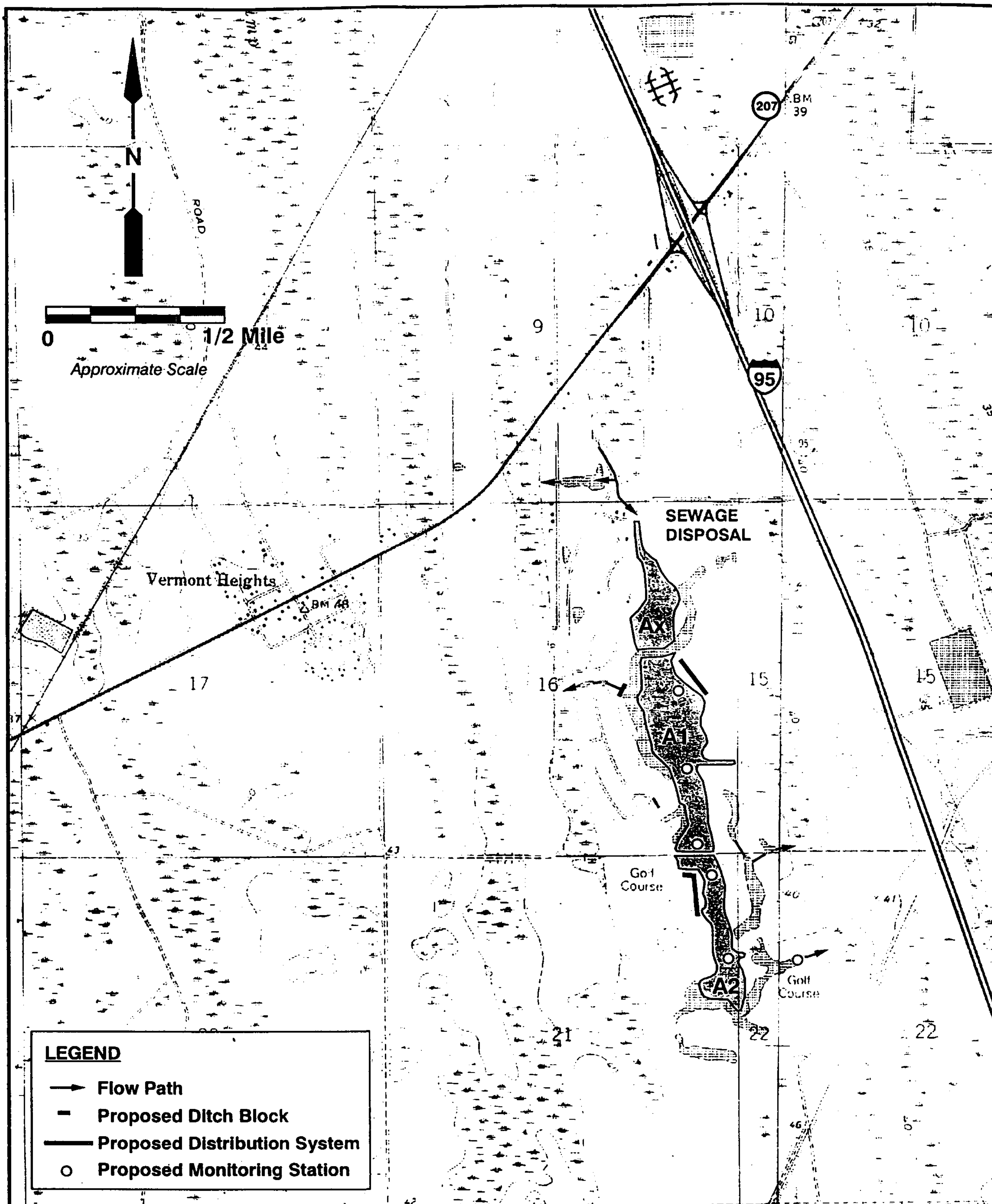
ST. JOHNS COUNTY - SR 207

CDM

environmental engineers, scientists, planners, & management consultants

Proposed Wetland Treatment System

Figure No. 2



ST. JOHNS COUNTY - SR 207

CDM
environmental engineers, scientists, planners, & management consultants

Proposed Wetland Treatment System

Figure No. 2

APPENDIX C
CITY OF TITUSVILLE
MITIGATION OF GROUND WATER WITHDRAWAL

TITUSVILLE FLORIDA FOUNDED 1867

CITY OF TITUSVILLE

WATER RESOURCES DEPARTMENT

MITIGATION OF GROUNDWATER WITHDRAWAL, VIA REDIRECTION OF STORMWATER RUN-OFF TO THE PARKLAND WETLAND

SEPTEMBER 1996

REVISION A.2
B. HUNTER

Post-it® Fax Note 7671	Date 10-3-96	# of pages ▶ 8
To William Dunn	From	
Co./Dept.	Co.	
Phone #	Phone # 407-268-6050	
Fax # 352-335-2959	Fax # 407-268-6054	

1.0 SCOPE

This document is intended to supplement the City of Titusville, Consumptive Use Permit (CUP) renewal application. This document specifically addresses the vehicle to mitigate the effects of groundwater withdrawals associated with Phase II of the Area II Wellfield Refurbishment Project. This Document includes data supplied by the St. Johns River Water Management District, hereafter referred to as the District.

2.0 BACKGROUND

The City is in the final stages of constructing 16 replacement wells in the existing Area II Wellfield. This program was necessary due to the advanced age of the original wells, and the lack of required aquifer management tools. The City is sensitive to the fragility of the local aquifer, and is dedicated to the preservation and proper management of this limited resource. These new wells are designed to enhance these management capabilities through the use of telemetry and instrumentation. These tools provide the interface, control, and data compilation required to maintain a proper balance of withdrawal in given geographical locations.

Phase II of this project entails an additional 6 to 8 wells, for which the City has applied for District permitting. These wells are to be located adjacent to the Parkland Wetland. (see location map). This site places the wells closer to the center of the bubble, as opposed to the fringe areas that experience deviations in chloride levels. One concern surrounding this site is the possibility of induced drawdowns in this wetland due to the presence of the wells. The District models indicate that drawdowns in excess of 10 feet could occur due to the absence of a solid confining layer in this area.

