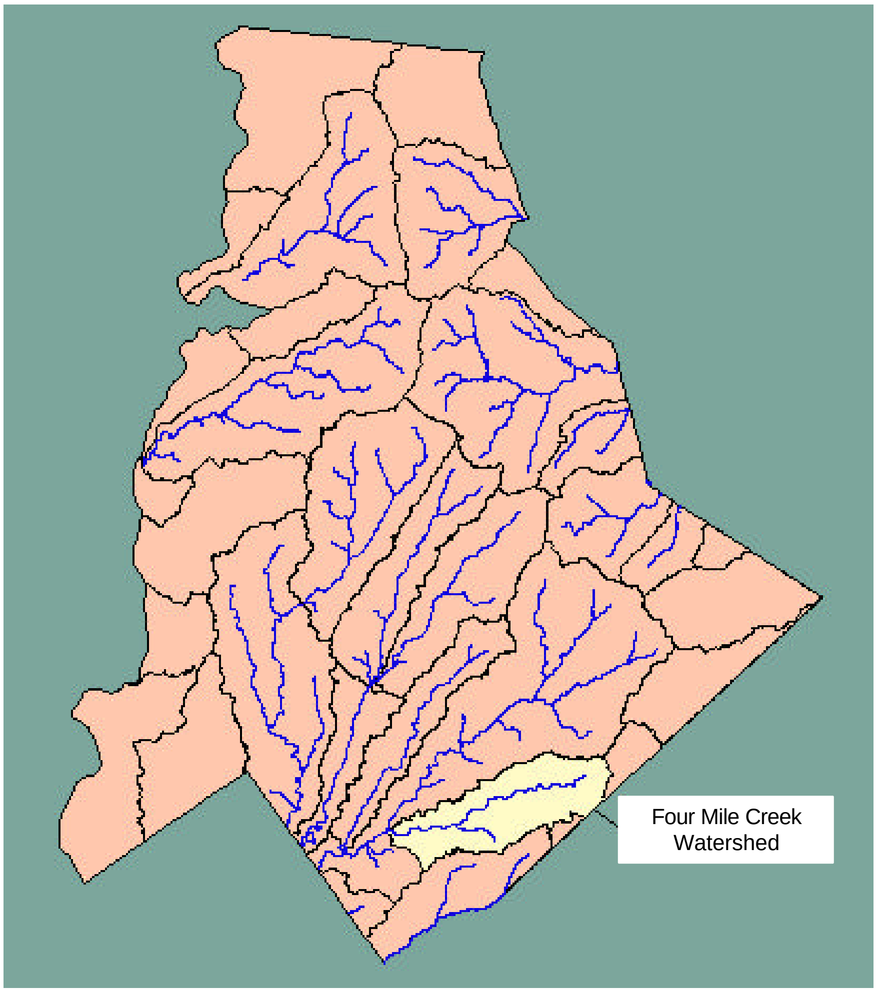
Watershed Study No. 4

Four Mile Creek Watershed

Preliminary Engineering Report

MCSWS Project No. 61001



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Prepared For:

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MECKLENBURG COUNTY
STORM WATER SERVICES

PRELIMINARY ENGINEERING REPORT
FOR
MECKLENBURG COUNTY MITIGATION PLANS

FOUR MILE CREEK WATERSHED

ACKNOWLEDGEMENT

The project staff of Watershed Concepts, a Division of HSMM, Inc., would like to give thanks to Mecklenburg County Storm Water Services (MCSWS) for its assistance and support during this project.

DISCLAIMER

This watershed-wide study is for planning purposes only. These study results and recommendations are preliminary and should not be used for construction without additional detailed engineering design analysis.

CERTIFICATION

I hereby certify that this Preliminary Engineering Report for Mecklenburg County was prepared by me or under my direct supervision.

Signed, sealed, and dated this ____ day of November 2001.

By: Joseph B Chapman

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Senior Vice President

NORTH CAROLINA PROFESSIONAL SEAL 20506 ENGINEER JOSEPH B. CHAPMAN

MECKLENBURG COUNTY
STORM WATER SERVICES

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GLOSSARY

Term used in this report	Definition
100-year Flood	The flood that has a 1% probability of being equaled or exceeded in any given year.
Base Flood Elevation (BFE)	Water surface elevation for the 1% probability flood (100-year flood).
Existing Conditions	The land use condition of the watershed based on the state of development as of the date of this study.
Existing Condition Floodplain (ECF)	The floodplain delineated for the 1% probability flood (100-year flood) using the current land use conditions in the watershed (existing conditions). The boundaries of this floodplain are the same as shown in Flood Insurance Rate Maps (FIRMs).
Future Conditions	The land use condition of the watershed based on the projected ultimate buildout in the watershed. It was previously defined in Floodplain Land Use Maps (FLUMs) of Mecklenburg County.
Future 100-year Flood	The flood that has a 1% probability of being equaled or exceeded in any given year under the future conditions of land use
Future Condition Floodplain (FCF)	The floodplain delineated for the 1% probability flood (future 100-year flood). The boundaries of this floodplain are the same as shown in Flood Insurance Rate Maps (FIRMs)

EXECUTIVE SUMMARY

FOUR MILE CREEK WATERSHED

This Preliminary Engineering Report briefly describes a study of the Four Mile Creek morphology, bank stability problems, flood hazard areas, and potential mitigation measures. Public records from the Mecklenburg County website, aerial photographs, and specific references listed at the end of this report have been consulted in preparation of this report. The gathering of information has been supplemented by several field visits, surveys, and photography of the areas under study.

The Four Mile Creek basin constitutes a highly developed section of Mecklenburg County (Figure E1). This basin includes the major tributary of Rocky Branch and the main stem of Four Mile Creek. The Four Mile Creek watershed is in reasonably stable condition due to four main factors:

1. Stabilized stream banks because of a sewer main line extending along the creek

2. Heavily vegetated banks and floodplains

3. Numerous road crossings and other man-made structures that form grade controls and limit bank erosion or stream scour

4. Past stabilization efforts along the creek

Flooding of the structures within the existing 100-year floodplain occurs in only two general neighborhoods on Four Mile Creek (Figure E2 and E3). A total of 9 residential structures are affected, of which one experiences minor inundation and the rest are located in the flood fringe areas (within 2 ft of BFE). A summary of affected structures is shown in Table E1. All structures are Post-FIRM (built after 1981), and flood damages are minor or nonexistent. Three mitigation measures were considered for these two neighborhoods: elevating the structures two feet above the BFE, berm construction, and acquisition.

