Lee County

NORTHWEST LEE COUNTY
SURFACE WATER MANAGEMENT PLAN

Volume 1 – Watershed Report

BOYLE

March 2005

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LEE COUNTY
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1. EXECUTIVE SUMMARY

Lee County, located on the west coast of Florida, is characterized by high rainfall amounts and flat topography typical of Southwest and South Florida. The northwest region of Lee County consists of five principal watersheds, Yucca Pen Creek, Durden Creek, Greenwell Branch, Longview Run, and Gator Slough, draining into Charlotte Harbor Bay. Yucca Pen Creek, Durden Creek, and Gator Slough have a significant part of their upstream drainage area in Charlotte County. Except for Yucca Pen Creek, all these watersheds are interconnected with the Cape Coral canal system. Burnt Store Road (County Road 765) is the major road crossing these streams; it is a major north-south evacuation route. There is limited development within these watersheds, especially in areas west of Burnt Store Road. The area west of Burnt Store Road is essentially cleared, but mostly undeveloped. Majority of the areas east of Burnt Store Road remain undeveloped, and include a large number of pothole wetlands interconnected by shallow dirt access ways providing for storage and conveyance of surface water.

A surface water management plan was developed for the northwest region of Lee County, which includes an overall assessment of existing conditions. Main focus of this study was to develop a Geographic Information System (GIS) database necessary for surface water management, develop a hydrologic/hydraulic model of the surface water system, identify issues of concern, and assess existing and future Level of Service (LOS) deficiencies for flooding along Burnt Store Road. Water quality modeling was also included as part of project scope to assess the existing and future quality of runoff in these watersheds. Identification of potential surface water improvement projects to meet the level of service

desired for roadway flooding, and best management practices to minimize water quality issues were defined to be the key components of this study.

STUDY OBJECTIVES

The main objectives of this study were:

- Assess the existing level of service for roadway flooding along Burnt Store Road.
- Develop future landuse scenarios and assess the future level of service for roadway flooding.
- Assess existing and future water quality levels in the study area.
- Develop proposed improvement alternatives with a focus on Burnt Store Road control structures to meet the level of service desired for roadway flooding, and assess the proposed level of service.
- Recommend Best Management Practices (BMPs) to address the water quality issues in the existing conditions.
- Obtain conceptual permit from South Florida Water Management District for the proposed improvement alternatives.

DATA DEVELOPMENT

Existing data were collected from various sources for the study watersheds. These data included topographic information, aerial photographs, landuse/soils information, permit information, rainfall and streamflow data. GIS data for the study area were collected from various agencies and were processed to set up the database for modeling. This database included landuse, soils, topography, aerial photographs, and an inventory of existing control

structures. A limited field survey with a detail sufficient for a master plan level study was performed to obtain the geometric characteristics of conveyance elements. Watershed boundaries and subbasins were delineated under GIS environment using the available topographic data. The delineation of subbasins was dictated to a large extent by the shallow concentrated flow paths and the network of pothole wetlands east of Burnt Store Road. The total drainage area of the study watersheds west of US-41 is approximately 48.4 square miles. Overall slope of the study watersheds is 2.6 ft per mile or approximately 0.05%.

WATER QUANTITY MODELING

GIS and other computer-based models and tools were used to characterize the existing conditions hydrology of the study watersheds. ICPR Version 2.2 was selected as the hydrologic/hydraulic model for this study. The inventory of the conveyance elements developed for the study area was used to develop the node-link configuration for the ICPR model. An analysis of tide elevations in Matlacha Pass indicated that the maximum tide elevation is approximately 2.2-ft NGVD 1929, ignoring storm surge effects; a conservative tide elevation of 2.5-ft was used as the tailwater condition in this study.

Existing conditions hydrologic/hydraulic model of the study area was developed using ICPR model. This model was calibrated and verified for a major rainfall event of June 2003 using Next Generation Weather Radar (NEXRAD) rainfall data. Since the drainage area of Gator Slough east of US-41 was not modeled, the observed streamflow data obtained from USGS were used to develop a rating curve input for the ICPR model to represent the Gator Slough inflows. A roadway flooding of approximately 4-inch to 6-inch was observed by Lee County at Durden Creek Main culvert and at Culvert #6 along Burnt Store Road; this

flooding depth was simulated by the calibrated ICPR model. Gumbel statistical analysis of long-term observed streamflow data at the USGS streamgage provided the Gator Slough inflow rating curves for various design storms. Ten design storm events were simulated using the calibrated existing conditions model to determine the existing conditions flood stages in the study area.

Lee County's Level of Service (LOS) criterion for roadway flooding along Burnt Store Road is to have no roadway flooding for more than 24 hours during the 25-yr, 72-hr design storm. This LOS criterion was not met at Durden Creek Main culvert and Culvert #6 along Burnt Store Road. Existing conditions floodplain maps were developed based on the modeling results for 25-yr, 72-hr and 100-yr, 72-hr storm events.

Two future conditions landuse scenarios were established based on two development scenarios. These scenarios were incorporated in the existing conditions ICPR model as Directly Connected Impervious Areas to develop the future conditions ICPR models. Ten design storm events were simulated for the two future landuse scenarios and the level of service for roadway flooding along Burnt Store Road was assessed. The LOS criterion was not met at the same locations as in the existing conditions along Burnt Store Road.

The existing Lee County right-of-way is 200-ft wide along Burnt Store Road from Charlotte County line up to Van Buren Parkway and beyond. Burnt Store Road is an existing 22-ft wide paved roadway. Lee County has proposed to widen this road to a 4-lane road and eventually to a 6-lane road; the preliminary plans call for the use of entire 200-ft right-of-way for this widening. Lee County desired to include lengthening of the Burnt Store Road culverts to 200-ft as part of the proposed improvements. City of Cape Coral has proposed to raise the invert of two weirs along Gator Slough by 1-ft and has obtained permit from

SFWMD for the same. This was also considered as part of the proposed improvements. During field reconnaissance, a significant obstruction (derelict concrete structures) was identified in Durden Creek Main channel west of Burnt Store Road, which significantly reduces the conveyance capacity. Removal of this obstruction was also considered for the proposed conditions.

The following improvement alternatives were analyzed and recommended to meet the roadway flooding LOS criterion at Burnt Store Road:

(1) Upsizing of Durden Creek Main Culvert (Culvert #3)

(2) Upsizing of Culvert #6

(3) Removal of sedimentation and vegetation growth at Burnt Store Road culverts and side ditches

(4) Provision of a side ditch connection from Durden Creek Main culvert to Culvert #4 on the east side of Burnt Store Road

(5) Expansion of the side ditch along Burnt Store Road on the east side by 6-ft and lowering of ditch inverts by up to 1-ft

(6) Upgrade of the side-drains along the east side ditch at Burnt Store Road

(7) Expansion of two drop structures located at the southern end of the side ditches just north of Gator Slough

(8) Raising the Burnt Store Road elevation at Durden Creek Main culvert by 6-inches.

(9) Removal of the obstruction (derelict concrete structure) in Durden Creek Main channel east of Burnt Store Road

Due to the proximity of seasonal high water table to existing natural ground elevations, the size of storage facilities such as detention/retention ponds would become inordinately large and unfeasible. A proposed conditions ICPR model was developed using the improvement alternatives and the selected design storm events were modeled. The proposed improvements eliminated the roadway flooding along the entire length of the expanded Burnt Store Road within the study area during the 25-yr, 72-hr design storm event, meeting the LOS criterion. The probable construction costs for the proposed improvements was estimated to be approximately $470,000, not including the cost of lengthening or relocation of culverts/drop structures/ditch that are not to be upsized, the cost of raising the roadway elevation at Culvert #3, and detailed survey, engineering design and right-of-way/easement costs.

The USGS streamgage located east of US-41 in Gator Slough canal does not account for all the flows west of US-41. This streamgage should be moved from its current location to approximately 500’ downstream of US-41 culvert. This is essential to properly monitor the total flow in Gator Slough canal. Since there is only one raingage available for the entire study area, installation of a weather station in the vicinity of Burnt Store Road is recommended to aid in future studies.

A water budget analysis of the study area for the 25-yr, 72-hr design storm event indicates that the total outflow from the study area into Matlacha Pass/Cape Coral canal system is approximately 18,200 ac-ft. This is approximately two-thirds (66.8%) of the total inflow into the system. Significant inter-basin flows occur between the study watersheds because of the flat topography of the Northwest Lee County region.

WATER QUALITY MODELING

A spreadsheet model, developed by Environmental Research and Design, Inc. (ERD) was selected to model the existing conditions water quality in the study area. The ERD model is based on landuse characterization and performance evaluation studies for stormwater treatment systems performed specifically in Southwest Florida. Based on the landuse characteristics of the subbasins, the mean event concentrations of seven water quality parameters, mass loading of pollutants from the stormwater runoff, and total untreated pollutant concentrations were calculated.

The existing conditions landuse data of the study area were used to analyze water quality using the ERD model. The surface water quality standards of FDEP were considered to be the intended level of service for specific water quality parameters. Modeling results indicate that the concentrations of Biochemical Oxygen Demand (BOD), Total Phosphorus (TP), and Lead did not meet the level of service in the existing conditions. The future landuse scenarios developed for water quantity modeling were used to analyze the future conditions water quality in the study area. Modeling results indicate that the future conditions concentrations of BOD, TP, and Lead did not meet the desired level of service.

In order to reduce the concentrations of water quality parameters, various stormwater management systems were analyzed through literature survey and previous work performed within the State of Florida. Comparative removal efficiencies were obtained and summarized for on-line dry retention, on-line wet retention, off-line retention/detention systems, wet detention, and dry detention systems. The most effective stormwater management systems in terms of reducing stormwater pollutants appear to be dry retention, off-line retention/detention ponds, wet retention, and wet detention systems.

The proximity of seasonal high water table to the existing ground elevations is an issue for providing retention/detention treatment systems. Future studies should assess the seasonal high water table elevations in the study area using site-specific soil borings so that the feasibility of providing wet/dry retention or detention treatment systems could be determined.

The water quality treatment requirements for potential retention/detention systems were calculated for the areas not owned by the State east of Burnt Store Road. The treatment volumes required for 1-inch of runoff are 54 ac-ft for Yucca Pen Creek watershed, 24-ac-ft for Durden Creek watershed, and 130 ac-ft for Greenwell Branch watershed.

2. INTRODUCTION

WHAT IS A WATERSHED MANAGEMENT PLAN?

Significant improvements in the protection and restoration of the physical, chemical, and biological integrity of the nation's waters have been made in the last 25 years. The passage of the Clean Water Act and Safe Drinking Water Act has resulted in the control of pollution from point and non-point sources in specific regions of the nation. Problems regarding non-point sourced pollution and habitat degradation necessitate a comprehensive approach to a complex situation, and solutions that integrate disciplines and overlap geographical boundaries. This holistic, comprehensive approach is called a watershed management plan for surface water control. The watershed management plan approach to improving the physical, chemical and biological integrity of surface waters is a three-part process. These three components include identifying the watershed's natural boundaries, applying the latest scientific methods to identify problems, and coordinating the improvements within political, economic, and social constraints.

A watershed boundary incorporates all the areas that drain to a specific surface water body. The Charlotte Harbor Bay watershed encompasses a large drainage area that includes all lakes, rivers, estuaries, wetlands, streams and surrounding landscape in all or part of Lee and Charlotte counties.

In order to identify, characterize and evaluate the problems within a watershed, the latest scientific tools, techniques, and theory must be utilized. The proposed solutions must include the latest and most cost-effective methods of watershed rehabilitation, integrating various scientific disciplines and expertise.

Watersheds are seldom contained within a single political boundary. This necessitates a team approach incorporating several local, state and federal agencies, as well as the concerned public. Team members form a partnership and work together toward a common goal based on shared information, and an understanding of the priorities and responsibilities of all parties.

THE BENEFITS OF WATERSHED MANAGEMENT APPROACH

Coordination of a watershed management plan is beneficial for environmental, financial, social, and administrative reasons. A watershed management plan allows water resources managers from all levels of government view the "big picture" rather than just their portion of the watershed. This helps better understanding of the cumulative effects of human activities in a watershed on surface water runoff, water quality, fish and wildlife, drinking/irrigation water availability, and other environmental resources. The most critical problems are identified and priorities can then be set to allocate the available financial and human resources to minimize negative impacts of human activities on water/environmental resources.

The watershed management approach also can result in significant savings by improving communication and coordination, which will in turn reduce costly duplication of efforts and conflicting actions. This cooperation gives an active voice in resource management to the people who depend on the area resources for their recreation, health, and overall quality of life.

BACKGROUND

Lee County is located on the west coast of Florida, south of Charlotte County, north of Collier County, and west of Hendry County (Figure 2.1). Lee County region is characterized by flat topography and high rainfall amounts typical of southwest and south Florida. The northwest region of Lee County consists of five principal watersheds: Yucca Pen Creek, Durden Creek, Greenwell Branch, Longview Run, and Gator Slough. All these watersheds drain into Charlotte Harbor Bay of the Gulf of Mexico. Yucca Pen Creek, Durden Creek, and Gator Slough have a significant part of their upstream drainage area in Charlotte County. Burnt Store Road (County Road 765) running north-south is the major road crossing these streams. The city of Cape Coral corporate boundary is along Burnt Store Road. There is limited development within these watersheds, especially in areas west of Burnt Store Road. The area east of Burnt Store Road is essentially undeveloped except for few homes and a mine; this area is characterized by shrub vegetation, upland woods, and pothole wetlands. Future residential developments are anticipated in the watershed areas east of Burnt Store Road in the coming years. There are no formal surface water drainage systems east of Burnt Store Road in these watersheds; conveyance is primarily by sheet flow and via shallow swales until water reaches the Burnt Store Road.

Boyle Engineering Corporation was retained by Lee County Division of Natural Resources to prepare develop a surface water management plan for the northwest region including an overall assessment of existing conditions. South Florida Water Management District (SFWMD) provided grant funding to Lee County to expand the study area to include Gator Slough watershed and parts of the Cape Coral canal system west of Old Burnt Store Road. Main focus of this study was to develop a Geographic Information System (GIS)

database necessary for surface water management and a hydrologic/hydraulic model of the surface water system, and to identify issues of concern and assess existing and future Level of Service (LOS) deficiencies for flooding along Burnt Store Road. Water quality modeling was also included as part of project scope to assess the existing and future quality of runoff in these watersheds. Identification of potential surface water improvement projects to meet the level of service desired for roadway flooding, and best management practices to minimize water quality issues, if any, were defined to be the key components of this study. This report describes data development, modeling approach, results obtained, and proposed surface water improvement projects recommended to meet the level of service for roadway flooding and water quality in these watersheds.

STUDY OBJECTIVES

The main objectives of this study are:

- Assess the existing level of service for roadway flooding along Burnt Store Road.
- Develop future landuse scenarios and assess the future level of service for roadway flooding.
- Assess existing and future water quality levels in the study area.
- Develop proposed improvement alternatives with a focus on Burnt Store Road control structures to meet the level of service desired for roadway flooding, and assess the proposed level of service.
- Recommend Best Management Practices (BMPs) to address the water quality issues in the existing conditions.
- Obtain conceptual permit from SFWMD for proposed improvement alternatives.