This impact can be readily mitigated through the addition of monitor and control systems which would maintain the level in this wetland at predetermined points as required by the District. The source of the level maintenance water would be diverted storm water. This storm water generally flows through a series of ditches, north from the wetland, then west to the St. Johns River Basin. This water has been redirected by construction (over decades) of the Gardendale subdivision. Under natural conditions this water would have been retained in the wetlands and adjacent areas for normal recharge. The plan outlined in this document can redirect and retain this water to establish this natural recharge once again, while allowing the City access to additional sources. Titusville is listed in the District's "Needs and Sources Assessment" as the only entity in a Water Resources Caution Area with no identified additional source of water. Development of direct recharge by redirection of storm water is of critical interest to the City, due to the lack of new source alternatives.

3.0 THEORY

The stormwater in this area currently is channeled into this wetland by a series of ditches and culverts which outlet directly into the basin. The outfall of this wetland is at the extreme north end, where the water is directed into a ditch. This ditch then intersects with another which runs east - west. This intersection forms a Tee. After the tee, the water flows west, then turns north again, passing under Dairy Road, into American Village. The ditch continues north, turns west, flows under I-95, through Sherwood Subdivision, and eventually to the St. Johns Basin. (see flow marked on map, last page).

The ditch which runs east - west and intersects with the wetlands outfall, maintains a near continuous flow, even in periods of low rainfall. A control structure could be installed in this ditch, just west of the Tee. This structure could be elevated to divert water from the east side of Singleton Avenue into the wetland on an as needed basis. This structure would also allow the wetland to retain water which is placed directly into it. This apparatus can be utilized to maintain a constant level or variable level as dictated by the District.

