DOWNTOWN DRAINAGE STUDY CITY OF JOHNSON CITY, TENNESSEE

APRIL 2005

LD&A
Lamar Dunn & Associates Inc.

CDM Camp Dresser & McKee Inc.

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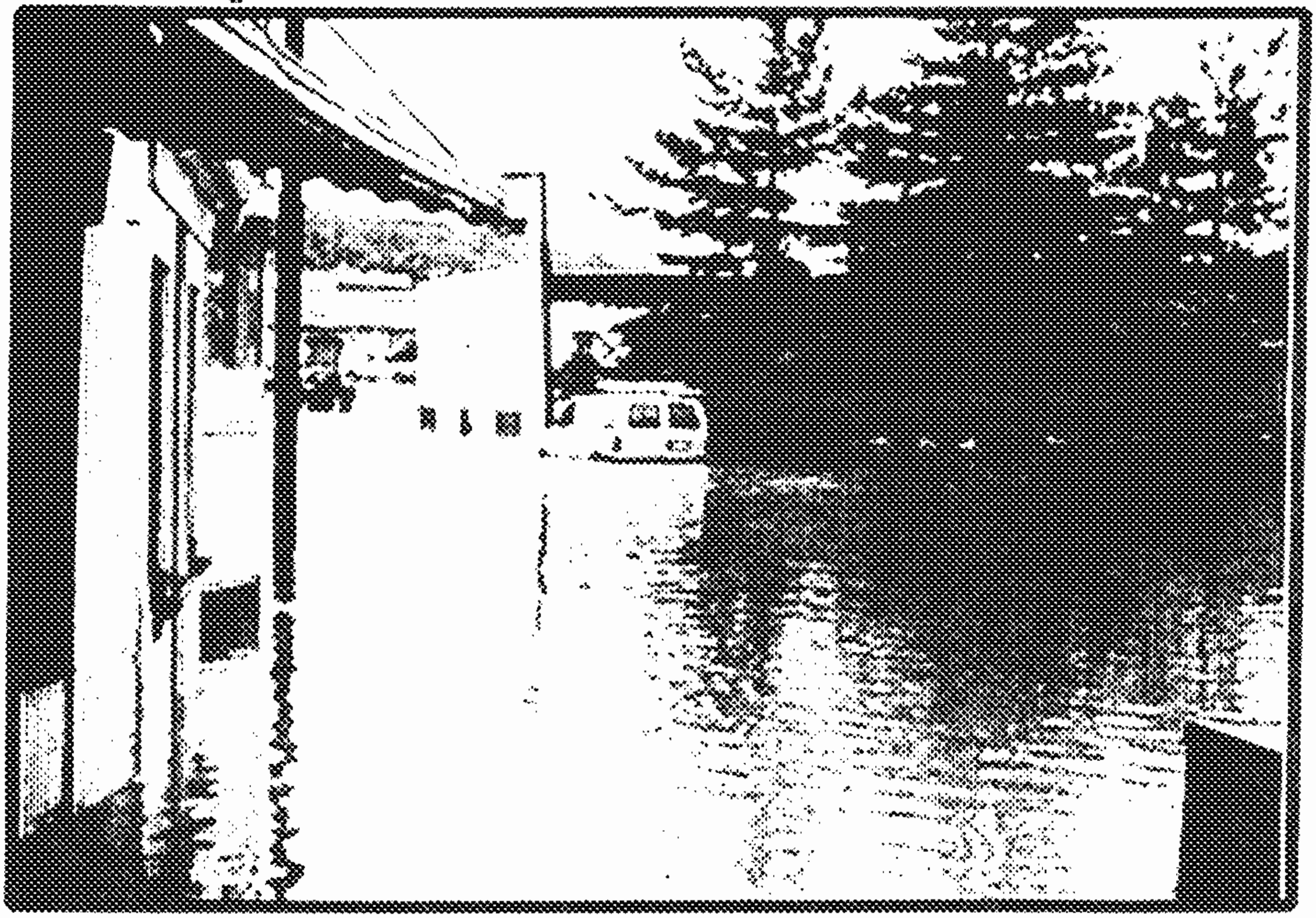

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LDA
Lamar Dunn & Associates Inc.

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CULLEN LAMAR DUNN
REGISTERED ENGINEER
STATE OF TENNESSEE
4/28/05

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Due to the reoccurrence of flooding in the downtown area of Johnson City, the City contracted with the team of Lamar Dunn & Associates, Inc. and Camp Dresser and McKee, to study the causes and potential solutions to the problem. The services were divided into two phases.

The first phase of the study was to collect data relative to Brush Creek and King Creek, upstream of the study area which was the central business district. However, in order to analyze the resulting flows from various storm events the entire upstream drainage basin of each creek was reviewed. In addition to reviewing published information such as previous flood studies, topographical maps, land use maps and rainfall data, meetings were held with the stakeholders.

Runoff from rainfall finds it way into drainage ways. The amount of runoff is a function of the parameters of the rainfall event. Such things as intensity and duration are important in the resultant flow. It is common to reference a given flood or storm event with a recurrence interval such as – a 100 year event. Unfortunately, this designation is most times interpreted as an event which would occur once every 100 years. Therefore, if a 100 year flood occurred this year it would be another 100 years before it would reoccur. The more correct designation is that a 100 year storm has a 1% probability of occurring in any given year (a 10 year storm would have a 10% probability). The analysis for this study used rainfall occurring over a twenty-four (24) hour period of a given amount of rainfall. The analysis uses statistics in predicting the flows and flood elevations.

A computer model was selected to predict the water surface elevations resulting from various storm events. During the time of Phase I activities, a flood event actually occurred. Not only was historical information available; but, members of the team could witness first hand flooding conditions in the central business district.

At the outset of Phase I, a public meeting was conducted to inform the stakeholders of the scope of the study. Assistance was solicited from the stakeholders in furnishing anecdotal information. After the model was developed but prior to it being calibrated, a second public meeting was conducted to share information. As a general statement, comments from the affected public confirmed the model's prediction of how the basin reacts during a major storm event. The model has the capability to show on fifteen (15) minute increments areas of flooding. Following the second public meeting the second phase of the study was commenced.

The second phase was to calibrate the model such that a more refined predication could be available for various storm events. The calibrated model was to identify existing problems resulting from a twenty-four (24)-hour 10-and 100-year frequency storm. This model was then to be used to predict flood ways resulting from changes in the basins such as drainage structures, roads, and channel improvements.

Using the model the team examined various alternatives to reduce the affects of flooding in the central business district. The team was charged with investigating alternatives which would give 100% protection for the 100 year frequency storm event, as well as the 10 year event. One additional scenario was to be investigated which would be considered the most cost effective program. A preliminary matrix was developed for various alternatives using criteria such as public acceptance, long term economic impact and environmental issues. That matrix was presented to the stakeholders in a public meeting, and amended to incorporate their comments. The Table - 1 is the amended matrix.

The most favorable alternative resulting from the matrix evaluation is called a downtown retention and greenway. That alternative would protect the central business district during the 100 year storm event; however, its implementation schedule would probably require several years. The reason for the limited action alternative resulting in a less favorable ranking than the no action alternative is due to the cost and constructability (The no action is less expensive and has no construction problems).

Using the Greenway as the preferred alternative, an eleven step execution plan is presented in Table - 2 on page 5.

TABLE - 1					
CRITERIA	**NO ACTION**	**LIMITED ACTION**	**10-YEAR**	**100-YEAR**	**DOWNTOWN RETENTION GREENWAY**
Feasibility/Cost	5	4	4	1	3
Constructability	5	3	3	2	3
Permitability	5	5	3	2	5
Right–of-Way/Acquisition	5	5	2	1	1
SW Level of Service	1	2	3	5	5
Grant Eligibility	1	1	4	4	5
Long Term Economic Impact	1	1	3	3	4
Public Acceptance	1	2	3	5	5
Total Score	24	23	25	23	31

Legend:

Ranking Values: Very Favorable = 5
Favorable = 4
Moderate = 3
Unfavorable = 2
Poor = 1

TABLE - 2

Priority	Description	Cost	Benefit to Downtown Area
1	Purchase Land	$7,500,000.00	This allows the projects to proceed and affected properties to be city owned.
2	Minor Improvements	$ 500,000.00	Negligible benefits for small storms (5-year frequency or less). No Benefit for larger storms.
3	Carver Park Detention	$2,500,000.00	Limited benefit for small storms (2-year frequency or less).
4	West King Street Detention	$1,200,000.00	Moderate benefit for small storms (2-year frequency or less). Negligible benefits for larger storms.
5	King Creek Main Stem Detention	$2,750,000.00	Limited additional benefit in the downtown area but will improve water quantity level of service in the upper watershed of King Creek.* Protects intersection.
6	Brush Creek Detention (Main Stem) Upstream of State of Franklin Road	$3,700,000.00	Moderate benefit for small storms (2-year frequency or less) Limited benefit for larger storms. * A more narrow flood plain.
7	Downtown Detention Facility	$3,700,000.00	Significant benefit for small and large storms with exception of street flooding.*
8	Channel Improvements (Carver Park to Downtown Detention Pond)	$3,300,000.00	Significant benefit for small and large storms with exception of street flooding in Brush Creek in the vicinity of Watauga and Kelly's Market.*
9	Channel Improvements (Watauaga to Downtown Detention Pond)	$4,200,000.00	Significant benefit for small and large storms.*
10	Greenway Amenities Downtown to Tennessee Street	$ 275,000.00	Limited water quantity benefit. Will provide maintenance and recreational access to King and Brush Creek.
11	Brush Creek Tributary Detention (Upstream of ETSU Ball Field)	$6,250,000.00	Limited additional benefit in the downtown area but will improve water quantity level of service in the upper watershed of Brush Creek in the vicinity of ETSU.*

*Assumes previous improvement has been implemented.

It is suggested that the implementation of the flood damage reduction effort be a part of a central business district redevelopment activity. The alternative requires the purchase of downtown real estate which is currently in the historic zone. Johnson City should take advantage of the opportunity to initiate an economic revitalization of the downtown area using the flood issues as a catalyst. If nothing is done to control flood water, buildings will continue to receive intermittent damage which will result in a continued degradation of the area. Unfortunately, continued flooding of the area leaves little incentive for beneficial investment in the area. The proposed alternative opens the creeks which enhance the environmental and aesthetics of the area.

Funding for the implementation of the Greenway alternative will most likely be from multiple-sources.

Results from the pursuit of the Greenway alternative would provide a complete new look to the central business district. It could greatly enhance the economic viability of the area by attracting new private investment. It is recommended that the city embark on the Greenway alternative in a phased approach. The initial efforts should be the development of a coordinated grantsmanship program at the local, state and federal level for a multi-year/multi-phased construction program. Consideration should be given to the development of master plan for the area around the project site. Such a master plan would give guidance as to how the area should be redeveloped. The feasibility and schedule for both the redevelopment and flood work should be integrated.

INTRODUCTION

I

SECTION I

INTRODUCTION

Johnson City dates back to the mid 1800's. The railroad was primarily instrumental in the establishment of the city. The depot began the central business district near the confluence of Brush Creek and King Creek. The twentieth century saw significant growth in the City. During that time, culverts were built to convey the waters to the two creeks underground. In time, buildings were constructed over these culverts. Then, culverts were not constructed large enough to handle flows during today's heavy storm events.

There have been numerous floods in the Central Business District over the history of the City. The King Creek and Brush Creek Watersheds include a significant amount of developed land and encroachment on floodplains, such as buildings and fill, have reduced the flow capacity of both tributaries. Future development in these watersheds without storm water quantity controls and the prohibition of further encroachment on the floodplains, will increase flood stages and velocities resulting in increased flood hazards.

The following excerpts from the Federal Emergency Management Agency, Flood Insurance Study (Washington County, Tennessee, October 16, 1996) present significant flood events that have been documented in the Brush Creek and Kings Creek watersheds.

"All Flooding in the City of Johnson City is caused by rainstorms. The largest flood known to have occurred on Brush Creek since 1875 was that of May 29, 1908. Flood marks are unavailable from that flood however, damages were incurred. Water covered the standard oak veneer and Allen Panel Companies, causing approximately $10,000 worth of damage. Several Cottages and warehouses were toppled.

The next three largest known floods on Brush Creek occurred on August 9, 1938, August 17, 1962, and June 22, 1974. Except for localized differences, the three water-surface elevation profiles are approximately the same. At Elm Street (river mile 5.6), the 3 crest elevations were 1,610.3, 1.610.6, and 1,610.7 feet NGVD, respectively. The recurrence interval for each of the 3 floods is approximately 15 years.

Damages due to 1938 and 1962 floods were approximately $25,000 and $60,000 respectively. Damages from the 1974 flood included the following: Gloria Mills was flooded to depth of 0.4 foot; water entered the buildings of Harris Manufacturing Company causing some damage; Volunteer Natural Gas Company had its office flooded to a depth of 1.3 feet; Church Brothers, a coal and gravel company, suffered $7,500 worth of damage (reference5).

Available water-surface elevation profiles for King Creek are limited to the floods of August 4, 1968, June 22, 1974, and August 17, 1977. The August 1977 flood was relatively minor. The August 1968 and June 1974 flood water surface elevation profiles are approximately the same. At river mile 0.42 downstream of Unaka Street, they reached an elevation of 1,626.5 feet NGVD, and have a recurrence interval of approximately 30 years. Flood from both storms was confined to the business district. Damage estimates are unavailable (reference 5).

Another large flood occurred in the City of Johnson City on July 3, 1962. Although a flood water-surface elevation profile is unavailable, a flooded area map shows that King Creek was partly responsible for flooding the business district and causing the $60,000 worth of damage attributed to the flood (reference 5).

> The development of the City of Johnson City has created many constrictions to Brush Creek's flow. There are buildings in the flood plain and bridges over the stream, and a large portion of Brush Creek in the downtown area is covered. These encroachments have reduced the flow capacity of the stream and increased stages for high flows.
>
> The drainage basin of King Creek within the City of Johnson City is highly developed with a large percentage covered by paved street and buildings. During intense storms, the channel capacity is exceeded; water flows down West Market Street and West King Streets and floods the business district.
>
> The August 17, 1977, flood caused some damage in the downtown area including flooding some basements (reference 7). The flood reached an elevation of 1,763.2 feet NGVD with a recurrence interval of approximately 25 years at river mile 14.46."

From this information it is evident that the downtown flooding issues are not new, and continue to be compounded by development in the King Creek and Brush Creek watersheds. Economic losses continue to escalate.

In March of 2003, the City retained the team of Lamar Dunn & Associates, Inc. (LD&A) and Camp Dresser and McKee (CDM) to study the issues relative to flooding. The scope of the study was divided into two phases. The first phase was the investigation phase. That phase included: a) collecting the historical data, b) assisting with public meetings to obtain eyewitness accounts, c) select a computer model for hydraulic calculations, d) collect field data, and e) demonstrate the capabilities of the selected computer model. The second phase of the study was to: a) calibrate the model in order to predict the actual field responses of each drainage basin to storm events, b) review the model and its findings with the stakeholders, c) perform model runs for storm events of different recurrence frequencies, d) develop potential mitigation alternatives, e) develop a decision matrix using the alternatives, f) review the findings with the City and stakeholders, and g) present a final report and computer model of the basins.

Even though the scope of study was limited to the downtown area, a review of the entire drainage basin of Brush Creek and King Creek upstream of Roane Street was required. All of the alternatives to be developed were to limit/reduce flooding in the downtown area. Figure I-1 shows the study area. As can be seen by maps in later sections of the report, there are areas where each of the Creeks gets outside their normal banks with no remedial action.

The basic principles of hydrology were used to assess the flooding issues. Hydrology is the study of the movement of water on the earth, which includes two major components: precipitation and surface runoff. The science of hydrology is utilized to predict the quantity of storm water runoff that may be expected for a given rainfall event. Conditions that may affect the amount of storm water runoff include the size of the watershed, the amount of rainfall that occurs, the duration of the storm event, the intensity of the storm event, moisture conditions of the receiving ground, the quantity of paved or covered surfaces within the watershed boundaries, the ground slope within the watershed, and other related factors. For these reasons, hydrology is often referred to as an art rather than a science.