PROJECT SCOPE

Scope of work defined for this project included the following:

Data Development:

Data Collection

Review of Available Data

Field Reconnaissance

Limited Survey of Control Structures

GIS Data Acquisition and Analysis

Delineation of Watershed Boundaries

Basin Characterization

Development of Surface Water Control Structures Inventory in GIS

Surface Water Modeling and Level of Service:

Existing Conditions Modeling

Establishment of Existing LOS Deficiencies

Existing Conditions Model Verification

Future Conditions Modeling

Future Conditions LOS Deficiencies

Surface Water Improvement Project Alternatives

Proposed Conditions Modeling with Selected Improvement Alternative(s)

Proposed Conditions LOS with Selected Improvement Alternative(s)

Water Quality Analysis/Modeling and Level of Service:

Data Collection

Existing Conditions Modeling

Establishment of Existing LOS Deficiencies

Future Conditions Modeling

Future Conditions LOS Deficiencies

BMP Alternatives

Assessment of the Effectiveness of the BMPs and Recommendations

Permitting:

Preparation of a Conceptual Permit Application

Final Report:

Preliminary Estimate of Probable Construction Costs

Final Report detailing the study approach, modeling, results, and recommendations

TASKS INVOLVED

The major tasks involved to achieve the objectives of this project are listed below:

- Data collection.
- New data development.
- Development of future landuse scenarios.
- Hydrologic and hydraulic model development for existing landuse conditions and future landuse scenarios.
- Level of service assessment for roadway flooding in the existing landuse conditions.
- Floodplain mapping.

- Water quality modeling for the existing landuse conditions and future landuse scenarios to identify issues of concern.
- Identification of improvement alternatives to meet the level of service desired for roadway flooding.
- Proposed conditions hydrologic/hydraulic modeling.
- Level of service assessment for roadway flooding with the proposed improvement alternatives and existing landuse conditions.
- Identification of feasible BMPs to address the existing water quality issues of concern.
- Recommendations for better surface water management within the study watersheds.

3. STUDY AREA

STUDY AREA

The study area includes Yucca Pen Creek, Durden Creek, Greenwell Branch, Longview Run, and Gator Slough watersheds. These watersheds drain parts of the unincorporated areas of Lee County and a portion of the City of Cape Coral. The study area is bound on the east by US-41 (North Tamiami Trail), on the west by Charlotte Harbor Bay, and on the north by the Lee-Charlotte county line (Figure 3.1). A part of the Cape Coral canal system west of Burnt Store Road is also considered in this study. All the study watersheds except Yucca Pen Creek basin connect with the Cape Coral canal system. A significant drainage area of Yucca Pen Creek and Durden Creek watersheds are in Charlotte County. Gator Slough drains approximately 33 square miles east of US-41 in Lee and Charlotte Counties; this area is not considered for modeling purposes in this study. Burnt Store Road is the major north-south connector within the study area and is an evacuation route. This road extends to the north beyond the Lee-Charlotte County line and to the south into the City of Cape Coral. Old Burnt Store Road is located west of Burnt Store Road within the City of Cape Coral. The total drainage area of the study watersheds west of US-41 is approximately 48 square miles; this area is considered for modeling in this study. The study area is characterized by flat topography typical of South Florida; the highest elevations range between 21.0'-23.0' NGVD 1929 in the eastern parts of the watersheds near US-41. The overall slope of the study watersheds is 2.6' per mile or approximately 0.05%.

The study watersheds are characterized by undeveloped areas as well as areas cleared for residential development and mining activities. About 30% of the study area has been

cleared for single-family residential development mostly within the City of Cape Coral limits and mining. Most of the study area east of Burnt Store Road remains undeveloped and includes grasslands, shrub vegetation such as palmettos and Brazilian peppers, and upland woods such as pine and maleluca trees. Area east of Burnt Store Road also includes a large number of pothole wetlands interconnected by vehicular access dirt ways acting as shallow swales providing for storage and conveyance of surface water to the west.

Soils within the study area predominantly consist of fine sands variations such as Boca and Hallandale Fine Sands. These soils are classified under the hydrologic soil groups of B/D and D.

PREVIOUS STUDIES

Two previously completed drainage studies of the project watersheds were reviewed to assess the existing conditions and to determine the availability of useful data for developing hydrologic/hydraulic models. A brief description of these previous studies is provided below.

Gator Slough and Cape Coral Canal System Improvements:

The City of Cape Coral entered into a cooperative agreement with SFWMD in 1997, for cost-share funding improvements to the Cape Coral canal system located in the northern part of the city. The improvements primarily included weir structure improvements such as raising the inverts of some weirs and rehabilitation of other weirs, and removal of vegetation growth in Gator Slough canal. The purpose of these improvements was two fold: 1) to allow additional storage in the canal system to reduce excessive and harmful discharge of fresh

water into the Matlacha Pass estuary, and 2) to increase drainage efficiency and reduce recurring flooding problems upstream in the North Fort Myers area. A detailed hydrologic/hydraulic modeling and analysis of Gator Slough watershed and the Cape Coral canal system was conducted by Boyle Engineering Corporation using XP-SWMM model. A permit was obtained from SFWMD to raise the inverts of five weirs controlling the flows in the study canals by 1-foot. This included one weir in Gator Slough just upstream of Burnt Store Road bridge.

Lee County Surface Water Management Plan:

Johnson Engineering conducted an elaborate study of all watersheds in Lee County in 1991, and prepared a surface water management plans for individual watersheds. These plans provided information on various surface water control structures in respective watersheds and included right-of-way maps. The details of surface water control structures were gathered from various sources including the floodplain study prepared by United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), and additional information provided by Lee County and other local governments. The data for the five project watersheds obtained from this report were used to verify and supplement the data collected from various sources and field reconnaissance for this project.

CONCLUSIONS

1. Northwest region of Lee County consists mainly of five watersheds. They are Yucca Pen Creek, Durden Creek, Greenwell Branch, Longview Run, and Gator Slough watersheds.

2. These watersheds drain parts of the unincorporated areas of Lee County and a portion of the City of Cape Coral. Gator Slough drains approximately 33 square miles east of US-41. A significant portion of Yucca Pen Creek, Durden Creek, and Gator Slough watersheds is in Charlotte County.
3. Except for Yucca Pen Creek, all these watersheds are interconnected with the Cape Coral canal System.
4. The total drainage area of the study watersheds west of US-41 is approximately 48 square miles.
5. Burnt Store Road is the major north-south connector within the study watersheds and is an evacuation route. This road extends to the north beyond the Lee-Charlotte County line and to the south into the City of Cape Coral. Old Burnt Store Road is located west of Burnt Store Road within the City of Cape Coral.
6. The study area is characterized by flat topography typical of South Florida. Overall slope of the study watersheds is only 2.6 ft per mile or approximately 0.05%.
7. About 30% of the study area has been cleared for single-family residential development, mostly within the City of Cape Coral. Most of the study area east of Burnt Store Road remains undeveloped, and includes a large number of pothole wetlands interconnected by vehicular access dirt ways acting as shallow swales providing for storage and conveyance of surface water.

RECOMMENDATIONS

1. Gator Slough basin drains a significant area east of US-41. It is also interconnected with the Cape Coral canal system. Since the areas east of US-41 and the

interconnections were studied indirectly in this study, an integrated study and model development that will include the entire drainage area and the entire Cape Coral Canal System is recommended.

4. DATA DEVELOPMENT

DATA COLLECTION

A variety of data are required to develop a hydrologic/hydraulic model for a watershed, define model-specific parameter values, verify model results, and develop a sound surface water management plan to address flooding and water quality issues. These data include, but are not limited to, existing and future landuse characteristics, soils characteristics, topography, rainfall and streamflow data, and details of existing water control and conveyance facilities and structures.

The data used for this project were obtained from a number of different resources. A list of data collected, their source, format, and a brief description are provided below:

Spot Elevation and One-foot Contour Map of the Study Area:

Source: Lee County

Format: Four mylar sheets (hardcopy)

Description: These maps covered a major portion of the study area. The spot elevations and contours were based on NGVD 1929 datum. The maps were dated 1990-91. The scale of the data was 1"=1000'. The contour interval was one foot.

Infra-red Aerials/Digital Ortho Quarter Quadrangles:

Source: Land Boundary Information System (LABINS) of the FDEP

Format: MrSID GIS format

Description: These aerials were dated 1999 and were in State Plane Florida West geographical coordinates with NAD 1983 horizontal datum and the distance unit in feet.

Aerial Photographs:

Source: Lee County

Format: MrSID GIS format

Description: These high-resolution aerials were dated 2003 and were in State Plane Florida West geographical coordinates with NAD 1983 horizontal datum and the distance unit in feet. These aerials covered the study area up to the Lee-Charlotte county line. The contour maps of 1990-91 differed significantly from the 2003 aerial photographs. Aerial photographs showed new homes and mine pit developments that were not represented in the contour maps.

Spot Elevations:

Source: South Florida Water Management District

Format: GIS Shape files

Description: Spot elevations in feet based on NGVD 1929. The GIS data were in State Plane Florida East geographical coordinates. This data covered the study area up to the Lee-Charlotte county line.

Contour Maps:

Source: Southwest Florida Water Management District

Format: GIS Shape files

Description: Two-foot and five-foot contours for Charlotte county area were obtained. This GIS data were in Universal Transverse Mercator (UTM) projection.

Landuse Map:

Source: South Florida Water Management District

Format: GIS – Arc/INFO coverage

Description: Landuse data covering the entire study area dated 2000. Projection: NAD_1927_StatePlane_Florida_East_FIPS_0901

USDA-NRCS Soils Map:

Source: South Florida Water Management District and Southwest Florida Water Management District (SWFWMD)

Format: GIS – Arc/INFO coverage (SFWMD) and Shape file (SWFWMD)

Description: SFWMD data covers the Lee County portion of the study area, in NAD_1927_StatePlane_Florida_East_FIPS_0901 projection.

SWFWMD data covers the Charlotte County portion of the study area, in NAD_1983_HARN_UTM_Zone_17N projection.

Construction Plans for Old Burnt Store Road Drainage Improvements:

Source: City of Cape Coral

Format: Hardcopy

Description: Construction plans for the installation of 24" RCPs across Old Burnt Store Road completed in April 2004.

Copies of Environmental Resource Permits:

Source: South Florida Water Management District

Format: Hardcopy

Description: Permits issued for various construction, development, and mining activities within the study area.

Raingage Rainfall data:

Source: Lee County

Format: Electronic (Excel Spreadsheet)

Description: 15-minute rainfall data from the Lake Fairways raingage located west of US-41 within the study area boundary for June 2003.

Next Generation Weather Radar (NEXRAD) Rainfall data:

Source: South Florida Water Management District

Format: Electronic (Excel Spreadsheet)

Description: Daily rainfall data from the NEXRAD network for the study area for June 2003.

Streamflow Data:

Source: United States Geological Survey (USGS)

Format: Electronic (Excel Spreadsheet)

Description: Mean daily streamflow data for the period 1984-2002 at the streamgage "USGS 264437081550100 GATOR SLOUGH AT US41 NEAR FT MYERS FL" and fifteen-minute streamflow data at this streamgage for June 2003.

GIS DATA DEVELOPMENT

Creation of Landuse Map for the Study Area:

The existing conditions landuse data for Lee County obtained from SFWMD was processed in GIS to develop a landuse shape file of the study area. The attribute table of this shape file included the three levels of Florida Land Use/Cover Classification System (FLUCCS) code. FLUCCS Level 2 landuse cover description and classification scheme obtained from SFWMD was added to the attribute table of the landuse shape file. Individual landuse categories were assigned landuse codes in the GIS database for further analysis to develop the hydrological characteristics of the watersheds. Figure 4.1 shows the Landuse Map of the study area. Table 4.1 provides the landuse codes and descriptions.

Creation of Soils Map for the Study Area:

The data obtained from SFWMD and SWFWMD were processed in GIS to develop the soils data of Lee County and Charlotte County areas, respectively. These data were merged to obtain a single soils shape file that covered the entire study area. Figure 4.2 shows the soils map of the study area. The SWFWMD soils database included both hydrologic soil group and soil description, while SFWMD data did not include hydrologic soil groups. Hydrologic soil groups from SWFWMD database were assigned to the corresponding soil descriptions in SFWMD database. For those soils not present in SWFWMD portion of the study area, the hydrologic soil group of a surrounding soil type was assigned. Table 4.2 provides the codes and descriptions of the soil types present in the study area.

Conversion of Spot Elevation/One-foot Contour Maps from Hardcopy to GIS:

The hardcopy mylar maps of spot elevations and one-foot contours obtained from Lee County were scanned to create JPEG files. These JPEG files were imported into GIS by georeferencing them in State Plane Florida West geographical coordinates using a world file that defines the x and y coordinates of a corner of the maps and a scale factor. This made it possible to overlay other GIS data on the spot elevation/contour map to delineate subbasins and the floodplain.

FIELD SURVEY

A limited field survey of the study watersheds sufficient for a master plan level study was performed to obtain the geometric characteristics of channels, swales, interconnects between watersheds, and water control structures in the existing conditions. Vertical elevations were determined by hand-held Global Positioning System (GPS) instrument with an accuracy of plus or minus 0.15 ft. Vertical Datum was based on NGVD 1929 and the horizontal datum was in NAD83-State Plane Florida West coordinates established based on existing County monumentation. These data were used as model input for hydraulic analysis. Electronic files of survey data are provided in the CD-ROM included with this report. AutoCAD drawings of surveyed control structures are included in Appendix A.

FIELD RECONNAISSANCE

Field reconnaissance of the study area was conducted to assess the existing conditions of the drainage ditches, channels, culverts, and other control structures. Extent of vegetation growth in the channels was assessed to determine the range of Manning's 'n' values to be

used in the model. Condition of the culverts was assessed regarding sedimentation that could reduce the conveyance. Sizes and inverts of the culverts and channel dimensions were also measured in the field for those structures that were not surveyed and for which no data were available from other sources; these structures were generally located along Gator Slough upstream of Burnt Store Road up to US-41.

CONCLUSIONS

1. Existing data were collected from various sources for the study watersheds. These data included topographic information, aerial photographs, landuse/soils information, permit information, rainfall and streamflow data.
2. The latest available contour map of Northwest Lee County region is dated 1990-91. Significant development has occurred in this region since 1991.
3. GIS data for the study area were collected from various agencies and were processed to set up the database for modeling.
4. A limited field survey with a detail sufficient for a master plan level study was performed to obtain the geometric characteristics of conveyance elements.
5. Field reconnaissance of the study area was performed to assess the existing conditions conveyance elements and to identify issues of concern.

