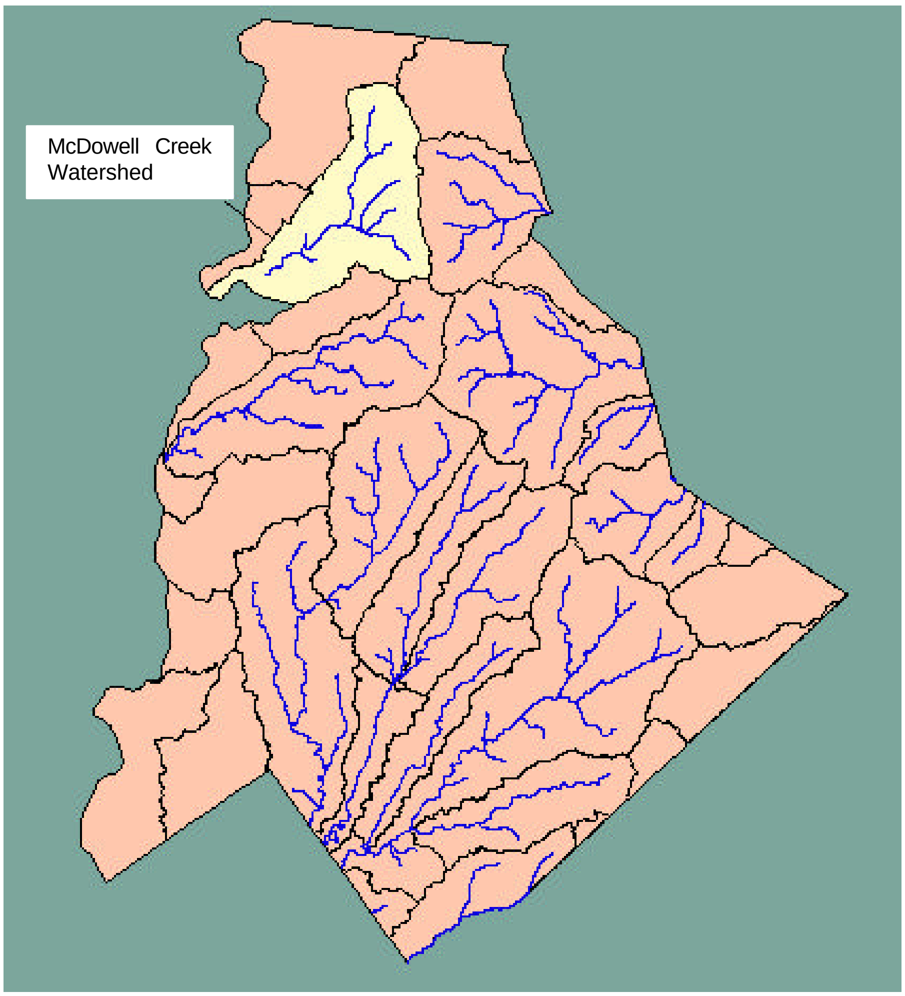
Watershed Study No. 6
McDowell Creek Watershed

Preliminary Engineering Report

MCSWS Project No. 28001



January 2002

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MECKLENBURG COUNTY
STORM WATER SERVICES

PRELIMINARY ENGINEERING REPORT
FOR
MECKLENBURG COUNTY MITIGATION PLANS

MCDOWELL 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 Mitigation Plans was prepared by me or under my direct supervision.

Signed, sealed, and dated this 11th day of January 2002.

By: ______________________________

Joseph B. Chapman, P.E.
Senior Vice President

MECKLENBURG COUNTY
STORM WATER SERVICES

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FOR
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MCDOWELL CREEK WATERSHED

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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).
Flood Fringe Areas	A buffer area bounded by the ECF (elevation of the BFE) and a point where the land elevation if 2 ft above the BFE.
Future Conditions	The land use condition of the watershed based on the projected ultimate buildout in the watershed.
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).
MCSWS	Mecklenburg County Storm Water Services
MCDEP	Mecklenburg County Department of Environmental Protection
NALGEP	National Association of Local Government Environmental Professionals
CMUD	Charlotte-Mecklenburg Utilities District

EXECUTIVE SUMMARY

MCDOWELL CREEK WATERSHED

This Preliminary Engineering Report briefly describes a study of McDowell Creek morphology, bank stability problems, flood hazard areas, and potential mitigation measures. Public records from the Mecklenburg County website, aerial photographs, interviews with public officials, 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.

Currently, the McDowell Creek watershed, shown in Figure E1, is not as highly developed as some of the other sections of Mecklenburg County. However, rapid development is visible virtually everywhere in the watershed, and conditions in this drainage basin will soon resemble those in other highly developed sections of the County. This watershed includes the tributaries of Caldwell Station Creek, Torrence Creek, Torrence Creek Tribs 1 and 2, and McDowell Creek Tribs 1 and 2.

McDowell Creek and its tributaries are in reasonably stable condition due to four main factors:

1. Stream banks stabilized by riprap or other means to safeguard a sewer main line that extends along the creek

2. Heavily vegetated banks and floodplains

3. Numerous road crossings and other man-made structures which form grade controls that limit stream scour and head-cutting

4. Past stabilization efforts along McDowell Creek and its tributaries

Flooding potential within the existing 100-year floodplain (ECF) can be identified in four general neighborhoods along McDowell Creek. A total of 15 residential structures are affected, none of which experience inundation because the finished floor elevations are above the BFE. All structures are located in the flood fringe areas (within 2 ft of BFE) as shown in Table E1. All structures are post-FIRM (built after 1981) and are shown in Figures E2 and E3. Three mitigation measures were considered for the four neighborhoods shown in Table E1 and Figures E2-E3: elevating the structures two feet above the BFE, berm construction, and acquisition.

McDowell Creek is approximately 9.2 miles long with an additional 10.3 miles of tributaries flowing into the creek. The watershed extends in a general northeast to southwest direction within the boundaries of the City of Huntersville, which is north of the City of Charlotte. McDowell Creek discharges into the Catawba River in the west side of Mecklenburg County, upstream of Mountain Island Lake, which is the primary source of Charlotte's drinking water supply. The banks and floodplains of McDowell Creek and its tributaries are densely vegetated and in some parts heavily wooded, creating a stable stream. The flow is mostly shallow and tranquil in a well-defined channel with relatively steep banks. Compared to other creeks, McDowell is less urbanized, although the rapid pace of development is evident along the stream and its tributaries. Frequent occurrence of point bars is indicative of increased sediment transport due to heavy development activity.

Table E1. Structures with ECF Flooding Potential in McDowell Creek Watershed							
No. of Structures	**Project Neighborhood/Area**	**No. Flooded**	**No. within 2ft of BFE**	**Avg. Fld. Depth***	**Median Depth***	**Highest Depth***	**Lowest Depth***
9	Henderson Park Rd/Leisure Ln/Lullwater Cv	0	9	-0.87	-1.30	-0.11	-1.63
2	Gilead Road	0	2	-1.39	-1.39	-0.86	-1.91
3	Cumbria Ct/Stonegreen Ln	0	3	-0.43	-0.63	-0.08	-0.78
1	Delancey Ln	0	1	-0.01	-0.01	-0.01	-0.01

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

The Rosgen stream classification system was utilized to provide an initial assessment of the morphology of McDowell Creek. The majority of McDowell 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.

McDowell Creek discharges into the Catawba River between the Cowins Ford Dam and Mountain Island Lake, the primary source of Charlotte's drinking water supply. This location on the Catawba River is also vital for the cities of Gastonia and Mount Holly, which have water supply intakes near the mouth of McDowell Creek. This watershed is actively being studied by various groups, including MCSWS (this study), Local Watershed Management Plan (NC Wetlands Restoration Program and CH2M-Hill), Water Quality Computer Model Simulation (MCDEP and TetraTech), and McDowell Creek Watershed Smart Growth for Clean Water Partnership (NALGEP, Charlotte, Mecklenburg County, Cornelius, Huntersville, Trust for Public Lands). It is important to note that these initiatives have different objectives, and as each initiative progresses, the participants are sharing information, communicating, and coordinating their efforts.

Primary pollutants from land development activities along McDowell Creek and its tributaries include nutrients, fecal coliform, and sediment. The Mountain Island Lake Marine Commission has already noted the introduction of Hydrilla (Hydrilla L.C. Rich). A Hydrilla-eating carp has been introduced to combat the problem. However, the direct cause of the problem stems from the abundant source of nutrients that fertilize this plant, flowing downstream through the McDowell Creek watershed. There are various land acquisition programs underway to protect and buffer the watershed from non-point source pollutants and development, including the Trust for Public Lands and the Mecklenburg County Park and Recreation Department. Together, through the Mountain Island Lake Initiative, each is purchasing large tracts of land to be preserved as open space.