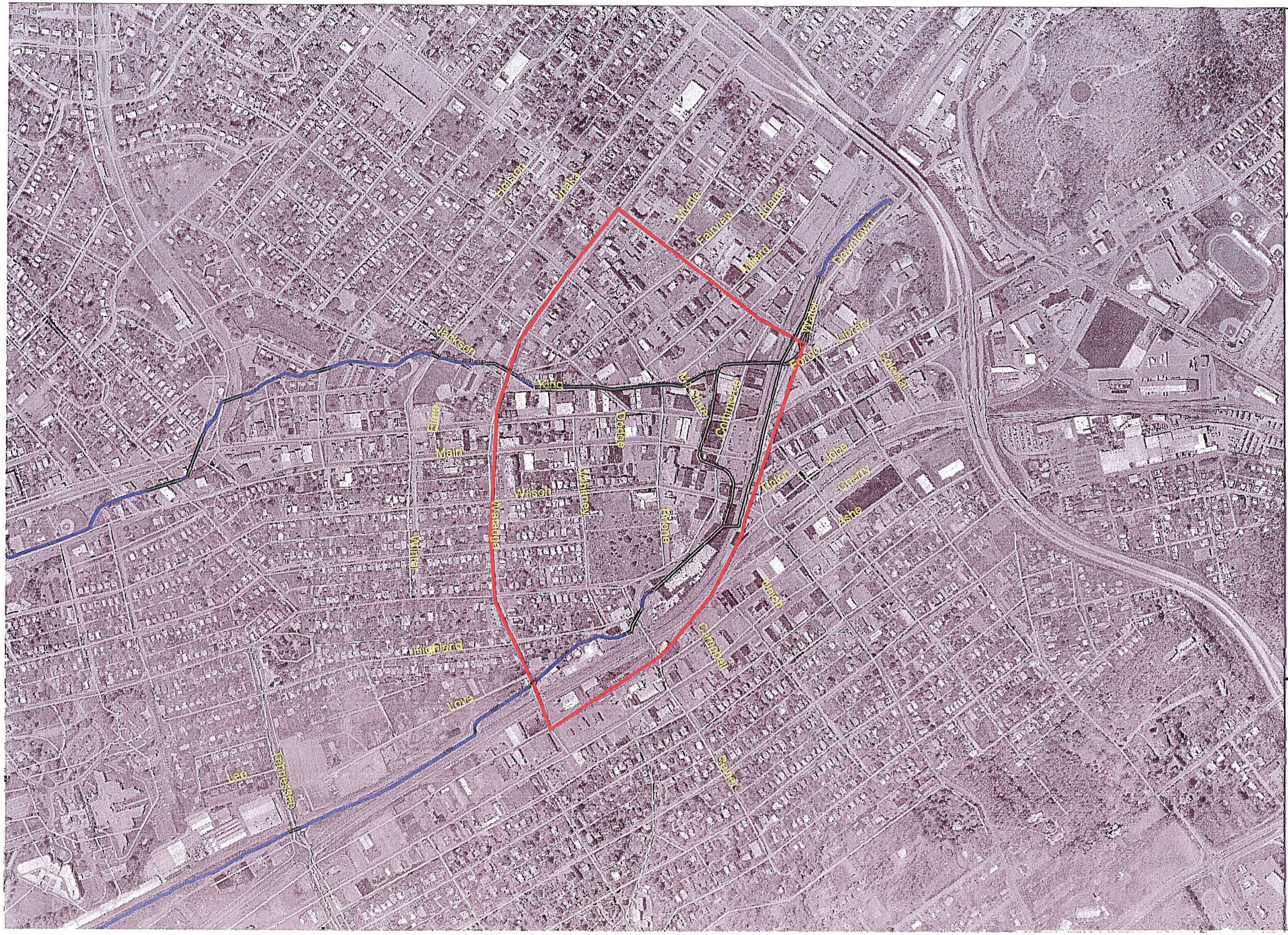

Figure I-1
City of Johnson City,
Tennessee

Brush Creek and King Creek
Downtown Study Area

Legend

Downtown Study Area
Model Conduits
Open Channel
Closed Conduit
Street Centerlines

N

200 0 200 400 600 Feet

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Published rainfall data are typically utilized in hydrologic analyses to determine the quantity of surface runoff generated by precipitation. This published rainfall data was developed from statistical analyses of historic rainfall events. In addition to total precipitation and event duration, the statistical analyses consider regional differences. The National Oceanic and Atmospheric Administration have published precipitation data that is widely utilized by professionals. The information published provides regional precipitation data for various "return period" storms. The return period refers to the chance a certain storm event may occur in any given year. In other words, a 2-year storm has a 50% chance of occurring in any given year, a 25-year storm has a 4% chance of occurring in any given year, and a 100-year storm event has a 1% chance of occurring in any given year. It is possible (although not statistically likely) for two 100-year storm events to occur in two consecutive years, or even the same year.

Today, storm water collection and conveyance systems, such as catch basins and pipe networks, are designed to accommodate more frequent (2-, 5-, 10-, or 25-year) storm events. However, current standards require major storm water management facilities, such as retention and detention basins, large dams, and flood prone areas, to be designed to accommodate less frequent and larger storms (50-, 100-, or 500-year).

Various methods have been developed to estimate the peak rate of surface runoff and the total quantity of runoff generated during storm events. Some methods are more sophisticated than others, but when properly considered, each method provides meaningful results. In general, all methods require the size of the watershed area to be determined, and land use characteristics to be identified, since it would be expected that one inch of rainfall on a one acre paved parking lot would generate more storm water runoff than one inch of rainfall on a farmer's one acre pasture. In addition, it would be expected that one inch of rainfall on the side of a mountain would generate more storm water runoff than one inch of rainfall on a flat pasture, since the accumulated precipitation would have more time to soak into the ground. Computer models have been developed to compute surface runoff quantities for selected storm events based on the range of hydrologic characteristics.

Hydrology is utilized to develop the quantity of runoff or peak rate of runoff for a selected storm event. Once developed, this information may then be utilized to design or evaluate the hydraulic capacity of storm water facilities. These facilities include detention and retention basins, storm water conveyance systems including pipes and culverts, or open channels, such as roadside ditches. In addition, surface runoff quantities for various storm events may be utilized to model floodplain characteristics including water surface elevations and floodplain limits.

COMPUTER MODEL

II

SECTION II

COMPUTER MODEL

This section provides a discussion of the methodology applied in collecting, evaluating and utilizing the various data for the modeling effort; stormwater modeling; hydrologic and hydraulic parameters for the watershed; and verification / calibration of the stormwater models.

The primary aspect of this study is the proper evaluation of water quantity (flooding) impacts to the downtown area of Johnson City, Tennessee. A good understanding of these impacts helps determine effective methods of controlling flooding and protecting public safety.

The RUNOFF (hydrology) and EXTRAN (hydraulics) blocks of the EPA Stormwater Management Model (SWMM), Version 4.4 were utilized to simulate water quantity. This section documents the methods used to perform the water quantity modeling evaluations, including identification of the serious problems in the downtown area to be addressed, the structure of the model software, and the assumptions and guidelines for using the model to represent the study areas within the City.

The following model screening criteria was utilized to choose the recommended water quantity model package for this study:

- Model credibility
  - Technically correct with demonstrated performance
  - Peer acceptance
  - Realistic
- Public domain and access to the source code
- Suitable for microcomputer applications
- Flexible and adaptable to the specific needs of the City of Johnson City, Tennessee, including growing needs to model stormwater quality
- User-friendly within the limits of data constraints
  - Pre- and post-processors to aid in data entry and results interpretation
  - Quality of documentation
- Maintenance of model by model developers
  - User groups
  - Periodic model updating and enhancements
- Applicable to the study area
  - Able to utilize existing City database

- Ability to utilize exiting databases from City of Johnson City Geographic Information (GIS), United States Army Corps of Engineers (USACOE), Federal Emergency Management Agency (FEMA) and United States Geological Survey (USGS).
- Represents key elements of stormwater management system (irregular and/or regular cross-sections, culverts, storage elements, boundary conditions, etc.)
- Calculates flows, velocities, and water surface elevations
- Considers backwater and surcharged pipe flow conditions
- Simulates flow reversals and interconnections
- Performs dynamic simulations of watershed-wide impacts
- Represents small basins (tens of acres) as well as large basins (hundreds of thousands of acres)
- Represents both urban and rural stormwater systems

RUNOFF provides an analysis of rainfall, runoff, infiltration, and simple hydrologic routing. The model is used to develop runoff hydrographs and to account for simple hydrologic routing of non-looping storm sewer systems. Output can also enter into EXTRAN at load points in the hydraulic network. RUNOFF was used to develop hydrographs for the 10-, and 100-year, 24-hour design storms.

The RUNOFF block of SWMM simulates the rates of runoff developed from basins using a non-linear reservoir approximation (Manning's equation). Hydrologic routing techniques are then used to route the overland flows through the pipe, culvert, and channel as required. Program results can be saved for input to the EXTRAN block of SWMM to perform dynamic hydraulic routing in downstream reaches.

RUNOFF was originally developed in 1970 as part of the original EPA SWMM. The program has been applied many times since its inception, and has gained worldwide acceptance. Over the years, the program has undergone many changes and modifications, although the main formulations and calculations remain mostly unchanged from the original codes.

Program modifications have been performed over the years by CDM and others to streamline program functions, and expand channel routing capabilities for use in stormwater master plan studies. A more complete documentation of the model's background and theory can be found in the SWMM 4.4 User's Manual.

EXTRAN provides dynamic flood routing for the channels, lakes, and structures in the city's Primary Stormwater Management System (PSWMS). Stages and flows from EXTRAN are the basis for the flood summary tables in the following sections. Stages estimated by EXTRAN could also be the basis for potential Federal Emergency Management Agency (FEMA) floodplain/elevation revisions. EXTRAN also reports average conduit peak velocities for use in problem area identification. EXTRAN was used to route design storms throughout the PSWMS in the Brush Creek and King Creek watersheds.

EXTRAN is a hydraulic flow routing model for open channel and/or closed conduit systems. It uses a link-node (conduit-junction) representation of the stormwater management system in an explicit finite difference solution of the equations of gradually varied, unsteady flow. EXTRAN receives hydrograph input at specific junctions by file transfer from a hydrologic model such as RUNOFF, and/or by manual input. The model performs dynamic routing of stormwater flows through the PSWMS to the points of discharge or outfalls. Since it is dynamic, it simultaneously considers both the storage and conveyance aspects of stormwater management facilities. The program will simulate branched or looped networks, backwater due to tidal or non-tidal conditions, free surface flow, pressure flow or surcharge, flow reversals, flow transfer by weirs, orifices, and pumping facilities, and storage at online or offline facilities. Types of conduits that can be simulated include circular, rectangular, horseshoe arch, elliptical, and basket handle pipes, plus trapezoidal or irregular channel cross-sections. Simulation output takes the form of water surface elevations and inundated areas at each junction and flows and velocities at each conduit.

EXTRAN was developed for the City of San Francisco in 1973. At that time, it was called the San Francisco Model or the WRE Transport Model. In 1974, EPA acquired this model and incorporated it into the SWMM package, calling it the Extended

Transport Model-EXTRAN to distinguish it from the TRANSPORT Model developed by the University of Florida as part of the original SWMM package. Since that time, the model has been refined, particularly in the way the flow routing is performed under surcharge conditions and in large open channel networks.

Several enhancements to EXTRAN have been implemented over the years since EXTRAN was originally released. In addition, minor changes were made to several algorithms for program efficiency and improved accuracy. The SWMM 4.4 User's Manual includes further details.

Hydrologic model parameters used for the model simulations are described in this section, and provide the resultant RUNOFF model data by hydrologic unit including: hydrologic unit alphanumeric identification, width, area, percent directly connected impervious area (DCIA), slope, Manning's roughness values, initial abstractions, infiltration rates, and soil storage values.

Topographic data was used to define hydrologic boundaries, overland flow slopes, channel slopes, critical flood elevations, and stage-area-storage relationships. Topographic data was made available from the City in the form of 2-ft contour data in a digital GIS format. Additionally, survey data was collected throughout Brush Creek and King Creek to characterize stream cross-sections, road profiles, and infrastructure inverts. The surveyed data was verified against contour information as a quality assurance measure.

Hydrologic units are generally defined by natural physical features or constructed stormwater management systems that control and direct stormwater runoff to a common outfall. The following general criteria were used to determine hydrologic unit boundaries:

- Large-scale physical features such as railroad grades and major roads were used to establish hydrologic divides.
- Hydrologic unit boundaries were delineated where structures of topographic features could appreciably impound water for the 100-year event.
- Johnson City Urban Drainage Study, Brush Creek Watershed.
- Flood Insurance Study, Washington County, Tennessee and Unincorporated Areas, October 16, 1996.
- Tennessee Valley Authority, Excerpts, Precipitation in Tennessee River Basin, July 1962.

The Brush Creek Watershed was subdivided into 23 hydrologic units ranging from approximately 29 acres to 659 acres. The King Creek Watershed was subdivided into 5 hydrologic units ranging from approximately 119 acres to 448 acres. Figure II-1 presents the hydrologic units used in the model and Table II-1 lists the spatial properties.

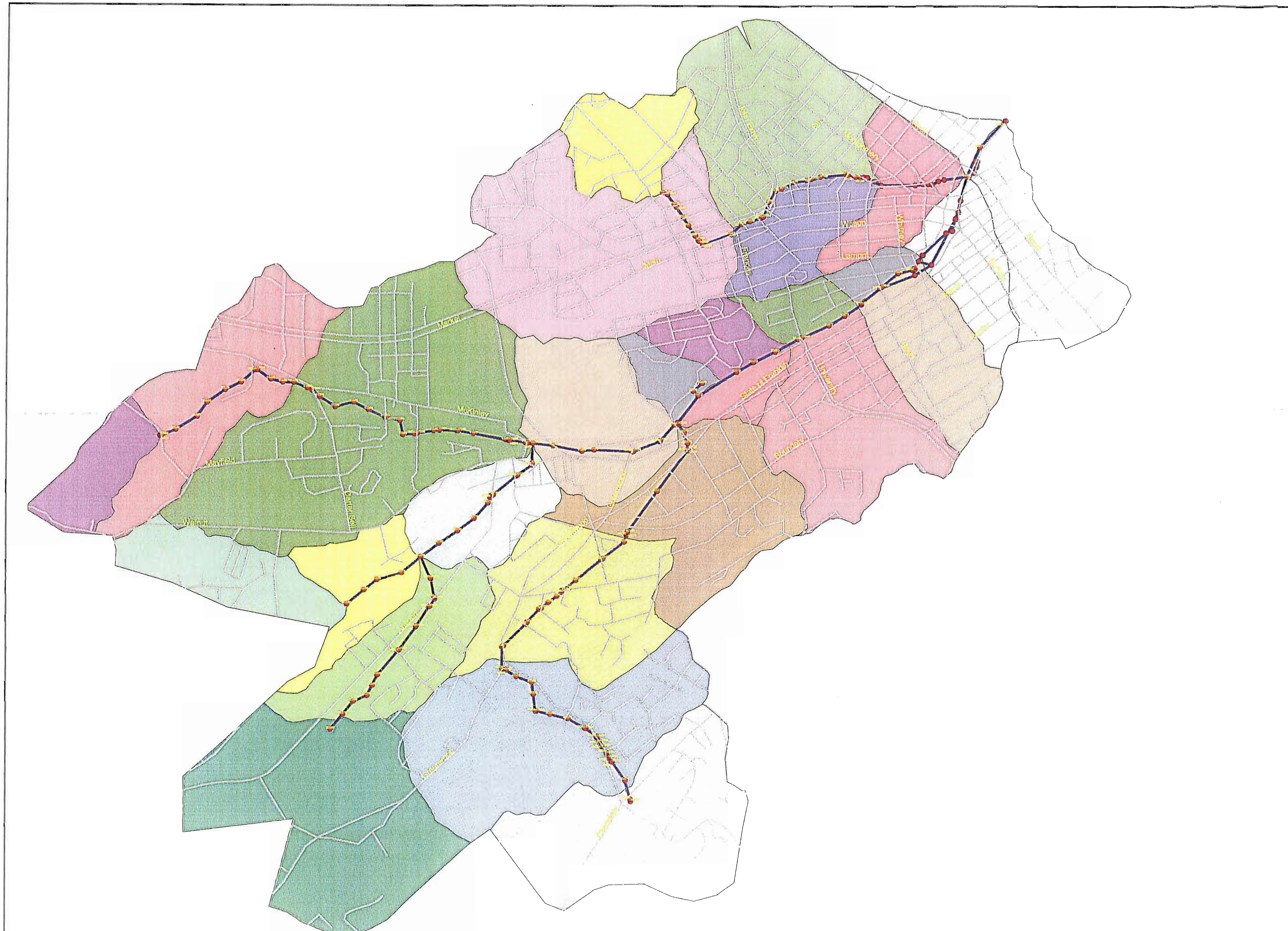

Figure II-1
City of Johnson City, Tennessee

Brush Creek and King Creek Hydrologic Units

Legend

Street Centerlines
JUNCTIONS
Conduits
Sub-Basins
1
2
3
4
5
6
7
8
9
10
11
12
13
14
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25
26
27
28

N

800 0 800 1600 Feet

LDA
CDM

Hydrologic basins were digitized as polygons as ArcView Shapefiles, which were then used to numerically calculate the area for each of the hydrologic unit delineations.

