TECHNICAL PUBLICATION 84-6

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April 1984

This public document was promulgated at an annual cost of $309.90 or $.62 per copy to inform the public regarding water resource studies of the District. RPD 787 R150

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SECTION I
INTRODUCTION

BACKGROUND

Events, deliberations and decisions at the state, regional, and local levels have set the stage for the evaluation of wastewater reuse contained in this report.

At the state level, the State Water Policy, Chapter 17.40 FAC, is very supportive of wastewater reuse, referring to it as a beneficial replacement for the use of higher quality water. Under this policy, the State and the Water Management Districts (WMD's) are required to "promote water conservation and reuse as an integral part of water management programs, rules, and plans and encourage the use of water of the lowest acceptable quality for the purpose intended." The Department of Environmental Regulation (DER) has also promulgated a specific rule (Chapter 17-6 FAC) that clarifies the regulatory constraints which are placed on wastewater reuse.

At the regional level in south Florida, the Governing Board of the South Florida Water Management District (SFWMD) in May of 1982 passed a motion authorizing District staff to begin rule making procedures for the use of wastewater in the District. At that same meeting, the Board began to implement a special condition on golf course irrigation permits requiring that permittees submit a wastewater reuse feasibility report within three years. Earlier that year, the SFWMD Board had exempted wastewater reuse from restrictions imposed during water shortage periods and this had generated a great amount of interest on the part of potential users and suppliers.

At the local level, there has been considerable interest by both potential users and potential suppliers. The potential users, especially the managers and superintendents of golf courses and parks, have requested that the WMD, DER, the Department of Health and Rehabilitative Services (HRS), and the local regulatory units of public health and zoning closely examine the feasibility of making this water source widely available. Potential suppliers of wastewater have indicated similar interests, but the priority concern of this group has been the potential savings in wastewater disposal costs that might result.

MAJOR PARTIES TO THE WASTEWATER REUSE ISSUE

Understanding the issue of wastewater reuse is a matter of understanding the perspectives of the different parties who have interests in the matter. It is important that these interests be clearly understood, since the cooperation of all of these groups will be necessary to overcome the obstacles to implementation of this technique. Following is a discussion of the objectives of the major groups involved in the process of planning and implementing wastewater reuse systems. .

1. Potential Wastewater Suppliers - This group represents those wastewater treatment facilities and authorities, both public and private, that produce the treated wastewater. Their chief interest is in finding an environmentally-acceptable and cost-effective method of disposal of the treated wastewater. The alternative methods of disposal that are environmentally acceptable, such as ocean outfall and deep well injection, may, in fact, be more costly than wastewater reuse. Wastewater reuse thus represents a technique that could both reduce costs and provide an environmentally-acceptable disposal method.

2. Potential Wastewater Users - This group represents the existing and future water users who can utilize the quality of water produced by a wastewater treatment plant. The users include both public and private operations and their main interest is to discover a cost-effective and assured source of water supply. Because of the locations of the treatment plants, the current prevailing treatment standards, the continuous flow of wastewater, and the

need for long-term commitments, the most promising potential users of wastewater effluent are landscaped areas which demand a daily flow of water. In addition, these potential users can accept, and would benefit from, the nutrients (phosphorus and nitrogen) which remain in the effluent stream after the standard treatment. Golf courses, parks, highway median strips, cemeteries and other open grassed and landscaped areas are generally the prime targets for wastewater reuse. In some localities, local agricultural users and even residential users are considered as potential customers.

3. Regional Water Managers - This group represents those organizations looking for water-conserving methods which would reduce the stresses on present fresh water supplies and also reduce the need for construction of additional regional supply facilities. Those involved at this level would be the State's Water Management Districts and the several county-wide, intercounty or regional water supply authorities.

4. Environmental and Public Health Agencies - This group represents those agencies that are charged with the responsibility of limiting risks and damages in the areas of environmental quality and public health. Included in this group are the State's DER and HRS and the Federal Environmental Protection Agency (EPA). The issues of treatment processes and structural and operational specifications of treatment facilities are covered by DER. The issues of bacterial, viral, and other pathogenic constituents in wastewater are defined, and standards are set, by the HRS through its Office of Epidemiology Research in Tampa. These state agencies are also responsible for incorporating the goals of the EPA into state regulations. Local public health departments, on the county level, act largely as an enforcement arm of the HRS.

PURPOSE OF THE REPORT

This report has two main purposes. The first is to look at the more potentially successful applications of wastewater reuse in south Florida and to estimate the impacts that development of these applications would have on the goals of each of the groups identified above.

The second purpose is to analyze alternative policy options, which could be adopted by the SFWMD to promote the implementation of wastewater reuse, and to summarize the impacts expected from the SFWMD's adoption of these policies. The District policies considered include:

- Conducting Further Research on Wastewater Reuse
- Promoting the Consideration of Wastewater Reuse
- Assisting in the Review and Evaluation of Regulations Affecting Wastewater Reuse
- Providing Planning Assistance for Groups that are Considering Wastewater Reuse
- Using the District's Regulatory Program to Impose Specific Requirements Regarding Wastewater Reuse

FOCUS OF THE REPORT

In order to focus this report, certain assumptions were made regarding both the classes of users considered and the potential sources of the wastewater. The strategy used was to concentrate on wastewater reuse systems which would be large enough to impact regional water supplies and would be likely to succeed in terms of other considerations including costs, public acceptability and adherence to environmental and health standards. In this report therefore, the analysis focuses on water reuse systems with the following specifications and definitions:

Wastewater Reuse. Wastewater reuse is defined as a process which treats, distributes, and applies municipal wastewater effluent (not sludge) a replacement or substitute for the existing freshwater supply. The wastewater reuse systems considered include only non-potable uses of water, due to problems of acceptability and additional treatment costs.

Wastewater Effluent for Reuse. This is the product water available from wastewater treatment plants for reuse. In order to conform to DER requirements, it is considered to be treated to the advanced secondary standards (AST) of FAC Chapter 17-6. Using this treatment, the effluent will be virtually free of harmful bacteria and viruses because suspended solids are removed to a level where the harmful agents are exposed to effective disinfection. The effluent will then meet the public health standards promulgated by the HRS through its Office of Epidemiology Research.

Potential Users and Application Methods. The primary potential users considered are large urban landscape systems such as parks and golf courses. These users offer several advantages since they would:

- Demand enough water on a day-to-day basis to achieve economies of scale,
- Tolerate nutrient levels in theproduct water,
- Be acceptable to the general public, and
- Be economically located with respect to supply sources.

Additional classes of users such as commercial agriculture could be considered only if they were reasonably close to supply sources and demonstrated permanent user status. Among the application alternatives allowed by DER in south Florida, factors such as soil characteristics, slope of the land, and average depth to the water table all favor a slow-rate reuse method over other methods, such as high-rate application and overland flow. Therefore, two inches per week is a practical initial ceiling on the application rate. Sprinkler irrigation is the assumed method of application since it is the current method of irrigation used by virtually all large urban landscape systems.

Potential Suppliers. Only wastewater treatments plants with an installed capacity in excess of 1 MGD are considered as potential suppliers. They have the advantages in that they generally:

- Process most of the wastewater generated in south Florida,
- Are large enough to allow economy of operation,
- Provide a fairly constant flow to potential users,
- Are economically located with respect to potential users. and
- Meet state standards with minimum cost for additional treatment, since at least secondary treatment either exists or is proposed.

These assumptions have been made to narrow the range of potential users and suppliers only to the extent that the combinations or networks that remain are consistent as a group, and are likely to have significant impacts. Extreme prospects have been culled out so that in assessing the potential markets, cost factors, and public acceptance, marginal choices are minimized.

STRUCTURE OF THE REPORT

The report including this present section has been divided into six parts as follows:

Section I. Introduction - This section has defined the purpose, scope and structure of the study.

Section II. Identification and Comparison of Users and Suppliers - This section identifies potential suppliers and potential users within the SFWMD and compares them on a county by county basis to obtain a preliminary indication of the potential for wastewater reuse within the District.

Section III. Cost Relationships for Use in the Design of Wastewater Reuse Systems - This section more carefully describes the design constraints required to meet regulatory requirements and develops cost relationships and estimated total costs which indicate the effects of the implementation of a wastewater reuse system on suppliers, users and the managers of regional water systems.

Section IV. Preliminary Feasibility Study of a Wastewater Reuse System for Palm Beach County - This section presents the results of a preliminary feasibility study for the development of a Wastewater Reuse System in Palm Beach County.

Section V. Development and Review of Policy Options - This section develops and describes a range of potential District policies toward wastewater reuse.

Section VI. Summary and Implications - This section summarizes the implications of the analyses and information presented in the report regarding alternative District policies toward wastewater reuse.

SECTION II.
IDENTIFICATION AND COMPARISON OF POTENTIAL WASTEWATER USERS AND SUPPLIERS

A first step in this study was to identify potential users and suppliers of wastewater throughout the District, and to determine the relative balance between the two. This step provided both an estimate of the potential regional significance of wastewater reuse within the SFWMD and an indication of areas within the system that may have limited wastewater supply or demand.

To identify the potential suppliers, the names, design capacities, treatment types, and disposal methods of all treatment plants (1 mgd or more capacity) within the District were obtained from a centralized computer listing provided by the Department of Environmental Regulation (DER). Some data were missing for a small fraction of the treatment plants, so this list was supplemented by information from various 201 planning documents (see references) and information from Regional Planning Councils. Counties that are only partially within the District were surveyed, and only those treatment plants located within the SFWMD boundaries were included. Total wastewater treatment capacities, by county, are presented in Table 2-1. The individual treatment plants, their design capacities, type of treatment, and disposal methods are presented as Table A-1 in Appendix A.

In several counties, a comparison of existing plant capacities with historical flows revealed large discrepancies, which indicates that wastewater treatment capacities are an inadequate indicator of present or future supply capability. These discrepancies arise because the stated treatment capacities are meant to cover peak rather than average flows, and generally include capacity installed to handle future growth. The amount of this excess present capacity seems to vary significantly from county to county. For this reason, projections of average wastewater flows were

TABLE 2-1 INDICATORS OF WASTEWATER REUSE POTENTIAL IN THE SFWMD

COUNTY	SUPPLY POTENTIAL: PRESENT[a] CAPACITY (MGD)	SUPPLY POTENTIAL: EST. 1990 FLOWS[b] (MGD)	DEMAND POTENTIAL: PERMITTED URBAN[c] LANDSCAPE USE (AC)	DEMAND POTENTIAL: POTENTIAL USE[d] (MGD)	SYSTEM POTENTIAL: MAXIMUM POTENTIAL SYSTEM[e] (MGD)	SYSTEM POTENTIAL: COUNTY SHARE OF MAX POTENTIAL SYSTEM (%)
Broward	200.45	114.39	10,289	39.9	39.9	24.4
Collier	10.90	8.95	4,425	17.2	8.9	5.5
Dade	301.78	158.31	6,145	23.8	23.8	14.6
Glades	0.00	0.00	195	0.8	0.0	0.0
Hendry	2.50	1.00	129	0.5	0.5	0.3
Highlands	0.00	0.00	0	0.0	0.0	0.0
Lee	30.18	19.88	5,607	21.7	19.9	12.2
Martin	9.50	4.38	2,654	10.3	4.4	2.7
Monroe	4.30	3.51	118	0.5	0.5	0.3
Okeechobee	4.00	0.00	0	0.0	0.0	0.0
Orange	27.00	7.61	976	3.8	3.8	2.3
Osceola	9.70	9.70	498	1.9	1.9	1.2
Palm Beach	94.60	66.60	14,378	55.8	55.8	34.2
Polk	0.00	0.00	205	0.8	0.0	0.0
St. Lucie	7.00	8.04	965	3.7	3.7	2.3
TOTAL	701.91	402.37	46,584	180.7	163.1	100.0

a. Covers plants with a capacity approved by DER of 1.0 MGD or more.
b. When estimated flows were less than 1.0 MGD, they were recorded as 0.0.
c. SFWMD permit categories of golf courses, landscape, and recreation areas.
d. Estimated from the acreages using an application rate of one inch per week.
e. Estimated as the smaller of the supply potential of 1990 flows (column 2) or the potential use (column 4).

formulated for each county, based on a) projected 1990 populations, b) an estimate of the percentage of the population served by sewer systems and c) a planning estimate of wastewater generated of 100 gallons per capita per day.

Projected populations were taken from the most recent "medium" growth rate projections produced by the Bureau of Business and Economic Research of the University of Florida. For counties that are not entirely within the District, the proportion of the District's total population that resided in these areas in 1980 (based on the 1980 Census of Population and Housing) was assumed to reside in these areas in the future.

The percentages of the population served by sewers were also estimated using the proportion of dwelling units so served from the 1980 Census of Population and Housing. The year 1990 was selected as a reasonable time in the future when comprehensive wastewater reuse systems could be implemented. The projected 1990 average wastewater flows, by county, are presented in column 2 of Table 2-1.

Potential wastewater users were identified from SFWMD permit files and other sources. Permit holders with a SFWMD land use designation of golf course, landscape, or recreation area were considered as potential candidates for wastewater reuse. The locations and acreages of all permitted golf courses, parks, cemeteries, and recreational areas were compiled in this manner. This list was supplemented by data from the Area Planning Board (APB) of Palm Beach County (1981); the Southwest Florida Regional Planning Council (1980); the Metro-Dade County Office of Planning (1982); and the Broward County Office of Planning (1980). Acreages for potential users that are not permitted by the SFWMD were obtained from the other sources mentioned above or were estimated. In a few cases, reasonable estimates were unavailable.

The individual sites and their respective acreages are listed in Table A-2, by county. An asterisk (*) indicates that an average value was substituted for a missing value. The total acreages and estimated demands for each county are presented in Table 2-1. One inch per week is considered to be a reasonable average purchase of waters by wastewater users. The "potential use" estimates in Table 2-1 were calculated using this application rate.

The data in the "maximum potential system" column of Table 2-1 are the lesser of the "potential demand" column or the "potential supply" column for each county, as an indication of the maximum capacity of any wastewater reuse system within that county. The total of 163.1 MGD represents about twenty percent of the estimated potable water consumption within the District. Three quarters of the potential system capacity would be located in the populous Lower East Coast counties of Dade, Broward, and Palm Beach. Palm Beach County shows the largest single share (34.2%). A wastewater reuse system would contribute to water supply capabilities during periods when the primary source (aquifer) is not full and discharging through the major canal system. In the Lower East Coast area, a wastewater reuse system would contribute to water supply capabilities only when discharges are not being made to tidewater. Once such discharges stop, the wastewater reuse system will have a cumulative positive impact on total water in the aquifer approximately equal to the sum of the daily wastewater reuse. For the Lower East Coast counties this could mean that as much as 44,000 AF of additional water would remain in the aquifer at the end of a drought that resulted in a four-month period of no discharge.

The significant potential impacts of the wastewater reuse system, compared with other water supply augmentation options, indicates that a close look should be taken at the costs and impacts of such a system on users and suppliers, and at the benefits to the regional system as a whole. The costs and impacts of wastewater reuse are developed and discussed in Section III and are used to test the economic feasiblity of a wastewater reuse system for eastern Palm Beach County in Section IV.

SECTION III
COST RELATIONSHIPS FOR USE IN THE DESIGN OF WASTEWATER REUSE SYSTEMS

This section is concerned with the appropriate design of wastewater reuse systems and the impacts that the implementation of such systems would have on all parties involved--i.e. the suppliers, the users, the regional water managers, and the environmental and public health agencies. As was indicated in Section I, the concerns and requirements of the environmental and public health agencies will be addressed by incorporating them into the design and operating criteria. Thus, the first step in this section is to define these regulatory requirements.

REGULATORY REQUIREMENTS

The state of Florida, through the Florida Department of Environmental Regulation (DER) and the Florida Department of Health and Rehabilitative Services (HRS) has a complex set of regulatory requirements for wastewater reuse. Since DER's standards exceed the federal standards of the Environmental Protection Agency (EPA), DER standards will be used for the design.

The Florida DER classifies wastewater reuse schemes as slow-rate, high-rate, overland flow, and absorption bed (septic tank) systems (DER, 1982), which is similar to the scheme that is used by the EPA. In Florida, the slow-rate application methods are predominantly used because of the wet hydrology (especially in south Florida), and the stringent regulatory requirements (University of South Florida, 1983).

The following list is a summation of the regulatory requirements that have the greatest economic impact on the overall design (DER, 1982):

1. BOD-same as secondary requirements
2. TSS-less than 5 mg/l
3. No detectable fecal coliforms

4. A backup disposal system, consisting of
   a) an alternative discharge system, and/or
   b) storage (7 days minimum required in south Florida) and subsequent disposal

5. Buffer zones-500 feet minimum distance to potable wells.

6. Buffer zones-public access (none required if irrigation occurs at night).

7. Monitoring wells may or may not be required, depending on the hydrogeology of the site.

8. Two inches per week maximum application rate for slow-rate systems (on an annual basis). This can be raised in specific instances if the hydrology permits.

In application, these requirements may be adapted somewhat to meet individual needs, as the regulations are largely enforced by local DER officials. Advanced secondary treatment, followed by chlorination, is needed to meet these regulations. Most treatment plants in south Florida currently treat wastewater to secondary standards. Addition of a tertiary filter (sized only for the flow that is used in the wastewater reuse system) and more chlorination facilities would bring the wastewater up to these standards. A backup disposal method is needed for those periods when irrigation is not desired or feasible. One option is to provide approved disposal capacity by an alternative method. Another option is to store water during the non-use periods and subsequently dispose of it through reuse or an approved alternate disposal system. The remaining requirements are designed to mitigate against potentially harmful impacts at the application site.

DEFINING THE IMPACTS

Having established the regulatory framework, it is now possible to define the impacts that would result from the implementation of a wastewater reuse system. Table 3-1 shows the potential impacts, whether each impact would cause additional costs or would enable costs to be avoided, and what group would be affected. This framework indicates that essentially no impacts are expected on the collection,

TABLE 3-1 IMPACT CATEGORIES FOR WASTEWATER REUSE SYSTEMS

CATEGORIES	IMPACT	IMPACTED GROUP
Advanced Secondary Treatment	*higher cost*	*supplier*
Storage facilities	*higher cost*	*supplier*
Transporting water to the user	*higher cost*	*supplier*
Alternative effluent disposal	*cost avoided*	*supplier*
Present water supply source	*cost avoided*	*user*
Separating waste and stormwaters	*higher cost*	*user*
Fertilizer requirements	*cost avoided*	*user*
Water shortage impacts	*cost avoided*	*user*
Regional supply capacity	*cost avoided*	*Regional water manager*

primary, and secondary treatment systems of the treatment plants. In the same way it is expected that the users will continue to operate with a similar irrigation (sprinkler) system, with negligible conversion costs.

A basic system would then involve the following impacts:

1. The supplier must apply tertiary filtration and additional chlorination to secondarily treated water to meet DER requirements.

2. The supplier must provide capacity for 3 days (7 days in S. Florida) storage of effluent if an alternative effluent disposal method is not available

3. The supplier or user must construct and operate pipelines to deliver the water to the place of use.

4. The supplier would reduce the use of the alternative effluent disposal method and save operating costs but probably no capital costs.

5. The user would reduce the use of present water supply facilities (wells, pumps, or public water supply systems), at some cost savings.

6. The user must integrate the wastewater into the irrigation system without violating restrictions on the mixing of wastewater and stormwater.

7. The user, recognizing that significant nutrients are supplied by the wastewater, could reduce applications of commercial fertilizers that are used to maintain turf.

8. The user would have reduced impacts during declared water shortages, since the use of the wastewater would be exempt from restrictions.

9. The regional water supplier would have more water available and have reduced demands during droughts, both of which would reduce the need for regional system improvements.

The next step is to detail the relationships which were used to generate treatment, storage, transport, effluent disposal, and present water supply costs.

COST RELATIONSHIPS

Cost relationships in treatment systems show very good economies of scale as the capacity (flow) of the plant increases (Marsden et. al., 1973). These relationships can range from aggregate (such as a relationship for "primary treatment") to detailed, itemized costing with a resultant increase in accuracy from ±60% to ±30% (Clark and Dorsey, 1982). The purpose of these relationships is to evaluate different alternatives with a minimum of design information in order to make enlightened economic decisions. The EPA has produced numerous texts documenting cost curves and regression relationships for components of treatment systems. A compilation of the relationships that can be used in a wastewater reuse project) can be found in Table 3-2. The usual formats for these costs are:

$$C = aQ^{\beta}$$

or:

$$C = aQ^{\beta_1} H^{\beta_2}$$

or:

$$C = aD^{\beta}$$

depending on the variables involved (the equations illustrated above are functions of flow Q, head H, and diameter D). Their use not only standardizes the cost estimating procedure, but, by separating out component costs of each treatment system, achieves greater accuracy and allows for separate updating, and conversion to local figures (see Table 3-3).