RECOMMENDATIONS

1. Since the topographic contour information available for the study area is dated 1990-91 and significant differences were noted between the contour maps and the 2003 aerial photographs, development of new topographic data is recommended for the

study area. This can be accomplished with the cooperation of South Florida Water Management District, City of Cape Coral, and Charlotte County. New technologies such as LIDAR are used elsewhere in Florida to develop elevation data for large areas. For example, Southwest Florida Water Management District is currently developing a District-wide elevation data using LIDAR. Such technologies should be used to develop new topographic contours of Northwest Lee County region for future studies.

2. GIS is playing a key role in several disciplines including water management to store, analyze, and manipulate spatial data. The GIS database of the study watersheds created in this study should be developed further to include other relevant watershed information. Digitization of data in other formats including hardcopy maps is important. Such a GIS database will serve as a valuable tool for water resources managers. Since the Northwest Lee County GIS database has been developed using the Lee County GIS standards, this database could be integrated seamlessly with other County-wide water resources GIS data as well as data from other County departments.
3. The GIS database of the Northwest Lee County region should be continuously updated to reflect the developments and changes within these watersheds to aid in efficient management of water resources in this region.
4. The field survey conducted for this study is limited in scope. Detailed survey should be performed for the engineering design of the proposed improvements and any future studies focused on specific watersheds.

5. WATERSHED BOUNDARY MAP

WATERSHED BOUNDARY AND SUBBASIN DELINEATION

Considering the level of detail necessary for a master plan study to define and properly analyze the drainage system in the study area, the watersheds were delineated under ArcGIS environment using the one-foot contour data, spot elevations, and aerial photographs. The watershed boundaries defined the contributing drainage areas to individual culverts under the Burnt Store Road. The watersheds were further delineated into 94 subbasins using topographic information and aerial photographs. The delineation of individual subbasins east of Burnt Store Road was dictated to a large extent by the shallow concentrated flow paths and the network of pothole wetlands. For the portion of the study area within City of Cape Coral, the watershed and subbasin boundaries were delineated using roadways as the watershed/subbasin divide. Significant inter-basin flows occur between the five watersheds at several locations east of Burnt Store Road because of flat topography. The northern boundary of Gator Slough basin delineated in this study near US-41 differs significantly from the boundaries reported by Johnson Engineering in 1991. Topographic information indicates that the area north of Lake Fairways subdivision is drained by Durden Creek and Greenwell Branch, instead of Gator Slough.

Since the topographic information used to delineate the watersheds and their subbasins is dated 1990-91, updated topographic data should be used in the future to refine the watershed/subbasin boundaries delineated in this study.

The areas of the subbasins ranged from 18± ac to 1,516± ac as shown in Table 5.1. The total drainage area was calculated to be 48.4 square miles or 30,976 ac.

Figure 5.1 shows the subbasin map of the study area. The Lee County mine located east of Burnt Store Road (Subbasin GS-7) and the Kodii mine, which is located within Subbasin GB-14 west of Burnt Store Road, are closed subbasins and are ignored for modeling purposes.

CONCLUSIONS

1. Five watersheds and their subbasins were delineated under ArcGIS environment with the use of the aerial photographs and spot elevations/contour maps, defining the contributing drainage area to individual culverts under the Burnt Store Road.
2. The study area was delineated into a total of 94 subbasins.
3. The delineation of subbasins was dictated to a large extent by the shallow concentrated flow paths and the network of pothole wetlands east of Burnt Store Road.
4. Significant inter-basin flows occur between the watersheds at several locations east of Burnt Store Road because of the flat topographic characteristic of the study area.
5. In the City of Cape Coral portion of the study area, watershed/subbasin boundaries were delineated using roadways as the divide.
6. Lee County mine and Kodii mine are closed subbasins.
7. Subbasins of the study watersheds ranged from 18± ac to 1,516± ac in area.
8. The total drainage area was 48.4 square miles or 30,976 ac.
9. The northern boundary of Gator Slough watershed delineated in this study near US-41 differs significantly from the boundaries reported by Johnson Engineering in 1991.

The area north of Lake Fairways subdivision is drained by Durden Creek and Greenwell Branch.

RECOMMENDATIONS

1. Since there are significant differences between the contour maps available for the study area and the latest aerial photographs, updated topographic data should be used to refine the watershed/subbasin boundaries delineated in this study.

6. SENSITIVE LANDS

The study area is characterized by very flat topography. The flow is primarily by sheet flow, shallow swales, and vehicular access ways on the east side of Burnt Store Road. Major portions of the drainage area east of Burnt Store Road are State-owned lands as shown in Figure 6.1. The areas adjoining Burnt Store Road on the east side and areas along US-41 are owned by private land-owners or Lee County, except for a parcel owned by the State (Figure 6.1). The State also owns the estuarine areas along the coastline west of the City of Cape Coral. Areas west of Burnt Store Road within the City of Cape Coral are privately owned. The lands owned by the State are generally not available for any proposed flood control/water quality improvements or for development. That leaves only a limited land available for proposed improvements in the study watersheds. The proposed improvements and right-of-way expansion, if any, have to be located within the limited areas owned by Lee County or private owners.

Longview Run watershed is a small watershed located entirely within the City of Cape Coral, west of Burnt Store Road. The area drained by this watershed includes old mine pit ponds and single-family residential developments. Gator Slough watershed drains an area of approximately 16 square miles west of US-41 and a significant area east of US-41 in Lee and Charlotte Counties. Hence the development plans of Charlotte County will significantly affect the flows in Gator Slough canal. Cooperation with Charlotte County and City of Cape Coral will be necessary to coordinate development that would increase flows in Gator Slough as well as other watersheds considered in this study. The Gator Slough canal has been channelized from US-41 up to the perimeter spreader waterway system in Cape Coral,

adjoining the salt marsh/mangrove estuarine areas. Durden Creek, Greenwell Branch and Longview Run watersheds also drain into the spreader waterway system. The purpose of the spreader waterway system is to help reduce the impacts of direct fresh water flows out of these watersheds into the estuaries and Charlotte Harbor Bay. The spreader system is a canal that parallels the estuarine areas adjacent to Charlotte Harbor Bay with the purpose of causing the water to sheet flow into the estuarine wetlands. Utilization of the excess capacity of the perimeter spreader system and Cape Coral canal system should be probed with the cooperation of the City of Cape Coral.

In addition to the above, presence of wetlands is a major factor to be considered in the determination of the proposed improvements and future development. Figure 6.2 shows the National Wetland Inventory (NWI) data of 1990 for the study area as obtained from SFWMD GIS database. Wetlands in the study area are classified into several types by NWI. Figure 6.2 shows the extent of NWI wetlands of the study area. Table 6.1 provides the wetland types and their description. A major portion of the study watersheds east of Burnt Store Road consist mainly of Palustrine Forested/Emergent Seasonal wetlands (PFO4/EM5C), Palustrine Forested/Emergent Temporary wetlands (PFO4/EM5A), and Palustrine Emergent Seasonal wetlands (PEM5C). Estuarine type of wetlands dominates the coastal areas including the mouth of Yucca Pen Creek and Durden Creek. Impacts to the wetlands should be a consideration in developing proposed improvement projects.

CONCLUSIONS:

1. State of Florida owns a major portion of the study watersheds east of Burnt Store Road. The State also owns the estuarine areas along the coastline west of the City of Cape Coral.
2. Only a limited area adjoining Burnt Store Road on the east and areas along US-41 are owned by Lee County or private owners.
3. Areas west of Burnt Store Road within the City of Cape Coral are privately owned.
4. Since the State-owned lands are generally not available for proposed improvements or development, only a limited land is available for proposed improvement projects in the study area.
5. The proposed improvements and right-of-way expansion, if any, have to be located within the limited areas owned by Lee County and private owners.
6. Durden Creek, Greenwell Branch, Longview Run, and Gator Slough watersheds drain into the perimeter spreader waterway system of the City of Cape Coral adjoining the estuarine areas. The purpose of the spreader waterway system is to help reduce the impacts of direct fresh water flow out of these watersheds into the estuaries and Charlotte Harbor Bay.
7. Cooperation between Lee County, Charlotte County, and City of Cape Coral is necessary to coordinate future development plans and improvement projects that will increase flows in the study watersheds.
8. National Wetland Inventory data of 1990 shows that a major portion of the study area east of Burnt Store Road contains wetlands, mainly Palustrine Forested/Emergent Seasonal wetlands (PFO4/EM5C), Palustrine Forested/Emergent Temporary wetlands

(PFO4/EM5A), and Palustrine Emergent Seasonal wetlands (PEM5C). Estuarine type of wetlands dominates the coastal areas.

RECOMMENDATIONS:

1. Coordination with the owners of the private properties east of Burnt Store Road in Lee County and west of Burnt Store Road in the City of Cape Coral will be necessary for obtaining additional right-of-way or drainage easements, if required, for roadway expansion/flood control/water quality improvement projects.
2. Utilization of the excess capacity of the perimeter spreader waterway system and the Cape Coral canal system for diverting the flows generated east of Burnt Store Road should be studied with the cooperation of the City of Cape Coral. An integrated hydrologic/hydraulic model that will include the five watersheds considered in this study as well as the Cape Coral canal system basins should be developed as part of the future studies.
3. Impacts to the wetlands should be a consideration in developing proposed improvement projects.

7. RIGHTS-OF-WAY

The Lee County right-of-way along the Burnt Store Road throughout the study area (from Charlotte County line to Van Buren Parkway) is 200-ft wide. This includes the existing 22-ft wide paved roadway and the side swales/ditches running North-South on either side of Burnt Store Road. The cross-drain culverts across Burnt Store Road are entirely within the Lee County right-of-way. There are also several side-drain culverts across City of Cape Coral streets such as Kismet Parkway, Deliliah Drive, and NW 26th Terrace that join Burnt Store Road on either side. Side drain culverts are also present beneath the driveways into the mining areas.

The available right-of-way along Burnt Store Road should be an important consideration for future roadway expansion as well as proposed flood control improvements. The shallow North-South swales/ditches running parallel to Burnt Store Road within the existing right-of-way help convey significant flows to Yucca Pen creek and Gator Slough canal. Hence future roadway expansion plans should incorporate provision for these conveyances and associated culverts and control structures as in the existing conditions. If future roadway expansion is planned to utilize the entire 200-ft right-of-way eliminating the side swales/ditches, purchase of additional right-of-way or drainage easements on either side of Burnt Store Road will be necessary to relocate the side swales/ditches. Cooperation with the City of Cape Coral and private land-owners will be necessary for this task.

CONCLUSIONS:

1. The existing Lee County right-of-way is 200-ft wide along Burnt Store Road from Charlotte County line up to Van Buren Parkway and beyond.
2. Burnt Store Road is an existing 22-ft wide paved roadway.
3. The existing right-of-way also includes several side-drain culverts across side streets joining Burnt Store Road.
4. Shallow swales/ditches are located on either side of Burnt Store Road within the existing right-of-way. These swales/ditches convey significant flows to Gator Slough canal and Yucca Pen Creek.
5. Future expansion plans for Burnt Store Road within the study area should incorporate provisions for the North-South swale/ditch conveyances on either side of the road and control structures.
6. Cooperation with the City of Cape Coral and private land-owners will be necessary for Burnt Store Road expansion plans.

RECOMMENDATIONS:

1. Purchase of additional right-of-way or drainage easements is recommended if the entire 200-ft right-of-way will be utilized for roadway expansion.
2. Development of the roadway expansion plan and improvements to surface water conveyance elements should be closely coordinated among Lee County departments as well as the City of Cape Coral.

8. GROUNDWATER TABLE

The study area comprises mainly of Pineda-Boca-Wabasso soil groups as identified from “Soil Survey of Lee County, Florida” published by the United States Department of Agriculture – Natural Resources Conservation Service. These soils are defined as “nearly level, poorly drained, deep and moderately deep, sandy soils; some have a sandy subsoil, some have a loamy subsoil, and some have a sandy, organic-stained subsoil underlain by a loamy subsoil.”

Some of the major soil types within the study area are listed below:

- Wabasso Sand
- Immokalee Sand
- Pineda Fine Sand
- Oldsmar Sand
- Felda Fine Sand, Depressional
- Anclote Sand, Depressional
- Myakka Fine Sand, Depressional
- Isles Fine Sand, Depressional
- Boca Fine Sand

The soil survey report indicates that the high water table for these soil types generally ranges from 0.0-1.0 ft below the existing ground elevations. The Gator Slough watershed master plan study conducted by Johnson Engineering in 1991 indicated that the groundwater table varied dramatically within this basin based on their field monitoring of wells. They

reported that groundwater elevation was lower adjacent to the main canal and the tributaries indicating well-drained soil conditions in Gator Slough watershed. Wet season water levels were found to be closer to the existing ground elevations at locations father away from the canal. Determination of accurate seasonal high water elevations through site-specific soil borings will be essential for the engineering design of flood control and water quality improvements such as wet and dry detention ponds in the areas east of Burnt Store Road.

CONCLUSIONS

1. The Soil Survey Report of Lee County indicates that the high water table for the soil types in the study area generally ranges from 0.0-1.0 ft below the existing ground elevations.
2. Previous Gator Slough basin master plan developed by Johnson Engineering indicated that groundwater elevations varied dramatically within the Gator Slough watershed. Similar findings are likely in the watersheds north of Gator Slough.
3. Wet season water levels were found to be closer to the existing ground elevations at locations father away from the canal, as indicted in the Johnson Engineering report.

RECOMMENDATIONS

1. Determination of accurate seasonal high water elevations through site-specific soil borings is recommended for the engineering design of flood control/water quality improvements such as wet and dry detention ponds in areas east of Burnt Store Road.

9. WATERSHED MODEL SELECTION

An important aspect of a comprehensive surface water management plan is the proper representation of the current hydrologic and hydraulic systems throughout the watershed. A good understanding of basin wide hydrologic and hydraulic processes is necessary to determine the most effective means of flood control, ensuring public safety and protecting environmental resources. Several computer-based hydrologic/hydraulic models are used for watershed studies by various agencies throughout the State of Florida. Some of the popular models are Interconnected Channel and Pond Routing model (ICPR), Storm Water Management Model (SWMM), Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS), and Hydrologic Engineering Center-River Analysis System (HEC-RAS). One of the most widely used computer-based hydrologic/hydraulic models for water analysis in Florida is ICPR; it has been accepted by the Water Management Districts for permitting purposes. Hence, the hydrologic and hydraulic analysis for this study was performed using ICPR Version 2.2 developed by Streamline Technologies, Winter Park, FL.

APPROACH:

The overall approach established to effectively model the study area and analyze various improvement alternatives includes the following tasks:

- Existing Conditions Hydrologic Characterization
- Existing Conditions Hydraulics
- Tailwater Conditions Determination
- Existing Conditions Model Calibration/Verification

- Existing Conditions Model Simulations for Various Design Storms
- Level of Service Criteria for Roadway Flooding
- Existing Conditions Level of Service for Roadway Flooding
- Existing Conditions Floodplain Mapping
- Future Conditions Hydrologic Characterization
- Future Conditions Model Simulations
- Future Conditions Level of Service for Roadway Flooding
- Future Conditions Floodplain Mapping
- Proposed Improvement Alternatives
- Proposed Conditions Model Simulations
- Proposed Conditions Level of Service for Roadway Flooding
- Proposed Conditions Floodplain Mapping

CONCLUSIONS:

1. A comprehensive surface water management plan should include proper representation of the hydrologic/hydraulic system within the study area with the use of an appropriate watershed model.
2. Several computer-based hydrologic/hydraulic models are available for surface water management studies. Some of the popular models are ICPR, SWMM, HEC-HMS, and HEC-RAS.
3. ICPR is one of the most widely used models in Florida and has been accepted by Water Management Districts for permitting purposes.
4. Version 2.2 of ICPR was selected as the hydrologic/hydraulic model for this study.

