HAVENS AND EMERSON, INC.
Consulting Engineers

TRANSMITTAL MEMO

TO: Steve Neff, P.E.
Acting Director of Engineering
City of Cape Coral
P.O. Box 150027
Cape Coral, Florida 33915-0027

Date: 8-26-93

Job No: 22033

Reference: Surface Water Master Plan

SIR/MADAM:

We are sending you ☒ Attached ☐ Under separate cover via ________ the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Samples
☐ Specifications ☐ Copy of letter ☒ Final Report

Copies	Date	No.	Description
5	7/93		Surface Water Master Plan - Phase I
			Plan of Study

4 delivered

THESE ...

Who took a Book?

☐ For App...
☒ For you...
☐ As reque...
☐ For revi...
☐ For bids
☐ Prints re...

Call everyone

Distribute Same to all concerned -

REMAR... Greg Gerald Steve
Bill
Connie

FRED REBSTOCK TOOK ONE COPY 9-1-93, WITH RICH GERACI!

GREG & KARL GOT ONE!
9-2-93

GAR

SIGNED H. Phillip Kyle

DISTRIBUTION ________

If enclosures are not as noted, kindly notify us at once.

HAVENS AND EMERSON, INC. • 3501 DEL PRADO BLVD. • SUITE 301
CAPE CORAL, FLORIDA 33904 • (813) 542-6540 • FAX (813) 542-1864

'97 JUL 21 AM 8 51

CITY OF CAPE CORAL

BEFORE THE STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

DEPARTMENT OF ENVIRONMENTAL REGULATION,	)	
	)	
vs.		Order No. 15
	)	
GAC PROPERTIES, INC., Lee County.	)	
	)	

CONSENT ORDER

This is a Consent Order between the State of Florida Department of Environmental Regulation (hereinafter referred to as the "Department") and Frank J. Callahan and Herbert S. Freehling, as Co-Trustees of GAC Corporation, GAC Properties Credit, Inc., and GAC Properties, Inc. (hereinafter referred to as "GAC").

Background: Permit applications were filed with the Department for certain dredge and fill work to be done at the Cape Coral Project of GAC. The Department issued a letter dated June 30, 1976 informing GAC of the Department's intent to deny certain of these permits. In addition, the Department issued Warning Notice No. 7996 dated July 9, 1976 regarding ongoing dredge and fill activities within the Cape Coral Project. On August 26, 1976, the Department set out by letter the modifications of the Cape Coral Project required to allow the completion of the project. Subsequently, the GAC verbally agreed to incorporate and implement the proposed, major modifications, subject to the approval of the Bankruptcy Court. It was also determined after the initial denial that GAC qualified for special consideration. This order represents the best efforts of the Department and GAC to improve an old project, begun prior to this decade. It does not signify water quality standards will be met in the interior canals, but is an attempt to buffer, treat, and improve water quality before it reaches Matlacha Pass or the Caloosahatchee River. This Consent Order resolves the alleged violations and serves as the authorization from the Department to complete the work.

1. GAC agrees that no development work shall be done waterward of the line identified as "A" drawn on Exhibit No. 1. Any work that has been done by GAC waterward of this line shall be restored. Restoration shall include the removal or replacement of all GAC-excavated fill material to natural elevation in the areas designated as "B" on Exhibit No. 1. Restoration shall commence within sixty (60) days of the date of entry of this Consent Order, continue in a continuous manner, and be completed to the satisfaction of the Department's district office within one (1) year of the date of entry of this Consent Order.

2. All work landward of "A" on Exhibit No. 1 will be done as described in Exhibit No. 2. The Department originally indicated its intent to deny the applications for permits because of its concern over water quality in the canal system and discharges from the canal system. GAC agrees to construct a pollution retention system landward of "A" on Exhibit No. 1. This retention system will consist of a perimeter spreader waterway to serve as a water distribution system for intercepting and releasing discharges of waters from certain areas of the Cape Coral development. GAC agrees to construct back-to-front sloping lots, swales and weirs within the inland portion of the undeveloped portion of Cape Coral, so as to retain as much of the runoff from the upland as possible, as well as increase the retention and percolation of freshwater to the aquifer. GAC shall prepare a hydraulic assessment to determine the maximum retention of runoff possible within the swales and canals. All work described in this paragraph of the Consent Order shall be performed as described in Exhibit No. 2.

3. Because of the water quality problems within the interior canal system, the Department cannot allow any direct

connection of Cape Coral waterways to waters of the State, which direct connections do not presently exist. Therefore, GAC shall install boat lifts to provide navigable access to Cape Coral canals which do not presently have access to waters of the state. The locations of the boat lifts are identified on Exhibit No. 1 as C_1, C_2 and C_3. Construction of the boat lifts shall be as described in Exhibit No. 2.

4. Because of the water quality benefits to be derived from the tidal wetlands surrounding Cape Coral and the treatment these natural areas provide for any indirect discharges from the Cape Coral area, GAC shall deed to the State, on the date of entry of this Consent Order, the lands owned by GAC as are described in the warranty deeds attached as Exhibits 3(a), 3(b) and 3(c).

5. GAC will deposit to the account of the Department's Pollution Recovery Fund the sum of $200,000 per year, each year for five (5) consecutive years, the first such deposit to be made within thirty (30) days of the entry of this Consent Order and following payments to be made on or before the annual anniversary date of the date of entry of this Consent Order. All money deposited in the Pollution Recovery Fund to the account of GAC projects shall be identified and all interest earned on the account of GAC projects shall be credited to the Pollution Recovery Fund account of these GAC projects. This money shall be used at the discretion of the Secretary of the Department, which use shall nonetheless be restricted in use to study water quality and quantity problems in the Cape Coral and Golden Gate Estates areas, to propose solutions to the problems identified, and as funds allow, to correct the identified problems in both projects. No more than $200,000 may be spent in any one fiscal year without the approval of GAC.

6. GAC hereby agrees to withdraw all permit applications pending for the Cape Coral development (File Numbers 36-10-3545, 36-24-3827, 36-10-3546 and 36-20-0274) on the same date as the entry of this Consent Order. The Department agrees

that this Consent Order will provide the necessary authorization to complete the work described in Exhibits 1 and 2. This Consent Order waives certification under PL 92-500, Section 401.

7. This Consent Order is enforceable under Section 120.69, Florida Statutes and can also be enforced under Section 403.161(1)(b), Florida Statutes.

JAMES E. YACOS and JOHN RODGERS CAMP, JR., as Co-Counsel for the Co-Trustees of GAC Corporation, et al.

By: John Rodgers Camp Jr
JOHN RODGERS CAMP, JR.

DEPARTMENT OF ENVIRONMENTAL REGULATION:

Terry Cole
TERRY COLE
Deputy General Counsel

Consented to by GAC this _____ day of _____________, 1977.

Herbert S. Freehling
HERBERT S. FREEHLING
as Co-Trustee

Frank J. Callahan
FRANK J. CALLAHAN
as Co-Trustee

DATED AND ENTERED this 19 day of april, 1977.

JW Landers Jr
JOSEPH W. LANDERS, JR.
Secretary

Department of Environmental Regulation
2562 Executive Center Circle, E.
Montgomery Building
Tallahassee, Florida 32301

RECEIVED
MAY 04 1979
DER SO. FLA. DISTRICT

BEFORE THE STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

DEPARTMENT OF ENVIRONMENTAL REGULATION)
)
vs.)
)
GAC PROPERTIES, INC.,)
)
Lee County, Florida.)

MODIFICATION TO CONSENT ORDER

The Department of Environmental Regulation (herein referred to as the "Department") and Frank J. Callahan and Herbert S. Freehling, as Co-Trustees of the GAC Corporation, GAC Properties Credit, Inc., and GAC Properties, Inc. (hereinafter referred to as "GAC") in executing the provisions of Consent Order No. 15 have found that certain modifications need to be made to the above mentioned Consent Order in order to carry out the environmental aims of the order.

Accordingly, the previously executed Consent Order (Order No. 15) is modified as follows:

1. All mosquito control ditches or other water courses in Unit 29 to be intersected by the spreader canal will be plugged east of and adjacent to the spreader canal excavation in a manner previously approved by the Department's district office;

2. All excavated material will be deposited in a location previously approved by the Department's district office;

3. The South Florida District Office of the Department is delegated the authority to approve in writing minor changes in the design of the spreader canal which it finds will enhance the function of the spreader canal or preserve additional wetland areas; and

4. Exhibit 2 of the Consent Order (Order No. 15) is modified by agreement of the parties as shown on the attachment

to this Modification to Consent Order and which is marked Exhibit 2, plate 3, revised December/1978.

Consented to by GAC this 18TH day of April, 1979.

HERBERT S. FREEHLING	FRANK J. CALLAHAN
as Co-Trustees	as Co-Trustee

DATED AND ENTERED this 27TH day of April, 1979.

JACOB D. VARN
Secretary

Department of Environmental
Regulation
2600 Blair Stone Road
Twin Towers Office Building
Tallahassee, Florida 32301

Exhibit 2 Plate 3

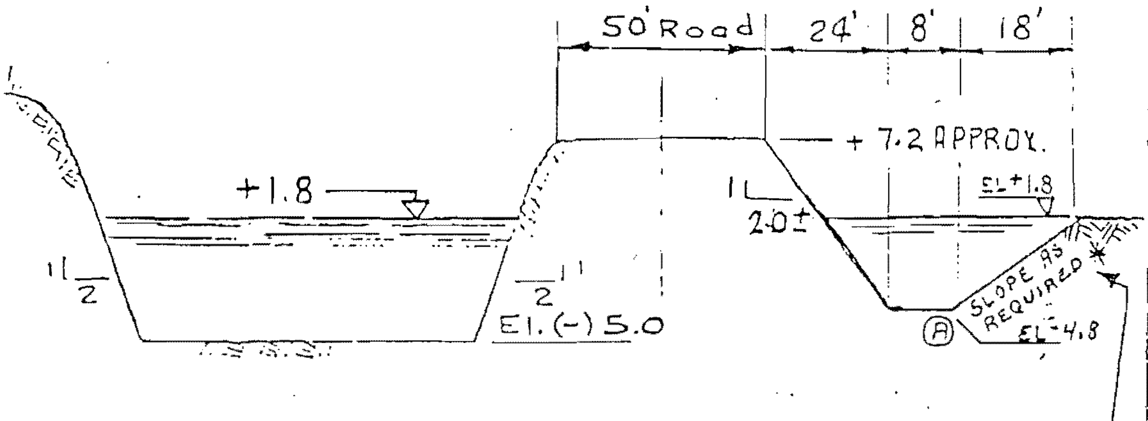
REVISED: DEC/1978

36-10-3545

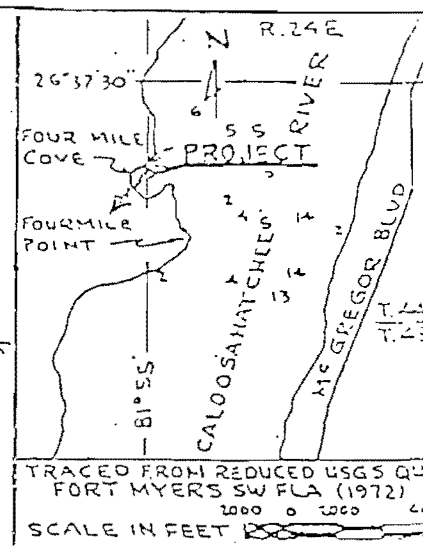
75K-1006

C3

UNIT 89



SECTION A-A



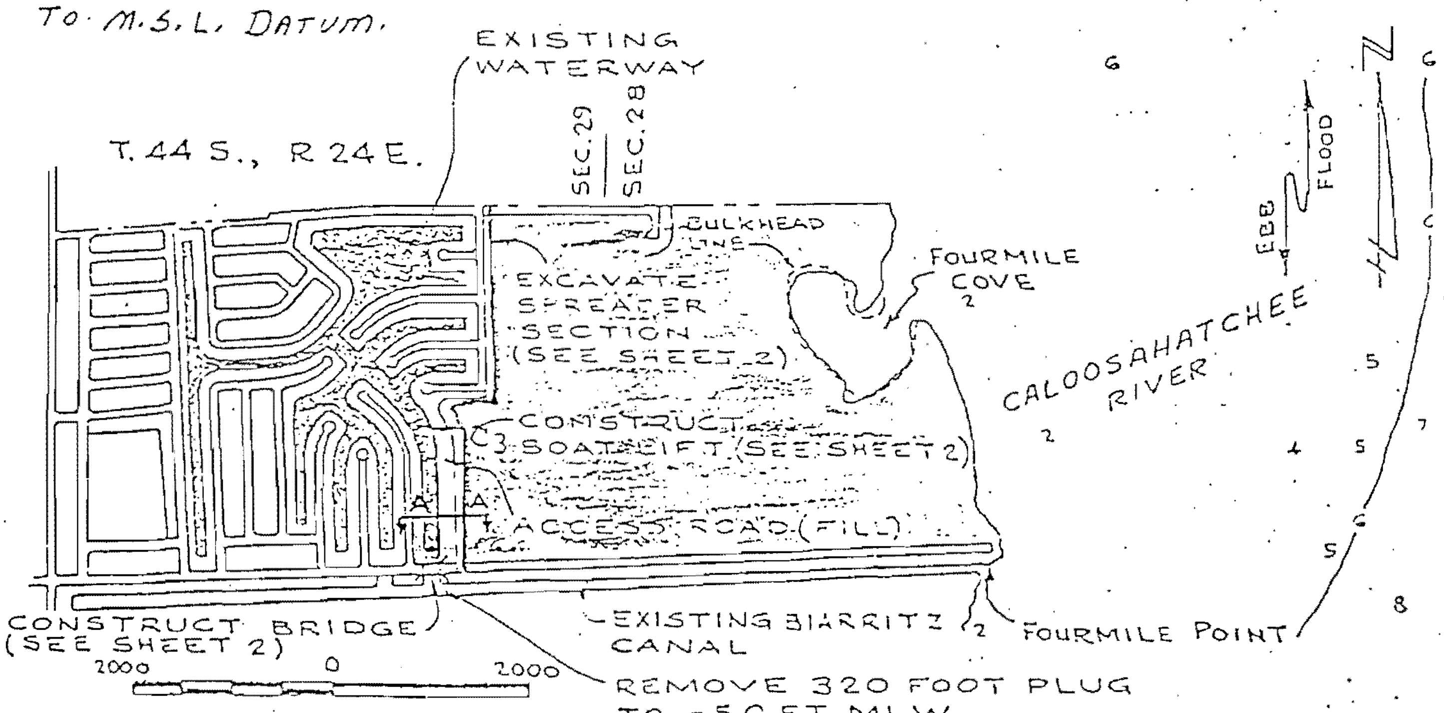
LOCATION SKETCH

"A" - Development Limits

Preserve Area

NOTE:
IF EXISTING GROUND ALONG NON-DEVELOPMENT PLAT LINE OF SPREADER W.W. IS LESS THAN EL. +1.8 M.S.L., FILL TO EL. +2.5 M.S.L. AND CONSTRUCT SIDE SLOPE TO MEET POINT (A)

NOTE: ALL ELEVATIONS REFER TO M.S.L. DATUM.



REV. 9/7?

NOTE

APPROXIMATELY 600 C.Y. OF SANDY MATERIAL TO BE DREDGED FROM BELOW MHW LINE AND PLACED ON APPLICANTS UPLAND BEHIND SUITABLE DIKES.

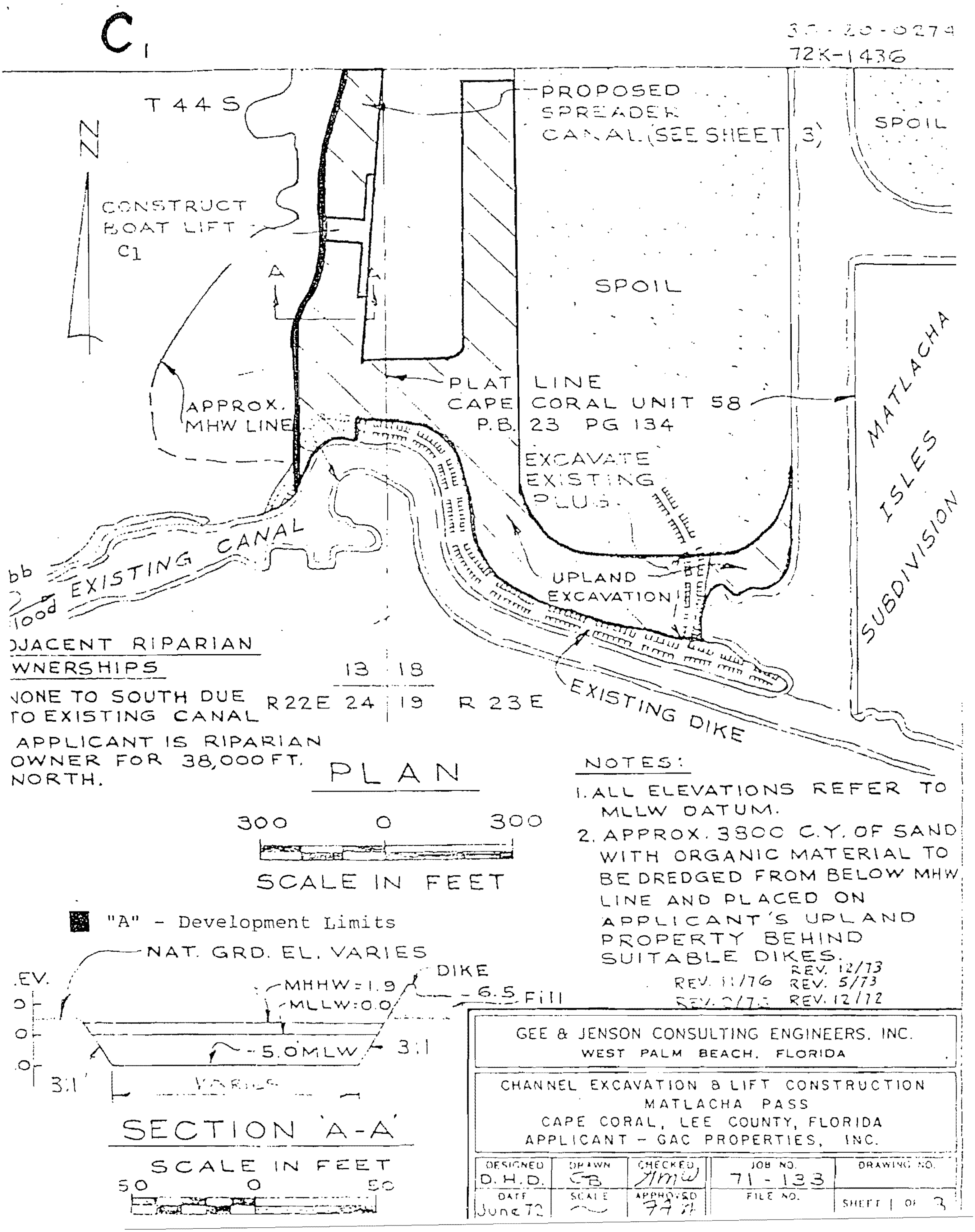
SEE ATTACHED LIST FOR ADJACENT RIPARIAN OWNERS.

GEE & JENSON CONSULTING ENGINEERS, INC.
WEST PALM BEACH FLORIDA

UNIT 89 DEVELOPMENT & CHANNEL
BIARRITZ CANAL
LEE COUNTY, FLORIDA
APPLICANT: GAC PROPERTIES, INC.

DESIGNED	DRAWN	CHECKED	JOB NO.	DRAWING NO.
D.H.D.	MGB	[signature]	72-45	
DATE	SCALE	APPROVED	FILE NO.	SHEET 1 OF 2
MAY 75	NOTED	[signature]		

Exhibit 2 Plate 1

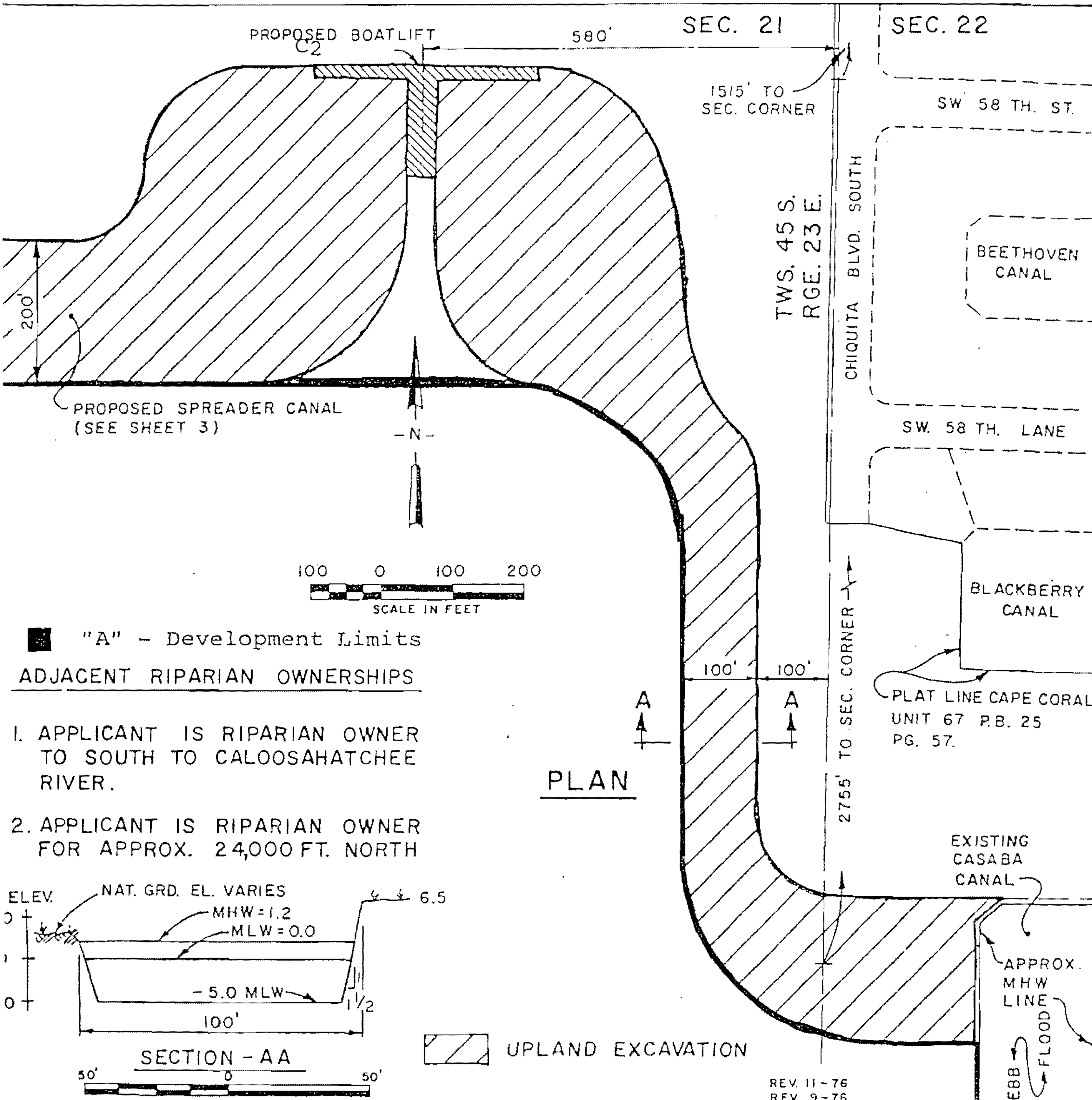


ıibit 2 Plate 2

C2

NEW PLAT AREA SOUTHWEST

36-10-3546
75K - 1005



NOTES

ALL ELEVATIONS REFER TO MLW DATUM.

APPROX. 3,200 C.Y. OF SAND WITH ORGANIC MATERIAL TO BE REMOVED FROM BELOW MHW LINE AND PLACED ON APPLICANT'S UPLAND BEHIND SUITABLE DIKES.

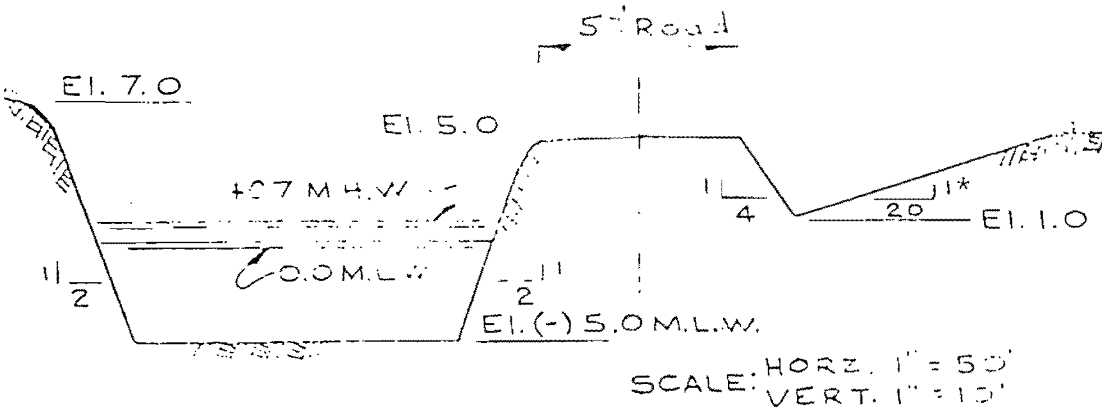
CHANNEL EXCAVATION & LIFT CONSTRUCTION
MATLACHA PASS & CALOOSAHATCHEE RIVER
CAPE CORAL, LEE COUNTY, FLORIDA
APPLICANT - GAC PROPERTIES, INC.

DESIGNED	DRAWN	CHECKED	JOB NO.	DRAWING NO.
P. M.	M. M.	[illegible]	71 - 133	
DATE	SCALE	APPROVED	FILE NO.	SHEET 1 OF 3
MAY 75	NOTED	[illegible]		

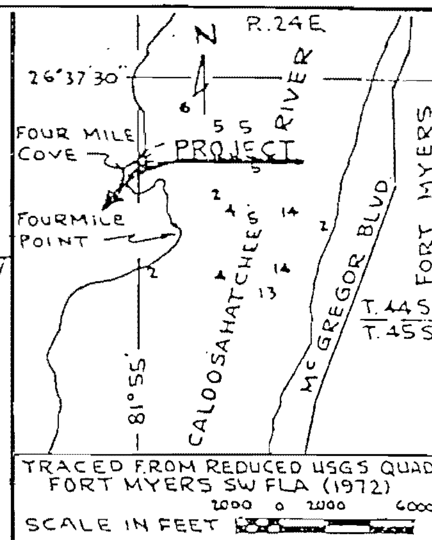
C3

UNIT 89

36-10-3545
75K-1006



SECTION A-A



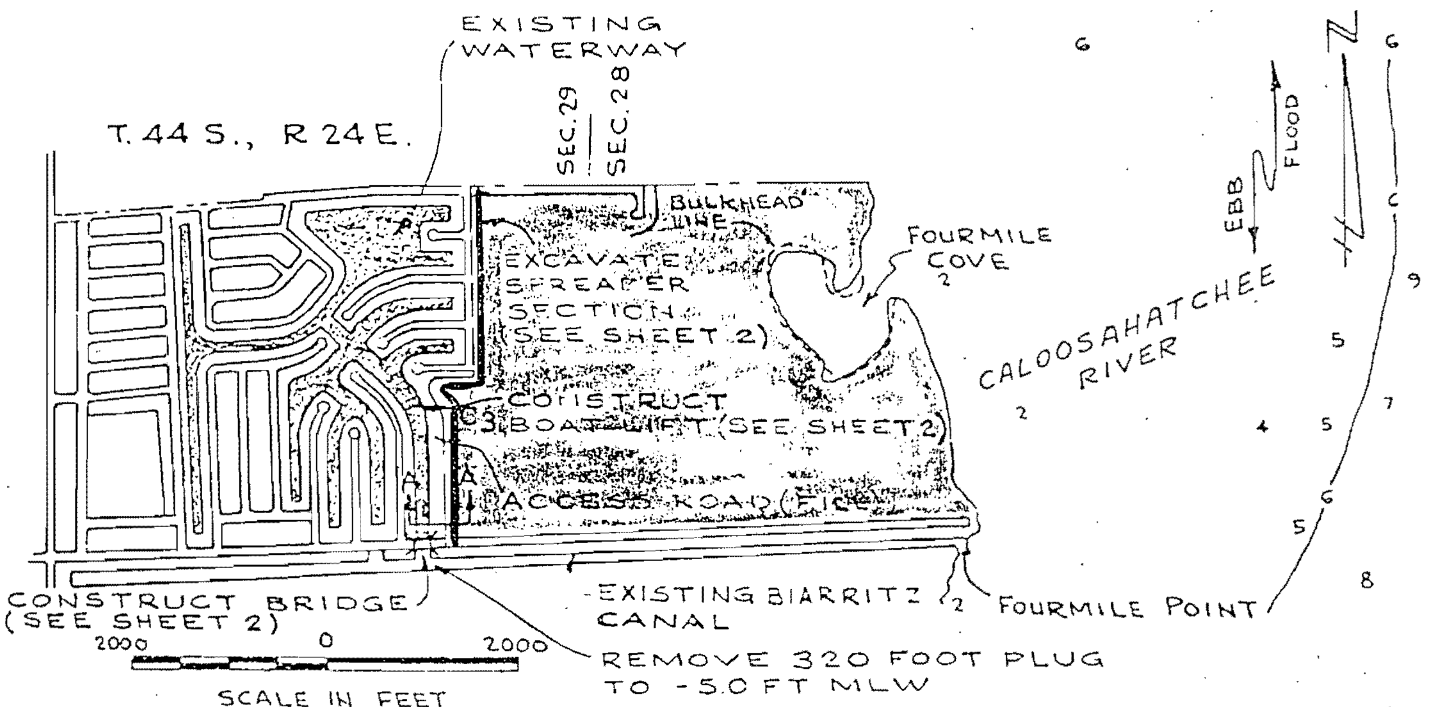
LOCATION SKETCH

"A" - Development Limits

Preserve Area

*1:20 or the landward edge of wetland vegetation.

NOTE: ALL ELEVATIONS REFER TO M.L.W. DATUM.



REV. 9/75

NOTE

APPROXIMATELY 600 C.Y. OF SANDY MATERIAL TO BE DREDGED FROM BELOW MHW LINE AND PLACED ON APPLICANTS UPLAND BEHIND SUITABLE DIKES.

SEE ATTACHED LIST FOR ADJACENT RIPARIAN OWNERS.

GEE & JENSON CONSULTING ENGINEERS, INC.
WEST PALM BEACH FLORIDA

UNIT 89 DEVELOPMENT & CHANNEL
BIARRITZ CANAL
LEE COUNTY, FLORIDA.
APPLICANT: GAC PROPERTIES, INC.

DESIGNED	DRAWN	CHECKED	JOB NO.	DRAWING NO.
D.H.D.	MGB	[signature]	72-45	
DATE	SCALE	APPROVED	FILE NO.	
MAY 75	NOTED	[signature]		SHEET 1 OF 2

:hibit 2 Plate 4

UNIT 89

C_3

36-10-3545
75K-1006

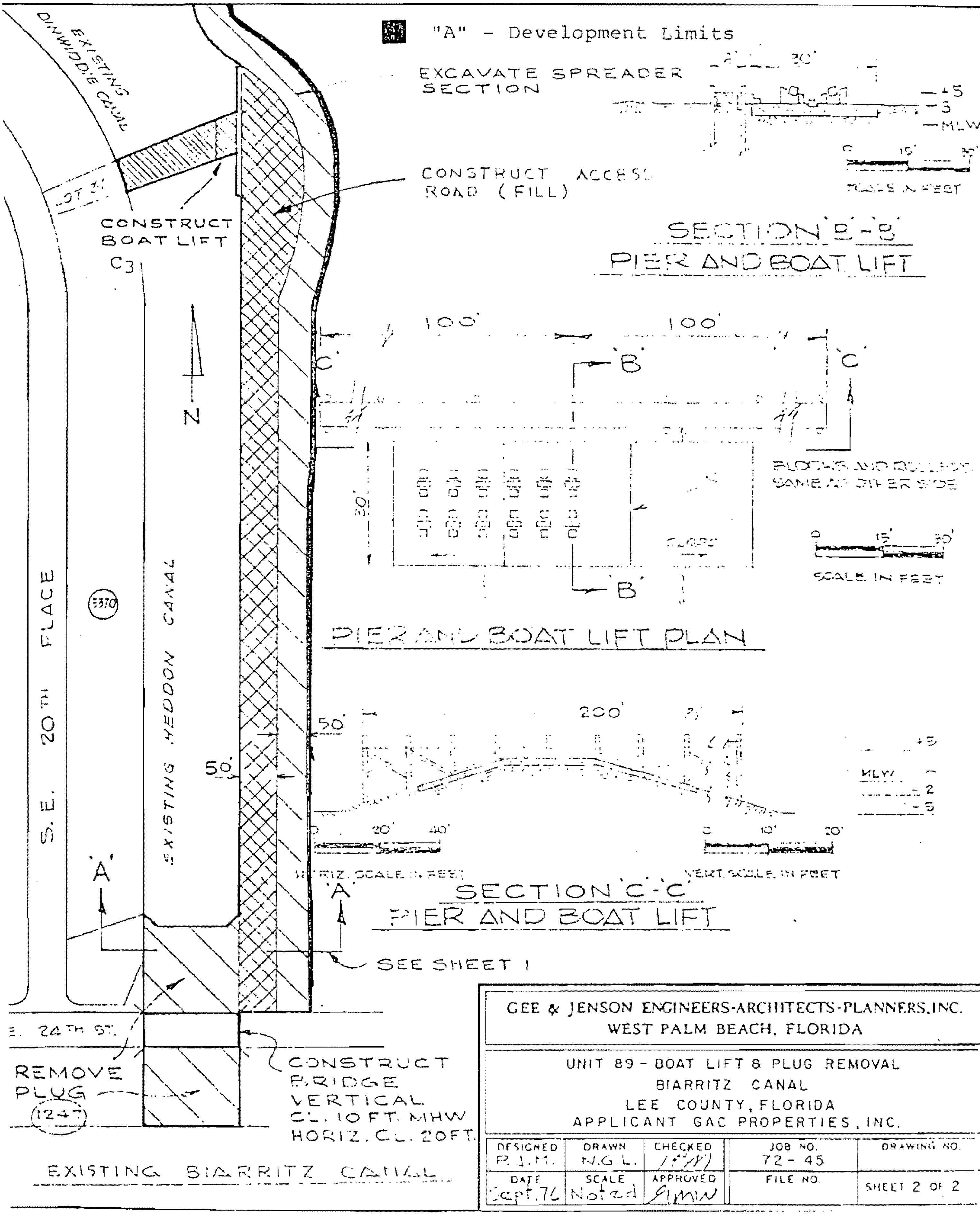


Exhibit 2 Plate 5

Construction of the boat lifts shall be to the following criteria:

1 - No transfer of water between the spreader waterway and state waters will be allowed.

2 - No part of the boat lifts will encroach beyond line A of Exhibit #1.

3 - The lift locations may be moved upstream from Locations C1, C2 and C3 up to 100 feet as long as such relocation does not open additional interior canals to state waters. The location of the boat lift may be moved downstream.

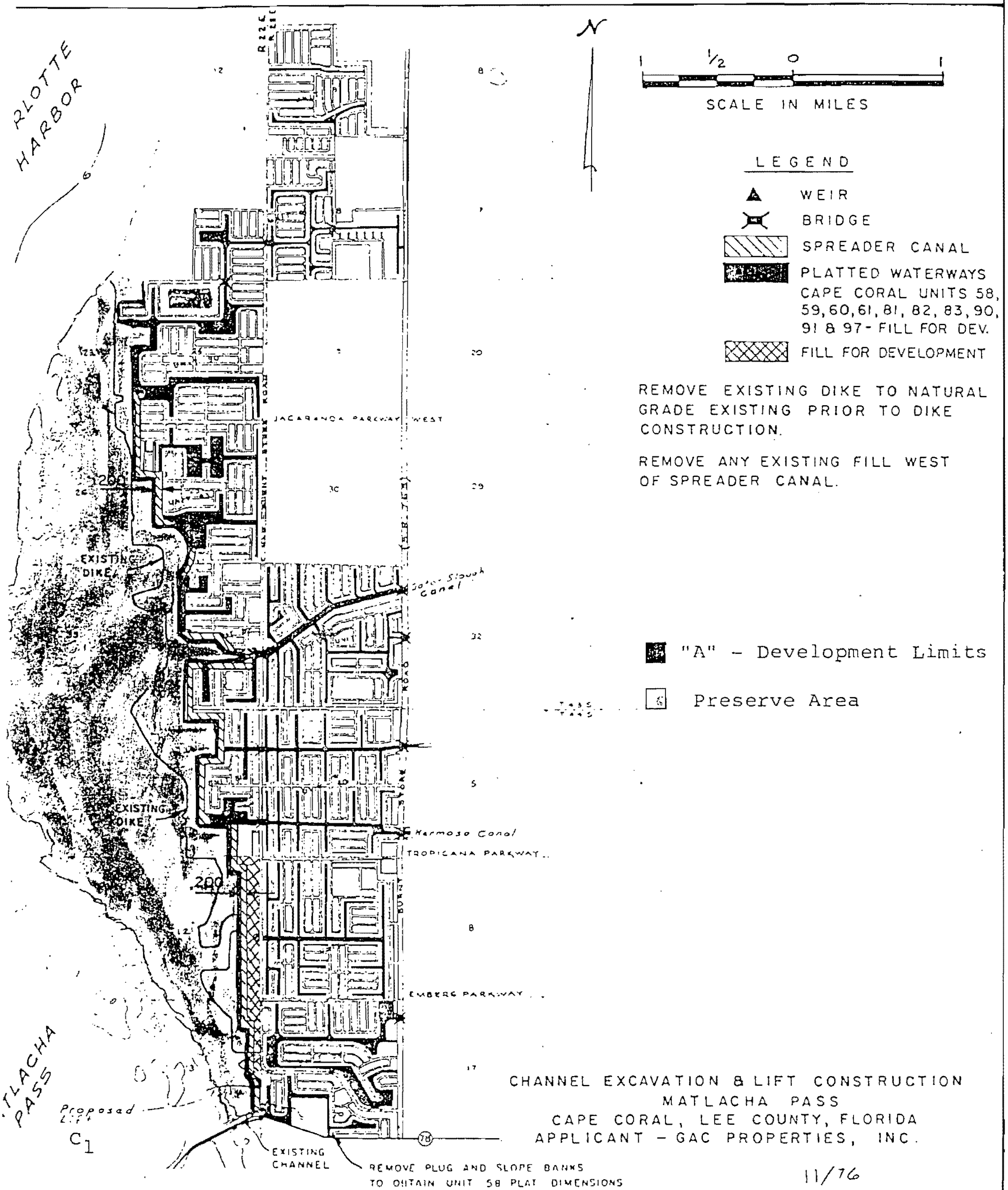
4 - The height, width and length of the earthen dam will be determined after establishing the seaward elevation of the spreader waterway and completing the hydraulic analysis.

5 - The type of mechanical transfer equipment will be at the discretion of GAC and its design engineer.

SPREADER WATERWAYS

Exhibit 2 Plate 6

36-20-0274
72-1436



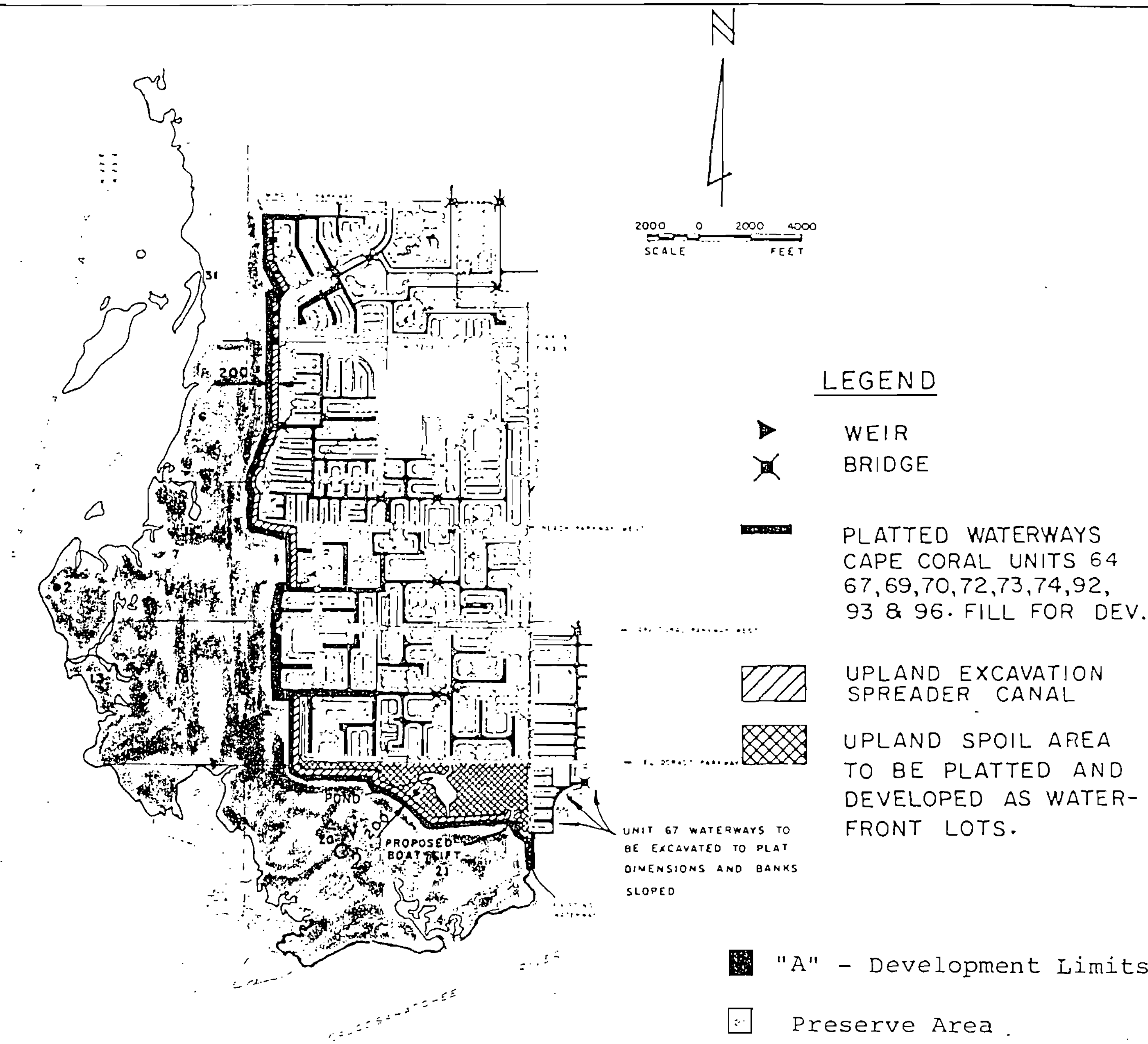
CHANNEL EXCAVATION & LIFT CONSTRUCTION
MATLACHA PASS
CAPE CORAL, LEE COUNTY, FLORIDA
APPLICANT - GAC PROPERTIES, INC.

11/76
10/76
9/76

SHEET 3 OF 3

SPREADER WA.ERWAY

36-10-3546
75 K - 1005

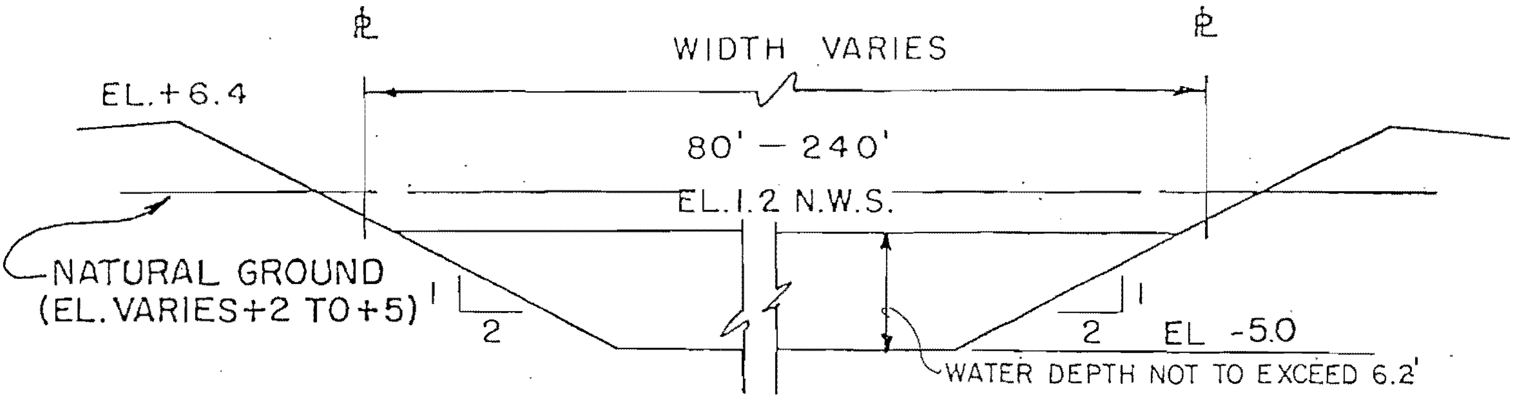


CHANNEL EXCAVATION & LIFT CONSTRUCTION
MATLACHA PASS & CALOOSAHATCHEE RIVER
CAPE CORAL, LEE COUNTY, FLORIDA
APPLICANT- GAC PROPERTIES, INC.

Exhibit 2 Plate 8

CROSS SECTIONS
INTERIOR CANALS AND SPREADER WATERWAY

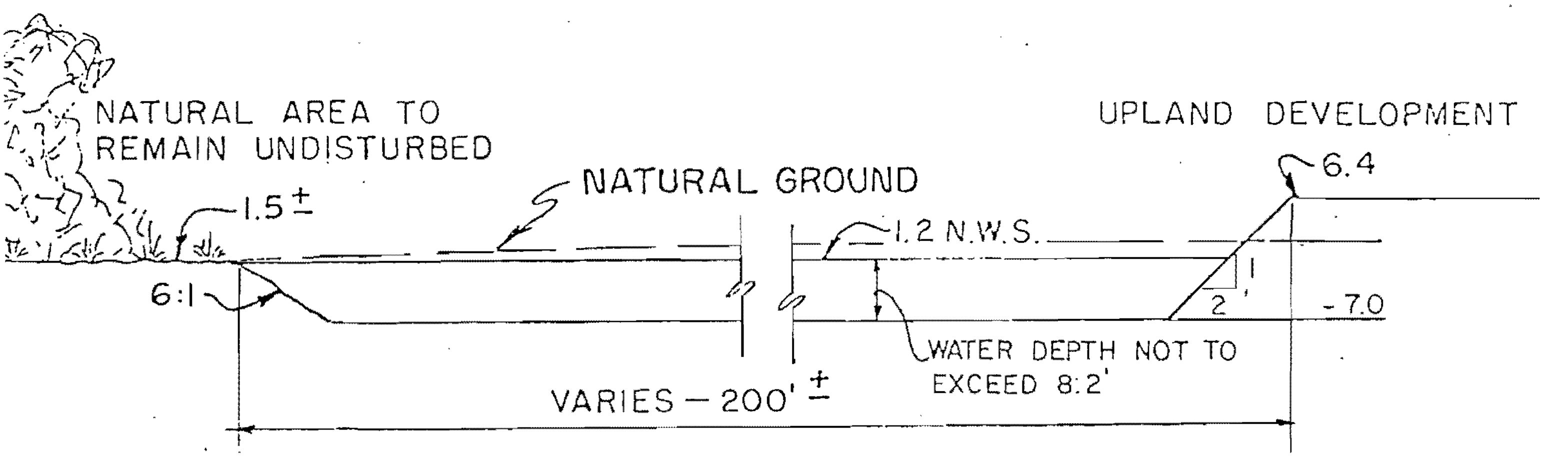
36-20-027
72K-1436



TYPICAL CANAL SECTION

SCALE

0 10Ft.



TYPICAL SECTION

SPREADER WATERWAY EXCAVATION

HORIZ. SCALE 0 40 FEET

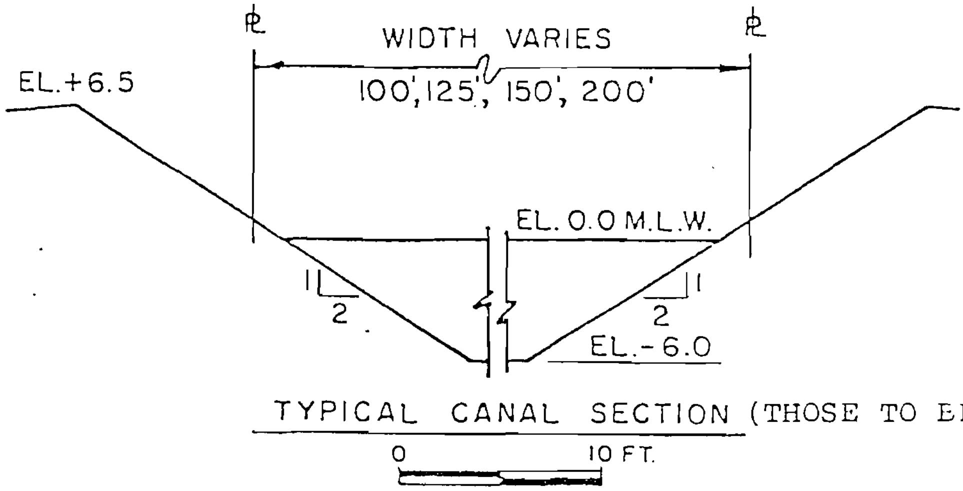
VERT. SCALE 0 20 FEET

NOTES: ALL ELEVATIONS REFER TO
MEAN SEA LEVEL DATUM.

N.W.S. — NORMAL WATER SURFACE.

CHANNEL EXCAVATION & LIFT CONSTRUCTION
MATLACHA PASS
CAPE CORAL, LEE COUNTY, FLORIDA
APPLICANT: G.A.C. PROPERTIES, INC.

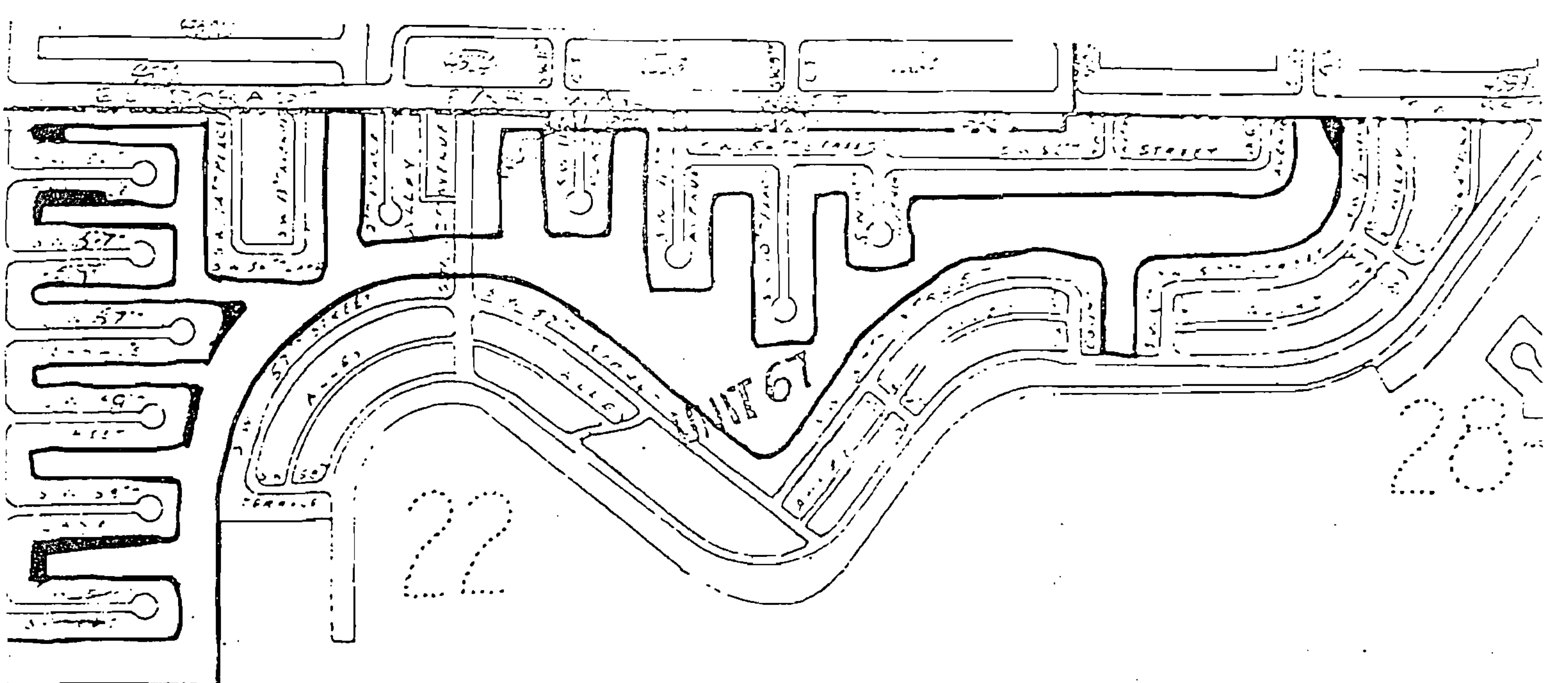
DESIGNED	DRAWN	CHECKED	JOB NO	DRAWING NO.
D.H.D.	G.J.B.	[illegible]	71-133	
DATE	SCALE	APPROVED	FILE NO	SHEET OF
12-75	NOTED			



UNIT 67

TYPICAL CANAL SECTION (THOSE TO BE DUG)

NOTE: ALL EL. REFER TO MLW



TO BE EXCAVATED	65,000	C.Y.
PLUS SLOPE ALL BANKS	35,000	C.Y.
	100,000	C.Y.
CANAL OVER DUG TO BE FILLED	8,500	C.Y.
FILL FOR LAND AREAS	250,000	C.Y.

Scale 1" = 1,000'

Exhibit 2 Plate 10

The Hydraulic Assessment is to evaluate and recommend adjustment to the water surface elevations, as required, to assure maximum retention and management of surface water while providing reasonable protection of the Cape Coral area from flooding during storms.

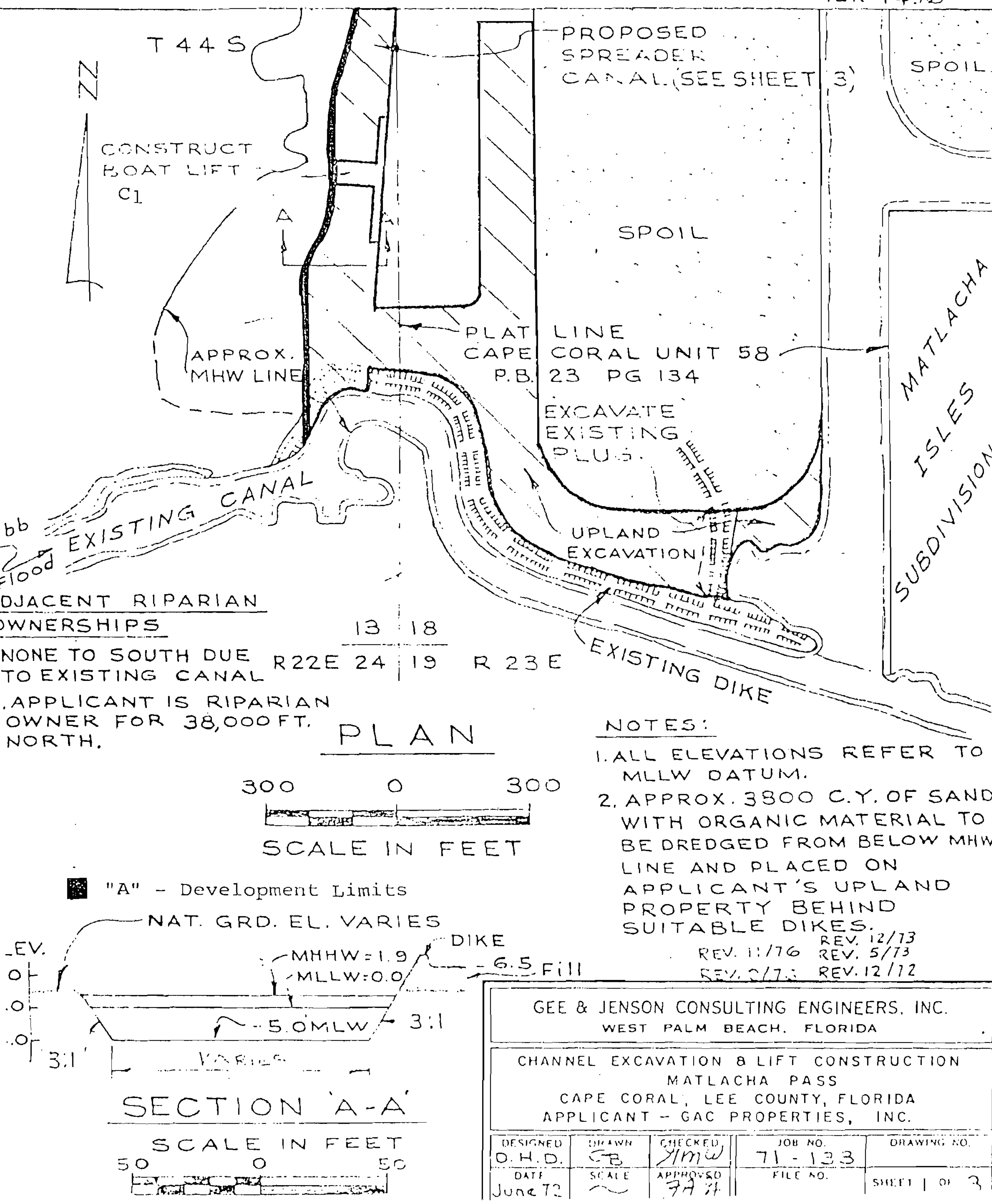
Included in the Assessment are the off-site drainage basin, storm drainage system evaluation, waterway analysis, control structure analysis, and discharge through the perimeter spreader waterway.

A report will be prepared depicting the Hydraulic System Assessment and recommendations for improvements to the system, such improvements to be implemented according thereto by GAC, upon concurrence by the District DER office.

Exhibit 2 Plate 1

C1

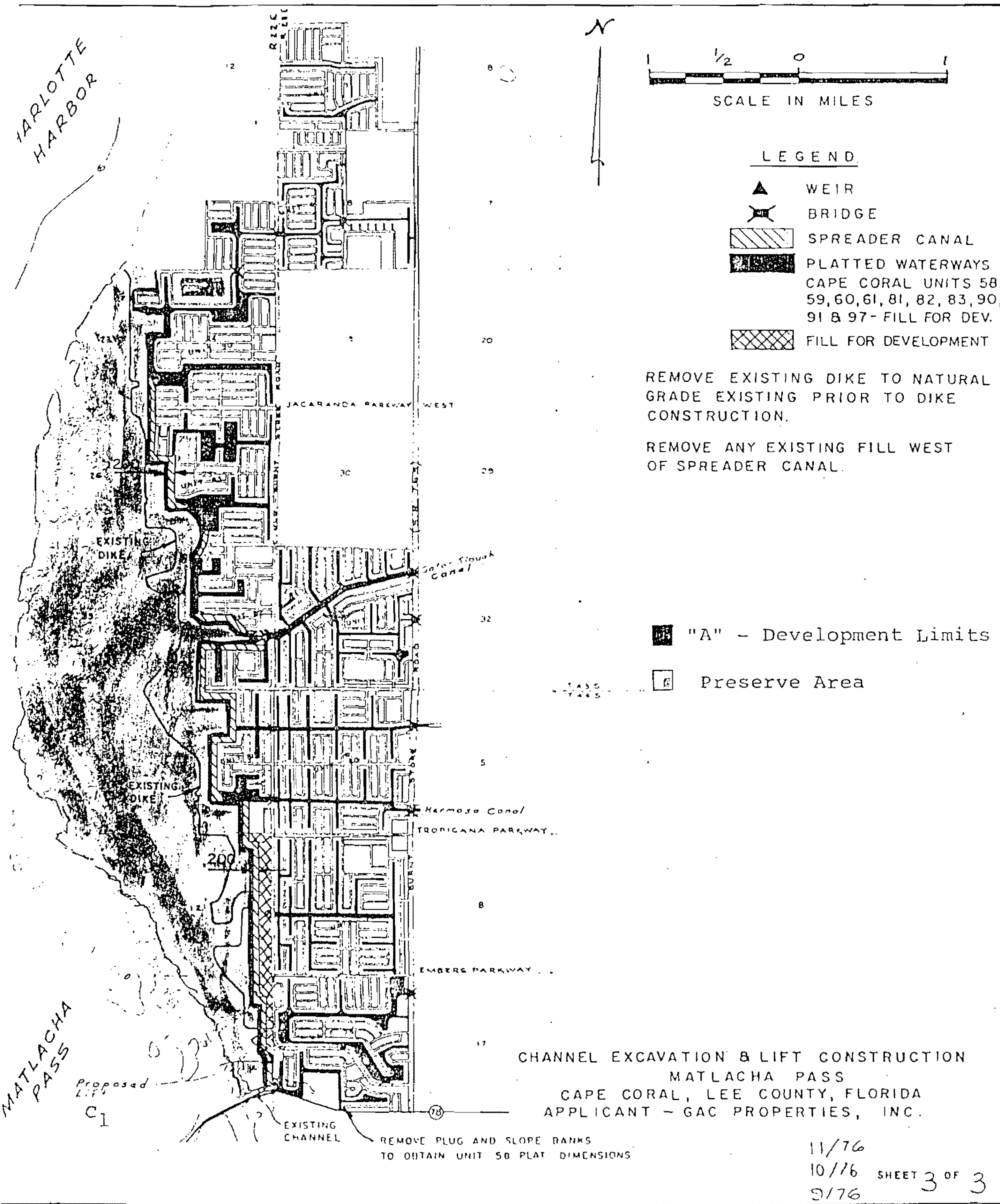
72K-1436



SPREADER WATERW..YS

Exhibit 2 Plate 6

36-20-0274
72-143C



DER Contract No. WM106

DEPARTMENT OF ENVIRONMENTAL REGULATION

AGREEMENT FOR

A WATER QUALITY AND CANAL

MANAGEMENT PROGRAM

RETURN THIS COPY

RECEIVED MAY 16 1985 ... DISTRICT

This agreement is entered into between the DEPARTMENT OF ENVIRONMENTAL REGULATION, hereinafter referred to as DER, and the CITY OF CAPE CORAL, hereinafter referred to as the CONTRACTOR.

WITNESSETH:

WHEREAS, during the development of the City of Cape Coral, extensive dredge and fill work was completed by Gulf American Corporation (GAC); and

WHEREAS, in 1977 the DER and GAC entered into Consent Order #15 to resolve alleged permit violations in the dredge and fill operations; and

WHEREAS, as a part of this Consent Order GAC was required to deposit $200,000 per year for five consecutive years into a Pollution Recovery Trust Fund; and

WHEREAS, the Consent Order states that "this money shall be used at the discretion of the Secretary of the DER, which use shall nonetheless be restricted in use to study water quality and quantity problems in the Cape Coral and Golden Gate Estates areas, to propose solutions to the problems identified and as funds allow, to correct the identified problems in both projects"; and

WHEREAS, the 208 Water Quality Study has been completed and the CONTRACTOR is in a position to design and implement the water quality management programs; and

WHEREAS, there are sufficient funds in the Pollution Recovery Trust Fund to accomplish the water quality management program.

NOW, THEREFORE, the parties hereto agree as follows:

CONTRACTOR RESPONSIBILITIES

The CONTRACTOR shall implement a water quality and canal management program in accordance with ATTACHMENT I - SCOPE OF SERVICES, attached hereto and made a part hereof.

REPORTS

CONTRACTOR shall submit monthly reports on water quality data and quarterly progress reports to the DER project manager. The final report shall be due 30 days after contract completion.

TERM OF AGREEMENT

This contract is effective on the date of execution and shall remain in effect until April 1, 1987, by which date all requirements shall have been completed.

COMPENSATION

For satisfactory performance, DER agrees to compensate the CONTRACTOR on a lump sum basis in the amount of $60,000. This amount shall be at least matched by the CONTRACTOR.

PAYMENTS

The CONTRACTOR may invoice the DER on a convenient basis, but not more frequently than monthly, based on percentage of completion of the project. The invoice shall also reflect the amount of funds expended by the City as match in connection with this project.

A final invoice must be submitted within 30 days of contract completion.

MANAGEMENT

The DER Project Manager is Ms. Gail M. Sloane, Phone 813/332-2667. The CONTRACTOR's Project Manager is

Mr. Ellis Shapiro (City Manager), Phone 813/574-0412. All matters shall be directed to the project managers for appropriate action or disposition.

The CONTRACTOR agrees to the following terms:

1. The DER may terminate this contract for its convenience. In this event, the CONTRACTOR shall be compensated for work completed and irrevocable commitments made.

2. All services shall be performed by the CONTRACTOR in accordance with the attached scope of services to the satisfaction of the Secretary of the DER or her designated representative.

3. If the CONTRACTOR fails to perform in a timely and proper manner, in the judgment of DER, DER may terminate the contract by written notice, specifying the effective time/date. In this event, the CONTRACTOR will be compensated for any work satisfactorily completed.

4. The DER may at any time, by written order designated to be a change order, make any change in the work within the general scope of the agreement (e.g., specifications; time; method or manner of performance; requirements; etc.). Any change order which causes any increase or decrease in the CONTRACTOR's cost or time shall require an appropriate adjustment and modification (amendment) to the agreement.

5. The CONTRACTOR shall maintain books, records and documents directly pertinent to performance under this agreement in accordance with generally accepted accounting principles consistently applied. The DER, the State, or their authorized representatives shall have access to such records for audit purposes during the term of the contract and for three years following contract completion.

6. The CONTRACTOR agrees to indemnify, defend, save and hold harmless the DER from all claims, demands, liabilities and

suits of any nature arising out of, because of, or due to any act by the CONTRACTOR, its agents or employees to the extent permitted by Florida law.

7. The CONTRACTOR covenants that it presently has no interest and shall not acquire any interest which would conflict in any manner or degree with the performance of services required.

8. The CONTRACTOR warrants that no person or agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee exepting bona fide employees or agencies maintained by the CONTRACTOR for the purpose of securing business.

9. The DER reserves the right to unilaterally cancel this agreement for refusal by the CONTRACTOR to allow public access to all documents, papers, letters, or other material subject to the provisions of Chapter 119, Florida Statutes, and made or received by the CONTRACTOR in conjunction with this contract.

It is expressly understood and agreed that this contract states the entire agreement and that the parties are not bound by any stipulations, representations or promises not printed in this contract.

CITY OF CAPE CORAL	FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION
	~~Assistant~~ Secretary
DATE: 5/28/85	DATE: 5/8/85

ATTACHMENT 1

SCOPE OF SERVICES

The City of Cape Coral agrees to implement the following recommentations of the 208 Water Quality Study:

1. Retain a qualified aquatic scientist at the staff level. The responsibilities of this position would include:

   a. Assist the Planning Department and the City Council in the development of the Management Action Plan (MAP).

   b. Assist in the day-to-day activities needed to implement the MAP.

   c. Coordinate and oversee the canal maintenance programs and canal-related activities (educational programs, stormwater management, dredge and fill activities).

   d. Interface with Planning and Public Works Departments and relevant County, State, and Federal agencies.

   e. Conduct an on-going water quality monitoring program and assess the information to determine problem areas and the effectiveness of the MAP.

   f. Conduct special projects and studies related to the Cape Coral waterway system (i.e. aquatic plant management experiments, littoral zone enhancement projects, stormwater system monitoring, etc.).

   g. Coordinate funding sources for canal maintenance (i.e. GAC Pollution Recovery Trust Fund for water quality enhancement and DNR for aquatic plant management programs).

2. Establish a Water Advisory Board or expand the authority of the existing Environmental Task Force to:

   a. Establish use priorities for the freshwater canal system to mimimize conflicting practices.

   b. Assist in the formulation of canal management policies.

   c. Examine the feasibility of establishing a Waterways Management Division.

3. Establish a citizens' awareness program concerning the waterway system.

   a. This program would be developed and administered by the City's aquatic scientist.

   b. Disseminate relevant information on homeowners' impacts on water quality, boating impacts, erosion control measures, aquatic plant management, etc.

   c. Periodically distribute and assess water quality awareness questionnaires to gauge citizens' understanding of canal problems and solutions.

   d. Develop City-sponsored fishing tounaments and other water-related activities to promote public awareness of the canal system.

   e. Encourage media coverage of water-related activities, problems and solutions.

4. Establish an on-going water quality monitoring program at selected sites to identify developing problem areas and gauge the effectiveness of stormwater and canal management activities.

a. Recommended Parameters and Frequency

(1)	Disssolved oxygen profiles	(monthly)
(2)	pH	(monthly)
(3)	Specific conductance /Salinity	(monthly)
(4)	Nitrogen species	(monthly)
(5)	Phosphorus species	(monthly)
(6)	Suspended solids	(monthly)
(7)	Turbidity	(monthly)
(8)	Fecal Coliform Bacteria /Metal	(monthly)
(9)	Oil and Grease	(monthly)
(10)	Total Chlorophyll	(monthly)
(11)	Chlorophyll _a_ (Phaeophyton corrected)	(monthly)
(12)	Copper	(monthly)
(13)	Phytoplankton (Number and Composition)	(seasonally)
(14)	Aquatic Macrophytes (Type & Percent Coverage)	(seasonally)
(15)	Cadmium	(annually)
(16)	Lead	(annually)
(17)	Pesticide Scan	(annually)

b. Potential Monitoring Sites

Gator Slough Canal (BF-1)
Lake Manitoba (BL-1)
Lake Holiday (BL-3)
Lake Kennedy (BL-2)
Lake Shamrock (BF-12)
Chipley Canal (Nobility Homes) (BF-4)
Meade Canal (BF-7)
San Carlos Canal (BF-3)
Selected, undeveloped canal and lake sites
Spreader waterways

c. Potential Funding Sources

(1) GAC Pollution Recovery Trust Fund
(2) Annual maintenance fees based on property assessment

5. Intense motorboating activity should be discouraged in the landlocked freshwater areas. This could be accomplished by "no wake" or horsepower restriction ordinances. This would not affect boating in open tidal canal areas or the spreader waterway system. Motorboating contributes petroleum based hydrocarbons which adversely affects aquatic life and potable and nonpotable water supplies. Additionally, large horsepower motorboats will increase turbidity and nutrient levels by resuspending bottom sediments in shallow areas of less than 8 feet. This can shade out the beneficial aquatic macrophytes and encourage algae growth, in turn requiring herbicide treatments.

6. Encourage passive boating (i.e. canoeing and small sail boats) in the freshwater system.

7. Establish a routine street sweeping and catch basin cleaning program for the urbanized areas, especially for curb and gutter areas and large parking lots (i.e., shopping centers). A regenerative, vacuum-type street sweeper should be used for maximum effectiveness.

8. Formulate and implement an erosion control ordinance. The Environmental Element of the City's Comprehensive Plan provides a good model ordinance.

9. Strengthen the swale maintenance and inspection program. It is recommended the program:

   a. Prohibit filling or culverting of swales.

   b. Ensure swales are at design depths and widths, grassed and free of debris.

c. Clean catch basins in swale areas regularly.

d. Require development to reestablish swale design criteria and revegetate swale bottoms in newly developing areas.

10. Increase stormwater retention/detention in the City.

a. Revise the recommended on-site stormwater retention formula provided in the Utilities Element of the City's Comprehensive Plan.

b. Locate additional off-site retention lakes (not existing lakes) in combination with the swale system, where needed.

c. Require an additional swale/berm system in the backyards of waterfront lots.

d. Where feasible, consider the expansion of the drainage box modifications program to provide swale retention, similar to the approach required by the GAC-DER Consent Agreement. Similar retention could be accomplished with small earth berms surrounding the drainage box or perpendicular to the swale.

e. Where retention is not feasible, consider a program of providing additional detention with filtration in the swale system. Additional detention/filtration devices include: V-notched earthen berms in swales, gravel berms, patches of thicker vegetation in swale bottoms, etc.

11. Reduce lawn fertilization amounts and frequency. Additionally encourage the use of organic or slow-release fertilizers (i.e., properly treated sewage effluent). These can be accomplished through citizen's awareness programs.

12. Encourage native or low maintenance vegetation for yard and shoreline landscaping.

13. Encourage pet owners to clean up after pets.

14. Ensure septic tanks are properly located and maintained. Conduct dye tracer studies in suspect septic tank areas. These are inexpensive and could be conducted by the City.

15. The Lee County Health Department has recently revised its septic tank criteria as a result of the Water Quality Assurance Act passed by the State Legislature in 1983. The Health Department recommends that public water be provided whenever 30% of a development unit is built-out, while public sewers are recommended whenever 50% of the unit is developed. Additionally, when any block, zoned single-family, reaches a 75% density or 50% for multi-family, no further septic tanks will be allowed until public water is provided.

The Health Department criteria are general and are not based on site-specific conditions, although individual permit applications require site-specific information. Even with this level of review, however, septic tank problems may occur. For example, stormwater sampling at the low density residential site (0.2 units/acre) near Academy Boulevard (S-2) provides strong evidence that elevated fecal coliform bacteria, nitrogen, and BOD levels in runoff and the sustained high bacteria levels in San Carlos Canal were a result of malfunctioning septic tanks. Elevated water table levels during wet weather conditions may enhance groundwater and stormwater mixing. This may result in septic tank effluent discharges into the canal through the swale system.

The Health Department density criteria should be used as a general guideline. If public health or water quality problems are evident prior to reaching the recommended density thresholds, however, these should be corrected immediately. These can be corrected by repairing the faulty septic tank(s) or if feasible, sewering the problem area.

16. Formulate a long-range, integrated aquatic plant management program for the freshwater canal/lake system with assistance of Lee County Hyacinth Control District. This program should include the use of chemical, biological, environmental manipulation, and mechanical aquatic plant management strategies.

17. Ensure adequate maintenance and public access points are available in the freshwater canal/lake system.

18. Encourage boat owners to inspect boats, trailers and propellers for aquatic plants after each use to prevent their transfer and spread to unaffected areas.

19. Encourage homeowners to remove automobile drippings on driveways. Sawdust can be used to remove residual oils. Additionally, waste oil recycling should be encouraged.

20. Cease current city-sludge spreading practices near surface water areas. Sludge spreading near Frontier Canal (BF-2 and BSSC 5) has resulted in frequent dissolved oxygen violations and nuisance aquatic plant growth.

21. Determine appropiate areas for sludge spreading.

22. Analyze the spreader waterway system to ensure its functional purpose and to determine baseline water quality and ecological conditions.

    The spreader waterway system on the City's western border was designed to collect stormwater runoff from the City and allow it to spread across wide wetland areas prior to discharging into the Matlacha Pass State Aquatic Preserve. In this manner, stormwater runoff is cleansed by the wetland vegetation and sheetflow is re-established prior to discharge into the aquatic preserve. This prevents abrupt salinity changes detrimental to most marine life.

    A few direct connections between the spreader waterway and Matlacha Pass State Aquatic Preserve have been observed. Periodical observations should be continued and remedial measures taken to prevent severe negative impacts on the aquatic preserve. The City, in conjunction with the Florida Department of Environmental Regulation, Florida Department of Natural Resources and Avatar, Inc., should undertake this examination. Monies in the GAC Pollution Recovery Trust Fund is a possible source to finance the needed studies and remedial measures.

WATER QUALITY MANAGEMENT PROPOSAL

Proposed Scope. In order to begin to implement the recommendations of the 208 Water Quality Study and begin a water quality management program, the City of Cape Coral requests the use of $30,000 from the DER Pollution Recovery Trust Fund per year for the next two (2) years. A match of at least $30,000 per year will be supplied by the City to ensure local support of the program.

The following expenditures are recommended for the implementation of the water quality management program. Any change or additional expenditures within the proposed budget are to be coordinated through the DER project manager.

First Year Estimated Budget

I. Expenditures

A. Staff

Aquatic Biologist (Salary & Benefits) See Appendix E for Job Description	$30,000

B. Equipment

(1) Dissolved Oxygen Meter	1,000
(2) Conductivity Meter	1,000
(3) pH Meter	1,000
(4) Microscope	5,000
(5) Coring Equipment	
(a) Echman Dredge	
(b) Bucket with filter screen	500
(6) Various Chemicals	1,500

C. Boat (Flat or V-Bottom)	1,000
(1) 7 1/2 horsepower motor	1,000
(2) Trailer	500
(3) Truck	P. W. Dept.

D. Miscellaneous Needs

(1) Glassware, samplers, rubber coat, boots, etc.	2,500
(2) Lee. Co. Environmental Lab-contract work	5,000
Office supplies, Printing Publications & Training	5,000
Contingencies	5,000
TOTAL	$60,000

II. Revenue

A. DER/Pollution Recovery Trust Fund	$30,000
B. City of Cape Coral	30,000
	$60,000

Second Year Estimated Budget

I. Expenditures

A. Staff

Aquatic Biologist (Salary & Benefits)	$30,000

B. Equipment

1.	Various Chemicals	$ 2,000
2.	Supporting Materials	8,000

C. Miscellaneous Needs

1.	Lab-contract work	8,000
2.	Office supplies & printing	8,000
3.	Publications & Training	2,000

D. Contingencies 2,000

TOTAL $60,000

II. Revenue

A.	DER/Pollution Recovery Trust Fund	$30,000
B.	City of Cape Coral	30,000
		$60,000

COUNCILMEMBER FLETCHER 09/17/93

RESOLUTION 74 - 93

A RESOLUTION OF THE CITY OF CAPE CORAL FOR THE ADOPTION OF THE "PLAN OF STUDY" FOR THE CAPE CORAL SURFACE WATER MASTER PLAN, DESIGNATED AS PHASE I, SUBMITTED IN JULY OF 1993; PROVIDING AN EFFECTIVE DATE.

WHEREAS, the City of Cape Coral has been required to prepare a master plan for surface water as an element of the State mandated Comprehensive Development Master Plan for the City of Cape Coral; and

WHEREAS, the City of Cape Coral has chosen to implement a dual water system for effluent disposal, fire flow, and lawn irrigation which is augmented by and dependent upon the Cape Coral canal system as an integral element of the system and the backbone of the surface water system; and

WHEREAS, the City of Cape Coral must also comply with National Pollution Discharge Elementation System, Department of Environmental Protection Agency, South Florida Water Management District, Game and Fresh Water Fish Commission, U.S. Environmental Protection Agency and Army Corps of Engineers requirements and guidelines to be addressed in said Surface Water Master Plan; and

WHEREAS, the City of Cape Coral must plan and design for maintaining effective drainage throughout the city for health, safety and protection of the public and respective public/private property; and

WHEREAS, the City of Cape Coral must develop and maintain, through this master plan endeavor a plan for preserving and/or enhancing the aesthetics and recreational appeal of the surface water system.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF CAPE CORAL, FLORIDA:

Section 1. The City of Cape Coral does hereby adopt the Plan of Study - Phase I and moves to proceed with the remaining Phases (II through IV) as outlined within said Plan.

Section 2. This Resolution shall take effect immediately upon its adoption.

ADOPTED BY THE CITY COUNCIL OF THE CITY OF CAPE CORAL AT ITS REGULAR SESSION THIS 11th DAY OF October, 1993.

Joseph M. Mazurkiewicz

JOSEPH M. MAZURKIEWICZ, JR.
MAYOR

ATTESTED TO AND FILED IN MY OFFICE THIS 19th DAY OF October, 1993.

Eula R. Jorgensen

EULA R. JORGENSEN, CITY CLERK

LEGAL REVIEW:

BRC

BRUCE R. CONROY
CITY ATTORNEY
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CITY OF CAPE CORAL
SURFACE WATER MASTER PLAN
PHASE 1
PLAN OF STUDY

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CITY OF CAPE CORAL
SURFACE WATER MASTER PLAN
PHASE 1
PLAN OF STUDY

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EXECUTIVE SUMMARY

INTRODUCTION

The City of Cape Coral is built around one of the most unique development concepts in existence. A series of large canals were constructed to provide drainage, recreational opportunities and a large number of waterfront residential properties. The City of Cape Coral recognized the enormous resource and cultural value of the canal system. The $2.5 billion system serves many purposes drainage, recreation, an attractive addition to properties, and a reservoir source for irrigation water.

Most communities in Florida and the United States typically seek to dispose of stormwater as quickly as possible, discharging it to streams and eventually the gulf or ocean. The City of Cape Coral has decided to adopt a conservational approach to stormwater management. The City has begun to treat stormwater not as a liability, but as a resource. In an effort to conserve this resource, stormwater is recycled by channeling it to the canal system, storing it and using it for irrigation water. Through the City's comprehensive planning process, it has initiated the development of progressive strategies to protect the value of this system while maximizing utilization of the canal system.

Recognizing the demands that will be placed on the system to relieve drainage problems while maximizing storage and still protect the water resource value, the City desires a comprehensive surface water management plan. This plan, unique to water management plans, is to be designed to manage the surface water system as a whole. It is to include consideration of all of the demands placed upon the water system and all the constraints for meeting these demands. Quantity concerns arise with excess surface water during wet seasons and the need for irrigation water during dry seasons. In view of pending U.S. EPA stormwater NPDES permit requirements and the need to protect water quality to maintain suitability for use, the City also desires to embed a framework for management and enhancement of surface water quality within the quantity control programs. Finally, the beauty of the canal system must be maintained in order to protect the viability of Cape Coral as a residential community.

City Objectives

The future of the City depends heavily on the comprehensive management of the surface waters in terms of aesthetic beauty, water supply, drainage and environmental maintenance. Our goal is to develop a plan to maximize the City's beneficial use of this complex system. The Surface Water Master Plan is to be designed to manage the physical processes occurring in the surface water system to best achieve the City's objectives. The primary objectives are

- Maintain effective drainage
- Provide irrigation water

- Maintain aesthetic and recreational appeal
- Successfully respond to regulatory requirements

Since some of these objectives may conflict (i.e. drainage vs. irrigation water storage), the plan will balance the objectives to maximize the total beneficial use of the surface water system.

MASTER PLAN DEVELOPMENT

The Master Plan sought by the City will tie all of the components impacting the surface water system in Cape Coral into one management package. Thus, the primary focus of the Master Plan development will be to establish a surface water management system. A phased development approach is proposed to accomplish this task. Also included in each phase is the provision of necessary management and engineering assistance in the following areas:

- Development of regulations and ordinances associated with seawalls, parcel development, onsite retention, swales and other surface water related issues
- Co-ordination of regulatory requirements of the NPDES program and Department of Community Affairs (DCA) comprehensive planning
- Continued regional drainage system upgrades as required by the City
- Close interface with city management, staff and the public to ensure key issues are addressed throughout the Master Plan development
- Methodologies for establishing program financing
- Property and easement acquisition
- Stormwater utility budgeting and resource allocation
- Determination of staff, equipment and physical facilities requirements
- Aquatic weed control methodologies

Phased Development

Development of the Master Plan will occur in four phases. Briefly, these phases are:

Phase I — Establishes the frame work for the Master Plan development. Based on previous studies and data, it provides a system description, defines community objectives and charts a plan of management development.

This phase also includes investigation of key problem areas, analysis of the stormwater utility structure, drainage designs for the industrial park and remediation of the spreader waterways.

Phase II — Focuses on providing all of the necessary detailed information and data required for a comprehensive understanding of the surface water system. The knowledge of the system gained during this phase is essential for development of proper management techniques. This phase includes all field data collection such as canal flow information, water quality samples, survey data, groundwater transmissivities, and ecological processes. Instrumentation networks will be developed and linked to data collection, storage and analysis computers. All data management systems will also be developed in this phase, including Geographic Information System (GIS).

Phase II will also include regional drainage design engineering for the Santa Barbara Boulevard commercial corridor.

Phase III — Assimilates the data into a watershed computer model. This computer model will be used to forecast flood and drought conditions based on historical weather data and detailed hydrologic analyses accomplished in Phase II. Phase III will include regional drainage design engineering as required by the City.

Phase IV — Analyzes the results of Phase III and develops management scenarios. Various management alternatives, such as canal interconnections, spreader waterway upgrades and weir controls will be developed and tested in the computer model developed in Phase III. The alternative package that best achieves the City's objectives simultaneously will be developed into the final Surface Water Management Master Plan. Phase IV will include regional drainage design engineering as required by the City.

PHASE I GOALS AND OBJECTIVES

The central theme of this project is the development of a Surface Water Master Plan. Phase I of this process was completed and included a review of existing data and literature, investigation into the operation and maintenance practices, objective and goal definition, and determination of regulatory requirements. These investigations were used along with scope tasks discussed above to prepare a needs assessment and develop a blueprint for Master Plan development

This document and its appendices represent the completion of Phase I of the Master Plan. As stated previously, the primary goal of Phase I was to formulate the strategy for development of the Surface Water Master Plan. Phase I included the collection of all existing data, not the development of new field data. It also included some specific tasks that required immediate attention. The specific scope items for phase I are listed below. These items and the deliverables that fulfilled the scope item are summarized.

A. Collect, review and summarize existing data related to surface water issues.

B. Develop recommendations for design and construction details of stormwater related improvements.

C. Inventory and assist city staff in prioritizing local drainage problems to identify short term improvements.

D. Provide engineering services for the following:
- Prepare plans to correct drainage deficiencies in areas of localized flooding at City Hall, the industrial park.
- The investigation, reporting and solution strategy for localized flooding along portions of Santa Barbara is carried out in this phase.
- Development of repairs to breaches along the spreader waterways. (Added to the Phase I contract.)

E. Analyze and prepare recommendations for the initial staffing and equipment needs of the stormwater utility.

F. Review computer models and GIS packages and make recommendations regarding a comprehensive data management systems.

G. Develop a Public Information Program.

H. Develop a detailed plan of study for the remainder of the Master Planning effort.

As stated previously, certain scope items (tasks B, C, D, E and F) were included in the Phase I contract for the primary purpose of resolving specific issues. While the deliverables that fulfill these tasks may be regarded as "stand alone" documents addressing specific issues, they will be regarded in the overall Master Plan development as well.

All of the scope tasks above offered the opportunity to gain valuable direct experience with the Cape Coral Surface Water System. Much of the insight gained during this process is indirectly reflected in the Plan of Study document.

A. Collect, review and summarize existing data related to surface water issues.

<u>**Deliverable:**</u>
Summary of Issues and Bibliography, Included as Appendices A and B.

<u>**Description:**</u>
The summary of issues report consists of a series of summary information briefs regarding specific topics related to the Surface Water Master Plan. The information was based on literature review, personal communication and observation. This appendix is designed to provide basic topical information and was used to stimulate thought towards developing a detailed project approach. Topics discussed include previous studies and reports, key regulatory issues, physical characteristics of the system as previously reported, environmental issues and other issues related to surface water in Cape Coral.

Appendix B is a bibliography of literature and data sets collected for this effort. A topical database containing reference to numerous articles and publications is being maintained at the office of Havens and Emerson in Cape Coral.

Conclusions:
These documents were designed to be unbiased reporting of currently available information. Valuable background information was obtained and no conclusions were drawn.

B. Develop recommendations for design and construction details of stormwater related improvements.

Deliverable:
Detail and Ordinance Recommendations, Appendix D in Plan of Study

Description:
This document is intended to define readily apparent drainage problems typically encountered in the City and offer conceptual design alternatives. Without well documented performance data on various designs, it is not prudent to establish detailed design recommendations at this time. However, a critical assessment of existing or planned drainage practices and suggestions for easily attainable modifications is in order since a significant portion of the City's drainage system is currently undergoing re-construction. Designs that promise to be effective and easily altered throughout the Master Planning effort will be suggested for implementation.

The purpose of the secondary drainage system in Cape Coral is essentially threefold, protect public safety and health, remove water from inconvenient areas and affect some degree of runoff water quality enhancement. The physical characteristics of Cape Coral and designs that have been implemented in the past complicate the simultaneous achievement of all three objectives. These characteristics are specifically defined in other documents but are indirectly borne out within the context of the discussions in appendix D.

Summary of Recommendations:

- Performance evaluations should be conducted for existing and promising advanced Best Management Practice (BMP) designs. Pilot projects may be constructed in conjunction with drainage system upgrades in the gravity sewer project areas. Performance evaluation should be conducted during the Surface Water Master Plan Study.

- Enforcement of existing regulations such as sediment control is paramount, especially in areas undergoing significant construction.

- Swales and lawns should be re-sodded as soon as construction or reconstruction is completed.

- New home construction should include side yard swales that direct surface runoff towards the street. New canal front homes should be required to install a swale behind the seawall to avoid direct discharge of stormwater into the canal. Since roof drainage typically contains very little pollution, it should be piped directly to the canal in order to save treatment volume in retention areas or swales.

- Ongoing stormwater system upgrades should be closely re-evaluated to ensure the City's long term drainage objectives are being met.

- Sediment controlling catch basins should be substituted for inlets wherever possible when reconstruction takes place.

- EPA mandated Stormwater Pollution Prevention Plans (SWPPPs) may receive a cursory review by the City. Certain activities exempt from the EPA program may be required to prepare a SWPPP mandated under local authority, i.e. require fueling stations to submit a local SWPPP.

C. Inventory and assist city staff in prioritizing local drainage problems to identify short term improvements.

Deliverable:
Local Problem Areas, Appendix C in Plan of Study

Description:
This section identifies stormwater problems in the City of Cape Coral and suggests resolutions. The primary focus centers on an inventory of local drainage problems and identification of required short-term improvements. It also includes a discussion of problem identification, a review of resolution approaches and suggests improvements to the current system. Problem areas were delineated by review of service request files, discussions with stormwater utility staff and observations. All service requests recorded in the stormwater utility database as of August 8, were mapped on the City Geo-Info System.

Conclusions:
Due to increasing backlogs of critical problems, operational adjustments have been made in prioritizing stormwater service requests. Major construction projects taking place throughout the City frequently disrupt or damage weak drainage pipes thus increasing the occurrence of sinkholes and other problems associated with failed storm drainage facilities. Stormwater utility personnel have responded well in resolving potentially dangerous situations prior to solving other problems. However, when stormwater utility

resources availability is compared to the volume of problems it is apparent that the stormwater utility is not currently structured, staffed or equipped to address drainage problems prior to their occurrence.

The second analysis focuses on the distribution of problems in an effort to determine if certain patterns exist. The analysis aids in identifying whether a particular area is plagued by drainage problems as a result of either one far reaching failure or a number of related individual failures.

Five areas with higher densities of service requests were visited to verify site conditions. The location of these areas, types, probable causes and possible solutions are described in the appendix.

D. Provide engineering services for the following:

a) Prepare plans to correct drainage deficiencies in areas of localized flooding at City Hall, the industrial park.

Deliverable:
Viscaya Industrial Park Drainage Design, Report and Construction Drawings

Description:
Engineering Design Report, Cost Estimate, Engineering drawings and specifications for drainage upgrades in the Viscaya Industrial Park and the area surrounding City Hall were prepared.

b) The investigation, reporting and solution strategy for localized flooding along portions of Santa Barbara Boulevard.

Deliverable:
Santa Barbara Drainage Works Study, Submitted under a separate cover

Description:
A thorough investigation of drainage problem along Santa Barbara Boulevard and short and long term drainage upgrade needs.

Conclusions:
Five immediate action remedies were recommended to the stormwater utility to alleviate various existing drainage problems. Long term potential problems with the existing drainage systems were also investigated in the light of drainage demands in a commercial corridor. An engineering design should be completed prior to anticipated development to bring the drainage systems up to acceptable standards for a major thoroughfare.

c) **Development of repairs to breaches along the spreader waterways. (Added to the Phase I contract.)**

Midway through Phase I, an additional design project was added to address the berm failures along the outboard bank of the spreader waterways.

Deliverable:
Design report, Plans, specifications, cost estimate and permits for fixing the leaks occurring in the spreader waterway system.

Description:
In an effort to protect the City's freshwater supply in the canal system and protect the mangrove wetlands west of the City by causing water discharging to Matlacha Pass to sheet flow across the wetlands, the City sought to repair the numerous breaches in the outboard berm. Surveys of the breach areas were conducted and remediation alternatives were presented to the City. Repair plans and specifications were developed and presented to the Florida Department of Environmental Regulation.

Conclusions:
It was determined that while the breaches in the spreader waterway berm must be closed, it is apparent that additional effort will need to be expended if the City wishes to achieve a comfortable level of protection against saltwater intrusion.

Since recovery of the spreader waterway as a freshwater system may represent a significant volume of useable water, it was decided that management techniques and alternatives will be developed within the Master Plan development. Potential protection methods include elevating the berm crest, installation of anti-intrusion devices, and tide control locks.