ESTIMATES OF COST IMPACTS

In this subsection, estimates of the costs for each of the nine categories in Table 3-1 are presented and discussed. These costs result from the application of

TABLE 3-2 : EQUATIONS USED TO ESTIMATE COSTS OF FACILITIES

FACILITY	EQUATION(S)
Gravity filter const: (Gutherman et al.)	
excavation	$1799.56Q^{.59901}$
equipment	$28863.05Q^{.69806}$
concrete	$13515.89Q^{.56330}$
steel	$8046.74Q^{.55305}$
labor	$37867.49Q^{.59019}$
pipe 2	$9521.02Q^{.73684}$
electrical	$17848.10Q^{.54705}$
housing	$15412.69Q^{.77921}$
contingencies	$25605.56Q^{.66069}$
total	$164165.50Q^{.66069}$
Gravity filter O&M:	
energy	$2436.50Q^{.86331}$
materials	$862.890Q^{.72147}$
labor	$1001.07Q^{.53384}$
total	$9842.35Q^{.63678}$
Media, Dual fil.: (Gutherman et al.)	
materials	$6469.83Q^{.80912}$
Backwash fil. const, peak flow rates, typical factor = 5: (Gutherman et al.)	
equipment	$2439.21Q^{.78004}$
labor	$1024.83Q^{.46432}$
pipe	$4508.27Q^{.48321}$
electrical	$8293.32Q^{.31159}$
contingencies	$1990.39Q^{.55613}$
total	$12755.15Q^{.55621}$
Backwash fil. O&M:	
labor	$256.39Q^{.13405}$
energy	$200.42Q^{1.00043}$
maint	$381.64Q^{.40610}$
total	$1125.01Q^{.45913}$
Surface washing const:	
equip	$8683.26Q^{.72415}$
labor	$1034.23Q^{.73539}$
pipe	$2797.76Q^{.57514}$
electrical	$14088.69Q^{.37436}$
contingencies	$3711.72Q^{.59754}$
total	$28782.98Q^{.59771}$
Surface washing O&M:	
labor	$79.51Q^{.46826}$
energy	$132.10Q^{.97356}$
maintenance	$208.89Q^{.20830}$
total	$810.60Q^{.59276}$
Storage < 10MGD, 3 day detention time required (DER): (Reed et al)	
construction	$16968Q^{.5884}$
lining	$25960Q^{.7750}$
embankment	$21679Q^{.4072}$
O&M:	
labor	$549Q^{.3328}$
materials	$202Q^{.5068}$
10-5000 MGD:	
construction	$12746Q^{.7230}$
lining	$22306Q^{.8944}$
embankment	$35132Q^{.4240}$
O&M:	
labor	$640Q^{.36974}$
materials	$106Q^{.8853}$
Chlorination:	
Capital	$61102Q^{.6316}$
Chlorination O&M:	
Chlorine	$2250Q$
materials	$1793Q^{.5322}$
labor	$4473Q^{.077}$
Submersible pumps, TDH = 50 ft: (Gutherman et al)	
Capital:	
excavation	$1717.83Q^{.20175}$
gpm	$458.86Q^{.20175}$
equipment	$18715.16Q^{.29266}$
gpm	$2257.79Q^{.29266}$
concrete	$1532.64Q^{.51187}$
gpm	$53.81Q^{.51187}$
labor	$3456.84Q^{.12519}$
gpm	$1523.81Q^{.12519}$
pipe	$2256.97Q^{.15965}$
gpm	$794.07Q^{.1596}$
electical	$966.15Q^{.12390}$
gpm	$429.50Q^{.12390}$
contingencies	$4715.43Q^{.23968}$
gpm	$982.70Q^{.23968}$
total2	$8521.35Q^{.23890}$
gpm	$5974.53Q^{.23890}$
O&M: (Gutherman et al)	
energy	$4838.86Q^{1.0024}$
gpm	$6.96Q^{1.0024}$
labor	$1490.61Q^{.23405}$
gpm	$322.31Q^{.23405}$
maintenance	$150.28Q^{.27991}$
gpm	$24.07Q^{.27991}$
total	$3653.69Q^{.50359}$
gpm	$135.43Q^{.50359}$
Centrifugal pumps: (Gutherman et al)	
Capital:	
Equipment	$310.11Q^{.78152}H^{.69174}$
gpm	$1.87Q^{.78152}H^{.69174}$
Labor	$704.47Q^{.68914}H^{.22625}$
gpm	$7.75Q^{.68914}H^{.22625}$
Pipes & Valves	$4109.39Q^{.75655}$
gpm	$29.10Q^{.75655}$
electrical	$276.59Q^{.80860}H^{.53109}$
gpm	$1.39Q^{.80860}H^{.53109}$
contingencies	$274.54Q^{.77240}H^{.48164}$
gpm	$1.75Q^{.77240}H^{.48164}$
total	$1756.97Q^{.77249}H^{.4819}$
gpm	$11.21Q^{.77249}H^{.48194}$
O&M: (Gutherman et al)	
energy	$29.97QH$
gpm	$0.04QH$
labor	$3379.27Q^{.50443}$
gpm	$124.57Q^{.50443}$
maintenance	$297.68Q^{.85775}$
gpm	$1.09Q^{.85775}$
total	$157.75Q^{.85194}H^{.73788}$
gpm	$0.60Q^{.85194}H^{.73788}$
Turbine Pumps: (Gutherman et al)	
Capital:	
equipment	$2858.07Q^{.68394}H^{.2986}$
gpm	$32.55Q^{.68394}H^{.29858}$
labor	$2126.99Q^{.63240}H^{.0459}$
gpm	$33.94Q^{.63240}H^{.04590}$
pipes & valves	$5787.43Q^{.68134}$
gpm	$67.05Q^{.68134}$
Turbine Pumps: (Continued)	
electrical	$198.08Q^{.65082}H^{.70649}$
gpm	$2.80Q^{.65082}H^{.70649}$
contingencies	$1344.59Q^{.67403}H^{.23608}$
gpm	$16.34Q^{.67403}H^{.23608}$
total	$8145.7Q^{.67391}H^{.23614}$
gpm	$99.07Q^{.67391}H^{.23614}$
O&M:	
energy	$404.17Q^{1.02044}H^{.35905}$
gpm	$0.51Q^{1.02044}H^{.35905}$
maintenance	$341.43Q^{.82443}$
gpm	$1.55Q^{.82443}$
labor	$5784.92Q^{.42875}$
gpm	$349.90Q^{.42875}$
total	$2331.40Q^{.77457}H^{.26774}$
gpm	$14.67Q^{.77457}H^{.26774}$
Pipeline Costs	
PVC pipe (diameter < 12 inches): Capital costs only (O&M estimated at .5% of capital costs, yearly): (Dodge, 1983)	
labor	$.2580D^{.2587}L$
materials	$.1205D^{1.7832}L$
Ductile iron pipe (diameter > 12 inches): (Dodge, 1983)	
labor	$.3249D^{.88832}L$
materials	$.2649D^{1.5549}L$
equipment	$.2905D^{.88982}L$
On-site replumbing costs: (OLAC, 1982)	
total	$75116.01Q$
Service connection costs: (OLAC, 1982)	
total	$125.24Q^{.99204}$
Ocean outfalls (for comparison): Capital costs only (O&M estimated at 2% of capital): (Dames&Moore, 1978)	
pumps	$664Q^{1.26}$
pipe	$1478Q^{1.37}$
diffuser	$648Q^{0.91}$
Evaporation/Percolation ponds: (Reed et al)	
O&M only:	
labor	$22011Q^{.6092}$
materials	$2816Q^{.5333}$

Wells (Deb, 1978)

Type	Diam	Depth	Equation
tubular sand & gravel	6-10"	35-250'	$2775d^{.299}$
gravel,	12-15"	50-220'	$2953d^{.373}$
packed sand	16-20"	50-350'	$2369d^{.408}$
& gravel	24-34"	50-220'	$2369d^{.482}$
shallow sand-	6"	140-400'	$2.01d^{1.413}$
stone, lime-	8-12"	200-600'	$2.92d^{1.450}$
stone or dolo-mite bedrock	15-24"	160-450'	$6.18d^{1.471}$
deep sand-	8-12"	600-2500'	$101d^{1.370}$
stone wells	15-19"	900-2000'	$4.56d^{1.429}$

SYMBOLS USED

VARIABLE	PARAMETER	UNITS
Q	flow	mgd, or gpm
H	head	feet of water
L	length	linear feet
D	diameter	inches
d	depth	feet

TABLE 3-3: COST UPDATING FACTORS (January, 1983)

CATEGORY	SOURCE	INDEX VALUE	INDEX FACTOR* WPB, FL
Construction-Capital:			
excavation	Bureau of Land Reclamation (BLR)	1.44	
equipment	Bureau of Labor Statistics (BLS), General Purpose Machinery Code, No. 114	308.1	1.001
labor	*Engineering News Record* Wage Index (ENR), skilled labor	350.03	0.711
pipes & valves	BLS Valves & Fittings Code, No. 1013	325.1	0.963
electrical	BLS Electrical & Instrumentation Code, No. 117	234.5	0.963
concrete	BLS Concrete	1.53	
contingencies	ENR Construction Cost Index	369.8	0.942
total	ENR Builders Cost Index	342.35	0.817
Operation and Maintenance:			
energy	electric rates	6¢/kwhr	none
labor	ENR skilled labor (wage/hr)	350.03 ($14.11)	
maintenance	Producers Price Index	283.9	0.781
materials	ENR materials index or price quote	340.3	0.781
total	Producers Price Index	283.9	0.996

*Computed from ENR construction cost indexes for various metropolitan areas. This factor is multiplied by the IndexValue to obtain an Adjusted Index Value for West Palm Beach, Florida.

the relationships presented in the previous subsection and from other data which follows. The relationships between the costs and the size of flows, distance covered, type of alternative discharge, and other relevant variables are presented so the reader can become familiar with the size and sensitivity of each of the cost categories.

Advanced Secondary Treatment (Tertiary Filtration and Additional Chlorination)

In order to meet the requirement of the Florida DER, some type of advanced treatment (beyond secondary treatment) is required. Many different treatment methods are possible, but the most common is tertiary filtration (which may be combined with alum coagulation) followed by chlorination.

Tertiary filtration consists mainly of physical treatment such as absorption on filter media (usually coal, gravel, or sand). Some biological breakdown also occurs within the media. Alum coagulation uses a chemical/physical process in which alum slowly coalesces with the suspended particles, causing them to settle (Diversified Utilities, 1979). Due to the reliability and regulatory acceptability of tertiary filtration alone, it was chosen as the design treatment process.

The major construction components involved with tertiary filtration are as follows:

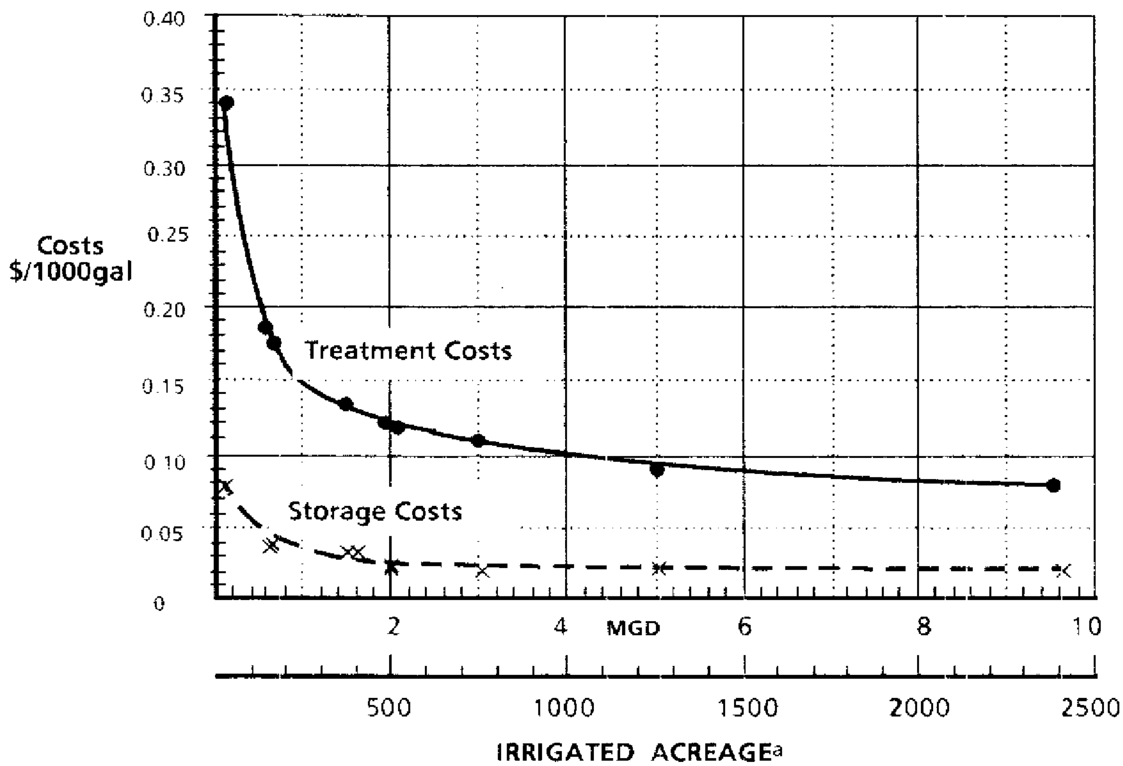
1. Gravity filter
2. Filtration media
3. Backwash pumping facilities
4. Surface washing facilities

The cost of the gravity filter is for the actual construction of the filter. The cost of the filtration media is for the sand, gravel, or coal within the filter. Backwash pumps are used to clean the filter by reversing the flow during the backwash cycle. Surface washing facilities keep the surface of the filter clean and free of debris. The major operating and maintenance cost components of these processes are energy, labor, and maintenance (on materials), under each of the components listed above except for the filtration media. All of the equations for these costs are listed in Table 3-2 (as taken from Gutherman et al). Each component was broken into subcomponents to allow for separate updating of all types of costs involved to January 1983.

Once the suspended solids have been reduced by filtration, chlorination is applied to kill bacteria and viruses which remain in the water. The cost equations for chlorination facilities in Table 3-2 were obtained from Reed et al (1980). The capital costs include construction and purchase of equipment. Operating costs include chlorine, materials and labor.

Figure 3-1 provides estimates of the total treatment cost for systems of various sizes. The costs are presented in dollars per thousand gallons and include capital and

Figure 3-1 Wastewater Reuse Treatment and Backup Storage Costs for Various Quantities of Effluent



[a] An average irrigation rate of 1" per week has been assumed in calculating the irrigated area

operating costs. The system size in Figure 3-1 can be expressed based on millions of gallons per day of flow or on the number of irrigated acres that the system can service. The irrigated area was estimated using an application rate of one inch per week. The estimated treatment costs show large economies of scale. Costs of a 0.4 MGD system exceed $.20 per thousand gallons, while costs of systems that handle more than 4.0 MGD are less than $.10 per thousand gallons.

Storage Facilities

Storage facilities must be designed and sized to meet DER requirements. If full backup disposal capacity is available, storage will not be required. Otherwise, storage will be needed for the wastewater until it can be either delivered for reuse or disposed of using off-peak available backup disposal capacity.

Cost equations for storage facilities in Table 3-2 were taken from Reed (et al). These equations were converted from a volume variable to a flow variable, based on a 7-day retention requirement (the minimum that DER will allow in south Florida). Systems with total design flows less than 10 mgd are costed by a different set of equations than systems with flows that are greater than 10 mgd. The major components of the capital costs are construction, lining (PVC), and embankment. Land costs are included within the construction costs. The major operating costs are labor and materials.

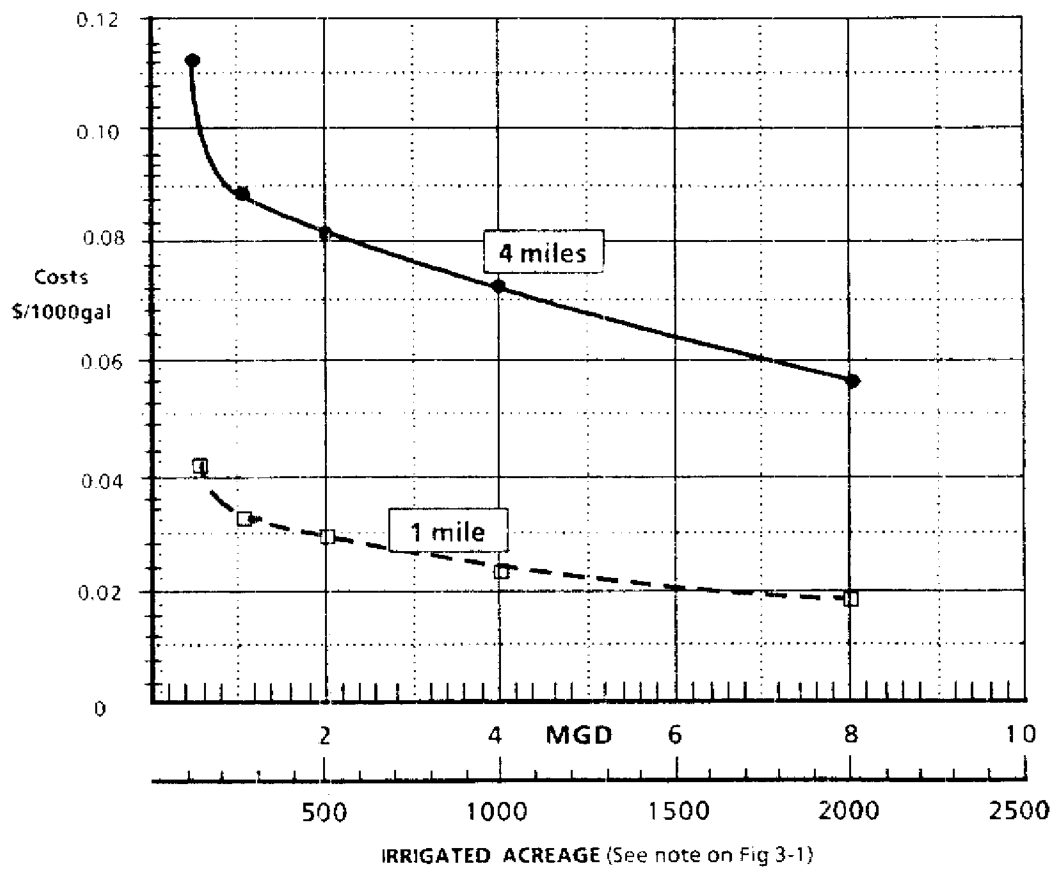
The storage facility is a simple excavated reservoir, with an additional PVC lining to conserve the treated water. (Once money is spent treating the water to advanced secondary standards, it would not be cost-effective to let it seep into the ground). The storage facilities would generally be located at the treatment site to take advantage of economies of scale and to be accessible to alternative disposal methods. However, in certain circumstances, golf course lakes could be used as a backup storage of good quality effluent.

The costs for storage facilities of a wastewater reuse system have good economies of scale of flow (size) as shown in Figure 3-1. The equations from Table 3-2 were used to evaluate costs for storage facilities (construction, operation and maintenance) for flow rates and acreages as indicated in Figure 3-1. In the range considered, storage costs vary from above $.05 down to $.02 per thousand gallons.

Transporting Water to the User

These costs are technically difficult to evaluate. Pipeline costs vary linearly with the length of the pipe, and non-linearly with diameter. The diameter, in turn, is non-linearly related to the flow (demand) of the user. These costs are also affected by the efficiency and head of the pumps selected, the static head of the system, the age of the pipe, etc. There is also an inherent tradeoff between pumping costs and pipeline costs (i.e., the larger the pipe, the lower the pumping costs, and vice versa). An optimization analysis was performed to select diameters of the planned pipelines with a minimum of given information (mainly the user's flow). Figure 3-2 gives examples of costs for various flows (or acreages) and

Figure 3-2. Wastewater Reuse Transportation Costs by Distance and Quantity Transported



distances. These costs also show significant economies to larger systems, which emphasizes the importance of system designs that fully consider pipeline networking opportunities.

Alternative Effluent Disposal

Alternative effluent disposal refers to the disposal system that will be used in lieu of wastewater reuse when demands for wastewater are temporarily reduced due to rainfall or other factors. Effluent disposal systems (other than wastewater reuse) which are used in south Florida include deep well injection, percolation/ evaporation ponds, and ocean outfalls. The installation of a wastewater reuse system would substitute for use of the alternative effluent disposal system and would reduce the operating costs, and in some cases the capital costs, associated with effluent disposal. Most existing wastewater treatment plants will have existing alternative disposal capacity. These plants will save on operating costs of the alternative system until their flows have increased beyond the capacity of the alternate effluent disposal system, i.e., during periods of peak flow. Then they will be faced with a capital decision of whether to invest in additional disposal capacity or to provide storage. New wastewater treatment systems will be in a position to save both capital and operating expenses.

Cost savings to the supplier vary with the type of disposal, e.g., deep well injection, percolation/evaporation ponds, or ocean outfalls. Examples of the costs of each of these disposal methods are illustrated in Table 3-5. First, it should be

Table 3-5. OPERATING COSTS OF ALTERNATIVE DISPOSAL METHODS

Method	Estimated Operating Cost ($/1000 Gallons)
Ocean Outfall	negligible
Deep Well Injection	$.08
Percolation Ponds	from $.04 (for systems over 4 MGD) to $.09 (for systems of .5 MGD)

noted that facilities utilizing ocean outfalls have very low operating costs, so their savings are assumed to be negligible. Operating costs for deep wells, under circumstances that are typical of south Florida, are presently estimated to be about

$.08 per thousand gallons.The operating costs for evaporation/percolation ponds were derived from the cost equations found in Table 3-2 (from Reed, et al). These costs indicate that all suppliers, except those that use ocean outfalls, could realize significant savings in operating costs by having wastewater reuse capability

Present Water Supply Source

Cost savings to users, which result from reducing the use of their present supply source, were estimated on the basis of information from SFWMD permit files (regarding the type of facilities that exist at the permit site, and the type of pumps or wells in use), cost equations from Table 3-2, and commercial water rates for the service area of the potential user (ACT Systems, 1980, or local water rate structures). For those potential users who have a SFWMD permit, it was estimated that they would save in operating costs (since capital costs have already been incurred for their existing system, there is no savings in that category). For groundwater withdrawal, operating costs were estimated as $.05/1000 gallons, based on average flow rates and operating and maintenance cost equations for the types of pumps that are typically used for irrigation systems. Those sites that currently use potable water generally pay commercial rates which can amount to $1.00/1000 gallons.

Separating Wastewater and Stormwater

In 1971, the District Governing Board adopted a "zero discharge" policy, which states that: "No permit will be granted for the discharge of wastewater from a new wastewater source into any waterway under the jurisdiction of the C&SFFCD" (Sept. 10, 1971). This basic tenet has been applied to the issuing of permits for surface water (stormwater) management systems that use wastewater effluent. In keeping with this policy, the District has promoted, through its regulatoy authority, the design of all stormwater systems so as to protect the quality as well as the quantity of water discharged into receiving waters.

With regard to wastewater reuse, the District's regulatory staff has required that the following criteria be met by surface water management systems when wastewater is involved (Rogers, 1982):

1. Effluent shall be discharged into isolated lakes which have storage capacity for the effluent (3 day volume minimum) plus the contributing area runoff volume for a 3 day/25 year rainfall event, prior to overflow into the stormwater system.

2. Effluent may only be discharged into any portion of the stormwater system if a water quality monitoring program gives positive assurances that water quality degradation will not result and that State water quality standards can be met. A continuous monitoring program would be a requirement if such discharge were permitted, and continuation of the discharge would be contingent on satisfactory monitoring results.

For this study, it has been assumed that receiving waters and application sites will be protected under the appropriate provision of the District's Stormwater Rule. The costs involved in meeting the stormwater quality protection requirements of the District and the DER will greatly vary from site to site. Not all users may need to modify their present system. In cases where modifications are needed, factors such as topography, soil type, natural and manmade systems, and proximity to receiving waters will all play an important part in estimating the costs of changes needed to allow reuse of wastewater. The costs should be far less when new surface water management systems are being constructed, since the requirements to meet wastewater reuse standards are specified in the preliminary stages of design.

In most cases in south Florida, golf courses are prime sites for wastewater reuse. The costs of developing additional storage areas that are isolated from their stormwater systems should be relatively small, since most golf courses have small lakes that could serve as holding ponds. On the other hand, the required additional storage and monitoring facilities and efforts might restrict the implementation of reuse in areas such as cemeteries, small parks, median strips, and residential areas.

Fertilizer requirements

The wastewater that will be applied will almost certainly contain significantly higher concentrations of nutrients than any alternative water supply for that site. These nutrients may substitute for commercial fertilizer apllications and hence result in some savings to the users. There are, however, divergent opinions regarding the value of these nutrients. On the one hand, the effluent contains nutrients that would benefit the irrigated vegetation. This conclusion has been confirmed by planning agencies and some users in other states, notably the California Extension Service (Harinandi, 1982) and the Texas Water Research Center (Sweazy et al, 1979). On the other hand, a survey of major wastewater users in the District indicates that these users do not perceive or explicitly acccount for any such benefits in their current fertilization practices.

The value of the nutrients in the wastewater, calculated in terms of reduced fertilizer materials and application costs, is in the range of $.07 to $.16 per thousand gallons. It is reasonable to assume that some significant proportion of the nutrients in wastewater are used by plants and these nutrients have a value since they can effectively substitute for fertilizer applications. An estimate of $.05 per thousand gallons is believed to be a reasonable, conservative estimate of this value. Further experience and documentation may be necessary to convince users of this benefit and to estimate more accurately the physical and economic value of the nutrients.

Water Shortage Impacts

Wastewater reuse has been exempted by the District from restrictions that would normally be imposed on irrigation during water shortage periods. The District, in essence, placed a value on wastewater reuse because this method does not tax the freshwater resource, especially during periods of drought. In addition, reuse helps to recharge the aquifer system.

Most uses of fresh water, including the possible concurrent use of fresh water from other sources by wastewater users, will be curtailed to various extents during a declared water shortage. The degree to which use is curtailed will depend upon the severity and the duration of the shortage. Because irrigation water will continue to flow to the wastewater user during a water shortage, several items should be considered:

1. The user will be able to provide better protection to capital investments in landscaping during a drought, while similar users are subject to losses ranging from mild to severe.
2. In cases where the continued irrigation of a landscape is necessary to mitigate the impact of use during severe dry conditions, the user has an advantage, since the normal use of the area can continue,.
3. The experience of the 1981-82 water shortage in south Florida indicates that wastewater users benefited from good public relations during a severe and trying time.