Table E1. Structures Within Existing 100-year Floodplain

No. of Structures	Project Neighborhood/Area	No. Flooded	No. within 2ft of BFE	Avg. Flood Depth*	Median Depth*	Highest Depth*	Lowest Depth*
3	Ashley Creek Dr	0	3	-0.52	-0.38	-0.4	-0.8
6	Iverleigh /Reverdy Oaks/ Stevens Ridge	1	5	-0.66	-0.76	0.22	-1.4

* Negative numbers indicate that the finished floor elevation is above the 100-yr flood elevation; depths are in feet.

Four Mile Creek can be divided into two reaches along its 10-mile stretch. For about 2.5 miles, from the headwaters to about 700 feet downstream of the Retana Drive overpass, the stream channel is fairly well defined, with gently sloping, well-vegetated floodplains. The channel bed

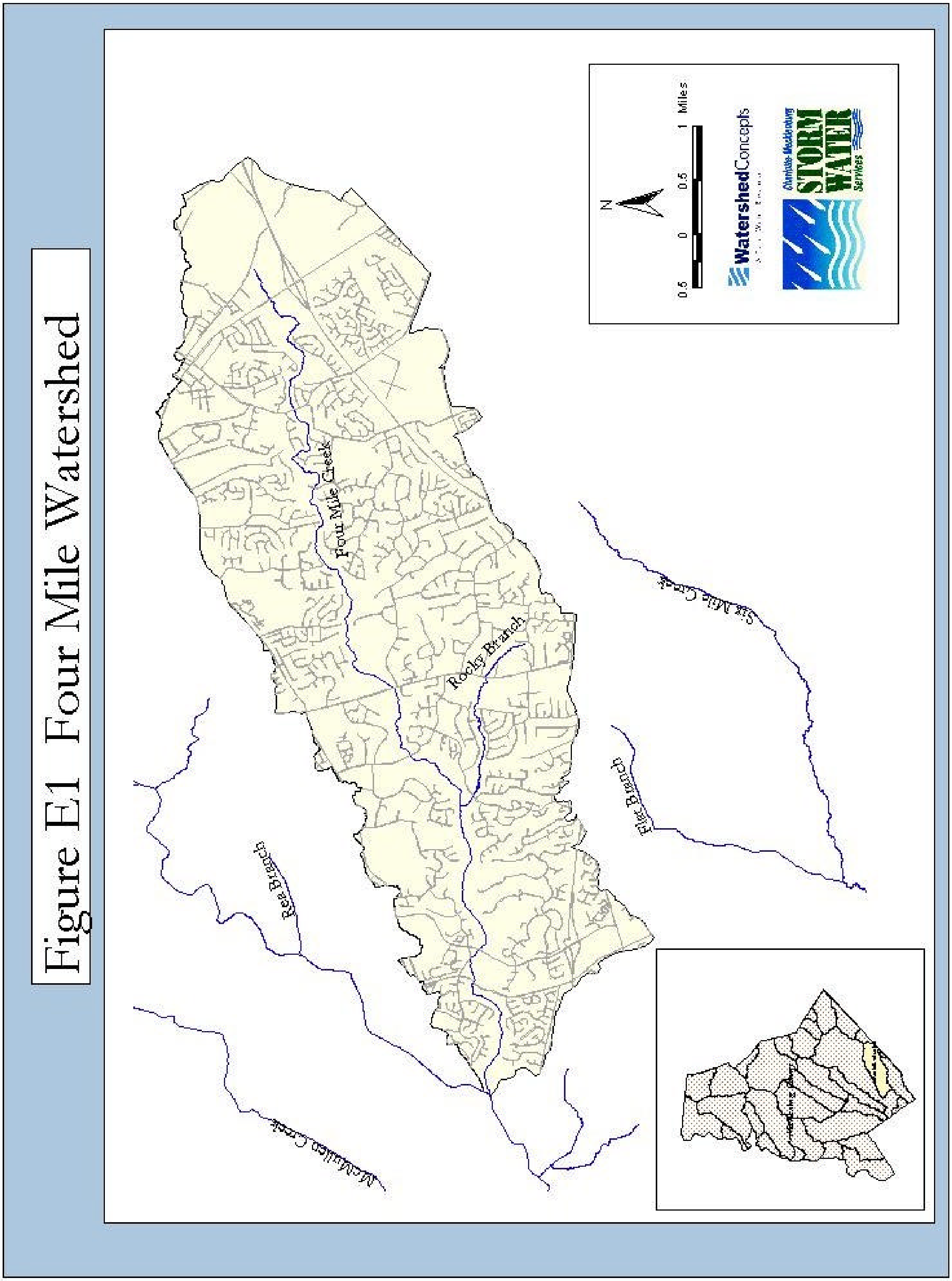

Figure E1 Four Mile Watershed

is generally rocky, consisting of an assortment of rocks to large boulders. There are occasional eroded sections of the stream. However, the channel shape seems to be stable, with gentle side-slopes of 3:1 or flatter, often cropped with rocks, but mostly covered by bushes and trees.

In its downstream reach, between stream station 41400 and the confluence with McAlpine Creek, the main channel demonstrates a somewhat different set of characteristics. The bed consists mainly of dense clay, highly eroded with almost vertical banks and an entrenched channel. Occasionally, the bed widens, and the base flow channel meanders inside the bed producing the typical point bars inside of the meander bends. The channel is heavily vegetated which somewhat helps stabilize the banks. However, signs of eroding banks and exposed roots are evident along this reach of the creek. The sediment-laden water in this reach indicates erosion of the banks, as well as possible contribution from the rapidly developing reaches of the creek. In addition to the point bars, there is sediment deposition near the road crossings and in the stabilized sections of the stream.

The Rosgen stream classification system was utilized to provide an initial assessment of the morphology of Four Mile Creek. The majority of Four Mile Creek is classified as a type G channel with some reaches possibly being classified as type F. Generally, the channel displays a low width/depth ratio, low sinuosity and relatively low channel slope. Indicators of a new Bankful flow line were observed below the historic top-of-bank, which imply that the channel has incised within the historic floodplain. This has most likely resulted from a combination of urbanization of the watershed and manual re-grading of the channel. The historic floodplain, which was formed as an alluvial plain bounded by gentle slopes of upland soils, currently forms a terrace that confines the channel.