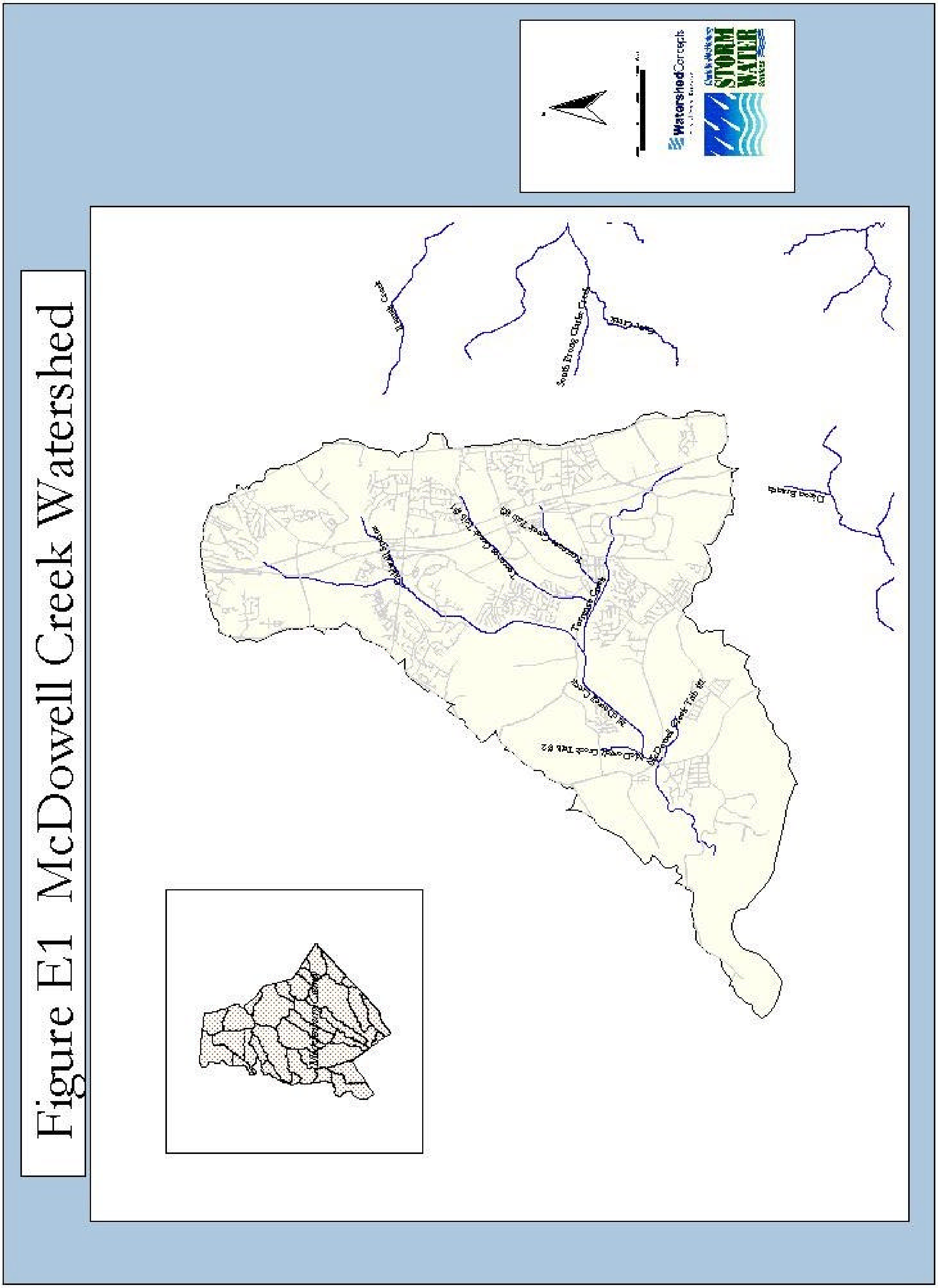

Figure E1 McDowell Creek Watershed

MCDEP maintains several monitoring stations along McDowell Creek and its tributaries. While the Macroinvertebrate Taxa Richness sampling and the Fish Bioassesment sampling has produced Poor and Fair ratings since 1994, 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. One flow monitoring station, USGS Gage 0214266000, located at McDowell Creek and Beatties Ford Road crossing, has been in operation since November 1996.

Presently, there are no major capital improvement projects in the watershed that may affect its hydrology. There are plans for the construction of approximately 8.7 miles of greenway trail along McDowell Creek and its tributaries, of which currently approximately 0.7 mile has been completed. The analyses and mitigation alternatives considered in this report will not be affected by the planned capital improvement projects of the County.

Flooding hazards for the structures lining the banks of the creek may be identified in four general neighborhoods affecting a total of 15 structures. All of the structures have finished floor elevations in the flood fringe areas (within 2 ft of BFE). Inundation damages in the case of a 100-year flood are nonexistent. **Three flood mitigation alternatives and a no-action alternative were considered for the affected structures in the McDowell Creek watershed. None of the mitigation measures resulted in a benefit:cost ratio greater than 1.0, therefore no flood mitigation measures are recommended for this watershed.**

There are several road crossings that are subject to overtopping in case of a 100-year flood. Flood depths over the roadway may be as high as 6.3 ft in one case for the future 100-year flood (FCF). Two smaller crossings on non-public roads would also be flooded severely. Several mitigation measures should be considered for the road crossings of this watershed, 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.

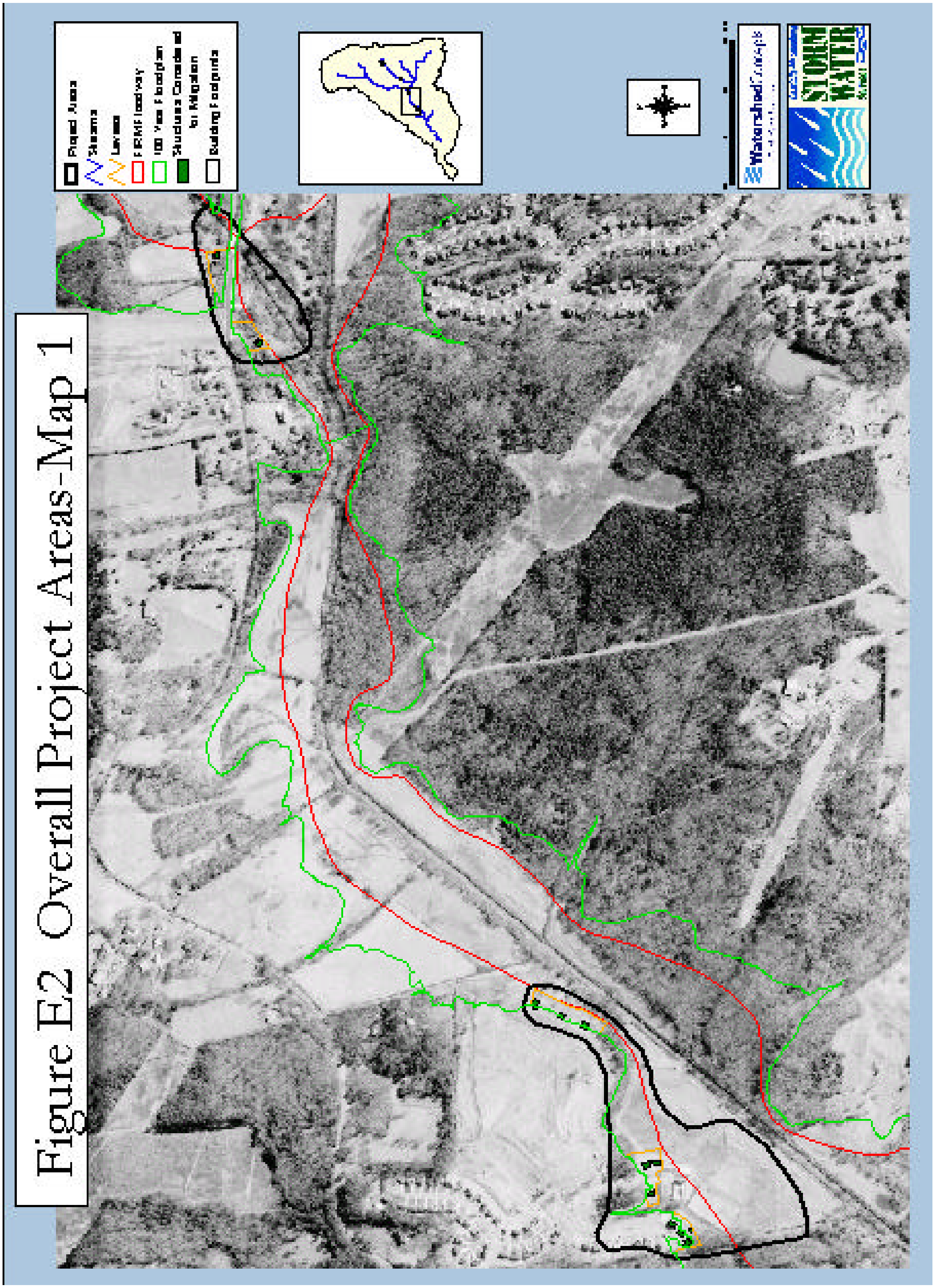

Figure E2 Overall Project Areas-Map 1

Figure E3 Overall Project Areas-Map 2

1. GENERAL WATERSHED CONDITIONS

1.1 Watershed Characteristics

The McDowell Creek basin includes a watershed of about 26.3 mi^2 in the northwestern part of Mecklenburg County. This basin includes the main stem of McDowell Creek as well as the adjoining streams of Caldwell Station Creek, Torrence Creek, Torrence Creek Tribs 1 and 2, and McDowell Creek Tribs 1 and 2.

McDowell Creek

McDowell Creek's main stem is approximately 9.2 miles long. The system flows in a general northeast to southwest direction north of the City of Charlotte. McDowell Creek discharges into the Catawba River on the west side of Mecklenburg County. Due to its distance from the center of town, existing development along the river is not as dense as that experienced in the other watersheds within the city. However, extensive residential and commercial development is occurring at the present time. Under the existing 100-year flood conditions (ECF), adjacent property suffers from a flooding potential in a number of residential sites.

