COLLIER COUNTY AND MARCO ISLAND WATER SUPPLY FEASIBILITY STUDY

HMA FILE NO. 89.12

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August, 1989

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August 23, 1989

Mr. Michael K. Arnold
Utilities Administrator
Collier County Utilities Division
2800 North Horseshoe Drive
Naples, FL 33942

SUBJECT: Collier County and Marco Island
Water Supply Feasibility Study
HMA File No. 89.12

Dear Mr. Arnold:

On behalf of Hole, Montes and Associates, Inc., James M. Montgomery-Consulting Engineers, Inc. and Missimer and Associates, Inc., we are pleased to submit the Collier County and Marco Island Water Supply Feasibility Study. The input and assistance provided by you and your staff during development of the Study has certainly added to the quality and comprehensiveness of the Report.

We are confident the Report provides sound recommendations and guidance for Collier County in its efforts to address the long-term water supply needs of existing and future residents of our community.

As previously discussed, the preliminary design data and cost model information is provided in the supplemental Preliminary Design Memorandum.

We look forward to an opportunity to assist Collier County during implementation of the program authorized by the Board of the County Commissioners.

Very truly yours,

HOLE, MONTES AND ASSOCIATES, INC.

Thomas M. Taylor, P.E.
Vice President

TMT/dj

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I. INTRODUCTION

A. Authorization

This Feasibility Study was authorized by the Collier County Board of Commissioners and the Scope of Services subsequently approved in an Agreement for Engineering Services. Authorization to proceed was received by letter dated March 30, 1989. The Study involved a review and evaluation of potential water resources and existing treatment technologies that could be implemented to provide a long-term, reliable water supply to Marco Island.

The Feasibility Study was performed by a team of professionals, each having specific background and experience related to key elements of the project. Hole, Montes and Associates, Inc. served as the project team leader and coordinator, with background as Collier County's "Engineer of Record" and authors of the County's 1986 Water Master Plan. Missimer and Associates, Inc. performed the hydrogeologic investigations during the Study and has served as Collier County's and Marco Utilities' hydrogeologic consultant for the past several years. James M. Montgomery, Consulting Engineers, Inc. is an internationally recognized leader in the water treatment field, as well as hydrogeology, and provided technical design and process evaluation for the various treatment technologies.

B. Scope

The Study will identify and evaluate the feasibility of developing potential water resources for the long range water demands of Marco Island. In addition, since it is our belief that this is not only a water resource analysis for Marco Island, the Study has been expanded to encompass the planned

North County Wellfield and Treatment Facility. Various tasks included within the Study are briefly described as follows.

1. Examine existing available preliminary surveys, applications, data, reports and plans.

2. Organize and evaluate available data from the South Florida Water Management District, USGS, Marco Island Utilities and others regarding existing hydrogeologic studies and investigations.

3. Prepare historic and projected population and water demands for the Marco Island water service area.

4. Perform a preliminary evaluation of the various potential water sources for service to Marco Island based on existing quantity and quality data, including:

    a. Lower Tamiami Aquifer from a combination of East Golden Gate and North Collier County,
    b. Water Table Aquifer from the Sabal Palm Road area,
    c. Water Table Aquifer from the Fakahatchee Strand area, and
    d. Floridan Aquifer

5. Based upon a review of available data for each of the water sources outlined, estimate wellfield drawdown, well spacing, water quality characteristics and possible wellfield location.

6. Prepare an evaluation of the permittability of each wellfield and coordinate with the South Florida Water Management District.

7. Obtain a listing of existing SFWMD Consumptive Use Permits in the proposed wellfield or supply areas.

8. Prepare a planning level estimate of probable construction and operation and maintenance costs for each wellfield.

9. Prepare appropriate preliminary schematic treatment processes for the potential water supplies and outline key design parameters for each process. Process technologies will include:

   a. Lime Softening plus Ozone
   b. Membrane Softening
   c. Reverse Osmosis
   d. Electrodialysis

10. Conduct a review of existing and proposed regulations which could impact the feasibility of utilizing any of the water supplies or treatment technologies.

11. Evaluate the permittability of each process including disposal of treatment by-products, e.g. lime sludge and reject water.

12. Prepare a planning level estimate of probable construction and operation and maintenance costs for each treatment process.

13. Prepare and outline a transmission system for the applicable alternatives to transport water to Marco Island.

14. Prepare and tabulate the capital, O&M and present worth costs of each alternative determined to be feasible upon completion of the evaluation.

15. Prepare a written report providing and illustrating pertinent data, investigations, conclusions and recommendations regarding the feasibility of Collier County supplying water to Marco Island.

The following sections of this Report provide a summary of our review and evaluation of the potential water resources and technologies available to provide Marco Island with a long-term, reliable water supply.

II. BACKGROUND

A. Current Situation

The hydrogeology and normal annual rainfall pattern of Southwest Florida regularly results in low groundwater levels through the dry weather winter and spring seasons. Extended low rainfall periods can and have, on a short term basis, affected those water supplies that are most influenced by the water table aquifer. One of the supplies that has historically been affected is the Marco Island Utilities' raw water supply lakes located on the mainland, northeast of the County Road 951 and U.S. 41 East highway intersection. The raw water supply is located on land leased from the Barron Collier Company. The land lease expires in 1994 and is not expected to be renewed.

As a supplement to the lake supply, an infiltration trench system was installed in Section 26, approximately one mile north of the existing lake system to assist in meeting the long term water demands. This trench was placed into operation in December of 1986. An additional infiltration trench was recently installed along the south line of Section 26. Water is pumped from the trenches and either discharged into the lakes for replenishment or optionally pumped directly to the treatment plant.

Raw water is transmitted approximately 8 miles via high service pumps, through parallel 12-inch and 14-inch diameter transmission mains south along S.R. 951 to the Marco Island Utilities water treatment plant located on the island. A booster pump is located approximately midway along S.R. 951. A subaqueous crossing of the Marco River is a 30-inch diameter main, which should be capable of handling ultimate water needs of the island.

B. Water Quality

The lake and supplemental infiltration gallery system has generally provided an acceptable quality of water for treatment by the existing lime softening facility operated by Marco Utilities; however, the supply is susceptible to potential salt water intrusion during high demand and extended low rainfall periods. Records indicate that the lake supply remains within potable standards, although chloride levels have approached the potable drinking water standard of 250 ppm on several occasions. The drinking water standard apparently has not been exceeded since November 1977 when rock mining and dewatering activity was occurring on the site.

III. WATER DEMANDS

Projection of water demand for Marco Island has proven to be a difficult task. The combination of extended water use restrictions over each of the past several dry seasons, seasonal influx of part-time residents and tourists, a high irrigation demand and low water pressures makes Marco Island atypical of most other communities in southwest Florida.

The water use restrictions placed on Marco Island has resulted in lower annual average day, maximum month and maximum day demands than would normally be required to fully serve the system users. The 1986 Water Master Plan for Western Collier County prepared by Hole, Montes and Associates, Inc. used 200 gallons per capita per day applied to the "peak seasonal population" plus commercial use to determine the projected water demands. Based on the analysis within this Study, the previous assumptions appear to remain reasonable. An estimated maximum month to annual average day factor is 1.35 and a maximum day to annual average day factor is 1.5. This equates to approximately 300 gallons per day per person water demand on Marco Island during the peak season, of which an estimated 65% is used for irrigation purposes.

Minimum capacity of the water resource components should be based on maximum month average day demands, while system storage provides excess capacity for higher daily demands. Pumping and distribution system components should be capable of meeting maximum day plus fire flow or peak hour demands.

Projected housing units, resident and peak seasonal populations are provided below. Housing unit and resident population projections were obtained from the Collier County Planning Department. Seasonal populations were developed using estimated occupancies during winter season and are considered reasonable based on available data. Using the 200 gpcd and commercial flows as previously used in the 1986 Water Master Plan, projected annual average day demand in 1990 is 6.17 MGD and is projected to increase to 12.84 MGD by 2010. Table 1 provides projections of annual average day, maximum month average day and maximum day demands for each year from 1990 to 2010. In addition, water consumption for potable uses is estimated to be around 100 gpcd, while water consumption is usually for non-potable uses such as car washing and irrigation. Water resource and treatment facilities should be designed to supply maximum month average day requirements, and is used as the demand basis to size system components and construction phasing within this Report. Table 2 provides a breakdown of the estimated potable and irrigation water needs for the design maximum month average day from 1990 through 2010.

HOUSING UNIT AND POPULATION PROJECTIONS

	1988	1990	1995	2000	2005	2010
Housing Units[1]	12,288	13,419	16,418	20,526	24,445	28,120
Resident[1]	10,093	10,910	13,754	16,688	19,874	22,832
Seasonal	17,063	18,746	23,635	28,674	34,149	39,313
Total Design Pop.	27,156	29,656	37,389	45,362	54,023	62,145

Note: 1) 1988 thru 2005 obtained from Demographic and Economic Profile of Collier County, Revised 9/1/88, Collier County Planning Department.

2) Year 2010 is projected as approximate buildout of Marco Island.

TABLE 1

PROJECTED WATER DEMAND

YEAR	ANNUAL AVERAGE DAY (MGD)	MAXIMUM MONTH AVERAGE DAY (MGD)	MAXIMUM DAY (MGD)
1990	6.165	8.323	9.248
1991	6.483	8.752	9.725
1992	6.801	9.181	10.202
1993	7.118	9.609	10.677
1994	7.436	10.039	11.154
1995	7.754	10.468	11.631
1996	8.085	10.915	12.128
1997	8.416	11.362	12.624
1998	8.746	11.806	13.119
1999	9.077	12.254	13.616
2000	9.408	12.701	14.112
2001	9.761	13.177	14.642
2002	10.113	13.653	15.170
2003	10.466	14.129	15.699
2004	10.818	14.604	16.227
2005	11.171	15.081	16.757
2006	11.505	15.532	17.258
2007	11.838	15.981	17.757
2008	12.172	16.432	18.258
2009	12.505	16.882	18.758
2010	12.839	17.333	19.259

NOTE:
1) Maximum Month Average Day is 1.35 X Annual Average Day
2) Maximum Day is 1.5 X Annual Average Day

TABLE 2

ESTIMATED BREAKDOWN OF
POTABLE AND IRRIGATION DEMANDS

YEAR	MAXIMUM MONTH AVERAGE DAY (MGD)	POTABLE[1] DEMAND (MGD)	IRRIGATION DEMAND (MGD)
1990	8.323	2.966	5.357
1991	8.752	3.121	5.631
1992	9.181	3.275	5.906
1993	9.609	3.430	6.179
1994	10.039	3.584	6.455
1995	10.468	3.739	6.729
1996	10.915	3.898	7.017
1997	11.362	4.058	7.304
1998	11.806	4.217	7.589
1999	12.254	4.377	7.877
2000	12.701	4.536	8.165
2001	13.177	4.709	8.468
2002	13.653	4.882	8.771
2003	14.129	5.056	9.073
2004	14.604	5.229	9.375
2005	15.081	5.402	9.679
2006	15.532	5.565	9.967
2007	15.981	5.727	10.254
2008	16.432	5.890	10.542
2009	16.882	6.052	10.830
2010	17.333	6.215	11.118

Note: 1) Estimated potable demand is 100 gpcd.

IV. WATER RESOURCES

A. General

This section of the Report provides a description and analysis of available water resources that could potentially be developed as long range supplies for Marco Island. The sources investigated include a) the existing water supply lakes and infiltration system b) the Water Table Aquifer north of U.S. 41 E and east of C.R. 951 c) the Water Table Aquifer in the Fakahatchee Strand area d) the Water Table Aquifer in the Sabal Palm area e) Deep Saline Aquifers and f) the Lower Tamiami Aquifer in the Golden Gate Estates and North County areas.

The analysis considers several criteria in order to reach conclusions as to the feasibility of developing the resources as long term water supplies for Marco Island. The criteria include water quantity, water quality and permittability. After preparing conclusions as to the feasibility of developing the various potential resources, a cost-effective analysis was performed to complete the feasibility study.

B. Existing Water Supply Lakes

Marco Island Utilities has historically obtained its water supply from a lake system at the northeast corner of U.S. 41 and SR 951 (see Figure IV-1). As a supplement to this supply, an infiltration trench system was installed in Section 26, approximately one mile north of the existing lake in order to assist in meeting the water demands (Figure IV-2). This trench was placed into operation in December of 1986 and an additional infiltration trench was recently installed along the south line of Section 26. The lake and infiltration systems are generally recharged by rainfall and lateral

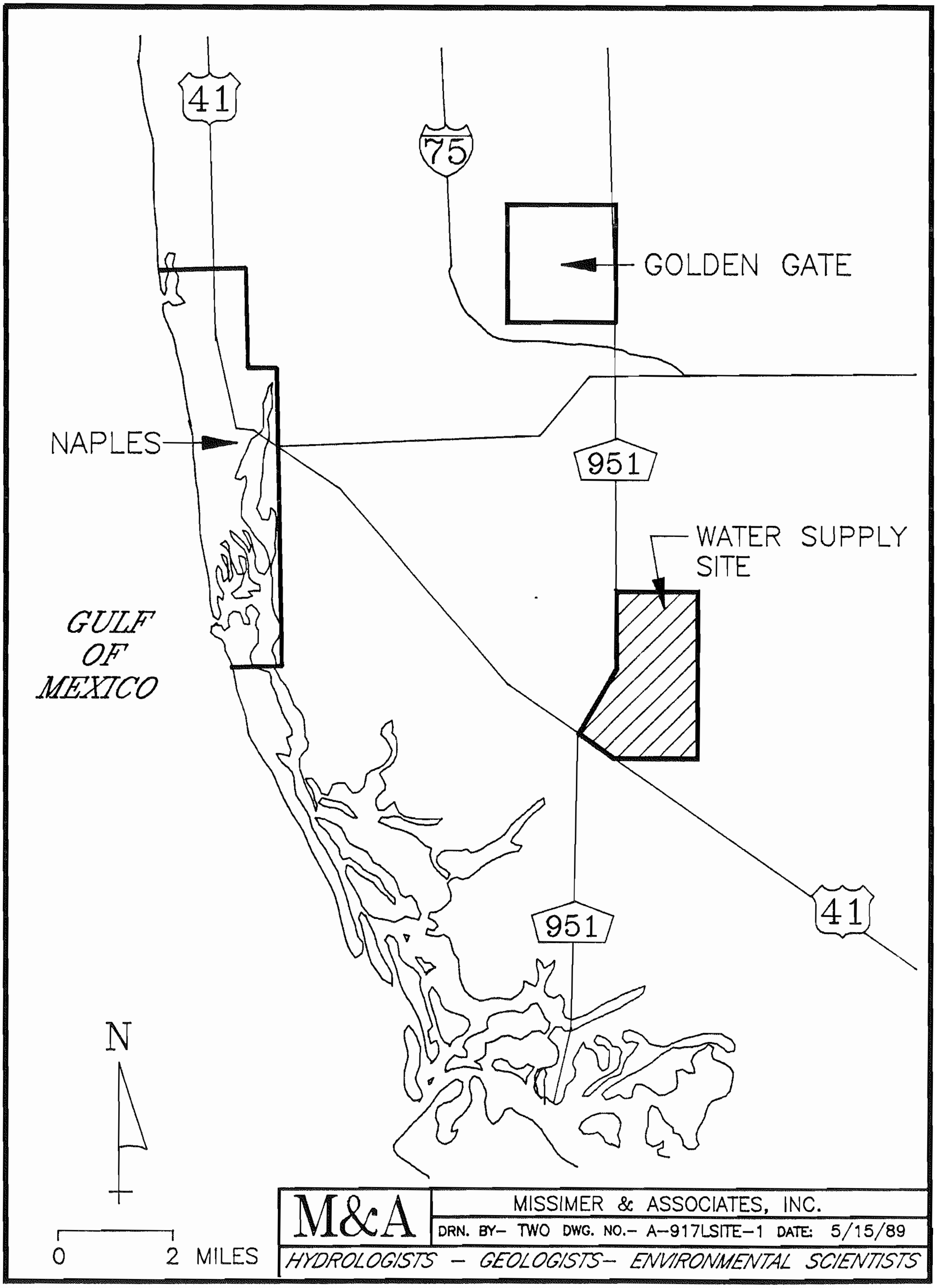


FIGURE IV-1 LAKE/INFILTRATION GALLERY SITE.

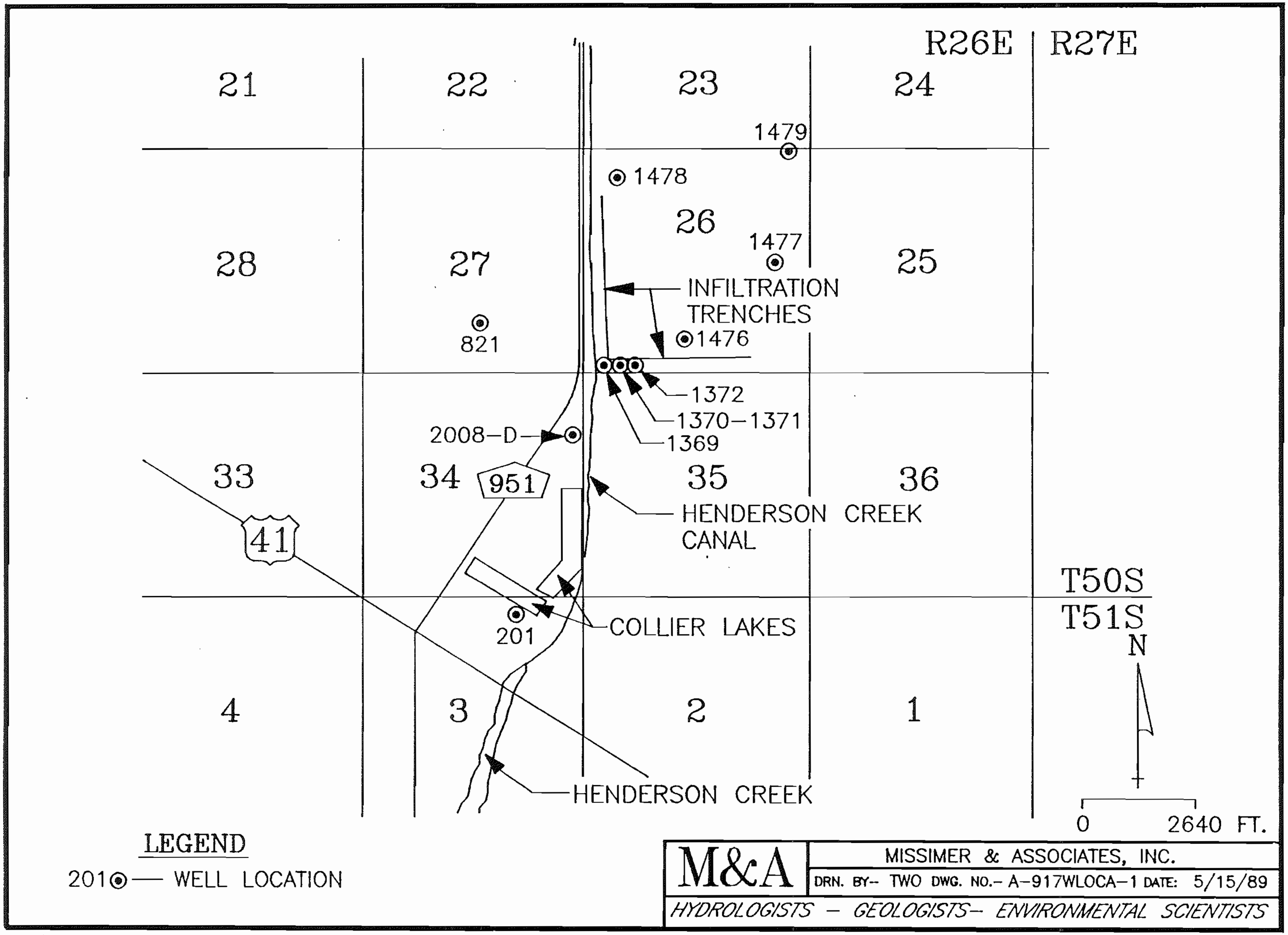


FIGURE IV-2 LOCATION OF WELLS FOR WATER QUALITY SAMPLING.

movement of groundwater through the Water Table Aquifer. Water is pumped from the trenches and either discharged into the lakes for replenishment or optionally pumped directly to the treatment plant. Marco Utilities presently has a Consumptive User Permit allowing 6.23 MGD withdrawals from the system.

Two studies of the aquifer system at the site have been performed to develop an estimated safe yield. One study utilized a 3-dimensional model to evaluate existing pumpage and drawdown records at the lakes. A second study utilized a solute transport model to analyze the potential for saltwater intrusion into the lake/infiltration trench system.

The model output, together with information regarding groundwater quality, seasonal climatic factors, and hydrologic records, were used to determine an estimated safe yield. The purpose of this hydraulic modeling investigation was to determine the production capability of the shallow aquifer at the project site without causing excessive saltwater intrusion resulting in potable standard violations. The evaluation considered local water quality information, site specific testing of a significant portion of the withdrawal system, and computer modeling.

The primary factor considered in determining the potential for saltwater intrusion was aquifer head. Ten (10) years of historical data from the existing system indicates that dissolved chloride concentrations have not increased above the potable limit as long as the water level remained above sea level. On this basis, a minimum allowable average water level in the shallow aquifer was set at +1 foot NGVD. For the 1-in-10 year return period dry season, the water level was allowed to decline to a minimum of -1.5 feet NGVD, but only at the end of the dry period.

Under extreme dry season conditions, the saline water which is present in the lower part of the aquifer will rise during the dry season due to hydrodynamic and density related forces. Recharge during the wet season should be sufficient to replenish the aquifer to its normal wet season level and, in a similar manner, force the saline water downward. Approximately 20 feet of potable quality water between the base of the infiltration trench and the higher chloride water also provides some margin of safety.

Determination of the available safe yield involved an evaluation of water level declines at numerous pumping rates and various seasonal conditions. Ultimately, the 1-in-10 year dry season water level criteria were the most restrictive, and the safe yield amount was determined to be approximately 11 million gallons per day. However, further observations and study showed that an 11 MGD yield using this model was not adequately sensitive to water quality changes. Therefore, a solute transport model was used to more accurately evaluate safe yield.

An analysis was also performed to determine the quantity of water which could be safely produced from the existing lakes during the wet season. For this evaluation, Henderson Canal was simulated as a recharge boundary within the upper layer. The model showed that for wet season conditions, the lakes will be able to provide 7 MGD while maintaining the lake level at or above +1.5 foot NGVD. As the lake elevation declines to near the 1.5 feet level, pumpage from the infiltration trench system must be increased to minimize drawdown of the lake system.

A detailed analysis of the hydrogeologic characteristics of the project site used the MODFLOW hydraulic model (McDonald and Harbaugh, 1988) in order to determine the availability of fresh water from the water-table aquifer/lake system. This analysis made a logical and reasonable extension of hydraulic and water quality characteristics beyond the site boundaries and the computer model was developed to evaluate impacts. The investigation lead to a number of preliminary conclusions. 1) The amount of water available from a proposed expanded infiltration trench system was determined to be approximately 11 million gallons per day (MGD) pumped on an average daily basis. 2) The withdrawal of 11 MGD from the expanded infiltration trench system does not allow for additional withdrawals from the lake system during the dry season. However, the lakes may be used as a conduit in the transmission system. This could be accomplished by pumping from the trench system into the lakes and then pumping from the lakes using the existing facilities. 3) During the wet season, the lakes could provide up to 7 MGD of water without allowing water levels to decline below +1.5 foot NGVD. 4) Pumping of the lake system during the wet season will allow the infiltration gallery area to recharge and maintain a high wet season water level.