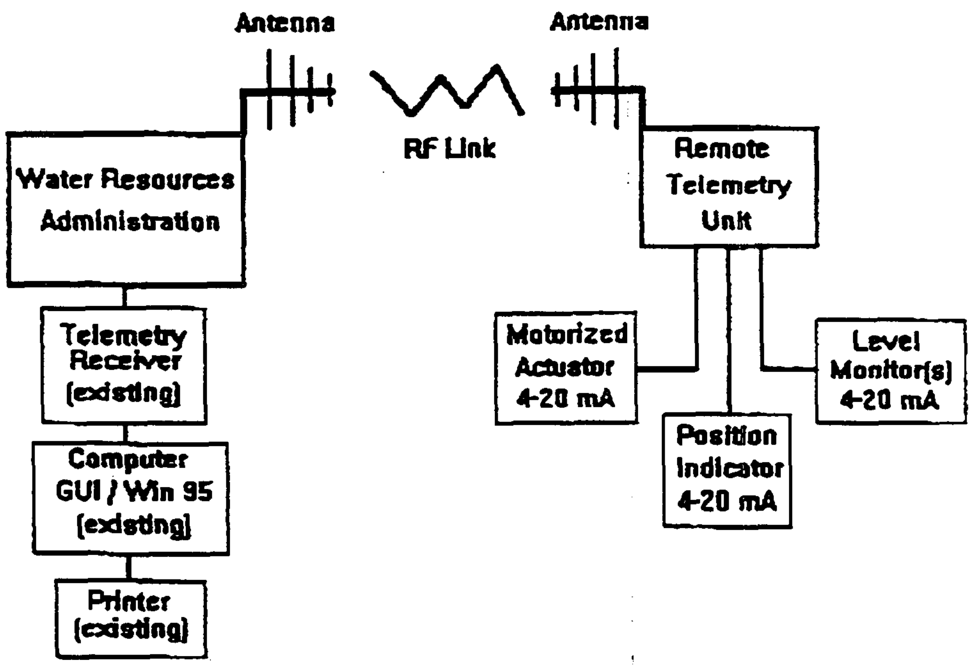
What these levels should be at any given time period are not known at this time, and will require study by the District or CH2M Hill, under contract to the District. This dictates that the control structure be variable in nature, with a wide rang of operation. This approach will minimize the risk involved with too much or tool little control range. In all probability, the optimum levels could not be ascertained until historical data is available. Therefore, these figures might change after operation of the wells for a period of time. To this end, a control, monitoring, and data system should be included as part of this control structure.

4.0 CONTROL & MONITORING

As part of the Wellfield Project (phase I) , the City designed and built a Monitor, Control, and Data system to enhance the management of the aquifer. This is a radio based telemetry system which continuously monitors the water level and flow of each well. The wells can be started and stopped remotely, and flow can be controlled via a butterfly valve actuated with an electrical motor. The position of this valve is also transmitted back to the central site. In addition, this system monitors for intrusion, and electrical malfunctions. Flows and runtimes are stored in a data base for compilation. This system also will perform automated static and drawdown measurements.

These parameters are received at the central site and processed though a Graphical User Interface (GUI). This gives the operator a visual representation of these conditions at a glance. Alarms are both visually and audibly annunciated. In the event of loss of flow, inadvertent closing of the butterfly valve or drawdown within 5 feet of the screen top, the operator is immediately informed so that corrective action may be taken. The flow and level data has been very useful in the planning of well run times and "rest periods". The City currently utilizes this system to prevent chloride fluctuations.

The proposed control structure can easily be tied into this same system. A level monitor or monitors would be placed strategically within the wetland and ditch system to continuously monitor water levels. A motorized actuator would be used to control the elevation and slew rate of the sluice gate. Position feedback indicators would transmit the elevation of the gate back to the central site. (see block diagram) These control and monitor functions would be integrated into the GUI to graphically represent the wetland levels, gate elevation, and operational status of the system. Alarm setpoints could be established to alert the operator in the event of water levels which exceed or fall below the criterion established by the District. This system has the capability to "close loop" the system and provide autonomous control of the control structure elevation if so desired. Initially, operator control is suggested, due to the close proximity of this structure to the central site.



System Block Diagram

5.0 DATA

The telemetry system is capable of delivering several formats of report. The water levels can be recorded at intervals determined by the District. The current software has the ability to scale in engineering units, convert between engineering units, and perform simple and complex algorithms to manipulate data as required. In addition, the system can export this data to numerous spreadsheet formats. Therefore any combination of water level, date to date periods, and rainfall comparisons can be made.