E. **Analyze and prepare recommendations for the initial staffing and equipment needs of the stormwater utility.**

Deliverables:
Stormwater Utility Operations and Management Plan, Included as Appendix E in final draft

Assistance provided to Stormwater Utility and Utility Department in Budget Analysis, April - June 1992

Description:
This document is divided into three parts. Part I is a review of the Stormwater Utility Organization as it existed on July 10, 1992. It includes a discussion of the various functions and divisions of the Stormwater Utility. The structure of the stormwater utility as it appears in this report was the most current at the time of its writing. Since the stormwater utility has been undergoing rapid change and expansion over the past year, an updated version of the organizational tree is contained in the preface. The major difference is at the top of the organization since management of the stormwater utility has since been transferred from the utility department to the engineering department. As the Stormwater Utility evolves, updates to this report may be conducted to coincide with Master Plan development.

Part II presents a conceptual organizational plan for the stormwater utility. It also suggests reorienting Utility Department and Stormwater Utility personnel into functional groups in which skills and resources exist in a pool rather than dividing personnel along strictly departmental groups. Allocation of monetary and capital resources would occur on a per project basis rather than a per department basis. Accounting and management plans to administer such a program are included.

Part III presents a conceptual design for computer systems and software that would be required to enable Utility heads to manage the system described in Part II. This section describes the functions of a Management Information System (MIS), Geographic Information System (GIS) and Supervisory Control and Data Acquisition (SCADA) system. It also describes data exchange possibilities between these systems to enhance data management between parties.

F. Review models and GIS and make recommendations regarding a comprehensive data management system.

Deliverables:
Geographic Information System (GIS) Selection for the Surface Water Master Plan, Appendix F & G

Advisement to Engineering Department regarding GIS hardware, software and data construction

Description:
In recent years GIS technology has gained increasing popularity among government and private organizations because of its ability to efficiently handle spatial data. The result has been an improvement in the delivery of services to customers of these organizations. Recognizing the need and desire to improve delivery of services to its citizens, the City of Cape Coral is considering the options available in implementing a GIS for specific engineering purposes.

GIS provides diverse application potential. The information provided through a mapped data system serve facilities managers, city planners, engineers, homeowners, businesses and government personnel. The system development is geared towards engineering applications as they pertain to the Surface Water Management Plan and future engineering, public works and engineering applications. The proposed GIS system will:

- Provide a data storage and analysis tool for the enormous amounts of data necessary to accurately define and model the surface water system of Cape Coral.
- Provide a readily available set of maps of existing stormwater infrastructure, designed improvements and modifications as they occur.
- Serve as a data storage device for the surface water management computer model to be developed during the planning process.
- Provide a platform for universal data storage system for other city departments.

At the time this project was conceived, it was assumed that the City Information Services would continue using the WANG Geo-Info system. While this system provided excellent planning and property information management, it was considered too inflexible for use in an engineering capacity. Thus the utility department sought the development of a completely new GIS system with the accuracy and flexibility for engineering and utility purposes. ArcCAD operating on a Personal Computer was recommended as the system of choice.

Conclusion:

Based on the response to the original draft GIS report and subsequent conversations with city staff, it is recommended that ArcCAD be installed on a powerful personal computer for Master Plan Development. A precise coordinate grid will be established from measured survey points throughout the City and recorded on the new ArcCAD system. Existing spatial data maintained on the City Geo-Info system will be fit into this corrected grid in an effort to provide a basis for long term upgrading of the spatial data maintained on the City system.

It is anticipated that the City will be installing ArcINFO to replace the Geo-Info System. Since ArcCAD and ArcINFO are produced by the same software company, the data developed in ArcCAD will be compatible with the City new GIS. At project conclusion, the ArcCAD system may be used to manipulate specialized engineering data that would not have to be maintained on the main City system.

Drainage infrastructure including canals, weirs, pipes and inlets will be input into the GIS system. This will enhance the Stormwater Utility's ability to track and correct drainage and canal problems. Approximately 25% of the drainage inlets and pipes will be field verified for location and size in Phase II of this study.

The GIS system will also be used to maintain the voluminous data expected to be collected in Phase II and to arrange and manipulate data into a useable computer model format. The GIS will then be used to display and organize data from which the Master Plan will be developed.

G. Develop a Public Information Program.

Deliverable:
Public Information Program, Appendix H of Phase I report

Description:
A task identified in the first phase of the Surface Water Master Plan is to develop the guidelines and structure of a quality Public Information Program. The objective of this program is to provide the City with a mechanism for positive communication with the public and will assist in obtaining public support for the remainder of the Master Planning effort.

The goals of this program include:

- Develop methods and procedures to better educate the citizens of Cape Coral on surface water related items such as how the spreader waterway works, how water withdrawals from the canals effects recreational activities in the canal system, what is being accomplished with the Master Planning effort, etc.

- Provide a mechanism for public input.

- Gain public support for further developing/improving the stormwater utility.

Program structure
The first task to be undertaken in developing a quality Public Information Program is the organization of a public relations committee. Their primary function will be to determine the means, methods, and subject material to be used that will begin and continue to educate the citizens of Cape Coral on Surface Water Master Planning. The committee should consist of non-technical as well as technical members. This will provide for a more well rounded approach when procedures and public education material are developed for distribution. In discussions with city staff it was determined that the public information committee should consist of the following:

- Publicly elected official or individual that is well respected in the community

- 2 members from the public at large

- 2 city staff members (1 from public relations)

- 2 members from Stormwater Master Planning consultant team

The 7 member committee should be a workable size so that work can be accomplished in an effective and timely manner.

Methods to Educate the Public
There are various effective methods available that can be used to better inform or educate the citizens of Cape Coral on what is to be accomplished during the Master Planning effort. The methods recommended for consideration are:

- Video presentations

- Displays/brochures

- Media releases and T.V. programs

- Public presentations to organizations and Town Hall meetings

- Direct communication link with the public, direct mail, etc.

- Grade school, high school, and college classroom lectures

Summary
The public relations committee will be charged with the task of implementing an effective Public Information Program. The means and methods previously discussed can assist the committee in developing an effective program. As the Stormwater Master Plan evolves, some of these methods may prove to be more effective than others. Some may even prove to be ineffective or new methods may need to be developed. However, this material will provide the committee with direction to initiate a more effective, on-going information program.

H. Develop a detailed plan of study for the remainder of the Master Planning effort.

Deliverable:
Plan of Study

Description:
This document is the culmination of the first Phase of the Master Plan development. The body of the document provides an overview of the physical function of the surface water

system in Cape Coral and presents a methodology for completing the Master Plan development. The appendices provide additional detailed information referenced in the main body of the text.

The first three sections of this document provide an introduction to the surface water system and an overview of surface water management efforts to date. The fourth section describes the surface water system in greater technical detail and points out the numerous processes affecting the operation of the system. It also describes the Master Plan development process in general terms. The fifth section discusses the numerous tasks within the Master Plan development strategy. The sixth section is a schedule of tasks to be completed.

The key to developing an approach of Master Plan Development is developing a keen understanding of all the processes affecting the surface water system. Figure 1 shows how major systems connected to the canal system are affected by one another.

The strategy begins with a comprehensive field data collection program to develop a clear picture of the processes taking place within the surface water system. Following data reduction and analysis, a computer simulation of the surface water system will be constructed. This computer simulation will be used to test the limits of the surface water system under various conditions such as drought or flood. It will then be used to analyze and compare various management strategies. Finally, a Master Plan that derives maximum benefit of the surface water system within stated constraints will be finalized.

Throughout the process of developing the plan, important management issues will be addressed. These issues include regulatory requirements (including NPDES), Department of Community Affairs and state planning needs, Stormwater Utility expansion, engineering design standards, environmental quality and public education and awareness. Public workshops will also provide important input to management objective and constraint development. These objectives and constraints will play a large part in determining the final form of the Master Plan.

Section I Background

Section I provides project background and objectives for Phase I. This project was conceived as the City recognized the necessity for comprehensive management of its extensive and complex surface water system. The surface water system is important to the vitality of the City because:

- Attractive canals will enhance and maintain property values

- Maintenance of the drainage system is necessary to reduce localized flooding as development increases.

INTERACTION OF MAJOR SUB-SYSTEMS WITHIN THE SURFACE WATER SYSTEM

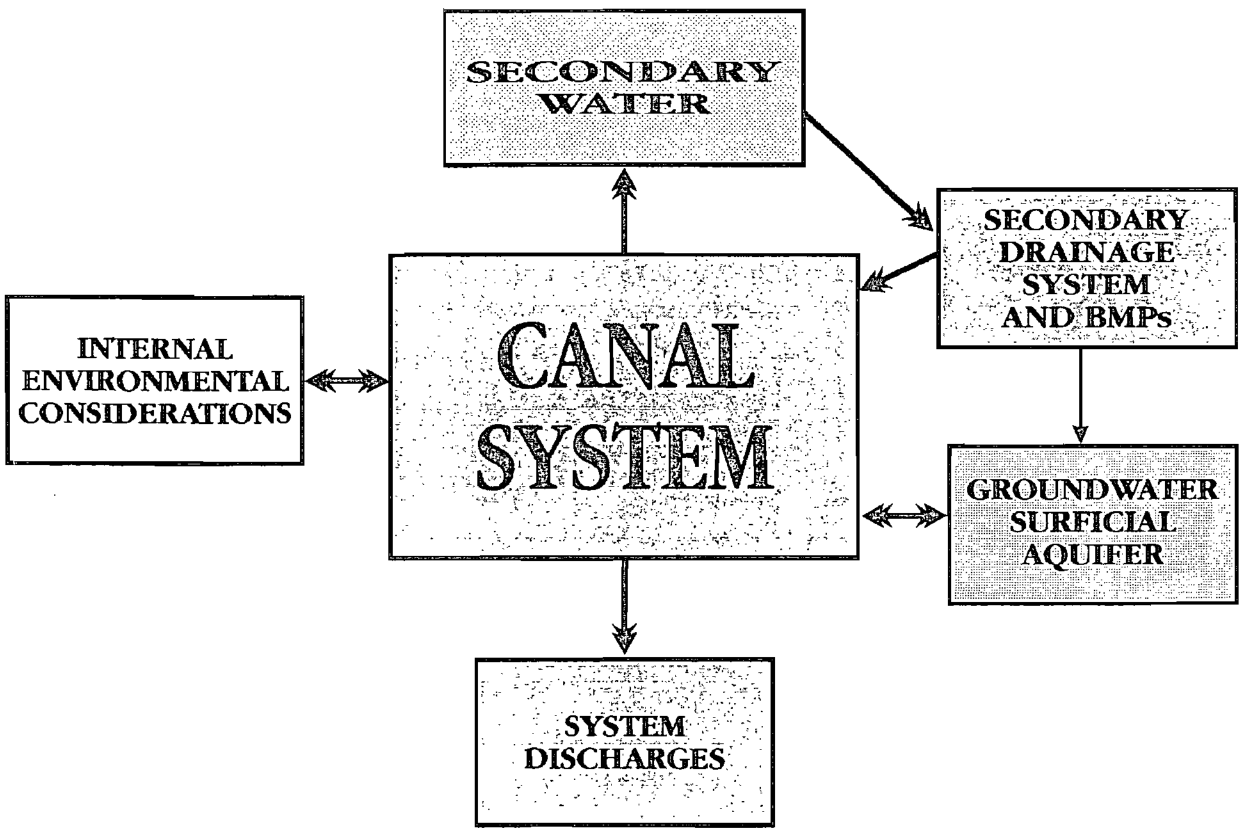


FIGURE 1

- The ability to obtain a sufficient supply of irrigation water from the canals will offset expensive potable water supply projects

- Increasingly stringent regulatory requirements will necessitate greater control on water quality prior to discharge to receiving waters

Section II Objectives
The Plan of Study is intended to outline the recommended steps to establish a comprehensive and effective management plan. Section II details the surface water management objectives around which the plan will be built. These objectives are:

- Provide Drainage
- Maximize freshwater storage for the dual water irrigation system
- Maintain and/or improve the water quality in the canal system
- Be able to meet all regulatory requirements for existing and future permits including Comprehensive Planning requirements.

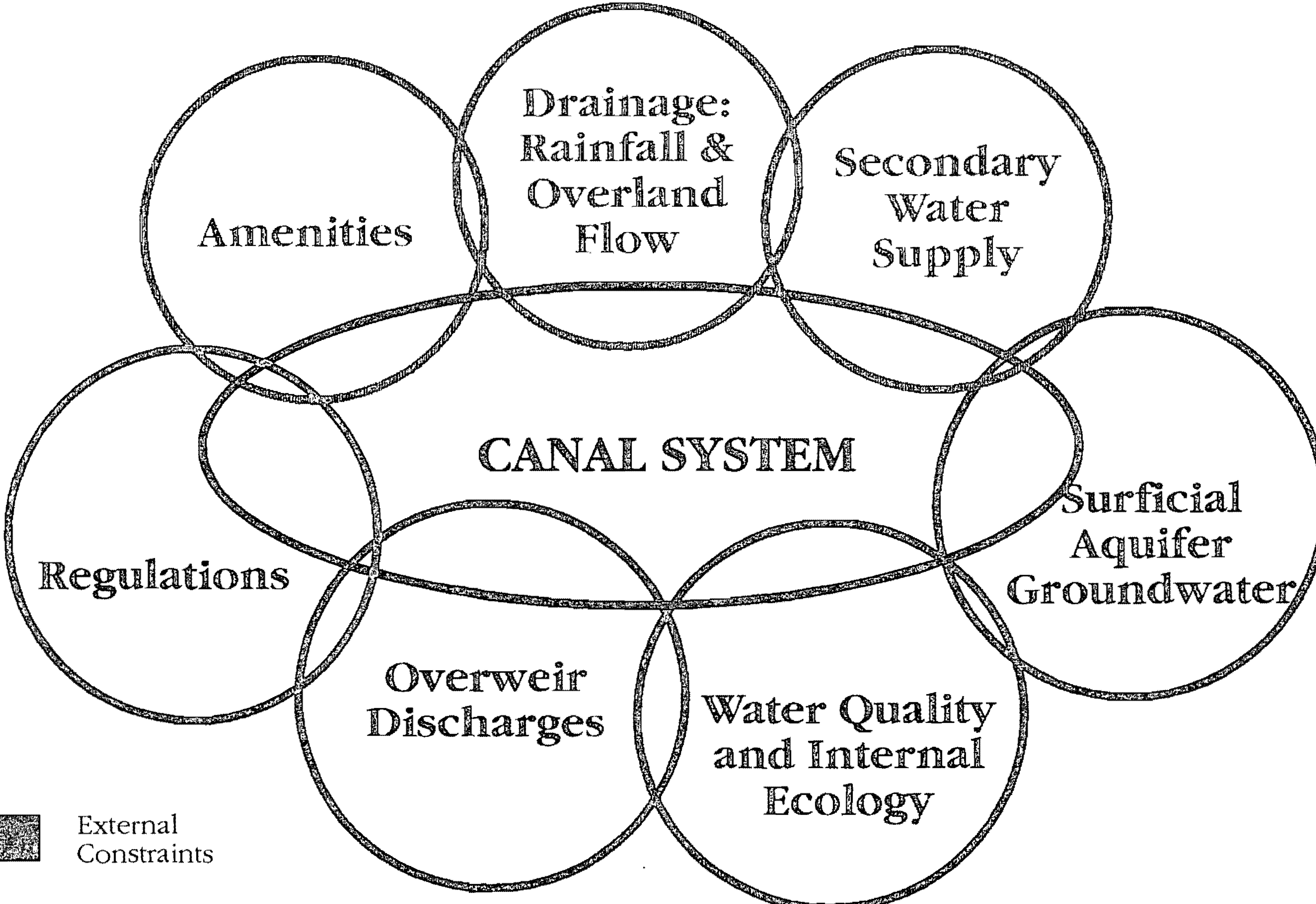
The Master Plan development program incorporates consideration of all of these objectives as each one is essential to the success of the City. Figure 2 shows the interconnection between benefits and constraints. The importance of attaining each objective should be weighed against:

- Public Safety
- Public Health
- Value Provided
- Protection of Resources
- Growth Planning
- Costs

Section III Management Resources
Section III is a comparative analysis of management resources necessary for comprehensive surface water management and those that are available to the City. Management objectives are attained through the use of available management resources (see Figure 3). Necessary management resources include:

- Thorough understanding of the complex surface water system
- Mechanism to address regulatory requirements
- Proper engineering design criteria and enforcement
- Well developed lines of communication with citizens
- Long term and short term prioritization policies
- Means to implement chosen actions

CANAL RELATED CONCERNS

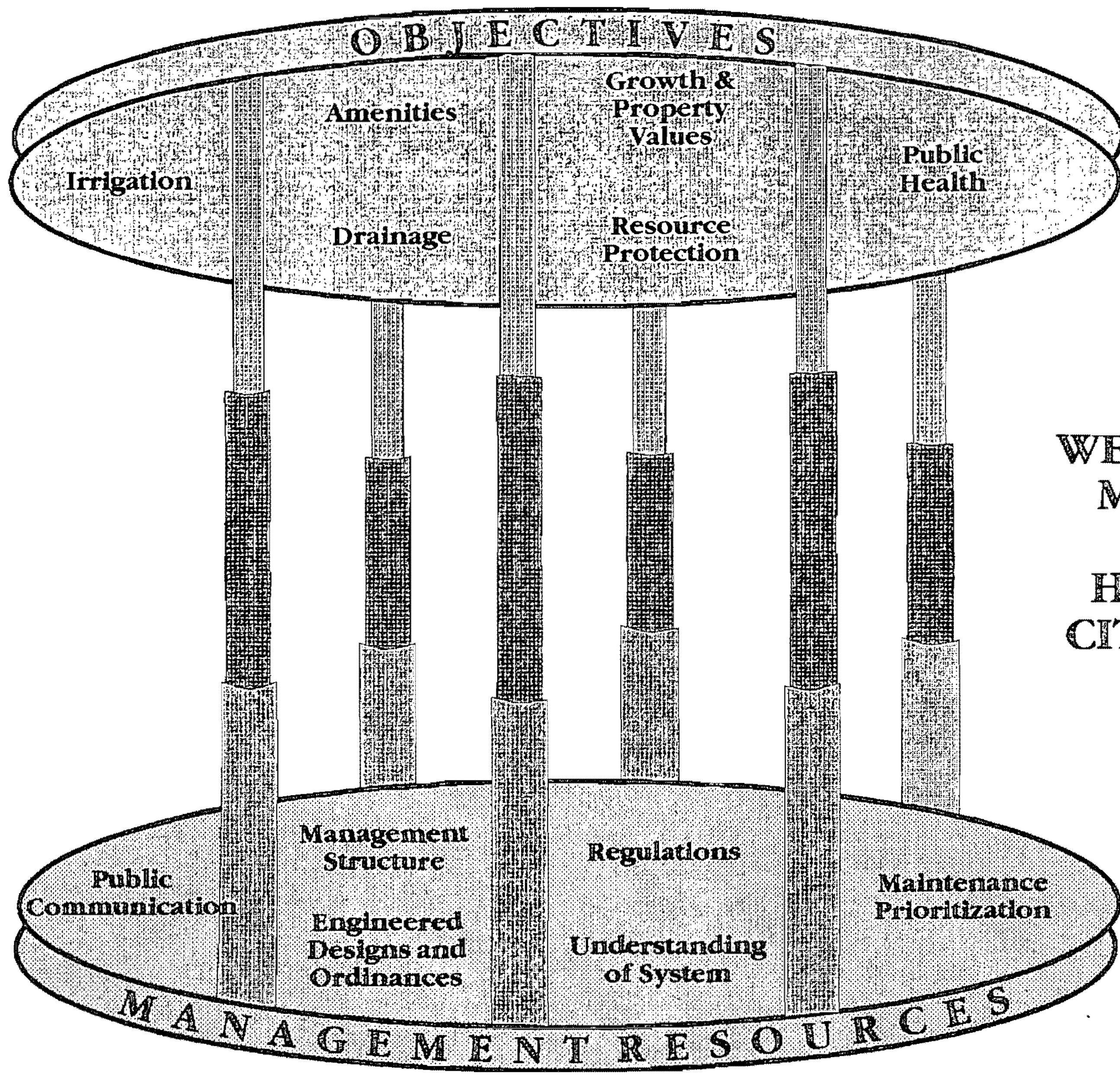


External Constraints

Physical Constraints

Benefit Considerations

FIGURE 2



WELL DEVELOPED MANAGEMENT RESOURCES HELP BALANCE CITY OBJECTIVES

FIGURE 3

It should be recognized that these resources can only be provided through co-operation between the various levels of city government. The City has made significant advances in developing these management resources in recent years through the establishment of the Stormwater Utility. However, the Stormwater Utility provides a portion of all of the management resources required. Additional management services have yet to be developed in other segments of the City government. Under the Master Plan development, the City will be provided with the means to obtain and develop the resources necessary for comprehensive management of the surface water system.

Section IV Project Description and Approach

Concerns and constraints

Section IV begins the Master Plan development description with a through technical analysis and refinement of City objectives, or benefit concerns, and constraints. These benefits and constraints are tied together through the City's extensive canal system. Real benefits include:

- Drainage
- Secondary Water supply
- Attractive Amenities (i.e. water views, boating, etc)

Constraints are divided into physical constraints and external constraints. Major physical constraints consist of:

- Surficial Aquifer characteristics
- Water Quality and canal ecology
- Overweir discharge as a physical boundary

Exterior constraints are those placed on the City from outside pressures including regulatory requirements and public activism.

Surface water system description

The surface water system in Cape Coral is not an isolated system nor a collection of dissociated parts. It is rather a system of complex integrated processes. The processes that are tied together through the canal system to comprise the full surface water system include:

- Storm drainage
- Dual water system
- Surficial Aquifer Groundwater
- Surface discharges
- Processes within the canal system
- Aquatic Ecological Processes

A change in one segment of the system will give rise to changes to all systems connected to it. The limited scope of previous studies precluded serious investigation into these complex interactions. By recognizing that these processes are integrated into one system, a management plan may be developed to maximize the use of these processes together, rather than as individual pieces.

In order to fully develop the approach, it was necessary to develop a detailed picture of all the processes connected to the canal system. Figure 1 was expanded to show additional detail and is presented in Figure 4. The project approach was largely developed by considering which processes must be understood and which ones might be controlled to increase the beneficial use of the canal system.

Combining constraints and system understanding into a Master Plan
The Master Plan development approach is formulated by understanding the City's objectives, recognizing technical and regulatory constraints and developing a full understanding of the complex physical processes affecting the surface water system.

The proposed method for development of the Master Plan is based on a "multi-objective planning" approach which allows for interaction with the project engineers and scientists in a manner that leads to a technically sound and acceptable result. Multi-objective planning, as the name implies, is a process for development of a project which attempts to satisfy all of the goals and objectives set forth by the City within a set of constraints imposed by the City, its citizens and the regulatory bodies (via rules and criteria) that have jurisdiction over the project. Because the mutual maximization of all of the goals and objectives is usually not possible in a project of this nature, the process also contains a feedback mechanism that attempts to satisfy each objective to an acceptable level through use of tradeoffs and compromises for the mutual good of all involved or affected parties. This process is intimately tied to benefit/cost relationships as well as budget considerations so that an affordable set of alternatives can be formulated.

The overall process for the execution of the project is provided in Figure 5. The program discussed in this section focuses primarily on the full development of the Surface Water Master Plan. Additional vital tasks not included in this section but to be included in the overall project scope include:

- Implementation of Public Communication Program
- Continued regional drainage design upgrades
- Assistance with Stormwater Utility growth and future development
- Periodic assessment of financial needs

Section V Detailed Methodology
Section V of this document describes the phased project development in greater technical detail.

Following are brief descriptions of the major elements within Phases II, III, and IV of the study. While there is a degree of dependence between elements, they are described here individually

RELATIONSHIPS WITHIN THE SURFACE WATER SYSTEM

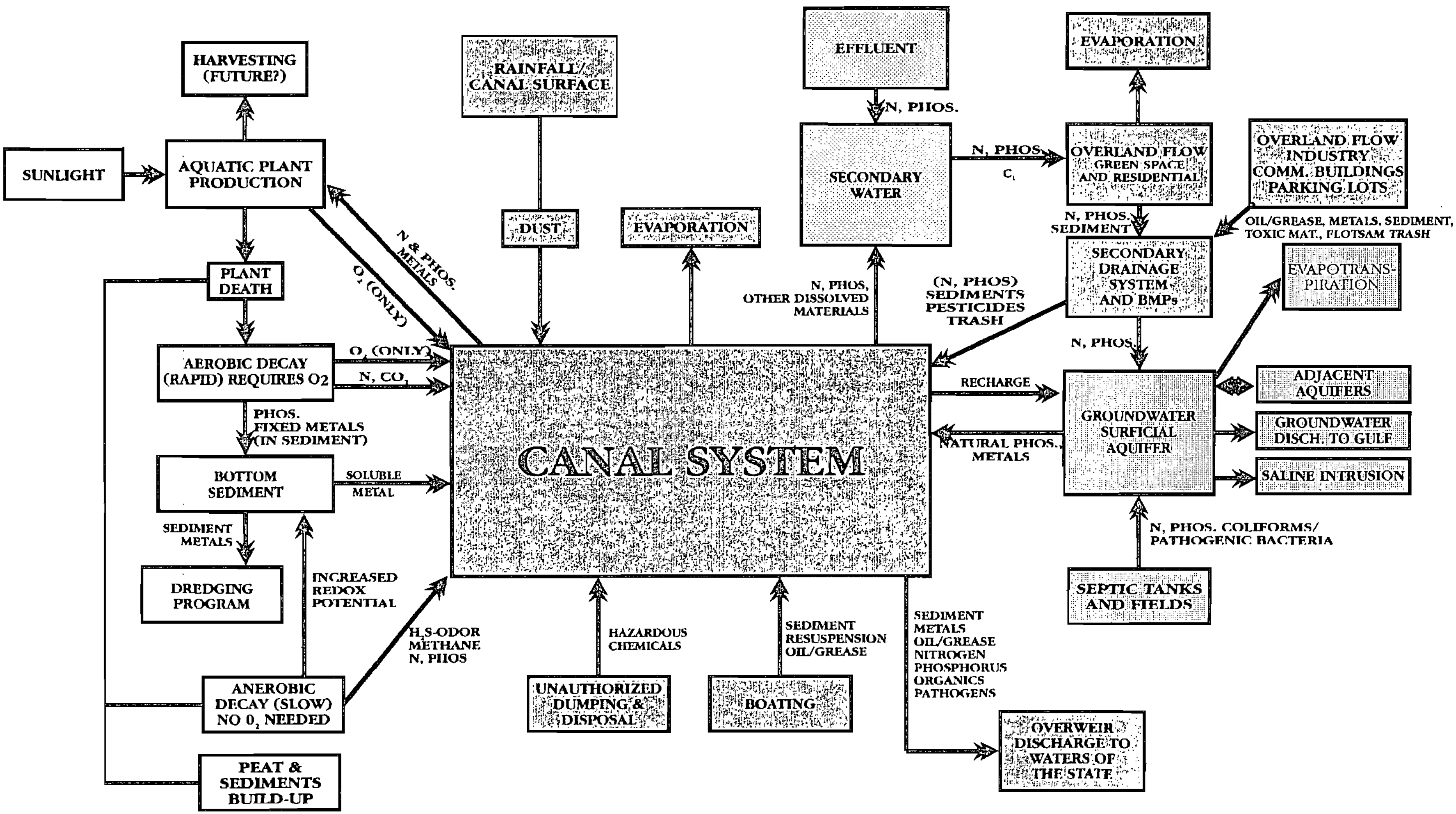


FIGURE 4

MASTER PLAN DEVELOPMENT

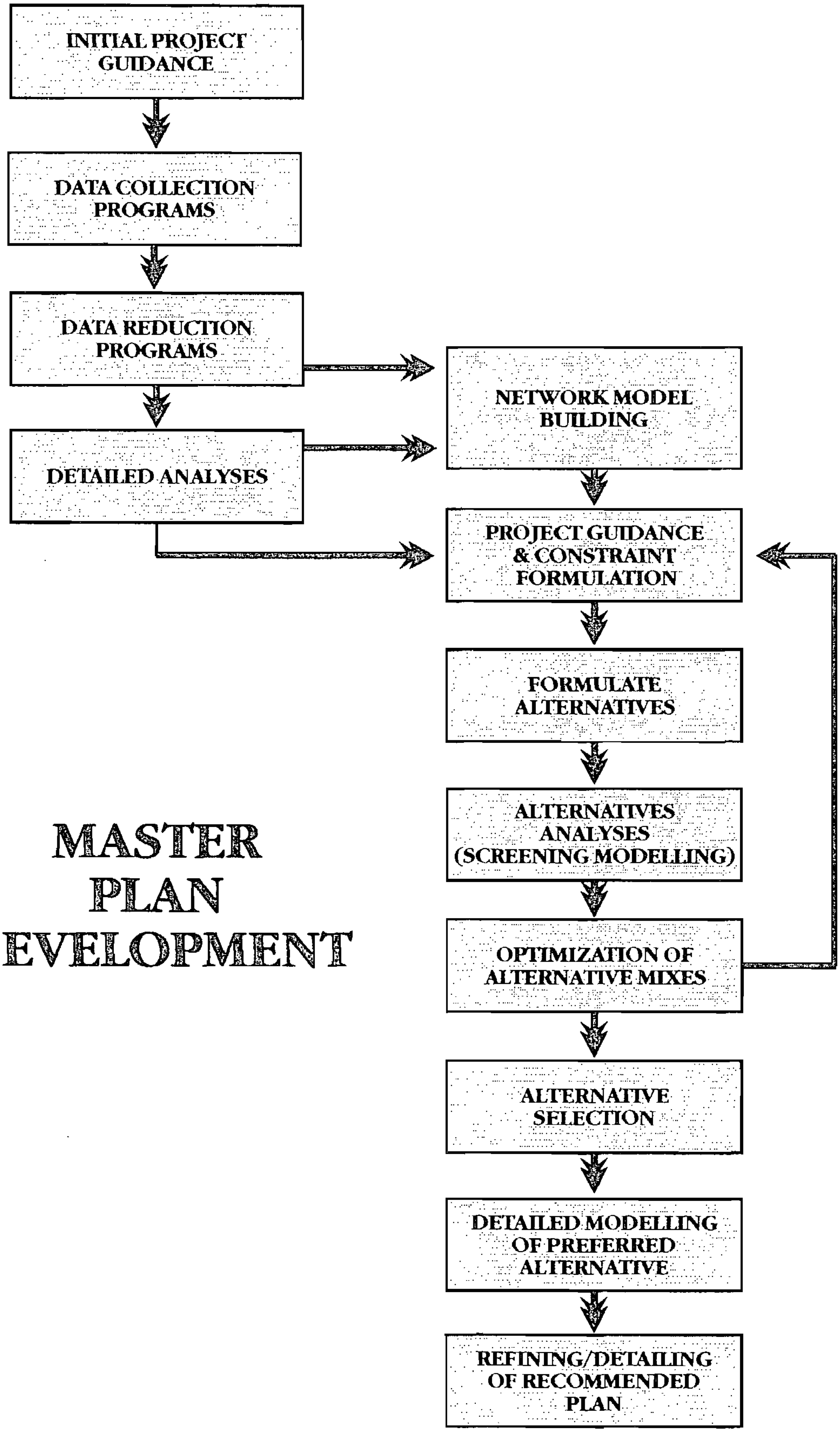


FIGURE 5

to give an overview of the planning effort required. Within each phase, sub-sections are arranged in the order they will occur, although some chronological overlap is expected with certain elements.

Phase II of the Master Plan development seeks to fill in critical data gaps through the use of direct field measurement. Much of the data required to develop the necessary water management techniques does not currently exist. The combined effects of the complex hydrologic system and the expected future demands on the system significantly reduces the tolerance for insufficient or erroneous data. Phase II also includes the necessary elements for data management, Geographic Information System data development, data reduction and preliminary analyses of data. Major task divisions in Phase II are:

- Interim Project Guidance
- Data reduction Program
- Process analyses

Phase III of the Master Plan will ensue near the end of the data collection tasks. Phase III concentrates on construction of a city-wide hydrologic computer model. This model will be used to predict the effects of extreme rain events, droughts and average year conditions. The model will be able to provide the most accurate estimates to date on the drainage systems ability to prevent flooding, the availability of irrigation water during the dry season and provide key information for water quality issues.

The model will then be used to evaluate the effects of various water management alternatives to enhance the benefits derived from the surface water system.

Phase III task divisions are:

- Network Model Building
- Formulation of Alternatives
- Development of Constraints
- Analysis of Alternatives

Phase IV of the Master Plan will focus on developing the best mix of water management alternatives. The model developed in Phase III will be used to evaluate promising mixes of these alternatives. The model will then be used to perform a detailed evaluation on the performance of the best management package. Design specifics will be developed and system operations will be refined. Finally, the Master Plan will be formalized under this phase, including implementation and operational plans. Phase IV task divisions are:

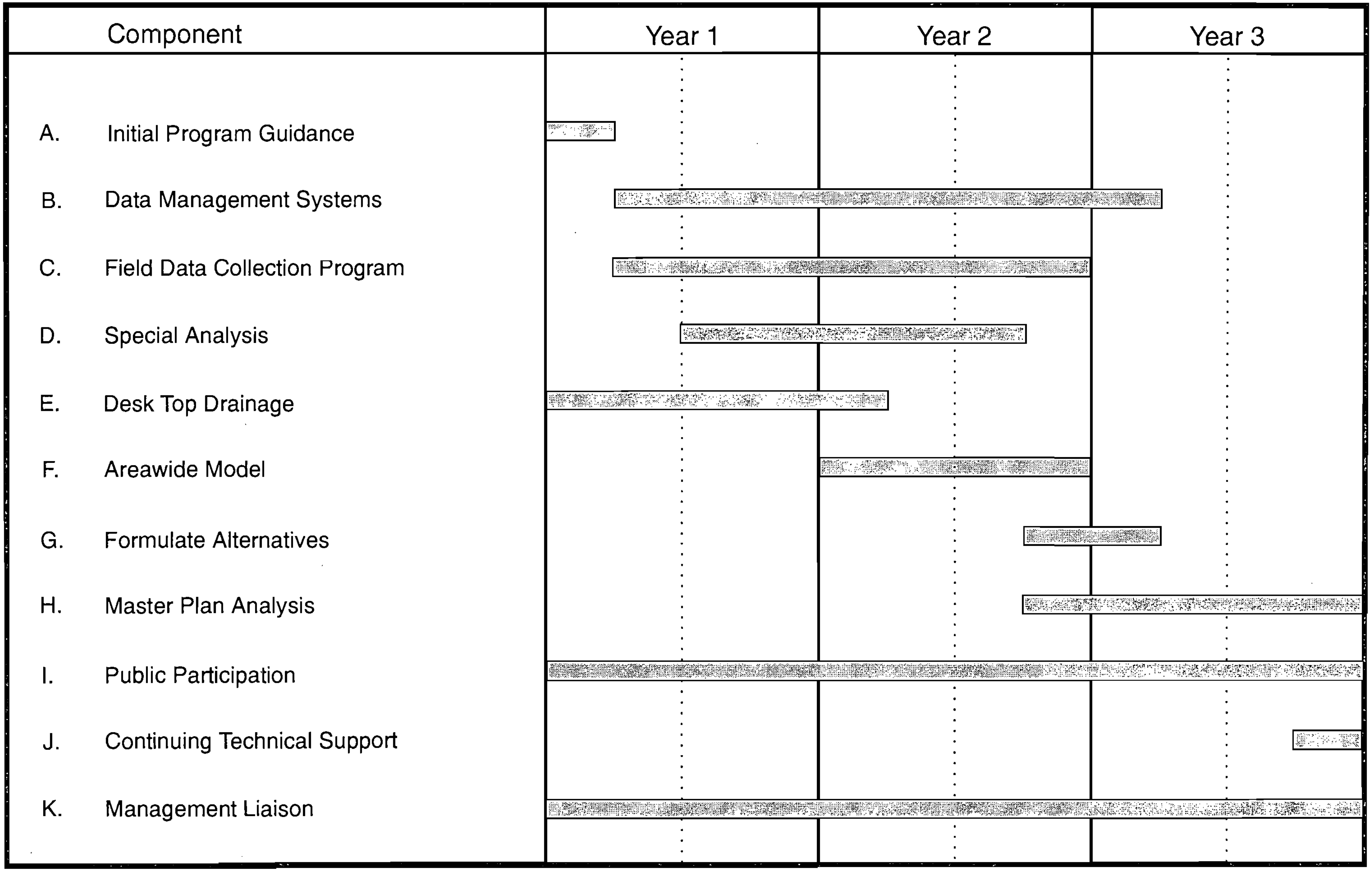
- Master Plan Tradeoff Analysis
- Selection and Detailing of Recommended Plan

Section VI Schedule
Section VI is a presentation of the detailed schedule of tasks to be completed.

Figure 6 identifies a schedule showing the Master Plan being completed in three years.

Schedule

Cape Coral Surface Water Master Plan



URE 6

SECTION I - INTRODUCTION

A. BACKGROUND

The City of Cape Coral owns and maintains a massive system of canals, drainage pipes and roadside swales which, tied to the surficial aquifer, collectively comprise the surface water system. This system is responsible for collecting and conveying stormwater flows, for providing recreational opportunities to residents, and for providing a source of water for the secondary or irrigation water system. The major distinguishing feature of Cape Coral is the canal system and the ability to reside on a canal with boating access to either various parts of the City or to the open waters of the Caloosahatchee River and the Gulf of Mexico.

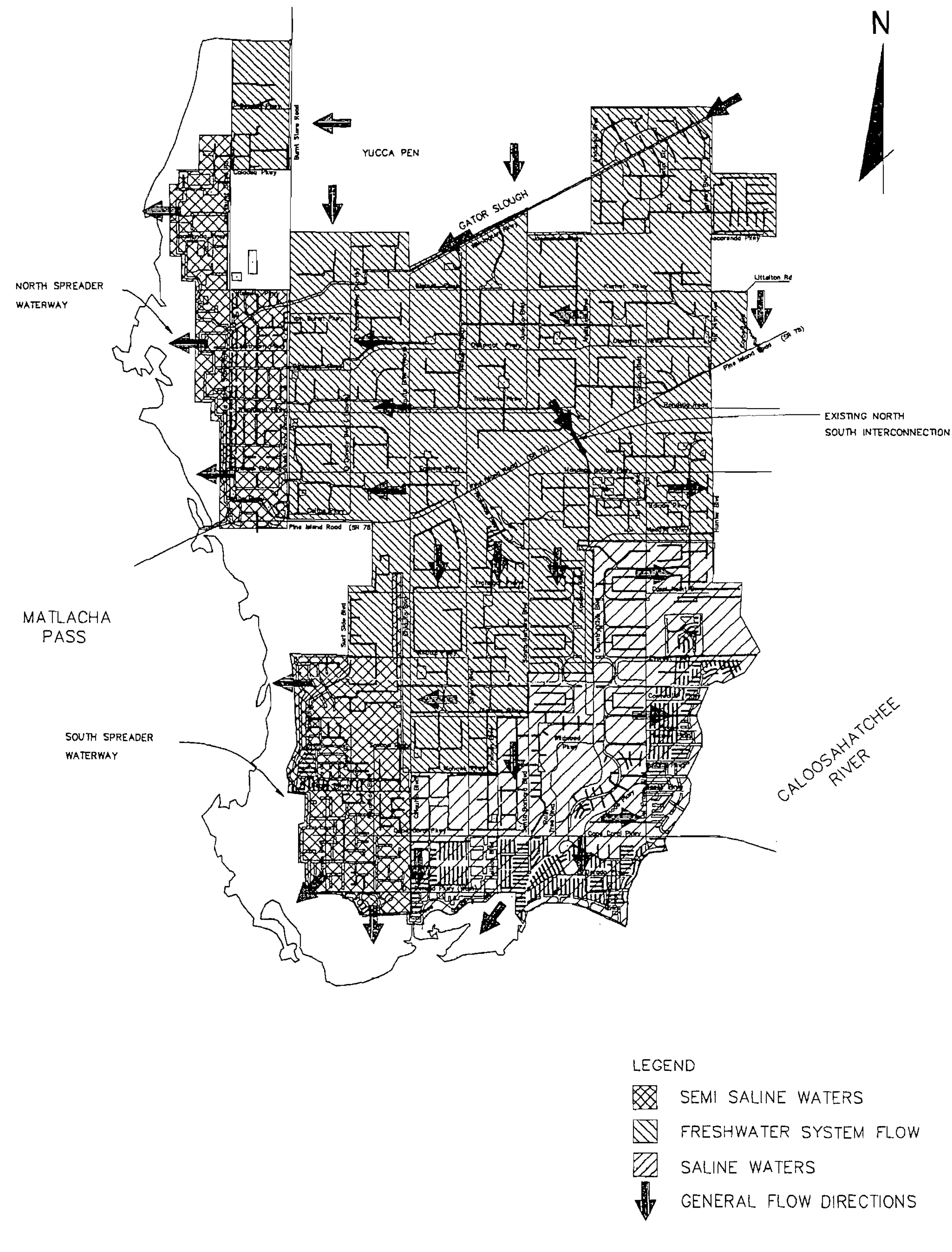
The magnitude of the Cape Coral surface water system sets it apart from other communities and creates a unique challenge to the City for responsible planning and management. There are over 400 miles of canals within the 114 square miles of the City boundaries. Approximately 295 miles of the canal are freshwater systems and the remaining 105 miles are saltwater environment. Since the majority of the City was developed for the sale of lots, there are huge tracts of sparsely developed land which has roadside swales, inlet structures, and drainage pipes in place. In all, there are approximately 2,400 miles of swales, 375 miles of drainage pipes and over 45,000 inlets to maintain.

Much of this piped system was installed with low cost materials and has received minimal maintenance since being constructed in the late 1950's, 1960's, and 1970's. The canals act as receiving waters for the piped drainage system and the roadside swales serve dual functions as conveyance and treatment for the runoff from lots and roadways. Fresh and saltwater canals are divided by a series of 58 weirs which control the water level in the upper, freshwater canals. Figure 1.1 shows the division between fresh and saltwater areas of the City.

City officials are acutely aware of the vital importance of the surface water system to the future wellbeing of the community. Some of the major reasons for this importance are as follows:

- Unattractive canals will negatively impact property values
- Lack of attention to the surface drainage system will result in increased localized flooding
- The ability to obtain a sufficient supply of irrigation water from the canals will offset expensive potable water supply projects
- Increasingly stringent regulatory requirements will necessitate greater control on water quality prior to discharge to receiving waters

Unsatisfactory resolution of the above could limit Cape Coral's growth potential.



HAVENS AND EMERSON, INC.
AVALON ENGINEERING, INC.

PROJECT AREA
SALINITY AND FLOW PATTERNS

FIGURE 1.1

The City has taken several steps to improve the ability to manage and maintain the surface water system including the establishment of a stormwater utility by Ordinance 18-90 (April 1990), the design of drainage improvements in the downtown area, and the replacement of drainage pipes in conjunction with construction of sanitary sewers. Other ongoing maintenance efforts include drainage inlet cleaning, canal dredging, swale maintenance and responding to drainage related service requests to the degree possible with a limited budget.

Because of the importance and magnitude of the surface water system, the City seeks to develop a master plan to guide the decision process with regard to such issues as priorities, funding, technical approach, and regulatory compliance. The master plan should serve as a "roadmap" for many years to guide the City to it's objectives for surface water use. This document is intended to be the first step in the planning process.

B. OBJECTIVES OF THIS STUDY

The Plan of Study for the Cape Coral Surface Water Management Plan is intended to outline the recommended steps to accomplish a comprehensive and effective planning effort for surface water issues in Cape Coral. Because of the size and complexity of the system it is clear that there will be many elements involved in such a planning effort.

In preparation of the Plan of Study existing data was collected and reviewed, helping to assure that duplication of effort will be minimized if not eliminated. A reasonable understanding of the scope, dimensions and physical workings of the surface water system was gained, allowing a logical assessment of the needs and objectives of the planning effort. Additionally, continued discussion with City staff over the period of producing this report has led to a better understanding of past and current operations, fiscal opportunities and constraints, and organizational issues.

In addition to the Plan of Study element of this assignment, there are several other products to be delivered as a portion of the Phase I planning effort. These products include the following:

- Index of existing data related to surface water issues in Cape Coral.
- Recommendations for design and construction ordinances and details for near term improvements.
- Inventory and prioritization of localized drainage problems.
- Analysis of utility staffing and equipment needs.
- Recommendations on computer models and GIS systems.
- Develop recommendations for public information programs.

In addition to the above noted specific items, all of which are useful in the development of the plan of study, construction plans and specifications were to be developed for drainage improvements in the industrial park area including the area near the city offices. Also, drainage problems along Santa Barbara Boulevard were to be analyzed to determine the cause of frequent flooding in that area.

C. ORGANIZATION OF THIS REPORT

It is our intent and hope that this document will be reviewed and used by a variety of city staff and other interested parties with a range of interests and levels of understanding of some of the issues addressed herein. For ease of reference the ancillary products listed above are included as appendices to this report. The only exceptions are the design documents for the industrial park area which are bound separately. Appendix A - Summary of Issues, and Appendix B - Bibliography of Existing Data are most useful when used in conjunction with the main body of this report. The other appendices are included for convenience of reference but can be viewed as stand-alone documents focusing on specific elements of surface water management.

The body of this report consists of five sections including this introductory Section One. Section Two defines the objectives of the surface water master plan. Section Three identifies data and resources available to manage the surface water system and compares this to a baseline level of information required for effective management of the system. Section Four provides an overview of study requirements and concepts. Section Five provides the details of the recommended elements of study and the methodology to accomplish the recommendations. It is this section which outlines the steps which should be taken to complete the planning process. Section Six proposes a schedule for implementation of the planning steps recommended in Section Five.

SECTION II - OBJECTIVES

A. INTRODUCTION

The goal of the Surface Water Master Plan is to provide the City of Cape Coral with a comprehensive operational plan to:

- Provide adequate drainage and flood control throughout the City
- Maximize the storage capacity of the surficial system
- Maintain and/or improve the water quality and aesthetic value of the canal system
- Conform to regulatory requirements

This section presents the City objectives as related to the management of the surface water system.

B. SURFACE WATER MANAGEMENT CONCERNS - CITY OBJECTIVES

The City of Cape Coral has recognized the need to develop a comprehensive management plan for its very unique surface water system. The Cape Coral canal and drainage system represents a significant infrastructure investment to the City. Physical elements alone are estimated to be valued at approximately $2.5 billion. In addition, the presence of the canals has allowed significant savings in stormwater transmission piping and may provide substantial savings in the future as a freshwater reservoir. Water views and recreational opportunities of the canal system also significantly enhance property values in the City and are a primary attraction to new residents settling in the area. A properly developed and implemented comprehensive management plan will assure that the City will protect the value of this system and maximize its use.

It is important to recognize that the surface waters in the City must be managed as a multiple use resource. By nature, these uses are inherently interdependent. Proper management of the canal system must consider this interdependence in all decision making processes.

Unlike any previous investigation, this management plan will provide the City with an "owners manual" for its surface water system that effectively and concurrently manages all demands placed on the surface waters in Cape Coral.

As the owner, the City of Cape Coral has the primary responsibility of making the best use of its surface water system to accomplish the following tasks:

- Provide drainage
- Maximize freshwater retention for the dual water irrigation system
- Maintain and/or improve the water quality in the canal system

- Be able to meet all regulatory requirements for existing and future permits including Comprehensive Planning requirements

1. DRAINAGE CONTROL

Drainage may be defined as effecting the removal of water from areas where it is not desired. In the management plan this includes providing infrastructure upgrades and methods for properly operating and maintaining the system. The drainage system may be viewed as two connected systems; (1) the primary system which provides collection and conveyance for entire basins and includes all of the canals, and (2) the secondary drainage system which may be considered as all conveyances between direct runoff and the primary system including all swales, inlets, piping and culverts.

a) Primary System

Management of demands placed on the canal system is crucial to the successful growth of the City. The canal system must be able to provide conveyance to protect the City from flooding. A delicate balance between the apparently contradictory objectives of meeting drainage demands and maximizing water storage must be maintained while also considering the many other uses of the canal system. The management plan for the primary system will consider effects on the secondary drainage system, irrigation water quality and supply, discharge regulations, aesthetic value, and recreational value.

b) Secondary Drainage System

The secondary drainage system serves two purposes; (1) move stormwater off of the land and into the canals and (2) provide pollution control. Typically it is in the secondary drainage system that the first opportunity presents itself for the control of quantity and quality of runoff. Secondary system designs should incorporate considerations for protecting the integrity of the primary drainage system as well, especially in terms of sediment and pollution loading. Surficial aquifer recharge and response may also be an important consideration as it relates to water storage as a secondary water supply.

2. SECONDARY WATER SUPPLEMENT (IRRIGATION)

The secondary water system in Cape Coral, developed under the WICC Plan (Boyle Engineering, 1988), provides irrigation water and fire service through a system parallel to the potable water supply. Secondary water is comprised of reclaimed water and water from the freshwater canal system.

When the City is completely developed the required withdrawal from the canal system is estimated to be 74 MGD (WICC, 1988), nearly eighty percent of the irrigation demand, through the six month dry season. If this estimate is correct, a heavy reliance will be placed on freshwater storage in the surficial aquifer. Since the canal system was originally designed to provide efficient drainage of uplands and the aquifer, close control of canal discharge must be maintained in order to maximize storage in the canal aquifer system.

Storage demands for the irrigation system must be balanced against drainage requirements. Withdrawal requirements may also impact water quality and environmental concerns.

3. MAINTAIN AESTHETIC APPEAL

The canal system is more than just another utility system. Real estate values are enhanced by water views and boating access. It is necessary, therefore, to protect the extrinsic value of the canals. Discussions with real estate professionals indicate that preference for canal front homes are based on:

- Proximity to Gulf access
- Water view
- Boating in canals including dockage
- Other canal recreational opportunities such as fishing and bird watching

The availability of economical irrigation water is also perceived by many in the real estate industry as a significant future asset to property values.

While achieving the qualities of the aesthetic amenities does not necessarily conflict with other demands placed on the canal system, there is a significant potential for heated debate over what is aesthetically pleasing. It is recognized that what constitutes a desirable aesthetic feature is a highly subjective matter and may be widely variable between individuals.

Unquestionably however, floating aquatic vegetation and algal blooms are always considered undesirable in appearance as are foul odors that may emanate from eutrophic waters. These types of problems have occurred in Cape Coral in the past and it is expected that they may be re-experienced, possibly with greater frequency as development continues. It is important to have the means and knowledge to respond to these situations properly.

4. REGULATORY AND COMPREHENSIVE PLANNING REQUIREMENTS

The government of Cape Coral must not only respond to public and economic pressures, but must be prepared to address regional, state and federal regulatory requirements. In an ever changing regulatory climate, it would be beneficial for the City to have the mechanisms in place to address regulatory concerns. A key element of this preparation would be the establishment of a comprehensive baseline data set, watershed contributing areas and water quality management procedures.

In addition to Florida Department of Community Affairs (DCA) requirements for management planning and implementation of stormwater and water supply systems, new Federal and State regulatory requirements for surface water discharges are on the horizon (see III.C.2 and Appendix D, Section C). It is most likely that future regulation affecting Cape Coral's surface waters will focus on water quality at discharge points. This will leave responsibility for maintenance of the canal water quality in the hands of local governments. It would be extremely beneficial for the City to begin to plan approach alternatives before deadline pressures are added to the equation.

C. CITY'S PRIORITY CRITERIA

As primary provider of drainage and water service, the City must prioritize its' objectives to best address these issues with limited resources.

City objectives must be weighed against constraining criteria. Ideally, the City would be able to meet all of its objectives at little cost. Unfortunately, from a technical standpoint, many of the objectives are directly or indirectly contradictory . The solution of these contradictions does not come without costs. It is imperative that the City adopt criteria by which to rank objective importance.

Criteria that should be considered include:

- Public Safety - to guard against accidental drowning, road hazards, swift currents or other dangerous situations.
- Public Health - as it relates to water supply quality issues. Also, the City may consider the necessity of achieving separation of citizens from habitats where nuisance or dangerous species may be found.
- Value Provided - by maintaining drainage, supply and aesthetic amenities and planning for future use demands
- Protection of Resources - both natural and sustaining resources are typically protected by governmental bodies rather than private individuals.
- Growth Planning - and the potential stresses increased populations place on water demands, pollution and discharge requirements.
- Costs - associated with providing or not providing services and protection. Benefits must be weighed against costs in almost all cases.

SECTION III - SURFACE WATER MANAGEMENT RESOURCES

A. INTRODUCTION

With the purposes and benefits of developing a surface water management plan established it is necessary to plan for specific management resources. These resources may or may not currently be available, however they are required in order to implement a successful management program. Once the resources have been acquired, they may be combined to form a comprehensive management system.

Management resources are those tools or standards used by decision makers to effectively initiate activity, continue an activity, or alter an activity. Proper management of the surface water system requires:

- Understanding components of the complex system
- Satisfying regulatory requirements
- Proper engineering design criteria
- Developing channels of communications with the public
- Responsible priority criteria
- Means for implementing management decisions

This section presents the necessary elements for a successful surface water management program, outlines general findings of currently available management elements within the City of Cape Coral and identifies deficiencies, and addresses management needs and resources that will be established through the master planning process. Figure 3.1 is a graphical representation of how management tools support the achievement of the City's goals and objectives.

B. COMPREHENSIVE MANAGEMENT STANDARDS

The effective implementation of the surface water management program must be based on a solid understanding of the independent demands and the ability of the system to meet these demands. It is this understanding of the system combined with realistic expectations of attainable goals that provides the base framework from which daily operational decisions should be made. By applying reasonable guidelines to reliable data, the system manager is able to consistently make the best decisions to achieve the City's goals and objectives.

1. THOROUGH KNOWLEDGE OF A COMPLEX SYSTEM

The most important resource the surface water management can have is a thorough knowledge of the surface water system. This involves an understanding of each of the individual processes

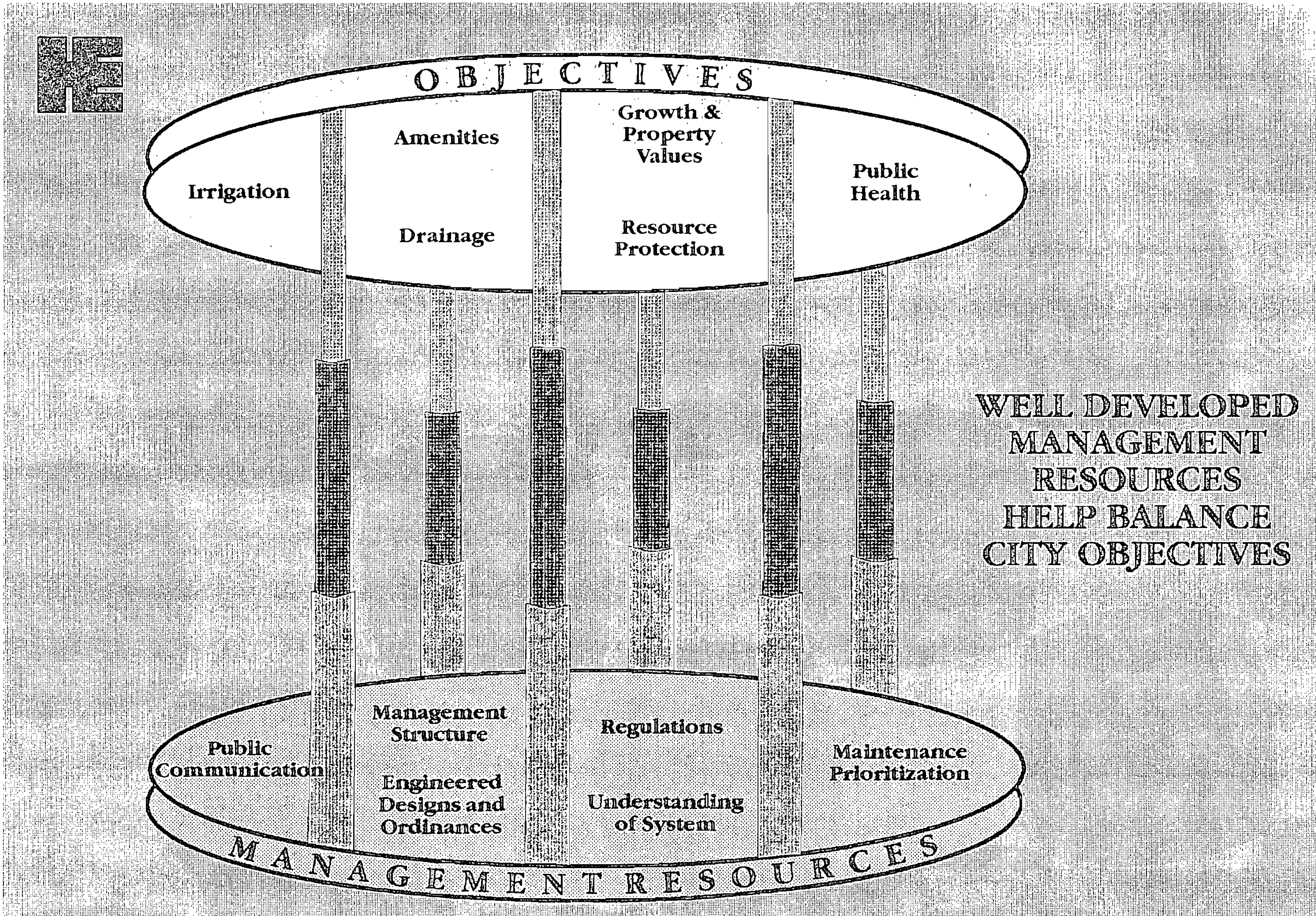

OBJECTIVES
Irrigation
Amenities
Drainage
Growth & Property Values
Resource Protection
Public Health
Public Communication
Management Structure
Engineered Designs and Ordinances
Regulations
Understanding of System
Maintenance Prioritization
MANAGEMENT RESOURCES
WELL DEVELOPED MANAGEMENT RESOURCES HELP BALANCE CITY OBJECTIVES

FIGURE 3.1

and demands placed on the system as well as the relationship each has to one another. Key elements of this understanding include:

- Drainage requirements including canal, culvert, inlet and swale maintenance planning for effecting runoff and making use of Best Management Practices (BMP).

- Overland and canal interaction in terms of outfall conditions, sediment loading, and pollutant removal.

- Canal and aquifer storage capacity especially as it relates to storage and retrieval of surface water for the secondary water system.

- Understanding of flow patterns as they will be altered by secondary water withdrawals at varying times and locations. The prediction of the processes involved are rather complex. An understanding of them is necessary to assure maximum secondary water quantity of suitable quality.

- Development impacts as they have long term effects on aesthetic quality & runoff quantities including septic tank effluents, increased runoff volume and pollutants and aquatic weed propagation in the canals.

2. MECHANISM TO ADDRESS REGULATORY CONCERNS

Regulatory structures in Florida seem to be ever changing and expanding. As pressures increase to meet statewide and national standards for water resource management, it will be increasingly important for water managers to understand current regulations affecting their systems and anticipate changes in the regulatory framework. Regulatory requirements and concerns include:

- Comprehensive planning requirements - Florida's Department of Community Affairs (DCA) requires that drainage and water supply elements of the City's local comprehensive plan be submitted for review.

- Surface water consumptive use permit - administered by the South Florida Water Management District (SFWMD) for the secondary water system is required to be renewed from time to time. If additional withdrawals are necessary, proof that the canal system can support the additional demands without adverse impact may become necessary in the future.

- Water quality and quantity - of overweir and direct outfall discharges into waters of the US or waters of the state. The United States Environmental Protection Agency (USEPA) National Pollutant Discharge Elimination System (NPDES) surface water program may soon require the City of Cape Coral to present a surface water quality management program. See Section III.C.2.b and Appendix D, Section C for greater detail.

- Irrigation water quality - canal water quality will directly affect the quality of the water residents use for irrigation. Consideration for water quality on terrestrial vegetation must also be evaluated.

3. PROPER ENGINEERING DESIGN CRITERIA AND ENFORCEMENT

Two levels of engineering design must be considered when evaluating the performance of the drainage system and surface waters of Cape Coral. The first, or primary drainage system includes all canals and control structures. The secondary drainage system includes all conveyances of runoff from the upland into the canal system, including swales, inlets, catch basins, piping systems, culverts and outfalls.

a) Primary System

Since the primary system is built and operated by the City of Cape Coral, design criteria are essentially self imposed rules to accomplish the purpose of the primary system. Currently this includes conveyance of all waters the canal system receives and control of the discharge to waters of the state. It also includes all the amenities the canal system provides the residents. In the future, the canal system will be heavily relied upon for irrigation water supply.

b) Secondary System

Rules regarding the secondary system are those imposed upon landowners who are discharging into the City drainage system (i.e. the canals). The unique nature of Cape Coral's drainage processes and variable soil conditions pose a challenge to the designer of drainage systems, not only to meet design criteria, but to effectively accomplish desired treatment results. The nature of design criteria would be more effective based on performance standards rather than an arbitrary set of dimensional guidelines. It is important that a thorough technical understanding of Cape Corals unique natural, dimensional and cultural characteristics be considered when drafting ordinances.

Legal compulsion makes codes and ordinances some of the stormwater managers most powerful tools when properly applied and enforced. For codes to be effective in producing the desired results, it is critical that they be based on sound technical practice. Also, they must be properly and fairly enforced.

Proper engineering and design standards should address:

- Overland drainage characteristics
- Enforcement mechanisms
- Establishment of codes from existing lot dimensions
- Guidelines for development including construction practice

4. DEVELOPMENT OF COMMUNICATION CHANNELS WITH PUBLIC

Public attitudes and pressures play an important role in refining management objectives. Surface water management is a public enterprise and affects large numbers of people. Since much of what occurs in the canal system affects citizen perception of their quality of life, it is important for the successful surface water management plan to continually monitor the pulse of public sentiment. Project meetings will be held near the beginning of Phase II to explain the project development process. Additional public forums will be held throughout the project as described in Section V.F, V.I, and V.J.

Since public attitudes are formed as a consensus of common values and opinions, they are forever subject to change. It is also important to recognize that public opinions are often not technically but emotionally based and therefore should not be used to defend a technically unfeasible or improper action. Since opinions are subject to change, decisions that allow flexibility in matters of taste should be sought over narrowly defined value interpretations.

5. MEANS TO PRIORITIZE ACTIONS

Once all readily available data are acquired, the surface water manager must prioritize functional goals and create work or action items. The surface water manager involved in the prioritization process must keep the primary objectives in proper focus where lesser issues may cloud the process. The goal of prudent decision making is to base action on important items and avoid being lost in urgent but less meaningful obligations. It would be very helpful to adopt a set procedural policy criteria as a means of maintaining consistency in decision making.

Two areas of prioritization should be considered. One is the immediate or short term remediation of service requests and the other is the long-term planning goals for system wide upgrades. Short term problem solving is necessary to protect public health and maintain a positive responsive image. Long term upgrades should be planned to help avoid future short term problems and accomplish the City's major goals.

It is therefore important to focus on resolving both short-term and long-term problems concurrently. The first step in resolution is problem definition. Work items may then be classified by effort and effect and prioritized based on well defined criteria to meet the City's objectives.

6. MEANS TO IMPLEMENT CHOSEN ACTIONS

Once action items are prioritized, they must be implemented in order to have real value to the City. Implementation of technically feasible solutions requires economic feasibility as well. Financial programming and allocation of monetary, personnel, time and equipment resources is a key element of accomplishing stated goals.

Implementation plans should also include project management guidelines, fiscal management programming and project performance evaluation.

C. EXISTING MANAGEMENT RESOURCES

This section presents a comparative analysis of necessary management resources described above and current management practices within the City, especially the Stormwater Utility Department.

An investigation was conducted to assess the current availability of management resources described above. This investigation included a review of all pertinent literature and engineering reports, observation of the utility operation, discussions with city staff and field observations.

It should be recognized that the Stormwater Utility is a fairly new operation. Significant improvements in performance over the past year have been realized as the utility continues to experience management structure changes and staff growth. This analysis attempts to give a snapshot of surface water management as it existed in December of 1992. The next section will discuss existing and future management needs that will be provided during the Surface Water Master Plan development. Figure 3.2 provides a pictorial representation of the surface water management resources acquired thus far.

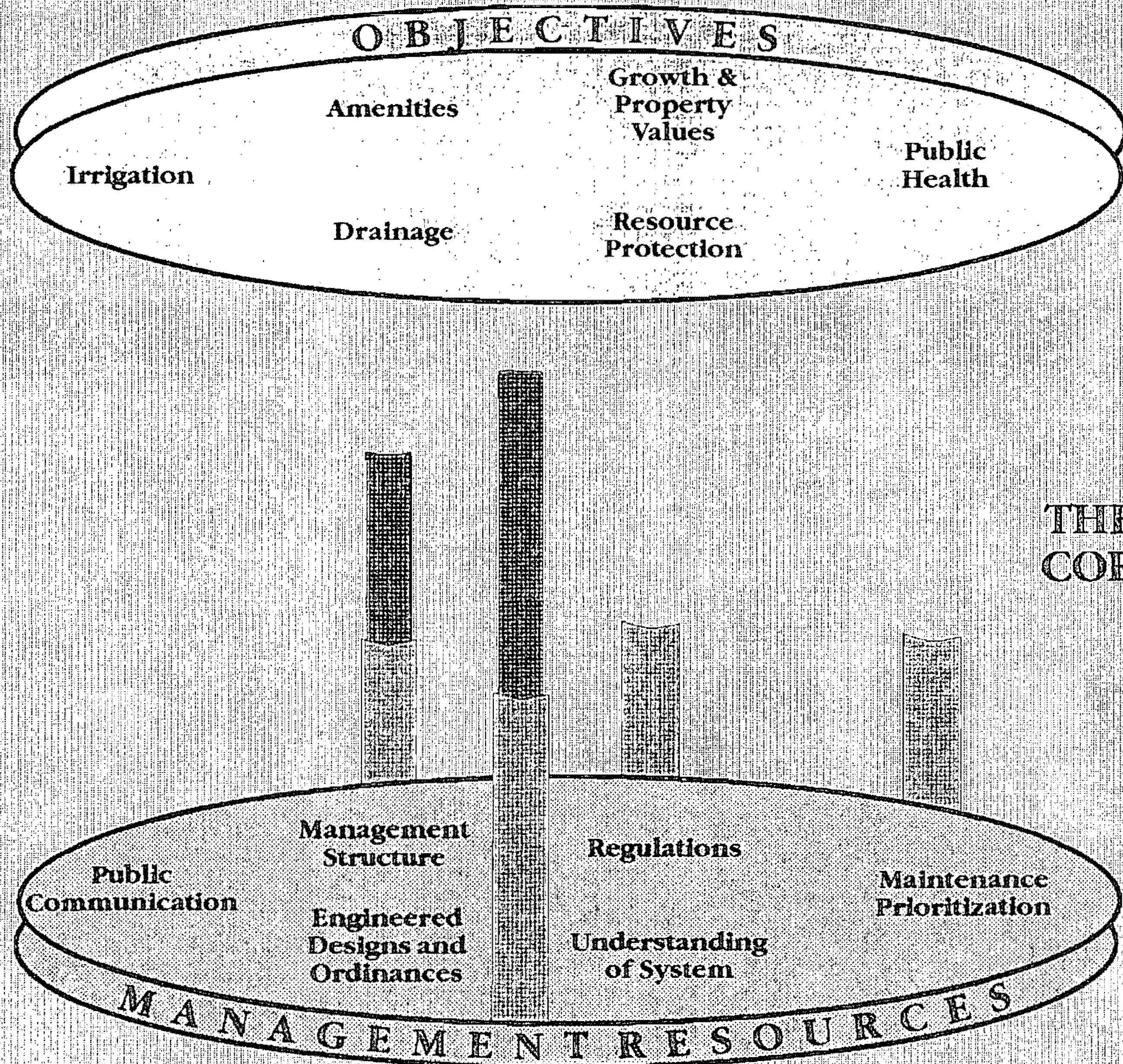
1. EXISTING UNDERSTANDING OF SURFACE WATER SYSTEM

a) Secondary Drainage system

Maps of the primary and secondary drainage systems are maintained on the City's Geo-Info System. These maps were constructed from the developers original design drawings of the drainage system and have been updated in areas where as-built information is available. Also, engineering designs for drainage modifications in several areas in the City have been completed.

b) Primary Drainage System

A number of studies of the canal system have been conducted over the years. These studies were limited in scope and magnitude. They typically attempted to describe or



THE CITY OF CAPE CORAL'S CURRENT STATE

FIGURE 3.2

quantify particular aspects of the City's primary drainage system. No studies to date have addressed the complex inter-relationships of the numerous processes affecting the canals.

c) **Existing Studies**

Existing studies and computer models of the surface water system have lacked the field data to accurately describe realistic conditions and properly calibrate the models. Existing computer models have been based on regional generalizations and place a heavy dependence on theoretical assumptions. Thus, the results they have produced should be only viewed as generalizations and not be assumed to present a realistic view of actual conditions. A brief description of various key studies is presented below.

- **1975-77 "Summary of Water Quality Records For GAC Properties", Gee & Jenson**

  A series of water quality monitoring reports were written during the final phases of canal construction. These summaries may provide a baseline from which to evaluate changes in the canal system water quality at approximately 24 stations. Further study of these records will be conducted during future phases of the Master Plan.

- **1979 "A Water Management Study of the Cape Coral Canal Networks", Connell, Metcalf and Eddy**

  This report presented a computer model study of canal stage elevation and flow conditions in the canal system during a 10 year storm event. Computations were based on idealized trapezoidal canal cross-sections, regional soil typing and generalized runoff hydrographs.

  This effort was used to evaluate and adjust the canal water elevations in order to assure maximum retention while providing flood protection in order to satisfy DER requirements. The study included a brief discussion of groundwater and pollution control efforts designed into the development. It is interesting to note that this study was used to set weir elevations throughout the City. However, since then some weir elevations have been re-adjusted according to reasons other than those in the CME system plan.

  Limitations of this report include the following:

  - Primary drainage systems (i.e. canals) should typically be loaded with at least a 25 year storm event for capacity determination. This study considered a maximum of a 10 year storm event.

- Computations utilized trapezoidal cross sections as designed. These cross sections do not represent either as built conditions, current degraded state or probable future cross sections (i.e. seawalled). Fathometer profiles by USGS in 1986 showed significant discrepancies from as-built profiles.

- Provided limited field measurements on canal flow conditions vs. rainfall events.

- Offered backwater calculations only for the final design weir elevations and did not consider maximizing freshwater storage.

- No supporting field data for groundwater or pollution control efforts were offered.

▪ **1982 "Use of the Freshwater Canals as a Secondary Water Supply Source for the City of Cape Coral", Post Buckley Schuh & Jernigan**

This report was written to determine the feasibility of developing the freshwater canal system as a source for the secondary water system. It included a computational investigation of the hydrologic cycle including an attempt at describing aquifer/canal interaction. Results of this report were used to support development of the canal system as an irrigation water source.

Limitations of this report include:

- General calculations were based on limited verified data.

- 11 MGD of irrigation water through the dry season was deemed available from canal storage alone. Approximately 74 MGD (WICC, 1988) was predicted for future demands.

- Assumed a heavy reliance will be placed on surficial aquifer storage which is left essentially unquantified in this study.

- Empirical or field data to verify model results was not gathered or presented.

▪ **1984 "The Cape Coral 208 Water Quality Study", S. W. Florida Regional Planning Council & City of Cape Coral Planning Division**

The 208 study included a comprehensive water quality survey of the canal system in Cape Coral including background water quality data, runoff data, flow measurements and baseline biological data. This report represents the most complete body of knowledge regarding ecological issues surrounding the Cape Coral canal system.

Limitations of this report include:

- Field data collection spanned a period of 8 months and was limited in extent and numbers of stations.

- Seasonal effects were not completely quantified.

- Possible effects on water quality of using the canal system as an irrigation supply source were not investigated.

- **1988 "Water Independence for Cape Coral (WICC) Master Plan" Boyle Engineering**

  WICC provided the water supply infrastructure plans for the City including potable water and secondary water systems. It developed all pump stations and withdrawal requirements for the canal system based on the 1984 PBSJ feasibility report.

  Limitations of this report include:

  - This report recognized that a full empirical data set was not available to test the accuracy of assumptions used in the hydrologic models. However, it advocated development of the canal system as an irrigation water source.

  - Did not conclusively state irrigation water demands will be met by surface waters.

  - Canal water quality was not addressed.

- **1989 "An Ecological Assessment of the Cape Coral Residential Waterway System", Cape Coral Environmental Resources Division**

  This report provides and in-depth analysis of the chemical and biologic processes taking place within the canal system. An assessment of runoff water quality and its impact on the canal ecology is also presented. Alternatives for improving water quality in the canal system were presented.

  Limitations of this report include:

  - All intended major uses of the canal system were not adequately addressed.

  - Presentation of design alternatives and supporting data was poorly understood by the public spawning skepticism of the study.

d) Cape Coral "Environmental Resources Division"

In 1985, the Environmental Resources Division was formed. A periodic water quality sampling program at stations throughout the canal system began in 1986 and was operated until 1988. This program was resumed in October of 1991 and has been operated since.

Short term field studies of environmental conditions have presented summaries of numerous water quality samples and environmental conditions. These field data intensive studies have generally been of short duration and often did not attempt to analyze seasonal variations. However, reviewed together they help to assemble a picture of historical conditions in the canal system and will be of use during future phases of the Master Plan.

2. MECHANISMS TO RESPOND TO REGULATORY REQUIREMENTS

Water use, transmission and disposal systems have been coming under increasing regulation in the State of Florida and throughout the United States in the past few years. The multi-use nature of Cape Coral's system has made it a prime regulatory target in the past and will most likely draw significant regulatory attention in the future.

a) Current Permit Requirements

To date, the City of Cape Coral has properly and successfully obtained surface water related permits from various regulatory agencies. These include:

- Consumptive use permit for Dual Water Program, SFWMD 1988. Allows an annual allocation of 5.22 billion gallons and a maximum monthly withdrawal of 23.4 million gallons from canal system for dual water. (Permit #36-00998-w, Condition 10)

- DCA regulates the growth of cities and counties in the state by requiring Comprehensive plans for growth to be prepared. The City of Cape Coral is in the process of updating its comprehensive plan including the Drainage Element. While the drainage and surface water related elements are prepared by the City Community Development Director, no mechanism for continual update and adjustment of surface water management element currently exists.

- USEPA NPDES stormwater discharge permit for the Everest Parkway Waste Water Treatment Plant.

- No dredge permits for canal maintenance have been denied by the Department of Environmental Regulation (DER) or the US Army Corps of Engineers (USACOE). Dredge permitting is an ongoing process.

- Currently, it is unnecessary to obtain SFWMD permits for surface water management for commercial parcels under 10 acres total area and under 2 acres of impervious area where an exemption from permit is granted by SFWMD. However, all developmental sites must be reviewed by an engineering technician within the Stormwater Utility during the building permit process. A letter of exemption from SFWMD must be presented to the City prior the City's release of permit.

- All saltwater canals in the City of Cape Coral are within the jurisdictional boundary of a general permit issued by USACOE and DER for the construction of seawalls along canal banks. Application to DER and USACOE under the general permit must be made before pursing a City permit. To date, no involvement by USACOE or DER is required for the construction of bank stabilization in the freshwater canal system. A City seawall permit must be obtained in either case.

Although one of the stated duties of the Environmental Resources Division is to assist with the application and acquisition of permits, no formal structure for pursuing permits has been established.

b) Future Permit Requirements

While the City has been successful in the past in obtaining required permits, it is prudent to be aware of future regulatory changes and requirements from federal, state, and regional agencies.

i) Federal Regulations - The USEPA is the main governing body concerned with Federal water quality and quantity issues. The USACOE has historically been concerned with water body use, but has increasingly become involved with jurisdictional wetland regulation as well.

Of primary concern to the City of Cape Coral are the recent developments in EPA regulations. Over the past few years the USEPA has embarked on a program to reduce pollutants carried by runoff that impact waters of the US with renewed vigor. This program is administered under the National Pollutant Discharge Elimination System (NPDES). The approach taken under this program is to monitor water quality and quantity at points where water from a particular basin discharges into a receiving water. The owner of the outfall structure is then given the responsibility of maintaining or improving discharge water quality.

The goal of the program is generally to reduce the discharge of pollutants to the "Maximum Extent Practical" (MEP) and to prohibit non-stormwater discharges into storm sewers. MEP in Florida means SFWMD types of criteria, as USEPA indicates that these are among the best in the Country.

The City can expect SFWMD rules and water quality criteria to govern. As the City knows, SFWMD generally creates technology based performance limits which can be somewhat arbitrary. As stated earlier Cape Coral may be in a difficult position, since there is little workable space within the City to implement the level of detention storage SFWMD could technically impose. High seasonal groundwater levels confound the situation. It will be certain that future stormwater quality solutions will need to be creative. It is conceivable that Cape Coral may have to negotiate "bubble" types of permits in which some areas are substantially controlled and others hardly at all.

While many of the large cities throughout Florida have been busy responding to NPDES surface water discharge requirements, many have found that they were poorly structured and not prepared for the task of developing surface water plans. Although the City of Cape Coral will probably soon be required to submit a permit application to the USEPA, no mechanism has been developed to fund or carry out such a monumental task.

ii) State Regulations - Both Florida Statues and the Florida Administrative code are enforced by the DER. Most of DER's surface water rules in freshwater areas are delegated to the South Florida Water Management District (SFWMD), a regional entity authorized by state law. These rules govern design standards for stormwater treatment facilities and water use issues.

The DNR does not generally form policy or rule enforcement, but is mandated to manage all natural resources of the state especially water resources. DNR is currently managing the aquatic preserves west and south of Cape Coral including Matlacha Pass and has a vested interest in what is discharged from the canal system. Their greatest concerns will probably be focused on pollutant loads and maintaining certain dry season freshwater discharges.

Both SFWMD and DNR will most likely be involved in permitting consumptive use of the surface waters in Cape Coral. Since the existing permitted withdrawal (23.4 MG/month from canals) will not be sufficient to provide the expected canal withdrawals for irrigation at buildout (74 MGD, WICC), the City will need to apply for a greater allocation. However, prior to granting additional withdrawal permits from the canal system, the City will most likely have to conclusively show that the canal system is capable of supporting the additional withdrawal without adverse affects.

iii) Regional Regulations - The regional agency responsible for promoting intergovernmental cooperation on technical and political issues in South West Florida is the South West Florida Regional Planning Council (RPC).

The RPC acts in an advisory role to the communities in its jurisdiction and as a liaison to the DCA, which administers Florida's Growth Management Act. The RPC consists of a board of local governmental representatives supported by a permanent staff. The RPC has review and comment authority for the issuance of permits and approval of local plans. It does not have the authority to issue permits or approve plans and does not maintain or enforce its own statutes and regulations.

c) Summary

The City has typically responded well to regulatory requirements. However, the rapid increase in new regulations may soon leave the City in the uncomfortable position of not being able to meet regulatory demands. Enforcement consequences could be very costly for the City to bear or avoid if mechanisms to address regulatory issues are not in place.

Close coordination with involved agencies during the development of these mechanisms not only helps to anticipate regulatory demands but may help shield the City from unreasonable or unexpected regulatory changes.

The Surface Water Management Plan will need to address all state water rules administered by SFWMD as well as present facts and data to conclusively show that the surface waters of Cape Coral will be capable of providing the necessary flood control while also supporting the expected irrigation supply demands. It must also properly address the concerns of DNR and the SWFRPC surface water management guidelines.

3. EXISTING ORDINANCES AND ENGINEERING DESIGN CRITERIA

a) Primary System

Other than the consumptive use permit granted by the SFWMD, the canal dredging program and the Connell, Metcalf and Eddy weir adjustment plan (1979), no formal plan or restrictions on the operation of the canal system has been developed or required. It is noted that out of necessity, the CME study recommendations have not always been strictly followed sometimes giving rise to unanticipated problems elsewhere in the system. City ordinances do require private land owners to stabilize canal banks during the building process.

b) Secondary System

State standards for stormwater management are set forth in Florida Statutes Chapter 40 E and Florida Administrative Code Chapter 373. These standards are administered locally by the City and SFWMD.

The Stormwater Utility has primary responsibility during the permit process to enforce the state and regional standards for projects under 10 acres total area and with areas 2 acres or less of impervious area. Larger projects and municipal projects are reviewed by the SFWMD.

Small project permit requirements are found in SFWMD Volume 4 as well as the state codes mentioned above. These codes are minimum standards and may be clarified or made more stringent by local ordinance.

The City of Cape Coral recognizes that surface water management is a necessary function. Ordinances that address stormwater issues date to 1977. Until the formation of the Stormwater Utility in 1990, these ordinances addressed stormwater issues as they affected rights of way, seawalls, easement protection and infrastructure protection.

These issues are addressed in Section 3 of the City's Land Use and Development Regulations. Engineering design standards are contained in the City of Cape Coral's Engineering Design Standards Manual.

Existing state ordinances have provided guidance for a number of surface water management issues but do not adequately consider many important locally significant conditions. Because important local conditions are not accounted for in state ordinances, many stormwater practices which satisfy code conditions may not produce the intended results. The City may consider writing codes that clarify state codes and account for the special conditions found in Cape Coral.

4. DEVELOPMENT OF COMMUNICATION CHANNELS WITH PUBLIC

The Stormwater Utility actively uses three channels of communication with the citizens of Cape Coral. The most frequently used is the service request line for stormwater and surface water problems. Through this channel, citizens may report surface water problems and request service. It is the most direct and personal means of communication with the utility.

The second channel is the Environmental Resources Division's public information program where surface water issues are presented and discussed in public forums. This program is also active in producing press releases that inform citizens on particular topics related to surface waters.

The final, and perhaps most important channel is the City Council meetings and public workshops. Here citizens may express their views, opinions and concerns regarding policies and ordinances on all aspects of city life including stormwater and canal issues.

It is important to recognize that misinformed or biased views are often expressed in this forum. While the City has developed important channels of communications, the obstacle of misinformation has yet to be overcome. Therefore, the City must strive to educate the citizens of Cape Coral on surface water issues.

Cape Coral has shown a commitment to be accessible and responsive to its citizens as related to surface water issues. However, many problems continue to arise due to incomplete information, miscommunication etc. Much can be gained in terms of community care of the surface water system and co-operation between government and constituents through a well planned and executed public information program. Appendix H provides information for developing a public information program to educate the citizens on surface water issues.

5. EXISTING PRIORITIZATION PRACTICES

The current procedures used to prioritize surface water problems provide a framework on which criteria based upon a variety of independent considerations may be built. However, while the current prioritization criteria have served well to provide a system of handling complaints in a reasonable fashion, it would be prudent to revisit the prioritization practices during future phases of the Master Plan. This will provide for improving these policies to insure public safety and concentrated populations are given adequate consideration during the prioritization process.

Existing policy shows that complaint prioritization is to be based on the following criteria:

- **Immediate action** When the problem represents a threat to public safety or the protection of property. The most common of these are holes in or near a right-of-way which are usually a result of failed storm sewer pipes.

- **Priority 1** Drainage system or swale failure results in standing water for 5 or more days.

- **Priority 2** Drainage system or swale failure results in standing water for 3 to 5 days.

- **Priority 3** Drainage system or swale failure results in standing water for 24 hours.

To date, Stormwater Utility personnel have performed well in responding first to threats to public and private property caused by pipe failures and sinkholes. The flexibility in the operation of the utility allows for this type of subjective prioritization. However, the room for subjectivity may rapidly become diminished through political, legal or administrative pressures.

Thus, it may be important to establish a more comprehensive set of prioritization criteria that allows the utility to perform its function in a manner that is most beneficial to the residents of Cape Coral.

Specific problems or potential problems with the current prioritization criteria is misplaced priority and response to public perceptions.

a) Misplaced Priority

Strict adherence to the current criteria may result in a road flooding problem on a major road to be placed on a lower priority than long term standing water in less traveled areas of the City. This formulation accounts for the fact that standing water in a residential area may pose significant inconvenience to residents but neglects the possibility that short duration ponding on roads where traffic moves in excess of 40 mph may pose a more significant threat to public safety and a potential liability to the City.

b) Response to Public Perceptions

Another possible cause of misplaced priority are external pressures occasionally put on Stormwater Utility staff to perform politically expedient drainage remediation at the expense of more hazardous problems. It is important for City leaders to consider that Stormwater Utility is a service to all citizens of Cape Coral and help resolve these issues for the best interest of the community. Unfortunately, pressure to satisfy the most vocal citizens may outweigh technical and safety criteria in prioritizing remedial action. Many of these problems could be avoided with increased public education about the environment in which Cape Coral is located.

6. EXISTING MEANS FOR IMPLEMENTING MANAGEMENT DECISIONS

In addition to the land use and development ordinances, City Ordinance 18-90 authorized the creation of the Stormwater Utility, described legally in Chapter 22 of the City ordinances. The current methods used by the Stormwater Utility for implementing management decisions are performed by drainage crews, canal maintenance, permitting, and environmental resources. A general description of how these functional divisions are currently used is listed below:

a) Drainage Crews

Provide the necessary function of maintaining and repairing the City's storm drainage facilities, or secondary drainage systems. This includes all inlets, pipes and outfalls. There is a repair backlog since crews do not have time to perform preventative system upgrades.

b) Canal Maintenance

The canal maintenance division is responsible for maintaining depth in the canals for conveyance and navigability. Currently, the only operation performed by canal maintenance is dredging. Future operations may include aquatic weed harvesting and flotsam removal.

c) Permitting

The Stormwater Utility Department is responsible for setting swale and driveway elevations for new construction and swale repair. It is also responsible for reviewing site plans for commercial development to ensure all SFWMD and local regulations are met in the design process. Regulatory criteria must be met prior to issuance of a building permit.

d) Environmental Resources

The Environmental Resources Division (ERD) also falls under the umbrella of the Stormwater Utility. The mission of the ERD is to monitor the water quality in the canal system, propose and study environmental enhancements to the canal system and conduct a public information program to inform citizens on environmental issues.

ERD has participated in a number of local and regional studies in an effort to quantify environmental processes in the canal system.

The Stormwater Utility is aware that existing methods and resources are inadequate to address maintenance problems. The rate of service requests being filed exceeds the rate at which they are addressed. While new crews and equipment have been acquired over the past year, the Stormwater Utility remains understaffed and under-equipped to reverse this trend. The planned crew and staff additions over the next few budget years will help alleviate the work load. Stormwater Utility personnel are responding to complaints registered as far back as 1989. Only complaints of Priority 1 or higher are being considered for remediation. Details concerning staff and equipment are discussed Appendix E.

The preceding review of the City's management tools and practices has identified the following key deficiencies:

- Non existence of comprehensive system plan designed towards meeting all of the City surface water objectives.

- Lack of complete understanding of hydraulic and environmental processes within the full surface water/surficial aquifer system and interactions between various components such as runoff pollutant loadings, canal-aquifer exchange, storage capacity, etc.

- Unverified understanding of actual system capabilities and limitations.

- Lack of verification of technical assumptions used in previous model studies.

- Lack of documented data on which to base assumptions including data and information pertaining to flow, discharge, soil structure, and water quality.

- Inadequate mechanisms to address future regulatory requirements.

- Poor understanding of effectiveness of current design practices.

- Non compliance with existing management recommendations.

- Inadequate public information program that educate users of the system on all aspects of the surface water system.

- Limited scope in prioritization of problem areas.

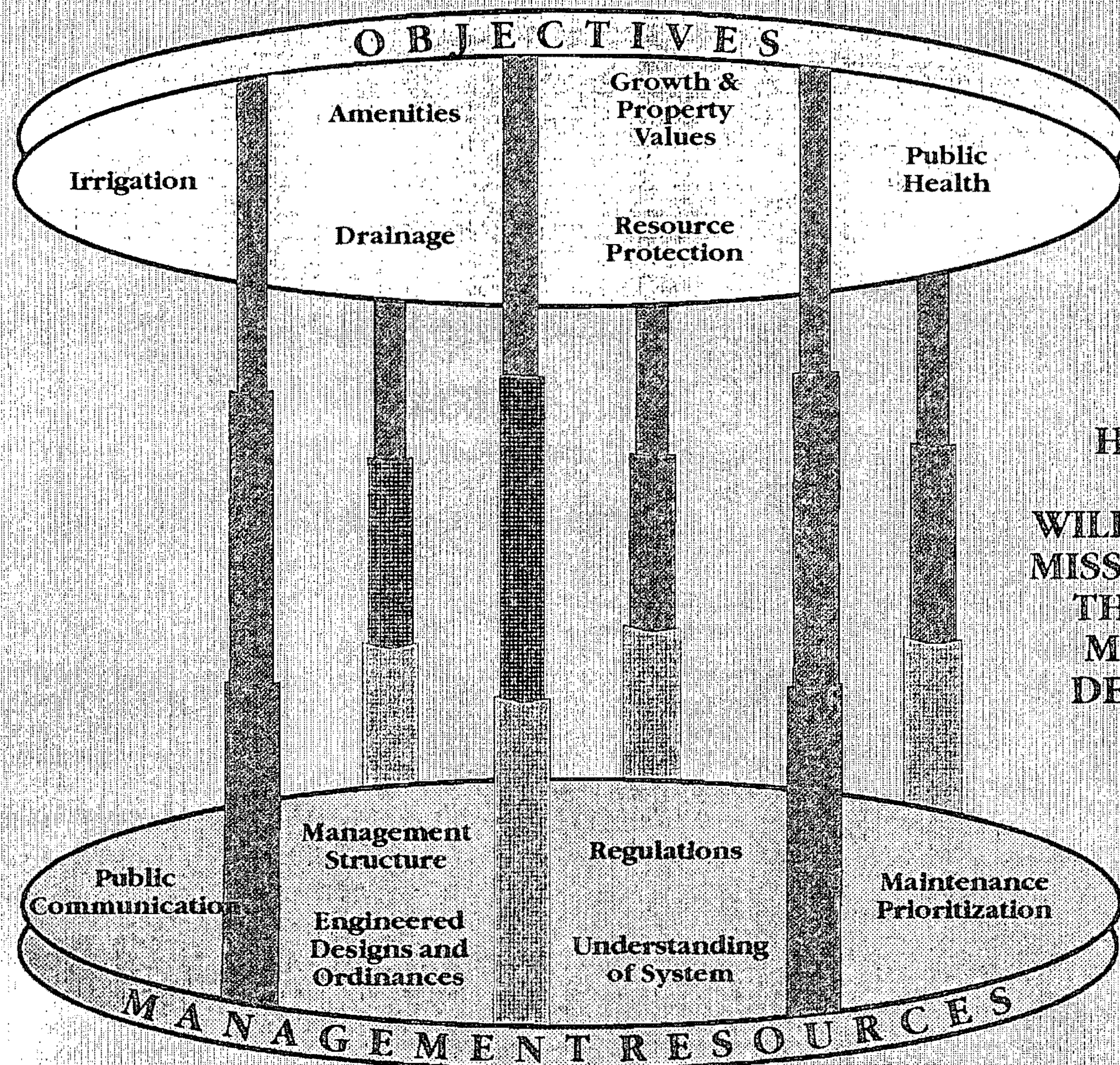
D. MASTER PLAN PROVISION FOR SURFACE WATER MANAGEMENT

Studies provided to date have not provided the City with an active surface water management structure. The City is still in need of a comprehensive tool that ties all of the existing management resources together to achieve the objectives stated earlier.

The Surface Water Master Plan will provide the City with that tool. Through the application of the most current technologies, the existing body of knowledge will be augmented with detailed measurements and analysis of actual conditions and provide the City with a progressive management program that can grow and change with the City's future surface water demands.

The goals of the proposed program are to collect and analyze specific and pertinent data, and develop the means to put this data to work in accomplishing the City's surface water management objectives. By the end of the Master Plan development stage, the City will have gained a thorough knowledge of the capabilities and limitations of its surface water system.

Unlike other studies, however, the project will not end with the acquisition of this knowledge. The Surface Water Master Plan project will provide the City with the tools to serve as a facilities management resource as shown in Figure 3.3. Thus all of the data and process development will be part of a perpetual analysis and management system. The surface water management program provided in the Master Plan includes:



HAVENS AND EMERSON WILL PROVIDE THE MISSING ELEMENTS THROUGH THE MASTER PLAN DEVELOPMENT

FIGURE 3.3

- Most complete analysis of canal system capabilities to date

- The means to address current and future regulatory requirements and protect aesthetic qualities of the canal system

- Engineering Criteria for city-wide standards and management system designs

- Development of public information and education programming

- Goal setting and reasonable prioritization criteria

- The operational structure and tools to achieve the above on a continual basis including data collection, analysis and management, computational methods, infrastructure maintenance and financial programming

1. A COMPLETE ANALYSIS OF CANAL SYSTEM CAPABILITIES

The development of this program will provide the City with an objective and detailed analysis of its canal system's capability to provide the City with primary drainage while acting as a reservoir for irrigation needs. Currently, the canal and surficial aquifer storage and yield capacities are poorly understood. This project will provide an accurate understanding of the physical processes that take place within the canal/surficial aquifer system that will affect the potential yield of the system.

