TEN MILE CANAL WATERSHED

TEN MILE CANAL

46C

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1. WATERSHED BOUNDARY MAP

The Ten Mile Watershed is located near the geographic center of Lee County. It encompasses approximately 68 square miles. The Six Mile watershed contributes 55 of the 68 square miles within Ten Mile Canal Watershed. The cross hatched area shown on page 46C-W4 contains the other 13 square miles. Most of the references to Ten Mile Canal watershed will be for the portion that does not include the previously studied Six Mile Cypress Watershed. The watershed is bounded on the north by Hanson Street and its extension east to Ortiz, north along Ortiz to SR 82, SR 82 southeast to Gunnery Road. The easterly boundary follows the extension of Gunnery Road southwest to the intersection of the west section line of 21-45-26, then follows section lines and quarter section lines as described in the Six Mile Ordinance until it intersects with Alico Road. The southern boundary is along Alico Road to US 41. At US 41 it goes south to Park Road, then follows west along Park Road to Ten Mile Canal. The western boundary is the western dike along Ten Mile Canal. This dike extends north to Hanson Street. The majority of the non-Six Mile watershed portion of the Ten Mile Canal watershed is that portion of the watershed north and west of Six Mile Cypress Parkway within the above described boundary.

The entire watershed lies to the east of the main conveyance which is Ten Mile Canal. The configuration of this watershed was created by construction of the Ten Mile Canal dike in approximately 1920. Very little has changed the watershed boundaries since this construction. At that time, the dike/canal was a part of the Iona Drainage District and referred to as the "Line A Canal." The main purpose of this dike/canal was not to provide a conveyance for this area but to provide a shield to prohibit water east of the dike from going west to the Caloosahatchee. Construction of this canal and its dike on the west side removed the upstream portion of several watersheds. Those watersheds that were changed were Carrell Road Canal, Winkler Canal, Whiskey Creek and Hendry Creek. The Carrell Road and Winkler Canal watersheds are within the City of Fort Myers. The greatest effect was on Hendry Creek since the majority of the Six Mile Slough Watershed was connected to Hendry Creek. The watershed boundary shown in the 1991 draft Soil Conservation Service report is similar to that shown on page 46C-W4.

Other less dramatic changes to the watershed have been made by the construction of Alico Road. Alico Road provides a distinct boundary for water that used to flow south into the Estero River and Mullock Creek watersheds. This water now flows west to Ten Mile Canal and enters Mullock Creek much farther downstream. Flow can occur both east and west across the east boundary. Antecedent conditions and rainfall are two primary factors in the determination of flow direction along this boundary.

Construction of Six Mile Parkway has solidified the watershed divide between Six Mile Cypress Slough Watershed and the remainder of the Ten Mile Canal watershed. This boundary was poorly defined prior to the construction of the road. There is very little deviation now of the watershed boundary along this roadway. There are locations that allow water to discharge from Six Mile Slough west in a more direct route to Ten Mile Canal. One is just north of Penzance Road. The second is at the north side of Daniels Parkway. These conveyances are strictly controlled and only used during times of high water in Six Mile Slough. A map of the watershed is shown on page 46C-W4.

The dike along the west side of the canal has been breached by road crossings. Most notable are the Six Mile Cypress Parkway road and ditches, the south ditch along Daniels Parkway, Colonial Boulevard road and swales and Winkler Boulevard. Overflow from the canal will occur during periods of high stages in the canal. To date, water has not been conveyed through these breaks in quantities that have been detrimental. Design of facilities west of the dike and canal should plan on receiving water from Ten Mile Canal as water levels approach the top of bank.

CONCLUSIONS

1. The boundary has not materially changed since 1979.
2. There can be circumstances (uneven rainfall distribution, etc.) in which surface water crosses the eastern boundary.
3. Roadway construction has clearly defined several boundaries.
4. Overflow from Ten Mile Canal can occur across the west side of the watershed.

RECOMMENDATIONS

1. Maintain the existing boundary.

2. Design projects west of west boundary in anticipation of overflow from Ten Mile Canal.

Boundary Map

2. SENSITIVE LANDS

The information necessary to complete this task is from reliable sources of historical data pertinent to the project needs. These data and their sources are discussed in detail in Volume II of the Six Mile Cypress Watershed Plan.

The Ten Mile Canal Watershed contains several core wetlands. The boundaries of these wetlands were mapped using the following criteria:

1) The wetland would be jurisdictional to all environmental agencies. NOTE: some wetlands may be isolated from "waters of the State" as defined by DER.

2) The wetlands were "persistent" in that wetland vegetative species dominate.

3) Depressional or hydric soils are present.

4) Evidence of past or present long term inundation.

5) Exclude areas with major infestations of exotic plant species. Will be included in flow-way on condition the exotics are removed.

6) Exclude areas with rare or unique upland types in order not to include them in wetland flow-ways or other wetland uses.

The core wetlands adjacent to the Ten Mile Canal were analyzed using rectified aerial photography with topographic contours (where available) and then field verified. The core wetlands map is shown on page 46C-W10.

Relevant "Lee Plan" (as amended January 31, 1990) policies were identified and reviewed for applicability to the Surface Water Management Plan for the Ten Mile Canal Watershed. Those applicable policies fall under goal 37, policies 1.1 and 1.7, goal 38, policies 1.2 and 1.4 and goal 39, policies 1.1, 2.1 and 3.4 which concern protection of life and property, surface water management and land planning and protection of groundwater resources.

Surface water in the Ten Mile Canal Watershed feeds into Ten Mile Canal, the primary drainage conveyance, then discharges into Mullock Creek, and thence to Estero Bay. Nearly the entire portion of the watershed excluding Six Mile is urban, resulting in severe alterations to the timing, quantity, and quality of water flowing into Estero Bay. These changes have adverse and continuing impact on sensitive lands.

Historically, a sheet flow of fresh water across wetland systems fed the headwaters of Hendry Creek, a major tidal creek of Estero Bay. The creation of Ten Mile Canal about seventy years ago and subsequent urban development of adjacent land has prevented this sheet flow from reaching these wetlands. These activities likely have caused changes to the biotic communities in the Hendry Creek, Mullock Creek and Estero Bay ecosystems. Salinity levels, duration, temporal and spacial variation are known to produce responses by estuarine organisms. Color, turbidity, pH, and macro-nutrients will produce important responses by estuarine organisms (see Estero Bay Report). Acidic stormwater will drive out many mobile organisms, high color and turbidity will sharply reduce primary production by phytoplankton and limit the depth distribution of seagrasses, and additional nutrients will contribute to the eutrophication of the Estero Bay ecosystem. All of these characteristics occur when the Ten Mile Canal discharges water as the result of wet season storms.

The intense urban development in the Ten Mile Watershed leaves few simple opportunities to restore historic water patterns. Projects that provide water detention/retention and water quality benefits (cleansing capabilities) are initial steps for preventing further water quality/quantity degradation.

Two general approaches should be considered:

1) Creation of new wetland systems within the canal.

2) Diversion of the water within the watershed to existing wetland systems.

Several examples of these approaches follow. A linear spreader system planted with harvestable wetland species can be constructed within several areas of the Ten Mile Canal right-of-way (see Ten Mile Proposed Plan and Profile) and is a recommended project. The diversion of sheet flow across an approximately 18-acre core wetland next to Ten Mile Canal just south of Colonial Boulevard may deserve consideration at a future date. Existing water elevations and culvert sizes may be constraints. The value of this land as commercial property may increase costs to the point that the benefits may be difficult to justify. A borrow pit located in the southern tip of Ten Mile Canal watershed can receive water from Ten Mile Canal. Each of these examples may provide some water detention and cleansing functions.

The options of increasing freshwater inflow to Hendry Creek and its adjacent eastern wetlands to more approximate historical levels should be considered. Spreader waterway systems to divert water flow from the Ten Mile Canal into the eastern marsh and mangrove systems adjacent to Hendry Creek would improve the relatively drier conditions. Two options may have merit. One spreader system could be located to divert water to the headwater region of Hendry Creek and the other located near the mouth of Ten Mile Creek extending toward Hendry Creek adjacent to the coastal marsh and mangrove system. Both of these options are beyond the scope of this study and require additional examination.

There appear to be no opportunities for storage and recovery of treated stormwater (see discussion Volume III). There is a proposed incentive and acquisition plan (July 16, 1991) for a riverine corridor in this watershed along the main trunk flow-way. There are no core wetlands associated with the primary system which could be included or should be considered for acquisition in the plan.

CONCLUSIONS

1. The discharge system of the Ten Mile watershed into Mullock Creek prevents fresh water from sheet flowing to the eastern tidal wetlands of Hendry Creek and then into the creek.
2. Existing freshwater wetlands to the west of Ten Mile Watershed have not received water that prior to about the past 70 years historically came from the east.
3. The Ten Mile Watershed exhibits severe alterations of the timing, quantity, quality and location of water flowing into Estero Bay as the result of drainage improvements and urban development over the past 70 years.

RECOMMENDATIONS

1. Construct a linear littoral system planted with harvestable wetland species within the Ten Mile Canal right-of-way.
2. Divert water from Ten Mile Canal into the borrow pit in the southern tip of Ten Mile Canal watershed.

The following require further study and cost analyses before considering implementation:

3. Divert water from Ten Mile Canal through a spreader waterway into the coastal marsh and mangrove systems that comprise the headwaters of Hendry Creek.

4. Divert water from Ten Mile Canal to a fresh water sheet flow pattern across the coastal marsh and mangrove systems next to Mullock Creek.

WETLANDS MAP

3. CONVEYANCE ELEMENTS

The conveyance elements along Ten Mile Canal have changed dramatically in the past twenty years from the original Line A Canal improvements to the present system. The Line A Canal originally had no water control structures to provide dry season water table maintenance. Also, there was no salt water barrier placed in the canal. The canal crossings were constructed only to provide access to the other side. Very little thought was given to the hydraulic consequences of placement of a particular crossing. The canal courses along the entire west edge of the watershed.