In order to obtain another analysis of the potential for pumpage induced vertical (upward) migration of saline water beneath the raw water sources, a solute transport model was used. The selected model was adapted to simulate two sets of conditions: 1) the infiltration trench, and 2) the lake system. The initial conditions used for the analyses were based on information collected during previous investigations, and the modeling attempted to simulate conditions which occurred during 1987.

The model selected to simulate the movement of saline water in response to pumping of the lake/infiltration trench system was developed by the U.S. Geological Survey, and is described in WRI report 85-4279, A Two-Constituent Solute Transport Model for Groundwater having Variable Density. A particular feature of this model which makes it applicable to the hydrogeologic system in the area of the withdrawal, is its consideration of effects of density variation within the flow field. Density variation is not a consideration for many currently used solute transport models because the models were developed to simulate migration of contaminants which are not usually present in concentrations high enough to show density stratification. The infiltration trench and the lake were modeled separately.

The resultant output of the infiltration trench computer model yielded a total dissolved solids (TDS) cross-section or map and an aquifer hydraulic pressure map at the end of the simulation time for a pumping rate of 1.5 MGD. This analysis shows that the TDS concentration in the aquifer at the location of the trench withdrawal point increased from approximately 256 mg/l to 821 mg/l. This corresponds to a final chloride concentration of 180 mg/l, an increase from an initial concentration of 100 mg/l. The chloride concentration in the cell 5 feet below the trench increased to about 250 mg/l.

The lake withdrawal simulation was performed and a total dissolved solids map was calculated with continuous pumpage at a rate of 5.3 MGD for 90 days with no vertical recharge of the lake. The TDS in the lake near the withdrawal points increased to about 920 mg/l, which corresponds to a chloride level of about 200 mg/l. At the end of the simulation time, the position of the 250 mg/l isochlor moved upward from the approximate 50 foot depth to a depth of about 20 feet.

Detailed records of water use, water storage in the lakes, rainfall, and dissolved chloride concentrations in the lakes are available from 1977 to present. A diagram showing the chloride concentrations from 1985 to March 1989 is provided on Plate 1 in Appendix A. Average day water use in a maximum use month has been as high as 6.45 MGD (April, 1988). The water storage in the lake system has been as low as 2.96 feet below sea level (NGVD) in May of 1985 and about 2.7 feet in April of 1989. Records indicate that the dissolved chloride concentration in the lake has approached the potable drinking water standard of 250 mg/l on several occasions, but has not exceeded it since November, 1977, when mining activity was still occurring on the site.

As shown on Plate 1, installation of the infiltration galleries appears to have helped stabilize the overall quality of water pumped from the system and provides some measure of protection during extreme dry periods assuming withdrawal rates remain in the 5 to 6 MGD range.

The combined lake/infiltration gallery system is a viable source of water if it is managed properly. Modeling of the system indicates that between 6.8 and 11 MGD should be produced from the system without causing water quality to exceed the potable water standard of 250 mg/l of dissolved chloride. It is prudent, however, to utilize the more conservative output of the solute transport model which resulted in a safe yield of about 6.8 MGD during critical dry periods. Records indicate the system has been pumped at a rate of 6.45 MGD without causing the dissolved chloride concentration to exceed 250 mg/l.

C. Water Table Aquifer - Section 35

Deltona purchased a site approximately seven (7) miles due east of the existing water supply lakes for the purpose of developing the area as a future water supply. The property, covering 160 acres, is located in Section 35, Township 50S, Range 27E, along an extension of Sabal Palm Road (see Figure IV-3). The site was originally selected by Deltona because it contains good quality water and is within an area that would be hydraulically recharged by the Golden Gate Estates canal system.

A preliminary investigation of the feasibility of developing this area as a raw water source was undertaken several years prior to the purchase of the property. The investigation included: drilling two test wells; pumping for a short period of time to determine water quality characteristics; and computer modeling to estimate potential yield.

Test wells were drilled and were cased to a depth of 40 feet. The geology of Section 35 is somewhat different than that of the existing lake supply site. There is approximately 2 feet of sand and soil overlying the Ochopee limestone unit. The limestone unit encountered contained only a minimum amount of marl throughout the depth of the boreholes, and the aquifer system appears to be insignificantly confined. Geologist's logs for wells CO-1707 and CO-1708, which were located near wells CO-263 and CO-264, are given in Tables 3 and 4. The test wells were each pumped for a period of approximately 1 hour. Well 263 produced water at a rate of 100 gpm, and well 264 was pumped at 20 gpm.

Water quality samples and laboratory results showed dissolved chloride concentrations in wells CO-263 and CO-264 were 53 and 95 mg/l, which is relatively low with respect to public supply standards. A chemical analysis of the water sample from well CO-263 is provided in Table 5. Although there is some salinity present, water taken from a depth of 40 feet indicates there is a sufficiently thick zone of fresh water

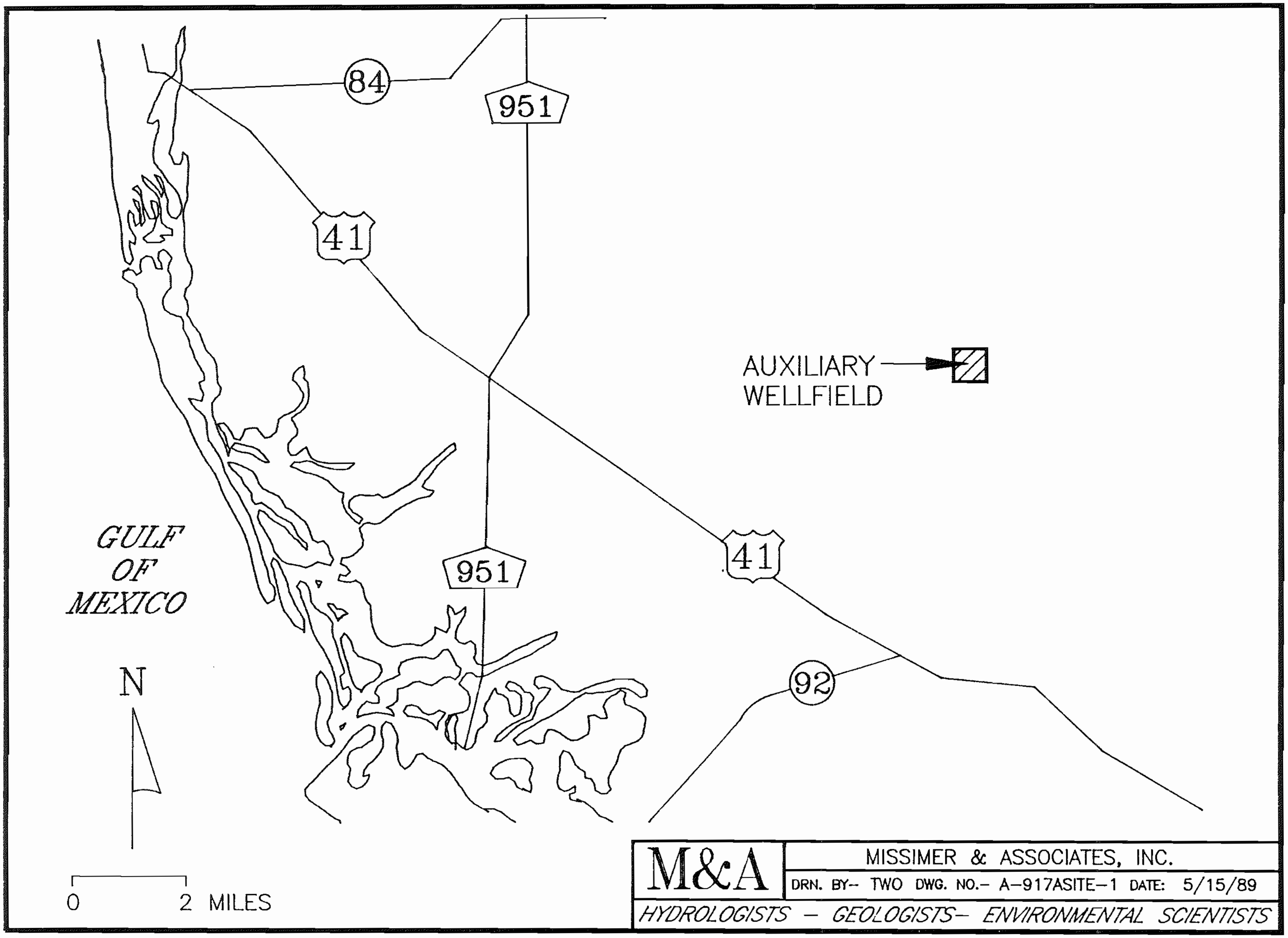


FIGURE IV-3 MAP SHOWING FUTURE LOCATION OF AUXILIARY WELLFIELD.

TABLE 3

GEOLOGIST'S LOG
WELL #CO-1707

Depth (feet)	Lithology
0-5	Sand, brown, fine to medium.
5-8	Sandy limestone, light cream-brown, poorly indurated, abundant coarse quartz sand, minor clay.
8-10	Sandy clay, olive-brown, stiff, minor phosphate, trace shell.
10-20	Limestone, cream-light gray, moderately indurated, marly, minor shell.
20-30	Limestone, cream-light gray, moderately well indurated, sparry, moldic porosity, common shell, trace sand.
30-40	Limestone, cream-light gray, moderately well indurated, sparry, moldic porosity (greater than above), abundant shell, trace sand.
40-50	Limestone as above, slightly more sand and finely phosphatic.
50-60	Limestone, as above, sand fraction coarser.
60-82	Sandy limestone, cream-light gray, moderately well indurated, sparry, moldic porosity, minor shell.
82-100	Sandstone, tan-light gray, moderately indurated, calcareous matrix, abundant shell.
100-120	Sandstone, tan-gray, moderately indurated (better induration with depth), medium to coarse quartz grains, coarse phosphate grains, abundant shell, common clay.

TABLE 4

GEOLOGIST'S LOG
WELL #CO-1708

Depth (feet)	Lithology
0-2	Sand, brown, fine to medium.
2-6	Sandy clay, olive-brown, stiff, medium to coarse quartz grains, trace limestone fragments, trace phosphate.
6-12	Sandy limestone, tan-light brown, poorly indurated, medium to coarse quartz grains, sparry, minor shell, minor clay.
12-20	Limestone, cream-gray, moderately indurated sparry, moldic porosity, common shell.
20-30	Limestone, cream-light gray, moderately well indurated, sparry, moldic porosity (greater than above), abundant shell, trace sand.
30-40	Limestone as above, slightly less indurated.
40-50	Limestone, cream-light gray, moderately indurated, fossiliferous, moldic porosity, common shell, minor quartz sand, trace fine phosphate.
50-55	Limestone as above.
55-60	Lost circulation - no cuttings.
60-70	Sandstone, cream-light tan, moderately indurated, quartz grains, fine to coarse, calcareous matrix, minor shell, trace phosphate.
70-80	Sandstone as above.
80-90	Sandstone as above, quartz coarser than above.
90-100	Sandstone, cream-light gray, moderately indurated, quartz grains, fine to medium, calcareous matrix, common shell, trace phosphate, trace limestone fragments.

TABLE 4

GEOLOGIST'S LOG
WELL #CO-1708
Continued:

Depth (feet)	Lithology
100-120	Sand and shell, cream-gray, poorly indurated, quartz grains predominate, minor sandstone fragments, trace coarse phosphate grains.

TABLE 5 CHEMICAL ANALYSIS OF WATER FROM THE SECTION 35 TEST WELLS

Well No. 263

Total Dissolved Solids	484 mg/l
p-Alkalinity	0 mg/l
Total Alkalinity	348 mg/l
Chloride	53 mg/l
Sulfate	1.0 mg/l
Fluoride	.10 mg/l
pH	6.6
Color	68 PCU
Turbidity	6.1 NTU
Total Hardness	360 mg/l
Calcium Hardness	190 mg/l
Magnesium Hardness	170 mg/l
Sodium, atomic adsorption	62 mg/l
Iron, atomic adsorption (filtered)	.11 mg/l
Manganese, atomic adsorption	.04 mg/l
Copper, atomic adsorption	.01 mg/l
Silica, atomic adsorption	6.0 mg/l

Calculations:

Carbonate Alkalinity	0 mg/l
Bicarbonate Alkalinity	348 mg/l
Carbonates, as CO_3	0 mg/l
Bicarbonates, as HCO_3	190 mg/l
Hydroxides, as OH	0 mg/l
Carbon Dioxide, as CO_2 (free)	0 mg/l
Total CO_2 by calculation	306 mg/l
pH_s	7.02
Stability Index	7.44
Saturation Index	-0.42

Well No. 264

Chloride	95 mg/l

which could be developed to supply potable water using conventional treatment methods. Based on information obtained, it is expected that a wellfield could be developed to produce water from wells in the upper 20 feet of the aquifer system. A number of low yield (less than 150 gpm) wells or infiltration trenches could be used. Further investigation may show that higher yield wells could be safely obtained.

Due to the stratified nature of water quality in the area, chloride profiles were obtained from the wells drilled at the site. The two wells were constructed in a manner which allowed for collection of samples at various depths. At several desired testing depths, a temporary casing and packer was installed and the well was cleared. The well was then pumped for several minutes in order to obtain a water sample and estimate formation yield. Following this, the casing was removed, drilling proceeded to the next depth selected for testing, and the process was repeated.

The water quality profile from each of the wells is shown on Table 6. Well CO-1707 showed that the water quality was potable (with respect to salinity) to a depth exceeding 100 feet. Below this point, water quality deteriorated rapidly. At Well CO-1708 the water quality remained potable to a depth between 60 and 100 feet. Below 100 feet, the salinity again increased at a rapid rate.

TABLE 6

WATER QUALITY ANALYSIS
WELL #CO-1707

Depth (feet)	Chloride Ion Concentration (mg/l)	Conductivity (umhos)
40	40	735
60	80	833
100	200	1274
120	760	3018

WATER QUALITY ANALYSIS
WELL #CO-1708

Depth (feet)	Chloride Ion Concentration (mg/l)	Conductivity (umhos)
40	40	810
60	180	1205
100	320	1619
120	720	2796

The rate of production from the wells at the various depths and an analysis of the drill cuttings indicate that the more highly saline water is present within portions of the aquifer which have a relatively low permeability. These lower portions of the aquifer are characterized by increased sand and sandstone indicative of reducing permeability with depth. The portions of the aquifer which contain fresh water were shown to be the most productive. This is typical of the shallow Tamiami Formation which has been tested elsewhere in the region.

The production capability of the 160 acres in Section 35 was assessed using a computer model and assumed aquifer coefficients. The aquifer coefficients selected were conservative using information from several tests conducted on the Tamiami Aquifer in Collier County. The conditions simulated included continuous pumpage for 150 days with no rainfall. In this case, the aquifer system was expected to react as an unconfined aquifer. The modeling utilized a transmissivity of 350,000 gpd/ft^2 and a specific yield of 0.1. The transmissivity value used is a conservative estimate, since additional studies have indicated that the transmissivity in the study area may range between 500,000 and 900,000 gpd/ft^2 (Missimer and Associates, Inc., 1980).

The limiting condition selected to determine the amount of water which could be safely withdrawn from the property was the drawdown within the wellfield boundaries. This drawdown was not allowed to exceed 5 feet for any pumping configuration. A number of pumping options were evaluated, and the one which yielded the best results included 24 wells situated along the property boundaries, with each well pumping 145 gpm. The water table drawdown was approximately 5 feet and relatively uniform across the property.

Based on the information collected, an estimate was made of the ability of the site to produce fresh water considering potential salinity changes induced by withdrawal. For this evaluation, an elementary solute transport model was used to evaluate the potential for vertical (upward) migration of saline water. This first analysis assumed that a system of infiltration trenches was used to make the withdrawal. The evaluation showed the site to be capable of yielding 5 to 6 mgd of freshwater without causing the saltwater interface to move vertically by an amount of more than 40 feet. For the modeled case, the quality of the water produced remained below about 160 mg/l dissolved chloride.

A similar evaluation was made for raw water production using wells approximately 40 feet deep. Results of this analysis showed that wells will experience salinity increases to unacceptable levels when pumped at rates exceeding 100 gpm. Therefore, the 145 gpm pumping rates used in the preliminary hydraulic model would be too high and a low yield system would have to be utilized.

The above analyses presented should be viewed as preliminary since quantitative testing of the aquifer characteristics has not been completed. Of particular importance are estimates of the vertical permeabilities of the zones between the approximate 50 and 120 feet depth. These permeability characteristics control the amount of saline water which could flow in the vertical direction in response to pumping induced drawdown. Any final determination of the production capacity of the site must include detailed analysis of the vertical flow characteristics.

D. Water Table Aquifer - Fakahatchee Strand

In 1986, the South Florida Water Management District published the Preliminary Assessment of the Groundwater Resources of Western Collier County, Florida. The assessment report indicates that a large area underlying the Fakahatchee Strand contains a thick sequence of highly transmissive limestones. Preliminary sampling indicated that the eastern portion contains high color, indicative of high organic content. The western area, however, appears to contain high quality water.

Although no independent testing of this potential water resource was performed during this Feasibility Study, the SFWMD Assessment Report states that water could be produced from the area in excess of 30 MGD. Two (2) pump tests conducted along Everglades Boulevard south of S.R. 84 yielded transmissities in excess of 900,000 gpd/ft. The potential high yield is due to the large areal extent and thickness of the formation and the proximity of major freshwater canals, which would act as a source of recharge in the dry season.

A preliminary meeting with the South Florida Water Management District warned of the obstacles associated with developing this as a major water supply. Due to the extremely remote location and obvious permitting constraints related to environmental concerns for the Fakahatchee Strand, this water resource was eliminated from further consideration during this Feasibility Study.

E. Water Table Aquifer - Sabal Palm Area

The South Florida Water Management District's report on the previously referenced Assessment of Groundwater Resources in Western Collier County, Florida described an area of moderate potential for development as a major water supply.

Over the past 12 years, a substantial quantity of information has been gathered on the water resources of the area south of S.R. 84 to Marco Island. There are two significant aquifers that occur at relatively shallow depth, the water-table aquifer and the Lower Tamiami Aquifer. In the area near the lakes where Marco Utilities presently obtains its water supply and to the south, the Lower Tamiami Aquifer is confined from the water-table aquifer by a thin marl or carbonate clay unit. In the Sabal Palm Road area and to the north, there are areas where there is no confinement and the entire system is a water-table aquifer.

Various well inventories have been conducted in this area and numerous test wells have been drilled. The locations of wells on which data are available is given in Figure IV-4. Information on each of the wells is given in Appendix B.

Water availability in the area from U.S. 41, south to the Marco River is severely limited due to the presence of saline water within both the water-table aquifer and the Lower Tamiami Aquifer. Existing water use permits in the area include the Eagle Creek Golf Course, the MacAllister Farm, a nursery, and a few other farms. A number of single-family homes also use wells tapping the shallow aquifers in this area. Many of these water users have experienced water quality problems in the past. Both aquifers contain saline water, which moves in response to changing seasonal conditions and pumping.

In the area of Sabal Palm Road and to the north, only a minor quantity of water is presently permitted. However, based on the well data collected to date and the quality of water in Henderson Creek Canal, the quantity of available freshwater in the water table aquifer appears to be limited. The Lower Tamiami Aquifer appears to contain non-potable water in all

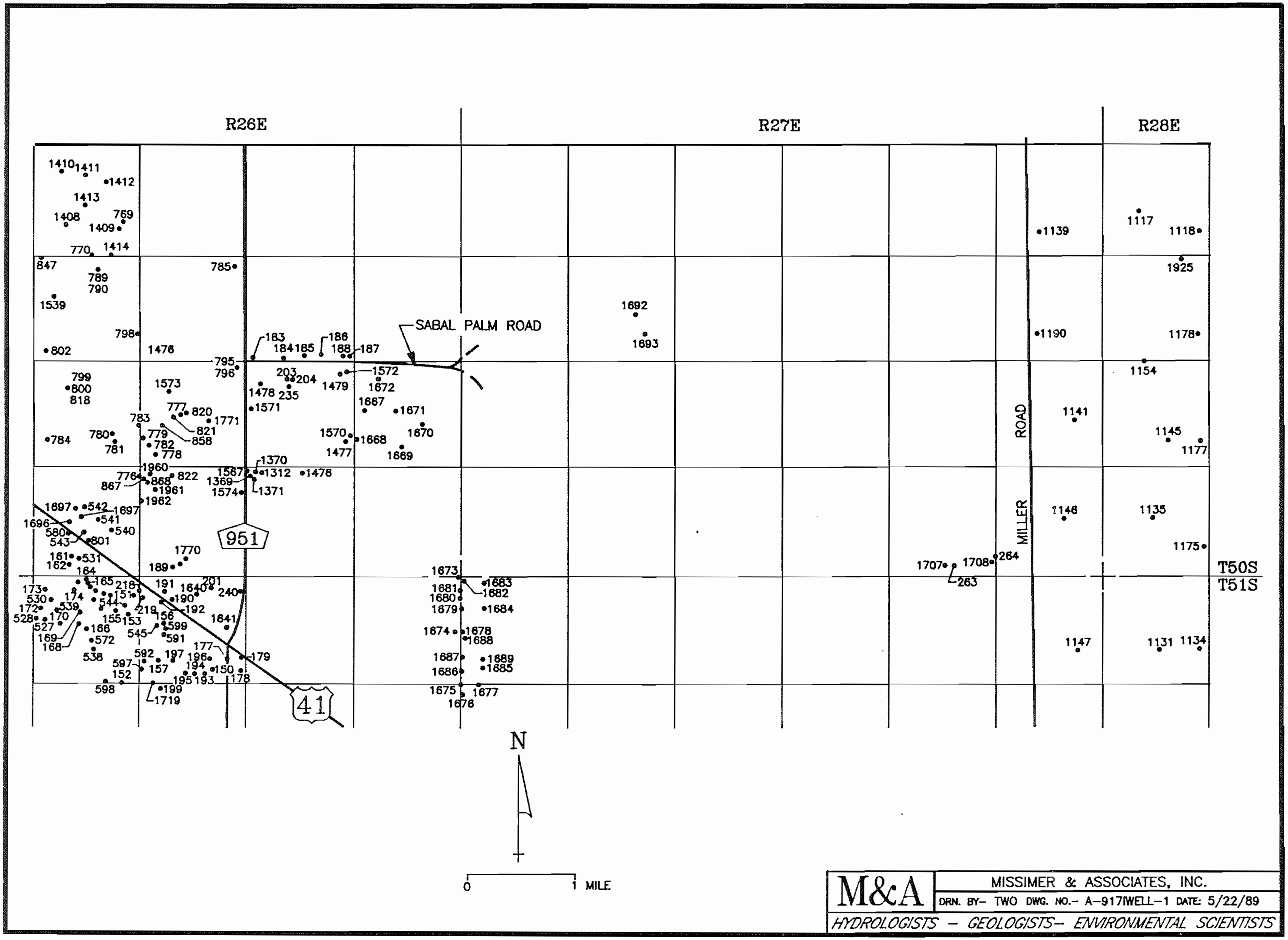


FIGURE IV-4 MAP SHOWING LOCATION OF INVENTORIED WELLS.

areas from Marco Island north to S.R. 84 within a corridor varying from 1/2 to 2 miles on either side of Henderson Creek Canal. The quality of water on the west side appears to be somewhat better than the east side. Water samples collected from Henderson Creek Canal during dry season low flow conditions have had chloride concentrations of up to 200 mg/l one mile upstream of the control structure. The occurrence of saline water in this area appears to be natural; the result of incomplete flushing of the aquifer. Future development of a large localized freshwater supply from the water table aquifer or the Lower Tamiami in this area is questionable. A series of infiltration trenches or low volume wells would have to be constructed which could potentially result in unacceptable impacts on nearby wetlands. Also, mitigation of impacts on existing permitted users would likely be cost prohibitive due to the large number of wells in the area.