The Telemetry system will have several excess inputs available for use. these are as follows:

1. Analog Input #1 .... RESERVED for gate position feedback
2. Analog Input #2 .... RESERVED for Water Levels
3. Analog Input #3 & #4 .... AVAILABLE
4. Analog Output #1 .... RESERVED for Gate position control
5. Analog Output #2 .... AVAILABLE
6. Digital Output #1................. AVAILABLE
7. Digital Output #2 .... AVAILABLE
8. Digital Output #3 .... AVAILABLE
9. Digital Output #4 .... AVAILABLE
10. Digital Input #1.................. RESERVED for system status
11. Digital Input #2 .... RESERVED for intrusion alarm
12. Digital Input 3 thru 16 .... AVAILABLE

These inputs may be utilized for additional control or monitoring as required by the District. It should be noted that additional level monitor inputs will require "piggy-back" of another RTU motherboard, due to the RESERVED status of the existing analog inputs. The City is capable of installing and configuring this Hardware / Software as required.

Totalizations and manipulations of data from any one (or combination) of these points is readily accomplished. The data required by the District can be tabulated and printed in any form, and delivered as hardcopy, diskette and / or via modem.

6.0 CONTROL STRUCTURE

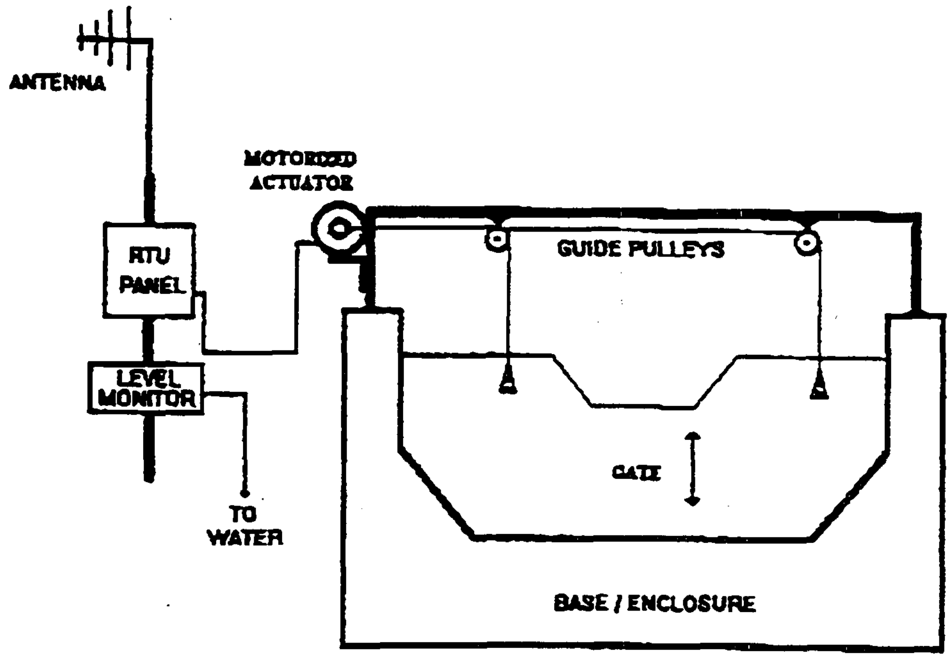
The physical control structure will be located within the drainage ditch, just west of the Tee connecting the wetland outfall into the east - west ditch. The structure could be fabricated of aluminum and stainless steel so as to be corrosion resistant.

The sluice gate would be housed in a channel complete with debris guards to prevent binding. The top of the gate will be connected to the motor / actuator with stainless steel cable and guide pullys. This arrangement will allow full travel without the need for gears which may become fouled with trash and debris. This structure can be manufactured locally at a metal fabrication shop, experienced with similar construction.

The Remote Telemetry Unit (RTU) will be mounted adjacent to this structure, in an enclosure mounted directly to the antenna mast. Signal and power cabling will run to the structure in rigid conduit for maximum protection from vandalism and mowing activities.

Level monitor(s) would be housed in a separate enclosure, mounted on the RTU mast. Bubbler tubing (or other sensing devices) would make entry into the water via corrosion proof schedule 80 PVC conduit. The 4-20 mA current loop signals to the RTU will connect to the RTU enclosure via Liquidtite flexible conduit.

Electrical power for the site will have to be provided as commercial power. Solar is a viable option for the RTU, but is limited in scope for the motorized actuator. Therefore the costs of a utility pole, Hand-hole, disconnect, and meter will be incurred.