The land use has also changed within the watershed. Agricultural uses, sparse residential and vacant lands have been replaced with light industrial, commercial, multi-family and more intense single-family development. About 30 percent of the watershed is now developed. Much of the development has large amounts of impervious coverage. Some have adequate quantity detention per South Florida Water Management District (SFWMD) regulations, while others have only water quality detention per SFWMD. This will adversely impact the primary conveyance, if all developments are not required to provide adequate quantity detention with the water quality detention.

In the early 1970's, expansions of the canal began. These expansions included all elements. The channel was deepened and widened. Also, some improvements to the west dike were made. The water control structures needed for water table maintenance and protection from salt water intrusion were constructed. There are three such water control structures in the canal today. Structures in or across Ten Mile Canal are shown on page 46C-WM.

The first control structure is the Tamiami Weir located immediately upstream from US 41. It provides a salt water barrier and dry season water level control. The crest elevation is 5.5' NGVD. The second control structure is about two and a half miles upstream from the first and immediately north of Daniels Parkway. The crest elevation is 10.0' NGVD. Each of these control structures has a pair of bottom opening gates. Each gate is 5' wide and 4' high. These gates provide flexibility in the management of the canal system. They provide additional maintenance capabilities that a simple fixed crest weir does not possess.

The third water control structure is a sand-cement rip rap bag shell over an earthen dike. It is located immediately north of Idlewild Street. A single 48" culvert with riser has been placed through this to provide the capability of bleed down capacity upstream of the weir. Structures of this type are relatively inexpensive to construct but operation of the flashboard riser is difficult. This structure has a crest elevation of 12' NGVD.

Changes have been made to most of the Ten Mile Canal crossings. The old wooden bridge at Park Road, south of Alico, has been completely removed. The next bridge is located at US 41. Two concrete bridges provide road crossing at this location. These bridges create very little constriction of the channel.

The next bridge upstream is at Briarcliff Road. The existing concrete bridge replaced a wooden structure in 1975. The replacement structure provided a much higher low chord and fewer bents to provide better hydraulic conveyance through the structure. The bridge does not span the entire width of the enlarged canal. If replaced, it should be lengthened to span the canal like the other bridges.

In late 1979 a new bridge was constructed across Ten Mile Canal for Six Mile Parkway. This bridge was built high enough that the low chord is well above the 25-year - 3-day design event. Also, relatively few pile bents were used, thereby providing good hydraulic characteristics. A replacement similar to the Briarcliff Bridge has been made at the Daniels Parkway crossing. The new bridge was constructed in 1979. Again the low chord was raised and the number of pile bents was greatly reduced. This bridge spans the entire width of the widened channel. The Daniels Parkway bridge was widened and a second bridge built with the road widening. This improvement kept the low chord well above the 25-year - 3-day event.

To the north of Daniels Parkway, a new bridge was constructed when Crystal Drive was extended east across Ten Mile Canal to Metro Parkway. This bridge was built in 1986. Approximately one and one-half miles north of Crystal Drive is the Idlewild bridge crossing. Both bridge crossings have been constructed with the low chord above the 25-year - 3-day design event and with relatively few piles in the canal.

South of Idlewild there is an aerial utility crossing. Aerial crossings represent additional obstacles to flow. It is preferable to bury utility crossings at least three feet below the bottom of the design or existing channel; whichever is lower. Clear markings should be placed at the top of bank on both sides to inform maintenance workers. Where an aerial crossing is a necessity, then consideration should be given for passage of maintenance vehicles in the canal. At a minimum, follow the bridge guidelines for low chord elevation given in Section 3, Volume III.

A railroad siding crosses Ten Mile Canal just south of Colonial Boulevard. This bridge has many supports that block flow of water and debris. This bridge collects large quantities of debris and aquatic plants that are floating downstream. Due to relatively low velocities, the energy losses were not significant during the 1990 observations. A reduction in the number of pile bents should be made when the railroad considers bridge replacement. Immediate replacement due to the bridge's constrictive nature should not necessary.

The Florida Department of Transportation constructed a concrete bridge over the canal when Colonial Blvd. was extended east in 1975. This bridge is built lower than most of the other bridges. High water has exceeded the low chord since the construction of the bridge. The bridge does not cause a major constriction at this time due to the small energy loss. It should be noted that flood waters may overtop the roadway in large storm events.

The most northerly crossing of the canal is at Winkler Road. This crossing was constructed in 1982. The low chord of this structure is lower than the Colonial Boulevard bridge. Upon reconstruction, this bridge should be raised.

One part of the conveyance system often neglected is the channel itself. Maintenance is its greatest need. Some areas have been excavated to design depth and/or width. Areas that have not been fully excavated are near Park Road, between Tamiami Trail (U.S. 41) and Six Mile Parkway and between Winkler Avenue and Hanson Street. Development has been allowed in a portion of the right-of-way near Park Road. Silt removal through normal maintenance is needed to keep the hydraulic capacity. Although needed along most of the channel, the most strategic initial silt removal should occur in the first 500 to 1,000 feet upstream from each weir. Plant removal is also important to maintaining the hydraulic capacity of the channel. Plant growth can easily reduce the flow capacity tenfold. See the discussion of Manning's 'n' in Section 7, Volume III. The aquatic plants have value to improve water quality, but require active management.

CONCLUSIONS

1. Several areas of the canal have not been excavated to the design cross section (Re: Original Ten Mile Canal plans of July 1975 vs 1990 SCS cross sections), among which are the following:

    a) Old Park Road area.

    b) Area between Tamiami Trail (U.S. 4l) and Six Mile Parkway.

    c) Area from south of the railroad bridge to Hanson Street.

2. The railroad bridge south of Colonial Boulevard collects debris and aquatic plants.

3. The primary conveyance is the Ten Mile Canal.

RECOMMENDATIONS

1. Bury all utility crossings with a minimum cover of three feet below the existing or design channel bottom, whichever is lower.
2. Excavate remainder of channel to design section.
3. Increase the frequency of aquatic plant removal upstream from the railroad bridge.

4. RIGHTS-OF-WAY

Much of the right-of-way or easement along Ten Mile Canal can be traced back to the old Iona Drainage District. Widths vary from approximately 260 feet at the south end to 135 feet wide at the north end. There are several places where there are variations along the route. These are shown graphically on pages 46CS-R/WM and 46CN-R/WM.

The canal and accompanying dike are built adjacent to the western right-of-way along its entire length. The eastern side of the right-of-way has some additional room for expansion, which is limited by several constraints. The first constraint is the Seminole Gulf Railway track. This runs parallel to the canal on the east side from approximately the Briarcliff conveyance entrance into Ten Mile Canal, north to Hanson Street. Widths vary in this reach of the canal. From Colonial Boulevard south to Daniels Parkway there have been several areas used for detention ponds as part of the Metro Parkway widening. With the railroad to the east, this limits any further expansion of the canal. South of Daniels Parkway there is 40 to 60 feet of additional width on the east side of the canal. A portion of this width could be made available to expand the canal, especially for littoral shelves to provide habitat diversity, water quality improvements and aesthetic improvements to the existing canal.

South of U.S. 41 there are some opportunities to widen the canal where previous borrow areas had been created. Review of development of these properties should include additional right-of-way or easements for water management purposes along Ten Mile Canal. Expansion of easements may also be considered for water quality treatment by allowing water to run from Ten Mile Canal into and/or through the existing borrow areas.

The rights-of-way/easements along Ten Mile Canal are generally of adequate size. Some of these are by occupation only. Some additional room would be desirable around the Tamiami Weir. The present weir configuration utilizes the entire existing right-of-way. See the map on page 46CS-R/WM for the location.

<u>CONCLUSIONS</u>

1. The existing Ten Mile Canal rights-of-way widths are adequate, but not excessive. In several places there is no room for expansion.

2. Some of the right-of-way or easement is presently by occupation only.

RECOMMENDATIONS

1. No encroachments or vacation of right-of-way reservations should be made along the existing right-of-way.

2. The County should continue to pursue perfection of those portions of the right-of-way where the County only has use by occupation.

5. GROUNDWATER TABLE

A network of groundwater table wells was installed prior to the 1990 wet season in order to determine the wet season water table elevation within the Ten Mile Watershed. Locations for the water table monitoring wells were selected on a general basis of one gage per six square miles. Topography and tributary channels were considered in the placement process. The actual area served is about one well per one and one-half square miles. The location of the wells was coordinated with the existing wells within Six Mile Cypress Watershed and proposed wells in Billy Creek and Whiskey Creek watersheds. A total of nine wells were placed in the thirteen square mile area crosshatched on page 46C-W4. These wells consist of a 1-¼" diameter wellpoint with a 30" screened section and a 4' section of galvanized steel pipe (see diagram in the Appendix page A-3). The top of the pipe is surveyed for elevation and used as a reference mark in obtaining water table readings. Readings were taken at intervals of two weeks during the 1990 wet season. They are included on a disk in Volume III and printed in Section 5, Volume III.

Surface water information, available from continuous surface water recorders, was used to supplement groundwater well readings in some locations. Lee County and the U.S.G.S. maintain continuous surface water recorders along Ten Mile Canal. These gages provide an indication of water table levels near the westerly boundary of the watershed.

The wells placed in this watershed provided more detailed information on the water table elevations than available in the 1988 Montgomery Report. The main reason is nine wells and several surface water recorders were utilized in this study vs no measurements from within the watershed in the Montgomery Report. The Division of Water Resources will be able to annually update the wet season water table map and eventually replace the Montgomery map. This will provide the community with data previously not available for design and review.

Groundwater elevations within this watershed vary relative to land surface. The wet season water table elevation adjacent to Ten Mile Canal is generally 2-3 feet below land surface whereas the groundwater table farther away from the canal is close to or above land surface. Groundwater wells have been located within the watershed as shown on the map on page A-1. These wells have been located to give a representative elevation of the water table during the 1990 wet season. Wet season water table elevations determined over the entire watershed are necessary in establishing water control elevations and are useful for planning and design purposes. This is particularly important in areas of existing wetlands within the watershed. Perpetuation of historical hydroperiods requires knowledge of the wet season water elevations. Upland areas also benefit from more water than would be held if the area was over drained.