Mecklenburg County Department of Environmental Protection (MCDEP) maintains one monitoring station along Four Mile Creek. While the Macroinvertebrate Taxa Richness sampling and the Fish Bioassesment sampling has produced Poor and Fair ratings since 1995, the overall Water Quality Index has consistently ranked as Average, Good and Good-Excellent. The overall water quality has remained generally consistent in the watershed since 1996. There are no USGS maintained stream gages on Four Mile Creek.

Presently, there are many capital improvement projects planned or in progress for Mecklenburg County. However, these projects are expected to have a minimal impact on the drainage and flooding processes in the Four Mile Creek watershed. The analyses and mitigation alternatives considered in this report will not be affected by the planned capital improvement projects of the County.

Three flood mitigation alternatives and a no-action alternative were considered for the affected structures in the Four Mile Creek watershed. None of the three mitigation alternatives proved to be economically justifiable. Therefore, no flood mitigation measures are recommended for this watershed. However, regular maintenance at man-made structures such as road crossings and storm water outfalls will be necessary to maintain stream stability.

Figure E2 Ashley Creek Neighborhood, Structures Considered for Mitigation


Figure E3 Reverdy Oaks Neighborhood, Structures Considered for Mitigation
Streams
Levees
100 year floodplain
Structures Considered for Mitigation
Building footprints
REVERDY
LAXTON
CAPE FEAR
PENDERLEA
LAUREL PARK
80 0 80 160 Feet
Watershed Concepts
STORM WATER
Study Area

1. GENERAL WATERSHED CONDITIONS

1.1 Watershed Characteristics

The Four Mile Creek basin includes a watershed of about 19 mi^2 in the southern part of Mecklenburg County. This basin includes the main stem of Four Mile Creek and the major tributary of Rocky Branch.

Four Mile Creek

Four Mile Creek extends in the general east to west direction across the City of Charlotte. Under existing 100-year flood conditions, about 10 miles of Four Mile Creek experiences flooding along the main stream from the confluence of McAlpine Creek to the headwaters. An additional 1.5 miles of Rocky Branch to the south of the main stream also floods, extending roughly from Four Mile Creek Road to Providence Road.

Fig. 1 At Windlock Drive, Looking U/S

Fig. 2 At Windlock Drive, Looking D/S

Rosgen classification of Four Mile Creek is presented in Section 1.4 of this report. Qualitative descriptions of the creek are given in the following paragraphs. Four Mile Creek can be divided into two reaches along its 10-mile stretch. For about 2.5 miles, from the headwaters to about 700 feet downstream of the Retana Drive crossing, the stream channel is fairly well defined, with gently sloping well-vegetated floodplains. The channel bed is generally rocky, consisting of an assortment of rocks to large boulders. There are occasional eroded sections of the stream. However, the channel shape seems to be stable, with gentle side-slopes of 3:1 or flatter, often cropped with rocks, but mostly covered by bushes and trees. Figures 1 and 2 show two photos of the creek, showing typical channel conditions at about stream station 41400, looking upstream and downstream, respectively.

Under the base flow conditions the flow is mostly tranquil (Figure 2), occasionally forming small pools and drops due to rock lining of the bed and banks (Figure 1). A main sewer line extends along the full course of Four Mile Creek. Many channel bank segments are stabilized by rock riprap due to the presence of the sewer line. The banks are also stabilized wherever roads cross the stream, and in a few places where individual homeowners or land developers have made an attempt to stabilize the banks. However, individual efforts seem to be non-engineered, and some of the riprap rocks line the channel bed rather than the banks (Figure 3).

Fig. 3 Near Maynard Road

Fig. 4 Near Barington Place

The floodplain in this reach is gently sloping, and generally well vegetated. In a few undeveloped reaches along the stream, the floodplain is heavily wooded. However, in the mostly developed remaining sections the cover is a mix of trees, grass, wild weed and bushes (Figure 4).

In its downstream reach, between stream station 41400 and the confluence with McAlpine Creek, the main channel demonstrates a somewhat different set of characteristics. The bed consists mainly of dense clay, highly eroded with almost vertical banks and an entrenched channel. Occasionally, the bed widens and the base flow channel meanders inside the bed, producing the typical point bars inside of the meander bends (Figures 5 and 6). The channel is heavily vegetated, which helps stabilize the banks. However, signs of eroding banks and

Fig. 5 Near Hugh Forest Road

Fig. 6 Near Silver Fox Road

exposed roots are evident along this reach of the creek. The sediment-laden water in this reach indicates that a certain degree of bank erosion does occur. However, the rapidly developing reaches of the creek probably contribute the larger portion of the sediments. In addition to the point bars, there is sediment deposition near the road crossings and in the stabilized sections of the stream.

Fig. 7 Near High Ridge Road

The channel bed and floodplain have been stabilized along most of the stream due to the sewer main line. The channel is also stabilized at the road crossings. Most of the riprap used for this purpose seems to be stable, possibly due to better design or construction. Figure 7 shows a typical reach of the stream at the sewer line crossing.

Fig. 8 Near Providence Road

The floodplain in this reach of the creek is also wide, heavily vegetated, and stable. In undisturbed sections, the floodplain is wooded with heavy undergrowth. In disturbed sections, due to the sewer line or other human activity, the cover is grass, weeds, and trees. Figure 8 shows a typical section near Providence Road crossing. Due to the similarity of the floodplains in the two reaches of Four Mile Creek, the behavior of the stream under the existing 100-year flood conditions is expected to be fairly similar. Because of the wooded nature and dense vegetation, water velocity will probably be low, with damages caused by the inundation of low-lying areas or lower levels of the homes. Velocities are expected to be too low to cause any major erosion or undercutting of the homes or foundations.

Rocky Branch

Rocky Branch is the major tributary of Four Mile Creek. Virtually all of the morphological descriptions of Four Mile Creek apply as well to Rocky Branch. The variety and density of vegetation in the floodplain as well as the nature of development in the respective watersheds are also very similar. Surveys of the Rocky Branch revealed that the two streams were similar in their morphology, and separate Rosgen analysis or treatment of the two streams was not necessary. For these reasons, in the remainder of this report, Four Mile Creek and Rocky Branch are treated as a single unit.