This will be accomplished through:

- Measurement of actual conditions
- Development of data analysis and management programs
- Computer simulation of system function
- Evaluation and design of structural alternatives
- Development of a surface water system operation plan

At the end of the study and development phase, the City will be provided with analysis tools developed to answer key management questions. These tools will be adapted for use by city personnel in managing the surface water system.

2. MEANS TO ADDRESS REGULATORY AND AESTHETIC CONCERNS

In addition to managing water quantities being stored or discharged, the Master Plan program will also consider the necessary elements of preserving aesthetic value of the canal system in a cost effective manner. The study will investigate the effectiveness of existing and new alternatives for the maintenance of canal beauty, water quality and regulatory restrictions. It is important to recognize the need for water quality maintenance to guard against aquatic weed growth, algal blooms and health concerns with increased utilization of canal water for the irrigation system.

Previous studies have indicated likely water quality problems and their effects. These studies have recommended methods for improving water quality, many of which have been implemented. However, the effectiveness of implemented practices have not been quantitatively evaluated. Furthermore, current state regulations are based on design rather that performance criteria and may not be effective in providing the desired treatment results.

Investigations will quantify potential water quality problems and their effect on irrigation water, canal aesthetics and regulatory requirements. Scientific data will be gathered on the effectiveness of alternative designs and Best Management Practices (BMPs) for preserving water quality. The result of this investigation will provide the City with the most efficient methods and designs of stormwater treatment.

Information gathered and analyzed during the investigative phase may be used to verify the City's ability to maintain a ready supply of irrigation water. The study program will provide data and analysis to quantitatively support optimal development of the dual-water system.

In addition to the irrigation supply, the data collection and management system will be extremely helpful in acquiring and maintaining surface water discharge permits that will most likely be required under USEPA's NPDES stormwater permit. The Surface Water Master Plan will also fulfill Florida's Department of Community Affairs requirement for planning for the multiple uses and management of the surface water system in the City.

Finally, the most effective methods of maintaining an attractive canal environment will be developed and plans for implementation will be assembled. It is important to note that the most effective methods may differ from region to region within the City boundaries.

3. PROPER ENGINEERING AND DESIGN CRITERIA

The Surface Water Master Plan will provide the City with a plan for operating and maintaining both its primary and secondary drainage system. The engineering portion of the plan will include system upgrade designs and design standards to assure future drainage works are compatible with the City's objectives laid out in the Master Plan.

a) Primary System

Once physical processes affecting the surface water are sufficiently documented, modifications to enhance the primary system will be developed. Possible modifications include the addition or modification of control structures, fine tuning operational procedures, and operation of control structures. Adjustment decisions will be assisted by real time data reporting, analysis using computer model simulations and adjustments via remote operation.

Also, modifications to the spreader waterways will be developed after thorough investigation of the processes impacting them. Since their construction, the spreader waterways have not been functioning as designed. Design improvements will be prepared to maximize utilization of spreader canal waters for the irrigation system while satisfying DER and DNR regulatory constraints.

b) Secondary Drainage System

Quantity and quality considerations will be used to shape engineering design criteria for future drainage installations. These criteria will be based on what has been proven to be effective in the City of Cape Coral. This set of engineered design criteria will provide the City's surface water manager with the necessary means to control stormwater quantity and quality at the runoff source. Furthermore, it will include every home and business in the responsibility for the quality of life in the City.

4. ESTABLISHING COMMUNICATION CHANNELS WITH PUBLIC

The Master Plan will provide for a quality public information program. The objective of this is to establish a mechanism for effective communication with the public as related to surface water issues. Keeping the public informed on what Stormwater Utility charges are being spent on will provide the City with a positive means to gain public support. Appendix H presents the basic structure and recommendations for developing a public information program in the Surface Water Master Plan.

5. ESTABLISHMENT OF RESPONSIBLE PRIORITY CRITERIA

The investigations performed during the Master Plan development will provide a solid basis for the establishment of priority criteria that optimize results of both long term and short term projects. Proper prioritization criteria may be developed only after gaining a thorough understanding of both the processes within the surface water system and the impact of various engineering works.

a) Long Term Priorities

Long term priorities will be required to produce the City's long range objectives of providing adequate conveyance of runoff, managing the surface water supply and maintaining the water quality within the canals. Actions taken will typically affect large portions or perhaps the entire City and will typically involve major engineering projects.

Engineering design criteria will be developed in order to maximize the system's capability to produce the desired results in a feasible manner. Evaluations of design alternatives must include cost and benefit analysis as well as public acceptance.

b) Short Term Priorities

Short term priorities will be developed to guide the Stormwater Utility department in its efforts to protect public health and safety, protect property and prevent nuisance flooding. Short-term projects are usually smaller in scale and scope but are no less important for the City to perform.

Even though these projects are smaller in scale, the design of small structures and drainage works must be closely monitored in order to protect the larger system and avoid contradiction with long term goals. Therefore, engineering designs must be able to provide adequate drainage and protect the integrity of the canal system to the maximum extent possible.

6. MEANS FOR IMPLEMENTING MANAGEMENT DECISIONS

In order to provide methods for implementing management decisions, the Master Plan will develop a data acquisition and analysis program and a stormwater utility operation and maintenance program.

a) Development of Data Acquisition and Analysis Program

The system will be arranged for operation by city personnel to assist in choosing the best course of action during a variety of situations. This will be accomplished through data acquisition, management and analysis with a computer model of the surface water system.

Data stations and communications will be established. Data will be summarized and presented in both graphical and data base format on a Geographic Information System (GIS). Data files for modelling applications will be prepared and stored on the GIS.

The canal management model will provide the surface water manager with the detailed information and predictions necessary to maintain the delicate balance between drainage

requirements and maximal freshwater storage in the canal-surficial aquifer system. The model will also be used to evaluate the effect of major alterations to the system.

b) Development of Stormwater Utility Operation and Maintenance Program

An operation and maintenance (O&M) program to execute the management program will be developed. This program will summarize all of the recommended action items to be carried out by surface water personnel. A number of documents that could be used as owner and operator manuals will be developed for specific pieces of the surface water system. While each of these elements will be contained within the Master Plan, separately they may be used to inform, guide and instruct specific operational crews.

The development of these operational plans will rely heavily on interaction with the current personnel. Each operational manual will combine the experience of the field personnel with the engineering technology developed during the investigative process. The intent of these manuals is to provide city personnel with clear, concise guidelines and straightforward procedures without all of the supporting detail. However, supporting detail and rationale will be provided in the main Master Plan document. Some of these operational manuals may be adopted as ordinance or remain as guideline reference materials for those who use them.

Operational manuals may include:

- Stormwater Structure Inspection for Commercial Development
- Stormwater Structure Design Criteria for City Drainage Works
- Canal Maintenance Operations
- Operation and maintenance of the Spreader Waterway System
- Regulatory Requirements and Procedures
- Surface Water Model Operation
- Geographic Information System Operation Guidelines
- Supervisory Control and Data Acquisition (SCADA) for Surface Water
- Extreme Event and Surface Water Crisis Management Guidelines
- Water Quality Protection Program for Surface Waters

i) Management Program - Once priorities have been established, the overall operational structure for the management of the surface water program will be further refined. As an understanding of the system and the development of management technologies progresses, the operational structure will be modified to provide the consistency to tie all of the surface water sub-systems into one manageable system.

The program will include staff structure and management, personnel and equipment projections, financing, and management priority guidelines.

Computer network systems may be developed to provide the specialized management and accounting functions required by the City. These systems may be developed to provide a tool for project tracking, performance evaluations and cost analysis within the stormwater utility while also providing an interface to the City's central accounting system.

ii) Financial Programming - A financial program designed to enable implementation of the program and operation of the surface water system will be developed. This analysis will consist of prioritization of necessary expenditures and alternative funding solutions. An exhaustive investigation of available public grants, loans and endowments will be conducted.

SECTION IV - PROJECT DESCRIPTION AND APPROACH

A. WHY CREATE A SURFACE WATER MASTER PLAN

The surface water system and more specifically the canal network, ties together many elements that are of significant importance to the City of Cape Coral. Successful management is contingent upon understanding these elements and the processes that link them together. By assuring proper management of these elements and interrelationships, the City will be able to derive the maximum overall benefit from its very unique system.

The Surface Water Master Plan seeks to establish an overall management and operation plan for the surface waters of Cape Coral that considers each of these elements as they individually and collectively comprise the surface water system of Cape Coral. This section delineates major surface water concerns and constraints, provides a qualitative description of the surface water system and outlines the overall approach to the project. Section V will provide a detailed description of the steps that will be taken to develop the Master Plan.

The discussion of the need for a surface water master plan begins with the expected benefits and constraints. Figure 4.1 shows the relationship between various canal related concerns. While not all of the elements indicated provide a direct benefit to the City, they all have in common the fact that they impact the beneficial use of the surface waters.

1. BENEFIT CONCERNS

Description of the key benefits derived from the canal system are described below with associated impacts and constraints.

a) Drainage

The originally designed and primary benefit derived from the canal system is the provision for upland drainage. Maximizing this benefit may adversely impact benefits derived from the secondary water supply, surficial aquifer levels, attractive amenities and water quality. It may be constrained by regulations, required water storage and dry season overweir discharges. (See Appendix A.4 and A.5)

b) Secondary Water Supply

Maximizing the use of surface waters as a supply source for residential irrigation may impact drainage capacity, overweir discharges, water quality and the amenities provided by the canal system. Development of the canal system as a water source may be constrained by surficial aquifer storage and yield capacities, surface and sub-surface

CANAL RELATED CONCERNS

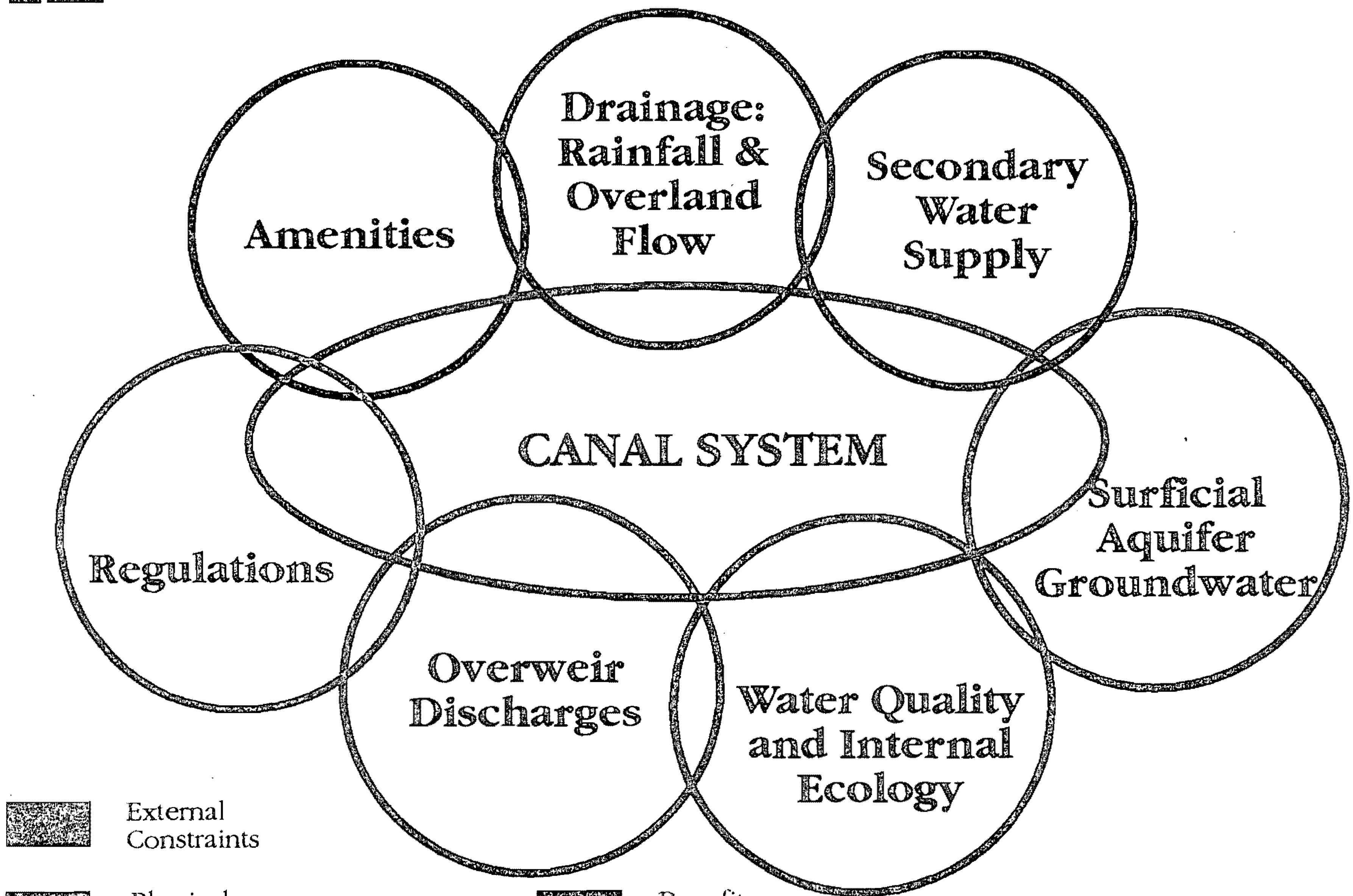


FIGURE 4.1

saline intrusion, internal water quality concerns, irrigation water quality regulations, use allocation regulations and the maintenance of attractive amenities. (See Appendix A.3)

c) **Attractive Amenities**

Intangible yet very valuable amenities are provided by the canal system. Property values throughout the City are enhanced by water views, boating access and recreational opportunities. Maintenance of these amenities may require changes in drainage practices, withdrawal rates and water quality maintenance procedures. The value of these amenities may be threatened by degraded water quality, submerged weed growth, and low canal levels. (See Appendix A.7, A.8 and A.9)

2. PHYSICAL CONSTRAINTS

Physical constraints are processes that play an important role in the surface water system's ability to provide the benefits described above. They include:

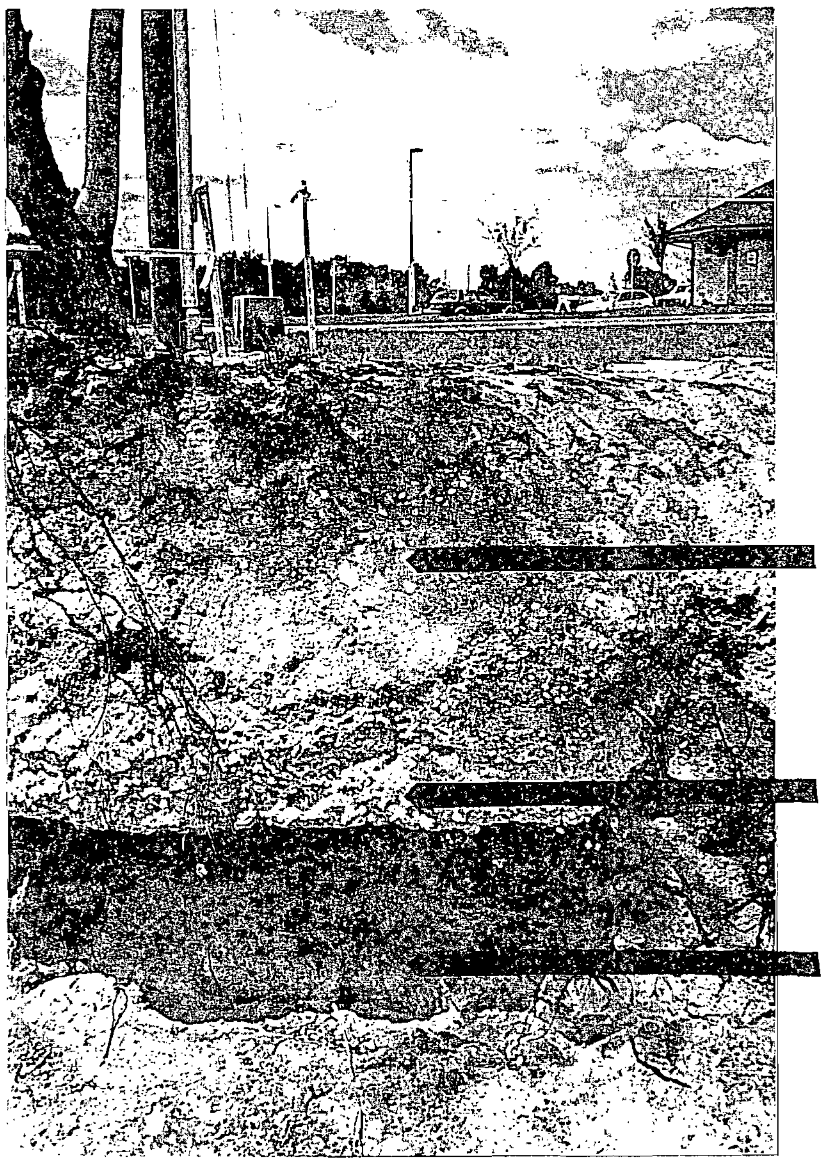
a) **Surficial Aquifer Groundwater Processes**

Soil characteristics and groundwater flow processes in the soil layers nearest the ground surface may significantly affect drainage processes, water levels in the canals and sub-surface saline intrusion. Irrigation water supply will be highly dependent on the ability of the near surface soil layers to store water and recharge the canals as water is withdrawn from them. Additionally, vertical percolation processes may impact drainage and stormwater quality treatment and horizontal groundwater flow may permit sub-surface saltwater contamination of surface waters. Figure 4.2 shows a typical soil section and possible hydraulic effects they may have. It is important to note that, aside from rainfall volumes, hydraulic properties of surface soils may be the only unalterable constraint in the whole system. They are also among the processes that are most poorly described by actual field measurements. (See Appendix A.3 and A.11)

b) **Water Quality**

Variations in water chemistry may serve to impact the suitability of canal water for irrigation and as an attractive amenity. While it may be difficult to predict the exact ecologic response to various natural and human influences, the ecologic system will respond to stresses placed upon it until a new equilibrium is reached. The biggest questions lie in whether particular actions produce system wide positive or negative results. Water quality may be affected by drainage practices, enforcement of regulations, circulation patterns and possibly naturally occurring soil chemistry. (See Appendix A.2 and A.7)

TYPICAL EARTH CUT WITH MARL LAYER



FILL MATERIAL
(MIXED SOIL)
POOR CONDUCTOR

MARL LAYER
IMPERVIOUS

SANDY SOILS
TRANSMISSIVITY
UNKNOWN

FIGURE 4.2

c) Overweir Discharges

While overweir discharges are essentially a regulatory constraint, they are given special consideration here since they represent an important boundary within the surface water network. Weirs also influence flows within the canal system and impacts canal levels.

Discussion of overweir discharges are mainly restricted to include only the weirs where freshwater spills over into marine waters. This is an important regulatory demarcation. Overweir discharge constraints may include adherence to certain water quality standards and maintaining minimum dry season flows for environmental reasons. Maintenance of certain ecological systems may become a regulation driven objective that in turn dictates overweir discharge characteristics. Overweir discharge requirements may be impacted by irrigation water withdrawals, the ability of the system to store water, modeled pre-development conditions and annual precipitation. (See Appendix A.3)

It would be desirous to have pre-development knowledge of ecologic conditions in the wetlands adjacent to the city. The ecologic response in adjacent waters to such actions as allowing significant discharge or retention of waters may then be conclusively documented. Monitoring of current conditions would also be useful in determining discharge requirements or limits that mimic natural variations in precipitation and avoid singular volume quotas.

3. EXTERIOR CONSTRAINTS

Exterior constraints are requirements placed on the system. Exterior pressures may originate from state agencies or outside environmental groups bringing political pressure on the City.

a) Regulations

Regulatory concerns must also be addressed if the City is to maintain a positive rapport with various authorities. Regulatory concerns include discharged water quality and quantity, water use allocations, water use quality, maintenance of infrastructure and internal practices. These concerns impact drainage, irrigation water use, water quality and overweir discharge requirements. While little might be accomplished in the way of altering regulations, they may be effectively addressed by incorporating their concerns in management programs. (See Appendix A.3)

The primary enforcement agencies SFWMD and DER have worked with the City to develop effluent reuse in its irrigation system as a condition of acquiring surface water use permits. This recent history leaves the City of Cape Coral in a good position to continue to develop cooperative water management partnerships with DER and SFWMD.

Also, the Department of Natural Resources will be concerned with the impact discharge controls may have on the estuarian ecosystem in Matlacha Pass and possibly the Caloosahatchee River

B. QUALITATIVE SYSTEM DESCRIPTION

The successful Master Plan will require careful qualitative descriptions of the many processes affecting the surface water system. The surface water system in Cape Coral is a complex arrangement of interacting sub-systems. Traditional hydrologic systems consist of precipitation, runoff, storage and transmission. For purposes of developing the Master Plan, the runoff, storage and transmission processes will be developed in detail. Figure 4.3 presents a pictorial model of the major physical sub-systems that interact to impact the surface water system of Cape Coral. The links between primary processes represent the possible paths of water and materials between each process.

1. INTEGRATED SYSTEM APPROACH

It was noted in section III that previous studies and plans focused on very specific segments of the surface water system. The limited scope of previous studies precluded serious investigation into the complex interactions of the processes tied to the overall system. Important technical considerations were either not considered or reserved for analysis of probable impacts at a later time.

By initiating this Master Planning effort, the City is taking a proactive approach to resolve the many issues that impact or are impacted by the management of its surface waters. To be successful, the Master Plan must be based on realistic and measured descriptions of all processes taking place within the system. By recognizing that these processes are integrated into one system, a management plan will be designed to maximize the use of the surface water system to achieve the City's multiple objectives under physical and regulatory constraints.

2. SUB-SYSTEM DESCRIPTIONS

a) Storm Drainage

The storm drainage, or secondary drainage system includes all conveyance of storm water to the primary drainage system (canals), pollution processes and stormwater treatment effectiveness. Figure 4.4 presents a diagram of the secondary drainage systems. The successful management plan must consider runoff volumes, pollutants picked up by runoff, percolation rates and treatment methods. (See Appendix A.4, A.7 and C)

INTERACTION OF MAJOR SUB-SYSTEMS WITHIN THE SURFACE WATER SYSTEM

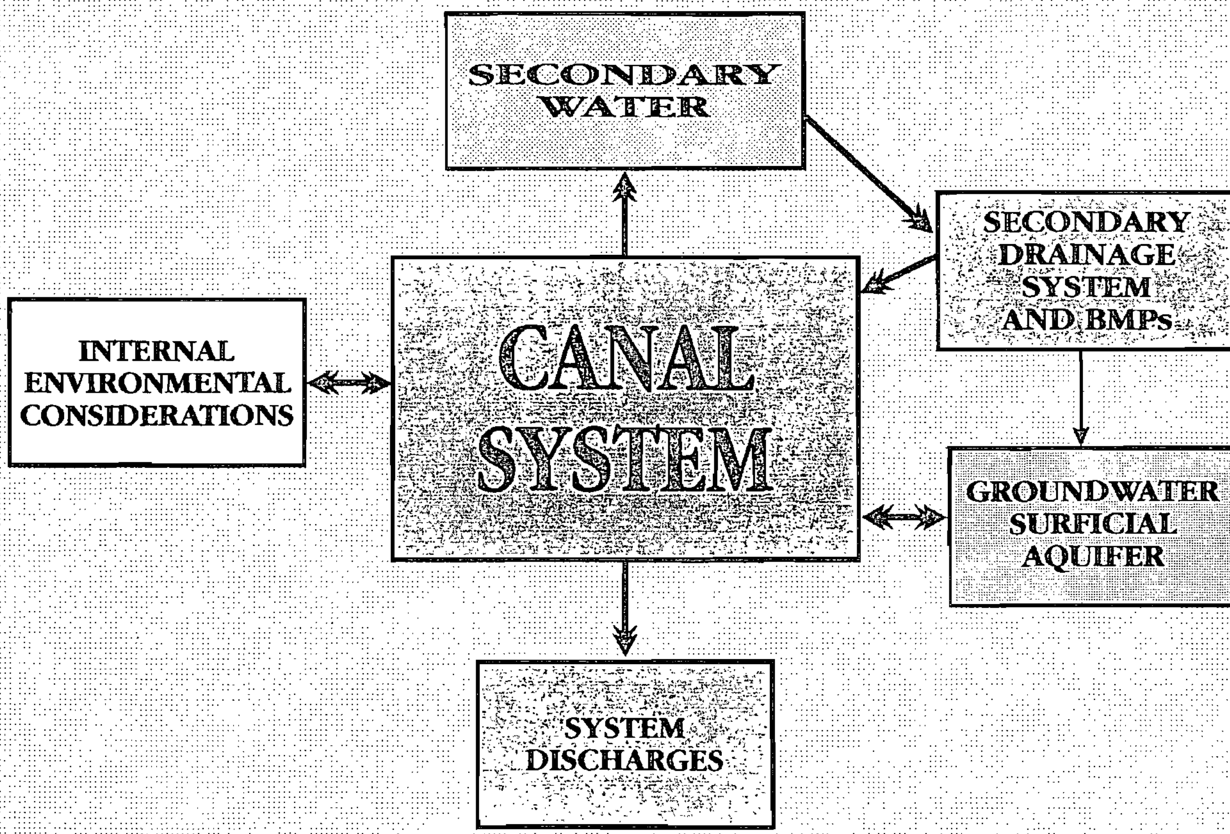


FIGURE 4.3

SECONDARY DRAINAGE SYSTEM

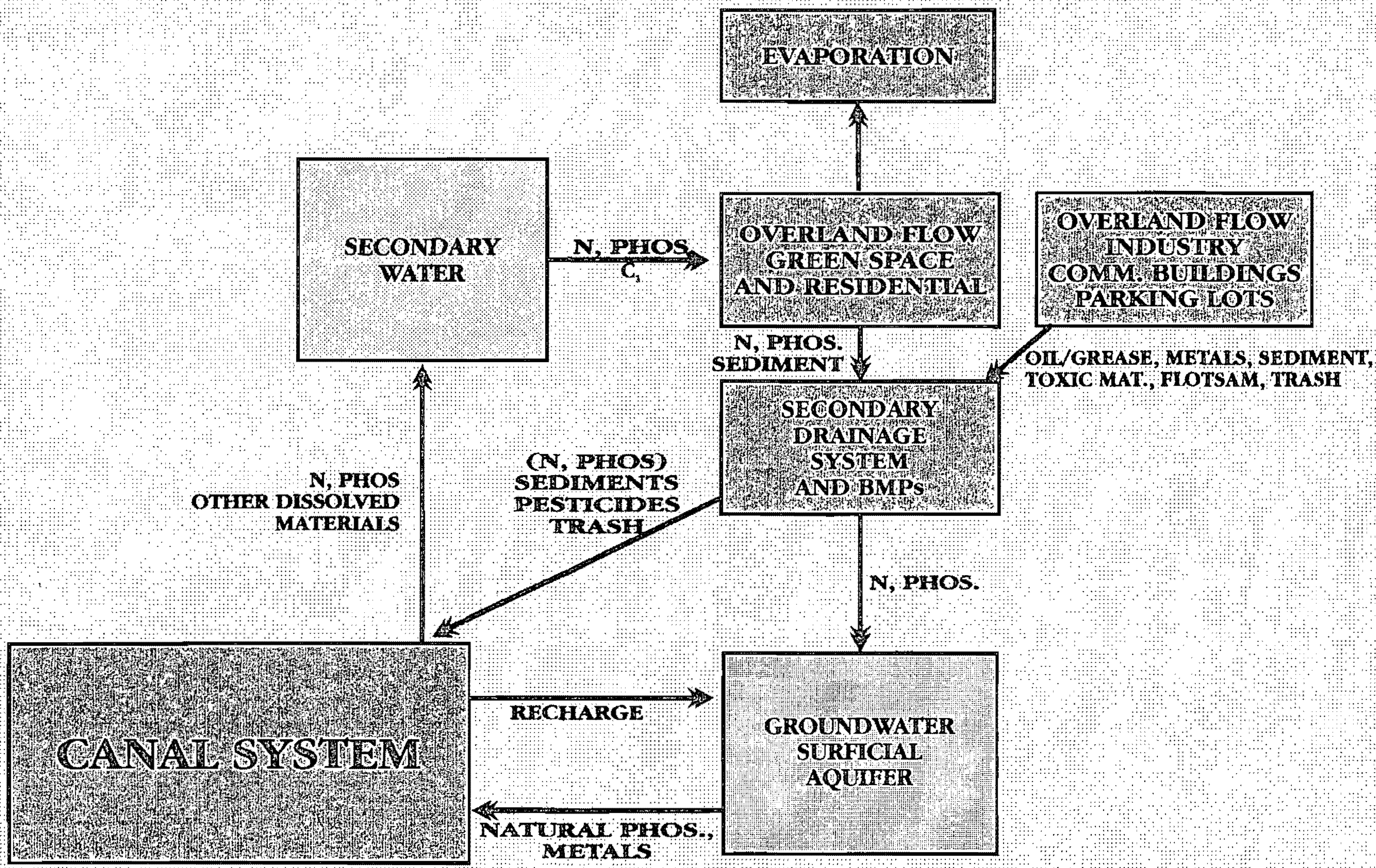


FIGURE 4.4

Flooding of the secondary system relates closely to the level of service to the residents. Acceptable levels of service must first be established. Determination of the improvements to the system required to meet those levels can then be made. Also, since the availability of sufficient hydraulic gradient from the street level to the canal water surface is the primary constraint, accurate prediction of tailwater elevation (i.e. canal level) is critical to realistic projections of local flooding conditions.

The roadside swales are a very important element of water quality in this system. Significant treatment takes place through the detention of runoff in the swales before entering the drainage system or infiltrating into the ground. The study will analyze swale maintenance, swale design, and improved inlet designs to maximize the benefits of these factors.

Maintenance of the surface water system will be an increasingly large task for the City as development continues, water supply becomes less abundant and quality concerns escalate. The aging of the infrastructure such as pipes, inlets, weirs and seawalls will also increase the need for maintenance. The planning process will develop the means to prioritize maintenance tasks based on a rationale resulting from policy decisions of the City.

Maintenance issues addressed will include lot mowing, street sweeping, swale cleaning, inlet cleaning, pipe cleaning, canal dredging, weed removal, and the replacement and repair of all facilities.

b) Secondary Water

Based on the direction Cape Coral has selected for water supply, the canal system is vitally important as a source for secondary water. Figure 4.5 presents a flow diagram of the secondary water system. Although it is difficult to separate water quality from flooding issues, there are additional aspects of the study related to water supply.

The long term demands for secondary water must be accurately predicted, not only in terms of quantity but withdrawal location as well. The availability of water is very dependant on point of withdrawal and economic delivery to the needed location. Accurate prediction of reclaimed effluent quantity, quality and location is also required.

The movement of water from lawn application to the canals must also be analyzed and accurately modelled. In a porous soil without seawalls the movement of the water back to canals would be nearly immediate. The presence of soil with low transmissivity and seawalls (or alternatively, soils with high transmissivity underlain with marl) will slow that process and have an impact on the quantity of water that can be withdrawn in a given time period. It has not been conclusively shown that either process is dominant in the project area.

SECONDARY WATER SYSTEM (IRRIGATION)

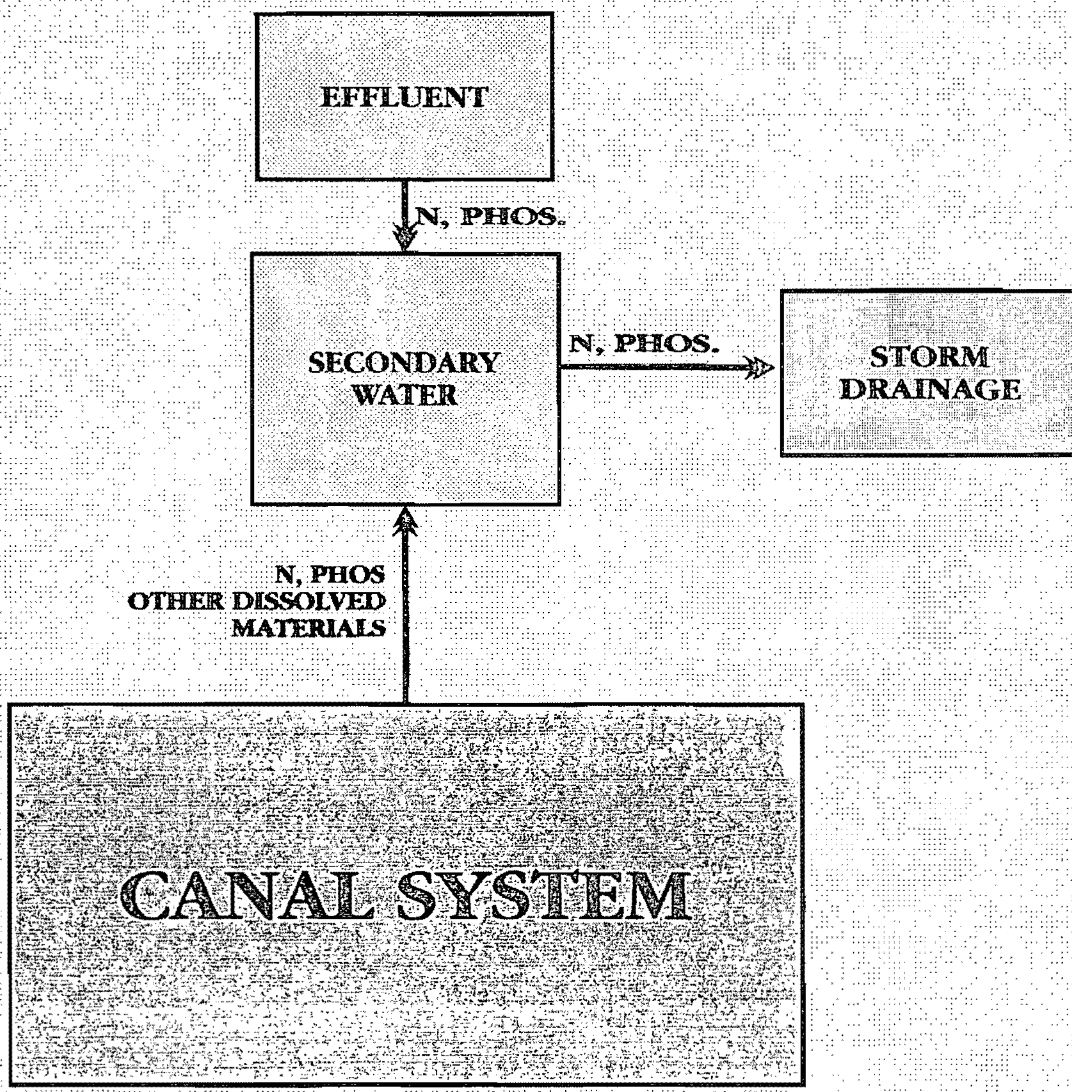


FIGURE 4.5

Canal water availability must be reliable for the secondary water system to be effective. The study will analyze the impact of proposed secondary water pumping station locations as well as contingent intakes to assure a high degree of canal water reliability. (See Appendix A.3)

The spreader canals along the borders of Cape Coral were intended to separate freshwater and saltwater environments. Because of breeches in the outer banks of the spreader system the separation has not been very effective. An element of the Master Planning process will be to investigate opportunities to reclaim the area between the spreader canals and the upstream weirs as storage areas for freshwater supplies. Maintenance of boat traffic without barriers is a key concern in this analysis. Another concern is the preservation and protection of environmental conditions along both sides of the spreader canals. (See Appendix A.7)

In the analysis of water supply issues the effect of surface water management decisions on the potable water supply aquifers below must be considered. The existence of private wells into the Upper Hawthorne, with the likelihood of connection to the surficial aquifer will be considered.

Also of concern is the possibility of increasing pollutant concentrations as relatively dilute concentrations are spray irrigated. As irrigated water evaporates, pollutant constituents may remain in higher concentrations and find their way back into the canal system.

c) **Surficial Aquifer**

The surficial aquifer may play a significant role in the surface water processes in a number of areas. Figure 4.6 presents a diagram of the surficial aquifer. These include but are not restricted to the following possibilities:

- Storage and yield capacities, especially for irrigation supply
- Canal/aquifer interaction and efficiency
- Freshwater discharges to marine systems via groundwater
- Saline intrusion through the groundwater systems
- Exchange to adjacent aquifers and possible contamination
- Pollutant removal and transmission

Another quality issue is the effluent from septic tanks entering the canals. Drain field failures may give rise to pathogenic and nutrient pollution. Septic tank drain fields might also allow leaching of nutrients that find their way to canal waters via runoff processes. This concern will be addressed by attempting to quantify the problem and develop means to lessen the impact of septic tanks on the canal water. (See Appendix A.3 and A.11)

SURFICIAL AQUIFER

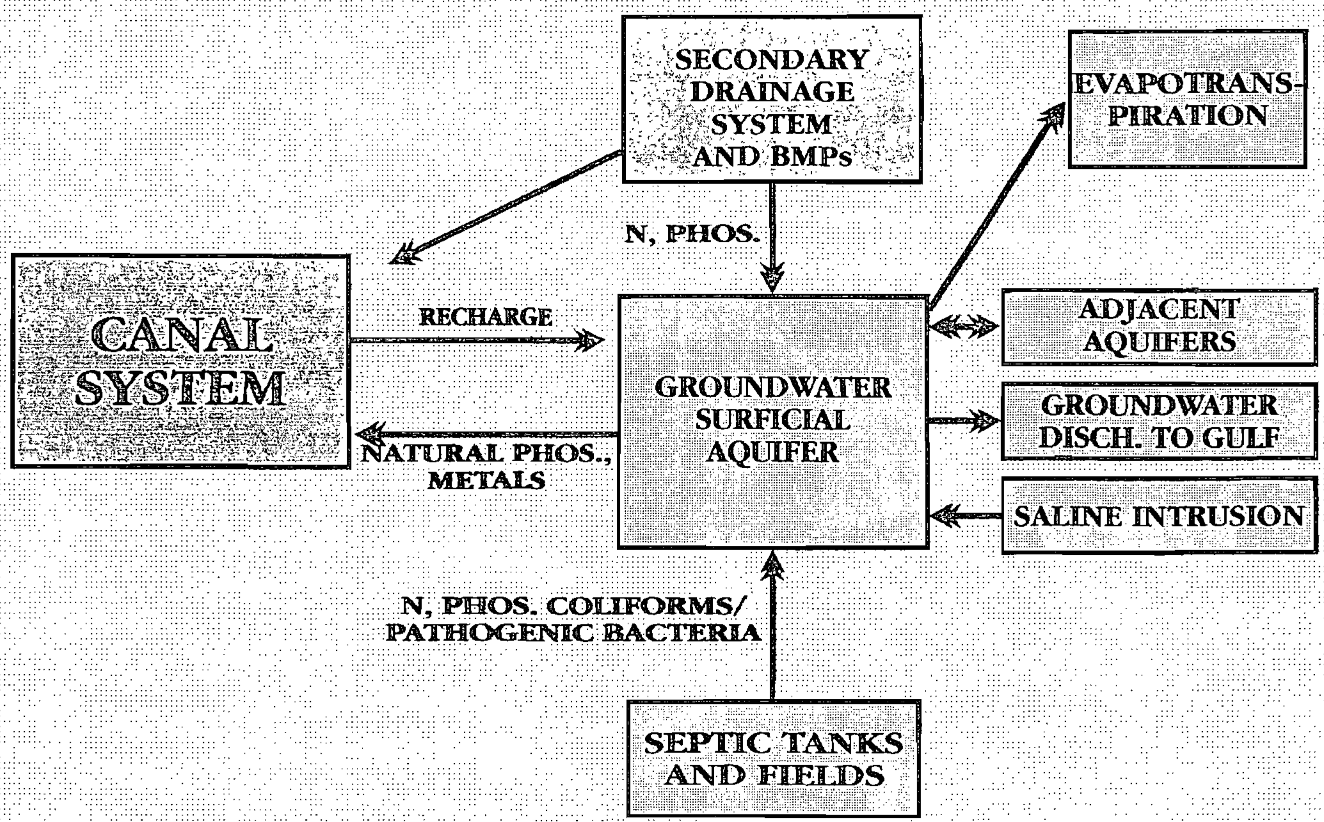


FIGURE 4.6

d) **Surface Discharges**

Surface discharges or overweir discharges shown in Figure 4.7 are important from the standpoint of flooding, retained freshwater quantities and water quality. Water quantity concerns will require balancing drainage requirements against surface water storage for secondary water.

Maintaining high water levels in some canals for storage purposes could increase primary and secondary system flooding potential. The analysis will evaluate the potential for controlling weir elevations on key canals to store or release water depending on actual data for rainfall, time of year, canal levels, and other conditions.

The Department of Natural Resources, Army Coups of Engineers, and U.S. Fish and Wildlife service may become increasingly interested in maintaining dry season freshwater discharges and restricting wet season discharges in order to maintain the health of adjacent ecosystems. Discharge water quality considerations will also be of significant importance in dealing with regulatory agencies.

Because of the large land mass encompassed by Cape Coral it is unusual to experience the same rainfall level throughout the City at the same time. Ultimately, with a series of controlled weirs, storm flows could be routed through the canal system in the most effective manner to maximize storage and not exceed established limits for tailwater conditions along any canal.

e) **Internal Processes**

Internal processes directly impact physical and ecologic processes within the canal system. These include the effects of boating, dredging, illegal dumping, direct rainfall, and evaporation. These activities may affect conveyance and storage properties, internal water quality and aquatic life. Figure 4.7 presents a diagram of the internal canal precesses and system discharges.

Increasing regulatory constraints will be addressed in the study. According to our most current interpretation of the rules, the Cape Coral canals that discharge to the Caloosahatchee River should be treated as outfalls under the NPDES program. However, in the recent past, some regulatory agencies have been claiming jurisdiction further and further upstream in the hydrologic path.

The intrusion of saltwater into freshwater zones is also a quality issue to be addressed. Measurement of chloride levels will be accomplished over time. This data will be extrapolated using a computer model (to be developed in the Master Planning effort) to predict the extent and level of chlorides. The model will also be used to predict conditions which are most conducive to increased chloride levels. Throughout the

INTERNAL PROCESSES AND SYSTEM DISCHARGES

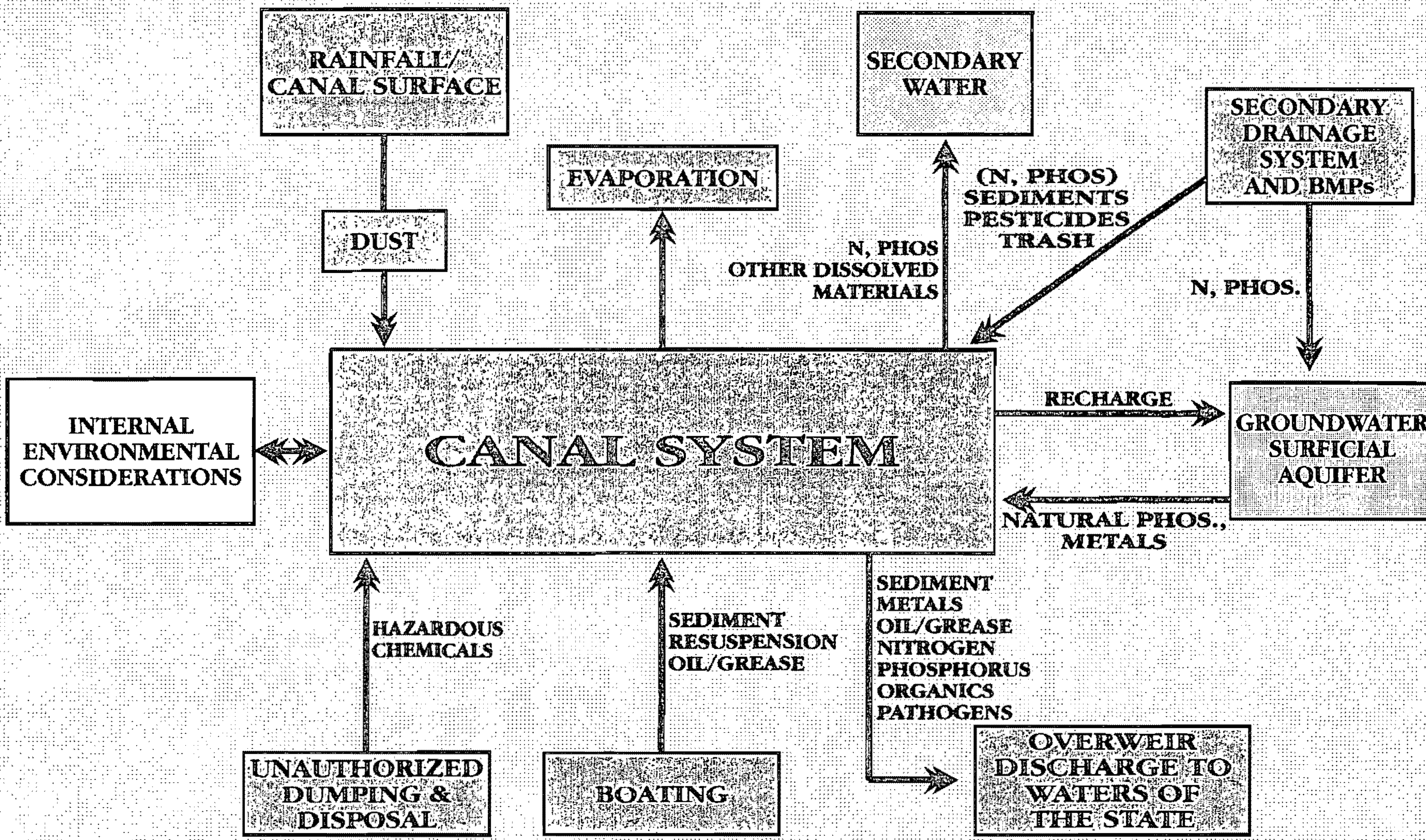


FIGURE 4.7

planning process there will be developments which require new or modified ordinances to accomplish desirable results related to surface water management. Such ordinances will be prepared in suggestion form and presented to the staff for review.

f) Aquatic Ecological Processes

The analysis of water quality issues is the most complex and difficult element of the study. While regulatory constraints are continuing to increase, canal aesthetics are probably the most pressing factor behind maintenance of high quality water in the canal system. The availability of sufficient quantities of suitable water for irrigation purposes is also vital to long-term financial wellbeing of the City.

While ecological processes are essentially internal, they represent a significantly different set of processes than the physical processes discussed above. However, these processes may significantly impact the perceived quality of the amenities provided by canal system. They also may be significantly impacted by drainage system maintenance practices. Figure 4.8 depicts a graphical representation of internal ecological processes within the canal system. Ecologic processes may be responsible for the trapping or release of pollutants, providing dissolved oxygen for fish, increased or decreased sedimentation and the proliferation of various forms of desirable or undesirable aquatic vegetation. It must be understood that ecological processes will always occur in the canal system. The development of the master plan will address means to promote those that are most beneficial to the community of Cape Coral. (See Appendix A.7)

A major factor in the maintenance of water quality is the aquatic life in canals. As development continues and seawalls are installed there is less opportunity for the formation of beneficial zones of desirable plant life which act as a natural treatment system by absorbing pollutants. Hardier plants such as cattails and less desirable plants such as hydrilla and algae may become established as habitat competition becomes limited. These undesirable plants can be ruinous to the perceived beauty and recreational use of the canal system. This aspect of water quality will be studied to determine long term effects and management alternatives.

Because of the short distance between applied irrigation water and the canals, there is a concern about the possible accumulation of nutrients from lawn fertilizer in the canals. Excessive nutrient levels in the canals will be undesirable from the standpoint of weed growth. The study will address this issue and the potential means to control nutrient levels in the canals.

INTERNAL ECOLOGICAL CONSIDERATIONS

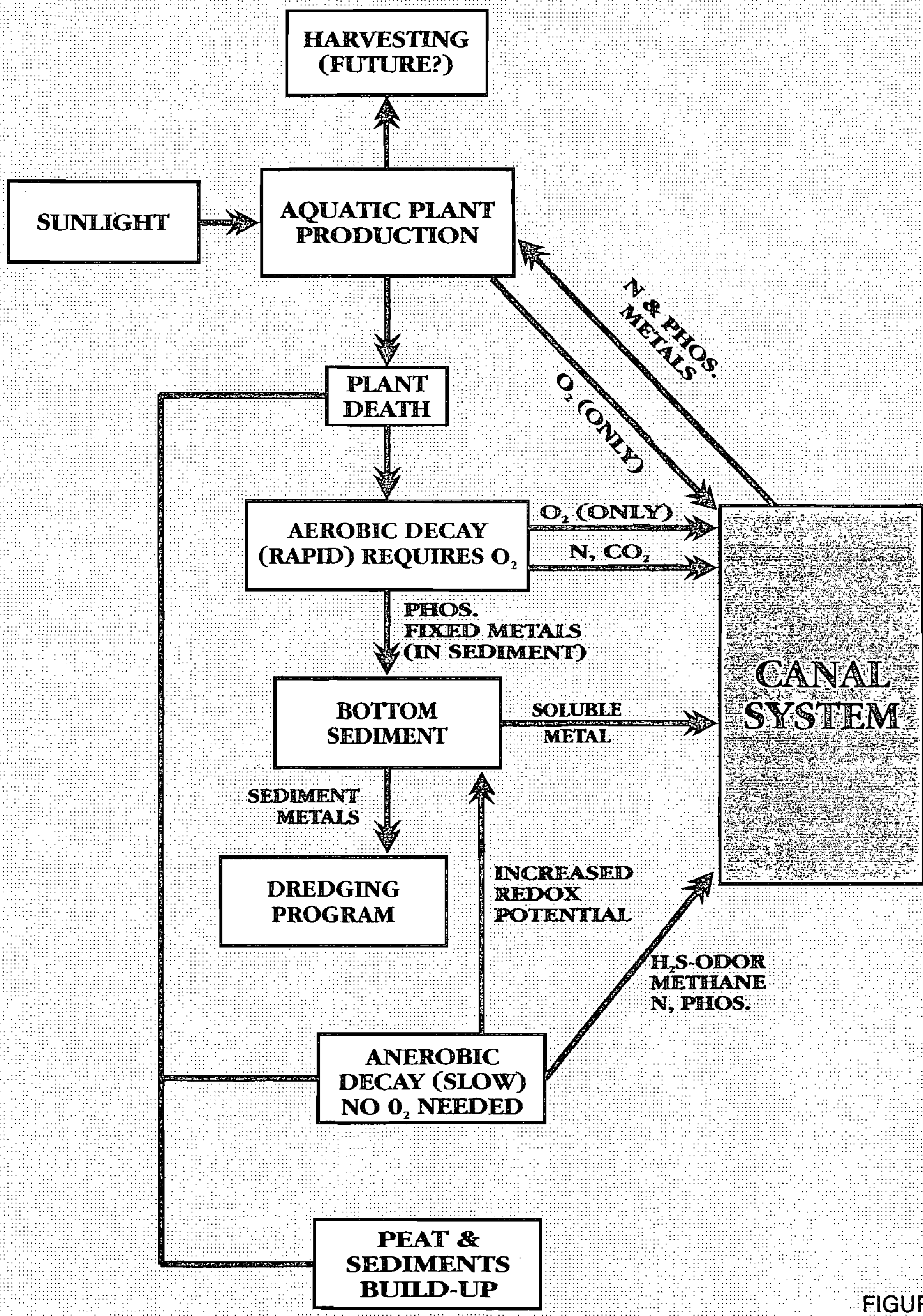


FIGURE 4.8

3. DETAILED INTEGRATED SYSTEM

Figure 4.9 shows each of the sub-system diagrams arranged to fit the simplified system diagram in Figure 4.3. This figure shows all of the hydrologic elements that are important to consider in developing the Surface Water Master Plan.

It is important to note that few of the processes or interactions included in this diagram have ever been described in sufficient technical detail to make accurate engineering judgements. The first part of the management plan development seeks to overcome this through a well designed data collection and compilation program and the building of a detailed computer model of the system. After the processes within the surface water system are described with a reasonable level of confidence, management alternatives that maximize the use of the surface water system may be explored.

D. OVERALL APPROACH TO MASTER PLAN DEVELOPMENT

As is evident from the foregoing discussions, there is a multitude of concerns, objectives, constraints and preferences that must be incorporated into the development of the Surface Water Master Plan. Their incorporation is vital if the selected plan is to be acceptable the City decision makers, the public and external regulatory bodies.

The importance of adopting a Master Plan to manage this complex system cannot be overemphasized. New and future agency regulations could cause the City to drastically alter its growth plan if a sound surface water management plan is not adopted. For this reason, the plan will address regulatory issues and concerns as related to surface waters. The plan will provide the regulatory agencies with the City of Cape Coral's clear, concise plan to manage and maintain its surface water system. This will promote regulatory concurrence of the Master Plan.

The proposed method for development of the Master Plan is based on a "multi-objective planning" approach which allows for interaction with the project engineers and scientists in a manner that leads to a technically sound and acceptable result. Multi-objective planning, as the name implies, is a process for development of a project which attempts to satisfy all of the goals and objectives set forth by the City within a set of constraints imposed by the City, its citizens and the regulatory bodies (via rules and criteria) that have jurisdiction over the project. Because the mutual maximization of all of the goals and objectives is usually not possible in a project of this nature, the process also contains a feedback mechanism that attempts to satisfy each objective to an acceptable level through use of tradeoffs and compromises for the mutual good of all of the involved or affected parties. This process is intimately tied to benefit/cost relationships as well as budget considerations so that an affordable set of alternatives can be formulated.

RELATIONSHIPS WITHIN THE SURFACE WATER SYSTEM

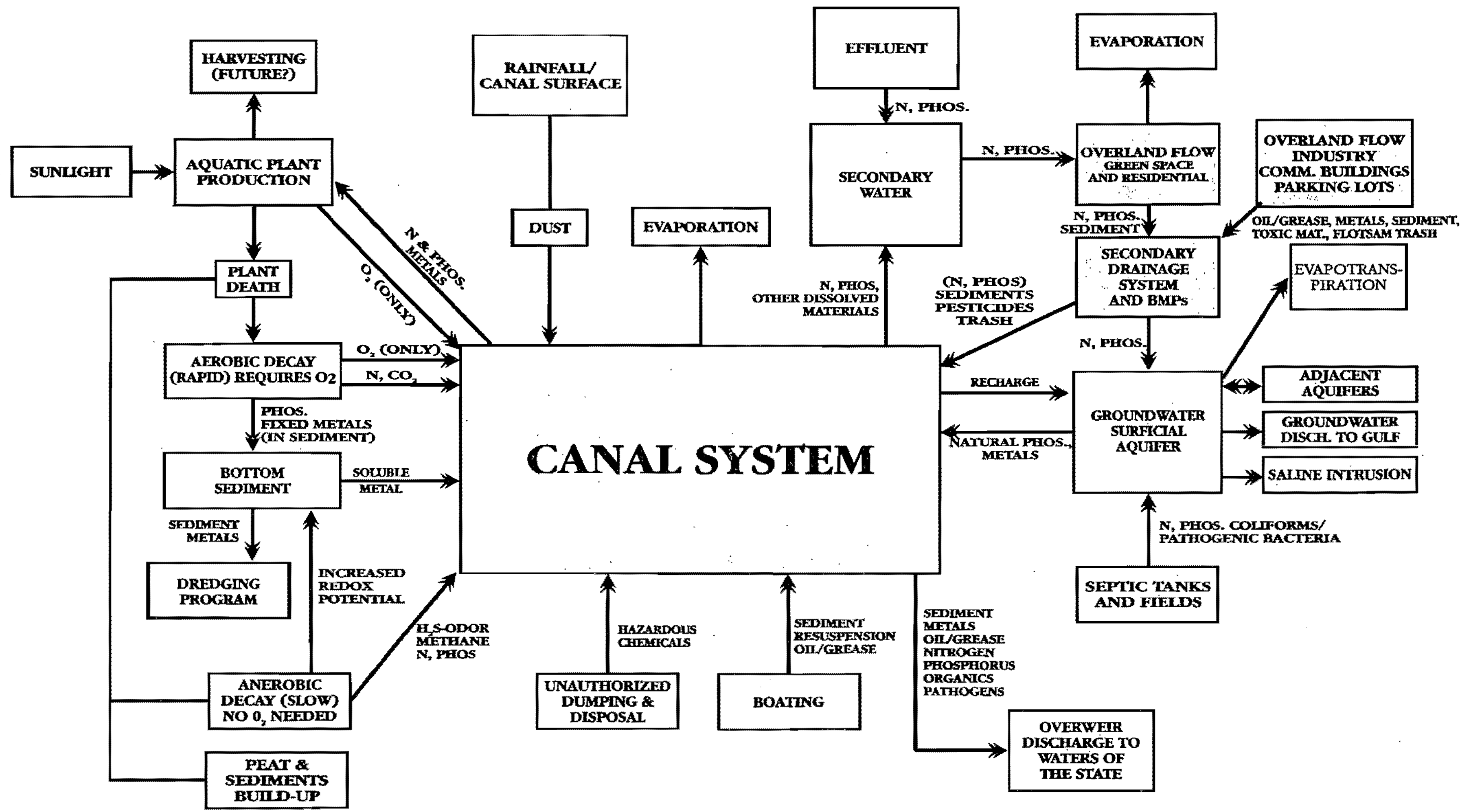


FIGURE 4.9

The overall process for the execution of the project is provided in Figure 4.10. Each of the elements shown there is discussed briefly in the following. More technical detail is provided in Section V of this report along with discussions of other parallel activities that will be required for the project.

1. DEVELOP STUDY OBJECTIVES AND CONSTRAINTS

Some of the objectives of this part of the project consist of the following:

- Provide Adequate Drainage and Flood Control
- Supplement WICC with a Reliable Secondary Supply
- Maximize Water Quality
- Minimize Capital and Operational Costs
- Others

Additional objectives may be added from interviews with City officials and from public participation.

Objectives will be quantified in terms of their relationships to one another as well as to other variables; and objective functions will be developed for use in the optimization process.

Some of the identifiable constraints on the degree to which objectives can be achieved consist of the following:

- Financial Resources Available
- Minimum Levels of Service
- Regulatory Engineering Criteria
- Construction Limitations within Wetlands
- Water Quality Criteria (in the City and Off-Site)
- Water Use Criteria and Restrictions (State)
- Minimum Discharges
- Minimum Flows for Lake and Canal Flushing
- Navigational Access Needs
- Minimum Water Levels for Navigation
- Maximum Safe Levels Related to Flood Protection
- Maximum Seasonal Water Levels Related to Septic Tank Drain Fields
- Others

Constraints will be quantified and used in both the modelling and optimization process.

In addition to the above, study preferences will be determined from interviews with City officials and from public participation activities. These are somewhat more difficult to quantify and some will likely be subjective in nature. However, a degree of quantification can be accomplished in

MASTER PLAN DEVELOPMENT

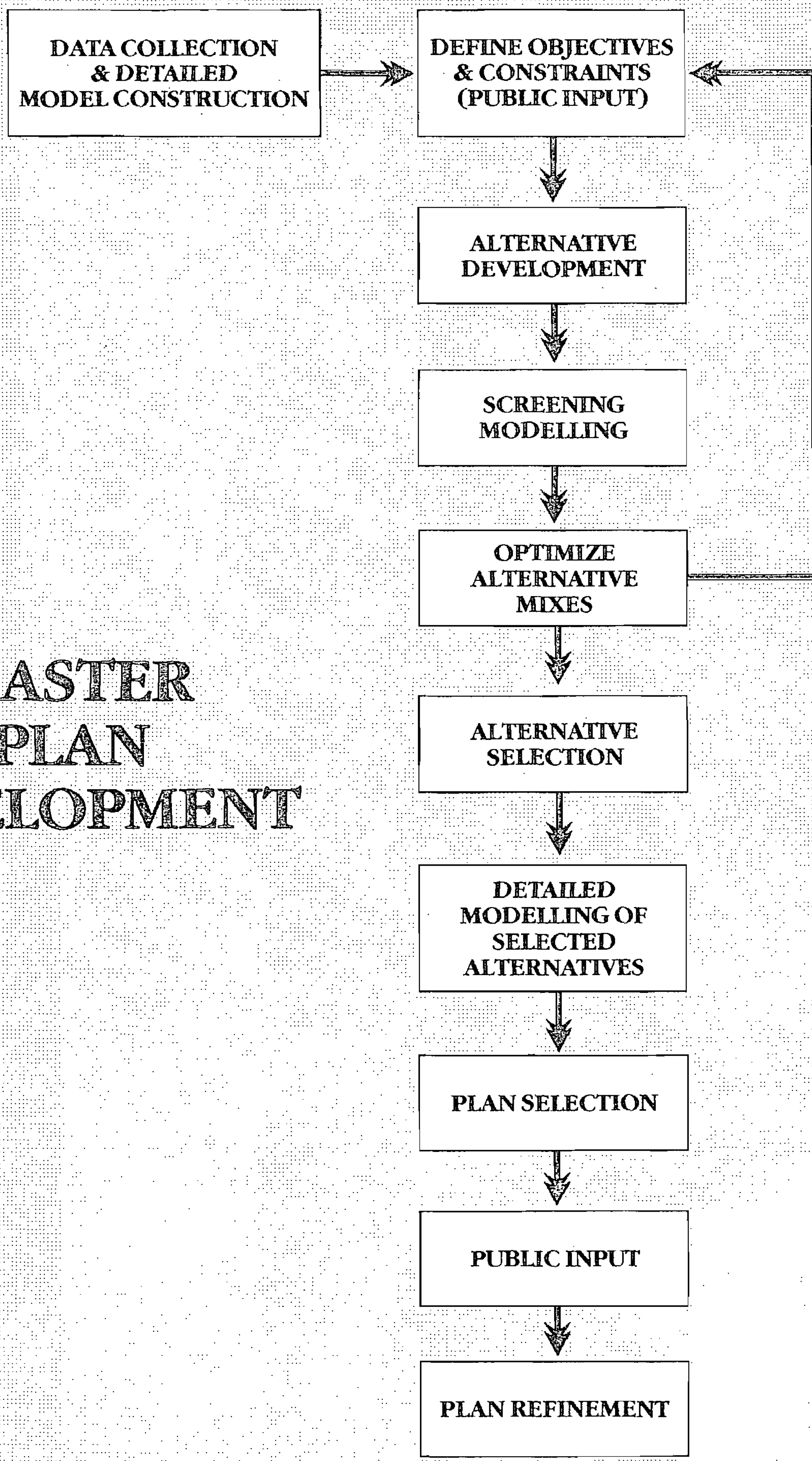


FIGURE 4.10

certain circumstances. For example, "willingness to pay" for various levels of service (i.e., availability of irrigation water) can be established. Another example would be the acceptability of lower water levels in terms of frequency (i.e., once every 10 years) in exchange for greater irrigation water supply at the same frequency.

2. DATA COLLECTION AND DETAILED MODEL CONSTRUCTION

During Phase I of the Master Planning effort, a comprehensive literature review, analysis of previous studies and a critical assessment of available data sets has revealed that precious little has really been quantified and supported with measured data. The processes described above must be measured and modeled before a well engineered management program can be developed. Some estimates of quantities have been made in the past but are based largely on assumed or overgeneralized parameters. Since the management plan seeks to balance the requirements of drainage, irrigation supply and water quality, investigations will focus on properly describing processes that affect these areas.

Of primary importance in developing a reliable management program is gaining a comprehensive understanding of actual conditions affecting the system. Much of what is known about the drainage system is based on subjective observation and empirical evidence rather than objective analysis. The data collection program is designed to provide measurements where none have been taken and to fill in gaps in existing data records. This data collection effort will provide engineers and planners with reliable facts on which to base important planning decisions.

The qualitative description of the physical processes and interactions provided in the previous article become a good starting point for evaluating the relevance of sub-system to sub-system exchanges. The next step in preparing a management program is the quantification of these exchanges in order to develop computer models that predict the behavior of these processes under various management scenarios.

Computer models will be relied upon to portray existing and future conditions with respect to water quantity and water quality conditions within the City and adjacent areas that contribute, or could potentially contribute, surface water flows to the City. The types of models to be employed depend upon the nature of the processes that must be evaluated. For example, the need to determine the availability of irrigation water on a drought frequency basis dictates the need for a continuous hydrology and hydraulics model. In addition, a different model may be used for prediction of water quality and/or biological processes so that the fate of pollutants entering the primary system can be determined. Another type of water quality model will likely be required for the generation of pollutant loadings from upland sources and for the evaluation of BMP (Best Management Practices) performance in pollutant load reduction.

The above detailed models will be constructed and tested extensively before using them in a predictive capacity. They will be calibrated and verified using historic data and data collected during the second phase of the project. Existing and build-out conditions will then be simulated to numerically document system performance, as well as existing and potential problem areas within the City.

3. ALTERNATIVE AND SCREENING MODEL DEVELOPMENT

The functions of the detailed tools are somewhat individual in nature and each will likely have different ways of generating output and displaying results. However, the system that they attempt to simulate must all work in concert since the proposed system changes that modify the behavior of one model will also usually modify the behavior of another. For example, if wet detention were to be evaluated, the candidate pond systems would not only provide for water quality treatment, but would also help attenuate flood peaks and prolong the opportunity for recharge of the surficial aquifer. Therefore, this BMP would have effects on drainage, flood control, and water supply. These methodologies must therefore be integrated so that the combined alternatives which best satisfy all of the project objectives can be identified.

The key to performing this complex operation in a cost effective manner lies in the use of "screening models" and optimization software. A screening model is a simplified version of the detailed model that can be executed comparatively quickly and used in a repetitive manner to evaluate numerous alternatives. It can be constructed through use of a smaller, less refined, version of the model network or it can possess simplified numerical algorithms that execute faster than the detailed model, or both. Its function is to provide a reasonable prediction of reality.

In constructing screening models, output data will be compared to output from the detailed models to insure that the "reasonably accurate" criterion is met. They will then be applied to the alternative data sets to generate performance data for each. Output will be processed into a number of formats that can be used to test a given alternative with respect to study objectives. For example, irrigation water supply availability would be processed into a yield versus frequency format that can be used to evaluate its effectiveness in providing irrigation water. At the same time, a stage duration analysis would be performed to determine resulting canal and lake stage reductions that may result as a tradeoff for using the available irrigation water. An example of this relationship is contained in Figure 4.11. Similar relationships can be constructed for water quality, environmental and other objectives.

For each alternative evaluated, the processed outputs will be routed to optimization programs to evaluate their comparative performance. These programs will employ results from the models as well as constructed cost functions and other constraint data to perform the evaluations.

At this point, it is usually determined that certain alternatives can be eliminated due to the fact that they can not meet the objectives within the stated constraints. It is also usually found that some of the constraints may need to be relaxed in order to make a more objective evaluation of

TYPICAL STAGE EXCEEDANCE CURVE FROM CONTINUOUS MODELLING OVER LONG PERIOD OF RECORD

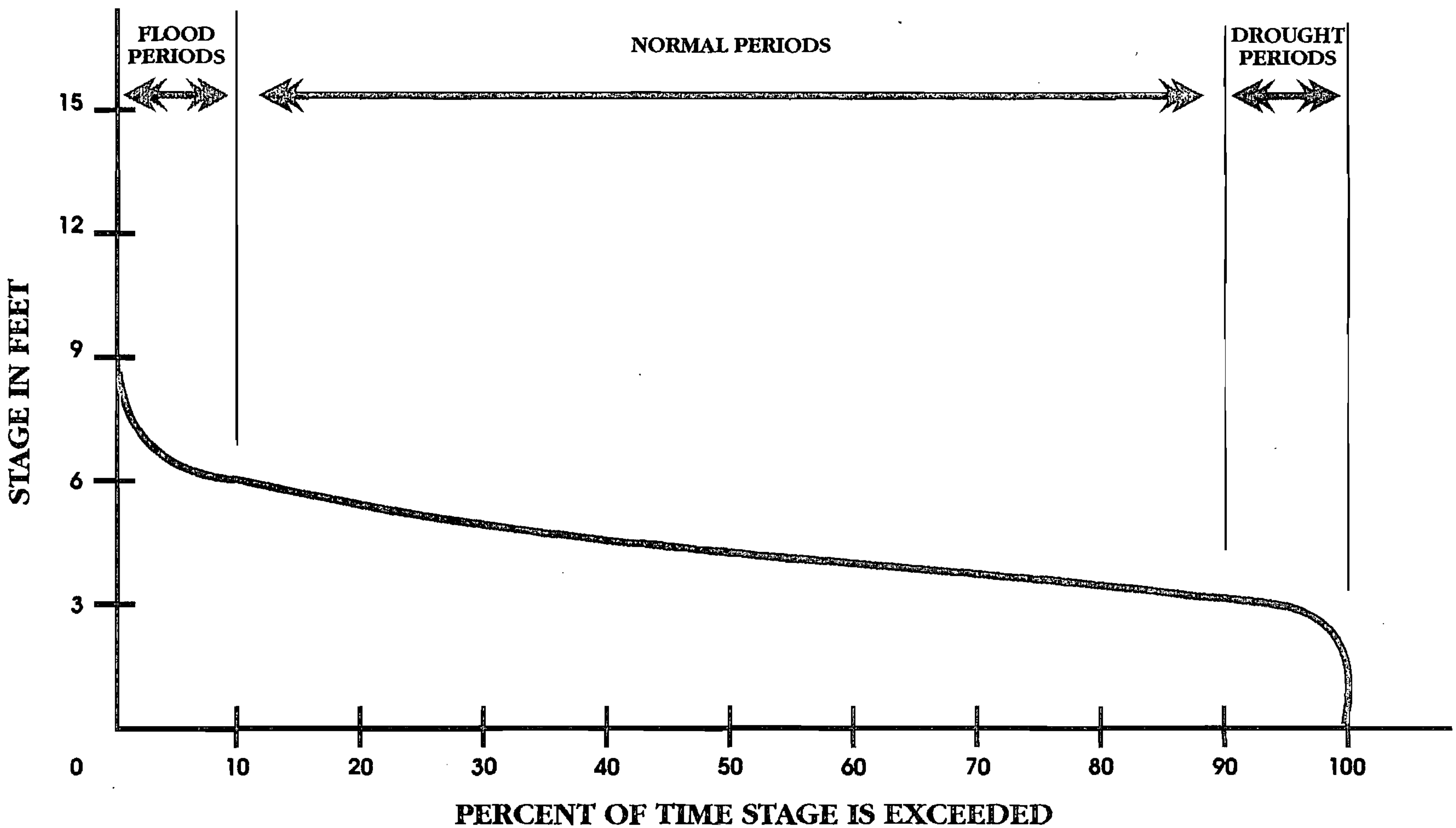


FIGURE 4.11

certain options. In addition, the initial evaluation process nearly always points to additional alternatives that should be tested. As a result, the process of alternative development and optimization is nearly always cyclic for at least two iterations, as indicated in Figure 4.10.

4. ALTERNATIVE SELECTION

The foregoing process will usually produce several alternatives that meet the overall objectives within the stated design constraints. These will be presented to City decision makers along with the consultant's recommendations for the selection of two or more alternatives that should be investigated in detail.

5. DETAILED MODELLING

The selected alternatives will be subjected to detailed modelling so that subtle approximations introduced by the screening models can be eliminated. The results will therefore have a high level of confidence from a technical point of view thus questions regarding accuracy and precision should not be a factor in the final decision making process. In addition, cost estimates for these alternatives will be refined.

Results will then be subjected to the optimization software so that each alternative can be graded in terms of the objectives and constraints previously established.

6. PLAN SELECTION

Results of the detailed alternatives analyses will be presented to the City of Cape Coral decision makers for selection of the final plan.

7. PLAN REFINEMENT

In any plan selection process, there is usually a need to refine the selected plan as a result of additional preferences presented by decision makers as well as the public. This task is included so that final modelling, cost analysis and presentation can be provided.

8. IMPLEMENTATION

The means to accomplish the necessary improvements and the recommendations for a well managed surface water system include adequate funding, proper staff and equipment, appropriate ordinances and public support. Each of these factors will be analyzed in the planning effort.

The City's Stormwater Utility is funded by user charges based on lot size and use. The fee structure will be analyzed and recommendations developed for necessary changes on a schedule required to match the level of spending. The financial analysis will also determine the most advantageous means of financing the needed capital improvements, including bonds, loans, grants and other potential sources of funds.

A schedule of implementation for all recommendations will be developed as part of the plan. Taking into consideration cost, relative priority, and regulatory requirements, each aspect of the Master Plan will be coordinated into an overall schedule.

The Master Plan will also include recommendations as to organizational needs of the City entity responsible for surface water management. Considered will be staffing, budget, equipment, systems such as GIS, and operational structure. (See Appendix E and F)

Critical to the success of the planning process is the acceptance and support by the public. The purpose of the utility, the need for planning, the critical nature of the surface water system, and the impacts of decisions on the future of Cape Coral must be presented in a way which results in strong public acceptance of the program. Development of a public information program will be included in the Master Planning process.

E. SUMMARY

The program discussed in this section focuses primarily on the full development of the Surface Water Master Plan. Additional vital tasks not included in this section but to be included in the overall project scope include:

- Implementation of Public Communication Program
- Continued regional drainage design upgrades
- Assistance with Stormwater Utility growth and future development
- Periodic assessment of financial needs

This section discussed the overall objectives for the master plan and discussed the technical considerations that must be incorporated into the plan development. It also provided an overview of the process through which the master plan will be developed.

Section V will provide technical detail on the accomplishment of the tasks necessary to develop the plan. It will tell the same story presented in Section IV.D but in greater technical detail. Section VI will provide the schedule of these tasks.

Following are brief descriptions of the major elements within Phase II, III, and IV of the study to be conducted. While there is a degree of dependence between elements, they are described here individually to give an overview of the planning effort required. Within each phase, sub-sections are arranged in the order they will occur, although some chronological overlap is expected with certain elements.

PHASE II

A. INITIAL PROJECT GUIDANCE - includes an assembly of existing data and definition and refinement of scheduling study tasks following review of Phase I by city staff.

B. DATA COLLECTION PROGRAM - execute field data collection programs.

C. DATA REDUCTION PROGRAM - analysis of field collected data for input into GIS and other computer model building tasks.

D. PROCESS ANALYSES - performance of data analysis for the purpose of describing important processes affecting the surface water system. Small scale modelling of specific processes will provide simplifying generalizations to be incorporated into the city-wide model. GIS multi-layer analysis will facilitate insight and understanding of system-wide inter-relationships.

E. NETWORK COMPUTER MODEL BUILDING - involves the preparation of baseline data and calibration of the full system model.

PHASE III

F. MID-COURSE PROJECT GUIDANCE - includes a critical assessment of data and analysis, evaluation of program objectives and development of criteria for value ranking of program alternatives.

G. FORMULATE ALTERNATIVES - development of engineered alternatives to achieve each of the major objectives of:

- drainage
- irrigation
- water quality.

PHASE IV

H. DEVELOPMENT OF CONSTRAINTS - Technical constraints will be developed through engineering analysis. Societal preferences will be developed through public workshops and incorporated into the set of analysis constraints.

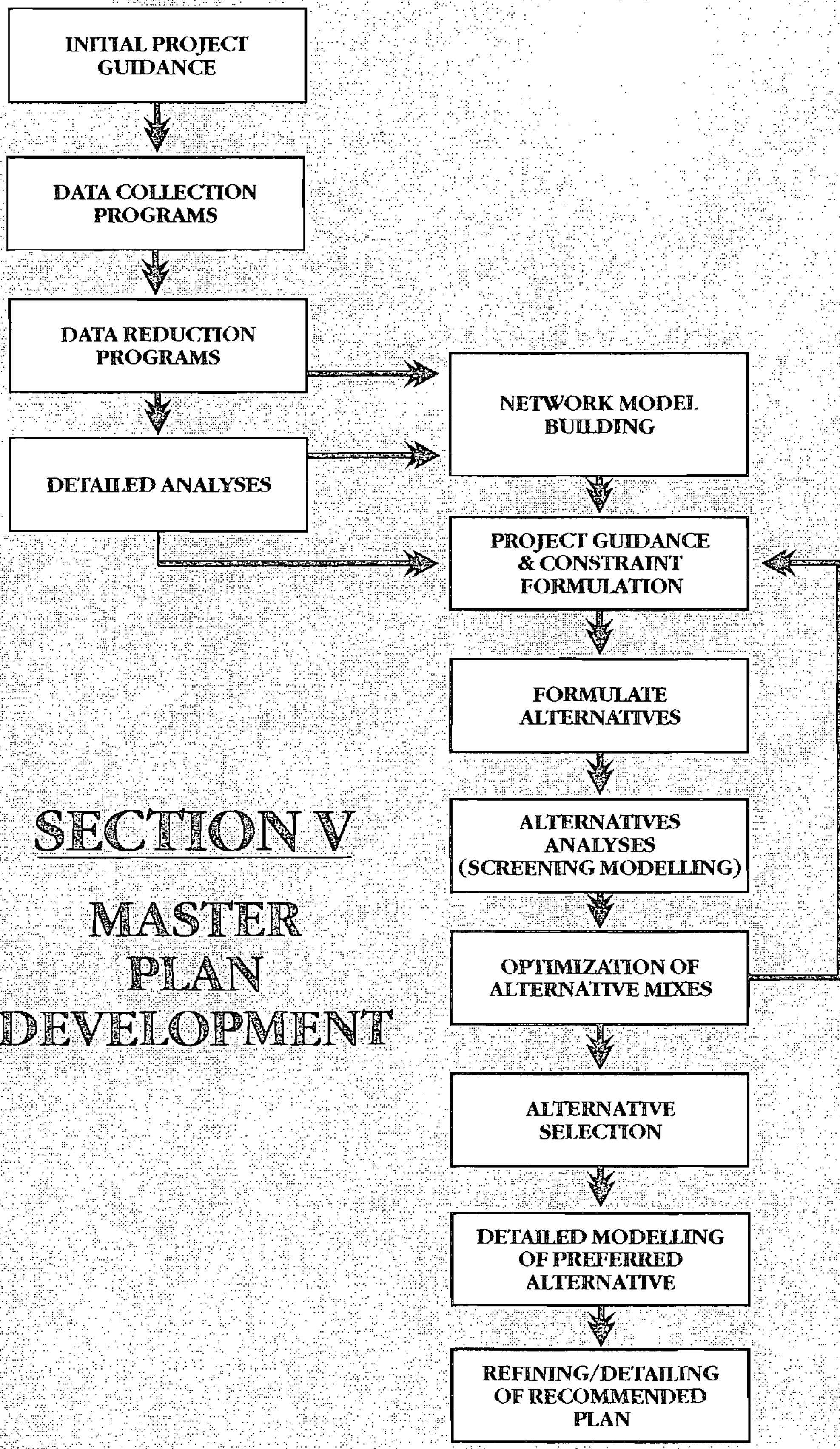
I. ANALYSIS OF ALTERNATIVES - screening and impact analysis of sub-program components. These components will be used to develop the best approach of managing each sub-program as if they could be individually operated.

J. MASTER PROGRAM TRADEOFF ANALYSIS - development of Master Plan that maximizes the full surface water system use through the best overall selection of various components of the drainage, irrigation and water quality programs.

K. SELECTION AND DETAILING OF RECOMMENDED PLAN - development and presentation of project and program oriented tasks to accomplish maximum surface water usage. This will involve alternative presentation, detailed modelling of the chosen alternative, incorporation into an overall master plan, plan refinement and implementation of master plan elements.

SECTION V

MASTER PLAN DEVELOPMENT



SECTION V - DETAILED DEVELOPMENT

In the previous section, major technical goals were defined and the overall project approach was developed. This section expands on the project development methodology and describes the approach in greater technical detail.

The project flow chart presented in Figure 4.10 has been expanded to provide a detailed picture of project development steps. Note that the data collection and model construction box has been broken down into the individual steps that are required for full model development. This stage of the project provides a detailed description of the system necessary for realistic system management. The flow chart shown at the beginning of each sub-section will give the reader a ready sense of project chronology.

A. INITIAL PROJECT GUIDANCE

The Master Plan study will commence with a critical evaluation of this document, adjusting the plan contained herein to reflect city staff and public analysis of project details. The City's commitment to resource allocation and expectations of milestone achievement will weigh heavily in the guidance of the project and prioritization of tasks delineated in this study plan.

Initial guidance includes an assembly of existing data and definition and scheduling of specific study tasks.

1. EVALUATION OF ADJUSTED STUDY PROGRAMS

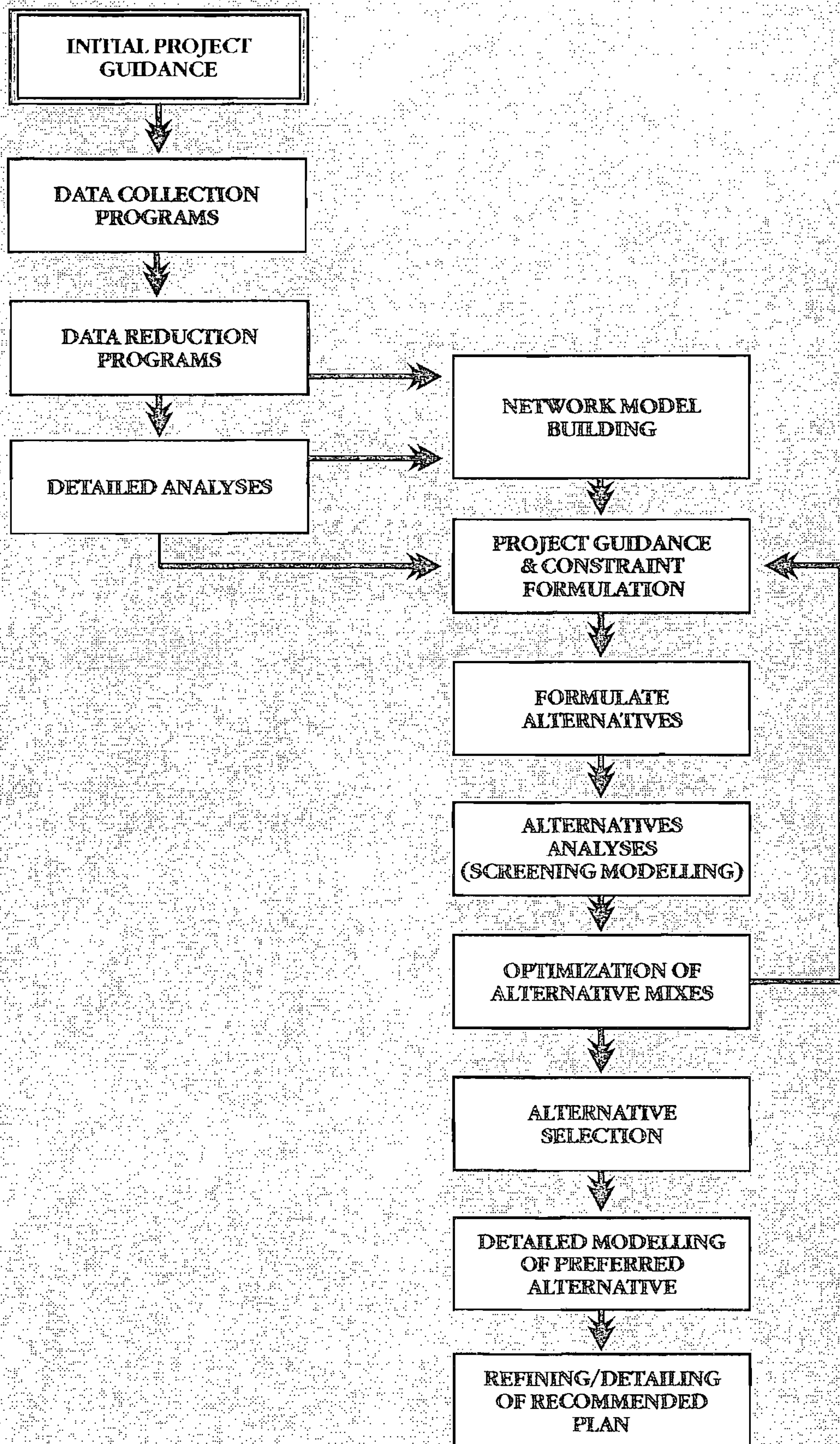
Once study objectives are affirmed by city staff, data collection program components will be adjusted to accommodate specific additions or changes to study objectives. Tabulations of individual data collection programs relevant to study objectives will be developed. Efforts to develop experiments and collect data that may be used in multiple analyses will ensure maximum data acquisition economy.

2. ASSIMILATION OF EXISTING DATA

Data acquired during the previous phase will be assimilated into the data management program. Voluminous data that has been located and documented will be acquired and added to the raw database. Appendix B includes listings of various sources that will be tapped. Data categories that will be targeted include:

- Topography
- Soils & Properties

SECTION V.A


INITIAL PROJECT GUIDANCE
DATA COLLECTION PROGRAMS
DATA REDUCTION PROGRAMS
DETAILED ANALYSES
NETWORK MODEL BUILDING
PROJECT GUIDANCE & CONSTRAINT FORMULATION
FORMULATE ALTERNATIVES
ALTERNATIVES ANALYSES (SCREENING MODELLING)
OPTIMIZATION OF ALTERNATIVE MIXES
ALTERNATIVE SELECTION
DETAILED MODELLING OF PREFERRED ALTERNATIVE
REFINING/DETAILING OF RECOMMENDED PLAN

- As-built Records
- Previous Survey Information
- Vegetation
- Land Use
- Zoning
- Meteorological Records
- Stream (Canal) Monitoring
- Water Quality
- Groundwater, (Quality, Levels, Well Logs, Etc.)
- Tidal Levels, Flows, Salinity
- Construction and Land Costs
- Best Management Practice Applications
- Permit Records
- Maintenance Records and Complaint Files

3. ESTABLISHMENT OF INTERIM DATA MANAGEMENT SYSTEM

Concurrent with the acquisition and compilation of existing data, an interim data management system will be developed to facilitate the critical value assessment of the data. Data will be sorted according to the categories listed above and individual items cross referenced according to data pertinence.

Computerized data management tools will be refined during this task. Strategies for the implementation of spatial (GIS) and non-spatial data management will be formulated to maximize data usefulness and assist in identifying critical data deficiencies. Data management procedures will address:

- Assignment of Operational Responsibilities
- Data Quality and Integrity Maintenance
- Coverage Detail
- Spatial Adequacy
- Statistical Relevance
- Output Objectives
- Hardware Interface Requirements
- Software File Structure Requirements
- Flexibility of Data Retrieval

Initial data entry will commence upon the establishment of management procedures. Three purposes will be served by immediately implementing the data management plan. First, as existing data is compiled and organized within a management system it may be more easily assessed in terms of its quality, value and utility. Secondly, using the analytical capabilities of GIS, preliminary inferences of processes occurring within the surficial system will be drawn and used to further refine field data collection efforts. Finally, the system's success and limitations in managing and analyzing this preliminary data may be critically evaluated. Adjustments to data management procedures may be implemented prior to execution of the full field program.

4. ESTABLISHMENT OF QUALITY CONTROL PROCEDURES

It is imperative during the development of data collection and management programs that quality control procedures be developed and implemented prior to the collection of the first data point. Due to the nature and expense of data collection and manipulation, quality control procedures must be established early in the study process and incorporated into daily operations.

The proposed approach deviates from the traditional milestone quality assessment procedures typically applied to engineering projects. Milestone quality assurance typically reviews progress at a specific level of completeness. For purposes of data collection, this system is flawed in that should poor execution result in poor quality data, it would not be discovered until milestone review time. Not only is effort wasted but the unrecoverable opportunity for data record may be lost.

Management of data quality may be better achieved by building the data collection team around techniques that not only recognize, but facilitate the daily maintenance of quality control. Such techniques that will be incorporated into the quality management include:

a) Assignment of Primary Responsibilities

The provision of clearly defined responsibilities of each team member and well defined task objectives mobilize the entire team in the same direction. Assignment of responsibilities avoids confusion and increases efficiency by properly vesting decision making authority to the most highly qualified individuals to accomplish a defined task. Responsibility is driven by product characteristics rather than process management guidelines.

It is important to keep in mind that products, or internal products, are any items passed from a provider member to a consumer team member. Products may include data files, task definitions, work schedules, reports, etc. This broad definition of products is meant to include transfer of items up and down hierarchal structures.

b) Internal Accountability on Part of Each Team Member

Each member of the team becomes accountable to other members of the team through product delivery. Product recipients determine the fitness and quality of the product for the intended purposes. This is the elemental basis of this quality management approach. Acceptance of a received product places responsibility for quality on the recipient, who invariably will add to the product and deliver it to the next consumer. It is the prerogative and obligation of each team member, regardless of team status, to return unsuitable products to a provider for necessary improvements.

It is the repetition of this process that ensures quality control along the product development path. This process places the responsibility for the addition of value and maintenance of quality on each member of the team. It is also readily apparent that the quality check process is continual and ingrained into the essences of product development.

c) Well Defined Provider-Consumer Relationships Within Team

When the primary responsibilities of each team member are defined, internal provider consumer links may be established. These links provide the mechanics of the system operation through which (value adding) tasks are transferred from providers to consumers. Development of these relationships may undergo several redefinitions through the project life depending on changes in product characteristics. Establishment of simple product transfer and review procedures will facilitate efficient team operation.

d) Recognition of Specialized Strengths of Individual Team Members

The establishment of the proposed quality control system inherently recognizes the specific expertise of individuals within the team. Maximization of individual expertise, and thus efficiency of team operation, may be accomplished when this recognition is further enhanced with respect of individual contribution. After all, combination of expertise is why teams are formed.

e) Commitment to Quality Procedures in Daily Operations

Finally, as the quality management procedures are established, team members must become committed to and comfortable with the techniques described. Keeping in mind that quality control is now a daily operational responsibility built into the system, milestone checks may now be used to evaluate the effectiveness of the quality control system, rather than the products resulting from the project.

5. SENSITIZE PROGRAM OBJECTIVES TO REFLECT CURRENT AND PENDING REGULATION

In light of ever changing regulatory climates, the most recent predictions of regulatory requirements will be assessed. Program objectives will be adjusted to accommodate the best regulatory information available. Regular meetings with regulatory agencies will not only assure that their concerns are being met but will also help protect the City from unexpected changes in regulatory policy.

6. PERFORM CRITICAL DATA REVIEW TO ASSESS DATA WORTH AND DEFINE EXACT DEFICIENCIES

Compiled sets of existing data will be individually assessed for data quality and overall value to the project. This critical review will require evaluation of completeness of the data set as well as its relevance to the project. Costs of developing existing raw data sets for use will be weighed against not using such data or developing alternate sources. Development costs will include the cost of developing complimentary data sets that may be necessary to render data useable (i.e. stream response hydrographs are not very helpful until something is known about rainfall).

GIS coverage will be created for a representative section of the project area to facilitate evaluation of data quality and completeness. The analytic capabilities available on GIS will assist in determining the usefulness of historic data sets and significant gaps in the existing body of knowledge. Gaps may occur spatially within data sets or represent the complete absence of a particular data set. In either case, finalization of the field data collection plan should not occur until existing data sets are individually reviewed and assessed for relevance to other data.

Creation of partial GIS coverage will also offer the opportunity to evaluate data management system performance in test cases. Field verification of the data management system will be performed to refine data entry procedures, test system processing capabilities, adjust data storage techniques, and to evaluate data accuracy, output structure, interface procedures and analysis techniques.

This task will culminate in a report consisting of:

a) Objective Analysis of Individual Data Sets
b) Summary of Completeness
c) Evaluation and Adjustment in Data Management Operations

7. RE-STATE PROBLEM DEFINITION IF NECESSARY

The data assimilation, review and analysis described above is unlike any that have previously been performed on the surface water system in Cape Coral. It is therefore expected that new insights will become apparent and the possibility that important processes may be revealed that had been previously overlooked. These are segments of the surface water system that were not identified prior to the collection and compilation of data as described above.

It is at this point of additional, yet still limited knowledge that an objective critique of study focus will occur. In effect, the project team will give brief pause to the conduct of the project to evaluate project direction and the definition of stated problems based on critical assessments of what had been learned in previous tasks. Project elements will also be weighed against client input, political pressures and regulation changes.