The average wet season water table for each well location was calculated with the same method used in the Six Mile watershed. This is also outlined in Section 5, Volume III of this report. A contour map showing the 1990 average wet season water table, based on the wells measured, is shown on page A-2. The contours in the Ten Mile Canal watershed have been matched with the contours of the 1990 data measured in the Six Mile watershed by the Division of Water Resources.

LEE COUNTY SOILS

The majority of the area has soils from the following groups: Boca, Hallendale, Immokalee and Malabar. These soils are in the B/D hydrologic group. The B classification is for those areas that are well drained. The D classification refers to those areas with a high water table. See the SCS Soil Survey of Lee County, Florida for more information. The measured water elevations in 1990 were similar to the information provided in the SCS Soil Survey of Lee County, Florida. The major differences are in areas immediately adjacent to the primary conveyance where water levels are drawn down.

CONCLUSIONS

1. Control structure elevations are important to the perpetuation of historical hydroperiods.
2. Continued monitoring of existing groundwater tables will provide valuable data for establishing control elevations.

RECOMMENDATIONS

1. Require control structures to be set relative to the average wet season water table.
2. Continue monitoring of groundwater tables to better establish needed control levels.

6. HYDROLOGY

The hydrology of the Ten Mile Watershed has been greatly affected by man over the last 70 years. The construction of the Line A dike and ditch provided the formation of this watershed as it exists today. The main feature of the watershed is what we know today as Ten Mile Canal.

This new watershed which is made up of portions of other tributary watersheds makes it one of the largest watersheds in Lee County. There are three major and several minor tributaries to Ten Mile Canal.

At the downstream end of Ten Mile Canal, the Alico Road conveyance contributes approximately 9 square miles. Slightly farther north is the Briarcliff channel. This conveys an additional 9 square miles to the Ten Mile Canal. Approximately one mile north of the Briarcliff ditch is the Six Mile Cypress Slough. The slough contributes about 37 square miles. The Alico Road, Briarcliff and Six Mile Slough subwatersheds combine to make the 55 square mile Six Mile Cypress watershed. A separate report was generated for Six Mile Cypress watershed in 1990. Farther north from Six Mile Slough are several smaller tributaries, such as are the ditch along Daniels Parkway, Harper Brothers Canal south of Colonial Boulevard and the North Colonial Waterway. The North Colonial Waterway provides an outfall for the area between Colonial Boulevard and the north boundary of the watershed. This is an area of approximately four square miles.

The rainfall was distributed as per the SFWMD distribution. The entire watershed received rainfall at the same time and the same rate. The one-day distribution was used for the four storms modeled. The computer modeling of runoff from this watershed was done using the HEC-1 program developed by the Army Corps of Engineers. This is the same model used in the Six Mile Cypress analysis. Modeling was done by Johnson Engineering, Inc. The SCS method was utilized within the HEC-1 model to determine runoff.

The rainfall used in the analysis of the 25-year event was the one-day amount taken fronm SFWMD data. See Section 6, Volume III for further explanation.

Measured rainfall from an event in 1987 at the Gateway site was distributed similar to the SFWMD distribution used in the HEC-1 analysis. 1990 measured rainfall is found in Section 6, Volume III.

The Alico subwatershed, Briarcliff subwatershed and the Six Mile Slough watershed were combined in this analysis. Several subwatersheds within the Ten Mile Watershed north and west of Six Mile Cypress Parkway were combined with those above. This portion of the watershed, crosshatched on page 46C-W4 had an approximate runoff in the 25-year event equal to the 69 csm. The previously modeled Six Mile Cypress watershed discharged at a rate of 37 csm. Since the analysis produced a value similar to that previously established by South Florida Water Management District in 1978, it is suggested that Lee County continue the use of 69 csm for the 25-year - 3-day allowable discharge for properties with direct access to the primary conveyance. An exception to the 69 csm rate is within the North Colonial Waterway subwatershed. This tributary was designed in 1983 for 37 csm from all undeveloped areas.

The value established in 1978 by South Florida Water Management District was a reiteration of design analysis done by Howard Needles Tammen & Bergendoff in their study of the Ten Mile-Six Mile watersheds. Their analysis was based on the rate water could be delivered to the canal. The canal was then designed for the expected flow. Thirty SFWMD permit files and four Lee County Development Order files were reviewed for design discharge rates. Discharge rates varied from 63 csm to 80 csm with an average of 77 csm. The South Florida Water Management District has used this 69 csm runoff value to review projects within the Ten Mile Watershed, as shown crosshatched on page 46C-W4, for the past twelve years.

Flows were measured at selected locations shown on the map in the Appendix. The flows measured on August 14, 1990 were all about 20 percent of the calculated 25-year design event. This showed that the simulated and actual distributions coincided. Measured flows are in Section 6, Volume III.

MONITORING

Several hydrological elements have been monitored during the course of this study. These include rainfall, stage (continuous recorders and crest gages) and the groundwater elevations that were discussed in the previous section. Monitoring all of these items is very important to the management of the surface water system in this watershed. Rapid development along some of the road corridors has occurred with very little detention. Continuation of this practice will cause future problems. Today the water is often stored on adjacent undeveloped property. The water does not reach Ten Mile Canal very fast. The problems will begin as more property is developed. Most of the potential problems will be in areas where many small projects having only water quality detention, occur as the primary development.

For example, rainfall and surface water elevations give a ready indication of the amount of plant growth in the system. High canal stages coupled with low rainfall and low runoff from the system indicate excessive plant growth in the channel. This information provides a very effective gage for the evaluation of the previous aquatic vegetation control and the need for future work.

This same information can be used in the calibration of the model. Measured water surface elevations, flows, aquatic vegetation and channel conditions are all a part of the calibration of hydrologic numerical models. The aquatic vegetation that is the greatest detriment are cattails or plants like hydrilla. These block large portions of the canal's cross section. With the use of incorrect channel roughness, modeling a 5-year rainfall event may produce stages equal to a 100-year event or vice versa. The rainfall input and the generated flows are validated when compared to measured flows and published statistical information by SCS and SFWMD.

Flow measurements from individual developments, both large and small, are important to understand the accuracy of the design parameters. Tailwater elevations and the condition of conveyances will make a large impact on discharge from the developments. Monitoring can provide a means of understanding the system and anticipating the portions that work well and those requiring an upgrade. Developments less than ten acres should be monitored to establish their cumulative effect. More emphasis on this in the review process should be considered.

All of the rainfall, crest gage, flow measurement data is included on the disk in Volume III. Comparisons were also made to historical data presented in Volume III of the Interim Plan. Crest gage information and flows prior to the late 1970's were the result of a smaller channel, smaller bridges and no weirs. All modeling was done with the wet season water table. Maps depicting the location of rain gages, crest gages and flow measurements are in the Appendix on pages A-4 through A-6.

CONCLUSIONS

1. The Six Mile Cypress Watershed exhibits runoff characteristics that approximate the 37 csm allowable runoff now used by South Florida Water Management District for the 25-year - 3-day event. The remainder of the Ten Mile Canal watershed approximately follows the 69 csm allowable runoff established by South Florida Water Management District for the 25-year - 3-day event.
2. The watershed is changing rapidly. This necessitates continued monitoring of the surface water conditions including rainfall, runoff and surface water elevations.
3. Excessive allowable runoffs from new developments will eventually overload the system as it is presently designed.
4. An accumulation of excessive runoff from small unregulated developments appears to be developing into a significant problem.

RECOMMENDATIONS

1. Continue to use the 37 csm and 69 csm criteria in the Six Mile and Ten Mile watersheds respectively with the noted exception for areas tributary to the North Colonial Waterway.
2. Monitor flows from typical commercial and residential developments to verify discharge during storm events.
3. Continue hydrological monitoring of the entire system (rainfall, flows, water surface elevations, etc.) for future updates of the backwater profile and runoff characteristics of this watershed.
4. Monitor runoff especially from the smaller developments to determine the deviation from the allowable runoff requirement and to estimate the significance of long range implications.

7. QUANTITY MODEL

Ten Mile Canal has been modeled with a numerical backwater profile model developed by the U.S. Corps of Engineers Hydrological Engineering Center. This model is commonly known as HEC-2. The existing conditions of Ten Mile Canal were modeled by the Soil Conservation Service as part of their modeling of several conveyances that contribute to the Estero Bay area. Adjustment of 'n' factors and flows have been made to the SCS work by Johnson Engineering to produce the analysis presented in this report. Final "n" factors used in the modeling of existing conditions were based on a properly maintained channel.

The cross sections used in this model were those taken by the Soil Conservation Service survey crew. This information is the most up-to-date data available for Ten Mile Canal. Prior to the SCS field survey in 1987, the canal had been cross sectioned and modeled by Johnson Engineering in 1979. Many improvements to the channel have been made since the 1979 modeling effort. Some of the cross sections measured by SCS had smaller channel areas than those used in the 1979 backwater profiles. This caused increased water surface elevations.

The Soil Conservation Service used the HEC-2 Model in their modeling work. This was a coordinated effort between Lee County and the Soil Conservation Service. This allowed the County to realize a cost savings in the Master Plan by being able to utilize the earlier contracted SCS work. In a limited number of locations, the Soil Conservation Service 1987 cross sections were more than a quarter of a mile apart. At these locations, existing cross sectional information in Johnson Engineering's files was used to supplement the newer cross sections. The new and old cross sections were checked to make sure that there was good correlation between them and that there were no major cross sectional differences. Some new cross sections were also taken at the downstream end of the channel. All elevations are referenced to the 1929 National Geodetic Vertical Datum (NGVD).

The starting water surface elevation for the four design events is +2.5 NGVD in Estero Bay. This is approximately equal to a spring high tide. The backwater profile was started in the vicinity of Estero Bay and calculated up Mullock Creek to obtain the starting water surface elevation for Ten Mile Canal. This backwater analysis only accounts for conditions created by the design rainfall events. Consideration of tidal conditions other than normal is beyond the scope of this contract. The Federal Insurance Study maps already provide a good source of tidal flood data.