F. Deep Saline Aquifers

In addition to those potential freshwater resources in south Collier County, investigations are now underway to evaluate deeper aquifers containing higher concentrations of dissolved solids and chlorides. These supplies require a higher level of treatment than the conventional lime softening process now utilized by Collier County and Marco Utilities. A reverse osmosis or electrodialysis treatment process will be required in order to develop these resources as a potable water supply.

In order to evaluate the feasibility of developing a source of saline water for treatment by the reverse osmosis or electrodialysis process, a test well was recently drilled on Marco Island to a depth of 800 feet below surface. The well was located on the site of the existing Marco Utilities water treatment plant. The test drilling program was designed to maximize the quantity and quality of data collected by using a combination of rotary mud and reverse air techniques. A 24-inch bore hole was drilled to 50 feet below land surface using the rotary mud method, and an 18-inch steel surface casing was installed and grouted to land surface with neat cement. An 8-inch diameter pilot hole was then drilled to 390 feet below land surface and reamed to a diameter of 18 inches. A 390 foot string of 12-inch diameter Schedule 80 PVC casing was installed and pressure grouted with neat cement.

After installation of the 12-inch diameter casing, drilling operations continued with an 11-inch diameter bore hole drilled to a depth of 500 feet below land surface using the reverse air method. A high flow zone was encountered at 475 feet, and drilling continued with the use of a smaller bit (6-inch diameter), in the event that a cement plug would be necessary. A 6-inch diameter bore hole was drilled from 500 feet below land surface to a total depth of 800 feet. Drill cuttings were collected at 5 foot intervals and at formation contacts for subsequent analysis. Water samples were collected at 20 foot intervals and analyzed for dissolved chloride concentrations and conductivity. A suite of geophysical logs, including gamma ray, caliper, flow velocity, spontaneous potential, electric resistivity, and fluid resistivity were obtained.

After geophysical logging was completed, the well was plugged with Type B cement up to 540 feet below land surface, the depth at which good quality water of significant volumes was encountered. Figure IV-5 shows the construction details and formations penetrated by the test well (CO-1769).

The 800-foot test well successfully penetrated the full thickness of the Hawthorn Group and into the Suwannee Limestone. A potentially useable aquifer was encountered between 330 and 545 feet below surface. This zone is termed

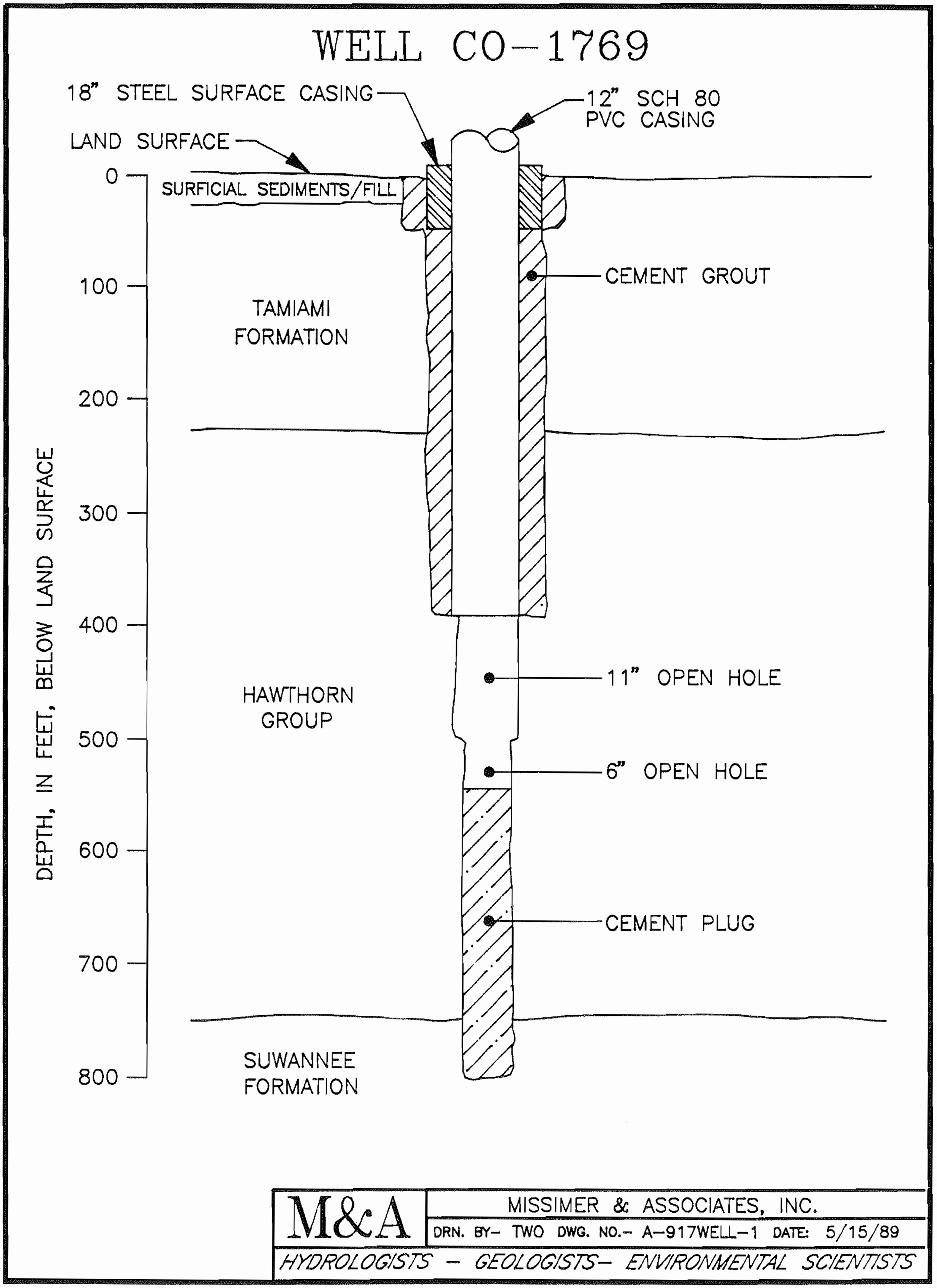


FIGURE IV-5 WELL CONSTRUCTION OF R.O. TEST WELL CO-1769.

Hawthorn-Zone II, as shown on Figure IV-6. The quality of water in this zone ranges from 1910 to 2080 mg/l of dissolved chloride. As shown in Table 7 and Figure IV-7, reasonably good quality water occurs throughout all of the lower section of the Hawthorn Group. However, at a depth of about 700 feet, water quality deteriorates from a dissolved chloride concentration of 1600 mg/l to a concentration of 3650 mg/l. At the bottom of the well the dissolved chloride concentration was 6550 mg/l.

All of the water encountered in the test well below a depth of 330 feet could be treated to potable standards by the reverse osmosis method.

Upon completion of the well and isolation of a production zone lying between 330 and 550 feet below surface, a step-drawdown test was conducted to give some approximate yield data (Table 8). Based on the data obtained, the well could be pumped at a rate of up to 1400 gpm, or 2 MGD. However, without having hydraulic coefficients to model the yield, a conservative individual well yield estimate would be about 1000 gpm or about 1.5 MGD.

During the step-drawdown testing, a water sample was collected for chemical analysis and treatment assessment by a reverse osmosis membrane manufacturer. Results of the testing and analysis by B.F. Goodrich is provided in Appendix C. The dissolved chloride concentration in the water was 2059 mg/l with a total dissolved solid concentration of about 4308 mg/l. There were no chemical parameters identified that would prohibit the water from being used to feed a reverse osmosis water treatment plant. The water did have a silt density index of about 5, which is above the typical design standard of 3. This would be expected to improve to an acceptable level upon further development of the well.

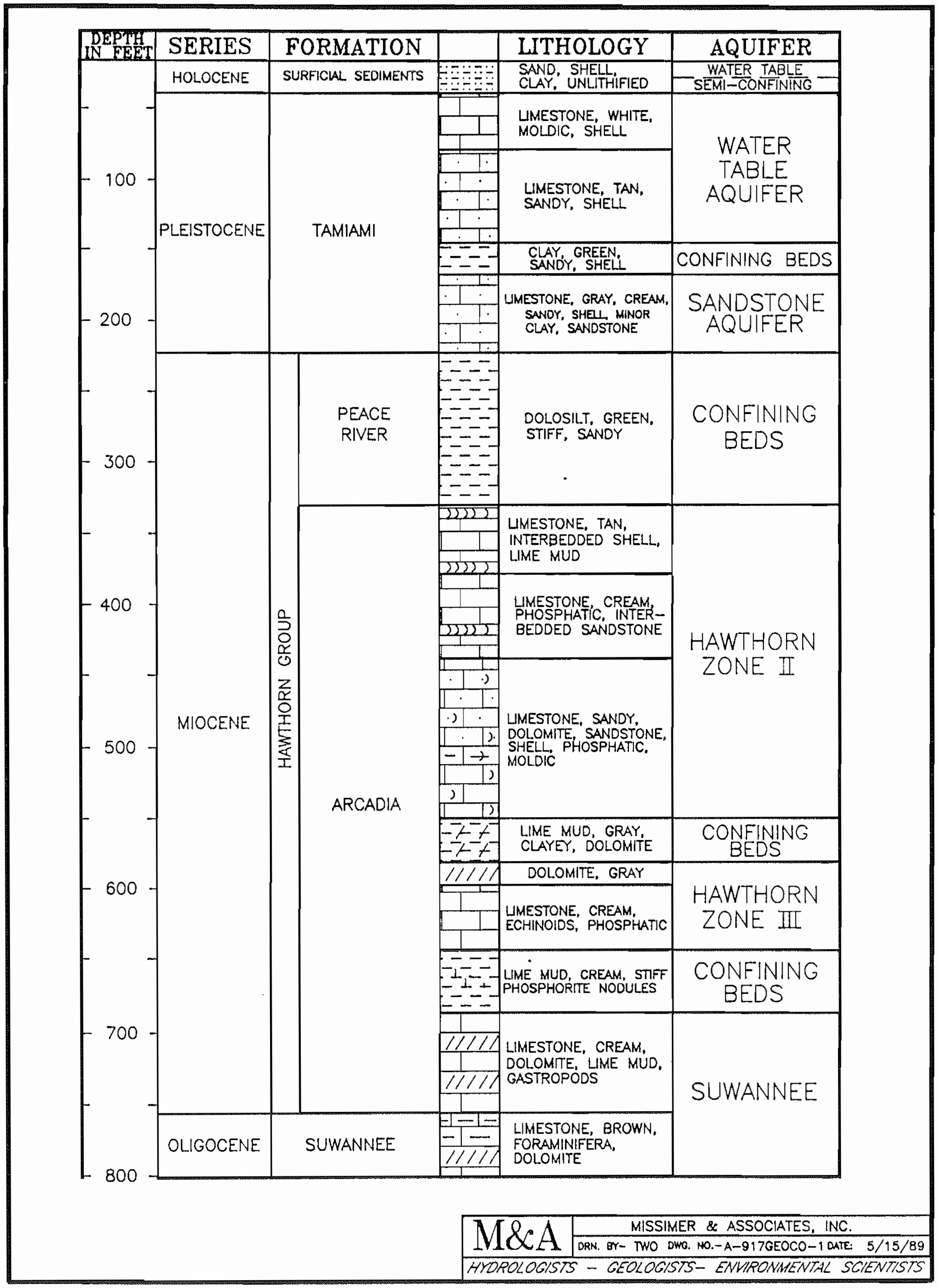


FIGURE IV-6 HYDROGEOLOGIC COLUMN OF WELL CO-1769.

TABLE 7

Water Quality Variation with Depth

for Marco Island Utilities R.O. Test Well CO-1769

Depth (feet)	Dissolved Chloride Concentrations (mg/l)	Conductivity (umhos/cm)
400	1970	6656
420	2040	7280
440	2040	7384
460	2080	7384
480	1940	7344
500	1920	7242
520	1940	7410
540	1910	7212
560	1800	6834
580	1750	6936
600	1700	6834
620	1700	6528
640	1700	6324
660	1600	6426
680	1700	6426
700	1600	6630
720	3650	12954
740	4450	15096
760	5350	17544
780	5650	18768
800	6550	21624

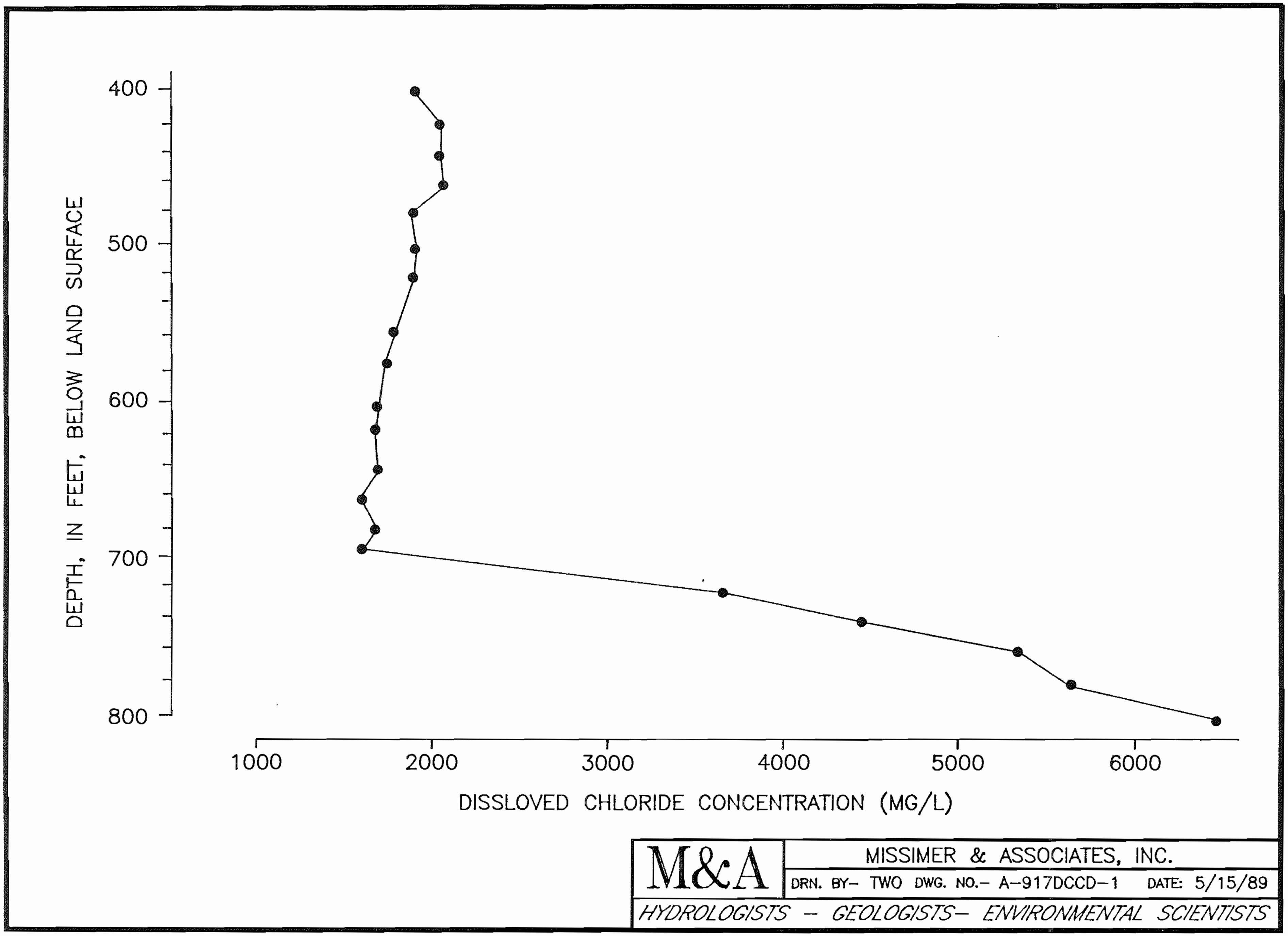


FIGURE IV-7 VARIATION OF DISSOLVED CHLORIDE CONCENTRATION WITH DEPTH.

TABLE 8 TIME AND DRAWDOWN DATA FOR R.O. TEST WELL CO-1769 DURING THE 3-STAGE STEP-DRAWDOWN TEST

Step #1

Q = 470 gpm SWL = 22.08' above lsd Q/S = 34.38 gpm/ft

Minutes from Start	Water Level (ft)	Drawdown (ft)
5	*8.10 above lsd	13.98
12	8.20	13.88
20	8.25	13.83
30	8.33	13.75
40	8.37	13.71
60	8.38	13.70
75	8.41	13.67

Step #2

Q = 790 gpm SWL = 22.08' above lsd Q/S = 31.49 gpm/ft

Minutes from Start	Water Level (ft)	Drawdown (ft)
5	2.65 below lsd	24.73
10	2.70	24.78
20	2.80	24.88
30	2.92	25.00
45	3.00	25.08

Step #3

Q = 907 gpm SWL = 22.08' above lsd Q/S = 30.02 gpm/ft

Minutes from Start	Water Level (ft)	Drawdown (ft)
5	7.75 below lsd	29.83
12	7.90	29.98
20	7.95	30.03
30	7.98	30.06
41	8.05	30.13
50	8.10	30.18
60	8.13	30.21

Note: lsd - land surface datum

Based on the preliminary test program, this is a viable source of water supply for Marco Island utilizing a reverse osmosis treatment process. The total dissolved solids and other parameters indicate that the water could be treated by a standard pressure facility with a product recovery rate of approximately 75%. Treatment techniques and design will be further discussed in subsequent sections of this Report.

While the test program does indicate that a water supply source is available, it is not known at this time what the safe yield of the source will be or if the long-term water quality stability will be adequate. Aquifer hydraulic coefficients must be obtained and solute transport modeling must be accomplished before final determination can be obtained. At the present time, an aquifer performance test program and some additional test drilling is being conducted on Marco Island. Final determination of the yield and stability questions should be available from Marco Utilities within 6 months.

Based on the data collected to date, it appears that at least 5 MGD of finished water could be safely obtained on Marco Island. This would require the development of a saline water wellfield with a yield of approximately 6.7 MGD (1.7 MGD reject). It should be noted that this estimate could be adjusted significantly depending on the results of the test program and modeling efforts.

The test drilling program conducted on Marco Island indicates there is a high probability that additional, treatable saline water in the Hawthorn Aquifer System is available in the vicinity of the existing lake/infiltration trench system. This mainland site is located upgradient with possibly a better water quality. There is a high probability that a least 6 to 8 MGD of saline water from the mainland could be developed, treated by reverse osmosis and transmitted to Marco Island for distribution.

A meeting with the South Florida Water Management District indicated the likelihood of obtaining a water use permit is good. The only major permitting issue is the disposal of the reverse osmosis concentrate water. This concentrate water is currently considered an "industrial waste" and disposal of such is highly regulated. Several options are available for reject disposal and will be discussed later in this Report.

G. Freshwater and Saline Aquifers in North Collier County

Another approach to providing Marco Island with an adequate water supply includes further development of Collier County's existing and planned wellfields, and interconnecting with the existing Marco Utilities transmission and distribution system. The County could then deliver treated water directly to Marco Island.

At the present time, the existing County wellfield located in Golden Gate Estates is committed to feed the existing East County Regional Water Treatment Facility. This wellfield and water treatment plant will be utilized to nearly full capacity within the next 2 to 5 years. Therefore, if water is to be supplied to Marco Island, it will be necessary to expand the Golden Gate Wellfield and/or locate and develop a new wellfield in the northern part of Collier County, as outlined in Collier County's Water Master Plan.

Detailed hydrogeologic evaluations were performed to locate, develop, and permit a major municipal wellfield for Collier County in Golden Gate Estates (Missimer and Associates, Inc. 1986; 1987). The expansion of this wellfield was completed in 1988. At present, there are a total of 16 production wells tapping the Lower Tamiami Aquifer. The installed capacity of the wellfield is 16 MGD. Although the wells can be pumped individually at a total of 16 MGD, the ability to deliver this volume of water to the water treatment plant will require the addition of a booster pump, due to head loss in the existing raw water transmission main.

Collier County and the City of Naples withdraw water from the Lower Tamiami Aquifer in Golden Gate Estates. The Lower Tamiami Aquifer is a very productive aquifer, particularly in the vicinity of Wilson Boulevard. A report produced by the South Florida Water Management District in 1986 suggests that the safe yield of the Lower Tamiami Aquifer in Golden Gate Estates is more than 30 MGD, if properly managed.

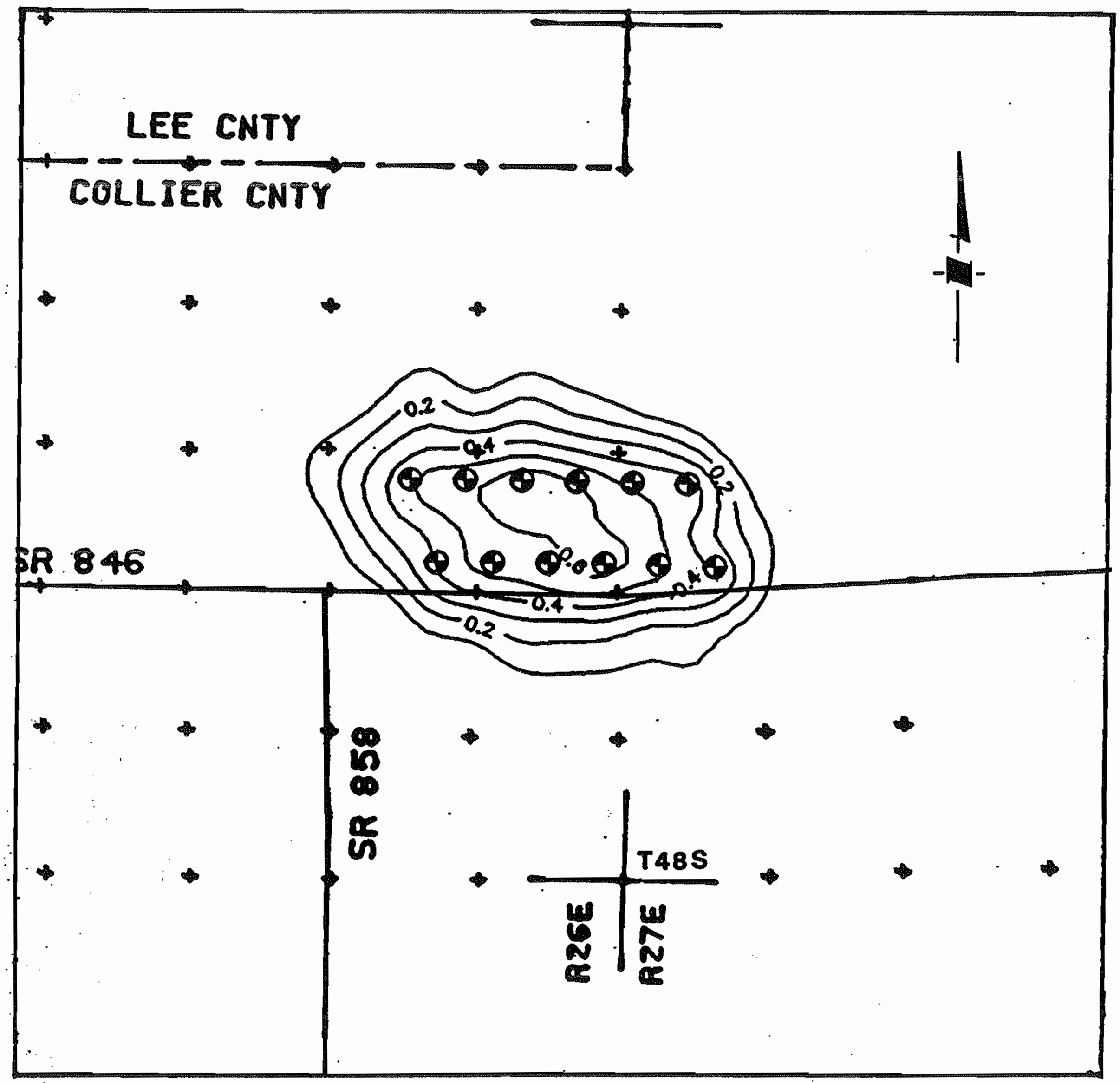
Based on information obtained in the most recent expansion of the Golden Gate Wellfield, the safe yield may be as high as 45 MGD or perhaps 50 MGD. In order to assess the true value, a three-dimensional groundwater model of the area would have to be developed. Although the true safe hydrogeologic yield of the Lower Tamiami Aquifer may be significantly higher than previously estimated, issues such as environmental considerations, resident protests, and conflict with the City of Naples, may limit future expansion of the wellfield.