Table II-1

Hydrologic Units

Basin	Area (acres)
1	42
2	168
3	118
4	29
5	159
6	52
7	268
8	72
9	49
10	47
11	219
12	659
13	263
14	92
15	121
16	122
17	300
18	448
19	120
20	268
21	273
22	412
23	322
24	138
25	116
26	141
27	196
28	433
Total Area	**5,647**

Rainfall data was used to generate the flows for stormwater evaluations. Data is generally characterized by amount (inches), intensity (inches per hour), frequency, return period (years), duration (hours), spatial distribution (location variance), and temporal distribution (time variance). The design rainfall amounts for the 10- and 100-year frequency, 24-hour duration storms used for this study are:

- 100-Year, 24-Hour – 6.4 inches of rainfall
- 10-Year, 24-Hour – 4.8 inches of rainfall

Rainfall intensities were then generated for each design storm using the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) Type II rainfall distribution.

Soils data were used to evaluate stormwater runoff, infiltration, and recharge potential for pervious areas. Information on the Hydrologic Soil Groups (A, B, C, or D; NRCS-TR-55) were obtained from the City of Johnson City. Hydrologic Soil Group A is comprised of soils with a very high infiltration potential and a low runoff potential. Hydrologic soil Group D is comprised of soils with very low infiltration potential and a high runoff potential. The other two categories fall between A and D soil groups.

The percentage of each soil group for each basin was compiled using an overlay map of the catchments, and digitized overlay of the hydrologic soil groups. From the overlay map showing basin boundaries, the percent of each soil group within a basin was calculated for each hydrologic unit evaluated as part of this study. Based on the data provided, the soil in the study area is approximately 90% soil group B. Figure II-2 presents soil data, and Table II-2 presents a soil summary.

The RUNOFF module of SWMM uses both soil storage and infiltration rates to determine the volume of surface water runoff. Soil capacity (or soil storage) is a measure of the amount of storage (in inches) available in the soil type for a given antecedent moisture condition. The antecedent moisture condition (AMC) identifies the moisture levels in the soil during the time of evaluation. AMC I simulates dry conditions, AMC II for normal conditions and AMC III for wet conditions. The average antecedent moisture condition (AMC II) was used for all design storm analyses.

In order to manage the volume of data required to generate the SWMM RUNOFF data sets, spreadsheets were developed using Microsoft Excel© to semi-automate the process. Flow path data, land use data (including percent imperviousness), soil data, and tributary area measurements for each basin were input into a spreadsheet. The spreadsheet calculates area-weighted averages using the global Horton infiltration parameters and other global hydrologic parameters based on land use to generate basin information that can be directly input to the SWMM RUNOFF data set.

Figure II-2
City of Johnson City, Tennessee

Brush Creek and King Creek Soil Data

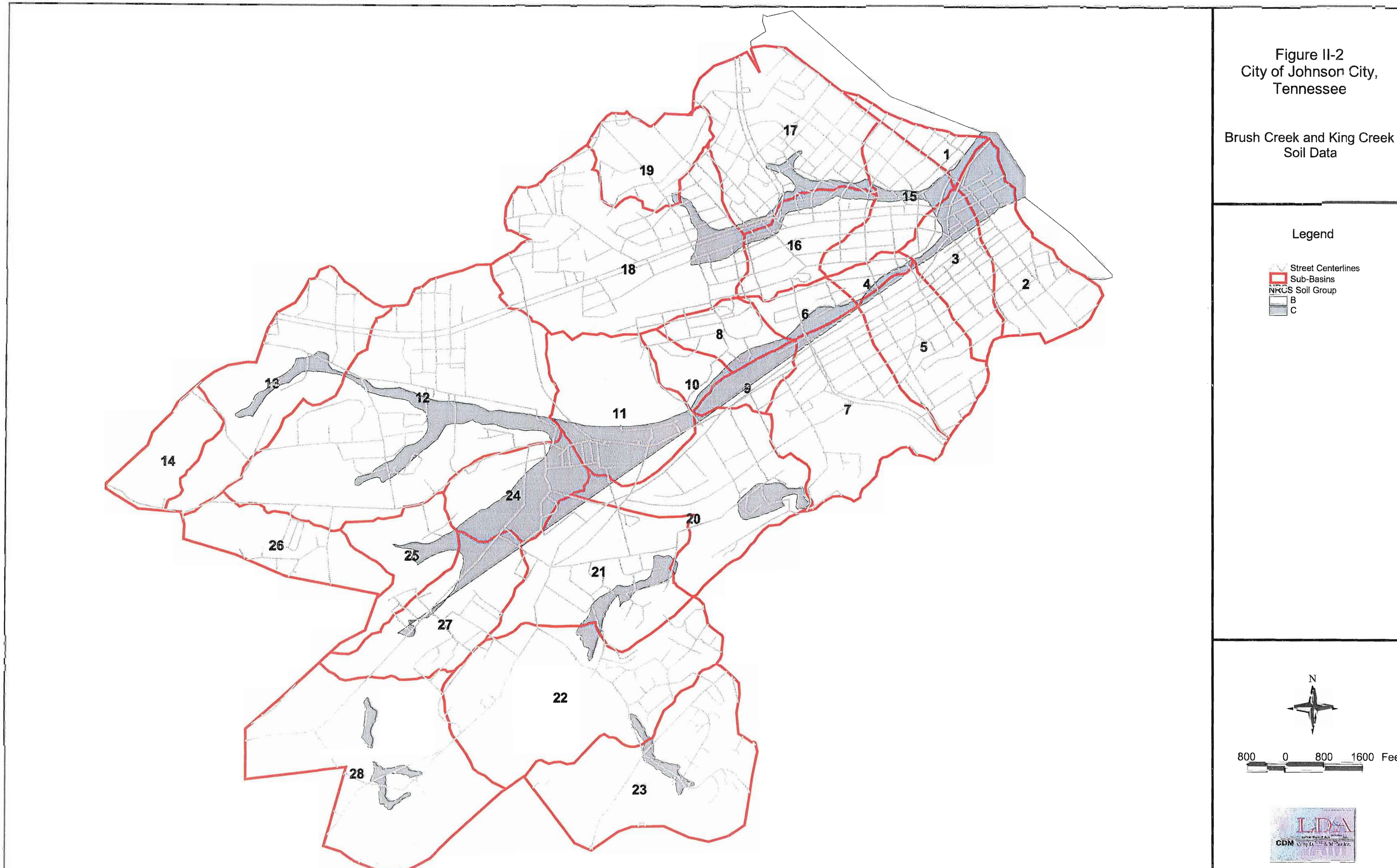


Table II-2

NRCS Soil Groups

	NRCS Soil Type (acres)		
Basin ID	**B**	**C**	**Total (acres)**
1	35	7	42
2	131	36	168
3	94	23	118
4	23	6	29
5	156	3	159
6	39	14	52
7	263	5	268
8	62	9	72
9	21	28	49
10	43	4	47
11	156	64	219
12	599	60	659
13	247	16	263
14	92		92
15	106	15	121
16	99	22	122
17	276	24	300
18	424	24	448
19	119	1	120
20	238	30	268
21	245	28	273
22	403	9	412
23	312	9	322
24	57	80	138
25	105	11	116
26	141	0	141
27	165	30	196
28	417	15	433
Total (acres)	**5,068**	**573**	**5,647**

The RUNOFF module of SWMM uses overland flow data in the form of width, slope, and Manning's roughness to create a physically based overland flow runoff plane to route runoff to conduits and storage for further routing. The overland flow hydraulic length (L) is the weighted-average travel length to the point of interest. The need for a weighted average is apparent for areas with odd geometry where a long, thin portion of the area may bias the L. For ponded areas, the point of interest chosen was the centroid of ponding. For areas where ponding does not occur, the point of interest is the outflow from the area. Overland flow length is used to better estimate hydrologic unit width for the RUNOFF overland flow routing by use of the equation:

$$A = LW;$$

where:

A = basin area (sq. ft.),

L = overland flow length (ft.), and

W = overland flow width (ft.)

The width was then checked on the base map to confirm that the length, does not appear to be biased.

Overland flow slope is the average slope over the hydraulic length and is calculated by dividing the difference in elevation by the hydraulic length. Length and slope information were estimated from topographic map data and field inspection data.

Manning's roughness is used for the overland flow routing using Manning's equation. Table II-3 lists typical values for shallow overland flow Manning's n. Note that pervious land use coverages appear "rough" because the depth of overland flow (a few inches) is equal to or less than the roughness feature.

Table II - 3

Estimate of Manning's Roughness Coefficients for Overland Flow

Source	***Ground Cover***	***Manning's n***	***Range***
Crawford and Linsley (1966)[a]	Smooth asphalt	0.012	
	Asphalt of concrete paving	0.014	
	Packed clay	0.03	
	Light turf	0.20	
	Dense turf	0.35	
	Dense shrubbery and forest litter	0.4	
Engman (1986)[b]	Concrete or asphalt	0.011	0.01-0.013
	Bare sand	0.01	0.01-0.16
	Graveled Surface	0.02	0.012-0.03
	Bare clay-loam (eroded)	0.02	0.012-
	Range (natural)	0.13	0.033
	Bluegrass sod	0.45	0.01-0.32
	Short grass prairie	0.15	0.39-0.63
	Bermuda grass	0.41	0.10-0.20
			0.30-0.48

Notes:

a *Obtained by calibration of Stanford Watershed Model*

b *Computed by Engman (1986) by kinematic wave and storage analysis of measured rainfall-runoff data.*

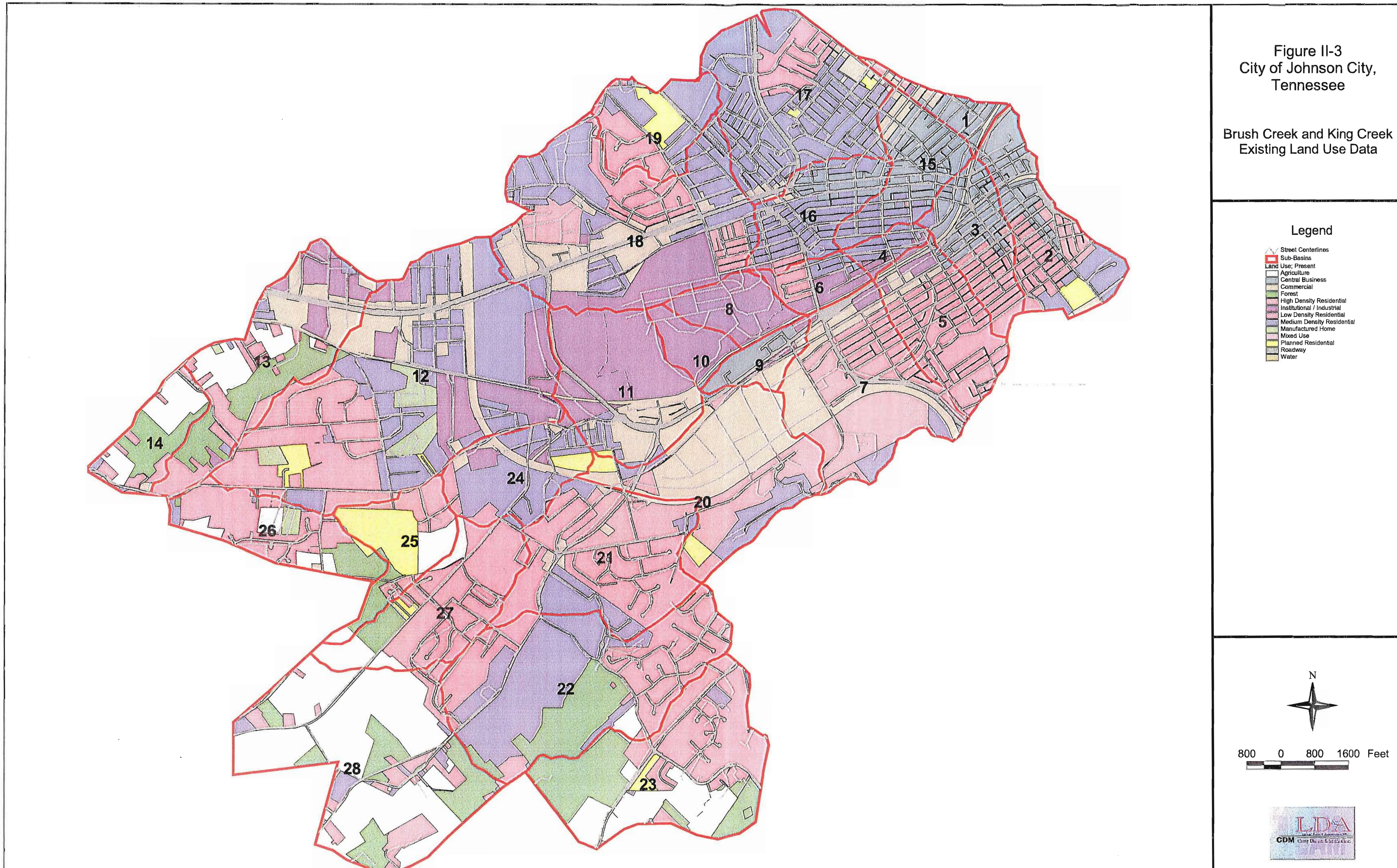
Land use data was used to estimate impervious areas for individual hydrologic units for use in runoff calculations. Imperviousness and directly connected imperviousness were estimated from the City of Johnson City's Current Land Use Criteria, and checked through a sampling of the major land uses. Existing land use data for the City was obtained from the aerial photography, and the City's Zoning GIS data.

Using the existing land use data, the percentage of each land use category within each basin was determined. The percent imperviousness of each hydrologic unit is one of the parameters used by the SWMM RUNOFF model to determine the volume and rate of surface water runoff. Based on this information, the area-weighted average percent imperviousness for each hydrologic unit was computed using the percent of each land use category within a hydrologic unit for existing conditions. Figure II-3 illustrates the existing land use condition. It is assumed that new development shall accommodate the increased runoff volumes and flow rates, therefore, future land use scenarios were not evaluated.

The Brush Creek and King Creek primary storm water management system consists of streams, culverts, and regional detention ponds. The first step in the model development was the creation of a simplified representation of the actual system for input into the storm water models. This was done by developing a model schematic, which was also used for checking input data and interpreting output data. The model schematic is presented in Figure II-4.

Figure II-3
City of Johnson City, Tennessee

Brush Creek and King Creek Existing Land Use Data



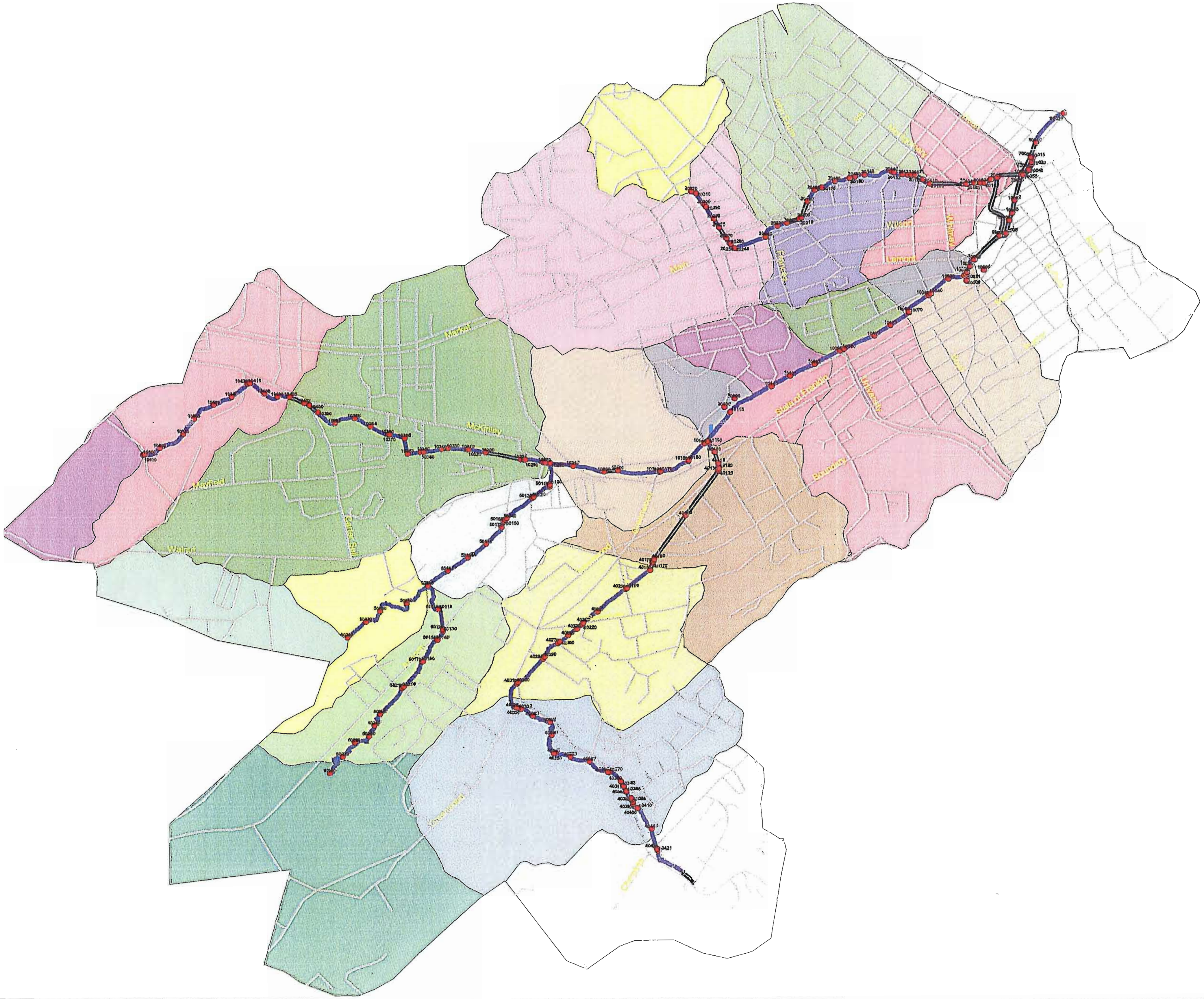


Figure II-4
City of Johnson City,
Tennessee

Brush Creek and King Creek
Model Schematic

Legend

- JUNCTIONS
- Model Conduits
  - Open Channel
  - Closed Conduit
  - Detention Facility
  - Street Centerlines
- Sub-Basins
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9
  - 10
  - 11
  - 12
  - 13
  - 14
  - 15
  - 16
  - 17
  - 18
  - 19
  - 20
  - 21
  - 22
  - 23
  - 24
  - 25
  - 26
  - 27
  - 28

N

800 0 800 1600 Feet

LD&A
CDM

Identification numbers for various system elements are shown on the schematic to provide a quick reference between the physical system and the model system. The following paragraphs describe the information used to develop the SWMM EXTRAN hydraulic model.