1.2 Development in the Watershed

Development has occurred and is continuing heavily along the entire length of Four Mile Creek and its tributaries. New development projects, individual homes, road crossings, and other man-made structures are currently under construction along the creek. The watershed may be approaching its ultimate buildout capacity in the not too distant future.

Inspection of the homes under construction indicates that homes are being built with finished floor elevations above the existing 100-year floodplain. However, many homeowners may have finished basements or made additions to their homes after the purchase of their property. This may have caused houses to be inundated in the floods of 1995 and 1997. Figure 9 illustrates a typical case. The two houses in the right and middle of the picture have a first floor elevation roughly at the elevation of the house on the far left. However, these houses have finished basements, and suffered inundation damage in the floods whereas the house on far left did not. Figure 4 shows a similar case where the house in the front of the picture suffered inundation while the house in the back, built on fill, did not.

Fig. 9 Houses on Stevens Ridge Road

General statistics of development in the Four Mile Creek watershed are summarized in Table 1. The table includes temporal distribution of development in the watershed as well as the development type according to the information available as of the year 2000. Table 1 clearly indicates the high level of development in this watershed, with over 80% of the units being in the single-family category. The actual percentage of units in this category may be higher if many of the units designated as unclassified in the County database are single-family units.

Table 1 also indicates the accelerating pace of development in the watershed. The number of units developed in each decade since 1970 had steadily increased, leading to less than 10% of the watershed that was still undeveloped as of the year 2000. The reason for the drop in numbers from before 1970 to the 70s decade is that all of the developed units prior to the year 1970 are lumped together in the first column of the table.

Table 1. Development in the Four Mile Creek Watershed*						
	Year Developed					Total
	Before 1970	1970-1979	1980-1989	1990-2000	Vacant/ Unclassified	
Parcels	1,770	1,545	3,996	5,002	1,249	13,562
Percentage	13.0%	11.4%	29.5%	36.9%	9.2%	100%

Land Use as of 2000					
	Single Family	Other Residential	Non-Residential	Vacant/ Unclassified	Total
Parcels	10,900	993	287	1,382	13,562
Percentage	80.4%	7.3%	2.1%	10.2%	100%

* Entire 19-mi^2 watershed within Mecklenburg County, including the Rocky Branch tributary

An existing sanitary sewer trunk line, completed in the late 1960's, extends along the entire length of the regulated portion of Four Mile Creek. Currently, no additional capital sewer improvements are planned along Four Mile Creek based on the Charlotte-Mecklenburg Utility Departments 2002 Capital Improvement Plan (CIP).

A review of CIP plans was completed for various City and County agencies including the following:

?? City and County Storm Water Services
?? Neighborhood Development
?? Charlotte Department of Transportation
?? Mecklenburg County Park and Recreation
?? Charlotte-Mecklenburg Planning Commission

Currently, the only planned CIP in this area that may affect the flood prone areas is the development of a greenway trail system along Four Mile Creek beginning at East John Street in the Town of Matthews and extending downstream approximately 10 miles to connect with the trail system along McAlpine Creek. Developments of such trails are announced for public information, similar to the example shown in Figure 10. A condensed map of the capital improvement projects for Mecklenburg County is shown in Figure 11. Because of the limited number and impact of planned improvements in the Four Mile Creek basin, the mitigation alternatives and analyses presented in this report will be valid under the planned development activities.

1.3 Aquatic Habitat and Environmental Monitoring

Four Mile Creek provides minimal conditions for the support of fish. For most of the year the stream is shallow and the heavy vegetation covering the banks provides for shade along the stream. However, the vegetation creates a haven for some riparian wildlife to exist along the banks of the creek and within the watershed. Observations in March and June 2001 indicate that the wildlife inhabiting the Four Mile Creek watershed include toads or frogs, turtles, beavers, birds, insects, and some species of small fish. From these observations and the environment in the vicinity of the stream it could also be concluded that other wildlife could exist in the Four Mile Creek basin, including snakes, other reptiles, rodents, squirrels, chipmunks, rabbits, fox, deer, and other small mammals and predators.

Fig. 10 Example of Proposed Greenway Trail

Mecklenburg County Department of Environmental Protection (MCDEP) maintains one monitoring station along Four Mile Creek. A summary of the collected water quality data is shown in Table 2. While the Macroinvertebrate Taxa Richness sampling and the Fish Bioassesment sampling has produced Poor and Fair ratings since 1995, the overall Water Quality Index has consistently ranked as Average, Good and Good-Excellent. The overall water quality has remained generally consistent in the Watershed Since 1996.

There are no USGS maintained stream gages on Four Mile Creek. The closest USGS station is No. 02146750 downstream of the confluence of McAlpine and McMullen creeks.