Considerable effort has also been made to assess the available quantity of water in the north Collier County area. Two potential sources of fresh water have been identified, the water-table aquifer (Coral Reef Aquifer) and the Lower Tamiami Aquifer, in the area north of Immokalee Road and east of I-75. The first major hydrogeologic investigations in this area were funded by the Big Cypress Basin of the South Florida Water Management District between 1981 and 1983. It was concluded by Missimer and Associates, Inc. that at least 30

MGD of water was available from this area for use as a municipal supply. A wellfield development plan for this area was prepared by Missimer and Associates for Collier County in 1987 and the hydraulic characteristics of the Lower Tamiami Aquifer were measured. The wellfield development plan suggested utilization of both the water-table aquifer and the Lower Tamiami Aquifer in an area located adjacent to the Mule Pen Quarry. The ultimate peak yield of the wellfield was projected at 36 MGD.

Recent evaluations of land costs and pending environmental legislation have raised questions concerning potential utilization of the water-table aquifer (Coral Reef Aquifer) in the Mule Pen Quarry area. In the Mule Pen Quarry area, the water table can be affected by withdrawal from the Lower Tamiami due to leakage in the limestone formations. However, utilization of the Lower Tamiami Aquifer is considered to be quite viable. The design and permitting of a minimum 8 MGD wellfield could be accomplished in the near future.

More recent modeling by James M. Montgomery, Consulting Engineers, Inc. during this Study indicates at least 13 MGD could be obtained from the Lower Tamiami with less than 1 foot of drawdown in the water table aquifer. The groundwater of the water table and Lower Tamiami aquifers were modeled to evaluate the possible impacts on surface water that could be expected from the withdrawal of groundwater from the Lower Tamiami Aquifer. The model was a 100-day transient simulation, with no recharge. Figure IV-8 indicates the drawdown that can be expected from 12 wells, each withdrawing 500 gallons per minute (8.6 MGD) from the Lower Tamiami. The east-west well spacing is 2000 feet, and the distance between the two rows of wells is 3000 feet. Figure IV-9 indicates the drawdown from 18 wells, each withdrawing 500 gpm (12.9 MGD). When the third row of wells was added, the drawdown at



SCALE

0 FEET 10000

WELL

SECTION CORNER

FIGURE IV-8

DRAWDOWN, IN FEET, FOR 12 WELLS EACH PUMPING 500 GPM

CONTOUR INTERVAL: 0.1 FOOT

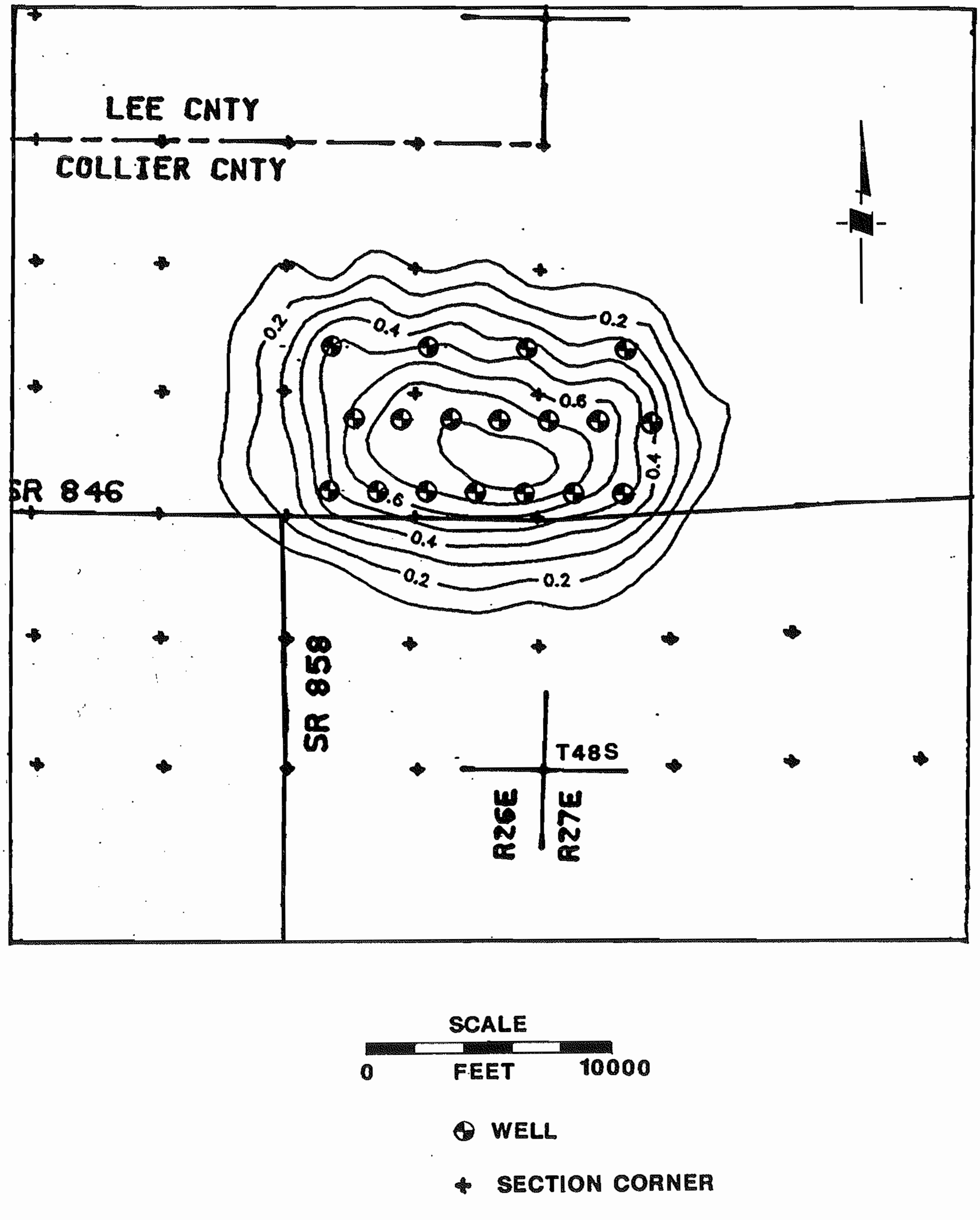


FIGURE IV-9

DRAWDOWN, IN FEET, FOR 18 WELLS EACH PUMPING 500 GPM

CONTOUR INTERVAL: 0.1 FOOT

the center exceeded 1 foot, so the spacing of the wells in the northern row was increased, to reduce the stress in the center of the well configuration. However, in order to permit this resource as a major water supply, more detailed modeling of drawdowns and potential impacts on nearby wetlands will be required to more accurately determine the safe yield of the water-table and Lower Tamiami Aquifers in the north Collier County area.

On a long-term basis, it is projected that the Golden Gate Estates Wellfield and proposed North County Wellfield will be fully utilized to serve the mainland area of Collier County. Water produced by the East Regional Water Treatment Facility and proposed North County Regional Water Treatment Facility could conceivably serve Marco Island, however, additional supplies need to be developed to meet the long-term needs of the County population.

Collier County is also underlain by a number of aquifers that contain treatable saline water. In northern Collier County, for example, there are several potential production zones located between 340 and 415 feet below surface, 480 and 605 feet below surface, and deeper than 640 feet below surface. There are also a number of deeper production zones. A hydrogeologic investigation of the Lower Hawthorn Aquifer was conducted on the Pelican Bay wellfield site located approximately 1/2 mile west of I-75 and north of Immokalee Road (Geraghty & Miller, 1977). The quality of water in the production zone contained a dissolved solids concentration of about 4300 mg/l. The measured transmissivity at the site was 45,000 gpd/ft. which is low compared to available shallow freshwater aquifers.

It is possible to treat the saline water found in the Lower Hawthorn Aquifer in north Collier County by the standard pressure reverse osmosis process. However, there are hidden costs that must be considered in the total analysis. First, the relatively low transmissivity of the production aquifer (the only one tested) would cause the wellfield to be extended over a large area requiring many low volume wells and very long runs of raw water transmission main. Second, since the saline wells would be drilled where freshwater aquifers occur near land surface, special retaining structures must be constructed around each production well to store all saline water produced during well drilling for removal from the site to an approved saltwater disposal area. Third, the reject water disposal would be discharged either into a deep injection well (Class I with tubing and packer) or into the Gulf of Mexico via an offshore discharge line. These items would result in considerable additional construction expense above utilization of the water-table aquifer or Lower Tamiami Aquifer.

Advantages of using deeper saline aquifers include elimination of environmental concerns for impacts on wetlands, reduced potential for contamination from surface sources and no impact on existing permitted users in the area.

V. SUMMARY OF PROJECTED YIELD AND PERMITTABILITY

A. General

The previous section of this Report describes each of the potential water resources investigated during this Study and generally assesses the viability of development as major municipal water supplies for Marco Island. This section briefly outlines the permittability of the viable resources and summarizes the estimated yield of each potential supply.

B. Existing Lakes and Infiltration System

The existing water supply system for Marco Island has historically encountered problems with chloride concentrations approaching potable drinking water standards during the annual dry season. Compounding the problem of low rainfall with high irrigation demand is the winter seasonal influx of part-time residents and tourists. The water supply demands, particularly for irrigation usage, strains the existing water supply system, and as growth in the area continues it will exceed the safe yield capacity of the system. Based on the water demand projections outlined herein, the existing supply system is already beyond capacity during winter season and is sufficiently assisted by mandatory water use restrictions during the highest demand periods.

The yield of the combined lake/infiltration trench system has been determined to be approximately 6.8 MGD during critical dry periods, while safely remaining within drinking water quality standards. The system has been pumped at a rate as high as 6.45 MGD without causing dissolved chloride concentrations to exceed 250 mg/l. However, if the system is to continue as a potable supply source, it is estimated that approximately 5 to 6 MGD would be an appropriate and permittable dry season use rate.

There are, however, serious doubts about the long-term viability of using the resource as a major potable supply system. Since the system is located on land that is leased with a 1994 expiration, it is likely that future incompatible development will occur adjacent to the lake. The lake and infiltration system could however coexist with development, if the system were utilized solely for irrigation supply. It is estimated that as much as 11 MGD could be withdrawn for irrigation while remaining below an acceptable level of 300 mg/l total dissolved chlorides. However, additional modeling of effects on wetlands would be required for use above the existing 6.23 MGD permitted capacity.

A meeting with the South Florida Water Management District resulted in a favorable reaction to possible use of the lake system for irrigation purposes. The feasibility of developing a dual system for Marco Island will be addressed later in this Report.

C. Water Table Aquifer - Section 35

The construction of infiltration trenches on 160 acres in Section 35, Township 50S, Range 27E owned by Deltona could produce a potable water supply of 5 to 6 MGD. It is estimated that 5 MGD could be withdrawn to supplement the existing lake system for use as a potable or irrigation source.

This potential resource has some advantages and disadvantages with regard to permitting. In terms of advantages, the site is relatively remote from other water users. It can likely yield a considerable volume of freshwater. There is a considerable natural restriction on the development of other water supplies in the area because of the vertical stratification of water quality. Therefore, large yield agricultural wells could not be drilled without causing saltwater to upcone to the surface. This likely would not be permitted. Another advantage is that the Golden Gate canal system transports water into the area during the wet season. This would allow recharge of the aquifer each wet season. Since the site is rather remote, it could be easily protected from contamination by non-compatible land uses.

There are two distinctive disadvantages to the site, excluding its distance from Marco Island. First, the site lies near wetland plant communities. Although these wetland areas are not pristine, having been altered by Golden Gate canal system drainage, the very presence of wetlands may restrict the use of the site for a wellfield. The degree of restriction that the wetlands would place on the wellfield development is however unclear at this time. The second disadvantage of the site is that the water will contain high concentrations of organic acids that will make it difficult to treat by conventional methods.

A meeting with the South Florida Water Management District resulted in generally a favorable response to potential use of this water resource; however, the environmental issues could pose a problem. Further investigation would be required to develop this as a major water supply source.

D. Water Table Aquifer - Fakahatchee Strand

Although the South Florida Water Management District's published Preliminary Assessment of the Groundwater Resources of Western Collier County (1986) indicated in excess of 30 MGD could be available in the Fakahatchee Strand area water table aquifer, it did not attempt to address the environmental issues related to its development as a major water supply.

Potential impact to wetlands within the Fakahatchee Strand would create serious concerns about development as a major water supply. The area could potentially be developed for future supplies; however, substantial time for detailed hydrogeologic testing and modeling, and environmental permitting would be required. Therefore, this alternative resource has been eliminated from further consideration in this Report.

E. Water Table Aquifer - Sabal Palm Area

The South Florida Water Management District's 1986 groundwater assessment report identified a large area north of U.S. 41 E and south of S.R. 84 as having moderate potential as a major water supply. The data assimilated and analyses performed during this Feasibility Study indicates that development of the area as a water supply for Marco Island is not feasible. The area is generally limited by the presence of environmentally sensitive areas, thin water producing strata, existing competing water users and severe impacts to water quantity and quality due to climatic conditions. Based on these concerns this potential resource has been eliminated from further consideration within this Report.

F. Deep Saline Aquifers

As highlighted within this section of the Report, the availability of freshwater in the southern portion of Collier County is restricted by environmental issues and varying quantity and quality due to seasonal climatic conditions. Therefore, the Study also focused on deep saline aquifers that could potentially produce large volumes of water of acceptable quality for use in reverse osmosis treatment processes. Due to the existence of several confining layers, deeper saline aquifer systems are not impacted by seasonal climatic conditions and also do not affect environmentally sensitive areas, although wellfield and treatment systems are generally more expensive.

An on-going test program by Marco Utilities does indicate that a water supply source is available, however, it is not known at this time what the safe yield of the source will be or if the long-term water quality stability will be adequate. Preliminary testing indicates that 5 to 6 MGD of finished water could be safely obtained from the Hawthorn Zone II Aquifer System with a wellfield located on Marco Island. Additional testing and modeling will better define the quantities available from this resource. At the present time, an aquifer performance test program and some additional test drilling is being conducted on Marco Island. Final determination of the yield and stability questions should be available from Marco Utilities within 6 months.

Based on the test drilling program conducted on Marco Island, there is a high probability that additional, treatable saline water occurs in the Hawthorn Aquifer System in the vicinity of the existing lake/infiltration trench system. This area is located upgradient and possibly contains a better water quality. There is a high probability that at least 6 to 8 MGD of saline water could be developed for reverse osmosis treatment with a wellfield extending along U.S. 41 East.

Conversations with the South Florida Water Management District indicates a high probability of obtaining a consumptive use permit for tapping the Hawthorn Aquifer System as a major water supply for Marco Island and Collier County.

G. Golden Gate Estates and North Collier County

The Golden Gate Estates area and northern portions of the County are blessed with an abundance of freshwater at relatively shallow depths. The Lower Tamiami Aquifer in Golden Gate Estates, which is now utilized as a resource by the City of Naples and Collier County, has an estimated yield capacity of between 30 and 50 MGD. The area has no other major competing users in the Lower Tamiami and single family residences are supplied by individual wells in the Water Table Aquifer. The feasibility of future expansion of the County's wellfield, however, is somewhat clouded by resident protests, environmental considerations and potential conflict with the City of Naples wellfield. Additional investigations will be required for future expansion in the Golden Gate Estates area. The northern Collier County area has two (2) aquifer systems that could provide large quantities of fresh water. The water table aquifer, previously termed the Coral Reef Aquifer has been identified as a potential resource capable of producing as much as 30 MGD. Located in the area of the Mule Pen Quarry, proposed siting of the wellfield is near environmentally sensitive wetland communities which could be impacted by large water withdrawals. Although much of the land surrounding the proposed site is to be acquired by the South Florida Water Management District under the Save Our Rivers program for use as a potable water supply, a substantial permitting and coordination process would be anticipated.

The Lower Tamiami Aquifer in the Mule Pen Quarry area has also been identified as being capable of producing large quantities of freshwater. Testing performed to date indicates a minimum of 8 MGD could be withdrawn from this system, with possibilities of going much higher. More recent modeling during this Study suggests 13 MGD could be obtained with more conservative wellfield design. The Lower Tamiami Aquifer in that area of the County is in part directly recharged by leakance from the Water Table Aquifer. Therefore, detailed modeling and monitoring will be required due to the previously noted presence of wetlands surrounding the wellfield area. It is believed that permitting of this resource can be accomplished although the time to complete the process could be rather long.

H. Water Resources Summary

As outlined within this section of the Report, several water sources are available to provide water to existing and future residents of Collier County and the Marco Island area. A summary of the various resources, a range of transmissivities and estimated yields is provided on Table 9.

The footnotes provide a brief description of physical and quality limitations on the saline aquifers in the area. Construction and operation and maintenance for treatment of the lower saline aquifers in the North County area would be cost prohibitive in comparison to the other available supplies.

TABLE 9

WATER RESOURCES SUMMARY

WATER SOURCE	TRANSMISSIVITIES ($1000's\ gpd/ft^2$)	ESTIMATED YIELD
Marco Island Lower Hawthorn (1)	100 to 300	5 to 6 MGD
Mainland Lower Hawthorn (1)	100 to 300	6 to 8 MGD
Existing Lake/Infiltration System	Not Applicable	5 to 6 MGD
Section 35 Water Table	300 to 900	5 to 6 MGD
Golden Gate Lower Tamiami	250 to 3,000	45 to 50 MGD
North County Lower Tamiami	150 to 250	8 to 24 MGD
North County Lower Hawthorn (2)	25 to 80	(2)
North County Deeper Saline (3)	500 to 2,000	(3)

Notes:

1) The Marco Island and South County Mainland Lower Hawthorn aquifer systems appear capable of providing water quality for low pressure reverse osmosis membrane treatment (250-300 psi).

2) The North County Lower Hawthorn aquifer system is capable of providing water quality for standard pressure reverse osmosis membrane treatment (400-600 psi). Yield of the North County Lower Hawthorn aquifer system could be unlimited; however, low transmisssivities make the number of wells, spacing and piping lengths cost prohibitive.

3) The North County Deeper Saline aquifer systems are capable of providing an unlimited supply of water. Seawater reverse osmosis membrane treatment would be required (800-1,200 psi).

VI. WATER TREATMENT ANALYSIS

A. General

Completion of the resource availability portion of the Feasibility Study allowed further investigation into the cost of treating the various supplies. Presented within this section of the Report are preliminary design and planning level cost model estimates for water treatment processes applicable to the water resources determined viable as major water supplies.

Four (4) treatment processes have been evaluated for the applicable water supplies. The processes are 1) reverse osmosis and 2) electrodialysis reversal for saline supplies, and 3) lime softening with ozone and 4) membrane softening for freshwater supplies.

B. Water Quality

Water quality data was assimilated on the Surficial (water table) Aquifer, Lower Tamiami Aquifer, and Lower Hawthorn Aquifer, for use in developing preliminary treatment design.

Surficial and Lower Tamiami Aquifer quality data presented in this Report was obtained from the Collier County Utilities Division. The Lower Hawthorn data was obtained from an analysis supplied by Missimer & Associates. This data was compared and verified with analysis data from the South Florida Water Management District report 86-1 and lab tests performed by James M. Montgomery, Consulting Engineers, Inc. The quality data is adequate to evaluate various treatment processes for comparison, however, prior to final design additional verification of the water source characteristics is recommended.

C. Preliminary Design

In order to obtain unit cost values for the mechanical equipment, a preliminary design was performed for the various treatment processes. Schematics of each process are provided in Figures VI-1 thru VI-4. Predesign models were used for the elevation of appropriate treatment components for each of the processes. A computer model of the reverse osmosis system was utilized for the selection of the reverse osmosis membrane. A predesign model was also developed for the lime softening treatment process. Similarly, the electrodialysis reversal units were sized by the manufacturer. Preliminary design of the membrane softening process is similar to the reverse osmosis process. The membrane softening units were sized based upon discussions with equipment manufacturers, published literature, and pilot tests in other South Florida communities. The process configuration utilized was similar to the reverse osmosis units with some exceptions including lower pressure feed pumps, lower pressure permeators and more membrane elements.

Preliminary design models are provided in a separate Preliminary Design Memorandum accompanying this Report.

D. Costs

Capital cost curves have been generated for the various treatment processes evaluated in this Report. These curves reflect the estimates presented in the cost models. Figures VI-5 through VI-8 represent capital costs for reverse osmosis, electrodialysis reversal, lime softening and membrane softening processes respectively. It should be noted that two (2) injection wells will be required for plant capacity greater than 8 MGD. Tables 10 through 13 show values utilized in generating these curves.