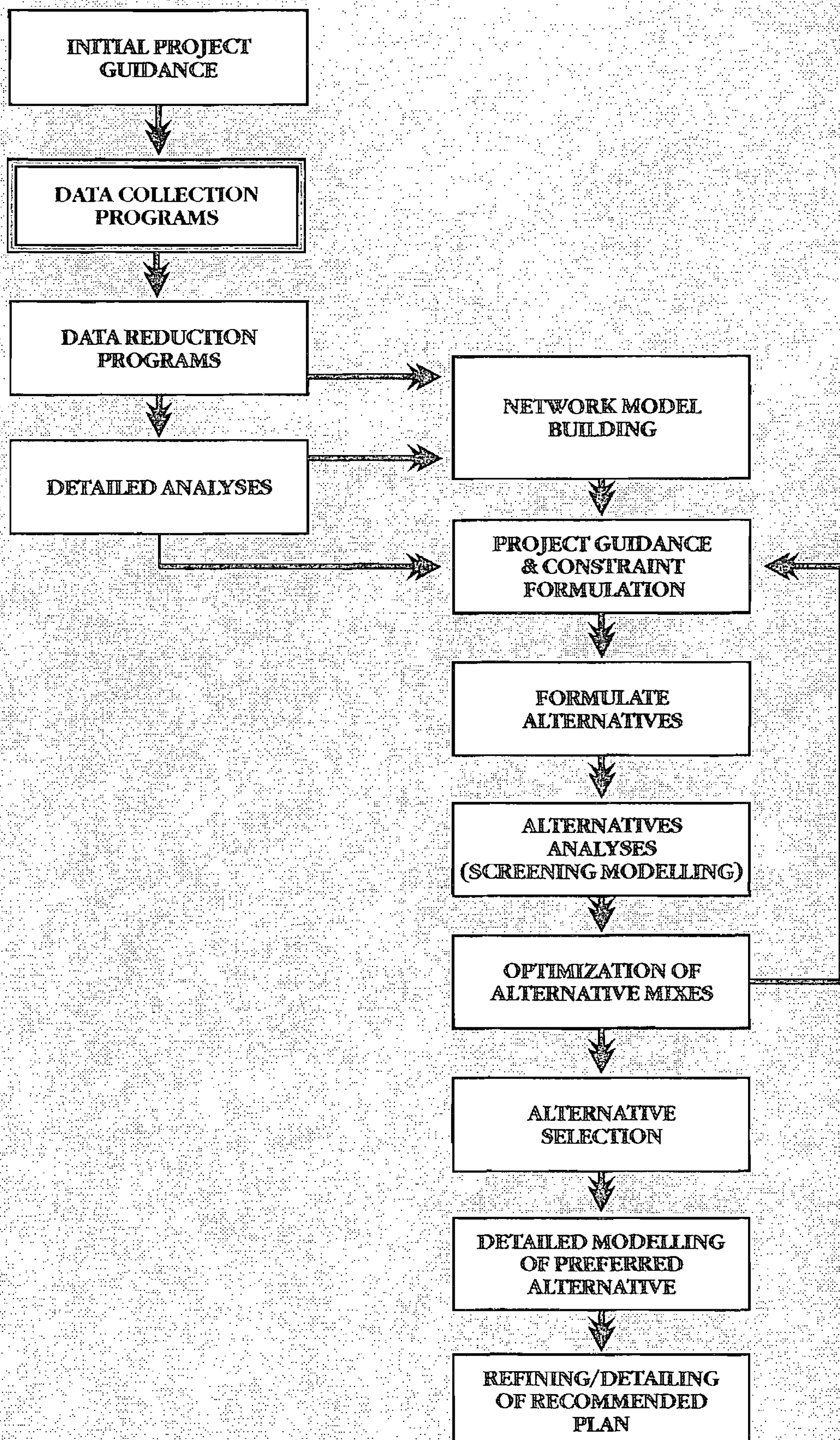
8. FINALIZE DETAILS OF DATA COLLECTION PROGRAM

Accounting for all objective adjustment, regulatory requirements, critical deficiencies, resource allocations and final problem definitions, the scope and cost of the data collection program will be finalized. These details will also specify finalized data formats to increase data reduction efficiency.

This task will culminate in the generation of a final data collection program that includes:

a) Restatement of Project Objectives
b) Brief Summary of Existing Data Sets
c) Statement of Data Deficiencies
d) Refinement of Data Collection Program
e) Adjustments to Data Management Systems

SECTION V.B


INITIAL PROJECT GUIDANCE
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OPTIMIZATION OF ALTERNATIVE MIXES
ALTERNATIVE SELECTION
DETAILED MODELLING OF PREFERRED ALTERNATIVE
REFINING/DETAILING OF RECOMMENDED PLAN

B. DATA COLLECTION PROGRAMS

At the outset of the planning effort it will be necessary to establish baseline conditions for the physical aspects of the surface water system. This includes surveying the canals, bridges and weirs to determine their actual dimensions. Characteristics of the piped system are relatively well documented by the cities as-built drawings. Since the accuracy of many of these drawings has been shown to be imperfect in the past, field verification will be required in areas which are projected for intense land use. Rainfall gauges, level recorders and flow meters will be used to collect additional information regarding actual conditions in piped systems and canals during and after a storm of known intensity and duration.

Soil type is difficult to map in Cape Coral because of the extensive soil mixing in the dredge fill process during construction of the City. It will be necessary to attempt to map soil type as accurately as is economically feasible. It should be noted that although the top few feet of soil in most parts of the City are difficult to describe, underlying layers might be describable with some regularity. Characteristics of underlying layers may have significant impact on surficial aquifer storage and must be understood.

Establishing a water quality baseline will also be necessary. An expanded monitoring program to collect samples from canals and inlets will be established. Measurement of chloride levels in key locations will be used for determining rate and direction of saltwater movement. Monitoring wells will be used to analyze the relationship between surficial and lower aquifers. The condition of the canals with respect to weed growth will be recorded at the time that the canals are being surveyed.

Certain key elements of the data collection program will be an ongoing effort. During this project a real time data collection network will be integrated with the City's proposed SCADA system. These data items include canal elevation, meteorologic data, water velocity, withdrawal flows and major water quality parameters. Recording of soil conditions found at excavations on City projects prior to and during the study will be useful.

The following is a description of data collection requirements and their importance to the Surface Water Master Plan development.

1. QUANTITY: DRAINAGE & SECONDARY IRRIGATION DRAINAGE

Drainage field investigations will focus on quantifying flows through the secondary system, the primary system and net discharge from the City. Necessary data collection efforts are described below.

a) **Establish Horizontal and Vertical Control**

This field survey effort will establish State Plane Coordinates and Elevations at numerous locations throughout the study area in preparation for photogammetry and GIS development. This information will be used to establish bench loops and to set temporary and permanent bench marks throughout the study area. Accuracy of the GIS is highly dependent on the accuracy of the coordinate base. Inaccuracies in developing the base map will propagate throughout all coverage that are subsequently entered.

b) **Photogammetry and Preparation of Topologic Data**

In conjunction with establishing survey control, upland survey information will be recorded in order to define and delineate sub-basins throughout the City. This information will be used in almost every aspect of the project including design of drainage systems, watershed contributions, establishment of basin boundaries, establishment of unit hydrographs and the exploration of design alternatives.

Photogammetry should cover not only the City, but also all contributing areas, including Gator Slough. Results of this effort will be provided on a horizontally rectified photo base at a scale of 1'' = 200' with one foot contours. In addition, all planimetric data including contours and spot elevations will be provided in digital form in State Plane Coordinates. National Map Accuracy Standards should be required related to altitude versus accuracy and contour interval. Spot elevations should be given at least at all street intersections, at all waterway crossings (street crown), low and high points in streets, tops of seawalls (where possible) and other significant locations.

c) **Canal Centerline Survey**

Previous reports (USGS, 1985) have shown that surprising variations in canal bathymetry may be encountered throughout the Cape. Fathometer profiles will be obtained for all wet canal systems. These will be obtained from a boat moving at a constant speed and registered to periodic shoreline markers or locational data logging devices. Water surface elevations will be recorded at the same time so that bottom elevations (with respect to NGVD) can be obtained.

The resulting profiles will have several uses for the study. They will be used to develop the cross section survey program, to locate deep canal key cuts and to map cross sections of lakes. They may also provide a qualitative evaluation of depth of organic layers in the deeper sections. (See Appendix A.4)

d) **Cross Section Surveys**

Canal cross sections surveys will be performed to characterize the hydraulic sections throughout the canal system. Locations for such surveys will be chosen to best typify a particular segment of canal. Fathometer centerline surveys and aerial photography will be used to identify areas that may require additional detailed surveys.

Cross section surveys will be conducted only in enough detail to provide adequate canal description for setting up the computer model. Surveys will be directed for each canal branch at minimum. Additional cross section surveys will be conducted where significant changes in canal sections are suspected after reviewing aerial photos and centerline surveys.

Technologies currently exist that may provide screening level bathymetric data adequate for computer model construction and may be used in early phases of the survey program. A full detailed survey program will be developed to grow as the City grows. Representative sections throughout the City will be needed during model development. Typical cross sections may be extrapolated from aerial photography.

Cross sections will be obtained using traditional field survey techniques. If cost effective, these sections should be horizontally (State Plane System) as well as vertically controlled so that they can be placed into the City's GIS system. Initially, only enough cross sections to fully define the City's canal system as well as the Gator Slough system in sufficient detail for modelling purposes will be required. Additional cross section surveys will most likely be necessary for design and construction details.

e) Conduct Surveys of Weirs and Other Water Control Structures

Existing information and survey data regarding weirs and other water control structures throughout the cape will be verified, including control elevations, alterations, and weir dimensions, by inspection and survey. An assessment of the structural and hydraulic integrity of each control will be conducted at the same time. Figure 5.1 identifies a weir that separates saltwater and freshwater.

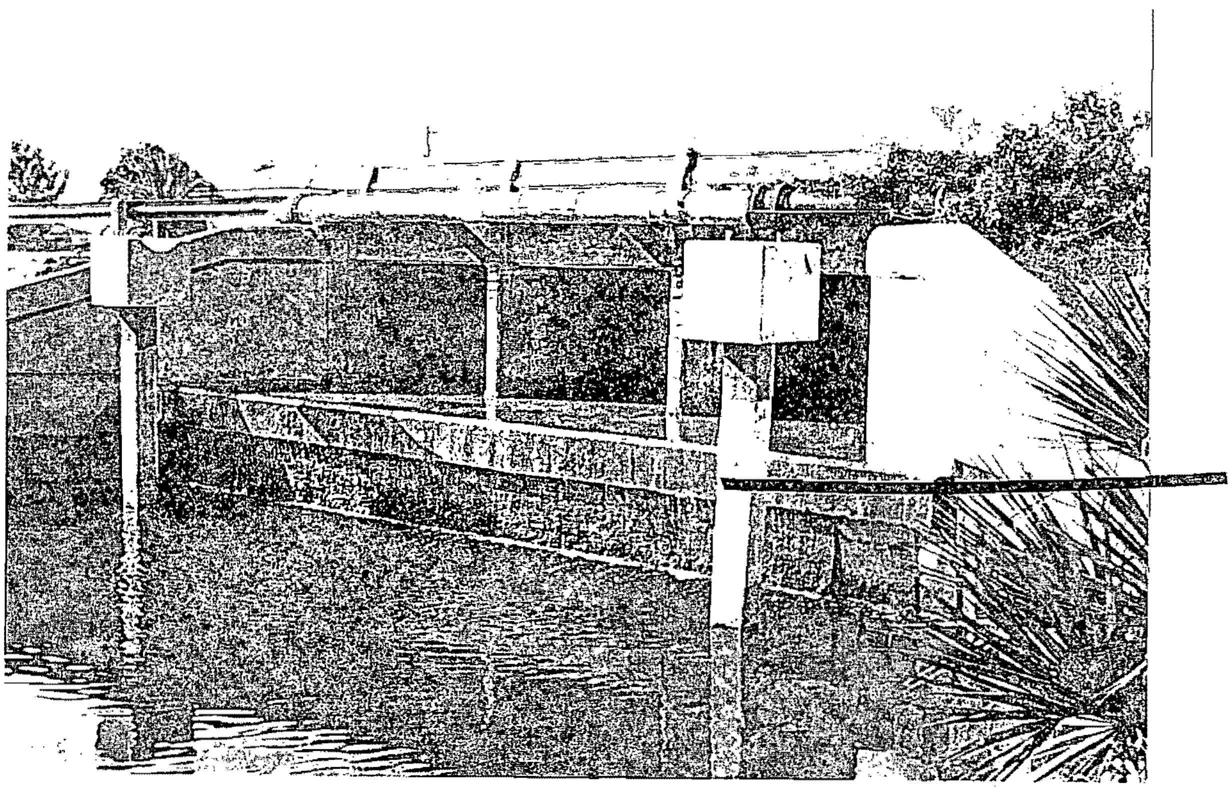
f) Inventory and Upgrade Types of Canal Protection Systems

An inventory of typical canal bank stabilization methods will be conducted. This information will be used to extrapolate the impacts of these various methods in the quantity, flow, and ecological segments of the program. Performance and expected life cycle costs may be evaluated. Figure 5.2 presents a photograph identifying two bank stabilization methods.

g) Survey and Inventory Pertinent Piping Systems and Appurtenances

Critical segments of the secondary drainage system will be inventoried and verified noting invert elevations and condition using narrative, photographs, and survey data. Selection of critical areas will be based on public safety, potential property damage, potential numbers of people affected and presence of existing problems. Surveys

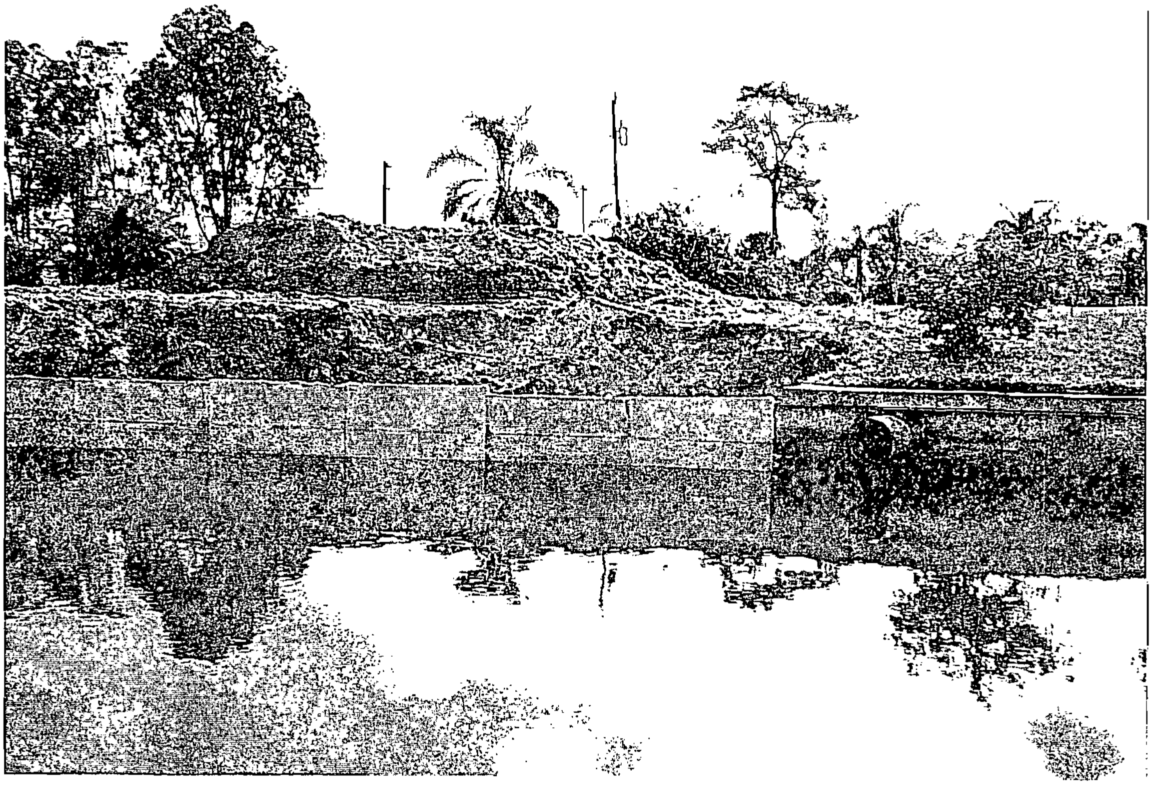
EXAMPLE OF A WEIR/CONTROL STRUCTURE FOUND WITHIN THE CANAL SYSTEM



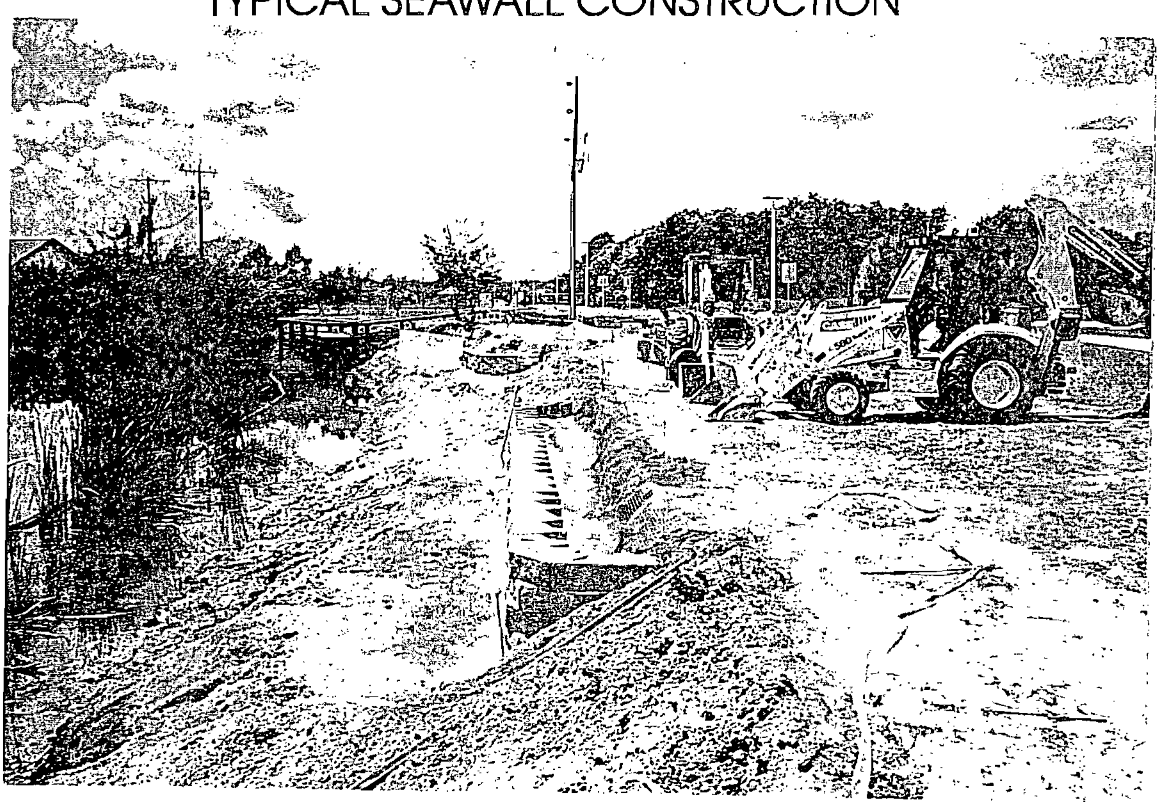
TYPICAL BRIDGE WEIR

FIGURE 5.1

CANAL BANK STABILIZATION ALTERNATIVES



TYPICAL SEAWALL CONSTRUCTION



BANK CONSTRUCTION WITH LITTORAL ZONE (SHELF)

FIGURE 5.2

conducted during this project will concentrate on problem areas, primary arteries, and areas expected to experience intense development over the next few years. It is estimated that the initial survey will cover approximately 25 percent of the existing secondary drainage service area. This survey information will be used to verify, modify, and add pertinent information to existing City drainage maps. (See Appendix A.4, A.5 and C)

Following the initial survey, a program for continued data collection and drainage map correction will be developed for implementation.

h) Catalog Existing Stormwater BMP (and Type) Throughout Area

The most common applications of Best Management Practices (BMP's) in the City will be cataloged. This will be the first step in evaluating the effectiveness of BMP's and will provide insight for improvements. This effort will be conducted in conjunction with pipe surveys described above and other data collection programs described below. (See Appendix A.12)

i) Conduct Physical (Topo and Soils) Survey of Spreader Canals

In addition to centerline fathometer and cross section surveys of the spreader waterways, investigations to reveal functional characteristics of the outer bank, or spreader weir will be conducted.

First a comparison of the bank elevation and tidal range will be performed to assess the effectiveness of the outer bank in preventing direct tidal intrusion. A full topographic survey of the spreader weir will be performed. Also, several tide gauging locations will be established inside and outside of the spreader weir for several months. A long term tide and weather station will be established to assist determining potential intrusion during extraordinary events. Volumes of saline water for various return interval storms will be estimated. This data will be used to establish most economical protection and saltwater removal systems.

Secondly, soil surveys in the vicinity of the spreader waterway will be conducted in an effort to quantify the potential for saline intrusion via groundwater seepage. Piezometric sections may be established to measure groundwater elevation response to tidal influence.

Measurement of the propagation of saline fronts (if they exist) using salinity profiles, both in groundwater and surface water will complete the picture of the spreader canal's susceptibility to saline intrusion. Groundwater salinity will be measured in the piezometers placed along the piezometric sections. (See Appendix A.7)

j) Conduct Rainfall and Evaporation Measurements

Rainfall, temperature, and evaporation stations will be established in various locations throughout the study area. This data may be used to calibrate historical observations at nearby stations to local conditions. Evaporation data is also a key piece of information necessary to understand the complete hydrologic cycle. Real time rainfall gauges along with real time stage data may be used in the future to anticipate necessary operational adjustments for the canal system. (See Appendix A.10)

k) Conduct Specialized Canal Conveyance Evaluations

Representative canal sections will be identified and studied to determine variations in flow characteristics (i.e. Mannings "n") along typical channel reaches. These measurements will be used in the computer model and to determine which cross section designs may best suit the City's surface water needs.

l) Conduct Network Hydrologic and Hydraulic Discharge Measurements

Canals will be instrumented at key points throughout the City to provide vital flow information. Gauge records will be used in conjunction with rainfall data to determine the runoff characteristics within major hydrologic units. This flow information will assist in developing the surface water management model and water quality model (to be explained in a later sub-section). In the early stages of this project, this information will enable the development of preliminary canal control elevation management methods during extreme storm events.

A permanent data collection program is recommended for use not only within this study but also as a monitoring and control support system in the future. It will consist of recorder measurements of rainfall, stage, water temperature, conductivity, and pH. It is estimated that between 25 and 30 sites, in addition to the 10 sites currently maintained by USGS, would be required within the City and in Gator Slough. These data should be directed to local data loggers for monthly retrieval and storage in the data base. Ultimately, the City may wish to tie them directly into SCADA via telephone line, cables, or telemetry. Capability would also be upgraded if operable structures are added. Gate openings or movable weir crest elevations can then be logged and/or remotely changed. (See Appendix A.4 and F)

m) Tidal Flow Measurement

Detailed flow and elevation measurements will be made at several locations in the tidal canal system over several months to accurately determine the tidal conditions at the Cape boundary and within the canal system. This information will then be used to develop synthetic tide records and prediction through correlation with NOAA tidal coefficients using harmonic analysis. Permanent tide stations will be established at key locations for long-term monitoring. The data collected during this study will augment the information presented in a U.S. Geological survey flushing study.

This information will be used to evaluate alternative modifications to the canal system to improve circulation and thus water quality through the saltwater canals. Incorporating this type of investigation within the Surface Water Management Program will necessitate consideration of all of the City's objectives rather than only those of narrowly focused studies.

n) Conduct Piezometric Transect and Seepage Measurements in Representative Areas Throughout the Study Area

The canal system's ability to provide freshwater for the City's secondary water system is of major concern to city planners. Typical measurement apparatuses are shown in Figure 5.3. It has not yet been conclusively shown that the canal-surficial aquifer system will store and yield future demands. The field investigations will provide the necessary data to conclusively support the feasibility of tapping the canal-surficial aquifer system as a freshwater resource. (See Appendix A.11)

i) Aquifer - Canal Response - One of the key factors affecting freshwater availability for irrigation is the water table storage seepage characteristics. The PBS&J study concluded that runoff and surface water storage would account for only 20 percent of the supplemental irrigation demand during the 1 in 10 year drought when the City is fully developed. The remaining 80 percent would come from water table storage. The rate at which seepage can occur under varying canal and water table elevations is therefore an essential parameter to determine whether the additional 80 percent can be made available. The purpose of these field studies is to directly measure this parameter at representative sites in the City. This will be accomplished by establishing piezometric transects perpendicular to canals throughout the City and monitoring water table elevation response to canal elevation changes and precipitation patterns.

Locations for piezometer transect sites will be selected to ensure variations in soil conditions are adequately described. Each transect should have at least four peizometers for regular water table readings. In addition, monthly seepage measurements (using seepage meters) will be obtained over a period of one week to quantify exchange between the surface water system and the water table. These data will be reduced to seepage rate versus head difference and used directly in the computer model.

Transect sites may be chosen after detailed soil information has been compiled. Test sites will be located where:

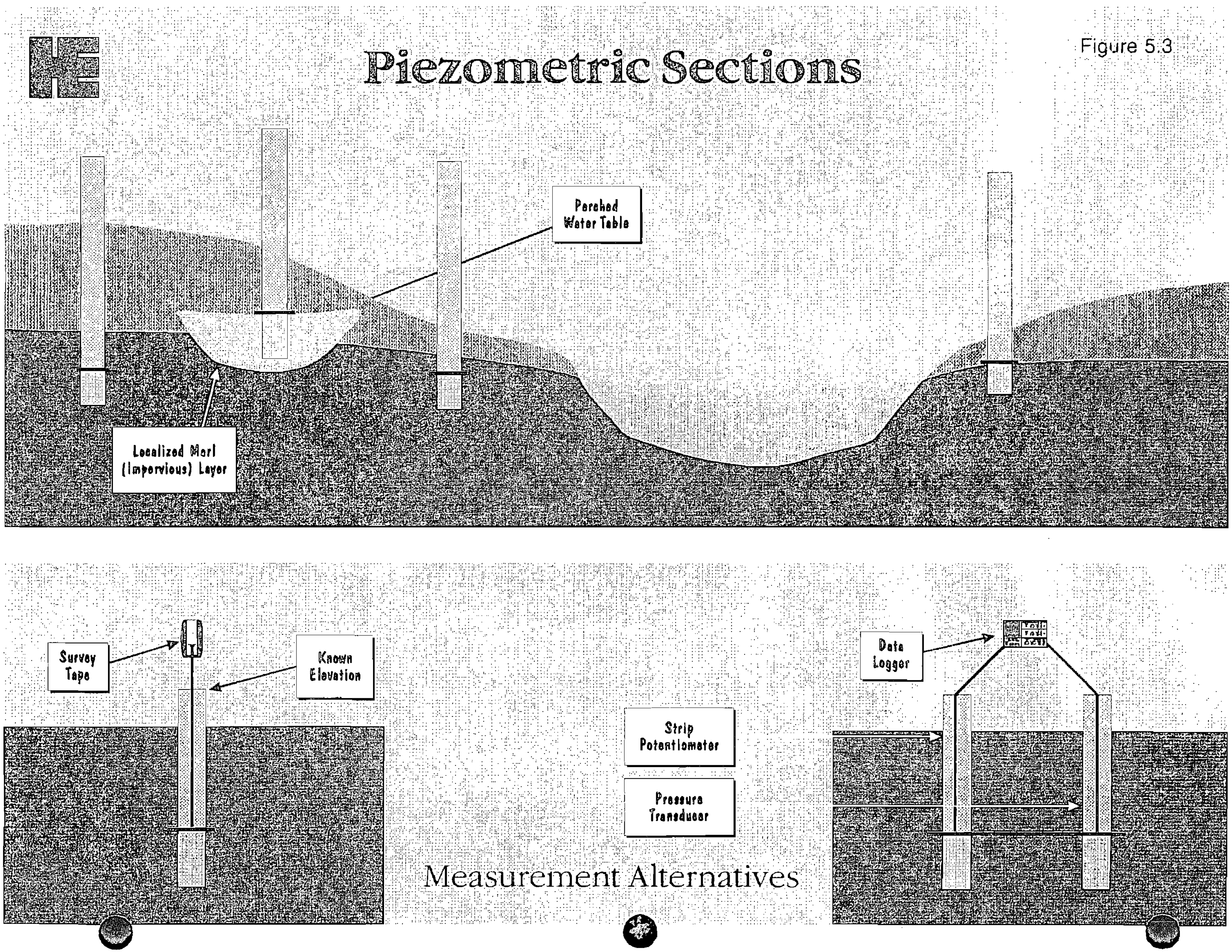

Piezometric Sections
Perched Water Table
Localized Marl (Impervious) Layer
Survey Tape
Known Elevation
Strip Potentiometer
Pressure Transducer
Data Logger
Measurement Alternatives

Figure 5.3

- Representative soil strata are expected.

- Zones where saltwater interaction with the freshwater aquifer is suspected.

- Zones where there are significant changes in canal elevation (near weirs).

The duration of this study should be at least one year so that the seasonal range of fluctuation can be measured.

A unique opportunity to qualitatively study seepage processes in the surficial aquifer will exist over the next two years as significant trench excavations will be performed while the gravity sewer system is installed throughout the City. Well planned and timed field studies may enable cost effective quantitative data collection.

ii) Aquifer Recharge Processes - Understanding surficial aquifer recharge processes is necessary to develop an accurate water budget model. Percolation tests will be performed in areas where adequate data is not available in order to typify vertical seepage for various land use and soil types. Evaluations of various temporary storage facilities (BMP's) will be conducted in order to quantify their effectiveness in enhancing vertical seepage and groundwater recharge. Variability in age, maintenance record, groundcover type, design and location will be evaluated. This data will assist in establishing effective stormwater permit criteria and development of groundwater recharge estimates.

Sites will be selected based on how well they are expected to represent conditions in other areas, preferably in the center of soil group designation zones. Percolation tests will also be performed in areas where surface infiltration works well and also where it does not. These tests will typically be conducted in conjunction with BMP effectiveness and improvement tests.

o) Soil Horizon Characterization

Local experience has indicated that surficial aquifer processes may be heavily influenced by localized soil strata. Impervious marl or clay layers may appear at any soil depth often reducing or preventing vertical percolation. It will be important, therefore, to collect the necessary data to understand the dynamics of vertical and horizontal groundwater movement. Data collection includes laboratory analysis of boring data, vertical percolation tests at various locations throughout the cape and development of map overlays of Soil Conservation Service maps and pre-development (c. 1958) aerial photographs.

Significant soil investigations have been conducted as part of the preparation for sewer construction in the Orange and Green Areas. These investigations may be sufficient to determine the value of additional characterizations in other parts of the City and the level of detail of these characterizations. Sewer pre-construction site investigations will also be used to the maximum extent possible.

2. WATER QUALITY

It is expected that maintenance of surface water quality will become an increasingly important issue in the future. State and federal agencies interested in some aspects of the quality of Cape Corals surface water include the US EPA through its NPDES program, State of Florida Department of Environmental Regulation (DER), Florida Department of Natural Resources and the citizens of Cape Coral.

Maintaining the good water quality standards generally seen throughout the City will very likely become an increasingly difficult task as more residents settle in Cape Coral. The data collection and analysis program will determine which methods and alternatives provide the best and most efficient means of maintaining surface water quality. The experience gained through these investigations will prepare the City to address water quality issues in advance of future development.

Proposed water quality programs may take two distinct approaches, system-wide characterization and localized detailed characterization. The choice of which approach to take is contingent on what is to be accomplished with the data and which will be deemed to be most accurate for the given purposes.

System-wide characterizations will be conducted in order to verify and calibrate both the system flow model and water quality models. Data collection efforts will be designed to gain an understanding of specific system-wide processes such as seasonal variations in water quality, salinity changes, and general health of the surface waters. Sample locations will be selected to include the combined contributions from many portions of the City. The detailed level approach assumes that all systems will behave in similar manners and give similar results. This approach would measure pollutant and quantity contributions from individual land pieces within a basin and predict resultant water quality at the outfall. Homogeneity of conditions outside test elements is assumed in this approach. An example of this would require sampling at the outfall of a particular basin and determining what upland characteristics within the basin cause water to be of a certain quality. This process may be repeated for a number of basins and comparative analysis conducted to build associations between water quality constituents and upland factors. The advantage of conducting micro-level measurements is that detailed understanding of the processes affecting water quality is gained. The drawback is of course, all assumptions are rarely valid from one location to another.

Of course neither approach will completely address the complex needs of the Surface Water Master Plan. Both approaches will be applied to most fully understand the surface water system. The system level investigations will be used to construct typical resultant water qualities within the city-wide model and to verify the influence of commonly encountered factors. Extrapolations may be verified basin by basin using system-wide results. The detailed level approach will be used to verify some of the internal assumptions made in the system-wide investigations. They will also be used to evaluate the effectiveness of various stormwater source controls.

a) System-Wide Level Investigations

i) Network Sampling - Instrumented measurements of water quality will be conducted throughout the City in conjunction with the hydrologic response measurements. Data retrieval or logging systems will be employed to gather both flow and water quality parameters such as pH, temperature and salinity, increasing the efficiency and effectiveness of the data collection network.

Approximately 30 sample sites will be selected to maximize drainage basin coverage while providing necessary detail to adequately describe the effects of upland characteristics. Factors to be considered in sample site choice include land use, historic sample locations, river influence, and drainage basin size. About half of the network stations will be outfitted to obtain more specific parameters depending on location. These parameters include suspended solids, nutrients (total phosphorous, organic phosphorous and nitrogen) dissolved oxygen, COD and BOD, selected metals and chlorides. These parameters should be monitored for at least 1 year.

Data collected under this system-wide program will be used to verify and calibrate the system flow computer model. Water samples will be collected to establish baseline conditions at various locations, determine the useability of canal water especially in areas subject to saline intrusion, and monitor seasonal changes.

Measurements will be performed on individual sub-basins (single secondary drainage network) as well as at strategic points within larger watersheds. Measurement location will be carefully chosen to consider completeness of basin coverage and previous sample efforts.

ii) Enhanced ERD Program - The current city-wide sampling program, conducted by the Environmental Resources Division (ERD), is designed to monitor long term trends at fixed locations throughout the City. While these data are valuable, ERD is understaffed and unable to conduct both the regular sampling program and address specific water quality data needs. Sampling efforts will consider special problem areas and ERD data will be augmented by the addition of sampling stations. Special sample collection oriented towards investigating specific problem areas and their net effect on the entire system will also enlarge coverage of the existing sampling program. These include comparisons of regional divisions such as septic versus sewered areas, heavily developed and undeveloped areas, relative home value and boat density.

Physical characteristics of the canal system will also be considered in this process including dead-end canals, well flushed versus poorly flushed tidal canals, salinity and dissolved oxygen distribution in canal key cuts and other deep areas (see Appendix A.7). Solutions to these problems will eventually be proposed once the prevalence and severity indicated during these investigations are complete.

b) Detail Level Investigations

Detail level measurements described below may take place under combined sampling programs. Runoff event sampling programs may be planned so multiple analysis can be conducted from individual sample sets. Measurement will primarily consist of automatic and manual sampling of runoff events.

These measurements will be structured for determining probable characteristic pollutants. This task will seek to identify and quantify specific pollutant types and sources in specific land use areas. The characterization of pollutants by land use category will greatly assist in the choice of BMP's in future designs. Some sample locations will be used to measure influences of specific upland conditions such as land use impacts.

i) Special Dry and Wet Season Sub-Surface Detailed Measurement Programs- Several investigations will be made to determine characteristic pollutant loadings from specific land uses. These measurements will provide the basis for the city-wide water quality computer model development. They will also assist in choosing the best BMP's to effect the greatest benefit to water quality.

These programs are designed to reveal the pollutant source/sink processes as they are related to groundwater. The objective is to model the effects groundwater flows have on surface water quality. This will be accomplished by comparing selected water quality parameters between nearly physically identical areas with the exception of the tested affect. For instance, parameters at a site with sewers installed will be compared with a site without central sewer. Test and control (null) sites will be established for each of the following pairs.

Test	Null
• Installed sewers	• No sewers but septic tank
• Septic tank	• No sewer or septic
• Irrigation water use	• No irrigation used
• Developing areas	• Areas without construction activities

Previous investigations (Personal Communications, ERD, 1992) have indicated that some soil types in Cape Coral contribute phosphorous and possibly other chemicals to the surface water. Field measurements are required to quantify net and total contributions of natural and human sources. The effects of water and environmental chemistry may play an important role in soil-water interactions. This should be quantified in order to properly determine nutrient sources including fertilizers, septic tank leachate and natural soil contributions. (See Appendix A.7)

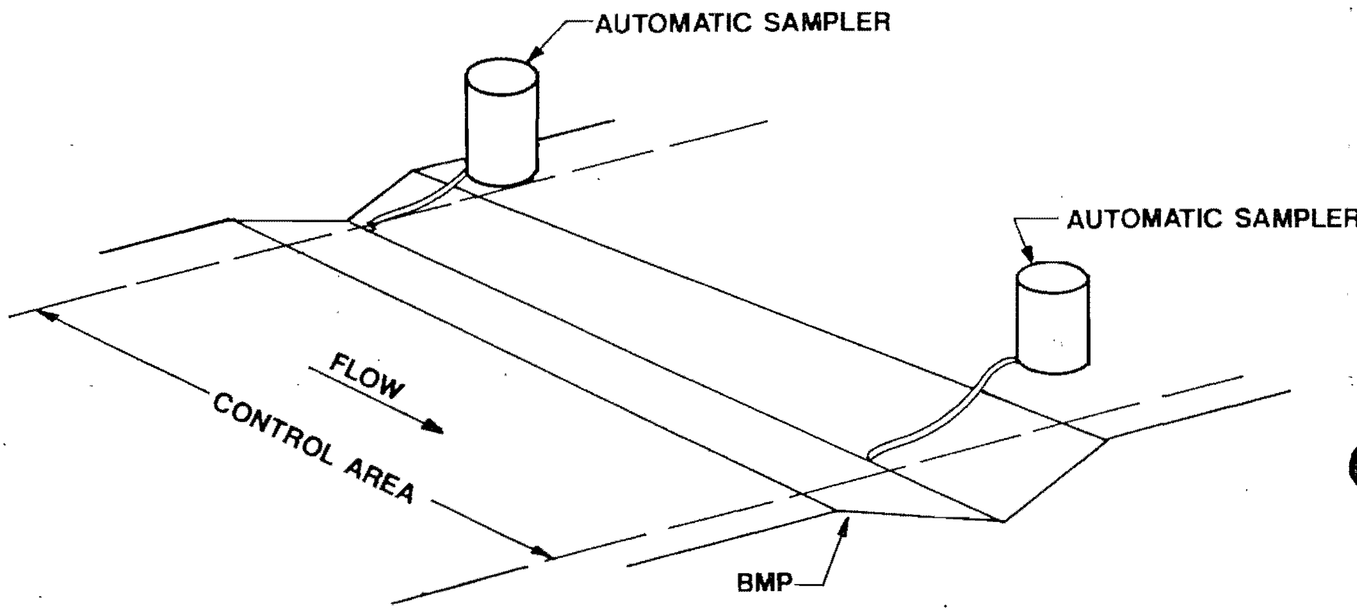
Field investigations will include an analysis of the potential nutrient concentration increases as irrigation water is cycled from the canal, spray irrigated, passed overland and returned to the canal. Phosphorus and nitrogen increases may result as a combination of factors including treatment plant effluent, lawn fertilizers and possible evapo-condensing. This task will include seasonal event sampling to determine typical Event Mean Concentrations (EMC's) for various land uses and will include control samples to ensure background effects can be filtered out of the data record.

Up to six sites having different land use and soil combinations will be monitored for one year depending on when the field program is initiated. Investigations will also include measurement of nutrient loadings from septic tank effluents to augment existing literature. Most test sites will be packaged with BMP effectiveness tests described below.

ii) BMP Effectiveness Tests - During the late 1970's, a series of BMP's were developed by various organizations such as FDER and USEPA for urbanizing areas that could remove urban pollutants and, in some cases, protect downstream aquatic life. Most of these practices involved extra detention, retention or infiltration of urban stormwater to enhance pollutant removal and provide additional stormwater management. Initial field testing demonstrated that BMP's could serve a dual purpose; controlling non-point source pollution from urban areas while providing effective stormwater quantity management.

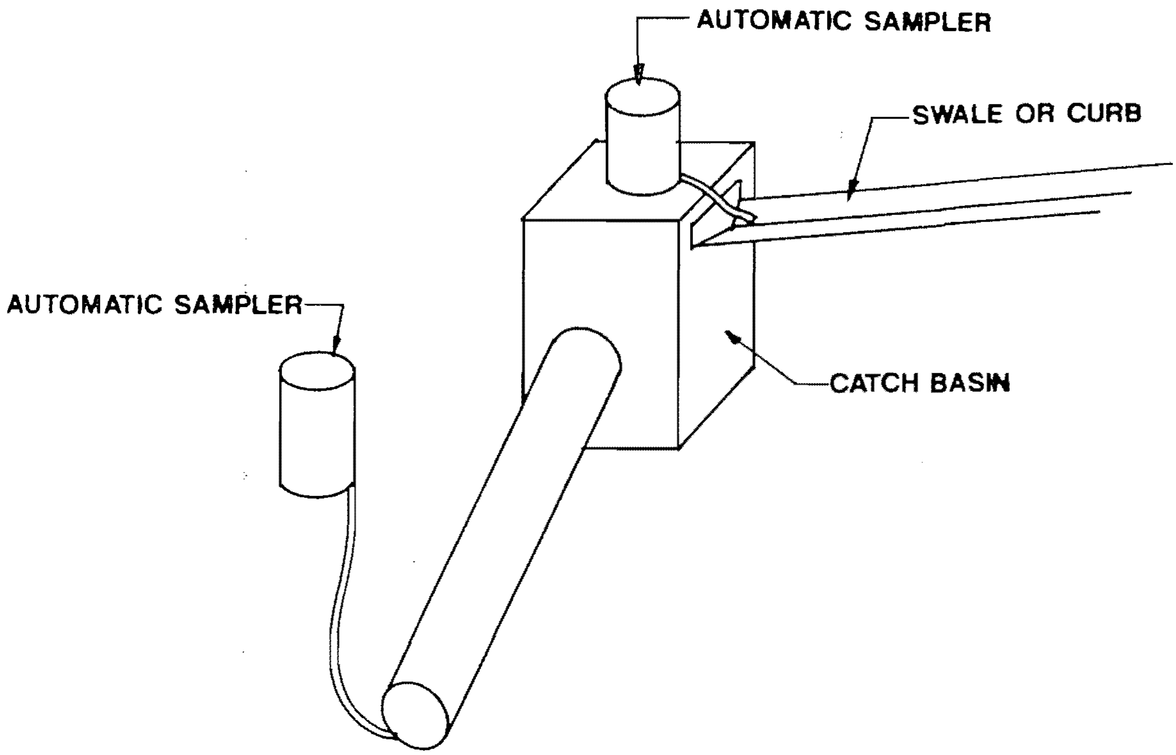
The Master Plan will seek to maximize pollutant removal, minimize implementation costs, reduce future maintenance and blend BMP's into the landscape. A number of new and existing BMP designs will be screened for probable success in Cape Coral's unique environment. Promising BMP upgrades will be tested against existing practices. Test locations will be selected and designs prepared in cooperation with SFWMD and city personnel. Typical configurations are depicted in Figures 5.4 through 5.7. Field data collection will focus on pollutant removal effectiveness and the effects of age on chosen designs.

The information gained in these investigations will enable city personnel to better understand stormwater management practices and will provide local engineers and developers with valuable elements for effective BMP design. Field investigations will help to quantify the following:



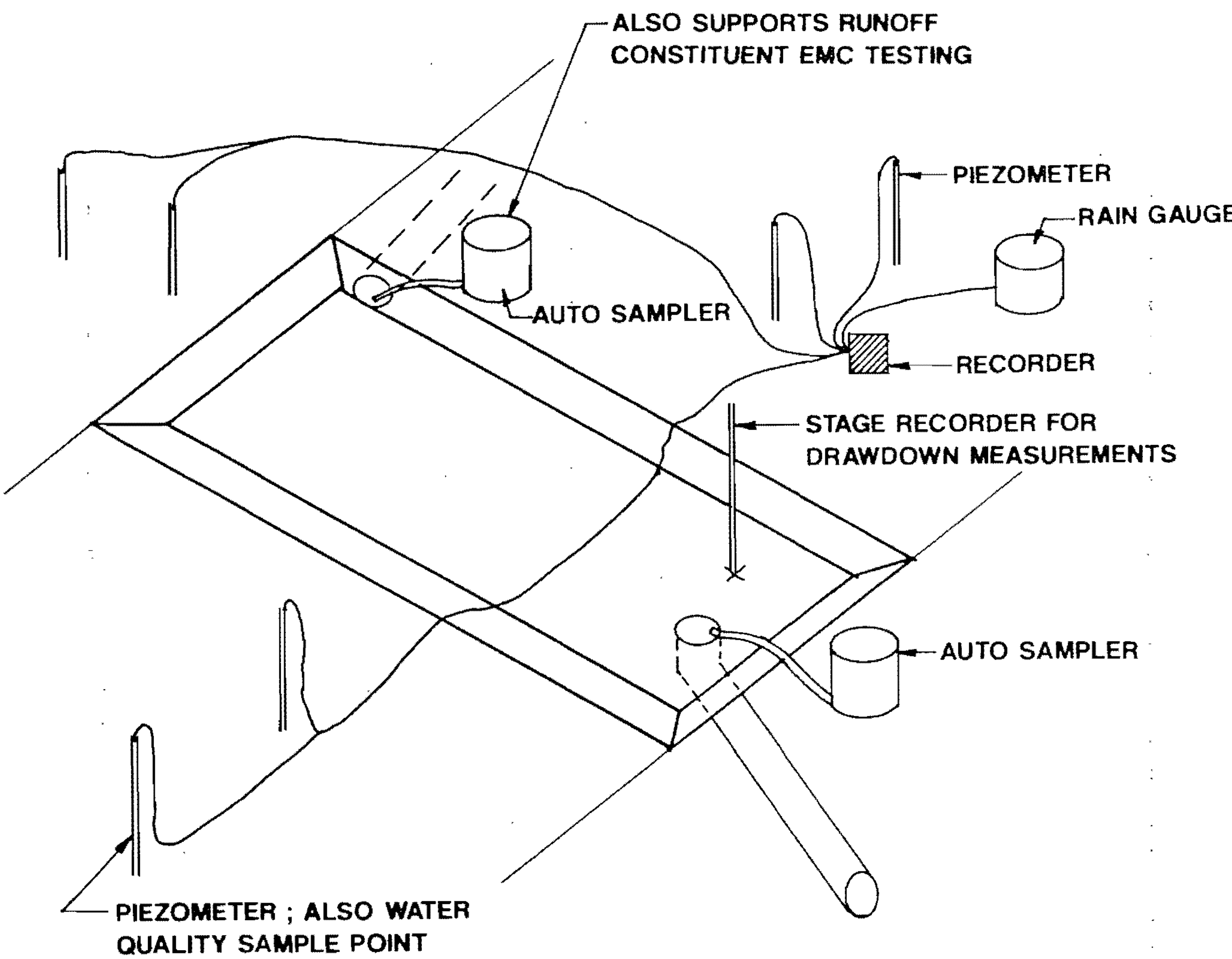
SWALE TEST

FIGURE 5.4



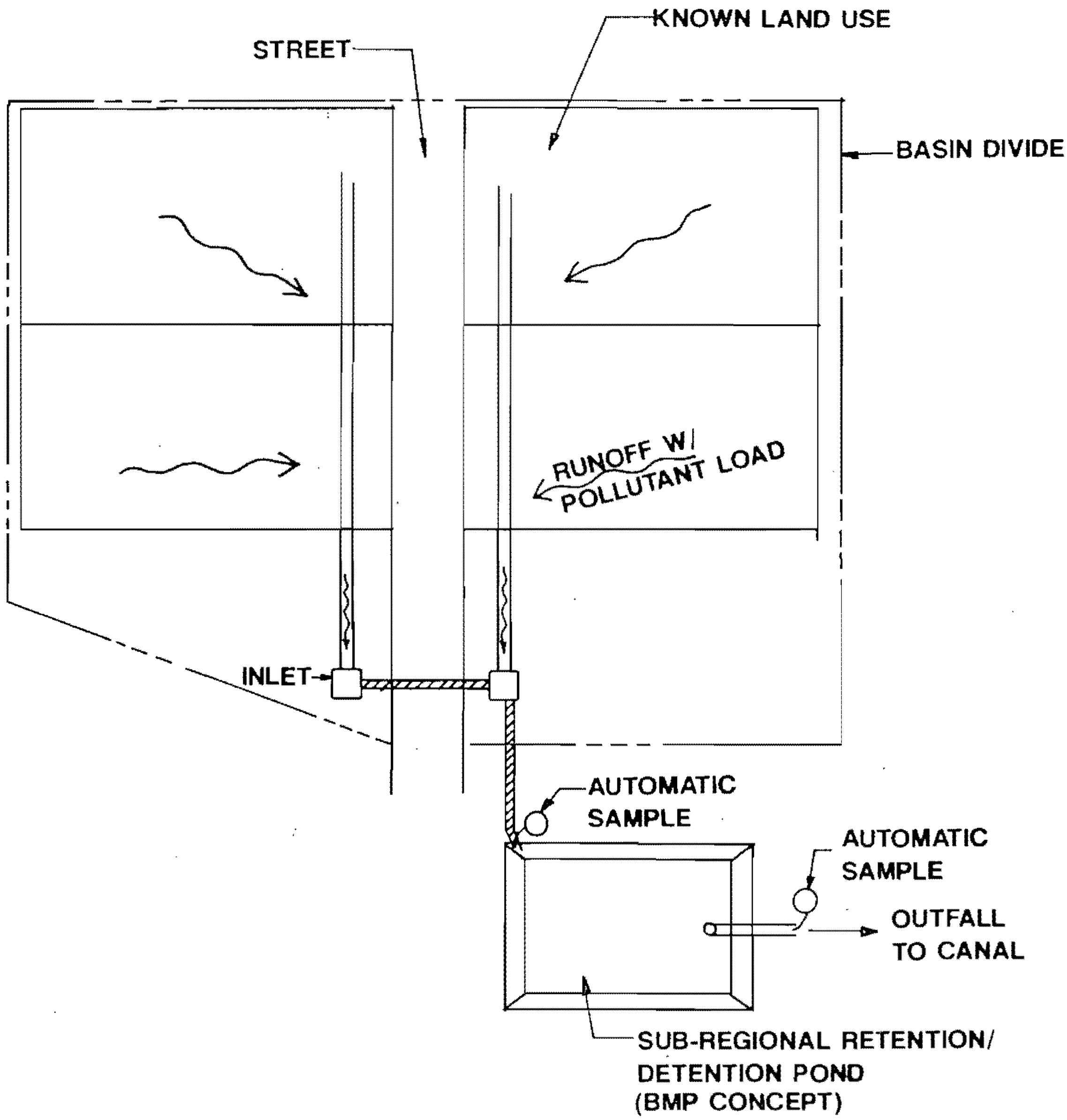
CATCH BASIN TEST

FIGURE 5.5



RETENTION POND
EFFECTIVENESS & SEEPAGE TEST

FIGURE 5.6



LAND USE POLLUTANT CONTRIBUTION DETERMINATION

FIGURE 5.7

- Types of stormwater benefits provided by the BMP and how they can be augmented.

- Performance levels it is likely to have in removing urban pollutants and how it can be enhanced in the design phase.

- What site conditions prevent or restrict the use of the BMP.

- How much it will cost to construct the BMP.

- What are the routine and non-routine maintenance tasks that must be performed for the BMP to function as intended and how much will these cost.

- What design and construction techniques are needed to prevent premature failure of the BMP.

- Determination of adverse or positive impacts the BMP will have on local habitat or downstream aquatic life.

- Evaluation of impacts the BMP will have on the human environment (i.e. safety, recreation, community acceptance).

Existing and potential new BMP designs will be screened for likely success in the unique environment in Cape Coral. Selected designs will be field tested in a demonstration project format. Inflow and outflow water quality parameters will be measured to determine the effectiveness of various BMP designs. Effective new BMP's and enhancements to existing BMP's will be cataloged and well documented for their applicability to particular needs of projects throughout the City.

Some measurement programs may supply data for multiple studies. Many of the measurements needed for BMP testing will be incorporated into other data collection programs such as those involving soil tests, land use emission quantification or the collection of baseline data. BMP types that will be included in this program are listed below.

- Existing Swales
- Modified Swales
- Drainage Systems With Inlets Converted to Catch Basins and Other Inline Treatment Methods
- Onsite and Inline Infiltration/Exfiltration Trenches
- Community Retention/Detention Treatment Ponds

- Regional online and offline treatment segments within canal systems including wetland treatment, hyacinth harvesting and other canal improvements to increase treatment.

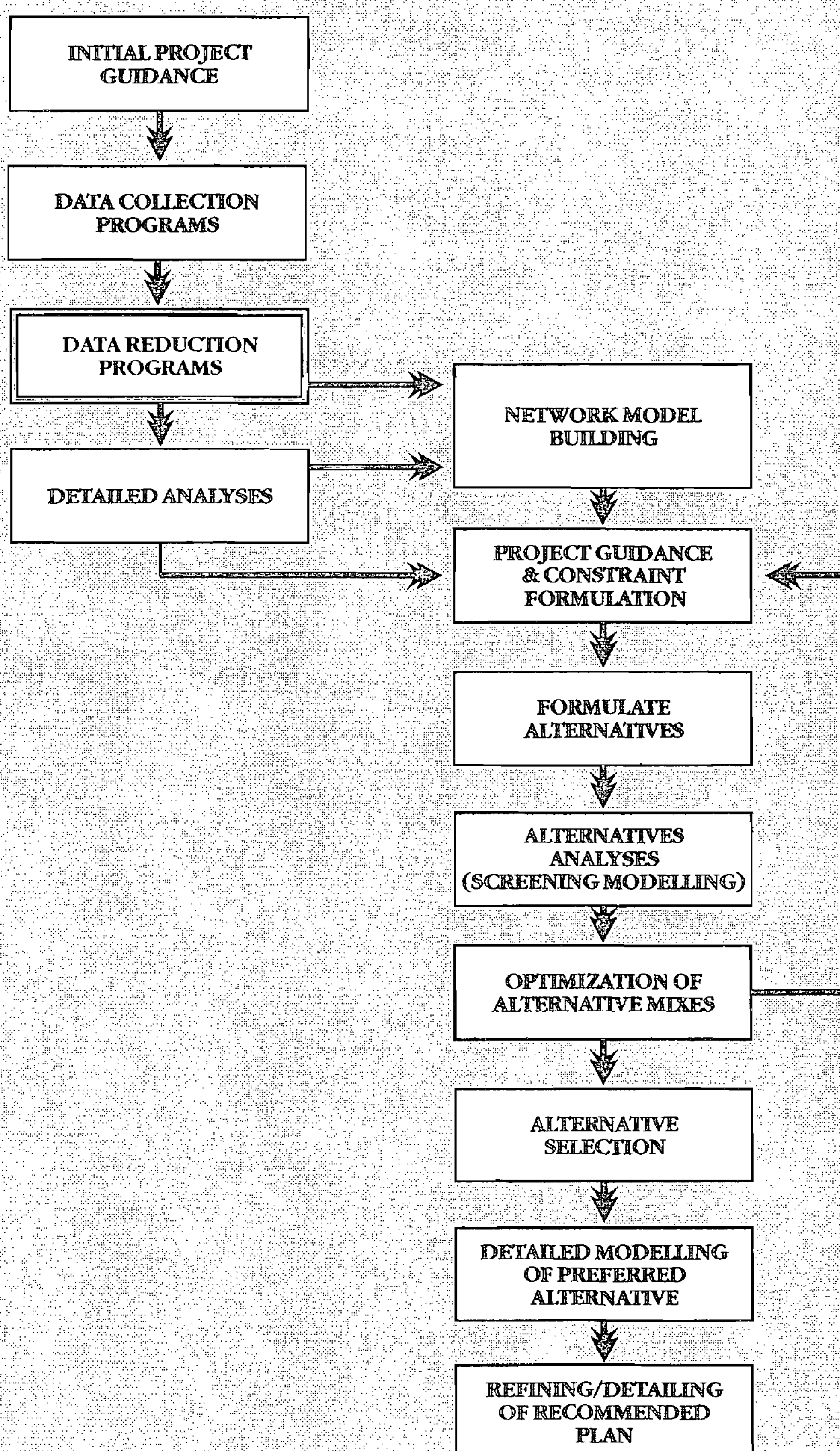
iii) Aquatic Plant and Biological Surveys with Water Quality Sampling - Examination for the presence or absence of indicator aquatic plant species may provide a cost effective means of measuring health or degradation of water bodies and other environments. Sampling and analysis of organism flesh is another means by which long term health of the system may be measured. By matching biologic conditions with water quality parameters, relative health of canal sections might be more rapidly assessed and problem solutions more rapidly found.
Additional ecosystem evaluations may be conducted within mangrove areas adjacent to the City to establish baseline condition data on ecosystem health, seasonal salinities, etc. These evaluations will also help to provide a verifiable understanding of the net effects of freshwater flow alterations such as increased wet season peak discharges or dry season restriction of freshwater.

Sporadic biologic screenings have been conducted throughout Cape Coral in the past. New screenings will help construct a baseline picture of the condition of the surface water system from which changes may be identified as they occur. Once changes are identified as either positive or negative, modifications to the management program may be initiated to produce desired results.

c) Limited Chloride Surveys of Sanitary Sewer Systems

A limited sampling program may be conducted to determine the extent of saline intrusion into the City sewer system. This data may be used in conjunction with utility department data in determining expected chloride loads reaching the irrigation system and steps to reduce chlorides in the system.

SECTION V.C


INITIAL PROJECT GUIDANCE
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NETWORK MODEL BUILDING
PROJECT GUIDANCE & CONSTRAINT FORMULATION
FORMULATE ALTERNATIVES
ALTERNATIVES ANALYSES (SCREENING MODELLING)
OPTIMIZATION OF ALTERNATIVE MIXES
ALTERNATIVE SELECTION
DETAILED MODELLING OF PREFERRED ALTERNATIVE
REFINING/DETAILING OF RECOMMENDED PLAN

C. DATA REDUCTION PROGRAMS

Data reduction is the process of converting raw data into useable and analyzable forms. Data reduction differs from data collection in that the raw data points are arranged to form a picture of the processes measured in the field. Reduction involves formulating mathematical relationships between measurements into real and understandable quantities. Reduction programs will be developed concurrently with the development of data collection programs to assure efficiency and data quality.

The approach to data reduction and storage for a project of this magnitude and complexity must be carefully chosen. The approach must allow for sufficient detail for the maintenance of special investigative data (such as BMP tests) while also permitting the use of city-wide data (such as land use boundaries) for network model applications. It should also be structured to become a permanent tool for the utilization of data collected prior to and during this project. This can be used as an input point for future data collection efforts.

1. APPLICATION OF GIS TECHNOLOGIES

Technical data acquired throughout the project will be maintained within a Geographic Information System (GIS). A GIS combines the power of computerized data bases and the analytic display of computer graphics to rapidly and effectively manipulate and display large amounts of data in understandable pictures. The power of a GIS is that it provides the means for rapid analysis of spatial and recorded data. Enormous amounts of data may be viewed and compared as they relate to location. Through its multi-layer processing capabilities, areas that possess any number of similar characteristics may be quickly identified.

GIS data is prepared in what is known as coverage. Coverages differ from maps by the addition of specific data to mapped entities. In GIS terminology, items that visually appear on the map are known as entities. Data that is attached to entities are known as attributes.

To create an analogy, imagine using a road map that shows roads connecting various towns throughout the state of Florida. Now imagine placing a selection device on a particular town and immediately being delivered a data list on that town that includes such information (or attributes) as the phone number and address list of every citizen, population trends, number of tourists each week and so on. GIS operates in much the same manner by delivering data tied to a particular entity on the electronic map.

Its real power, however lies in its ability to do comparative analyses within data lists and display them geographically. For instance, suppose flooding risk assessment is being conducted and it would be desirous to locate canal front homes in Cape Coral and sort them by elevation above sea level. GIS is capable of searching the data lists, effecting the analysis and displaying the results.

The GIS will provide a convenient means to access and display data on various aspects of the City's water infrastructure. Once the surface water management program is online, additional engineering, utility and public works information may be developed using the selected GIS. Also, since the selected software is a PC version of the City's recently selected mainframe GIS package, data transfer and integration will facilitate utilization of the system as an infrastructure management tool. (See Appendix F)

2. DATA COMPILATION

The GIS will be used to reduce, analyze and permanently store most of the system-wide information collected in the field data collection program. Data from small scale investigations might be stored on the GIS in raw or reduced form, depending on its usefulness to system-wide analysis.

a) Survey Reduction - Basin Delineation

Aerial photogammetry and ground elevation surveys will be used to develop accurate topographic maps. These maps will provide the basis for delineating watershed basins. Basin information will be combined with land-use and soils data to determine overland runoff characteristics throughout the City. An accurate understanding of basin characteristics is key to providing adequate drainage service.

b) Drainage Infrastructure

Existing drawings and maps of drainage structures will be entered into the GIS as a base record. Portions of this information will be used for computer model input data. All major control structures (weirs) will be field verified and mapped. Culvert size, slope, composition and elevations in critical areas will be field verified while non critical and non-problem drain pipes will be verified only as needed. Temporary storage and retention ponds may also be mapped with estimated or measured area, volume and retention or detention hydrographs entered in the database.

c) Canal Data

Data collected from canals include cross section and centerline depth, canal elevation, water quality data and discharge hydrographs. Further analysis may be conducted to determine the hydrologic response of basins and sub-basins.

d) Hydrologic Parameter Reduction

Hydrologic and water quality data files will be developed from field data. This data will be used for calibration and verification of network computer models for both event and continuous simulations. Field data stations will be mapped on the GIS and data will be stored within the GIS. Station data that will be reduced and stored include:

- Rainfall
- Evaporation
- Discharge
- Flow
- Groundwater Elevation
- Water Quality Sampling Data
- Canal Elevation
- Control Structure Elevation

e) Soil Information

Existing soil data will be complied on the GIS. This information will be used for comparative analysis in an effort to determine soil characteristics throughout the cape. Areas with limited or questionable data will then be further investigated to ensure proper soil characterization. Data sources include pre-development aerial photographs, pre-development contour maps, post development contour maps, soil borings data, SCS maps, and engineering test data.

f) Piezometric Surface

Groundwater elevation surveys will be reduced and displayed on a GIS water table coverage. Elevation changes over time will be easily recalled and displayed. By concurrently displaying groundwater elevation with soil types and various hydrologic parameters, surficial aquifer characteristics may be quantified. Computer models may be used to describe aquifer response to extreme events such as heavy rains or extended droughts. Analysis of this data will be used to make preliminary determinations of areas with potential high aquifer leakance, estimate storage and yield capacities, development of designs and implementation of management strategies.

g) Land Use

Existing and planned land use maps will be entered into the GIS. Land use type strongly affects runoff characteristics and pollutant contributions and will be a key data set used in the surface water computer modelling.

h) Freshwater Budget and Management

Canal elevation and piezometric surface information will be gathered by field survey initially and later through the SCADA system to determine the amount of water available within the system at a given time. Using real time stage data and canal survey information, the freshwater budget will be computed. This will provide the City with real time analysis of available water in the surface water system. GIS presentation may enable the rapid determination of the quantity of water available for use and where it is located. Control structure settings and other important factors could also be quickly analyzed and operational changes initiated based on the most current data. Seasonal planning decisions for control structure adjustment could also be made in advance of wet or dry seasons.

i) Tidal Flushing

Analysis of tidal flow information will improve prediction of salinity changes, pollutant transport and water circulation. System modifications similar to those proposed by USGS (1985) that improve water quality through enhanced circulation may be evaluated. Tidal flushing of the canal system may be a likely area for renewed regulatory scrutiny in the future.

j) Other Infrastructure

Other infrastructure information may be entered or refined on the GIS near the conclusion of the Surface Water Master Planning effort. This includes water, sewer and secondary water lines, roads and other technical information the City wishes to maintain on the system.

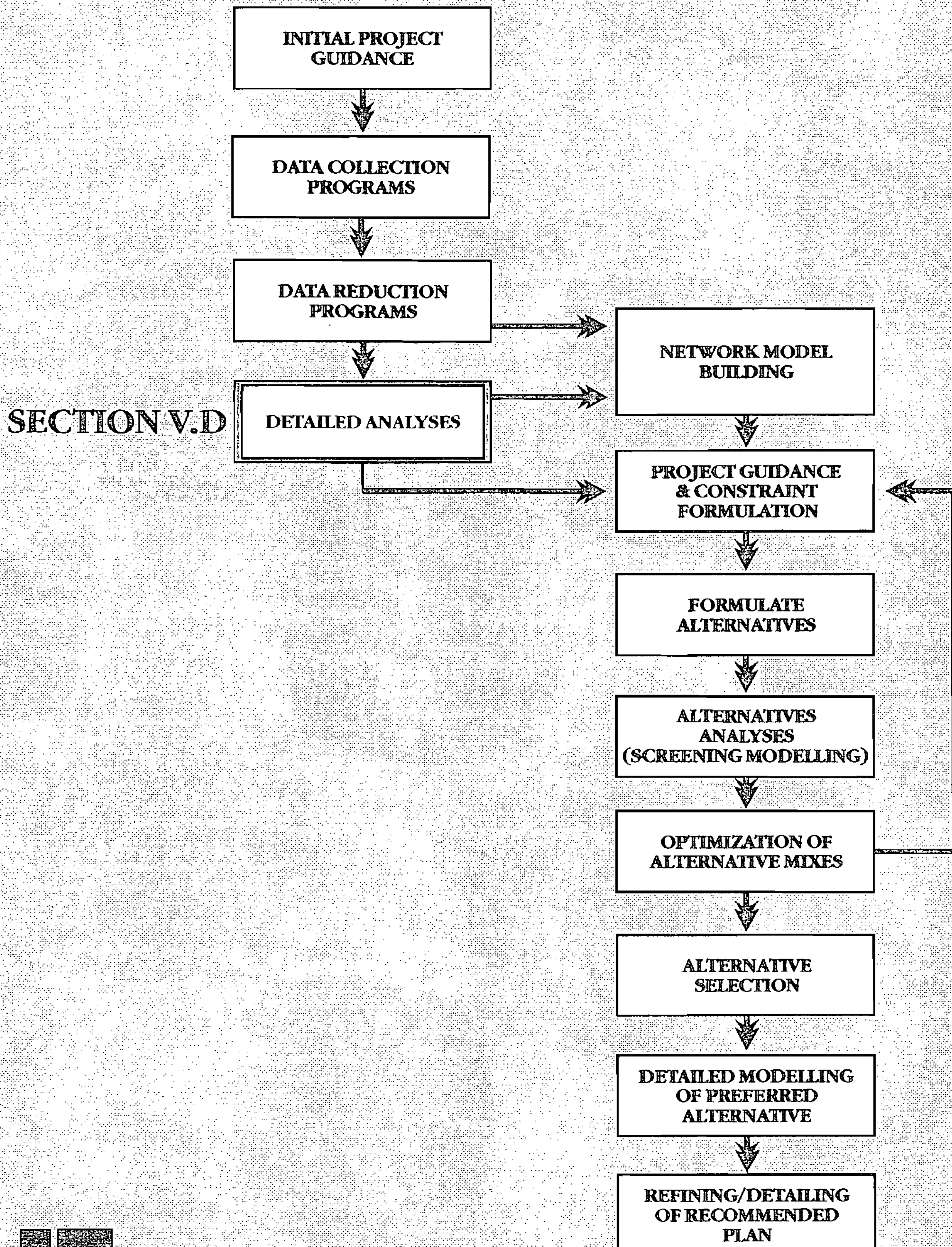
k) Response to Regulatory Agencies

GIS is a valuable tool for preparing regulatory responses and permit applications for large or complex watersheds. The City of Cape Coral will most likely be required to begin preparation of a NPDES permit application for surface water discharge in the near future. The NPDES surface water program requires continual data collection and plans for managing the watershed. The GIS may be set up to effectively handle the regulatory requirements placed on the City under this program.

3. DATA REDUCTION AND PRELIMINARY ANALYSIS

The GIS package will also be developed to maintain and prepare input data for use in the canal network model. Interface software will be developed to prepare collected data to define basins and nodes in a useable format. Parameters such as canal dimensions, flow data, groundwater levels and other necessary information will be exchanged through this interface between the GIS package and the surface water system computer model.

Interface software may also be used to create special model output layers that show the results of selected computer scenarios on project maps. Comparison of layers generated by various simulations will enhance determination of the relative merits of various management alternatives. Comparisons may also be made between model results and measured data to verify or refine model accuracy.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D. DETAILED ANALYSES

Following data reduction, detailed analyses will be performed to describe key locally varying processes within the surface water system. Currently available models will be used to develop mathematical descriptions of physical processes such as drainage, groundwater flows and pollutant loading. These mathematical descriptions will be used to refine the main network model and verify its predictions.

Localized process investigations will take data reduction and analysis one step further. A variety of tools including GIS analysis and process specific models will be employed to combine measured and pertinent parameters with physical principals to develop relationships that describe a localized process. For instance, suppose the network model requires the percentage of rainfall reaching the canals throughout the City. It would be unreasonable to compute such a variable within the network model each time it is run. It would also be unreasonable to measure this coefficient throughout the City.

However, mathematical relationships (or mathematical models) may be developed that describe percent runoff as a function of intensity, land use, vegetative cover, soil type and evaporation rates. These relationships may be calibrated and verified with field data then used within the network model.

Other investigations will be conducted to describe the function of special segments of the surface water system such as the spreader waterways. While results of these investigations may or may not have a direct impact on the network model, localized improvements might be based on the results and the benefits may be incorporated into the overall Master Plan.

1. SECONDARY DRAINAGE SYSTEMS

The secondary drainage system will be evaluated for its effectiveness. Evaluation techniques developed will serve primarily as detailed design evaluation tools for regional and sub-regional drainage works and the impact of specific site developments.

Since the drainage models used in this task will be used to model small drainage systems on an individual basis, they will operate outside the main network operation model. However, key basin parameters generated during these investigations will be used to update the main network (GIS) database.

The secondary drainage models will also be used to design elements of the secondary drainage system including placement of swales and inlets, pipe networks and outfalls. Sub-basin runoff estimates will be computed using data formatted in the GIS. Alterations of drainage characteristics within the basin could be immediately identified and a new analysis could be efficiently performed.

When interfaced with the GIS system, rapid analysis of drainage failure effects and system response to extreme rain events will be possible. This will aid in performing regional and sub-regional flooding risk analysis and aid in developing optimal design criteria. These models may be developed to operate along side the GIS with graphical input and output interfaces.

2. SURFICIAL AQUIFER ANALYSIS

Groundwater hydraulics in the surficial aquifer zone will be modeled to gain an understanding of aquifer storage and yield potential. These investigations will also be used to estimate the effects of localized soil anomalies such as impervious marl layers or highly pervious limestone layers.

Computations will be developed to predict the behavior of measured processes and verify conductivity and seepage coefficients. Soil strata behavior may then be inferred at locations throughout the City thorough analysis of collected soil data maintained on the GIS.

3. COST RELATIONSHIPS

For purposes of maximizing the utility gained from City resources, initial cost estimates must be made before value engineering analyses may be conducted. This involves the preparation of capital and operation and maintenance costs for drainage improvements and BMP applications including piping, inlets, ponds, enhanced swales, channel side improvements, land costs and both marine and freshwater canal interconnections.

A similar cost estimate may be prepared for the secondary irrigation system including pumping, transmission and spreader canal embankment improvements, isolation facilities, and possible deepwell or offline storage.

4. WATER QUALITY ANALYSES

In addition to modelling quantity issues using the AWSM model, water quality models will be constructed to describe current and future pollutant loadings throughout the surface water system.

Analyses will be performed in an effort to estimate existing nutrient and pathogenic loadings throughout the surface water system. Additional nutrient loadings that may result from irrigation using the secondary water system, and natural or background non-point loadings such as phosphorous leaching from local soils, will also be quantitatively estimated.

Drainage areas that represent single land use types will be selected for intensive sampling programs for the purpose of determining representative Event Mean Concentrations (EMC's) of pollutants. EMC loadings will be generated for degree and type of development.

EMC loading comparisons will also be developed to predict surface water changes when septic tanks are disconnected and impacts as more connections are made to the secondary water system. Net non-point emission factors will be developed for use in the computer model. This investigation will have the added value of further quantifying net benefits to the surface waters of such actions as installing sewers.

These computations will be used in water quality models to estimate pollutant loads as they are related to infrastructure improvements, soil types and land use. Water quality models that may be employed include SLAMM, EPA-WASP4, SWIM and other emissions prediction models. Water quality models are typically used to extend detailed localized investigations of pollutant loading impacts to larger regions. There are two dominant forms of water quality models, the empirical relationship models and conservative constituent models.

a) Empirical Relationship Models, Estimating Pollutant Loads

During field data collection and analysis, Event Mean Concentrations (EMC) will be determined and related to upland characteristics. With enough data redundancy using field measurements and previous studies such as National Urban Runoff Pollution (NURP) data, relationships between upland characteristics and non-point pollutant contributions may be made.

Overlaying pollutant contributions on current and future land use maps, estimates of total pollutant loads may be made with a fair amount of confidence. Much of this estimation may be done within the database portion of the GIS. Upland characteristics that may be targeted for evaluation include land use, irrigation water availability, expected landscaping techniques, and sewers versus septic tanks.

b) SLAMM - A Conservative Constituent Model, Transport Of Pollutants

Conservative constituent models track the transportation of pollutants (constituents) through a water system using the laws of conservation of mass and energy (conservative). Conservative constituent modelling requires knowledge of pollutant loadings and probable source - sink paths. Availability of pollutant, hydraulic behavior and ecologic characteristics will determine if a particular segment of the system contributes or removes pollutants. Conservative constituent models typically operate within localized systems describing transport processes in detail.

The Source Load and Area Management Model (SLAMM), permits the delineation of pollutant loadings from source areas and the definition of the effects of various type of controls including infiltration trenches, swales, wet ponds, catch basins and other

BMP's. Since SLAMM accommodates varying storm magnitudes, time series loadings as a function of detailed upland characteristics may be generated.

Using SLAMM, an enormous amount of detailed information may be created for use in assessing the effectiveness of various small scale stormwater quality controls. This model may be used on a number of small pilot watersheds to generate pollutant loadings and BMP effectiveness data that may be then extrapolated to the entire City. This approach will provide water quality information that can be used to negotiate water quality issues and controls with regulatory agencies.

c) Water Quality Model Calibration And Prediction

The results of the SLAMM model may then be compared to measured pollutant loadings within well characterized basins. Comparing actual field conditions to model predictions will allow for fine tuning. It may then be used in a continuous simulation form to generate time series of present loadings on an annual basis. Continuous simulations will be performed to compute pollutant loads for current development conditions. Also, this model may be used to predict pollutant impacts from future development.

Inflow and outflow water quality parameters will be reduced and analyzed to determine the effectiveness of various BMP designs. BMP effectiveness will be measured against site specific parameters such as land use, target pollutants, underlying soils and BMP life cycle costs. Those found to be applicable in the City will be analyzed to determine pollutant removal performance. This will assist in identifying designs that work best specifically in Cape Coral.

d) Relationships Between Aquatic Plants and Nutrient Levels

Studies have indicated the possibility of characterizing water quality parameters, specifically nutrient levels, through the analysis of large aquatic plants (macrophytes). Since nutrient levels in water bodies influence the ability of macrophyte species to compete, inferences of nutrient levels may be drawn by assessing the presence or absence of indicator species. Documenting changes in plant populations may be useful in predicting the advent of water quality problems prior to their occurrence. If these changes are tied to specific causes, problems such as algal blooms may be avoided before their occurrence.

A program will be developed to statistically match water quality parameters with indicator species. Results of this analysis will be used to train city staff in the early detection of water quality problems.

5. SPECIAL SYSTEM INVESTIGATIONS

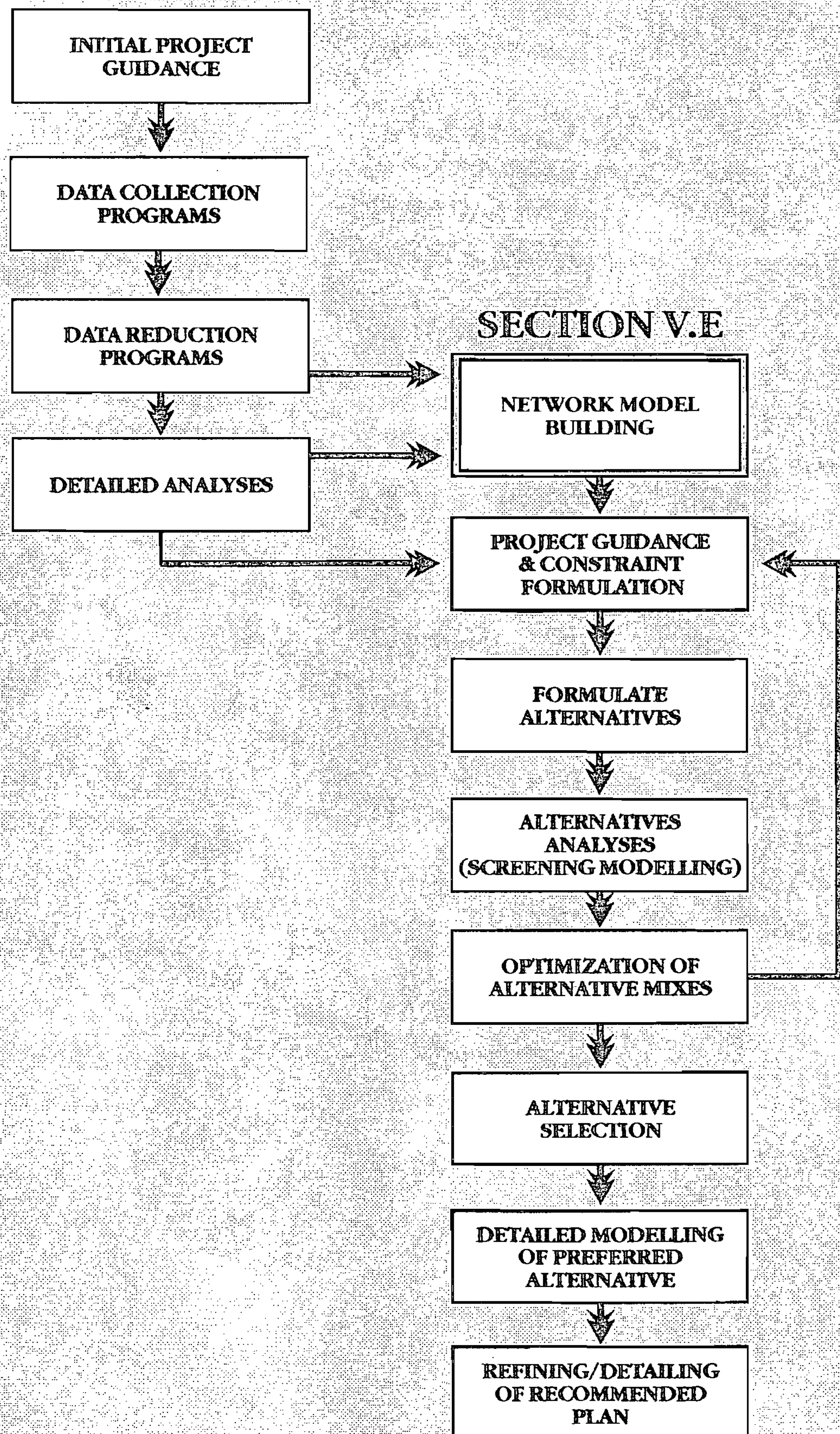
a) Marine Canal Flushing Model

The branch flushing model analysis previously conducted by the United States Geological Survey will be extended to include portions of the marine canal system previously not modelled. The existing and new analyses will undergo feasibility evaluation according to technical, fiscal and political constraints. This analysis will be used to identify attractive new canal connections in order to improve tidal circulation and flushing of the marine system.

b) Spreader Canal Saline Intrusion Models

A number of physical scenarios will be modelled from which a spreader waterway management program may be developed. The management of the spreader waterways will seek to establish a feasible approach to maximize freshwater utilization while avoiding single point discharges to the marine environment. Models that will be developed include:

- Probability analysis of annual tidal stage versus spreader canal berm elevations to determine likelihood of significant intrusion events.
- Estimate tidal spillover volumes into spreader canals for various storm tide elevations and durations.
- Develop empirical relationships between weather conditions and non-tropical storm tide characteristics using long term monitoring.
- Generate time series of spillovers tides into spreaders for typical design year condition.
- In conjunction with surficial aquifer analysis, perform groundwater modelling to estimate saline intrusion into the spreader waterways or other important supply canals.
- Perform detailed hydraulic analysis of effectiveness of seawater intrusion prevention through the use of various engineering alternatives including air diffusers, berm restoration and isolation systems.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PROJECT GUIDANCE & CONSTRAINT FORMULATION
FORMULATE ALTERNATIVES
ALTERNATIVES ANALYSES (SCREENING MODELLING)
OPTIMIZATION OF ALTERNATIVE MIXES
ALTERNATIVE SELECTION
DETAILED MODELLING OF PREFERRED ALTERNATIVE
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E. NETWORK MODEL BUILDING

This section presents an overview of the two key computational tools that will be used to develop the city-wide Master Plan. Two forms of models will be used extensively in Master Plan development, the physical network model and optimization routines. As discussed in section IV, the network model will be used to describe the physical operation of the canal network. Optimization routines will be employed to test the effectiveness of various management alternatives in achieving the City's goals. Items to be derived from this work include the following:

- Describe the canal aquifer system in detail as it performs today.
- Predict unaltered network response to future development.
- Predict the net effectiveness of treatment alternatives.
- Perform screening evaluations of various design mixes.
- Zero in on optimal system design and operation scheme.
- Predict redesigned network response under various operating conditions.

1. AWSM - A DRAINAGE AND IRRIGATION WATER QUANTITY MODEL

In general there are a number of questions regarding operation of the surface water system, its flood control performance, its water supply capability, water quality management, and its recovery with regard to the natural or man induced pollutants. Traditional modelling approaches would require several models, each having its own input data requirements and input data format. In an effort to minimize this diversity and thereby reduce the cost of data preparation and potential for inaccuracies that could be introduced, a single computer model be will provided for the primary system (canals, lakes and control structures).

The Aquarian Watershed Simulation Model (AWSM) is recommended for use in modelling long term system behavior as well as response to storm events. In its current form, AWSM is a quantity model (as opposed to quality) that tracks up to 13 variables and parameters throughout the surface water and surficial aquifer systems. Appendix G provides additional detail on AWSM, its data requirements and how it will be used to evaluate the existing Cape Coral system as well as proposed modifications. In addition, modifications to the model for water quality (concentration and mass loadings) will also be discussed.

The current version of AWSM models the following variables:

- Rainfall
- Evaporation from Surface Water Bodies
- Evapotranspiration from Vegetated Uplands
- Runoff to Surface Water Bodies
- Soil Moisture
- Percolation to the Water Table

- Water Table Elevation
- Two-dimensional Surficial Aquifer Flows
- Leakance Between Surficial and Deep Aquifers
- Seepage Between Surficial Aquifer and Surface Waters
- Surface Water Stages (Elevations)
- Flows Through Surface Water Systems
- Sinkhole or Spring Connections Between Surface Waters and Deep Aquifer

Irrigation will be included in the next version, which is currently underway, to be taken from the shallow aquifer, the deep aquifer, surface water bodies or external sources. The model is set up so that all parameters need not be supplied. For example, if the modeler wishes to only simulate surface systems, he simply does not input groundwater related elements.

Surface water features that are hydraulically modeled include:

- Open Channels, Lakes and Swamps
- Junction Channels
- Junction Channels with Structures
- Bridges
- Bridges with Risers
- Culverts
- Culverts with Risers
- Weirs and Orifices
- Gated Water Control Structures (Operable)
- Pump Stations (Operable)
- Offsite Inflows

AWSM allows for the simulation of very complex structures consisting of multiple elements.

Runoff simulation includes:

- Direct Rainfall (continuous & event)
- Direct (lumped) Basins (continuous & event)
- Kinematic Overland Flow (continuous & event)
- Unit Hydrograph Methods (event only)
- Santa Barbara Urban Hydrograph Method (event only)

Output from AWSM is stored in a digital data base for retrieval. For event simulations, the data is retrievable in a number of forms on a time increment stipulated by the user. This allows the user to retrieve time series plots (e.g. hydrographs) which can be developed for all pertinent parameters. In addition, flood stage-depth-duration analysis can be performed for quantifying flood damages and determination of flood severity.

2. COMPUTER MODEL CONSTRUCTION

a) Data Preparation for Models

Data preparation consists of the arrangement of model input data representing both the physical system as well as boundary conditions that are required to drive the models. Physical system data consist of sub-basins and their intrinsic hydrologic parameters such as conveyance system geometry (i.e. canal length and cross section). Most of the spatially varying information will be present in or derivable (such as soil transmissivity) from the GIS system once all the necessary coverages have been constructed.

Boundary condition data consist of those parameters that vary about the perimeter of the system to be modeled as well as those that vary over time such as rainfall or tidal elevation. All variables computed by the models are required as spatial and temporal boundary conditions. Temporal parameters include time such as rainfall, potential evapotranspiration, water table elevations, potentiometric head from well records, tides and other quantity and quality inputs to the system.

In addition to the above, historic and collected data representing system responses (stages, discharges, water table elevations and water quality parameters) are needed for calibration and verification of the models.

b) Detailed Model Setup and Testing

The Aquarian Watershed Simulation Model (AWSM) is recommended for system-wide hydrologic, hydrodynamic, and water quality modelling. Setup of the model requires that previously described data be modified to AWSM input format. This will require a degree of effort in translation of GIS coverages as well as the extraction of other point specific data from the project data base.

AWSM operates on a surface water and a groundwater network that segments the study area into nodes and reaches (or links) for computation of runoff, stages, discharges, water table elevations, groundwater flux, and water quality constituents. Data describing each of these nodes and links are then entered into the model either manually or through data file transfer.

The model network will be constructed to mimic and allow for:

- New structures to enhance circulation in the saltwater canals. This will be used to assess merits of improving tidal flushing under realistic community constraints.

- New drainage connections to determine net impacts to the surface water system should additional connections be desired. Also, the potential impacts of development throughout the City will be assessed.

- Existing and new retention/detention ponds as they affect water quality and quantity.

- Flexibility of location and use of elements of the irrigation system including withdrawal volumes, treatment plant inputs, side storage tanks, north-south canal water transfers, weir bypasses and canal interconnections.

- Spreader canal isolation systems to prevent or reduce saline intrusion into the canal system along the western fringe of the City.

AWSM will then be subjected to testing and quality control analysis to insure that the full range of modeled conditions that could potentially be encountered is covered by the physical input data. This task will result in modifications to the network as well as to the input data. Sensitivity analyses will be conducted as necessary on selected parameters that are considered to be critical to accuracy, e.g. aquifer storativity, saturated conductivity, Manning's "n" (roughness coefficient), etc. These tests may result in additional refinements as well as field data collection.

c) Detailed Model Calibration and Verification

The calibration and verification process is used to establish the accuracy of the model in predicting system behavior. This process consists of simulating historic events in a predictive mode and then comparing results to actual measured system behavior. During calibration, adjustments can be made to certain model parameters in order to produce predictions comparable to actual measured historic events. However, the verification process is then used to simulate additional events (not modeled during calibration) without further adjustments to model input data. If this second step produces adequate prediction of historic system responses, the model can be pronounced verified. One can then have a reasonable level of confidence in model outputs for predictive simulations for which historic data are not available.

3. MODEL USAGE

a) Initial Detailed Modelling

AWSM will be used to model existing conditions as well as buildout conditions for the City of Cape Coral. These will consist of both continuous (long term) and event simulations (e.g. 10-year, 25-year, and 100-year storm events). Continuous model results will provide an evaluation of water supply potential and future shortfall (with and without supplemental irrigation) as well as effects on hydroperiod (or the time water is retained) in the City's lakes and wetlands. This model will also provide a quantification of water availability and delivery from the surficial aquifer to the canal system. Storm event modelling will provide a quantification of maximum stages and flows throughout the City.

Detailed modelling will begin as soon as data compilation allows. Model results will be used to show how the surface water system functions in its current state and important processes will be identified. The results will also be used to begin the formulation of reasonable management alternatives.

b) Supportive and Landside Water Quality Modelling

Landside water quality modelling will serve to perform evaluations of BMP's as well as to provide water quality inputs to AWSM for system-wide modelling. The SLAMM model will be used to accomplish this purpose.

c) Receiving Water Models

Pollutant conditions predicted by SLAMM may be used to generate system-wide loading characteristics. Pollutant source-sink relationships will be formulated for various segments of the surficial system and incorporated into AWSM or addressed in a specialized receiving water quality model such as SWIM to determine where pollutants are coming from and their ultimate fate. The combined model will be used to predict the ultimate impact of pollutants and surface water discharge quality under current and future conditions.

Discharge water quality may be modeled for regulatory purposes at any number of boundaries. Exterior conditions and constraints may also be incorporated directly into the computer model.

d) Screening Models

As part of the alternative development and analysis process, it will be necessary to make many simulations with varying degrees of alternative implementation. Results from these simulations will be used directly in an optimization process.

In order to reduce this modelling to an acceptable level of effort, it will be necessary to construct screening models. These will potentially involve reduced study area with boundary conditions supplied from the detailed model, reduce internal complexity of the internal system being modeled, and the use of faster (but more approximate) algorithms for certain parts of AWSM itself. The screening models will be subjected to extensive testing as well as calibration and verification to insure that they are adequate for comparisons among alternatives.

Screening models will be employed after alternatives have been formulated in order to rapidly test for promising alternative mixes.

e) **Detailed Modelling of Alternatives**

Once a smaller set of optimized alternatives have been assembled, the detailed AWSM model will be used again to provide the highest level of accuracy and precision possible to compare them.

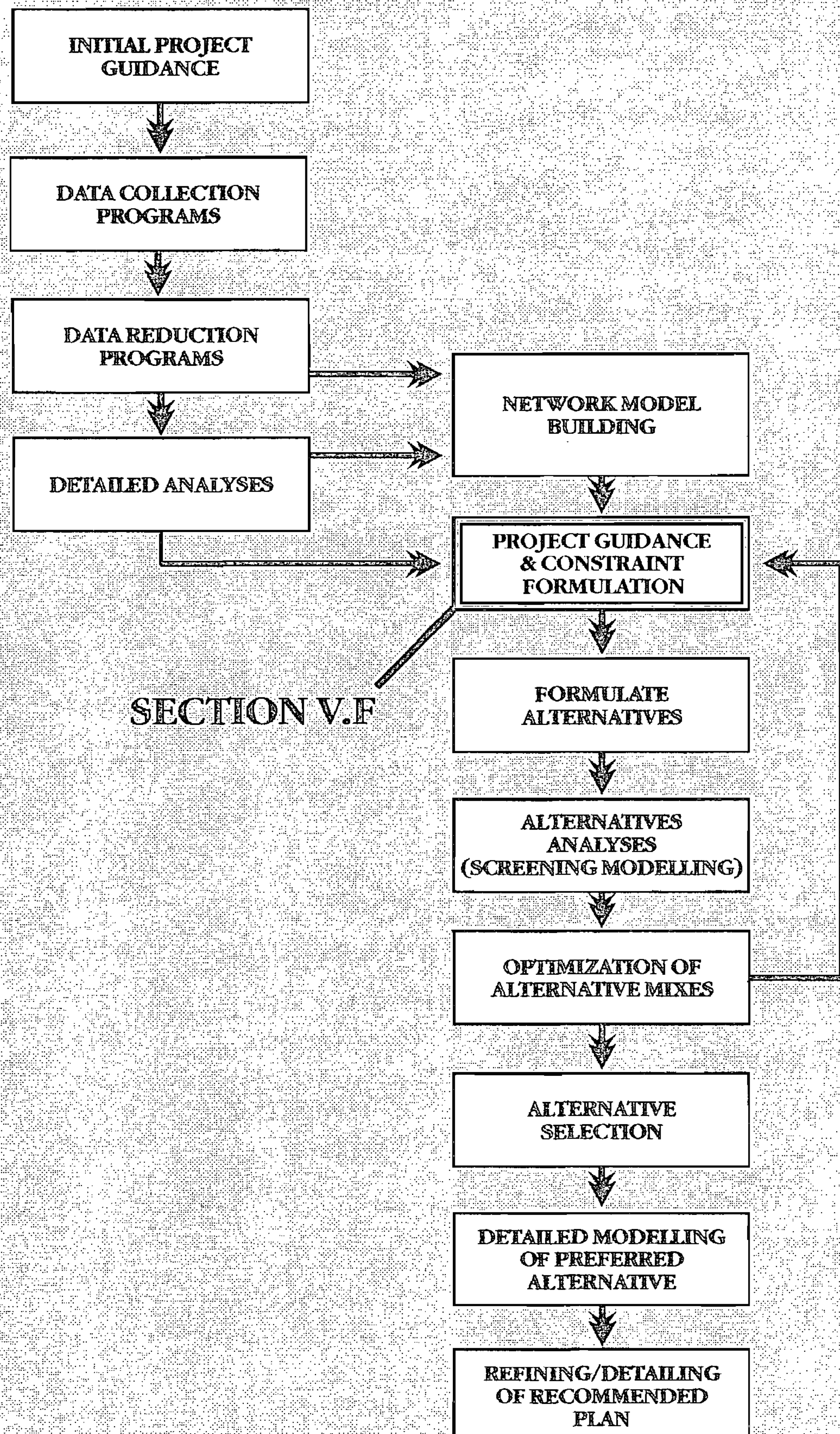
Descriptive and predictive results from these modelling efforts will be formatted for display within the GIS and presented to city staff and citizens through public workshops.