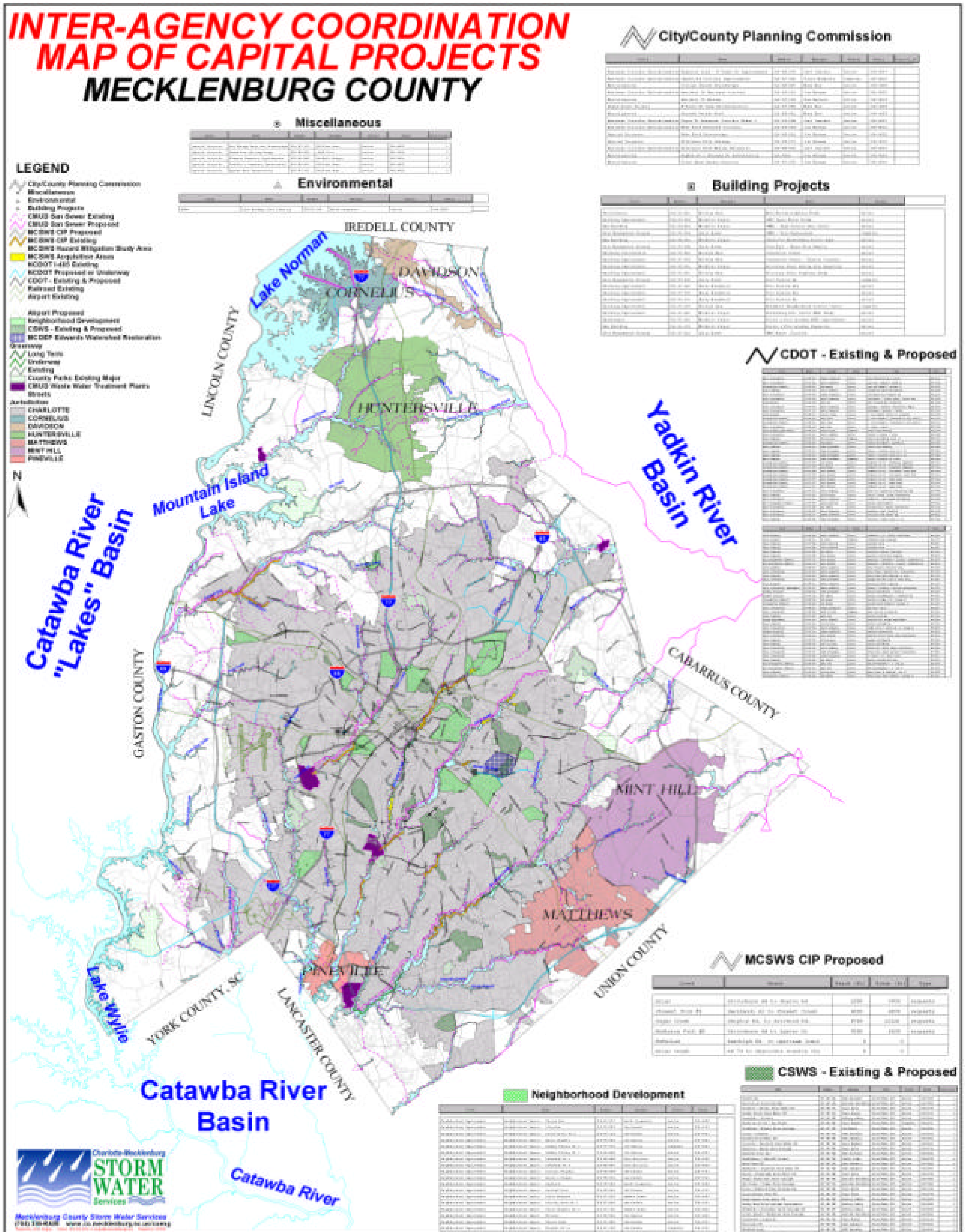

Fig. 11 Summary of the County Capital Improvement Projects

Table 2. MCDEP Water Quality and Habitat Monitoring Summary											
NC Piedmont Macroinvertebrate Taxa Richness		Sep-95		Sep-97		Oct-98		Aug-99		Aug-00	
Site	Location	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating
MC40A	Four Mile Cr. @ Elm Ln	2	Poor	3	Poor	1	Poor	4	Poor	3	Poor

Fish Bioassessment		Sep-96	
Site	Location	NCIB I	WQ Rating
MC40A	Four Mile Cr. @ Elm Ln	42	Fair

Water Quality Index		Aug-96		Jul-97		Jul-98		Jul-99		Aug-00	
Site	Location	WQI	WQI Rating	WQI	WQI Rating	WQI	WQI Rating	WQI	WQI Rating	WQI	WQI Rating
MC40A	Four Mile Cr. @ Elm Ln	69	Average	71	Good	77	Good-Excellent	71	Good	77	Good-Excellent

1.4 Rosgen Applied River Morphology Assessment

The Rosgen stream classification system was utilized to provide an initial assessment of the morphology of Four Mile Creek. The Rosgen system uses field measurements of stream features to describe a stream by morphologic type. An array of stream types is presented under the system that is delineated by slope, channel materials, width/depth ratio, sinuosity and entrenchment ratio. For the assessment of Four Mile Creek, the stream type is described at the geomorphic characterization level (Level I) of the hierarchical system of classification. At this level of inventory, the channel pattern, shape and slope are described (Rosgen, 1996). Information utilized as a part of this classification included aerial photography, USGS quadrangle maps, and other digital topographic information for investigation of the channel pattern and valley form. Additionally, field observations were made of the channel to identify geomorphic properties.

The data for Rosgen classification of Four Mile Creek is summarized in Table 3. The majority of Four Mile Creek is classified as a type G channel with some reaches possibly being classified as type F. Generally, the channel displays a low width/depth ratio, low sinuosity and relatively low channel slope. Indicators of a new Bankful flow line were observed below the historic top-of-bank, which imply that the channel has incised within the historic floodplain. This has most likely resulted from a combination of urbanization of the watershed and manual re-grading of the channel. The historic floodplain, which was formed as an alluvial plain bounded by gentle slopes of upland soils, currently forms a terrace that confines the channel.

Table 3. Rosgen Level 1 Classification Parameters Four Mile Creek	
Channel Length	50,174 ft
Downstream Invert	523.18 ft
Upstream Invert	665.62 ft
Channel Slope	0.30%
Valley Length	50,002 ft
Sinuosity	1.03
Average Bankful Depth	5 ft

The channel bank slopes are relatively steep with the slopes ranging from 1:1 to almost vertical. Despite these steep slopes the banks appear to be stable. The cohesive bank material and dense riparian vegetation act to stabilize the banks and resist erosive forces. In some locations, riprap has been placed along the toe of the banks to provide additional stability. Along reaches where riprap is not present and the bank material is less cohesive, channel widening processes are evident. This channel widening is resulting in an evolutionary transition to a type F channel. There are occasional reaches where the channel has developed sufficient belt width to begin to form a meandering pattern with stable point bars as Figures 5 and 6 show. However, being an urban stream, the heavy development on both sides of the stream does not allow free meandering of the main channel, and it demonstrates the low values of sinuosity as observed in this case.

1.5 Bank Stability Problem Identification

As described before, the stream has a wide densely vegetated floodplain for most of its length. In certain developing sections structures are being built on fill material which is usually well compacted, with grassed surfaces. Being on the fringes of the existing 100-year floodplain, and if well maintained, these embankments will probably not experience serious erosion problems. Regular maintenance at man-made structures such as road crossings and storm water outfalls will be necessary to maintain the stream integrity.