One component of this study was the survey and inventory of the storm water facilities in the Brush Creek and King Creek watersheds. The survey, conducted by a registered land surveyor, included major system components. Stream cross-sections and road profiles were surveyed from approximately 50-feet beyond top of each bank. The remainder of the stream cross-sections and road profiles were extracted from the city's GIS based 2-foot contour topographic data and "spliced" on to the surveyed cross-section data using an ArcView routine developed by CDM.

Lamar Dunn & Associates, Inc. and CDM staff performed the inventory throughout the Brush and King Creek watersheds. The inventoried facilities included locations, lengths, pipe/channel dimensions, and pipe/channel construction material. The survey and inventory information formed the foundation for the model representation of the modeled system. Lamar Dunn & Associates, Inc. and CDM staff performed additional field visits to further update and refine the data for the model and evaluations. Figure II-5 illustrates the survey data collected for this study and the cross sections "cut" from two foot contour data.

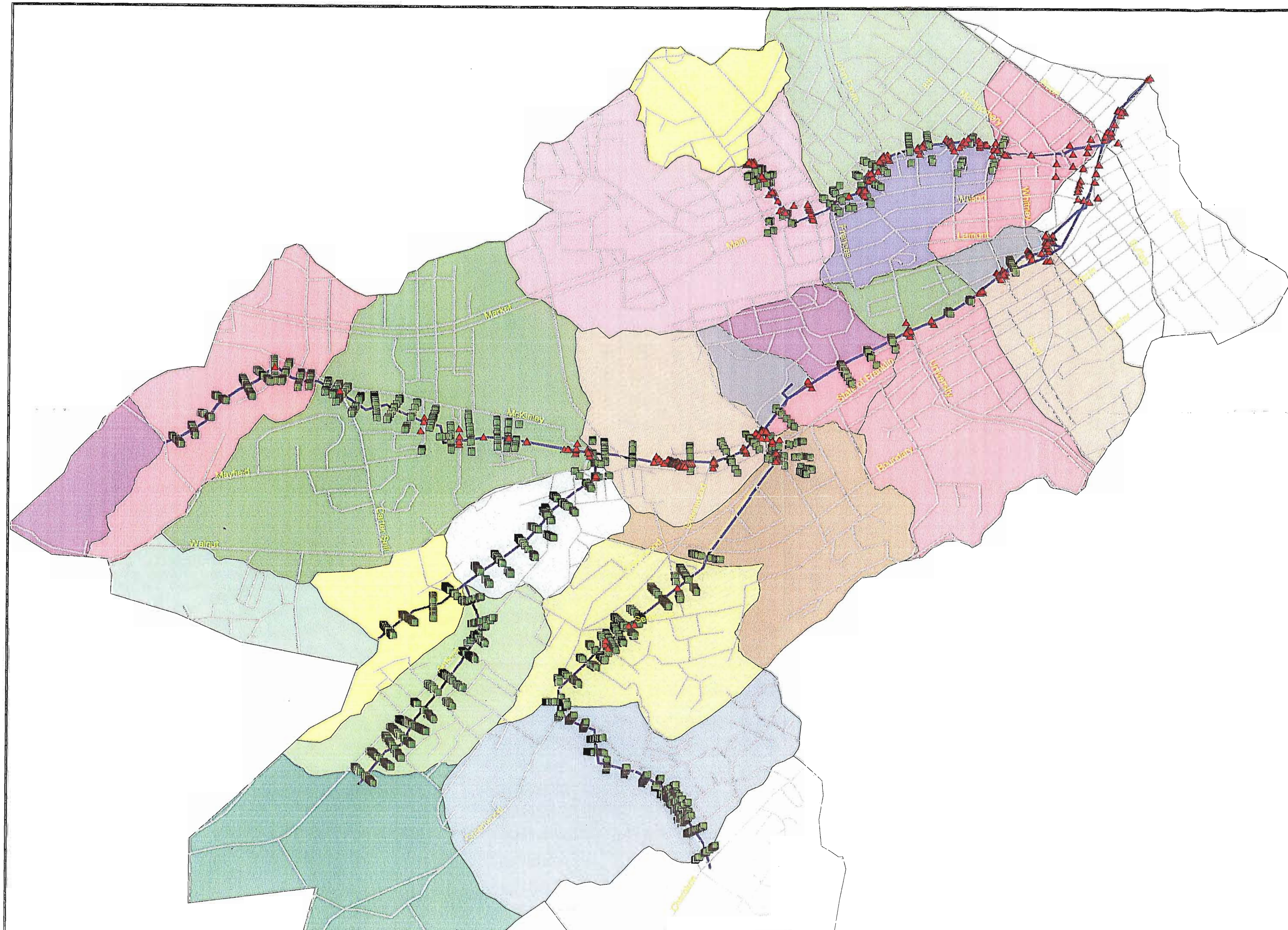


Figure II-5
City of Johnson City, Tennessee

Brush Creek and King Creek Survey and Cut Cross Section Data

Legend

- Survey Data
- "Cut" Cross Sections
- Street Centerlines
- Conduits

Sub-Basins: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28

N

700 0 700 1400 Feet

LD&A
CDM

Stage-area information was developed by planimetering topographic contours for major depression areas that could not be uniformly incorporated into channel cross sections. This process was done to more accurately reflect floodplain storage. The same procedure was applied to the existing detention ponds. Stage-area relationships for existing facilities were obtained from survey data, or estimated from topographic data provided by the City in the GIS topography data. The volume of storage was internally calculated by stormwater models using the trapezoidal method.

In the EXTRAN model, equivalent conduits were created in order to account for local or transitional losses. This was accomplished through standard procedures based upon Manning's equation. Conduits were lengthened and/or combined as necessary and Manning's roughness values were adjusted to maintain equal flow for an equal head loss.

Local losses such as headwalls, manholes, etc. cause abrupt changes in the hydraulic grade lines that are not accounted for implicitly in the model. Therefore, local losses must be incorporated into the Manning's n of the conduit (or alternative local loss methods must be used) to compute these discrete losses of head. The guidelines in Table II-4 and Table II-5 were used when assigning local loss coefficients.

Table II-4

Entrance Loss Coefficients

Type of Structure and Design of Entrance	Coefficient K_{ent}
Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. Cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius - 1/12 D)	0.2
Mitered to conform to fill slope	0.7
End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved	0.7
End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10° to 25° to barrel square edge at	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

Table II - 5

Exit and In-Pipe Loss Coefficients

Description	**K**
Inlet to manhole	0.25
Manhole in straight section of closed conduit	0.10
Manhole at a 45° bend	0.25
Manhole at a 90° bend	0.50
Exit closed conduit to lake	1.00*
Exit closed conduit to open channel	0.3-0.5

*Head loss at an abrupt enlargement is characterized by the equation (Vennard and Street, 1982):

$$h_L = k_L \frac{(v_1 - v_2)^2}{2g};$$

where:

h_L = head loss at enlargement in feet
k_L = approximately 1.0 (by experimentation)
v_1 = velocity in upstream conduit, ft/sec
v_2 = velocity in downstream conduit, ft/sec
g = acceleration of gravity = 32.174 ft/sec^2

$$h_L = k_{exit} \frac{v_1^2}{2g} = \frac{(v_1 - v_2)^2}{2g}.$$

The exit coefficient k_{exit}, is computed as:

$$k_{exit} = \frac{(v_1 - v_2)^2}{v_1^2}.$$

For lakes, v_2 is approximately 0, and the previous equation yields a value of 1.0 for k_{exit}.

It is recommended that system storage alterations (from equivalent pipes or representations) be checked to ensure that the system storage is properly represented. When using stage-area junctions to account for floodplain storage, it is important to ensure that the stage-area relationship does not include the area composed of open channels (top width) since EXTRAN channels also account for storage as well as conveyance.

Hydraulic boundary conditions are needed in order to simulate the tailwater effects on the system. For this study, the system outfall was modeled as a free outfall indicating there are no tailwater effects applied from downstream of the modeled system.

Several assumptions were made during the development of the hydraulic model. These include:

- The channel and conduit system were "clean" (currently this is not the case),
- Design storm rainfall information not specific to Brush and King Creek, and
- Base flow was estimated based on the water depth observed during field visits to the system.

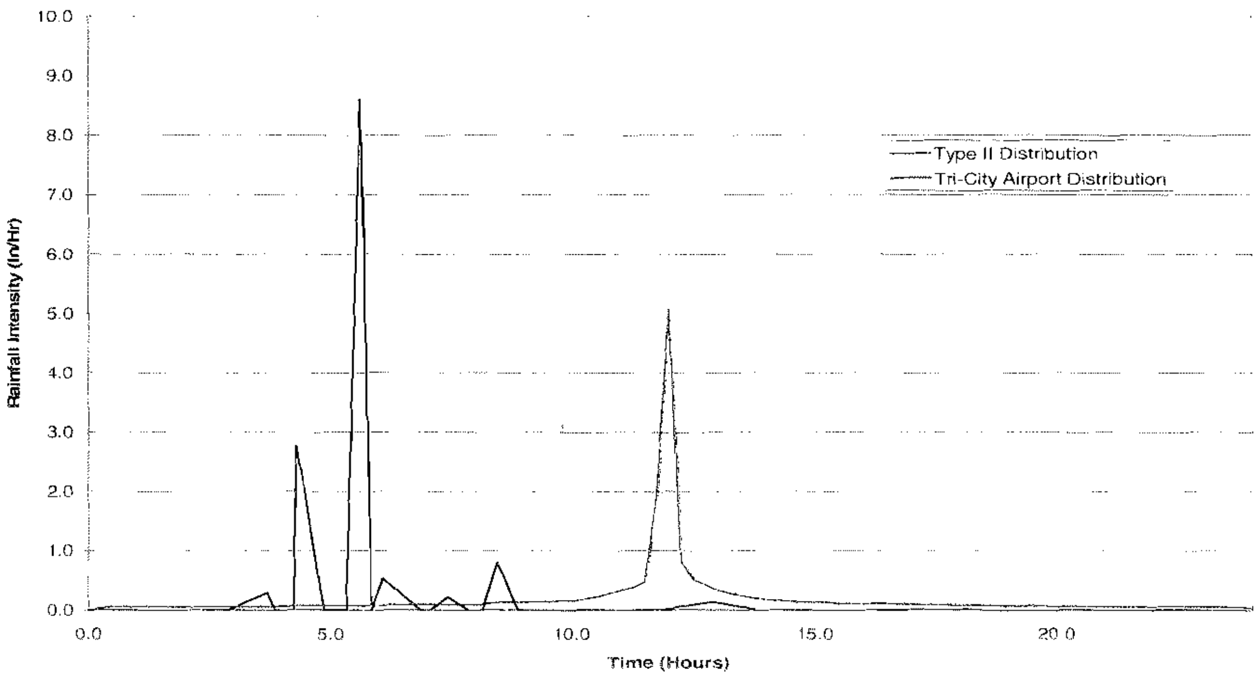
Calibration and verification are desirable to establish a "reality check" of predicted stages, flows, and velocities. For calibration or verification, data must be available in the form of rainfall, stage, flow, and/or high-water marks for specific storm events, land use, and hydraulic conditions.

Data was not available to perform a comprehensive calibration of the system model; however, the model results were verified with the system's response during the August 1, 2003 storm event. The August 1, 2003 storm event totaling 4.67 inches at the ETSU rain gauge was exacerbated by saturated soils from preceding storms on July 29, 30, and 31, totaling 0.11, 0.73, and 0.81 inches respectively. Flooded areas were reported throughout the study area and across the city forcing closure of much of the downtown area.

The National Climatic Data Center (NCDC) rain gauge data, located in the Brush Creek Watershed at East Tennessee State University (ETSU), was used to load the hydrologic and hydraulic models for King and Brush Creek. The ETSU rain gauge (Coop ID 404659) is a daily station located at latitude 36:17:00, and longitude 082:22:00. The gauge measure 4.67 inches of rain for the August 1, 2003 storm event. Data from the Tri-City Regional TN/VA Airport and the Brush Creek Wastewater Treatment Plant were also evaluated; however, the ETSU data was used due to the proximity to the study area.

Peak flood stages for this event were surveyed at six locations throughout the study area. Four of these locations coincided with the modeled system. The draft model was loaded by distributing the 4.67 inches of rainfall using a type II distribution as well as the distribution observed at the Tri-City Airport. The rainfall intensity distributions are presented in Figure II-6. The output data from each model run were compared to the observed data. Based on the initial results, the modeled flow from the type II rainfall distribution more closely resembled the observed flows of the system. This model was further refined to match the observed flood stages.

Figure II – 6
Rainfall Intensity Duration



At locations where the difference in peak stages were greater than 0.5 feet, the system characteristics were verified and roughness coefficients refined to achieve an error of no more than plus or minus 0.5 feet. The comparison of observed flood stages to the verified model predictions at these locations are presented in Table II-6.

Table II - 6

Model Verification

Junction	Location	Observed Flood Stage (ft-NGVD)	Modeled Flood Stage (ft-NGVD)	Interpolated Flood Stage (ft-NGVD)	Difference (ft)
10020	Sevier Street	1630.7	1631.0		0.3
10040	Watauga Avenue	1635.1	1635.3		0.2
10160	Leonard Street	1659.3	1659.3		0.0
10180	Lyle Street	1661.4	1661.1	1661.6	0.1

BENCHMARKING INFORMATION

III

SECTION III

BENCHMARKING INFORMATION

A. DESIGN STORM RESULTS

The calibrated model was used to predict peak stages in the downtown area for the 10- and 100-year, 24-hour design storms for the current land use condition. The results of these analyses are presented in this section. The model predicted flooding of various roads and structures for each event, including areas outside of the downtown area along Brush and King Creek. Figure III-1 presents the predicted floodplains for the 10- and 100-year, 24-hour design storms throughout the study area. Figure III-2 presents the floodplains for the 10- and 100-year, 24-hour design storms in the downtown area. Table III-1 and Table III-2 present the peak stages at each junction for the 10- and 100-year, 24-hour design storms respectively.