4. OPTIMIZATION ROUTINES

Results of the screening models will be weighed against defined objectives and constraints. Due to the complex technical nature of the system and the multiple benefits targeted, efficient computer algorithms will be employed to subjectively analyze the success of chosen alternatives.

This analysis consists of the use of either a linear or non-linear equation solver that is employed to optimize results from the screening models with respect to chosen objectives. It will be used in an iterative manner with the screening models and will ultimately result in the selection of a small set of promising alternatives.

Objectives usually consist of benefits derived in terms of water supply, drainage, flood control and water quality. An attempt is made to maximize these benefits in a manner that fits within the regulatory, fiscal and social preference constraints set up for the project. Costs can be employed as a constraint condition depending upon anticipated City revenues or they can be introduced as objective functions that are to be minimized (as opposed to maximized).



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F. PROJECT GUIDANCE AND CONSTRAINT FORMULATION

1. VALUE ENGINEERING OF PROJECT DIRECTION

Concurrent with the preparation of the AWSM model, a critical review and summary of findings to this point will be conducted. Individual elements that will be assessed according to their individual merits and relevance to the overall project include :

- Each Field Data Collection and Analysis Program
- Data Management Program
- Quality Management Program
- Ancillary Models and Computations
- Preliminary Estimates From the AWSM, SLAMM and Receiving Water Models

An extensive value engineering program will be used to critically review all results to date and to modify if necessary program objectives, problem definitions, and conceptual design alternatives. Changes in City objectives, federal and state regulations and public sentiment will also be considered during this assessment.

The mid-course project correction will culminate in a synopsis of the project successes to date. This synopsis will also include articulation of criteria which will be used to judge the merits of various sub-programs including:

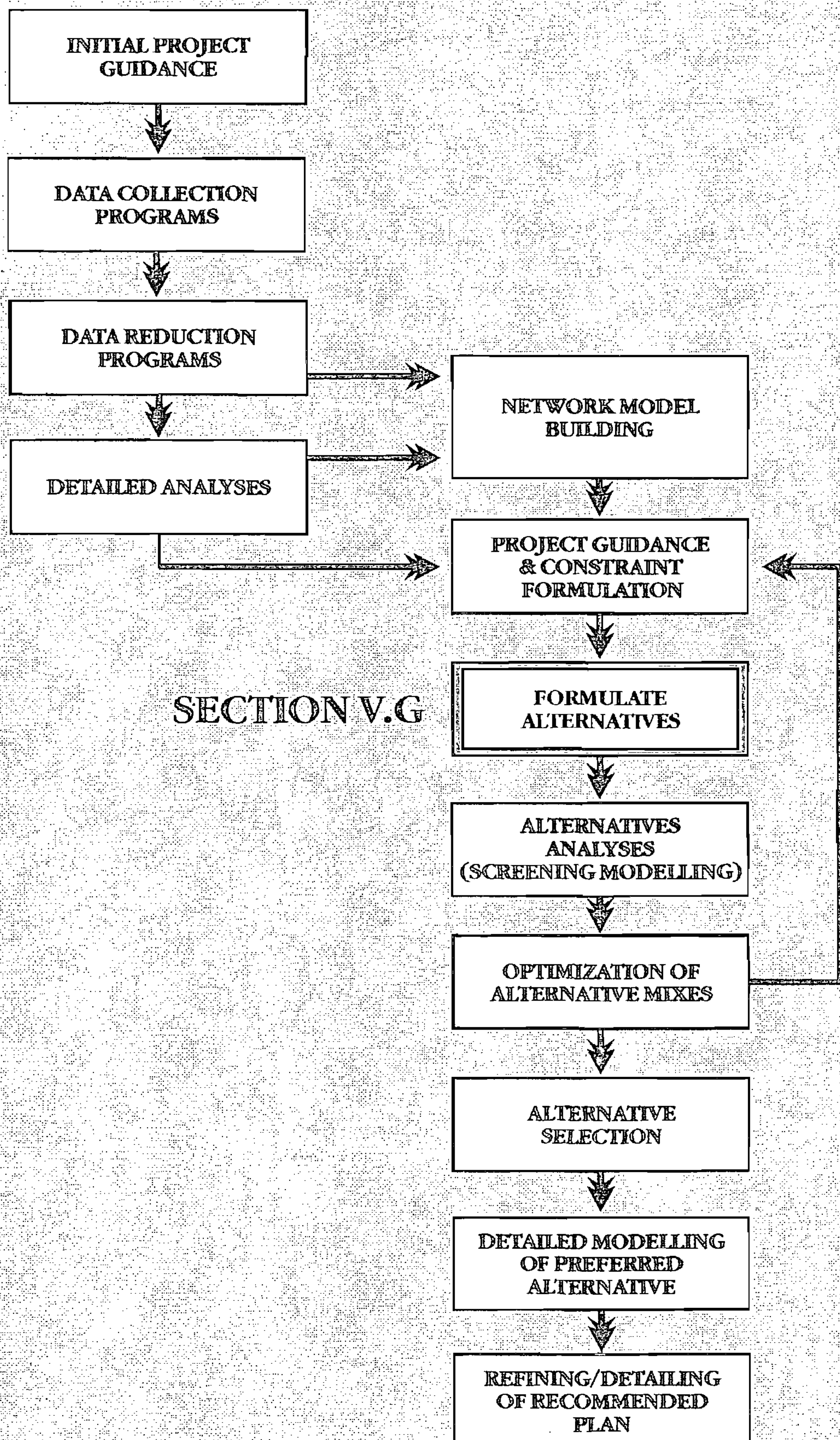
- Network Management Design Alternatives
- Level of Drainage Service
- Water Quality Maintenance or Improvement Methods
- Irrigation Water Yields
- Spreader Waterway Re-development
- Permanent Data Collection and Operational Control Systems
- Operation and Maintenance Functions

2. FORMULATION OF OBJECTIVES AND CONSTRAINTS

Immediately following the intensive Value Engineering program, an intensive round of public workshops will be held with city staff, city council and in open public forums to discuss project results to this point and plan development directions. Public workshops will be designed to bring many voices and opinions together to articulate community preference for the use of the surface water system. This public input will be vital to further plan development since the primary users and managers of the surface water system will be setting operational preferences. These socially directed preferences will be developed into plan objectives and constraints.

For successful implementation, expressions of program objectives and constraints must be specifically articulated. Objectives are end result goals such as ample supplies of irrigation water and flood control. Constraints are limitations on the processes used to achieve these goals. Constraints may be political in nature, such as how much money the community is willing to spend or technical in nature such as acceptable maximum and minimum canal water levels.

Once articulated, objectives and constraints will be written as functions of processes that control them. Objective functions are mathematical expressions of measured success based on decision variables. The objective functions must be written in terms of quantifiable measures such as water volume, costs, benefits and so on. Constraint functions serve as limits on objective functions and are also written in terms of decision variables. Decision variables are mathematical expressions of controllable values (such as canal water elevation) that may be adjusted to accomplish stated objectives.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G. FORMULATE ALTERNATIVES

Following the mid course project correction and development of objectives, approach alternatives will be formulated for the major sub-programs of drainage, irrigation water and water quality. Design concepts will be developed and fully articulated for each of the sub-programs. Design concepts will include stand alone improvements or may include various mixes of upgrades to achieve maximum results.

In order to maintain the freedom of developing the most beneficial alternatives for each sub-program, success criteria and technical conflicts with alternatives from other sub-programs will not be considered at this stage. Development and analysis of non-contradictory mixes of final design elements is an analysis task of its own.

1. DRAINAGE ALTERNATIVES

Drainage improvements may consist of stand alone improvements or include interdependent mixes of upgrades. Drainage improvements that will be considered include:

- Canal hydraulic drainage connections in both fresh and marine systems to improve overall hydraulic conductivity
- Use of manual and remotely operated weir level adjustments
- Fixed weir modifications
- Sub-regional storage ponds within the canal system
- Upland sub-regional storage ponds
- Enhanced secondary piping systems
- Canal roughness adjustments through cross section and bank stabilization design alternatives
- Levels of service based on land use
- Enhanced localized and onsite stormwater management
- Mechanical and gravity diversion of flood flows

2. IRRIGATION ALTERNATIVES

Improvements to the surface water system will be considered for the purpose of optimizing the storage and recovery of freshwater for the secondary water system. It has been estimated that when the City reaches buildout 74 MGD (WICC, 1988) will be needed from the freshwater canal/surficial aquifer system to meet irrigation demands (See Appendix A.3). Methods to enhance dry season yields that will be given consideration include:

- Canal and canal basin interconnections and flow control
- Weir level adjustments, both static and adjustable
- Multi-use storage ponds

- Partial or full utilization of spreader canal and adjacent canals by providing various types and degrees saline intrusion protection, including berm restoration, air diffusers barriers and /or "Venice, Italy" type saltwater isolation systems
- Changes in spatial location of canal pumpout points for better balance of supply and demand including the formulation of programs commensurate with demand, i.e. partial buildout demand projections
- Deep well injection and recovery alternatives;
- Differing or increasing degrees of water quality treatment of canal water if development effects of runoff, septage from outlying areas or nutrient concentration increases from irrigation cause deterioration
- Irrigation network redundancy of canal pump station intakes in event of partial system shutdown due to diminished canal water quality or quantity
- Chloride concentration control alternatives such as I/I control of sewer systems subject to brackish intrusion and effluent dilution schemes.
- Mandatory disconnection from the Upper Hawthorne aquifer to reduce inter-aquifer exchange.

3. WATER QUALITY MAINTENANCE ALTERNATIVES

Structural and management technologies that may be effective in maintaining or improving water quality will be developed. Approaches may be conveniently divided into either system-wide level or local level groups. System-wide level alternatives are those that approach water quality treatment on canal network-wide or regional levels such as large wetland treatment areas. Local level alternatives seek to maintain or improve water quality at the runoff source such as onsite BMP's. System-wide level alternatives that may be explored include:

- Canal interconnections and flow control in both marine and freshwater systems to improve circulation
- Regional and sub-regional wet or dry ponds
- Dilution schemes using gravity or forced water transfers;
- Canal maintenance and treatment
- Allowance of aquatic plant production coupled with harvesting as a pollutant removal technique
- Seawalls versus vegetated sloped bank alternatives
- Regional or city-wide upland management through the use of ordinances and inspection
- Localized reconstruction of canal bottoms to create nearly uniform depths to prevent stratification and eliminate localized pollutant sinks
- Allow stratification to create pollutant traps and couple with water treatment

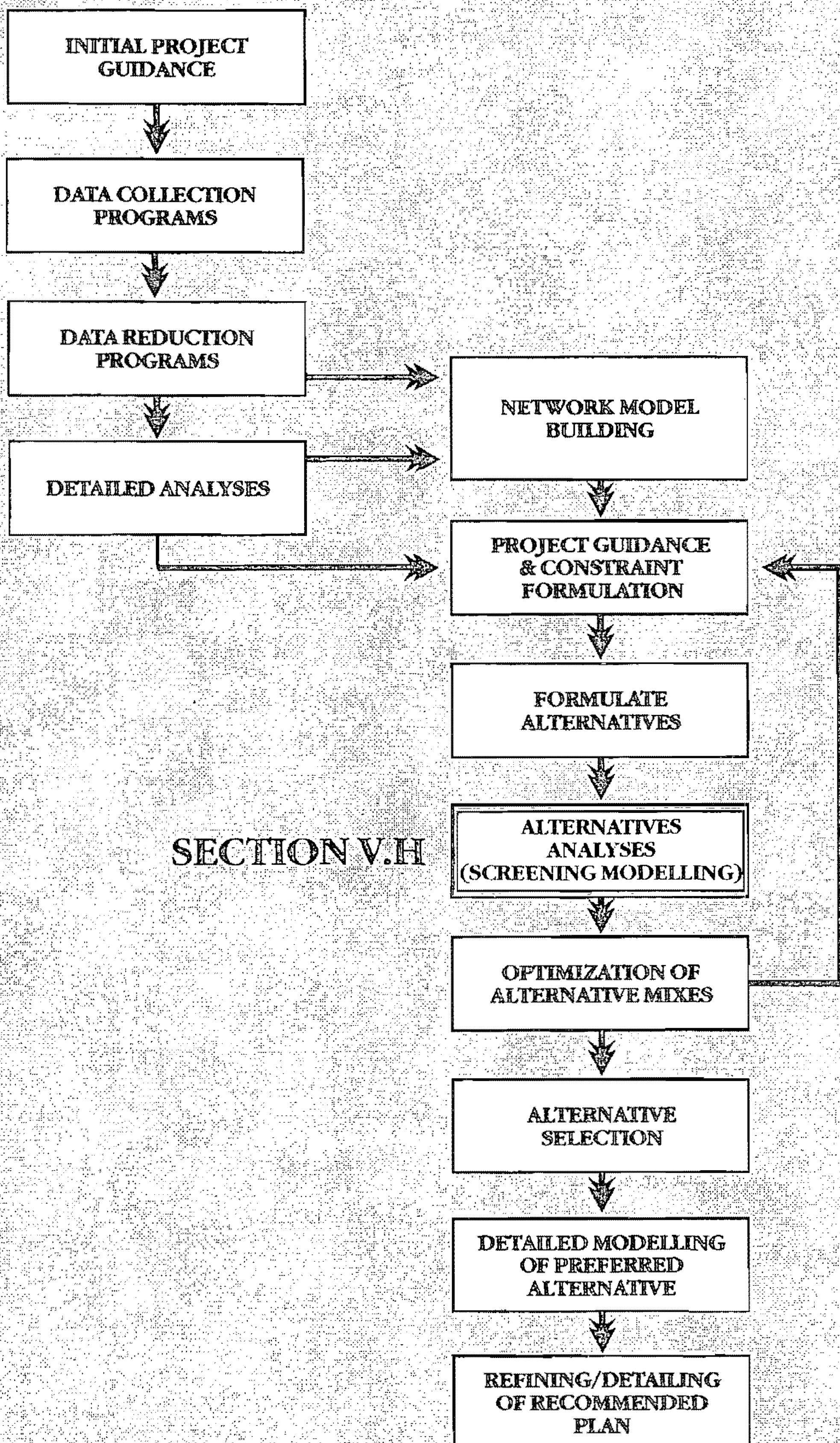
Local level design possibilities that will be investigated include:

- Enhanced or modified swales
- Conversion of inlets into catch basins

- Infiltration trenches & modified swales & modified inlets,
- New under drain systems feeding designated canal water quality treatment sections
- Localized macrophyte or biological controls
- Wet ponds treated with alum
- Sub-regional upland designated treatment areas and multi-use dry detention basins, i.e. parklands and greenspace.

A number of realistic mixes of the above alternatives will serve to increase level of control and costs. Flexibility will be developed into these mixes, enhancing the ability to accommodate site specific requirements and the preferences of the primary beneficiaries.

SECTION V.H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H. ALTERNATIVES ANALYSES (SCREENING MODELLING)

Once design elements described above are developed, they will assembled into various combinations to form alternative management packages. A simplified version of the network model will then be employed to rapidly estimate the performance of the various design packages. This segment presents the steps that must be taken to accomplish these performance predictions. These steps are:

- Sub-Program Analysis
- Alternative Package Development
- Screening Model Runs

1. SUB-PROGRAM ANALYSIS

Once relationships between the numerous design elements and have been developed, feasible combinations that address one of the three major areas of drainage, irrigation or water quality may be developed as performance test cases. A sample of this development is shown in Figure 5.8. Capital and operational cost functions for the various alternatives will also be incorporated and qualitative assessments of the derived benefits will be performed.

Full or partial system screening level modelling of individual sub-program test case combinations with the AWSM, SLAMM and water quality models may then be conducted to independently develop best management and engineering approaches for varying levels of buildout. These analyses will use the standard period of record for continuous simulation and for several design events.

Previously developed model-GIS interfaces will be used extensively to portray the complex results in a graphical format. Graphical representation of results will enhance understanding and provide a powerful tool for quantitative and qualitative analysis and discussions.

2. ALTERNATIVE PACKAGING

Up to this point, all analyses have been performed under the assumption that the individual sub-systems operate outside of the influence of other sub-systems. It is obvious that this is not true in the real Cape Coral.

Once sub-program analyses are completed, new alternative mixes will be developed from selected elements from each sub-program to form full system management packages. A picture of this process is shown in Figure 5.9. These new packages will be performance tested in the simplified version of the network model.

SUB-PROGRAM ANALYSIS

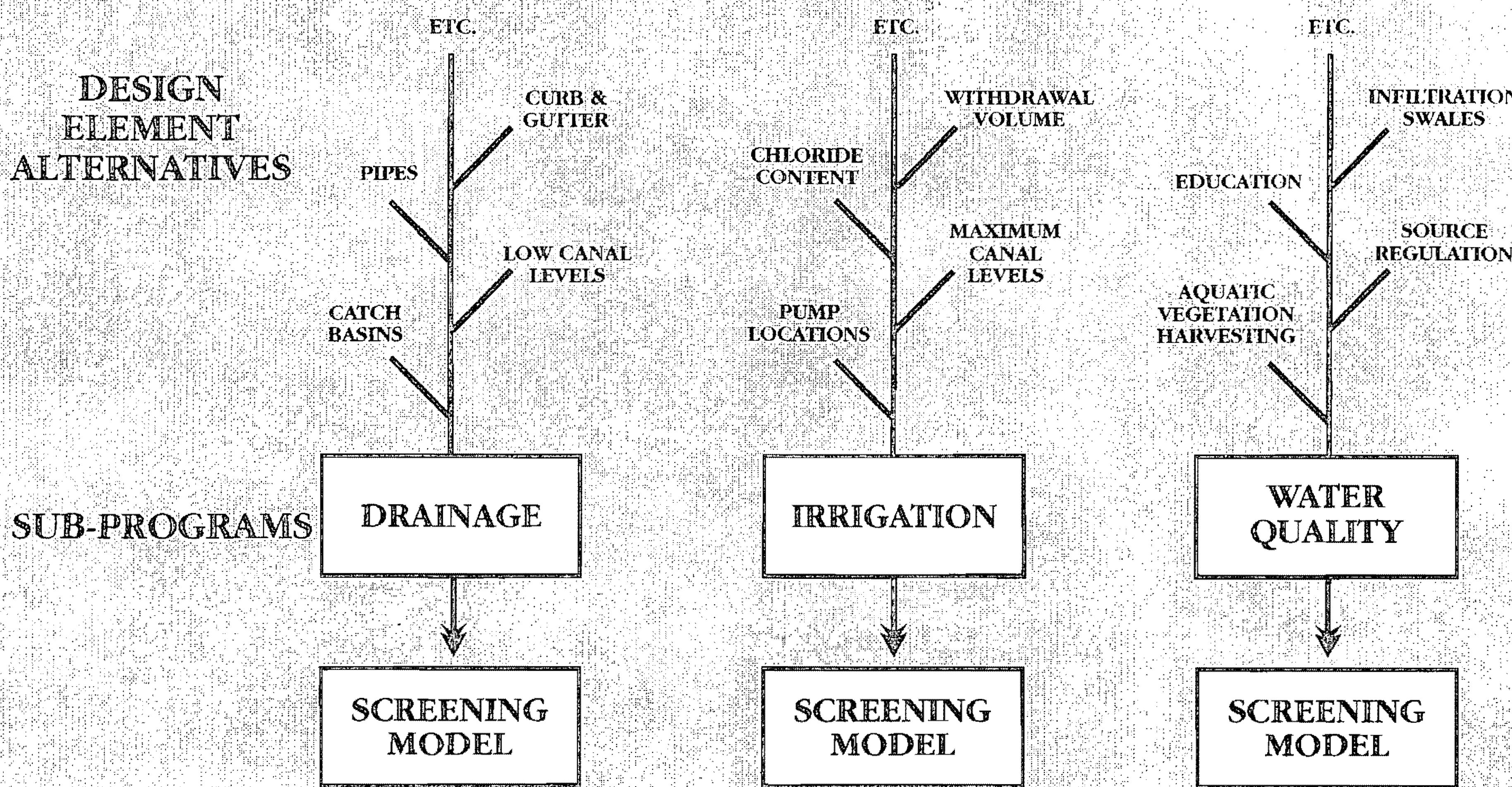


FIGURE 5.8

ALTERNATIVE PACKAGING

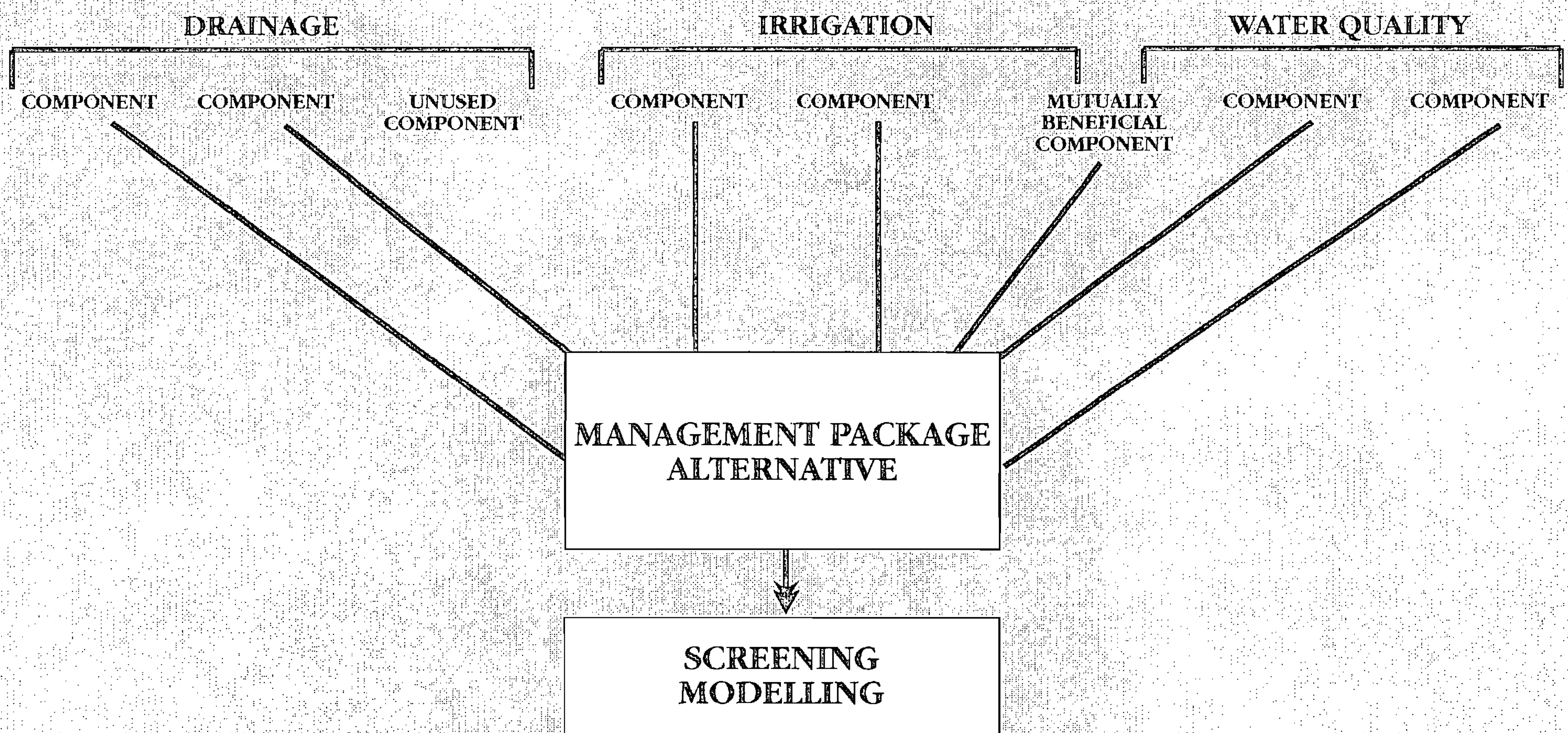


FIGURE 5.9

Intuitive expectations suggest that it will become obvious at this point that maximizing drainage service may jeopardize full development of freshwater yield for irrigation purposes. Conversely, maximization of irrigation water storage and yield quantities may impair drainage abilities or canal water quality such that localized stormwater quality control will become excessive and unrealistic. Maximum dry season retention may also result in minimum discharge limits beyond the spreader canals not being met, potentially violating regulatory constraints.

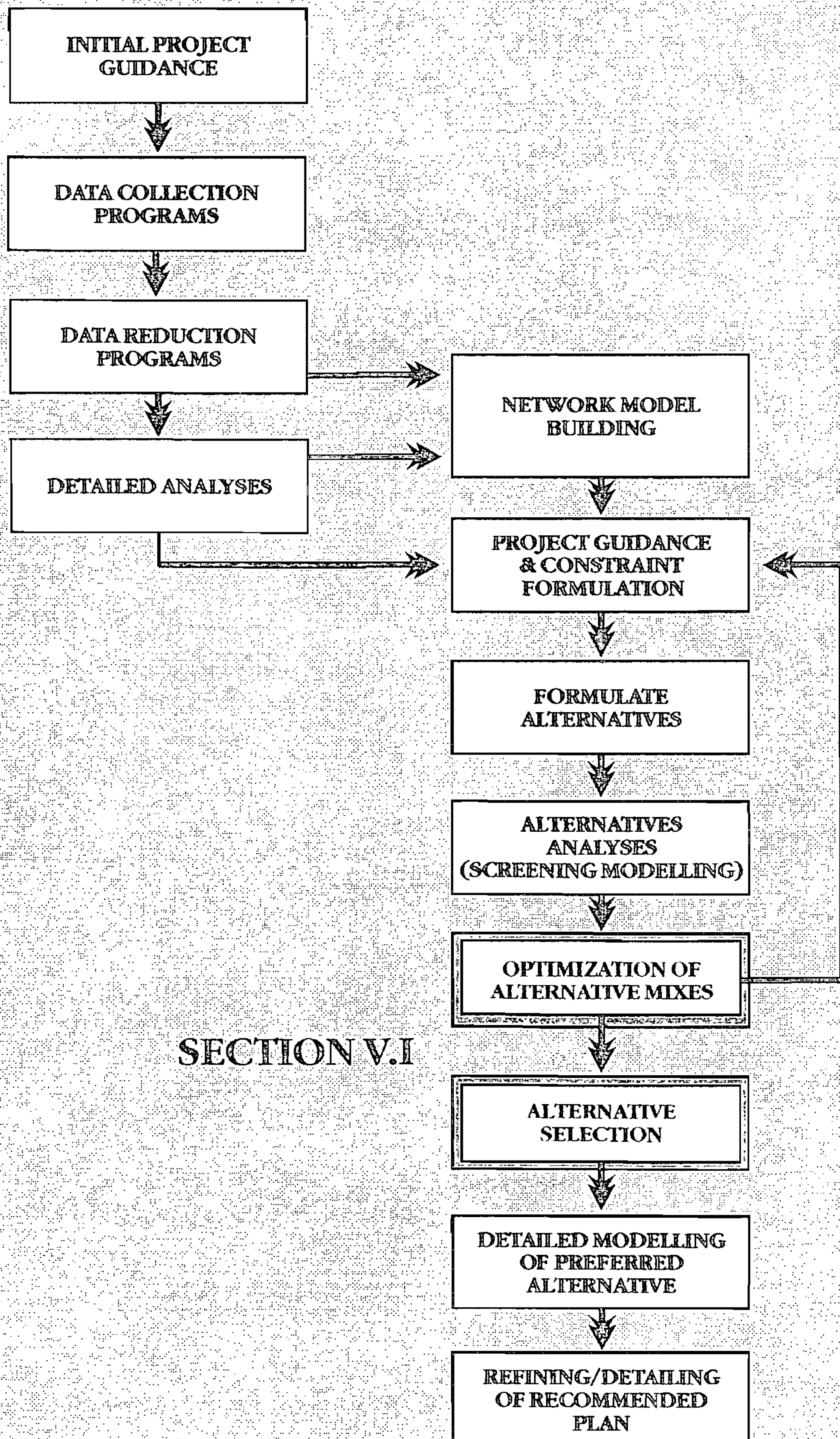
3. SCREENING MODEL RUNS

In previous sections, the AWSM model was used to describe in detail the surface water system as it performs today and may be expected to perform in various stages of buildout. This step was very important in that problems that are likely to occur in the future would be identified.

Selected design packages will be used within the separate AWSM, SLAMM, water quality and small models to begin development of constraint functions. Constraint functions describe relationships between specific decision variables and the impact on individual objective functions. For instance, one constraint function will describe the effect of increased water retention (decision variable) on providing adequate drainage (objective) while another will describe the effect of increased water retention (same decision variable) on irrigation water supply (different objective). The existing condition version of the screening model network will be subjected to the same level of calibration and verification that is used for the detailed model. Comparisons to historical data as well as the detailed model outputs will be made to assess the screening model's ability to provide a reasonable level of accuracy for alternative comparisons.

Since numerous system design alternative will be developed, a simplified version of AWSM will be employed to quantitatively predict the performance of selected alternative packages. Simplified versions of selected water quality models will also be employed to assist in quantifying success in the areas of water quality improvement alternatives. Results from the screening models will be processed using optimization routines where objective and constraint function sets are used to evaluate success in achieving City goals.

SECTION V.I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I. OPTIMIZATION OF ALTERNATIVE MIXES

As stated previously, the goal of the Surface Water Master Plan is to create the best overall selection of design elements that best satisfies City objectives. These possibilities must meet the technical, economic and community constraints discussed in previous chapters. However, a best selection will not be defined as one that is either the lowest capital cost, highest reliability, maximum benefit or other best measure. The best selection will consist of a measurable tradeoff of these elements or a plan that is best for the City overall.

The determination of the best selection from among many choices may be done if a mathematical statement of the problem after all variables and factors are developed. Commonly used mathematical principals and concepts may then be used to zero in on the best solution by comparing system response to objectives and constraints. The advantage of constructing mathematical statements to formulate a model is that the problem may be stated more concisely and comprehensibly while revealing important cause and effect relationships.

Optimization methods might best be shown by giving an example. Suppose in an effort to meet irrigation water demands, a design element of raising canal weirs is proposed. If only the objective of increased water storage was considered, the design alternative would be to raise the weir to the canal top. However, raising water levels that high would be constrained by community preference of maximum canal elevation, i.e. water level not to reach the seawall cap. Constraints may also be posed on a design element by other objectives such as keeping canal levels low in order to prevent flooding.

Achieving the optimal net benefit would require a number of iterations of altering the design element (raising the weir) to meet the objective (increased water storage) until it violates a constraint such as an upper limit (water overtops a seawall) or another objective (flood prevention) begins to suffer. Optimization could alternately be accomplished by simultaneously solving mathematical expressions of each of the objectives and constraints using weir elevation as a variable.

The study of this system involves the consideration of many more variables than canal elevation. Objectives are more complex than merely maximum water storage and minimum flooding. It is very probable that many more constraints will be found than maximum or minimum canal levels. The above example is but one small segment that will be considered in the overall Master Plan. The employment of optimization software will allow a similar analysis on many segments throughout the entire surface water system. Repeating the process for each of these segments will enable determination of the most promising alternative packages.

1. FIRST LEVEL OPTIMIZATION

The physical descriptions resulting from the screening model runs will be tested against objective functions and their constraint sets using commercially available optimization software. The first level of optimization will provide a realistic understanding of the surface water system's ability to meet the community's objectives (i.e. irrigation water and flood control) within identified constraints (i.e. canal elevation range and rainfall patterns). It is at this stage that various cost and benefit relationships involving important decision variables will be incorporated into the analysis.

A first level optimization analysis will include:

- Physical Constraints
- Expected Maximum and Minimum Extremes
- Available Funding
- Minimum Tolerable Levels of Service
- Water Quality Criteria, Both Internal and State Waters
- Regulatory Constraints
- Maximum Allowable Retention

The end result of the first level optimization will be twofold. The first will be a measure of the probable success in attaining the community objectives within given constraints. The second will be identification of promising design element mixes.

An evaluation of the results will be made and alternatives will be ranked in terms of their ability to satisfy study objectives within the defined constraints. These will also be ranked in terms of their ability to satisfy the preferences previously established. Mix alternatives that indicate a high degree of measured success in optimizing the utilization of the surface water system will be developed for presentation to the community.

2. REFORMULATION OF CONSTRAINTS

Following the analysis of initial solutions, a program to re-evaluate study preferences will be initiated. Since the value of obtaining specific objectives contains some degree of subjective reasoning, physical constraints and possibilities will be presented to city staff and public representatives along with well developed cost and benefit potential estimates.

Since it is expected that not all objectives and constraints will be satisfied, a second round of public workshops will be held to present findings of initial screening models and optimization results. For instance, suppose the initial set of constraints held provisions for no street flooding and for never taking the irrigation system offline due to low canal levels. It is likely that these constraints would not be mutually attainable at an acceptable cost. This would require some re-thinking on the part of the community as to what it is willing to accept in each of the areas of flooding, water supply and cost. Objective and constraint definitions would have to be relaxed and re-formulated according to the communities preference.

Development preferences will be re-defined along with equivalent substitutions in the workshop presentation process. Input received through this process will be formalized into mathematical definitions to be used as constraints to new optimization schemes.

3. ALTERNATIVE SELECTION

The process of developing objectives and constraints, running screening models and testing the results in optimization models will be repeated for as many iterations as necessary to find a workable plan. The involvement of the public in this process cannot be over emphasized if the overall plan is to gain community acceptance. By involving all those who wish to take part, the final plan may be developed within the confines of community consensus.

It may turn out that percent buildout, temporal population distributions and variable revenue generation will become decision variables in the full network optimization model to curb unrealistic costs of attainment. Staged implementation scenarios may also be played out according to population distribution expectations.

While certain alternative mixes may not be applicable throughout the study area, spatial mixes may offer some additional flexibility. Spatial variation in, say, monetary cost versus aesthetics may be investigated for overall impact. For instance, high value property owners may prefer to make additional capital expenditures for higher tech but more aesthetically pleasing treatment systems.

Eventually, a reasonable mix of plan elements that best fits technical and refined community objectives will be found. It is expected that only two series of alternative analysis will be necessary but additional analyses might be required. In any event, the refinement loop must be broken and a reasonable set of alternatives must be selected.

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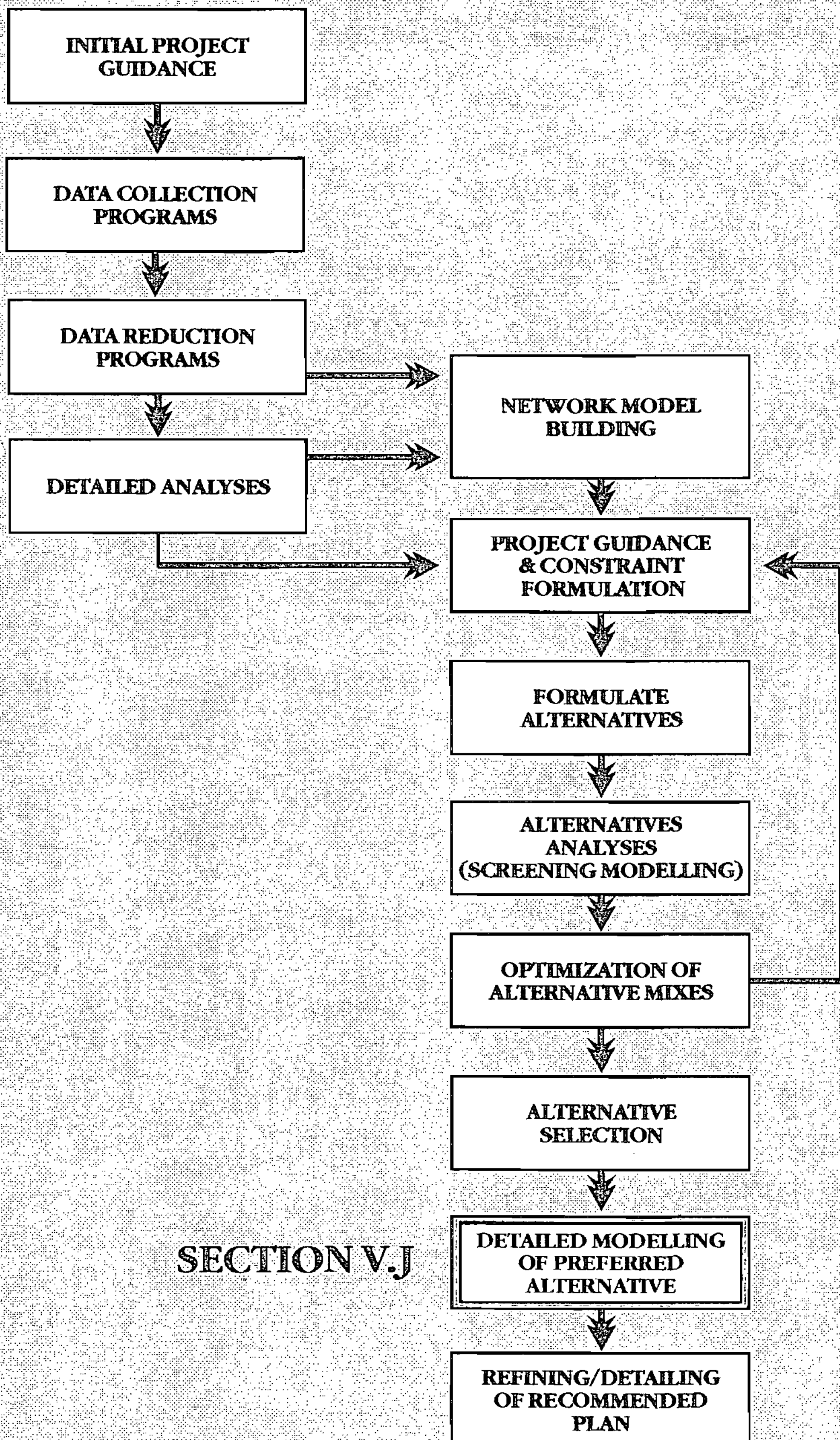

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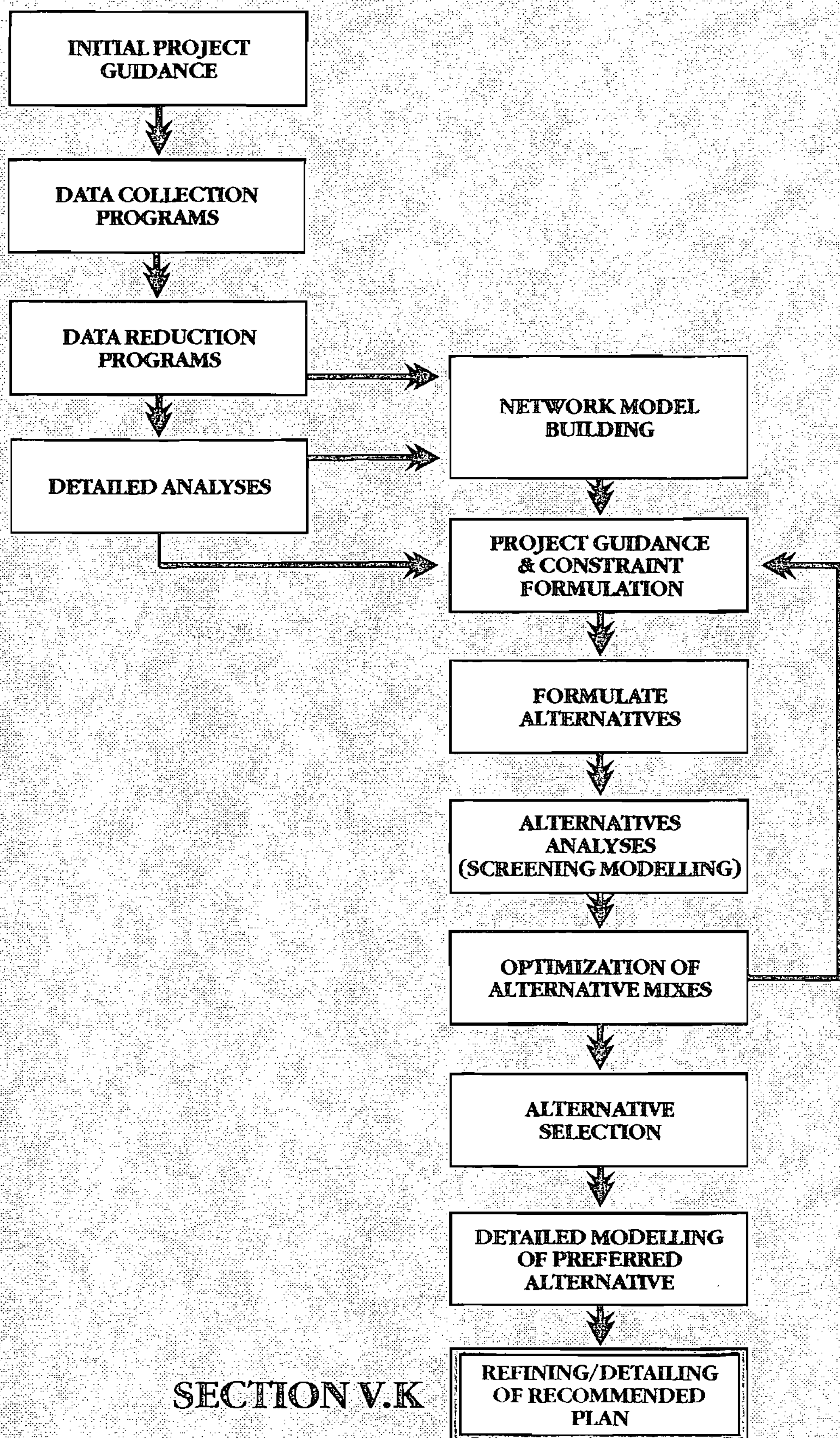
REFINING/DETAILING OF RECOMMENDED PLAN

J. DETAILED MODELLING OF PREFERRED ALTERNATIVE

The full model package including AWSM and its links to SLAMM and receiving water quality models will then be used to perform detailed simulations on the selected alternative package. These simulations will be used to test system sensitivity to slight changes in important variables. Continuous and event simulations will also be made to determine likely ranges of operational parameters and controls.

Design development will be initiated to begin to finalize specific details of alternative elements. Network design details will be tested within the model system to ensure control designs are concurrent with system-wide objectives. Final system designs will be thoroughly tested to verify operational procedures as well as quantify system performance.

Network design, operation and performance will be presented to city staff and citizens in a final workshop forum. Topics to be discussed will include expected impacts on drainage, water quality and aesthetics. It will also include instructional information on what citizens may expect as changes to their environment, the importance of individual involvement in the protection of property and infrastructure upgrades.


INITIAL PROJECT GUIDANCE
DATA COLLECTION PROGRAMS
DATA REDUCTION PROGRAMS
DETAILED ANALYSES
NETWORK MODEL BUILDING
PROJECT GUIDANCE & CONSTRAINT FORMULATION
FORMULATE ALTERNATIVES
ALTERNATIVES ANALYSES (SCREENING MODELLING)
OPTIMIZATION OF ALTERNATIVE MIXES
ALTERNATIVE SELECTION
DETAILED MODELLING OF PREFERRED ALTERNATIVE
REFINING/DETAILING OF RECOMMENDED PLAN

SECTION V.K

K. REFINING/(DETAILING) OF RECOMMENDED PLAN

The results of the study effort will culminate in a comprehensive set of recommendations for the management of the surface waters of Cape Coral. No longer will the system be viewed as one system from which conflicting benefits are derived, but as a balanced set of inter-dependent sub-systems.

1. PRIMARY SYSTEM CONTROL

Central to the management plan will be recommendations for primary system control mechanisms that will be developed to assure proper drainage, water supply and water quality throughout the surface water system. Modification possibilities include the addition or modification of control structures and interconnections, fine tuning operational procedures, creation of real time data acquisition and gate control network and additional storage alternatives.

Key city personnel will be trained in the use and application of the data acquisition and storage techniques, the custom version of AWSM, graphical interface and operational decision criteria. Training in the operation of the data and model systems will also be included in the project presentation.

Important ancillary issues such as maintenance plans, internal regulatory control, bank stabilization and navigation will also be addressed. Also, modifications to the spreader waterways will be developed. Design alternatives will be evaluated on all pertinent criteria in order to satisfy both the City's protection and regulatory requirements.

2. SECONDARY DRAINAGE

Well engineered drainage designs will be incorporated into the overall plan. Drainage designs will impact water quantities in the surficial system and water quality treatment prior to water reaching the canals. New engineering design criteria for the secondary drainage system will be developed to consider the effects of canal level fluctuations, stormwater treatment effectiveness, newly developed level of service standards and reasonable design alternatives. A comprehensive evaluation of Best Management Practices will be assembled and made available to the local engineering community.

Training in the use and operation of the secondary drainage model and the interface to the GIS will be provided. The secondary drainage model will serve primarily as a design evaluation tool for regional and sub-regional drainage works and the impact of specific site developments. Since this model will be used more in a documentive capacity rather than operational, this model will operate outside the main network operation model. However, key basin parameters generated by the detailed model will be used to update the main network (GIS) database.

3. OPERATION AND MAINTENANCE PLAN

A operation and maintenance (O&M) program to execute the management program will be developed. This program will summarize all of the recommended action items to be carried out by utility staff. A number of documents that could be used as owner and operator manuals will be developed for specific pieces of the surface water system. While each of these elements will be contained within the Master Plan, separately they may be used to inform, guide and instruct specific operational crews.

The development of these operational plans will rely heavily on interaction with the current utility personnel. Each operational manual will combine the experience of the field personnel with the engineering technology developed during the investigative process. The intent of these manuals is to provide city personnel with clear, concise guidelines and straightforward procedures without all of the supporting detail. However, supporting detail and rationale will be provided in the main Master Plan document. Some of these operational manuals may be adopted as ordinance or remain as guideline reference materials for those who use them. Operational manuals may include:

- Stormwater Structure Inspection for Commercial Development
- Stormwater Structure Design Criteria for City Drainage Works
- Canal Maintenance Operations
- Operation and maintenance of the Spreader Waterway System
- Regulatory Requirements and Procedures
- Surface Water Model Operation
- Geographic Information System Operation Guidelines
- Supervisory Control and Data Acquisition (SCADA) for Surface Water
- Extreme Event and Surface Water Crisis Management Guidelines
- Water Quality Protection Program for Surface Waters

4. EXPANDED AND ENHANCED ENVIRONMENTAL QUALITY MONITORING

Technology alternatives to meet regulatory requirements and aid in the preservation and enhancement of amenities provided by the canal system and will be presented. Initially the investigation will quantify potential quality hazards and their effect on aesthetics and irrigation water use. Effective measures will be presented for consideration. Public information programs will discuss the purposes and benefits of accepted finalized alternatives.

In addition to preservation techniques, modifications to the current monitoring operations will be developed in close cooperation with the Environmental Resources Division personnel. Results of short term investigations conducted during the Master Planning effort will be presented. A presentation of program modifications will include discussion of monitoring needs, program details, budget requirements and long term goals.

5. FINANCIAL PLAN AND PROGRAM

Through the course of the project, assistance in the preparation of annual budgets and long range forecasts will be provided. This assistance will be an ongoing effort to incorporate results of investigations as they occur.

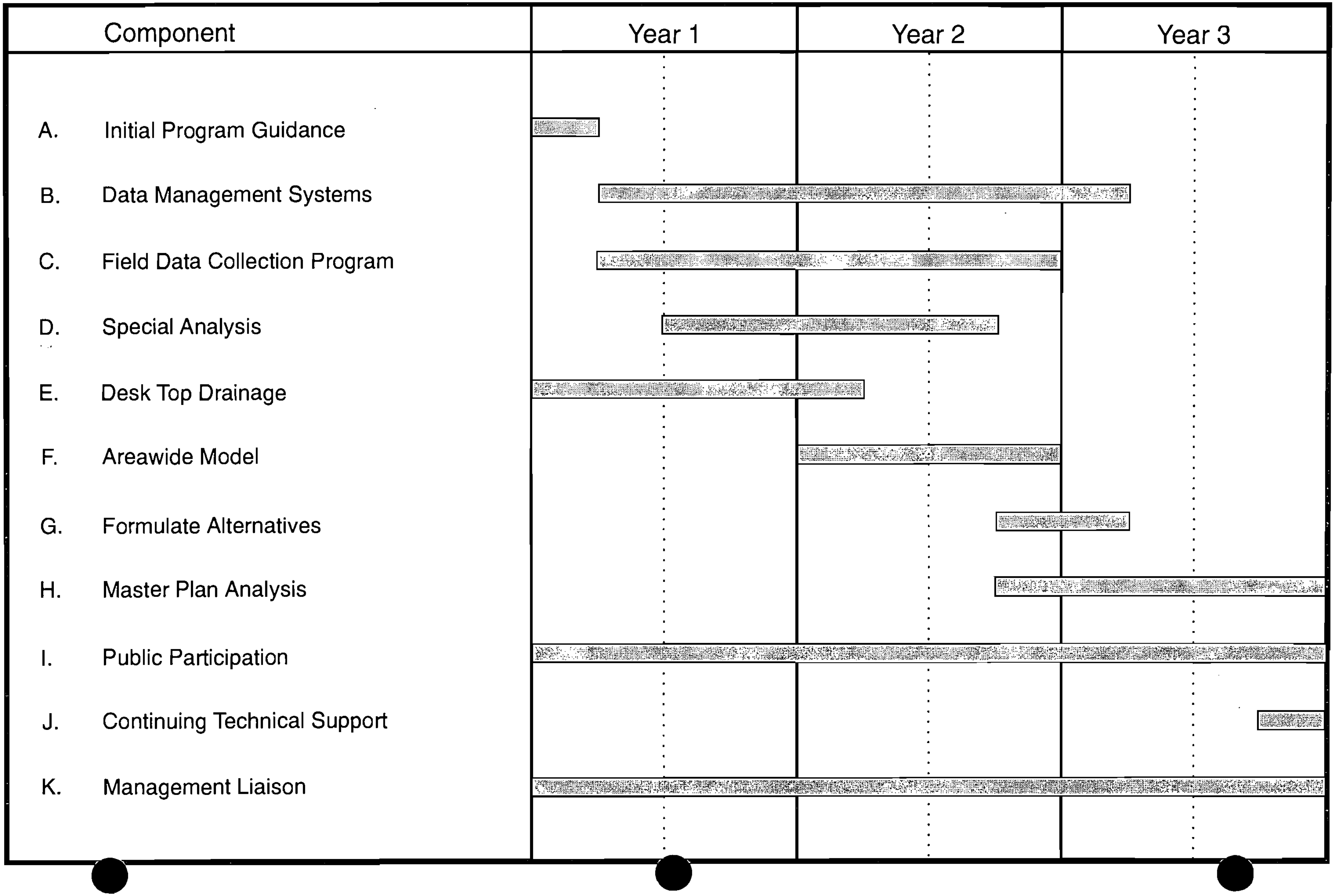
As data and operation management programs are developed, improved fiscal tracking and reporting procedures will be incorporated into the operation of the Stormwater Management Utility to enable ongoing production and cost accounting. Budget forecasts and management programming will be formalized in a financial program designed to enable implementation of the design and operation program. The final analysis will detail fiscal requirements to meet short and long range goals of the surface water management program. It will include prioritization of implementation steps in light of monetary constraints. It will also focus on funding solutions including revenue production, revenue source alternatives and financial management programming.

SECTION 6

SCHEDULE & TASK BREAKDOWN

Schedule

Cape Coral Surface Water Master Plan



Cape Coral Surface Water Master Plan

Task Breakdown

Component A	INITIAL PROGRAM GUIDANCE
	Task Description
A. 1	Refinement of Project Goals
A. 2	Assimilation of Existing Data
A. 3	Development of Preliminary System Information
A. 4	Critical Data Review
A. 5	Finalization of Data Collection

Component B	DATA MANAGEMENT SYSTEMS
	Task Description
B. 1	Initial Setup of Data Management System
B. 2	Establish Coordinate System – tic grid – base map
B. 3	Establish Primary Coverages
B. 4	Drainage Basin Delineation Coverage (City)
B. 5	Soil Coverages
B. 6	Land Use
B. 7	Canal Geometry Coverages
B. 8	Existing Infiltration Test Location Coverage
B. 9	Piping System Details
B. 10	Initial Model Scheme Coverage
B. 11	Download QA/QC Analysis of Exist Environmental Data
B. 12	Download QA/QC Analysis of New Environmental Data
B. 13	Spatial Corrections
B. 14	Develop Data Exchange to Models
B. 15	Develop Final Model Scheme for Phase III
B. 16	Problem Areas

Component C	FIELD DATA COLLECTION PROGRAM
	Task Description
C. 1	Aerial City Ground Control
C.1A	Aerial – Gator Slough Ground Control
C 2	Monuments/Benchmarks – City
C.2A	Monuments/Benchmarks/Gator Slough
C. 3	Spot Elevations – City
C. 4	Conduct Canal Centerline Surveys/Review Results
C. 5	Perform Canal Cross – Sectional Surveys/Inventory Canal Protections
C. 6	Inventory Control Structures
C. 7	Conduct Secondary System Piping System Surveys
C. 8	Catalog of Existing BMPS
C. 9	Spreader Canal Survey Program
C. 10	Conduct General Background Meteorologic Measurements
C. 11	Network Level Macro scale Surface Water Program
C. 12	Macro Scale Special, Water Quality Surface Water Program
C. 13	Subsurface Measurement Program
C. 14	Micro Scale Water Quality Measurements
C. 15	Report

Component D.	SPECIAL ANALYSIS
	Task Description
D. 1	Spreader Canal Intrusion Analysis
D. 2	Tidal Circulation Study
D. 3	Develop Surficial Aquifer Properties
D. 4	Develop Seepage Data and Relationship
D. 5	Develop Cost Relationship
D. 6	Estimate Nonpoint Emission Factors
D. 7	Develop Specific BMP Effectiveness Control Factor
D. 8	Develop Environmental, Physical and Regulatory Constraints

Component E.	DESK TOP DRAINAGE GUIDELINE INVESTIGATIONS / DESIGNS
	Task Description
E. 1	Establish Interim Guidelines
E. 2	Prototype
E. 3	Santa Barbara

Component F.	AREAWIDE MODEL BUILDING & TESTING
	Task Description
F. 1	Develop AWSM Model
F. 2	Develop Areawide SLAMM Model: Stormwater Pollutant Loadings
F. 3	Integrate Land Side Pollutant Emission Estimation Procedure
F. 4	Develop Water Quality Model (Limited)
F. 5	Initial Model Application
F. 6	Perform VE of Initial Results
F. 7	Conduct 1st Public Meeting: Areawide Performance Objectives
F. 8	Incorporate Optimization for Multiobjective Modeling Analysis

Component G.	FORMULATION & ANALYSIS OF SUBPROGRAM ALTERNATIVES
	Task Description
G. 1	Formulate Subprogram Alternatives
G. 2	Perform Subprogram Modeling using Screening/Optimization Models
G. 3	Summarize Results
G. 4	Conduct 2nd Public Hearing: Solicit Refined Objectives

Component H.	MASTERPLAN ANALYSIS
	Task Description
H. 1	Refine Objectives Screening Models
H. 2	Perform further Screening Model and Optimization
H. 3	Perform Simulations of Attractive Alternatives using Detailed AWSM
H. 4	Summary of Results
H. 5	Present to City for Refinement
H. 6	Perform further Detailed Analysis on Refined Final Plan
H. 7	Detail Recommended Plan
H. 8	Conduct 3rd Public Meeting
H. 9	Prepare Draft Report and Final Report
H. 10	Briefing Meetings with Regulatory Agencies
H. 11	Technology Transfer

Component I.	PUBLIC PARTICIPATION PROGRAM
	Task Description
I. 1	Conduct Community Outreach and Develop Community Profile
I. 2	Develop Newsletters, Videos and other Media

Component J.	CONTINUING TECHNICAL SUPPORT
	Task Description
J. 1	

Component K.	MANAGEMENT LIAISON
	Task Description
K. 1	Ordinance/Development Regulations
K. 2	Financial/Funding
K. 3	Meetings (Public/Staff)

APPENDIX A: SUMMARY OF ISSUES

Table of Contents

INTRODUCTION

Contained herein is a series of summary information briefs regarding specific topics related to the Surface Water Master Plan. This report is designed to provide basic topical information and provoke thought towards developing a detailed project approach. Specific information on most of these topics may be acquired at the Cape Coral office of Havens and Emerson. A topical database containing reference to numerous articles and publications is maintained for the use of all involved. A copy of this database, sorted by title, is attached.

Recommended documents for review are:

WICC Master Plan, Chapter 9, Boyle Engineering, 1988

City of Cape Coral Comprehensive Plan - Drainage Element

Use of Cape Coral Canals as a Secondary Water Supply, PBSJ, 1982

A Water Management Study of Cape Coral Canal Networks CME, 1979

Cape Coral 208 Water Quality Study - Executive Summary, SWF RPC, 1984

An Ecological Assessment of Unit 89 Waterway System, City of Cape Coral, ERD, 1989

Environmental Resources Management Plan, City of Cape Coral, 1991

An Ecological Assessment of the Cape Coral Freshwater Residential Canal System, City of Cape Coral ERD, 1989

. 1 **Comprehensive Plan Drainage Element**

A 20 page section in the Comp Plan describes the history, layout, operation and regulatory framework for the City's drainage system. It also includes hydrologic data. The element makes no promises of action being taken by the City to upgrade the drainage structure.

<u>Findings</u>

- Cape Coral lies in FDOT C-1 (Zone 8) storm frequency curve area. No design storm is specifically chosen in the element.
- Governing federal regulation is the Water Pollution Control Act.
- Governing state regulation is Ch. 373 Florida Statutes 1972, See FAC 17-40
- SWIM Act, Ch. 373.451, gave DER authority which was delegated to Regional WMD's.
- See also FDER Stormwater Rule FAC Ch. 17-25, attempting 80-95 percent removal of pollutants in stormwater requires treatment of first inch for sites >100 acres. Note design based, not performance based requirements.
- Originally all Cape Coral Ordinances mandated that land owners maintain ditches and swales (1987). However, Stormwater Utility has been maintaining the swale elevation in many swales since its establishment. In February 1993, an ordinance (2-93) was adopted charging the Stormwater Utilities with maintenance of swale elevation.
- GAC-DER settlement (1976) included:
    - Spreader waterways
    - $1,000,000 given to GAC Pollution Recovery Trust Fund
    - 9,000 acres of tidal wetland given to state
    - Creation of grassed swales throughout the undeveloped portion of the City
- Element advocates canal lining, dredging and vegetation control to increase velocities. These are not technically supported as necessary activities.
- Element describes drainage improvements needed in CRA area.
- Element contains cost estimates for upgrading drainage system at $53 million for:
    1. Expanded canal maintenance
    2. Expanded swale maintenance and street sweeping
    3. Pipe replacement 1,000,000 LF in 10 years
    4. Conversion of 15,000 inlets to CB's
- Recommends inlet box modification to retain 6" in the swale bottom.
- Recommends stormwater treatment with swale modifications and inspection. No mechanism to enforce this recommendation is specifically outlined in the drainage element other than the spirit of the GAC-DER settlement.

BEFORE THE STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

DEPARTMENT OF ENVIRONMENTAL REGULATION,	)	
	)	
vs.	)	Order No. 15
GAC PROPERTIES, INC., Lee County.	)	
	)	

CONSENT ORDER

This is a Consent Order between the State of Florida Department of Environmental Regulation (hereinafter referred to as the "Department") and Frank J. Callahan and Herbert S. Freehling, as Co-Trustees of GAC Corporation, GAC Properties Credit, Inc., and GAC Properties, Inc. (hereinafter referred to as "GAC").

Background: Permit applications were filed with the Department for certain dredge and fill work to be done at the Cape Coral Project of GAC. The Department issued a letter dated June 30, 1976 informing GAC of the Department's intent to deny certain of these permits. In addition, the Department issued Warning Notice No. 7996 dated July 9, 1976 regarding ongoing dredge and fill activities within the Cape Coral Project. On August 26, 1976, the Department set out by letter the modifications of the Cape Coral Project required to allow the completion of the project. Subsequently, the GAC verbally agreed to incorporate and implement the proposed, major modifications, subject to the approval of the Bankruptcy Court. It was also determined after the initial denial that GAC qualified for special consideration. This order represents the best efforts of the Department and GAC to improve an old project, begun prior to this decade. It does not signify water quality standards will be met in the interior canals, but is an attempt to buffer, treat, and improve water quality before it reaches Matlacha Pass or the Caloosahatchee River. This Consent Order resolves the alleged violations and serves as the authorization from the Department to complete the work.

1. GAC agrees that no development work shall be done waterward of the line identified as "A" drawn on Exhibit No. 1. Any work that has been done by GAC waterward of this line shall be restored. Restoration shall include the removal or replacement of all GAC-excavated fill material to natural elevation in the areas designated as "B" on Exhibit No. 1. Restoration shall commence within sixty (60) days of the date of entry of this Consent Order, continue in a continuous manner, and be completed to the satisfaction of the Department's district office within one (1) year of the date of entry of this Consent Order.

2. All work landward of "A" on Exhibit No. 1 will be done as described in Exhibit No. 2. The Department originally indicated its intent to deny the applications for permits because of its concern over water quality in the canal system and discharges from the canal system. GAC agrees to construct a pollution retention system landward of "A" on Exhibit No. 1. This retention system will consist of a perimeter spreader waterway to serve as a water distribution system for intercepting and releasing discharges of waters from certain areas of the Cape Coral development. GAC agrees to construct back-to-front sloping lots, swales and weirs within the inland portion of the undeveloped portion of Cape Coral, so as to retain as much of the runoff from the upland as possible, as well as increase the retention and percolation of freshwater to the aquifer. GAC shall prepare a hydraulic assessment to determine the maximum retention of runoff possible within the swales and canals. All work described in this paragraph of the Consent Order shall be performed as described in Exhibit No. 2.

3. Because of the water quality problems within the interior canal system, the Department cannot allow any direct

connection of Cape Coral waterways to waters of the State, which direct connections do not presently exist. Therefore, GAC shall install boat lifts to provide navigable access to Cape Coral canals which do not presently have access to waters of the state. The locations of the boat lifts are identified on Exhibit No. 1 as C_1, C_2 and C_3. Construction of the boat lifts shall be as described in Exhibit No. 2.

4. Because of the water quality benefits to be derived from the tidal wetlands surrounding Cape Coral and the treatment these natural areas provide for any indirect discharges from the Cape Coral area, GAC shall deed to the State, on the date of entry of this Consent Order, the lands owned by GAC as are described in the warranty deeds attached as Exhibits 3(a), 3(b) and 3(c).

5. GAC will deposit to the account of the Department's Pollution Recovery Fund the sum of $200,000 per year, each year for five (5) consecutive years, the first such deposit to be made within thirty (30) days of the entry of this Consent Order and following payments to be made on or before the annual anniversary date of the date of entry of this Consent Order. All money deposited in the Pollution Recovery Fund to the account of GAC projects shall be identified and all interest earned on the account of GAC projects shall be credited to the Pollution Recovery Fund account of these GAC projects. This money shall be used at the discretion of the Secretary of the Department, which use shall nonetheless be restricted in use to study water quality and quantity problems in the Cape Coral and Golden Gate Estates areas, to propose solutions to the problems identified, and as funds allow, to correct the identified problems in both projects. No more than $200,000 may be spent in any one fiscal year without the approval of GAC.

6. GAC hereby agrees to withdraw all permit applications pending for the Cape Coral development (File Numbers 36-10-3545, 36-24-3827, 36-10-3546 and 36-20-0274) on the same date as the entry of this Consent Order. The Department agrees

that this Consent Order will provide the necessary authorization to complete the work described in Exhibits 1 and 2. This Consent Order waives certification under PL 92-500, Section 401.

7. This Consent Order is enforceable under Section 120.69, Florida Statutes and can also be enforced under Section 403.161(1)(b), Florida Statutes.

JAMES E. YACOS and JOHN RODGERS CAMP, JR., as Co-Counsel for the Co-Trustees of GAC Corporation, et al.

By: John Rodgers Camp Jr.
JOHN RODGERS CAMP, JR.

DEPARTMENT OF ENVIRONMENTAL REGULATION:

Terry Cole
TERRY COLE
Deputy General Counsel

Consented to by GAC this _____ day of _____________, 1977.

Herbert S. Freehling
HERBERT S. FREEHLING
as Co-Trustee

Frank J. Callahan
FRANK J. CALLAHAN
as Co-Trustee

DATED AND ENTERED this 19 day of april, 1977.

J W Landers Jr
JOSEPH W. LANDERS, JR.
Secretary

Department of Environmental
Regulation
2562 Executive Center Circle, E.
Montgomery Building
Tallahassee, Florida 32301

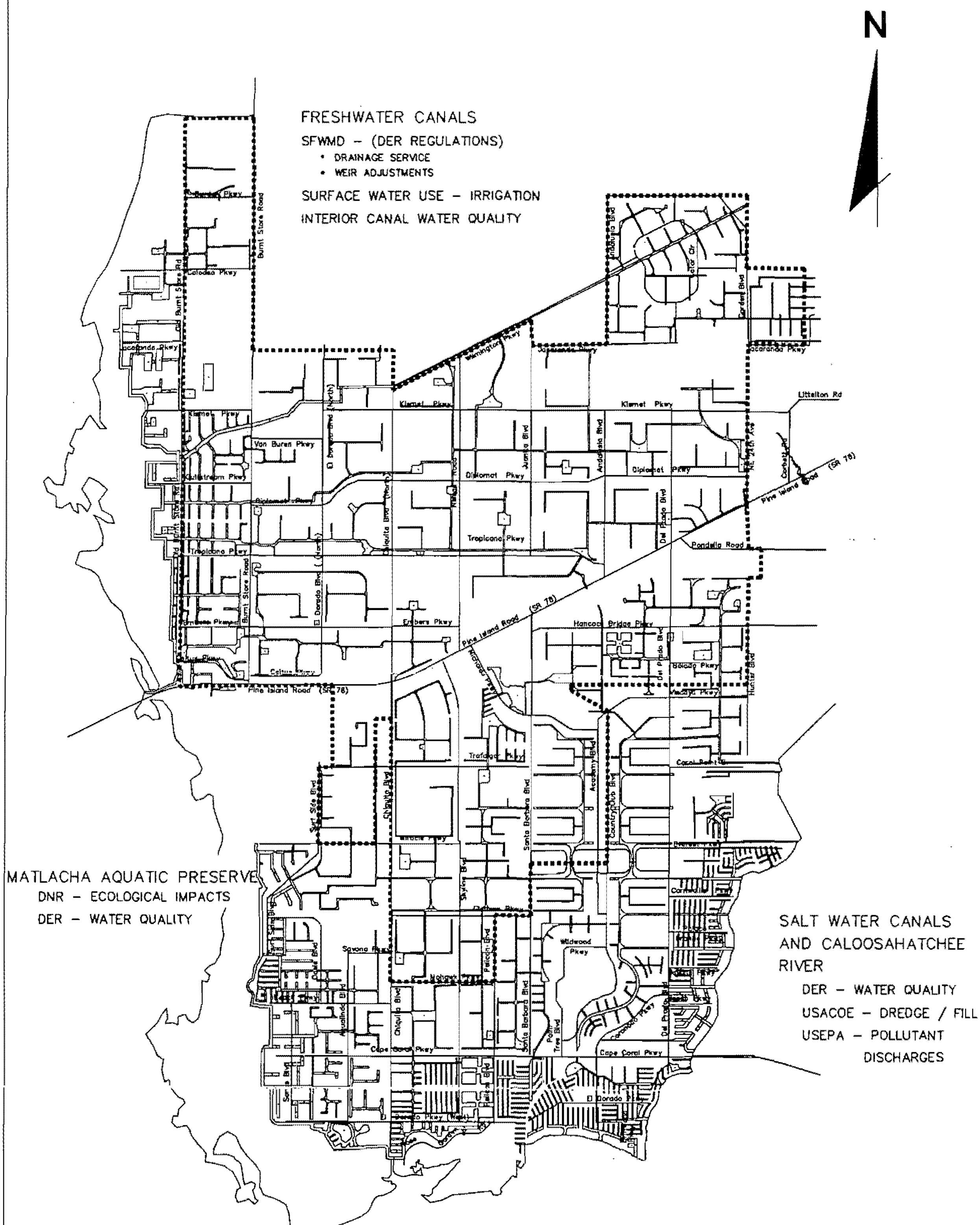
. 2 Governmental Agencies DER, EPA, SFWMD

Aside from local political pressures, there are external reviewing agencies that have an interest in the freshwater management of Cape Coral.

Findings

- **USEPA Permitting** The City of Cape Coral will most probably be required to submit an application for a National Pollutant Discharge Elimination System (NPDES) stormwater discharge permit at the same time Lee County is required to submit (probably late 1993 or early 1994) it's NPDES permit application or by the time the population reaches 100,000. It will be very important to address all water quality issues required by NPDES permit with the anticipation that the City of Cape Coral will have to apply. It is important to understand that once the NPDES permit is received, data collection must continue in order to have the permit renewed on a regular basis. NPDES surface water program will be a continuing program.
- **SFWMD** The South Florida Water Management District (SFWMD) views the City of Cape Coral's water management efforts favorably, especially for its commitment to installing a secondary water supply system for irrigation. The SFWMD may have funds available for the City of Cape Coral to pursue the expansion planning effort. However, the City of Cape Coral has already received funds for the secondary water. The availability of additional funds is questionable on these grounds.
- **SFWMD** has issued a surface water consumptive use permit for secondary water system. It allows the use of 6 pump stations to withdraw an annual allocation of 5.22 billion gallons with a maximum monthly allocation of 23.4 million gallons. At buildout an expected 74 MGD will be required from the canal system.
- **SFWMD** maintains jurisdictional authority of Florida Department for administering Environmental Regulation (FDER) regulations regarding stormwater in Cape Coral freshwater systems and is responsible for the enforcement of all state laws regarding surface water.
- In the past, **FDER** has expressed concern over the impact failures along the spreader waterway berms may have had on the mangrove forest and Matlacha Pass Aquatic Preserve. FDER reserves jurisdiction over marine (saline) waters. Records show that water in marine canals is typically of better quality than the Caloosahatchee River.
- **FDNR** Department of Natural Resources Management administers Matlacha Pass Aquatic Preserve under the Charlotte Harbor Management Plan. They too are concerned with the alteration of freshwater flows to Matlacha Pass.
- **Interagency Communication** We have not seen evidence of any special protocols for enhancing communication between the City and DER, SFWMD, and DNR.

Figure A.1 presents a City map identifying governmental jurisdictional and agency issues.



HAVENS AND EMERSON, INC.
CONSULTING ENGINEERS

GOVERNMENTAL JURISDICTIONAL AND AGENCY ISSUES

FIGURE A.1

. 3 Secondary Water System

Cape Coral has installed a secondary water system to relieve the potable water system of irrigation and fire service demands.

<u>Findings</u>

- The first phase of secondary water came on line in April 1992.
- The irrigation system is supplied by wastewater treatment plant effluent and canal water.
- Based on current irrigation use, canal withdrawals of 74 MGD is expected when City reaches buildout. (WICC, Boyle, 1988)
- For residential sites, use of secondary water is paid for by a flat rate fee of $5/month and the system is unmetered. Commercial properties and condos have a variable for structure based on size and usage.
- SFWMD recently publicly recognized the City of Cape Coral for it's secondary water system. (Fort Myers News Press, July 1992)

The secondary water system is the link that ties all of the City's major water systems together. Irrigation, water is drawn from the wastewater effluent and stormwater (canal) systems and allows expansion of the potable water treatment facilities to be minimized. Aside from filtration and disinfection, it is expected that canal water will not be treated prior to induction into the secondary system, thus health, suitability for irrigation and aesthetic qualities of the water in the canals becomes important to this system.

<u>Considerations for Surface Water Master Plan (SWMP)</u>

- Parameters that will need to be monitored for purposes of the irrigation system will include salinity, pH, phosphorous, nitrogen, BOD, coliforms, and metal contamination
- An undetermined percentage of irrigation water and the chemicals and other constituents contained in it will find its way back into the canal system.
- Effect that location and withdrawal rate of canal pump stations on total water budget and storage balance including:
  - Groundwater/canal stored volume
  - Canal drawdown effects
- Quantity of water available within the canals through the dry season
- Protection of spreader waterways from saline intrusion and development as additional storage area
- Techniques for increasing freshwater storage capacity of canal system
  - Alternative runoff storage
  - Use of potable system as a last resort

<u>Other Comments</u>

- The secondary water system is a politically controversial item in the City. Certain factions are lined up in opposition based on cost and fear of perceived health concerns in using treatment plant effluent.
- Real estate professionals have predicted property values in the future will be significantly enhanced by dual-water.
- Note that previously reported future irrigation usage will be about 116 mgd = 27,152 acre/inches. Cape Coral covers 75,240± acres. Expected demand might be out of line.

Excerpt from: PBSJ 1982 Canal Network Study

"The absolute quantity of water held in canal storage, assuming a weighted average drawdown of 1.5 feet, is able to supply only 11.1 MGD of irrigation water for the duration of the irrigation season without any recharge from the surficial aquifer. Therefore, the canal system alone is able to supply only 20 percent of the total withdrawal from the system, based on the defined criterion. The surficial aquifer supplies the remaining 80 percent of the total possible irrigation withdrawal for a 1-in-10-year drought rainfall shown in Table 7-1. <u>This indicates the high level of dependence of the whole system upon the surficial aquifer.</u>" (Emphasis added)

Excerpt from: WICC - Boyle 1984

"The demand for secondary water at buildout was estimated in Section 4 to be 116 MGD. Builtout wastewater flow, and therefore reclaimed water, was estimated to be 42 MGD. Accordingly, to meet the builtout secondary demand, approximately 74 MGD will be required from the canals. Unfortunately, sufficient data does not currently exist to say with certainty that 74 MGD can actually be withdrawn from the canal system.

The 1982 PBSJ study was a computer model of the canal system that attempted to simulate the overall Cape Coral hydrologic system in operation. The study concluded that 67 MGD could be withdrawn from the canal system during the dry season of an average rainfall year, assuming a drawdown of 1.5 feet below weir levels. The report further emphasized, however, that this was strictly the results of computer modeling and that there was no calibration with actual field data.

<u>**There are shortcomings**</u> (emphasis added) to this study making it difficult (if not impossible) to pinpoint exactly how much canal water is available. At this point in time, all that can be said for certain is that there indeed is a significant quantity of freshwater available and that the City should begin implementing the WICC Program and start using the system."

. 4 Drainage - Physical Description - Geologic Setting

City of Cape Coral is comprised of 114 (±) square miles of filled pineland, and cypress - mangrove marsh. Maximum elevation is approximately +18' NGVD in the very Northern reaches of the City. City dimensions are approximately 12 miles N-S and 9 miles E-W. Soil characterization maps show a high degree of variability. Many classifications indicate only that the land has been disturbed and not much is known of its physical properties. In most areas of the Cape, physical properties of soils between ground surface and the first aquae lude are poorly understood. Groundwater table elevations may vary significantly with season in many locations in the City. (PBSJ, 1982)

<u>Findings</u>

- 114 square miles; (approximately 12 x 9)
- Surficial hydrologic system 30'-100' thick underlain by 100' clay layer.
- Maximum elevation + 18 NGVD
- Based on discussions with personnel at USGS, SCS, and local engineers, soil characteristics are variable and poorly understood. SCS reports Cape Coral's overall soil type as matlacha series, characterized by mixed, somewhat poorly drained sands, shell and limestone fragments.Most soils are assumed to be poorly drained but areas of high porosity and transmissivity have been reported in some locations.
- City previously marsh, swamp, and pine hammocks.

<u>Considerations for SWMP</u>

- Gain better understanding of surficial aquifer - canal interaction (ERD has done some research on this)
- Possible soil characterization by historic (pre-development) aerials

Drainage- Physical Description- Upland

Planned use for most of the City is single family residential and most lots are already sold to individuals. At buildout it is expected most of the land throughout the Cape will be developed as such. With the desire to maintain lawns and provide drainage throughout the City, it is expected that nutrient loads reaching the canals increase in surface waters as a result of lawn fertilizer.

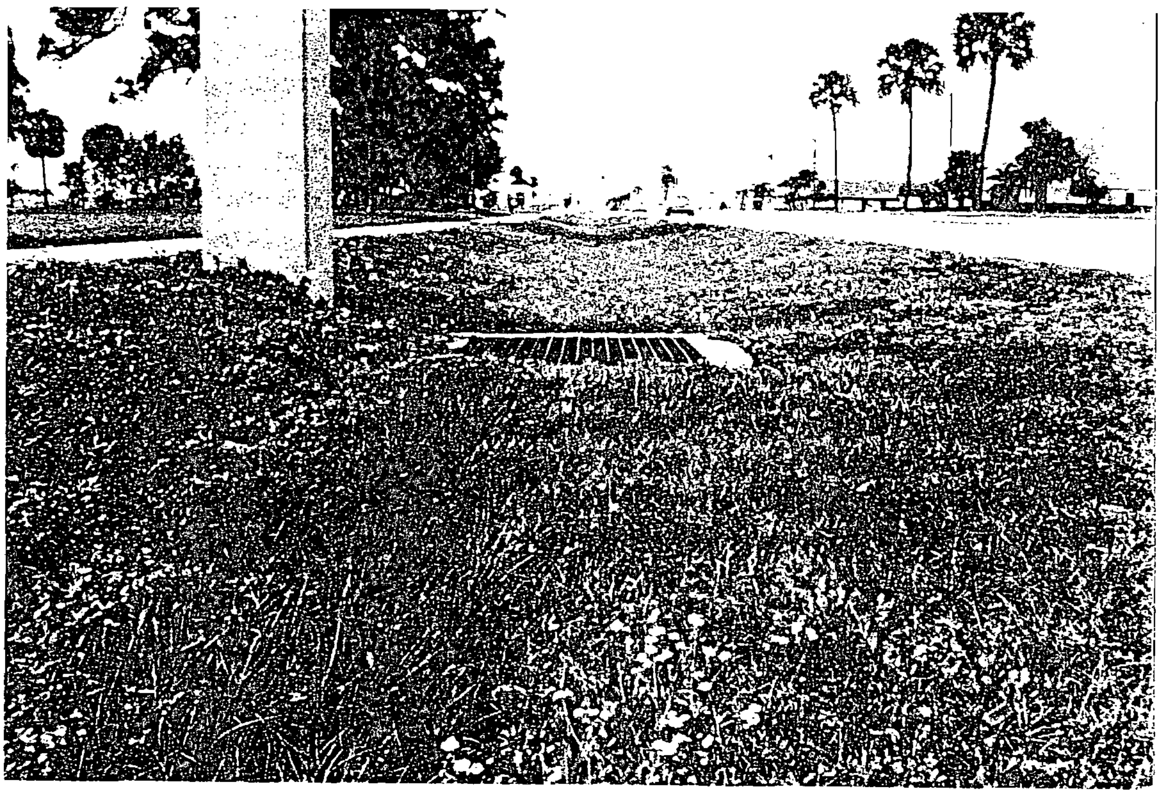
Most yard grass is either Bahia or St. Augustine. Bahia is less attractive but is drought resistant. More attractive is St. Augustine, a broad leaf that creates an expanding root mat. St. Augustine requires consistent irrigation.

The typical rainwater route is from the lawn to a swale in front of a residence to an inlet and thence an outfall into a canal. The inlet to outfall path is generally short and simple since so many canals exist throughout the City. Figure A.2 presents a typical swale which directs stormwater runoff from yards and streets to the area inlet. Flow is then directed to the canals via underground piping. Rainfall also runs across lawns and directly over seawalls.

The other upland consideration is the widespread use of septic tanks. Many leech beds are suspected to be not functioning properly (personal communication, Environmental Resources Division) and heavy nutrient loads from the leachate might be forced to the surface and across lawns to be washed into the canals directly or via the swale system. Some areas, specifically Lake Kennedy and Lake Manitoba, have experienced significant algal blooms most likely as a result of this process (personal communication, City of Cape Coral Environmental Resource Division). The septic tank nutrient problem should become less significant as the City installs sewers.

<u>Findings</u>

- DER Consent Order 15 (see ordinance section, paragraph two) mandates maximizing runoff retention by installing swales in front yards and having back to front sloping yards or installing swales along the seawall on the case of waterfront lots. Few swales are actually in place along seawalls.
- Culverts, in place of swales, exist in some of the older sections of the City.
- All swale and driveway stakeout surveys and inspections are processed through the stormwater utility.
- The City Stormwater Utility (SWU) has taken on the responsibility of setting the grade for new swales and maintaining them when built. Sod is placed where possible after maintenance, but the City sod supply is limited. Previously, citizens were to maintain swale, culvert and sod.
- It is common practice to lower the controlling elevation inlets to increase drainage efficiency. This also decreases retention time for pollutant removal. This is deemed necessary by residents and the utility since soils typically have a slow perc rate and seasonal water tables may be rather high causing water to stand in the swales for longer than desirable. Inlet box modification may be needed per drainage element; i.e. subsurface holes with gravel/sand backfill. Possibilities for improving swale percolation could be investigated.



TYPICAL SWALE AND INLET

FIGURE A.2

- According to SWU personnel, standing water in a swale is perceived as a drainage failure to many residents.
- According to the City's Comprehensive Plan, the City is to provide sanitary sewer service once an area is 50% builtout.
- Sporadic leech bed malfunction is suspected (Personal Communication City of Cape Coral ERD) as a contributor to nutrient pollution in certain segments of the canal system. (Personal Communication ERD; ERD 1989 Report)

Other Comments:

Faulty septic tanks, while currently a nutrient loading problem, should be reduced as the City installs sewerage to septic areas.

In light of complaint files and Stormwater Utility personnel experience, the public, by and large, does not understand the physical problems (i.e. slow perc) in the City and is often intolerant of any standing water in swales. However, runoff retention in the swale system is probably the best water quality treatment for removing pollutants, especially nutrients from overland runoff. Furthermore, the biggest contribution to pollutant loads in the future will most likely be the unrestrained use of lawn fertilizers. Explaining the function of the swale and convincing the public to apply fertilizers judiciously may be key educational objectives.

Case Study: (Late May 1992)
Recently, a request was made to ERD to investigate the cause of a very localized algal bloom. The algae in question appeared directly in front of the homeowners seawall and was not evident across the canal fronting adjacent properties. Furthermore, the homeowner has recently installed the secondary water system, which is currently all canal water, and admits to rather indiscriminate use. He also has lawn care service. It is uncertain if septic effluent or fertilizer are contributing nutrients to the canal, but they are suspected causes.

Drainage - Physical Description - Curb and Gutter

Curbs and gutters are the primary collection systems in industrial and commercial areas of the City. Currently, these are designed and inspected in the engineering department. On-site detention and retention is reviewed by the Stormwater Utility as per SFWMD rules.

<u>Findings</u>

- Curb and gutter inspection & review takes place under the engineering department (roads).
- Street sweeping is performed by the City - 90 lane miles/week. Commercial and industrial sites under construction are inspected by Stormwater Utility.
- There is no NPDES stormwater permit required at this time although the City will probably be required to apply in late 1993.
- Few attempts have been made at treating stormwater from these areas with BMP's or other methods. However, studies in other cities have shown that these areas contribute the largest amounts of oil and grease, metals and other toxic substances to stormwater.
- Often inlets are too infrequent along commercial or high traffic corridors. These areas are often temporarily flooded giving rise to unsafe driving conditions.

<u>Other Comments:</u>

The City is not required to submit NPDES stormwater application at this time. Currently, cities with populations under 100,000 are not required to apply. However, this may change as the rules are subject to modification in late autumn of 1993 or early 1994. Stormwater discharges may also be subject to NPDES permit conditions under the Lee County permit.

Curb & Gutter

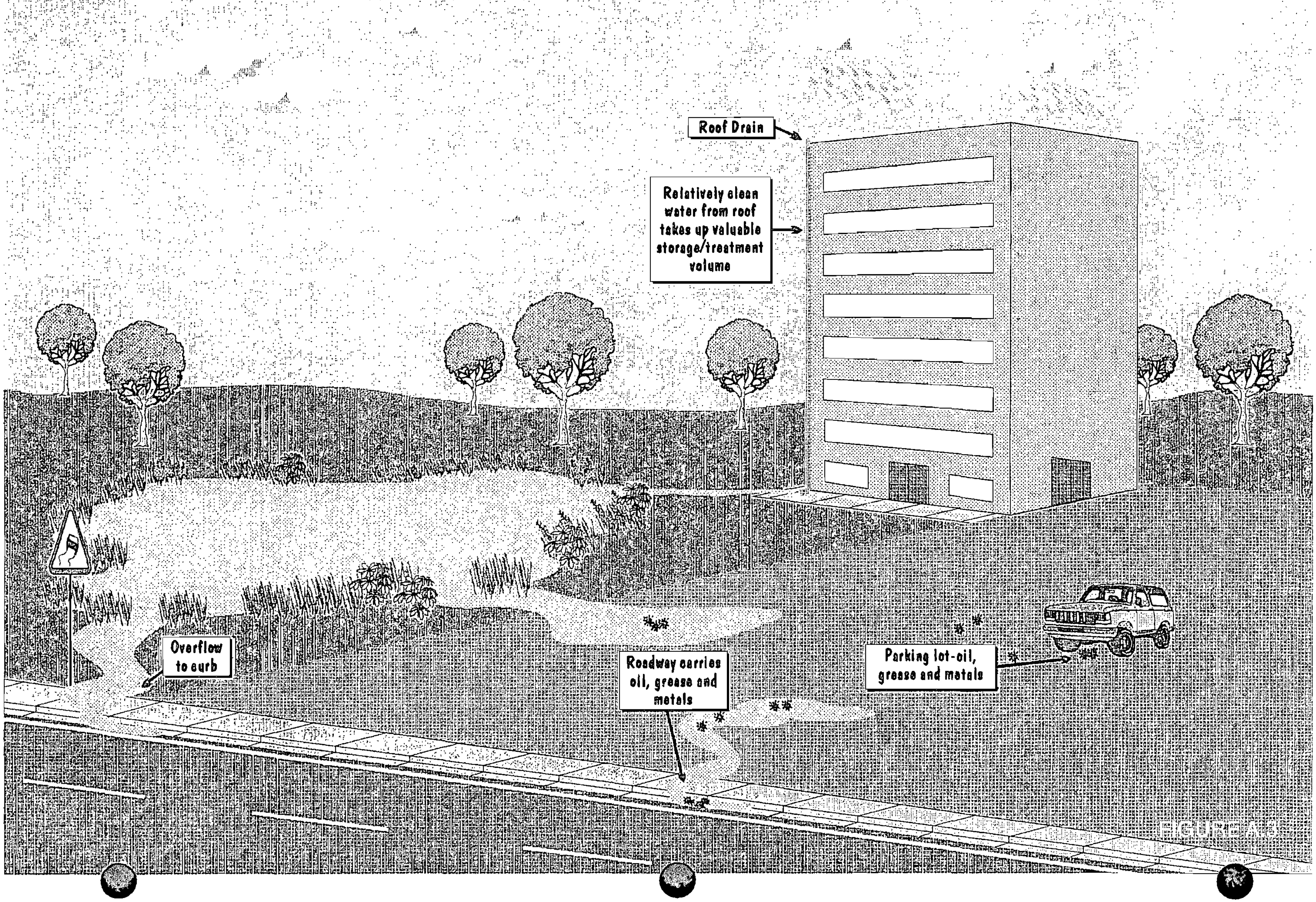


FIGURE A.3

Drainage - Physical Description - CB's and Pipes

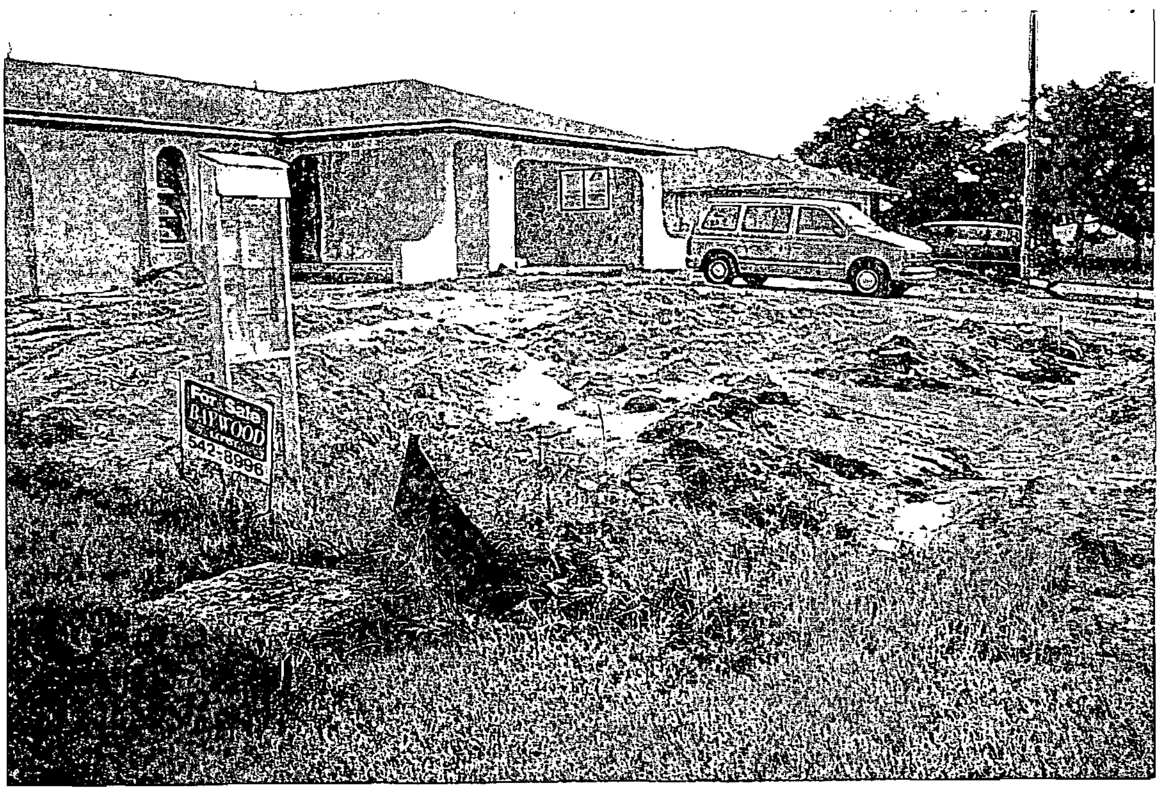
In residential areas, water in the swale is discharged into an inlet box or catch basin and routed to the canals. In industrial areas small networks of inlet boxes and pipes perform a similar function.

Findings:

- Much of the pipe installed throughout the City is under sized and made of corrugated metal pipe (CMP), (Personal Observation). It is suspected much of the CMP has failed, especially in the saltwater canals. Contributions to sediment load may result.
- Most inlet boxes are merely ground surface to pipe connections. Occasionally, these become silted in and causing stormwater to back-up. Some have recently been retro-fitted with French drain and other Best Management Practices (BMP).
- One of the most significant violations to the pipe system occurs during construction projects which release large amounts of soil to be washed into pipes and clog them. An example of soil potentially making its way to the canals is presented in Figure A.4
- The City is scheduled to replace a significant number of under street cross connections while installing the gravity sewer system throughout much of the City.
- The Stormwater Utility maintains and replaces the CB/pipe system. Methods include trenching and replacement, PVC slip lining and Insituform restoration.
- The Stormwater Utility is attempting to acquire a vac-truck for cleaning and maintaining the flow in these pipes. An alternative method such as line flushing and sediment capture might be investigated.
- Extensive drainage networks are found in the CRA (downtown) area, industrial park and where there are large drainage areas between canals.
- The inlet/pipe system design maps are available in the City's current GIS. Accuracy of the information is not always verified by field inspection.
- The large number of small drainage networks may make it possible to field test a variety of BMP's under very similar operating conditions during Master Plan development.
- Swale repair work sometimes includes the practice of removing the 6" retention lip at the inlet box. It is noted that this practice is not in keeping with Consent Order 15.
- Typically the entire drainage system is undersized. Replacement of one segment under a road will have little to no effect in improving overall system performance. Cost estimates of upgrading all the drainage systems in the City have been at least $53 million. (Comp Plan, Drainage Element)
- No distinction in level of service has been established between residential and commercial areas.