Fig.1 At Statesville Road

Rosgen classification of McDowell Creek is presented in Section 1.4 of this report. Qualitative descriptions of the creek and its tributaries are given in the following paragraphs. Similar to the other creeks in the City of Charlotte, there is a sewer trunk line along McDowell Creek and its tributaries. Installation of these trunk lines has resulted in stabilized banks and trained stream alignment throughout the length of the McDowell Creek system. The banks and floodplains are densely vegetated and in some parts heavily wooded, creating a stable stream. Figure 1 shows the stream at its upstream end at Statesville Road crossing. The flow is shallow and tranquil in a well-defined floodway with relatively steep banks. Figure 2 shows the creek downstream, past the confluence with McDowell Trib 1 at Beatties Ford Road. The flow in this area is shallow and tranquil with stabilized banks and a relatively straight main channel alignment. The sewer trunk line is on the right bank of the

Fig. 2 Near Beatties Ford Road

Fig. 3 McDowell Creek near McDowell Trib 1

Fig. 4 Torrence Creek Trib 2 near McDowell Creek

Fig. 5 Caldwell Station Creek at Statesville Road

creek. Vegetation is taking over the riprap and is dense along the more gently sloped banks in this section. Compared to other creeks, McDowell is in a less urbanized setting, although the rapid pace of development is evident along the stream and its tributaries. Frequent occurrence of point bars is indicative of increased sediment transport due to heavy development activity.

The McDowell Creek system was observed under base flow conditions when the photos of this report were taken. Under the observed conditions, the flow is mostly tranquil and shallow. The floodway is lined with heavy brush and tree growth making access to the stream difficult in most places, although the banks must have been disturbed and cleared at one time for the installation of the sewer main line. By visual observation, the manholes of the sewer line seem to be below the 100-year flood level in many places visited. There is a greenway along the creek near the intersection of Bradford Hill Lane and Gilead Road, further stabilizing the banks and floodplain in that region of the creek.

The most significant tributary of McDowell Creek is Torrence Creek. The nature of the banks, the vegetation, flow conditions, and floodplain of the two streams are very similar. Figure 3 shows McDowell Creek further upstream from where Figure 2 was taken. Figure 4 shows Torrence Creek Trib 2 near Gilead Road Crossing. The tranquil nature of the creek with an occasional point or middle bar and heavily vegetated banks are similar conditions in both cases.

Although MCSWS regularly maintains areas of known flooding problems, the tendency of vegetation to establish over depositions in the streambed can affect the hydraulic capacity of the stream. Figure 5 shows Caldwell Station Creek at Statesville Road crossing. Deposition has occurred immediately in front of one of the two box culverts. Vegetation has taken root and now sizable trees and brush line the deposits. Flood flows may not be able to uproot the trees and the capacity of the culvert may be compromised. Figure 6 shows Torrence Creek at Bradford Hill Lane crossing. The flow of the entire creek is occurring in the right barrel of the triple circular culvert. Signs of vegetation taking root on the deposited sediments are visible. If floods of sufficient magnitude that flush the sediments downstream of the culvert do not occur, more vegetation may stabilize the deposits and eventually compromise the capacity of the culvert. In order to maintain full capacity for the stream and ensure the safe passage of a flash flood, it may be necessary for the County to undertake a stream maintenance program or install hydraulic structures for sediment exclusion from the structures at road crossings. The maintenance program would include keeping the road crossing free of unwanted vegetation, other obstructions, and sediment deposits, and assuring that bridges and culverts will operate at or near their design capacity during a flood. Further discussion of a creek maintenance program will be presented later in this report.

Fig. 6 Torrence Creek Trib 1 at Bradford Hill Lane

Fig. 7 Near Westmoreland Road

Fig. 8 At Glenwyck Lane

As mentioned before, the banks and floodplain of this stream are very well vegetated and stable. This is clear throughout the figures shown above, and the remainder of this report. The typical cross section of the floodway in the upstream reaches of the creek has vertical walls and a flat bed (a U-section), about 8-10 feet wide and about 8-10 feet deep (Figs. 1 and 4). At its downstream reaches, the floodway becomes wider and the banks are less vertical, acquiring side slopes of 1½:1 or so (Figs. 2 and 3). The floodplain along most of this stream is fairly wide and very gently sloping, and generally heavily vegetated or wooded. The minimum vegetative cover is thick tall grass. Occasionally, there are signs of human activity on the floodplain such as earth moving and construction. However, unless very current activity has occurred, vegetation seems to be able to take hold, and erosion of the banks or floodplain does not seem to be a serious problem. The floodplains in two sections of the creek are shown in Figure 7 (near Westmoreland Road) and Figure 8 (at Glenwyck Lane, off Bud Henderson Road).

McDowell Creek Tributaries

The tributaries of McDowell Creek, with a combined total of 10.3 miles, constitute longer total stream mileage than McDowell Creek's main stem. The main tributaries are Caldwell Station Creek, Torrence Creek, Torrence Creek Tribs 1 and 2, and McDowell Creek Tribs 1 and 2. The general geologic, hydrologic, climatologic and botanical conditions of these tributaries are similar to those of McDowell Creek. As a result, the morphological characteristics of these streams are also similar. At a field visit on May 2, 2001 the morphologic similarity of McDowell Creek and its tributaries was studied and documented. In addition to similar morphology between the main stem and the tributaries, the general pattern of development along the streams is also similar. Because of this similarity in behavior of the entire system, McDowell Creek and its tributaries are treated as a single unit.

Fig. 9 At Stawell Drive

Fig. 10 At Bradford Hill Lane

1.2 Development in the Watershed

Development along McDowell Creek and its tributaries is less intense than other basins of the City of Charlotte at present. However, heavy commercial and residential development activity is underway. Visual judgment based on the site visit of May 2, 2001 suggested that a number of residential and commercial buildings are near or within the floodplain. Four cases of such structures in the flood fringe areas are presented in the next four figures, although sites with flooding potential are not limited to those shown in these figures. Figure 9 shows houses on Stawell Drive. These are three of 7 houses whose footprints plot within the ECF. Figure 10 shows houses on the intersection of

Fig. 11 Gilead Road Crossing

Torrence Crossing Drive and Bradford Hill Lane. Several houses in this neighborhood are in the flood fringe areas. Figure 11 shows an older house on Gilead Road. The elevation certificate for this house places the finished floor elevation above the BFE. However, the lower level garage could be flooded. There are other older houses in the same neighborhood with footprints in the ECF or the FCF. Figure 12 shows houses on Leisure Lane, off Bud Henderson Road. In plan view, the entire row of houses on the creek side of this street is located within the ECF. There was extensive development activity with earth moving at the time of the site visit in this neighborhood.

Fig. 12 At Leisure Lane

General statistics of development in the McDowell 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 indicates that about 80% of the parcels in the basin are in single-family or other residential categories and about 14% of the parcels are still undeveloped (as of the year 2000). The table also indicates the accelerating pace of development in the watershed since about one third of the parcels were developed in the 1990's.

Table 1. Development in the McDowell Creek Watershed*

	Year Developed					Total
	Before 1970	1970-1979	1980-1989	1990-2000	Not Specified	
Parcels	4,938	390	1,323	4,908	3,880	15,439
Percentage	32.0%	2.5%	8.6%	31.8%	25.1%	100%

	Land Use as of 2000				
	Single Family	Other Residential	Non-Residential	Vacant/ Unclassified	Total
Parcels	11,179	1,082	983	2,195	15,439
Percentage	72.4%	7.0%	6.4%	14.2%	100%

* Entire watershed, including all tributaries

Existing sanitary sewer trunk lines, completed in the mid 1980's, are installed along the entire length of FEMA-regulated portions of McDowell Creek and its tributaries. Currently, no additional capital sewer improvements are planned along the creek based on the Charlotte-Mecklenburg Utility Department 2002 Capital Improvement Plan (CIP). A greenway trail is planned along the creek, which will be explained in more detail later. Development of such trails is announced for public information similar to the example shown in Figure 13.

Fig. 13 Example of Proposed Greenway Trail

A review of the capital improvement plans (CIP) 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 the McDowell Creek basin includes the creation of three greenway trails (See Fig. 13) consisting of:

1. Approximately 2.4 miles along Torrence Creek from Bradford Hill Lane towards upstream
2. Approximately 2.7 miles along Torrence Creek Trib 1, from its confluence with Torrence Creek towards upstream
3. Approximately 3.6 miles along McDowell Creek from Bradford Hill Lane towards downstream.

The general locations of these trails and their proximity to the potentially flooded structures within the basin are shown in Figure 14. The full length of some of the proposed greenway trails extend beyond the limits of Figure 14, and have been eliminated so that the potentially flooded areas can be shown in as much detail as possible.

Of the above list, approximately 0.7 mile of item 1, from Bradford Hill Lane to McCoy Road has been completed, and another 0.6 mile from Bradford Hill Lane to the confluence with McDowell Creek is under construction. The remaining trails have been proposed for future construction. The construction of these greenway trails is not expected to alter the drainage and flooding patterns in the watershed and the flood mitigation analyses of this report will be valid unless other major alterations are planned for the watershed due to newly planned CIP's.

A condensed view and lists of the capital improvement projects for Mecklenburg County are shown in Figure 15.