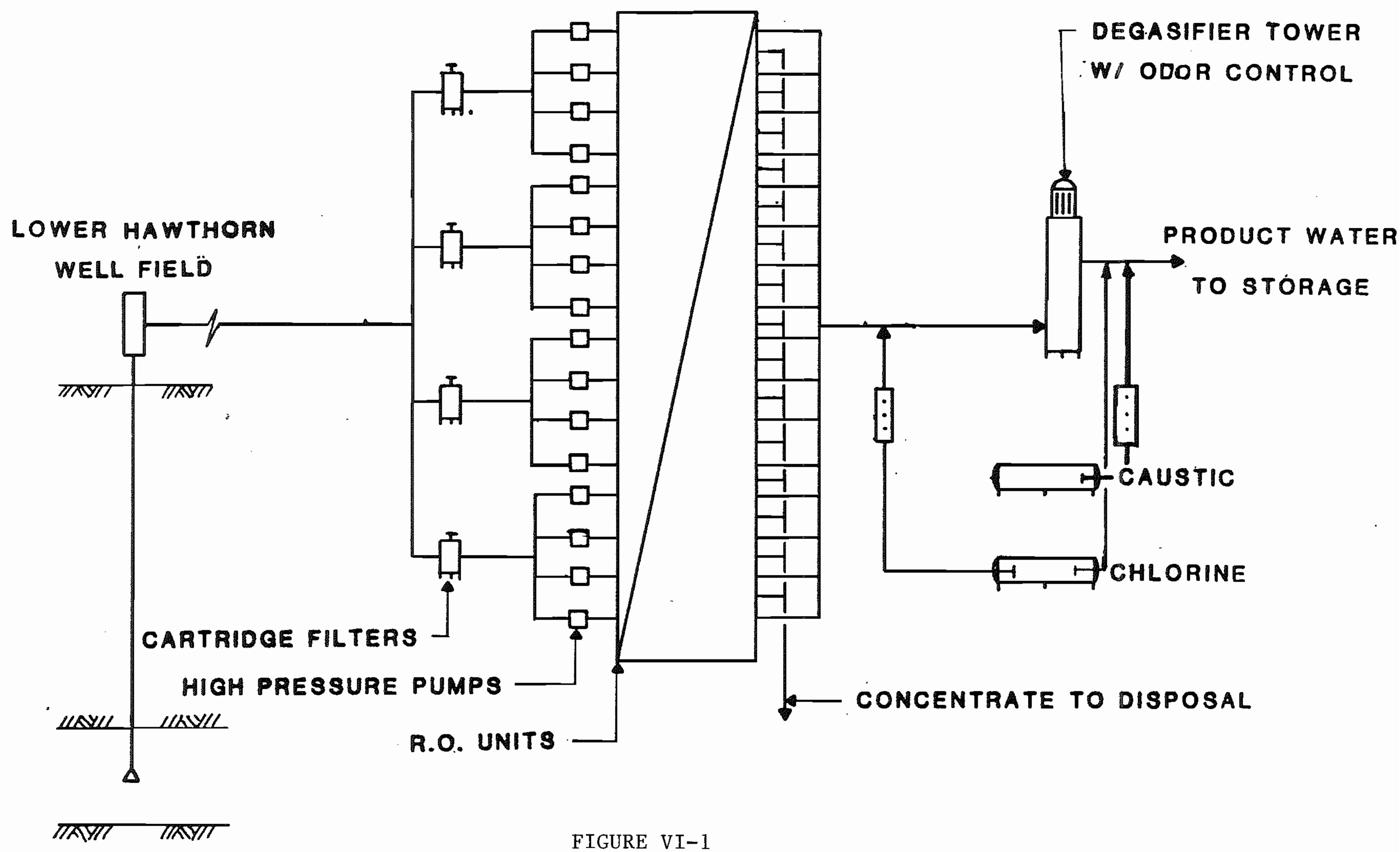


FIGURE VI-1

REVERSE OSMOSIS PLANT SCHEMATIC

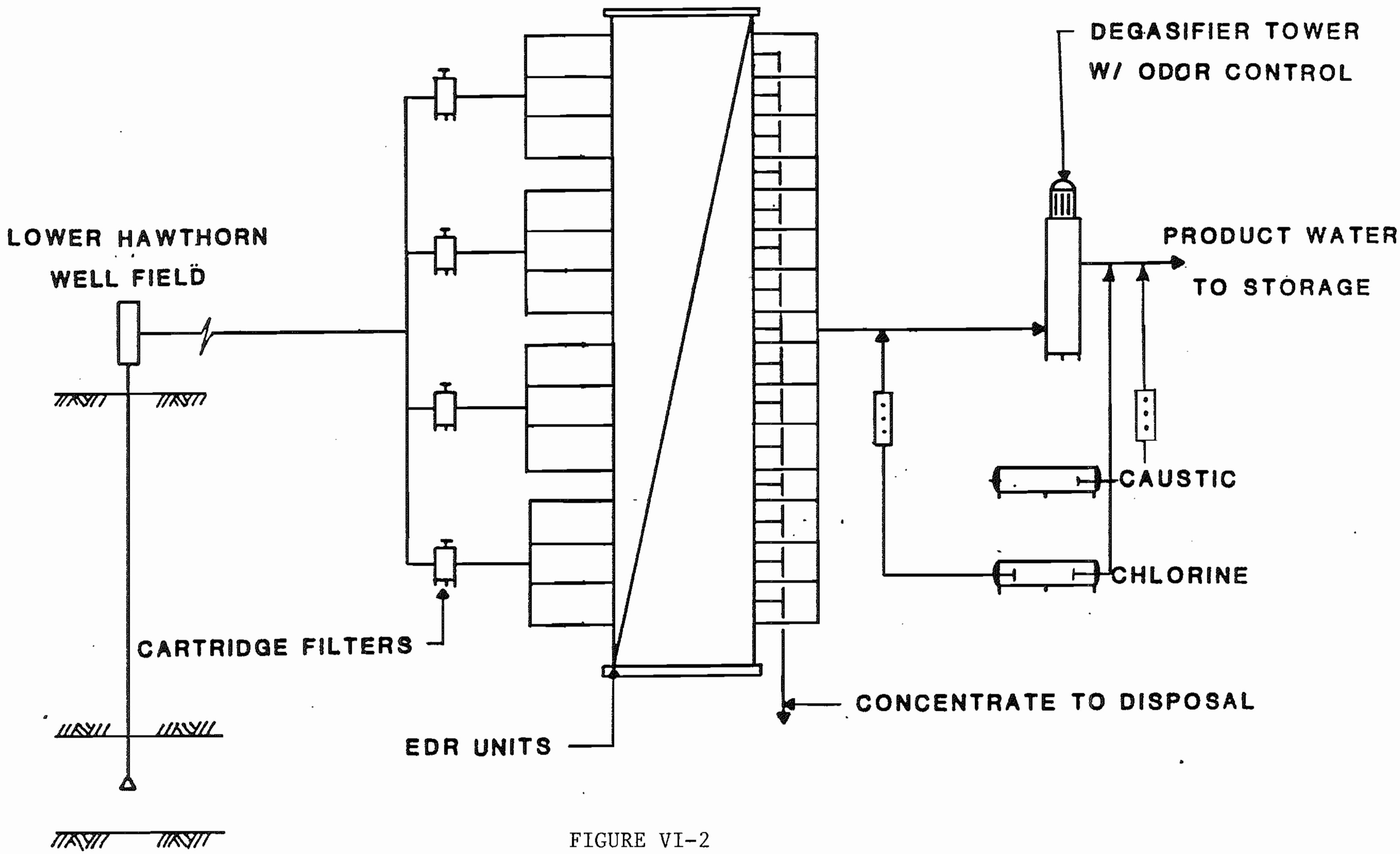


FIGURE VI-2

EDR PLANT SCHEMATIC

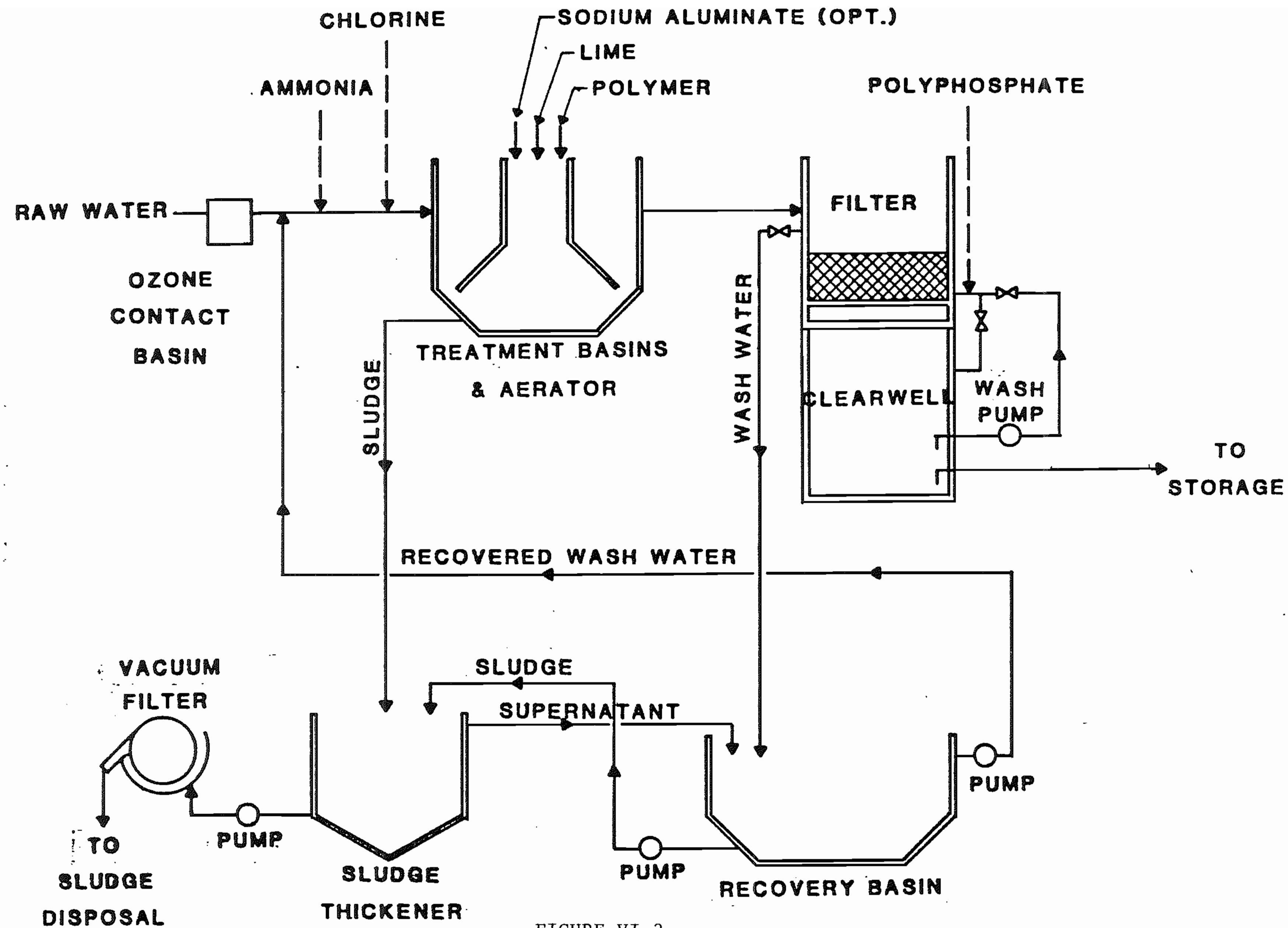


FIGURE VI-3

LIME SOFTENING PLANT SCHEMATIC

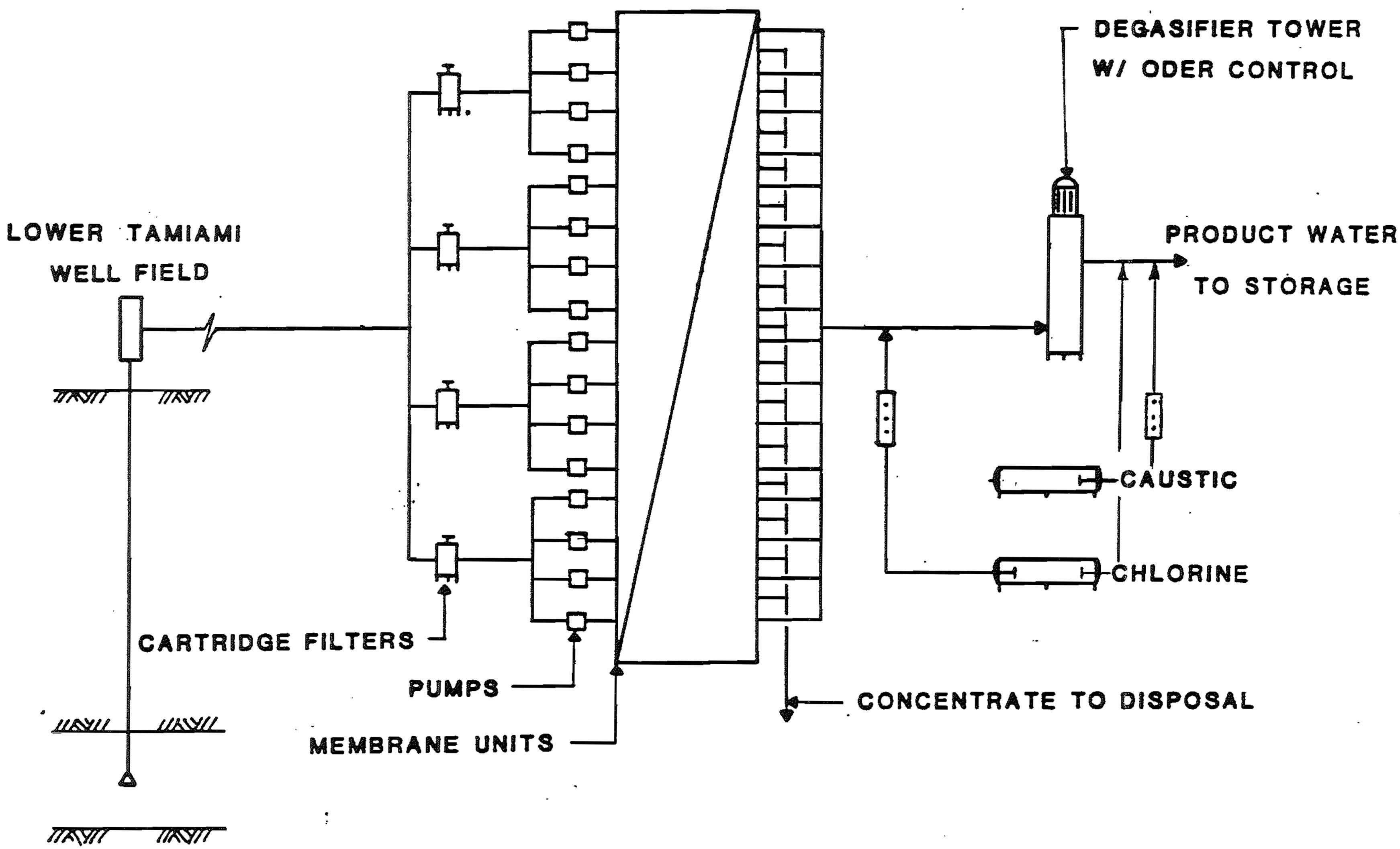


FIGURE VI-4

MEMBRANE SOFTENING PLANT SCHEMATIC

The capital cost values shown in the model were taken from recent construction bids and manufacturers' cost estimates. The capital and operational and maintenance costs were checked against published cost curves and actual costs for similar construction.

In addition, operation and maintenance costs have been estimated for each treatment process. Operation and maintenance costs for the four treatment processes are divided into two categories. These categories are flow related costs ($/1000 gal.) and fixed annual costs ($/yr.). Flow related cost represent chemical addition, membrane replacement and power consumption. Fixed annual costs represent labor and outside contract costs. The operation and maintenance are summarized in Tables 14 thru 17 for the four treatment processes.

Treatment present worth comparisons were made between the electrodialysis reversal and reverse osmosis treatment processes for the Lower Hawthorn water supply. A comparison was made between lime softening with ozone and the membrane softening treatment process for the Lower Tamiami water supply.

A description of the cost models, capital and O & M cost analysis for the various treatment processes and design capacities are provided in the Preliminary Design Memorandum accompanying this Report.

HMA MARCO ISLAND

R.O. COST CURVES

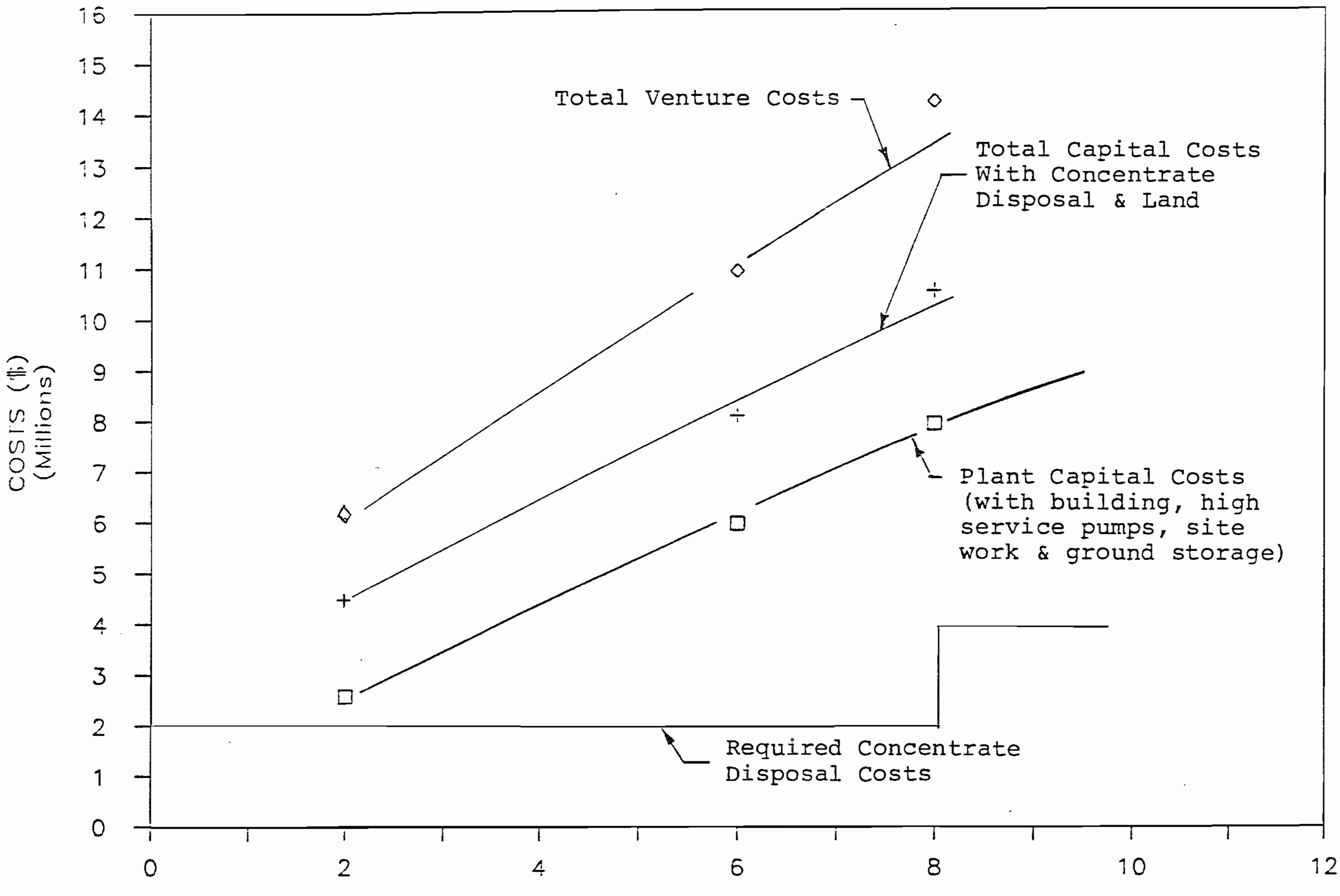
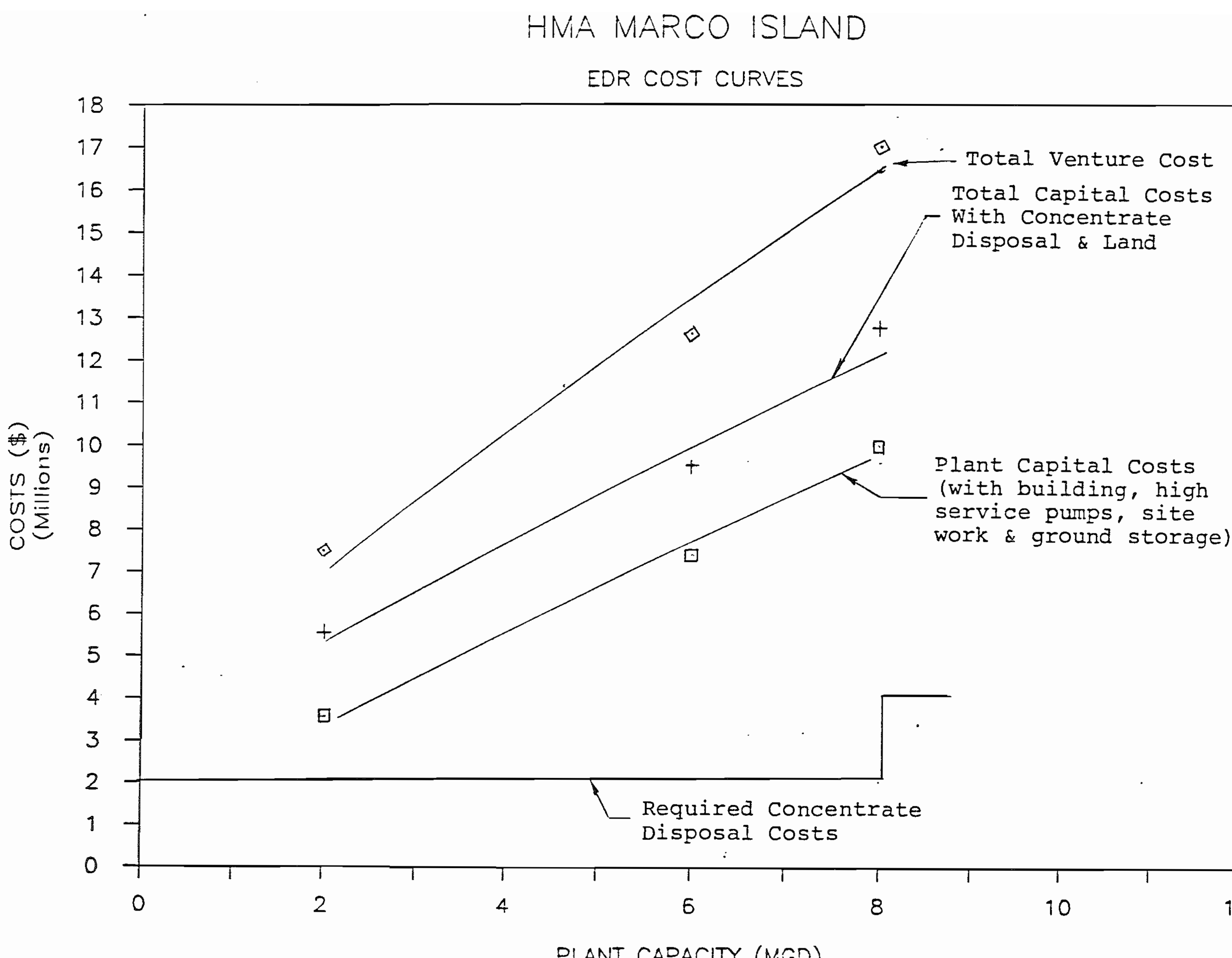


Figure VI-5


HMA MARCO ISLAND
EDR COST CURVES
COSTS ($)
(Millions)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
0
2
4
6
8
10
12
Total Venture Cost
Total Capital Costs With Concentrate Disposal & Land
Plant Capital Costs (with building, high service pumps, site work & ground storage)
Required Concentrate Disposal Costs
PLANT CAPACITY (MGD)
Figure VI-6