Considerations for MP

In light of the sheer number of poorly performing systems, it may be best to concentrate on completely upgrading entire pipe systems in critical areas.



CONSTRUCTION SITE
WHERE SOIL CAN POTENTIALLY
ENTER A CATCH BASIN THUS SOIL IS
TRANSPORTED TO THE CANAL SYSTEM

FIGURE A.4

Drainage - Physical Description - Canals

Note: This segment only reports on canals as they pertain to drainage.

The canals receive water from drainage outfalls, and overland flow and are responsible for channelizing much of the surficial aquifer groundwater. The only external sources are from Gator Slough and sheet flow crossing the north city boundary.

Canals are maintained by the Stormwater Utility with two dredges. The current dredge program requires upland disposal areas. In densely developed areas of the City these are often difficult to find.

From the data acquired to date, the canals have performed in their drainage role satisfactorily. SWU staff, reports a few instances when canals have been a few inches low of topping the seawall, although dock flooding is a common occurrence.

In many areas of the City, boats become grounded at their docks when weirs are lowered to allow the passage of greater flows. This presents a case where weir elevation adjustment to resolve drainage and septic field flooding problems conflicts with the desire to maintain navigable depths in the canal.

Canal Capacity

One of the fundamental issues in this project is determining the current and future capacity of the canal system. Connell, Metcalf and Eddy have modeled the flows in the canal system. One of the major assumptions made in the modeling effort was that the existing (in 1979) canal configurations were used. It is noted that the physical dimensions and parameters of the canal system are constantly undergoing change. Roughness measurements for various canal configurations do not appear in the literature. Also, this model assumed a 10 year event where present day practice is to model a primary system for a 25, 50, or 100 year event.

It is the City's policy to require a seawall or alternative means of canal bank stabilization when a property is developed. Seawall installation appears to be unofficially encouraged and a grass roots effort is underway to outlaw alternative means of bank stabilization. This effort is motivated by the perception seawalls will increase canal conveyance and storage capacity. However, it is not yet known what effect this may have on individual or basin hydrographs, nor is it certain what canal cross-section may be required for continued effective discharge.

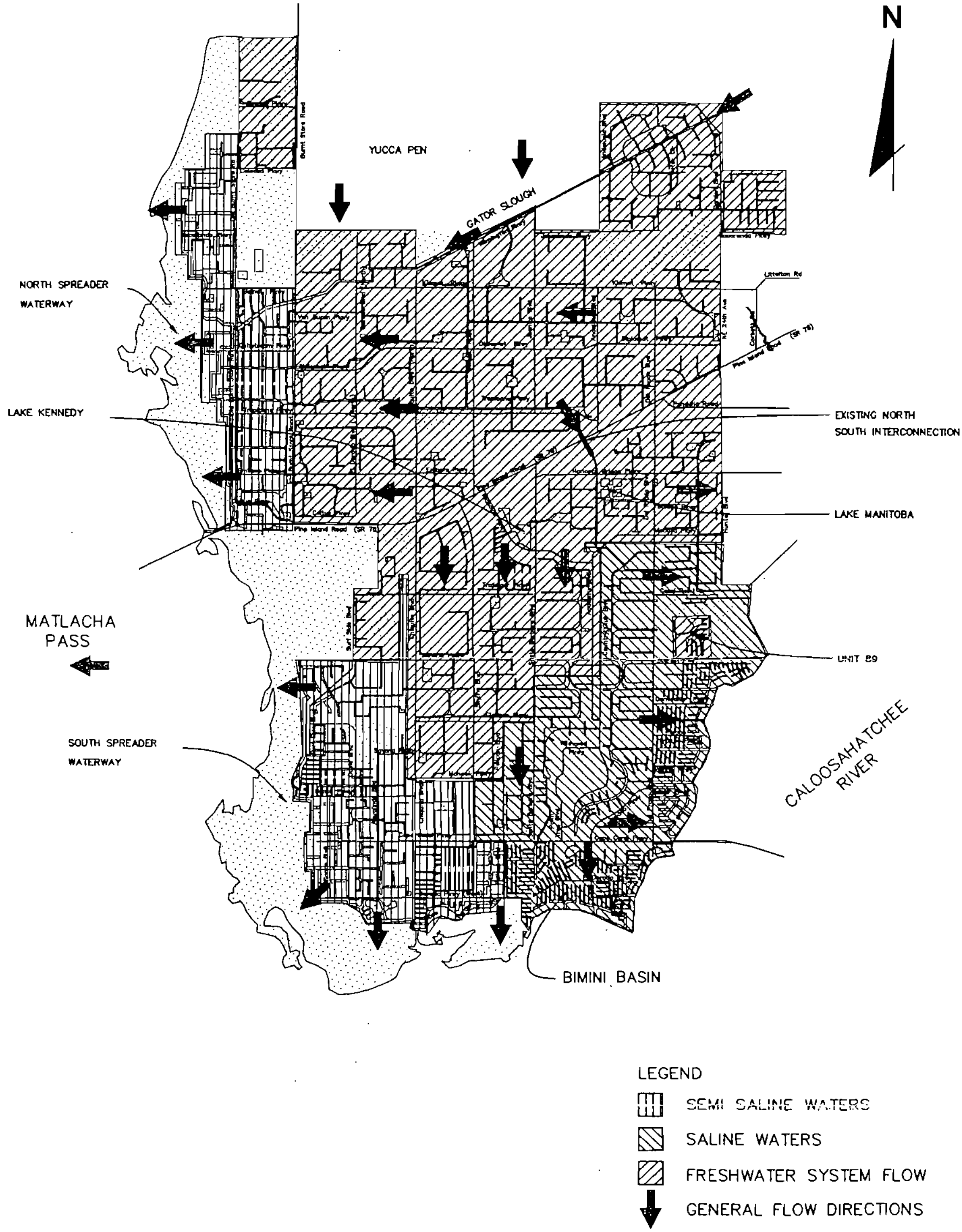
Findings

- Canal cross-sections are constantly undergoing change. To what extent this effects hydraulic capacity is unknown.
- North and south systems have been connected across Pine Island Road. This system is closeable and reversible (two-way).
- Aquatic plant growth has been experienced in Cape Coral. Certain types of plants have been known to greatly retard flows in canals in Florida. There are three commonly used means of

control; biological, chemical and mechanical harvesting, all of which are available to the City through Lee County Hyacinth Control. Currently, chemical is most common (Lee County Hyacinth Control). Biological (grass carp) is also employed in select areas.

- Canal cross-section is maintained by dredging by the SWU.
- Unstable banks occur throughout the Cape. However, many banks in undeveloped areas have naturally stabilized with vegetation.
- No flooding has been experienced in the past as a result of inadequate service from a canal.
- Daily discharge has been recorded by USGS since 1986 at all weirs where freshwater empties into saltwater.
- Freshwater on the west half of the City is channeled into the spreader waterway system which is designed to discharge as sheet flow through the mangroves that border Matlacha Pass. This waterway system has been breached in a number of areas providing channels for discharge rather than creating the intended sheet flow situation.

Figure A.5 presents a map identifying salinity and freshwater flow patterns.



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SALINITY AND FLOW PATTERNS

FIGURE A.5

. 5 Drainage - Problem Areas - Identified Areas

A number of areas experience drainage problems on a regular basis during the wet season. The primary causes of localized flooding are restricted, undersized or failed pipes or improperly designed or unmaintained swale configurations.

<u>Findings</u>

- CRA downtown experiences drainage problems primarily due to undersized pipes. This area has a high percentage of impervious area and is served by curb and gutter. Upgrades have been designed by Avalon.
- Industrial Park - near City Hall, this area has high impervious percentage as well as large areas of ungrassed open area. This is an area in the City to have pollution problems other than phosphorous and nitrogen; especially sediment, oil and grease. Upgrade designs are being finalized by the project team.
- Santa Barbara Boulevard - residential and commercial area experiences frequent localized flooding. Precise causes have been investigated and reported.
- Northern end of City - Much of the unimproved areas are in an incessant battle with surface water during the wet season due to:
    1) influx of water across northern city boundary
    2) inadequate swales
    3) clogged or inadequate CB/pipes
- Palmetto Pines - older residential neighborhood bordering the city golf course. Water management practices at the golf course and lack of swale maintenance on the part of the residents has caused standing water in driveways and swales. Co-operative effort between SWU and the golf course is underway to correct problems.

Figure A.6 presents a map identifying localized problem areas within the City.

Drainage - Problem Areas - Priority

With the advent of a stormwater utility and the associated user fee, more complaints have been reported and filed. Unfortunately, staff is currently insufficient to respond to all service requests. Typically, these problems are due to improper swale configuration or CB/pipe system disrepair.

<u>Findings:</u>

- Currently, CB and pipe crews are under equipped and under staffed. The 1990 Drainage Sub-element recommends the addition of 7 to 9 drainage crews (approximately 30 personnel).
- Complaints are being entered into a Q&A database for prioritization and response. This will assist in further defining problem areas.
- Priority for repair is set by number of days standing water is present after an event.

Immediate response	- public threat i.e.: sinkhole caused by failed pipe.
Priority 1	- water stands 5 days or more
Priority 2	- water stands 1-5 days
Priority 3	- water stands for 24 hours

A large backlog of priority 1 complaints exists, as well as priority 2 and 3.

- Most drainage failures are a result of undersized or inadequate pipe facilities. Many commercial zones were developed in areas with residential drainage designs and never upgraded.
- Changes in prioritization are addressed in APPENDIX C and D

<u>Considerations for SWMP</u>

- New priority criteria based on significance of impact as well
- It is important to note that unless entire drainage basins are redesigned and upgraded, little to no advantage may be gained in drainage performance.

. 6 Drainage - Extraordinary Events

One of the greatest threats to all of South Florida is the possibility of a landfalling hurricane. Cape Coral has not sustained a direct "hit" or the full effects of a landfalling hurricane in the vicinity, since it has been built. FEMA has conducted surge modeling for the area. These maps have been acquired. In addition to storm surge, heavy rainfall associated with tropical events will further tax the drainage system. The effects of flooding and the recession of flood waters on the canals has not been studied in any of the reviewed literature.

Hurricanes - Between 1830 and 1969, a total of 46 hurricanes and tropical storms have passed within 50 miles of Lee County coast (Department of the Army, 1969). Between 1969 and present, there have been at least 6 additional hurricanes and tropical storms in the eastern Gulf whose winds and waves reached Lee County coast (NOAA, 1973).

The Ft. Myers area statistically is influenced by hurricane force winds (<74 mph) every 11 years. The probability of a hurricane (winds <125 mph) occurrence in any single year over a 50 mile stretch of coast in Lee County is 2% (NOAA, 1972; Jones, 1980).

Tropical storm statistics and the absence of extensive washover fans both indicate that the west-central Florida coast has not been dominated by hurricanes or large storms. Maps of hurricane tracks indicate that most of these storms, once they have entered the Gulf of Mexico, pass off to the north and northwest. Tropical storms approaching from the west are relatively rare. A recent study from the Sarasota barrier island coast does suggest that the west-central Florida coast has been struck by extremely large hurricanes in the geologic past (Knowles, 1983; Knowles and Davis, 1983). The geologic data (large, thick, extensive, buried washover fans) suggest that these super-storms may occur every several hundred years. A listing of the effects of past storms along Lee County is provided in Appendix B.

Findings

- Most of the currently populated segments of Cape Coral lies within an "A" flood zone. "A" zones are inundated by the 100 year flood. Elevation is +9' MSL or +8 MSL depending on location (See Flood Insurance Rate Maps, from FEMA).
- Slab elevation of most structures is at least 9'. However, in older areas of the City, slab elevations may be as low as +6' MSL.
- Predictions of inundation and drainage velocity effects on the canal system has not been thoroughly studied.
- Water velocities from advancing or retreating storm surge may cause significant damage along the Caloosahatchee River.
- FEMA storm surge model at Cape Coral Bridge predicts maximum surge elevation of 11.1' for a landfalling storm and 6.7' for a near miss storm.

. 7 Environmental & Water Quality - Overview

The land that now makes up Cape Coral is a drastically altered environment. Very little evidence of its past landforms is evident today.

The largest likely pollutant threat in the Cape Coral canals are nutrients, i.e. phosphorous and nitrogen. The primary sources of phosphorous and nitrogen include improperly operating septic tanks and lawn fertilizer. There is also some indication that the native soil in the area may contain some degree of phosphorous (ref. Personal Communication, Preliminary Experiment, ERD). Another pollution problem is the introduction of silt and sediment into the water column as a result of overland runoff, construction activities, and unstablized bank erosion. Finally, overland runoff from commercial areas and streets may provide localized loads of oil and grease and heavy metals. While primary pollutants have been identified and samples taken to quantify the amount of pollutants in the water column, loading rates have not been predicted or quantified at this time.

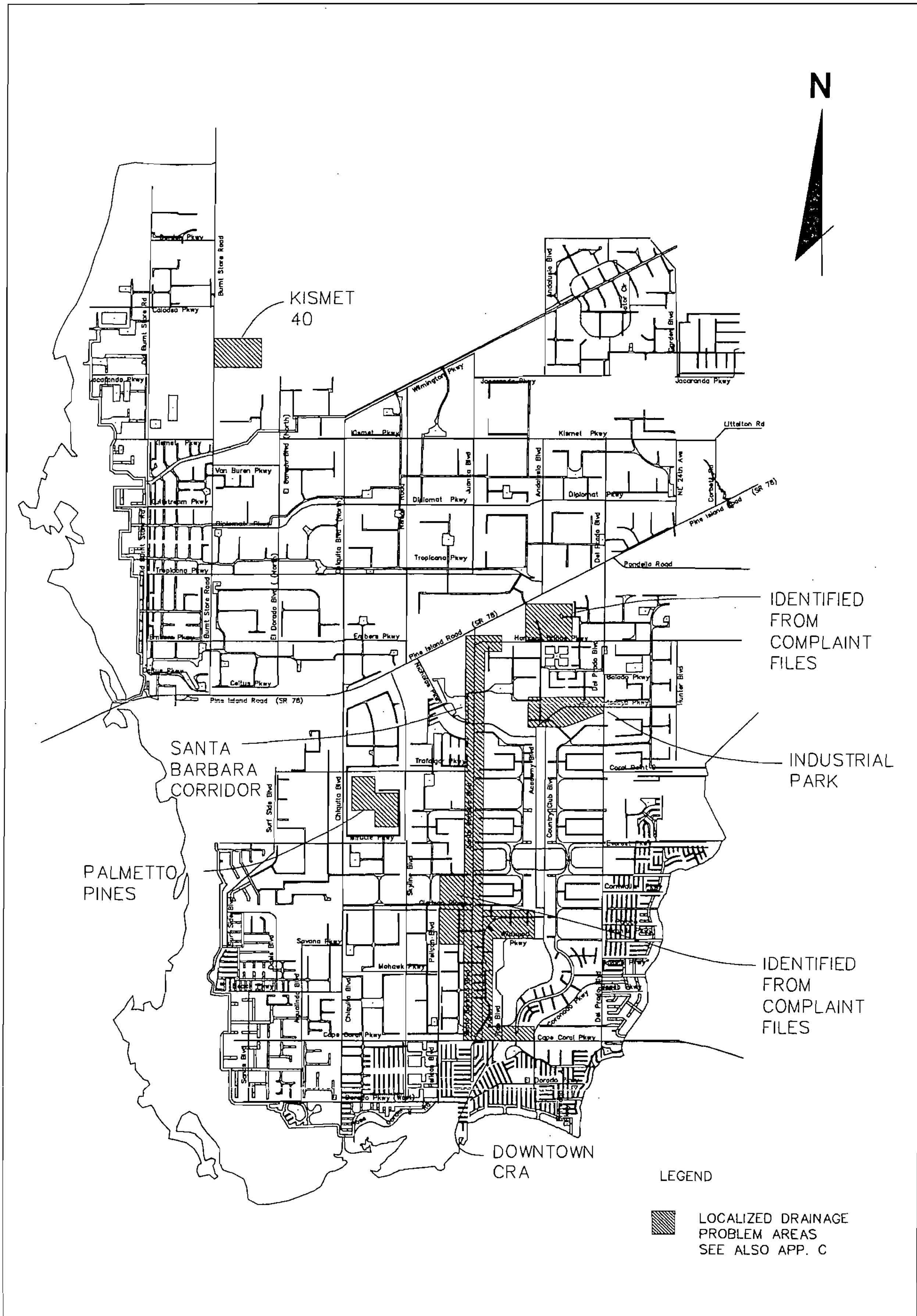
Overall water quality conditions are good to excellent throughout most of Cape Coral's freshwater canal system according to the 208 Water Quality Study. However, localized problem areas do exist (see study for specific site locations). Water quality deterioration at these sites include: algae growth and elevated phosphorus and biochemical oxygen demand resulting from inadequately treated storm water runoff containing lawn fertilizers; high bacteria populations resulting from malfunctioning septic tanks; elevated oil, grease and gasoline levels from motorboat activity; siltation from home and seawall construction activity; and trace amounts of pesticides and herbicides from surface runoff.

<u>Findings</u>

- Due to the extensive dredge and fill activities, precise soil classification is difficult
- Soil Conservation Service classifies the Cape generally as Maltlacta Series. Many areas are designated "Disturbed Urban" in detailed classifications. Note most of the disturbed layers are 2 - 5 feet below grade. It could be valuable to classify sub-soils.
- Approximately 2/3 of the saltwater system canals are seawalled
- Seawalls are extant at most developed waterfront lots in the freshwater system
- The spreader waterways have numerous breaches which allow saltwater contamination of large portions of the freshwater system. Groundwater exchanges may also contribute to contamination.
- The canal network supports a variety of habitats. Water discharges from the canal network may significantly impact adjacent waters; i.e. Matlacha Pass and the Caloosahatchee River.
- Very few large land tracts are available for purchase for filter marshes or dredge disposal areas. This is especially true in the more developed sections of the City.
- Preliminary experiments have pointed to the possibility of a natural phosphorus contribution from native soils.
- The drainage element in the Comp Plan states that the drainage for the road network must be improved to increase retention and detention. Road drainage is largely the responsibility of the engineering department where curb and gutter exist.
- Water quality parameters (i.e. phosphorous, BOD, etc.) were monitored for a 208 study in 1984. Water quality is sampled by the Environmental Resources Division monthly at 32 locations throughout the City

- All freshwater to saltwater discharges have been monitored by USGS at the discharge points (weirs) since 1986.

Figure A.7 presents a map identifying localized water quality problems.



HAVENS AND EMERSON, INC. CONSULTING ENGINEERS	LOCALIZED DRAINAGE PROBLEM AREAS	FIGURE A.6

Environmental and Water Quality - North System

The canal system north of Pine Island Road generally flows from east to west. Except for the brackish western edge, it is a freshwater system. (Breaches in the spreader waterway and possibly groundwater exchanges have allowed additional saline intrusion.) It is considered as one drainage basin since there is only one true outlet structure of the North Spreader Waterway. There are five major sub-basins which empty into the spreader waterway, listed below from north to south:

- Gator Slough
- Horseshoe Canal
- Hermosa Canal
- Bonefish Canal
- Shadroe Canal

Note that Horseshoe and Hermosa are interconnected and drain approximately 75% of the north area. Also, Bonefish Canal is a small saline system.

Finally, the canal system that drains units 84, 85, 87, and 88, an isolated section northeast of the rest of the City, is channeled into the marshy area at the head of Yellow Fever Creek, which empties into the Caloosahatchee River. There also appears to be a connection between the east end of the Hermosa Canal system and Hancock Creek. The direction of this flow is uncertain.

__Findings__

- Inflow
  - Gator Slough - drains 75 square miles (possibly more) of wetland northeast of the City. Crosses top of the City
  - North Wetland - known locally as the Yucca Pen, belongs to North Ft. Myers and drains (sheet flow) into Gator Slough.
  - Rain and groundwater from within the basin itself

- Outflow
  - North Spreader Waterway - All of the main canal systems; (except parts of the system in unit 32 drain into the north spreader waterway which is designed to allow sheet flow across wetlands and into Matlacha Pass.
  - Yellow Fever Creek and to some extent Hancock Creek- drains parts of unit 32 to the river
  - Pine Island Road Connection - a 36" RCP culvert with slide gate and pumps connects the north and south freshwater systems to assure the south freshwater system will have enough water to supply the reuse system.
  - Aquifer discharges are uncertain

- There are five weirs that separate the freshwater and tidal waters along Burnt Store Road.
- Except for the fraction of water that crosses Pine Island Road and down Yellow Fever Creek, all the water north of Pine Island Road discharges into Matlacha Pass via spreader waterway, marsh, and mangrove. A seasonal salinity study has been conducted by USGS in both spreader waterway systems, the connecting canals, and Matlacha Pass

- Numerous breaches in the spreader waterway allow channelized tidal flows into and out of the canal system. A survey of these has been conducted as part to the salinity study performed by ERD, DER, and USGS. An effort is currently underway to repair these breaches.
- Control elevation of North Spreader berm is insufficient to protect freshwater character of the system during large wind storms.

Environmental and Water Quality - South System

The upland area south of Pine Island Road is significantly more populated then the north system. Most of the east half of the southern section of land area is developed to a 50% or greater density.

There are eight hydrologic units in the south half of the City, most of which are connected to another by either canal, culvert, or weir. Additional connections between freshwater systems are planned under the WICC program in effort to "balance" the water levels throughout the canal system.

Approximately half of the south system is freshwater, 20% brackish and 30% saltwater. Freshwater is held in the central portion by a ring of weirs which isolate the freshwater canals from saltwater areas. Water quality in most of the freshwater canals is good with isolated areas of poor quality and eutrophic conditions. These areas are centered by Lake Kennedy, Lake Manitoba and unit 89.

The brackish segment is limited to the western edge of the south system. This area was originally isolated from saltwater by the spreader waterway and a boat lock at the end of the spreader waterway. However, several failures in the spreader waterway berm allow saltwater from Matlacha Pass to inundate this system, causing it to be brackish. (See salinity study of Matlacha Pass, ERD; Morrison) Subsurface exchange is also suspected.

The most densely populated areas are concentrated in the southeast section of the City and have direct boat access to the river or Gulf. Water quality in these areas is generally good but certain areas have shown signs of stagnation and anoxic conditions at depth, especially in the lake basins. An extensive modeling study of tidally forced flushing of these systems has been conducted by USGS. Field calibration measurements were taken as part of this study. (See USGS Report; Simulation of Cape Coral Canals...) The model study suggested the installation of 11 tide gates to interconnect portions of the saltwater system in an effort to more thoroughly and efficiently flush the system. This area is almost completely seawalled.

<u>Findings</u>

- Breaches in the south spreader waterway have allowed saline intrusion, turning this system into a brackish water system. Repair of these breaches & continued proper operation of the boat lock may permit this system to obtain a freshwater condition. Like the North Spreader System, control elevation of the spreader is insufficient to protect the spreader system from saline intrusion during storm tide events. Stratification (freshwater layer over saltwater layer) in localized deep "holes" may present a problem. Subsurface exchange is also suspected.
- According to the 208 Study and some of ERD's reports, the freshwater system in the south section of the City generally has good water quality. Some areas with high development that are unsewered have shown signs of degradation. (Personal Communication, ERD)
- Most water front lots in the southeast section of City that have direct access to the Gulf of Mexico have been developed. These areas are completely seawalled and have sanitary sewers installed. Water quality is generally good, although periods of poor water quality have been observed during periods of low flow in dry seasons.

Spreader Waterway

Stratification

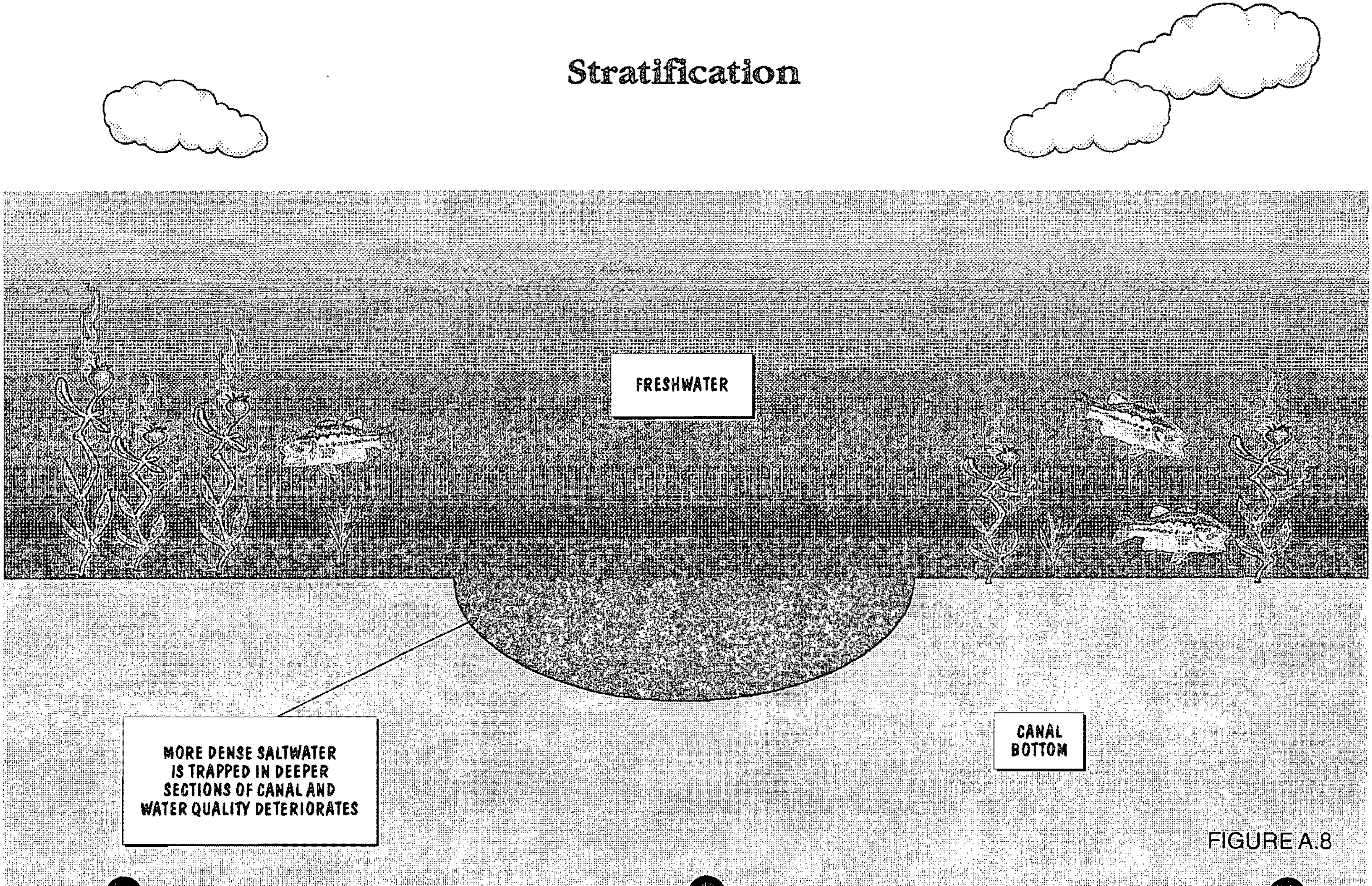


FIGURE A.8

- Flushing analyses for the saltwater system in the southeast segment have been conducted by the USGS. Recommendations: 11 tide gates could (Caveat Navigation) be installed to improve flushing of this system. However, some gates may interfere with navigation therefore being unacceptable
- Unit 89 on the east side of the City has remained a freshwater system through the use of a spreader canal and a boat lift. Its hydraulic isolation from the rest of the system made it an ideal location for a mini-comprehensive ecological assessment (conducted by Morrison in 1989). Boat access to the river is via a boat lift.
- The Water Independence for Cape Coral (WICC) Master Plan recommends installation of numerous basin interconnections throughout freshwater systems to assure basin leveling and adequate supply for the irrigation system. The impacts of such actions to quality and drainage has not been studied in detail.
- Only one external flow enters the south area of Cape Coral, this being the connection under Pine Island Road connecting the south canal system with the north canal system. All other in-flow is a result of groundwater and stormwater runoff.
- Discharges from the south system are directed to the river or west spreader waterways.
- Many properties in the of City have culverts rather than swales in front yards.
- There seems to be little evidence of swales along the seawall as recommended by the drainage element. Swale maintenance may become more important as swales fill in as they trap sediments.
- The most common complaint regarding canals in the saltwater sections is the siltation and the need for dredging. This is indicative of high sediment loads being deposited in the canals.
- Sediment source fractions are unquantified. These sources may include constructions and upland activities, river deposits, corroded pipe failures, and plant growth/death.

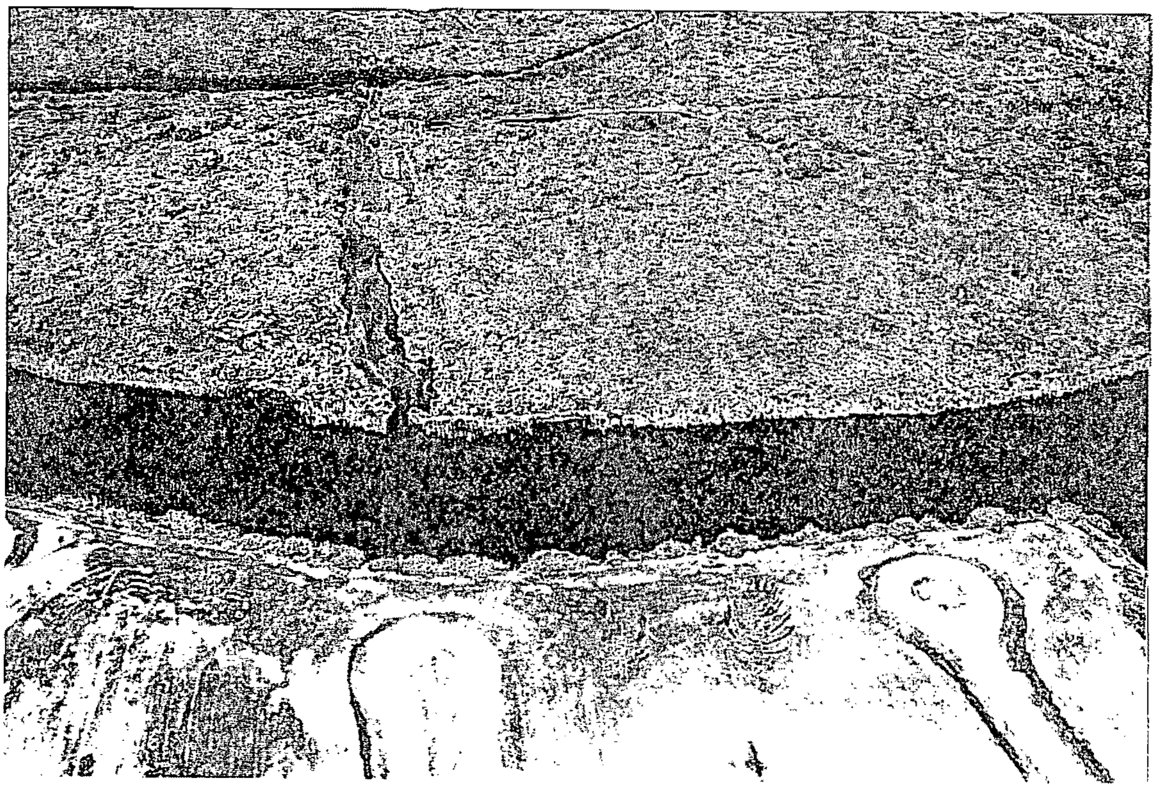
Spreader Waterway

The spreader waterways on the west side of the City were designed to allow freshwater sheet flow discharges into the fringe wetlands while preventing saline water intrusion into the canal system. Unfortunately, the structure was not correctly constructed and numerous breaches in the barrier berm have resulted. The physical and ecological effects have been documented in USGS open file reports, DER reports and reports by Cape Coral ERD. Figure A.9 presents an example of a breach in the spreader canal system.

From the standpoint of the reclaimed water system, it would be desirable to repair these breaches in an attempt to convert them to freshwater canal systems. Monies have been set aside from a trust fund setup under the DER-GAC Consent Order 15 settlement to repair the breaches. Both DER and the Department of Natural Resources (DNR) appear to be concerned with the volume of freshwater reaching the mangrove system and grass beds in Matlacha Pass.

Findings

- There are numerous breaches in the spreader waterway allowing saline intrusion into the canal system. Saltwater species (mangrove) have begun to establish in the canal system. Also, freshwater species (Typha-cattail) have established along some breaks.
- The City is interested in changing these brackish canals to a freshwater state so they may be used as a source for the secondary water system.
- Concerns may be raised on the future regarding freshwater supply to the mangrove wetland system. Furthermore, the mangroves appear to have been thriving on the nutrient enriched water coming from the Cape.
- Concerns over freshwater availability should be weighed against the potential upstream withdrawals if extra freshwater canal area is not made useable by fixing the spreader berm. Depending on soil transmissivities, the control elevation will be fixed and the now brackish waterways will be dependent on upstream (freshwater) sources rather than tidal waters to remain full for navigation purposes or saline intrusion will still occur through groundwater.
- Controlling elevation (+1' to +2' msl) of the spreader system is probably too low to prevent saline intrusion during storm events (storm tides often > +3, +4). No means of evacuating stagnant saline lenses in deeper canal segments after one of these occurrences has been developed.



SPREADER CANAL BREACH

FIGURE A.9

Environmental and WQ - Water Quality Issues

Description: Below is a brief summary of the water quality issues that are being addressed or may need to be addressed throughout this study.

1) Septic and Sewerage
The City is mandated to sewer all areas that have developed 50% or more of the platted lots in a given area. At this time sewers have either been installed or are planned for installation throughout the eastern half of the south section of the City. Certain areas such as Lake Kennedy and Lake Manitoba have experienced eutrophication as a result of nutrient loading. The suspected cause are poorly drained soils in leech beds and improperly operating septic tanks.

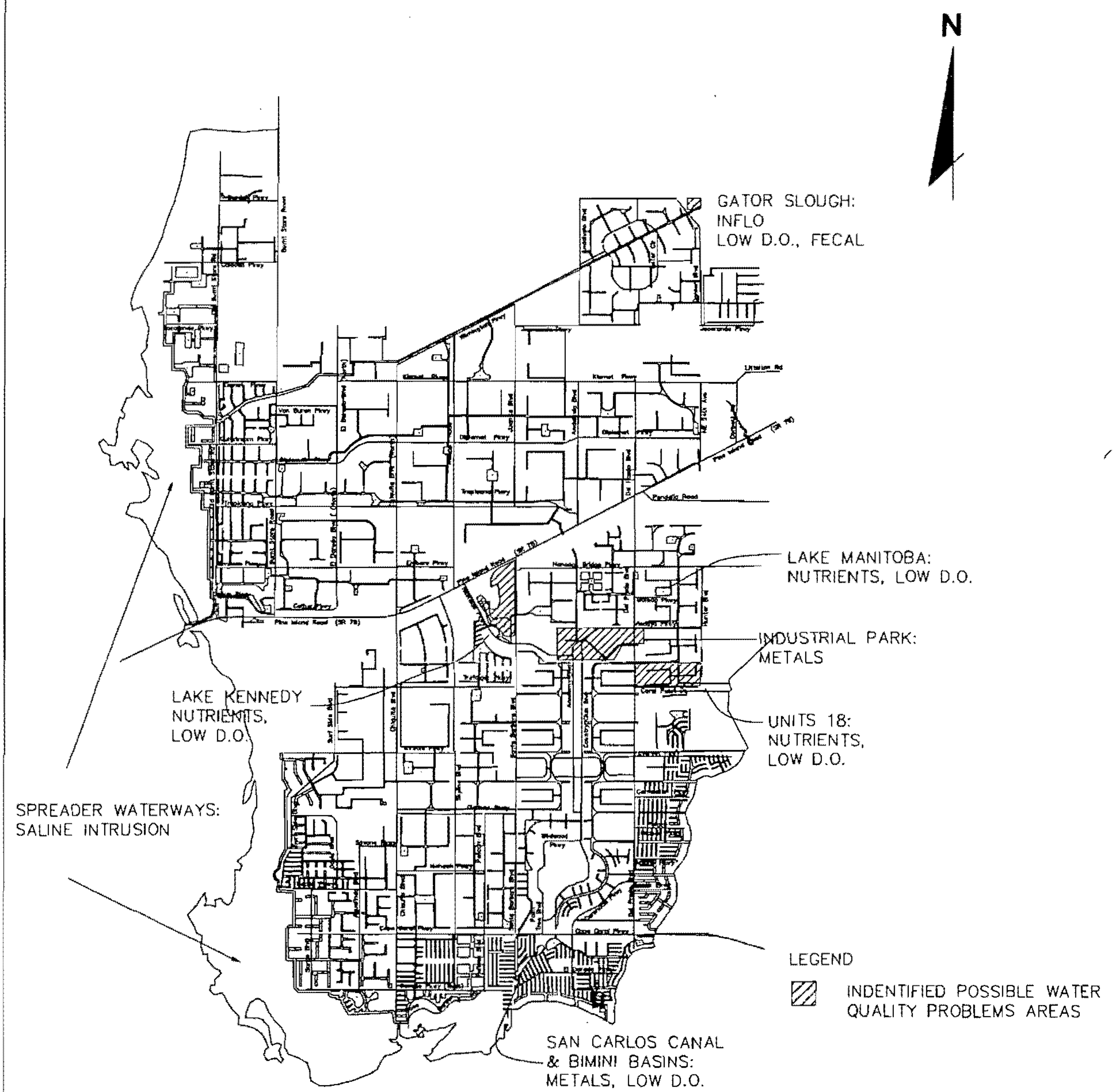
2) Street/Parking Lot Runoff
Most street and parking lot runoff in commercial areas are channeled into gutter and catch basin systems & piped directly to the canals. Many areas have little or no retention/detention treatment. Many of these areas are suspected sources for oil and grease loadings and heavy metal pollution.

3) Lawn Fertilizing
As Cape Coral is primarily a residential city, it is expected that high nutrient loads may come as a result of extensive lawn fertilization. Historically, lawn fertilizing services supply far more fertilizer than is necessary to keep a lawn green. It is expected that higher phosphorous and nitrogen loads will be a result of this practice. The most likely best defense will be a properly operating swale retention system and public awareness.

4) Public Awareness
One of the biggest water quality issues we may encounter may be in fact related to public awareness of the processes taking place in the canal system. At this time the canals appear to be relatively pristine to the average citizen and require little attention. This lack of awareness appears to pervade all segments of the community from City Hall to the home owner. It must be impressed upon all citizens that they individually contribute to the health maintenance or the degradation of the canal system and that their actions directly affect the quality of life in Cape Coral.

5) Stagnation
It is apparent from some surveys that particularly deep pockets occur throughout the canal system. These are generally in areas where extra fill was required and the contractor simply removed additional material from the canal bottom. Many of these areas experience stratification, especially in the saltwater and the brackish areas. With the advent of the rainy season, the top layer may become fresh while the saltwater layer remains deep in these holes. Saltwater biota begin to die creating anoxic conditions in these areas. This problem appears to be somewhat widespread and random.

6) Algal Blooms and Macrophyte Growths
Algal blooms have been known to appear in Lake Kennedy and Lake Manitoba as a result of high nutrient loading. Failed septic tanks are the suspected source of these nutrients. Literature review and interviews of people with long histories in Cape Coral indicate that significant algal blooms have not taken place in other parts of the City.



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LOCALIZED WATER QUALITY PROBLEM AREAS

FIGURE A.7

Environmental and Water Quality - Ecological Issues

Description: Below is a brief summary of certain ecological issues that are being addressed or may need to be addressed in this master planning effort.

1) Habitat for Aquatic Organisms (Littoral Shelf)
The extensive use of seawalls in the marine environment of Cape Coral has reduced the surface area available for the establishment of benthic marine organisms i.e. oysters, clams, algaes. These organisms have been shown to be effective in removing certain pollutants from the water column including suspended sediment and phytoplankton (which consume phosphorous and nitrogen). The City has adopted a policy of installing rip-rap along a minimum of 50% of a seawalled lot. There are design standards for minimum rock size and placement on this rip-rap.

The City has also adopted a policy of requiring seawalls or other forms of bank stabilization for all waterfront lots including freshwater canals. While alternatives to seawalls are currently allowed in freshwater canals, there appears to be lack of public interest in developing these alternatives (Note: ERD and Engineering have constructed an alternatives to seawalls demonstration project near Lake Kennedy.) Seawalling in the freshwater system could eliminate the now existing littoral shelf where aquatic plants and wetland species are found.

2) Aquatic Vegetation
The proliferation of aquatic vegetation must be assessed for its impact on canal capacity, navigation, water quality and aesthetics.

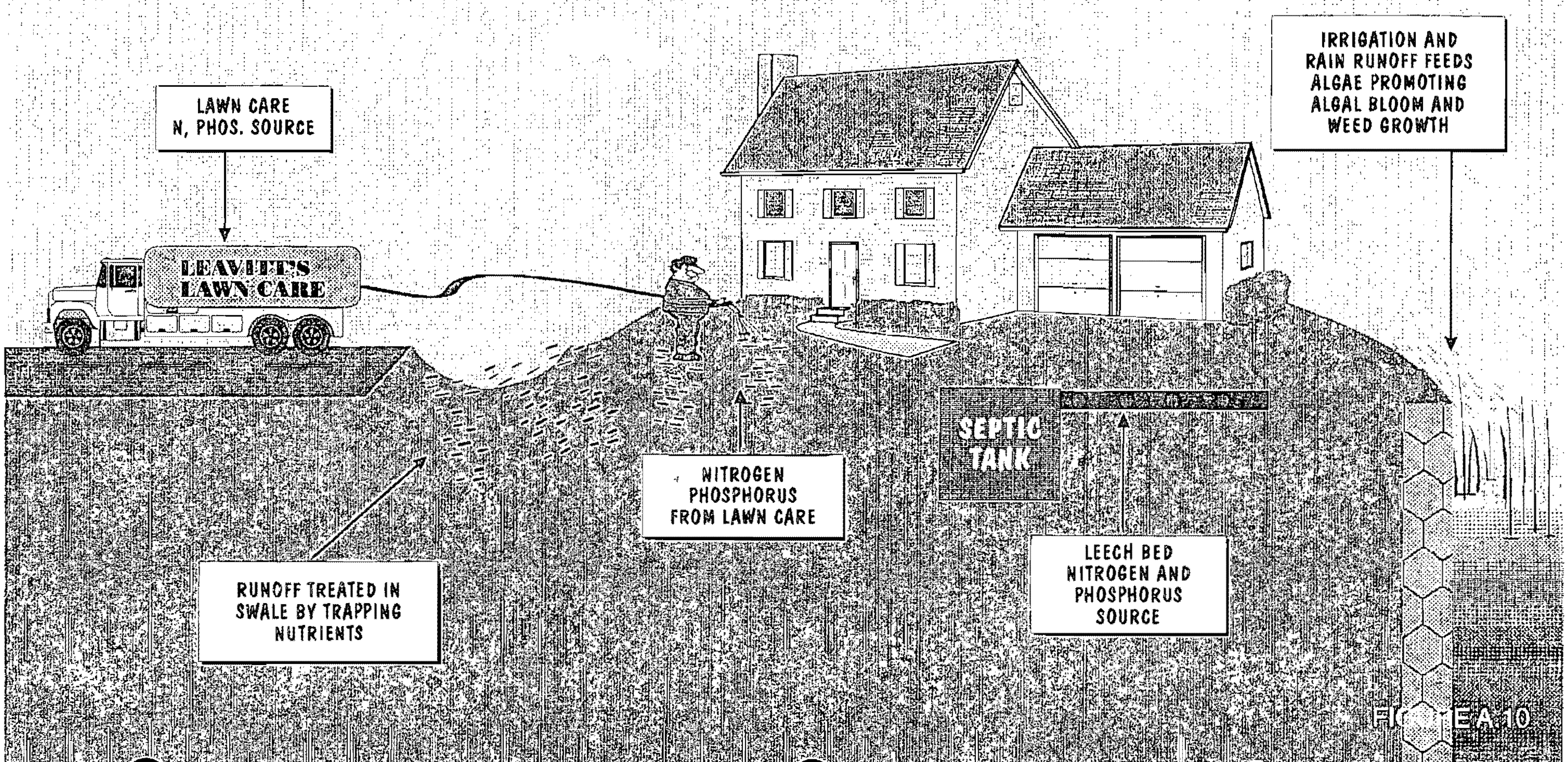
There are two types of aquatic vegetation to consider. One would be submergent and the other emergent. Of the emergent by far the most pervasive is the cattail. These have been shown to be effective removers of nutrients in overland flow and from the water column. However, they do tend to slowly propagate into deeper water by building mats out of dead, individual plants. Cattail do require a littoral shelf on which to establish themselves. Other emergent types would include various rush grasses, although these are less prevalent in the saline environment. Occasionally, mangroves may be found, however, in small and insignificant numbers. Extensive mangrove forests exist on the downstream side of the spreader waterways.

Of the submergent types, the most potentially detrimental species is hydrilla. Hydrilla is an exotic species. It is opportunistic and strongly competitive with other species. Hydrilla can grow in deeper water, it grows very rapidly and can significantly increase head loss in a canal. Fortunately, Cape Coral does not have a hydrilla problem at this time. While it is found in rare instances, it is not as pervasive as it has become in other areas of Florida. Lee County Hyancith Control is monitoring weed growth in Cape Coral.

It may be important to investigate ecological response to harvesting of aquatic vegetation. Cape Coral is planning on implementing a aquatic weed harvesting program some time in the future. It is uncertain if removal of native vegetation may prompt the colonization of hydrilla in canals.

There are three common methods of removal of submergent aquatic vegetation. The chemical method sprays herbicide on water to kill the plants. A drawback to this method is that while the plant may die it falls to the bottom and decays, re-introducing the nutrients back into the

Nutrient Sources in Drainage Upland



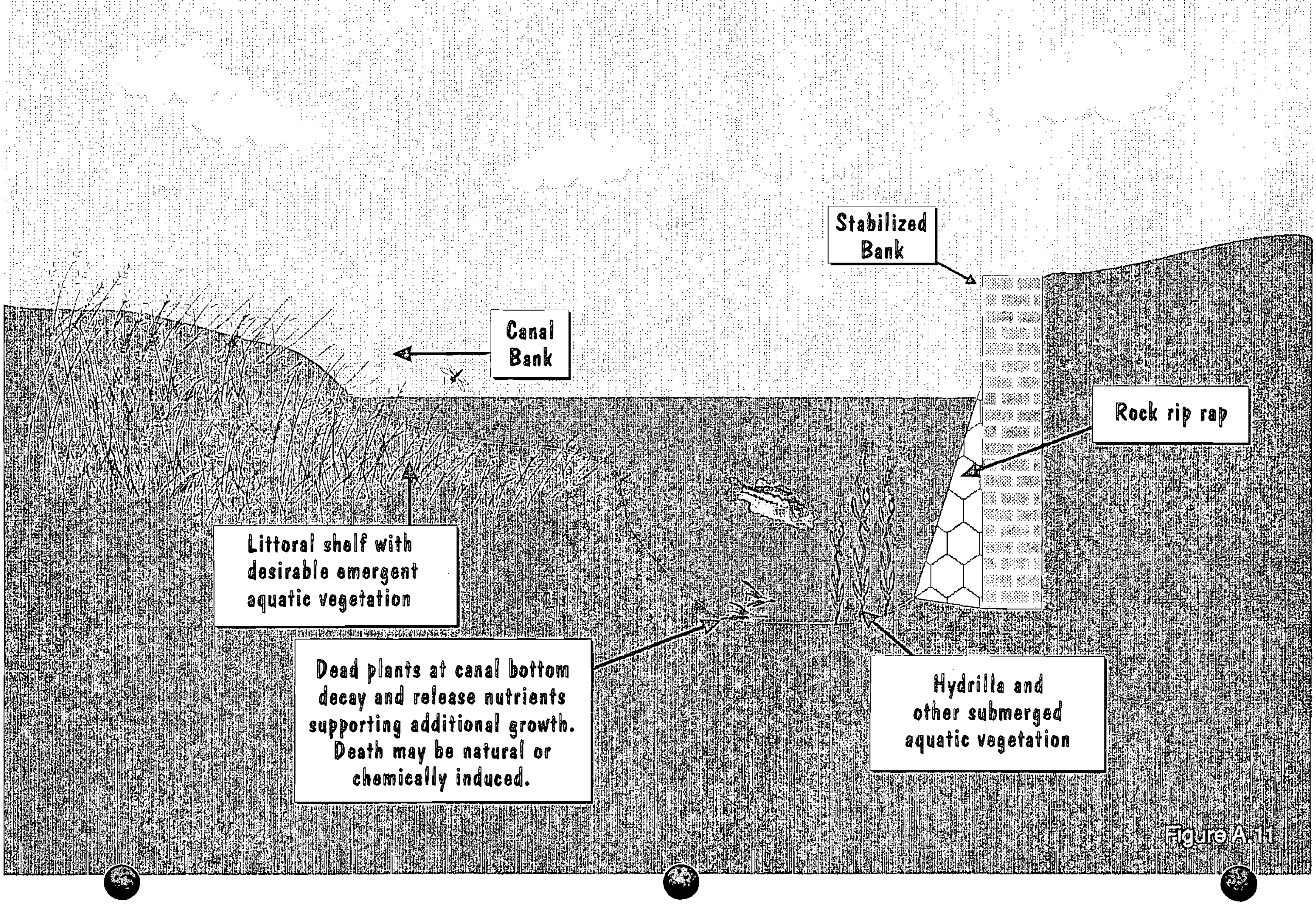
water column. The bacterial decay process consumes a large percentage of available dissolved oxygen (DO). In extreme cases, all DO is used and anaerobic decay begins to take place. This often gives rise to foul odors and the release of metal pollution from sediments. Chemical control is thereby the least desirable method of control.

The second method of control would be the use of a Tripoid Grass Carp. The Grass Carp feeds on aquatic vegetation and can clean a canal or water body of hydrilla very rapidly. Unfortunately, these fish may prefer other native vegetation over hydrilla. Grass Carp have been used effectively in Cape Coral in unit 89 on the east side of the City. Biological control is relatively inexpensive and has proven to be effective. Circumstances such as detrimental effects on other fish populations or removal of all vegetation may limit the use of Grass Carp.

The third method of aquatic vegetation control is the use of mechanical harvesters. While this method is the most expensive option, it may also be the most effective method of removing the vegetation and the nutrients from the water column. The City of Cape Coral had planned to purchase an aquatic weed harvester for FY 1992-93. This program has been withheld at this time.

A final note on aquatic vegetation. Growth rate and distribution of aquatic vegetation will be largely dependent on the availability of suitable habitat and available nutrients. Furthermore, macrophyte vegetation is preferred over phytoplankton (algas) which can exist in a free floating form within the water column. It is expected that Cape Coral will have an abundant supply of nutrients in the canal system, however, the lack of suitable habitat for macrophyte establishment may promote the condition suitable to frequent algal blooms.

Ecological Issues



. 8 Fish and Fishing

The availability of fish in the canals is considered a recreational resource by many citizens (Personal Contact). Currently the fishing in the canal system throughout the freshwater system in Cape Coral is locally noted for bass and associated species, especially in the freshwater canals north of SR 78. Other fish found in the Cape are snook, redfish and mullet in the saltwater system and brackish water systems.

Certain areas of the Cape, especially in the saltwater system, have been devoid of fish for some time according to citizen reports. Some freshwater species have also shown declines in larger fish in some areas in portions of developed areas such as the Lake Kennedy - Lake Manitoba systems. According to city staff, more data is needed on actual fishing pressure and harvest and on actual fish production potential of canals. Concerns have also been raised that if basic food manufacture (primary productivity) is limited, fish production will be as well. Evidence so far suggests that total amounts of fish in Cape Coral canals are average. The sizes suggest that trophy fish have declined and reproduction is uncertain. Another concern is the possibility of heavy-metals in fish flesh. Mercury and lead in runoff may be passed on to fish and concentrated to potentially toxic levels.

. 9 Navigation

One of the biggest selling points for landowners in Cape Coral is the use of the canal system as a place to dock and use their boats. Nearly every waterfront owner has a boat dock and many have a boat. Sail boat access is limited to those areas that are saltwater open to the river and do not have a bridge between the house and the river, while saltwater canals have gulf access for smaller boats. Furthermore, lots along the spreader waterway system have access to the river or Matlacha Pass via locks. The older canals in the southeast section of the City have been experiencing siltation problems and reduction in available depth for navigation. Aside from upland flooding problems, this is probably the most visible responsibility of the stormwater utility.

The canal maintenance program run by SWU currently has two dredges operating. Both dredges are capable of moving approximately 40,000 cubic yards of material per year. The second dredge was scheduled to be in that program, however, from time to time it has been removed from the program to take care of small but urgent dredging problems. Progress in the southeast section is slow due to the lack of upland area for dredge spoil disposal.

<u>Findings</u>

- There are two dredges operating in the canal maintenance program. The program has a formidable task and is apparently severely underequipped and understaffed to accomplish the tasks set for it. However, staff has shown that it is more cost effective to perform its own dredging rather than contract it out.
- The availability of land may restrict dredging operations in the future. The City may be urged to begin developing spoil site options. One option may be to look into right-of-way acquisition for spoil sites. These may double as parks & recreation facilities since spoil sites might only be used every 10 to 15 years.
- A harvesting program may be initiated under the canal maintenance program to deal with current and future aquatic weed problems.
- Silt screens are used during dredging and seawall construction operations. These aren't always completely effective.
- A smaller, easily transportable dredge would alleviate the stress put on the canal maintenance operations to clear small but troublesome shoaling spots.
- Dredging operations are performed with a 20 foot buffer on either side of the canal.
- Canal surveys are performed as required by canal maintenance division. No citywide surveying program has yet been conducted and the extent of required maintenance is unknown.

.10 Weather

Precipitation patterns are those typical in South Florida. Rainfall amounts are considered to be approximated by the rain gauge at Page Field. The cell-like nature of summer storms and local effects such as the presence of the river and Pine Island Sound may play a role in altering local rainfall patterns. Rain gauges are located at the RO Plant and mosquito control gauges are distributed in populated areas during the wet season. Review of literature has revealed only very generalized rainfall distribution (iso-lines).

<u>Findings</u>

- Cape Coral is in a hurricane susceptible area. Storm surge and heavy rain must be considered.
- Depending on detail of the predictive model, a network of rain gauges or possibly a radar system (obtainable from NOAA) may be desired. Radar has the advantage of being able to indicate the aerial extent of an event as well as its intensity. Radar images might also be acquired through local cable companies.

Groundwater - .11 Aquifer Description

The aquifer system below Cape Coral consists of a surficial aquifer, the Hawthorn system and the Swannee system. The typical layer descriptions are best described by the following information.

Domestic wells tap the mid-Hawthorn aquifer which has good quality freshwater. It does have a high lime content but is usable with little or no treatment. Many older homes that now receive city water continue to use their wells for irrigation.

The municipal supply comes from the brackish lower Hawthorn aquifer. At this time, the only operational water plant is the RO plant in Southwest Cape Coral. Wells that tap the supply aquifer are scattered throughout the City are monitored by the City.

Of greatest concern to this project are the dynamics of the surficial aquifer. The discussion from here will deal with this layer. Soils in the surficial aquifer are variable throughout the City and are largely dependent on the dredge and fill activity that has taken place in the past. The consensus among individuals (i.e. Henry LaRose, USGS; Howard Yamataki, Soil Conservation Service) with experience in Cape Coral is that while the origin of surface soils are difficult to typify, it is generally of a clastic (calcified silty sand) nature with low to moderate effective porosity (10-20%) and low to moderate transmissivity (5000 - 25,000 gpd/ft). The surface soils (5-30 ft thick) are often underlain with limestone or a marl (0-50 ft thick) especially in the Southeast and East-central areas of the Cape.

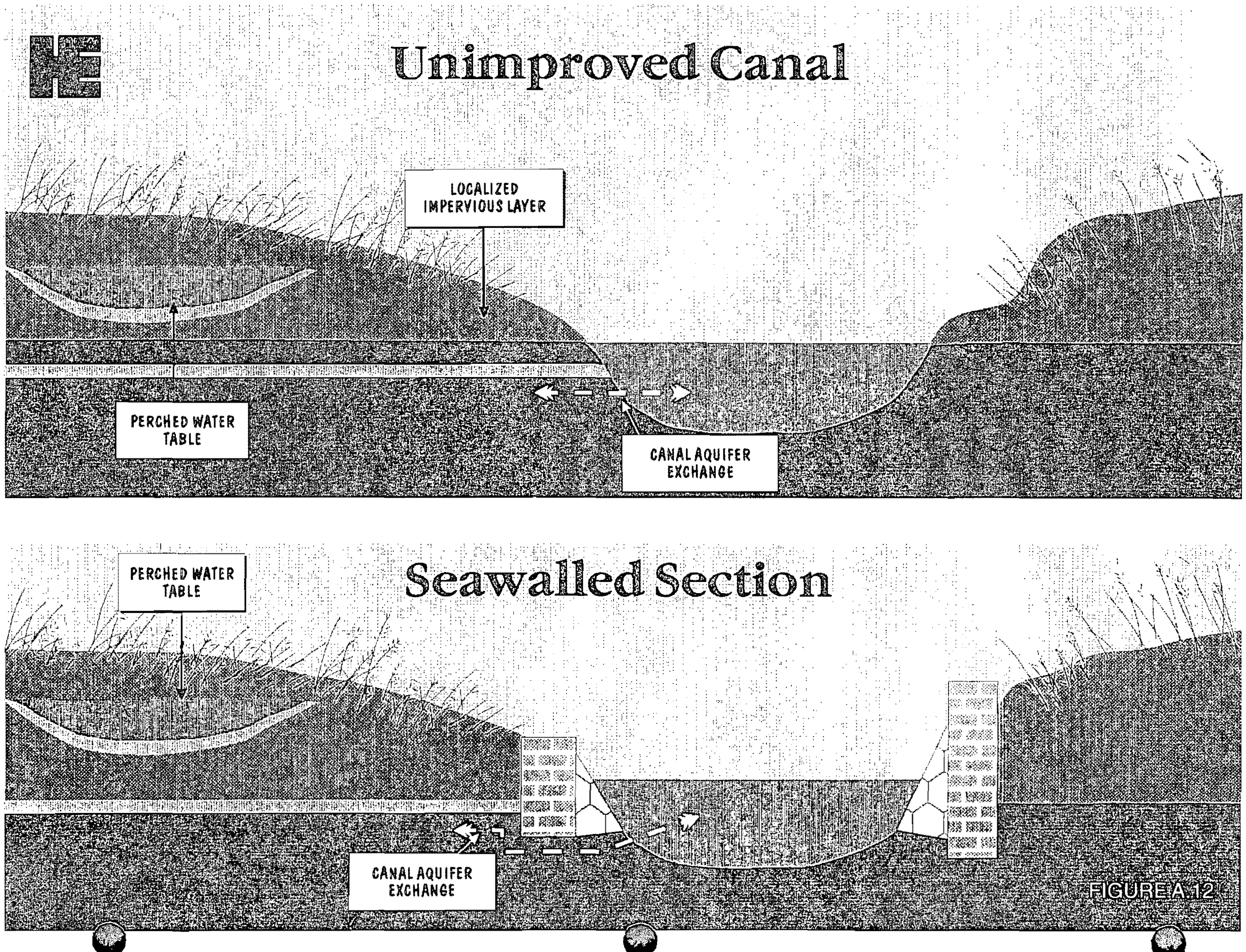
The surficial aquifer is important to this project in that it's characteristics weigh heavily on the secondary water supply. It has been shown that the canals will supply only 11 MGD of 74 MGD required to augment the secondary system (WICC Master Plan - 1984). By understanding the capacity and transmissivity of the surficial aquifer, we can make better estimates of seasonal weir elevations that may be required and the relocation or addition of weirs in the freshwater system.

To date, limited data exists regarding the hydraulic characteristics of the surficial aquifer and are generally very site specific. Reports include surface water withdrawal study at Lake Fairways (Missimer) and occasional toxic waste cleanup investigations and plans (Missimer). Boring logs are available throughout the area where gravity sewers are installed.

Findings

- The Upper Hawthorn aquifer is used for domestic supply. Many old well casings in the City have failed and allow saline intrusion into this aquifer. A well plugging program is underway.
- Water from the Lower Hawthorn (chloride $\approx$600 ppm) is used at the municipal RO plant. Well fields are scattered throughout the City.
- The soil types in the surficial aquifer are variable throughout the study area. The general opinion is that it is a poorly drained soil and the aquifer is a low production aquifer.
- Deep well injection of storm/canal water has been proposed as a possible means for storing this resource until it is needed. This idea has been rejected by the City but may merit further consideration

- The Health Department depends on the SCS survey and a set of 1958 aerials to determine probable soil conditions. Most septic tanks require excavation of native soil and replacement with granular material in the leech bed.
- Due to its limited productive capacity, few reports concerning the hydraulics of the surficial aquifer are available.
- Plans to raise weir elevations to increase storage must account for the possibility of more transmissive layers underlaying the intended storage area.
- A groundwater monitoring network of 11 wells has been established by the City in conjunction with the well plugging program.


Unimproved Canal
LOCALIZED IMPERVIOUS LAYER
PERCHED WATER TABLE
CANAL AQUIFER EXCHANGE
Seawalled Section
PERCHED WATER TABLE
CANAL AQUIFER EXCHANGE
FIGURE A.12

SFTD INC.

?.O Box 567, Lehigh Acres, FL 33970
[illegible] Blvd., Alva, FL 33971
[illegible]-3431

P.O. Box 492, Harrison, NY 10528
40 Congress St., Harrison, NY 10528
914-835-4470

MONITOR WELL CONSTRUCTION DETAILS

CLIENT: CITY OF CAPE CORAL DATE: OCT. 16,1991
PROJECT: W.I.C.C. REUSE REGIONAL SYSTEM
CAPE CORAL, FL.

WELL LOCATION	WELL #	WELL TOTAL DEPTH (IN FEET)	CASING DIAMETER (IN INCHES)	CASING INTERVAL (IN FEET)	SCREEN INTERVAL (IN FEET)	FINISH
COURTHOUSE	CCC-1	13	2	0-5	5-13	ABOVE GRADE. 6" PROTECTIVE STEEL CASING.
COUNTRY CLUB	CCC-2	13	2	0-5	5-13	ABOVE GRADE. 6" PROTECTIVE STEEL CASING.
SE 10th AVE.	CCC-3	18	2	0-10	10-18	ABOVE GRADE. 6" PROTECTIVE STEEL CASING.
GOLF COURSE	CCC-4	14	2	0-4	4-14	ABOVE GRADE. 6" PROTECTIVE STEEL CASING.
COUNTRY CLUB & SE 7th PLACE	CCC-5	14	2	0-4	4-14	TO GRADE, METER BOX.
8th PLACE	CCC-6	17	2	0-7	7-17	ABOVE GRADE. 6" PROTECTIVE STEEL CASING.
BOLADO PKWY.	CCC-7	14	2	0-4	4-14	TO GRADE, METER BOX.
ACADEMY BLVD.	CCC-8	14	2	0-4	4-14	ABOVE GRADE. 6" PROTECTIVE STEEL CASING.
EVEREST PKWY.	CCC-9	14	2	0-4	4-14	ABOVE GRADE. 6" PROTECTIVE STEEL CASING.
EL DORADO PKWY.	CCC-10	14	2	0-4	4-14	TO GRADE, METER BOX.
PELICAN BLVD.	CCC-11	17	2	0-7	7-17	ABOVE GRADE. 6" PROTECTIVE STEEL CASING.

Florida Department of Environmental Regulation
South District • 2269 Bay Street • Fort Myers, Florida 33901-2896 • 813-332-2667
Bob Martinez, Governor Dale Twachtmann, Secretary John Shearer, Assistant Secretary
Phillip Edwards, Deputy Assistant Secretary

QUARTERLY REPORT ON GROUND WATER MONITORING
Rule 17-28.700(6)(k)2.

5236M02763   DATE July 24, 1992

DER PERMIT # DC36-184332

City of Cape Coral
tallation Name
.O. Box 150027 Cape Coral Florida 33915-0027 Lee
ress City State Zip County
David D. Kuyk Utilities Director
er or Authorized Representative's Name Title

hod of Discharge Spray Irrigation

e of Industry Wastwater Treatment

ort for Period June 1, 1992 to Sept. 1, 1992
date date

ach monitoring data as approved in monil ter monitoring report
ns When applicable, attach additional ranges in the
k und water quality and the discharge ported description.
lude any changes in size, direction of n it, and concentration
nges of plume constituents in violation rds.

SUBMITTAL #2
JUNE 1, 1992 TO SEPT 1, 1992

E: Pursuant to Rule 17-28.700(6)(k)3., hange in the permitted
ume, location or chemical, physical or m on of the discharge
ne, the permittee shall notify the depar y the department,
nit a new report stating the volume and icrobiological
positions of the discharge at the point th the ground water at
site boundary.

CERTI

ertify under penalty of law that I have p am familiar with the
ormation submitted in this document and a based on my inquiry
those individuals immediately responsible ...g the information, I believe
the information is true, accurate, and complete. I am aware that there are
nificant penalties for submitting false information, including the possibility of fine
imprisonment.

[signature]
er or Authorized Representative's Signature   7-24-92
Date

Form 17-1.216(2)
Effective January 1, 1983

PARAMETER MONITORING REPORT
(Rule 17-3.402, 17-3.404 - 17-3.406)

6M02763

Sample Date June 22nd, 1992

oring Well # 1

Well Type: [X] Background
[ ] Site Boundary
[ ] Intermediate
[ ] Compliance

Name CCC-1

ification of Groundwater G-II

Developed* Prior to
e Collection (Yes/No) YES

Ground Water Elevation
Storet Code 072020: (NGVD) 7' 1" ft

of Laboratory: City of CAPE CORAL Water Reclamation Plant Lab

T	Parameter Monitored	Sampling Method	Analysis Method	Analysis Result	Units	Sample Filtered/Unfiltered	Preservatives Added
0	pH (field)	All wells were purged with a rod and cylinder pump to 4 well volumes.	S.M. 423	6.7	std.	unfiltered	None
4	Specific Conductance (field)		S.M. 205	950	uohms/cm	"	"
0	Chloride		S.M. 407A	90	ppm	"	"
5	Sulfate		S.M. 426C	26.5	ppm	"	"
9	Sodium	The samples were collected with a teflon coated bailer.	EPA 273.1	30.2	ppm	"	HNO_3
6	cal Coliform		S.M. 909C	<10	#/100mL	"	none
0	Total Organic Carbon		EPA 415.1	18.9	ppm	"	H_2SO_4
0	Total Dissolved Solids		S.M. 209B	594	ppm	"	none
0	Nitrate (N)		S.M. 418C	0.0	ppm	"	H_2SO_4

* development is the process of pumping the well prior to sampling in order to obtain representative ground water sample.

Form 17-1.216(2)
: January 1, 1983

PARAMETER MONITORING REPORT
(Rule 17-3.402, 17-3.404 - 17-3.406)

/ 5236M02763

Sample Date June 22nd, 1992

toring Well / 2

Well Type: [ ] Background
[ ] Site Boundary
[X] Intermediate
[ ] Compliance

Name CCC- 2

sification of Groundwater G-II

Developed* Prior to
le Collection (Yes/No) YES

Ground Water Elevation
Storet Code 072020: (NGVD) 5' 7" ft

of Laboratory: see well #1

:T)	Parameter Monitored	Sampling Method	Analysis Method	Analysis Result	Units	Sample Filtered/Unfiltered	Preservatives Added
)0	pH (field)	see well #1	S.M. 423	6.9	std.	unfiltered	None
94	Specific Conductance (field)		S.M. 205	600	uohms/cm	"	"
:0	Chloride		S.M. 407A	15	ppm	"	"
:5	Sulfate		S.M. 426C	15	ppm	"	"
:9	Sodium		EPA 273.1	3.22	ppm	"	HNO_3
6	Fecal Coliform		S.M. 909C	<10	#/100mL	"	None
0	Total Organic Carbon		EPA 415.1	14.9	ppm	"	H_2SO_4
0	Total Dissolved Solids		S.M. 209B	364	ppm	"	none
0	Nitrate (N)		S.M. 418C	0.0	ppm	"	H_2SO_4
	VOC's (annually)						

development is the process of pumping the well prior to sampling in order to obtain
:sentative ground water sample.

17-1.216(2)
:tive January 1, 1983

8-17-92

8-17-92
gave to
Rick Orth

CITY OF CAPE CORAL WATER RECLAMATION PLANT
MEMO

TO: JOE KAYE
FROM: ROB JOHNSON
RE: MONITORING WELL #2 FECAL TEST

JOE, THE RETEST OF MONITORING WELL #2 SHOWED THAT THERE WERE <10 FECALS PER 100mL.

HRS #E55261

PARAMETER MONITORING REPORT
(Rule 17-3.402, 17-3.404 - 17-3.406)

..36M02763

..oring Well # 3

..Name CCC- 3

..ification of Groundwater G-II

..Developed* Prior to
.. Collection (Yes/No) Yes

..of Laboratory: see well #1

Sample Date June 22nd, 1992

Well Type: [ ] Background
[ ] Site Boundary
[ ] Intermediate
[X] Compliance

Ground Water Elevation
Storet Code 072020: (NGVD) 1' 0" ft

	Parameter Monitored	Sampling Method	Analysis Method	Analysis Result	Units	Sample Filtered/Unfiltered	Preservatives Added
)	pH (field)	see monitoring well #1	S.M. 423	6.8	std.	unfiltered	none
1	Specific Conductance (field)		S.M. 205	750	uohms/cm	"	"
)	Chloride		S.M. 407A	50	ppm	"	"
5	Sulfate		S.M. 426C	43.6	ppm	"	"
)	Sodium		EPA 273.1	22.3	ppm	"	HNO_3
5	Fecal Coliform		S.M. 909C	< 10	#/100mL	"	none
)	Total Organic Carbon		EPA 415.1	15.2	ppm	"	H_2SO_4
)	Total Dissolved Solids		S.M. 209B	500	ppm	"	none
)	Nitrate (N)		S.M. 418C	0.0	ppm	"	H_2SO_4

..development is the process of pumping the well prior to sampling in order to obtain ..sentative ground water sample.

PARAMETER MONITORING REPORT
(Rule 17-3.402, 17-3.404 - 17-3.406)

[illegible]36M02763

Sample Date June 22nd, 1992

oring Well # 4

Well Type: [X] Background
[ ] Site Boundary
[ ] Intermediate
[ ] Compliance

Name CCC- 4

ification of Groundwater G-II

Developed* Prior to
le Collection (Yes/No) YES

Ground Water Elevation
Storet Code 072020: (NGVD) 2' 0" ft

of Laboratory: see well #1

:T)	Parameter Monitored	Sampling Method	Analysis Method	Analysis Result	Units	Sample Filtered/Unfiltered	Preser- vatives Added
)0	pH (field)	see well #1	S.M. 423	7.0	std.	unfiltered	None
)4	Specific Conductance (field)		S.M. 205	950	uohms/cm	"	"
:0	Chloride		S.M. 407A	45	ppm	"	"
:5	Sulfate		S.M. 426C	170	ppm	"	"
)9	Sodium		EPA 273.1	25.3	ppm	"	HNO_3
16	Fecal Coliform		S.M. 909C	<10	#/100mL	"	None
30	Total Organic Carbon		EPA 415.1	48.0	ppm	"	H_2SO_4
)0	Total Dissolved Solids		S.M. 209B	862	ppm	"	None
)0	Nitrate (N)		S.M. 418C	0.04	ppm	"	H_2SO_4

l development is the process of pumping the well prior to sampling in order to obtain esentative ground water sample.

PARAMETER MONITORING REPORT
(Rule 17-3.402, 17-3.404 - 17-3.406)

s # 5236M02763

Sample Date June 22nd, 1992

nitoring Well # 5

Well Type: [ ] Background
[ ] Site Boundary
[X] Intermediate
[ ] Compliance

ll Name CCC- 5

assification of Groundwater G-II

ll Developed* Prior to
mple Collection (Yes/No) YES

Ground Water Elevation
Storet Code 072020: (NGVD) 2' 4" ft

ne of Laboratory: see well #1

DRET ode	Parameter Monitored	Sampling Method	Analysis Method	Analysis Result	Units	Sample Filtered/Unfiltered	Preser-vatives Added
)400	pH (field)	see well #1	S.M. 423	7.5	std.	unfiltered	None
)094	Specific Conductance (field)		S.M. 205	600	uohms/cm	"	"
)940	Chloride		S.M. 407A	35	ppm	"	"
)945	Sulfate		S.M. 426C	7.7	ppm	"	"
)929	Sodium		EPA 273.1	15.4	ppm	"	HNO_3
1616	Fecal Coliform		S.M. 909C	<10	#/100mL	"	None
)680	Total Organic Carbon		EPA 415.1	44.0	ppm	"	H_2SO_4
)300	Total Dissolved Solids		S.M. 209B	446	ppm	"	None
)620	Nitrate (N)		S.M. 418C	0.67	ppm	"	H_2SO_4
	VOC's (annually)						

ell development is the process of pumping the well prior to sampling in order to obtain
presentative ground water sample.

PARAMETER MONITORING REPORT
(Rule 17-3.402, 17-3.404 - 17-3.406)

HS # 5236M02763

Sample Date June 22nd, 1992

onitoring Well # 6

Well Type: [ ] Background
[ ] Site Boundary
[ ] Intermediate
[X] Compliance

ell Name CCC- 6

lassification of Groundwater G-II

ell Developed* Prior to
ample Collection (Yes/No) YES

Ground Water Elevation
Storet Code 072020: (NGVD) 0' 8"

ame of Laboratory: see well #1

TORET Code	Parameter Monitored	Sampling Method	Analysis Method	Analysis Result	Units	Sample Filtered/Unfiltered	Preser-vatives Added
00400	pH (field)	see well #1	S.M. 423	7.0	std.	unfiltered	none
00094	Specific Conductance (field)		S.M. 205	11,000	uohms/cm	"	"
00940	Chloride		S.M. 407A	2840m	ppm	"	"
00945	Sulfate		S.M. 426C	524	ppm	"	"
00929	Sodium		EPA 273.1	1820	ppm	"	HNO_3
31616	Fecal Coliform		S.M. 909C	< 10	#/100mL	"	None
00680	Total Organic Carbon		EPA 415.1	76.0	ppm	"	H_2SO_4
70300	Total Dissolved Solids		S.M. 209B	6132	ppm	"	none
00620	Nitrate (N)		S.M. 418C	0.0	ppm	"	H_2SO_4

*Well development is the process of pumping the well prior to sampling in order to obtain representative ground water sample.

DER Form 17-1.216(2)
Effective January 1, 1983

PARAMETER MONITORING REPORT
(Rule 17-3.402, 17-3.404 - 17-3.406)

S # 5236M02763 — Sample Date June 22nd, 1992

nitoring Well # effluent weir — Well Type: [ ] Background [ ] Site Boundary [ ] Intermediate [ ] Compliance

ll Name Reclaimed Water

assification of Groundwater G-II

ll Developed* Prior to
mple Collection (Yes/No) N/A

Ground Water Elevation
Storet Code 072020: (NGVD) n/a f

me of Laboratory: see well #1

ORET ode	Parameter Monitored	Sampling Method	Analysis Method	Analysis Result	Units	Sample Filtered/Unfiltered	Preser-vatives Added
)0400	pH (field)	see well #1	S.M. 423	7.2	std.	unfiltered	None
)0094	Specific Conductance (field)		S.M. 205	2100	uohms/cm	"	"
)0940	Chloride		S.M. 407A	465	ppm	"	"
)0945	Sulfate		S.M. 426C	1033	ppm	"	"
)0929	Sodium		EPA 273.1	244	ppm	"	HNO_3
31616	Fecal Coliform		S.M. 909C	<1	#/100mL	"	None
)0680	Total Organic Carbon		EPA 415.1	6.2	ppm	"	H_2SO_4
70300	Total Dissolved Solids		S.M. 209B	1350	ppm	"	None
)0620	Nitrate (N)		S.M. 418C	0.30	ppm	"	H_2SO_4
	VOC's (annually)						

Well development is the process of pumping the well prior to sampling in order to obtain epresentative ground water sample.

F Form 17-1.216(2)
Effective January 1, 1983

CITY OF CAPE CORAL REGIONAL WATER REUSE SYSTEM
MONITOR WELL LOCATIONS

WELL #CCC-1: (BACKGROUND WELL) - Monitored quarterly
Specific Location: At City Hall Mini-Park, Nicholas Parkway S.E., on northeast side of park, next to city vehicle-reserved parking lot.

WELL #CCC-2: (INTERMEDIATE WELL) - Monitored quarterly
Specific Location: In median of Country Club Boulevard next to light standard immediately south of intersection with S.E. 13th Street.

WELL #CCC-3: (COMPLIANCE WELL) - Monitored quarterly
Specific Location: At end of S.E. 10th Avenue, immediately south of intersection with S.E. 14th Terrace, between pavement and canal.

WELL #CCC-4: (BACKGROUND WELL) - Monitored quarterly
Specific Location: On Cape Coral Golf and Country Club, +/- 75 feet north of the 11th Tee. Enter from the end of S.E. 8th Avenue, immediately north of intersection with S.E. 41st Street.

WELL #CCC-5: (INTERMEDIATE WELL) - Monitored quarterly
Specific Location: In median of Country Club Boulevard next to light standard immediately east of intersection with S.E. 8th Avenue.

WELL #CCC-6: (COMPLIANCE WELL) - Monitored quarterly
Specific Location: At the end of S.E. 43rd Street, immediately west of intersection with S.E. 8th Place, between pavement and canal.

WELL #CCC-7: (INTERMEDIATE WELL) - Monitored annually
Specific Location: In median of S.E. Bolado Parkway, next to light standard immediately west of intersection with S.E. 19th Place.

WELL #CCC-8: (INTERMEDIATE WELL) - Monitored annually
Specific Location: At Jason Verdow Memorial Park, Academy Boulevard, next to where left field fence of Field #1 intersects right field fence of Field #2, adjacent to parking lot.

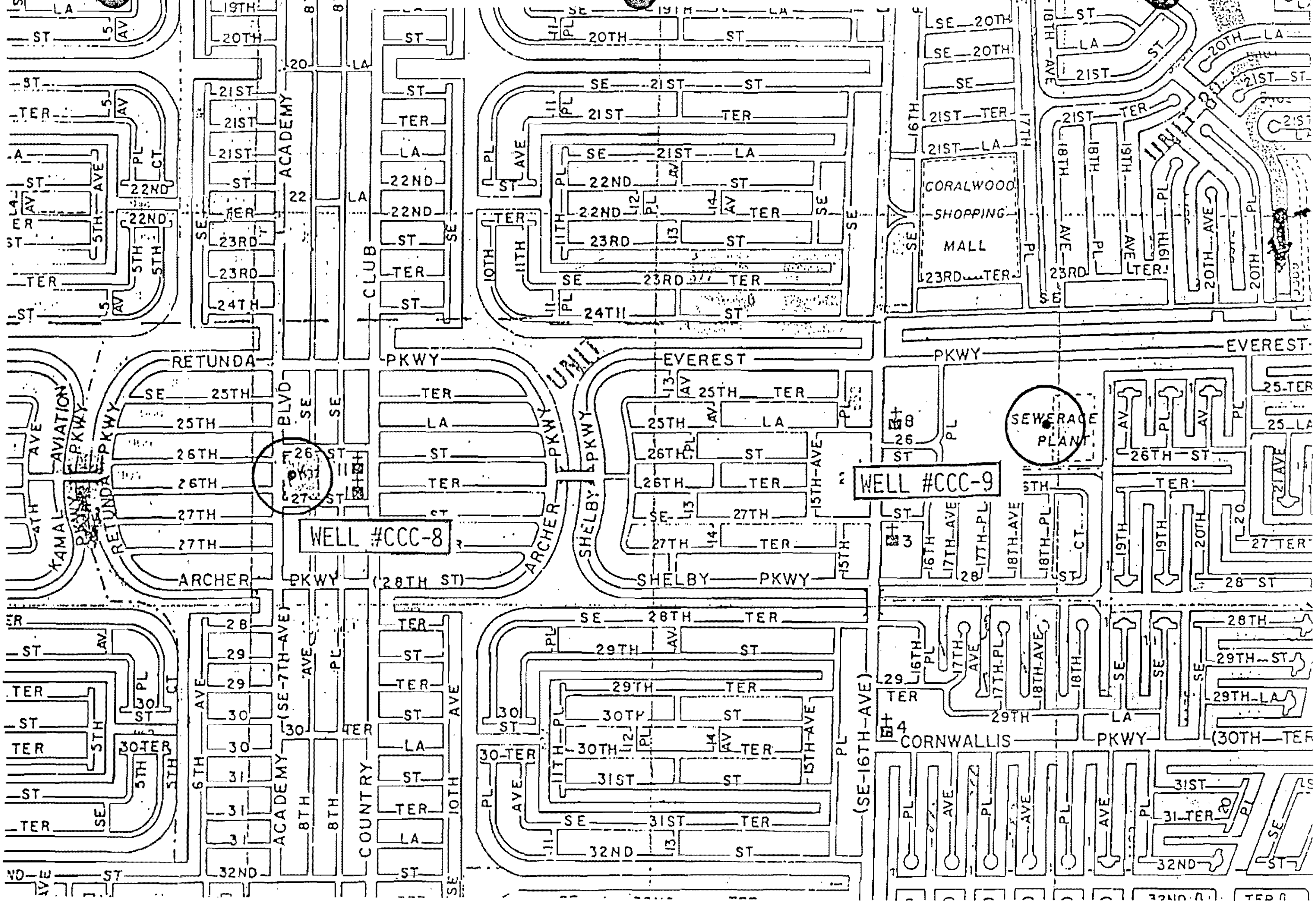
WELL #CCC-9: (INTERMEDIATE WELL) - Monitored annually
Specific Location: At wastewater treatment plant, Everest Parkway, immediately south of the Utilities Department office building, in the grassy area adjacent to the parking lot.

WELL #CCC-10: (INTERMEDIATE WELL) - Monitored annually
Specific Location: In median of S.E. El Dorado Parkway, next to light standard immediately west of intersection with S.E. Elm Court.

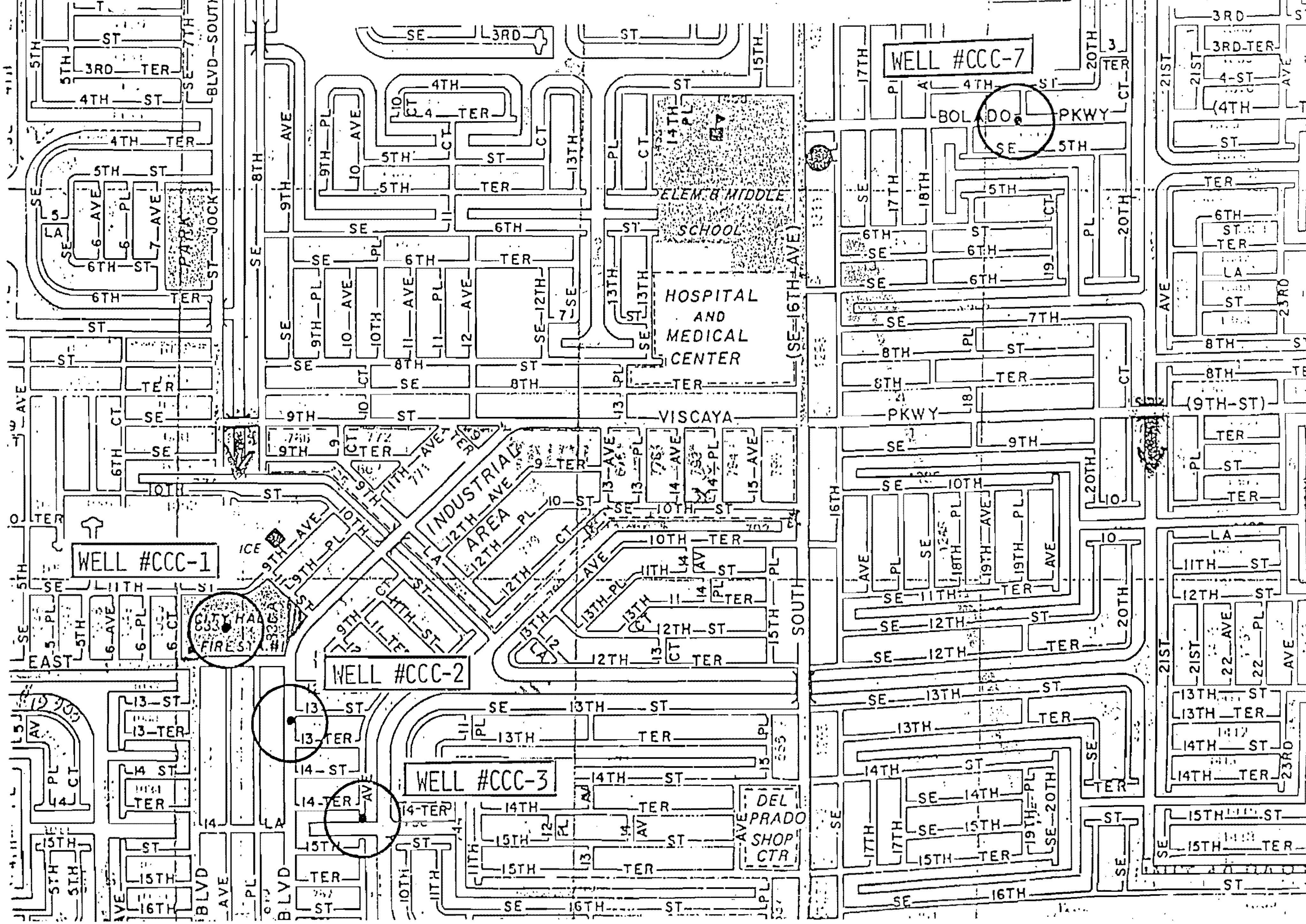
WELL #CCC-11: (INTERMEDIATE WELL) - Monitored annually
Specific Location: At Pelican Field Baseball Complex, Pelican Boulevard S.E., next to outfield fence of north field close to cedar trees, near the northeast parking lot.

RECLAIMED WATER: 24-Hour composite sample to be monitored monthly for groundwater parameters.

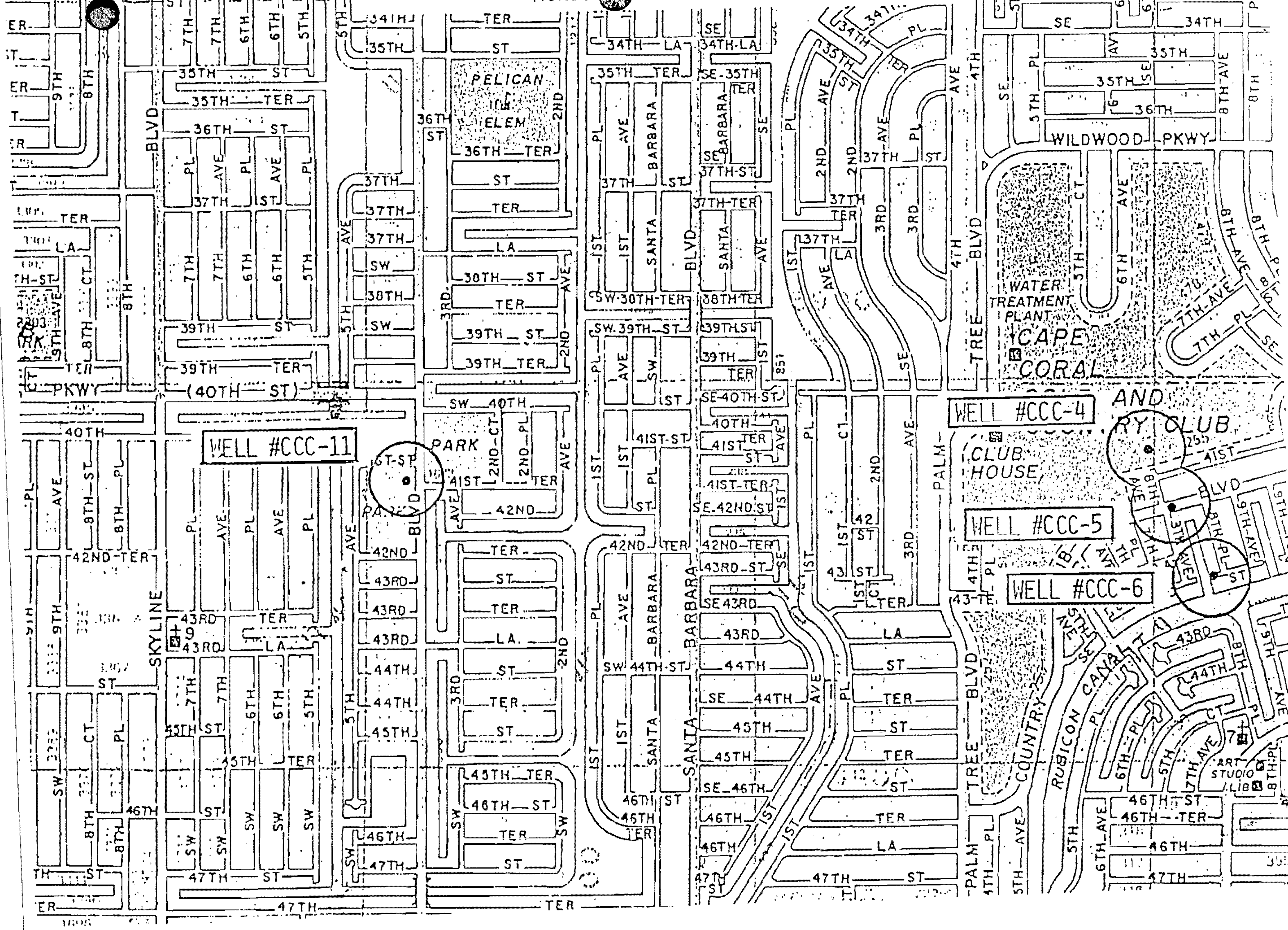
CITY OF CAPE CORAL REGIONAL WATER REUSE SYSTEM
MONITOR L LOCATIONS

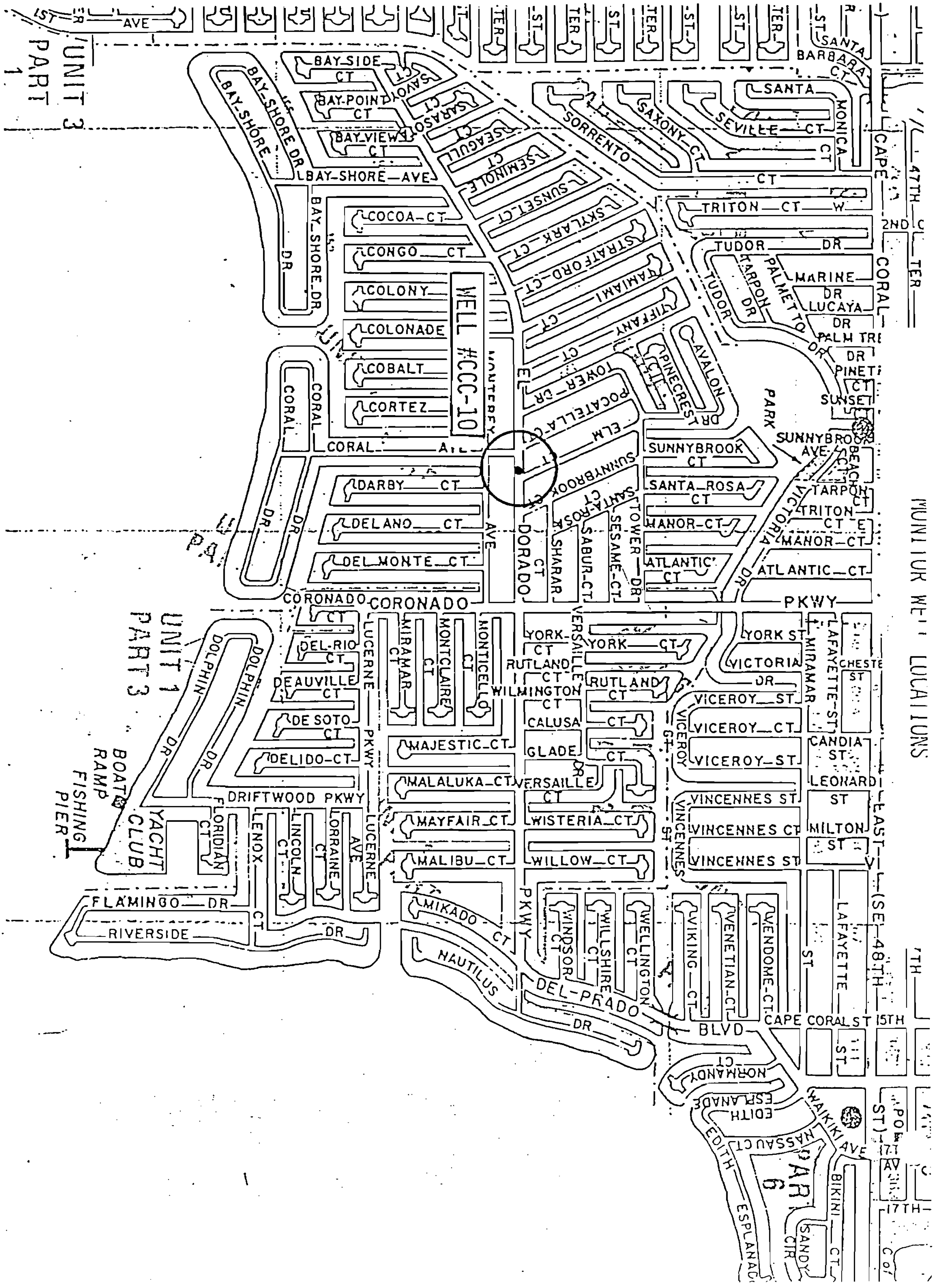


MONITOR WELL LOCATIONS



CITY OF CAPE CORAL REGIONAL WATER REUSE SYSTEM
MONITOR WELL LOCATIONS





MONITOR WELL LOCATIONS
WELL #CCC-10
UNIT 3 PART 1
UNIT 1 PART 3
BAY-SIDE CT
BAY-POINT CT
BAY-VIEW CT
BAY-SHORE DR
BAY-SHORE AVE
SAVONA CT
SARASOTA CT
SEAGULL CT
SEMINOLE CT
SUNSET CT
SKYLARK CT
STRATFORD CT
TAMIAMI CT
TIFFANY CT
TOWER DR
SORRENTO CT
SAXONY CT
SEVILLE CT
SANTA MONICA CT
SANTA BARBARA CT
TRITON CT W
TUDOR DR
TARPON DR
PALMETTO DR
MARINE DR
LUCAYA DR
PALM TREE DR
PINETREE CT
SUNSET CT
AVALON DR
PINECREST CT
POCATELLA CT
ELM CT
PARK
SUNNYBROOK AVE
SUNNYBROOK CT
SANTA ROSA CT
BEACH CT
TARPON CT
TRITON CT E
MANOR CT
ATLANTIC CT
VICTORIA DR
COCOA CT
CONGO CT
COLONY CT
COLONADE CT
COBALT CT
CORTEZ CT
MONTEREY CT
CORAL DR
CORAL AVE
DARBY CT
DELANO CT
DEL MONTE CT
EL DORADO AVE
DORADO CT
SHARAR CT
SABUR CT
SESAME CT
TOWER DR
CORONADO CT
CORONADO PKWY
DOLPHIN DR
DEL-RIO CT
DEAUVILLE CT
DE SOTO CT
DELIDO CT
LUCERNE PKWY
MIRAMAR CT
MONTCLAIRE CT
MONTICELLO CT
YORK CT
VERSAILLE
RUTLAND CT
WILMINGTON CT
CALUSA CT
GLADE CT
MAJESTIC CT
MALALUKA CT
MAYFAIR CT
WISTERIA CT
MALIBU CT
WILLOW CT
YORK ST
VICTORIA DR
VICEROY ST
VICEROY CT
MIRAMAR ST
LAFAYETTE ST
CHESTER ST
CANDIA ST
LEONARD ST
VINCENNES ST
VINCENNES CT
MILTON ST
EAST (SE 48TH)
DRIFTWOOD PKWY
FLORIDIAN CT
LENOX CT
LINCOLN CT
LORRAINE CT
LUCERNE AVE
YACHT CLUB
BOAT RAMP
FISHING PIER
FLAMINGO DR
RIVERSIDE DR
MIKADO CT
NAUTILUS DR
DEL-PRADO BLVD
WINDSOR CT
WILLSHIRE CT
WELLINGTON CT
VIKING CT
VENETIAN CT
VENDOME CT
CAPE CORAL ST
NORMANDY CT
EDITH ESPLANADE
NASSAU CT
WAIKIKI AVE
BIKINI CT
SANDY CIR
CAPE CORAL PKWY
47TH TER
2ND
17TH

Personal Communication with Howard Yamataki, USDA SCS, Ft. Myers

Septic Tanks

- In Cape Coral, leech beds usually must be excavated and filled since most soils have too slow of a perc and leech beds "fill up"
- Health Department uses most conservative high water table and 2' separation between HWT and leech field bottom
- State code 10B-6; based on public safety rather than hydraulically functioning system
- Lee County Health Department strictly adheres to parameters in 10B-6. It has investigated problems with improper engineering of septic systems in the past.
- SCS survey identifies the water table elevation used by the Health Department. This information is augmented with other information sources.