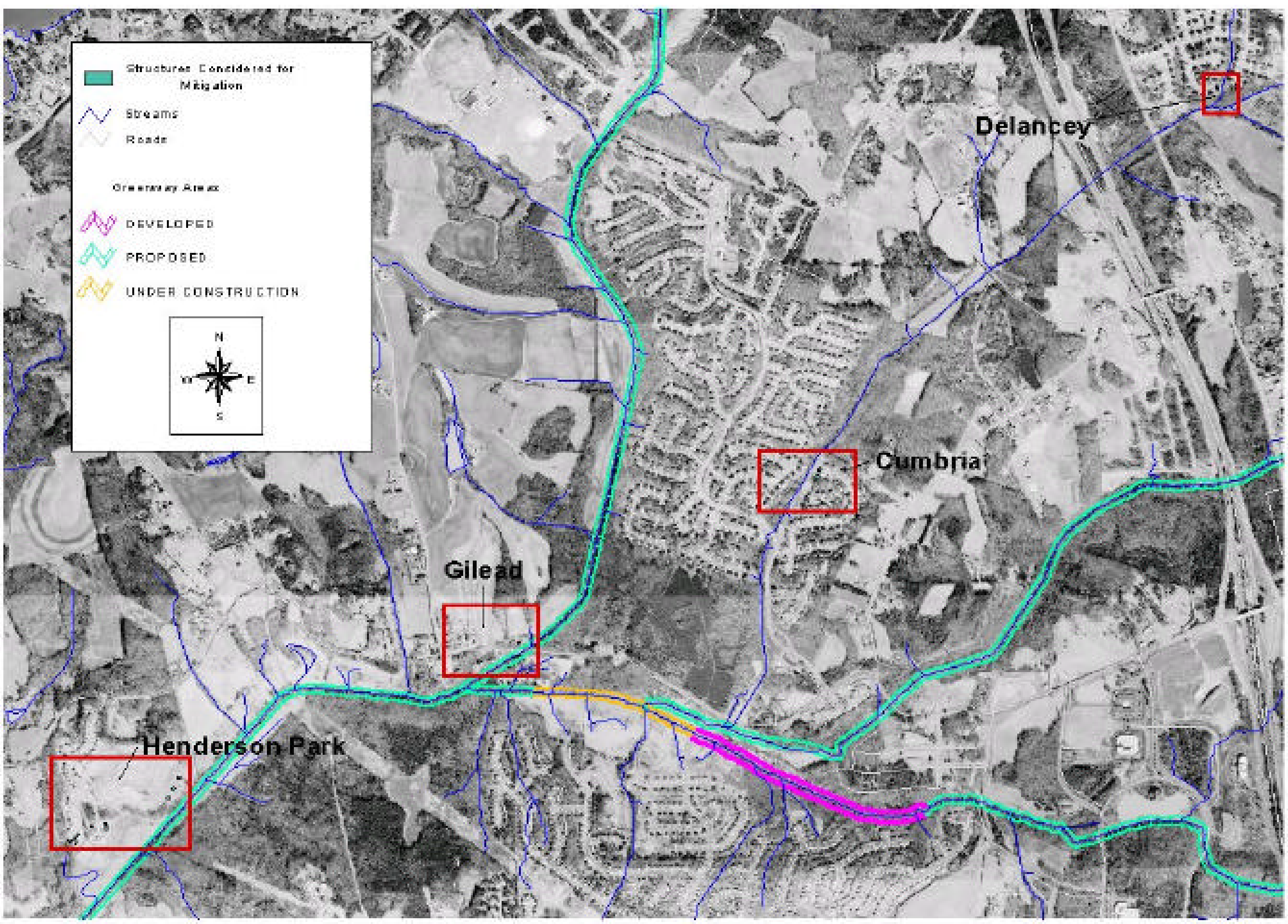

Fig. 14 Greenway Trails and their Relationships to Potential Flood Areas

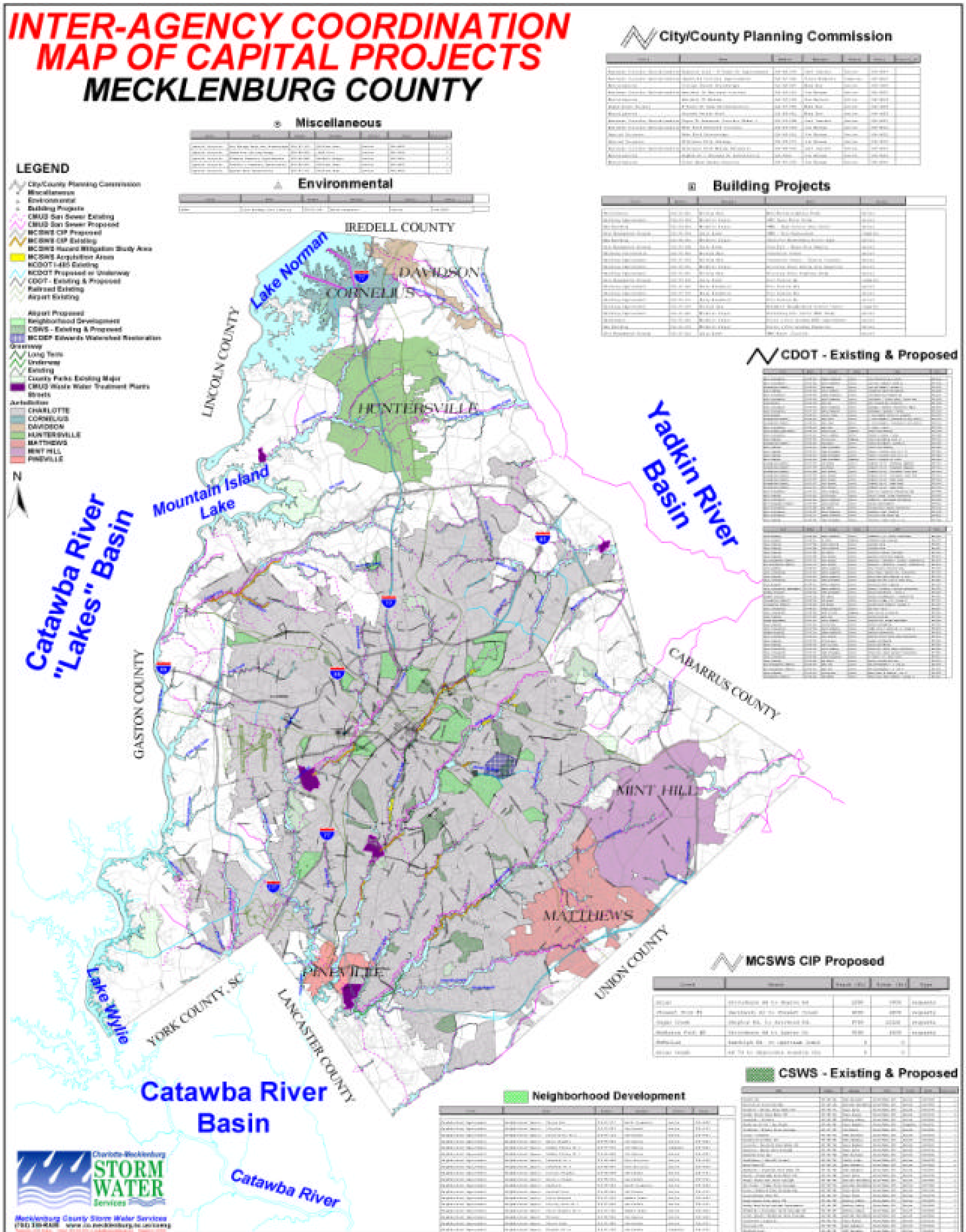

Fig. 15 Summary of City-County Capital Improvement Projects, 1999

1.3 Aquatic Habitat and Environmental Monitoring

The McDowell Creek watershed drains in a westerly direction into the Catawba River between the Cowins Ford Dam that forms Lake Norman (Charlotte drinking water supply) and the upper reaches of Mountain Island Lake (Charlotte's primary drinking water supply). This location on the Catawba River is also vital for Charlotte's neighbors to the west, as the cities of Gastonia and Mount Holly also have water supply intakes near the mouth of the McDowell Creek. This watershed is actively being studied by various groups. Active studies at this time include:

?? Mecklenburg County Storm Water Services (MCSWS) and Watershed Concepts (this report)

?? Local Watershed Management Plan (NC Wetlands Restoration Program and CH2M-Hill)

?? Water Quality Computer Model Simulation (MCDEP and TetraTech)

?? McDowell Creek Watershed Smart Growth for Clean Water Partnership (NALGEP, Charlotte, Mecklenburg County, Cornelius, Huntersville, Trust for Public Lands)

It is important to note that while various initiatives are underway, each has a different objective. Yet as each initiative progresses, the participants are communicating and coordinating their efforts and sharing information. Parallel with these studies, CMUD is performing wastewater master planning for the watershed to make sure that the availability of sewer capacity does not impact future watershed growth. As of the date of this report, none of these initiatives has final reports to supplement the information presented.

There are various land acquisition programs underway to protect and buffer the watershed from non-point source pollutants and development, including the Trust for Public Lands and the Mecklenburg County Park and Recreation Department. Together, through the Mountain Island Lake Initiative, each is purchasing large tracts of land to be preserved as open space.

Primary pollutants from land development activities include nutrients (phosphorus and nitrogen from fertilizers), fecal coliform (animal waste and sanitary sewer overflows) and sediment (bank erosion and construction activities). The Mountain Island Lake Marine Commission has already noted the introduction of Hydrilla (Hydrilla L.C. Rich), an extremely aggressive, invasive aquatic plant that chokes the oxygen from a water body and directly impacts water quality. A Hydrilla-eating carp has been introduced to combat the problem. However, the direct cause of the problem stems from the abundance of nutrients that fertilize this plant, flowing downstream through the McDowell Creek watershed.

During the site visit to McDowell Creek in May 2001, fish of 4-5 inches long and frogs of various sizes were observed in a few sites. In addition, other signs of riparian wildlife were present along the stream. These included the teeth marks of beavers, footprints of small hoofed animals, and mammalian droppings. These observations point to the existence of a number of animals along the creek. The list would include varieties of reptiles, rodents, small mammals, birds, insects and other species that thrive in this environment. The dense vegetative growth along the creek was found to be heavily infested with ticks, suggesting that there is sufficient warm-blooded animal life for the survival and proliferation of the ticks.