Four storm events were modeled. They are the 1-year - 1-day, 5-year - 1-day, 25-year - 1-day and 100-year - 1-day events. The result of analyzing these storm events provides information relative to allowable discharge, road elevations and finished floor elevations needed to design and/or review proposed development or reconstruction of existing infrastructure. The HEC-2 Model should be updated often enough to keep current with structures that have been replaced or channel modifications that have been made. Specific channel improvements are needed around Park Road from Tamiami Trail (U.S. 41) to Six Mile Parkway, and from south of the railroad bridge to Hanson Street.

The input and output files for the existing HEC-2 analysis are provided on disks in Volume III of this report. A plotted plan and profile has been provided at the end of this section for the 1-year and 25-year events. This allows quick determination of design or review information. The existing profiles are shown on pages 46C-PP1 through 46C-PP4. Comments on the existing facilities have been made in Sections 3 and 11.

CONCLUSIONS

1. The SCS cross sections improved the accuracy of input data to the HEC-2 backwater profile model.
2. Vegetation in the channel greatly affects the flood profile.
3. Channel improvements are needed as noted above.

RECOMMENDATIONS

1. Update the HEC-2 model with additional or revised cross sectional or structural data as it is made available.
2. Provide channel maintenance including vegetation removal.
3. Excavate the channel to the design section in the three reaches discussed above. See Sections 11 and 13 of this report.

8. WATER QUALITY

INTRODUCTION

The Ten Mile Canal (TMC) Watershed has been included as part of the Lee County Surface Water Management Master Plan. The TMC has been modeled with the Non-Point Source (NPS) Water Quality Model to determine pollutant loadings generated from the watershed and delivery of those pollutants to the TMC outfall into Mullock Creek, just downstream of Park Road. The model results were compared with water quality grab samples to check the relative magnitude of the results. The primary purpose of the modeling effort was to compare the relative differences in loadings and pollutant deliveries between existing and different future scenarios. This allowed for a comparison of different land use and watershed management options from a water quality impact perspective. The primary goal of the effort was to identify means by which downstream waters would not be degraded beyond existing conditions by future discharges from the TMC watershed.

Using the same methodology as applied to the Six Mile Cypress (SMC) Watershed (CDM, 1990), the NPS Model was applied to the watershed and results were obtained for total annual pollutant loading to the Ten Mile Canal for total nitrogen (TN), total phosphorus (TP), lead (Pb), and zinc (Zn). Also, estimated were total pollutant delivery to the watershed outfall and predicted concentrations at the following four locations along the canal: 1) Colonial Boulevard, 2) Daniels Parkway, 3) Tamiami Weir, and 4) Park Road. The TMC watershed is graphically depicted on Page 46C-W4.

MODEL PARAMETERS

A detailed description of the NPS model, including a summary of modeling parameters, is contained in Volume III of this report. The parameters used in modeling water quality included land use characteristics, soils, point sources and wet detention best management practices (BMP's). A summary of model parameters is provided in Table 8-1 of Section 8, Volume III of this report.

Existing land use in the Ten Mile Canal watershed remains predominantly forest, pasture, open land or wetland (69%), especially in the eastern portions of the watershed. Urbanization to date has occurred along the major road corridors including Hanson Street, Metro Parkway, Colonial Boulevard, Daniels Parkway and

Plantation Road. Commercial and light industrial development is found primarily along the Hanson Street and Metro Parkway corridors. It is important to note that Metro Parkway development parallels much of Ten Mile Canal. Existing residential development is found primarily along Daniels Parkway and Plantation Road, and consists of low to medium density neighborhoods.

The SMC watershed comprises 81% of the combined TMC/SMC basin and was considered as a contributing watershed to the TMC for this effort. Existing land use in the SMC watershed is predominantly comprised of forest, open land or pasture wetlands (74%) with some crop (11%) and suburban type land uses (12%). A small amount of industrial land use (3%) is currently located along Alico Road in the SMC.

Event mean concentrations (EMC's) were input to the model for the various land uses based on literature values (CDM, 1990). Land use specific EMC's are presented in Table 8-1 in Volume III of this report.

The Ten Mile Canal watershed was divided into 11 major subwatersheds based on hydrologic information provided by Johnson Engineering, Inc. Nine subwatersheds were given a letter designation from A to I. Two additional subwatersheds contribute to the TMC (SMC 1 and SMC E). These two subbasins comprise the Six Mile Cypress Watershed previously modeled for the Surface Water Master Plan. Their inclusion in the modeling effort was necessary since the Six Mile Cypress watershed discharges into the Ten Mile Canal upstream and downstream of the Tamiami Weir.

Future development within the Ten Mile Canal Watershed is expected to be intense. Several residential communities are in the development order process seeking approval to begin construction. Other important factors associated with future development within the watershed include the introduction of a central wastewater collection system, various road improvements, and a planned professional athletic facility. The Lee County Division of Planning has produced a Future Land Use Map that was used as a basis for modifying the existing land use data for future model predictions. Overall, there is projected to be a 40% change in existing land use in the TMC basin from predominately forest, open land, pasture and wetlands to residential, commercial and industrial land use in the future. Details of land use changes by subwatershed are provided in the Appendix of this report.

Limited central wastewater collection and transmission service exists in the TMC basin. The City of Fort Myers provides central sewer to a majority of the commercial and industrial areas in the northern part of the watershed. In addition, Lee County provides wastewater service along Metro Parkway north of Daniels Parkway. Other than Brookshire Village, residential areas are served by on-site septic systems.

A few package plants serve recreational vehicle parks and hospitals. These package plants do not directly discharge to surface waters. Based on groundwater monitoring well water quality data evaluated for several package plants, contribution of metals and nutrients to the surface water from percolation ponds or drainfields was judged to be negligible for this modeling study.

Predominant soils identified for the Ten Mile Canal Basin include the Hallandale-Boca, Immokalee-Myakka, and Oldsmar-Malabar-Immokalee series. These soils all belong to the hydrologic soils group "B/D". Developed areas will typically exhibit a "B" type characteristic (27%) due in part to an increased depth to the water table while undeveloped and pre-developed soils are typically type "D" (56%). Wetlands and lakes comprise the remaining hydrologic group. Details of subwatershed soils are provided on disks in Volume III of this report.

Existing detention/retention BMP coverage was determined from existing surface water permits and confirmed with aerial photographs. Wet detention comprises 70% of BMP's in south Florida (CDM, 1985). Therefore, a wet detention BMP was modeled for all treatment scenarios. Based on discussion presented in the Non-Point Source Evaluation for SMC (CDM, 1990), treatment rates of 30% for TN, 50% for TP, 80% for Pb and 70% for Zn were used in this study.

WATER QUALITY DATA

To provide comparative data for the NPS model results, three sets of water quality samples were collected by Lee County Environmental Laboratory in October, November and December, 1990. In addition, historical water quality information was reviewed in detail (Pratt, 1979; Ceilley and Kibbey, 1990; Clark, R.S., 1987; FDER, 1988). Lee County Laboratory sampling sites are located at Palm Avenue, Colonial Boulevard, Crystal Drive, Daniels Parkway, Six Mile Cypress Parkway, the Tamiami Weir and Park Road. Average concentrations for these sites are presented below:

TABLE 8-1

TEN MILE CANAL WATER QUALITY (mg/L)

Station # - Name	TN	TP	TN:TP	Pb	Zn
91 - Palm Avenue	1.34	0.63	2.2	<0.02	<0.01
80 - Colonial Blvd.	0.62	0.12	5.2	<0.02	<0.01
60 - Crystal Drive	0.82	0.17	4.8	<0.02	<0.01
50 - Daniels Parkway	0.75	0.01	75	<0.02	<0.01
40 - Six Mile Cypress Pkwy.	0.86	0.05	17	<0.02	<0.01
20 - Tamiami Weir	2.02	0.06	34	<0.02	<0.01
10 - Park Road	2.49	0.04	62	0.20	<0.01

It should be emphasized that the primary purpose of the model is to provide results for comparative management decisions. Results are based on long-term annual conditions, and comparison with a short-term data base is not expected to be exact. A baseline water quality monitoring program is recommended to allow for additional confidence in model results and also to document the effects of adding treatment capability and improving watershed management.

Elevated nutrient levels at the Palm Avenue station were observed in both 1990 data and historical data. There is also noticeable increase in vegetation in the Ten Mile Canal upstream of the Palm Avenue station. Additional sampling to identify a possible point source in this area is recommended.

The TN:TP ratio is commonly used to estimate the nutrient that limits biological productivity in a given system. Using criteria of TN:TP ratios between 10 and 30 for co-limitation (FDER, 1988), it appears the TN is limiting in the northern TMC, while a shift to TP as limiting nutrient occurs downstream. Discussion of the TMC TN:TP ratios is provided in the results section of this chapter.

MODEL SCENARIOS

As a baseline of comparison with future scenarios, an existing scenario was modeled (A1). In addition, five future scenarios were also simulated. A summary of the six scenarios modeled is described briefly as follows:

A1 - Baseline, existing land use conditions

B2 -Future land use (Lee Plan) with all new development having wet detention BMP coverage.

B3 -Future land use with all new development having wet detention BMP coverage with regional Resource Protection Area (RPA) system in Six Mile Cypress Watershed.

C2 -Future land use with all new development having wet detention BMP coverage and full retrofitting of existing areas.

C3 -Future land use with all new development having wet detention BMP coverage with regional RPA system in Six Mile Cypress Watershed and full retrofitting of existing areas.

C4 -Future land use with all new development having wet detention BMP coverage with regional RPA system in Six Mile Cypress Watershed and retrofitting of existing areas to reflect current

Capital Improvement Projects.