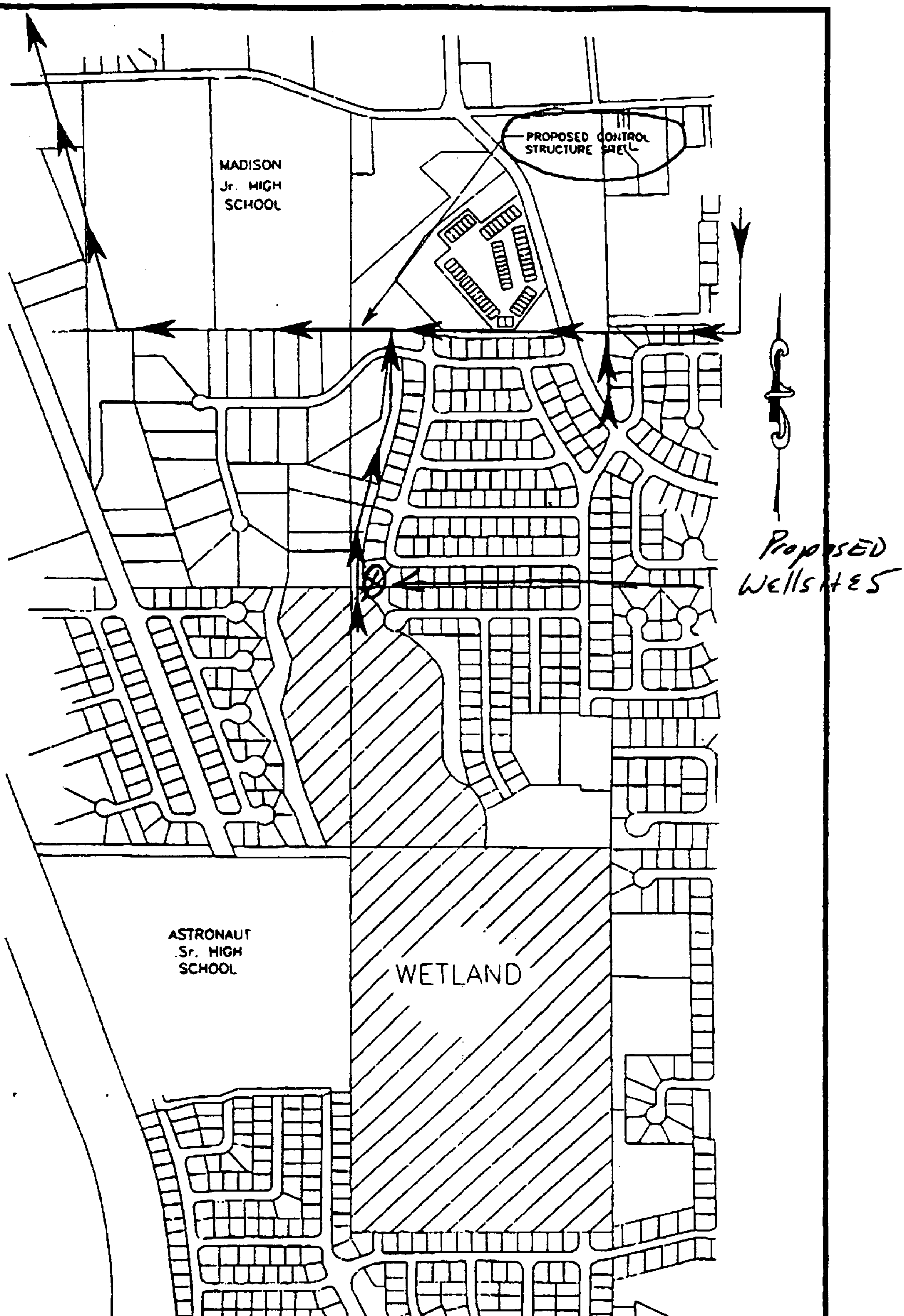
CONTROL STRUCTURE (CONCEPTUAL)