Although the preceding factors are positive, it is difficult to provide estimates of the value of avoided losses. These losses will depend on the expected frequency and duration of required water use cutbacks, the susceptibility of the particular user to losses, and the amount of rainfall that occurs during the period of cutback.

For these reasons, potential wastewater users should view this technique as a type of insurance in which the premiums that are paid and the ultimate losses that are avoided can only be calculated on a case-by-case basis. Since the frequency and extent of risk cannot be provided, the choice must be made on an individual basis.

Regional Water Supply Costs

Wastewater reuse is of interest from a regional water supply perspective because it could help mitigate present or future inadequacies of water supplies during a drought. In this view, wastewater reuse could be substituted for other changes to the regional water supply system as a method to improve water supply. This approach is most applicable when reuse involves water that would otherwise have been disposed of by ocean outfall or deep well injection. If wastewater reuse substitutes for percolation, then the possible regional water supply benefits would be significantly reduced.

The impact on the regional water supply system can be measured in terms of the costs of an alternative improvement that can be avoided because of the wastewater reuse. The appropriate alternative would be that method which is the least costly for each basin under investigation.

Analyses by the SFWMD can help to shed some light on these costs. Data are presented in Table 3-6 to show the estimated capital plus operating costs, in dollars

TABLE 3-6: COSTS FOR SELECTED ALTERNATIVE WATER SUPPLY MEASURES

Measure	Cost of Additional Dry Season Supply ($/1000 Gallons)	Areas Where Applicability Has Been Studied	SFWMD Source Reference
Retrofit of Indoor Water Conservation Devices	Negative	Urban Areas	An Analysis of Water Supply Backpumping for the Lower East Coast Planning Area
Water Supply Backpumping	$.008 to $.018	Coastal Dade, Broward & Palm Beach Counties	Same as above
Holeyland Storage Area	$.021	Lake Okeechobee and Lower East Coast Basins	Water Quality Management Plan for the S-2 and S-3Drainage Basins in the Everglades Agricultural Area
Cyclic Storage in Confined Aquifers	$.13 to $.35	Upper East Coast, Lower West Coast	Advanced Water Supply Alternatives for the Upper East Coast Planning Area and Water Use and Supply Development Plan, Volume III C.

per thousand gallons, of various methods for providing additional water during a drought. These are not the only cost-effective measures that may be applicable in specific locations, but provide a relevant group for comparison purposes. Three conclusions were drived from this analysis. First, some conservation measures can actually save money rather than costing additional funds. For instance, District calculations indicate that programs for installing indoor water conservation devices, such as that recently undertaken by the City of Orlando, can be expected to save more in water heating and water and sewer treatment costs than they would cost to implement. Second, in areas where additional water can be stored in or distributed through existing regional supply facilities, the alternative supply costs are likely to be very low, as is indicated by the water supply backpumping costs and proposed costs of the Holeyland Storage Area. Third, in areas that are not served by the regional system, the remaining choices are more limited. Methods that may be used in such areas include deep well storage and retrieval, desalination, and transporting water from areas of adequate supply such as the inland portions of coastal counties.[1] The costs of deep well storage are presented because this method could be applied in both the Lower West Coast and Upper East Coast Planning Areas.

The costs per thousand gallons, presented in Table 3-6, are not directly comparable to wastewater reuse costs. This is because the former refer to additional water supplied during a dry period. Wastewater reuse would only add to regional supply capabilities during periods when the basin was not discharging water. For example, during wet periods when coastal canals were discharging, wastewater reuse would only contribute to runoff and would not increase groundwater storage. However, once the coastal discharges stopped, wastewater reuse would mean additional water in the coastal basin. For purposes of this study it has been assumed that discharges leaving the system cease for a period of four months during dry periods. Thus the costs in Table 3-6 should be multiplied by 3 (1-year ÷ 4-months) to be comparable to the regional water supply benefits of wastewater reuse on the basis of the wastewater used through the full year.

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[1]In its Water Use and Supply Development Plan for the Lower West Coast the District estimated costs for a Regional Wellfield System, a Regional Reservoir System, and a Regional System drawing water from the Caloosahatchee River all of which fit this last category. See Water Use and Supply Development Plan, Volume III C, Lower West Coast, Part 4.

SECTION IV

PRELIMINARY FEASIBILITY STUDY OF A WASTEWATER REUSE SYSTEM FOR PALM BEACH COUNTY

The cost relationships that were presented in the previous section show how costs vary as size, distance, method of alternative disposal, and other characteristics of a wastewater reuse system change. In this section, these relationships are applied to a preliminary feasibility study of a wastewater reuse system for eastern Palm Beach county. The design and costs that are used in this preliminary study are a reasonable approximation that can be used both to analyze broad policy implications and to identify systems that warrant detailed study. This preliminary study does not, however, represent an optimized system and is not a substitute for a detailed design investigation.

Eastern Palm Beach County was selected for the case study because it has a large population and hence is assured of an ample supply of wastewater, and it has numerous golf courses and other large irrigated landscape areas, which assure a large potential demand. In fact, the data in Table 2-1 indicate that Palm Beach County has the largest potential system size of any of the counties, and includes one-third of the potential wastewater reuse system capacity in the District.

The feasibility study is described below in three steps. The first step is the System Design and Cost Analysis that describes the suppliers, the users, the design and cost of the pipeline network to link them, and the necessary treatment system. The second step is the System Cost-Effectiveness Analysis that covers the costs and savings associated with the impact categories presented in Section III, and provides an estimate of the relative cost-effectiveness of participation to suppliers and users in Palm Beach County. The final step provides interpretations of the case study results.

SYSTEM DESIGN AND COST ANALYSIS

The system that was designed considered all wastewater treatment plants listed in Table A-1. In addition, some smaller plants were included when it was felt that these plants might improve the economies of the planned wastewater reuse system. This could occur, for example, when potential irrigation sites were located near the treatment plant and no other treatment plant with excess capacity was located nearby. Descriptions of the treatment plants that were included in the case study are presented in Table 4-1.

TABLE 4-1. WASTEWATER TREATMENT PLANTS INCLUDED IN THE PALM BEACH COUNTY CASE STUDY

201 REGION/SUBREGION	TREATMENT PLANT	DISPOSAL SYSTEM	CAPACITY MGD
ENCON	ENCON regional	AWT[a]	4.0
Central/North Central	Anchorage Drive	intracoastal outfall	4.85
	Seacoast (main)	perc. pond	3.6
	Cabana Colony	perc. pond	0.35
Central/East Central	East Central Reg.	deep well inj.	40.0
Central/Royal Palm	Royal Palm Beach	perc. pond	1.1
Central/Acme	Acme	perc. pond	1.5
South Central	S.C. #1	perc. pond	1.5
	S.C. #2	perc. pond	2.5
	Village of Golf	perc. pond	0.5
	S.C. Regional	ocean outfall	12.0
Southern	Glades Road	ocean outfall	10.0
	S.R. #1	perc. pond	0.5
	S.R. #2	perc. pond	3.72

[a] Advanced Wastewater Treatment (Tertiary)

Potential irrigation sites were identified primarily from the list of potential users in Table A-2. In addition, USGS quadrangle maps, Mark Hurd aerial quadrangles, and maps from the Area Planning Board of Palm Beach County were consulted. To simplify the identification of the users, especially on maps, the irrigated sites were assigned identification numbers based on the system used in the Area Planning Board land use study (1981), along with a type designation (GC for golf course, PK for park or CM for cemetery). Recreational areas were generally not included, as it was felt that many of these sites were small and that the more stringent health regulations which apply would further reduce their feasibility. A few sites were dropped because they were located far from any treatment plant. A total of 84 potential users were identified and these sites covered an estimated 11,580 acres of irrigated landscape.

The design of the pipeline system to connect the suppliers and users was facilitated by land use maps that were generated by the Computervision® system of the Geographic Sciences Division. A pipeline system was designed for each of seven planning regions and subregions within the county. The routes selected were drawn along the shortest route following major rights-of-way. Judgment was then used to determine when pipelines should be shared and when they should remain separate.

The proposed system network is mapped in Figures 4-1 through 4-9 and is described in Table 4-2. The figures show the treatment plants, the users, and the pipelines linking them. Table 4-2 shows the length, total acres served, and the identification codes of the sites served by each pipeline.

In order to compute the costs of treatment and transportation associated with this system, a computer program (REUSE) was developed (see Appendix B for a listing of this program). This program was used to calculate the size of each pipeline necessary to minimize system costs, based on the length of the pipe and the wastewater flow; to estimate the capital and operating costs of the pipeline and pumping system; and to estimate the capital and operating costs of treatment and storage systems. This program thus provides estimates of impacts for the first three categories covered in Table 3-1, namely treatment, storage, and transportation. The next step is to combine these data with estimates of impacts in other categories to determine the overall cost-effectiveness to the participants of wastewater reuse systems in Palm Beach County.

TABLE 4-2. SITES EVALUATED IN EASTERN PALM BEACH COUNTY FOR THE WASTEWATER REUSE FEASIBILITY STUDY

ENCON REGION--ENCON Treatment Plant

PIPE ID	DISTANCE (FEET)	AREA (ACRES)	ALL SITES SERVED (APB #)
A	3,720	1,284	776C, 66 PK, 85PK, 78GC, 31GC, 79GC, 19PK 20PK, 20GC, 57GC
B	13,120	418	66PK, 77GC
C	4,280	188	66Pk
D	24,800	230	77GC
E	2,000	366	85Pk, 78GC, 31GC, 79GC, 19PK. 20PK, 20GC, 57GC
F	22,500	554	85PK, 78GC, 31GC, 79GC
G	5,600	100	31GC
H	1,000	454	85PK, 78GC, 79GC
I	11,300	349	85PK, 78GC
J	4,200	51	85PK
K	1,000	298	78GC
L	10,960	312	19PK, 20PK, 20GC, 57GC
M	5,500	120	57GC
N	6,800	192	20GC, 19PK, 20PK
O	1,700	126	19PK
P	1,400	66	20PK, 20GC
Q	1,200	36	20PK

CENTRAL REGION, NORTH CENTRAL SUBREGION--Palm Beach Gardens (PBG), Cabana Colony (CB) and Anchorage Drive (AD)Treatment Plants

PLANT	PIPE ID	DISTANCE (FEET)	AREA (ACRES)	ALL SITES SERVED (APB #)
PBG	A	10,040	502	49GC
CC	B	7,680	168	52GC
AD	C	5,580	395	70GC, 60GC, 22GC
	D	7,300	235	70GC, 60GC
	E	4,100	130	60GC
	F	7,880	105	70GC

CENTRAL REGION, ROYAL PALM AND ACME SUBREGIONS--Royal Palm (RP) and Acme Improvement District (AID) Treatment Plants

PLANT	PIPE ID	DISTANCE (FEET)	AREA (ACRES)	ALL SITES SERVED (APB #)
RPB	A	6,200	386	1CM, 29GC, 30GC
	B	1,220	175	29GC
	C	9,920	211	1CM, 30GC
	D	1,700	170	30GC
	E	9,920	41	1CM
AID	A	320	782	80GC,75GC
	B	9,860	632	80GC
	C	5,660	150	75GC

TABLE 4-2. (Cont.) SITES EVALUATED IN EASTERN PALM BEACH COUNTY FOR THE WASTEWATER REUSE FEASIBILITY STUDY

CENTRAL REGION, EAST CENTRAL SUBREGION--East Central Regional Treatment Plant

PIPE ID #	DISTANCE (FEET)	AREA (ACRES)	ALL SITES SERVED (APB #)
A	4,040	2,444	42/62GC, 36GC, 43GC, 84GC, 1/2GC, 9CM, 85GC, 21GC, 34GC, 4CM, 50GC, 71GC, 51GC 65GC, 7CM, 8CM, 54GC, 59GC, 24GC, 23GC, 25GC, 6CM, 5CM, 32GC, 33GC, 35GC
B	10,180	1,634	84GC, 35GC, 42/62GC, 43GC, 36GC, 85GC, 9CM, 1/2GC, 50GC, 4CM, 34GC, 21GC, 65GC, 51GC, 71GC
C	600	61	84GC
D	6,900	1,573	35GC, 42/62GC, 43GC, 36GC, 85GC, 9CM, 1/2GC, 50GC, 4CM, 34GC, 21GC, 65GC, 51GC, 71GC
E	3,480	360	42/62GC
F	18,620	500	35GC, 42/62GC
G	25,740	140	35GC
I	1,960	1,073	43GC, 36GC, 85GC, 9CM, 1/2GC, 50GC, 4CM, 34GC21GC, 65GC, 51GC, 71GC
J	1,080	41	43GC
K	5,220	1,032	36GC, 85GC, 9CM, 1/2GC, 50GC, 4CM, 34GC, 21GC,65GC, 51GC, 71GC
L	19,760	1,007	85GC, 9CM, 1/2GC, 50GC,, 4CM, 34GC, 21GC, 65GC, 51GC, 71GC
M	2,000	502	85GC, 9CM, 1/2GC, 50GC, 4CM, 34GC, 21GC
N	5,800	505	65GC, 51GC, 71GC
O	7,600	70	65GC
P	9,040	435	51GC, 71GC
S	1,480	285	51GC
T	23,140	150	71GC
U	11,160	476	9CM, 1/2GC, 50GC, 4CM,
V	7,000	123	9CM, 1/2GC
W	20,060	100	1/2GC
X	3,380	353	50GC, 4CM, 34GC, 21GC
Y	10,780	328	4CM, 34GC, 21GC
Z	2,080	34	4CM
AA	2,040	197	34GC
BB	15,940	97	21GC
CC	2,660	810	33GC,22GC,5CM,6CM, 23GC, 24GC,25GC,59GC, 54GC,8CM,7CM
DD	7,920	633	33GC, 32GC, 5CM, 6CM, 23GC, 24GC, 25GC
EE	2,160	247	33GC
FF	4,880	386	32GC, 5CM, 6CM, 23GC, 24GC, 25GC
GG	1,840	95	32GC
HH	8,980	291	5CM, 6CM, 23GC, 24GC,25GC
II	5,480	9	5CM
JJ	3,280	282	6CM, 23GC, 24GC, 25GC
KK	6,220	18	6CM
LL	5,080	265	23GC, 24GC, 25GC
MM	6,800	36	24GC
NN	1,160	186	23GC, 24GC
OO	9,440	79	25GC
PP	10,960	177	59GC, 54GC, 8CM, 7CM
QQ	660	40	59GC
RR	3,580	137	54GC, 8CM, 7CM
SS	3,300	48	54GC
TT	13,400	89	8CM, 7CM
UU	1,320	8	8CM
VV	3,960	81	7CM

TABLE 4-2: (Cont.) SITES EVALUATED IN EASTERN PALM BEACH COUNTY FOR THE WASTEWATER REUSE FEASIBILITY STUDY

SOUTH CENTRAL REGION--Palm Beach County No. 5 (PB5), Palm Beach County No. 3 (PB3), Village of Golf (VG) and South Central (SC) Treatment Plants

PLANT	PIPE ID	DISTANCE (FEET)	AREA (ACRES)	ALL SITES SERVED (APB #)
PB5	A	18,260	155	56GC
PB3	B	1,820	110	74GC
	C	7,440	416	58GC, 64GC
	D	2,040	101	64GC
	E	5,860	315	58GC
VG	F	1,840	50	63GC
	G	7,600	115	45GC
SC	H	780	1,491	10GC, 17GC, 47Gc, 67GC, 68GC, 81GC 46GC, 15GC,14GC, 13GC, 2CM
	I	6,000	995	47GC, 17GC, 81GC, 10GC,68GC, 67GC
	J	5,320	386	10GC, 68GC, 57GC
	K	3,400	29	10GC
	L	3,540	357	68GC, 67GC
	M	4,420	160	67GC
	N	4,500	609	17GC, 81GC, 47GC
	O	1,060	175	17GC
	P	1,600	314	81GC
	Q	5,060	120	47GC
	R	8,360	496	13GC,14GC,15GC;46GC, 2CM
	S	7 690	22	2CM
	T	1 [illegible]20	474	13GC,14GC,15GC,46GC
	U	2,440	120	13GC
	V	3,920	354	14GC,15GC,46GC
	W	2,440	114	14GC
	X	10,980	240	15GC,46GC
	Y	3,460	50	15GC
	Z	6,060	190	46GC
	AA	6,740	193	18GC,19GC
	BB	2,040	160	18GC
	CC	8,140	33	19GC

SOUTHERN REGION--South Regional No. 2 (SR2), South Regional No. 1 (SR1) and Glades Road (GR)Treatment Plants

PLANT	PIPE ID	DISTANCE (FEET)	AREA (ACRES)	ALL SITES SERVED (APB #)
SR2	A	380	300	38GC, 73GC
	B	10,420	160	73GC
	C	3,480	140	38GC
SR1.	D	8,960	40	53GC
GR.	E	2,200	240	86PK
	F	1,820	2,012	37GC, 39GC, 40GC, 41GC, 82GC, 83GC, 86GC, 7GC, 5GC, 87PK
	G	1,100	1,737	37GC, 39GC, 40GC, 41GC, 82GC
	H	14,320	258	37GC
	I	7,800	1,479	39GC, 40GC, 82GC, 41GC
	J	6,280	913	41GC
	K	11,380	566	39GC, 40GC, 82GC
	L	540	203	39GC
	M	4,660	363	40GC, 82GC
	N	780	163	40GC
	O	14,240	200	82GC
	P	3,920	275	83GC, 8GC, 7GC, 5GC, 87PK
	Q	3,440	60	83GC
	R	7,840	215	8GC, 7GC, 5GC, 87PK
	S	6,680	105	8GC, 87PK
	T	580	15	87PK
	U	1,180	90	8GC
	V	7,000	110	7GC, 5GC
	W	6,260	10	5GC
	X	4,580	23	3CM
	Y	2,140	294	4GC, 9GC
	Z	2,500	131	9GC
	AA	2,540	190	6GC, 8PK, 10Pk
	BB	1,120	92	6GC, 10PK
	CC	8,560	79	10PK