Mecklenburg County Department of Environmental Protection (MCDEP) maintains several monitoring stations along McDowell Creek and its tributaries. A summary of the collected water quality data is shown in Table 2. While the Macroinvertebrate Taxa Richness sampling and the Fish Bioassesment sampling do include Poor and Fair ratings since 1994, the overall Water Quality Index has consistently ranked as Average, Good and Good-Excellent. The overall water quality has generally remained consistent in the watershed since 1996. One flow monitoring station, USGS Gage 0214266000, has been in operation since November 1996 at the MC3 site, located at McDowell Creek and Beatties Ford Road crossing.

Table 2. MCDEP Water Quality Monitoring Summary

NC Piedmont Macroinvertebrate Taxa Richness		Jul-94		Sep-97		Jun-98		May-99		Jul-00	
Site	Location	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating
MC4	McDowell Cr @ Beatties Ford Rd	14	Good/Fair	8	Fair	5	Poor	8	Fair	7	Fair
MC2A	McDowell Cr @ Sam Furr Rd	5	Poor	8	Fair						
MC2A1	McDowell Cr @ Gilead Rd	8	Fair	6	Poor	6	Poor	7	Fair	6	Fair
MC3E	Torrence Cr @ Bradford Hill Rd	12	Fair	12	Fair	7	Fair	10	Fair	7	Fair

Fish Bioassessment		May-96	
Site	Location	NCIB I	WQ Rating
MC4	McDowell Cr @ Beatties Ford Rd	42	Fair
MC4A	McDowell Cr @ Neck Rd	46	Fair/Good
MC2A	McDowell Cr @ Sam Furr Rd	46	Fair/Good
MC2A1	McDowell Cr @ Gilead Rd	46	Fair/Good
MC3E	Torrence Cr @ Bradford Hill Rd	46	Fair/Good

Water Quality Index		May-96		May-97		May-98		Jun-99		May-00	
Site	Location	WQI	WQI Rating	WQI	WQI Rating	WQI	WQI Rating	WQI	WQI Rating	WQI	WQI Rating
MC4	McDowell Cr @ Baetties Ford Rd	71	Good	73	Good	70	Good	74	Good	76	Good /Exc.
MC4A	McDowell Cr @ Neck Rd	62	Average	66	Good	69	Average	70	Good	77	Good /Exc.
MC2A1	McDowell Cr @ Gilead Rd	72	Good	77	Good/Exc.	75	Good/Exc.	80	Excellent	--	--
MC3E	Torrence Cr @ Bradford Hill Ln	73	Good	79	Good/Exc.	71	Good	71	Good	71	Good

1.4 Rosgen Applied River Morphology Assessment

The Rosgen stream classification system was utilized to provide an initial assessment of the morphology of McDowell 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 McDowell 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 field observations, aerial photography, USGS quadrangle maps, and other digital topographic information for investigation of the channel pattern and valley form.

The data for Rosgen classification of McDowell Creek is summarized in Table 3. The low sinuosity of the channel is primarily due to the installation of the sewage main line and straight alignment of the stream in many reaches. Generally, the channel displays a low width/depth ratio, low sinuosity and relatively low channel slope. However, after careful examination of the tendencies within the creek, the majority of McDowell Creek was classified as a type G channel with some reaches possibly being classified as type F. 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 McDowell Creek

Channel Length	48,714 ft
Downstream Invert	641.49 ft
Upstream Invert	724.18 ft
Channel Slope	0.17%
Valley Length	48,405 ft
Sinuosity	1.01
Average Bankful Depth	5 ft

The channel bank slopes are relatively steep with the slopes ranging from 1:1 to vertical. Despite these steep slopes, the banks appear to be fairly 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 shown in Figures 4 and 5.

The channel profile appears to be relatively stable and not subject to excessive degradation or aggradation. There is evidence, however, of a significant sediment load that is being transported by the stream. Depositional features such as mid-channel bars, side bars and embryonic point bars are evident along many reaches of the stream. It is likely that the primary source of this depositional material is from construction activities within the watershed and that this material is being transported though the stream system without significant aggradation of the channel bed.

1.5 Bank Stability Problem Identification

As described before, the stream and its tributaries have a wide densely vegetated floodplain. The floodplain and the channel itself are stabilized against severe floods and serious erosion. The main floodway channel and the adjoining floodplain seem to be in a stable state.

Moderate to low deposition of sediments was observed in a field visit to McDowell Creek on May 2, 2001. The flat creek slopes do not provide sufficient grade for the flow to carry large suspended or bed sediment loads. Occasionally, there would be point or middle bars on the stream as shown in Figures 3 and 4. This is an indication of good vegetative cover along the stream, relatively stable channel, and low erosion of the banks. In general, bank instability does not seem to be a major problem along McDowell Creek.

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 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.

There are no structures in the McDowell Creek watershed with finished floor elevations below the BFE. Structures analyzed for potential flood damage are limited to those with finished floor elevations in the flood fringe areas. 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 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 website 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 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 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 McDowell 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 were extrapolated for each individual structure. To perform this task, a line was manually drawn from each structure to the creek centerline. The Watershed Concepts WISE program was then utilized to perform the extrapolation and output of elevations for the different frequency floods for each individual structure. 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 *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 deemed feasible, and when the ratio is smaller than 1.0, the measure is rejected.

The benefit:cost program has built-in data for the costs of acquisition or elevating the structure for Mecklenburg County. 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 are affected in the McDowell Creek watershed, the only other mitigation measure considered was the construction of flood levees, as described in the next section of the report.

As suggested by 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). Four such project areas are identified for the McDowell Creek watershed as described in the next section of the report.

2.6 Improvements

There are no severe flooding problems in the McDowell Creek watershed. Only four neighborhoods were identified with flooding potential, as reported in the next section of this report. Preliminary analyses indicated that only a few structures are 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 watershed: elevating the structure, acquisition of the property, or construction of flood levees. **None of the three measures provided a benefit:cost ratio higher than 1.0. Therefore, no action is recommended for this watershed.**

3. FLOOD HAZARD MITIGATION

3.1 FEMA Regulated Stream Service Requests

There have been 91 Service Requests filed through the City/County Customer Service system (336-RAIN) hotline in the McDowell Creek watershed. The majority of the service requests involve channel bank erosion. For each request a severity category has been specified. However, except for 3 cases, the exact type of the request has not been identified. Instead, only the severity of the requested service is recorded in the system database. Table 4 summarizes the flood related service requests by severity in the McDowell Creek watershed. Only one of the requests is for property that has been identified in this report as having a flood potential (15130 Stonegreen Ln.). A total of 10 of the complaints are for property located immediately adjacent to the McDowell Creek floodplain. However, except for 15130 Stonegreen Lane, no structures on the remaining nine parcels have been identified as being in the flood fringe areas.

Table 4. Service Requests in McDowell Creek Watershed

Severity of Service Requested[1]	Frequency	No. in Potential Flood Zone[2]	No. in B:C Analysis[3]
A	4	0	0
B	20	0	0
C	67	1	1

1 A to C: Most to least severe; categorized by the Charlotte-Mecklenburg Storm Water Services

2 Lots with structures whose footprints intersected with the flood boundaries

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

3.2 Repetitive Loss Structures

According to information provided by Mecklenburg County Storm Water Services, no reports of repetitive losses exist within the McDowell Creek watershed.

3.3 Permanent Storm Water Easements

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

3.4 Roadway Overtopping Problem Locations

From HEC-RAS modeling results of McDowell Creek watershed, roadway overtopping locations were investigated based on the existing and future 100-year flood conditions. Table 5 summarizes the roadway overtopping problem locations for the study streams and tributaries. Locations of the overtopping roads are shown in Figure 16. Several conclusions and recommendations can be derived from Table 5:

1. Considering the fact that a flow depth of 24 inches (2 ft) can sweep away a moving vehicle, there will be several problem locations in case of a 100-year flood. The most prominent of these is McIlwaine Road. The crossing will be in 3.2 and 6.3 ft of water, respectively, for the existing and future 100-year floods. However, this is due to a backwater effect from

McDowell Creek, not a high-velocity floodwater of equivalent depth. Among measures to mitigate this hazard are warning signs for approaching motorists and consideration for raising the elevation of the stream crossing as a future CIP for the Huntersville DOT. Other problem spots for large depths of water are on private crossings, identified as a farm bridge and a foot bridge, which should be abandoned in case of a flood. All other problem areas listed in Table 5 would require warning signs to alert motorists to avoid the crossing in case of a flood.

2. Flood hazards at road crossings could be minimized by assuring that culverts and bridges along the entire stream system have the maximum capacity to pass the flood flows. Regular inspection and 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 (or other indicators) should be provided at all problem sites such that drivers could be guided away from the edge of the road in case of a flood. The protection should be adequate so that if a vehicle is stranded or swept away, it can be stopped by the guardrail, preventing the vehicle from entering deeper and faster moving flow regions and allowing for rescue crews to reach the stranded vehicle.