RECOMMENDATIONS:

1. Version 3.0 of ICPR was released in 2003. Further developments of the software will be on Version 3.0. Several local governments and agencies have converted their older ICPR models to Version 3.0. The watershed model developed as part of this study should be converted to ICPR Version 3.0 in future master plan studies.
2. The Cape Coral canal system model was developed using SWMM by the City of Cape Coral. An integrated study of Northwest Lee region and City of Cape Coral canal system should be based on a single integrated model of the entire surface water drainage system. Conversion of the Cape Coral canal system model from SWMM to ICPR Version 3.0 and integration with the Northwest Lee County model is recommended. Cooperation with the City of Cape Coral is necessary for this task.

10. EXISTING CONDITIONS HYDROLOGY

EXISTING CONDITIONS HYDROLOGIC CHARACTERIZATION

Hydrologic characterization of the subbasins was accomplished using GIS and other computer-based models and tools. The runoff curve number for a subbasin was developed based on the existing landuse and the hydrologic soil group of various soil types within the subbasin. The standard Soil Conservation Service (SCS) table of curve numbers identifies the values for specific combinations of landuses and the four hydrologic soil groups namely A, B, C, or D.

Runoff Curve Number:

GIS tools were utilized to calculate the runoff curve numbers efficiently and accurately using the landuse and soils GIS layers developed from the data obtained from SFWMD and SWFWMD. As the first step, the FLUCCS landuse categories in the GIS database were compared with those given in the SCS curve number table. The FLUCCS landuse categories were assigned comparable landuses in the SCS curve number table as given in Table 4.1. The “wood or forest” landuse category in the study area was assumed to be of “good cover” type. Though the subbasins within the City of Cape Coral limits are platted for single-family residential development, most of the lots remain vacant. Hence the landuse category “Open Spaces (Fair condition – 50% to 75% grass cover)” was assigned to those areas.

The soils GIS database included the hydrologic soil group for each soil category in the study area. Areas identified as open water with the soil code of “W” were assigned a

runoff curve number of 100. Similarly streets and roads were assigned a curve number of 98 irrespective of the soil category. “B/D” hydrologic soil group was considered as “D” group in “wood or forest” areas and as “C” group in areas that have been cleared or developed such as commercial/residential areas and in “pasture/range” landuses.

The existing conditions landuse, soils, and subbasins shape files were converted to grids within ArcGIS with a resolution of 50 ft. A map calculation algorithm was applied to develop a grid that will have the unique combination of subbasin code, landuse code, and soil code as its grid value. The database of this combination grid gave the number of grids for each unique landuse-soil combination within each subbasin. Each landuse-soil combination was assigned the appropriate runoff curve number as explained above to calculate the composite runoff curve numbers for the subbasins. Table 10.1 provides the details of runoff curve number calculations for the existing landuse conditions.

Time of Concentration:

The time of concentration for surface flow was calculated for each subbasin using the TR-55 methodology of SCS. The maximum sheet flow length considered was 300-ft and a 2-year/24-hour rainfall depth of 4.5-inches was used for sheet flow travel time calculations. In open lands with shallow concentrated flow for long distances and variable vegetation and terrain, the following criteria were used:

- Establish slope over the entire shallow concentrated flow path if the terrain is generally flat (slopes less than or equal to 0.005 ft/ft). Otherwise, actual slopes were used with each segment.

- Extend the standard shallow concentrated flow calculation from TR-55 methodology to vary Manning's "n" value to account for varying terrain and vegetation. Establish 1 to 4 representative segments (combine like-segments as needed). Calculate time of concentration for each segment and sum for composite shallow concentrated flow time. Typical range of Manning's "n" values and the corresponding photograph/infra-red aerial signature interpretation are given below.

  A. Heavy wooded upland vegetation (includes palmetto, pine with under story of brush): Classic Infrared image color: Dappled Pink; Manning's "n": 0.10-0.12

Actual Ground Shot

Infra-red Aerial

B. Upland vegetation (includes sparse palmetto and prairie grass)

Classic Infrared image color: Pale Pink; Manning's "n": 0.07-0.08

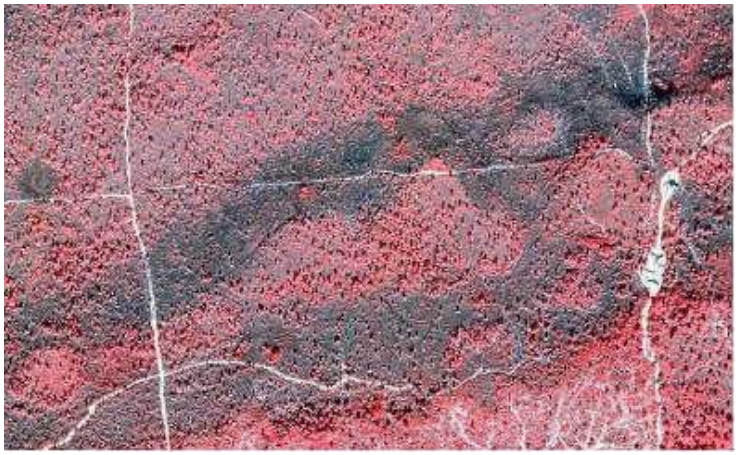
Actual Ground Shot

Infra-red Aerial

C. Intermittent marsh (includes seasonally wet areas with prairie grass and transitional wetland vegetation)

Classic Infrared image color: Pale Pink to Pale Gray; Manning's "n": 0.05-0.06

Actual Ground Shot



Infra-red Aerial

D. Standing water marsh (includes wet areas with prairie grass and wetland vegetation)

Classic Infrared image color: Pale Gray to Black; Manning's "n":0.04-0.045

Actual Ground Shot

Infra-red Aerial

For open channel flow travel time, an average flow velocity of 3 ft/sec was used and the open channel flow length was divided by the average flow velocity to get the travel time component for each subbasin.

The time of concentration for each subbasin is the sum of travel times for the three flow components namely sheet flow, shallow concentrated flow, and open channel flow. Table 10.2 provides the Time of Concentration Summary for the entire study area. Individual travel time calculations for each flow component for all subbasins are provided in Appendix B.

Unit Hydrograph Selection:

The flat topography of the study area poses a unique situation to determine the appropriate unit hydrograph for the study watersheds. The most widely used unit hydrographs have a peak factor of 256 or 323. But these peak factors are not appropriate for very flat watersheds. SFWMD has recommended the use of a peak factor of 100 for watersheds with slopes less than 5 feet per mile through a technical memorandum dated June 25, 1993. A copy of that memorandum is included in Appendix C. Overall slopes in the study watersheds are about 2.6 feet per mile based on the spot elevations. Hence a peak factor of 100 was used for modeling. A triangular dimensionless unit hydrograph with a time base of 12.91, as given below, was recommended by the author of ICPR modeling software (Peter Singhofen) to be used with the peak factor of 100.

t/tp	q/qp
0	0
1	1
12.91	0

CONCLUSIONS

1. Hydrologic characterization of the subbasins was accomplished using GIS and other computer-based models and tools.
2. Runoff curve numbers for individual subbasins were calculated using GIS tools and landuse and soils GIS layers.
3. Most of the study area exhibits runoff characteristics typical of open lands and flat topography with large aerial storage, large sheet flow areas, shallow channels/swales, and very little impervious areas.
4. The composite runoff curve number for the subbasins ranged from 70 to 92.
5. Time of concentration for surface flow was calculated using the TR-55 methodology of SCS. A maximum sheet flow length of 300-ft and a 2-year/24-hour rainfall depth of 4.5-inches were used for sheet flow travel time calculations.
6. An average flow velocity of 3 ft/sec was assumed for open channel flow.
7. Time of concentration of the subbasins ranged from 41 min to 403 min depending on the subbasin area and land surface characteristics.
8. Considering the flat topography of the study area, a unit hydrograph peak factor of 100 was used for modeling per SFWMD recommendation. Overall slopes of the study watersheds are about 2.6 feet per mile. A triangular dimensionless unit hydrograph with a time base of 12.91 was used, as recommended by the author of ICPR software.

RECOMMENDATIONS

1. Runoff curve numbers of subbasins developed in this study should be updated as future developments and other landuse changes occur in the study area.

2. Time of concentration for individual subbasins developed in this study should be updated as more detailed topographic data becomes available.

11. CONVEYANCE ELEMENTS

CONVEYANCE ELEMENTS

An inventory of all existing conveyance elements such as culverts, weirs, and drop structures within the study area was developed as a GIS database to aid in developing the hydraulics part of the model. Table 11.1 provides the inventory of conveyance elements including inverts, lengths, diameters/dimensions, and materials.

CHANNEL CROSS-SECTIONS

Channel cross-sections were obtained from the field survey. Fourteen cross-sections were surveyed in the extensive areas east of Burnt Store Road. These cross-sections represented the shallow flow paths such as vehicular access dirt ways that act as "conveyance channels" and extend for thousands of feet. The photographs given below show a typical shallow flow path of vehicular access way acting as a "conveyance channel." These cross-sections were smoothed to represent a defined channel to maintain a reasonable conveyance.

A Typical Shallow Flow Path/Vehicular Access Way Acting as a "Conveyance Channel"

Vehicular Access Way East of Burnt Store Road Acting as a “Conveyance Channel”

BURNT STORE ROAD CULVERTS

Burnt Store Road acts as the ridgeline for the east-west flow from the vast unincorporated Lee County areas on the east. There are eight culvert crossings under Burnt Store Road north of Gator Slough bridge, and four drop structures on the side ditches next to Burnt Store Road at Gator Slough. These culverts and drop structures convey all the eastern flow across Burnt Store Road. Some of these culverts appear to be undersized for the flows generated by large rainfall events, resulting in significant roadway flooding.

Brief description and photographs of these culverts and drop structures north of Gator Slough are provided below.

Culvert #1 – Yucca Pen Creek at Burnt Store Road: This is the northern most culvert of the study area located approximately 0.85 miles south of the Lee-Charlotte county line. This is a double 7-ft x 10-ft concrete box culvert. There is some minimal sedimentation within the channel upstream and downstream of this culvert and the channel has minimal vegetation growth.

Culvert #1 – Yucca Pen Creek at Burnt Store Road

Culvert #2 – Durden Creek North Branch at Burnt Store Road: This is a double 30-inch RCP culvert crossing in the northern branch of Durden Creek. This branch joins the main channel of Durden Creek west of Burnt Store Road at NW 34th Avenue. Culvert #2 is located approximately 0.57 miles south of Culvert #1.

Culvert #2 – Durden Creek North Branch at Burnt Store Road

Culvert #3 – Durden Creek Main at Burnt Store Road: This is a triple 48-inch HDPE pipe culvert crossing in the main channel of Durden Creek. This culvert is located approximately 0.31 miles north of the intersection of Durden Parkway at Burnt Store Road. This was previously a 3-ft x 10-ft concrete box culvert which was replaced with HDPE pipes following the failure of the box culvert during a major rainfall event in June 2003.

Culvert #3 – Durden Creek Main at Burnt Store Road

Culvert #4 – Greenwell Branch North at Burnt Store Road: This is a 4-24" RCP culvert crossing in the northern branch of Greenwell Branch. This culvert is located approximately 0.19 mile south of the intersection of Durden Parkway at Burnt Store Road. This culvert is located across the Kodii Mine pit and is north of the Fire Station. The downstream side headwall of this culvert is made of "cement bag riprap" and is damaged as shown in the photograph below. Severe sedimentation and trash accumulation has occurred in the pipes, thereby significantly reducing the flow capacity.

Culvert #4 – Greenwell Branch North at Burnt Store Road

Culvert #4 – Downstream Side Headwall

Culvert #5 – Greenwell Branch Main at Burnt Store Road: This is a 4-24" HDPE pipe culvert crossing in the main channel of Greenwell Branch south of the Fire Station. This culvert is located approximately 0.57 miles south of Culvert #4. This was previously a 4-24" RCP culvert and was replaced with HDPE pipes after the June 2003 rainfall event. This culvert discharges directly into the Cape Coral canal system. Severe erosion of the rubble riprap was observed at this culvert on the upstream and downstream sides. Erosion and failure of the northern bank was also observed on the downstream side as shown in the photographs below.

Culvert #5 – Greenwell Branch Main at Burnt Store Road

Culvert #5 – Downstream Face

Culvert #5 – Failure of Bank on the Downstream Side

Culvert #6 at Burnt Store Road: This is a 4-24" RCP culvert across the Lee County Mine. This culvert joins the east and west side ditches running parallel to Burnt Store Road. This culvert is located approximately 1 mile south of Culvert #5. Roadway flooding occurs at this culvert during major rainfall events. Significant sediment accumulation has occurred at this culvert.

Culvert #6 at Burnt Store Road

Culvert #7 at Burnt Store Road: This is double 30-inch RCP culvert joining the east and west side ditches running parallel to Burnt Store Road across the Lee County Mine. This culvert is located approximately 0.6 mile south of Culvert #6. Minimal sedimentation was observed at this culvert.

Culvert #7 at Burnt Store Road

Culvert #8 at Burnt Store Road: This is a 4-36" RCP culvert joining the east and west side ditches running parallel to Burnt Store Road. This culvert is located approximately 0.47 miles north of Gator Slough bridge. Severe sedimentation was observed at the upstream and downstream sides of this culvert that could greatly reduce the conveyance capacity. Dense vegetation growth was observed on the downstream side of this culvert.

Culvert #8 at Burnt Store Road

Culvert #9 at Burnt Store Road: This is a 4-ft x 8-ft box culvert crossing located approximately 0.13 miles south of Gator Slough bridge. This culvert discharges directly into the Cape Coral canal system. Some vegetation growth was observed on the upstream and downstream sides of this culvert.

Culvert #10 at Burnt Store Road: This is a bridge located in Arroz Canal of the Cape Coral canal system approximately 0.18 miles south of Culvert #9. The dimensions of the flow section beneath the bridge are 11-ft x 34-ft. A concrete weir is located in Arroz Canal approximately 120' upstream of this bridge.