Water Tables

- The Health Department will alter the water table elevation in filled areas according to whether historic aerials (1958) show an area as wetland or upland.
- It has been found that soil types are not responsible for the occurrence of wetlands as much as either subsurface features, topography, and/or general hydrology. However, new soils may form within a wetland system.
- Clastic soils, the most prevalent in the Cape, are sands with high carbonate content. They are porous, but have low transmissivity.

The unanswered questions include:

i) What are the water bearing capacities of soils in the Cape?
ii) What happens to septic tank function if the water table is raised by raising canal elevations?
iii) How do we apply currently available data SCS, historical aerial and current aerial photos with a field program to classify soil/hydrologic units in the Cape.
iv) Is the perceived occurrence of slowly percolating soils a result of dredge/fill activities, localized marl layers or characteristic of all soils in the surficial aquifer system.

.12 Technologies

Below is a brief list of possible technologies we may consider for this project.

1) SEDIMENT AND NUTRIENT REMOVAL
Part of our project is to review existing practices and design criteria. Enforcement mechanisms may become a factor here. These systems may be recommended for local or regional applications and include:

- Inline (pipe) sediment and pollutant traps
- Better swale design practices; backyard swales
- Inlet box modification; possibly increase perc around the box using gravel or sand backfill. Most local soils have poor absorption.
- Biological nutrient removal in the canal system

2) WATER SUPPLY - IRRIGATION
If it is found that a 76 MGD withdrawal from the canal system is unrealistic, an alternative method of stormwater storage may be sought.

- Automated weir control - to maximize storage but also be able to respond to flooding threat.
- Deep well injection; store excess stormwater in an aquifer for retrieval during dry seasons. (Reported to be previously unpopular option with the City; Personal Communications)

3) BANK STABILIZATION
The emphasis in the City historically has been for the establishment of seawalls along all banks. Alternatives to seawalls may offer the same erosion protection with added environmental advantages. Alternatives include:

- Geo web
- Geo block
- Tiered banks
- Upland walls with littoral shelf

4) ENVIRONMENTAL IMPROVEMENTS
Various options to consider are:

- Grass Carp- a sterile fish that feeds on aquatic vegetation
- Artificial floating habitats- create small bio-filter reefs that use filter feeding organisms to remove sediment and phytoplankton and thus nutrients from the water column. Might work in freshwater environments as well.
- Aeration
- Tide Gates to improve circulation in marine system (as per USGS study)

5) DATA AND PREDICTIVE CAPABILITIES

- GIS- Considers the integration of engineering data with Management Information System, GIS, and SCADA.

- Aerial Photography- Some companies offer direct digitizing from stereoscopic photographs. Techniques exist to determine water depths and other environmental parameters from aerial photography.

- Modeling Effort- May include consideration or investigation of:

  - Water quality/pollutant transport
  - Hydrograph and capacity predictions of various extant and future channel cross-sections.
  - Extreme Event- Tropical event rain and storm surge drainage.
  - Adjustable weirs

.13 Multi-Use Resources

The canal system in Cape Coral was created to effect primary drainage, provide upland fill material, and serve as amenity to its citizens in the form of water view, boating, and fishing. The system has worked well in these capacities since they do not contradict each other.

However, it is quickly becoming apparent that the canal system will serve two additional functions in the future. These are stormwater quality treatment and service as a freshwater reservoir.

Since maximizing drainage and maximizing storage are direct contradictions in function and maximum water quality treatment potential contradicts certain perceived amenities, a new approach to canal system management must be developed.

Maximal use of the surface water system will depend largely on the canal/surficial aquifer system's capacities and in large part on the relative importance the City places on each function. For instance, storage might be maximized by adding some weirs which inhibit navigation.

The City must recognize that placing additional demands on the system may occur at the expense of other uses. It must also recognize that not enough is known about the physical processes occurring in the surface water system to make determinations of it's capabilities.

.14 Priority Criteria

As the dominant public entity, the City of Cape Coral has taken responsibility for:

1) Protection public health and safety
2) Protecting private property
3) Maintaining public order
4) Enhancing the quality of life maintained by the citizens of Cape Coral

These responsibilities should be reflected in the way the City prioritizes drainage and surface water issues.

Prioritization schemes may be conveniently divided into a number of time horizons. For purposes presented here, only two will be considered; long term and short term priorities. Long term priorities guide actions that will enable the City to meet its long term objectives. Short term priorities guide actions taken as a daily, weekly, or monthly basis and generally are immediate response to continual goals.

It should be recognized that projects that fit short term priorities but violate long term constraints should be avoided.

<u>Findings</u>

- Long term surface water priorities have not been formally established. These may be, in order:

    1) Provide adequate drainage in canal system
    2) Provide adequate drainage through the upland system
    3) Maintain a freshwater supply from the system
    4) Maintain water quality and aesthetic appeal of canal system
    5) Maintain navigability in canal system
    6) Avoid conflicts with state or federal regulations

- Short term prioritization criteria have been established by policy. These criteria provide the stormwater utility with a prioritization guide for addressing drainage failures in order of importance. These criteria begin to address the major concerns of protecting safety and property, but fall short of being a comprehensive set of criteria. They lack consideration for long term priorities and do not consider possible long term ramifications of practices used to remediate many drainage failures.
- It appears that some projects are conducted without regard to technical criteria but are rather politically prioritized. This may cause neglect of more important items and is probably very cost ineffective.

APPENDIX B - BIBLIOGRAPHY

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CLAPP, CORNELL
1990
MAP
AVAILABLE COLOR PHOTO OF CAPE CORAL. NOT YET PURCHASED.
9 X 9 MOSAIC ANY SCALE (1"=1/4 MI?) COST 1ST PRINT $1500 EACH ADDITIONAL $150
CALL 407-851-7880
DATAM DATAG

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DURING JUNE 1989-MAY 1990 RAINFALL AVERAGED 9 INCHES BELOW
NORMAL. DROUGHT OF 1 IN 10 YEARS. DATA CONCERN MOSTLY SE FLA
W/SOME SW
DATAH DATAC, DATAM, RAINF, AQUIF

ANGELO, RICH
CITY OF CAPE CORAL-RO PLANT PERSON
PC WHIZ, SELF TRAINED. RECOGNIZED THROUGH CITY AS PC GURU.
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SELF EXPL ORDINANCES
POLIC CCUTIL

CITY OF CAPE CORAL GIS
FITCH, MITZI
CCC ISS DIV DIGITAL, MAP
AVAIL ACCESS TO CITY GIS HARDCOPY & .DXF OUT REQUESTABLE.
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DEV; DETERMINE FLUSHING OF CONFIGURATIONS; MASS EXCHANGE OF NUTRIENTS;
VERIFY SEPTIC TANK LEACHATES IN CANALS; VERIFY APPLICATION OF PREDICTIVE
WQCAN BMPAP, CANAV, CAPHYL, WQMGT

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FEMA
SEP 85
MAP
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LEE CO AUTH: WATER RES DIV PERSON
RESEARCH ENGINEER. KNOWS DATA SOURCES
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SFWMD PERSON
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WEIR BRIDGE MAP OF CAPE CORAL "AS BUILTS"
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SOILG SOILD

APPENDIX C - LOCAL PROBLEM AREAS

A. INTRODUCTION

This section presents the identification and resolution of stormwater problems in the City of Cape Coral. The primary focus will center on an inventory of local drainage problems and identification of required short-term improvements. It also includes a discussion of problem identification, a review of resolution approaches and suggests improvements to the current system.

Problem areas are defined as those areas experiencing inadequate drainage on a regular basis. The severity, frequency, duration and extent of problems is widely variable throughout the city. With few exceptions, drainage failures in the city result in some degree of inconvenience and rarely pose a threat of immediate injury or damage.

It is beneficial for discussion to categorize problems as either local or regional problems. Regional problem areas are those that result in inconvenience to large numbers of individuals or businesses such as in the downtown (CRA) area. Localized problems generally impact a few properties and are mostly found in residential areas and typically result from small system failures.

Major areas of concern are identified as those problems that affect or are encountered by large numbers of people on a regular basis. Typically these types of problems occur in high traffic or business zones but may also represent problems affecting a number of residential blocks. Solution of regional problems usually involves thorough investigation and design.

Most service requests recorded in the database pertain to very site specific or local problems and typically impact fewer people than regional problems might. Many of the causes of localized drainage failures are similar in nature and may be related to improper installation, design or material choice. Although localized problems are smaller in extent, they are not necessarily of lesser importance as they may pose a significant threat to property or injury.

It is these local problems that are addressed in this section. The inventory and analysis contained in this section is based on a review of the city's stormwater service requests files, onsite observation and discussions with city staff.

B. METHODOLOGY

Review of service request files

The city has maintained a system for logging drainage service requests since 1987. Beginning in 1992, these service requests have been entered into a computerized database for storage and retrieval. This has allowed summary analysis of the growing service request file through the use of database utilities.

Three different approaches were used to analyze the service request files, each offering a different insight towards prioritizing responses. The first is an analysis of the number of service requests filed vs. resolution in order to determine demands on the stormwater utility and its ability to address problems. The second technique was to map the filed and resolved service requests to determine the distribution of requests and to locate areas experiencing an inordinate numbers of problems. The final analysis investigates request types and prioritization and discusses typical causes of these problems as observed in the field.

Service Requests & Resolution
The first analysis was performed to determine the work load and effectiveness of the stormwater utility. A comparison was made between the number of service requests registered in each category and the number of resolved issues in each year since 1987. The results of this analysis indicate that while the stormwater utility's capacity has increased significantly in the past two years, the rate of incoming service requests exceeds their ability to address problems.

Spatial Analysis
The second analysis was performed to determine the city-wide distribution of service requests and request types. This was accomplished by adding key data to the database and mapping the service requests using the cities Geo-Info System. The resulting maps (attached) assisted in identifying areas with high densities of requests. Service requests were overlaid by the storm sewer system and certain key factors causing the problems could be identified.

Discussions with City Staff
Service Request and resolution maps were then discussed with city staff. Insight was gained based on their experience with recurring problems in identified areas. These conversations assisted in determining probable causes and possible solutions. Valuable insight concerning the severity of particular problems was also gained during these discussions.

Site Visits
Finally, problem areas were visited to determine if cause and effects could be further detailed. Included in site investigations were inspections of existing pipes and inlets, swale inspections, identification of outfall problems and probable cause determination. The results of these investigations were compared with request descriptions as recorded in the database.

C. FINDINGS

Service Requests Filing and Resolution
There are approximately 2,000,000 feet of drainage pipe, 45,000 inlet boxes and 3,400 miles of swale in Cape Coral. The Stormwater Utility is responsible for maintaining and repairing

clogged or failed pipes, inlet boxes, catch basins and recently added swale grades. The Utility is also responsible to maintain flow and navigation in the city's nearly 400 miles of canals.

Since 1989, drainage problems throughout the city have been addressed by the Stormwater Utility. A review of the files shows that most service requests originate in residential areas. Typically, a resident will phone in a drainage service request. The request is logged and an inspector is dispatched to the site for assessment. The inspector determines the cause and extent of the problem and assigns a priority to the service request. Recently, city council approved an ordinance placing responsibility for swale elevation maintenance on the Stormwater Utility.

Written policy shows that service request prioritization is to be based on the following criteria:

Immediate action -	When the problem represents a threat to public safety or the protection of property. The most common of these are sinkholes in or near a right-of-way which are usually a result of failed storm sewer pipes.
Priority 1 (P1) -	Drainage system or swale failure results in standing water for 5 or more days.
Priority 2 (P2) -	Drainage system or swale failure results in standing water for 3 to 5 days.
Priority 3 (P3) -	Drainage system or swale failure results in standing water for 24 hours.

As of 8-18-92, 1228 service requests have been filed with the stormwater utility. Table 1 presents the number of service requests in each category. Table 2 presents the number of resolutions and pending resolutions in each category.

TABLE 1

INITIAL SERVICE REQUEST DATE

CATEGORY	Not Dated	1987	1988	1989	1990	1991	1992	Count
Canal	0	3	30	2	8	8	16	**67**
Catch Basin	9	0	0	0	3	26	207	**245**
CBP1	0	0	0	0	0	1	0	**1**
CBP2	0	0	0	0	0	1	0	**1**
Misc	37	0	0	2	3	10	30	**82**
Pipe	1	2	1	0	1	43	72	**120**
Pipe-P1	1	0	1	0	0	21	8	**31**
Pipe-P2	0	0	0	0	0	7	0	**7**
Pipe-P3	0	0	1	0	0	6	0	**7**
Sink Hole	1	0	0	0	2	41	63	**107**
Swale	3	2	0	1	0	12	133	**151**
Swale P1	3	1	0	4	22	176	107	**313**
Swale P2	0	0	1	2	6	30	13	**52**
Swale P3	0	1	0	1	0	30	11	**43**
Street Sweep	0	0	0	0	0	0	1	**1**
Count	**55**	**9**	**34**	**12**	**45**	**412**	**661**	**1228**

TABLE 1: Initial service request filing date by category. Data is taken from Stormwater Utility service request database as of August 8, 1992. Some entries in the data base did not have request dates recorded, as shown in the first column. Also, re-registered requests were excluded from this analysis.

(At the time of table development, data entry of service requests was incomplete. The most significant exclusion was approximately 400 additional canal service requests.)

TABLE 2

1^{ST} RESOLUTION DATE

CATEGORY	Not Re-solved	1987	1988	1989	1990	1991	1992	Count
Canal	30	2	5	2	6	4	18	67
Catch Basin	127	0	0	0	2	17	99	245
CBP1	0	0	0	0	0	1	0	1
CBP2	1	0	0	0	0	0	0	1
Misc	46	0	0	2	2	11	21	82
Pipe	65	1	1	0	1	27	25	120
Pipe-P1	9	0	0	0	0	16	6	31
Pipe-P2	3	0	0	0	0	4	0	7
Pipe-P3	4	0	0	0	0	3	0	7
Sink Hole	36	0	0	0	1	28	42	107
Swale	109	1	0	0	0	12	29	151
Swale P1	83	0	0	2	8	139	81	313
Swale P2	21	0	1	1	3	16	10	52
Swale P3	14	0	0	0	0	18	11	43
Street Sweep	0	0	0	0	0	0	1	1
Count	548	4	7	7	23	296	343	1228

TABLE 2: Date of first crew response to filed service requests by category. Data is taken from Stormwater Utility service request database as of August 8, 1992. Un-resolved requests were totaled based on records with no entry in the resolution date field.

(At the time of table development, data entry of service requests was incomplete. The most significant exclusion was approximately 400 additional canal service requests.)

An examination of the two tables shows that while the stormwater utilities ability to respond to service requests has increased dramatically in the past two years, the number of incoming requests continues to exceed resolutions. To date nearly half of all service requests remain unresolved. Most service requests and resolutions have occurred in the past two years (1991 and 1992) with approximately 1073 (412 + 661) service requests and 639 (296 + 343) resolutions. The dramatic increase in requests may be attributed to the increase public awareness of the utility existence.

Presented in table 3 is an estimate of the time required by the drainage crew to complete all projects backlogged in the service request file as of June 10, 1992. This estimate was compiled for this report based on job time estimates from the utility department, current crew capability and the service request database and assumes no additional workload aside from the service requests on hand.

TABLE 3

BACKLOG RESOLUTION

JOB TYPE	# REQUESTS	AVERAGE CREW TIME PER JOB	CREW DAYS NEEDED TO ELIMINATE BACKLOG
CB-Inlet	152	.33 days	50
Pipe/Sinkhole	166	1 day	166
Swale	423	2 days	846
			1,062

To complete existing request backlog	1,062 crew days
	÷ 2 crews
	531 work days

Due to increasing backlogs of critical problems, operational adjustments have been made in prioritizing service requests. Major construction projects taking place throughout the city frequently disrupt or damage weak drainage pipes thus increasing the occurrence of sinkholes and other problems associated with failed storm drainage facilities. Stormwater utility personnel have responded well by putting full effort into resolving potentially dangerous situations before any other problems. However, with only seven drainage crew members available, the utility is not currently structured or sufficiently staffed and equipped to address drainage problems prior to their occurrence.

Although staff and equipment have increased and should become more effective and be able to resolve more service requests, it is expected the number of requests will continue to increase as population increases. These deficiencies may be better assessed once the utility has operated with its recent staff increases for a period of time. Deficiencies in crew numbers and equipment may continue to hinder the utility's ability to respond to particular types of service requests efficiently.

SPATIAL DISTRIBUTION

The second analysis focuses on the distribution of problems in an effort to determine if certain patterns in the occurrence of problems exist. The analysis will aid in identifying whether a particular area is plagued by drainage problems as a result of either one far reaching failure or a number of individual related failures.

Maps were prepared to show the distribution of all reported problems since 1987. Inspection of the map revealed five areas with an inordinate number of service requests in relatively small areas of 15 blocks or less. Service requests were then separated into related categories of swale, catch basin, canal and pipe and mapped individually. The four category maps were analyzed for spatial distribution of specific problem types. It appears that areas with many service requests are generally in residential areas and appear to be mostly swale problems. Also, most grouped requests are swale related service requests.

The areas with higher densities of requests were then visited to verify site conditions. The location of these areas, types, probable causes and possible solutions are described below.

1. Unit 25, West of Academy Boulevard between SE 21 Street and SE 24 Street

This residential area is approximately 45% developed. Most service requests in this area result from swale failures. However, most swale grades appear to be uninterrupted with some minor grade changes that may cause very localized drainage problems. It is also possible that some forms of pipe failures may have occurred resulting in standing water after heavy storms. Based on observations in similar areas of the city, pipe failures would most likely be related to clogging rather than corrosion since the adjacent canals are freshwater.

No related problems are apparent except for localized swale grade changes and a few overgrown inlets on vacant lots. Most of these problems should be resolved by survey, grading and inlet clean-out prior to additional development.

2. Unit 63, Golf Course homes west of Palmetto Pines Country Club

A number of problems had previously plagued this area including swale infill, improper swale grades, undersized pipes and pipe backup resulting from the golf course operation of retention ponds. An effort to alleviate these flooding problems by surveying and correcting swale grading and pipe repair is being conducted by stormwater utility crews and golf course personnel and should be completed by winter of 1993.

3. Unit 49, Immediately East of Skyline Boulevard and South of Gleason Parkway including all north south roads between SW 7 Place and SW 5 Place

This is a residential area that is approximately 60% developed. Many of the homes appear to be 5 to 10 years old. Observations reveal the potential for more problems than have been reported. Many sections of the swales along these roads are hydraulically isolated from any inlets and frequent road flooding is suspected. The most prominent problem in this area is the lack of an established and continuous grade in the swales. The area may also be more effectively drained with the addition of a few inlets.

The most effective approach to correct drainage problems in this area would most likely be similar to the one taken to correct drainage problems in the Palmetto Pines area. Recommendations include an inspection of inlets and pipes to verify proper conductance, computation of pipe capacity checking them against design storm runoff estimates and development of a repair plan including swale grading and the addition or replacement of drainage pipes.

4. Unit 15, North and West of Cape Coral Golf and Country Club

This is a residential area that is approximately 75% developed. Many of the homes appear to be 5 to 10 years old. Observations reveal the potential for more problems than have been reported. Problems in this area are mostly linked to swale failures. Swales have not been maintained by individual property owners and evidence of minor standing water is apparent. The conductivity of the swales in this area is reduced by improper grade causing water to be trapped at the upper reaches of the swales. Occasional street flooding may result as water is forced into the street to bypass obstructions in the swale. Most inlets appear to be in good condition and no evidence of pipe failure was readily apparent.

The recommended resolution is to conduct a basin by basin survey and grading project. Also, swale retention volumes should be computed and pipe systems should be evaluated to ensure they are capable of carrying the necessary discharges.

5. Kismet 40 Project, Kismet Parkway and Burnt Store Road

Flooding problems in the vicinity of Kismet Parkway and Burnt Store Road have been reported to the SFWMD over the past summer. Investigations have shown that the flooding is most likely caused by siltation of the Gator Slough outfall and restricted flow through underdrive culverts. These culverts and the swales they serve are in a Lee County Right of Way. In addition to the clogged pipes, it is also possible that the two inlets serving Kismet Parkway and their pipes are too small to provide sufficient drainage and several inlets have been destroyed.

The capacity of city and county drainage systems in the area should be re-evaluated as to their sufficiency in providing drainage service. Request should be made to Lee County to perform maintenance on the Burnt Store Road drainage system.

APPENDIX D
DETAIL AND ORDINANCE RECOMMENDATIONS

A. INTRODUCTION

In addition to the problems recorded in the service request files, observation and discussion with utility staff indicate that many unrecorded (in service request database) drainage and canal problems occur throughout the City. Most problems are associated with inadequate maintenance by property owners, both on developed and undeveloped lots. Problems may also be largely associated with inadequate design during the development of the City, projects conducted for the City, and residential construction activities.

Many of these problems may be avoided at little cost with ordinances that address specific causes. However, approaching the resolution of typically encountered problems through the development and mandating of design practices is only as effective as the enforcement.

This document is intended to define readily apparent drainage problems typically encountered in the City and offer conceptual design alternatives. Without well documented performance data on various designs, it is not prudent to attempt detailed design recommendations at this time. However, a critical assessment of existing or planned drainage practices and suggestions for easily attainable modifications is in order since a significant portion of the City's drainage system is currently undergoing re-construction. Designs that promise to be effective and easily altered throughout the Master Planning effort will be suggested for implementation.

B. OBJECTIVES

The purpose of the secondary drainage system in Cape Coral is essentially threefold, protect public safety and health, remove water from inconvenient areas and affect some degree of runoff water quality enhancement. The first two objectives are strongly motivated by public attitudes and receive much public interest. The third is motivated by regulatory requirements and long-term solutions to canal water quality but is often overlooked by the general public as an immediate concern.

The physical characteristics of Cape Coral and designs that have been implemented in the past complicate the simultaneous achievement of all three objectives. These characteristics are specifically defined in other documents but will be indirectly bourn out within the context of the discussions that follow. At this point it will suffice to indicate that these complexities constrain the development of city-wide design applicability.

Recognizing these constraints incorporates flexibility into the definition of the City's objectives. Specific goals include:

- Moving water from unsafe or inconvenient areas to locations that may pose less inconvenience

- Design drainage systems to afford varying degrees of stormwater treatment where possible and practical

- Reduce constraint of public pressure by raising public awareness of all City objectives and design functionality

- Reduce or eliminate conditions that worsen pre-existing drainage problems

- Create and maintain flexibility within stormwater permitting processes for specific design approaches where practical

C. <u>ORDINANCE</u>

1. FEDERAL REGULATION

The U.S. Environmental Protection Agency has recently been increasing their interest in stormwater quality protection under the National Pollution Discharge Elimination System (NPDES) program. Newly adopted regulations require municipalities over 100,000 population and industrial operations to submit permit applications by October 1, 1992. It is important to note that certain activities conducted by municipalities fall into the category of industrial operation and must be permitted accordingly. Permit conditions require the development of a Storm Water Pollution Protection Plan (SWPPP) for each operation by April 3, 1993 and implementation of this plan by October 1, 1993. Smaller municipalities operating industrial activities defined by the law must permit each activity.

Although industrial operations are required to prepare and implement a plan, a well defined enforcement structure has not been developed. It should also be noted that no regulatory agency is reviewing the SWPPP. Although it is unlikely that regulators will soon be checking up on all the industries in the area, industrial operators are responsible for preparing a plan and complying with the law. Fines up to $25,000/day may be levied on operations found to be non-compliant. Direct defiance, such as not developing a plan, may bring penalties retroactive to the deadline dates stated above.

With the help of strong lobbies in Washington, certain industrial activities have been exempted from complying with the EPA permit requirements, including fueling stations and agricultural operations. However, a Federal exemption does not preclude local authorities from requiring a SWPPP from these potentially significant pollution sources. It may be in the City's best interest to do so in order to maintain control of the quality of surface runoff that is ultimately discharged to the canals. Once pollutants reach the canals, they become the responsibility of the City regardless of the source.

2. STATE REGULATIONS

Both Florida Statues and the Florida Administrative code, with respect to water resources, are enforced by the DER. Most of DER's surface water rules in freshwater areas are delegated to the South Florida Water Management District (SFWMD), a regional entity authorized by state law. Most drainage issues are addressed in SFWMD permitting manual, Volume 4. These rules govern design standards for stormwater treatment facilities and water use issues.

Since SFWMD rules are generally more stringent than USEPA, the City can expect SFWMD rules and water quality criteria to govern. As the City knows, SFWMD generally creates technology based performance limits which can be somewhat arbitrary. As stated earlier Cape Coral may be in a difficult position, since there is little workable space within the City to implement the level of detention storage SFWMD could technically impose. High groundwater levels confound the situation. It will be certain that future stormwater quality solutions will need to be creative.

The DNR does not generally form policy or rule enforcement, but is mandated to manage all natural resources of the state especially water resources. DNR is currently managing the aquatic preserves west and south of Cape Coral including Matlacha Pass and has a vested interest in what is discharged from the canal system. Their greatest concerns will probably be focused on pollutant loads and maintaining certain dry season freshwater discharges.

3. LOCAL ORDINANCES

A description of each of the existing ordinances or legally binding agreements and their effectiveness as related to surface water issues are:

a) Department of Environmental Regulation (DER) Order No. 15

A consent order between DER and Gulf American Corporation (GAC) signed in 1977 that attempted to improve the conditions in the canal system and buffer, treat and improve the quality of water reaching the Caloosahatchee river and Matlacha Pass. It does not pretend to assure water quality standards within the canal system will be met. The consent order required the developer to:

- Cease work waterward of a DER established line and restore areas waterward of this line to the natural elevation.
- Construct a pollution retention system including the spreader waterway. GAC also agreed to construct all lots to slope back to front to maximize swale treatment of runoff prior to discharge to the canals and construct swales and weirs.

- Install boat lifts or locks to avoid direct hydraulic connection between the canal system and waters of the State for the north spreader waterway, the south spreader waterway and unit 89.

- Deed the tidal wetlands surrounding the Cape to the State of Florida

- Deposit one million dollars to the GAC Pollution Recovery Trust fund account for use in the study of water quality problems, development of solutions and implementation in the residential canal system.

b) Easements and Rights of Way

Section 3.24 of the Land Use and Development Regulations (CCC Ordinance 72-77) controls the use of City owned right of way areas (ROW) and establishes fees for developing properties adjoining the ROW's. Swales exist in most City ROWs. Recently, the ordinance was changed giving the City responsibility of ensuring that proper grades (established by City survey personnel) are maintained (Section 3.25).

c) Construction and Design Practices

Resolution 104-76 set forth policies with respect to the construction and maintenance of drainage facilities in residential areas. Some drainage details have also been adopted in the City of Cape Coral Engineering Standards Manual that address design details of specific stormwater structures.

d) Stormwater Utility

The Stormwater Utility was created by Ordinance 18-90 which established the utility fee structure and program responsibilities. Ordinance 18-90 also established the initial rate for the Stormwater Management Utility. It did not specify technical responsibilities, or a management structure

D. <u>REGULATORY, POLITICAL AND TECHNICAL CONSTRAINTS</u>

Stormwater practices in the City must be designed to fit within regulatory, political, technical and cost constraints. These constraints play an important role in determining which practices are feasible.

1. REGULATORY CRITERIA AND CONSENT ORDER SWALE AGREEMENT

Surface water management in Cape Coral must conform to Regional (SFWMD), state and federal guidelines as well as the Gulf American Corporation (GAC) and Department of

Environmental Regulation (DER) consent order agreement. Currently, DER surface water rules are administered by SFWMD except those that occur in saltwater.

2. POLITICAL

Since surface water management is a public enterprise, it is subject to public scrutiny. New ordinances and design details are likely to affect new home builders, City contractors, commercial enterprises and private citizens. New requirements, while necessary, may not be entirely popular.

Cost also becomes an issue. Since maintenance, repairs, upgrades or new installations cost money to implement no matter who does it, the cost will be borne by the citizens of Cape Coral at some point. However, the cost of not implementing necessary drainage and water quality measures in terms of stagnate property values and quality of life is potentially much greater than original design, construction and maintenance costs. Also, regular maintenance costs may be unnecessarily high when improper designs are chosen in an effort to keep construction costs down.

Political conflict may stem from firmly held opinions of what is visually pleasing. It is necessary to consider aesthetic impacts when creating ordinances and design details.

3. TECHNICAL

Stormwater management practices in the City of Cape Coral are impacted by varying physical characteristics throughout the City. These characteristics must be considered when developing stormwater management design concepts. They include:

- Soil Permeability
- Varying water tables
- Shallow slopes
- Lawn Growth

a) Soil Permeability

Soil permeability is variable throughout Cape Coral but is generally characterized as poorly drained. According to limited existing data, horizontal seepage rates are relatively low and vertical percolation is moderate. Thin but impermeable clay-shell strata have been observed in many areas of the City at varying depths. When these occur very near the surface, they may prevent vertical percolation and a corresponding reduction in the effectiveness of retention and detention ponds to dissipate water over reasonable time periods.

b) **Seasonally High Water Tables**

Water table aquifer levels fluctuate significantly between wet and dry seasons. Typically, groundwater lies 4-10' below surface elevation in the dry season and 1-4 ft. during the wet season. Occasionally, the bottom of certain swales lie below the seasonal high water table. When water tables are very close to the surface, ground absorption capacity may be severely limited.

c) **Shallow Slopes**

Cape Coral is also characterized by very mild slopes. Vertical alignment control is critical to assure adequate slopes for drainage purposes.

d) **Lawn Growth**

Much of the drainage system in Cape Coral lies in the grassed swales fronting most homes in the City. The swale system is often significantly impacted by the lack of lawn maintenance in swales and near drainage structures. Commonly used lawn grasses, especially broad leaf grasses such as Floritam, tend to create a root thatch that causes the elevation of the lawn to rise. As grass rises the swale bottom slope is altered and underdrive culverts may become blocked, often resulting in a decrease in flow efficiency. Depending on grass species, this process may take as little as three years before restorative maintenance is required.

4. COSTS - FIRST TIME AND MAINTENANCE

The costs of first time installation and expected annual maintenance costs must be considered when choosing alternate design criteria. Although the homeowner eventually bears the cost of implementing and maintaining the drainage system, alternate programs may be considered. Installation and maintenance may be either solely the responsibility of the homeowner constrained by design ordinances, solely the responsibility of the City utility department funded by utility fees or a combination of the two. These will be further evaluated throughout the Master Planning effort.

E. MAJOR PROBLEM AREAS

Regional and localized drainage problems that represent possibly more serious hazards have been observed in certain sections of the City but do not appear in the service request files. These include the areas currently under study or design. They are:

- Community Redevelopment Area (CRA) - Downtown Cape Coral Design completed, construction not yet begun

- Industrial Park and City Hall design completed

- Santa Barbara Boulevard Study completed with a recommended action plan

Unreported problems often exist in public areas and may not yet be recognized as priority problem areas. These areas include existing and potential problems along the Hancock Bridge Parkway corridor, State Road 78 corridor, the Industrial Park area and numerous small commercial zones planned throughout the City.

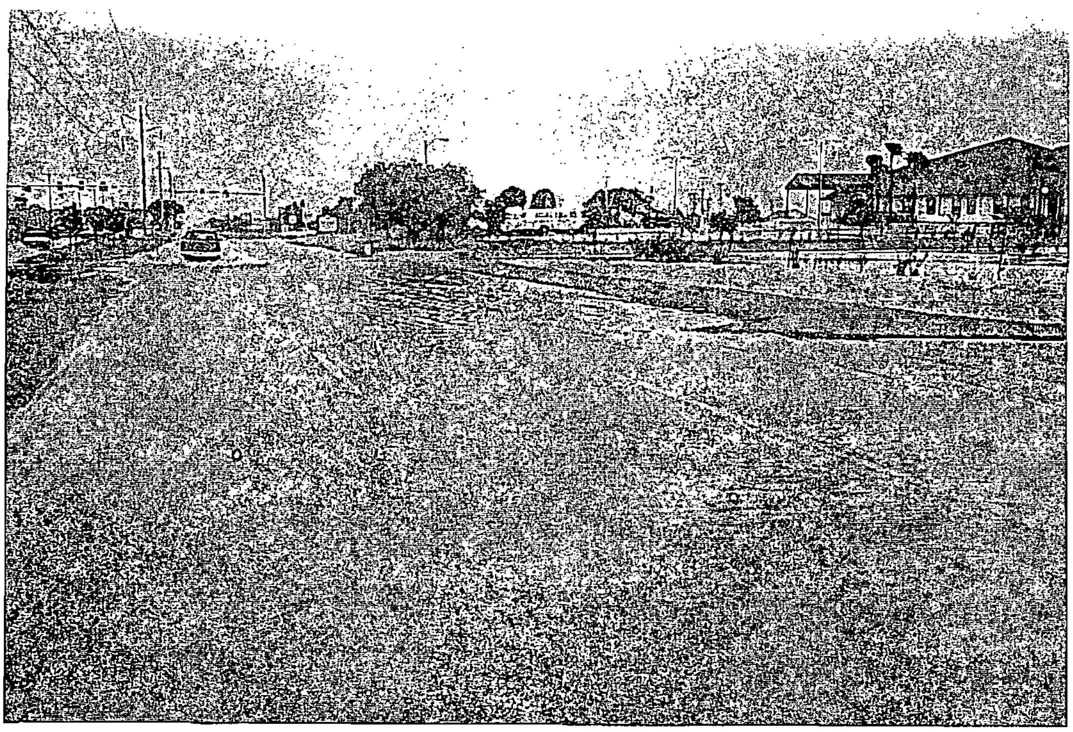
Most regional or localized drainage problems may be attributed to one or more of the following causes:

Problem 1a:
Inadequate distribution of inlets and drainage systems - Throughout most of the City inlets are spaced approximately 1000 feet apart. Accepted stormwater practice along high volume roads with curb and gutter section in Southwest Florida is one inlet every 500 feet with a maximum run of 300 feet (length of road contributing runoff) on either side of the inlet. As development occurs along commercial corridors, roadway flooding hazards will increase if additional inlets are not provided.

Problem 1b:
Inadequate or undersized pipe systems - Engineering calculations and experience indicates that the pipes servicing existing inlets are not capable of carrying the peak volume of water reaching inlets during a storm event. As a result, roadway flooding is often observed up to 2 hours following a typical summer storm event. While this may be tolerable in residential areas, for public safety it should not be tolerated on major roads. Figure D.1 presents an example of road flooding after a typical summer storm event.

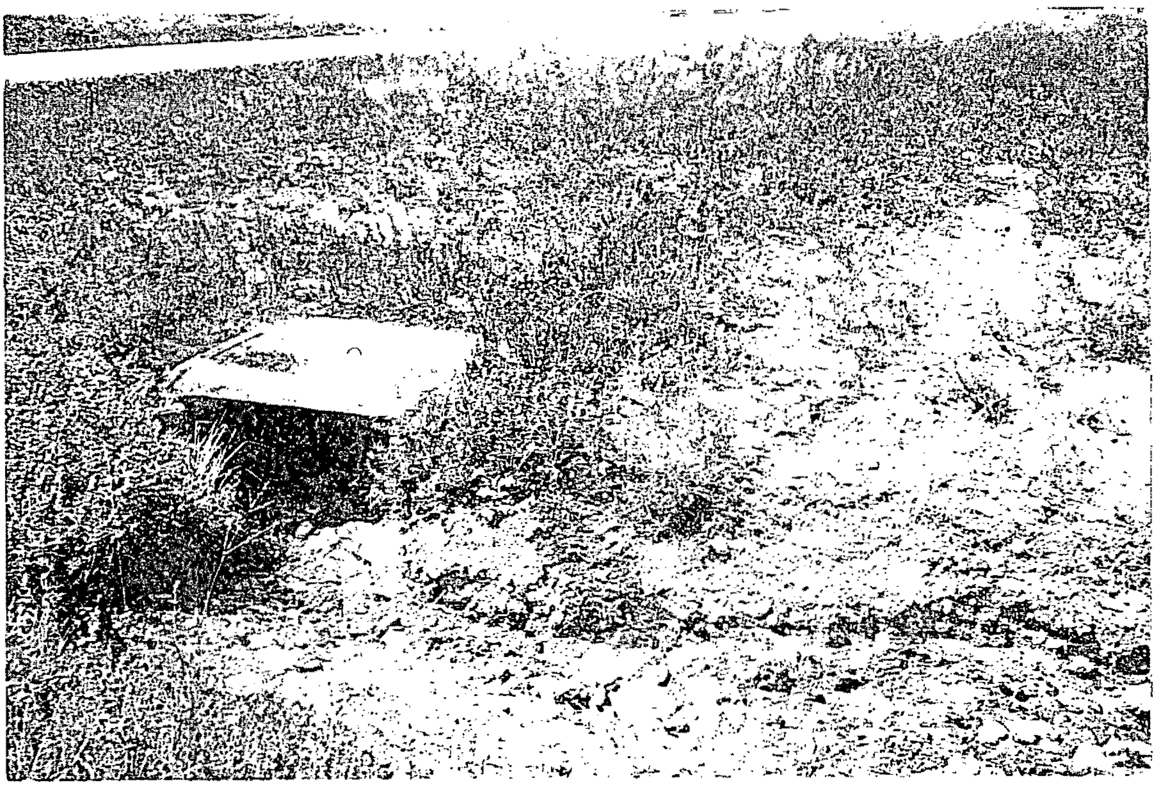
Solution 1:
The combined solution to poor distribution and undersized pipes is not necessarily only upsizing existing systems but may lie in providing additional systems. Sound engineering designs coupled with economic analysis will be necessary to provide the optimal solution.

Problem 2:
Inadequate discharge attenuation - While most commercial properties in the City conform to the South Florida Water Management District (SFWMD) requirement of holding the first 1/2 inch of rainfall onsite, increased retention or detention may be desirable. The SFWMD rule is based on an effort to improve water quality by capturing the "first flush" of stormwater runoff which is expected to contain most of the pollutants coming off of a property. The area included in the retention volume calculations are only impervious surfaces that are not roofs of buildings. The rest of the rainfall event is allowed to discharge unimpeded to the City stormwater system.



HAZARDOUS FLOODING ALONG SANTA BARBARA BOULEVARD DURING THE WET SEASON

FIGURE D.1



EXAMPLE OF SOIL EROSION DIRECTED
TO STORMWATER PIPING

FIGURE D.2

Design standards that conform to the SFWMD ½" retention rule are based on the assumption that dry retention ponds will drain (by percolation) within 48 hours. Two commonly encountered conditions in Cape Coral make this assumption invalid. The first is that summer rainstorms that drop more than ½" of rain frequently occur within 24 hours of each other. The second is that surface soils in many parts of the City are incapable of transmitting enough water to drain within 24 hours or are underlain by an impervious marl layer which holds water near the surface. The actual extent of these types of soil problems is unknown but is suspected to be fairly wide spread. It also appears that local engineering designs do not adequately account for variable soil conditions.

Solution 2:
Many summer rainstorms may drop up to 1.5 inches of rain locally within a very short time. If much of the direct runoff could be slowed, or detained, the peak loads to the stormwater system may be reduced. Onsite detention may be easily accomplished through a number of currently available technologies and should not add significant burden to a property owner. This will be investigated during the Master Planning effort to determine feasible methods. It is recognized that onsite detention requirements would exceed SFWMD requirements but may be imposed by City ordinance. The advantage gained by the City in requiring onsite detention would be that smaller drainage systems might be required.

Surface soil, under laying soil conditions and vertical seepage computations should be documented for each detention or retention pond constructed in the City. Additional study of the impacts of various soil types will be included in the Master Plan development.

Problem 3:
Damaged drainage systems - Pipe failures in Cape Coral are commonly associated with one or more of the following:

Corrosion - is generally restricted to metal pipes connected to saltwater canals. Soil infiltrates through holes in the pipe causing pipe blockage and sinkholes on the surface. Pipes may also collapse. Once pipe failure occurs, much of the soil surrounding the pipe is washed into the canal.

Crushing - Pipes may have been crushed by vehicles or construction machinery.

Sinkholes - are formed when broken pipes or failed pipe joints allow significant amounts of sediment to enter the pipe while velocities in the pipe are high enough to carry this soil away. Often these failures occur under roadways resulting in pavement failure.

Solution 3:
Damaged pipes must be replaced or repaired to restore service. Often, the pipe is in such a deteriorated state that patching the pipe is a wasted effort. It should be noted that when pipes are replaced, they should be sized according to a master drainage plan for the area in question.

Furthermore, downstream pipes that are deteriorated should be replaced at the same time. Pipes in saltwater areas should be replaced with corrosion resistant pipes, such as concrete or PVC.

Problem 4:
Pipe Clogging - A significant amount of soil is washed into drainage systems throughout the City every year. This soil loading reduces the carrying capacity of already undersized systems. Sand and silt may enter through inlets or corroded pipes. Typically this sand originates as erosion from swales and vacant lots. This problem is made worse by vehicles traveling over undeveloped lots which kills stabilizing ground cover and encourages rapid erosion. Construction activities without effective sediment traps are another major source of pipe clogging.

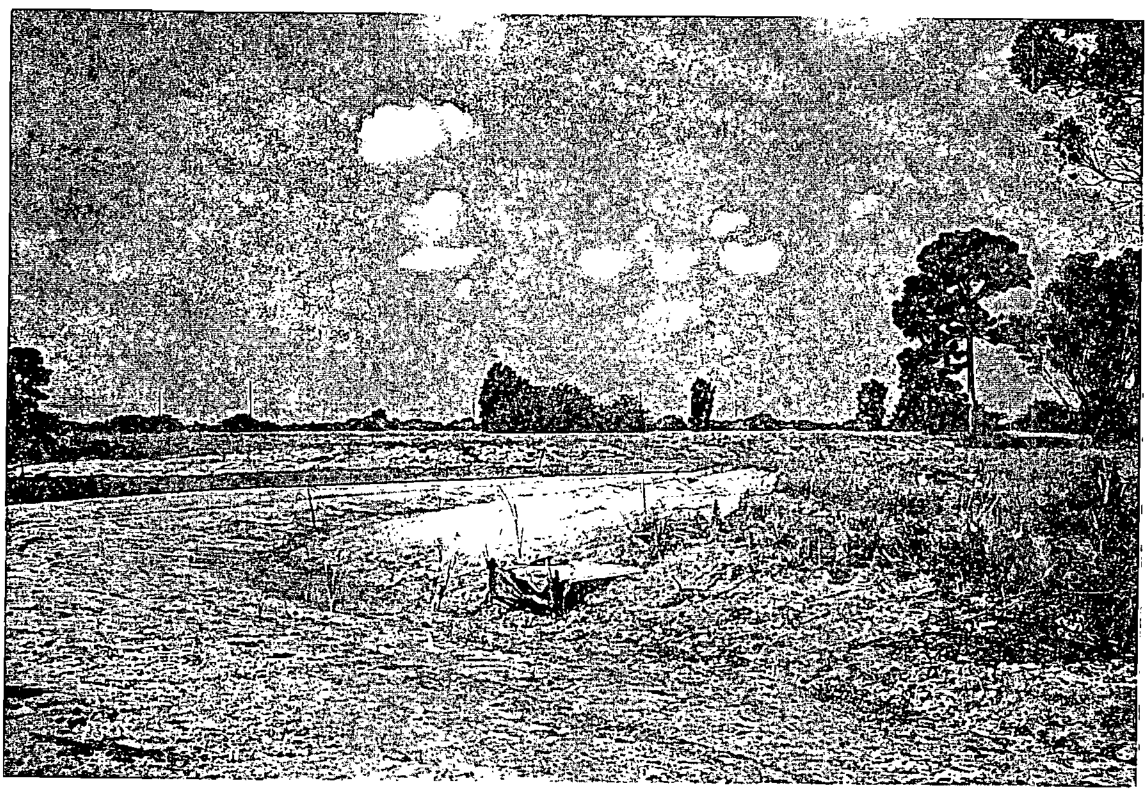
Canal outfall pipes may also occasionally be blocked by sediment build up, vegetation growth or a combination of the two. Figure D.2 presents a situation in which soil is being eroded into a storm drainage system. Note the lack of ground cover.

Solution 4:
Prevention of sediment loading is an integral part of finding lasting solutions to drainage system clogging. Specifically, swale repair must be completed with proper soil stabilization and vacant lots should be protected against soil erosion. Enforcement of sediment control ordinances during construction will also help to eliminate sediment sources. Figure D.3 provides an example of what appears to be an effective measure to prevent eroded soil from entering the storm drainage system.

Another opportunity to remove sediment is by trapping it in catch basins. Most inlet boxes in the City perform adequately as designed but are not designed to cause the removal of sediment from stormwater runoff. It is desirable to replace failed inlets with catch basins to achieve some level of sediment removal. Currently, inlet cleaning typically requires 3 crew hours per inlet. This time could be reduced to approximately 1 man-hour with the use of a Vacuum Cleaning System. This will be investigated and suggestions will be made during the Master Planning effort.

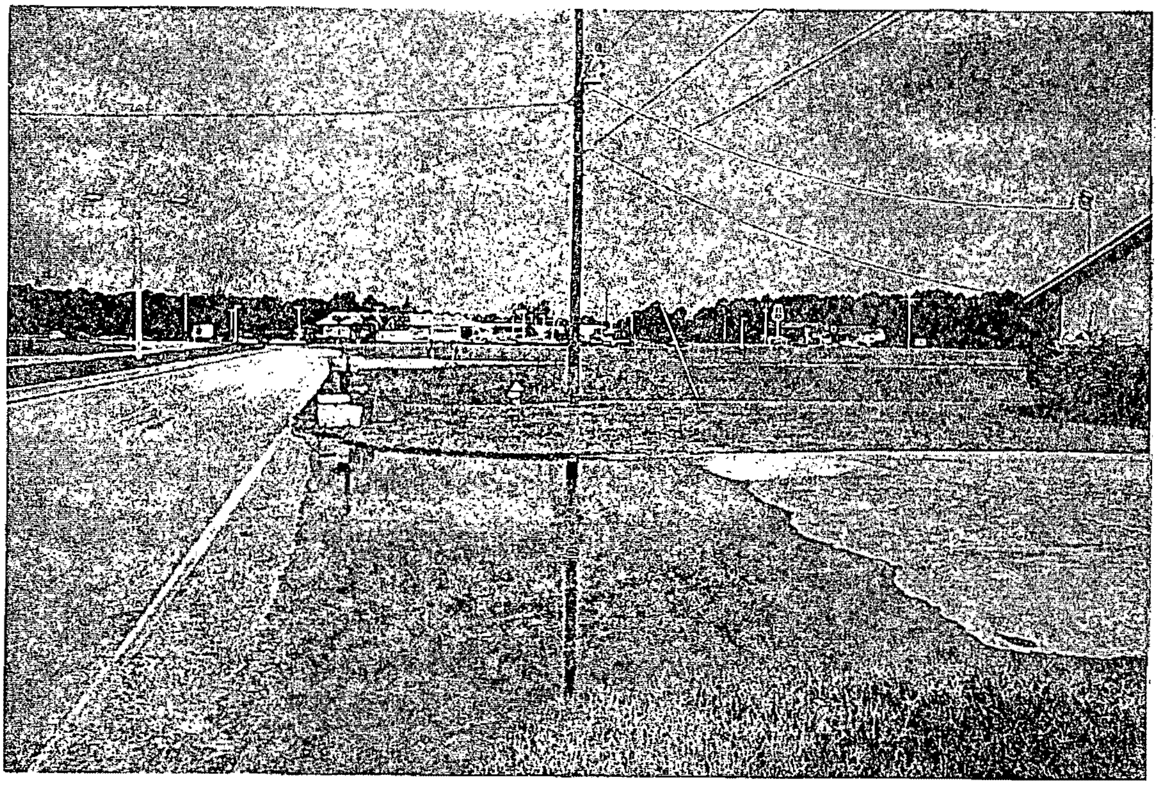
Existing procedures are to replace clogged pipes because City crews are not provided with pipe cleaning equipment. The feasibility of providing crews with cleaning equipment will also be investigated during the Master Planning effort.

Special problems in residential neighborhoods
Residential areas are vulnerable to additional drainage problems. Drainage systems in residential areas differ from those in commercial areas by the overland route stormwater takes to reach the inlets. In residential areas, stormwater flows across lawns to a roadside grassed swale and then to an inlet. In commercial areas stormwater flows across generally impervious surfaces to a curb and gutter system.



CATCH BASIN WITH PROTECTION
FROM SOIL INTRUSION DURING
CONSTRUCTION ACTIVITY

FIGURE D.3



SOD OVERGROWTH PREVENTING STORMWATER
RUNOFF FROM BEING DRAINED

FIGURE D.4

The proper function of this type of system relies on the proper maintenance of the swale grade, properly sized and maintained pipes, clear outfalls and canal elevation. Keeping it clear of growth other than grass while maintaining the protective ground cover will generally suffice to guard against swale erosion failure. Swale function is also dependent on protecting the swales from soil transport from vacant lot erosion and from disturbing the swale grade with vehicular traffic.

It is also important to note that swale performance problems will typically recur every 7-10 years if regular maintenance is not performed. Swale problems are the most common drainage failure and probably the most visible to the average citizen.

Problem 5:
Swale and culvert failures - Swales and underdrive culverts may become blocked with sediment buildup, sod growth or by damage from vehicles. Often this results in forcing runoff out of the swale and into the roadway. Figure D.4 provides an example of stormwater blocked by sod growth.

Swale infill due to construction activities - Home construction usually results in the near complete destruction of ground cover on the lot under construction. Often sediment barriers are ineffective or not properly maintained resulting in destruction of the swale. This often causes stormwater to be forced onto the pavement creating a traffic hazard. Temporary access drives to the site also disrupt the flow of water along the swale.

Swale infill due to inadequate lawn maintenance - Quite often swales and under drive culverts are blocked by sod. Broad leaf lawn grasses thatch quickly, a process whereby clippings or dead grass forms a mat on which newer growth establishes. They also are very efficient sediment traps. Over time, the lawn effectively "rises" in elevation and results in an alteration of the swale grade. The thick growth blocks culverts and inlets and prevents water from flowing from road and driveway pavement to the swale. Discussions with utility staff indicate that significant flow retarding thatching may occur in 3 to 7 years, depending on grass variety.

Improper swale grade or non-existent inlets - Swale grades away from inlets as well as adequate swale grades leading to low spots without inlets has been observed in some areas of the City. Most problems of this type stem from original construction errors and exist in sparsely developed areas but may become increasingly problematic as development increases.

Solution 5:
Codes regarding sediment control appear to be adequate for the protection of the drainage system. However, it appears enforcement could be improved during construction activities. This should improve by toughening construction inspection techniques thus letting the contractor know that the City is very serious about keeping their drainage systems clean.

Swale maintenance recently became the responsibility of the Stormwater Utility Department. This will provide the City with the control necessary to properly maintain the swales. However, the utility will need the proper means, methods, and equipment to address this task. Recommendations concerning this will be provided as the Master Planning effort is further developed.

F. DRAINAGE SYSTEM RECONSTRUCTION IN GRAVITY SEWER PROJECT AREAS

As new gravity sewers are installed in the orange and green areas, swales and drainage systems will be upgraded. This process will allow the City to correct many of the immediate swale problems identified above on a large scale. However, before extensive reconstruction occurs some key issues should be addressed. These are:

- Existing swale design in terms of capacity, treatment and convenience.
- Appropriateness of planned drainage system upgrades
- Protection of existing drainage systems from degradation due to construction activities.
- Opportunity to install experimental test sections for advanced BMP evaluation

1. EXISTING SWALE DESIGN

Except for those areas where inadequate maintenance has resulted in swale failures, the existing design practices appear to be functioning well as drainage devices. Problems do exist at swale driveways where grass thatches to an elevation higher than the pavement resulting in entrapment of water in the swale driveway. Another significant, and possibly greater problem from the standpoint of traffic safety occurs at culverted driveways where yard runoff travels down the driveway and into the street. The water remains on the pavement trapped by grass higher than the pavement.

The solution to these problems might be effected by sloping all drives away from the street causing them to serve as conduits between the street and swale, while maintaining driveway elevation above grade. A concrete apron may be installed along the drive at its lowest point to prevent lawn encroachment onto the apron and alleviate the driveway flooding problem. Low profile culverts will allow the passage of water under the driveway. Where elevation restrictions dictate, multiple small diameter conduits might provide sufficient underdrive transmission. Slot drains, although expensive, would work well with apron wraps to the swale.

The effectiveness of roadside swales in enhancing water quality has not been scientifically evaluated in Cape Coral. However, swales have been shown to be effective in trapping sediment, organic litter (clippings) and oil and grease on an event basis in other areas of the state. It is also suggested that swales help reduce the amount of nitrogen and phosphorus which are expected to originate from lawn fertilizers. Nitrogen and phosphorus removal efficiencies should be tested for various swale and BMP configurations. This will be performed in the Master Planning effort.

2. APPROPRIATENESS OF SYSTEM UPGRADES

During the evaluation of the drainage system along the Santa Barbara corridor, it was determined that two root causes resulted in most of the temporary road flooding of Santa Barbara Blvd. These were clogged pipes and undersized pipes. A review of expected land use also revealed significant shortcomings in the spacing of inlets for future drainage needs. It became readily apparent that the existing drainage infrastructure along Santa Barbara Boulevard will not provide for an effective level of stormwater removal as this corridor continues to develop because:

- Inlets are spaced 2 to 3 times the distance necessary for adequate overland drainage for the Boulevard's expected level of service, according to FDOT and standard engineering practice.

- Typically, the full length of connecting pipe systems are inadequate to carry stormwater away from the roadway. Effective drainage along Santa Barbara will require larger collector pipes and an expansion of individual systems.

Prior to recommending specific upgrades, a review of currently designed upgrades was conducted. It was discovered that the drainage system upgrades along Santa Barbara Boulevard, do not include planned expansion of the drainage system. Also, no additional inlets and their associated cross drains under the right of way are planned. This exclusion will most likely necessitate trenching across the right of way at a later date. Also, systems that carry water to the canals under back streets may need replacement with larger pipes at a later date.

Aside from neglecting expansion of complete systems along Santa Barbara, the value of arbitrarily replacing all cross-drains throughout the project area is questionable. While many steel cross drains that come in contact with saltwater are in obviously deteriorated condition, numerous pipes throughout the City appear to be in good to excellent condition. It may not be pragmatic to proceed with expenditures on infrastructure improvements prior to analysis of full drainage system physics and the affect these improvements have on the City's objectives.

3. PROTECTION OF EXISTING SYSTEM

Federal, state and local regulations require erosion protection and containment on construction sites. The City has much to gain by committing to the enforcement of erosion containment and holding contractors accountable for rectifying damage to the drainage system.

G. PROBLEMS IN RESOLUTION

This section provides an analysis of current City priority criteria and its application to drainage problems. The existing procedures provide a framework on which improved criteria may be built.

While the current prioritization criteria have served well to provide a system of handling service requests in a reasonable fashion, if applied strictly they do not adequately address potential impact in terms of public safety or numbers of people affected.

Existing adopted policy shows that service request prioritization is to be based on the following criteria:

Immediate action -	When the problem represents a threat to public safety or the protection of property. The most common of these are sinkholes in or near a right-of-way which are usually a result of failed storm sewer pipes.
Priority 1 -	Drainage system or swale failure results in standing water for 5 or more days.
Priority 2 -	Drainage system or swale failure results in standing water for 3 to 5 days.
Priority 3 -	Drainage system or swale failure results in standing water for 24 hours.

To date, Stormwater Utility personnel have performed well in responding first to threats to public and private property caused by pipe failures and sinkholes. The flexibility in the operation of the utility allows for this type of subjective prioritization. However, the room for subjectivity may rapidly become diminished through political, legal or administrative pressures. Thus it would be prudent to establish a more comprehensive set of prioritization criteria that allows the utility to perform its function in a manner that is most beneficial to the residents of Cape Coral.

Specific problems or potential problems with the current prioritization criteria include:

- Misplaced priority
- Response to public perceptions
- Inadequate staff and equipment

1. MISPLACED PRIORITY

Strict adherence to the current criteria may result in a road flooding problem on a major road to be placed on a lower priority than long term standing water in less traveled areas of the City. The current formulation accounts for the fact that standing water in a residential area may pose significant inconvenience to residents but neglects the possibility that short duration ponding on roads where traffic moves in excess of 40 mph may pose a more significant threat to public safety.

2. RESPONSE TO PUBLIC PERCEPTIONS

Another cause of misplaced priority is the external pressure placed on stormwater staff to respond to politically urgent requests at the expense of more hazardous problems. City management personnel may be better served if it considered that Stormwater Utility is a service to all citizens of Cape Coral. Unfortunately, pressure to appease the most vocal citizens occasionally outweigh technical and safety criteria in prioritizing drainage remediation action. Much of the problem lies in the lack of public education about the environment in which Cape Coral is located and the problems Stormwater Utility personnel are faced with on a daily basis. The public information program to be implemented in the Master Planning effort is intended to help avoid these situations.

3. INADEQUATE STAFF AND EQUIPMENT

In preceding sections, numbers and types of service requests and problems with prioritization have been discussed. It should be noted that the rate of requests being filed exceeds the rate at which they are addressed. Unfortunately the Stormwater Utility remains understaffed and under-equipped to reverse this trend. Currently, utility personnel are responding to service requests registered as far back as 1989. Only service requests of Priority 1 or higher are being considered for remediation. Details concerning staff and equipment are discussed in Appendix E, Stormwater Management and Operation.

H. PRIORITIZATION OF CITY DRAINAGE UPGRADES

The first step in developing the best program is to identify the City's needs, goals and objectives and apply priority criteria. This step is crucial to effective planning and assists City directors in expending a majority of their effort on resolving important issues rather than being distracted by "urgent" but essentially trivial matters.

1. CITY DRAINAGE NEEDS

At the core of this plan it is necessary to consider the City's primary motivations for providing drainage service. It is necessary to state exactly what the City expects to accomplish by establishing and maintaining a drainage system. These include:

a) Public Safety

Provide adequate drainage so as not to threaten the health and well being of the public. This includes traffic safety, high water hazards, high velocity flooding, disease control through the elimination of standing or polluted water and pollutant transport. As the provider of the drainage service, the City implicitly assumes some level of responsibility for harm due to system failures.

b) Protection of Property

Both public and private property may sustain damage due to flooding. Since it is cost prohibitive to guard against all flooding events, the City must define an acceptable level of risk of damage to property. Obviously, property damage due to flooding during minor rain events is intolerable while widespread damage due to catastrophic flooding would be expected. Typically in coastal communities such as Cape Coral, flooding damage should be minimal during a 25 year storm event.

Drainage deficiencies also contribute to the deterioration of road surfaces, especially when pavement in a flooded or near flooded state is repeatedly exposed to traffic. The increased cost of road repair should be weighed against storm system installation and maintenance.

c) Attractive Business Climate

Maintaining adequate drainage is necessary for a vital business climate. Businesses may experience difficulty in attracting clientele if ingress and egress to a business is hindered or if roads to the business are unsafe and inconvenient to use. Business development will be encouraged by assurance of adequate property protection and ease of access. A commitment to provide proper drainage shows businesses that the City is serious about encouraging their establishment in Cape Coral.

d) Attractive Residential Climate

Maintaining Cape Coral's image as an attractive place to live is vital to the City's economic survival. Aside from the potential flooding threat to property, nuisance drainage deficiencies detract from the overall perceived quality of life. These include minor residential road flooding, standing water in drainage structures, post flooding deposits of sediment in roads and water quality in canals. Unfortunately perceptions and definition of tolerable and intolerable nuisances are widely varied among those not directly involved in the daily remediation of drainage problems.

2. PRIORITY CRITERIA

To develop priority criteria it must be decided where to best apply the City's manpower and monetary resources. Since these resources are limited, it is imperative that the City establish and consistently apply priority criteria in order to direct its efforts toward achieving its most important goals and not waste its resources on marginally effective projects.

Priority criteria may appear similar to the goals previously mentioned, but differ in the sense that they are decision making tools rather than decisions themselves. Important aspects to answer are which problems are most important and why they are so perceived. The priority criteria that may be considered are, in order:

1. Potential for a situation of immediate public danger to develop. (i.e. Automobile at speed losing control in standing water)

2. Potential for sudden and thus unavoidable damage to property. (i.e. Flood waters rise before an owner can move valuable items to safe ground)

3. Number of people affected. (i.e. Major roads take precedence over small residential roads serving a few families)

4. Project costs and available funds.

5. Effectiveness of proposed solution

6. Potential dollar value loss due to damage.

7. Avoidable or manageable public health concerns.

8. Potential business or real estate (tax) dollar value loss due to inconvenience.

9. Public perception.

3. ADJUSTED PRIORITY CRITERIA

It is suggested that new priority criteria be fit into to the existing priority classifications. This will have the effect of adjusting the techniques employed by the utility inspectors while avoiding possible confusion on the part of those executing the remediation. Placing the above considerations into the context of the existing priority classifications results in redefined priority criteria:

Immediate response: Potential direct threat to the health and welfare of the public. These would include such failures as sinkholes in public easements and right of ways. Potential direct threat for loss or damage of public and private property

Priority 1:

a) Indirect threat to public safety, i.e. standing water in high speed roadway

b) Situation in which a direct threat may develop, i.e. a failing pipe may result in a sinkhole formation.
c) Indirect threat to private property damage

Priority 2:

a) Severe inconvenience to small number of people
b) Moderate inconvenience to large numbers of people
c) Potential to develop into Priority 1 problem
d) Incessant inconvenience, incessant situation may contribute to loss or damage of public or private property. May pose health risk.

Priority 3:

a) Moderate inconvenience to small numbers of people
b) Poses eventual health risk
c) Aesthetically unappealing condition

I. PRE-EXISTING RECOMMENDATIONS FOR IMPLEMENTATION

Previous studies have recommended investigation or implementation of various improvements to the drainage system that may enhance water quality in the canal system. Varying degrees of opposition or apathy has caused these concepts to remain bound in the studies that proposed them. However, the following concepts are founded on sound scientific principals and merit re-consideration.

1. DIRECT RUNOFF TO ROADSIDE SWALES

Lot grading practices has historically split yard runoff between the front yard swale and over the seawall in the back yard. Fertilizers, pet wastes and organic litter from back yards are directly discharged to the canal system creating nutrient loading problems. This could be avoided by requiring new homesite development to grade canal front lots to drain primarily towards the roadside swale in the front yard. While it is recognized it is unfeasible to direct all yard runoff to the front, much could be gained by increasing the percentage that is currently directed towards the roadside swale.

2. CANAL FRONT SWALES

Swales have been shown to be effective in treating first flush volumes to remove organic litter and sediment. By placing a shallow swale to capture and retain the first flush runoff from back yards and channelling the rest around the treatment area, some degree of water quality treatment could be expected. (SWFRPC, 208 Water Quality Study - Cape Coral, 1984; Morrison, An Ecological Assessment of the Cape Coral Residential Waterway System)

3. ALTERNATIVES TO SEAWALLS

In 1984, the Southwest Florida Regional Planning Council and the City Planning Department published a report to present attractive alternatives to vertical bulkheads for canal bank stabilization. Seawalls have been shown to significantly reduce littoral zone habitat where desirable aquatic plants provided nutrient removal from the water column. Occasional harvesting of these plants removes the nutrients entirely from the system. Reductions in nutrient removal by large desirable plants allows the nutrients to remain in the water for consumption by algae and less desirable plants such as hydrilla.

Alternative stabilization designs allow for attractive water fronts that protect upland property while preserving the littoral habitat zones. Alternatives have been suggested by Duncan (1989) and have been demonstrated in a full scale mockup project near Lake Kennedy at the Sun Splash Water Park.

It is understood that the seawall issue is a controversial issue in the City of Cape Coral, but there are very good reasons for investigating their effects and the effects of promising alternatives.

4. AQUATIC PLANT HARVESTING

As mentioned above, large aquatic plants represent nutrient sinks that remove nitrogen and phosphorus from canal water. If these plants are removed from the system, they carry with them the nutrients and other pollutants trapped within their fibers.

5. FILLING OF DEEP POCKETS IN CANAL SYSTEM

Significant changes in canal topography have been documented in (USGS Open File Report, 1991; Duncan, 1989). As these deep pockets are poorly flushed, water may become trapped and anoxic conditions may develop. Chemical processes that occur under anoxic conditions allow the release of pollutants such as metals and nutrients and may give rise to foul odors. During extreme events, this polluted water may be transported out of the pocket to adjacent water. Eliminating the flushing problems by filling the canal pockets will be further explored in the Master Planning effort.

J. ALTERNATIVE BMP EVALUATIONS

In addition to evaluating the effectiveness of existing BMP's, new alternatives should be evaluated for their ability to meet the City's objectives. New BMP's will be explored to improve stormwater quality, fit the aesthetics of the surrounding landscape and compliment drainage effectiveness. Alternatives to be considered during the Master Planning effort include:

• **Catch Basin replacement**
Inlets throughout the Cape are typically designed without sediment traps. Replacing inlets with catch basins that trap sediment may significantly reduce sediment loads and have some pollutant trapping abilities. Since city-wide replacement would be very costly, alternatives such as placing large catch basins directly upstream of outfalls may be a cost effective solution. Catch basins must be cleaned out regularly to be effective.

• **Infiltration trenches**
Infiltration trenches consist of perforated pipes placed in a porous medium. The medium is protected from adjacent soil by surrounding it with filter fabric. Stormwater is channeled through the pipe and sediment and pollutants are trapped in the porous medium. However, after a number of years, the porous medium may become clogged. Currently, no methods for rejuvenating infiltration trenches have been developed.

• **Sub-regional retention ponds - with smart boxes**
Lot sized dry detention ponds may be constructed at strategic locations in drainage basins. First flush volumes would be directed to the dry pond for infiltration treatment. The remaining runoff would be diverted directly to the outfall through the use of a smart box. This type of BMP would allow fully culverted front yards which are probably more desirable by homeowners.

• **Regional wet and dry detention ponds**
Larger basin runoff volumes may be treated in regional wet detention ponds or man-made treatment wetlands. Alum may be used to precipitate phosphorus if it is found to be the limiting nutrient in the natural ecosystem. Wet ponds and marshes have been shown to be effective in trapping sediment, nutrients and metals.

• **Artificial habitats in marine systems**
Compact habitat substrates have been experimentally tested in various marine systems to remove algae from the water column. Substrates are colonized by filter feeding marine organisms that feed on algae. These filter feeders also remove sediment and some metals. Waste from these organisms provide food for higher organisms such as shrimp and crabs, which in turn are food for many species of local fish. Experiments could be conducted by monitoring water quality in an experimental canal and in a control canal.

• **Improved swales and onsite dry retention**
The performance of vertical percolation treatment systems may be improved by altering sub-surface soil conditions and vegetative cover. Swales and dry retention ponds have been observed to hold stormwater between rain events. This renders them useless to water quality treatment. It is evident that impermeable soil layers exist near the ground surface in many areas in the City. These soil layers may be perforated or bypassed with a direct conduit so stormwater may pass to more permeable layers.

• Sub-surface wet sediment tanks
Large sub-surface tanks that act as large catch basins may be installed at the end of drainage systems. Due to the high water tables, these tanks will most likely remain underwater for much of the year. Thus they would perform in a similar manner to a septic tank in which solids are trapped and cleaner water is discharged. This BMP would require routine cleanout.

K. SUMMARY OF RECOMMENDATIONS

- Performance evaluations should be conducted for existing and promising advanced BMP designs. Pilot projects may be constructed in conjunction with drainage system upgrades in the gravity sewer project areas. Performance evaluation should be conducted during the Surface Water Master Plan Study.

- Stricter enforcement of existing regulations is necessary, especially in areas undergoing significant construction.

- Swales and lawns should be re-sodded as soon as construction or reconstruction is completed.

- New home construction should include side yard swales that direct runoff towards City swales along the street or in backyards. New canal front homes should be required to install a swale behind the seawall to avoid direct runoff discharge into the canal.

- Ongoing stormwater system upgrades should be closely re-evaluated to ensure the City's long term drainage objectives are being met.

- Catch basins should be substituted for inlets wherever reconstruction takes place.

- EPA mandated SWPPPs should receive at least a cursory review by the City. Certain activities exempt from the EPA program may be required to prepare a SWPPP mandated under local authority, i.e. require fueling stations to submit a local SWPPP..

APPENDIX E
MANAGEMENT AND OPERATION PLAN

SECTION A - STORMWATER UTILITY REVIEW

A. UTILITY ORGANIZATION

The utility department is responsible for water supply, wastewater collection and treatment, and management of stormwater for the City of Cape Coral.

The structure of the utility department is detailed in Section B. It is important to note, however, that while all of the water related utilities may function separately, the systems they serve are all dependent on each other in some form. These inter-relationships are defined in the Water Independence for Cape Coral Master Plan which the City is in the process of implementing. The benefits and inter-relationships may be best described by the diagram in Figure E.1.

The inter-relationships described by Figure E.1 can be perceived as economic ties. The viability of each system bears directly or indirectly on the other systems. Thus, the health of the entire water resource is heavily dependent on the health and proper maintenance of the individual systems.

1. STORMWATER UTILITY

This section focuses on the stormwater utility system and describes its operation capacity and demands placed on the utility. This utility was established to maintain the drainage system in the City within the constraints of state guidelines. Unlike any other stormwater utility in the state, Cape Coral's Stormwater Utility has the added responsibility of maintaining the extensive canal system for use as a drainage system, irrigation water supply source, and recreational and aesthetic resource. These added responsibilities are not taken lightly as the City is highly dependent on it's canal system for these functions.

a) Structure

The stormwater utility is managed by the utility department. Currently, there are 32 personnel working for the stormwater utility. Figure E.2 presents the existing organizational structure of this utility.

The stormwater utility is managed by the stormwater utility coordinator, whose responsibility is to ensure the daily operation of the utility work crews. His

Interrelationships of Water Systems of Cape Coral

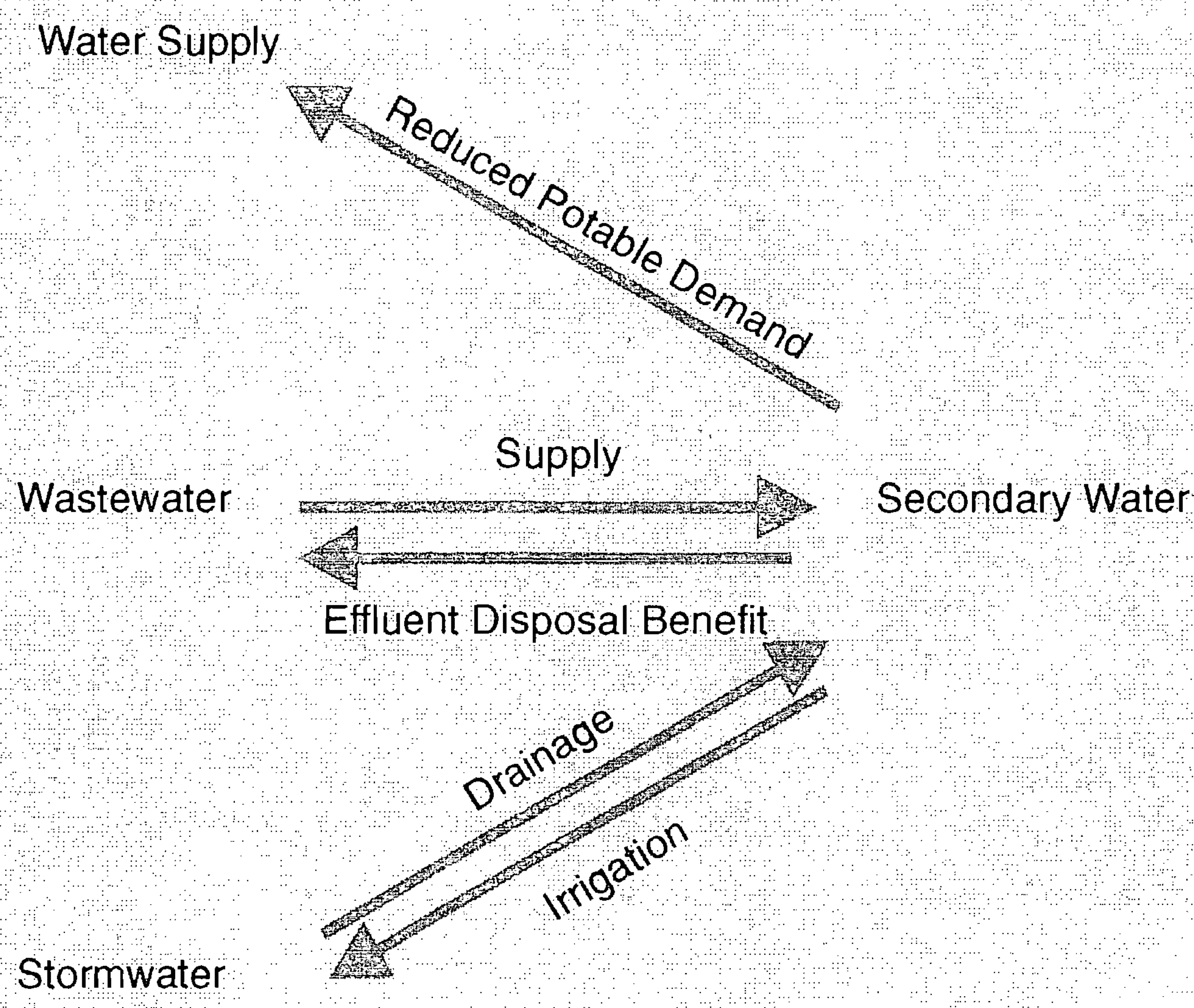


FIGURE E.1

Stormwater Utility
Existing Function

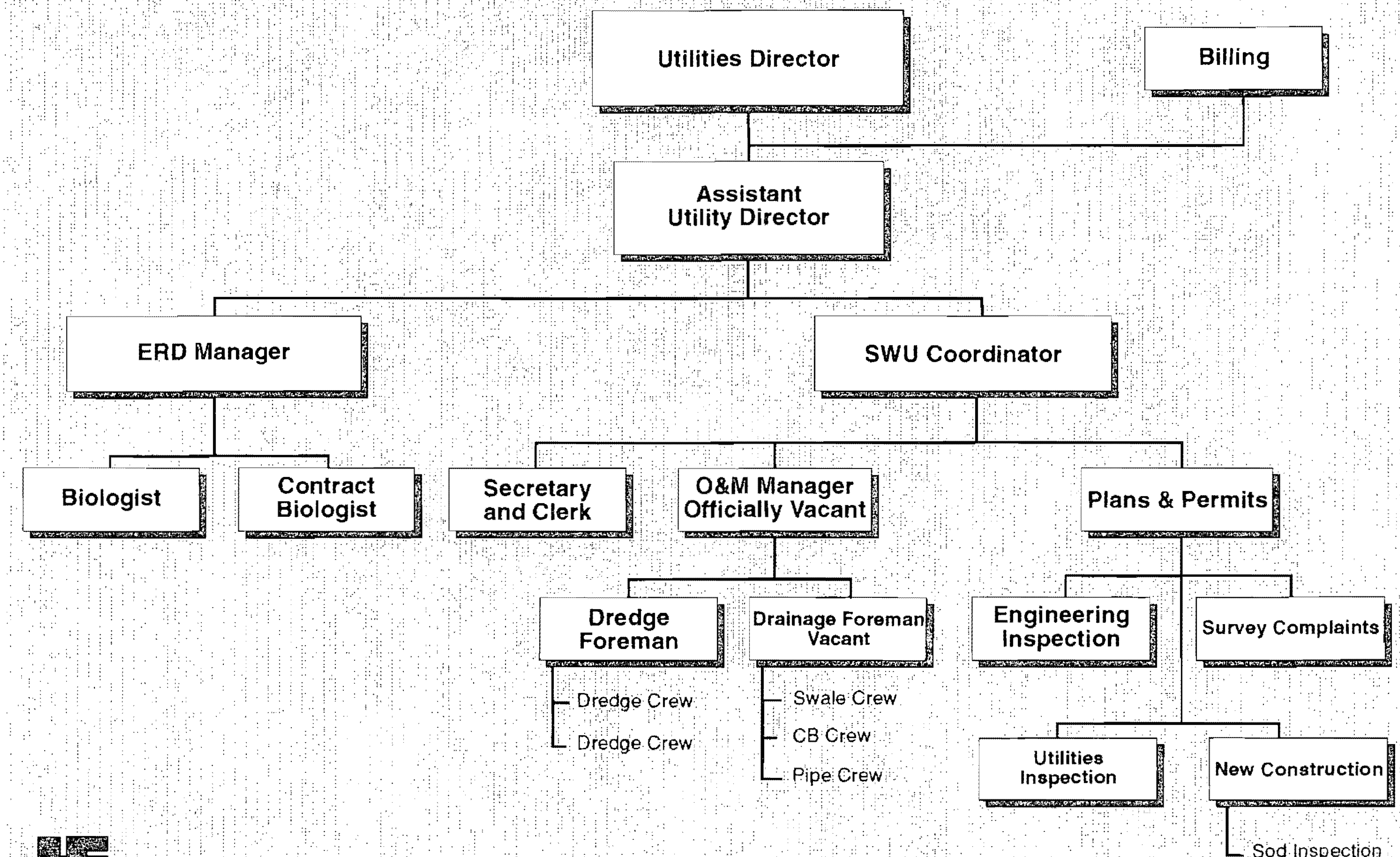


FIGURE E.2

responsibilities do not include oversight of the Environmental Resources Division or plan review and permitting duties. Stormwater utility administration also includes secretarial staff, a service request clerk and two billing clerks.

The service request clerk receives and logs citizen's requests. The requests are prioritized and recorded in a Q&A$_{TM}$ database and include location, request type, category, a description of the problem and action taken. A typical service request form is shown in Figure E.3. The benefit of using the Q&A$_{TM}$ database is that it allows summary analysis of service requests in the database in terms of any number of parameters. Thus, one may quickly determine the number of service requests registered in a specific category. This data is presented in following chapters.

2. RESPONSIBILITIES, DEMANDS, AND CAPABILITIES

The remainder of this section outlines the specific responsibilities of the stormwater utility, the demands placed upon it by the City and a description of the capabilities of the utility to respond to those demands.

a) Canal Maintenance

The canal maintenance division has the responsibility to maintain navigation and conveyance of the canal system. They perform dredging operations, build and maintain, and remove dredge spoil.

Dredging operations have been carried out by the City since 1987. Originally under the management of Public Works, dredging operations became the centerpiece of the new stormwater utility. The task that lies ahead of this operation is quite formidable.

It is commonly accepted that many miles of canals in the populated areas of the City are in need of dredging to restore the navigability and conveyance. Areas in the northern reaches of the City also have shown signs of inadequate depths in the canals. Aside from a dozen formal complaints and limited utility and scientific surveys, little information on the extent and seriousness of canal sedimentation throughout the City is available at this time. A thorough survey of the canal system is planned in Phase II of the Surface Water Master Plan. Estimates of dredging requirements and a program to accomplish it may be developed in detail at that time.

Progress in dredging operations is slow by nature. Further hindering progress are the limited availability of spoil site locations, canal and bridge dimensional constraints, and limited manpower resources.

Currently, dredge operations consist of two eight inch dredges, each operated by a crew of 6. The dredges operate with 3 crew members working 10 hour shifts, four days per

STORMWATER UTILITY
INQUIRY/COMPLAINT

LOCATION: SE

CATEGORY: CB

CANAL NAME:

NAME: ROW

ST. NO.:

STREET: SANTA BARBARA BLVD.

PHONE:

COMMENTS: BETWEEN 2905 & 2917

1ST COMPLAINT DATE: 1/16/92

COMPLAINT: CB

SWI.DTF Retrieved form 197 or 753 Total Forms: 753 Page 1 of 5

FIGURE E.3

week, one-half of the crew working Monday - Thursday and the other working Wednesday - Saturday. Thus the two mid-week days have 3 crew members on hand to perform maintenance tasks and carry out dike building, sediment removal and spoil site restoration. In addition to the two dredges, the canal maintenance crew has one 14 yard tandem dump truck and 1 front end loader at its disposal for hauling away dried spoil material.

i) **Capabilities** - Effectiveness of the canal maintenance operation has been increasing steadily over the past few years. This is due largely to crew familiarity and the addition of the second dredge to the program. However, progress through the canal system is slow and will remain so under current operational capacity. At this time, approximately 10 linear miles of canals are dredged annually. A canal maintenance schedule has been developed by the stormwater utility and is proceeding in the southeast corner of the City. It is expected that progress will decrease over the next 6-12 months as one of the dredges is moved around the City to clear areas receiving numerous service requests.

MATERIAL REMOVED

FY	CUBIC YARDS
1987-88	9,380
1988-89	9,095
1989-90	5,921
1990-91	24,621
1991-92 (1)	10,863 (2)

(1) New dredge added December 1991
(2) October 1991 to February 1992

The cost of dredge removal has decreased as efficiency in the dredging department has increased. The latest analysis performed by the finance utility department shows removal costs near $9.75/cy. This is below cost estimates provided in private sector proposals solicited by the utility department.

ii) **Expansion** - The canal maintenance operations appears to be inadequately staffed and equipped to respond to all present and future dredging needs. According to the current schedule and in light of the current progress rate, the freshwater system will not see a dredge until approximately the year 2000. The addition of one 10" dredge, which would provide a significantly higher production capacity than either of the two 8" dredges, would be helpful in providing preventative and corrective maintenance in low density development areas. A larger dredge would not be effective in the space restricted areas in which the existing dredges now operate.

The City may also consider the addition of an aquatic weed harvester. Submerged aquatic vegetation, such as hydrilla, can significantly reduce the carrying efficiency in a canal. Chemical treatment is only temporarily effective since the nutrients that cause rapid weed growth remain in the water column and are readily available for the next generation of plants. A large scale aquatic plant program would require removal of these nutrients in the form of adult plants by mechanical or biologic means. An analysis of the extent and the potential for aquatic weed problems in the future that may result from neglect of this maintenance item will be explained in greater detail in the final draft of the Master Plan Phase I Report.

iii) ROW Acquisition - Vacant land used for spoil basins is rapidly disappearing. The City may soon be lacking enough vacant land close to dredge sites that removal costs may become cost prohibitive. Adequate spoil sites are most severely lacking in the heavily populated areas in the southeast sections of the City.

It is recommended that the City establish spoil sites in key locations to insure the cost effectiveness of future dredging operations. Since dredging activities are expected to return to an area every 10-15 years, these spoil areas may be maintained as local green space or City parking areas. Parks and Recreation may be approached to determine interest in jointly purchasing and maintaining these lands.

iv) Contracting Small Dredging Projects - Due to the production demands and costs of mobilizing and demobilizing a dredge to perform small problem area projects, it may be more cost effective to hire local marine contractors for such jobs. For example, one local contractor indicated the removal of approximately 300 cubic yards (from a particular section of canal near Saratoga Lake) of material would cost the City approximately $3.25/cy if he was allowed to keep the spoil material. Contracting small jobs would have the added advantage of expediting politically urgent dredge jobs while freeing the second dredge to resume in the maintenance program.

b) Service Requests

Citizen service requests are called into the stormwater utility and recorded on a database. Database recording offers the advantage of quickly organizing and reporting problem area statistics.

Service Requests are categorized as one of the following types: canal (C), catch basin/inlet box (CB), pipe failure (P), swale (S), or sink hole (SH). They are prioritized by duration of inconvenience. Priority schedule is as follows:

Immediate Response:	Threat to life or property
Priority 1:	Inconvenience lasts for 5 days or more
Priority 2:	Inconvenience lasts for 3-5 days
Priority 3:	Inconvenience lasts 24 hours - 3 days

As of June 10, 1992, 753 service requests existed on the utility database. These requests have been categorized as indicated below.

Complaint Category	# of Complaints
Canal	12
Catch Basin/Inlet	152
Pipe P1	24
P2	7
P3	5
Other	68
Sink hole	62
Swale P1	258
P2	48
P3	34
Other	83

Service requests may be sorted by category and priority and mapped on the City's existing GIS. It would be very beneficial if strap numbers were recorded in the request file as this is the primary means of locating a property on the City's GIS. It will be very helpful to map service requests on a utility GIS for planning, response management and trend analysis.

c) Drainage

i) Pipes and Sinkholes - There are approximately 2,000,000 feet of drainage pipe, 45,000 inlet boxes and 3,400 miles of swale in Cape Coral. The drainage department is responsible for maintaining and repairing clogged or failed pipes and inlet boxes/CB's. Sinkholes are generally associated with a pipe failure and the resulting underground excavation of soil.

Many of the pipes in older sections of the City are made of steel or iron and lie in an inter-tidal zone. The result is frequent corrosion failure in these areas. Once pipe failure occurs, much of the soil surrounding the pipe is washed into the canal. Many of the drainage pipes existing in the City are also undersized resulting in further drainage deficiencies. Most pipe repairs or replacements require 8-16 crew hours.

Most inlet boxes in the City perform adequately as designed but are not designed to cause the removal of sediment from runoff water. It is desirable to replace failed inlets with catch basins to achieve some level of sediment removal. Problems with inlets are generally restricted to clogging or failure of the concrete cover. Inlet cleaning typically requires 3 crew hours per inlet.

ii) Swale Maintenance - The drainage crews, with the assistance of inspection and survey teams, perform swale regrading and maintenance as well as driveway culvert clearing. Survey crews are involved in establishing the grading plan and staking out the project. Typically, the protective grass covering is removed to achieve the proper grade. Unfortunately, funds for sod or seed purchase are often limited and the soil is left exposed to erode and refill the swale at the next rainfall.

According to City Ordinance 18-90 (Chapter 22 Code of Ordinances), the property owner is responsible for maintaining all swale elevations and maintaining a clear under drive culvert if one exists. Private contractor prices for regrading the swale along one lot are estimated at approximately $1000. However, stormwater utility has been maintaining all swales as they are able when requested by citizens. Maintenance by the utility has the advantage of assuring that cross boundary flows are correct which reduces the risk of neighbor disagreements over water problems. However, the commitment of time and resources to swale maintenance may require a reduction in other, possibly more important, services. Currently the drainage crew uses approximately 16 crew hours per swale regrading.

iii) Other Responsibilities - Aside from addressing service requests, the drainage crews are often called upon to effect repairs during emergency situations. Often situations arise where drainage facility failures require immediate attention in order to prevent loss of public or private facilities.

Drainage personnel are also often required to participate in large reconstruction jobs. These projects typically affect entire neighborhoods and may take 1-2 months to complete. An example of one such project is the one currently underway at Palmetto Pines subdivision.

iv) Capabilities - The drainage department maintains a staff of 6 split into 2 crews equipped with two backhoes, a front end loader, a 14 cy dump truck, and two flatbed trucks. The current drainage sub-element recommends expansion of swale and CB maintenance to 7-9 equipped crews. Crews generally require 3 to 4 personnel and usually 1 or 2 pieces of heavy equipment. The sub-element also calls for the replacement of 1,000,000 linear feet of drainage pipe, the conversion of 15,000 inlets to catch basins, and the purchase of catch basin cleaning and additional street sweeping equipment. The estimated cost (1989) of bringing City drainage facilities up to standard is $53 million.

Below is an estimate of the time required by the drainage crew to complete all projects backlogged in the service request file as of June 10, 1992. This estimate is based on job time estimates from the utility department, current crew capability and the service request database and assumes no additional workload aside from the service requests on hand.

The expanding backlog of service requests indicates a greater demand for corrective drainage service than is able to be supplied by the stormwater utility. It is recognized that the utility has recently acquired additional equipment which should improve crew effectiveness. However, it is unlikely that these additions will be sufficient to reduce the backlog of service requests and provide an acceptable level of service.

JOB TYPE	# REQUESTS	AVERAGE CREW TIME JOB	CREW DAYS NEEDED TO ELIMINATE BACKLOG
CB-Inlet	152	.33 days	50
Pipe/Sinkhole	166	1 day	166
Swale	423	2 days	846
			1,062

To complete existing request backlog	1,062 crew days
	÷ 2 crews
	531 work days
	106 work weeks

Additional analysis of service request files show widespread drainage problems with a few areas showing a higher density of service requests. The preliminary analysis supports the continuation of the City's current approach of city wide, long term planning, such as the Master Plan effort already under way, coupled with engineering solution of problem prone areas such as the Industrial Park area.