4. Depth sensors and a relay system could be installed on or near the crossings such that they 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

Stream/Road	Crossing Structure Type	Culvert Size No. @ Size (ft)	Top of Road Elevation (ft NAVD)	100-Yr Flood Elevation Existing (ft NAVD)	Flood Depth Existing (ft)	100-Yr Flood Elevation Future (ft NAVD)	Flood Depth Future (ft)
McDowell Creek							
Sam Furr Road	Bridge		701.3	700.5	--	702.3	1.0
Torrence Creek							
Farm Bridge	Bridge		669.5	673.7	4.2	674.8	5.3
Torr. Cr, Trib 1							
Foot Bridge	Bridge		669.3	673.2*	3.9	674.1*	4.8
Gilead Road	Culvert	2@ 8X7.5 Box	679.5	679.5	--	680.0	0.5
Stumptown Road	Culvert	2@6 Cir	705.8	706.5	0.7	707.0	1.2
McDowell Cr Trib 1							
McIlwaine Road	Bridge		661.8	665.0**	3.2	668.1**	6.3
Caldwell Station Creek							
Statesville Road	Culvert	3@8X7 Box	718.7	717.0	--	718.9	0.2

* Backwater from Torrence Creek
** Backwater from McDowell Creek

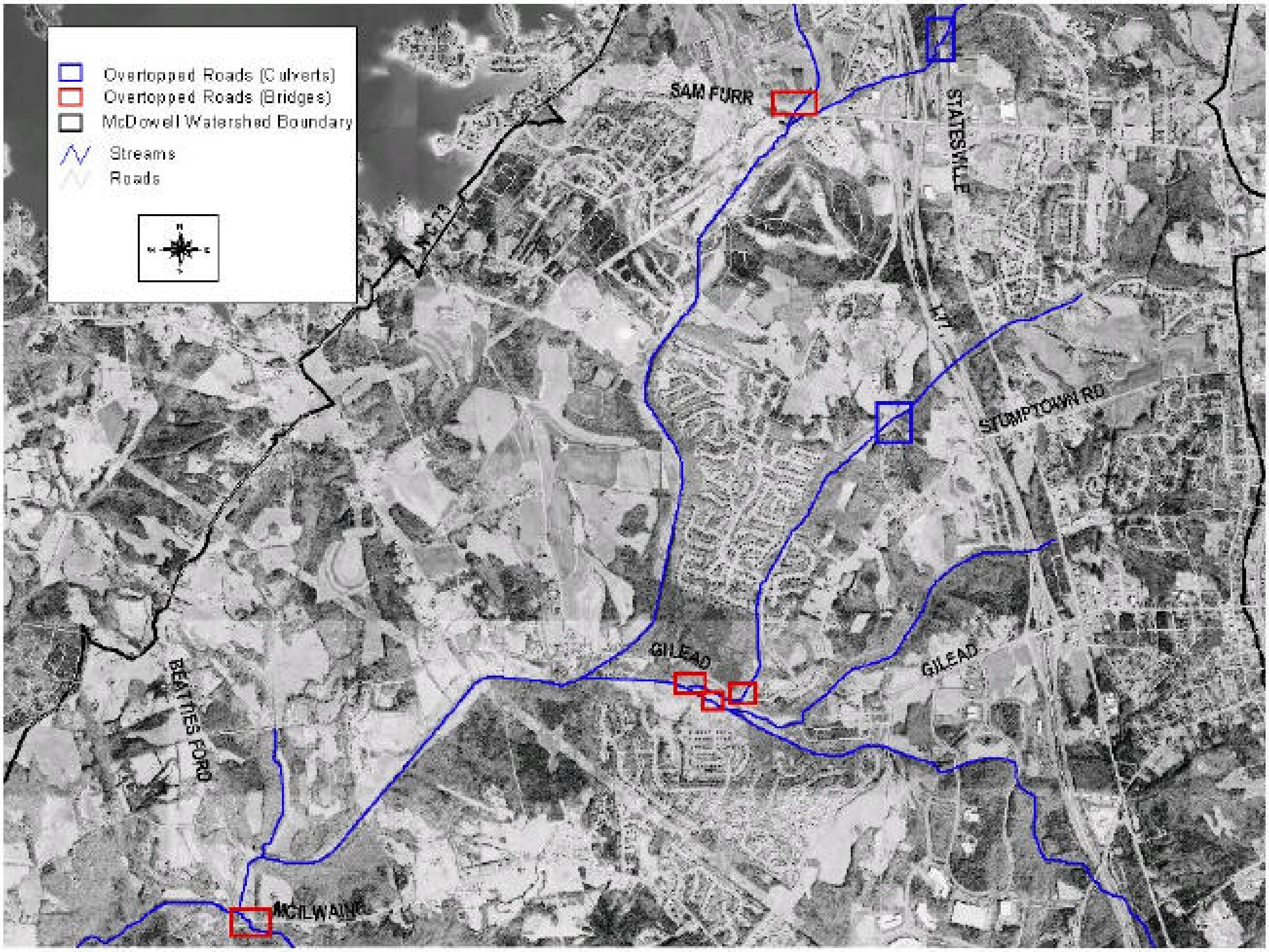

Fig. 16 Road Overtopping Location Map

3.5 Flood Mitigation Improvement Analysis

Three flood mitigation measures were recognized as the only viable options for the structures that are in the flood fringe areas (within two feet of the BFE) in the McDowell Creek watershed. These measures were acquisition, elevating the finished floor of the structure two feet above the BFE, or construction of a berm or dike to contain the floodwater. The benefit:cost analysis for the four project areas, shown in Figures E2 and E3, 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. Details of the analysis will be presented later. 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. The low benefit:cost ratios of these neighborhoods and structures is indicative of the fact that all of the structures have finished floor elevations above the BFE. None of the structures would actually experience inundation in case of a 100-year flood. The small amount of damages calculated by the benefit:cost program for these structures results from the statistical probability of occurrence of a 500-year flood.

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 is going to be economically justified, either for an entire project area or for individual structures.

Table 6. Summary of the Benefit:Cost Analysis for the Four 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**
9	Henderson Park Rd/Leisure Ln/Lullwater Cv	54,016	1,597,405	0.03	26,615	407,750	0.07	42,858	265,672	0.2
Highest individual	7641 Henderson Park	8,450	146,479	0.06	4,349	35,867	0.12	--	--	--
2	Gilead Rd	3,855	196,051	0.02	2,210	69,460	0.03	3,212	112,001	0.03
Highest individual	8010 Gilead Rd	2,745	107,056	0.03	1,623	45,410	0.04	--	--	--
3	Cumbria Ct/Stonegreen Ln	24,821	998,853	0.03	17,267	226,768	0.08	21,201	50,507	0.42
Highest individual	15129 Stonegreen Ln	13,652	347,509	0.04	10,077	82,508	0.12	--	--	--
1	Delancey Ln	32,310	344,039	0.09	10,526	74,423	0.14	18,816	44,216	0.43
Highest individual	15701 Delancey Ln	32,310	344,039	0.09	10,526	74,423	0.14	18,816	44,216	0.43

*Benefits and costs are in dollars

Compared to other basins within Mecklenburg County, the McDowell Creek watershed is in a younger state of development and does not suffer from severe flooding problems. Based on the latest County elevation certificate data and survey results, a total of 15 structures would be within the fringe of the ECF or the FCF. Table 7 shows the flooding statistics for these structures, all of which are residential and post-FIRM (built after 1981). The flooded homes can be grouped into four project areas, listed in Table 7. The four 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.

Table 7. 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***
9	Henderson Park Rd/Leisure Ln/Lullwater Cv	0	9	-0.87	-1.30	-0.11	-1.63
2	Gilead Road	0	2	-1.39	-1.39	-0.86	-1.91
3	Cumbria Ct/Stonegreen Ln	0	3	-0.43	-0.63	-0.08	-0.78
1	Delancey Ln	0	1	-0.01	-0.01	-0.01	-0.01

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

Alternative Evaluation

Within the McDowell Creek watershed there are a total of 15 structures, which are in the flood fringe areas (within 2 ft of BFE). These structures have been clustered into four 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.

Alternative 1 - Acquisition

In this alternative, the structure in danger of flooding is purchased and removed. 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 potentially 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 limiting 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 carried out outside the benefit:cost program, and involve estimations of material needed, haul distances, placement, 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 McDowell Creek watershed.**

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

Henderson Park/Leisure/Lullwater Neighborhood

The summary of the benefit:cost analysis for the Henderson Park Road, Leisure Lane and Lullwater Cove neighborhood is shown in Table 8. The general neighborhood is shown in Figure 17. A total of 9 structures in this neighborhood are in flood fringe areas. The highest benefit:cost ratio for any of the mitigation measures for the neighborhood is 0.161 for the levee (flood barrier) alternative, well below the acceptable level of 1.0 for adoption of the mitigation measure. The highest benefit:cost ratio for an individual structure in this neighborhood is 0.12 for the elevation option for 7641 Henderson Park. The levees in this neighborhood are used for a cluster of houses, and hence individual costs for this option cannot be used for comparison of structures.