Culvert #9 South of Gator Slough Bridge at Burnt Store Road

Culvert #10 (Bridge) at Burnt Store Road

DROP STRUCTURES

There are four drop structures at the southern end of the side ditches running parallel to Burnt Store Road located immediately north of Gator Slough bridge. These structures convey the flows in the side ditches to Gator Slough canal. Dimensions of the drop structures are given below:

1. D-5180A: Located on the east side of Burnt Store Road. Weir – 44”x52”. Pipe – 1x36”, 38’ long. Weir invert elevation = 3.2
2. D-5180B: Located on the east side of Burnt Store Road. Weir – 36”x48”. Pipe – 1x36”, 34’ long. Weir invert elevation = 3.2
3. D-5190A: Located on the west side of Burnt Store Road. Weir – 48”x75”. Pipe – 34”x53”, 38’ long. Weir invert elevation = 3.0
4. D-5190B: Located on the west side of Burnt Store Road. Weir – 36”x48”. Pipe – 1x36”, 32’ long. Weir invert elevation = 3.0

All these structures are tidally influenced. Gator Slough canal is tidally controlled up to the weir just east of the Burnt Store Road bridge. This has also been reported in the previous Johnson Engineering study of 1991.

BURNT STORE ROAD SIDE DITCHES

A shallow side ditch runs parallel to Burnt Store Road on the east side throughout its length north of Gator Slough canal except for the section between Durden Creek Main culvert (Culvert #3) and Greenwell Branch North culvert (Culvert #4). There is a high point

between these two culverts on the east side of Burnt Store Road that blocks the north-south flow. On the west side of Burnt Store Road, a shallow side ditch runs from north to south starting from Culvert #6 up to the drop structures just north of Gator Slough canal. The depth of these ditches generally ranges from 1' to 2' and the bottom is approximately 6-ft wide. The last stretch of the west side ditch draining to the drop structures is 3' to 4' deep for approximately 700-ft. These ditches have been observed to carry high flows during major rainfall events. Dense vegetation growth is observed in some sections of these ditches.

BURNT STORE ROAD SIDE-DRAINS

There are seven side-drains in the east side ditch running parallel to Burnt Store Road at the side streets and driveway connections into the mining area. Most of them consist of 24" RCPs. Several of these structures are undersized causing localized flooding of the side streets or driveways. There are four side-drains in the side ditch on the west side of Burnt Store Road conveying the flows southward to Gator Slough canal.

CONCLUSIONS

1. An inventory of all existing conveyance elements in the study watersheds and their characteristics was developed as a GIS database.
2. Typical cross-sections of vehicular access dirt ways acting as channels were obtained from field survey.
3. Burnt Store Road acts as the ridgeline for the east-west flow from the unincorporated Lee County areas on the east.

4. There are eight cross-drain culverts in Burnt Store Road north of Gator Slough bridge. A box culvert and a smaller bridge act as cross-drains across Burnt Store Road between Gator Slough bridge and the intersection of Van Buren Parkway.
5. There are four existing drop structures on the side ditches next to Burnt Store Road at Gator Slough (two on each side).
6. Some of the Burnt Store Road cross-drain culverts appear to be undersized for the flows generated by major rainfall events resulting in significant roadway flooding.
7. Moderate to severe sedimentation and trash accumulation was observed at several Burnt Store Road culverts north of Gator Slough affecting their conveyance capacity.
8. Dense vegetation growth was observed in the channels north and south of Yucca Pen Creek culvert, south of Durden Creek North culvert and Durden Creek Main culvert. Conveyance west of Durden Creek Main culvert is through a stretch of channel of moderately dense vegetation growth.
9. Erosion of the rubble riprap was observed at Culvert #5 especially on the downstream side. Channel bed erosion and bank failure were also observed at this culvert.
10. Headwall damage was observed at the downstream side of Culvert #4.
11. Grates are missing in the drop structures at Gator Slough. Severe trash accumulation limits their conveyance capacity.

RECOMMENDATIONS

1. The GIS inventory of the conveyance elements developed in this study should be continuously updated. When an integrated study of Northwest Lee region and Cape

Coral canal system is performed, this GIS inventory should be expanded to include other conveyance elements within the canal system.

2. A regular maintenance program should be developed and implemented for the Burnt Store Road control structures. This program should include removal of trash accumulation, sedimentation, and vegetation growth at periodic intervals to maintain the full conveyance capacity of the control structures and channels.
3. Damages to the existing structures should be repaired.
4. Eroded riprap should be repaired to maintain the structural integrity of the culverts.
5. Bank stabilization is necessary on the downstream side of Culvert #5.

12. WATER QUANTITY MODEL - EXISTING CONDITIONS HYDRAULICS

NODE-LINK CONFIGURATION

The existing conditions hydraulics of the study area along with the inventory of the conveyance elements was used to develop the node-link configuration for the ICPR model. Figure 12.1 depicts the node-link diagram for the existing conditions. There are 204 nodes, 63 pipes, 149 channels, 84 weirs, and 4 drop structures in the ICPR model. Further, there are 114 cross-sections representing various swale/channel dimensions.

MODEL GROUPS IN ICPR

The ICPR model was setup with six groups as listed below:

- YUCCAPEN – Yucca Pen Creek watershed
- DURDEN – Durden Creek watershed
- GREENWEL – Greenwell Branch watershed
- LONGVIEW – Longview Run watershed
- GATOR – Gator Slough watershed
- BASE – This group contains all surveyed cross-sections east of Burnt Store Road

TAILWATER CONDITIONS DETERMINATION

Tailwater conditions of the study area are influenced by the daily tide level fluctuations. The 2004 daily high and low tide predictions (not considering storm surge effects) for Bascule Bridge tide station in Matlacha Pass were obtained from National

Oceanic and Atmospheric Administration's (NOAA) Center for Operational Oceanographic Products and Services (CO-OPS) website (http://co-ops.nos.noaa.gov). These data are referred to Mean Lower Low Water (MLLW) elevation of the station. The tide data obtained from CO-OPS are given in Table 12.1. Based on the discussions with CO-OPS staff, a value of 0.4' is to be subtracted from the tide elevations referred to MLLW to get the tide elevations in NGVD 1929 datum at this tide station. The maximum predicted 2004 tide elevation is 2.6-ft in MLLW or 2.2-ft in NGVD 1929. Lee County preferred using a conservative tide elevation of 2.5-ft in NGVD 1929 for all design storms as the tailwater condition. Same tailwater condition was assumed for model calibration/verification simulation. The effect of storm surges on the tide/tailwater conditions was ignored for all model simulations.

EXISTING CONDITIONS MODEL CALIBRATION/VERIFICATION

A major rainfall event occurred in the study area during June 2003. There were widespread flooding in the study watersheds; floodwaters overtopped Burnt Store Road at two culverts and roadway flooding was observed on Old Burnt Store Road. This event was considered for model calibration/verification. The June 2003 Next Generation Weather Radar (NEXRAD) rainfall data were obtained from SFWMD. These data were daily accumulations for the NEXRAD grids covering the study watersheds. Fifteen-minute rainfall accumulations for the period from 6/17/2003 to 6/24/2003 at Lake Fairways raingage were obtained from Lee County. This 15-minute raingage data distribution was assumed for NEXRAD data and the daily NEXRAD accumulations were converted to 15-minute accumulations. Fifteen-

minute streamflow data for the USGS streamgage in Gator Slough at US-41 were obtained and input hydrograph was developed in ICPR as a rating curve.

The roadside ditches along US-41 on both sides carry significant flows, but the USGS streamgage located on the east side of US-41 does not account for this flow. Lee County obtained flow measurements in US-41 side ditches and in Gator Slough downstream of US-41 culvert for two rainfall events during July-August 2004. These measured flows were compared with the flows reported by USGS. It was determined that the USGS flows were approximately half of the flows measured by Lee County in Gator Slough downstream of US-41. The photograph below shows the flow in the west side ditch along US-41 immediately north of Gator Slough for a rainfall event in August 2004. Hence a multiplication factor of 2 was applied to the 15-minute flows recorded by USGS to develop a rating curve for Gator Slough inflow. Moving the USGS streamgage from its current location to approximately 500-ft downstream of US-41 culvert is essential to properly monitor the total flow in Gator Slough canal downstream of US-41 culvert.

Flow in the West Side Ditch along US-41 at Gator Slough for August 2004 Rainfall Event

A roadway flooding of about 4”-6” was observed by Lee County at Durden Creek Main culvert (Culvert #3) and at Culvert #6 along Burnt Store Road; a flood stage of 7.3’ was measured in subbasins LV-2 and LV-3 along Old Burnt Store Road. Flooding was extensive in areas east of Burnt Store Road. Excessive flows at Durden Creek Main culvert caused erosion problems and this culvert failed during this rainfall event. The photograph below shows the depression formed in the southbound lane of Burnt Store Road at this culvert.

Failure of Durden Creek Main Culvert at Burnt Store Road during the June 2003 Event

ICPR model simulations were performed using NEXRAD rainfall data and the rating curve for Gator Slough inflows. Model parameters such as nodal storage and roadway overtop weir lengths were adjusted to calibrate the model. The calibrated model replicated the observed flooding depths along Burnt Store Road, but could not simulate flooding on Old Burnt Store Road. The maximum stage simulated along Old Burnt Store Road in subbasins

LV-2 and LV-3 was only 6.5'. More investigations on the hydraulics and conveyance within these subbasins, the effect of the existing mine pits, and interconnects between Burnt Store Road side ditch and these subbasins should be carried out to calibrate the model in Old Burnt Store area. The widespread flooding east of Burnt Store Road was simulated by the ICPR model. Table 12.2 shows the simulated stages on Burnt Store Road and comparison of observed and stimulated stages on Old Burnt Store Road.

SELECTED DESIGN STORM EVENTS

Ten design storm events were considered for modeling in this study. Their durations and recurrence intervals are given below:

1. 2-year 24-hour event
2. 5-year 24-hour event
3. 10-year 24-hour event
4. 25-year 24-hour event
5. 100-year 24-hour event
6. 2-year 72-hour event
7. 5-year 72-hour event
8. 10-year 72-hour event
9. 25-year 72-hour event
10. 100-year 72-hour event

Of these ten design storms, 5-year 24-hour event, 25-year 72-hour event, and 100-year 72-hour event are required to be modeled by SFWMD for permitting purposes.

GUMBEL STATISTICAL ANALYSIS OF GATOR SLOUGH INFLOW

In order to determine the peak inflow into the system at US-41 culvert in Gator Slough, Gumbel statistical analysis of the long term observed USGS stream flow data was performed. This analysis outlines a procedure to statistically determine the magnitude of extreme events such as flooding at specific recurrence intervals. The annual maximum flood flow value, in daily mean series, detected in a channel section is an extreme event. Since the watershed was not submitted to hydrologic modifications during the period of years under analysis, these series can be treated as homogeneous and independent values. These conditions allow us to associate the probable frequency and then the return interval to a given discharge event and to apply those values to the statistical analysis methods. Gumbel Analysis has been proved to be one of the most reliable methods for hydrologic time series. A double exponential probability distribution allows assignment of an expected flow rate for all return periods. The Gumbel Statistical analysis methodology adopted is described in Appendix D.

USGS Streamgage Located at the Confluence of Gator Slough Channel and East Side Ditch of US-41

The USGS daily mean flows for years 1984-2002 were obtained and used for analysis. Table 12.3 gives the recurrence intervals and flows for 24-hr and 72-hr events calculated based on Gumbel statistical analysis. For modeling purposes, as discussed previously, a multiplication factor of 2 was incorporated to the calculated peak flows to account for flows from ditches located on the east and west side of US-41 north of Gator Slough. The observed streamflow hydrograph in Gator Slough at US-41 from USGS 15-minute flow data for the period 6/17/2003 to 6/24/2003 was smoothed and this distribution was applied with the peak flows to develop rating curves for various design storms. Figures 12.2 and 12.3 show the inflow hydrographs for 24-hr and 72-hr design storms.

EXISTING CONDITIONS MODEL SIMULATIONS FOR VARIOUS DESIGN STORMS

Model verification was accomplished using the existing conditions of the study area as of June 2003. After that flooding event, Lee County replaced the failed culvert at Durden Creek Main in Burnt Store Road with a triple 48-inch HDPE pipe culvert. The 4-24" RCP culvert at Greenwell Branch Main (Culvert #5) in Burnt Store Road was replaced with a 4-24" HDPE pipe culvert. A berm was present across the channel downstream of Culvert #5; a CMP culvert through the berm provided limited conveyance downstream of Culvert #5 until June 2003 rainfall event. This berm and the CMP culvert were removed after this rainfall event to provide for better conveyance downstream of Culvert #5. The City of Cape Coral replaced several CMP culverts crossing Old Burnt Store Road with 24-inch RCPs and the pipe extensions from Old Burnt Store Road to the canal system were replaced with 24-inch HDPE pipes. The construction plans for these Old Burnt Store Road drainage improvements

were obtained from the City of Cape Coral. The verified ICPR model was modified to represent these culvert/pipe changes along Burnt Store Road and Old Burnt Store Road to develop the 2004 Existing Conditions Model for simulating various design storms.

The selected design storm events were simulated using the 2004 Existing Conditions Model. Table 12.4 gives the rainfall depths for various return intervals and durations based on SFWMD design guidelines. Tables 12.5 and 12.6 give the summary of node maximum stage conditions and link maximum flow conditions for selected nodes along Burnt Store Road and Old Burnt Store Road for all design storm events. The 2004 Existing Conditions ICPR model input data is provided in Appendix E.

LEVEL OF SERVICE CRITERION FOR ROADWAY FLOODING

Lee County's level of service criterion for roadway flooding for Burnt Store Road is given below:

- No roadway flooding for more than 24 hours during the 25-yr, 72-hr design storm.

In this report, the existing, future, and proposed conditions roadway level of service were evaluated using this level of service criterion.

EXISTING CONDITIONS LEVEL OF SERVICE FOR ROADWAY FLOODING

Based on the results provided in Tables 12.5 and 12.6, existing conditions level of service deficiencies are summarized in Table 12.7. This table indicates that the maximum depth of roadway flooding at the Durden Creek Main culvert (Culvert #3) is 4.10 inches during the 25-yr 72-hr design storm event. The flood stage increased from the existing edge

of pavement elevation of 11.60' to a maximum stage of 11.94'. The stage stayed at 11.94' for 9 hrs and dropped back to the road elevation after 30 hrs. Roadway flooding depth of 4.30 inches was also observed at Culvert #6 in Burnt Store Road, with the stage increasing from the edge of pavement elevation of 9.50' to 9.84'. The flood stage stayed at 9.84' for one hour and dropped back to the road elevation in 20 hrs. Thus the roadway level of service criterion is not met at these two culverts along Burnt Store Road.

EXISTING CONDITIONS FLOODPLAIN MAPPING

Existing conditions floodplain maps for the 25-yr 72-hr and 100-yr 72-hr design storms were digitized in ArcGIS software to determine the extent of flooding in the study watersheds using the model simulation results for the 2004 Existing Conditions Model as discussed in Section 4.8. Figures 12.4 and 12.5 show the existing conditions floodplain maps for both design storms. The differences in node maximum stage conditions between the 25-yr 72-hr and the 100-yr 72-hr design storms are provided in Table 12.8. This table shows those locations where there is a change in the node maximum stage as it is not clearly visible on the respective hardcopy floodplain maps. These maps were created using the simulated node maximum stages and the spot elevations/one-foot contour maps provided by the County.