The five future scenarios were projected to have BMP's on all new development. Regional resource protection areas (RPA's) planned for the SMC were modeled for three scenarios (B3, C3 and C4). In addition, the retrofitting of existing non-BMP land use in the TMC Basin with two levels of detention storage was also modeled (C3, C4). Additional storage was not applied to projects with wet detention BMP's due to the extended drawdown (5-days) associated with such systems. Also, retrofit storage was not applied to projects in the SMC due to existing treatment being provided by the SMC wetland. Based on preliminary project locations, the C2 and C3 scenarios included an estimated 95.5 Ac-Ft of retrofitted wet detention storage. This additional storage volume equates to 1.0 inch of storage for existing non-BMP areas in the majority of the TMC, and 1.2 inches for the subwatershed directly upstream of a proposed in-line detention area adjacent to Palm Avenue. Targeting a goal of 1.0 inch of storage to be equal to 100% BMP coverage, this additional storage equals to 100% coverage for existing non-BMP land use. The specific projects included in this scenario are an in-line wet detention area in the north end of the TMC, a 20-acre filter marsh, and an off-line retention area downstream of the Tamiami Weir. Descriptions of these projects are included in the recommendations section of this chapter. Scenario C4 was modeled with only the in-line wet detention area and the 20-acre filter marsh providing retrofit wet detention storage. This scenario would provide 0.81 inches and 0.36 inches of additional wet detention storage for the most upstream subwatershed and the remainder of the TMC basin, respectively.

Total nitrogen (TN) loads are expected to increase, but TN levels are expected to slightly decrease due to increased total flow and changes in land use. However, the average concentration for the three samples collected at the lower two stations of 2.26 mg/L is not expected to decrease below the program goal of 1.20 mg/L, even with implementation of recommended projects. Additional monitoring is recommended to identify the source of the elevated nitrogen levels in the TMC. TP levels discharged from the Ten Mile Canal are, and are expected to remain, below the program goal of 0.07 mg/L. Concentrations of Zn presently meet the 17-302 standard and are expected to meet the standard under future conditions. Five of six samples at the downstream end of the Ten Mile Canal had Pb levels below the 17-302 standard. It is expected that the elevated sample was an anomaly and that Pb should be within the standard in the future.

A complete retrofit of existing developed land without BMP's would require 95 Ac-Ft of storage to provide one inch of detention. The best location for this storage is in the downstream reaches, where two of the three recommended projects are located. As other opportunities in the watershed become available, such as enhanced treatment for new land development, downtown revitalization projects, roadway repairs, etc., additional storage should be encouraged. The Ten Mile Canal Watershed currently has a LOS designation of "C" for water quality, but may be upgraded to a LOS of "A" with the incorporation of the recommended projects.

RESULTS

Total annual pollutant loadings for TN, TP, Pb, and Zn were generated for each subwatershed. Pollutant loadings were also developed for subwatersheds after considering existing and future wet detention BMP's and impacts from the various scenarios (Table 8-2). Detailed input, output and loading tables are provided on disks in Volume III of this report.

Using the loading data, pollutant concentrations were calculated for annual average flow conditions for each subwatershed. These concentrations were then attenuated to acknowledge treatment processes occurring within the canal. A phosphorus assimilation coefficient for channels was used to account for physical absorption, settling and biological uptake (SFWMD, 1989). Nitrogen assimilation was assumed to be 60% of that for phosphorus to maintain a treatment efficiency relative to phosphorus and associated with typical wet detention BMP's. Lead and zinc were also assigned assimilation factors relative to TP for wet detention BMP's. These attenuations were estimated for the TMC channel upstream of the confluence with the SMC. It is believed that attenuation downstream of the SMC confluence was compromised due to the increased hydraulic loading from the SMC; thus, no attenuation was given for the reach downstream of the SMC confluence. The SMC loads were attenuated in accordance with the methods used in the Phase I Report for the SMC prior to entering the TMC. Predicted concentrations for four stations are presented in Table 8-2.

The water quality samples described earlier were collected primarily under low flow conditions in the TMC. Storm generated flow should generate significantly higher concentrations of pollutants than observed.

However, the data collected provides trends that the modeling effort should duplicate.

In the upper portion of the watershed, elevated nutrient concentrations are observed at the Palm Avenue station, but are not duplicated at the Colonial Boulevard station immediately downstream (Table 8-1). Only a small subwatershed discharges to the TMC between these two stations, which most likely would not cause this reduction in nutrient levels. The model simulates TN slightly high for the Colonial Boulevard Station (Table 8-2), but this is not unreasonable when compared with higher TN levels observed at Palm Avenue.

Total nitrogen (0.81 mg/L) was simulated accurately against actual data (0.75 mg/L) for the Daniels Parkway Station. However, the predicted TP concentration (0.09 mg/L) did not match the observed level (0.01 mg/L). Observed TP levels at Daniels Parkway were much lower than any other station, and may be characteristic of dry weather grab sampling.

An interesting anomaly between actual and simulated data occurs for nitrogen at the Tamiami Weir and Park Road stations. The model simulates a slight increase in TN concentration for these downstream stations (Table 8-2) while the observed data shows a significant increase (Table 8-1). This observed trend is not duplicated for phosphorus. A possible cause of this may be in the form of a point source contribution and additional sampling is recommended in the vicinity of these stations.

Comparison of model results with actual data collected for Pb and Zn was difficult, due to all but one sample being below the detection level for both parameters (0.02 and .01 mg/L, respectively). The model simulated concentrations in the 0.01 to 0.04 mg/L range for Pb and Zn.

Critical to any watershed analysis of water quality and evaluation of watershed management options is the understanding of the condition of the receiving water at the downstream end of the given watershed. Knowledge of characteristics such as circulation patterns, designated use, limiting nutrients and assimilative capacity of the receiving water are necessary in order to suggest options for watershed management. Several studies have been completed on the TMC's receiving water, Estero Bay. A basic understanding of circulation patterns (Clark, 1987) and designated use (FDER, 1990) exists. Information on limiting nutrients is not as well defined. The most extensive and most recent information available (Ceilley and Kibbey, 1990) indicates that, based on the FDER criteria stated earlier, both TN and TP exist as

Table 8-2

co-limiting nutrients in Estero Bay. TN:TP ratios average approximately 15 for six stations. Other studies (Clark, 1987 and FDER, 1988) and data collected as part of this Master Plan for Estero Bay tributaries other than TMC, suggest that TN is limiting for upstream areas and TP becomes limiting as discharges approach Estero Bay. The assimilative capacity of Estero Bay is not documented and fully understood at this time, and is suggested as an issue for future study.

Based on the available data that suggest that TN and TP exist as co-limiting nutrients for Estero Bay, efforts should be focused on controlling TP in the TMC watershed, rather than attempting to control TN. Although reducing future loads of both TN and TP is a program goal, maintaining either nutrient at existing levels should help in achieving a non-degredation goal for the ultimate TMC receiving water, Estero Bay.

One advantage of controlling TP is that the model predicted that future loads of TP slightly decrease compared to existing loads. A primary finding of this study is that even with the incorporation of wet detention BMP's on future development (Scenario B2), an additional 28,700 lbs/yr of TN (17%) are projected to be generated, while TP loads are expected to decrease by 340 lbs/yr (-1%). This difference in future modeled TN and TP loads is directly related to treatment efficiencies for these parameters by future wet detention BMP's, 30% and 50%, respectively.

A second advantage of focusing on reducing TP loads is that treatment efficiencies of conventional wet detention BMP's or other innovative water treatment methods that may be considered, such as alum treatment, are considerably more effective for TP as compared to TN.

Significant increases in loads for Pb and Zn are predicted for future conditions, even after considering reductions associated with future wet detention BMP's that average removal efficiencies of 70% for Pb and 80% for Zn. An additional 2720 lbs/yr (117%) of Pb and 2260 lbs/yr of Zn (77%) are predicted to be generated in the TMC watershed system (Scenario B2). The majority of the loading increase for metals will result directly from increases in commercial and industrial land use. Event mean concentrations for Pb and Zn are higher for these land uses than for any others in the watershed (Table 8-1, Section 8, Volume III of this report).

The incorporation of resource protection areas (RPA's) within the SMC watershed (Scenario B3) will remove future land use that would otherwise contribute additional pollutant loading to the TMC. RPA's are predicted to result in a net decrease in TP of 845 lbs/yr (3.3%) compared to future loadings without RPA's. This is equivalent to reducing future TP loads to below existing levels by 4.6%. Future loadings of TN, Pb and Zn are projected to also benefit from RPA's by 1.2%, 4.7% and 2.8% , respectively (Table 8-2).

Two options were examined for retrofitting existing land in the TMC that does not have water management systems providing wet detention BMP coverage. These areas were most likely built prior to regulatory requirements for water management, and thus do not contain detention/retention BMP's. However, a recent change in Florida Statutes, CH. 17-40.420 may require retrofitting of these areas in the future (FDER, 1990). A partial retrofit of these areas will enhance the TP reductions provided by the RPA's by an additional 0.9% (Scenario C4), while a full retrofit will increase the reduction to 2.3% (Scenario C3). Estimated loads for TN, Pb and Zn will also be reduced due to these retrofit options, but will not be reduced below existing loading levels that were predicted (Table 8-3).

SUMMARY AND RECOMMENDATIONS

Based on the NPS modeling results, incorporation of regional RPA's in the SMC watershed, application of wet detention BMP's to future development and retrofitting existing land use in the TMC that presently does not have water quality treatment with regional wet detention BMP's, a net reduction of 6.9% is estimated for TP loadings when compared to estimated loadings for existing conditions. TN, Pb and Zn loadings will also be reduced from estimates of future loadings without the RPA's and retrofit detention storage, but net increases of 15%, 88% and 63%, respectively, are predicted to occur relative to existing loads. The large increase in Pb and Zn loadings will be primarily from land use changes to commercial and industrial type land uses.

To meet the retrofit requirements simulated by the NPS model, several projects were identified within the TMC watershed that may provide the necessary stormwater detention storage. These projects are described below under the subsection, Structural Improvements. In addition, it will be necessary to provide substantial maintenance for these proposed projects and for existing projects within the TMC watershed to remove or "harvest" pollutants that have either settled out of the water column or have been taken up by aquatic vegetation.

Recommended maintenance efforts are described below under Management Practices. Finally, a water quality monitoring plan is also recommended.