Figure III-1
City of Johnson City, Tennessee

Brush Creek and King Creek
Design Storm Results Downtown
10-Year and 100-Year Floodplains

Legend

- 10-Yr, 24-Hr Floodplain
- 100-Yr, 24-Hr Floodplain
- Street Centerlines
- JUNCTIONS
- Conduits

N

200 0 200 400 Feet

LDA
CDM

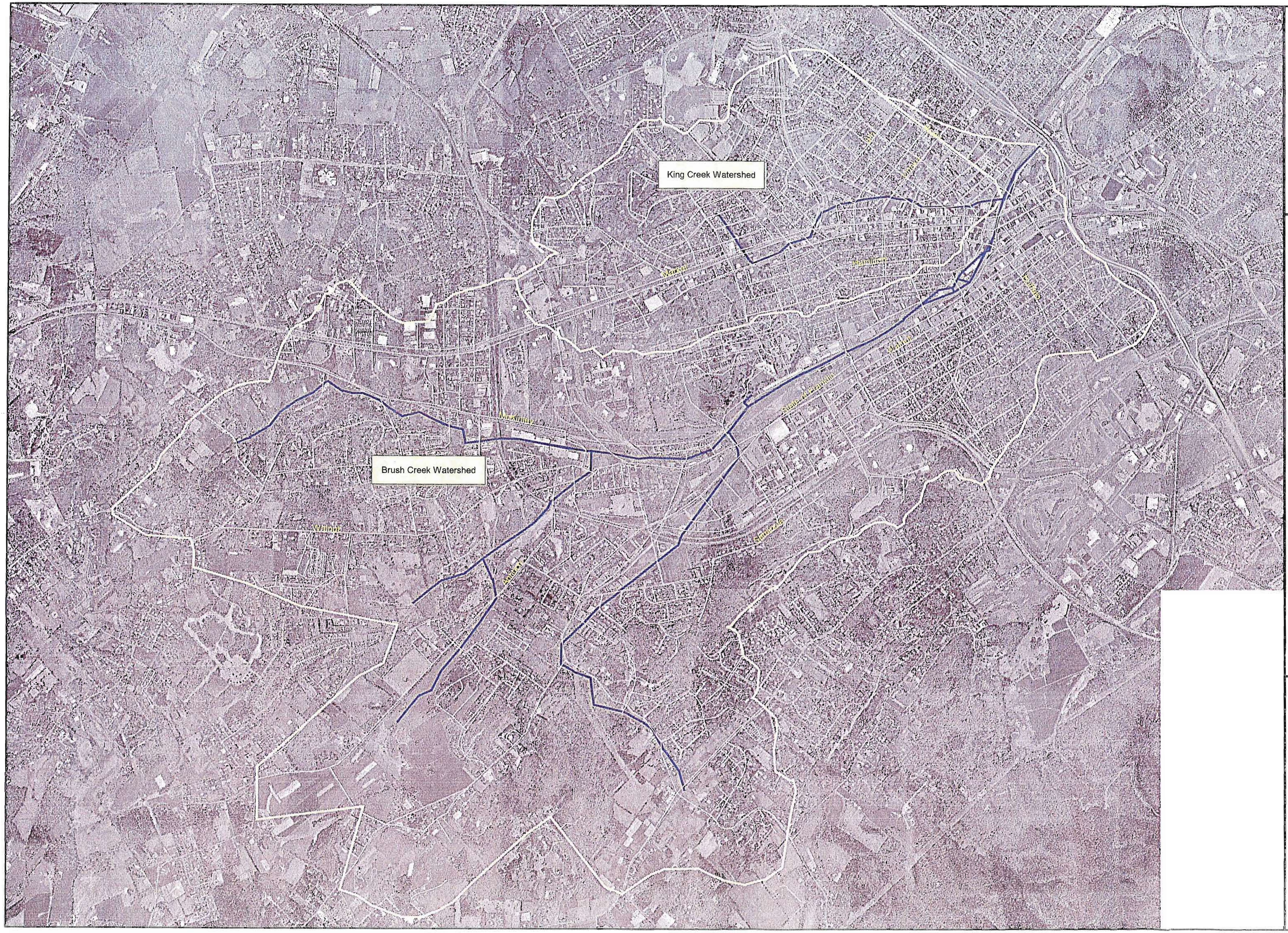


Figure III-2
City of Johnson City, Tennessee

Brush Creek and King Creek Watersheds

Legend

Street Centerlines
Conduits
Major Watersheds

N

900 0 900 1800 Feet

TABLE III - 1

10-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	10-Year Flood Stage (ft-NGVD)	10-Year Flooding (ft)
60300	1715			1719.4	
60270	1711			1713.9	
60260	1710.5			1712.4	
60250	1707.5			1710.2	
60240	1706.5			1709.1	
60230	1704			1708.4	
60210	1702.5	BEECHWOOD DRIVE	1706.0	1703.9	
60200	1701			1703.9	
60170	1695		1701.0	1699.5	
60160	1694.5	DRIVEWAY/ACCESS ROAD		1698.5	
60150	1692.75		1695.3	1697.2	2.0
60140	1692.5	DRIVEWAY		1697.2	
60130	1691	ANTIOCH ROAD	1698.0	1694.1	
60120	1690.5			1693.0	
60110	1686	DRIVEWAY	1690.0	1690.0	
60100	1685.5			1688.5	
50250	1706.5			1708.7	
50230	1698.5			1702.3	
50220	1688.5			1692.0	
50210	1684.5			1686.9	
50200	1681			1684.9	
50185	1680.5			1683.9	
50180	1679			1681.1	
50175	1674.5			1677.2	
50170	1672	RAILROAD	1674.5	1676.5	2.0
50160	1671.3			1675.6	
50150	1671	ANTIOCH ROAD	1676.0	1675.6	
50140	1670.5			1674.7	
50130	1669.1	EMBREEVILLE ROAD	1673.0	1673.6	0.6
50120	1669			1671.7	
50110	1666.6	WEST WALNUT STREET	1673.2	1671.4	
50100	1666.23			1671.2	

TABLE III - 1

10-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	10-Year Flood Stage (ft-NGVD)	10-Year Flooding (ft)
40421	1804	CHEROKEE ROAD	1812.0	1807.7	
40420	1803			1807.4	
40415	1800.5			1805.5	
40410	1799.5	DRIVEWAY	1802.5	1802.9	0.4
40400	1797			1802.5	
40390	1796.75	LONE OAK ROAD	1800.0	1802.5	2.5
40388	1796.5			1800.9	
40387	1796	DRIVEWAY	1800.5	1800.9	0.4
40386	1795			1800.9	
40385	1794	DRIVEWAY	1797.3	1800.9	3.7
40384	1792.5			1800.9	
40383	1792	DRIVEWAY	1796.5	1800.9	4.4
40382	1791.5			1800.9	
40381	1791	DRIVEWAY	1795.5	1800.9	5.4
40380	1798.5			1801.3	
40370	1786	DRIVEWAY	1790.5	1790.8	0.3
40360	1784			1787.6	
40357	1764.5			1767.8	
40353	1750.5			1755.4	
40350	1744.5	UNNAMED ROAD	1750.0	1751.4	1.4
40340	1742.5			1747.8	
40338	1736.5			1743.1	
40336	1730.5			1734.0	
40333	1714.5			1718.5	
40332	1705	GREENWOOD DRIVE	1710.0	1711.6	1.6
40330	1704.5	GREENWOOD DRIVE		1711.4	
40320	1701			1705.3	
40310	1694	GREENWOOD DRIVE	1700.0	1700.9	0.9
40300	1693			1697.1	
40290	1688.5	COLONY PARK DRIVE	1696.0	1696.9	0.9
40280	1688			1692.0	
40270	1685	MEADOWBROOK DRIVE	1690.0	1691.3	1.3

TABLE III - 1

10-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	10-Year Flood Stage (ft-NGVD)	10-Year Flooding (ft)
40260	1684.5			1688.2	
40255	1683			1687.2	
40230	1682			1686.5	
40220	1681.5	SEMINOLE DRIVE	1685.5	1686.3	0.8
40210	1680			1685.8	
40207	1680.5			1684.0	
40200	1674.5	ASHLEY ROAD	1679.0	1680.8	1.8
40190	1674			1678.1	
40180	1670.5	RAILROAD		1678.1	
40178	1668.5	RAILROAD		1676.5	
40175	1668			1674.7	
40170	1667.5	BOUNDARY DRIVE	1674.0	1674.7	0.7
40165	1667			1674.0	
40160	1666.5	ETSU ATHLETIC FIELDS	1673.0	1674.0	1.0
40135	1660	ETSU ATHLETIC FIELDS	1668.0	1669.7	1.7
40130	1656.03			1661.4	
40125	1656.37	JACK VEST DRIVE	1661.5	1661.4	
40120	1656.39			1660.8	
40118	1654.2	GREENWOOD DR/STATE OF FRANKLIN RD	1662.4	1659.6	
40110	1653.59			1659.0	
40100	1652.9	AMSOUTH BANK DRIVEWAY	1659.8	1658.7	
30100	1648			1657.2	
30090	1653			1657.2	
20320	1664.05	HARDING AVENUE	1667.8	1669.5	1.7
20310	1661.33			1663.7	
20300	1657.1	POLK AVENUE	1663.0	1663.6	0.6
20290	1656.33			1659.3	
20280	1652.09	JOHNSON AVE AND WEST MARKET ST	1657.0	1658.3	1.3
20275	1649.4			1653.8	
20270	1646.71			1653.7	

TABLE III - 1

10-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	10-Year Flood Stage (ft-NGVD)	10-Year Flooding (ft)
20260	1646.5	PARK ACCESS ROAD	1649.5	1653.5	4.0
20250	1646.25			1652.0	
20248	1644.5			1649.1	
20242	1640.5			1645.0	
20230	1637.9			1643.1	
20220	1636.63	HILLCREST DRIVE	1640.8	1642.7	1.9
20210	1635.41			1640.9	
20200	1632.93	JOHN EXUM / WEST MARKET STREET	1640.0	1640.8	0.8
20190	1629.93			1637.4	
20180	1629.2	JOHN EXUM PARKWAY	1637.1	1637.3	0.2
20170	1628.22			1636.2	
20165	1628			1633.4	
20160	1626.04	BELMONT AND ROBINSON	1629.7	1632.6	2.9
20150	1626.53			1631.0	
20148	1624.7			1630.4	
20140	1622.47	UNAKA AVENUE	1630.0	1628.6	
20132	1621.84			1627.4	
20131	1620.4			1627.3	
20130	1620.62			1626.6	
20121	1619.76		1624.0	1625.9	1.9
20120	1619.4	JACKSON AVENUE		1625.0	
20110	1618.63			1623.8	
20105	1616.66	KING STREET	1621.7	1623.6	1.9
20104	1612.4	WEST KING STREET	1619.5	1620.8	1.3
201031	1612.1		1618.3	1620.0	1.7
20103	1611.8	BOONE STREET	1617.5	1619.9	2.4
20102	1611.3		1617.0	1619.8	2.8
20101	1609.9	MCCLURE STREET	1618.0	1619.7	1.7
20100	1609.5		1618.0	1619.2	1.2
10610	1756	NUNLEY DRIVE	1759.0	1759.1	
10600	1755.75			1758.0	

TABLE III - 1

10-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	10-Year Flood Stage (ft-NGVD)	10-Year Flooding (ft)
10580	1746.5			1747.2	
10560	1738.5			1739.9	
10540	1732.25			1733.3	
10520	1724.5			1727.5	
10500	1718			1720.4	
10420	1714	CLOVERDALE LANE	1717.4	1718.9	1.5
10410	1712			1714.5	
10408	1708.75			1711.2	
10406	1706.25			1708.6	
10405	1701.5	CARTER SELLS ROAD	1706.5	1708.4	1.9
10402	1701			1706.4	
10400	1700.5	PARKING LOT	1704.3	1706.4	2.1
10390	1697.5			1699.8	
10388	1693			1694.5	
10386	1688.5			1690.5	
10384	1686.25			1690.4	
10380	1684.5	TRAILER PARK ROAD	1687.0	1688.8	1.8
10370	1684			1686.4	
10366	1682.25			1685.6	
10363	1678.75			1685.6	
10360	1677.6	L.P. AUER ROAD	1682.8	1685.6	2.8
10350	1677.4			1685.6	
10340	1675	CSX RAILROAD - NO OVERFLOW		1685.6	
10330	1674.8			1679.0	
10320	1671.42	BURLINGTON PLANT BRIDGE #2	1678.8	1678.0	
10310	1671.77			1673.7	
10300	1668.52	BURLINGTON INDUSTRIES	1674.0	1672.0	
10291	1665.33			1670.5	
10290	1664.2	BURLINGTON PLANT BRIDGE #1	1672.2	1670.5	

TABLE III - 1

10-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	10-Year Flood Stage (ft-NGVD)	10-Year Flooding (ft)
10280	1664.1			1669.8	
10270	1662.58	MCKINLEY ROAD	1668.7	1669.8	1.1
10260	1662.47			1666.0	
10250	1662			1666.0	
10240	1659.1			1664.8	
10200	1657.95	STATE OF FRANKLIN ROAD	1682.0	1662.6	
10190	1656.87			1661.7	
10180	1654.98	LYLE STREET	1659.4	1660.9	1.5
10170	1654.88			1660.0	
10160	1652.31	LEONARD STREET	1657.3	1658.6	1.3
10150	1652.97			1658.4	
10140	1651.58	GREENWOOD DRIVE	1658.7	1658.3	
10120	1651			1657.9	
10115	1648.5			1657.2	
10110	1644.5			1651.1	
10105	1642.25			1649.2	
10092	1640			1646.3	
10090	1636.59	TENNESSEE STREET	1645.1	1646.1	1.0
10080	1636.19			1644.1	
10077	1632.75			1640.8	
10073	1630.25			1639.8	
10070	1628.57	SOUTHERN RAILROAD	1637.2	1638.8	1.6
10060	1628.93			1638.6	
10050	1626.87	WATAUGA AVENUE	1634.3	1638.4	4.1
10040	1627.41			1635.2	
10038	1625.3			1635.0	
10032	1624.3	KELLYS FOOD PARKING	1631.3	1634.8	3.5
10031	1624.25			1631.8	
10030	1624.2			1631.6	
10020	1624.1			1631.0	
10010	1623.6	DOWNTOWN LOOP	1633.9	1630.6	
10009	1631			1633.1	

TABLE III - 1

10-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	10-Year Flood Stage (ft-NGVD)	10-Year Flooding (ft)
10008	1630			1631.7	
10006	1621			1622.3	
10005	1613.2			1620.8	
10004	1609.7		1622.5	1620.3	
10003	1608.6		1621.5	1618.4	
10002	1609.1		1619.8	1616.8	
10001	1607		1618.0	1615.5	
70055	1608.4			1615.2	
70050	1608.4			1615.2	
70040	1607.8			1615.2	
70030	1607.1			1615.2	
70020	1607			1615.2	
70015	1606.8			1615.2	
70010	1606.8			1615.2	
70005	1606.7			1614.9	
90010	1605.12			1614.2	
90020	1602.75	BOUNDARY		1608.6	

TABLE III - 2

100-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	100-Year Flood Stage (ft-NGVD)	100-Year Flooding (ft)
60300	1715			1720.1	
60270	1711			1714.5	
60260	1710.5			1712.8	
60250	1707.5			1710.8	
60240	1706.5			1709.8	
60230	1704			1708.9	
60210	1702.5	BEECHWOOD DRIVE	1706.0	1705.5	
60200	1701			1704.6	
60170	1695		1701.0	1701.1	0.1
60160	1694.5	DRIVEWAY/ACCESS ROAD		1699.4	
60150	1692.75		1695.3	1697.6	2.4
60140	1692.5	DRIVEWAY		1697.6	
60130	1691	ANTIOCH ROAD	1698.0	1695.5	
60120	1690.5			1693.5	
60110	1686	DRIVEWAY	1690.0	1690.4	0.4
60100	1685.5			1689.2	
50250	1706.5			1709.1	
50230	1698.5			1702.7	
50220	1688.5			1692.6	
50210	1684.5			1687.5	
50200	1681			1685.7	
50185	1680.5			1684.6	
50180	1679			1681.7	
50175	1674.5			1678.1	
50170	1672	RAILROAD	1674.5	1677.5	3.0
50160	1671.3			1677.2	
50150	1671	ANTIOCH ROAD	1676.0	1677.2	1.2
50140	1670.5			1675.5	
50130	1669.1	EMBREEVILLE ROAD	1673.0	1674.0	1.0
50120	1669			1672.8	
50110	1666.6	WEST WALNUT STREET	1673.2	1672.6	

TABLE III - 2

100-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	100-Year Flood Stage (ft-NGVD)	100-Year Flooding (ft)
50100	1666.23			1672.0	
40421	1804	CHEROKEE ROAD	1812.0	1809.0	
40420	1803			1808.2	
40415	1800.5			1806.6	
40410	1799.5	DRIVEWAY	1802.5	1803.0	0.5
40400	1797			1803.1	
40390	1796.75	LONE OAK ROAD	1800.0	1803.1	3.1
40388	1796.5			1801.5	
40387	1796	DRIVEWAY	1800.5	1801.5	1.0
40386	1795			1801.5	
40385	1794	DRIVEWAY	1797.3	1801.5	4.3
40384	1792.5			1801.5	
40383	1792	DRIVEWAY	1796.5	1801.5	5.0
40382	1791.5			1801.5	
40381	1791	DRIVEWAY	1795.5	1801.5	6.0
40380	1798.5			1802.1	
40370	1786	DRIVEWAY	1790.5	1791.1	0.6
40360	1784			1788.5	
40357	1764.5			1768.7	
40353	1750.5			1756.5	
40350	1744.5	UNNAMED ROAD	1750.0	1752.1	2.1
40340	1742.5			1748.9	
40338	1736.5			1744.4	
40336	1730.5			1734.9	
40333	1714.5			1719.6	
40332	1705	GREENWOOD DRIVE	1710.0	1712.3	2.3
40330	1704.5	GREENWOOD DRIVE		1712.1	
40320	1701			1706.1	
40310	1694	GREENWOOD DRIVE	1700.0	1701.4	1.4
40300	1693			1698.2	
40290	1688.5	COLONY PARK DRIVE	1696.0	1697.5	1.5
40280	1688			1693.1	