CONCLUSIONS

1. The node-link configuration of the existing conditions hydraulics of the study area was developed using the inventory of conveyance elements.
2. Based on the analysis of tide data at Bascule Bridge tide station in Matlacha Pass obtained from NOAA, the maximum predicted 2004 tide elevation is 2.2' in NGVD

1929. A conservative tide elevation of 2.5’ in NGVD 1929 was assumed as the tailwater condition for all design storms and for model calibration/verification simulation. The effect of storm surges on the tide/tailwater conditions was ignored for all model simulations.

3. The existing conditions ICPR model of the study area was developed and calibrated and verified for a major rainfall event of June 2003 using NEXRAD rainfall data and observed 15-min streamflow data in Gator Slough at US-41 obtained from USGS. The calibrated model was able to simulate the observed Burnt Store Road flooding depths at Culvert #3 and Culvert #6. The widespread flooding east of Burnt Store Road during this rainfall event was simulated using the ICPR model.
4. The existing conditions model was not able to simulate the flood stages observed near Old Burnt Store Road in Subbasins LV-2 and LV-3. These subbasins contain large mine pit ponds. Representation of conveyance to and from these mine pit ponds is not sufficient in the existing conditions model due to lack of field data.
5. Ten design storms were considered for modeling.
6. Gumbel statistical analysis of long-term streamflow record at the USGS streamgage in Gator Slough provided the peak flows for the ten design storm events at US-41.
7. Since modifications were made to two culverts along Burnt Store Road and several cross-drains along Old Burnt Store in 2003-2004 after the calibration storm event, a 2004 Existing Conditions Model was developed using the calibrated and verified model.
8. Selected design storms were simulated using the 2004 Existing Conditions Model.

9. The roadway level of service criterion of “no roadway flooding for more than 24 hours during the 25-yr 72-hr event” was not met at Culvert #3 and Culvert #6 along Burnt Store Road indicating that these culverts are undersized to convey the floodwaters across Burnt Store Road.
10. Existing conditions floodplain maps were developed for 25-yr 72-hr and 100-yr 72-hr design storm events. These maps show widespread flooding in the areas east of Burnt Store Road.

RECOMMENDATIONS

1. The existing conditions ICPR model of the study area developed in this study should be continuously updated as changes occur to the hydrology and hydraulics of the study area.
2. ICPR should be used as the model of choice for future studies for consistency.
3. More investigations on the hydraulics and conveyance within Subbasins LV-2 and LV-3, the effect of the existing mine pits, and interconnects between Burnt Store Road side ditch should be carried out to further refine the model.
4. The USGS streamgage located east of US-41 in Gator Slough canal does not account for all the flows west of US-41. This streamgage should be moved from its current location to approximately 500’ downstream of US-41 culvert. This is essential to properly monitor the total flow in Gator Slough canal.
5. Culvert #3 and Culvert #6 across Burnt Store Road are undersized. These culverts should be upsized to eliminate roadway flooding.

13. FUTURE CONDITIONS HYDROLOGY & HYDRAULICS

FUTURE CONDITIONS HYDROLOGIC CHARACTERIZATION:

For future conditions hydrology of the study watersheds, two different development scenarios (Case A and Case B) were established by Lee County.

Case A: 1 home in 10 acres in unincorporated areas.
1 home in 0.25 acres in incorporated areas that have already been cleared.
1 home in 0.50 acres in incorporated areas that have not yet been cleared.

Case B: 1 home in 2.50 ac in unincorporated areas.
1 home in 0.25 acres in incorporated areas that have already been cleared.
1 home in 0.50 acres in incorporated areas that have not yet been cleared.

It was decided that these future conditions landuse scenarios would be incorporated in the model as Directly Connected Impervious Areas (DCIA) for each subbasin with the same runoff curve number and time of concentration values as in the 2004 existing conditions model. No development was assumed for those subbasins under State-owned lands. Tables 13.1 and 13.2 give the DCIA calculations for future landuse conditions Case A and Case B.

FUTURE CONDITIONS MODEL SIMULATIONS

The 2004 exiting conditions model was modified to incorporate the subbasin DCIA values to develop the future landuse conditions models. Model simulations were carried out

using the same design storms as explained in Section 4.8. Tables 13.3 through 13.6 give the summary of node maximum stage conditions and link maximum flow conditions for selected nodes along Burnt Store Road and Old Burnt Store Road for future landuse conditions Case A and Case B for all design storm events.

FUTURE CONDITIONS LEVEL OF SERVICE FOR ROADWAY FLOODING

Based on the results provided in Tables 13.3 through 13.6, future conditions level of service deficiencies for future landuse conditions Case A and Case B are summarized in Table 13.7. This table indicates that there is 4.10-inches of roadway flooding in Durden Creek Main culvert at Burnt Store Road. The flood stage increased from the edge of pavement elevation of 11.60’ to a maximum stage of 11.94’; the flood stage stayed at 11.94’ for a total period of 9 hrs and dropped back to the road elevation after 30 hrs. Roadway flooding depth of 4.30-inches was simulated at Culvert #6 at Burnt Store Road, with the flood stage increasing from the edge of pavement elevation of 9.50’ to 9.84’. The flood stage stayed at 9.84’ for one hour and dropped back to the road elevation in 20 hrs. Thus the roadway level of service criterion is not met at these two culverts along Burnt Store Road for both future landuse conditions.

FUTURE CONDITIONS FLOODPLAIN MAPPING

The floodplain maps for the future landuse conditions for the 25-yr, 72-hr and the 100-yr, 72-hr design storms were digitized in ArcGIS software for both Case A and Case B to determine the difference in flooding conditions compared to the existing conditions. Figures 13.1 through 13.4 show the future conditions floodplain maps for both design storms.

The difference between the existing conditions node maximum stages and the future conditions node maximum stages are provided in Tables 13.8 and 13.9. These tables show that the maximum stage difference in the study watersheds is in the range of 0.15'-0.16' for both future landuse conditions Case A and Case B.

CONCLUSIONS

1. Two development scenarios were considered in the study watersheds to define the future landuse conditions. No development was assumed for those subbasins under State-owned lands. Each development scenario was translated into a DCIA percentage for each subbasin and represented in the ICPR model.
2. Future conditions ICPR models were developed using the 2004 existing conditions model by incorporating the DCIA values.
3. Simulations of the selected design storms by the future conditions model indicate that the roadway level of service criterion was not met at Culvert #3 and Culvert #6 along Burnt Store Road as in the existing conditions.

14. WATER QUANTITY MODEL - PROPOSED IMPROVEMENTS

PROPOSED IMPROVEMENT ALTERNATIVES:

The roadway level of service criterion was not met at Culvert #3 and Culvert #6 along the Burnt Store Road in the existing conditions. Improvement alternatives were specifically proposed to divert water from these culverts south to Gator Slough canal.

- Lee County is planning to expand Burnt Store Road to a 4-lane highway and eventually to a 6-lane highway in the study area. This expansion is proposed to utilize the entire 200-ft wide right-of-way. Hence 200' culvert lengths were considered as the proposed conditions.
- City of Cape Coral had previously studied the effect of raising two weirs along Gator Slough by 1-ft to store more fresh water within the canal system and obtained a construction permit from SFWMD for this improvement. This has not been constructed till now; but these improvements to be constructed by City of Cape Coral were considered for the proposed conditions.
- During the field investigations, a significant obstruction was identified in Durden Creek Main channel west of Burnt Store Road. Broken concrete structures have been dumped in the channel within a private property to a depth of approximately 5-ft. This obstruction affects the conveyance capacity of the channel significantly. This obstruction should be removed to provide proper channel conveyance. Discussions with SFWMD indicate that removal of this obstruction will be considered as routine maintenance and a permit would not be required. Removal of this obstruction was considered as one of the proposed improvement alternatives.

- Maintenance of Burnt Store Road by removing sediment and trash accumulation was considered as a proposed improvement alternative. This was represented in the model by removing the bottom clip obstructions at respective Burnt Store Road culverts.
- Since the roadway level of service was not met at Culvert #3 and Culvert #6 along Burnt Store Road, expansion of these culverts were considered as proposed improvement alternatives. The existing triple 48-inch HDPE pipes at Culvert #3 are not sufficient to convey floodwaters across Burnt Store Road without causing roadway flooding. An additional culvert was considered at this crossing as a proposed alternative. Three options were evaluated for this additional culvert from 36-inch to 48-inch size.
- Culvert #6 consists of 4-24" RCPs in the existing conditions. This culvert was upsized to be 4-30" RCP pipe culvert as one of the improvement alternatives.
- Improved conveyance of floodwaters through the side ditch along the east side of Burnt Store Road is important. If the proposed roadway expansion will utilize the entire 200-ft right-of-way, additional right-of-way or easement must be obtained on the east side of Burnt Store Road to provide equivalent conveyance capacity. The existing side ditch is generally shallow with depths of up to 1-ft and with an average bottom width of 6-ft. An expanded side ditch was considered as a proposed improvement. There is no direct connection between Durden Creek Main culvert (Culvert #3) and Greenwell Branch North culvert (Culvert #4). A 12-ft wide 1-ft deep ditch was considered between these culverts to divert floodwaters to the south. The side ditch from Culvert #4 up to the drop structures located near Gator Slough was expanded to 12-ft and the inverts were lowered by up to 1-ft to provide a positive

slope towards the south. The seven side-drains located along the east side ditch south of Culvert #5 were expanded by one additional pipe of the same size as the existing pipe(s). Purchase of right-of-way or drainage easement for a width of 15’ will be necessary to implement this improvement alternative.

- The side ditches on both side of Burnt Store Road connect to the drop structures near Gator Slough. Expansion of the side ditches requires expansion of the drop structures to convey flows to Gator Slough. One drop structure on either side of Burnt Store Road was considered to be expanded to a Type E ditch bottom inlet structure as specified in the Florida Department of Transportation Design Manual. The existing outfall pipes from the drop structures to the headwalls at Gator Slough will be maintained to avoid the construction cost of modifying the Gator Slough headwalls. Expanded drop structures at Gator Slough were considered as one of the improvement alternatives.
- Burnt Store Road is a major north-south connector in this region and is also an evacuation route; hence total elimination of roadway flooding on this important road would be preferable. The existing Burnt Store Road roadway elevations at Culvert #3 and Culvert #6 are not high enough compared to the flood stages on the east side causing frequent roadway flooding on Burnt Store Road. To accomplish this, raising the roadway elevation at Culvert #3 by 6 inches was considered as one of the improvement alternatives along with upsizing the culverts at both locations.

PROPOSED CONDITIONS MODEL SIMULATIONS

Combinations of the proposed improvement alternatives were modeled using ICPR for the study watersheds. Addition of a fourth pipe at Durden Creek Main culvert (Culvert #3) using various pipe size upgrades (36-inch, 42-inch, and 48-inch) along with expansion of the side ditch and side-drains east of Burnt Store Road using the existing road elevation at this culvert did not satisfy the desired level of service for roadway flooding at this location.

Since the seasonal high water elevation is generally within 1-ft below the existing ground surface elevations, deepening the channel west of Culvert #3 would not be permittable due to impacts to adjacent environmental resources. For modeling purposes, a deepened channel along with an additional 48" pipe at Culvert #3 was analyzed without raising the roadway elevation. Though this satisfied the roadway level of service at the culvert, it caused flooding in the areas west of Burnt Store Road within the City of Cape Coral by approximately 0.35-ft. Hence this combination of improvements is not hydraulically feasible, nor permittable.

Storage of floodwaters east of Burnt Store Road using regional detention/retention systems was also considered as a possible improvement alternative. However, due to the proximity of seasonal high water table to existing natural ground elevations, the size of this facility would become inordinately large and unfeasible. Further determination of seasonal high water table elevation using soil borings in the areas east of Burnt Store Road is necessary, and should be considered in the future studies to determine the possibility of regional surface water storage facilities.

Raising the roadway elevation by 6 inches to elevation 12.10' NGVD 1929 at Culvert #3 along with other improvement alternatives, satisfied the desired level of service for

roadway flooding at this culvert. Though the level of service criterion allows roadway flooding for up to 24 hours during the 25-yr, 72-hr design storm event, this combination of proposed improvements totally eliminate roadway flooding at this culvert. Hence raising the elevation of roadway by at least 6 inches should be an important consideration in the design of the expanded Burnt Store Road being considered by Lee County in the study area.

Culvert #6 has 4-24" RCPs in the existing conditions, which are undersized for conveyance of the 25-yr, 72-hr design flood without causing roadway flooding. Expansion of this culvert to a 4-30" RCP culvert along with other improvement alternatives helps eliminate the roadway flooding at this culvert. Elevating the roadway above the existing elevation of 9.70-ft would not be required at this location.

The following list includes all recommended improvement alternatives that would provide the desired level of service for roadway flooding along the entire length of Burnt Store Road north of Gator Slough bridge.

- Remove the obstruction in Durden Creek Main channel downstream of Culvert #3.
- Expand all Burnt Store Road culverts to 200-ft length to match the proposed roadway expansion.
- Upsize Culvert #3 to be a 4-48" HDPE pipe culvert crossing using the existing pipe inverts.
- Upsize Culvert #6 to be a 4-30" RCP culvert crossing using the existing pipe inverts.
- Provide a 1-ft deep side ditch with 12-ft bottom width along the east side of Burnt Store Road, from Culvert #3 to Culvert #4, for approximately 2,700-ft.

- Provide the equivalent of the existing side ditch conveyance on either side of the expanded Burnt Store Road.
- Expand the bottom width of side ditch along the east side of Burnt Store Road by 6-ft from Culvert #4 to the drop structures immediately north of Gator Slough canal for a length of approximately 16,000-ft. Lower the inverts of this side ditch by up to 1' as shown in the proposed conditions ICPR model.
- Upgrade the side drains east of Burnt Store Road south of Culvert #5 using one additional pipe of the same size and material.
- Modify the drop structures D-5180B and D-5190B on both sides of Burnt Store Road at Gator Slough to a Type E Ditch Bottom Inlet as per Florida Department of Transportation Design Manual.
- Remove all sedimentation and trash accumulation in the Burnt Store Road culverts north of Gator Slough canal.
- Remove the dense vegetation growth in the side ditches and around culverts along Burnt Store Road.
- Raise the elevation of the roadway by a minimum of 6 inches at Durden Creek Main culvert (Culvert #3), as part of the proposed roadway expansion.

Tables 14.1 and 14.2 provide the peak flood stages for the existing conditions after the removal of the obstruction in Durden Creek west of Burnt Store Road and the proposed improvements as listed above for 25-yr, 72-hr storm event. The maximum rise in flood stage was 0.02-ft during the 25-yr, 72-hr storm event; the rise in flood stage upstream of Culvert #9 was 0.15-ft, but the proposed flood stage is more than 3-ft below the roadway elevation. The

proposed improvements cause a maximum of 0.10-ft rise in flood stage east of Culvert #3 during the 100-yr, 72-hr storm event. The rise in stage at Culvert #9 is also 0.15-ft for the 100-yr, 72-hr storm event, but the proposed stage is more than 3-ft below the roadway elevation at this culvert. Increase in stages along the Gator Slough canal from US-41 to the weir just east of Burnt Store Road are due to the rise in weir invert being constructed by the City of Cape Coral, and not due to the proposed improvements recommended in this study. The City of Cape Coral study considered the Gumbel statistical estimates of Gator Slough inflows at US-41, while this study doubled the Gumbel statistical estimates to account for flows not measured by the USGS streamgage. This is the reason for rise in flood stages in Gator Slough canal due to 1-ft rise in Gator Slough weir inverts.