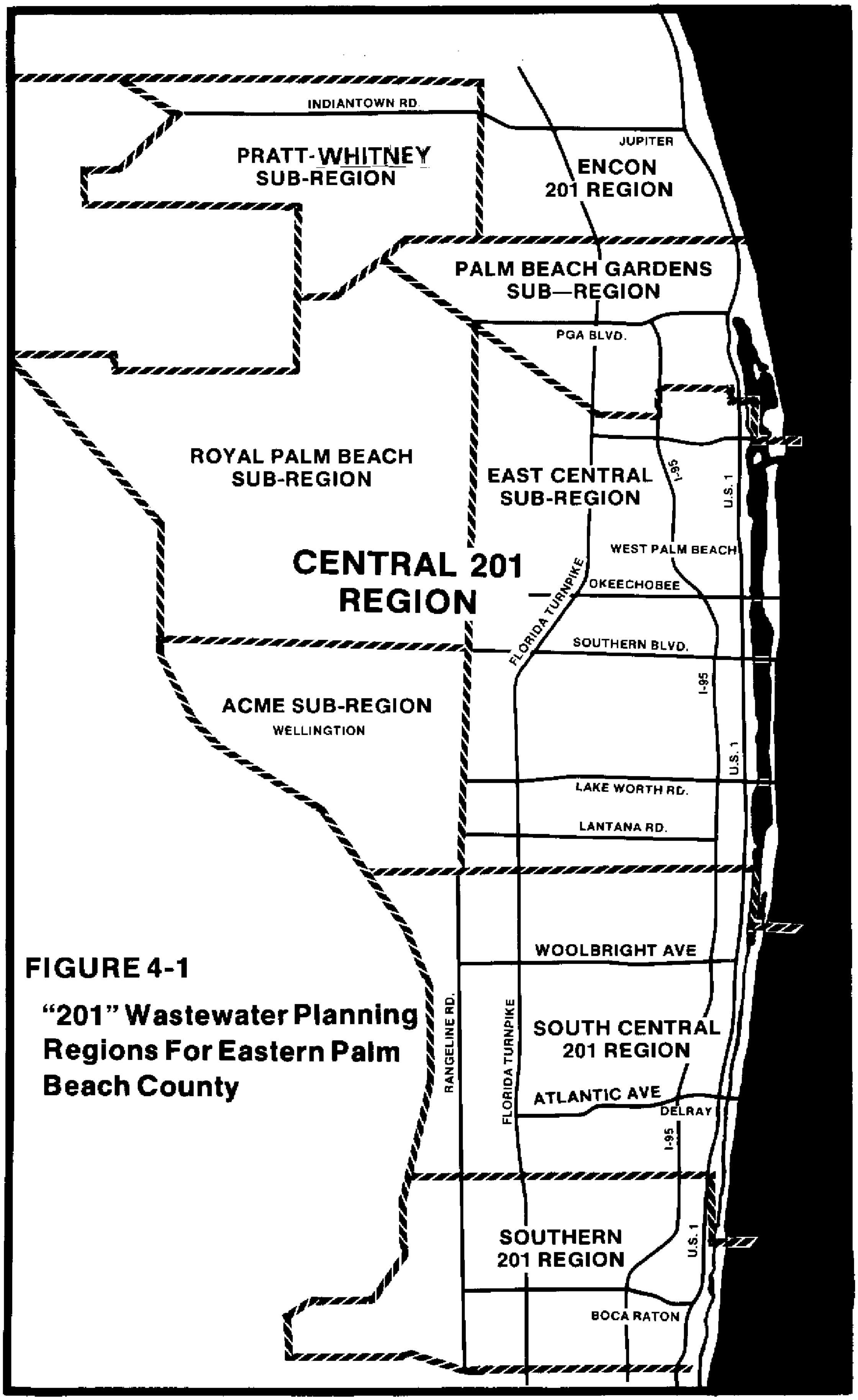

FIGURE 4-1

"201" Wastewater Planning Regions For Eastern Palm Beach County

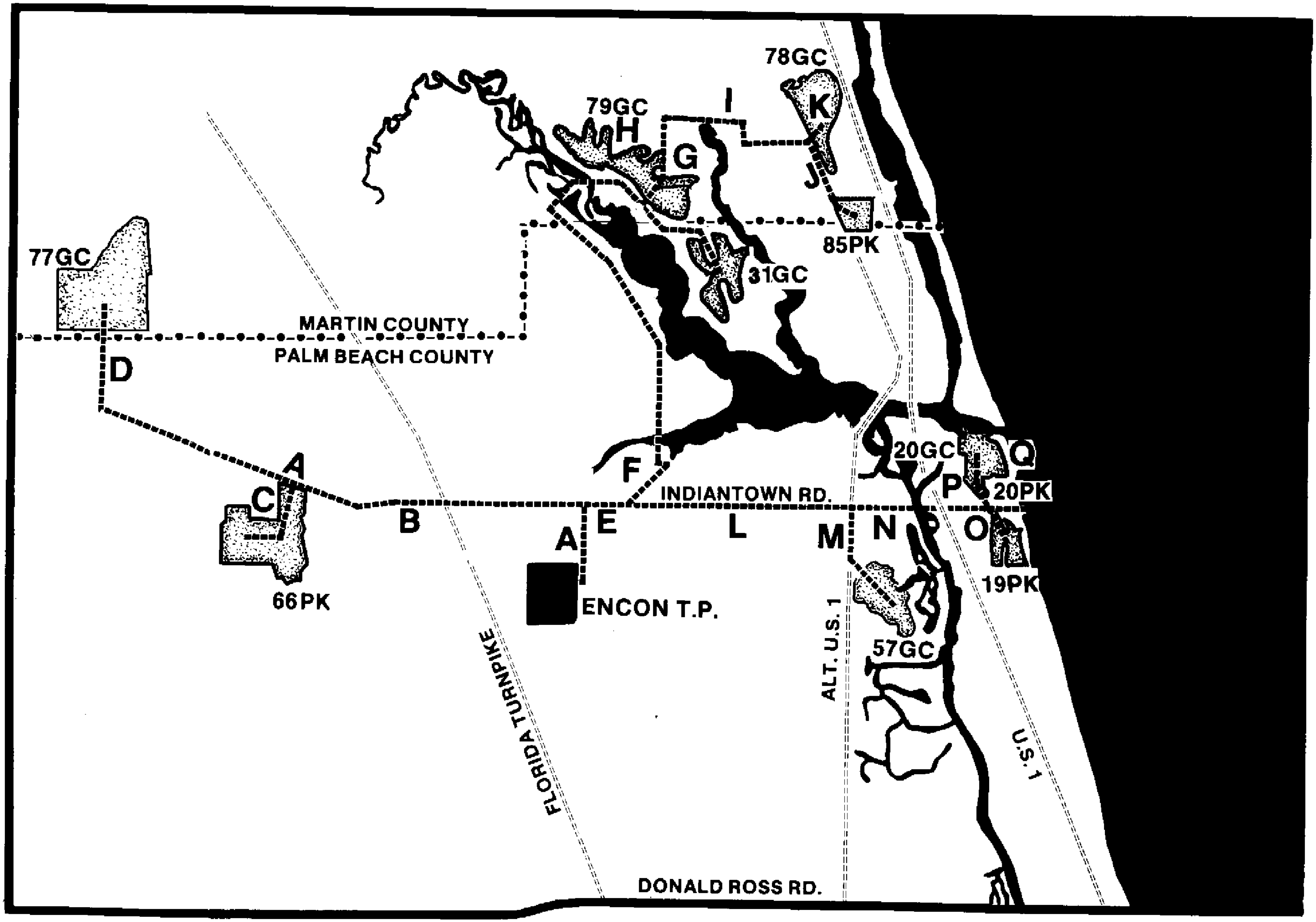

FIGURE 4-2 ENCON 201 Region

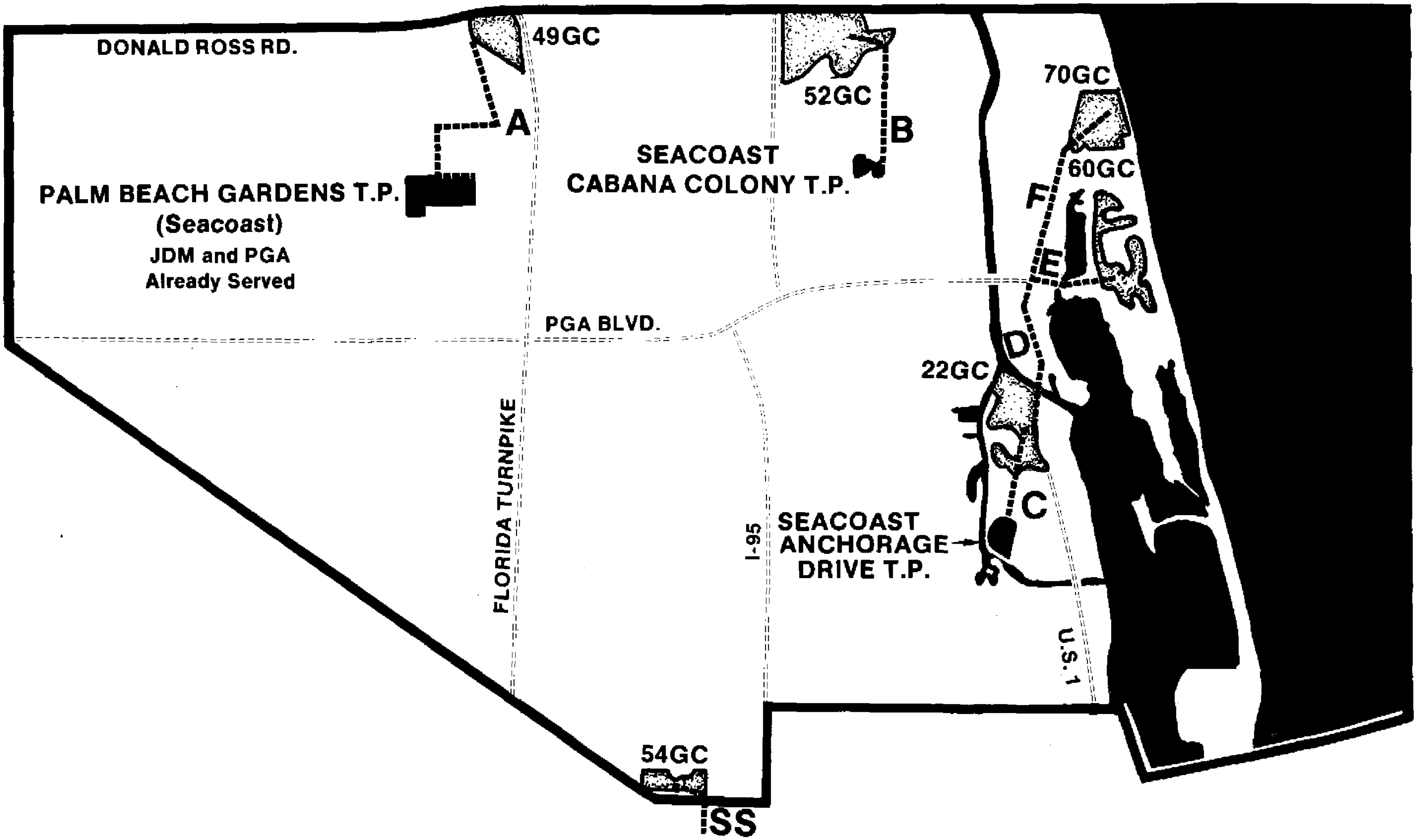

FIGURE 4-3 Central 201 Region, North-Central Subregion

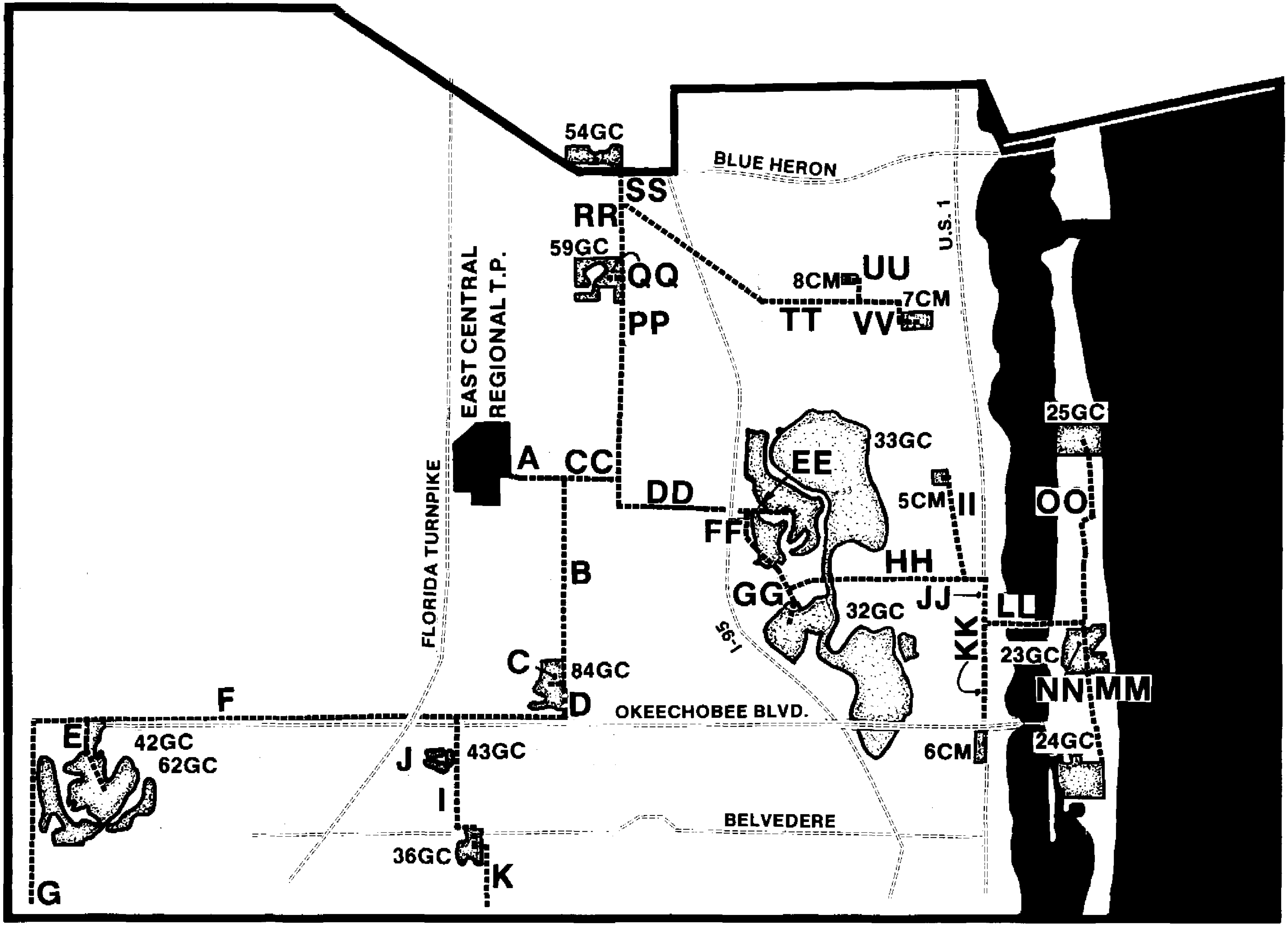

FIGURE 4-4 Central 201 Region, East-Central Subregion, North Half.

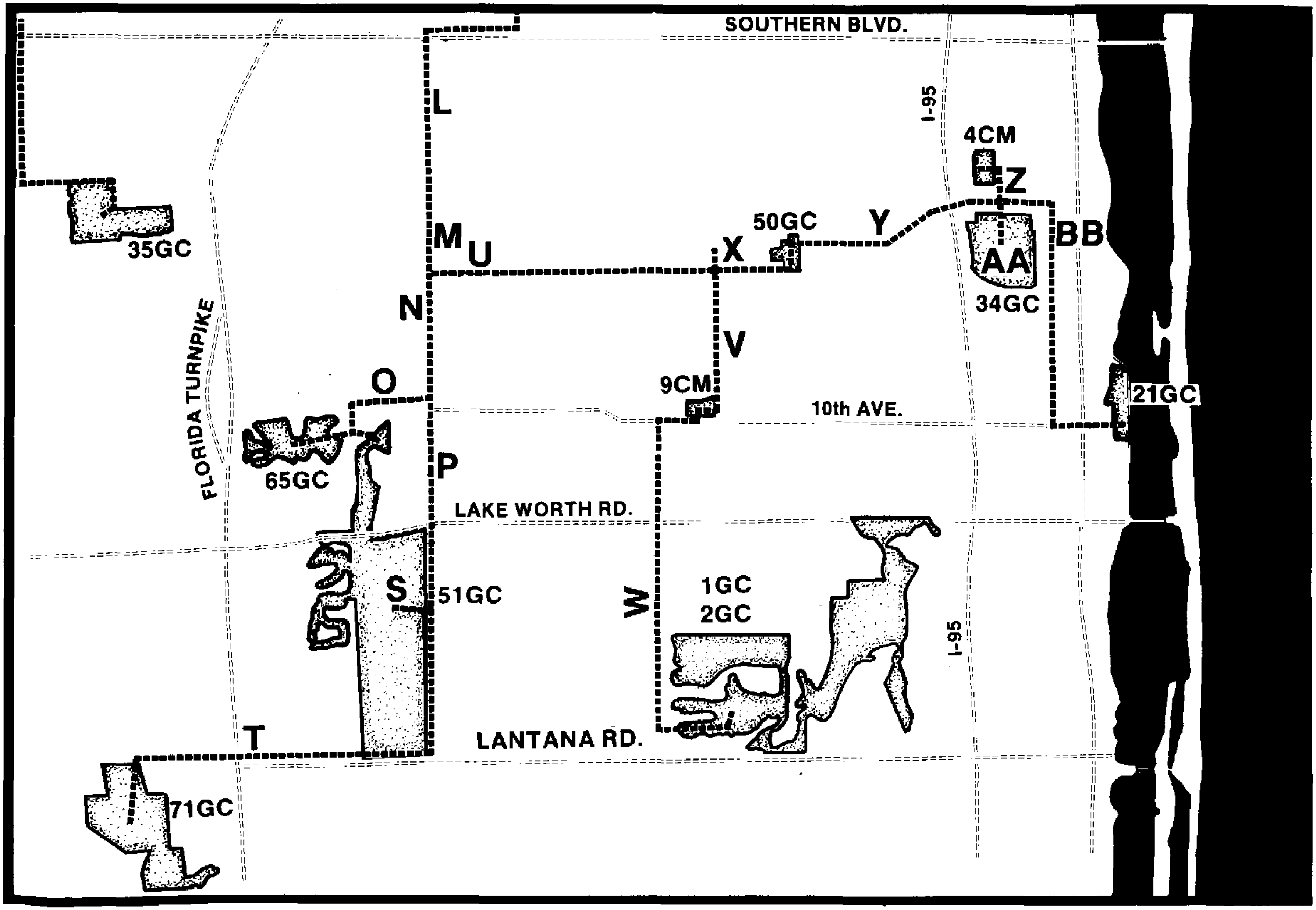

FIGURE 4-5 Central 201 Region, East-Central Subregion, South Half

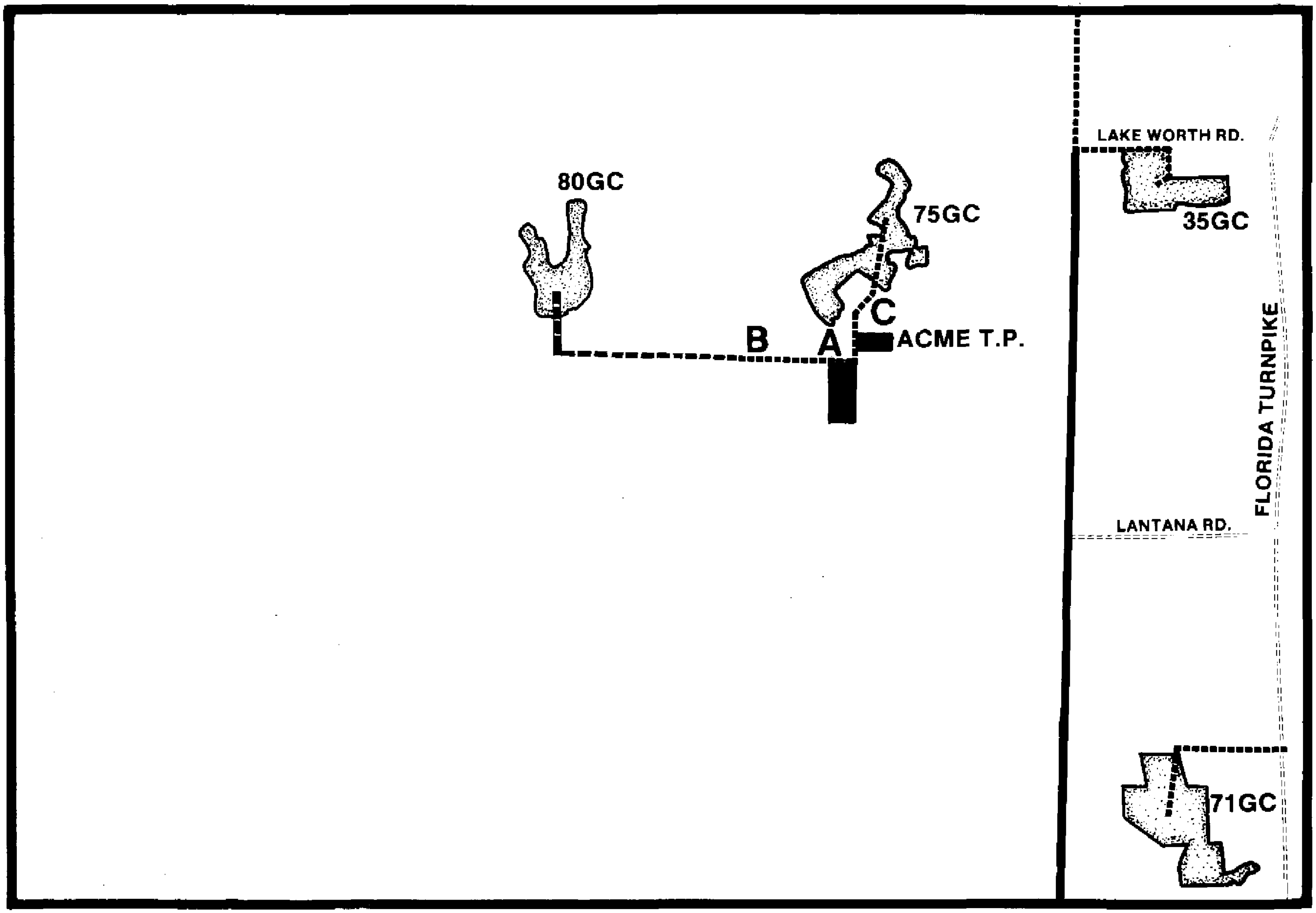

FIGURE 4-7 Central 201 Region, Acme Subregion

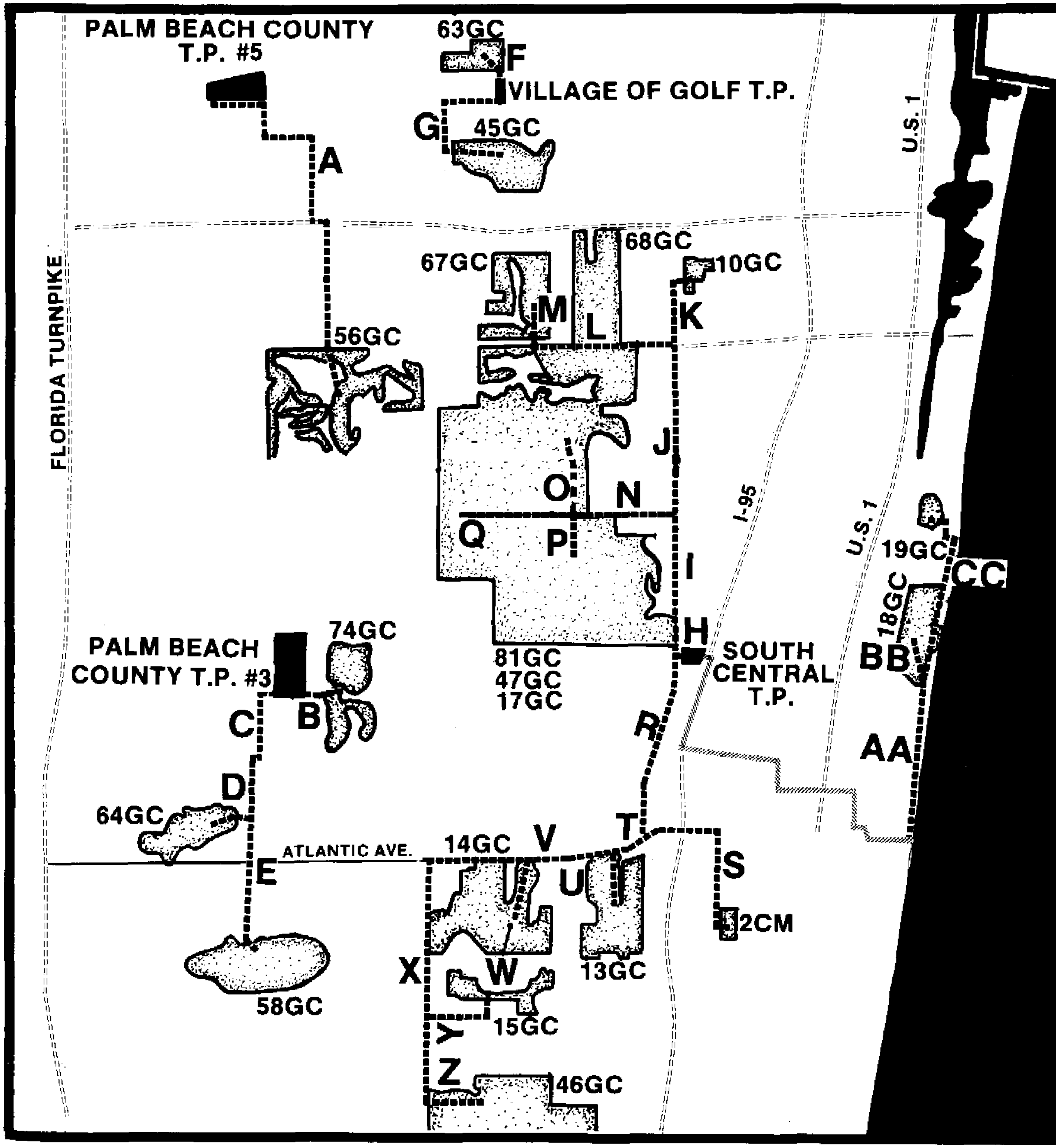

FIGURE 4-8
South-Central
201 Region

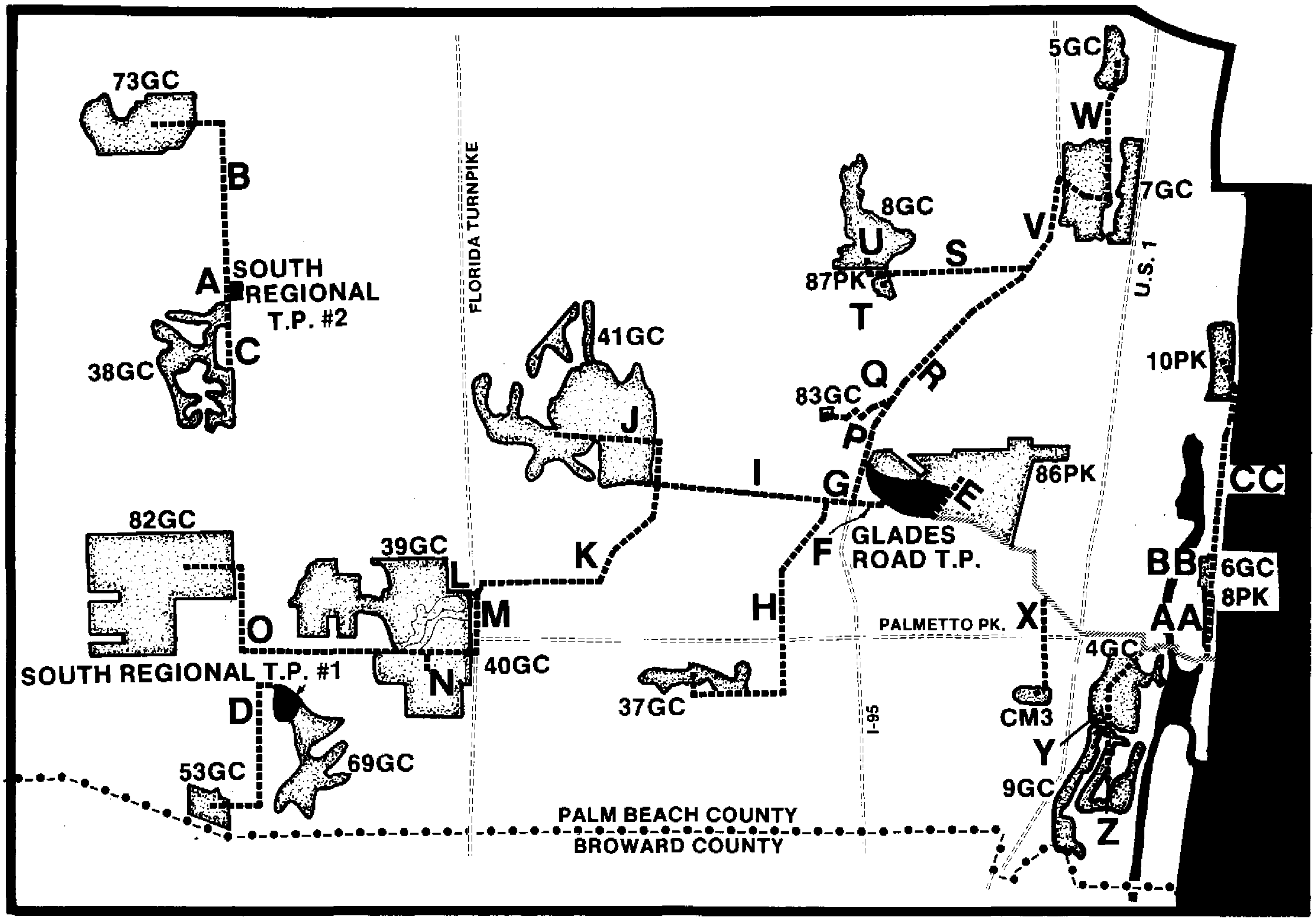

FIGURE 4-9 Southern 201 Region

SYSTEM COST-EFFECTIVENESS ANALYSIS

This step provides an analysis of the cost-effectiveness of the wastewater reuse systems to the participants. The cost-effectiveness analysis is based on the impacts described in Table 3-1, with the exception of the following:

1) storage costs - these costs were not considered because this analysis deals with existing systems which have approved disposal capacity to back up the reuse system;
2) separating wastewater and storm water - these costs could not be estimated without a detailed knowledge of each user's existing stormwater management system;
3) water shortage impacts - these costs were not considered because the frequency and severity of water shortages in this area are not known; and
4) regional supply capacity - these costs were not considered since they are not of direct benefit to the participants.