STRUCTURAL IMPROVEMENTS

1. Construction of an in-line wet detention system at the north end of the TMC. This will include a combination weir and floating vegetation screen. The location of the weir/screen would be adjacent to Palm Avenue. This project includes a sediment catchment area within the Ten Mile Canal, upstream of the weir to allow for removal of accumulated sediments.
2. Construction of sediment catchment areas upstream of the three existing weirs within Ten Mile Canal.
3. A 20-acre filter marsh within the Ten Mile Canal right-of-way, between Daniels Parkway and the Tamiami Weir. This project would allow for polishing of stormwater runoff prior to discharge to the receiving waters of Estero Bay.
4. An off-line retention system using existing borrow lakes downstream of the Tamiami Weir. This project would be significant in size (120 acres) and would provide for treatment of the first flush of pollutants associated with runoff from the developed Ten Mile Canal Watershed. A bypass system would be hydraulically designed to allow runoff from the Six Mile Cypress watershed to continue downstream.

The system would work like a surge tank, but be used for water quality rather than quantity. Water would be diverted into the lakes during the rising limb of the hydrograph, when the "first flush" generally occurred where most of the runoff is from the Ten Mile Canal Watershed. The time to peak is about one day for this area. Two days or more are required for the peak runoff from Six Mile Cypress Watershed to reach the downstream end of the Ten Mile Canal. This time differential will allow the capture of early, poorer quality runoff from the Ten Mile Canal Watershed. Runoff from the Six Mile Cypress watershed would then pass the facility and discharge to Mullock Creek. The ideal storage time for water held in this detention area is ten days, although discharge will be dependent on water levels in the Ten Mile Canal following the storm event.

5. Diversion projects to the Six Mile Cypress Watershed that have been previously discussed in the Six Mile Report. These projects would serve to help restore the hydroperiod of the Six Mile Cypress and would allow for additional treatment of pollutants.

MANAGEMENT PRACTICES

1. To remove pollutants that have been taken up in vegetation and would otherwise contribute to the Ten Mile Canal, regular maintenance is recommended for the following areas:

   a) Removal of submerged aquatic vegetation along the entire length of the Ten Mile Canal.

   b) Harvesting removal of emergent portion of aquatic vegetation in the 20-acre filter marsh between Daniels Parkway and the Tamiami Weir.

   c) Removal of vegetation associated with the recommended structure along Palm Avenue.

   d) Removal of sediments in catchments constructed upstream of the existing TMC weirs.

2. During the dry season, small volume discharges through the Tamiami Weir bleeder gates are recommended. This would be designed to follow storm events when excess water may be available for discharge. Water levels could be lowered to provide for some storage of runoff early in a storm. Total volumes of these discharges will be minor when compared to storm related discharge during the wet season. The purpose of these discharges will be to provide base flow during the dry season. Water quality benefits resulting from this release would need to be determined. Previously, only wet season releases have been made through the gates. Coordination with SFWMD would be necessary to establish guidelines for dry season releases.

WATER QUALITY MONITORING

Continuation of the water quality monitoring program is recommended to allow for better comparison of model results with actual data, and also to provide a baseline of data that will allow for documentation of water quality improvements due to construction of water quality projects and improved maintenance. Average values that are out of an expected range should prompt further monitoring or investigation.

An addition to the grab sample monitoring could be some storm event sampling. The grab samples are indicative of base flow and may show trends in water quality over several years. Flow weighted composite samples from storm events can be used to estimate annual loadings more accurately than the grab samples. The use of composited samples should minimize the cost of laboratory work.

9. WATER BUDGET

An analysis has been prepared for the Ten Mile Watershed in order to evaluate the hydrologic balance within the basin. The major components of water sources and sinks which affect its hydrologic balance have been assessed. Potential locations for surface water detention and ground water recharge have also been identified and evaluated. Certain elements of the water budget equation were obtained from a combination of on-site measurements, United States Geological Survey continuous stage recorder information, and available rainfall data.

The primary components of water entering the watershed are precipitation, surface water inflows and ground water inflows. Surface water inflows from adjacent watersheds are minimal under normal summer conditions and are not considered in this analysis. Also, ground water inflows tend to balance out with ground water outflows and are thereby insignificant in comparison to the major source of basin recharge which is precipitation. Precipitation within the Ten Mile Watershed was evaluated primarily from the daily rainfall gage maintained at Page Field. This gage provides daily rainfall for the entire year and is located in close proximity to the Ten Mile Watershed. Additional rainfall information available from the Southwest Florida Regional Airport and other private gages is provided in Volume III, Section 6 of this report. A total of 49.09 inches of rainfall was recorded at Page Field during 1990.

The primary components of water losses in the water budget analysis include surface water runoff, groundwater outflows, evaporation and transpiration (ET), vertical leakage and consumptive water withdrawals. Of these, evapotranspiration and surface water runoff constitute the main elements of water loss. Surface water runoff was estimated by calculating the volume of water discharged over the Tamiami Weir. This volume includes runoff from both the Ten Mile Watershed and the Six Mile Watershed. The annual depth of runoff over these basins is 13.03 inches. Although there are no records available for evapotranspiration within the subject area, an estimate is made using the equation given on page 46C-W50. This estimate is slightly lower than expected annual ET values provided in the Montgomery Report.

WATER BUDGET ANALYSIS

The water budget analysis for the Ten Mile Basin was prepared using similar procedures as were used in the Six Mile Basin analysis. The primary components of water entering and exiting the basin are evaluated over an annual cycle. A generalized analysis is provided on page 46C-W50.

In addition to the generalized analysis presented here, a separate study was done by Tomasello Consulting Engineers, Inc. Their study included computer modeling of the Six Mile Cypress Basin with and without backpumping water from the Ten Mile Canal. The water for this backpumping was based on excess flow over the Daniels Parkway weir in Ten Mile Canal from October 1989 through March 1990. The results of the modeling show that the hydroperiod can be extended for more than a month, if water is available. The backpumping will also increase the amount of groundwater available in the slough for environmental enhancement. Further details are available in the Tomasello, 1991 report titled "Long Term Water Budget Model, Six Mile Cypress Watershed."

A second pump facility could be placed at the newly constructed weirs at the intersection of Ten Mile Canal and Six Mile Slough. Lifting water from this portion of the Ten Mile Canal is the last chance to extend the hydroperiod in Six Mile Slough prior to its release to tidal water. Observations and monitoring should be done to determine the need for this facility.

Additional pumps can be located to transfer water from Carrell Canal and Canal 'L' into Ten Mile Canal. These pumps would utilize rapid runoff from highly developed areas instead of allowing that runoff to be discharged to the Caloosahatchee. This construction would need to be coordinated with the City of Fort Myers since Carrell Canal is within the City boundary.

Details of the conceptual plans mentioned above are provided in the Six Mile Basin report. The sketch on page 46C-W50 shows the conceptual surface water plan used in the above computer model. Also, a graph is shown on page 46C-W51 which indicates the approximate volume of water discharged over Tamiami Weir during 1990. This graph is based on USGS continuous stage recorder data.

The amount of water passing the Tamiami weir averages forty million gallons per day for the year. About two-thirds of the water is discharged during three months of the year at a rate slightly greater than one hundred million gallons per day. The runoff discharged for the remainder of the year averages less than twenty million gallons per day.

The most practical methods of harnessing this resource would be through direct irrigation or aquifer storage and recovery (ASR). Direct irrigation decreases treatment and storage costs. ASR allows use of water when supplies are limited or non-existent for direct irrigation. Use for environmental enhancement as described above is similar to the direct irrigation. There is no treatment cost with this type of use. These methods provide capacity to store or use the water much better than the limited storage capacity available in existing wetlands. Some water is needed in the wetlands for environmental reasons. This should be addressed as properties are developed.

The use of surface impoundments within the watershed could decrease the peak runoff. More water would then be available for later release as base flow through the weirs. Long term storage is not practical due to shallow depths of storage and the high rate of evapotranspiration.

Basin-wide detention and/or groundwater recharge facilities are not practical in this watershed unless large pumps are used to manage the water. Gravity basins would require large amounts of land due to the shallow depth of storage. A more feasible solution would be common detention for small groups of property. These can be cost effective if the property owners work together.

WATER BUDGET ANALYSIS - TEN MILE WATERSHED

FOR HYDROLOGICAL YEAR 1990

The following is a generalized water budget analysis for the Ten Mile Watershed for 1990. Detailed information for some of the components of the budget equation is not available without extensive field measurements and observation. The components of water gains or losses that are not readily measurable can be calculated empirically or considered negligible relative to the other components of the equation.

$$(P + SR_{in} + GW_{in}) - (ET + SR_{out} + GW_{out} + L + W) = dS$$

P = Precipitation

SR_{in} = Surface Runoff (into system)

SR_{out} = Surface Runoff (out of system)

GW_{in} = Ground Water Flow (into system)

GW_{out} = Ground Water Flow (out of system)

ET = Evapotranspiration

L = Leakage From Water Table

W = Consumptive Water Use

dS = Change in Basin Storage

Over an annual cycle, groundwater inflows and groundwater outflows will tend to balance and therefore, those terms are excluded from the equation. Surface water inflows and vertical leakage from the water table aquifer are negligible compared to other components of the equation. Consumptive use from the water table was assumed to be negligible because there are no municipal wellfields in the basin withdrawing from the water table aquifer. The use of surficial aquifer water from wells is minimal as shown by the Montgomery Report in 1988. Agricultural and other irrigation uses were considered under ET. Also, the change in basin storage over an annual cycle is assumed to be zero. The resulting equation is:

$$P - ET - SR_{out} = O$$

For 1990, precipitation (P) was 49.09" as recorded at Page Field. Surface water runoff (SR_{out}) was approximately 13.03" based on available continuous recorder information for 1990. Annual evapotranspiration (ET) is then estimated to be 36.06" from the equation above.

CONCLUSIONS

1. Large volumes of water are released from the Ten Mile Canal Watershed each year.
2. The hydroperiod in the Six Mile Slough needs to be extended (i.e. increase duration of hydroperiod).
3. Backpumping of excess surface water from the Ten Mile Watershed into the Six Mile Watershed will both extend the Six Mile Slough hydroperiod and improve water quality in Ten Mile Canal and thus Estero Bay. See Sections 8, 11 and 13 of this report.
4. Other uses of the water during the wet season will lessen the impact to Estero Bay salinity, if the impact is verified.
5. Surficial storage capacity is limited.