TABLE III - 2

100-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	100-Year Flood Stage (ft-NGVD)	100-Year Flooding (ft)
40270	1685	MEADOWBROOK DRIVE	1690.0	1692.2	2.2
40260	1684.5			1689.5	
40255	1683			1688.4	
40230	1682			1687.6	
40220	1681.5	SEMINOLE DRIVE	1685.5	1687.3	1.8
40210	1680			1687.3	
40207	1680.5			1685.2	
40200	1674.5	ASHLEY ROAD	1679.0	1682.8	3.8
40190	1674			1682.6	
40180	1670.5	RAILROAD		1682.6	
40178	1668.5	RAILROAD		1678.9	
40175	1668			1675.0	
40170	1667.5	BOUNDARY DRIVE	1674.0	1675.0	1.0
40165	1667			1674.3	
40160	1666.5	ETSU ATHLETIC FIELDS	1673.0	1674.3	1.3
40135	1660	ETSU ATHLETIC FIELDS	1668.0	1669.9	1.9
40130	1656.03			1662.3	
40125	1656.37	JACK VEST DRIVE	1661.5	1662.3	0.8
40120	1656.39			1661.6	
40118	1654.2	GREENWOOD DR/STATE OF FRANKLIN RD	1662.4	1661.6	
40110	1653.59			1660.6	
40100	1652.9	AMSOUTH BANK DRIVEWAY	1659.8	1660.4	0.6
30100	1648			1658.5	
30090	1653			1658.5	
20320	1664.05	HARDING AVENUE	1667.8	1669.8	2.0
20310	1661.33			1664.2	

TABLE III - 2

100-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	100-Year Flood Stage (ft-NGVD)	100-Year Flooding (ft)
20300	1657.1	POLK AVENUE	1663.0	1663.9	0.9
20290	1656.33			1660.0	
20280	1652.09	JOHNSON AVE AND WEST MARKET ST	1657.0	1659.2	2.2
20275	1649.4			1655.0	
20270	1646.71			1654.8	
20260	1646.5	PARK ACCESS ROAD	1649.5	1654.7	5.2
20250	1646.25			1652.5	
20248	1644.5			1649.6	
20242	1640.5			1645.5	
20230	1637.9			1643.9	
20220	1636.63	HILLCREST DRIVE	1640.8	1643.5	2.7
20210	1635.41			1641.7	
20200	1632.93	JOHN EXUM / WEST MARKET STREET	1640.0	1641.6	1.6
20190	1629.93			1640.0	
20180	1629.2	JOHN EXUM PARKWAY	1637.1	1640.0	2.9
20170	1628.22			1637.4	
20165	1628			1634.1	
20160	1626.04	BELMONT AND ROBINSON	1629.7	1633.2	3.5
20150	1626.53			1631.7	
20148	1624.7			1631.2	
20140	1622.47	UNAKA AVENUE	1630.0	1630.4	0.4
20132	1621.84			1628.1	
20131	1620.4			1628.0	
20130	1620.62			1627.2	
20121	1619.76		1624.0	1626.2	2.2
20120	1619.4	JACKSON AVENUE		1625.4	
20110	1618.63			1624.2	
20105	1616.66	KING STREET	1621.7	1623.9	2.2
20104	1612.4	WEST KING STREET	1619.5	1621.1	1.6

TABLE III - 2

100-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	100-Year Flood Stage (ft-NGVD)	100-Year Flooding (ft)
201031	1612.1		1618.3	1620.4	2.2
20103	1611.8	BOONE STREET	1617.5	1620.4	2.9
20102	1611.3		1617.0	1620.3	3.3
20101	1609.9	MCCLURE STREET	1618.0	1620.2	2.2
20100	1609.5		1618.0	1620.2	2.2
10610	1756	NUNLEY DRIVE	1759.0	1759.6	0.6
10600	1755.75			1758.5	
10580	1746.5			1747.4	
10560	1738.5			1740.3	
10540	1732.25			1733.7	
10520	1724.5			1728.1	
10500	1718			1720.9	
10420	1714	CLOVERDALE LANE	1717.4	1719.2	1.8
10410	1712			1714.8	
10408	1708.75			1711.7	
10406	1706.25			1709.1	
10405	1701.5	CARTER SELLS ROAD	1706.5	1708.8	2.3
10402	1701			1706.9	
10400	1700.5	PARKING LOT	1704.3	1706.9	2.6
10390	1697.5			1700.3	
10388	1693			1695.0	
10386	1688.5			1691.2	
10384	1686.25			1691.2	
10380	1684.5	TRAILER PARK ROAD	1687.0	1689.1	2.1
10370	1684			1688.3	
10366	1682.25			1688.3	
10363	1678.75			1688.3	
10360	1677.6	L.P. AUER ROAD	1682.8	1688.3	5.5
10350	1677.4			1688.3	
10340	1675	CSX RAILROAD - NO OVERFLOW		1688.3	
10330	1674.8			1679.5	

TABLE III - 2

100-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	100-Year Flood Stage (ft-NGVD)	100-Year Flooding (ft)
10320	1671.42	BURLINGTON PLANT BRIDGE #2	1678.8	1678.9	0.1
10310	1671.77			1673.8	
10300	1668.52	BURLINGTON INDUSTRIES	1674.0	1673.6	
10291	1665.33			1671.1	
10290	1664.2	BURLINGTON PLANT BRIDGE #1	1672.2	1671.0	
10280	1664.1			1670.0	
10270	1662.58	MCKINLEY ROAD	1668.7	1670.0	1.3
10260	1662.47			1666.5	
10250	1662			1666.5	
10240	1659.1			1665.5	
10200	1657.95	STATE OF FRANKLIN ROAD	1682.0	1663.8	
10190	1656.87			1662.3	
10180	1654.98	LYLE STREET	1659.4	1661.4	2.0
10170	1654.88			1660.8	
10160	1652.31	LEONARD STREET	1657.3	1660.2	2.9
10150	1652.97			1659.9	
10140	1651.58	GREENWOOD DRIVE	1658.7	1659.7	1.0
10120	1651			1659.1	
10115	1648.5			1658.5	
10110	1644.5			1652.1	
10105	1642.25			1650.4	
10092	1640			1647.4	
10090	1636.59	TENNESSEE STREET	1645.1	1647.0	1.9
10080	1636.19			1645.8	
10077	1632.75			1642.3	
10073	1630.25			1641.0	
10070	1628.57	SOUTHERN RAILROAD	1637.2	1639.6	2.4
10060	1628.93			1639.3	

TABLE III - 2

100-YEAR, 24-HOUR DESIGN STORM PEAK STAGES

Junction	Junction Invert (ft-NGVD)	Location	Road/Driveway Crest Elevation (ft-NGVD)	100-Year Flood Stage (ft-NGVD)	100-Year Flooding (ft)
10050	1626.87	WATAUGA AVENUE	1634.3	1639.1	4.8
10040	1627.41			1635.5	
10038	1625.3			1635.3	
10032	1624.3	KELLYS FOOD PARKING	1631.3	1635.0	3.7
10031	1624.25			1631.8	
10030	1624.2			1631.6	
10020	1624.1			1631.0	
10010	1623.6	DOWNTOWN LOOP	1633.9	1630.6	
10009	1631			1633.7	
10008	1630			1632.2	
10006	1621			1625.0	
10005	1613.2			1624.7	
10004	1609.7		1622.5	1624.0	1.5
10003	1608.6		1621.5	1622.7	1.2
10002	1609.1		1619.8	1621.1	1.3
10001	1607		1618.0	1618.4	0.4
70055	1608.4			1617.9	
70050	1608.4			1617.9	
70040	1607.8			1617.9	
70030	1607.1			1617.8	
70020	1607			1617.8	
70015	1606.8			1617.8	
70010	1606.8			1617.8	
70005	1606.7			1617.2	
90010	1605.12			1615.6	
90020	1602.75	BOUNDARY		1610.3	

PROPOSED MITIGATION COMPONENTS

IV

SECTION IV

POTENTIAL MITIGATION COMPONENTS

There are many types of non-structural and structural measures that can either solve or alleviate stormwater flooding problems. The US Federal Emergency Management Agency (FEMA) has adopted four main floodplain management strategies (French and Associates Ltd., 1998). Table IV-1 summarizes the non-structural and structural measures that can be used to achieve these strategies, which include:

- Modify human susceptibility to flood damage by reducing disruption through avoidance of hazardous, uneconomic or unwise use of floodplains,
- Modify the impact of flooding by assisting individuals and communities prepare for, respond to and recover from flood damage,
- Modify flooding itself by constructing improvements that control floodwater,
- Preserve and restore natural resources by reestablishing and maintaining floodplain environments in their natural state.

These solution types can be adapted and applied in a broader stormwater management context. The focus of this study is on structural solutions as applied to the flooding issues in the downtown area. A general discussion of structural controls is presented in the following section.

TABLE IV-1

FEMA FLOODPLAIN MANAGEMENT STRATEGIES AND SOLUTIONS

Strategy	Solution
Modify Susceptibility to Flood Damage	Floodplain regulations
	Land use planning codes and ordinances
	Engineering design policies and standards
	Floodplain preservation and restoration
	Floodproofing flood-prone structures
	Flood forecasting/warning systems
Modify Impact of Flooding	Public information and education programs
	Emergency response plans
	Disaster assistance, flood insurance and financial incentives
	Post-flood recovery plans
Modify Flooding Itself	Facilities to store excess runoff
	Dikes, levees, and floodwalls to keep excess runoff away
	Channel improvements to convey excess runoff
	Runoff source controls that encourage infiltration and on-site detention
Preserve and Restore Natural Resources	Regulations to protect environmental sensitive areas
	Land use planning codes and ordinances
	Engineering design policies and standards
	Floodplain, open space, and wetland preservation and restoration
	Public information and education programs
	Financial incentives

Runoff source controls limit the discharge of runoff into the stormwater management system. Runoff can be controlled at its source by:

- Reducing the amount of impervious area through alternative site development designs that reduce the area of pavement and concrete on roadways, parking lots, and sidewalks, or through the use of pervious paving materials,
- Constructing stormwater management facilities that promote infiltration of runoff into the soil.

Investments in runoff source controls will minimize the cost of all the other types of structural improvements that merely redistribute stormwater runoff within the system. Apart from source controls, there are three ways to control excess runoff in stormwater management systems:

- Convey excess runoff elsewhere. This involves moving flows to an appropriate location either by gravity or pumping.
- Store excess runoff. This involves detention or retention to hold back flows at critical times.
- Accommodate excess runoff. This involves either preventing or minimizing damage to flood prone structures.

Conveyance improvements are often the best hydraulic solution to flooding problems that are caused by a localized constriction within the drainage system. These improvements are typically designed to increase the existing conveyance capacity, allowing the water to move more quickly or efficiently downstream away from the flooded area. While generally improving flooding conditions upstream, an evaluation of conveyance improvements must consider the potential increase of flooding conditions downstream. Table IV - 2 shows various conveyance improvement options.

TABLE IV - 2

CONVEYANCE IMPROVEMENTS

TYPE	DESCRIPTION
Bridge replacement	Replacement of existing bridge
Culvert replacement	Replacement of existing culvert
Culvert addition	Addition of culvert, parallel to existing culvert
Constrained channel improvements	Channel widening/regrading to increase flow capacity, constrained by available space
Unconstrained channel improvements	Available space allows room to construct two-stage naturalized stream
Channel realignment	New channel alignment within the same reach
Diversion channel	Diversion channel to a new reach, tributary, or watershed
Storm sewer replacement	Replacement of existing storm sewer pipe
Storm sewer addition	Addition of storm sewer pipe, parallel to existing storm sewer
Storm sewer realignment	New storm sewer alignment within the same reach
Diversion storm sewer	Diversion storm sewer to a new reach, tributary, or watershed
New pump station	Construct a new pump station where gravity solutions are not feasible
Modify existing pump station	Modify existing pump station (upgrade capacity or reconfiguration of operating controls)
Add flow reduction controls	Low-head restrictive devices (e.g., gates, weirs) to reduce stage/flow downstream
Remove flow reduction controls	Remove restrictive devices to increase stage/flow downstream

Detention improvements are often the best hydraulic solution to flooding problems that result from excessive runoff volume or where conveyance improvements are ineffective. While detention generally improves flooding conditions downstream, an evaluation of storage improvements must consider increases in flooding conditions upstream, particularly in areas of flat terrain. Detention facilities can also be extended to include design features that promote the settling of pollutants captured by the facility, and reduce erosive flow velocities downstream of the facility. Table IV - 3 shows various detention improvement options.

TABLE IV - 3

DETENTION IMPROVEMENT OPTIONS

TYPE	DESCRIPTION
Modify existing detention facility	Provide additional storage and/or reconfiguration of control structures
Open detention facility	Construct a new detention facility, generally using open excavation
Closed detention facility	Detention facility with closed top, generally underground
Ravine storage/Stream impoundment	In-line dam/control structure within open channel to impound water
Street/Parking lot storage	Regulate inlets to allow storage within street right-of-way or parking lot
Dredging	Dredging of deposited sediment, etc. from lakes, ponds, streams, or channels
Flow reduction controls	Capacity restriction within existing pipe (e.g., orifice plate to throttle flows)
Modify existing detention facility	Provide additional storage and/or reconfiguration of control structures

Floodplain management improvements address flooding problems by either preventing flooding, or by keeping excess runoff away from buildings or roadways. Decisions to use floodplain management improvements are usually based on cost rather than hydraulic benefit, that is, in cases where the costs of conveyance and detention options are high compared to their effectiveness. Buy-out is included here as a structural solution, since heavy equipment is typically used to demolish the structure and to re-grade the land after purchase. The raising of roads should be considered as a last resort option. Minor resurfacing projects might be beneficial, but extensive road raising will reduce available surface storage, and could result in new flooding problems elsewhere. Table IV - 4 shows various floodplain management improvement options.

TABLE IV - 4

FLOODPLAIN MANAGEMENT IMPROVEMENT OPTIONS

TYPE	DESCRIPTION
Buy-out	Purchase and demolition of home, business, and/or private property
Relocate	Relocation of residential building
Flood berm	Dykes or berms using earthen materials
Flood wall	Flood walls, dykes, or levees using concrete material or sheet piling
Floodproofing	Closures and sealants to waterproof existing buildings
Flood warning systems	Real-time monitoring, detection and notification of hazardous conditions
House raising	Elevate supporting structure of house
Road raising	Additional pavement/base material layers to eliminate minor road flooding

The recommended structural solutions to drainage problems will only achieve the desired level of flood control, if appropriate measures are implemented to maintain the capacity of the existing primary stormwater management system. These measures include:

- Ongoing maintenance program. This program could include routine and as-needed maintenance activities to remove vegetation, silt, sediment, and debris from the system in order to achieve its original design capacity. Maintenance alone may solve current flooding problems.
- Repair and replacement program. An annual investment in renewing aging stormwater infrastructure helps to preserve the structural integrity of the system, and may extend its useful life, prevent failures, and assure reliable service.
- Floodplain preservation. Preserving existing floodplains helps to retain natural flood storage volumes, allows natural stream morphologic processes to occur, and protects stream and riparian habitat. This can be achieved through ordinance modifications that prohibit floodway encroachment or floodplain fill, easement acquisition, or establishing setbacks. Preservation of floodplain storage can also be tied to various land use planning initiatives,

which can significantly reduce the capital cost of recommended structural improvements.

- Runoff source controls for future development. On-site detention/retention and runoff volume controls are recommended to limit future flooding, erosion, and water quality problems in developing areas. These can be achieved through ordinance modifications and regulatory compliance with costs typically borne by the property developer.

ALTERNATE ANALYSIS

V

SECTION V

ALTERNATIVE ANALYSIS

As required by the agreement, alternatives were investigated to reduce flooding in the downtown area. The 24-hour, 10- and 100-year frequency storms within King Creek and Brush Creek Primary Stormwater Management System utilizing mitigation measures for 100% protection. Also, another alternative was to be investigated which would be considered the most cost effective program. Figure V – 1 graphically displays the 10- and 100-year alternative scenarios.

Table V – 1 presents the flood protection for the 10-year, 24-hour design storm along the two creeks. The protection area was shown in Figure I-1; but, generally is from Kelly's Market to the confluence with King Creek and on King Creek from Carver Park downstream.