Table 8. Mitigation Measures for Henderson Park/Leisure/Lullwater Neighborhood

Possible Mitigation Project								
Acquisition			Elevation			Levee		
Benefit	Cost	Ratio	Benefit	Cost	Ratio	Benefit	Cost	Ratio
$54,016	$ 1,597,405	0.034	$ 26,615	$ 407,750	0.065	$ 42,858	$ 265,672	0.161

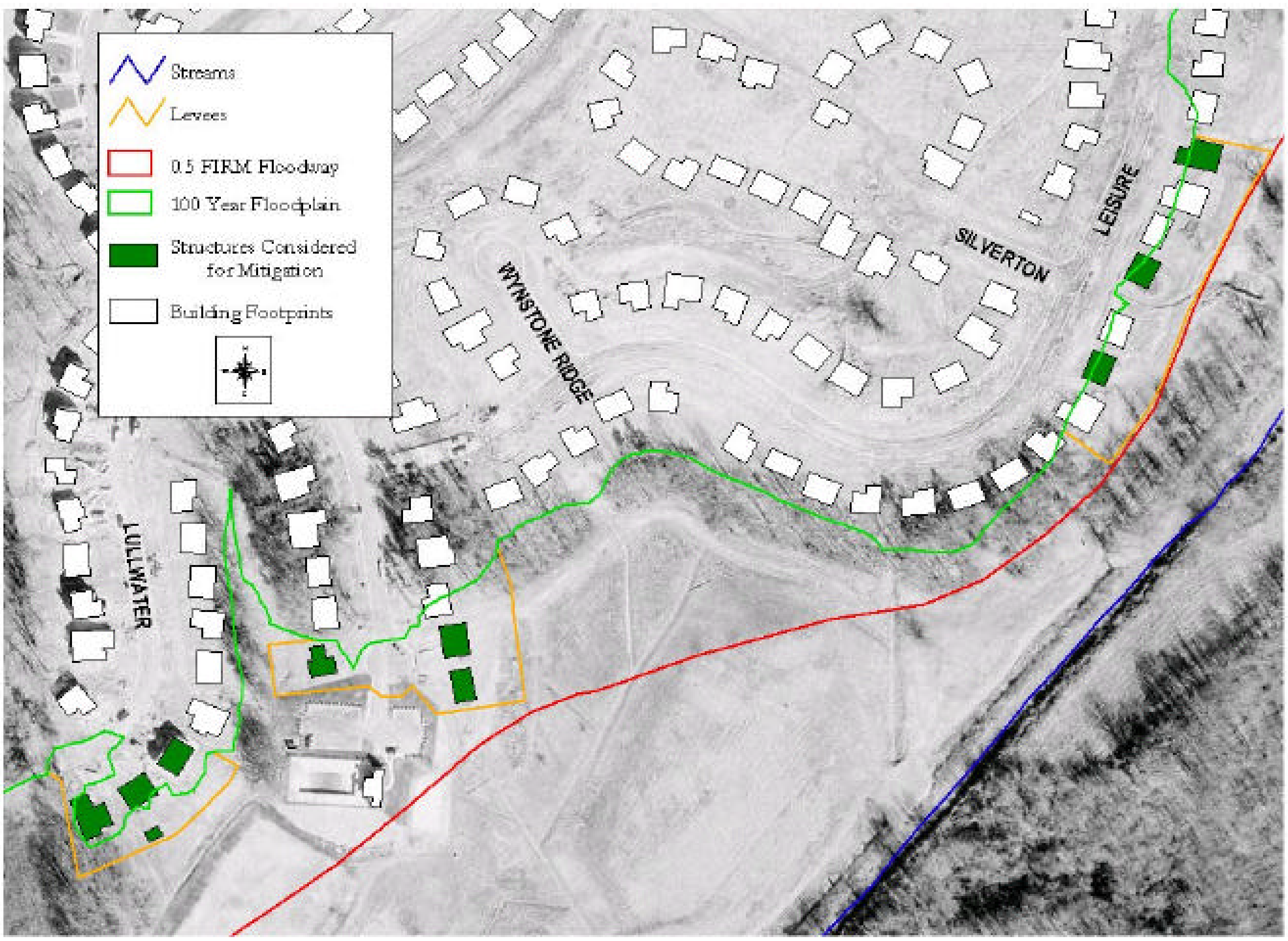

Fig. 17 Houses with Flooding Potential in Henderson Park/Leisure/Lullwater Neighborhood

Gilead Neighborhood

The summary of the benefit:cost analysis for the Gilead Road neighborhood is shown in Table 9. The general neighborhood is shown in Figure 18. Two structures in this neighborhood are in flood fringe areas. The highest benefit:cost ratio for any of the mitigation measures for the neighborhood is 0.03, well below the acceptable level of 1.0 for adoption of the mitigation measure. The low benefit:cost ratio indicates that the finished floor elevations of these houses are above the BFE, and the small benefit figures result from the low probability of flooding in case of a 500-year flood. The highest benefit:cost ratio for an individual structure in this neighborhood is 0.04, still well below the feasible level of 1.0.

Table 9. Mitigation Measures for Gilead Neighborhood

Possible Mitigation Project								
Acquisition			Elevation			Levee		
Benefit	Cost	Ratio	Benefit	Cost	Ratio	Benefit	Cost	Ratio
$ 3,855	$ 196,051	0.020	$ 2,210	$ 69,460	0.032	$ 3,212	$ 112,001	0.029

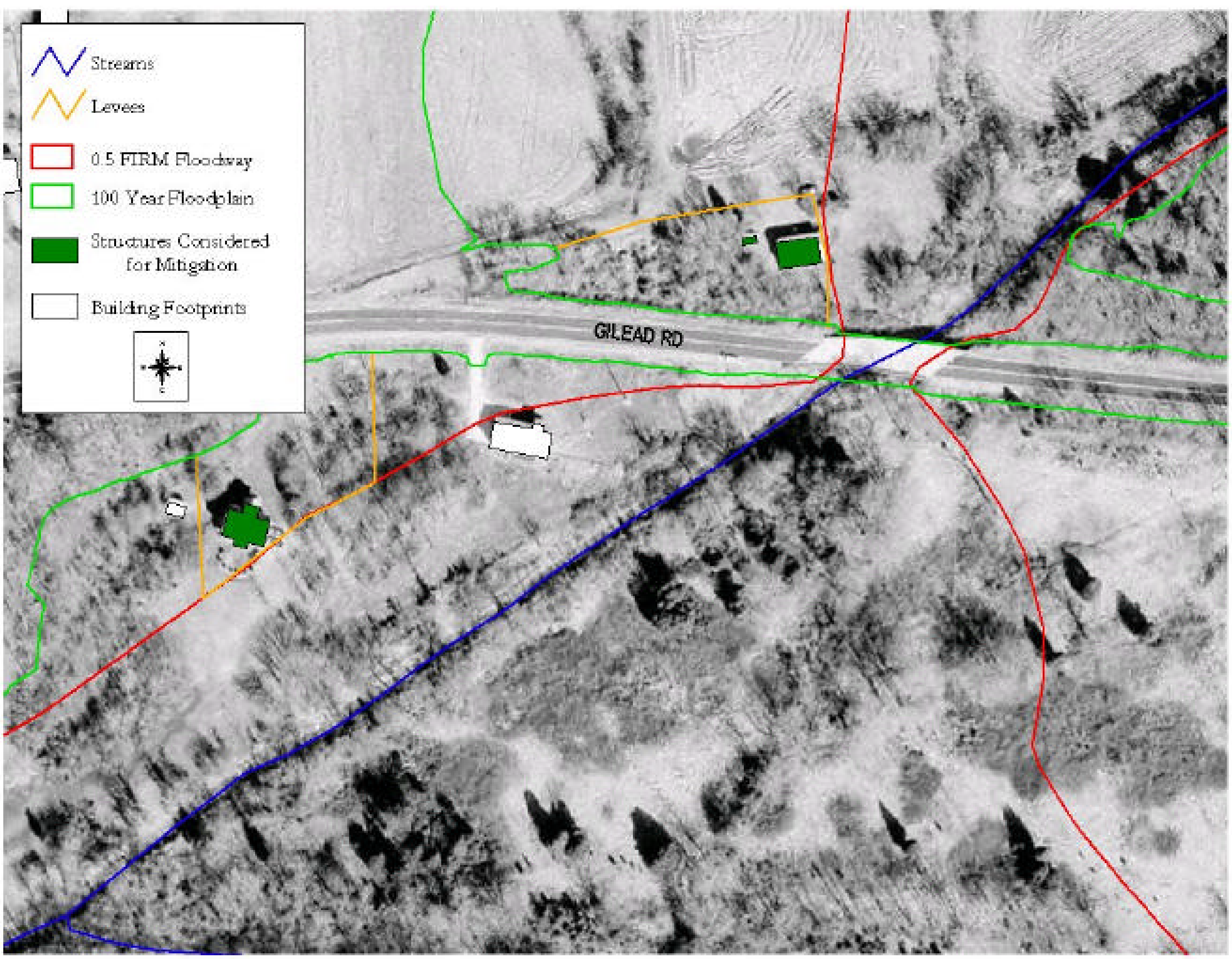

Fig. 18 Houses with Flooding Potential in Gilead Neighborhood

Cumbria/Stonegreen Neighborhood

The summary of the benefit:cost analysis for the Cumbria Ct and Stonegreen Ln neighborhood is shown in Table 10. The general neighborhood is shown in Figure 19. Three structures in this neighborhood are in flood fringe areas. The highest benefit:cost ratio is 0.42 for the levee alternative, decidedly below the acceptable level of 1.0 for feasibility of the mitigation measure. The highest benefit:cost ratio for an individual structure in this neighborhood is 0.12, still well below the feasible level of 1.0.