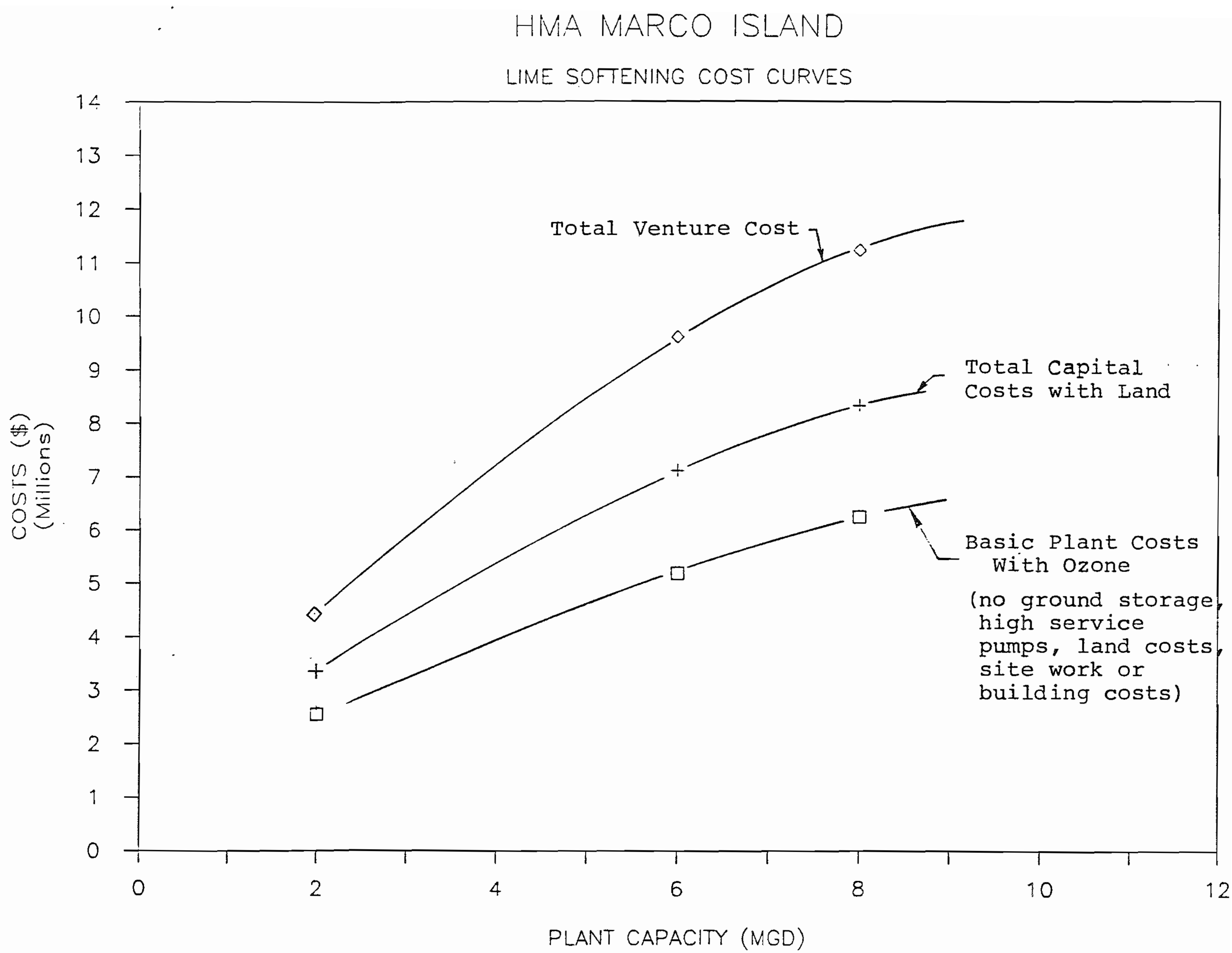

HMA MARCO ISLAND
LIME SOFTENING COST CURVES
Total Venture Cost
Total Capital Costs with Land
Basic Plant Costs With Ozone
(no ground storage, high service pumps, land costs, site work or building costs)
COSTS ($) (Millions)
PLANT CAPACITY (MGD)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

Figure VI-7

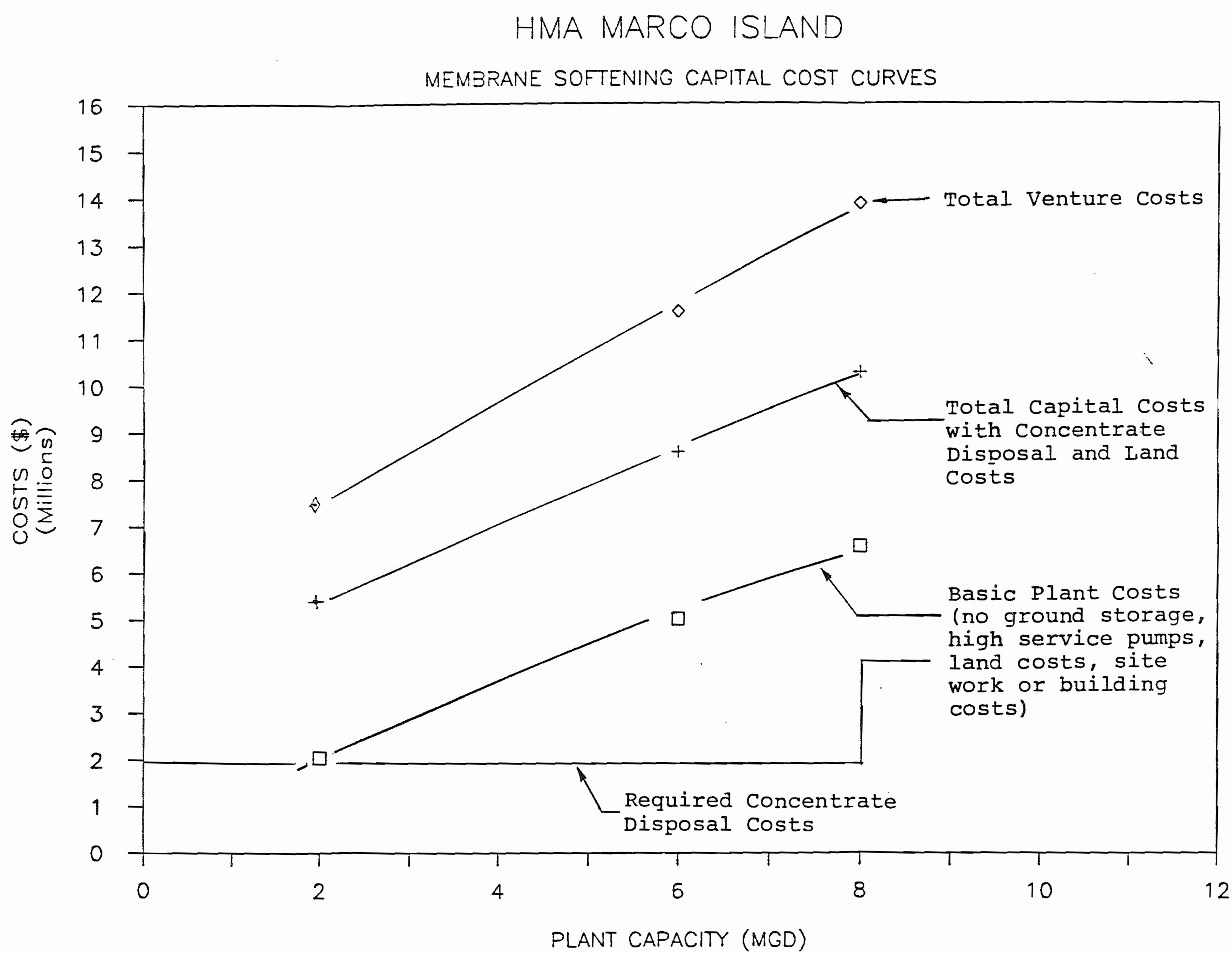

HMA MARCO ISLAND
MEMBRANE SOFTENING CAPITAL COST CURVES
COSTS ($) (Millions)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Total Venture Costs
Total Capital Costs with Concentrate Disposal and Land Costs
Basic Plant Costs (no ground storage, high service pumps, land costs, site work or building costs)
Required Concentrate Disposal Costs
0
2
4
6
8
10
12
PLANT CAPACITY (MGD)

Figure VI-8

TABLE 10

REVERSE OSMOSIS
CONSTRUCTION COST CURVE DATA

Capacity	Plant Capital Costs (a)	Total Capital with Concentrate Disposal & Land	Total Venture(b)
2 MGD	$2,650,000	$4,730,000	$6,386,000
6 MGD	$6,200,000	$8,345,000	$11,266,000
8 MGD	$8,228,000	$10,842,000	$14,637,000

(a) Capital costs do include ground storage, high service pumps and building construction but do not include land costs or concentrate disposal.

(b) Includes 35% for engineering, administration, legal, financial and contingencies.

TABLE 11

ELECTRODIALYSIS REVERSAL
CONSTRUCTION COST CURVE DATA

Capacity	Plant Capital Costs(a)	Total Capital with Concentrate Disposal and Land	Total Venture(b)
2 MGD	$3,506,000	$5,626,000	$7,595,000
6 MGD	$7,314,000	$9,434.000	$12,616,000
8 MGD	$9,993,000	$12,613,000	$17,029,000

(a) Capital costs do include ground storage, high service pumps and building construction but do not include land costs or concentrate disposal.

(b) Includes 35% for engineering, administration, legal, financial and contingencies.

TABLE 12

LIME SOFTENING WITH OZONE CONSTRUCTION COST CURVE DATA

Capacity	Plant Capital Costs (a)	Total Capital with Land and Sludge Disposal	Total Venture(b)
2 MGD	$2,546,000	$3,276,000	$4,422,600
6 MGD	$5,192,000	$7,169,000	$9,608,000
8 MGD	$6,252,000	$8,373,000	$11,234,000

(a) Capital cost do not include ground storage, high service pumps, building construction or land costs.

(b) Includes 35% for engineering, administration, legal, financial and contingencies.

TABLE 13

MEMBRANE SOFTENING CONSTRUCTION COST CURVES

Capacity	Plant Capital Cost(a)	Total Capital with Land and Concentrate Disposal	Total Venture(b)
2 MGD	$2,572,000	$5,590,000	$7,547,000
6 MGD	$5,009,000	$8,605,000	$11,575,000
8 MGD	$6,566,000	$10,316,000	$13,885,000

(a) Capital Costs do not include ground storage, high service pumps, building construction, land costs or concentrate disposal.

(b) Includes 35% for engineering, administration, legal, financial and contingencies.

TABLE 14

ESTIMATED
OPERATIONAL & MAINTENANCE DATA
REVERSE OSMOSIS SYSTEM

	Flow Related Costs ($/1000)		Fixed Annual Costs ($/year)
Power	0.35		
Chemicals	0.22		
Membrane Replacement	0.09		
	0.66		
		Labor	948,000
		Renewal and Replacement	86,000
		Total (6 MGD plant)	1,034,000

Note: Labor and renewal vary with plant capacity

ESTIMATED
OPERATIONAL AND MAINTENANCE COSTS
FOR VARIOUS R.O. CAPACITIES
($/1000 GAL.)

2 MGD	6 MGD	8 MGD
$1.36	$1.13	$0.99

TABLE 15

ESTIMATED
OPERATIONAL AND MAINTENANCE COST
FOR THE ELECTRODIALYSIS REVERSAL PROCESS

	Flow Rated Costs ($/1000 gal.)	Fixed Annual Costs ($/yr.)
Power	0.88	
Chemical Cleaning	0.01	
Membrane Replacement	0.12	
Filter Cartridge	0.04	
Transfer Pumps	0.04	
Degasifier/Odor Control Blower Power	0.04	
Total:	1.13	
Labor		948,000
Renewal and Replacement		86,000
Total:		1,034,000

Note: Labor and replacement vary with plant capacity.

ESTIMATED
OPERATION AND MAINTENANCE COST
VARIOUS EDR PROCESSES
($/1000 GAL.)

2 MGD (Expansion)	6 MGD	8 MGD
$1.83	$1.56	$1.45

TABLE 16

ESTIMATED
OPERATIONAL AND MAINTENANCE DATA
LIME SOFTENING WITH OZONE SYSTEM

	Flow Related Costs ($/1000 gallon)		Fixed Annual Costs ($/year)
Power	0.07		
Chemicals	0.11		
Total	0.17		
		Labor	948,000
		Renewal and Replacement	88,000
		Total (6 MGD plant)	1,036,000

Note: Labor and renewal vary with plant capacity

ESTIMATED
OPERATIONAL AND MAINTENANCE COSTS FOR
VARIOUS LIME SOFTENING CAPACITIES
($/1000 GAL.)

2 MGD	6 MGD	8 MGD
$0.87	$0.64	$0.53

TABLE 17

ESTIMATED
OPERATIONAL AND MAINTENANCE DATA
MEMBRANE SOFTENING SYSTEM

		Flow Related Costs ($/1000 gallon)		Fixed Annual Costs ($/year)
Power		0.13		
Chemicals		0.13		
Membrane Replacement		0.13		
	Total	0.39		
			Labor	948,000
			Renewal and Replacement	87,000
			Total (6 MGD)	1,035,000

Note: Labor and renewal vary with plant capacity.

ESTIMATED
OPERATIONAL AND MAINTENANCE COSTS
FOR VARIOUS MEMBRANE SOFTENING CAPACITIES
($/1000 GAL.)

2 MGD	6 MGD	8 MGD
$1.09	$0.85	$0.75

VII. MARCO ISLAND ALTERNATIVE COST ANALYSIS

A. Alternative Descriptions

The water resource investigations indicate that several combinations of supplies are available to meet the water demands of Marco Island, based on the hydrogeological data available today. However, no single source of water appears of sufficient quality to meet the potable and irrigation needs of Marco Island.

The preceeding Water Treatment Analysis section provides capital and O&M cost data based on preliminary designs to treat the available raw water supplies.

This section of the Report provides a comparative cost analysis of three (3) system alternatives that are potentially feasible to serve Marco Island, including one alternative using a dual system for irrigation. As outlined in the three (3) alternatives, each includes development of a saline wellfield (Lower Hawthorn Aquifer) on Marco Island and a secondary source on the mainland. The mainland supply options include the 1) Lower Hawthorn, 2) the existing lake/infiltration system and future Section 35 for potable use, or 3) the existing lake/infiltration system and future Section 35 for irrigation use.

A summary of the water sources and approximate quantities to be obtained from each to provide a total of 16 MGD is outlined below.

ALTERNATIVE 1

Marco Island Lower Hawthorn	6.0 MGD	(1990)
Mainland Lower Hawthorn (1)	6.0 MGD	(1994)
Future Mainland Expansion	4.0 MGD	
Total	16.0 MGD	

(1) Continue use of lake/infiltration system through 1994 lease expiration.

ALTERNATIVE 2

Marco Island Lower Hawthorn	6.0 MGD	(1990)
Existing Lake/Infiltration (1)	6.0 MGD	(1994)
Future Section 35-Water Table	4.0 MGD	
Total	16.0 MGD	

(1) Requires acquisition of lake/infiltration system site (±800 acres).

ALTERNATIVE 3

Marco Island Lower Hawthorn	6.0 MGD	(1990)
Existing Lake/Infiltration (1) for Dual Irrigation Supply	6.0 MGD	(1994)
Future Section 35 - Water Table for Dual Irrigation Supply	4.0 GMD	
Total	16.0 MGD	

(1) Requires use of existing lake/infiltration system for irrigation supply after dual system phase-in period.

B. Probable Costs

Probable costs to construct facilities under Phase I of three (3) outlined alternatives are provided herein. Phase I improvements are proposed to provide 12 MGD of water to Marco Island. Future expansions and additional capital expenditures will be required by the late 1990's depending on actual growth and water demands. It should be noted that the existing 12-inch and 14-inch raw water transmission main will require replacement under all three (3) alternatives due to conflict with the planned S.R. 951 four-laning and inadequate hydraulic capacity. The dual system option provides separate irrigation lines to approximately 50% of the island. The entire island is projected to ultimately use about 11 MGD for irrigation.

Capital cost summaries for each alternative are provided on Tables 18 thru 20 with detailed estimates provided in Tables 21 thru 23. As shown in the cost summary tables, the probable capital costs for the alternatives are nearly equal, ranging from $32.0 million to $33.3 million. Therefore, present worth analyses were performed using estimated treatment O&M costs and utilizing an estimated $0.30/1000 gallons for operation and maintenance of a separate irrigation system.

TABLE 18

CAPITAL COST SUMMARY

ALTERNATIVE 1

1.	Marco Island Lower Hawthorn	
	a) Well Construction (5 wells & 2 rotational)	$ 455,000
	b) Pumps, Controls, Valves & Emergency Power	650,000
	c) Wellfield Transmission Main	750,000
	d) R.O. Treatment Facility (inc. Reject Well)	8,345,000
	Subtotal	$10,200,000
2.	Mainland Lower Hawthorn - Phase I	
	a) Well Construction (5 wells & 2 rotational)	$ 455,000
	b) Pumps, Controls, Valves & Emergency Power	650,000
	c) Wellfield Transmission Main	750,000
	d) R.O. Treatment Facility (inc. Reject Well)	8,345,000
	e) Replace Existing Raw Transmission Main	3,300,000
	Subtotal	$13,500,000
	TOTAL CONSTRUCTION COST	$23,700,000
	+ 35% engineering, administration, legal, financial and contingencies	8,295,000
	TOTAL PROJECT COST	$31,995,000

TABLE 19

CAPITAL COST SUMMARY

ALTERNATIVE 2

1.	Marco Island Lower Hawthorn	
	a) Well Construction (5 wells & 2 rotational)	$ 455,000
	b) Pumps, Controls, Valves & Emergency Power	650,000
	c) Wellfield Transmission Main	750,000
	d) R.O. Treatment Facility (inc. Reject Well)	8,345,000
	Subtotal	$10,200,000
2.	Existing Lake/Infiltration System	
	a) Refurbish Existing Lime Softening Plant	$ 1,000,000
	b) Add Ozonation Equipment	600,000
	c) Replace Existing Raw Transmission Main	3,300,000
	Subtotal	$ 4,900,000
	TOTAL CONSTRUCTION COST	$15,100,000
	+ 35% engineering, administration, legal, financial and contingencies	5,285,000
	+ Lake/Infiltration System Land Purchase	12,000,000
	TOTAL PROJECT COST	$32,385,000

TABLE 20

CAPITAL COST SUMMARY

ALTERNATIVE 3

1. Marco Island Lower Hawthorn

a) Well Construction (5 wells & 2 rotational)	$ 455,000
b) Pumps, Controls, Valves & Emergency Power	650,000
c) Wellfield Transmission Main	750,000
d) R.O. Treatment Facility (inc. Reject Well)	8,345,000
Subtotal	$10,200,000

2. Existing Lake/Infiltration System for Irrigation Supply

a) Relocate Raw Water Pumping and Storage	$ 500,000
b) Construct Filters and Chlorination System	500,000
c) Replace Existing Raw Transmission Main	3,300,000
d) Construct Island Dual System	10,180,000
Subtotal	$14,480,000

TOTAL CONSTRUCTION COST	$24,680,000
+ 35% engineering, administration, legal, financial and contingencies	8,638,000
TOTAL PROJECT COST	$33,318,000

TABLE 21

PROBABLE CAPITAL COSTS

ALTERNATIVE 1

A.	Marco Island Lower Hawthorn		
	1. Well Construction	5 wells & 2 rotational @ $65,000/well	$ 455,000
	2. Pump Station & Controls	Pump, Pipe & Valves- 7 ea @ $30,000/well	210,000
	3. Pump House	5 each @ $10,000/each	50,000
	4. Central Control Buildings	2 each @ $60,000/each	120,000
	5. Electrical System	1 lump Sum	100,000
	6. Emergency Generator System	2 each @ $35,000/each	70,000
	7. Telemetry System	1 Lump Sum	100,000
	8. Wellfield Transmission Main	12,500 ft., 16-inch @ $60/LF	750,000
	9. 6.0 MGD R.O. Treatment Facility		8,345,000
		Subtotal	$10,200,000
B.	Mainland Lower Hawthorn - Phase I		
	1 thru 9 - Same as Above		$10,200,000
	10. Replace Existing Raw Transmission Main	26,400 L.F., 30-inch @ $125/L.F.	3,300,000
		Subtotal	$13,500,000
		TOTAL CONSTRUCTION COST	$23,700,000
	+ 35% for engineering, administration, legal, financial and contingencies		8,295,000
		TOTAL PROJECT COST	$31,995,000

TABLE 22

PROBABLE CAPITAL COSTS

ALTERNATIVE 2

A. Marco Island Lower Hawthorn

1.	Well Construction		
	5 wells & 2 rotational @ $65,000/well		$ 455,000
2.	Pump Station & Controls		
	Pump, Pipe & Valves- 7 ea @ $30,000/well		210,000
3.	Pump House		
		5 each @ $10,000/each	50,000
4.	Central Control Buildings		
		2 each @ $60,000/each	120,000
5.	Electrical System		
		1 lump Sum	100,000
6.	Emergency Generator System		
		2 each @ $35,000/each	70,000
7.	Telemetry System		
		1 Lump Sum	100,000
8.	Wellfield Transmission Main		
	12,500 ft., 16-inch @ $60/LF		750,000
9.	6.0 MGD R.O. Treatment Facility		8,345,000
		Subtotal	$10,200,000

B. Existing Lake/Infiltration System (Potable Use)

1.	Refurbish Existing Lime Softening Plant		$ 1,000,000
2.	Add Ozonation Equipment		600,000
3.	Replace Existing Raw Transmission Main		
	26,400 L.F., 30-inch @ $125/L.F.		3,300,000
		Subtotal	$ 4,900,000

TOTAL CONSTRUCTION COST	$15,100,000
+ 35% for engineering, administration, legal, financial and contingencies	5,285,000
+ Lake/Infiltration System Land Purchase 800 acres @ $15,000/acre	12,000,000
TOTAL PROJECT COST	$32,385,000

TABLE 23

PROBABLE CAPITAL COSTS

<u>ALTERNATIVE 3</u>

A.	Marco Island Lower Hawthorn		
	1.	Well Construction 5 wells & 2 rotational @ $65,000/well	$ 455,000
	2.	Pump Station & Controls Pump, Pipe & Valves-7 ea @ $30,000/well	210,000
	3.	Pump House 5 each @ $10,000/each	50,000
	4.	Central Control Buildings 2 each @ $60,000/each	120,000
	5.	Electrical System 1 lump Sum	100,000
	6.	Emergency Generator System 2 each @ $35,000/each	70,000
	7.	Telemetry System 1 Lump Sum	100,000
	8.	Wellfield Transmission Main 12,500 ft., 16-inch @ $60/LF	750,000
	9.	6.0 MGD R.O. Treatment Facility	8,345,000
		Subtotal	$10,200,000
B.	Existing Lake/Infiltration System (Irrigation Use)		
	1.	Relocate Raw Water Pumping and Storage	$ 500,000
	2.	Construct Filters and Chlorination System	500,000
	3.	Replace Existing Raw Transmission Main 26,400 L.F., 30-inch @ $125/L.F.	3,300,000
	4.	Construct Island Storage 2 - 3 MG. Tanks @ $600,000/tank	1,200,000
	5.	Construct Repump Facilities 2 @ $200,000/each	400,000
	6.	Construct Major Irrigation Transmission Mains 38,000 L.F., 16-inch @ $60/L.F.	1,080,000
	7.	Construct Distribution System (± 50% coverage) 300,000 LF @ $25/LF	7,500,000
		Subtotal	$14,480,000
		TOTAL CONSTRUCTION COST	$24,680,000
		+ 35% for engineering, administration, legal, financial and contingencies	8,638,000
		TOTAL PROJECT COSTS	$33,318,000

C. Present Worth Analysis

A present worth analysis was performed on each of the three (3) outlined alternatives in order to determine a ranking of lowest total cost. Although the second phase capital cost expansion of facilities was not included, the cost difference would remain nearly the same or widen between the three (3) alternatives. Completion of a dual system would be comparable to additional expansion of the R.O. treatment and supply system to provide ultimate water supplies to Marco Island. O & M costs for total annual demand was included in the analysis. Tables 24 thru 26 illustrate the Present Worth of the alternatives. A summary is provided below:

ALTERNATIVE	CAPITAL COST	TOTAL PRESENT WORTH
1	$31,995,000	$72,063,167
2	$32,385,000	$63,752,116
3	$33,318,000	$63,186,982

As noted, Alternative 3 has the lowest total present worth although a slightly higher capital cost. The second lowest total present worth is Alternative 2 and third Alternative 1. The long term operation and maintenance cost savings of the dual pipeline system (Alt.3) versus the O&M cost of high level treatment of water used for irrigation is the reason for the final ranking of total present worth costs.