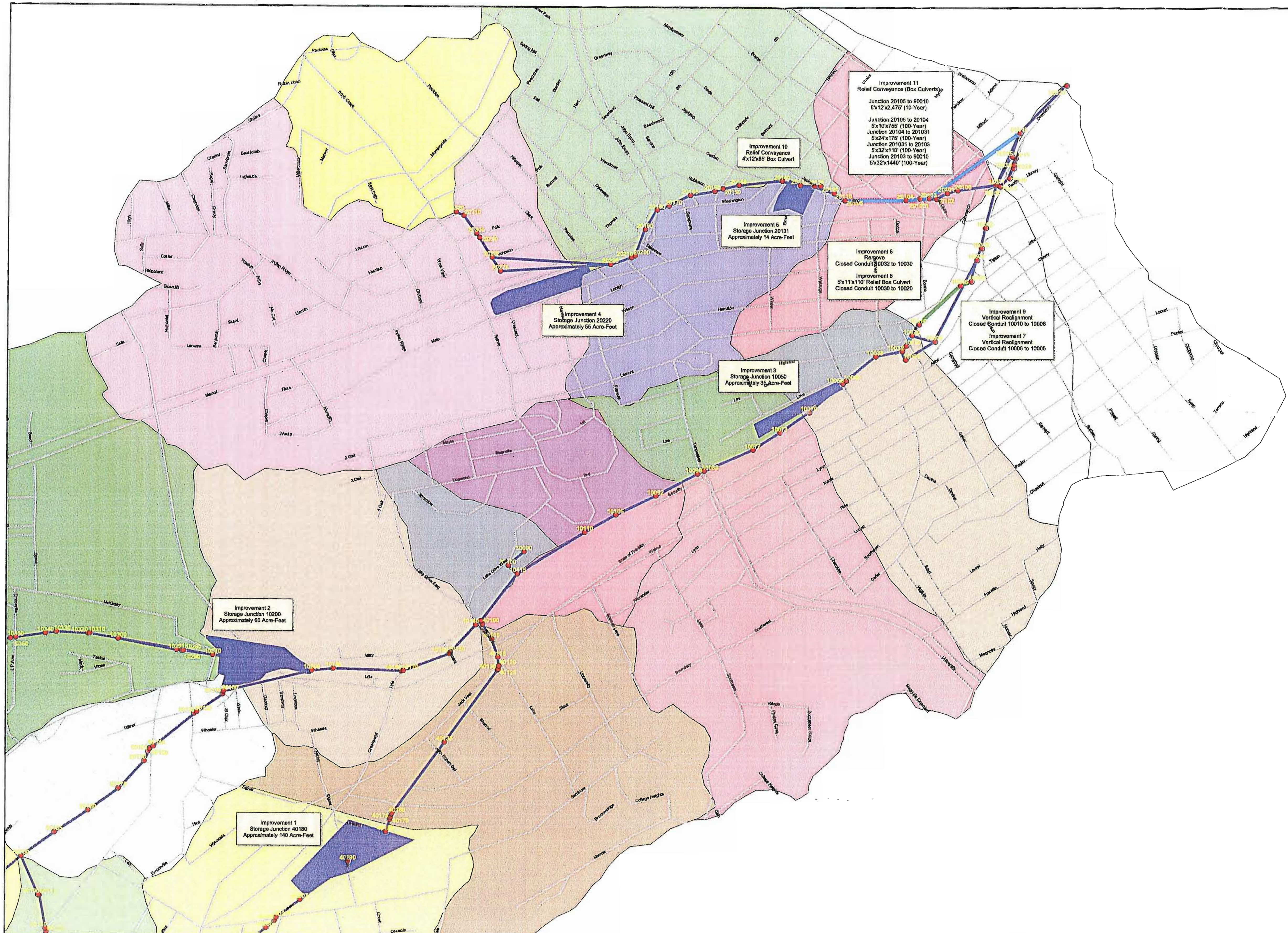


Figure V-1
City of Johnson City, Tennessee

Brush Creek and King Creek Alternative Scenarios
10-Year and 100-Year Events

Legend

- Junctions
- CONVEYANCE ALTERNATIVES
  - RELIEF
  - REMOVE CLOSED CONDUIT
  - VERTICAL REALIGNMENT
- Jcfe00alt6_conduits.shp
- STORAGE ALTERNATIVES
- Street Centerlines
- Sub-Basins: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28

N

500 0 500 1000 Feet

LDA
CDM

TABLE V - 1

10-YEAR, 24-HOUR DESIGN STORM IMPROVEMENTS

IMPROVEMENT ID	JUNCTION	IMPROVEMENT DESCRIPTION
1	40180	Storage; Approximately 140 Acre-Feet
2	10200	Storage; Approximately 60 Acre-Feet
3	10050	Storage; Approximately 35 Acre-Feet
4	20220	Storage; Approximately 55 Acre-Feet
5	20131	Storage; Approximately 14 Acre-Feet
6	10038 to 10030	Remove Conduit Under Kelly's Market
7	10006 to 10005	Vertical Realignment
8	10030 to 10020	5 x 11 x 110 Relief Box Culvert
9	10010 to 10006	Vertical Realignment
10	20130 to 20110	4 x 12 x 85 Relief Box Culvert
11	20105 to 90010	6 x 12 x 2,475 Relief Box Culvert

The improvements presented in this scenario takes advantage of the available area to address not only flooding issues in the downtown area, but to improve the flooding level of service that occurs in the upper watersheds.

The project team also performed an evaluation of the improvements in King Creek alone (Improvements 4, 5, 10, and 11). These improvements addressed the downtown flooding problems at the confluence of Brush Creek and King Creek. Peak stages in the vicinity of Kelly's Market along Brush Creek however were not significantly reduced.

Additionally, the project team evaluated numerous improvements to address the 100-year, 24-hour design storm flooding problems. These improvements are similar to those presented for the 10-year design storm however incorporates additional conveyance capacity. The improvements presented in Table V - 2 provide flood protection for the 100-year, 24-hour design storm along Brush Creek and King Creek from Kelly's Market and Carver Park to the downtown area.

TABLE V - 2

100-YEAR, 24-HOUR DESIGN STORM IMPROVEMENTS

IMPROVEMENT ID	JUNCTION	IMPROVEMENT DESCRIPTION
1	40180	Storage; Approximately 140 Acre-Feet
2	10200	Storage; Approximately 60 Acre-Feet
3	10050	Storage; Approximately 35 Acre-Feet
4	20220	Storage; Approximately 55 Acre-Feet
5	20131	Storage; Approximately 14 Acre-Feet
6	10038 to 10030	Remove Conduit Under Kelly's Market
7	10006 to 10005	Vertical Realignment
8	10030 to 10020	5 x 11 x 110 Relief Box Culvert
9	10010 to 10006	Vertical Realignment
10	20130 to 20110	4 x 12 x 85 Relief Box Culvert
11	20105 to 90010	5 x 20 x 755 Relief Box Culvert 5 x 24 x 170 Relief Box Culvert 5 x 32 x 110 Relief Box Culvert 5 x 32 x 1,440 Relief Box Culvert

The improvements presented again take advantage of the available area to address not only flooding issues in the downtown area, but to improve the flooding level of service that occurs in the upper watersheds, as did the 10-year scenario.

The evaluation of the improvements in King Creek alone (Improvements 4, 5, 10, and 11) indicated that the improvements were not able to address the downtown flooding problems for the 100-year event.

The project team evaluated the effects of a more natural (open channel) conveyance system and storage facility located in the downtown area. The improvement includes opening approximately 4,000 linear feet of the downtown piped system and creating complex trapezoidal channels to accommodate base flow, small storm events and large storm events up to the 100-year, 24-hour design storm. The volume of the downtown storage facility is estimated to be approximately 65 acre-feet with a maximum wet pool depth of approximately seven feet.

In addition to the functional capacity of the alternative, the concept presents an opportunity to develop a downtown greenway system and stimulate an economic rebirth to the downtown area. Figure V - 2 presents a conceptual illustration of the alternative.

Figure V-2
City of Johnson City, Tennessee

Brush Creek and King Creek Design Alternative
100-Year, 24-Hour Design Storm

Legend

- Downtown Detention Facility (Approx)
- Proposed Conveyance
  - Open Channel/Greenway
- Existing System
- Street Centerlines

An alternative of no action was reviewed. Basically, that alternative would have no project cost associated with it; but, property values in the affected area will continue to be less than desirable. This will result in less property tax and potentially sales tax. If the area continues to flood on some frequency, there would be no incentive by the property owners to invest in improvements.

A limited action alternative was investigated for the purpose of limiting construction expenditures. It was determined that this alternative provided essentially no more protection than the "no action" alternative; but, had a cost component associated with it.

A decision matrix was developed comparing the following alternatives: a) no action, b) limited action, c) 10-year and 100-year, and e) greenway. Table V – 3 is the matrix with the scores.

TABLE V-3

DECISION MATRIX

CRITERIA	NO ACTION	LIMITED ACTION	10-YEAR	100-YEAR	DOWNTOWN RETENTION GREENWAY
Feasibility/Cost	5	4	4	1	3
Constructability	5	3	3	2	3
Permitability	5	5	3	2	5
Right–of-Way/Acquisition	5	5	2	1	1
SW Level of Service	1	2	3	5	5
Grant Eligibility	1	1	4	4	5
Long Term Economic Impact	1	1	3	3	4
Public Acceptance	1	2	3	5	5
Total Score	24	23	25	23	31

Legend:

Ranking Values: Very Favorable = 5
Favorable = 4
Moderate = 3
Unfavorable = 2
Poor = 1

PUBLIC INVOLVEMENT

VI

SECTION VI

PUBLIC INVOLVEMENT

The City has a keen interest in good communication with the stakeholders. At the outset, an initial public meeting was conducted basically to alert the public that a study was being prepared, discussing the scope, and soliciting input.

Near the end of Phase I, another public meeting was conducted. At that meeting, preliminary results of the modeling effort were discussed. The stakeholders generally confirmed that the model's predicted response of the stream was consistent with their historical knowledge.

After the alternative analysis had been performed and the decision matrix of Section V developed, another public meeting was conducted. In that session, the team reviewed the work to date including the conceptual alternatives. The matrix was presented without values being assigned to public opinion. Flood proofing of structures was discussed including both wet and dry approaches. Pictures were shown of greenway areas in other cities and the construction of culverts.

During the public presentation of candidate solutions, it was made clear that a final decision had not been made. There were numerous questions from those in attendance. One issue raised concerned a tentatively located detention basin in the Mary Street area. A stakeholder raised a question concerning shifting the basin from privately owned property to property already owned by the City just upstream. That comment was heeded in the final draft of the report. Other discussions centered around the August 2003 flood which was still fresh on the stakeholders' minds. Potential funding sources were discussed; both grants and loans. After considerable discussion, the moderator asked for an unofficial vote concerning the most favorable alternative. The greenway alternative received a near unanimous vote.

Other activities which involved the stakeholders occurred immediately after the second public meeting where site visits were conducted by the team to view flood elevations (water marks). During these visits, the stakeholders were given an opportunity to express whatever concerns they had relative to the program. Overflowing sanitary sewers during flood conditions was mentioned. It was also pointed out during the stakeholder meeting(s) that a historic district was in place.

SELECTED ALTERNATIVE

VII

SECTION VII

SELECTED ALTERNATIVE

After the public meeting discussing the various alternatives, values were assigned to the public acceptance category on the matrix. Therefore, it was clear that the public supported the option referred to as the Greenway Alternative. The next step was to further refine that alternative and develop a phasing approach for it.

The selected alternative has six (6) distinct segments. They are: a) approach the downtown flooding issue as an opportunity to redevelop the affected area; the first step would be to purchase the required land, b) make minor improvements to streets and drainage structures, c) construct King Creek storage (two projects), d) construct Brush Creek storage (upstream of State of Franklin Road), e) construct downtown storage with water amenity including opening up the creeks for a more environmental friendly situation (two projects), and f) constructing the walking/bike trails and other greenway features to enhance the environmental and aesthetics factors of the area, and constructing storage upstream of ETSU baseball fields.

Discussions with the staff indicate that attention should be given priority to the King Creek, and develop a phasing schedule to maximize early benefit from initial expenditure. The public expressed an interest for the team to be mindful of the historic district, and to propose the use of land already owned by the City, where possible.

The land acquisition for the entire program is estimated to be approximately $7.5 million. There are various grant programs available which could minimize the City's out-of-pocket expenditure.

The Tennessee Department of Environment and Conservation administers Real Estate Transfer fund dedicated to use by local government for the purchase of lands for natural area, greenways, and other approved recreational use. The grants can also be used for recreational projects, trial development and approved capitol expenditures. The overall Stormwater design will take advantage of state funds to purchase additional park and greenway acres, and develop infrastructure on some existing City park lands. Fishing ponds, walking trails, ball fields, and green buffers are just a few of the projects which can be paid for with a mix of local and state funds.

The proposed minor improvements would include redirecting flow from existing catch basins for more efficient use of existing drainage structures, and some street grade realignment. Also, minor flood proofing should be considered. This effort would have a greater response to minor storms than major flood events. The model indicates the improvements would be effective for possibly up to a 5-year storm. These projects can be funded by monies resulting from the Stormwater utility. The initial phase of this activity should be budgeted at $0.5 million.

The most meaningful measures would include the construction of detention facilities within the drainage basins, and opening up culverts for better passage of water.

In order for all these improvements to be realized, it is proposed that they be done in phases. This arrangement allows the use of grant programs, private development involvement to supplement the use of City funds. The first phase or project would be to regrade Carver Park for multi-uses. There is presently a new City recreation building being constructed on the site away from King Creek. The remainder of that lot can be graded for ballfields; but, in a fashion which would allow it to act as a detention basin during flood events. There would be no recreational activities occurring during a flood event; therefore, the land could have a dual use. It is anticipated that it would cost approximately $2.5 million for this project. It is understood that the City might consider using some of its own construction crews to perform the work. It is recommended that the City consider $.05 million recreational grant application to be prepared for the project. Table VII-1 shows the breakdown of estimated cost assuming it is done by an independent construction contractor. The estimate is based on 2004 pricing.

TABLE VII – 1

PROJECT COST ESTIAMTE
CARVER PARK DETENTION BASIN

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
1	Clear & Grub	1	EA	$ 5,000.00	$ 5,000.00
2	Demolition	1	EA	$ 50,000.00	$ 50,000.00
3	Excavation	30,000	CY	$ 50.00	$ 1,500,000.00
4	Control Structures	2	EA	$ 35,000.00	$ 70,000.00
5	Channel Improvements	1	EA	$ 25,000.00	$ 25,000.00
6	Seeding & Landscaping	1	EA	$ 5,000.00	$ 5,000.00
7	Fine Grade/Topsoil	70,000	SY	$ 1.00	$ 70,000.00
8	Erosion Control	1	EA	$ 25,000.00	$ 25,000.00
				SUBTOTAL	$ 1,750,000.00
				CONTINGENCY	$ 350,000.00
				ESTIMATED TOTAL CONSTRUCTION COST	$ 2,100,000.00
OTHER PROJECT COSTS:					
1.	Design				$ 75,000.00
2.	Surveying				$ 10,000.00
3.	Engineering Services During Construction				$ 35,000.00
4.	Permitting				$ 10,000.00
5.	Geotechnical				$ 10,000.00
6.	Inspection				$ 50,000.00
7.	Bidding Services				$ 10,000.00
				PROJECT CONTINGENCY	$ 200,000.00
				TOTAL ESTIMATED PROJECT COST	$ 2,500,000.00

The computer model predicated a need for a total storage volume in the downtown area. The Carver Park area is close enough to downtown for its volume to be considered a part of the total downtown requirements. The team in concert with the staff identified another area along King Creek between Carver Park and the confluence of the creeks which could be effectively used as a part of the downtown volume. That project is recommended to the second project after the minor improvements. Table VII-2 shows the breakdown of its estimated project cost. Again, if the city were to construct this project by force account, the actual cost would be somewhat less than the estimated $1.2 million. The estimate does not include land cost (which has been previously identified). At this level of study, actual construction activities may shift from one property to another as design is refined.

TABLE VII – 2

PROJECT COST ESTIMATE
WEST KING STREET DETENTION

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
1	Clear & Grub	1	EA	$ 10,000.00	$ 10,000.00
2	Demolition	1	EA	$ 60,000.00	$ 60,000.00
3	Excavation	10,000	CY	$ 50.00	$ 500,000.00
4	Control Structures	4	EA	$ 15,000.00	$ 60,000.00
5	Channel Improvements	1	EA	$ 10,000.00	$ 10,000.00
6	Seeding & Landscaping	1	EA	$ 10,000.00	$ 10,000.00
7	Fine Grade/Topsoil	15,000	SY	$ 2.00	$ 30,000.00
8	Erosion Control	1	EA	$ 25,000.00	$ 25,000.00
				SUBTOTAL	$ 705,000.00
				CONTINGENCY	$ 145,000.00
				ESTIMATED TOTAL	$ 850,000.00
OTHER PROJECT COSTS:					
1.	Design				$ 45,000.00
2.	Surveying				$ 10,000.00
3.	Engineering Services During Construction				$ 20,000.00
4.	Permitting				$ 10,000.00
5.	Geotechnical				$ 15,000.00
6.	Inspection				$ 50,000.00
7.	Bidding Services				$ 10,000.00
				PROJECT CONTINGENCY	$ 190,000.00
				TOTAL ESTIMATED PROJECT COST	$ 1,200,000.00

The next project on King Creek would be to regrade Kiwanis Park to provide detention in the upper area. This project will provide minimal affects in the downtown area; however, it will provide protection to an area near the intersection of John Exum and Market. Table VII-3 shows a breakdown of the estimated project cost for this project. This project is another one which the city may wish to construct by force account. Since this project would impact a transportation component, consideration should be given to making application for T-21 funds.