Table 10. Mitigation Measures for Cumbria/Stonegreen Neighborhood

Possible Mitigation Project								
Acquisition			Elevation			Levee		
Benefit	Cost	Ratio	Benefit	Cost	Ratio	Benefit	Cost	Ratio
$ 24,821	$ 998,853	0.025	$ 17,267	$ 226,768	0.076	$ 21,201	$ 50,507	0.420

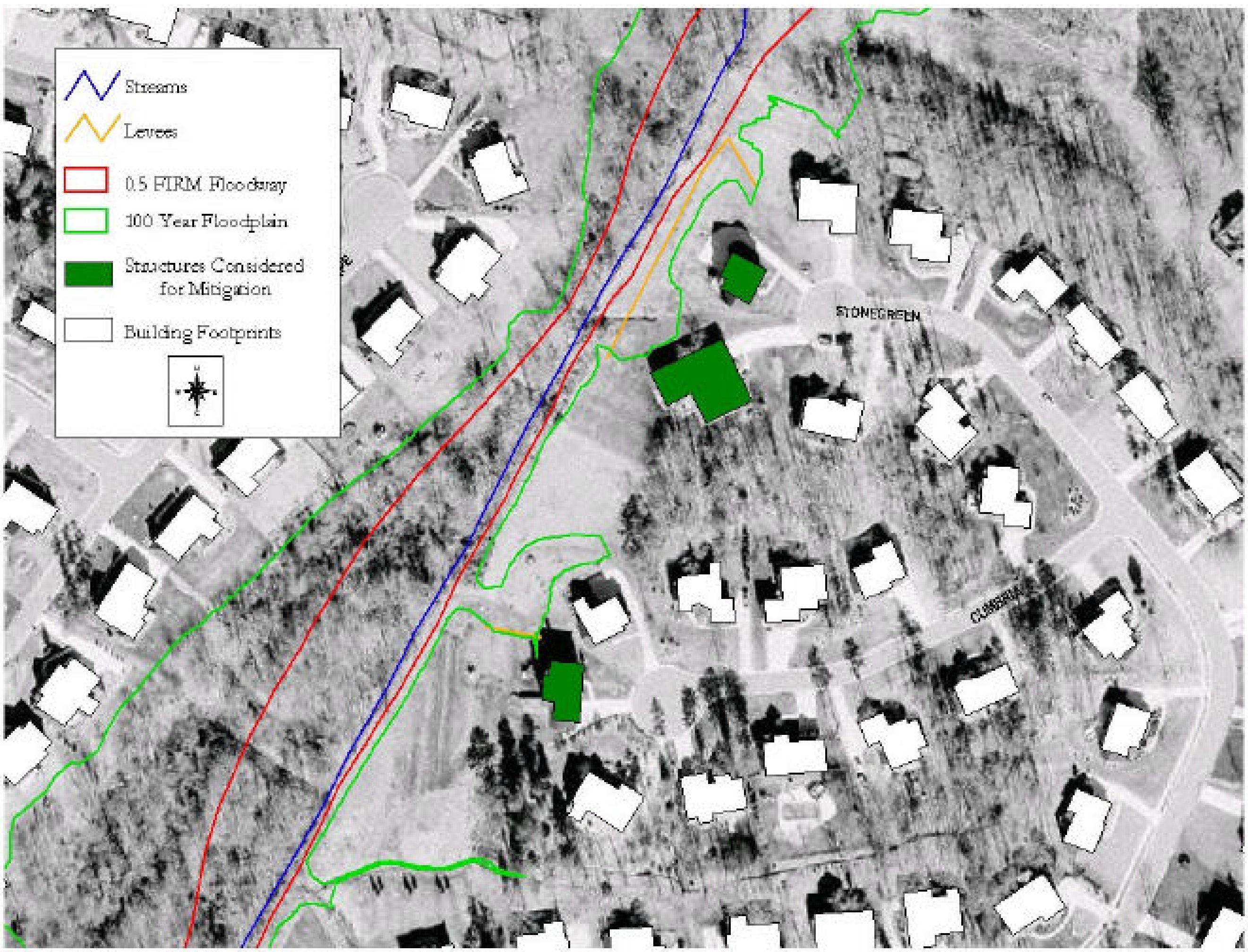

Fig. 19 Houses with Flooding Potential in Cumbria/Stonegreen Neighborhood

Delancey Neighborhood

The summary of the benefit:cost analysis for the Delancey Lane neighborhood is shown in Table 11. The general neighborhood is shown in Figure 20. A single structure in this neighborhood is in flood fringe area. The highest benefit:cost ratio of any of the mitigation measures considered is 0.43 for the levee (flood barrier) alternative, which is below the acceptable level of 1.0 for the alternative to be economically feasible. This benefit:cost ratio of 0.43 is also the highest individual value since only one house is affected in this area. The levee option is included in the analysis for this neighborhood since the levee would be constructed for the protection of this structure only, and all the costs can be attributed to this single structure.

Table 11. Mitigation Measures for Delancey Neighborhood								
Possible Mitigation Project								
Acquisition			Elevation			Levee		
Benefit	Cost	Ratio	Benefit	Cost	Ratio	Benefit	Cost	Ratio
$ 32,310	$ 344,039	0.09	$ 10,526	$ 74,423	0.14	$ 18,816	$ 44,216	0.43

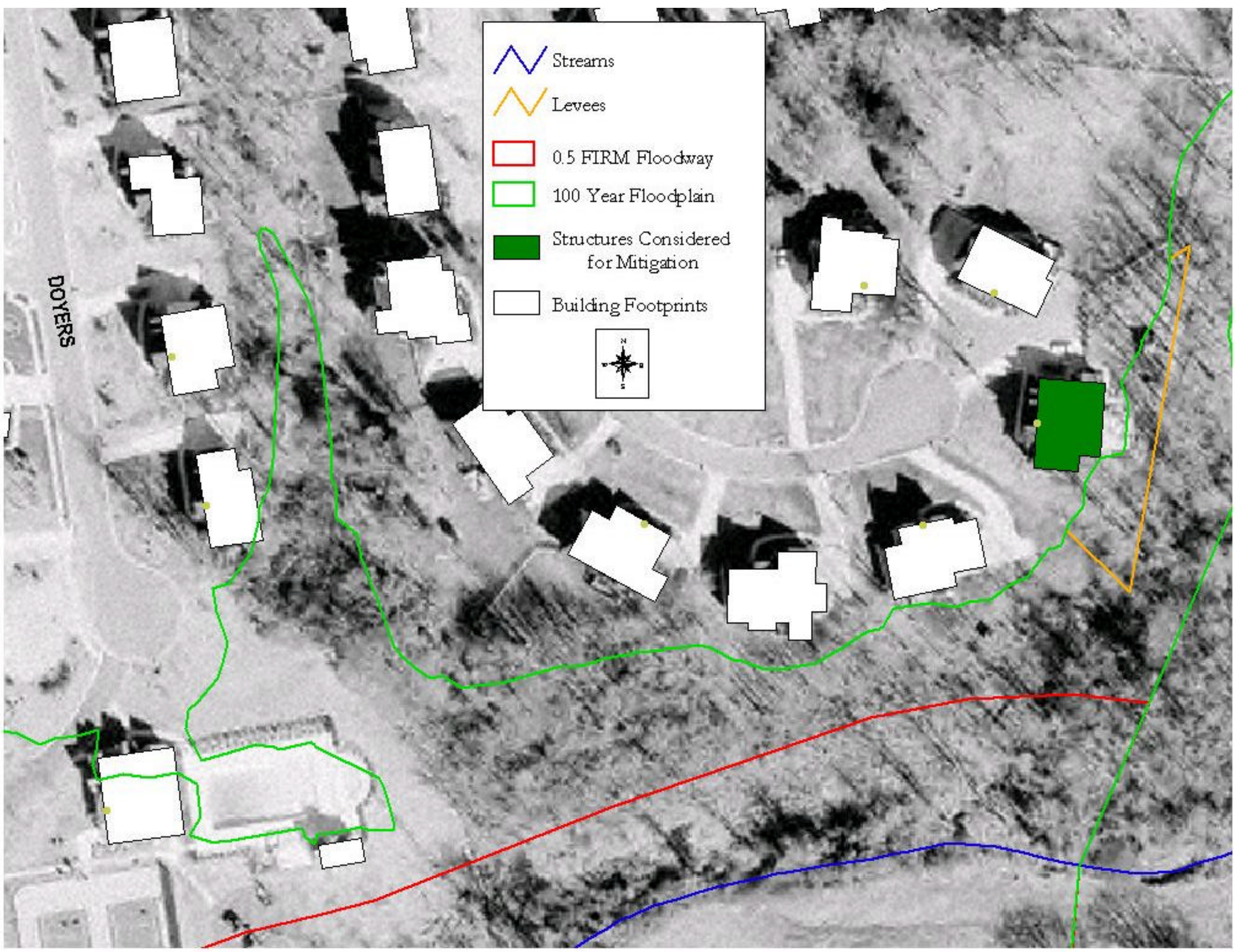

Fig. 20 House with Flooding Potential in Delancey Neighborhood

4. CONCLUSIONS AND RECOMMENDATIONS

The McDowell Creek basin constitutes a young but fast developing section of Mecklenburg County. McDowell Creek and its main tributaries, McDowell Trib.1, Caldwell Station, Torrence Creek, and Torrence Creek Tribs. 1 and 2 are all in a reasonably stable condition due to four main factors:

1. Stream banks stabilized by riprap or other means to safeguard a sewer main line that extends 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 McDowell Creek and its tributaries

In the event of a 100-year flood, flooding hazard for the structures lining the banks of the creek may be identified in four general neighborhoods. A total of 15 structures are affected, all of which are located in the flood fringe areas (within 2 ft of BFE). Flood inundation damages are 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 are recommended for this watershed.

There are several road crossings that are subject to overtopping in case of a 100-year flood. Flood depths over the roadway may be as high as 6.3 ft in one case for the future 100-year flood (backwater effect). Two smaller crossings on non-public roads would also be flooded severely. Several mitigation measures should be considered for the road crossings of this watershed, 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:

Rosgen, D. 1996. Applied River Morphology, Wildland Hydrology, Pagosa Springs, CO.

Federal Emergency Management Agency 1995. *Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings*, Manual 259, FEMA Mitigation Directorate, January.

Federal Emergency Management Agency 1996. *Benefit-Cost Program , Riverine Flood Module*, Version 1.11, Revised February 10 (software distributed by FEMA).

R.S. Means 2000. *Site Work and Landscape Cost Data*, 20th Annual Edition, Construction Publishers & Consultants, Kingston, MA 02364-0800

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