The low flow channel bed is highly eroded and entrenched, especially in the lower reach as described before. Further erosion of the banks is hampered by the heavy vegetative growth and dense tree roots along the banks. In the long run, the stream will probably traverse the route to maturity by some bank failure, sediment deposition, new entrenchment, and then another repeat of the cycle. Localized bank failure problems will have to be mitigated. However, barring a devastating blow to the vegetative environment, the stream banks are at a stable situation at present.

2. BENEFIT:COST ECONOMIC ANALYSIS

2.1 Riverine Flood Model Overview

FEMA's Riverine Flood Model (Version 1.11, February 1996) was utilized to perform flood damage and benefit:cost analysis. This model is based on Quattro-Pro spreadsheet and its results are consistent with Mecklenburg County's previous analyses that had used the same program. In this model, built-in probability based damages are calculated for a structure given the finished floor elevation of that structure. The model calculates benefits (= damages avoided by undertaking a certain mitigation measure) vs. the estimated cost of that particular mitigation measure.

Structures analyzed for potential flood damage included those with finished floor elevations below the current 100-year flood, and those in the flood elevation fringes (within 2 ft of the current and future 100-year flood). The benefit:cost model estimates damages on the basis of the 10-, 50- 100- and 500-year floods and hence calculates damages for structures with finished floor elevations above the current BFE. The flood elevations were determined using the US Army Corps of Engineers model HEC-RAS (Version 2.2, March 1999). The future 100-year flood elevations were based on the County's projected land use estimates for the year 2020.

The benefit:cost model utilizes two levels of data input, a level 1 with minimal data requirements (using default values) and a level 2, with detailed data regarding a structure's type, use, replacement value, contents value, and relocation costs. For the purposes of this study, level 2 analysis was adopted for two reasons: 1) this level of analysis produces more realistic damage estimate information, and 2) the analyses are consistent with the County's previous benefit:cost analyses. The program uses the input flood elevations and flows to determine a probabilistic estimate of the damages to the structure based on the finished floor elevation of the structure. The probabilistic tables are built into the program and are not altered by the user.

2.2 Economic Data

To perform the level 2 benefit:cost analysis, the model utilizes several attributes and values for each structure. This type of information was gathered for each affected structure from the GIS data at the Mecklenburg County website. Information provided to the model included:

Building Type: Structures are categorized as single story without basement, two-story with basement, etc. The structure type is used by the model for selecting the specific built-in lookup table for flood depth vs. damage as percent of the structure value.

Building Value: The building values as given in the Mecklenburg County GIS site were multiplied by 1.25 to reflect the building values in 2001 dollars. These values were used as the replacement values for the affected structures.

Content Value: The content value of each structure was assumed to be 25% of the current (2001) replacement value of the structure. This assumption is consistent with the previous benefit:cost analyses of Mecklenburg County.

Floor Elevation: For each affected structure, the elevation of the lowest finished floor was provided to the model. The model uses this parameter as the zero damage elevation for the structure. The finished floor elevation data were obtained from the Mecklenburg County GIS data and elevation certificate files, supplemented by surveys performed by ESP Associates Surveyors.

Relocation Cost: A constant relocation cost per household was used as the basis for economic analysis. This relocation cost was determined by Mecklenburg County and had been used in their previous benefit:cost analyses.

The present value of all benefit and cost figures were calculated using a 7.0% discount rate, a 30-year project life for the elevate and levee mitigation option, and a 100-year project life for the acquisition option. These assumptions are consistent with the specifications of the Riverine Flood Model (1996, p. 6-15).

2.3 Hydraulic Data

In order to determine the level of flooding at each structure, the model requires flow and elevation data to be entered for 10-, 50-, 100-, and 500-year floods. This information already existed for Four Mile Creek from HEC-RAS modeling of the creek performed earlier by Watershed Concepts. However, HEC-RAS output files list elevations at specific cross sections along the stream. Therefore, water surface elevations had to be calculated for each individual structure by determining the location of the structure relative to its encompassing cross sections, and interpolating the water surface elevation between those cross sections. The flows and their corresponding water surface elevations are the required data for the model to determine flood damages to each structure.

2.4 Modeling Process

The benefit:cost model includes a series of default depth-damage curves based on nationwide flood loss information. Specific depth-damage curves for Mecklenburg County were developed and used for this analysis utilizing flood loss data from the storm event of July 1997. Damages to each structure are calculated by the model based on the flood depth above the finished floor elevation of the structure, and the probability (or frequency) of occurrence of that flood in a given span of time. Damages are annualized for the benefit:cost analysis.

2.5 Economic Analysis

For any mitigation measure considered, the *damages* as determined by the benefit:cost program become the *benefits* of adopting that mitigation measure. In other words, assuming the mitigation measure completely eliminates the flooding problem for a given structure, the *avoided* flooding damage is the benefit derived from that particular mitigation measure. This benefit, when compared to the cost of undertaking the mitigation measure, constitutes the basis for the benefit:cost analysis. When the ratio of benefit to cost is greater than 1.0, the measure is adopted, and when the ratio is smaller than 1.0, the measure is rejected.

The benefit:cost program calculates the benefit to cost ratios for projects involving acquisition or elevation based on the information supplied by the user. However, for other mitigation measures, the cost was separately determined and the benefit:cost ratio calculated. Due to the fact that only a few residential structures were affected in the Four Mile Creek basin, the only other mitigation measure considered was the construction of flood levees, as described in the next section of the report.

As suggested by the Mecklenburg County Storm Water Services (MCSWS), it was decided that mitigation measures should not be concentrated on individual buildings. Instead, MCSWS preferred the concept of mitigation projects, whereby the mitigation measures were considered for the improvement of a project area or a neighborhood community. On the basis of this concept, the mitigation measures have been proposed for project areas (or problem neighborhoods). Two such project areas were identified for the Four Mile Creek basin as described in the next section of the report.

2.6 Improvements

There are no severe flooding problems in the Four Mile Creek basin. Only two neighborhoods were identified with relatively mild flooding problems, as reported in the next section of this report. Preliminary analyses indicated that only a few structures were involved in the affected areas, and the least expensive mitigation measures would be the only feasible ones. Therefore three basic mitigation measures were considered for this basin: Elevating the structure, acquisition, or flood levees. None of the three measures provided a benefit:cost ratio higher than 1.0. Therefore, no action is recommended for this basin.