TABLE 24
PRESENT WORTH ANALYSIS
ALTERNATIVE 1

YEAR	CAPITAL COST 6.0 MGD MARCO	CAPITAL COST 6.0 MGD MAINLAND	EXISTING LIME SOFTENING	FIXED ANNUAL O & M COST MARCO R.O.	FIXED ANNUAL O & M COST MAINLAND R.O.	FLOW RELATED O&M LIME SOFTENING	FLOW RELATED O&M MARCO & MAINLAND R.O.	TOTAL ANNUAL COST	PRESENT WORTH FACTOR	PRESENT WORTH
1990	$13,770,000		$1,036,000	$1,034,331		$372,300	$39,989	$16,252,620	1.0000	$16,252,620
1991			$1,036,000	$1,034,331		$372,300	$117,060	$2,559,691	0.9346	$2,392,287
1992			$1,036,000	$1,034,331		$372,300	$194,130	$2,636,761	0.8734	$2,302,947
1993			$1,036,000	$1,034,331		$372,300	$270,958	$2,713,589	0.8163	$2,215,103
1994		$18,225,000		$1,034,331	$1,034,331		$1,802,189	$22,095,851	0.7629	$16,856,925
1995				$1,034,331	$1,034,331		$1,879,259	$3,947,921	0.7130	$2,814,868
1996				$1,034,331	$1,034,331		$1,959,481	$4,028,143	0.6663	$2,683,952
1997				$1,034,331	$1,034,331		$2,039,702	$4,108,364	0.6227	$2,558,278
1998				$1,034,331	$1,034,331		$2,119,681	$4,188,343	0.5820	$2,437,616
1999				$1,034,331	$1,034,331		$2,199,902	$4,268,564	0.5439	$2,321,672
2000				$1,034,331	$1,034,331		$2,280,123	$4,348,785	0.5083	$2,210,487
2001				$1,034,331	$1,034,331		$2,365,676	$4,434,338	0.4751	$2,106,754
2002				$1,034,331	$1,034,331		$2,450,987	$4,519,649	0.4440	$2,006,724
2003				$1,034,331	$1,034,331		$2,536,540	$4,605,202	0.4150	$1,911,159
2004				$1,034,331	$1,034,331		$2,621,850	$4,690,512	0.3878	$1,818,981
2005				$1,034,331	$1,034,331		$2,707,404	$4,776,066	0.3624	$1,730,846
2006				$1,034,331	$1,034,331		$2,788,352	$4,857,014	0.3387	$1,645,071
2007				$1,034,331	$1,034,331		$2,869,058	$4,937,720	0.3166	$1,563,282
2008				$1,034,331	$1,034,331		$2,950,006	$5,018,668	0.2959	$1,485,024
2009				$1,034,331	$1,034,331		$3,030,712	$5,099,374	0.2765	$1,409,977
2010				$1,034,331	$1,034,331		$3,111,660	$5,180,322	0.2584	$1,338,595
										$72,063,167

TABLE 25
PRESENT WORTH ANALYSIS
ALTERNATIVE 2

YEAR	CAPITAL COST 6.0 MGD MARCO R.O.	CAPITAL COST 6.0 MGD EXISTING SYSTEM	FIXED ANNUAL O & M COST MARCO ISLAND R.O.	FIXED ANNUAL O & M COST EXISTING SYSTEM	FLOW RELATED O&M MARCO ISLAND R.O.	FLOW RELATED O&M EXISTING SYSTEM	TOTAL ANNUAL COST	PRESENT WORTH FACTOR	PRESENT WORTH AMOUNT
1990	$13,770,000		$1,034,331	$1,036,000	$39,989	$372,300	$16,252,620	1.0000	$16,252,620
1991			$1,034,331	$1,036,000	$117,060	$372,300	$2,559,691	0.9346	$2,392,287
1992			$1,034,331	$1,036,000	$194,130	$372,300	$2,636,761	0.8734	$2,302,947
1993			$1,034,331	$1,036,000	$270,958	$372,300	$2,713,589	0.8163	$2,215,103
1994		$18,615,000	$1,034,331	$1,036,000	$348,029	$372,300	$21,405,660	0.7629	$16,330,378
1995			$1,034,331	$1,036,000	$425,099	$372,300	$2,867,730	0.7130	$2,044,691
1996			$1,034,331	$1,036,000	$505,321	$372,300	$2,947,952	0.6663	$1,964,220
1997			$1,034,331	$1,036,000	$585,542	$372,300	$3,028,173	0.6227	$1,885,643
1998			$1,034,331	$1,036,000	$665,521	$372,300	$3,108,152	0.5820	$1,808,944
1999			$1,034,331	$1,036,000	$745,742	$372,300	$3,188,373	0.5439	$1,734,156
2000			$1,034,331	$1,036,000	$825,963	$372,300	$3,268,594	0.5083	$1,661,426
2001			$1,034,331	$1,036,000	$911,516	$372,300	$3,354,147	0.4751	$1,593,555
2002			$1,034,331	$1,036,000	$996,827	$372,300	$3,439,458	0.4440	$1,527,119
2003			$1,034,331	$1,036,000	$1,082,380	$372,300	$3,525,011	0.4150	$1,462,880
2004			$1,034,331	$1,036,000	$1,167,690	$372,300	$3,610,321	0.3878	$1,400,082
2005			$1,034,331	$1,036,000	$1,253,244	$372,300	$3,695,875	0.3624	$1,339,385
2006			$1,034,331	$1,036,000	$1,334,192	$372,300	$3,776,823	0.3387	$1,279,210
2007			$1,034,331	$1,036,000	$1,414,898	$372,300	$3,857,529	0.3166	$1,221,294
2008			$1,034,331	$1,036,000	$1,495,846	$372,300	$3,938,477	0.2959	$1,165,395
2009			$1,034,331	$1,036,000	$1,576,552	$372,300	$4,019,183	0.2765	$1,111,304
2010			$1,034,331	$1,036,000	$1,657,500	$372,300	$4,100,131	0.2584	$1,059,474
									$63,752,116

TABLE 26
PRESENT WORTH ANALYSIS
ALTERNATE 3

	CAPITAL COST		FIXED ANNUAL O & M			FLOW RELATED O&M					
YEAR	6.0 MGD MARCO R.O.	IRRIGATION SYSTEM	EXISTING LIME SOFTENIN	MARCO R.O.	IRRIGATION SYSTEM	EXISTING LIME SOFTENING	MARCO R.O.	IRRIGATION SYSTEM	TOTAL ANNUAL COST	PRESENT WORTH FACTOR	PRESENT WORTH AMOUNT
1990	$13,770,000		$1,036,000	$1,034,331		$372,300	$39,989		$16,252,620	1.0000	$16,252,620
1991			$1,036,000	$1,034,331		$372,300	$117,060		$2,559,691	0.9346	$2,392,287
1992			$1,036,000	$1,034,331		$372,300	$194,130		$2,636,761	0.8734	$2,302,947
1993			$1,036,000	$1,034,331		$372,300	$270,958		$2,713,589	0.8163	$2,215,103
1994		$19,548,000		$1,034,331	$270,000		$1,454,160	$157,242	$22,463,733	0.7629	$17,137,582
1995				$1,034,331	$270,000		$1,454,160	$192,063	$2,950,554	0.7130	$2,103,745
1996				$1,034,331	$270,000		$1,454,160	$228,308	$2,986,799	0.6663	$1,990,104
1997				$1,034,331	$270,000		$1,454,160	$264,552	$3,023,043	0.6227	$1,882,449
1998				$1,034,331	$270,000		$1,454,160	$300,687	$3,059,178	0.5820	$1,780,442
1999				$1,034,331	$270,000		$1,454,160	$336,932	$3,095,423	0.5439	$1,683,601
2000				$1,034,331	$270,000		$1,454,160	$373,176	$3,131,667	0.5083	$1,591,826
2001				$1,034,331	$270,000		$1,454,160	$411,830	$3,170,321	0.4751	$1,506,220
2002				$1,034,331	$270,000		$1,454,160	$450,374	$3,208,865	0.4440	$1,424,736
2003				$1,034,331	$270,000		$1,454,160	$489,027	$3,247,518	0.4150	$1,347,720
2004				$1,034,331	$270,000		$1,454,160	$527,571	$3,286,062	0.3878	$1,274,335
2005				$1,034,331	$270,000		$1,454,160	$566,225	$3,324,716	0.3624	$1,204,877
2006				$1,034,331	$270,000		$1,454,160	$602,798	$3,361,289	0.3387	$1,138,469
2007				$1,034,331	$270,000		$1,454,160	$639,261	$3,397,752	0.3166	$1,075,728
2008				$1,034,331	$270,000		$1,454,160	$675,834	$3,434,325	0.2959	$1,016,217
2009				$1,034,331	$270,000		$1,454,160	$712,298	$3,470,789	0.2765	$959,673
2010				$1,034,331	$270,000		$1,454,160	$748,871	$3,507,362	0.2584	$906,302
											$63,186,982

VIII. MARCO ISLAND ALTERNATIVE SELECTION

In addition to the cost analysis and comparisons of the various alternatives, several other criteria should be considered in determining the best method of meeting the long-term water needs of Marco Island. Each of these criteria, are listed below along with a brief narrative analyses.

A. Cost 1

Alternative 3 - Rank 1

The capital costs of all three (3) alternatives are essentially equal; however, the operation and maintenance costs clearly indicates the two (2) reverse osmosis treatment plant system is more expensive. The conservatively estimated $0.30/1000 gallon for irrigation system O & M is significantly less than the other alternatives and will continue to become more cost effective as treatment criteria become more restrictive and power costs escalate. Operating a secondary piping system is the least expensive alternative.

Alternative 2 - Rank 2

Based on the Present Worth Analysis, a combination of constructing, operating and maintaining a Marco R.O. treatment plant and purchase of the existing lake/infiltration system site for continued lime softening is less expensive than the two (2) plant reverse osmosis treatment alternative.

Alternative 1 - Rank 3

The two (2) reverse osmosis treatment alternative with one plant located on Marco Island and the other on the mainland is the highest cost alternative.

B. Flexibility to Meet New Regulations

Alternative 1 - Rank 1

Reverse osmosis membrane technology has continued to advance through reduced power consumption requirements while maintaining capability to remove contaminates. This is particularly important since ever changing drinking water treatment standards require greater contaminant removals.

Alternative 3 - Rank 1

Essentially equal to Alternative 1 using reverse osmosis for potable water. The secondary irrigation system requires minimal treatment prior to distribution.

Alternative 2 - Rank 3

The lime softening treatment process has limited capability for removing synthetic organic compounds and must be modified by the addition of other unit treatment processes for organics removal. These processes include ozone, activated carbon absorption, and use of other oxidizing agents such as premangates. The softening processes have almost reached maximum attainable performance level without major refinements and further developments.

C. Reliability

Alternative 1 - Rank 1

Construction of two (2) treatment plants utilizing different sources for potable supply provides the most reliable alternative. In the event major system breakdown, storm damage or supply problems should occur the other operating facility could provide emergency supply.

Alternative 3 - Rank 2

Construction of a R.O. treatment system for potable demand and a separate irrigation system using surficial supply also provides a reliable system.

Alternative 2 - Rank 3

Use of water from surficial supplies in the South County area for potable use does not eliminate the potential for drought impacts and saltwater intrusion, and is therefore the least reliable alternative.

D. Best Use of Resources

Alternative 3 - Rank 1

The dual system alternative allows beneficial use of water of lower quality for continued use as a irrigation supply. Development of land adjacent to the supply could be compatible for irrigation uses. Allowing acceptable use of the available surficial water, development of adjacent land and retaining the mainland Lower Hawthorn for other potable uses is the highest and best use of the resources.

Alternative 1 - Rank 2

Allows development of land adjacent to existing supply lake and creates potable water from brackish water. The mainland Lower Hawthorn supply would essentially be used to meet potable and irrigtaion demands.

Alternative 2 - Rank 3

Severely restricts development of land adjacent to and surrounding surficial supply sources.

E. Resource Permittability

Alternative 3 - Rank 1

Uses a lower quality water for higher and better use as an irrigation supply. Saline water on the mainland could be developed in the future for potable use.

Alternative 1 - Rank 2

Creates a potable supply from a brackish water source which is not affected by drought or potential contamination.

Alternative 2 - Rank 3

Does not relieve the concern for drought condition impacts and water quality degradation.

F. Environmental Permittability

Alternative 1 - Rank 1

All alternatives include development of a reject water disposal system within the permitting constraints of State and Federal regulations. The reverse osmosis systems also have no potential impact to wetland plant communities and therefore have the least impact on the environment.

Alternative 2 - Rank 2

Use of surficial supplies has potential to impact wetland plant communities during severe drought conditions.

Alternative 3 - Rank 2

Same potential as Alternative 2.

G. Ease of Implementation

Alternative 1 - Rank 1

Relatively contained treatment plant construction sites with limited need to coordinate with other entities.

Alternative 2 - Rank 2

Requires coordination with land owners during land acquisition of surficial supply system. This could be a difficult undertaking.

Alternative 3 - Rank 3

Requires cooperation of land owners for use of surficial supply. Requires major construction effort to install secondary water system.

H. Selection Criteria Summary

A tabulation of the ratings of each alternative is provided on Table 27. The various criteria used in comparing the three (3) alternatives indicates Alternative 2 is not the best approach to providing long term water supply to Marco Island. The other two alternatives can be considered equal based on the criteria used in the evaluation. However, other factors should be considered in final alternative selection.

Recent State legislation requires the various Water Management Districts to access water resources and availability to each community in order to determine "critical water supply areas". The South Florida Water Management District has designated the City of Cape Coral and City of Ft. Myers as "critical water supply areas" and has mandated dual water system construction as part of their Consumptive Use Permits for water supply. Based on the history of the Marco Island area and results of this Study, the SFWMD could so designate Marco Island. A dual system would also allow reuse of wastewater effluent for irrigation; however, significant modifications to the Marco Wastewater Treatment Plant may be required in order to meet new regulations.

The acquisition of rights to use water from the existing lake/infiltration system for irrigation purposes may not be feasible since the property is in private ownership.

Construction of a dual system would likely fall under the County's responsibility in order to ensure connection to the irrigation system and success of the program.

Table 27

SUMMARY OF SELECTION CRITERIA

Criteria	Alternative 1	Alternative 2	Alternative 3
Costs	3	2	1
Flexibility	1	3	1
Reliability	1	3	2
Best Use of Resources	2	3	1
Resource Permittability	2	3	1
Environmental Permittability	1	2	2
Implementation	1	2	3
TOTAL	11	18	11

Note: Lowest total points denotes highest ranking.

IX. REGULATORY

A. Drinking Water Regulations

A number of proposed and existing regulations regarding drinking water supply could impact the development of water sources for Marco Island. These include organics in potable water, radio nuclides in potable water, the disposal of concentrate from membrane processes and the disposal of lime softening sludge.

Synthetic organics consitute a number of man made compunds which are regulated by both the State and Federal governments. Generally, these compounds are introduced into the environment by human activities and in essence the only aquifer that could be effected by these would be the surficial aquifers and with some potential for the Lower Tamiami Aquifer. It is anticipated that the regulatory requirements on these chemicals will become more stringent. Currently, thirty of these compounds are regulated and it is anticipated that more will be added in the future. These compounds are removable with air stripping, ozone and hydrogen peroxide or activated carbon. However, EPA only recognizes the use of activated carbon or air stripping as acceptable means to remove these compounds. The air stripping process will most likely ultimately be regulated under the air pollution control regulations and hence will become a process that is not viable. It is not anticipated that synthetic organic compounds would be found in the waters obtained from the Lower Hawthorn Aquifer.

The United States Environmental Protection Agency has been charged with regulating byproducts generated by the disinfection process in water treatment plants. Particular emphasis is given to trihalomethane compounds. Currently, trihalomethane compounds are regulated at a level of 100 ppb. The EPA has been required to review this regulation. More stringent regulations are anticipated and it is anticipated that one or two strategies will occur.

1. The total limitation on trihalomethanes will be reduced to somewhere between 20 or 50 parts ppb and that the compounds will be regulated as a group.

2. It is a possibility that the four individual trihalomethane compounds will be regulated individually, most likely with an upper limit of 20 ppb or less.

The significance of the increased regulation is very important for the treatment of the Surficial and the Lower Tamiami Aquifer waters. Existing lime softening processes cannot remove total trihalomethanes down to these levels. Suitable additional processes include air stripping, granular activated carbon and ozone. However, air stripping as stated before, will most likely become an obsolete process due to regulation of volatile organic chemical admissions into the atmosphere. Ozone is a process which has been demonstrated effectively in Florida waters which are similar to those in the Surficial and Tamiami Aquifers. It should be a viable candidate for use in the County. Granular activated carbon facilities, although they do work, are not economically feasible. The activated carbon unit process requires extensive operational funding and staffing.

B. Liquid and Solid Residuals

A significant consideration in the development of major water supplies is the production and disposal of liquid and solid by-products from the treatment processes. Regulations governing the handling and disposal of such by-products continue to become more restrictive.

The disposal of concentrate from either a membrane softening process, electrodialysis process or reverse osmosis process will be required if that is chosen as a water treatment process. Disposal of concentrate is a highly regulated by-product in the State of Florida. The Environmental Protection Agency has generally classified concentrate as an industrial waste. The acceptable means of disposal are an ocean outfall discharge, deep injection well by using a Class I injection well, or surface spreading where the Surficial Aquifer exceeds 2000 mg/l TDS. The disposal of concentrate will continue to be heavily regulated in the future. Most likely the surface spreading would be discontinued since there is a potential for soil contamination and exceeding the sodium absorption ratio of the soil. Also, discharge of concentrate into Marco Island surface waters would be prohibited since there are a number of Outstanding Florida Waters in the Collier County and Marco Island area. This could prohibit disposal area in adjoining non-designated waters. An extensive analysis will need to be completed on the mixing zone requirements for a surficial water discharge. The most environmentally acceptable means of disposal is the use of deep injection wells. These have been installed in a number of instances in the State. However, they do add substantially to the cost of the treatment system. Deep well injection was used in the cost analyses performed within this Report.

Lime softening with ozone or potassium permangate water treatment facilities produce a lime sludge which require disposal in a land fill site or some other acceptable means of disposal. Currently, lime sludges are not considered to be hazardous waste and are generally considered to be useful resources. The addition of chemicals such as potassium permangate for organics oxidation may result in downgrading of the sludge from a suitable substance to a rating that is somewhat less suitable.

X. NORTH COUNTY ALTERNATIVE SELECTION

Hydrogeologic investigations performed to date indicate a significant water resource is available in the North County area in the vicinity of Mule Pen Quarry. The surficial aquifer, termed the Coral Reef, and the Lower Tamiami Aquifer contain water of sufficient quality and quantity for development as a public water supply. Any limitations placed on development of this area as a major water supply would involve potential impact to wetlands from water table drawdowns.

The South Florida Water Management District has placed a large portion of the adjoining Bird Rookery Swamp on the "Save Our Rivers" land acquisition list. The SFWMD has placed the area on it's priority list to ensure preservation as a major potable water resource.

In order to develop the resource as a public supply, additional hydrogeologic modeling and careful wellfield design will be required to minimize water table drawdown. Wells would be installed in the Lower Tamiami Aquifer for first phase development of 8 MGD.

The preliminary design and cost analyses performed in previous sections of this Report indicates that lime softening with ozone disinfection and membrane softening are both acceptable means of treating water from the Lower Tamiami Aquifer. The lime softening process has been shown as the most cost effective method of treatment; however, more stringent limitations on contaminants, particularly trihalomethanes, could force major upgrades to the lime softening process. A list of advantages and disadvantages of lime softening and membrane softening is provided below.

Lime Softening

Advantages

1) Capital cost for 8 MGD treatment facility is approximately $2.7 million less than membrane softening ($11.2 million vs. $13.9 million).

2) Basic process is the same as existing East County Regional Water Treatment Plant with similar operation and maintenance requirements.

3) Considered a reliable treatment process with good finished water quality

4) Wastes less than 5% of raw water during treatment process for filter backwashing, etc.

Disadvantages

1) Process can meet current and proposed treatment criteria; however, potential future drinking water standards may not be met with current technology.

2) Sludge by-product of significant quantities is difficult to handle and adds substantial cost to the annual O & M.

Membrane Softening

Advantages

1) Treatment process is capable of removing organic contaminants to meet current and proposed drinking water standards.

2) Membrane manufacturing technology continues to improve contaminants removal capability.

3) Considered a reliable treatment process with good finished water quality.

Disadvantages

1) Capital cost for 8 MGD treatment facility and reject deep well is approximately $2.7 million more than lime softening.

2) Operation and maintenance costs are approximately 30% to 40% higher than lime softening.

3) Wastes approximately 15% of raw water during treatment process as concentrate.

Other criteria for evaluating the alternative, such as environmental resources and permittability are essentially equal between the two (2) processes.

Although the cost of membrane softening is higher than the lime softening process based on today's membrane technology, it is believed that improving technology and more strigent drinking water standards will ultimately make the lime softening treatment process obsolete. Therefore, based on this analysis Collier County should proceed toward development of the Lower Tamiami Aquifer and construction of a membrane softening treatment facility.

XI. CONCLUSIONS AND RECOMMENDATIONS

The investigations and analyses performed during this Feasibility Study has resulted in several conclusions regarding water resources and treatment technologies available to meet the long-term water demands of Marco Island and County service areas.

It is apparent that high quality water is somewhat limited in the south County area and that no single source of water is sufficient to meet the needs of Marco Island. Based on the projections, approximately 6 MGD of potable water and 11 MGD of irrigation water (17 MGD total) will be required to serve Marco Island at build-out during peak season maximum month. It has also been determined that the existing lake/infiltration system is not capable of meeting maximum month demands during drought conditions which is currently permitted for 6.23 MGD.

Water resources and estimated yields from aquifer systems in the south County area include 1) Marco Island Lower Hawthorn, 5 to 6 MGD 2) Mainland Lower Hawthorn 6 to 8 MGD 3) Existing Lake/Infiltration System 5 to 6 MGD and 4) Section 35 Water Table 5 to 6 MGD. It should be noted that additional hydrogeologic investigations and modeling will be required to more accurately determine safe yields of the resources, particularly the Lower Hawthorn Aquifers since minimal data is currently available.

The surficial (water table) supplies can be treated using the lime softening process in order to meet current drinking water standards. However, proposed and future contaminant regulations will likely result in unattainable limitations using the lime softening process. Quality data obtained during recent testing on Marco Island indicates the total dissolved solids (TDS) and chloride concentrations in the Lower Hawthorn Aquifer can be treated using low pressure reverse osmosis. A secondary water system for irrigtion supply has been determined to be cost-effective for Marco Island and makes best use of the resources, although implementation factors are considerable.