RECOMMENDATIONS

1. Reduce the volume of water released by increasing the use of excess water.
2. Construct a pump facility to move water from the upstream side of the Daniels Parkway weir in Ten Mile Canal to Six Mile Slough.
3. Integrate control structures into the Six Mile Watershed Plan to control pool levels and to provide for capture of surface water runoff during periods of low pool levels.
4. Investigate the potential for extending the Six Mile Slough hydroperiod through the capture of excess runoff from urban areas to the west and also from the Ten Mile system by backpumping recapture procedures in areas additional to Daniels Parkway.
5. Investigate the inclusion of excess canal water as an irrigation source to replace the use of potable water.

TEN MILE CANAL WATERSHED

CONCEPTUAL SURFACE WATER CONSERVATION PLAN

WATER VOLUME PASSING TAMIAMI WEIR

TEN MILE CANAL

10. SYSTEM CAPACITY

The capacity of Ten Mile Canal was determined for its design conditions in the Howard Needles Tammen & Bergendoff study in the mid 1970's. This capacity was equated to the 20-year event. SFWMD later equated the channel/weir capacity to the 25-year event. The majority of the canal has been excavated to the design cross section. Proposed improvements discussed in the next section itemize those areas that still need improvements to reach the design capacity.

Some of the assumptions used in the original modeling still apply to the modeling done for this report. The most important assumptions are that there are no depositions of silt or other material in the channel and that the aquatic vegetation is kept to a minimum. Silt deposition or aquatic vegetation that blocks the flow path decrease the capacity of the system. The decreased capacity may or may not cause flooding depending upon where it is located.

Widening the channel to provide a littoral shelf as discussed in Section 8 would appear to provide additional capacity for storm events and/or decrease the water elevations. The water surface elevation may actually increase if groins are placed in the existing channel and high roughness is created by aquatic vegetation. The conceptual design analyzed with the HEC-2 profile provided herein has the planted linear marsh without groins in the channel. Careful analysis will be required prior to construction of a facility with groins.

The recommended allowable discharge is 69 csm for the 25-year event from the Ten Mile Canal portion of the watershed shown on the map on page 46C-W4. Some existing development may exceed this rate. New developments should be required to meet this allowable discharge. The exception would be that portion of the watershed served by the North Colonial Waterway (Subwatershed A). This subbasin was only designed for 37 csm from all undeveloped land.

LEVEL OF SERVICE

Ten Mile Canal, with some modifications, will have adequate capacity to convey the 25-year - 3-day runoff from this watershed. The recommended modifications are given in Section 11. A major requirement to maintain this capacity is proper maintenance of aquatic vegetation. Existing maintenance provides for less than a 5-year Level of Service. Minor (local road) flooding may occur due to existing channel conditions. See Section 10, Volume III for a suggested maintenance schedule. This aquatic vegetation provides uptake of nutrients and metals as discussed in Section 8, therefore the management of aquatic vegetation is crucial to the water quantity and quality capacity of this conveyance. Physical harvesting and removal from the system may be the most preferable method of control. The proposed conditions will allow conveyance of the 25-year - 3-day event with some flooding between the canal top of bank and the railroad embankment. See the backwater profiles on pages 46C-PP5 through 46C-PP8.

The conveyance crosses two evacuation routes, US 41 and Colonial Boulevard. Neither roadway is overtopped by the 25-year storm. The low chord of the Colonial Boulevard bridge is near the 25-year stage. Any future replacement should be designed higher to more readily allow debris to pass under the bridge. The US 41 bridges are quite adequate to convey the 25-year - 3-day flows.

Some of the tributaries appear to be inadequate to deliver the estimated 25-year 3-day flows. This does not cause any problems with the canal. It does indicate that localized flooding may occur upstream of the canal in the areas served by some tributaries. Improvement of the tributaries should include water level control structures to maintain hydroperiods for wet and dry season.

<u>CONCLUSIONS</u>

1. The Ten Mile Canal, with present maintenance, will convey the runoff from a 5-year - 1-day event with minor flooding.
2. The Ten Mile Canal will convey the runoff from a 25-year design rainfall event with water surface elevations as shown for channel design conditions with aquatic vegetation cleared from the canal.
3. The low chord of the bridges at Colonial Boulevard and Winkler Avenue are approximately equal to the 25-year design event.
4. Some of the tributaries do not have adequate capacity to convey the 25-year - 3-day event to Ten Mile Canal.

RECOMMENDATIONS

1. Adopt the 25-year - 3-day design event as the acceptable design level of service for any structure built in or across the canal.
2. Any bridge crossing the canal should have the low chord 3 feet above the 25-year - 3-day water surface elevation.
3. Finalize construction of the remaining reaches that have inadequate cross sectional area and improve the amount of maintenance.

11. PROPOSED IMPROVEMENTS

Three sections of the Ten Mile Canal have not been excavated to the design cross section as noted in Section 3. Also, three bridges do not meet the recommended criteria for clearance above the 25-year event. See Section 10, Volume III. These bridges could cause flooding if debris floats down the conveyance and is caught on the upstream side of these structures. Each of these structures should be redesigned to meet the Lee County criteria applicable at the time of their replacement. The railroad bridge that crosses the canal, just south of Colonial Boulevard, has a low chord that needs to be raised and has numerous pile bents within the channel. Replacement of this structure should incorporate a higher low chord and fewer pile bents. The second structure is the Colonial Boulevard Bridge. This bridge has a low chord that is significantly less than 3 feet above the 25-year event. The low chord of the Winkler Avenue bridge is also less than 3 feet above the 25-year event.

Excavation of the channel to the design cross section should be accomplished to provide capacity for runoff from the 25-year - 3-day storm event. The order of need is 1) from Tamiami Trail (US 41) to Six Mile Parkway, 2) from south of the railroad bridge to Hanson Street and 3) in the area of Park Road. The suggested order of completion is based on the present channel deficiency and how the work could be coordinated with other projects. The present deficiency in size is of primary importance. Based on the SCS cross sections and analysis of the results of the HEC-2 profiles, the most downstream area was ranked last in the three areas requiring excavation. Proposed profiles showing the channel and bridge improvements are on pages 46C-PP5 through 46C-PP8.

Additional improvements to the Ten Mile Canal are needed for water quality enhancements. The linear marsh project, from Daniels Parkway to the Tamiami Weir, will be constructed entirely within existing canal ROW. Approximately 20 acres will be excavated to a depth of 1 to 2 feet below the canal control elevation. The wetland area will be approximately 15,000 feet long and 60 feet wide, and planted with wetland vegetation. This shelf would use plants that would be harvested on a regular basis with other plants in the main canal. Sodding and seeding will be required for the access road, which will be needed for maintenance of the wetland. Erosion control will also be required for areas of elevated velocities.

In-line wet detention located north of the North Colonial Waterway within the ROW should improve water quality. This project consists of expansion of the 60 foot wide channel to a width of 120 feet with a sheet pile or concrete weir across the canal. The excavation is about 4,000 linear feet to a depth of six feet. Construction of littoral shelf wetlands on one or both sides of the canal will comprise approximately 1.5 acres. Seeding and sodding will be required, as will erosion control measures adjacent to the structure. A 20 foot wide access road for maintenance will be required along the entire length of the project.

A diversion structure is proposed for the downstream end of the Ten Mile Canal to take advantage of existing lakes immediately east of the canal ROW. Landowner agreement(s) are needed to provide perpetual use of these borrow pits. A diversion structure, similar in nature to the structure at the downstream end of the Six Mile Cypress, will be required. Purchase of land will also be required to provide a flow path from the canal to the lakes. Erosion control will be required for areas of elevated velocity.

Some of the above named projects could be combined for a net savings of money when constructed. As an example, the needed channel excavation from Tamiami Trail to Six Mile Parkway is along a portion of the proposed linear marsh. All of the channel excavation and adjacent excavation for the proposed marsh could be done together, then have sod and other plants placed at the same time. In this case, there would only be one contract, contractor, mobilization, etc.

Construction of the backpumping facility at Daniels Parkway will significantly increase the length of the Six Mile Slough hydroperiod. Improvement to the overall water quality may be achieved also. This would be a secondary gain. Important to the program would be the monitoring of water quality to ensure the Slough was assimilating the water and its potential pollutants.

<u>CONCLUSIONS</u>

1. There is a limited area available along the east flood plain for expansion.
2. Water quantity and quality improvements are pressing needs in this watershed.
3. There is a potential to combine water quantity and quality improvements with other construction for a net savings to the County.

4. A pump facility at Daniels Parkway would elongate the Six Mile Cypress Slough hydroperiod in the lower reaches.

RECOMMENDATIONS

1. Excavate constricted areas (see Conveyance Elements pg. 46C-W14) of the canal to the design cross section.
2. Design and construct the littoral shelf from Daniels Parkway to Tamiami Weir along Ten Mile Canal.
3. Design and construct the diversion to an existing borrow pit. The water would return to the canal after a set period of time for water quality enhancement.
4. Design and construct an in-line detention facility upstream of the intersection of Ten Mile Canal with North Colonial Waterway.
5. Require all new or replacement crossings of Ten Mile Canal to span the entire width of the canal and have the low chord 3 feet or more above the 25-year storm event.
6. Construct a pump facility to move water from Ten Mile Canal to Six Mile Slough for hydroperiod elongation.