Treatment, transportation, alternative effluent disposal, present water supply source, and fertilizer costs are covered in this analysis. The treatment and transportation costs are provided by the system design and cost analysis, as presented in the previous step (page 30). A proportional allocation method is used to assign costs to each individual user, based on the user's share of total demand (for treatment cost) or his share of flow through each pipeline (for transportation costs). The chief advantage of this allocation scheme is its simplicity. Other methods have been developed (Heaney and Dickinson, 1982) to meet equity principles that are not met by the proportional allocation method. These methods based on equity have been applied to the problem of analyzing wastewater reuse in Palm Beach County (Sample, 1983) and they generally show that a somewhat larger system is cost-effective. However, this refinement in procedure was felt to be too detailed for the present preliminary study and thus the proportional allocation method was used.

The alternative effluent disposal (operating) costs were estimated based on the data presented in Section III. The estimates of cost savings from reduced use of the present water supply source were based on $.05/1000 gallons as a typical operating cost for wells in south Florida for users whose present source is groundwater. For users of potable water, data on system charges were used. For fertilizer benefits, the value of $.05/ 1000 gallons, which was developed in Section III, was used.

The cost-effectiveness analysis of the wastewater reuse system to each user is presented in Table 4-3. This table shows the impact for each of the five estimated categories, and the net total impact on each user.

CASE STUDY RESULTS

In this step, the results of the case study are analyzed from a technical standpoint to identify those systems that warrant a more detailed study. The net savings figure, which is presented in Table 4-3 for each user, is an indicator of whether a wastewater reuse system would provide an advantage to that user and supplier.

An examination of the net savings estimates in Table 4-3 indicates that relatively few users and suppliers would find it advantageous to participate in a wastewater reuse system. Only 13 of the 84 potential users (15%) are estimated to find the wastewater reuse system cost-effective and they cover only 8% of the potential irrigated area. Several other users were at or close to the break-even point because they were located close to potential suppliers. This latter group includes the Polo Club and Wellington Country Club, which are located near the Acme Treatment Plant, and the Sandalfoot Cove Golf Course, which is located adjacent to the Southern Regional Treatment Plant No. 2. These users are also potential candidates for more detailed studies.

TABLE 4-3: ESTIMATED SAVINGS OF SUPPLYING WASTEWATER FROM VARIOUS TREATMENT PLANTS TO POTENTIAL USERS IN PALM BEACH COUNTY

ENCON REGION--ENCON Treatment Plant

							SAVINGS IN CENTS PER THOUSAND GALLONS					
SITE NAME	Treatment Plant.	APB #	SFWMD PERMIT #	AREA (AC)	DIST. (FT)	PIPE ID'S	Treat-ment	Trans-portation	Altern Disposal	Present Supply*	Fertilizer	Net Savings
Carlin Park	ENCON	19PK		10	25180	A,E,L,N,O	(9.6)	(22.2)	4	5	5	(17.8)
Loxahatchee Bend Park	ENCON	66PK		188	21120	A,B,C,	(9.6)	(11.3)	4	5	5	(6.9)
Jonathan's Landing	ENCON	57GC	50-00237	120	22180	A,E,L,M	(9.6)	(13.4)	4	5	5	(9.0)
Turtle Creek	ENCON	79GC	43-00140	105	29220	A,E,F,H	(9.6)	(13.8)	4	5	5	(9.4)
Jupiter Dunes	ENCON	20GC		30	24880	A,E,L,N,P	(9.6)	(18.2)	4	5	5	(13.8)
Tequesta C. C.	ENCON	31GC	50-00273	100	33820	A,E,F,G.	(9.6)	(17.1)	4	5	5	(12.7)
Jupiter Hills	ENCON	78GC	43-00054	298	41520	A,E,F,H,I,K	(9.6)	(21.7)	4	5	5	(17.3)
Unknown Park	ENCON	85PK		51	44720	A,E,F,H,I,J	(9.6)	(25.5)	4	5	5	(21.1)
Ranch Colony	ENCON	77GC	43-00138	230	41640	A,B,D	(9.6)	(17.7)	4	5	5	(13.3)

CENTRAL REGION, NORTH CENTRAL SUBREGION--Palm Beach Gardens (PBG), Cabana Colony (CC) and Anchorage Drive (AD)Treatment Plants

SITE NAME	Treatment Plant.	APB #	SFWMD PERMIT #	AREA (AC)	DIST. (FT)	PIPE ID'S	Treat-ment	Trans-portation	Altern Disposal	Present Supply*	Fertilizer	Net Savings
Frenchmen's	CC	52GC	50-00091	168	7680	B	(18.4)	(5.7)	10	5	5	(4.1)
Eastpointe C. C.	PBG	49GC	50-00111 50-00941	502	10040	A	(12.5)	(4.5)	4	5	5	(3.0)
N.P.B. C. C.	AD	22GC	50-00084	160	5580		(13.5)	(3.0)	0	5	5	(6.5)
Lost Tree Club	AD	60GC	50-00421	130	16980	C,D,E	(13.5)	(11.)	0	5	5	(14.5)
Seminole G. C.	AD	70GC	50-00394	105	20760	C,D,F	(13.5)	(12.9)	0	5	5	(16.4)

CENTRAL REGION, ROYAL PALM AND ACME SUBREGIONS--Royal Palm Beach (RPB) andAcme Improvement District (AID) Treatment Plants

ROYAL PALM SUBREGION

SITE NAME	Treatment Plant.	APB #	SFWMD PERMIT #	AREA (AC)	DIST. (FT)	PIPE ID'S	Treat-ment	Trans-portation	Altern Disposal	Present Supply*	Fertilizer	Net Savings
Cemetery	RPB	1CM		41	26,040	A,C,E	(13.6)	(17.6)	7	5	5	(14.2)
Royal Palm C. C.	RPB	30GC	50-00561	170	17,820	A,C,D	(13.6)	(11.)	7	5	5	(7.6)
Indian Trail C. C.	RPB	29GC	50-00269	175	7,420	A,B	(13.6)	(5.5)	7	5	5	(2.1)

ACME SUBREGION

SITE NAME	Treatment Plant.	APB #	SFWMD PERMIT #	AREA (AC)	DIST. (FT)	PIPE ID'S	Treat-ment	Trans-portation	Altern Disposal	Present Supply*	Fertilizer	Net Savings
Gould Prop. (Polo Club)	AID	80GC	50-00883	632	10,180	A,B	(10.9)	(5.5)	6	5	5	(0.4)
Wellington Country Club	AID	75GC		150	5,980	A,C	(10.9)	(5.5)	6	5	5	(0.4)

*Cost of existing supply from other currently-available sources. Self-supplied wells are estimated to cost 5¢/1000 gal.
Numbers in parentheses ( ) have negative values and thus represent a cost rather than savings

TABLE 4-3: (Cont.) ESTIMATED SAVINGS OF SUPPLYING WASTEWATER FROM VARIOUS TREATMENT PLANTS TO POTENTIAL USERS IN PALM BEACH COUNTY.

CENTRAL REGION - EAST CENTRAL SUBREGION--East Central Regional Treatment Plant

SITE NAME	APB #	SFWMD PERMIT #	AREA (AC)	DIST. (FT)	PIPE ID'S	SAVINGS IN CENTS PER THOUSAND GALLONS Treat-ment	Trans-portation	Altern Disposal	Present Supply*	Fertilizer	Net Savings
Cemetery	9CM		23	68,220	A,B,D,I,K,L,M,U,V	(8.1)	(29.9)	8	88	5	63.0
Breakers C. C.	23GC		100	38,000	A,CC,DD,FF,HH, JJ,LL,NN	(8.1)	(23.3)	8	55	5	36.6
Palm Beach C. C.	25GC		79	46,280	A,CC,DD,FF,HH, JJ,LL,OO	(8.1)	(30.8)	8	55	5	29.1
Everglades C. C.	24GC		86	44,520	A,CC,DD,FF,HH LL,NN,MM	(8.1)	(28.8)	8	55	5	31.1
Cemetery	5CM.		9	33960	A,CC,DD,FF,HH,II	(8.1)	(31.2)	8	44	5	17.7
West Palm Beach C. C.	34GC		197	75,380	A,B,D,I,K,L,M,U, X,Y,AA	(8.1)	(33.4)	8	5	5	(23.5)
Cemetery	4CM		34	79,460	A,B,D,I,K,L,M,U,X, ,Y,Z	(8.1)	(38.)	8	5	5	(28.1)
Century Village	84GC	50-00890	61	14,820	A,B,C	(8.1)	(7.7)	8	5	5	2.2
Cemetery	8CM		8	35,960	A,CC,PP,RR,TT,UU	(8.1)	(36.9)	8	5	5	(27)
The Presidential	33GC	50-00224	247	16,780	A,CC,DD,EE	(8.1)	(42.4)	8	5	5	(32.5)
Meadowbrook	43GC	50-00120	41	24,160	A,B,D,I,J	(8.1)	(12.3)	8	5	5	(2.4)
Belvedere G. C.	36GC	50-00899	25	28,300	A,B,D,I,K	(8.1)	(11.2)	8	5	5	(1.3)
Palm Beach Lakes	32GC	50-00257	95	21,340	A,CC,DD,FF,GG	(8.1)	(45.9)	8	5	5	(36)
Lone Pine G. C.	59GC	50-00954	40	18,320	A,CC,PP,QQ	(8.1)	(14.1)	8	5	5	(4.2)
Holiday C. C.	54GC		48	24,540	A,CC,PP,RR,SS	(8.1)	(19.3)	8	5	5	(9.4)
Breaker's/Flagler	42GC	50-00203	200	43,220	A,B,D,F,E	(8.1)	(17.5)	8	5	5	(7.6)
Mayacoo Lakes	62GC	50-00537	160								
Woodlawn Cemetery	6CM	50-00257	18	37,980	A,CC,DD,FF,HH, JJ,KK	(8.1)	(61.2)	8	5	5	(51.3)
Royal P. B. Mem.	7CM	50-00218	81	38,600	A,CC,PP,RR,TT,VV	(8.1)	(33.8)	8	5	5	(23.9)
Palm Beach Nat'l	65GC	50-00268	70	61,460	A,B,D,I,K,L,N,O	(8.1)	(29.3)	8	5	5	(19.4)
The Fountains	51GC	50-00440	285	64,380	A,B,D,I,L,N,P,S	(8.1)	(27.3)	8	5	5	(17.4)
Forest Hills Golf	50GC	50-00099	25	64,600	A,B,D,I,K,L,M,U,X	(8.1)	(27.6)	8	5	5	(17.7)
Atlantis Golf & C.C.	1/2GC	50-00452	100	68,220	A,B,D,I,K,L,M,U,V	(8.1)	(29.9)	8	5	5	(20.0)
Lake Worth Mun.	21GC	50-00866	97	91,320	A,B,D,I,L,M,U,X, Y,BB	(8.1)	(42.9)	8	5	5	(33.0)
Sherbrooke	71GC		150	86,040	A,B,D,I,K,L,N,P,T	(8.1)	(37.9)	8	5	5	(28.0)
Banyan G. C.	35GC	50-00443	140	65,480	A,B,D,F,G	(8.1)	(28.)	8	5	5	(18.1)

*Cost of existing supply from other currently-available sources. Self-supplied wells are estimated to cost 5¢/1000 gal. Numbers in parentheses ( ) have negative values and thus represent a cost rather than a savings.

TABLE 4-3: (Cont.) ESTIMATED SAVINGS OF PROVIDING WASTEWATER FROM VARIOUS TREATMENT PLANTS TO POTENTIAL USERS IN PALM BEACH COUNTY.

SITE NAME	Treatment Plant.	APB #	SFWMD PERMIT #	AREA (AC)	DIST. (FT)	PIPE ID'S	SAVINGS IN CENTS PER THOUSAND GALLONS Treat- ment	Trans- portation	Altern Disposal	Present Supply*	Fertilizer	Net Savings
SOUTH CENTRAL REGION--South County Regional No. 1 (SCR1), South County Regional No. 2 (SCR2), South County (SC) and Village of Golf (VG)Treatment Plants												
Indian Springs C. C.	SCR1	56GC	50-00981	155	18,260	A	(18.9)	(10.4)	6	5	5	(13.3)
G. C. Villa Del Ray	SCR2	74GC	50-00898 50-00859	110	1,820	B	(12.3)	(2.8)	5	5	5	(0.1)
Oriole Golf & Tennis	SCR2	64GC	50-00078	101	9,480	C,D	(12.3)	(6.6)	5	5	5	(3.9)
King's Point C. C.	SCR2	58GC	50-00971 50-00975	315	13,300	C,E	(12.3)	(7.4)	5	5	5	(4.7)
Military Trail G. C.	VG	63GC		50	1,840	F	(18.5)	(4.)	9	5	5	(3.5)
Cypress Creek C. C.	VG	45GC	50-00394	115	7,600	G	(18.5)	(5.5)	9	5	5	(5.)
Cemetery	SC	2CM		22	16,830	H,R,S	(9.1)	(15.5)	0	30	5	10.4
Village of Golf	SC	17GC		175	12,340	H,I,N,O	(9.1)	(8.5)	0	5	5	(7.6)
Hunter's Run G. C.	SC	81GC	50-00636	314	12,880	H,I,N,P	(9.1)	(8.3)	0	5	5	(7.4)
Quail Ridge G. C.	SC	68GC	50-00419	197	15,640	H,I,J,L	(9.1)	(9.4)	0	5	5	(8.5)
Leisureville G. C.	SC	10GC		29	15,500	H,I,J,K	(9.1)	(12.4)	0	5	5	(11.5)
Delray Dune G. C.	SC	47Gc	50-00851	120	16,340	H,I,N,Q	(9.1)	(10.6)	0	5	5	(9.7)
Delray C. C.	SC	13GC	50-00944	120	14,480	H,R,T,V	(9.1)	(9.6)	0	5	5	(8.7)
Pine Tree G. C.	SC	67GC	50-00535	160	20,060	H,I,J,L,M	(9.1)	(13.4)	0	5	5	(12.5)
Hamlet Golf & Tennis	SC	14GC	50-00284	114	16,920	H,R,T,V,W	(9.1)	(12.7)	0	5	5	(11.8)
Lakeview G. C.	SC	15GC		50	28,920	H,R,T,V,X,Y	(9.1)	(20.1)	0	5	5	(19.2)
Del-Aire G. C.	SC	46GC	50-00534	190	31,520	H,R,T,V,X,Z	(9.1)	(20.2)	0	5	5	(19.3)
Gulfstream G. C.	SC2	18GC	50-00377	160	8,780	AA,BB	(17.4)	(8.3)	0	5	5	(15.7)
Little Club G. C.	SC2	19GC	50-00434	33	14,880	AA,CC	(17.4)	(14.3)	0	5	5	(21.7)
SOUTHERN REGION-- Southern Regional No. 1 (SR1), Southern Regional No. 2 (SR2) and Glades Road (GR) Treatment Plants												
Boca Greens	SR2	38GC	50-00632	140	3,860	A,C	(14.8)	(4.9)	4	5	5	(5.7)
Southern Manor	SR2	73GC		160	10,800	A,B	(14.8)	(8.3)	4	5	5	(9.1)
Sandalfoot Cove	SR1	69GC	50-00411	158	0		(17.2)	(0)	9	5	5	1.8
Hillsboro C.C.	SR1	53GC	50-00032	40	8960	D	(17.2)	(8.7)	9	5	5	(6.9)
Boca Raton Hotel & Club	GR2	4GC	50-00328	163	2,140	Y	(13.7)	(2.2)	0	44	5	33.1
Royal Palm Yacht	GR2	9GC	50-00159	131	4,640	Y,Z	(13.7)	(5.2)	0	44	5	30.1
South Beach Park	GR2	8PK		25	2,540	AA	(13.7)	(4.6)	0	44	5	30.7
Spanish River Park	GR2	10PK		46	12,220	AA,BB,CC	(13.7)	(16.2)	0	50	5	25.1
Red Reef Ex.	GR2	6GC		13	3,660	AA,BB	(13.7)	(8.0)	0	44	5	27.3
Cemetery	GR2	3CM		23	4,580	X	(45.3)	(7.7)	0	44	5	(4.0)
Fla. Atlantic Univ.	GR	86PK	50-00655	240	2,200	E	(8.2)	(2.3)	0	5	5	(0.5)
Univ. Park	GR	83PK	50-00119	60	9,180	F,P,Q	(8.2)	(8.9)	0	5	5	(7.1)
Boca West	GR	41GC	50-00992	913	17,000	F,G,I,J	(8.2)	(7.7)	0	5	5	(5.9)
Boca del Mar	GR	37GC	50-00054 50-00055	258	17,240	F,G,H	(8.2)	(8.7)	0	5	5	(6.9)
Boca Lago	GR	39GC	50-00888	203	22,640	F,G,I,K,L	(8.2)	(11.9)	0	5	5	(10.1)
Boca Teeca	GR	7GC	50-00088	100	20,580	F,P,R,V	(8.2)	(13.6)	0	5	5	(11.8)
Broken Sound	GR	8GC	50-00489	90	27,260	F,P,R,S,V	(8.2)	(18.7)	0	5	5	(16.9)
IBM Park	GR	87PK		15	20,840	F,P,R,S,T	(8.2)	(18.6)	0	5	5	(16.8)
Boca Woods	GR	82GC	50-00737	200	41,000	F,G,I,K,M,O	(8.2)	(23.1)	0	5	5	(21.3)
Boca Raton at Hidden Valley	GR	5GC	50-00970	10	26,840	F,P,R,V,W	(8.2)	(30.)	0	5	5	(28.2)
Boca Rio	GR	40GC	50-00292	163	27,540	F,G,I,K,M,N	(8.2)	(15.5)	0	5	5	(13.7)

*Cost of existing supply from other currently-available sources. Self-supplied wells are estimated to cost 5¢/1000 gal.

2 indicates an ocean outfall group, separate from the other pipelines within the system

Numbers in parentheses ( ) have negative values and thus represent a cost rather than a savings

An appropriate conclusion from this preliminary analysis would be that relatively few existing treatment plants or irrigation users would voluntarily participate in a wastewater reuse system in Palm Beach County.

The data that were used to estimate the net cost savings reflect only the concerns of the participants and do not consider the benefit to the regional supply system. For much of eastern Palm Beach County, especially those areas that are served by the Lake Worth Drainage District, changes in regional storage (e.g., through water supply backpumping or storage in Lake Okeechobee) or other regional system modifications would be a very cost-effective means to increase water supplies. Other portions of the county (e.g., the C-17 and C-18 basins) are not connected to the regional storage system. In these basins, and especially those areas near or east of the Intracoastal Waterway, changes in the regional system would have little effect on local supplies and it would be much more expensive to augment existing supplies through water resource devlopment at the local level. These areas should therefore be considered for potential application of wastewater reuse to meet the needs of future development.

In addition, all but two of the 13 users who are estimated to find reuse to be cost-effective are currently using potable water for landscape irrigation, and it is the large cost of this water that swings the analysis to favor their participation in wastewater reuse. These users are clustered in Palm Beach, using water supplied by the City of West Palm Beach, and in Boca Raton, using water supplied by that city. These two areas are also prime candidates for more detailed studies.

SECTION V
DEVELOPMENT AND REVIEW OF POLICY OPTIONS

In this section potential District policies regarding wastewater reuse are developed and described. These policies range from the generation and dissemination of information to the imposition of specific requirements regarding wastewater reuse under the District's regulatory program. The policy options discussed in this section do not cover every posture that the District might adopt, but rather provide a broad and systematic coverage of the classes of options which could be considered. With the understanding of the options developed in this section, and the information and impact analyses presented in Sections I through IV, the stage will be set to summarize the implications of adopting the policy options. This integration of options and implications is presented in Section VI.

Section V is divided into five subsections, each of which covers a potential District policy. The subsections are generally arranged from the least to the most prescriptive, as follows:

- Conducting Further Research on Wastewater Reuse
- Promoting the Consideration of Wastewater Reuse
- Assisting in the Review and Evaluation of Regulations Affecting Wastewater Reuse
- Providing Planning Assistance for those Considering Wastewater Reuse
- Incorporating Requirements for Consideration of Wastewater Reuse into the District's Regulatory Program

Option 1. Conducting Further Research on Wastewater Reuse

Implementation of this option would entail a continuation of basic research in the area of wastewater reuse along the lines presented in this report. This report considered only one type of system - existing wastewater plants serving existing large urban landscape areas. This type of system was selected because it was thought to be the most practical option which could also make a significant contribution to the improvement of water supply capabilities. Additional research could:

- refine the estimates of costs and impacts that were developed in this report,
- conduct preliminary feasibility design studies in other counties,
- explicitly consider local factors such as the salinity of available wastewater and the location of reuse sites relative to wellfields and the saltwater intrusion line,
- consider other types of systems such as a dual water system (as has been implemented in St. Petersburg) and integration of irrigation and wastewater disposal in new planned unit developments,
- study the sensitivity of wastewater reuse systems to the environmental and health regulations presently in effect.

The principal District actions under this option would be to complete additional basic and applied research for use by the District as well as by suppliers, users, and local governments that may consider implementation of wastewater reuse. Research under this option would provide a factual basis which would support the District's efforts under all other options and so should reflect the specific options and strategies which are adopted.

Option 2. Promoting the Consideration of Wastewater Reuse

The choice of this option by the District would signify a supportive, yet limited role in the development of wastewater reuse within south Florida. Under this option, the District would promote the development of wastewater reuse but would not provide substantive input regarding its applicability under specific circumstances. Instead, the District would focus on the potential benefits to users and suppliers and would use examples of successful implementation as reasons why wastewater reuse should be given careful consideration. The District could also function as a facilitator in bringing potential suppliers and users together. Implementation of this option would require a minimum of additional support in terms of further research and could be carried out by selected District staff who would act as information disseminators and facilitators.