In addition, hydrogeologic investigations performed to date indicates a significant quantity of untapped water is available in the Golden Gate Estates and North County area. The Lower Tamiami Aquifer in Golden Gate Estates is projected to have a safe yield of 45 to 50 MGD. Pending applications for Consumptive Use Permits by the City of Naples and Collier County total 26.9 MGD (annual average) with a maximum daily withdrawal of 40.3 MGD. The Lower Tamiami in the Mule Pen Quarry area is projected to have a safe yield of 8 to 24 MGD. Water quality from the Lower Tamiami in both areas can be sufficiently treated using the lime softening process; however, membrane softening should be capable of meeting more stringent treatment requirements as new regulations are promulgated.

Several recommendations have been developed for the County's consideration in pursuing further development of water supplies for County service areas and Marco Island.

1) Encourage Marco Utilities to proceed with additional hydrogeological testing and modeling to more accurately define the safe yield of the Lower Hawthorn Aquifer system on Marco Island.

2) Encourage Marco Utilities to construct reverse osmosis treatment facilities on Marco Island of sufficient capacity to maximize safe production from the Lower Hawthorn Aquifer.

3) Consider and weigh the benefits and liabilities of constructing a dual system on Marco Island for irrigation supply versus development of a Mainland Lower Hawthorn Wellfield and reverse osmosis treatment facility.

4) Proceed with detailed hydrogeologic investigations, modeling and permitting of the Mainland Lower Hawthorn Aquifer system in the vicinity of the County's Manatee Road Storage and Repump Facility site.

5) Determine the County's role, if any, in the provision of water supply to Marco Island.

6) Consider development of a formal water conservation program for Marco Island.

7) Proceed with detailed hydrogeologic investigations, modeling and permitting of the Lower Tamiami Aquifer system in the vicinity of Mule Pen Quarry.

8) Proceed with steps necessary to obtain appropriate easements, rights-of-way or acquisitions for wellfield and treatment facility construction for the North County Regional Water Treatment Facility.

9) Proceed with plans to install a membrane softening treatment facility for the North County Regional Water System.

10) Endorse and encourage the South Florida Water Management District's plans to purchase land in the North County area under the "Save Our Rivers" program for preservation as a public water supply.

11) Authorize the Utilities Division to add detailed (three dimensional) hydrogeological modeling of the Golden Gate Lower Tamiami Aquifer system to the Capital Improvements Plan to determine ultimate safe yield.

12) Investigate and evaluate methods of retaining surface and groundwater during wet season for potable and/or irrigation use during dry season. Such methods including but not limited to retention in canals, lakes and underground aquifer storage and recovery.

13) Accept this Report on the study of water supplies for Marco Island and Collier County.

APPENDIX A

LAKE/INFILTRATION SYSTEM QUALITY DATA

APPENDIX B

WELL INVENTORY

TABLE 3-9. LIST OF INVENTORIED WELLS WITH CONSTRUCTION DETAILS AND WATER QUALITY

Well Number	Total Depth(ft)	Casing Depth(ft)	Casing Diameter(in)	Use	Aquifer	Dissolved Chlorides(mg/l)	Conductivity
CO-150	--	--	--	Irrigation	--	170	910
CO-151	103	98	2	Observation	Tamiami	720	--
CO-152	140	140	2	Observation	Tamiami	--	--
CO-153	66	61	2	Observation	Tamiami	400	--
CO-154	65	62	2	Observation	Tamiami	420	--
CO-155	62	57	2	Observation	Tamiami	680	--
CO-156	63	58	2	Observation	Tamiami	440	--
CO-157	65	60	2	Observation	Tamiami	--	--
CO-161	--	--	2	Observation	--	--	--
CO-162	--	--	8	Irrigation	--	170	--
CO-164	--	--	1.25	Domestic	--	150	910
CO-165	--	--	2	Domestic	--	230	--
CO-166	21	--	2	Irrigation	Water-table	220	1250
CO-167	50	--	2	Domestic	Tamiami	230	1250
CO-168	--	--	--	Domestic	--	250	1290
CO-169	--	--	2	Domestic	--	200	1210
CO-170	40	--	2	Domestic	Tamiami	300	1460
CO-171	--	--	2	Domestic	--	420	1870
CO-172	--	--	--	Domestic/Irr.	--	290	1353
CO-173	--	--	--	Domestic/Irr.	--	250	1320
CO-174	--	--	--	Domestic	--	220	1265
CO-175	--	--	2	Domestic	--	120	1010
CO-177	--	--	--	Irrigation	--	220	1122
CO-178	--	--	--	Irrigation	--	300	1375
CO-179	--	--	--	Plugged	--	20	380
CO-183	44	--	2	Domestic/Irr.	Tamiami	200	1265
CO-184	33	--	2	Irrigation	--	180	1408
CO-185	45	--	2	Irrigation	Tamiami	380	1815
CO-186	42	--	2	Domestic/Irr.	Tamiami	280	--
CO-187	--	--	2	Domestic	--	420	1947
CO-188	--	--	2	Irrigation	--	260	1540
CO-189	--	--	4	Domestic/Stock	--	80	605
CO-190	--	--	--	Irrigation	--	12	352

TABLE 3-9. LIST OF INVENTORIED WELLS WITH CONSTRUCTION DETAILS AND WATER QUALITY - Continued:

Well Number	Total Depth(ft)	Casing Depth(ft)	Casing Diameter(in)	Use	Aquifer	Dissolved Chlorides(mg/l)	Conductivity
CO-191	--	--	--	Irrigation	--	45	627
CO-192	--	--	--	Irrigation	--	40	528
CO-193	40	--	--	Irrigation	Tamiami	260	1250
CO-194	40	--	2	Irrigation	Tamiami	240	1180
CO-195	40	--	2	Irrigation	Tamiami	300	1430
CO-196	34	--	4	Irrigation	Tamiami	260	1150
CO-197	40	--	2	Irrigation	Tamiami	280	1260
CO-201	--	186	2	--	--	--	--
CO-202	15	12	5	Observation	Water-table	--	--
CO-203	25	18	2	Observation	Tamiami	80	--
CO-204	25	18	2	Observation	Tamiami	--	--
CO-217	45.5	30	8	Irrigation	Tamiami	380	--
CO-218	45	40	2	Observation	Tamiami	--	--
CO-219	15	10	2	Observation	Water-table	--	--
CO-235	50	10	8	Observation	Water-table	200	--
CO-236	40	35	2	Observation	Tamiami	--	--
CO-237	40	35	2	Observation	Tamiami	--	--
CO-238	15	10	2	Observation	Water-table	--	--
CO-240	--	40	2	Observation	Tamiami	--	--
CO-263	40	35	2	Observation	Tamiami	60	--
CO-264	35	30	2	Observation	Tamiami	100	980
CO-527	18	--	--	Domestic/Irr.	--	320	1800
CO-528	32	--	2	Irrigation	--	370	1775
CO-530	--	30	2	Domestic/Irr.	Tamiami	550	2425
CO-531	80	--	4	Irrigation	--	150	1950
CO-538	46.6	--	6	Irrigation	--	660	2445
CO-539	--	--	6	Irrigation	--	280	1645
CO-540	--	--	8	Irrigation	--	130	1120
CO-541	63	--	8	Irrigation	--	94	966
CO-542	--	--	8	Irrigation	--	100	911
CO-543	72.5	8	--	Irrigation	--	120	940
CO-544	45	30	8	Irrigation	Tamiami	--	--
CO-545	45	26	8	Irrigation	Tamiami	--	--

TABLE 3-9. LIST OF INVENTORIED WELLS WITH CONSTRUCTION DETAILS AND WATER QUALITY - Continued:

Well Number	Total Depth(ft)	Casing Depth(ft)	Casing Diameter(in)	Use	Aquifer	Dissolved Chlorides(mg/l)	Conductivity
CO-572	150	--	2	Observation	--	--	--
CO-580	160	--	2	Observation	--	--	--
CO-591	11.5	6.5	2	Observation	Water-table	--	--
CO-592	12.5	7.5	2	Observation	Water-table	--	--
CO-593	12	7	2	Observation	Water-table	--	--
CO-596	11	6	2	Observation	Water-table	--	--
CO-597	40	38	2	Observation	Tamiami	230	--
CO-598	50	35	2	Observation	Tamiami	1000	--
CO-599	50	43	2	Observation	Tamiami	180	--
CO-769	10	2	2	Irrigation	Water-table	40	850
CO-770	40	40	2	Domestic/Irr.	Tamiami	170	1280
CO-776	52	--	8	Irrigation	--	200	1400
CO-777	16	--	8	Stock	Water-table	130	1200
CO-778	--	--	8	Irrigation	--	--	--
CO-779	24	--	14	Irrigation	Water-table	30	880
CO-780	--	--	8	Irrigation	--	130	1140
CO-781	47	--	8	Irrigation	--	190	1350
CO-782	14	--	8	Irrigation	Water-table	--	--
CO-783	11	--	8	Irrigation	Water-table	110	1000
CO-784	73	--	6	Irrigation	--	50	750
CO-789	60	45	2	Observation	Tamiami	140	920
CO-790	15	10	2	Observation	Water-table	46	650
CO-791	60	45	2	Observation	Tamiami	80	650
CO-792	15	10	2	Observation	Water-table	18	500
CO-795	60	45	2	Observation	Tamiami	160	1150
CO-796	15	10	2	Observation	Water-table	22	620
CO-798	15	10	2	Observation	Water-table	62	750
CO-799	65	45	2	Observation	Tamiami	100	870
CO-800	15	10	2	Observation	Water-table	34	650
CO-801	100	--	8	Irrigation	--	500	2380
CO-802	--	--	6	--	--	90	1100
CO-818	4.5	3	2	Observation	Water-table	--	--
CO-820	176	168	2	Observation	--	450	--

TABLE 3-9. LIST OF INVENTORIED WELLS WITH CONSTRUCTION DETAILS AND WATER QUALITY - Continued:

Well Number	Total Depth(ft)	Casing Depth(ft)	Casing Diameter(in)	Use	Aquifer	Dissolved Chlorides(mg/l)	Conductivity
CO-821	16	11	2	Observation	Water-table	40	850
CO-822	--	--	8	Irrigation	--	190	1350
CO-847	--	--	2	Irrigation	--	--	--
CO-858	58	--	14	Irrigation	--	--	--
CO-867	50	35	2	Observation	Tamiami	178	1390
CO-868	50	35	2	Observation	Tamiami	--	--
CO-1117	42	--	--	Observation	Tamiami	429	--
CO-1118	62	--	--	Observation	Tamiami	153	--
CO-1131	42	--	--	Observation	Tamiami	201	--
CO-1133	42	--	--	Observation	Tamiami	150	--
CO-1134	62	--	--	Observation	Tamiami	111	--
CO-1135	49	--	--	Observation	Tamiami	315	--
CO-1139	43	--	--	Observation	Tamiami	159	--
CO-1140	42	--	--	Observation	Tamiami	48	--
CO-1141	42	--	--	Observation	Tamiami	790	--
CO-1145	48	--	--	Observation	Tamiami	790	--
CO-1146	42	--	--	Observation	Tamiami	114	--
CO-1147	42	--	--	Observation	Tamiami	93	--
CO-1154	42	--	--	Observation	Tamiami	63	--
CO-1175	52	--	--	Observation	Tamiami	111	--
CO-1177	62	--	--	Observation	Tamiami	920	--
CO-1178	63	--	--	Observation	Tamiami	730	--
CO-1408	22	--	2	Irrigation	--	440	2300
CO-1409	--	43	2	--	Tamiami	280	1910
CO-1410	--	--	2	--	--	300	--
CO-1411	--	--	2	--	--	80	1200
CO-1412	58	--	2	--	--	240	1450
CO-1413	--	--	2	Domestic	--	60	980
CO-1414	--	--	2	Domestic	--	100	910
CO-1476	20	20	2	Observation	Water-table	17	--
CO-1477	20	20	2	Observation	Water-table	4.5	--
CO-1478	20	20	2	Observation	Water-table	38	--
CO-1479	20	20	2	Observation	Water-table	215	--

TABLE 3-9. LIST OF INVENTORIED WELLS WITH CONSTRUCTION DETAILS AND WATER QUALITY - Continued:

Well Number	Total Depth(ft)	Casing Depth(ft)	Casing Diameter(in)	Use	Aquifer	Dissolved Chlorides(mg/l)	Conductivity
CO-1539	16	6	2	Observation	Water-table	--	--
CO-1570	100	80	4	Observation	Tamiami	--	--
CO-1571	93	80	4	Observation	Tamiami	--	--
CO-1572	92	40	4	Observation	Tamiami	--	--
CO-1573	183	138/143	1.25	Observation	--	--	--
CO-1574	155	--	--	Observation	--	--	--
CO-1629	22	15	6	PS	Water-table	--	--
CO-1640	96	--	--	--	--	--	--
CO-1641	23	23	2	Observation	Water-table	--	--
CO-1667	23	23	2	Observation	Water-table	190	1300
CO-1668	23	23	2	Observation	Water-table	60	950
CO-1669	23	23	2	Observation	Water-table	280	1650
CO-1670	23	23	2	Observation	Water-table	300	1800
CO-1671	23	23	2	Observation	Water-table	300	1800
CO-1672	23	23	2	Observation	Water-table	260	1780
CO-1673	40	--	6	Not Used	--	56	--
CO-1674	--	--	2	Domestic	--	60	--
CO-1675	70	40	2	Domestic	Tamiami	78	--
CO-1676	70	40	2	Domestic	Tamiami	78	--
CO-1677	70	40	8	Irrigation	Tamiami	80	--
CO-1678	40	--	8	--	--	--	--
CO-1680	40	--	8	--	--	--	--
CO-1681	40	--	8	--	--	120	--
CO-1682	40	--	8	--	--	--	--
CO-1683	40	--	8	--	--	--	--
CO-1684	40	--	8	--	--	--	--
CO-1685	80	--	8	--	--	--	--
CO-1686	40	--	8	--	--	--	--
CO-1687	40	--	8	--	--	--	--
CO-1688	40	--	8	--	--	--	--
CO-1689	40	--	8	--	--	--	--
CO-1692	120	116	2	Observation	Tamiami	820	--
CO-1693	120	116	2	Observation	Tamiami	1200	--

TABLE 3-9. LIST OF INVENTORIED WELLS WITH CONSTRUCTION DETAILS AND WATER QUALITY - Continued:

Well Number	Total Depth(ft)	Casing Depth(ft)	Casing Diameter(in)	Use	Aquifer	Dissolved Chlorides(mg/l)	Conductivity
CO-1695	23	21	2	Observation	Tamiami	100	--
CO-1696	21	21	2	Observation	Tamiami	74	--
CO-1697	23	21	2	Observation	Tamiami	90	--
CO-1707	120	116	2	Observation	Tamiami	--	--
CO-1708	120	116	2	Observation	Tamiami	--	--
CO-1714	27	--	2	Domestic	Water-table	160	--
CO-1715	60	--	2	Domestic/Irr.	--	140	--
CO-1716	--	--	--	Domestic	--	--	--
CO-1717	60	--	2	Domestic	--	140	--
CO-1719	--	--	--	--	--	--	--
CO-1770	35	13	4	Observation	Water-table	38	648
CO-1771	35	22	4	Observation	Water-table	50	1058
CO-1920	--	--	8	Irrigation	--	92	1000
CO-1925	45	40	4	Observation	Tamiami	100	1030
CO-1960	74	63	2	Observation	Tamiami	200	--
CO-1961	74	60	2	Observation	Tamiami	240	--
CO-1962	75	70	2	Observation	Tamiami	240	--

APPENDIX C

REVERSE OSMOSIS FEEDWATER AND TREATMENT ANALYSIS

TABLE 3-7
PAGE 1
B.F. GOODRICH
POTENTIAL FEEDWATER FOR R.O.
FEED ANALYSIS

PROJECT CODE: MIS
COLLECTED: 2/28/8 BY: MR. WESTPHALL
RECEIVED: 3/1/89
ANALYZED: 3/2/89 BY: JPH/ZAS
MEMBRANE TYPE: MODEL #:

COMPONENT	FEED PPM	PRODUCT PPM	BRINE PPM	REJECTION %	RECOVERY %	RECOVERY RATIO
ALKALINITY*	176.0	5.8	686.6	98.7	75.0	ERR
ALUMINUM	<DL	0.00	0.0	NA	NA	NA
BARIUM	0.009	0.000	0.0	99.8	75.0	ERR
BORON	0.50	0.20	2.0	84.0	83.3	ERR
CALCIUM	140.02	0.700	558.0	99.8	75.0	ERR
CHLORIDE	2058.6	20.586	8203.5	99.6	75.1	ERR
CHROMIUM	<DL	0.000	0.0	NA	NA	NA
CONDUCTIVITY**	6360.0	63.600	25344.6	99.6	75.1	ERR
COPPER	<DL	0.000	0.0	NA	NA	NA
FLUORIDE	<DL	0.000	0.0	NA	NA	NA
IRON	<DL	0.000	0.0	NA	NA	NA
LEAD	<DL	0.000	0.0	NA	NA	NA
MAGNESIUM	160.9	0.805	641.2	99.8	75.0	ERR
MANGANESE	<DL	0.000	0.0	NA	NA	NA
NITRATE	<DL	0.000	0.0	NA	NA	NA
PHOSPHATE	11.9	0.000	47.6	100.0	74.9	ERR
PHOSPHORUS	1.3	0.000	5.0	100.0	74.9	ERR
POTASSIUM	54.0	0.540	215.2	99.6	75.1	ERR
SILICON	6.64	0.664	26.5	96.0	76.8	ERR
SODIUM	1135.2	11.352	4523.8	99.6	75.1	ERR
STRONTIUM	7.39	0.037	29.4	99.8	75.0	ERR
SULFATE	525.0	2.625	2092.1	99.8	75.0	ERR
ZINC	<DL	0.000	0.0	NA	NA	NA
IONIC STRENGTH	0.0875	0.0008	0.3486			
pH	7.35	5.99	7.77			
TEMPERATURE (C)	25.0					

RECOMMENDED SCALE INHIBITOR
BFGOODRICH AQUAF

OVERALL RECOVERY (%) IS 0.8 (ENTER AS A DECIMAL, NOT AS A PERCENT)

FOULANTS PROJECTION	%
CALCIUM CARBONATE SCALING INDEX	1.03
CALCIUM SULFATE (%)	37.2
CALCIUM FLUORIDE (%)	0.0
BARIUM SULFATE (%)	249.0
STRONTIUM SULFATE (%)	108.8
SILICA (%)	56.6
FERRIC HYDROXIDE (%)	0.0

IF THE '% OF SATURATION' EXCEEDS 100 THEN ANTISCALANT IS REQUIRED!

*ALKALINITY IN PPM $CaCO_3$
**CONDUCTIVITY IN umhos/cm

TABLE 3-7
PAGE 2
B.F. GOODRICH
POTENTIAL FEEDWATER FOR R.O.
FEED ANALYSIS

CATIONS	FEED		PRODUCT		BRINE	
	PPM	MEQ/L	PPM	MEQ/L	PPM	MEQ/L
ALUMINUM	0.00	0.00	0.00	0.00	0.00	0.00
BARIUM	0.01	0.00	0.00	0.00	0.04	0.00
CALCIUM	140.02	6.99	0.70	0.03	557.98	27.84
CHROMIUM	0.00	0.00	0.00	0.00	0.00	0.00
COPPER	0.00	0.00	0.00	0.00	0.00	0.00
IRON	0.00	0.00	0.00	0.00	0.00	0.00
LEAD	0.00	0.00	0.00	0.00	0.00	0.00
MAGNESIUM	160.91	13.24	0.80	0.07	641.23	52.75
MANGANESE	0.00	0.00	0.00	0.00	0.00	0.00
POTASSIUM	54.00	1.38	0.54	0.01	215.19	5.50
SODIUM	1135.20	49.38	11.35	0.49	4523.77	196.78
STRONTIUM	7.39	0.17	0.04	0.00	29.45	0.67
ZINC	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CATIONS	1497.53	71.15	13.43	0.61	5967.65	283.55
ANIONS						
BICARBONATE	214.72	3.52	7.06	0.12	837.70	13.73
CHLORIDE	2058.60	58.07	20.59	0.58	8203.52	231.42
FLUORIDE	0.00	0.00	0.00	0.00	0.00	0.00
NITRATE	0.00	0.00	0.00	0.00	0.00	0.00
PHOSPHATE	11.94	0.38	0.00	0.00	47.58	1.50
SULFATE	525.00	10.94	2.63	0.05	2092.13	43.58
TOTAL ANIONS	2810.26	72.91	30.27	0.75	11180.93	290.23
TOTAL IONS(TDS)	4307.8	144.1	43.7	1.4	17148.6	573.8

CATION/ANION BALANCE 98%

ADDITIONAL COMPONENTS	FEED	PRODUCT	BRINE
ALKALINITY, TOTAL (ppm CaCO3)	176.0	5.8	686.6
ALKALINITY, BICARBONATE (ppm CaCO3)	176.0	5.8	686.6
ALKALINITY, CARBONATE (ppm CaCO3)	<DL	NA	NA
CARBON, TOTAL ORGANIC (ppm)	1.62	NA	NA
CARBON DIOXIDE (ppm AS ION, CALCULATED)	14.7	11.8	23.6
CHLORINE, TOTAL (ppm Cl2)	<DL	NA	NA
HARDNESS, TOTAL (ppm CaCO3)	1021.4	5.1	4070.4
OSMOTIC PRESSURE (PSI)	39.5	0.3	176.8
SILICA ,TOTAL (ppm SiO2, CALCULATED/Si)	14.2	1.4	56.6
SPECIFIC GRAVITY (g/ml)	1.00	NA	NA
TDS (ppm AS NaCl BY CONDUCTIVITY)	3428.8	29.3	15173.1
TURBIDITY (NTU)	4.75	NA	NA

TABLE 3-7
PAGE 3
B.F. GOODRICH
POTENTIAL FEEDWATER FOR R.O.
BACTERIAL ANALYSIS

BACTERIAL TYPE	FEED	PRODUCT	BRINE
AEROBIC			
YEAST AND MOLD (COLONIES PER ML)	0	NA	NA
STANDARD PLATE COUNT (COLONIES PER ML)	0	NA	NA
TOTAL COLIFORM (COLONIES PER 100 ML)	0	NA	NA

TNTC INDICATES TOO NUMEROUS TO COUNT

BACTERIAL TYPE	FEED	PRODUCT	BRINE
ANAEROBIC			
SULFIDE GENERATING BACTERIA (DEGREE OF INFECTION)	0	NA	NA

DEGREE OF INFECTION:
3 = HEAVY INFECTION
2 = MODERATE INFECTION
1 = SLIGHT INFECTION
0 = NO INFECTION

NOTES:

<DL = LESS THAN DETECTION LIMIT
NA = NOT ANALYZED
RATIO = SPECIFIC ION RECOVERY / OVERALL RECOVERY
% REJECTION IS BASED ON FEED-BRINE AVERAGE CONCENTRATION

REMARKS: ***THIS PROJECTION IS BASED ON ASSUMING A RECOVERY RATE AS LISTED ON PAGE 1. THIS RECOVERY SHOULD ONLY BE USED AS A GUIDE AND IS NOT MEANT TO SUGGEST A MAXIMUM OR MINIMUM RECOVERY.