7.0 SUMMARY

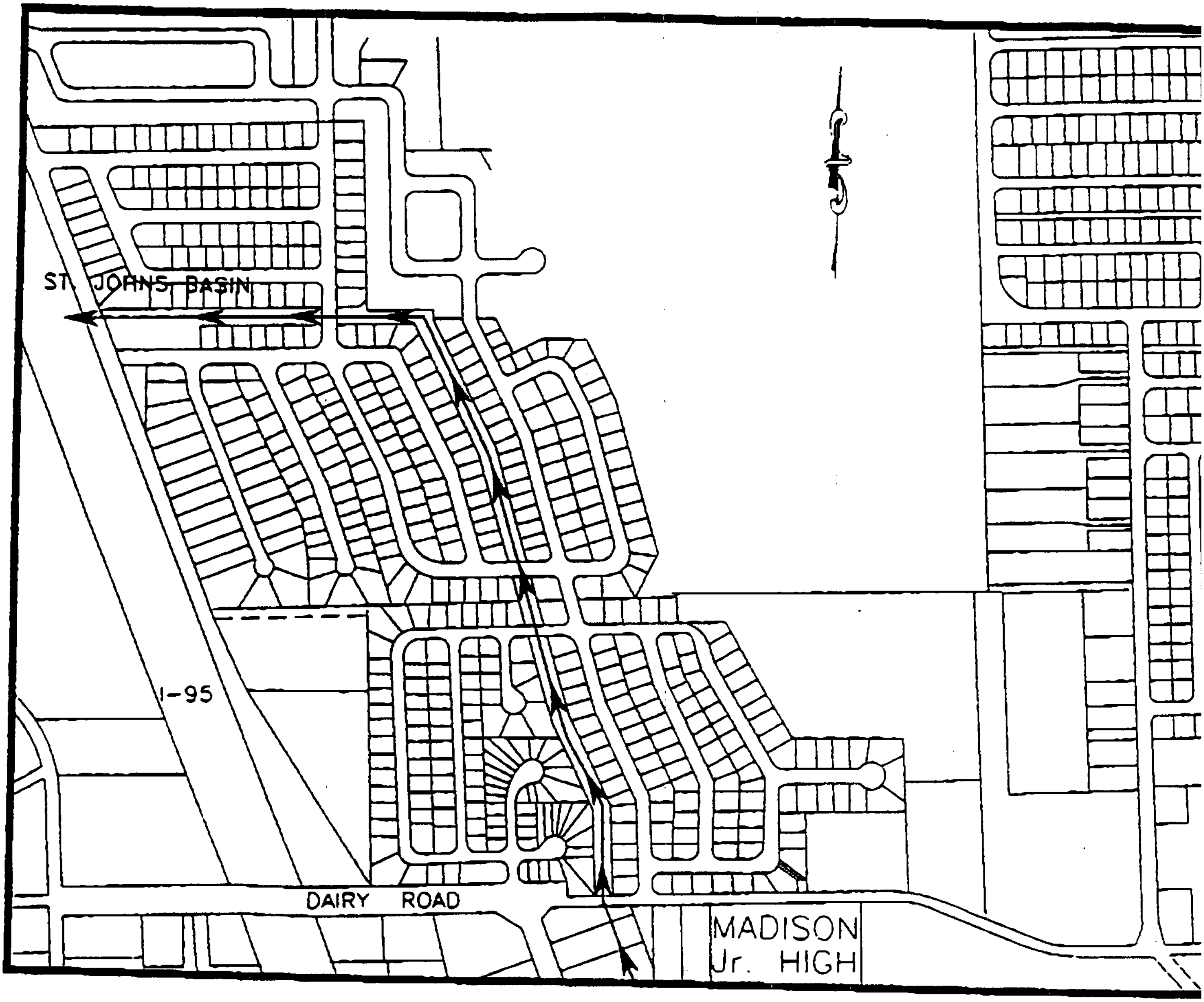
The addition of this control structure will allow the redirection and retention of stormwater in the Parkland Wetland Basin. The addition of this water at strategic points in time should allow for the mitigation of possible drawdowns in this wetland due to pumping activities in this area.

The design of this structure by it's very nature allows enough control range so as to permit the construction of the new wells with high degree of certainty of success. Therefore the construction of these wells can be accomplished simultaneously with the control structure. It is important to note that these wells are not intended to be run on a continual basis, but are to augment the existing wellfields, and allow some "rest" time for the wells in the outlying fringes of the bubble.

In addition, this action may help to alleviate the flooding conditions which have occurred downstream. This periodic flloding has been a source of consternation to the residents of the Parlkand / American Village. To that end, Brevard County has lowered drainage elevations in this area, to channel even more water into the St. Johns Basin. The net effect of the addition of this control structure should be positive in this aspect as it pertains to the direct recharge of the Area II Wellfield.



AREA II WELLFIELD – RECHARGE WETLAND



CUMULATIVE FLOW PATTERN (NORTH)