Option 3. Assisting in Review and Evaluation of Regulations Affecting Wastewater Reuse

The potential for wastewater reuse is clearly conditioned by the regulations imposed on its implementation at the local, District, and state levels. Under this option the District would provide a regulatory environment which would be conducive to wastewater reuse while still protecting the environment, water quality, and public health. Implementation of this option would include a review by the District of its own regulations, including those governing surface water management and water shortage management, to see if they unduly restrict the implementation of wastewater reuse. The District could act as an advocate to see that the impacts of other agencies' regulations on water supplies and on the costs and feasibility of wastewater reuse to the participants are fairly considered along with environmental, water quality, public health, and other considerations which these regulations are designed to protect.

Implementation of this option would require substantive information regarding the impacts that present and proposed regulations have on water supplies and on costs to the participants. It will also require effort by District staff to coordinate the involvement with other agencies and to present input to the appropriate forum.

Option 4. Providing Planning Assistance for those Considering Wastewater Reuse

This option would involve participation by the District in the identification and implementation of systems which are to the mutual benefit of suppliers and users. The primary concern within this option is the degree to which the District should become involved in matching the suppliers and users.

Regional feasibility studies, similar to the study presented in Section IV, could play a major role in the preliminary identification of systems on a regional basis. The District is very well equipped to address issues from a regional viewpoint since its interests transcend local jurisdictions and utility service areas. Studies could be focused on areas which are likely to experience supply limitations and which do not have access to the regional surface water system.

District involvement would also be needed once the preliminary identification of systems had been completed. The consideration of wastewater reuse would be promoted and the results of the preliminary feasibility could be used in support of this effort. The District could also support further technical studies, either directly or through cost-sharing or other financial means.

Option 5. Incorporating Requirements for Consideration of Wastewater Reuse into the District's Permitting Process

Under this option, the District would incorporate requirements that would favor consideration of wastewater reuse into its permitting rules. This option would include a description of specific conditions under which the consideration of wastewater reuse by permittees would be required and conditions under which permission to use water from other sources would be denied.

Requiring the consideration of wastewater reuse could supplement or substitute for the planning assistance envisioned under Option 4. For instance, detailed feasibility studies could be required of those areas that are identified as prime candidates in preliminary feasibility studies. Consideration of wastewater reuse could also be imposed as a universal requirement on certain classes of users. These requirements would place a significant portion of the responsibility for the feasibility investigations and design studies on the potential users and suppliers.

As part of the implementation of this option, it would be necessary to develop criteria which specify the conditions under which a water use permit would be denied or limited. These criteria would have to address the self-interest of the parties involved in developing such a system as well as the water supply availability and cost considerations which would delimit the District's interests.

If the District is considering support of wastewater reuse without prescriptive actions, then it is also important to note that the factors controlling the applicability of reuse would be in the hands of the DER, the EPA, and other environmental and health related agencies. From the perspective of the wastewater suppliers and users, the costs of wastewater disposal generally dominate the impacts of wastewater reuse. In this case, regulatory changes beyond the District's control, such as allowing some treatment plants to discharge primary treated effluent through ocean outfalls and DER's requirements regarding backup storage and disposal capacity, could have a major influence on the success of the District's efforts.

SECTION VI
SUMMARY AND IMPLICATIONS

This section summarizes the major findings of the current study and the implications of these findings with regard to various policy options that the District may adopt toward wastewater reuse. These implications, together with the more detailed information presented in the earlier sections, should substantially assist in the final selection of the District's posture and policies toward this issue.

This section is comprised of two parts--a summary of findings contained within this report and the implications arrived at by integrating these findings into the policy options found in Section V.

Summary of Findings

The major findings of this study, which have direct implications regarding whether and how wastewater reuse should be pursued, are:

1. **Wastewater reuse could potentially contribute a substantial amount of additional water for use within the region, but implementation of this method is highly dependent upon local conditions.**

Implementation of the maximum feasible system, as presented in Section 2, could add about 50,000 acre-feet to dry season supply capabilities. This is compared to 147,000 acre-feet that was estimated for four water supply backpumping stations and 300,000 acre-feet that was estimated for the Holeyland storage area project. Due to cost considerations, wastewater reuse should not be considered as a major factor in determining overall adequacy of water supplies. Instead, its value lies in the particular circumstances of its application, whether they be the cost effectiveness to particular participants, the supply difficulties peculiar to particular subareas of the District, or specific local factors such as the location of the irrigated site between a wellfield and the saltwater intrusion line.

2. **Wastewater reuse, in the present environment, is likely to be economically advantageous to a small to modest proportion of suppliers and users.**

Since the specifications and factors for each area or county will vary, the actual percentage of cost-effective networks of suppliers and users will also vary. However, the analysis of Section IV indicated that the maximum system could be achieved only through coercion or subsidization--i.e. that it was not cost-effective to the participants.

3. **The potential water supply benefits will be heavily conditioned by location in the District since location determines both the stringency of present supplies and the alternative costs of additional supplies.**

Options for augmenting water supply capabilities vary significantly from area to area as does the stringency of present and projected supply conditions. Water supply benefits of wastewater reuse will be the smallest where supply augmentation can take place through changes to the present regional system (water supply backpumping or a "Holeyland storage area" type system). They will be the largest where more expensive methods (e.g., deep aquifer storage or desalination) are required and/or no means, such as District canals, exist for transporting water.

4. **A system initiated by individual users is not as likely to approach the best or most extensive system as is a system initiated by potential suppliers. The potential economics in treatment and pipeline sizing would not be captured.**

Systems developed for this study show that costs vary significantly as the size of the treatment system varies. Furthermore, the opportunity to share pipelines is also an important feature of the system design. Feasibility studies initiated on the basis of service to individual users would have less chance of discovering these possibilities than studies designed around the service capabilities of suppliers.

5. **Capital costs are a significant percentage of total costs, making system implementation significantly more feasible under a new, rather than a retrofit, program.**

Many of the costs of conventional wastewater disposal and irrigation, including investment in wells and stormwater system improvements by users, and development of alternative disposal methods by suppliers, could be avoided if a wastewater reuse system were incorporated into the original design and construction of the facilities. However, in a retrofit system, these investments will have already been made and will not be recoverable as a result of the switchover to wastewater reuse.

Implications Regarding District Policy Options

This subsection attempts to compare the findings listed above with the options detailed in Section 5 of this report. Each option is covered on an individual basis.

Option 1. Conducting Further Research on Wastewater Reuse

As mentioned in Section 5, action under this option provides a factual basis for the implementation of the other District policy options on wastewater reuse. It is felt that the analyses conducted for this report have shown that policy-oriented research produces information which can be used to guide District actions. The orientation of further research efforts in the area of wastewater reuse should reflect the particular needs of those policy options which the District desires to implement.

Option 2. Promoting the Consideration of Wastewater Reuse

With regard to the findings listed above, the exercise of this option should focus on those areas of the District where preliminary studies indicate that wastewater reuse is most likely to be beneficial to the participants. However, the Palm Beach County case study shows that the District should not expect an overwhelming participant interest in any specific locale as the result of its efforts. Areas which would be prime candidates would be those:

- where supply stringencies are evident
- which are isolated from the regional system
- which are undergoing rapid development, and where new parks, golf courses and wastewater disposal systems are being constructed

The findings further indicate that District efforts under this option should focus on promoting regional feasibility studies and supplier-oriented studies rather than user-oriented studies.

Option 3. Assisting in the Review and Evaluation of Regulations Affecting Reuse

The implications regarding this option are as follows:

1. Some impacts of the existing regulations affecting wastewater reuse are unknown, e.g., the costs of separating stormwater and the wastewater reuse system to protect both flood control capability and water quality have not been thoroughly investigated.

2. Since reuse systems are most cost-effective for new development, special care should be given to analyzing rules which affect this type of development.

Option 4. Providing Planning Assistance for Those Considering Wastewater Reuse

Since adoption of this option would extensively involve District staff in the specifics of individual system design, several controlling considerations are indicated by this analysis.

1. A regional system feasibility study should be undertaken in each case as an appropriate first step.

2. A regional or basin-level survey should be conducted to "weed out" system design efforts that would not be effective. Systems that appeared to be effective within such a general study would then be considered as practical sites for a complete analysis.

3. A District research program or District participation in the funding of studies would be necessary if this option were selected.

Option 5. Incorporating Requirements Regarding Wastewater Reuse into the District's Permitting Process

The implications of the adoption of this option include:

1. If individual applicants for permits in designated user classes are required to submit feasibility studies and/or implement reuse, many efforts will not be advantageous.

2. A requirement for supplier-oriented studies is more likely to achieve the desired information, yet the District has no substantive control over most of the wastewater suppliers.

3. The appropriateness of wastewater reuse regulations will vary greatly from place to place across the District.

4. If the District were to deny or limit water permits on the basis that wastewater was potentially available for reuse, then this action should be part of a comprehensive strategy for each basin, which considers present supplies, the costs of additional supplies, and the impacts of the reasonably cost-effective supply alternatives.

SECTION VII

REFERENCES

Act Systems, 1980. Florida Water Utility Rate Survey.

Augustine, B., 1983. personal communication with B. Adams, SFWMD staff.

Bell, Frederick, 1977. 201 Facilities Plan for Okeechobee County and Okeechobee City, Fla.

Broward County Office of Planning, 1980. Broward County Metropolitan Area Map Atlas.

Camp, Dresser and McKee. Facility Plan for South Palm Beach County, volumes 1, 2, and addendum.

Clark and Dorsey, 1982. "A Model of Costs for Treating Drinking Water", J. AWWA, Dec. , 1982, pages 619-627.

CH_2M Hill and Hensley-Schmidt, Inc., 1979. 201 Facilities Plan for the City of Ft. Pierce, Florida, St. Lucie County, Fla.

Dade County, Office of Planning, 1982. unpublished technical communication.

Dames and Moore, 1978. Analysis of Operating and Maintenance Costs for Municipal Wastewater Treatment Systems, EPA 430/9-77-015.

Deb, A.K., 1978. Dual Water Supply Seminar and Workshop, NSF, West Chester Penn., October 27, 1978, Section 4.

Dent, R., 1982. personal communication with D. Sample.

Diversified Utility Services, 1979. Engineering report on the Effectiveness of Alum Coagulation Treatment for Spray Irrigation of Wastewater Effluent at South Palm Beach Utilities Corp., Palm Beach Co,., Fla..

Dodge Guide, 1983. Dodge Guide to Heavy Construction Costs, McGraw-Hill, New York, 1983.

Florida, State of, Department of Environmental Regulation, 1982. Land Application of Domestic Wastewater Effluent in Florida.

Greeley and Hansen, 1973. Water Quality Management Plan technical supplement (for Dade County).

Gutherman, et al., 1979. Estimating Water Treatment Costs, United States Environmental Protection Agency, Rept. No. EPA-600/2-79-162, August, 1979

Harivandi, M.A. 1982. The Use of Effluent Water for Turfgrass Irrigation. Calif. Turfgrass Culture 32(3,4):1-4.

Johnson-Prewitt, 1978. 201 Facilities Plan, Clewiston Study Area, Hendry County, Fla.

Marsden, et. al., 1973. "Regression Analysis Applied to the Wastewater Treatment Field"., J. WPCF., 1973.

Needles, et. al., 1980. 201 Facilities Plan , City of La Belle, Fla.

OLAC, 1982. Orange and Los Angeles Counties Water Reuse Study Facilities Plan, volumes 1 and 2.

Palm Beach County, 1981. Area Planning Board, Maps, Charts and Statistical Data.

Palm Beach County, 1978. Environmental Quality Control Board, Palm Beach County 208 Areawide Waste Treatment Managment Plan.

Reed, et. al., 1979. Cost of Land Treatment, for the U.S. EPA.

Robert and Company, 1978. Palm Beach County Central 201 Facilties Plan.

Robinson, 1981. letter to ENCON (Hazen and Sawyer, Inc.)

Rogers, R. 1982. Memo from Richard A. Rogers, Director, Resource Control Department, SFWMD to Roy Duke, South Florida District Manager,DER, October 20, 1982.

Ross, Saarinen, Bolton, and Wilder, 1979. Engineering Festibility Study of Effluent Spray Irrigation for Boca Raton, Fla.

Russell and Axon,1979, 201 Facility Plan--Palm Beach County, Fla, Glades Region.

Russell and Axon, 1980, 201 Facilities Plan, South Central Palm Beach County.

Sample, David J. 1983. An Engineering, Economic and Financial Feasibility Analysis of Wastewater Reuse in Eastern Palm Beach County, Florida. Master's Thesis, Department of Environmental Engineering Sciences, University of Florida, Gainesville.

South Florida Water Management District, 1980. Advanced Water Supply Alternative for the Upper East Coast Planning Area.

South Florida Water Management District, 1980. Water Use and Supply Development Plan, Volume IIIC, Lower West Coast.

South Florida Water Management District, 1982. An Analysis of Water Supply Backpumping for the Lower East Coast Planning Area.

South Florida Water Management District, 1982. Water Quality Management Plan for the S-2 and S-3 Drainage Basins in the Everglades Agricultural Area.

Southwest Florida Regional Planning Council, 1980. Support Services in Southwest Florida.

Smith and Gillespie, 1978, Moore Haven 201 Facilities Plan.

Suddath, J., 1982. personal communication with D. Sample.

United States Department of Commerce, Bureau of the Census, 1980. 1980 Census of Population and Housing, Summary Characteristics for Governmental Units and Standard Metropolitan Statistical Areas, Florida (PHC 80-3-11) and unpublished data.

Unites States Environmental Protection Agency and the Army Corps of Engineers, 1977. Land Treatment of Municipal Wastewater, technology transfer, EPA625/1-77-008.

Uhiversity of South Florida, 1983, Land Application of Wastewater, Seminar.

Wells, D.M., R.M. Sweazy, and G.A. Whetstone, 1979. Long-term Experiences with Effluent Reuse. JWPCF 51(11):2641-2648

APPENDIX A:

DISTRICT-WIDE INVENTORY OF WASTEWATER SOURCES AND POTENTIAL WASTEWATER IRRIGATION SITES

TABLE A-1 WASTEWATER TREATMENT PLANTS WITHIN THE JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT*

NAME	DESIGN CAPACITY	TYPE TREATMENT & DISPOSAL
BROWARD COUNTY		
BOUD #2 North Regional	63.2 MGD	Extended aeration to the Atlantic Ocean
Boud Palmdale Plant #1B	1.0 MGD	Contact stabilization discharge to evapopercolation lake. Thence to surface water
Coral Springs Improvement District	2.0 MGD	Contact stabilization aerated oxidation pond to seepage ditch
Davie, Town of Utility System #2	1.0 MGD	Contact stabilization with tertiary filters to oxidation pond
Deerfield Beach, City of	4.0 MGD	Contact stabilization to Hillsboro Canal Div. to Broward N. Reg.
Fort Lauderdale - Coral Ridge	8.0 MGD	Activated sludge & contact stabilization & aux. trickling filter plant
Fort Lauderdale Plant A	8.2 MGD	Activated sludge, with ZIMPRO sludge treatment
Gulfstream Utility Company	2.5 MGD	Contact stabilization
Hollywood Wastewater Treatment Plant	38.0 MGD	
Lauderhill East	2.3 MGD	Complete mix activated sludge discharges to C-l2 Canal to Boud North Reg.
Lauderhill West	6.0 MGD	Contact stabilization with tertiary filters to perc. ponds
Lohmeyer, G. T. Regional WWTP	25.0 MGD	Oxygen activated sludge to Intracoastal
Margate, City of, WWTP	6.0 MGD	Activated sludge WWTP discharging to 24 in. disposal well
Modern Pollution Control	1.0 MGD	Percolation pond
North Lauderdale, City of	3.2 MGD	Act sludge with cont. stab. discharge to perc. ponds and to canal
Oakland Park, City of	4.1 MGD	Activated sludge
Plantation, City of	1.2 MGD	Contact stabilization
Plantation, City of #l North	3.3 MGD	Contact stabilization with oxidation pond ditch to Holloway Canal, C-ll Canal
Sunrise #5 East	1.2 MGD	Contact stabilization

*Includes all treatment plants with a capacity greater than or equal to 1 mgd.

TABLE A-1 (Cont.) WASTEWATER TREATMENT PLANTS WITHIN THE JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT*

NAME	DESIGN CAPACITY	TYPE TREATMENT & DISPOSAL
BROWARD COUNTY- CONTINUED		
Sunrise North Plant #1A	3.3 MGD	Contact stab. perc. ponds spray irrigation and evaporation
Sunrise Plant #2	2.3 MGD	Contact stab. & pure oxygen with tertiary pressure filters, discharge to ponds
Sunrise System #5 West	1.25 MGD	Contact stabilization & aerobic sludge digestor
Sunrise, City of Plant #1B	4.5 MGD	Contact stab. discharging to lagoons for spray irrigation
Sunrise, City of Plant #3	3.0 MGD	Contact stabilization
Tamarac, City of West WWTP	4.9 MGD	Contact stab. discharging to canal system with spray irrigation
TOTAL	**200.45 MGD**	
COLLIER COUNTY		
City of Naples	5.4 MGD	Activated sludge (comp mix) effluent to pond to Gordon River
Collier County District A	1.5 MGD	Extended aeration to perc. ponds
Immokalee Water & Sewer District	1.5 MGD	Oxidation ditch (extended aeration)
Marco Island Utilities	2.5 MGD	Contact stabilization to polishing pond thence to spray irrigation
TOTAL	**10.9 MGD**	
DADE COUNTY		
Andover Subdivision	1.7 MGD	Activated sludge discharges to Snake Creek Canal
Aventura MDWSA	1.5 MGD	Contact stab. discharges to 5 acre lake overflow to ICW. Div. No-dist. reg. 8/8l
Cutler Ridge	4.0 MGD	Complete mix utilizing aeration clarification chlorination Homestead Air Force Base 3.0 MGD
Homestead, City of	2.2 MGD	Contact stabilization to perc. pond
Kendale Lakes WWTP	3.2 MGD	Activated sludge with discharge to deep injection well
Leisure City STP Units #1,2&3	2.38 MGD	2.38 MGD Total: .63 MGD act. sludge 1.25 MGD cont. stab.0.50 MGD ext aeration

*Includes all treatment plants with a capacity greater than or equal to 1 mgd.

TABLE A-1 (Cont.)WASTEWATER TREATMENT PLANTS WITHIN THE JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT*

NAME	DESIGN CAPACITY	TYPE TREATMENT & DISPOSAL
DADE COUNTY- CONTINUED		
MDW&SA South District Regional WWTP	50.0 MGD	Activated sludge discharge to deep injection wells
MDWASA Central District WWTP	121.0 MGD	Activated sludge discharge to ocean outfall
MDWASA Goulds-Perrine	6.0 MGD	Contact stabilization STP discharging to seepage trenches
MDWASA N. District WWTP	60.0 MGD	Oxygen activated sludge discharging to Atlantic Ocean
MDWASA Opa-Locka	12.0 MGD	Thru N. Miami outfall no data available
MDWASA Westwood Lakes	2.7 MGD	Discharging to Snapper Creek Canal
MDWASA Sunny Isles	5.7 MGD	Primary STP thru North Miami outfall data inconsistent
North Miami Beach Utility Co.	1.7 MGD	Contact stabilization discharging to Intracoastal Waterway
North Miami Plant #1	10.0 MGD	Primary wastewater TP discharge North Miami Ocean outfall
North Miami Plant #2	6.0 MGD	Primary WWTP discharge thru North Miami Ocean outfall
Opa Locka Airport STP	1.0 MGD	Secondary hi-rate trickling filter to Biscayne Canal. Flow div. to N. Dist.
S. Dade Utilities-Bel Aire	1.0 MGD	Contact stabilization to soakage pit
Sky Lake Development	1.0 MGD	Contact stabilization to soakage trench
Sunset Park General Waterworks	5.7 MGD	Complete mix sewage treatment with deep well injection
TOTAL	**301.78 MGD**	
LEE COUNTY		
Cape Coral, City of (Plant B)	4.0 MGD	Contact stabilization to Caloosahatchee River
Fiesta Village	5.0 MGD	Contact stabilization perc. ponds spray irrigation

*Includes all treatment plants with a capacity greater than or equal to 1 mgd.

TABLE A-1 (Cont.) WASTEWATER TREATMENT PLANTS WITHIN THE JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT*

NAME	DESIGN CAPACITY	TYPE TREATMENT & DISPOSAL
LEE COUNTY-CONTINUED		
Ft. Myers Beach Sewer District	2.7 MGD	Contact stabilization with effluent to polish and perc. ponds
Ft. Myers, City of (Raleigh St. Plant)	9.0 MGD	Pure oxygen/aeration & trickling filter with effluent to Caloosahatchee River
Ft. Myers, City of	6.0 MGD	Contact stabilization with effluent to Caloosahatchee River
Lehigh Utilities, Inc.	1.4 MGD	Contact stabilization to retention pond
Sanibel Sewer Systems #4	1.0 MGD	Contact stabilization to retention pond
Waterway Estates 1667 Inlet	1.08 MGD	Contact stabilization to Caloosahatchee River
TOTAL	**30.18MGD**	
HENDRY COUNTY		
U. S. Sugar	2.5 MGD	Secondary treatment, retention
TOTAL	**2.5 MGD**	
MARTIN COUNTY		
Hutchinson Island	7.5 MGD	STP with surge TNK tert. filters dual drainfields
Stuart, City of	2.0 MGD	Trickling filter and act. sludge fac./St. Lucie River to deep well prim. outfall sec.
TOTAL	**9.5 MGD**	
MONROE COUNTY		
Key West, City of	4.3 MGD	None: Raw collection w/outfall to Atlantic
TOTAL	**4.3 MGD**	
OKEECHOBEE COUNTY		
Okeechobee, City of	4.0 MGD	Contact stabilization w/disposal via spray irrigationx
TOTAL	**4.0 MGD**	

*Includes all treatment plants with a capacity greater than or equal to 1 mgd.

TABLE A-1 (Cont.) WASTEWATER TREATMENT PLANTS WITHIN THE JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT*

NAME	DESIGN CAPACITY	TYPE TREATMENT & DISPOSAL
ORANGE COUNTY		
OCS&W Dept/Sand Lake Road WWTP	15.0 MGD	Contact stabilization sewage treatment plant
Orlando/McLeod Road WWTP#2, City of	12.0 MGD	High rate trickling filter sewage treatment plant
TOTAL	**27.0 MGD**	
OSCEOLA COUNTY		
Kissimmee, City of (Interim)	1.0 MGD	Contact stabilization with underdrained sprayfield
Kissimmee/Martin Street, WWTP	1.7 MGD	Contact stabilization sewage treatment plant w/effluent to Lake Tohopekaliga
Reedy Creek Improvement District	6.0 MGD	Activated sludge
St. Cloud, STP, City of	1.0 MGD	Trickling filter to St. Cloud Canal Tert. filters
TOTAL	**9.7 MGD**	
PALM BEACH COUNTY		
Acme Improvement District	1.5 MGD	Activated sludge
Belle Glade, City of	2.0 MGD	Contact stabilization
Boca Raton, City of	10.0 MGD	Contact stabilization
Century Village	1.9 MGD	Contact stabilization with discharge to perc. pond & golf courses
East Central Regional WWTP	40.0 MGD	Extended aeration to five deep injection wells
Loxahatchee Env. Control District	4.0 MGD	Extended aeration chem precip. settling, chlorination to pond
Pahokee, City of STP	1.2 MGD	
Palm Beach Co. #3	2.5 MGD	Contact stabilization to perc. pond
Palm Beach Co. System #5 - Le Chalet	1.5 MGD	Contact stabilization
Royal Palm Beach Utility Co.	1.1 MGD	Contact stabilization
Seacoast Util. - Palm Beach Gardens	3.6 MGD	Complete mix activated sludge
Seacoast Utilities	4.8 MGD	Activated sludge STP with off site disposal

*Includes all treatment plants with a capacity greater than or equal to 1 mgd.