PROPOSED CONDITIONS LEVEL OF SERVICE FOR ROADWAY FLOODING

The proposed improvements eliminate the roadway flooding along the entire length of the expanded Burnt Store Road within the study area during the 25-yr, 72-hr design storm event, meeting Lee County's desired level of service.

COST ESTIMATE

Table 14.3 provides the Engineer's opinion of probable construction costs for the recommended improvement alternatives to meet the level of service criterion for roadway flooding in the study area. The total estimated construction cost is approximately $470,000. This estimate does not include the cost of lengthening or relocation of culverts/drop structures/ditch that are not to be upsized, the cost of raising the roadway elevation at Culvert #3, and detailed survey, engineering design and right-of-way/easement costs.

CONCLUSIONS

1. Several improvement alternatives were considered to meet the desired level of service for roadway flooding along the Burnt Store Road without affecting downstream flood stages.
2. Combinations of the improvement alternatives were modeled using ICPR to assess the roadway flooding extent.
3. Soil survey report indicates that the seasonal high water table is within 1-ft below the existing ground elevations in the study area. Hence the size of retention/detention systems to store floodwaters would become inordinately large and unfeasible in the areas east of Burnt Store Road.
4. Specific improvement alternatives that have been identified and modeled will eliminate roadway flooding along the expanded Burnt Store Road during the 25-yr, 72-hr storm event.
5. The maximum increase in flood stages due to the proposed improvement alternatives is 0.02-ft for the 25-yr, 72-hr storm event and 0.10-ft for the 100-yr, 72-hr storm event.

RECOMMENDATIONS

1. Remove the obstruction in Durden Creek Main channel downstream of Culvert #3. Based on discussions with SFWMD, this is considered to be a maintenance activity and would not require a permit.
2. Increase the length of all cross-drains along Burnt Store Road to 200-ft to match the proposed roadway expansion.

3. Upsize Culvert #3 to a 4-48” HDPE culvert, using the existing pipe inverts.
4. Upsize Culvert #6 to be a 4-30” RCP culvert, using the existing pipe inverts.
5. Provide a 1-ft deep side ditch with 12-ft bottom width along the east side of Burnt Store Road, from Culvert #3 to Culvert #4, for approximately 2,700-ft.
6. Provide the equivalent of the existing side ditch conveyance on either side of the expanded Burnt Store Road.
7. Expand the bottom width of side ditch along the east side of Burnt Store Road by 6-ft from Culvert #4 to the drop structures immediately north of Gator Slough canal for a length of approximately 16,000-ft. Lower the inverts of this side ditch by up to 1-ft as shown in the proposed conditions ICPR model.
8. Upgrade the side drains east of Burnt Store Road south of Culvert #5 using one additional pipe of the same size and material.
9. Modify the drop structures D-5180B and D-5190B on both sides of Burnt Store Road at Gator Slough to a Type E Ditch Bottom Inlet as per Florida Department of Transportation Design Manual.
10. Remove all sedimentation and trash accumulation in the Burnt Store Road culverts north of Gator Slough canal.
11. Remove the dense vegetation growth in the side ditches and around culverts along Burnt Store Road.
12. Raise the elevation of the roadway by a minimum of 6 inches at Durden Creek Main culvert (Culvert #3), as part of the proposed roadway expansion.

15. WATER QUALITY MODEL

WHAT IS WATER QUALITY?

Water is essential to human life and to the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (river and lakes) and groundwater environments, across coastal and inland areas. Water has two dimensions that are closely linked - quantity and quality. Water quality is commonly defined by its physical, chemical, biological and aesthetic characteristics. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health.

Water quality in a body of water influences the way in which communities use the water for activities such as drinking, agriculture or commercial purposes. More specifically, the water may be used by the community for:

- Supplying drinking water
- Recreation (swimming, boating)
- Irrigating crops and watering stock
- Industrial processes
- Protection of aquatic ecosystems
- Wildlife habitats
- Education

IMPORTANCE OF WATER QUALITY

Water resources are of major environmental, social and economic value to the nation, and if water quality becomes degraded this resource will lose its value. Water quality is

important not only to protect public health, water also provides ecosystem habitats, is used for farming, fishing and mining, and contributes to recreation and tourism. If water quality is not maintained, it is not just the environment that will suffer; the commercial and recreational value of our water resources will also diminish.

WATER QUALITY PARAMETERS

Water quality is closely linked to the surrounding environment and land use. Other than in its vapor form, water is never pure and is affected by community uses such as agriculture, urban and industrial use. The modification of natural stream flows by dams and weirs can also affect water quality.

Rivers frequently act as conduits for pollutants by collecting and carrying them from catchments and, ultimately, discharging it into the bay. Stormwater, which is highly rich in nutrients, organic matter and pollutants, finds its way into rivers and oceans mostly via the stormwater drain network. Water quality may also be affected by bacteria from sewer overflows or other runoff into stormwater drains.

The presence of contaminants and the characteristics of water are used to indicate the quality of water. Some of these water quality parameters considered for modeling in this study are as given below:

Biological Oxygen Demand (BOD)

Biological Oxygen Demand, or BOD, is a measure of the quantity of oxygen consumed by microorganisms during the decomposition of organic matter. BOD is the most commonly used parameter for determining the oxygen demand on the receiving water of a municipal or industrial discharge. BOD can also be used to evaluate the efficiency of

treatment processes, and is an indirect measure of biodegradable organic compounds in water.

Total Suspended Solids (TSS)

Total suspended solids (TSS) include all particles suspended in water, which will not pass through a filter. Suspended solids are present in sanitary wastewater and many types of industrial wastewater. There are also nonpoint sources of suspended solids, such as soil erosion from agricultural and construction sites. As levels of TSS increase, a water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen. TSS can also destroy fish habitat because suspended solids settle to the bottom and can eventually blanket the riverbed. Natural movements and migrations of aquatic populations may be disrupted.

Total Phosphorus (TP)

Total Phosphorus (TP) is an essential nutrient for all life forms, and is the eleventh-most abundant mineral in the earth's crust. In surface waters, phosphorus is usually present as phosphate (PO4-P). Phosphorus is needed for plant growth and is required for many metabolic reactions in plants and animals. Excessive concentrations of phosphorus can quickly cause extensive growth of aquatic plants and algal blooms. Several detrimental consequences may result. Excessive algae and plant growth can lead to depletion of the oxygen that is dissolved in the water. Water can hold only a limited supply of dissolved oxygen (DO) and it comes from only two sources, diffusion from the atmosphere and as a by-product of photosynthesis. Excessive growth leads to depletion of DO because of nighttime respiration by living algae and plants and because of the bacterial decomposition of

dead algae/plant material. Depletion of DO adversely affects many animal populations and can cause fish kills.

Total Kjeldahl Nitrogen (TKN)

Nitrogen is usually the most significant nutrient in estuarine and marine waters, but not in freshwater ecosystems. Total Kjeldahl Nitrogen (TKN) is a measure of organically bound forms and includes organic nitrogen and ammonia nitrogen. Ammonia is a bioavailable nutrient. It is very soluble in water. Depending on the pH and temperature, a fraction of the total ammonia exists as an undissociated form (NH_3). This can be toxic to some fauna. As pH increases and as temperature increases, the fraction decreases. Oxidized nitrogen including nitrite and nitrate nitrogen, are dissolved bioavailable forms.

Heavy Metals

Although some heavy metals such as copper and zinc are important trace elements for aquatic life, they can be toxic to some aquatic biota at higher concentrations. They also can exhibit additive or synergistic effects, i.e. where there are additive effects from two or more metals present, their individual toxicities are combined; where there are synergistic effects, the combined effect is greater than the sum of the individual effects.

Measurements of these water quality parameters can be used to determine, and monitor changes in, water quality, and determine whether the quality of the water is suitable for the health of the natural environment and the uses for which the water is required.

WATER QUALITY MODELING

A water quality model is a tool for simulating the movement of precipitation and pollutants from the ground surface through pipe and channel networks, storage treatment

units and finally to receiving waters. Both single-event and continuous simulations may be performed on catchments having storm sewers and natural drainage, for prediction of flows, stages and pollutant concentrations. Each water quality model has its own unique purpose and simulation characteristics.

Models commonly used for estimating the pollutant loadings/concentrations are spreadsheet models, SWMM (Storm Water Management Model), SLAMM (Source Loading and Management Model) and BASINS (Better Assessment Science Integrating Point and Nonpoint Sources). Based on Lee County's preference, a spreadsheet model was selected for water quality analysis in this study. This spreadsheet model, developed by Environmental Research and Design, Inc. (ERD) of Orlando, FL, has several advantages over other similar models such as:

- Easy set-up
- Public domain model/access
- Can be customized to fit any situation
- Modeler retains control over computational algorithms
- Can be easily modified for future conditions and other stormwater management systems

The disadvantages of ERD model are:

1) No provision for incorporating the effects of water quality best management practices.
2) It is limited to estimation of pollutant loadings on an annual basis, although the methodology can be adapted to monthly estimations.

ERD MODEL METHODOLOGY

The ERD model is based on landuse characterization and performance evaluation studies for stormwater treatment systems performed specifically in Southwest Florida. The data utilized for the development of ERD model were obtained from studies and scientific literature prepared by SFWMD, SWFWMD, St. Johns River Water Management District (SJRWMD), FDEP, USGS, Collier County, and Lee County.

Steps necessary to determine the total untreated constituents concentration in a watershed using ERD model are given below:

1. Comparison of landuse categories
2. Determination of mean event concentrations
3. Estimation of pollutant loadings from stormwater runoff
4. Estimation of total untreated constituents concentration in mg/l

Comparison of Landuse Categories

Since the landuse categories used by ERD model differ from the landuse categories of the GIS database developed in this study, a landuse use comparison was conducted in order to estimate the mean event concentrations of pollutants using ERD model. The landuse categories were compared between those provided in the ERD model documentation and the categories included in the SFWMD GIS landuse data used in this study. Table 15.1 provides the landuse comparison.

Determination of Mean Event Concentrations

After comparison of the landuse categories, the mean event concentrations provided in Table 7 of the ERD model document (Appendix F) were utilized to associate the concentrations for different landuse categories to the landuse categories in SFWMD GIS data Table 15.2 provides the mean event concentrations for different landuse categories in the study watershed.

Estimation of Pollutant Loadings from Stormwater Runoff

Once the mean event concentrations for the selected water quality parameters in the study area is finalized, the mass loading of the pollutants from the stormwater runoff is determined using the following formula:

Load (kg/year) =

$$\sum_{n}^{i=1}\left[\left(A_i * \frac{43560\, ft^2}{acre} * R * CV_i * \frac{1\, ft}{12 inches} * \frac{7.48 gallons}{ft^3} * \frac{3.785 liter}{gallon} * C_i * \frac{1 kg}{10^6 mg}\right)\right]$$

where Ai = Area of Landuse Category, i (acres)

n = Number of different Landuse Categories

Ci = Concentration of selected runoff constituent in land use category i (mg/l)

R = Annual rainfall at site (inches/year)

CVi = Runoff "C" value for land use category i (dimensionless)

The runoff coefficients as a function of the curve number and directly connected impervious areas (DCIA) were estimated from Table 4 of the ERD model document (Appendix F) for modeling purposes.

The average total annual rainfall for Fort Myers area from 1960-1993 is 53.15 inches based on the ERD model document.

Estimation of Total Untreated Constituents Concentration in mg/l

Once the mass loading of pollutants is calculated, the final estimated total untreated constituents concentration in mg/l is calculated using the following formula:

$$\text{Total Untreated Constituents Concentration (mg/l)} = Load\left(lbs / yr\right) * V$$

where V = Total runoff volume (liters)

EXISTING CONDITIONS WATER QUALITY MODELING

The methodology described above and the data attached as part of the Appendix F from the ERD model document were used to develop a spreadsheet model to determine the untreated pollutant concentration in the existing conditions for the study area. Each subbasin delineated within a watershed was characterized based on different landuse categories and respective runoff curve numbers. For each curve number, the runoff coefficients for the existing condition landuse was extrapolated from Table 4 of ERD model document (Appendix F) with a DCIA percentage of zero. Table 15.3 provides the runoff coefficients for

different runoff curve numbers for DCIA of zero percent, 5 percent and 30 percent of the subbasin area.

After estimating the pollutant loadings for each subbasin, the total untreated annual constituents concentration was calculated for each watershed in mg/l. Table 15.4 summarizes the total untreated constituents concentration for each watershed in mg/l. The estimated concentrations were then compared with the standard criteria from FDEP for surface water quality parameters and also the results of laboratory tests of grab samples obtained by Lee County at different locations along Burnt Store Road during 2002-03. Table 15.5 gives the concentrations of constituents for the grab samples.

The water quality modeling calculations done for each of the subbasin within the study area, for existing landuse conditions, using the ERD model is attached as part of Appendix G**.**

FUTURE CONDITIONS WATER QUALITY MODELING

For future conditions modeling, runoff coefficients were determined for the same curve numbers but with two different DCIA percentages.

Case A:

Subbasins with DCIA < 1.4% were assigned DCIA = 0

Subbasins with DCIA of 27-30% were assigned DCIA = 30%

Case B:

Subbasins with DCIA > 1.4% and < 5.5% were assigned DCIA = 5%

Subbasins with DCIA of 27-30% were assigned DCIA = 30%

DCIA percentages for each of the subbasins were calculated based on different landuse criteria as described in Chapter 4. The runoff coefficients for different curve numbers for each of these DCIA percentages are provided in Table 15.3. Calculations were performed based on the ERD methodology and the total untreated annual constituents concentration were summarized for both future landuse conditions Case A and Case B. Table 15.6 summarizes the untreated annual constituents concentration for future landuse conditions Case A and Case B.

WATER QUALITY LEVEL OF SERVICE

Based on discussions with Lee County, Surface Water Quality Classifications published by FDEP, Rule 62-302.530 (Appendix I) were considered to be the intended level of service for specific water quality constituents. This document did not provide acceptable concentration values for Total Suspended Solids (TSS) and Total Kjeldahl Nitrogen (TKN). Table 15.7 gives the standard concentrations of water quality constituents and modeled concentrations. The comparison between these values show that BOD, TP, and Lead concentrations did not meet the level of service in the study area.

A comparison was also made between the modeled water quality constituents concentration with the laboratory results of the grab samples as a “validation” of ERD model results (Tables 15.5 and 15.7). Of all the constituents, the modeled existing conditions concentrations of TP, TKN and Zinc compare reasonably with the grab samples concentrations measured along Burnt Store Road. The remaining modeled concentrations vary significantly compared to grab samples.