COST ESTIMATES[1]

1.	Channel Excavation[4]		
	Tamiami Trail (US 41) to Six Mile Parkway - 140,000 CY		$ 880,000
	South of Railroad Bridge to Hanson Street- 60,000 CY		480,000
	Park Road area - 60,000 CY		660,000
			$2,020,000
		Engineering 12%[2]	242,400
		Contingency 25%[3]	565,600
		Sub-Total	$2,828,000
2.	Water Quality Improvements		
	Littoral Shelf - 20 acres[4]		$ 920,000
	Diversion to Borrow Pit[5] - with 2 control structures	2,500,000	
	In-Line Wet Detention[4] - 70' crest @ 12.5' NGVD	488,000	
			$3,908,000
		Contingency 25%[6]	977,313
		Engineering 21%[2]	1,016,405
		Sub-Total	$5,901,718
3.	Hydroperiod Extension Daniels Parkway	$ 265,400	
		Engineering 12%[2]	31,200
		Contingency 15%[3]	44,400
		Sub-Total	$ 341,000
		TOTAL	**$9,070,718**

1Item numbers below correspond to item numbers in recommendations on previous pages.
2Engineering includes design, related surveying, permit applications, contract documents and construction observation.
3Contingency calculated on construction subtotal and engineering.
4Within existing easement.
5Agreement with landowner needed.

6Contingency calculated on construction subtotal.

12. FUNDING

Lee County has recently established a water conservation utility that could collect fees to provide stormwater quantity and quality improvements. These fees have two basic forms; one is a monthly fee that is used for design, operation and maintenance of facilities. A second portion of the collected monies is for debt retirement. This is for capital projects either within a geographic area or that have County-wide benefits. The present means of general funding is ad valorem taxes.

The three bridge reconstructions mentioned in the proposed improvements are all associated with transportation needs. These structures do not presently constitute a significant hydraulic constriction and therefore are not proposed to be funded through the Water Conservation Utility. These structures should be funded through transportation funds at the time of their replacement.

The first group provides flood control in three reaches. The project involves final excavation of the canal to design cross sections. This work is for the benefit of those within the watershed. Funding for this work would most likely be paid by those within the benefitted portion of the Ten Mile Watershed. The portion of the watershed conveyed by Six Mile Slough will not be affected by this work.

The second group of three projects listed under proposed improvements, with costs given in Section 11, are all improvements for water quality. These improvements will ultimately benefit Estero Bay. Because of the regional benefit, these projects could be paid for on a County-wide basis. Funding for these could come from planned reserves or a bond issue to be paid by additional fees or from a special levy of ad valorem taxes. These projects would most likely be completed over a two to three year period. Income to pay for these projects could be spread over a similar or longer period of time.

Should the existing borrow areas or other areas south of U.S. 41 be needed for water quality improvements, a cooperative venture between Lee County and the landowner(s) could be accomplished. This cooperative venture would most likely be in the form of an easement. The County would provide maintenance of the facility. The landowner would provide an easement to the County for maintenance and construction access.

Several funding mechanisms were discussed in the funding feasibility report by Camp Dresser & McKee dated November 1989. Many of these will be available from time to time and should be utilized by the utility. Of special interest are those mechanisms where grants are available through South Florida Water Management District or other agencies. Although these funds are not available on a regular basis, ignoring this potential source would be less than prudent. Funding for projects benefiting Estero Bay, due to its Outstanding Florida Waters classification may be available from FDNR, FDER and/or SFWMD.

CONCLUSIONS

1. Facilities for the surface water management system should be funded by all available sources.
2. Funding for O&M should be from a broad source such as ad valorem taxes or the Water Conservation Utility.
3. Funding for capital improvement projects in this watershed should be from transportation funds for bridges, watershed-wide funding for flood control and/or a County-wide funding source for water quality improvements that will benefit Estero Bay.

RECOMMENDATIONS

1. Provide monies for study and design of environmental alternatives listed in Section 11.
2. Pursue additional funding to improve the quality of the surface water flow from Ten Mile Canal into Estero Bay.
3. Coordinate with State agencies to secure possible funding of the projects that will improve Estero Bay water quality.

13. IMPLEMENTATION

The implementation of recommendations for this watershed are threefold; 1) maintenance, 2) water quantity improvements relative to canal cross sections and bridges and 3) water quality improvements focusing on quality of water discharged to Estero Bay. This is the recommended order of conveyance improvements.

The Division of Water Resources and the Operation and Maintenance Division of the Department of Transportation and Engineering should work closely together to provide optimum maintenance of the aquatic vegetation and silt deposits in Ten Mile Canal. As discussed in Volume III, the silt removal would be on a rotating basis, once every three years. The aquatic vegetation removal would be done on a bi-annual basis. These two departments already work very closely on the operation and maintenance of weirs and other facilities.

The bridge replacements for water quantity improvement will require coordination with three separate agencies. The first bridge is a railroad bridge that is part of the Seminole Gulf Railway system. The Colonial Boulevard bridge involves the Florida Department of Transportation. The Winkler Avenue bridge is within the City of Fort Myers. Coordination with each of these entities should begin as soon as possible so that the planning for bridge replacements, even though they may be many years away, will start with good information.

It is very important that the Long Range Planning Division of the Department of Transportation and Engineering be familiar with recommended criteria for crossing Ten Mile Canal. This information will be very useful to them and their consultants in the design of new or replacement bridge crossings in the future.

While the bridge replacements will be mostly coordination and review efforts for the Division of Water Resources, the excavation of channels to full design sections will require plans and specifications to be completed by DWR. It is suggested that some of the channel work be coordinated with proposed water quality enhancements to decrease costs. Joint funding from outside sources may also be more readily available for multi-purpose projects. Plans have already been completed for the Daniels Parkway pump facility. Funding for construction of this project is now needed.

MONITORING OF EXISTING HYDROLOGICAL CONDITIONS

The Ten Mile Watershed has several gages for measuring rainfall, surface water levels and groundwater levels. There are also data collection points for water quality. This network of data collection should be kept in good operating condition and utilized to monitor the development of this basin. Another type of data that would be useful for long term water budgeting is from a pan evaporation gage. A suggestion is to locate these gages at one-third of the recording rain gage sites. In addition to this monitoring system, selected large and small developments should be monitored to verify the use of the 37 csm in the Six Mile Watershed and the North Colonial Waterway Subwatershed and 69 csm in the remainder of the Ten Mile Watershed as a design value for allowable discharge in the 25-year event. Wet and dry season groundwater levels would also show the improvement made by new works and provide future design information.

These monitoring tools will allow future decisions within this watershed to be based on a more complete set of data than has been available in the past. The other very important part of the monitoring is that much of the older data is not relevant due to changes in the size and/or operation of the water management system. The continued monitoring will also allow trends to be established or detected. This information will allow the managers of the water management system to make more informed decisions in the future.

FUNDING

There are two main areas that require funding; one is operation and maintenance, the other is the Capital Improvements Program. The operation and maintenance should be funded through the Water Conservation Utility fee or other existing sources of income that are County-wide. Funding sources for the Capital Improvements Program are a little more diverse. They include working closely with the transportation area to make improvements on bridges that are necessary and to work with several sources to enhance the water quality in Estero Bay. These may include but not be limited to additional Water Conservation Utility fees, one-time ad valorem tax assessment or grants from state or federal agencies. Some of these include the FDNR, FDER and SFWMD.

CONCLUSIONS

1. Maintenance of the canal is important to provide maximum flood protection and maintain or improve water quality.
2. Bridge improvements will be required as replacements are made.
3. Portions of the canal are not constructed to the design section.
4. Water quality improvements are needed for the canal to deliver better water to the receiving body, Estero Bay, an Outstanding Florida Water.
5. Hydrologic monitoring is necessary for informed management of the surface water system.
6. Provisions of this plan should be disseminated to all relevant agencies working and reviewing projects in this area to insure a uniform review.

<u>RECOMMENDATIONS</u>

1. Increase maintenance program to remove excessive plants at least twice each year and remove siltation once every three years.
2. Coordinate with the City of Fort Myers, Florida Department of Transportation, Seminole Gulf Railway and Lee County Department of Transportation and Engineering on bridge replacements.
3. Excavate the undersized portions of the canal to the design cross sections. See Section 11.
4. Design and construct the in-line detention, backpumping facilities, linear marsh and borrow pit holding areas as funds are available. See Sections 8 and 11.
5. Continue the monitoring of water quantity and quality as it exists now and add monitoring of selected developments.
6. Make the information available to all relevant agencies through the Division of Water Resources.

MAPS

DISK INVENTORY

DISK #	FILE NAME	WATERSHED	CONTENTS
1	DRAWING FILES		
	17500A26.DWG	46C	Ten Mile Canal Plan & Profile Sh. 1
	17500A27.DWG	46C	Ten Mile Canal Plan & Profile Sh. 2
	17500A28.DWG	46C	Ten Mile Canal Plan & Profile Sh. 3
	17500A29.DWG	46C	Ten Mile Canal Plan & Profile Sh. 4
	17500A59.DWG	46C	Ten Mile Canal Core Wetlands Map
	17500A70.DWG	46C	Ten Mile Canal Boundary Map
	LEEWS46C.DWG	46C	Ten Mile Canal Watershed Map
	WS46CNRW.DWG	46C	Ten Mile Canal N. Right-Of-Way Map
	WS46CSRW.DWG	46C	Ten Mile Canal S. Right-Of-Way Map
2	HYDROLOGIC (HEC-1) MODELING		
	10M1H1.DAT	46C	Ten Mile Canal HEC-1 Input - 1 Year
	10M1H1.OUT	46C	Ten Mile Canal HEC-1 Output - 1 Year
	10M5H1.DAT	46C	Ten Mile Canal HEC-1 Input - 5 Year
	10M5H1.OUT	46C	Ten Mile Canal HEC-1 Output - 5 Year
	10M25H1.DAT	46C	Ten Mile Canal HEC-1 Input - 25 Year
	10M25H1.OUT	46C	Ten Mile Canal HEC-1 Output - 25 Year
	10M100H1.DAT	46C	Ten Mile Canal HEC-1 Input - 100 Year
	10M100H1.OUT	46C	Ten Mile Canal HEC-1 Output - 100 Year
3	WATER SURFACE PROFILE (HEC-2) MODELING		
	46C-EXH2.DAT	46C	Ten Mile Canal Existing HEC-2 Input
	46C-EXH2.OUT	46C	Ten Mile Canal Existing HEC-2 Output
	46C-PRH2.DAT	46C	Ten Mile Canal Proposed HEC-2 Input
	46C-PRH2.OUT	46C	Ten Mile Canal Proposed HEC-2 Output