TABLE A-1 (Cont.)WASTEWATER TREATMENT PLANTS WITHIN THE JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT*

NAME	DESIGN CAPACITY	TYPE TREATMENT & DISPOSAL
PALM BEACH COUNTY-CONTINUED		
South Central Regional WWTRP	15.0 MGD	Activated sludge to ocean outfall
South Palm Beach Util. Corp. (Amer. Homes)	3.0 MGD	Contact stab. tertiary alum.
South Central Reg. Plant #2 (PBC)	2.5 MGD	Contact stabilization discharging to nine perc. ponds coagulation dual media filtration to ponds
TOTAL	**94.6 MGD**	
ST. LUCIE COUNTY		
Fort Pierce Utility Authority	5.0 MGD	3.5 MGD activated sludge and 1.5 MGD contact stabilization
GDU-Port St. Lucie - North	2.0 MGD	Complete mix facility discharging to the St. Lucie River
TOTAL	**7.0 MGD**	

*Includes all treatment plants with a capacity greater than or equal to 1 mgd.

Appendix A

TABLE A-2 POTENTIAL WASTEWATER IRRIGATION SITES WITHIN JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NAME	PERMIT NO.	IRRIGATED AREA
BROWARD COUNTY		
American Golfers Club (Incl. in Coral Ridge Prop.)		
Arrowhead Golf and Country Club		153 Acres
Bonaventure Assoc.	06-00108-W	243 Acres
Broken Woods Golf	06-00376-W	67 Acres
Broward Comm. College	06-00354-W	16.67 Acres
Broward Co. Aviation (Ft. Laud/Hollywood Air.)	06-00431-W	54.5 Acres
Broward Co. Parks Dept. (Sports Complex)	06-00310-W	432 Acres
Broward Co. Park & Rec. (Lakeview Park)	06-00382-W	85 Acres
Broward Co. Rec. Dept. (Lyon's Tradewinds Pk)	06-00347-W	425 Acres
Broward Memorial Gardens		
Century Village East	06-00076-W	780 Acres
Colony West Country Club		150 Acres
Cooper Colony Country Club	06-00407-W	60 Acres
Coral Ridge Country Club	06-00105-W	212 Acres
Coral Ridge Properties (Village II GC)	06-00412-W	136 Acres
Country Club of Coral Springs	06-00377-W	103 Acres
Crystal Lake Country Club	06-00394-W	117 Acres
Dania Country Club	06-00250-S	35 Acres
Deerfield Country Club	06-00034-W	62.7 Acres
Deerfield High School	06-00385-W	17.5 Acres
D C Properties (Deer Creek CC)	06-00244-W	175 Acres
Diplomat Country Club		105 Acres
Ece Grande Golf Course		61 Acres
Emerald Hills Country Club	06-00061-W	108.5 Acres
Emerald Hills Country Club	06-00062-W	64.7 Acres
Evergreen Cemetery		
Forest Lawn Memorial	06-00068-W	40 Acres
Foxcraft Golf and Tennis		83 Acres
FPA Corporation	06-00024-W	662 Acres
Ft. Lauderdale Country Club	06-00056-W	280 Acres
Ft. Lauderdale, City of	06-00122-W	248 Acres
Goodyear Tire & Rubber (Blimp Base)	06-00336-W	30 Acres
Highland Meadows MHP	06-00048-W	50 Acres
Highland Village MHP	06-00059-W	20 Acres
High School CCC, Bro.	06-00245-W	25 Acres
Hillcrest Golf & Country Club	06-00099-W	140 Acres
Hollybrook Golf & Tennis	06-00406-W	170 Acres
Hollywood Beach Golf & Country Club		77 Acres
Hollywood Lakes Country Club		285 Acres
Hollywood Memorial Gardens	06-00075-W	45.65 Acres
Hollywood Memorial Gardens	06-00063-W	28.82 Acres
Hollywood, City of	06-00052-W	205 Acres
Inverrary Country Club	06-00344-W	320 Acres
Jacaranda Country Club	06-00149-W	260 Acres
Lago Mar Country Club		169 Acres
Lauderdale Lakes, City of	06-00181-W	8 Acres
Lauderdale Memorial Gardens		
Lauderdale Memorial Park		
Leisureville Fairway		N/A
Leonard W. (Adios Country Club)	06-00416-W	102.4 Acres
Mainlands Golf Course		16 Acres
Martinique Village		139 Acres
Montwood, Inc. (Woodmont Country Club)	06-00089-W	281 Acres

TABLE A-2 (Cont.) POTENTIAL WASTEWATER IRRIGATION SITES WITHIN JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NAME	PERMIT NO.	IRRIGATED AREA
BROWARD COUNTY--CONTINUED		
Nationwide Builders (Holiday Springs G&CC)	06-00021-W	120 Acres
Oakridge Country Club	06-00307-W	170 Acres
Orange Brook Golf Course		205 Acres
Oriole Golf & Tennis Club		160 Acres
Palm-Aire Country Club	06-00357-W	19 Acres
Pembroke Lakes Golf	06-00026-W	80 Acres
Pine Island Ridges Golf Course		333 Acres
Oriole Golf & Tennis Club		160 Acres
Palm-Aire Country Club	06-00357-W	19 Acres
Pembroke Lakes Golf	06-00026-W	80 Acres
Pine Island Ridges Golf Course		333 Acres
Pines Par Three		N/A
Plantation Golf Club	06-00408-W	32 Acres
Pompano Beach, City of	06-00081-W	45 Acres
Pompano Beach, City of (Pompano Beach GC)	06-00025-W	150 Acres
Pompano Beach Country Club		45 Acres
Pompano Park Golf Club		
Pompano Park Raceway	06-00193-W	90.3 Acres
Queen of Heaven Cemetery	06-00106-W	24 Acres
Rolling Hills Golf	06-00393-W	160 Acres
Sabal Palm Country Club	06-00083-W	120 Acres
Sharon Gardens Memorial Park (2 cemeteries)		
So. Broward Park Dis. Com.	06-00130-W	140 Acres
Spring Tree Country Club		213 Acres
Star of David Memorial Gardens		
Sunrise Country Club		189 Acres
Sunset Golf Course		N/A
Sunset Memorial Gardens		
Tamarac Country Club	06-00383-W	145 Acres
Tam O'Shanter Country Club	06-00384-W	90 Acres
Temple Beth El Memorial Gardens		
Westlawn Memorial Gardens		
Whispering Lakes Golf	06-00023-W	35 Acres
Woodlands Golf Assoc.	06-00094-W	245 Acres
Wynmoor Limited	06-00039-W	130 Acres
	TOTAL	**10,288.74 Acres**
COLLIER COUNTY		
Big Cypress Country Club		N/A
City Natl. Bank of Miami (Eagle Creek G & T)	11-00179-W	125 Acres
Club at Pelican Bay		N/A
Collier Dev. Corp.	11-00021-W	144 Acres
Country Club of Naples	11-00064-W	115 Acres
Forest Lake Country Club		98 Acres*
The Glades, Inc.	11-00020-W	245 Acres
Golden Gate Golf	11-00138-W	77 Acres
High Point Country Club	11-00019-W	15 Acres
Hole-In-The-Wall Golf Club	11-00030-W	180 Acres
Imperial Golf Club	11-00058-W	260 Acres
Kings Lake, Ltd.	11-00145-W	50 Acres
Lakeland Country Club		98 Acres*
Lely Estates, Inc. (Lely CC)	11-00131-W	300 Acres
Manchester Inv, Inc. (Sherwood Park)	11-00196-W	50 Acres
Marco Island Utilities	11-00104-W	741 Acres

Appendix A

TABLE A-2 (Cont.) POTENTIAL WASTEWATER IRRIGATION SITES WITHIN JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NAME	PERMIT NO.	IRRIGATED AREA
COLLIER COUNTY-CONTINUED		
Marco Shore Golf & Country Club		N/A
Moorings Golf Club	11-00054-W	38 Acres
Naples Bath & Tennis	11-00008-W	80 Acres
Naples Golf & Beach Club	11-00063-W	107 Acres
Naples Memorial Gardens	11-00220-W	12 Acres
Natl Audubon Society	11-00048-W	N/A
Palm River Country Club	11-00139-W	75 Acres
Pine Lakes Country Club		98 Acres*
Placid Lakes Country Club		N/A
Quail Run Country Club	11-00224-W	55 Acres
Riviera Golf Club	11-00053-W	85 Acres
Royal Poinciana Golf Club	11-00045-W	312 Acres
Shelter Corp. of Canada (Bear's Pan CC)	11-00130-W	150 Acres
Smith, G C	11-00045-W	45 Acres
Spanish Wells Country Club		N/A
The Moorings, Inc.	11-00200-W	44 Acres
US Home Corporation	11-00050-W	45 Acres
US Home Corporation (Foxfire)	11-00221-W	125 Acres
US Home Corporation (Lakeland CC of Naples)	11-00150-W	53 Acres
West Fla. Investments (Bay Forest)	11-00206-W	50 Acres
Whispering Pines, Inc.	11-00210-W	54.16 Acres
Wilderness Country Club	11-00057-W	170 Acres
Wyndemere Holdings	11-00167-W	232 Acres
	TOTAL	**4,425.16 Acres**
DADE COUNTY		
Bayshore Golf Course		153 Acres
Biltmore Golf Course		82 Acres
Bleaufontaine, Inc.	13-00024-W	120 Acres
Briar Bay Golf Course		38 Acres
California Club North		130 Acres
California Country Club		360 Acres
Calusa, Inc.	13-00072-W	105 Acres
Club West, Inc. (CC of Miami)	13-00I09-W	225 Acres
Colonial Palms Golf Course		83 Acres
Continental Golf Course		23 Acres
Coral Gables, City of	13-00055-W	139 Acres
Coral Gables, City of	13-00049-W	1.48 Acres
Coral Gables, City of	13-00056-W	57.8 Acres
Costa Del Sol Golf Course		326 Acres
Country Club Aventur	13-00052-W	225 Acres
Crooked Creek Golf Course		87 Acres
Diplomat Presidential		265 Acres
Doral Country Club	13-0006I-W	600 Acres
Doral Pk Joint Venture	13-00I07-W	110 Acres
Fla. Inter. University	13-0002I-W	70 Acres
Fontainbleau East and West		464 Acres
Granada Golf Course		43 Acres
Greynolds Park		67 Acres
Haulover Beach Golf Course		46 Acres
Homestead AFB Golf Course		93 Acres
Indian Creek		93 Acres
Kendale Lakes Golf & CC	13-0003I-W	170 Acres
Kendale W. Golf & CC	13-00032-W	77.34 Acres

TABLE A-2 (Cont.) POTENTIAL WASTEWATER IRRIGATION SITES WITHIN JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NAME	PERMIT NO.	IRRIGATED AREA
DADE COUNTY-CONTINUED		
Key Biscayne Golf Course		98 Acres
Kings Bay Country Club		184 Acres
La Gorce Country Club		66 Acres
Metro Dade County	13-0007l-W	293 Acres
Miami Lakes Inn & CC	13-000l9-W	53.5 Acres
Miami Shores Country Club	13-0004l-W	120 Acres
Miami, City of (Melreese CC)	13-00095-W	50 Acres
Miami, City of (Miami CC)	13-00090-W	95 Acres
Normandy Shores Golf Course		149 Acres
Palmetto Country Club		177 Acres
Par Three Golf Course		45 Acres
Redland Golf & Country Club	13-00074-W	110 Acres
Riviera Country Club	13-00088-W	105 Acres
Sago Bay Golf Course		N/A
The California Club	13-00034-W	120 Acres
Trafalgar Dev. of Fla.	13-00020-W	110 Acres
Turnberry Isles Country Club		61 Acres
Westview Country Club	13-00022-W	55 Acres
	TOTAL	**6,145.12 Acres**
GLADES COUNTY		
Airboats of Buckhead, Inc.	22-00005-W	5 Acres
General Development Corp.	22-00006-W	190 Acres
Hendry Isles Golf Course		
	TOTAL	**195 Acres**
HENDRY COUNTY		
Clewiston Golf Course		98 Acres*
Layton, J	26-00147-W	31 Acres
	TOTAL	**129 Acres**
HIGHLANDS COUNTY		
(No Golf Courses in SFWMD)		
LEE COUNTY		
Alden Pines, Ltd.	36-00204-W	55 Acres
Ayers & G. Drake, Tru H (Corkscrew G.)	36-00252-W	113 Acres
Boca Grande		98 Acres*
Bonita Bay	36-00282-W	2375 Acres
Bonita Springs Golf & CC	36-00186-W	160 Acres
Cape Coral CC & Golf Course	36-00056-W	187 Acres
Cape Coral Exec. Golf Course	36-00051-W	29 Acres
City of Ft. Myers	36-00019-W	135 Acres
Cypress Lake Country Club		N/A
Cypress Pines Country Club	36-00303-W	89.2 Acres
Eagle Ridge Golf Course		N/A
Eastwood Golf Course	36-00368-5	N/A
El Rio Golf Club	36-00026-W	35 Acres
Equity Service Group (Paddle Creek)	36-00278-W	22.1 Acres

TABLE A-2 (Cont.) POTENTIAL WASTEWATER IRRIGATION SITES WITHIN JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NAME	PERMIT NO.	IRRIGATED AREA
LEE COUNTY-CONTINUED		
Fiddlesticks Country Club	36-00287-S	98 Acres*
Fort Myers Country Club		98 Acres*
Lake Lawn Country Club	36-00070-W	33 Acres
Landing Yacht & Golf Club	36-00138-W	150 Acres
Lan Ron Builders, Inc. (Lake Fairways MHP)	36-00212-W	35 Acres
Lee County School Board	36-00133-W	23 Acres
Lehigh Acres Dev. (Mirror Lakes)	36-00143-W	160 Acres
Lehigh Acres Dev. (Lehigh Acres CC)	36-00144-W	115 Acres
Lehigh Corporation (Deer Run GC)	36-00351-W	67 Acres
Lochmoor Country Club	36-00025-W	81 Acres
Mariner Prop., Inc. (Casa Ybel Beach & Sport)	36-00107-W	10 Acres
McGregor Villas, Inc.	36-00138-W	150 Acres
Myerlee Country Club	36-00268-S	98 Acres*
Palmetto Pine Country Club	36-00032-W	95 Acres
Punta Gorda Isles Co.	36-00066-W	365 Acres
San Carlos Golf, Inc.	36-00308-W	90 Acres
Seven Lakes Assoc.	36-00088-W	125 Acres
Stardial Investments(Bay Beach GC)	36-00322-W	45.5 Acres
Suncoast Investments (Del-Tura CC)	36-00264-W	79 Acres
S Seas Plantation Co.	36-00109-W	75 Acres
The Dunes Golf & Country Club	36-00044-W	109 Acres
Timberlake, Ltd. (The Forest)	36-00161-W	120 Acres
Useppa Island		35 Acres
Whiskey Creek Country Club, Inc.	36-00055-W	52 Acres
	TOTAL	**5,606.8** Acres
MARTIN COUNTY		
Crane Creek Country Club	43-00027-W	64.3 Acres
Eaglewood Joint Venture (PUD)	43-00220-W	50.1 Acres
Heritage Ridge Golf Club	43-00126-S	33 Acres
Holiday Country Club		N/A
Indian River Plantation	43-00042-W	127 Acres
Joe's Point Venture	43-00130-W	34 Acres
Jonathan's Landing	43-00221-W	180 Acres
Jupiter Golf Club, I C.	43-00054-W	298 Acres
King Mountain Condo Assn.	43-00013-W	45.6 Acres
Mariner Sands Dev. Co.	43-00064-W	215 Acres
Martin Co. Bd. of County Commissioners	43-00156-W	30 Acres
Martin Co. Golf & CC	43-00031-W	160 Acres
Mid-Rivers, Inc.	43-00069-W	105 Acres
Miles Grant Country Club	43-00067-W	88 Acres
Mobile Oil Estates	43-00030-W	458 Acres
North Trail Golf Club	43-00026-W	35.4 Acres
Pipers Landing, Inc.	43-00198-W	66.4 Acres
Ranch Colony, Inc.	43-00138-W	230 Acres
River Bend Golf Course	43-00091-W	67.59 Acres
Southern Realty Group (Martin Down's CC)	43-00204-W	101.3 Acres
The Little Club Condo	43-00202-W	20 Acres
The Yacht & Country Club	43-00032-W	140.1 Acres
Turtle Creek Club	43-00140-W	105 Acres
	TOTAL	**2,653.79** Acres

TABLE A-2 (Cont.) POTENTIAL WASTEWATER IRRIGATION SITES WITHIN JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NAME	PERMIT NO.	IRRIGATED AREA
MONROE COUNTY		
Key West Golf Course	44-00003-S	60.5 Acres
Ocean Reef Club, Inc.	44-00001-W	57 Acres
	TOTAL	**117.5 Acres**
OKEECHOBEE COUNTY		
Okeechobee Golf and Country Club		N/A
ORANGE COUNTY		
Blue Mountains Joint Venture	48-00121-W	253 Acres
Greater Orlando	48-00063-W	178 Acres
Orange Lake Country	48-00135-W	237.5 Acres
Orlando Naval Training	48-00091-W	59 Acres
Sea World of Florida	48-00058-W	248 Acres
	TOTAL	**975.5 Acres**
OSCEOLA COUNTY		
Little England, Inc.	49-00118-W	498 Acres
	TOTAL	**498 Acres**
PALM BEACH COUNTY		
Arvida Corporation	50-00489-W	90 Acres
Atlantis Country Club	50-00452-W	100 Acres
Atlantis Golf Club	50-00406-W	150 Acres
Banyan Golf Club	50-00443-W	140 Acres
Belle Glade Golf Course		N/A
Belvedere Golf Club	50-00849-W	25 Acres
Biernbaum, R.	50-00697-W	135 Acres
Boca Del Mar Associates	50-00054-W	142 Acres
Boca Del Mar Assoc.	50-00055-W	116 Acres
Boca Greens Country Club	50-00632-W	140 Acres
Boca Grove Plantation	50-00841-W	179 Acres
Boca Lago Country Club, Inc.	50-00888-W	202.6 Acres
Boca Raton Hotel & Club	50-00328-W	120 Acres
Boca Raton, City of	50-00832-W	165 Acres
Boca Rio Golf Club	50-00292-W	163 Acres
Boca Teeca Corp.	50-00088-W	100 Acres
Boca Woods Country Club	50-00737-W	200 Acres
Boynton Beach, City of	50-00951-W	110 Acres
Cadillac Fairview In.	50-00981-W	155 Acres
Cadillac Fairview	50-01001-W	88.26 Acres
Century Village West	50-00688-W	101 Acres
Century Village, Inc.	50-00890-W	60.7 Acres
City of Boynton Beach	50-00039-W	20 Acres
City of West Palm Beach	50-00257-W	17.5 Acres
City of West Palm Beach	50-00247-W	35 Acres
City of West Palm Beach	50-00256-W	45 Acres
City of West Palm Beach	50-00487-W	110 Acres
Country Manors Condo.	50-00150-W	37.6 Acres
Covered Bridge Condo.	50-00050-W	45 Acres
Crouch/Palermo Fla.	50-00945-W	120 Acres

TABLE A-2 (Cont.) POTENTIAL WASTEWATER IRRIGATION SITES WITHIN JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NAME	PERMIT NO.	IRRIGATED AREA
PALM BEACH COUNTY-CONTINUED		
Crystal Lakes RV Resort & Golf C.	50-00828-S	N/A
Delray Beach Country Club	50-00944-W	120 Acres
Delray Dunes Golf & CC	50-00851-W	120 Acres
Dept. of Natural Resources	50-00741-W	812 Acres
DGC Assoc. by Pair, Inc.	50-00534-W	190 Acres
Dimensional Builders, Inc.	50-00526-W	80 Acres
Eastpointe Country Club	50-00941-W	123.9 Acres
EPIC Corporation	50-00059-W	168 Acres
Flagler System, Inc.	50-00203-W	200 Acres
Fla. Atlantic University	50-00655-W	240 Acres
Fla. Planned Communities	50-00110-W	216 Acres
Fla. Power & Light Co.	50-00742-W	8.3 Acres
Forest Hill Golf, Inc.	50-00099-W	25 Acres
Fountains Golf & Racquet	50-00440-W	225 Acres
Fountains of Palm Beach	50-00165-W	100 Acres
Frenchmans, Inc.	50-00091-W	168 Acres
Gould Florida, Inc.	50-00883-W	632 Acres
Greentree Villas Condo.	50-00472-W	80 Acres
Greenway Village S	50-00642-W	22 Acres
Gulf Stream Golf Club	50-00377-W	160 Acres
Hidden Valley Golf	50-00970-W	10 Acres
High Point of Delray	50-01030-W	31.55 Acres
High Point of Delray	50-00666-W	68.2 Acres
Holigolf, Inc.	50-00255-W	35.2 Acres
IBM C/O Jerry Delane	50-00502-W	39.7 Acres
John I. Leonard High School	50-00140-W	20 Acres
John T. Oxley Farms	50-00007-W	116 Acres
Jonathan's Landing	50-00237-W	120 Acres
J.D.M. Country Club	50-00852-W	590.8 Acres
Kings Point Community Assoc.	50-00975-W	95 Acres
Kings Point Housing	50-00971-W	220 Acres
Lake Worth, City of	50-00866-W	97 Acres
Levitt Homes, Inc.	50-00760-W	11.1 Acres
Lion Country Safari, Inc.	50-00374-W	400 Acres
Lone Pine Golf Club	50-00954-W	40 Acres
Lost Tree Club, Inc.	50-00421-W	130 Acres
Lucerne Lakes Golf Course	50-00388-W	55 Acres
Lucerne Park, Ltd.	50-00967-W	32.6 Acres
Markborough Properties	50-00845-W	197 Acres
Mark M. Nicolaysen	50-00032-W	40 Acres
Mayacoo Lakes Country Club	50-00537-W	160 Acres
Meadowbrook Mobile Home Park	50-00120-W	41 Acres
Mirror Lakes Home.	50-00583-W	23.6 Acres
No I Condo Assoc.	50-00848-W	40 Acres
N. Palm Beach Co WCD	50-00617-W	507 Acres
Oriole Homes Corporation	50-00078-W	101 Acres
Palm Greens #2 Condo.	50-00859-W	70 Acres
Palm Hill Villas	50-00865-W	19 Acres
P.B Co. Parks & Rec. Dept.	50-00814-W	21.4 Acres
P.B. Lakes Golf Club	50-00233-W	95 Acres
Pelican Harbor, Inc.	50-00725-W	11 Acres
Perini Land & Dev. Co.	50-01022-W	190.7 Acres
Pierce	50-00394-W	115 Acres
Pine Tree Golf Club, Inc.	50-00535-W	160 Acres