3. FLOOD HAZARD MITIGATION

3.1 FEMA Regulated Stream Service Requests

There have been 258 Service Requests for the Four Mile Creek watershed filed through the City/County Customer Service system (336-RAIN) hotline. Table 4 summarizes the flood related service requests by type and severity. These service requests reflect the problems of the entire watershed and not necessarily those of the individual structures. As shown in Table 4, 12 of the service requests are for property located in or immediately adjacent to the Four Mile Creek floodplain.

Table 4. Service Requests in Four Mile Creek Basin

Type of Service Requested	Severity[1]	Frequency[2]	No. in Potential Flood Zone[3]	No. in B:C Analysis[4]
Critical Blow-out	A	2	0	0
Blow-out	B	12	0	0
Tail Ditching	B	27	0	0
Pipe Outlet Repair	C	4	0	0
Channel Cleaning	C	115	3	0
Channel Erosion Maintenance	C	104	3	0
Other Maintenance	C	9	0	0
Capital	C	3	0	0
Street Maintenance	C	1	0	0
Yard Flooding	C	14	0	0
Not Specified	--	103	6	0

1 A=Most severe; C=Least severe; categorized by the Charlotte-Mecklenburg Storm Water Services

2 Of the total 258 complaints 103 were unspecified; others had multiple service request types

3 Lots with structures whose footprints intersected with the flood boundaries

4 Lots with structures that were analyzed for benefit:cost ratio for mitigation measures

3.2 Flood Insurance Claims and Repetitive Loss Structures

There have been two previous Flood Insurance claims filed through the National Flood Insurance Program. One claim was filed in 1978 and the other in 1990. The total payment on these claims was approximately $5000. There are no repetitive loss properties located within the Four Mile Creek watershed.

3.3 Permanent Storm Water Easements

There are no permanent Storm Water Easements in the Four Mile Creek watershed that provide access to Four Mile Creek or its tributaries.

3.4 Roadway Overtopping Problem Locations

From HEC-RAS modeling results of Four Mile Creek basin, roadway overtopping locations were investigated based on the 100-year future flood conditions. Table 5 summarizes the roadway overtopping problem locations for Four Mile Creek and Rocky Branch. Several conclusions can be readily derived from Table 5:

1. Considering the fact that a flow depth of 24 inches (2 ft) can sweep away a moving vehicle, the Raintree Lane crossing will be hazardous under both the existing and the future conditions. Among measures to mitigate this hazard are warning signs for the approaching motorists, tall guardrails or indicators to guide the vehicles away from the edge of the road in case of a flash flood, and consideration for raising the elevation of the stream crossing as a future CIP for the Charlotte DOT. The Providence Road location would not pose a serious hazard. However, warning signs are also recommended for the Providence Road crossing.

2. Flood hazards at the Raintree Lane crossing could be minimized by making sure that the culverts at this site, as well as the entire stream system, have the maximum capacity to pass the flood flows. Regular maintenance schedules should be established at all stream crossings to assure that sediment and other debris such as fallen trees or urban trash do not collect at the upstream face of the culverts and bridges, compromising their flow capacity.

3. Guardrails should be provided at this site such that if a vehicle is stranded or swept away, it can be stopped by the guardrail, preventing the vehicle from entering deeper flow regions and allowing for rescue crews to reach the stranded vehicle.

4. Depth sensors and a relay system may be installed on or near the crossing such that it would alert emergency response teams to the high water depth and allow them to re-route traffic or prepare for emergencies at the site.

Table 5. Roadway Overtopping Problem Locations

Four Mile Creek Crossing	Structure Type	Culvert Size No. @ Size (ft)	Top of Road Elevation (ft, NAVD)	100-yr Flood Elevation Existing (ft, NAVD)	Food Depth Existing (ft)	100-Yr Flood Elevation Future (ft, NAVD)	Flood Depth Future (ft)
Providence Rd	Culvert	5@8X13.5 Box	574.5	572.4	--	574.9	0.4
Raintree Lane	Culvert	4@14x8.5 Box	563.0	565.1	2.1	566.0	3.0

3.5 Flood Mitigation Analysis

Three flood mitigation measures were recognized as the only viable options for the structures that would be flooded or are on the fringes (within two feet) of the existing 100-year floodplain in the Four Mile Creek basin. These measures were acquisition of the property, elevation of the finished floor two feet above the base flood elevations, and construction of a berm or floodwall to contain the floodwater. The benefit:cost analysis for the two project areas (Figures E1 and E2) were performed using the standard methods described in FEMA's Manual 259, Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings (FEMA, January 1995), and the Riverine Flood model (Version 1.11, February 10, 1996) developed by FEMA. The summary of the benefit:cost analysis is shown in Table 6. The benefit and cost values in this table are the present values of the annual benefits and costs of each mitigation option. Also included in Table 6 are the highest benefit:cost ratios for individual structures to provide a means of judging the range of variation. Because only benefit:cost ratios greater than 1.0 were considered economically feasible, it is clear from these figures that no mitigation measure proves to be economically justified, either for an entire project area or for individual structures.

Table 6. Summary of the Benefit:Cost Analysis For the Two Mitigation Project Areas

		Mitigation Options*								
		Acquisition			Elevation			Levee		
No. of Structures	Project Neighborhood/Area	Benefit	Cost	B:C	Benefit	Cost	B:C	Benefit	Cost	B:C
3	Ashley Creek Dr	13,608	736,905	0.02	10,258	179,125	0.06	11,757	102,758	0.11
Highest individual	1132 Ashley Creek	5,483	243,509	0.02	3,990	58,358	0.07	--	--	--
6	Iverleigh /Reverdy Oaks /Stevens Ridge	53,858	2,508,058	0.02	41,175	501,736	0.08	46,470	192,624	0.24
Highest individual	1611 Stevens Ridge	24,734	554,336	0.04	18,915	106,553	0.18	--	--	--

*Benefits and costs are in dollars

Compared to other basins within Mecklenburg County, the Four Mile Creek basin is a more recently developed area of the County and does not suffer from some of the severe flooding problems experienced in the other basins. Based on the latest County elevation certificate data, a total of 9 structures would be flooded or be within the fringe of the 100-year floodplain (existing or future conditions). Table 7 shows the flooding statistics for these structures, all of which are residential and Post-FIRM (built after 1981). As mentioned before, these houses typically would have finished basements or additions near the stream. The flooded homes can be grouped into two project areas, one in the Ashley Creek Drive, shown in Figure E3, and one clustered in the Iverleigh, Reverdy Oaks, and Stevens Ridge area, shown in Figure E2. The two groups have been treated separately in Table 7 and in applying mitigation measures so that individual benefit:cost analyses could be performed for each project area.