There is evidence at numerous locations throughout the City where utility personnel have conducted remedial construction on the swale/inlet system and have not complied with regulations and ordinances. It is important that utility crews follow these regulations including swale sodding and maintenance of the inlet control elevation 6 inches above the swale bottom.

c) Permitting

The City of Cape Coral has obtained review and permit authority for stormwater discharges from the South Florida Water Management District (SFWMD) for projects under 10 acres in land area and less than 2 acres in impervious surface. Development of stormwater is controlled by the City in the following manner:

> Residential and Duplex - Driveway and swale grades are surveyed and staked by stormwater utility inspectors. A technician checks and approves grading on the building permit. A fee of $45 is charged for sod/swale stakeout and $75 for driveway stakeout.

Triplex and Commercial - Drainage plans are provided to stormwater utility personnel and are checked against SFWMD criteria. Regulations enforced are per SFWMD's Volume 4 permitting manual. Final site inspection is made to ensure compliance with the approved plans. The fee for this is $130, half of which is to be received by the stormwater utility.

Development of Regional Impact (DRI) - If the DRI meets the above area criteria, stormwater permits may be approved by the City stormwater utility personnel. The process is much like commercial development except that comments are processed through the planning department rather than directly.

Currently, permitting is being handled by one staff member with another staff in training to bear some of the review load. The City is required to respond (approve or deny) to a permit application within 5 working days. The addition of the second inspection position alleviates the threat of not meeting the deadline due to illness or other circumstances. As development in the City continues, additional personnel may be required in the future.

Seawall inspection is currently processed through the building department. However, as the seawalls are an integral part of the drainage system and the design and construction practices directly affect the canal system, some form of approval should be required by the stormwater utility. Specific items often overlooked by the building department inspectors is improper back lot grading, allowance of soil to be washed into the canals during construction, and improperly maintained silt curtains.

Finally, the permit fee structure was designed to support the personnel and equipment used to review and process the plans. It is apparent that the stormwater share of fee collection is inadequate to support the review process. Last year only $64,000 in fees was collected while review and inspection operational costs ran near $140,000 including three survey personnel, one engineering technician, and three vehicles. It would probably be justifiable to investigate new fee structures or possibly raise fees to ensure permit and review costs are covered by the fees collected at this time.

d) Environmental Resources Division

The Environmental Resources Division (ERD) was established in 1986 as a result of the DER-GAC settlement. The mission of ERD is to monitor ecological and water quality parameters, to protect the environment in the canals and wetlands adjacent to Cape Coral from degradation and educate the citizenry of environmental issues.

In the past, ERD has evaluated surface water quality for the 208 Water Quality Study, performed ecological assessments of the entire Cape and Unit 89 subdivision, and implemented a water quality monitoring program. Today ERD continues the vital water quality program at 32 sites throughout the City. ERD also investigates and responds to citizens concerns when canals show signs of degradation.

The data collected by ERD is helping to create a picture of the general health of the Cape Coral canal system. The detail in this picture will become increasingly important to the City as regulatory pressures increase on the City to maintain surface water quality. It is expected that Cape Coral will soon be required to submit an NPDES stormwater permit application.

The NPDES, as administered by the U.S. EPA, is requiring industry and local governments to acquire a stormwater discharge permit. The philosophy is that pollutants received into waters of the U.S. may be monitored at the discharge point. Regulations combined with data acquired at these points may be used to compel local governments to enforce water quality regulations inside the local drainage basin.

The program consists of two phases. Phase I requires the applicant to submit baseline data on a number of water quality parameters and a description of the drainage basin. Phase II will require a monitoring program be established and regular reports be submitted to the governing body. The program is not a one time permit application but an ongoing effort to eliminate pollutant discharges into waters of the state and waters of the U.S..

With ERD in place, the City of Cape Coral has the organization in place to perform monitoring required by NPDES. However, it is uncertain whether enough monitoring stations have been established for Cape Coral to be able to have the necessary control over what is being discharged into it's system. It would be helpful to add one or two technical staff positions for tasks of sample collection and preparation in order to free up higher level positions for more efficient use of time.

Currently, ERD operates on a budget of approximately $220,000. It is staffed by one PhD level biologist and two staff biologists, and half of the water treatment lab technician's time which requires approximately $10,000 of that budget. Additional expenditures are required for sample analysis, operations, lab equipment purchases, and computer purchases. As nearly $40,000 is spent annually for outside sample analysis, it may be more cost efficient to buy or share in the cost of additional wet lab equipment to decrease long term costs of sample analysis. This equipment may be shared with the water treatment department in order to reduce redundancy in the utility department.

SECTION B - STORMWATER MANAGEMENT AND OPERATIONS PLAN

In the preceding section, the existing organization of the stormwater utility was reviewed. The next two sections focus on the 5 year Stormwater Management and Operations Plan.

B. STORMWATER MANAGEMENT AND OPERATIONS PLAN

1. INTRODUCTION

The development of the 5 year Stormwater Management and Operation Plan involves major planning and budget considerations for the new Cape Coral stormwater utility. It also includes the future integration of the stormwater utility into the overall utilities organization. The new Stormwater Utility Operating Plan can be broken down into three major areas.

- Facilities Plan
- Management Plan
- Financial Plan

a) Facilities Plan

The Facilities Plan describes the new stormwater facilities to be constructed, including a description of the construction phases and future plans for expansion. It incorporates a forward-looking assessment of new and existing SFWMD, FDER and EPA compliance requirements for stormwater treatment and disposal. The Facilities Plan also includes an evaluation of the condition of the existing stormwater facilities. The evaluation consists of a "needs" inventory of freshwater canal and stormwater infrastructure rehabilitation along with a forecast of system expansion.

b) Management Plan

The Management Plan specifies the commitments to be made for effective management, operation and maintenance of the new stormwater utility. It also provides the framework for integrating all utility operating divisions.

The Management Plan provides two levels of information and control:

- An operating plan to define the tasks in managing, staffing, and equipment needs.
- Assurances that commitments are made to proper staff and support management resources.

c) Financial Plan

Both the Facilities Plan and the Management Plan provide the basis for developing the cost to operate the stormwater utility. The two basic components are:

- A forecast of annual operating costs
- A projection of required capital expenditures.

The supporting types of financial analysis include:

- A cash flow analysis to demonstrate the revenue sufficiency.
- An analysis to determine the funding of future projects.
- The availability of outside funding sources such as SFWMD grants, FDER state loan and EPA.

d) Management and Operations Plan

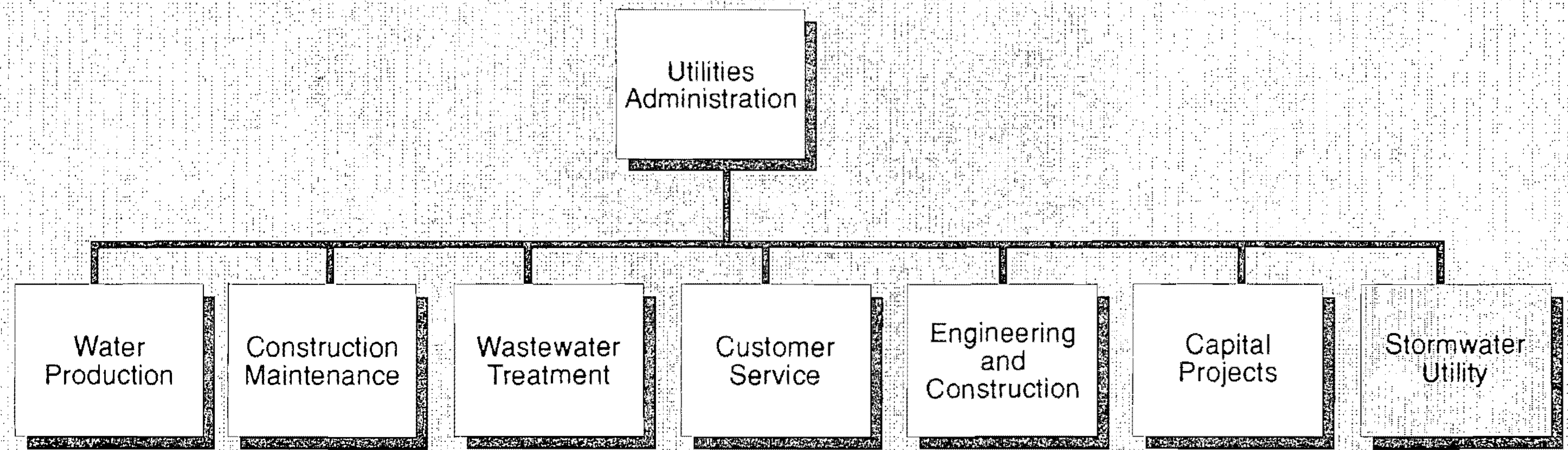
The development of a Management and Operations Plan is the footprint for the Cape Coral stormwater utility expansion within the existing utility department. Major areas to be effected include:

- Overall Utility Organization
- Staffing and Personnel Management
- Engineering and Legal Services
- Budget and Planning
- Accounting Practices and Tracking Systems
- Expenditure Controls and Purchasing Procedures
- Existing Policies and Standards
- Utility Rate Review
- Billing and Collections
- Records Management
- Regulatory Compliance
- External Relations

2. EXISTING UTILITY ORGANIZATION

The existing utility organization was originally designed and established to administer the needs of six operating divisions: water production, construction maintenance, wastewater treatment, customer services, utility engineering/construction management, and capital projects. This organization has expanded to accommodate management of the new stormwater utility. These changes have resulted in the current official utility organization as of March 1992, shown in Figure E.4.

Utility Department



Source: City of Cape Coral Finance Office

FIGURE E.4

- Utility Administration - is responsible for providing administrative support for the six operating divisions through which the goals and objectives of utility services can be achieved.

- Water Production - Division provides for present and future water needs and compliance with DER, EPA, and SFWMD rules and regulations.

- Construction Maintenance - Division is responsible for maintenance, installation, replacement, and repairs to the water and sewer distribution/collection systems.

- Wastewater - Division is responsible to maintain a high water quality standard to the downstream water users and to dispose of the City's waste sludge (residuals) in a manner as not to create a nuisance to the public from obnoxious odors.

- Customer Service - Division provides a myriad of service-oriented activities which include: collection of fees, monitor tax rolls, accept applications and deposits for new customers and construction, monitor delinquent accounts and maintain utility records.

- Utility Engineering/Construction Management - Division oversees the utility expansion program to include dual water, new treatment plant and sewer expansion areas.

- Capital Projects - These are major projects which are required to replace worn facilities, upgrade and meet changing regulations or increase capacity due to an increasing demand.

- Stormwater Utility- During the developing years of the utilities department, organizational changes have been necessary to adjust to the expansion of the existing facilities and new environmental compliance regulations. On April 30, 1990 City Council passed Ordinance #18-90 creating a stormwater utility program, in order to meet City stormwater management goals and responsibilities in compliance with SFWMD, FDER and EPA regulations. This program includes maintenance of the existing stormwater sewers, catch basins, street gutters, treatment structures, swales, and canals; replacement of deteriorating facilities and construction of new stormwater handling and treatment facilities.

a) Recent Changes and Utility Functions

The rapid expansion of the City of Cape Coral has required a corresponding expansion of utility services. While the financial and official structure has remained the same, the daily functional structure of the utilities department has changed.

The creation of the new stormwater utility and a new reclaimed water system expansion of wastewater collection systems have dramatically increased the administrative and information management requirements within the utility. Utility division and funding levels for 1992 are presented below.

TABLE 1

	1992 Budgeted Staff	1992 Budgeted Cost
Utility Administration	12	15,408,485
Water Production	17	3,302,435
Construction Maintenance	51	2,618,214
Wastewater Treatment	34	2,519,086
Stormwater Utility	36	4,155,000
Customer Services	12	279,747
Utility Engineering/Construction Management	--	--
Capital Projects	--	--

The current organization is established with two separate sections, the utility engineering section and the operations section. The utility engineering section is responsible for engineering, construction management, permits and construction, and special projects. The Assistant Utilities Director has taken responsibility for the three major operating sections (water, wastewater and stormwater) and the billing, accounting and finance sections (See Figure E.5).

The utility engineering division is presently organized into four major functional areas.

- Engineering
- Construction Management
- Permits and Construction
- Special Projects

The major engineering programs for the expansion of the stormwater collection systems, wastewater collection system and reclaimed water distribution system has dramatically increased outside consultant engineering contracts resulting in engineering drawings and construction program reloads. As the demand for more detailed plan reviews for new projects, permits for new construction, surveys, inspections, and other related information increases, the City should begin to implement methods to effectively manage data requests and engineering information.

These management systems may be supported with computer based and engineering record systems to effectively meet the increased demands and provide methods to record

Current Utility Organization

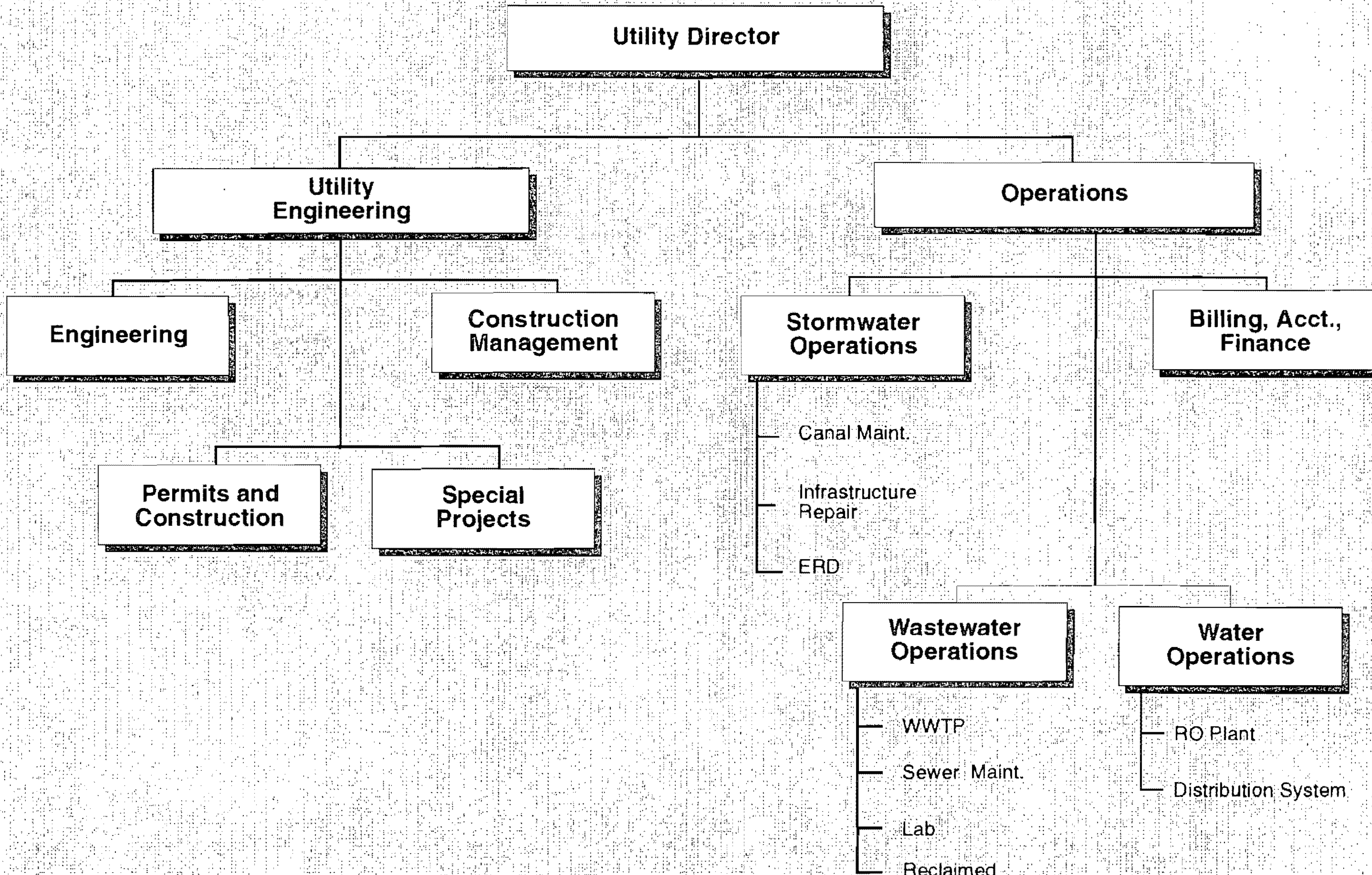


FIGURE E.5

the construction and field changes as they occur. These record drawings will form the basis of "as-built" drawings to be used by the operation and maintenance staff in their daily activities.

b) Utilities Operating Divisions

The water, wastewater and stormwater sections now function as separate operating units, each with a separate construction maintenance section for repairs to the water distribution systems and the wastewater collection system. These individual operating units were formed independently as the water, wastewater and stormwater programs developed. Each operating unit has an established unit cost that is reflected in a separate utility charge.

The three (3) major water and wastewater processing facilities that require high levels of operation and maintenance include the Everest Parkway Wastewater Treatment Facility, the Southwest Wastewater Treatment Facility now under construction, and the R.O. Water Treatment Facility. Control of the new reclaimed water transmission systems and the water production facilities are the responsibility of individual manager(s) who report to the Assistant Director of Utilities.

c) Stormwater Utility

The stormwater utility operation is the responsibility of the stormwater utility coordinator under the direction of the Assistant Utilities Director (See Figure E.6). This new section has daily responsibility for operation and maintenance activities associated with the stormwater drainage canals, and the associated stormwater drainage system. The sampling and monitoring of the water quality in the drainage canals is supervised by the Environmental Resource Manager.

The 1992 budget, shown in Tables 2 and 3, reflects an expansion of the stormwater utility and an increase in staffing along with a projected increase in required maintenance and construction equipment.

It is anticipated that as the stormwater and reclaimed programs become more intensive, there will be additional staffing and budget requirements necessary to meet the system demands. As growth occurs, the utility department should initiate a program to evaluate and implement an organizational plan to maximize utilization of financial resources, key technical staff and new equipment.

Stormwater Utility
Existing Function

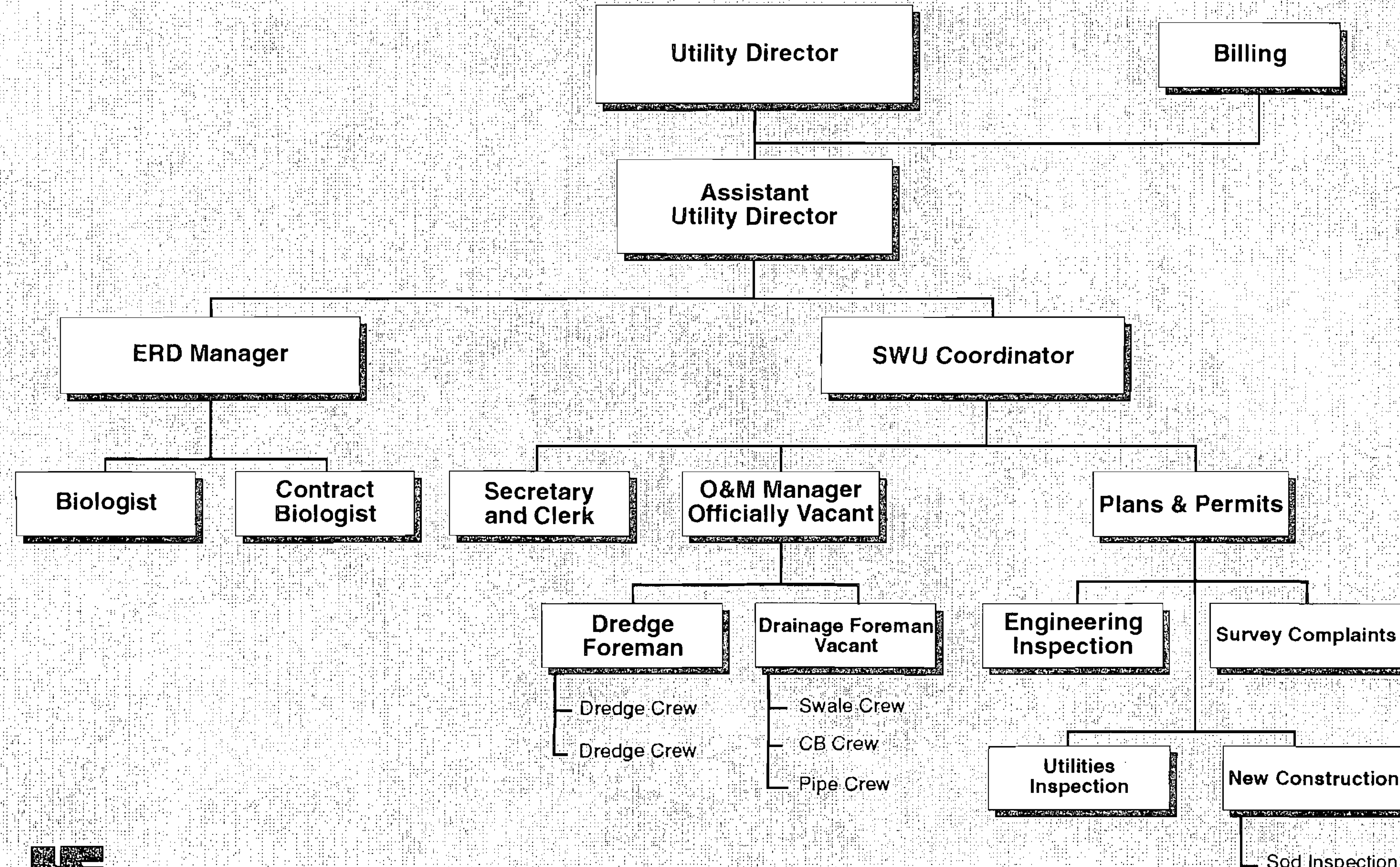


FIGURE E.6

Table 2

STORMWATER UTILITY
1992 STAFFING BUDGET

POSITION COMPARATIVE	FY 1991	FY 1992
Canal Maintenance Supervisor	1	0
Stormwater Utility Coordinator	0	1
Environmental Resource Manager	1	1
Foreman	1	1
Environmental Biologist	1	1
Utility Inspector	1	1
Surveyor I	2	2
Survey Tech	2	2
Equipment Operator I	1	6
Equipment Operator II	3	4
Equipment Operator III	1	3
Engineering Inspector II	1	1
Engineering Tech	0	1
Secretary	0	1
Staff Assistant	1	1
Laborer	3	7
Clerk	2	3
Totals	21	36

Table 3

MAINTENANCE AND CONSTRUCTION EXPENSE
APPROVED FY 1992 CAPITAL OUTLAY
STORMWATER UTILITY FUND

Construction Downtown Area	1,718,414
Misc. Furniture	1,175
Tools	60,000
2 - 1 Ton Crew Cabs	36,600
1 - Utility Vehicle	12,807
1 - 2 Ton Flat Bed Truck	34,100
1 - Dump Truck	69,700
1 - 1 Ton Truck	20,500
2 - Loader/Backhoe Truck	75,000
1 - Front End Loader	75,000
1 - Alum. Boat	2,000
1 - Motor	3,000
Misc. Aquatics	55,000
Hydraulic Lift	13,000
1 - Oil Spill Control Kit	60,000

3. FUTURE UTILITIES GROWTH

As the Cape Coral utility's programs grow, an ongoing planning effort will be required to keep up with this growth.

One way to improve the utility's programs as they grow is to review similar functions in areas such as construction repair of water distribution, wastewater collection, stormwater collection and reclaimed water distribution. The combinations of similar and dissimilar functions within the water, wastewater and stormwater sections is a key element in the "New Management" plan. The new management plan will use the Stormwater Utility Master Plan as the foundation for the controlled expansion of utility engineering and utility operations.

The Stormwater Master Plan is designed to accomplish the following basic goals:

- Develop a management plan for the stormwater utility to meet the existing and future stormwater drainage, storage and usage demands.
- Develop methods to insure high quality supply from the canal system to augment the secondary water systems.
- Preserve property values through the maintenance of the canal systems' aesthetic beauty and recreational functionality.
- Develop positive attitudes among users of the canal system, through a public information program, with regard to protecting a valuable water supply and recreational resource.

4. FUTURE PROGRAM

The utility growth program was developed with the support of the City's Utilities staff projections and based on experiences with similar programs throughout the State of Florida.

The City of Cape Coral Stormwater Utility is entering an initial growth period. New revenue sources may soon be available to build new facilities and establish the long term management programs. These programs will form the basis for a controlled expansion to meet future water demands. Major elements to be considered in this long term program include:

- A planned expansion of the utilities engineering section with emphasis on new automated Management Information Systems (MIS) and engineering graphic information system (GIS) to support the on-going, utility expansions.
- Operational control strategies for use, control, and supplemental treatment of stormwater as an additional water resource to the reclaimed water system.

- A preventative maintenance program for the canals, catch basins, stormwater lines, control weirs, control structures and provide adequate maintenance equipment to provide system reliability.

- On-going in-house water quality monitoring program for stormwater and reclaimed water to meet all SFWMD, FDER and EPA water quality criteria.

- Effective inspection and permitting program to control all discharges into the stormwater system.

- A programmed expansion of the staff and selective purchasing of specialized equipment to meet the needs of new operation and maintenance programs.

- Specialized training on new maintenance equipment and computerized information management systems to improve program productivity.

The proposed five year program will require a gradual increase in both staffing requirements and overall program costs, to reflect the growth of the system operation and maintenance activities. The 1991 - 1992 budget year of the new stormwater utility indicates an immediate need to increase the catch basin and pipe replacement programs and the canal dredging operations. These increased needs, will be complemented with the delivery of new construction equipment, resulting in improvements in the operation and maintenance of the stormwater collection system.

5. NEW MANAGEMENT PROGRAMS

The future management of the stormwater utility program will depend on the implementation of new management programs and tools to maximize the use of new equipment, and increase employee productivity. Future management programs and systems that may be integrated into the system include:

- Planned restructuring of the stormwater utility, wastewater collection system, reclaimed water distribution system and potable water distribution system, into functional operating groups. Centralized functional groups such as engineering, construction, maintenance, operation, and administration will allow the managers to utilize highly skilled personnel and the new sophisticated equipment throughout the entire system.

- A computerized stormwater management program that will utilize the engineering design stormwater model as a basis for future operational control. This advanced system will combine the on-line data collected from automated stage gages, water quality monitors and real time data to project the available storage for stormwater and the distribution of stormwater as a supplement to the reclaimed water system. This real time computerized operating tool will provide the stormwater utility managers with a hands-on operating system to maximize the use of the stormwater utility system.

- The combined operation of the new stormwater utility, the reclaimed water system, and the potable water system, will require new management methods and tools to meet the new system operation and maintenance requirements. The five year management plan reflects the initial needs to meet these new demands.

- The implementation of supportive management, operating and maintenance training programs to help staff effectively use the new maintenance equipment and computerized programs.

- Develop an updated computerized cost accounting program to interface with the City's existing budget and billing system. This system could be used to track unit costs.

6. UTILITY RESTRUCTURING

The existing utility organization, as discussed above in B.1, was established as the individual components water, wastewater, reclaimed water and stormwater. As the growth of each section developed they established their own identity. This included specialized technical personnel and sophisticated equipment. However, as Cape Coral's service area grows, there is a need to maximize the use of key technical staff and new sophisticated equipment throughout all sections of the utility.

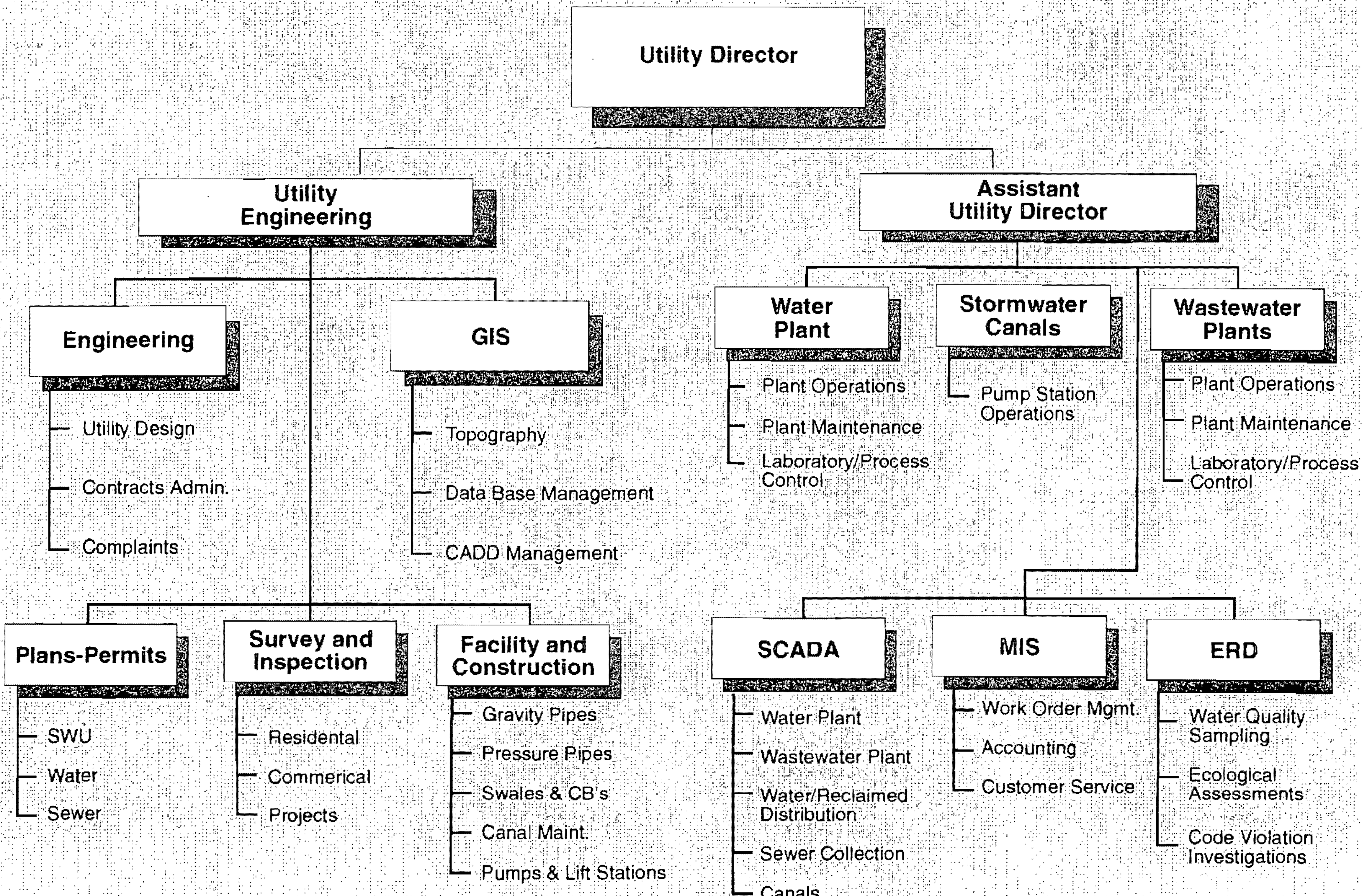
The combining of operating groups such as line construction and repair section of the wastewater, reclaimed water, water and stormwater services sections into a specialized construction group is an example of combining functional operations. This new line construction group would be able to selectively isolate the technical skills of the existing work crews and key pieces of construction equipment to handle the most difficult jobs. There are no rules that say a construction equipment operator has to be isolated strictly to work in the water distribution system. The future of solving day to day problems will require a cooperative effort from all concerned.

In meetings with staff, various organizational options were reviewed. Figure E.7 presents the proposed future utility organization. This figure shows the utility department organized by function (task oriented) rather than the existing departmentalized (product oriented) organization. Essentially, utility operations are organized such that similar tasks are carried out by one specialized "functional group". This structure has the advantage of avoiding duplication of equipment and increasing efficiency in manpower and equipment utilization.

The utility engineering section under the Utility Engineer Director would be broken down into five (5) major groups responsible for: Engineering, the GIS system, plan permits, survey and inspection, and facility construction.

CONCEPTUAL FUTURE UTILITY ORGANIZATION

FIGURE E.7



The Assistant Utility Director would be responsible for six (6) major sections which include the water treatment plants, the wastewater treatment plants, operation of the reclaimed water system and stormwater canals, the environmental resource operations, the SCADA systems and the management information system.

This proposed modification to the existing utility organization should occur gradually over the next five (5) years as the needs dictate.

SECTION C - CAPE CORAL UTILITIES FUTURE ORGANIZATION INFORMATION MANAGEMENT SYSTEM

C. INTRODUCTION

In previous sections we examined the advantages of organizing the utility into functional groups. This section examines how the effective use of manpower, equipment and administrative resources might be achieved by implementing comprehensive management techniques and by installing the information management systems necessary to manage these resources.

As a result of discussions with utility staff and experts in utility management, a PC based management system is proposed. This system is a network of computer subsystems which are designed around the operations of critical functions of the future utility organizational structure: administration, engineering, and operations.

These operational requirements vary in type and quantity depending on the individuals that are using them. For instance, the Utility Director (administrative) may require information on the manpower and equipment effort required for completion of a particular project. On the other hand, a work crew (engineering) may not need such economic information but require information about what is physically present in the field, such as the depth, type, age, and maintenance record of a particular piece of pipe.

Functionally, one single system may not meet the informational needs of all parties involved, often providing too much, too little or the wrong kind of information. Therefore, it is important to recognize the potential value of a series of interconnected subsystems. Each subsystem will be capable of exchanging required updated data with other systems at the different organizational levels to maintain system integrity, while performing specialized tasks to provide complete information required by a particular operation.

1. UTILITY ORGANIZATION MANAGEMENT TOOLS

Referring to the utility organization presented in previous sections, Cape Coral Utilities Department may be viewed as three independent but interconnected operations: Administration, Engineering and Infrastructure Maintenance, and Plant Operation. Each of these department functions would utilize its own specialized information system (See Figure E.8) which is linked to other information systems within the Department. For instance, administration would operate under a Management Information System (MIS) which provides data storage and retrieval for work order processing , management of crews, management of individual line item accounts within the budget, service requests and summary reports to assist in preparing annual budgets. Infrastructure information would be stored, updated and retrieved on a Geographic Information System (GIS). This GIS would include maps of the infrastructure with detailed engineering information on specific components and provide a database from which to run operational models. Finally, operational control would be handled within the Supervisory Control and Data

Acquisition (SCADA) system. SCADA information and control would be used primarily by daily operations of the water supply, wastewater collection, treatment, and stormwater management systems.

Each of these independent operating systems would provide unique information important to the functional groups which they serve. Management and administrative personnel's daily concerns are more focused on the costs associated with operating and maintaining various components of the utility system than they are with the actual operations of those systems. Facilities and construction maintenance personnel are more concerned with the physical location of infrastructure components and how they are built than with the economics of operating them. Additionally, they are not too concerned with instantaneous demands on a particular section of the system unless, of course, they require special operating conditions to be maintained while they repair or install a particular piece of the system. Operations and control concerns are with collection and distribution pump operation, water through-put in plants, water demand and collection service demand. They are not too concerned with the cost of operating the system nor are they concerned with detailed information regarding particular pieces of the system but rather whether components are operating properly.

It is important however that each of these sub-systems be able to readily transfer summary information between one another. For instance, management might report to GIS summary maintenance cost data on a particular piece of the infrastructure. This information would be stored until a better method of maintenance or operation is sought or a similar application is planned. The purpose for such information storage and transfer program is to achieve data detail and integrity within individual sub-systems providing for the transfer of necessary data between sub-systems. Much of the interactive system may be installed on hardware currently maintained by the utility department and may incorporate many of the procedures already being used within the department.

City of Cape Coral
Information Management Components

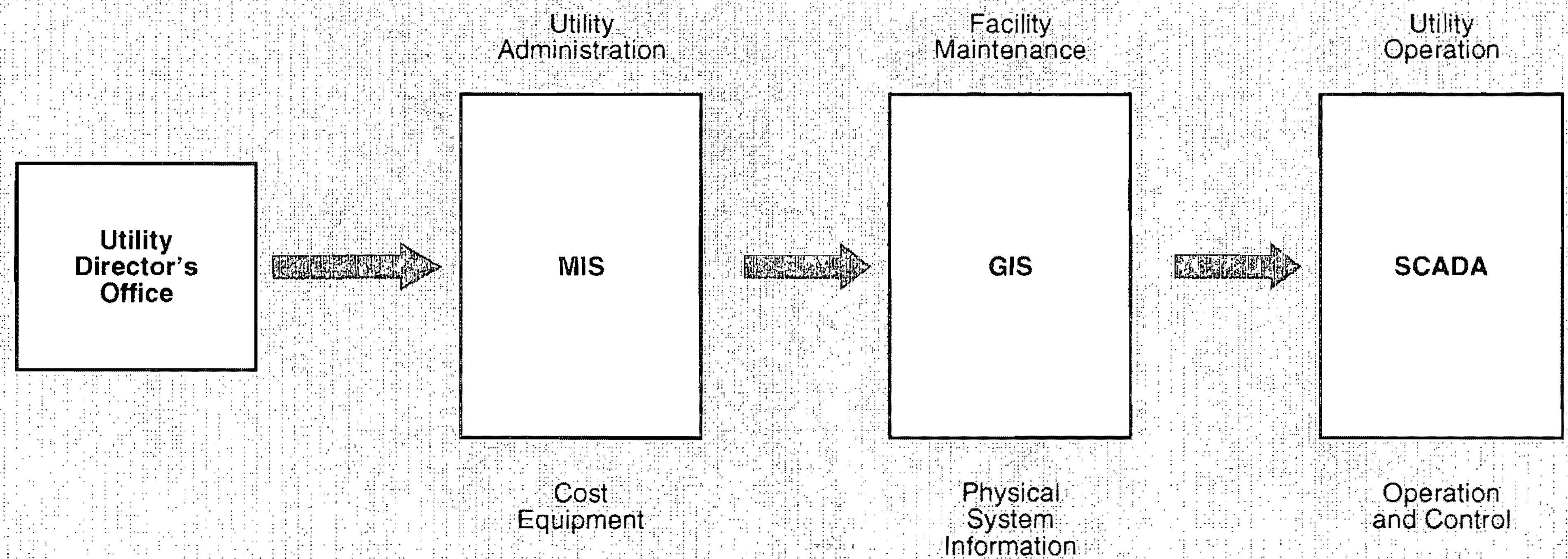


FIGURE E.8

2. UTILITY COMPUTER NETWORK

Considering the proposed discrete systems and the interactive communication that will take place, the function and operation of the three primary systems (MIS, GIS, and SCADA) and subsystems within these (as depicted in Figure E.9) are examined in the following paragraphs.

a) Management Information System

Currently the utility is managing operating budgets with one proprietary software and service requests with another proprietary software package. These are not integrated into one package nor are data they manage compiled in a summary fashion. In addition there are limitations to the software currently being used. Thus, they rely heavily on user creativity and thoughtfulness in properly managing individual accounts within the utility system.

Currently, there are various management information systems available, such as Hazen Systems Utilities and Management software as well as other stand alone, proprietary work order management and cost accounting programs. These programs can be run on a PC and could provide the utility department with a powerful and comprehensive management tool. A management information system may be installed on a PC platform and be networked throughout the utility department to include functions such as:

- Manage the data required to properly process service requests
- Process work orders and make crew allocations
- Maintain line item expenditure and revenue accounts
- Track equipment amortization, equipment performance, and crew performance
- Establish criteria for various work crews in the system
- Assist in preparation of annual budgets
- Track and predict needed materials
- Process permit applications and service connections

Note that the management information system does not include data concerned with particulars of the physical environment. Management information systems would process and store only data regarding items such as the following:

- Service Requests - Service requests could be managed and stored in a manner similar to that currently being conducted by the utility staff using a Q&A system. Service requests are received, compiled, and stored on a data base. This system would also provide preliminary prioritization of requests and provide information easily transferrable to a GIS for geographic analysis.

- Prepare Work Orders - Once a service request is received, the nature of the required action would be assessed by an operator then given to an inspector. The inspector would determine what type of repair would be required and would report

INFORMATION PATHWAYS

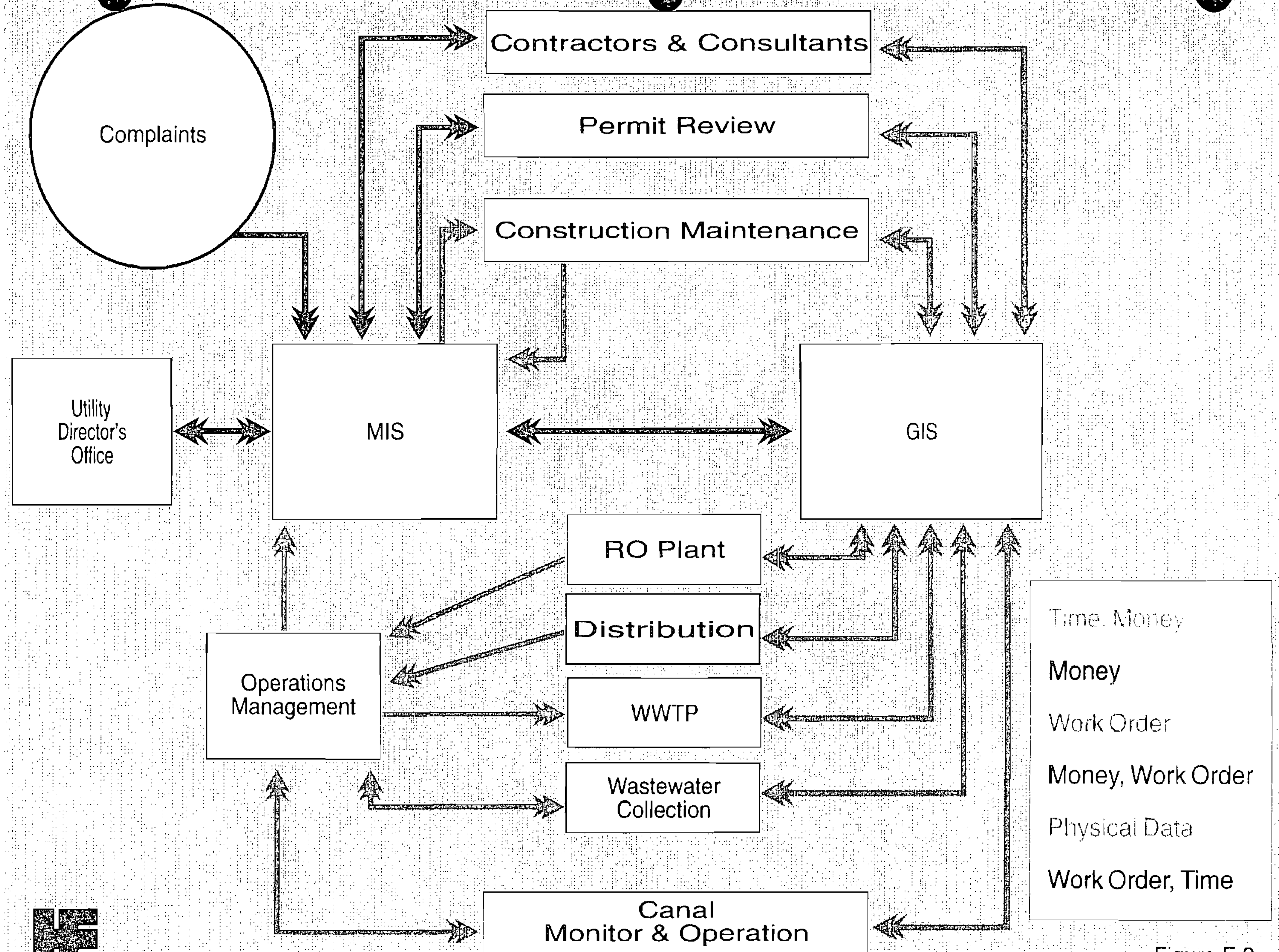


Figure E.9

it back to management. The MIS could then be used to prepare a work order and allocate crew resources and time according to service request priority. Note that using this system requires only one inspector trip. This communication of the problem to work crews is immediate.

- Crew Allocations - Within the management information system would be a list of various crews, their associated equipment, their performance capabilities and current utilization throughout the City. Crew resources may be allocated depending on the size of a particular project and analyzing performance records. A work order would then be dispatched to the crews. Since all utility systems are maintained by one functional group, there will not be multiple mobilizations of crews if more than one system requires attention.

- Time Reports - Work crews upon receiving the work order would perform a given task and report back to the MIS operator the time, equipment and material resources expended for the particular work order. Storing and analyzing this information will aide in forecasting annual crew and equipment allocation needs during budget preparation. Furthermore, the time reporting would assist in analyzing operation costs of the various elements in the utility system.

- Cost Accounting - Resource liabilities may be assessed to the various budget line items as defined in the work crew time report or work orders. Accurate task cost accounting is critical for the effective operation of the proposed utility organization. This will insure that activities of the various functional groups are billed to the proper revenue account.

- Equipment Amortization - equipment owned by utilities department would be tracked for amortization and replacement scheduling using the management information system. Information on a particular piece of equipment will be readily available for use in budgeting forecasts.

- Budget Preparation - using information derived from detailed tracking of the operational costs and revenues generated under the various accounts, budget predictions and requests may be made in a more precise and efficient manner. Supporting data for any particular budget item within the utility system will be readily available. Furthermore, budgeted items can be further justified by careful tracking and compilation of service request and service request information. Accurate cost summary information when combined with demographic predictions, may be utilized to predict additional unit costs that would be incurred by the utility system as it continues to expand.

- Performance Criteria - performance criteria, performance tracking and performance goals may be established by carefully tracking production of various work crews. This would help to assure maximum utilization and efficiency of the work crews and equipment as well as provide justification for budgeting additional crews as required.

- Utility System Integration - the MIS would provide operational and resource data to management personnel throughout the utility department. Likewise, it would require summary information from the various subsystems throughout the City. This would include summary information from:

  - The existing RO Plant computer network including demand, output, costs of operation and revenue generation
  - Wastewater treatment plant cost of operation, equipment and supply needs
  - Construction management section, supply needs, equipment amortization and crew performance
  - Engineering permits
  - Service connection summary information and generated revenue
  - Canal maintenance, performance levels, equipment and supply needs.

b) Geographic Information System

A Geographic Information System (GIS) and its associated data base could be utilized to maintain information regarding physical aspects of utility system networks. GIS is essentially a hybrid tool consisting of an electronic map and relational data base. GIS are capable of maintaining specific data which are attributed to individual or groups of elements within the systems data base. For instance, information may be provided on a particular pump station regarding its power needs, pump type, capacity, volume, repair history and maintenance schedule. All of these types of information are not always required by the MIS nor is it required by the SCADA system. However, both systems will be able to request specific data items from the GIS. This information would be extremely valuable to work crews, developers, various consultants to the City and contractors that may request detailed information on utility networks. Data requests could be made to the GIS by either private and public entities or by the MIS in preparation of work orders. The GIS would also maintain preventative and restorative maintenance information and provide a powerful but easily understood planning tool. This information could be reported on a regular basis via a network download from the MIS. Furthermore, geographic information could be retrieved by any network within the utility department through network interconnections.

Network Response Models

In addition to the flexibility with which data may be accessed for specific utility needs, the GIS would also maintain synoptic data collected by the various instrumented components in the City's water resource SCADA networks. This information could be prepared as input to network response models such as the proposed model for the canal drainage system. Operators of the GIS would be capable of updating information and then spawning a canal network response model simulation to predict network performance under various scenarios. Analysis of the simulation output would be made available to assist SCADA operators in the decision to adjust the drainage system prior to the commencement of a particular event. Maintaining current and accurate up-to-date data would facilitate such simulations in predicting network response to extreme rainfall or drought events. It would also assist in making informed decisions to more effectively manage the system under such conditions. This would further facilitate future planning and a more intelligent and informed approach to Cape Corals future needs.

Finally, data summary records and logs that would be transferred from the SCADA system could be stored in the GIS data base. This would facilitate graphic display and analysis of current and historical conditions throughout the City's water resources network.

Cape Coral's water resources are inseparably interdependent. In the future, additional models of the potable and irrigation water distribution systems and the waste collection system may be installed as additional modules on the GIS. Detailed data on any particular network in the management system should be readily available for analysis under daily and emergency operational scenarios.

c) Supervisory Control and Data Acquisition System (SCADA)

The City of Cape Coral has recognized the value of telemetered data acquisition and control system for the operations of the utility. A detailed plan for implementing SCADA is provided in the WICC Master Plan (1988) including:

1) The SCADA system in use at the RO plant by which various operations throughout the plant are monitored.

2) The developing SCADA system for the wastewater collection network will include pump operation and line volumes.

3) A SCADA system for both water distribution networks will include pump operation, line pressures, canal withdrawal, and various other parameters.

A SCADA system for the canal system is to be implemented under the current Stormwater Master Planning effort. It is also expected that SCADA will be installed at the wastewater treatment plant expansion at Everest Parkway.

Most of the SCADA system terminals will be physically installed at a central location. Data from remote terminal units (RTU's), or branch SCADA Systems (i.e. RO plant) would be fed into a central computer for processing. Information would be immediately assessed and reviewed by operators and necessary actions taken by the operators. Furthermore, SCADA operations would automatically generate end of the month reports regarding water quality and environmental standards as required by various agencies.

Selected summary data items from the SCADA will be transferred to the GIS system for storage and ready retrieval. Therefore, it would be necessary that data transfer programs be established so that the GIS and SCADA systems would be able to communicate with each other. Finally, refined summary numbers could be transferred to the MIS system for review and reporting on the utility systems function and performance criteria. This would also aide in predicting future demands on all of the utility water systems. Most detailed data such as individual samples or the un-summarized flow data would most likely be stored on magnetic tape as a separate SCADA record.

SCADA System Operation

All utility components may be operated in a single SCADA system or individual SCADA systems may be operated for various functions of the City's utility structure including:

1. Water Supply - SCADA operators would be able to monitor and control the performance of all water supply plants, including water quality standards, well head pressure, plant head pressure, water volume production and tank levels.

2. Wastewater Treatment Plant - The implementation of Cape Coral's reclaimed water system necessitates continuous monitoring of water quality of the effluent water in addition to various parameters that are regularly monitored within the plant. These include tank levels, flows at critical points in the plant, and flow balancing.

3. Wastewater Collection System - It may become desirable to monitor the performance of critical segments of the wastewater collection system. SCADA operators could quickly assess a situation in which a particular pump may be malfunctioning and take corrective action to avoid potential costly and dangerous system backups.

4. Water Distribution - The water distribution network may be monitored by SCADA. Remote monitoring of booster pump operations and pressures, along with storage tank levels, may be desirable.

5. Stormwater - Canal stage and environmental parameters may be monitored remotely for proper operation of the canal system. Remote terminals may operate weirs, pumps, or gate valves to achieve various desired results in the drainage/irrigation canal system.

6. Dual Water System - May be also equipped with SCADA devices in a manner similar to the potable water distribution system network with the addition of wastewater plant effluent monitoring and the interaction between canal network and irrigation water supply pumps.

Considering the interaction that the secondary water system has with the wastewater treatment plant and the canal system, it is easy to recognize the importance of maintaining an efficient flow of information between all utility systems. Fluctuations in effluent discharge will naturally facilitate changes in the removal rate of water from the canal system. However, choices will have to be made with regard to which canal or canal basins would be targeted for water removal at a particular time. As irrigation demand increases with expanding population, the exchange of information between the secondary water operation and the drainage and wastewater treatment systems may be required to assure a proper balance of supply and demand.

3. IMPLEMENTATION

Detailed planning and implementation of the integrated management networks may be accomplished under the Stormwater Master Plan development. A preliminary implementation schedule is considered below. Most progressive changes and initial technology applications take place within the stormwater utility. This will allow many of the procedures to be developed and refined on a relatively small, but realistic scale. As the operation of MIS and GIS becomes established, additional utility functions may be added to the network. Near the end of the program development utility department may finally ease into the new organizational and management structure detailed in Section B above.

a) Year #1

Physical response models will be chosen in the current phase of the Surface Water Master Plan along with a detailed implementation plan outline.

Management and expansion offices are currently using Q&A to handle service requests and other software packages to manage individual budget accounts. At present, stormwater utility revenues are collected through a separate billing system. Potential problems have been identified with this system and are not addressed in this section. However, alternative billing procedures may be advantageous or desired in the future. It is suggested that management information and network software packages be chosen

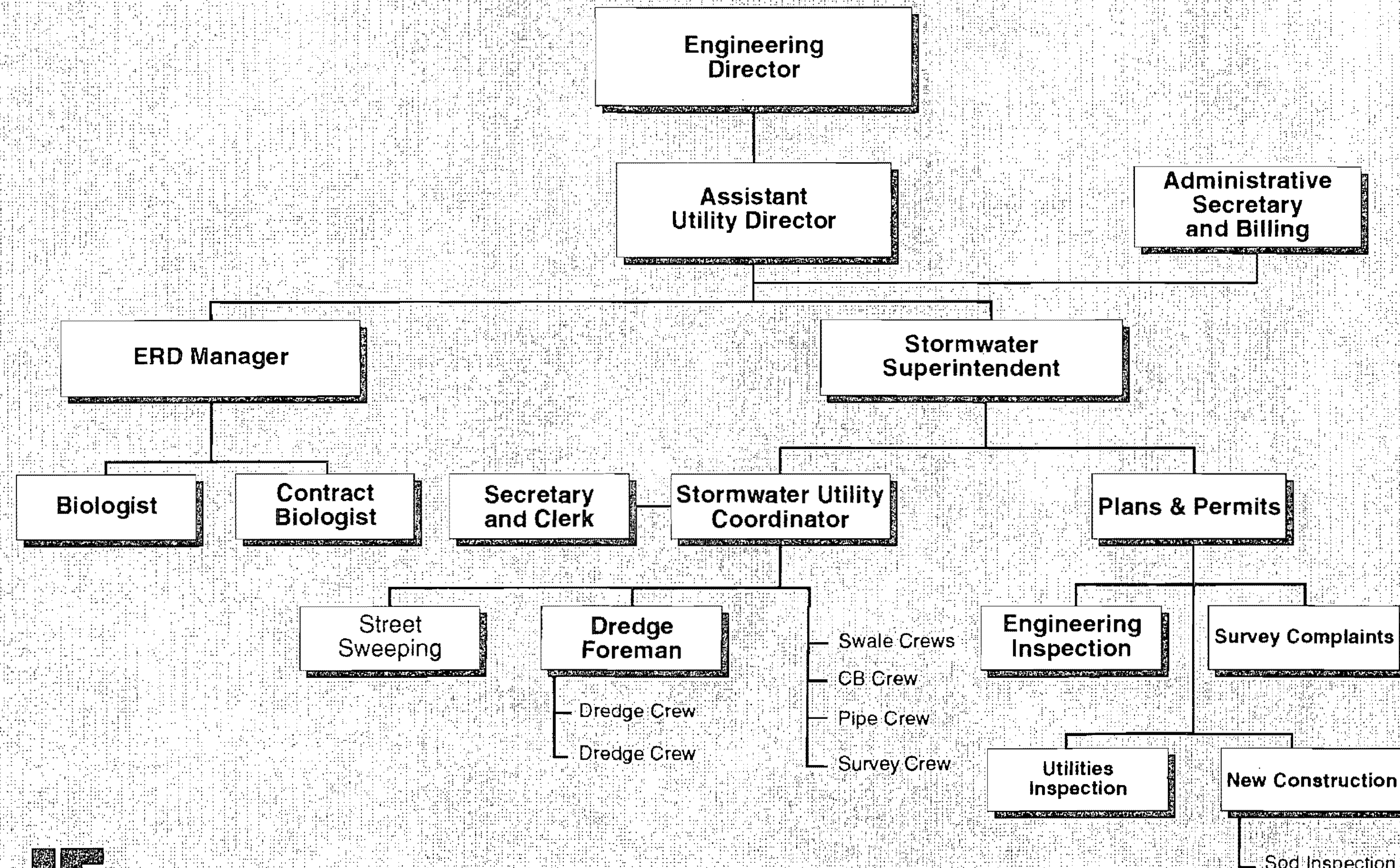
MANAGEMENT AND OPERATIONS PLAN UPDATE

The Management and Operations Plan contained in this appendix was prepared to fulfill scope item E of the Phase I Surface Water Master Plan. This report was researched in the spring of 1992 while the stormwater utility was operated under the Cape Coral Utility Department. It was prepared with much input and assistance of both stormwater staff and the utility engineering department. The document was designed to provide a conceptual plan of integrating the stormwater utility into the utility department and to advance the technologies used to manage all utility service according to the utility engineers' desires.

Since the time this report was prepared, management of the stormwater utility has been transferred to the city engineering department. While most of the information provided in the functional descriptions of the stormwater utility are valid, some structural changes have taken place. Also, since the management plans were developed around utility integration, much of the future operational plans no longer apply. However, the concepts and technologies presented may be applied to the future organization of the stormwater utility and related departments.

The organizational structure of the stormwater utility as of May 1993 is presented in the attached figure. Additional organizational assistance will be provided through the development of the Master Plan.

Stormwater Utility (May 1993)
Existing Organization by Function



under the Stormwater Master Planning effort. Also a detailed layout and implementation plan may be developed at this time. Budget and accounting tasks have been completed for FY 92-93 using methods that have been used in the past.

Through Year #1 the staff and administration must continue defining needs and setting goals for the utility department. Qualified consulting firms may continue to assist by working closely with utility staff to identify data needs, software and hardware selection, system programming, and training.

Under the current contract for the Surface Water Management Master Plan, a GIS system will be chosen. Installation of hardware and software may begin, the canal network response model will be under development and data collection and entry into the GIS system may begin. The Management Information System may also be chosen and installed. Network linking of GIS/MIS and SCADA should be planned as well.

The stormwater utility account could be set up on the MIS system for accurate account tracking while training the utility department staff in preparation for additional utilities to be added to the system. Account tracking parameters could be identified and compiled as the pilot program for budgeting with the MIS system.

b) Year #2

By fiscal Year #2 stormwater utility operational staff and equipment should be fairly well completed. The GIS and physical model should continue to be programmed as data begins to be made available for use by the various field crews. Staff and computer personnel should be trained and network interfaces established during this fiscal year. In Year #2 the MIS implemented by the stormwater utility during the first year could begin to add additional utility accounts. Additional budget and accounting personnel could be trained in the effective use of the MIS at this time as well.

c) Year #3

Finally, in Year #3 functional groups in construction maintenance and operation may be organized. SCADA systems will continue to be developed and interfaced with GIS and MIS systems. The final interfaces between GIS and MIS and final data needs and formats may be established.

4. SUMMARY

Effective management of the expanding Cape Coral Utility Department will depend upon the use of accurate cost, infrastructure, and operational data. The use and implementation of the proposed systems would facilitate the management of the utility department, especially as it may be divided into functional groups. While additional staff and personnel may be needed at the managerial level, the utility department will be better able to manage its manpower and equipment resources and maintain an accurate track of data required at all levels. Linking systems as proposed will enable a greater flexibility in the use of information retrieved and acquired by the functional groups. Furthermore, the interaction between the MIS, GIS, and SCADA network will provide utility and city planners access to vital information necessary to make critical and informed decisions to the allocation of the limited resources of time, money, equipment, manpower, and responsible use of the City's water resources.

APPENDIX F
SELECTION OF GEOGRAPHIC INFORMATION SYSTEM

A. INTRODUCTION

1. STATEMENT OF PURPOSE

The purpose of this appendix is to define the operation and implementation of a Geographic Information System, its use during the surface water management planning process and its role in the management of Cape Coral's infrastructure in the future.

2. DESCRIPTION

In an effort to improve operational efficiency and information accuracy, the City of Cape Coral has discussed developing computer and remote sensing technologies. It is suggested that three primary systems be developed to manage data, the Geographic Information System (GIS), the Management Information System (MIS) and Supervisory Control and Data Acquisition (SCADA) system. The fundamental functions of these systems and the interfaces connecting them are described in the Appendix E. This appendix focuses primarily on the details of choosing and developing the GIS system.

The National Center for Geographic Information and Analysis defines GIS as "a computerized database management system for the capture, storage, retrieval, analysis, and display of spatial (tagged by location) data." GIS is essentially a hybrid tool consisting of an electronic map and relational data base. GIS is capable of maintaining specific data which are attributed to accurately located map elements within the system data base.

In recent years GIS technology has gained increasing popularity among government and private organizations because of its ability to handle spatial data more efficiently. The result has been an improvement in the delivery of services to customers of these organizations. Recognizing the need and desire to improve delivery of services to its customers, the City of Cape Coral is considering the options available in implementing a GIS for specific engineering purposes.

3. APPLICATIONS

GIS provides diverse application potential. The information provided through a mapped data system serve facilities managers, city planners, engineers, homeowners, businesses and governmental personnel. The virtues of maintaining a GIS data base for each of these groups are too numerous to detail for the purposes of this report. It will suffice to enumerate the purposes of the system development application as they pertain to the Surface Water Management Plan and future engineering, public works and utility applications. The proposed GIS system will:

- Provide a data storage and analysis tool for the enormous amounts of data necessary to accurately define and model the surface water system of Cape Coral.
- Provide a readily available set of maps of existing stormwater infrastructure, designed improvements and modifications as they occur.
- Serve as an input and output device for the surface water management computer model to be developed during the planning process.
- Be capable of receiving and storing summary data from the SCADA system.

Cape Coral's water resources are inseparably interdependent. In the future, additional computer models of the potable and irrigation water distribution systems and the waste collection system may be developed and GIS data links established. Detailed data on any particular network in the management system should be readily available for analysis under daily and emergency operational scenarios. In the future, the system may be further developed to include

- Water and wastewater system maps and engineering data for use by engineers, work crews and system managers.
- Roadway engineering and maintenance functions.
- Data transfer interfaces to MIS for analysis of infrastructure costs, operations and improvements.
- Public view stations where citizens, engineers and contractors may access information that directly concern them.

B. SYSTEM SELECTION

Two key parts of a GIS are the hardware platform and application software. The choices made with respect to both of these will determine the capabilities and limitations of the entire system. A third and critically important element of GIS development is defining use criteria which will ultimately steer both data type and accuracy requirements.

The system chosen will be capable of maintaining engineering accuracy data, easily used by a wide variety of technical personnel and provide a comprehensive data interface for computer modelling of infrastructure systems. It will be easily accessed and updated by city personnel for use in infrastructure repairs and modifications. It is envisioned that at some point in the future, GIS access terminals will be present in most utility, engineering and public works offices.

1. EXISTING CITY GIS

Prior to initiating a search for a new GIS system for the utility department, the existing city Geo-Info$_{TM}$ program was evaluated for potential use. While very useful data for planning and city operation functions is maintained on the WANG Geo-Info module, it was determined it lacked the necessary criteria of user demand accessibility, complex model data transfer capabilities and sufficient dimensional accuracy necessary for engineering use. The existing program architecture also requires highly trained personnel to update and recover data.

In discussion with city staff it was decided that a streamlined GIS be developed for use in the engineering oriented departments of the city. The new system will maintain the large quantities of engineering data without the added burden of non-engineering data currently maintained on the existing system. It should be stressed that the proposed GIS is not designed to replace the existing Geo-Info program, but is designed to provide the specialized function of maintaining accurate engineering information for the efficient maintenance of Cape Coral's infrastructure.

2. HARDWARE CRITERIA

In selecting a hardware platform there are basically three choices: mainframe, minicomputer/workstation, and personal computer. Although recent improvements in performance have resulted in the distinction between the three becoming somewhat blurred, for this discussion the distinction is still appropriate.

Of the three available choices a mainframe computer is the option which provides the highest level of performance in terms of computing speed and memory capacity. Yet, because of the great cost involved most organizations find a mainframe under utilized for the expense involved.

At the middle level of performance is the minicomputer or workstation. These machines are much more attractively priced than mainframes, but still provide quite respectable computing speed and memory capacity. In addition, they typically offer built-in networking capabilities and graphics capabilities superior to personal computers. However, workstations run on different operating systems, are limited by available software and are somewhat more expensive while PC technology continues to advance towards workstation performance standards.

The third alternative is personal computers (PC). While they rank last in terms of computing speed, networking speed and memory capacity, they do have a number of advantages. Among these are low cost, portability, ability to be used for a wide variety of other applications, and support for numerous peripheral devices. It should also be mentioned that some of the high-end personal computers approach workstation level performance.

A PC is recommended for developing the GIS in question. The PC offers the advantages of low cost and familiarity among utility personnel. The recommended system will consist of

- 486 or P5 (586) processing unit, 50 Mhz clock (minimum)
- 32 to 64 MB RAM
- Dual high capacity Hard drives
- Offline storage for backup, Bernoulli Box or Tape Drive
- 17" High resolution graphics screen
- Digitizer, plotter and other peripherals as needed

The PC system recommended will serve as a single stand-alone GIS station. Ultimately, several GIS stations may become desirable. At that time, the central station can be connected to a Novell Network and all database and graphic information transferred through the Network server. This will provide immediate access to the GIS from any connected station.

3. SOFTWARE CHOICE

In discussion with utility staff it was determined that the GIS should be AutoCAD based. Auto-CAD has become the industry standard for engineering design drawings and are easily imported into most GIS formats. Furthermore, utility staff are already familiar with Auto-CAD and may easily learn a CAD based GIS. It was also determined that the data developed on the GIS should be portable to higher level machines.

ESRI, ArcCAD, FMS/AC, and Geo/SQL all use AutoCAD as their graphics engine. As AutoCAD-based applications these products can be seamlessly integrated with numerous other AutoCAD-based applications for project management, civil engineering, and surface modeling.

After initial screening, two GIS packages were scrutinized for best suitability for the City of Cape Coral. These are Arc-CAD and Geo/SQL. Both products were well reviewed on the basis of vendor information and interviews with users of both systems in similar applications. Both packages are capable of supporting the large database, operating on both PC and larger systems, supporting view stations and interfacing with computer models.

Arc-CAD by ESRI is recommended. Many of the larger governmental units in south Florida have acquired Arc-CAD including the South West Florida Regional Planning Council and Sarasota, Orange, Palm Beach and Lake counties. South Florida Water Management District uses Arc-Info, the mainframe version of ESRI.

C. <u>DATA REQUIREMENTS</u>

The most important part of the GIS is the information in the database. Data within the GIS is typically stored in a series of coverages or layers. Each of these coverages consists of thematically associated data. More specifically, this data consists of map features at precise physical locations and their associated descriptive attribute files. Data and coverages of interest to different areas of concern are listed below.

Surface Water:
canals, soil, land use, basins and swale divides, existing infrastructure, planned infrastructure (from Master Plan), weirs, water quality stations and parameters, complaint history, dredging history, survey contours, bank stabilization, rainfall variability, water table data, composite runoff, and harvesting records

Modeled Surface Water Data:
water elevation, flow conditions, pollutant transport, flushing time zones, discharge requirements, and aquifer response/storage

Potable Water System:
lines, valves, booster stations, elevated storage tanks, pressure at location, future modeling data, service histories, and wells
Secondary Water System:
lines, valves, pump station, hydrants, service histories, water quality sample location, and groundwater wells

Sanitary Sewer System:
lines (all plan and profile information), manholes, pump stations, flow histories, service histories, and future modeling data

General:
roads, block numbers, landmarks, canals, private wells, septic tanks, development ratios, and horizontal and vertical control stations

1. DATA INPUT

Another important concern is getting the information into the system. Operator-hours alone can easily exceed 80% of the cost of the system development. Steps to implement the system must be carefully planned so that the system can produce benefits to City in the early stages. This section will briefly mention some of the important considerations.

Because the City desires to build a system with an engineering level of precision one of the first steps will be to establish a horizontal control network. As proposed, photogrammetry may be used to provide much of the topographic data for the system. Under this scenario the firm contracted to provide the photogrammetric data will establish this control as part of their scope of services.

a) **Data Input**

Data can be entered into the system in a number of ways. In practice a combination of all of these is typically used. Graphic information may be manually digitized or scanned from existing maps. It may also be input by file transfer from existing digital maps. Attribute (non-graphic) data will be input either by keyboard entry or file transfer from existing databases or measurement devices. Special attention should be given to investigating the availability and quality of existing data before beginning the task of data entry.

b) **Quality Control Program**

As mentioned earlier, information is the most important component of the system. To insure the quality of data is high a program of quality control procedures practiced on a continual basis will be instituted and followed from the very beginning.

c) **Updating and Archiving Data**

Another key aspect of system data is how to up-date the system. In the course of the daily activities of the Stormwater Utility information pertaining to parts of database will change. A system of updating information in a timely fashion will be developed and instituted for city staff. In addition, to prevent possible loss of data in the system procedures to backup the database at regular intervals will be implemented.

D. SYSTEM USES

In the introduction to this chapter a definition of GIS described very generally for what purposes such a system is used. In this section some specific uses of an engineering level GIS are mentioned.

1. MODEL DEVELOPMENT

For the purpose of developing a Stormwater Master Plan, GIS can be used to build data sets for models of existing and future conditions that effect stormwater flow. This may be accomplished through the mapping and then manipulation of coverages such as basin divides, land use, soil types, and stormwater system information. After manipulation, data is then exported in a file format which can be used by computer aided engineering or analysis programs.

2. DISPLAY/MAPPING OF MODEL RESULTS

Once the system has been modeled, results can then be exported back into the GIS for display/mapping. An example might be to map the parts of the system prone to flooding during a particular storm event.

3. MAPPING OF CITY INFRASTRUCTURE

Another use for GIS is as tool to more efficiently map the various infrastructures. By having the ability to attach attribute information to the various map features, the GIS can store a wealth of data that can be updated or otherwise modified much more easily than with manually drafted maps. In addition, the maps produced with GIS have the advantage of being seamless and more accurate.

4. NETWORK TRACING

GIS technology also allows the data about gravity sewer, pressure water, and electrical networks to be queried to perform complex tasks. This aids City personnel during maintenance and repair tasks. It is also very useful in quickly analyzing the effects of changes in one part of the system on the rest and simulating actual utility operation.

5. MAPPING OF AREAS OF ENVIRONMENTAL CONCERN

With increased environmental awareness the mapping of environmentally sensitive areas within a municipality has become more important. GIS goes beyond CAD mapping of such areas in that the information may be used for analysis purposes. Cause and effect relationships are often more easily identified using coverage overlay features.

6. QUERY OF DATABASE

One of the most important capabilities of a GIS is the ability perform complex queries on the database. Based on the selective retrieval of information, the system is able to track permits and complaints, perform suitability analyses, and provide construction information for work crews. By using these query capabilities the GIS can create files of selected sets of information which may be exported to these other systems such as the MIS and SCADA systems.

7. PRODUCT GENERATION

Once the system has been built users will begin to request to get information out of the system. The information can be extracted from the system in several ways.

Often the type of information be requested can be best displayed in tabular form. Customized reports for submittal to regulatory agencies can be generated from the database.

Other types of information might be best displayed in map form. Maps may be retrieved for display on the monitor screen or may be plotted to hard copy for use by planners, engineers, work crews, or private citizens.

E. OTHER CONSIDERATIONS

1. STAGED EXPANSION OF THE SYSTEM USES

To receive the maximum amount of benefit from the system in the shortest period of time many organizations stage the development of their systems.

The proposed strategy is to stage the development of coverage data. By beginning with only data essential to the surface water management plan data integrity of the system will be protected from the onset. Detailed attribute information the system will be added as it is available. Additional infrastructure coverages may then be added either as it exists or as it becomes available. A suggested list includes:

- Topographical
- Surface waters
- Water infrastructure
- Roads and streets
- Electrical

2. TRAINING

Often neglected is the need for adequate training of the users of the system. Users typically come from a variety of backgrounds with a wide range of computer knowledge. No system will be used optimally unless steps are taken to insure an adequate level of expertise.

A program that involves key city personnel during the development stage will greatly assist in the transition to regular use by the city. Instruction in the use of all hardware and software will be provided during the implementation process once the system is complete.

Once initial system setup and data entry for major layers is completed, key City personnel will become increasingly incorporated into the GIS development process. The best use of the system may be achieved by maintaining the continuity created by involving system users from the beginning.

Perhaps the two most important aspects of a successful program are knowing how to use it and knowing what can be expected from it. The first aspect is focused more towards data managers, technicians, and operators and requires comprehensive training. The second aspect involves informing managers, planners, and engineers of the systems capabilities and training for effective information retrieval.

As system development nears completion, the consultant will work closely with GIS managers in developing training seminars for daily operators as well as those who will use the system on an infrequent basis.

3. SECURITY

Maintaining the integrity of information in the system is a vital concern in GIS. A number of security measures will be developed into the system to prevent loss or corruption of the database. Some of these include regular system backup, the use of passwords, establishing certain files as read only, and setting up certain stations for viewing only.

F. CONCLUSION

This appendix has provided recommendations for the purchase of hardware and software for an infrastructure GIS. It has been shown that the GIS will be indispensable during the development of the Surface Water Management Plan and as a long term utility management tool.

Platform

Having considered the needs of the City's Utility Department it is our recommendation that the platform for the system be personal computer based. Specifically, we would recommend a 486 or P5 running at 50 or 66 mhz with a minimum of 32 mb of RAM. Also, the system should have a high storage capacity hard drive, preferably 250 to 500 mb, with backup storage by Bernoulli box or tape drive. At some point in the future the option to upgrade the system to the workstation platform may be examined.

Peripherals that are recommended include display, input,and output devices. For display a large (17" minimum) screen color monitor is suggested. For input a large format digitizing tablet (24" by 36" active area minimum) would be needed. For output a plotter and printer should be purchased.

This station could be linked by network with 2 to 3 existing personal computers to provide a mix of capabilities at several stations throughout the Utility Department.

Software

Arc-CAD by ESRI is recommended for its versatility, expendability and portability. It meets the discussed criteria of accuracy and support software capabilities.
will be detailed in the Phase I final report.

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APPENDIX G
MODELLING

A. INTRODUCTION

In general there are a number of questions regarding operation of the system, its flood control performance, its water supply capability, water quality management, and its recovery with regard to the natural or man induced introduction of pollutants. Traditional modeling approaches would require several models, each having its own input data requirements and input data format. In an effort to minimize this diversity and thereby reduce the cost of data preparation and potential for inaccuracies that could be introduced, it is recommended that a single model be provided for the primary system (canals, lakes and structures).

The Aquarian Watershed Simulation Model (AWSM) is recommended for use in modeling long term system behavior as well as response to storm events. In its current form, AWSM is a quantity model (as opposed to quality) that tracks up to 13 variables and parameters throughout the surface water and surficial aquifer systems. This appendix provides a brief description of AWSM, its data requirements and how it will be used to evaluate the existing Cape Coral system as well as proposed modifications. In addition, modifications to the model for water quality (concentration and mass loadings) will also be discussed.

B. DESCRIPTION OF AWSM

The base model proposed is the Aquarian Watershed Simulation Model (AWSM), distributed by Aquarian Software, Inc.. This is a relatively new code that was developed by Rodney D. Ghioto and David A. DeLoach, of Ghioto & Associates (members of the project team), to address a variety of needs using a single physical source of input data.

The current version of AWSM models the following variables:

- Rainfall (spatially and temporally varied input)
- Evaporation form Surface Water Bodies
- Evapotranspiration from Vegetated Uplands
- Runoff to Surface Water Bodies
- Soil Moisture
- Percolation to the Water Table
- Water Table Elevation
- Two-dimensional Surficial Aquifer Flows
- Leakance Between Surficial and Deep Aquifers
- Seepage Between Surficial Aquifer and Surface Waters
- Surface Water Stages (Elevations)

- Flows through Surface Water Systems
- Sinkhole or Spring Connections Between Surface Waters and Deep Aquifer

Irrigation will be included in the next version, which is currently underway, to be taken from the shallow aquifer, the deep aquifer, surface water bodies or external sources. The model is set up so that all parameters need not be supplied. For example, if the modeler wishes to only simulate surface systems, he simply does not input groundwater relate elements.

Surface water features that are hydraulically modeled include:

- Open Channels, Lakes and Swamps
- Junction Channels
- Junction Channels with Structures
- Bridges
- Bridges with Risers
- Culverts
- Culverts with Risers
- Weirs and Orifices
- Gated Water Control Structures (Operable)
- Pump Stations (Operable)
- Off-site Inflows

AWSM allows for the simulation of very complex structures consisting of multiple elements.

Runoff simulation includes:

- Direct Rainfall (continuous & event)
- Direct (lumped) Basins (continuous & event)
- Kinematic Overland Flow (continuous & event)
- Unit Hydrograph Methods (event only)
- Santa Barbara Urban Hydrograph Method (event only)

Output from the model is stored in a digital data base for retrieval. For event simulations, the data is retrievable in a number of forms on a time increment stipulated by the user. Time series plots (e.g. hydrographs) can be retrieved for all parameters. In addition, flood stage-depth-duration analysis can be performed for quantifying flood damages and determination of flood severity.

For continuous simulations, the data are stored as daily of hourly averages and can be retrieved as discussed above. In addition, statistical analysis is also available on any parameter for determination of resource reliability or system performance over years. Other analyses that are included consist of relations between parameters, water budgets (surface and surficial aquifer) and double mass curves (used to determine yield). A duration analysis is also included which is useful for pre- and post-project hydroperiod comparisons.

AWSM has been used and has been well calibrated on two projects over the past two years thereby demonstrating its ability to simulate both flood events as well as long term continuous records. It has also been successfully linked with the Arc-Info Geographical Information System (GIS) Data Base by Ghioto & Associates for a 46 square mile watershed in Pasco County, Florida. This capability insures that spatial data are handled only once thereby minimizing the opportunity for input data errors.

AWSM is well suited to programming for operational strategies through incorporation of operable structures and pumps with settings that can be changed automatically with conditions within the system. Because it continuously tracks soil moisture, it can be made to simulate irrigation events as well.

Beyond its current capabilities, the largest advantage of this model is that it can be modified by the authors as necessary to include any new capability or refinements that may be dictated by the project including data linkages to the selected GIS system, SCADA, and other software systems. Additional advantages are that it can be licensed to the City, upon completion of the modeling efforts, and training of city Staff can be provided on use of its output data base as well as its use for future model updates. Its programming structure and execution speed are such that it can be modified for use in a real time mode to do operational projections based on field conditions. This may also be a useful feature as system modifications are incrementally made requiring operation in a partially completed condition.

AWSM is currently implemented on PCs. However, it is anticipated that a work station version will be available in the near future.

C. DETAILED MODEL SETUP

As discussed in the foregoing report, AWSM will be used on a detailed model network and on a screening model network. These will be referred to as the "detailed" and "screening" models in following discussions. In setting up either model, there are a number of tasks that must be accomplished and considerations taken into account.

1. INITIAL MODEL NETWORK

The starting point for model building is the development of an initial network of surface water nodes and reaches for which we wish to compute water surface elevations (stages) and discharge rates, respectively. This network will be constructed for the detailed network using the following criteria:

- Placement of nodes at all primary system extremities
- Placement of nodes at all channel junctions
- Placement of nodes upstream and downstream of all water control structures

- Placement of nodes upstream and downstream of all road crossings
- Placement of nodes at all irrigation withdrawal locations
- Placement of nodes at all lakes
- Placement of nodes where channel configuration changes

Fathometer profiles will be used along with aerial photography and field visits to determine the initial placement of nodes in the primary system. After this process has been completed, additional nodes will be distributed throughout the network to bring overall spatial precision up to an acceptable level.

Reaches will then be defined to produce linkages between the nodes described above. These will consist of channel reaches, bridges, culverts, weirs and gates, and pump stations. The geometry of the resulting network will then be used to determine locations of initial field surveys required to specify channel cross sections and structure information for the model.

2. SUB-BASIN DELINEATIONS

In theory, a sub-basin contributory to each node in the system can be drawn. For areas within the City, these will be defined as collections of smaller sub-basins already defined for the secondary drainage systems. For areas outside of the City, this step will include delineations of natural and man-made divides based on aerial photogrammetry and field investigations. These sub-basins will be added to the GIS for subsequent model input data development.

Groundwater nodes will initially be determined from a direct projection of the sub-basin delineations vertically downward through the surficial aquifer. These will then be reviewed to determine if additional spatial precision is needed for modeling water table elevations or seepage flows to and from channels and lakes. Another reason for refinement consists of areas where surface soils or aquifer properties differ enough (spatially) to warrant higher precision. Where additional precision is needed, further refinements to the surface sub-basins and surficial aquifer nodes will be made.

Groundwater links will be established between groundwater nodes using the above described geometry. In addition, seepage connections to surface water bodies will also be developed.

3. DEVELOPMENT OF SUB-BASIN DATA

Information required for hydrologic specification of sub-basins includes: area, percent impervious, soil properties (e.g. saturated conductivity, porosity, matrix suction head, etc.). These data are a function not only of the Sub-basin Geometry Coverage, but also include spatial data from the Soils and Landuse Coverages. All three GIS coverages will be mathematically intersected resulting in a fourth coverage containing polygons with unique combinations of parameters. This last coverage will then be used to develop sub-basin weighted values for all hydrologic parameters required by AWSM.

4. DEVELOPMENT OF SURFICIAL AQUIFER DATA

Surficial aquifer properties include: thickness of the aquifer, thickness of the confining layer, saturated conductivity and storativity. These properties will be developed from previous geologic and hydrogeologic studies and data collection programs. Soil borings associated with past construction projects will also be used. It is anticipated that additional borings will be required to adequately determine spatial variability. These data will be included in the GIS on separate coverages. The resulting coverages will then be used to determine groundwater node and link input data based on spatially weighted values.

5. DEVELOPMENT OF SEEPAGE DATA

AWSM requires estimates of saturated conductivity in the upper aquifer/soil zone to enable an accurate depiction of seepage rates between surface water bodies and the surficial aquifer. These data will depend not only on the intrinsic property values, but also on the model's resolution. Therefore, their specification will need to be refined through use of the seepage field studies coupled to localized models of the aquifer in the vicinity of the collected data (at piezometer transects). These models will consist of two-dimensional representations of the profile (along the transect and vertically downward). Calibrated saturated conductivities obtained through use of these models will then be input to AWSM.

6. DEVELOPMENT OF LONG TERM HISTORIC DATA

Continuous modeling will require that all necessary rainfall data, evaporation data, and boundary condition data be provided in a time series format without interruption. In order to accomplish this requirement, it is necessary to evaluate all of the data records to determine where data gaps may exist and to develop methods for filling those gaps. Filling data gaps will consist of direct substitution of alternate data records or through statistical correlation where considered necessary. This process will also determine the lengths of data records available for calibration and verification that will be possible as well as the length of data records available for long term continuous predictions. The end product of this task is a series of data files that will be used directly by AWSM for simulations and for comparisons of results to historic conditions.

7. RAINFALL FREQUENCY ANALYSIS FOR STORM EVENTS

Rainfall frequency analysis of long term rainfall stations will be performed to determine volumes and durations of rainfall for storm event simulations. The computer program FREQ, developed by Ghioto & Associates will be used for this task. It will produce frequency relationships for all of the desired rainfall durations in tabular and graphical form.

D. DETAILED MODEL TESTING

After all of the model input data has been assembled, the resulting data sets will be tested through repetitive simulations on both a continuous and event basis. This process will lead to additional model refinements, that will add precision and accuracy to the model, as well as provide for the elimination of obvious data problems introduced during the data preparation process.

Refinements normally made include the specification of overland popoffs and connections that hydraulically occur during major storm events. These and other changes will increase the complexity of the model and possibly generate additional surveys to obtain physical data for their inclusion.

E. DETAILED MODEL CALIBRATION AND VERIFICATION

It is extremely important that the predicted hydrologic and hydrodynamic response of the system be modeled as accurately as possible. For continuous modeling over a period of several years, a relatively small but persistent error can have a significant effect of predicted water availability. In addition, water quality simulations depend heavily on both hydrology and hydrodynamics to predict both loadings and the fate of pollutants in the system.

The calibration and verification process is used to establish the accuracy of the model in predicting system behavior. This process consists of simulating historic events in a predictive mode and then comparing results to actual measured system behavior. During calibration, adjustments can be made to certain model parameters in order to force the model to reproduce the historic events. However, the verification process is then used to simulate additional events (not modeled during calibration) without further adjustments to model input data. If this second step produces adequate prediction of historic system responses, the model can be pronounced verified. One can then have a level of comfort in believing model outputs for predictive simulations for which historic data are not available.

Important calibration and verification variables for this process consist of stages, surface water discharges and water table elevations. Additional variables including seepage and water quality constituent concentrations will also be used in the calibration and verification process.

F. SCREENING MODEL SETUP

Even though AWSM is a relatively fast model with respect to run times, the detailed model is expected to be too slow for the intense usage that will be required in development and evaluation of alternatives in the multi-variate analysis segment of the project. Therefore, simpler screening models are necessary that provide a reasonable level of accuracy with a minimum number of computations. Screening models will be developed first by reducing the complexity of the models through provision of fewer sub-basins, nodes and reaches. In addition, the physical size of the network can be reduced by supplying previous (detailed model) model computations as boundary conditions to a smaller study area. This latter method may be useful in handling the Gator Slough system (or the upper part of it) as a computed boundary condition. A third method of model simplification can result from handling water control structures and road crossings with families of rating curves instead of the more rigorous (but more accurate) convergence algorithms that AWSM currently uses.

The screening model will be subjected to the same level of testing, calibration and verification used for the detailed model to insure that they provide a reasonable approximation to system behavior. It should be noted here that screening models will provide a rapid methodology for comparing alternatives under varying degrees of implementation. Once final alternatives are selected, they will be modeled again with the detailed model to insure that the proper level of accuracy is obtained.

Selected outputs from the screening models will be routed to data files which will then be read and analyzed by the optimization software. It is anticipated that these analyses will result in additional alternative combinations that will then be run through the screening and optimization processes. Therefore, the use of screening models can be considered to be iterative to some extent.

G. MODIFICATIONS OF AWSM FOR WATER QUALITY SIMULATIONS

There are a number of models available for water quality evaluations including some that compute hydrodynamics at the same time. However, these are usually for short term simulations and provide very little insight into the more important water quality questions related to mass loadings to the canal system or receiving (offsite) waters. Enhancement of AWSM to model water quality is logical because system behavior (and loadings) can be predicted over long periods of time.

1. ANTICIPATED MODIFICATIONS TO AWSM

These modifications will be provided in two major areas: computation of upland loads and computation of constituent concentrations within the primary system. In the first case, it is possible that AWSM could be directly linked with SLAMM to compute upland and BMP loadings to the canals and lakes. If not, a similar algorithm will be constructed for this purpose and results will be calibrated to SLAMM outputs as well as collected data.

A mass transport algorithm will be added to the hydrodynamics portion of AWSM to handle instream predictions of constituent concentrations. This algorithm should be capable of simulating salinity, nitrogen, phosphorous, and suspended sediment (at a minimum) and should incorporate longitudinal dispersion terms. It should also be capable of incorporating evaporation effects as well as groundwater inflow and outflow into computation of concentrations. A similar mass transport algorithm will be added to the groundwater portion of the model to track pollutants and other water quality constituents in the surficial aquifer.

AWSM will be fitted with the ability to accept both point source and distributed source inputs for the surface water and groundwater algorithms. For example, distributed sources will be used to simulate inputs from septic tank systems and irrigation within sub-basins, atmospheric loadings and other similar sources. Point sources will consist of inputs from secondary conveyance systems (e.g.SLAMM) and similar single location contributions. These can also be used to model the fates of spills and other emergency conditions if warranted.

The above model modifications will be subjected to calibration and verification processes for transport of constituents and will be incorporated into both the detailed and screening models.

2. DEVELOPMENT OF WATER QUALITY DATA

AWSM will require boundary condition data for water quality as well. In addition, calibration and verification data will be necessary within the system.

Boundary condition data will consist of the specification of quality parameters for the deep aquifer from well data and an estimation of atmospheric contributions using previous studies within Florida. Surface water quality data for boundary conditions will not be necessary since the entire contributory watershed will be modeled. However, quality of sources to the system (e.g. irrigation water from the STP's) will be necessary. Historic information as well as additional water quality data collected during the project will be used for calibration and verification.

APPENDIX H
PUBLIC INFORMATION PROGRAM

A. INTRODUCTION

A task identified in the first phase of the Surface Water Master Plan is to develop the guidelines and structure of a quality Public Information Program. The objective of this program is to provide the City with a mechanism for positive communication with the public and will assist in obtaining public support for the remainder of the Master Planning effort.

The goals of this program include:

- Develop methods and procedures to better educate the citizens of Cape Coral on surface water related items such as how the spreader waterway works, how water withdrawals from the canals effects recreational activities in the canal system, what is being accomplished with the Master Planning effort, etc.

- Provide a mechanism for public input.

- Gain public support for further developing/improving the stormwater utility.

This document outlines the structure of the Public Information Program. Phase 2 of the Cape Coral Surface Water Master Plan will provide for implementation of this program.

B. PROGRAM STRUCTURE

The first task to be undertaken in developing a quality Public Information Program is the organization of a public relations committee. Their primary function will be to determine the means, methods, and subject material to be used that will begin and continue to educate the citizens of Cape Coral on Surface Water Master Planning. The committee should consist of non-technical as well as technical members. This will provide for a more well rounded approach when procedures and public education material are developed for distribution. In discussions with city staff it was determined that the public information committee should consist of the following:

- Publicly elected official or individual that is well respected in the community

- 2 members from the public at large

- 2 city staff members (1 from public relations)

- 2 members from Stormwater Master Planning consultant team

The 7 member committee should be a workable size so that work can be accomplished in an effective and timely manner.

C. METHODS TO EDUCATE THE PUBLIC

There are various effective methods available that can be used to better inform or educate the citizens of Cape Coral on what is to be accomplished during the Master Planning effort. The methods recommended for consideration are:

- Video presentations
- Displays/brochures
- Media releases and T.V. programs
- Public presentations to organizations and Town Hall meetings
- Direct communication link with the public, direct mail, etc.
- Grade school, high school, and college classroom lectures

1. VIDEO PRESENTATION

Professionally developed videos may be produced to pictorially present detailed information on selected subjects. Once developed, they can be circulated to television media and various organizations throughout the City. They can be made accessible to the public by providing self operating video booths at City Hall and other public locations. These presentations will generally last approximately 15 minutes. Video presentations to consider include:

- Spreader waterway history and function.
- Surface water quality Best Management Practices (BMPs)
- Goals of the Surface Water Master Plan
- The many roles the stormwater system plays in our community

2. DISPLAYS/BROCHURES

This method can be effectively used by providing displays and brochures of selected educational material in locations such as City Hall, the public library, etc. Subject material may include:

- Explanations and diagrams which describe how the freshwater canals depend on groundwater for supply irrigation.

- Exhibits explaining the history and the purpose of the spreader canal system.

- Diagrams depicting BMPs as related to stormwater runoff quality and quantity.

Brochures could also be distributed quarterly by enclosing them with utility bills. This is the one direct method which provides all users with educational materials.

3. MEDIA

The media such as local educational television networks, radio broadcasts, newspapers, and magazines can also be used effectively to better educate the public on surface water. Local educational television stations could show the video presentation, as previously discussed, at selected times. Local radio broadcasts could be used for public discussions and dialogue on the subject. This will provide citizens with an opportunity to ask special interest or general questions with regard to Surface Water Master Planning. Local newspapers and magazines could be used to provide column series or documentaries and educational materials such as those mentioned for displays and brochures.

4. PUBLIC PRESENTATIONS

Public presentations may be used as an effective public information program. Public presentations could be performed for organizations such service clubs, Cape Coral Engineering Club, Chamber of Commerce, etc. The video presentation discussed earlier could also be used in this forum.

5. DIRECT COMMUNICATION LINK WITH THE PUBLIC (SURFACE WATER HOT-LINE)

A direct communication link (hot-line) will provide the general public with a direct means of communication concerning Surface Water Master Planning. This will consist of providing the public a location to call for the specific purpose of asking questions or expressing concerns about surface water issues. Phone calls received would provide information such as name of caller, date of call, question, and answer (all information will be recorded).

This program may provide information to help select subjects for displays, brochures, presentations etc. An example of this is if citizens were asking repetitive questions concerning a specific subject such as "Why does the water level in the canal rise and fall?" or "Why are the canal systems at different levels?" then this would provide an indicator that we may want to focus on providing educational information concerning this subject.

6. LECTURES TO GRADE SCHOOL, HIGH SCHOOL, AND COLLEGE LEVEL STUDENTS

Discuss the engineering, ecology, biology, sociology, etc. associated with the surface water system.

D. SUMMARY

The public relations committee will be charged with the task of implementing an effective Public Information Program. The means and methods previously discussed can assist the committee in developing an effective program. As the Stormwater Master Plan evolves, some of these methods may prove to be more effective than others. Some may even prove to be ineffective or new methods may need to be developed. However, this material will provide the committee with direction to initiate a more effective, on-going information program.