TABLE A-2 (Cont.) POTENTIAL WASTEWATER IRRIGATION SITES WITHIN JURISDICTION OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NAME	PERMIT NO.	IRRIGATED AREA
PALM BEACH COUNTY-CONTINUED		
Presidential Country Club	50-00224-W	247 Acres
P.B. National Golf & CC	50-00268-W	70 Acres
Quail Ridge, Inc.	50-00419-W	197 Acres
Radice Corporation	50-00908-W	89.8 Acres
Retirement Builders	50-00855-W	71 Acres
Royal Palm Beach Colony	50-00269-W	175 Acres
Royal Palm Memorial Gardens	50-00218-W	81 Acres
Royal Palm Yacht & CC	50-00159-W	131.3 Acres
Royal Palm Bch. Golf & CC	50-00561-W	170 Acres
Sandalfoot Cove Country Club	50-00411-W	155 Acres
Seminole Golf Club	50-00349-W	105.4 Acres
St. Andrews Dev. Corp.	50-00799-W	658 Acres
Summit Assoc, Ltd.	50-00331-W	327 Acres
Tequesta Country Club	50-00223-W	100 Acres
The Hamlet of Delray	50-00284-W	114.2 Acres
The Little Club, Inc.	50-00434-W	33 Acres
The Trails Golf & Country Club	50-00896-W	47 Acres
Trafalgar Dev. of Fla.	50-00111-W	357 Acres
Univ. Park Country Club	50-00119-W	60 Acres
Villa Delray Golf	50-00049-W	130 Acres
Village of N. Palm Beach	50-00084-W	127.2 Acres
Willow Bend Assoc.	50-00631-W	25 Acres
	TOTAL	**14,377.61 Acres**
POLK COUNTY		
Grenelefe Corporation	53-00029-W	40 Acres
Poinciana Golf & Racquet	53-00020-W	120 Acres
River Ranch, Inc.	53-00017-W	45 Acres
	TOTAL	**205 Acres**
ST LUCIE COUNTY		
Ft. Pierce-St. Lucie C RB	56-00001-W	640 Acres
General Development Corp.	56-00100-W	225 Acres
Hollingsworth EL	56-00390-W	50 Acres
Indian Pines Golf Club	56-00101-W	50.4 Acres
	TOTAL	**965.4 Acres**

APPENDIX B:

COMPUTER LISTING FOR PROGRAM REUSE

Appendix B
Program REUSE Listing

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      PROGRAM REUSE(TAPE2,TAPE3)
      COMMON AREA,DIAM,N
C     PROGRAM REUSE(MODIFIED)
C THIS PROGRAM ESTIMATES THE COSTS OF TRANSMISSION LINES, PUMPING STATIONS,
C (BOTH CAPITAL AND O&M COSTS), TERTIARY FILTRATION COSTS, STORAGE COSTS,
C AND THE SUM TOTAL OF THESE COSTS FOR VARIOUS OPTIMUM DIAMETER SIZED PIPE
C (PREVIOUSLY FOUND), AT VARIOUS DISTANCES, FOR WASTEWATER REUSE AT VARIOUS
C SIZED GOLF COURSES............
      DIMENSION PIPE(50),PUMP(50),PUMPOM(50),TOTAL(50),
     $HEAD(50),FLOWM(50),FLOWG(50),PIPOM(50)
      REAL MEDIA,MEDIAA,MEDTG
      DIMENSION DIAM(50),DIST(50),AREA(50)
      CHARACTER*60,REGION
      CHARACTER*2,PIPID(50)
C THE FOLLOWING DATA VALUES REPRESENT THE CAPITAL RECOVERY VALUES FOR:
C CRF1        PIPES      10%SALVAGE      10%INTEREST     30YEARS
C CRF2        PUMPS      10%SALVAGE      10%INTEREST     10YEARS
C CRF3        FILTER      0 SALVAGE      10%INTEREST     20YEARS
C CRF4        STORAGE     0 SALVAGE      10%INTEREST     30YEARS
C CRF5        CHLOR.      0 SALVAGE      10%INTEREST     15YEARS
C LENGTHS OF TIME WERE ESTIMATED FROM OLAC STUDY.......
      CRF1=.10547
      CRF2=.15647
      CRF3=.11746
      CRF4=.10608
      CRF5=.131474
      DO 995 IJLK=1,17
      READ (2,140) REGION,N,AREATO
      READ (2,155) (PIPID(I),AREA(I),DIST(I),I=1,N)
      CALL OPTIM
      WRITE (3,165) REGION
      WRITE (3,147)
      WRITE (3,145)
      DO 5 I=1,N
5     WRITE (3,150) PIPID(I),AREA(I),DIAM(I),DIST(I)
      WRITE (3,147)
C
C
C
C FLOW IN MGD (FLOWM) AND GPM (FLOWG) AT AN APPLICATION RATE
C OF 1 INCHES PER WEEK..........
      DO 10 I=1,N
      FLOWG(I)=AREA(I)*2.6937
      FLOWM(I)=FLOWG(I)*(1440./1000000.)
10    CONTINUE
C
      FLOWGT=AREATO*2.6937
      FLOWMT=FLOWGT*(1440./1000000.)
C COST OF PIPE, CAPITAL, IN DOLLARS PER 1000 GALL....
C
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```
      DO 25 I=1,N
      IF (DIAM(I).GE.12) GO TO 20
      PIPE(I)=1.25*(.258*(DIAM(I)**.2587)*DIST(I)+.1205*
     $(DIAM(I)**1.7832)*DIST(I))
      PIPOM(I)=(.005/1.25)*PIPE(I)
      GO TO 22
20    PIPE(I)=1.25*(.3249*(DIAM(I)**.88832)*DIST(I)+.2649*
     $(DIAM(I)**1.5549)*DIST(I)+.2905*(DIAM(I)**.88982)*
     $DIST(I))
      PIPOM(I)=(.005/1.25)*PIPE(I)
22    CONTINUE
C
C
C
C HEAD OF SYSTEM, IN FEET
      C=100.
      HSTAT=0.0
      IF (DIAM(I).GE.12.) C=120.
      HEAD(I)=HSTAT+(DIST(I)*(FLOWG(I)**1.85)/((.0955*
     $(C**1.85)*(DIAM(I)**4.86))))
C
C
C
C
C
C
C COST OF PUMPS, CAPITAL, IN DOLLARS
      PUMP(I)=(1.87*(FLOWG(I)**.78152)*(HEAD(I)**
     $.69174)+7.75*(FLOWG(I)**.68914)*(HEAD(I)**.22625)+
     $29.1*(FLOWG(I)**.75655)+1.39*(FLOWG(I)**.80860)*
     $(HEAD(I)**.53109)+1.75*(FLOWG(I)**.77240)*(HEAD(I)
     $**.48164))
C
C
C
C COST OF PUMPS, OPERATION AND MAINTENANCE, DOLLARS PER 1000 GALL....
C
      PUMPOM(I)=.04*(FLOWG(I)*HEAD(I))+124.57*(FLOWG(I)
     $**.50443)+1.09*(FLOWG(I)**.85775)
25    CONTINUE
C
C
C
C
C
C COSTS OF TERTIARY FILTRATION, DOLLARS PER 1000 GALL....
C
C GRAVITY FILTER CONSTRUCTION.....
      GRAVC=1799.56*(FLOWMT**.59901)+28863.05*(FLOWMT**.69806)
     $+13515.89*(FLOWMT**.5633)+8046.74*(FLOWMT**.55305)+
     $37867.49*(FLOWMT**.59019)+9521.09*(FLOWMT**.73684)+
     $17848.1*(FLOWMT**.54705)+15412.69*(FLOWMT**.77921)+
```

```
     $25605.56*(FLOWMT**.66069)
      GRAVCA=CRF3*GRAVC
      GRAVTG=GRAVCA/(365000.*FLOWMT)
C BACKWASH PUMPING FACILITIES, PEAK FACTOR IS 5
C
       BACKC=2439.21*((5*FLOWMT)**.78004)+1024.83*((5*FLOWMT)**
     $.46432)+4508.27*((5*FLOWMT)**.48321)+8293.32*((5*FLOWMT)**
     $.31159)+1990.39*((5*FLOWMT)**.55613)
C
      BACKCA=.11746*BACKC
      BACKTG=BACKCA/(365000.*FLOWMT)
C
C DUAL MEDIA FOR FILTER.....
C
C
      MEDIA=6469.83*(FLOWMT**.80912)
C
      MEDIAA=CRF3*MEDIA
      MEDTG=MEDIAA/(365000.*FLOWMT)
C SURFACE WASHING CONSTRUCTION FACILITIES....
C
C
C
      SURFC=8683.26*(FLOWMT**.72415)+1034.23*(FLOWMT
     $.73539)+2797.76*(FLOWMT**.57514)+14088.69*(FLO
     $.37436)+3711.72*(FLOWMT**.59754)


C
      SURFCA=SURFC*CRF3
      SURCTG=SURFCA/(365000.*FLOWMT)
C
C
C
C
C
C GRAVITY FILTER OPERATION AND MAINTENANCE.....
C
      GRAVOM=2436.5*(FLOWMT**.86331)+862.89*(FLOWMT**.72147)+
     $1001.07*(FLOWMT**.53384)
C
      GRVMTG=GRAVOM/(365000.*FLOWMT)
C
C
C BACKWASH FILTER O&M
C
      BACKOM=256.39*(FLOWMT**.13405)+200.42*(FLOWMT**1.0043)+
     $381.64*(FLOWMT**.40610)
C
      BCKMTG=BACKOM/(365000.*FLOWMT)
C
C SURFACE WASHING FACILITIES O&M...
C
      SURFOM=79.51*(FLOWMT**.46826)+132.1*(FLOWMT**.97356)+
```

```
     $208.89*(FLOWMT**.2083)
C
      SURMTG=SURFOM/(365000.*FLOWMT)
CC
C
C
C COSTS FOR STORAGE FOR 7 DAYS  DOLLARS PER 1000 GALL....
C
C
      IF (FLOWMT.GT.4.) GO TO 30
      STORC=27935.*(FLOWMT**.5884)
      STORL=50060.*(FLOWMT**.7750)
      STORCA=STORC*CRF4
      STOCTG=STORCA/(365000.*FLOWMT)
      STORLA=STORL*CRF4
      STOLTG=STORLA/(365000.*FLOWMT)
      STORE=30611.*(FLOWMT**.4072)
      STOREA=STORE*CRF3
      STOETG=STOREA/(365000.*FLOWMT)
C
      GO TO 38
30    STORC=23519.*(FLOWMT**.723)
      STORL=47593.*(FLOWMT**.8944)
      STORCA=STORC*CRF4
      STOCTG=STORCA/(365000.*FLOWMT)
      STORLA=STORL*CRF4
      STOLTG=STORLA/(365000.*FLOWMT)
      STORE=50318.*(FLOWMT**.4240)
      STOREA=STORE*CRF3
      STOETG=STOREA/(365000.*FLOWMT)
38    CONTINUE
C
C REPLUMBING COSTS......
C
      REPLM=75116.01*.1*FLOWMT
      RERTG=.02
C
C STORAGE O&M COSTS....


C
      IF(FLOWMT.GT.10) GO TO 45
      STOROM=549.*(FLOWMT**.3328)+202.*(FLOWMT**.5068)
      GO TO 50
45    STOROM=640.*(FLOWMT**.36974)+106.*(FLOWMT**.8853)
50    CONTINUE
      STOMTG=STOROM/(365000.*FLOWMT)
C
C
C
C CHLORINATION COSTS.....
C
C CAPITAL....
      CHLORC=61102.*(FLOWMT**.6316)
```

```
      CHLOCA=CRF5*CHLORC
      CLOCTG=CHLOCA/(365000.*FLOWMT)
C
C CHLORINATION O&M
C
      CHLORM=2250.*FLOWMT+1793*(FLOWMT**.5322)+4473.*
     $(FLOWMT**.077)
      CLOMTG=CHLORM/(365000.*FLOWMT)
C TOTAL TREATMENT COSTS, INCLUDING STORAGE...
C
C
      TOTRC=GRAVC+BACKC+MEDIA+SURFC+STORL+STOPC+CHLORC+STORE
C
      TOTRCA=GRAVCA+BACKCA+MEDIAA+SURFCA+STORCA+STORLA+CHLOCA
     $+STOREA+REPLM
      TOTRTG=TOTRCA/(365000.*FLOWMT)
C
      TRTOM=GRAVOM+BACKOM+SURFOM+STOROM+CHLORM
      TRTMTG=TRTOM/(365000.*FLOWMT)
C
      TTMTA=TOTRCA+TRTOM
      TTMTTG=TTMTA/(365000.*FLOWMT)
C
C TOTAL COSTS, DOLLARS PER 1000 GALL......
      TPUMP=0.0
      TPIPE=0.0
      TPIPOM=0.0
      TPMPOM=0.0
      DO 100 I=1,N
      TPUMP=PUMP(I)+TPUMP
      TPIPE=PIPE(I)+TPIPE
      TPIPOM=PIPOM(I)+TPIPOM
      TPMPOM=PUMPOM(I)+TPMPOM
      TOTAL(I)=CRF1*PIPE(I)+PIPOM(I)+CRF2*PUMP(I)+
     $PUMPOM(I)
      TOTAL(I)=TOTAL(I)/(365000.*FLOWM(I))
100   CONTINUE
      TPIPEA=CRF1*TPIPE
      TPIPTG=TPIPEA/(365000.*FLOWMT)
      TPUMPA=CRF2*TPUMP
      TPMPTG=TPUMPA/(365000.*FLOWMT)
      TPOMTG=TPIPOM/(365000.*FLOWMT)
      TMPTG=TPMPOM/(365000.*FLOWMT)
      TOPLA=TPIPEA+TPUMPA+TPIPOM+TPMPOM
      TOPLTG=TOPLA/(365000.*FLOWMT)
C
C
      TOTA=TOPLA+TTMTA
      TOTATG=TOPLTG+TTMTTG
C


      WRITE (3,305) REGION
      WRITE (3,205)
```

```
      WRITE (3,200) AREATO
      WRITE (3,210) FLOWMT
      WRITE (3,220) GRAVC,GRAVCA,GRAVTG
      WRITE (3,222) BACKC,BACKCA,BACKTG
      WRITE (3,224) MEDIA,MEDIAA,MEDTG
      WRITE (3,226) SURFC,SURFCA,SURCTG
      WRITE (3,228) STORC,STORCA,STOCTG
      WRITE (3,230) STORL,STORLA,STOLTG
      WRITE (3,231) STORE,STOREA,STOETG
      WRITE (3,232) CHLORC,CHLOCA,CLOCTG
      WRITE (3,233) REPLM,REPTG
      WRITE (3,234) GRAVOM,GRVMTG
      WRITE (3,236) BACKOM,BCKMTG
      WRITE (3,238) SURFOM,SURMTG
      WRITE (3,240) STOROM,STOMTG
      WRITE (3,242) CHLORM,CLOMTG
      WRITE (3,244) TOTRC,TOTRCA,TOTRTG
      WRITE (3,246) TRTOM,TRTMTG
      WRITE (3,248) TTMTA,TTMTTG
      WRITE (3,250) TPIPE,TPIPEA,TPIPTG
      WRITE (3,252) TPIPOM,TPOMTG
      WRITE (3,254) TPUMP,TPUMPA,TPMPTG
      WRITE (3,256) TPMPOM,TMPTG
      WRITE (3,258) TOPLA,TOPLTG
      WRITE (3,260) TOTA,TOTATG
C
      WRITE (3,305) REGION
      WRITE (3,300)
      WRITE (3,302)
      WRITE (3,340)
      DO 138 I=1,N
138   WRITE (3,330) PIPID(I),AREA(I),DIAM(I),DIST(I),PIPE(I),
     $PIPOM(I),PUMP(I),PUMPOM(I),TOTAL(I)
      WRITE (3,340)
140   FORMAT (A60,I2,F8.0)
145   FORMAT (1X,'*',1X,'PIPID',5X,'AREA',3X,
     $'DIAM',3X,'DISTANCE',1X,'*',/)
147   FORMAT (1X,36('*'))
148   FORMAT (1X,('*'),37X,('*'))
150   FORMAT (1X,'*',2X,A2,5X,F6.0,4X,F3.0,4X,F6.0,2X,'*')
155   FORMAT (1X,A2,F6.0,F6.0)
165   FORMAT ('1',3X,A60,//)
168   FORMAT (F6.0)
200   FORMAT (1X,'TOTAL AREA',T50,F12.2,' ACRES',/)
205   FORMAT (1X,'ITEM',T55,'CAP. COST',T90,'AMZ. COST',T120,
     $'UNIT COST',//)
210   FORMAT (1X,'TOTAL FLOW',T50,F12.2,' MGD',/)
220   FORMAT (1X,'GRAVITY FILTER CONTRUCTION COST',T50,F12.2,'$',T80,
     $F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
222   FORMAT (1X,'BACKWASH FACILITIES COST',T50,F12.2,'$'
     $,T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
224   FORMAT (1X,'FILTRATION MEDIA MATERIALS COST',T50,F12.2,
     $'$',T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
226   FORMAT (1X,'SURFACE WASHING FACILITIES COST',T50,F12.2,
```

```
     $'$',T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
228   FORMAT (1X,'STORAGE CONSTRUCTION COST',T50,F12.2,'$',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
230   FORMAT (1X,'STORAGE LINING COST',T50,F12.2,'$',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
231   FORMAT (1X,'STORAGE EXCAVATION COST',T50,F12.2,
     $'$',T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
232   FORMAT (1X,'CHLORINATION FACILITIES COST',T50,F12.2,


     $'$',T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
233   FORMAT (1X,'REPLUMPING COSTS',T80,F12.2,
     $'$ PER YEAR',T110,F12.3,'$ PER TG',/)
234   FORMAT (1X,'GRAVITY FILTER OPERATING COST',T80,F12.2,
     $'$ PER YEAR',T110,F12.3,'$ PER TG',/)
236   FORMAT (1X,'BACKWASH FACILTIES OPERATING COST',T80,F12.2,
     $'$ PER YEAR',T110,F12.3,'$ PER TG',/)
238   FORMAT (1X,'SURFACE WASHING FACILITIES OPERATING COST',
     $T80,F12.2,
     $'$ PER YEAR',T110,F12.3,'$ PER TG',/)
240   FORMAT (1X,'STORAGE OPERATING COST',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
242   FORMAT (1X,'CHLORINATION OPERATING COST',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
244   FORMAT (1X,'TREATMENT CAPITAL COSTS',T50,F12.2,'$',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
246   FORMAT (1X,'TREATMENT OP. MAIN. COSTS',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
248   FORMAT (1X,'TOTAL TREATMENT COSTS, AM7.',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
250   FORMAT (1X,'PIPES, CONSTRUCTION COST',T50,F12.2,'$',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
252   FORMAT (1X,'PIPES, OP. MAIN. COSTS',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
254   FORMAT (1X,'PUMPS, CAP. COSTS',T50,F12.2,'$',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
256   FORMAT (1X,'PUMPS, OP. MAIN. COSTS',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
258   FORMAT (1X,'TOTAL PIPELINE COSTS, AMZ.',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
260   FORMAT (1X,'TOTAL COSTS',
     $T80,F12.2,'$ PER YEAR',T110,F12.3,'$ PER TG',/)
300   FORMAT (1X,'PIPEID',6X,'AREA',2X,'DIAMETER',2X,
     $'DIST',10X,
     $'PIPE COST',10X,'PIPE OM COST',7X,'PUMP COST',9X,
     $'PMP OM COST',8X,'TOTCOST')
302   FORMAT (12X,'AC',7X,'IN',7X,'FT',16X,'$',15X,
     $'$ PER YEAR',13X,'$',14X,'$ PER YR',10X,'$ PER TG',/)
305   FORMAT ('1',9X,A60)
330   FORMAT (1X,'*',1X,A3,5X,F5.0,5X,F3.0,5X,F6.0,4(8X,F10.0),8X,
     $F10.3,3X,'*',/)
340   FORMAT (1X,128('*'))
995   CONTINUE
      STOP
```

```
      END
      SUBROUTINE OPTIM
      COMMON AREA,DIAM,N
C     SUBROUTINE OPTIM (MODIFIED)
C THIS SUBROUTINE PICKS AN OPTIMUM DIAMETER OF A PIPELINE, USING
C OPTIMIZATION TECHNIQUES TO PERFORM THE TRADEOFF BETWEEN LARGER
C DIAMETER PIPES WITH HIGHER CONSTRUCTION COSTS AND LOWER PUMPING
C COSTS; AND SMALLER DIAMETER PIPES WITH LOWER CONSTRUCTION COSTS,
C AND HIGHER PUMPING COSTS.......
      DIMENSION DIAM(50),DIAM5(50),AREA(50),FLOWG(50)
      R=1.0
      DO 1000 I=1,N
      FLOWG(I)=AREA(I)*R*2.6937
      DIAM(I)=5
C DIAM1 IS THE TOTAL COST OF THE PIPELINE, AND DIAM2 IS THE
C SECOND DERIVATIVE....
C
C FIRST, FOR PVC PIPE.....
C
50    DIAM1=.0101*(DIAM(I))**(-.7413)+.03265*(DIAM(I))**.7832-


     $2.07E-4*FLOWG(I)**2.85*(DIAM(I))**(-5.86)
      DIAM2=-.00749*(DIAM(I))**(-1.7413)+.02557*(DIAM(I))**(-.2168)+
     $1.213E-3*(FLOWG(I)**2.85)*DIAM(I)**(-6.86)
      DIAM5(I)=DIAM(I)-(DIAM1/DIAM2)
C
C EPS IS THE ERROR TERM, EPSILON
C
      EPS=ABS(DIAM5(I)-DIAM(I))
      IF (EPS.LT..00001) GO TO 100
      DIAM(I)=.9*DIAM(I)+.1*DIAM5(I)
      GO TO 50
100   IF (DIAM(I).GT.12) GO TO 200
      GO TO 500
200   DIAM(I)=DIAM5(I)
C
C FOR DUI PIPE.....
C
C
300   DIAM1=.04382*(DIAM(I))**(-.11168)+.06254*(DIAM(I))**.5549
     $+.03924*(DIAM(I))**(-.11018)-2.90E-4*FLOWG(I)**2.85*(DIAM(I))
     $**(-5.86)
      DIAM2=-.00489*(DIAM(I))**(-1.11168)+.03470*(DIAM(I))**(-.4451)-
     $.00432*(DIAM(I))**(-1.11018)+1.699E-3*FLOWG(I)**2.85*
     $(DIAM(I)**(-6.86))
      DIAM5(I)=DIAM(I)-(DIAM1/DIAM2)
      EPS=ABS(DIAM5(I)-DIAM(I))
      IF (EPS.LT..00001) GO TO 500
      DIAM(I)=.9*DIAM(I)+.1*DIAM5(I)
      GO TO 300
500   DIAM(I)=DIAM5(I)
      IF (DIAM(I).LT.5) DIAM(I)=4.
      IF (DIAM(I).GE.5 .AND. DIAM(I).LT.7) DIAM(I)=6.
```

```
      IF (DIAM(I).GE.7 .AND. DIAM(I).LT.9) DIAM(I)=8.
      IF (DIAM(I).GE.9 .AND. DIAM(I).LT.11) DIAM(I)=10.
      IF (DIAM(I).GE.11 .AND. DIAM(I).LT.13) DIAM(I)=12.
      IF (DIAM(I).GE.13 .AND. DIAM(I).LT.15) DIAM(I)=14.
      IF (DIAM(I).GE.15 .AND. DIAM(I).LT.17) DIAM(I)=16.
      IF (DIAM(I).GE.17 .AND. DIAM(I).LT.19) DIAM(I)=18.
      IF (DIAM(I).GE.19 .AND. DIAM(I).LT.22) DIAM(I)=20.
      IF (DIAM(I).GE.22 .AND. DIAM(I).LT.27) DIAM(I)=24.
      IF (DIAM(I).GE.27 .AND. DIAM(I).LT.33) DIAM(I)=30.
      IF (DIAM(I).GE.33 .AND. DIAM(I).LT.39) DIAM(I)=36.
      IF (DIAM(I).GE.39 .AND. DIAM(I).LT.45) DIAM(I)=42.
      IF (DIAM(I).GE.45 .AND. DIAM(I).LT.48) DIAM(I)=48.
      IF (DIAM(I).GE.48 .AND. DIAM(I).LT.51) DIAM(I)=48.
      IF (DIAM(I).GE.51) DIAM(I)=0.
C THIS LAST LINE MAKES IT POSSIBLE TO CHECK IF TWO PIPELINES NEED
C TO SERVE THE AREA, BECAUSE IT WILL BE THE ONLY CASE IF THE COSTS
C EQUAL ZERO WITH LARGE AREAS.....
1000  CONTINUE
      RETURN
      END
```

11.10.35.UCLP, AA15,   0.512KLNS.