Alternative Evaluation

There are a total of 9 structures which may be flooded in a 100-year flood, or are in the flood fringes (within 2 ft of the BFE) in Four Mile Creek. These structures have been clustered into two project areas as shown in Table 7. A total of four alternatives were analyzed for these project areas. Additional alternatives were considered, but ruled out as economically infeasible after preliminary analyses.

Table 7. Structures Under Existing Flood Hazard in the Four Mile Creek Basin							
No. of Structures	**Project Neighborhood/Area**	**No. Flooded**	**No. Not Flooded but within 2ft**	**Avg. Flood Depth***	**Median Depth***	**Highest Depth***	**Lowest Depth***
3	Ashley Creek Dr	0	3	-0.52	-0.38	-0.4	-0.8
6	Iverleigh /Reverdy Oaks /Stevens Ridge	1	5	-0.66	-0.76	0.22	-1.4

* Negative numbers mean that the finished floor elevation is above the 100-yr flood elevation; depths are in feet.

Alternative 1 - Acquisition

In this alternative, the structure in danger of flooding is purchased and destroyed. FEMA regulations specify this alternative to be adopted if the benefit:cost ratio equals or exceeds 1.0. Calculations for determining the cost of this alternative are programmed into the benefit:cost program as described in Section 2 of this report. A return rate of 7% and project life of 100 years were used for this alternative. As indicated in Table 7, none of the project areas or individual structures meets this requirement and hence this alternative is not feasible.

Alternative 2 - Elevation

This alternative involves elevating the flooded structure 2 ft above the BFE. The costs of elevating structures in Mecklenburg County are programmed in the benefit:cost program as well. The adoption criteria for this alternative is also a benefit:cost ratio of 1.0 or higher. Table 7 shows that none of the project areas or individual structures meets the criteria of this alternative, and hence this alternative is abandoned as well.

Alternative 3 **–** Flood Barrier

In this alternative, the cost of the construction of an earthen levee as a flood barrier is considered. The levee is designed with a 3-ft freeboard, i.e., the elevation of the top of the levee is placed at 3 ft above the BFE. By its nature, this alternative is better suited to project areas or a cluster of structures than for individual units. Calculations for the cost of a levee are performed outside the benefit:cost program, and involve estimations of material needed, haul distances, and equipment mobilization and demobilization. Results of the calculations are summarized in Table 7, and indicate that this alternative is also too expensive and should be abandoned.

Alternative 4 **–** No Action

This is the default alternative, when the benefit:cost analysis shows that adopting any of the other mitigation measures results in more costs than benefits. After elimination of the other alternatives as described above, this alternative is the only acceptable one for the Four Mile Creek basin.

Although the No-Action alternative is the only feasible one recommended for Four Mile Creek, results of the benefit:cost analysis for the individual project areas are summarized below.

Ashley Creek Neighborhood

A summary of the benefit:cost analysis for the Ashley Creek neighborhood is shown in Table 8. The highest benefit:cost ratio is 0.114 for the levee (flood barrier) alternative, well below the acceptable level of 1.0 for adoption of a mitigation measure.

Table 8. Mitigation Measures for Ashley Creek Neighborhood								
Possible Mitigation Project								
Acquisition			**Elevation**			**Levee**		
Benefit	**Cost**	**Ratio**	**Benefit**	**Cost**	**Ratio**	**Benefit**	**Cost**	**Ratio**
$ 13,608	$ 736,905	0.02	$ 10,258	$ 179,125	0.06	$ 11,757	$ 102,758	0.11

Reverdy Oaks Neighborhood

A summary of the benefit:cost analysis for the Reverdy Oaks neighborhood is shown in Table 9. The highest benefit:cost ratio is 0.241 for the levee (flood barrier) alternative, also well below the acceptable level of 1.0 for adoption of the mitigation measure.

Table 9. Mitigation Measures for Reverdy Oaks Neighborhood								
Possible Mitigation Project								
Acquisition			**Elevation**			**Levee**		
Benefit	**Cost**	**Ratio**	**Benefit**	**Cost**	**Ratio**	**Benefit**	**Cost**	**Ratio**
$ 53,858	$ 2,508,058	0.02	$ 41,175	$ 501,736	0.08	$ 46,470	$ 192,624	0.24

4. CONCLUSIONS AND RECOMMENDATIONS

The Four Mile Creek basin constitutes a highly developed section of Mecklenburg County. Four Mile Creek and its major tributary, Rocky Branch, are in a reasonably stable condition due to four main factors:

1. Stabilized stream banks because of a sewer main line extending along the creek

2. Heavily vegetated banks and floodplains

3. Numerous road crossings and other man-made structures that form grade controls and limit bank erosion or stream scour

4. Past stabilization efforts along the creek

In the event of a 100-year flood, flooding hazard for the structures lining the banks of the creek may be identified in only two general neighborhoods. A total of 9 structures are affected, of which one experiences inundation and the rest are located in the flood fringe areas (within 2 ft of BFE). Flood damages are minor or nonexistent. Of the three mitigation measures considered for these two neighborhoods, namely elevating the structures, berm construction, and acquisition, none proved to be economically justifiable. No flood mitigation measures for the flooded neighborhoods are recommended for this watershed.

There are two road crossings that are subject to overtopping in case of a 100-year flood. Flood depths over the roadway may be as high as 3 ft in one case for the future 100-year flood. Several mitigation measures should be considered for this site, which include warning signs for the approaching motorists, tall guardrails or indicators to guide the vehicles away from the edge of the road in case of a flash flood, raising the elevation of road at the stream crossing, and emergency response team notification. Regular maintenance at man-made structures such as road crossings and storm water outfalls will be necessary to maintain the stream capacity and stability.

5. REFERENCES

The following sources have been consulted in the preparation of this report:

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Mecklenburg County, North Carolina, Website, www.co.mecklenburg.nc.us