WATER QUALITY BEST MANAGEMENT PRACTICES (BMPs)

A review of literature was done on previous work performed within the State of Florida for quantifying the pollutant removal efficiencies associated with various stormwater management systems. Comparative removal efficiencies were obtained and summarized for on-line dry retention, on-line wet retention, off-line retention/detention systems, wet detention, and dry detention systems. Estimated pollutant removal efficiencies were generally available for total nitrogen, orthophosphorus, total phosphorus, TSS, BOD, copper, lead and zinc.

The terms “detention” and “retention” are often used interchangeably by engineers. A brief definition of each is given below:

Detention: The collection and temporary storage of stormwater, generally for a period of time ranging from 24-72 hours, in such a manner as to provide for treatment through physical, biological or chemical processes with subsequent gradual release of stormwater to downstream receiving waters.

Retention: On-site storage of stormwater with subsequent disposal by infiltration into the ground or evaporation in such a manner as to prevent direct discharge of stormwater runoff into receiving waters.

Table 15.8 gives the summary of pollutant removal efficiencies of stormwater treatment systems for various water quality constituents in Florida. Existing literature suggests that only dry retention systems are capable of providing approximately 80% reduction in pollutant loads. Off-line retention/detention facilities are capable of providing approximately 80% reduction in TP, TSS, BOD, and Zinc, but provide only a 60-75% reduction in annual pollutant loadings for TN, Copper and Lead. Wet retention systems

provide 80% reduction for TSS only; their removal efficiencies for TN, TP, and BOD range from 40-50%.

Good pollutant removal efficiencies are achieved in wet detention systems for orthophosphorus, total phosphorus, TSS, BOD and heavy metals, although removal efficiencies are less than 80%.

Overall, the most effective stormwater management systems in terms of retaining stormwater pollutants appear to be dry retention, off-line retention/detention ponds, wet retention, and wet detention systems. Previous studies have emphasized use of these treatment systems to maximize the pollutant removal effectiveness of stormwater management programs.

There are two County-owned parcels and several privately owned open lands available east of Burnt Store Road (Figure 6.1) that can be used for water quality treatment. However, as explained in the previous section, the proximity of the seasonal high water table to the existing ground elevations is an issue for providing retention/detention treatment systems. Soil survey report indicates that the seasonal high water table is within 1-ft below the existing ground elevations. Future studies should assess the seasonal high water elevations in potential parcels using soil boring so that the feasibility of providing wet/dry retention or detention treatment systems could be determined.

Since vast areas east of Burnt Store Road are State-owned, the water quality treatment requirements for potential retention/detention systems were calculated only for the areas not owned by the State. The land area to be treated is approximately 650 ac in Yucca Pen Creek, 290 ac in Durden Creek watershed, and 1550 ac in Greenwell Branch watershed. Table 15.9 provides the treatment volume required in these three watersheds east of Burnt Store Road.

Future development projects east of Burnt Store Road should be required to provide treatment for 1-inch of runoff generated from the developed areas through wet or dry retention/detention ponds.

CONCLUSIONS

1. Based on the ERD model analysis (Appendix G), BOD, Total Phosphorus, and Lead are the water quality constituents that do not meet the water quality standards set by FDEP in the existing as well as future landuse conditions.
2. Water quality modeling of future landuse conditions indicates slight increase in constituent concentrations compared to the existing landuse conditions.
3. Literature review indicates that wet/dry retention or detention systems are the most effective water quality BMPs in the South Florida region.
4. The pollutant removal efficiencies of these water quality BMPs are in the range of 60% to 90%.

RECOMMENDATIONS

1. Future developments within the unincorporated areas of Lee County east of Burnt Store Road should be required to provide treatment for 1-inch of runoff generated from the developed areas through wet or dry retention/detention systems as the BMPs.
2. Accurate determination of the seasonal high water tables in the areas where these BMPs will be located is necessary for the proper design of these treatment systems.

16. WATER BUDGET

A water budget analysis of the study area was performed using modeled flows, since there are no observed flow data for any of the study watersheds at Burnt Store Road or west of Burnt Store Road. Since the 25-yr, 72-hr design storm was critical in terms of the level of service for roadway flooding, an analysis of inflow and outflow was performed for this design storm event.

INFLOW

Total drainage area of the study watersheds is approximately 30,965 acres excluding the area of Gator Slough watershed east of US-41. Rainfall depth of the 25-yr, 72-hr design storm event is 10.5-inches in the study area. This provides an inflow of 27,095 ac-ft into the system. In addition to the rainfall, Gator Slough receives inflow at the US-41 culvert and through the west-side ditch along US-41. Based on the Gumbel statistical analysis and considering a multiplication factor of 2 as discussed in Section 12, the total upstream inflow into Gator Slough canal is approximately 122 ac-ft during the 25-yr, 72-hr design storm event at US-41. Yucca Pen Creek, Durden Creek, Greenwell Branch, and Longview Run watersheds do not receive any upstream inflow. Hence the total inflow into the system is approximately 27,220 ac-ft as shown in Table 16.1. Thus the upstream inflow in Gator Slough represents only 0.45% of total inflow. Figure 16.1 graphically represents the inflow into the system.

Significant inter-basin flows occur between the study watersheds mainly because of flat topography. These inter-basin flow paths were represented in the ICPR hydrologic/hydraulic model as weirs. There are also defined channels and swales that act as

inter-basin conveyances, especially around Burnt Store Road and west of Burnt Store Road. The time history of flows through the inter-basin conveyance elements as given by the ICPR model were analyzed and the net inflow into individual watersheds were calculated. These results are also presented in Table 16.1. Approximately 37% of the rainfall volume over the Durden Creek watershed was lost as inter-basin flow to Yucca Pen Creek and Greenwell Branch watersheds. A majority of this loss occurs through channel C-2260B, which is a part of the Cape Coral Canal System west of Burnt Store Road, into Greenwell Branch watershed. The other watersheds gain a net positive inflow because of inter-basin flows (Table 16.1).

WATER BUDGET

The outflow from individual watersheds into Matlacha Pass/Cape Coral Canal System was determined from the modeled flows obtained by ICPR simulation of the 25-yr, 72-hr design storm event. Final outflow volume ranges from 1,343 ac-ft from Longview Run watershed to 6.863 ac-ft from Gator Slough watershed. The remainder of the total inflow is lost as infiltration into the soil or still within the system as surface storage at the end of the 300-hr simulation period. The percentage of outflow ranges from approximately 60% to 80% of the total inflow into the individual watersheds (Table 16.1). Considering the entire study area, the total outflow from the system is approximately 18,200 ac-ft or about two-thirds (66.8%) of the total inflow into the system. This is equivalent to an average runoff of approximately 7-inches from the entire study area. One-third of the total inflow into the entire study area is either lost as infiltration or stored within the system. A prolonged simulation should increase the outflow at the expense of system storage. Figure 16.1 shows a

graphical representation of water budget for the study area for the 25-yr, 72-hr design storm event.

CONCLUSIONS

1. A water budget analysis of the study area was performed using the 25-yr, 72-hr design storm event modeling results.
2. The total inflow into the system is approximately 27,220 ac-ft. Only 0.45% of this inflow volume is through the upstream inflow into Gator Slough at US-41.
3. Significant inter-basin flows occur between the study watersheds mainly because of flat topography.
4. There is a net loss of about 37% of the total rainfall volume from Durden Creek watershed due to inter-basin flows. The remaining four watersheds gain a net positive inflow due to inter-basin flows.
5. Outflow from individual watersheds ranges from approximately 60% to 80% of their respective total inflow.
6. The total outflow from the entire study area is approximately 18,200 ac-ft or about two-thirds (66.8%) of the total inflow into the system.
7. One-third of the total inflow into the entire study area is either lost as infiltration into the soil or stored within the system at the end of the simulation period.

17. STUDY RECOMMENDATIONS

The recommendations of this master plan study for surface water management in the Northwest Lee County watersheds are summarized below.

1. Gator Slough basin drains a significant area east of US-41. It is also interconnected with the Cape Coral canal system. Since the areas east of US-41 and the interconnections were studied indirectly in this study, an integrated study and model development that will include the entire drainage area and the entire Cape Coral Canal System is recommended.
2. Since the topographic contour information available for the study area is dated 1990-91 and significant differences were noted between the contour maps and the 2003 aerial photographs, development of new topographic data is recommended for the study area. This can be accomplished with the cooperation of South Florida Water Management District, City of Cape Coral, and Charlotte County. New technologies such as LIDAR are used elsewhere in Florida to develop elevation data for large areas. For example, Southwest Florida Water Management District is currently developing a District-wide elevation data using LIDAR. Such technologies should be used to develop new topographic contours of Northwest Lee County region for future studies.
3. GIS is playing a key role in several disciplines including water management to store, analyze, and manipulate spatial data. The GIS database of the study watersheds created in this study should be developed further to include other relevant watershed

information. Digitization of data in other formats including hardcopy maps is important. Such a GIS database will serve as a valuable tool for water resources managers. Since the Northwest Lee County GIS database has been developed using the Lee County GIS standards, this database could be integrated seamlessly with other County-wide water resources GIS data as well as data from other County departments.

4. The GIS database of the Northwest Lee County region should be continuously updated to reflect the developments and changes within these watersheds to aid in efficient management of water resources in this region.
5. The field survey conducted for this study is limited in scope. Detailed survey should be performed for the engineering design of the proposed improvements and any future studies focused on specific watersheds.
6. Since there are significant differences between the contour maps available for the study area and the latest aerial photographs, updated topographic data should be used to refine the watershed/subbasin boundaries delineated in this study.
7. Coordination with the owners of the private properties east of Burnt Store Road in Lee County and west of Burnt Store Road in the City of Cape Coral will be necessary for obtaining additional right-of-way or drainage easements, if required, for roadway expansion/flood control/water quality improvement projects.
8. Utilization of the excess capacity of the perimeter spreader waterway system and the Cape Coral canal system for diverting the flows generated east of Burnt Store Road should be studied with the cooperation of the City of Cape Coral. An integrated hydrologic/hydraulic model that will include the five watersheds considered in this

study as well as the Cape Coral canal system basins should be developed as part of the future studies.

9. Since there are several wetlands in the study area, especially east of Burnt Store Road, impacts to the wetlands should be a consideration in constructing surface water improvement projects. Formal determination of jurisdictional wetland boundaries within the project areas with the cooperation of SFWMD should be considered.
10. Purchase of additional right-of-way or drainage easements is recommended if the entire 200-ft right-of-way will be utilized for roadway expansion.
11. Development of the roadway expansion plan and improvements to surface water conveyance elements should be closely coordinated among Lee County departments as well as the City of Cape Coral.
12. Determination of accurate seasonal high water elevations through site-specific soil borings is recommended for the engineering design of flood control/water quality improvements such as wet and dry detention ponds in areas east of Burnt Store Road.
13. The hydrologic/hydraulic modeling was accomplished using ICPR Version 2.2 in this study. Version 3.0 of ICPR was released in 2003; further developments of the software will be on Version 3.0. Several local governments and agencies have converted their older ICPR models to Version 3.0. The watershed model developed as part of this study should be converted to ICPR Version 3.0 in future master plan studies.
14. ICPR should be used as the model of choice for future studies for consistency.
15. The Cape Coral canal system model was developed using SWMM by the City of Cape Coral. An integrated study of Northwest Lee region and City of Cape Coral

canal system should be based on a single integrated model of the entire surface water drainage system. Conversion of the Cape Coral canal system model from SWMM to ICPR Version 3.0 and integration with the Northwest Lee County model is recommended. Cooperation with the City of Cape Coral is necessary for this task.

16. Runoff curve numbers of subbasins developed in this study should be updated as future developments and other landuse changes occur in the study area.
17. Time of concentration for individual subbasins developed in this study should be updated as more detailed topographic data becomes available.
18. The GIS inventory of the conveyance elements developed in this study should be continuously updated. When an integrated study of Northwest Lee region and Cape Coral canal system is performed, this GIS inventory should be expanded to include other conveyance elements within the canal system.
19. A regular maintenance program should be developed and implemented for the Burnt Store Road control structures. This program should include removal of trash accumulation, sedimentation, and vegetation growth at periodic intervals to maintain the full conveyance capacity of the control structures and channels.
20. Damages to the existing structures should be repaired.
21. Eroded riprap should be repaired to maintain the structural integrity of the culverts.
22. Bank stabilization is necessary on the downstream side of Culvert #5.
23. More investigations on the hydraulics and conveyance within Subbasins LV-2 and LV-3, the effect of the existing mine pits, and interconnects between Burnt Store Road side ditch should be carried out to further refine the model.

24. The USGS streamgage located east of US-41 in Gator Slough canal does not account for all the flows west of US-41. This streamgage should be moved from its current location to approximately 500’ downstream of US-41 culvert. This is essential to properly monitor the total flow in Gator Slough canal.
25. Since there is only one raingage available for the entire study area, installation of a weather station in the vicinity of Burnt Store Road is recommended to aid in future studies.
26. Future developments within the unincorporated areas of Lee County east of Burnt Store Road should be required to provide treatment for 1-inch of runoff generated from the developed areas through wet or dry retention/detention systems as the BMPs.
27. Accurate determination of the seasonal high water tables in the areas where these BMPs will be located is necessary for the proper design of these treatment systems.

Proposed Improvements:

1. Remove the obstruction in Durden Creek Main channel downstream of Culvert #3. Based on discussions with SFWMD, this is considered to be a maintenance activity and would not require a permit.
2. Increase the length of all cross-drains along Burnt Store Road to 200-ft to match the proposed roadway expansion.
3. Upsize Culvert #3 to a 4-48” HDPE culvert, using the existing pipe inverts.
4. Upsize Culvert #6 to be a 4-30” RCP culvert, using the existing pipe inverts.

5. Provide a 1-ft deep side ditch with 12-ft bottom width along the east side of Burnt Store Road, from Culvert #3 to Culvert #4, for approximately 2,700-ft.
6. Provide the equivalent of the existing side ditch conveyance on either side of the expanded Burnt Store Road.
7. Expand the bottom width of side ditch along the east side of Burnt Store Road by 6-ft from Culvert #4 to the drop structures immediately north of Gator Slough canal for a length of approximately 16,000-ft. Lower the inverts of this side ditch by up to 1-ft as shown in the proposed conditions ICPR model.
8. Upgrade the side drains east of Burnt Store Road south of Culvert #5 using one additional pipe of the same size and material.
9. Modify the drop structures D-5180B and D-5190B on both sides of Burnt Store Road at Gator Slough to a Type E Ditch Bottom Inlet as per Florida Department of Transportation Design Manual.
10. Remove all sedimentation and trash accumulation in the Burnt Store Road culverts north of Gator Slough canal.
11. Remove the dense vegetation growth in the side ditches and around culverts along Burnt Store Road.
12. Raise the elevation of the roadway by a minimum of 6 inches at Durden Creek Main culvert (Culvert #3), as part of the proposed roadway expansion.