The Brush Creek detention upstream of the State of Franklin Road could be constructed on City owned property. A similar project was reviewed in the Mary Street area, and revised to the City owned property. This change was in response to input at a public meeting. The project can be constructed at either site with similar results. If the City had an interest in redeveloping the Mary Street area, the detention basin could be incorporated into that project. If the project is constructed on the City owned property, the estimated cost is shown in Table VII-4. If redevelopment grants were secured to redevelop the Mary Street area, the detention basin could be partially funded by that method.

The Keystone project is the downtown detention facility. This multi-purpose project is required before the full effect of the flood damage protection can be realized. The project should be a part of a downtown redevelopment program which has an associated water amenity. The project, if properly planned, can be a catalyst for an economic resurgence to the downtown. Table VII-5 shows a breakdown of the estimated cost for this phase. This project is in the historic district which could present some challenges.

TABLE VII-3

PROJECT COST ESTIMATE
KIWANIS PARK DETENTION BASIN
KING CREEK MAIN STEM DETENTION

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
1	Clear & Grub	1	EA	$ 10,000.00	$ 10,000.00
2	Demolition	1	EA	$ 30,000.00	$ 30,000.00
3	Excavation	40,000	CY	$ 40.00	$ 1,600,000.00
4	Control Structure	1	EA	$ 50,000.00	$ 50,000.00
5	Channel Improvements	1	EA	$ 50,000.00	$ 50,000.00
6	Seeding & Landscaping	1	EA	$ 25,000.00	$ 25,000.00
7	Re-establish Fields & Equipment	1	EA	$ 50,000.00	$ 50,000.00
8	Erosion Control	1	EA	$ 40,000.00	$ 40,000.00
				SUBTOTAL	$ 1,855,000.00
				CONTINGENCY	$ 395,000.00
				ESTIMATED TOTAL	$ 2,250,000.00
OTHER PROJECT COSTS:					
1.	Design				$ 90,000.00
2.	Surveying				$ 20,000.00
3.	Engineering Services During Construction				$ 40,000.00
4.	Permitting				$ 20,000.00
5.	Geotechnical				$ 20,000.00
6.	Inspection				$ 50,000.00
7.	Bidding Services				$ 10,000.00
				PROJECT CONTINGENCY	$ 250,000.00
				TOTAL ESTIMATED PROJECT COST	$ 2,750,000.00

TABLE VII – 4

PROJECT COST ESTIMATE
BRUSH CREEK MAIN STEM DETENTION
UPSTREAM OF STATE OF FRANKLIN ROAD

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
1	Clear & Grub	1	EA	$ 10,000.00	$ 10,000.00
2	Demolition	1	EA	$ 5,000.00	$ 5,000.00
3	Excavation	50,000.0	CY	$ 50.00	$ 2,500,000.00
4	Control Structure	1	EA	$ 50,000.00	$ 50,000.00
5	Channel Improvements	1	EA	$ 50,000.00	$ 50,000.00
6	Seeding & Landscaping	1	EA	$ 20,000.00	$ 20,000.00
7	Erosion Control	1	EA	$ 50,000.00	$ 50,000.00
8	Fine Grade/Topsoil	200,000	SY	$ 1.00	$ 200,000.00
				SUBTOTAL	$ 2,885,000.00
				CONTINGENCY	$ 315,000.00
				ESTIMATED TOTAL	$ 3,200,000.00
OTHER PROJECT COSTS:					
1.	Design				$ 110,000.00
2.	Surveying				$ 20,000.00
3.	Engineering Services During Construction				$ 50,000.00
4.	Permitting				$ 25,000.00
5.	Geotechnical				$ 25,000.00
6.	Inspection				$ 60,000.00
7.	Bidding Services				$ 10,000.00
				PROJECT CONTINGENCY	$ 200,000.00
				TOTAL ESTIMATED PROJECT COST	$ 3,700,000.00

TABLE VII – 5

PROJECT COST ESTIMATE
DOWNTOWN DETENTION FACILITY

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST		TOTAL	
1	Demolition	1	EA	$	100,000.00	$	100,000.00
2	Box Culvert Demolition	300	LF	$	100.00	$	30,000.00
3	Excavation	20,000	CY	$	100.00	$	2,000,000.00
4	Channel Improvements	1	EA	$	25,000.00	$	25,000.00
5	Outlet Structure	2	EA	$	25,000.00	$	50,000.00
6	Seeding & Landscaping	1	EA	$	50,000.00	$	50,000.00
7	Utility Relocation	1	EA	$	400,000.00	$	400,000.00
8	Erosion Control	1	EA	$	50,000.00	$	50,000.00
9	Street Closing/Abandonment	1	EA	$	25,000.00	$	25,000.00
					SUBTOTAL	$	2,730,000.00
					CONTINGENCY	$	470,000.00
					ESTIMATED TOTAL	$	3,200,000.00
OTHER PROJECT COSTS:							
1.	Design					$	120,000.00
2.	Surveying					$	20,000.00
3.	Engineering Services During Construction					$	60,000.00
4.	Permitting					$	20,000.00
5.	Geotechnical					$	20,000.00
6.	Inspection					$	50,000.00
7.	Bidding Services					$	10,000.00
					PROJECT CONTINGENCY	$	200,000.00
					TOTAL ESTIMATED PROJECT COST	$	3,700,000.00

The City has established a historic/conservation overlay district in order that appropriate measures be taken to ensure preservation of structures of historic value to Johnson City. Figure VII-1 shows the historic district. No structure within the district is to be demolished or altered except as provided in the code. However, issues for consideration are outlined in the guidelines of the District which include property values and local economy. Without flood damage reduction measures, some of the structures in the District will continue to decay. Therefore, the City should work with the Historic Zoning Commission to allow the much needed flood abatement project to proceed in order to provide protection for structures which otherwise are in jeopardy. The proposed flood damage reduction project will enhance the property values and the general economy of the City. The aesthetics of the area will be improved with the project as well as the environmental issues. A very minor portion of the historic district would require demolition.

With the construction of the downtown detention in place, the next project should be channel improvement on King Street which would complete the entire proposal in that basin. Table VII-6 shows the estimated cost for this project.

TABLE VII – 6

PROJECT COST ESTIMATE
CHANNEL IMPROVEMENTS (CARVER PARK TO DOWNTOWN DETENTION FACILITY)

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
1	Demolition	1	EA	$ 200,000.00	$ 200,000.00
2	Box Culvert	700	LF	$ 500.00	$ 350,000.00
3	Excavation	1,000	CY	$ 200.00	$ 200,000.00
4	Misc Stone	1,100	TON	$ 20.00	$ 22,000.00
5	Pavement Replacement	100	TON	$ 100.00	$ 10,000.00
6	Clean-up/Seeding	1	EA	$ 50,000.00	$ 50,000.00
7	Bridge Construction	2	EA	$ 450,000.00	$ 900,000.00
8	Erosion and Sediment Control	1	EA	$ 50,000.00	$ 50,000.00
9	Utility Relocation	1	EA	$ 300,000.00	$ 300,000.00
				SUBTOTAL	$ 2,082,000.00
				CONTINGENCY	$ 418,000.00
				ESTIMATED TOTAL	$ 2,500,000.00
	OTHER PROJECT COSTS:				
1.	Design				$ 160,000.00
2.	Surveying				$ 40,000.00
3.	Engineering Services During Construction				$ 80,000.00
4.	Permitting				$ 40,000.00
5.	Geotechnical				$ 50,000.00
6.	Inspection				$ 110,000.00
7.	Bidding Services				$ 20,000.00
				PROJECT CONTINGENCY	$ 300,000.00
				TOTAL ESTIMATED PROJECT COST	3,300,000.00

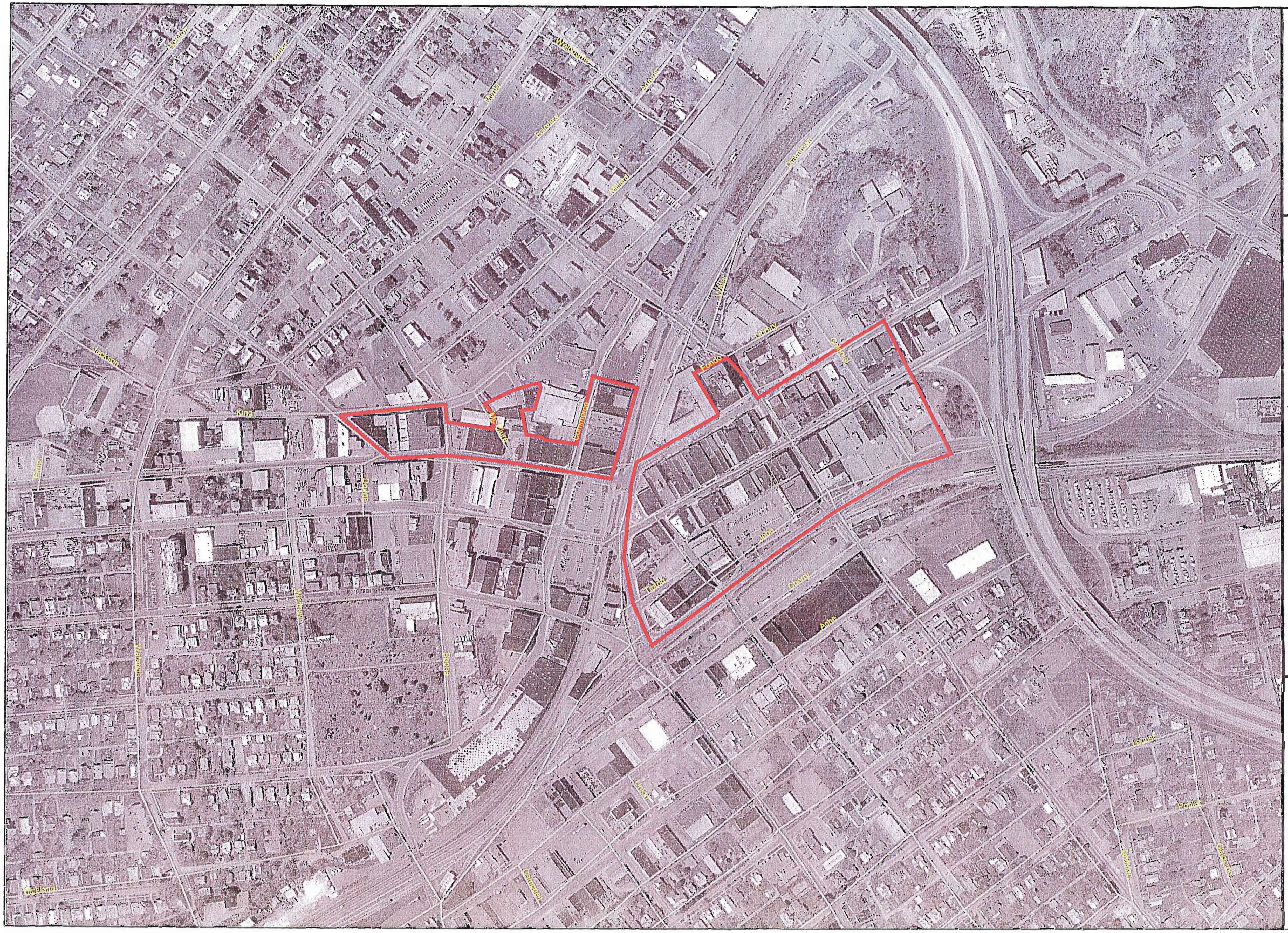


Figure VII-1
City of Johnson City,
Tennessee

Brush Creek and King Creek
Downtown Historic District

Legend

Historic District
Street Centerlines

N

100 0 100 200 300 Feet

LDA
CDM

The next proposed project is the channel improvements in the Brush Creek basin. This work would generally be from Watauga to the downtown basin. This project will keep the flood flow out of the State of Franklin Road. Table VII-7 shows the estimated cost for this proposal.

TABLE VII - 7

CHANNEL IMPROVEMENTS (WATAUGA TO DOWNTOWN DETENTION FACILITY)

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
1	Demolition of Ex Box Culvert	3000	LF	$ 50.00	$ 150,000.00
2	Bridge Construction	4	EA	$ 325,000.00	$ 1,300,000.00
3	Excavation	1,000	CY	$ 100.00	$ 100,000.00
4	Misc Stone	1000	TON	$ 20.00	$ 20,000.00
5	Pavement Replacement	100	TON	$ 100.00	$ 10,000.00
6	Seeding & Landscaping	1	EA	$ 50,000.00	$ 50,000.00
7	Channel Construction	3500	LF	$ 250.00	$ 875,000.00
8	Erosion and Sediment Control	1	EA	$ 100,000.00	$ 100,000.00
9	Utility Relocation	1	EA	$ 400,000.00	$ 400,000.00
				SUBTOTAL	$ 3,005,000.00
				CONTINGENCY	$ 495,000.00
				ESTIMATED TOTAL	$ 3,500,000.00
OTHER PROJECT COSTS:					
1.	Design				$ 170,000.00
2.	Surveying				$ 40,000.00
3.	Engineering Services During Construction				$ 80,000.00
4.	Permitting				$ 40,000.00
5.	Geotechnical				$ 40,000.00
6.	Inspection				$ 110,000.00
7.	Bidding Services				$ 20,000.00
				PROJECT CONTINGENCY	$ 200,000.00
				TOTAL ESTIMATED PROJECT COST	$ 4,200,000.00

Even though the proposed greenway amenities do not contribute directly to flood damage protection, they assist enormously with the aesthetics of the area. Table VII - 8 shows the estimated cost for an area from Tennessee Street to the downtown detention basin. It is recommended that consideration be given to extending this treatment all along Brush Creek and the State of Franklin Road. In fact, it would be desirable to have a similar project up King Creek from the downtown detention to Kiwanis Park and eventually connecting to the one on Brush Creek. It is recommended that T-21 funds be sought for these projects. Bike/walking trails are fundable projects.

Table VII – 9 has the estimated project cost for an upstream detention of the East Tennessee State University baseball fields. This project does very little from the downtown flooding situation. However, it may be considered to reduce flooding along Brush Creek upstream of downtown. This project is shown as the last of all phases due to the fact it does not address the primary purpose of the study.

Table VII – 10 is a summary of the proposed projects in a preferred order of execution.

TABLE VII – 8

PROJECT COST ESTIMATE
GREENWAY AMENITIES (TENNESSEE STREET TO DOWNTOWN DETENTION FACILITY)

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
1	Clearing and Grubbing	1	EA	$ 5,000.00	$ 5,000.00
2	Excavation	1000	CY	$ 20.00	$ 20,000.00
3	Base Stone	2000	TON	$ 20.00	$ 40,000.00
4	Trail Paving	1000	TON	$ 100.00	$ 100,000.00
5	Seeding & Landscaping	1	EA	$ 20,000.00	$ 20,000.00
6	Erosion and Sediment Control	1	EA	$ 10,000.00	$ 10,000.00
				SUBTOTAL	$ 195,000.00
				CONTINGENCY	$ 20,000.00
				ESTIMATED TOTAL	$ 215,000.00
OTHER PROJECT COSTS:					
1.	Design				$ 15,000.00
2.	Surveying				$ 5,000.00
3.	Engineering Services During Construction				$ 5,000.00
4.	Permitting				$ 5,000.00
5.	Bidding Services				$ 5,000.00
				PROJECT CONTINGENCY	$ 25,000.00
				TOTAL ESTIMATED PROJECT COST	$ 275,000.00

TABLE VII – 9

PROJECT COST ESTIMATE
BRUSH CREEK UPSTREAM DETENTION
UPSTREAM OF ETSU

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
1	Clear & Grub	1	EA	$ 15,000.00	$ 15,000.00
2	Demolition (Paving/Bridge Only)	1	EA	$ 25,000.00	$ 25,000.00
3	Excavation	100,000	CY	$ 45.00	$ 4,500,000.00
4	Control Structure	1	EA	$ 50,000.00	$ 50,000.00
5	Low Flow Channel	1	EA	$ 75,000.00	$ 75,000.00
6	Seeding & Landscaping	1	EA	$ 15,000.00	$ 15,000.00
7	Erosion Control	1	EA	$ 25,000.00	$ 25,000.00
8	Fine Grade/Topsoil	150,000	SY	$ 2.00	$ 300,000.00
				SUBTOTAL	$ 5,005,000.00
				CONTINGENCY	$ 495,000.00
				ESTIMATED TOTAL	$ 5,500,000.00
OTHER PROJECT COSTS:					
1.	Design				$ 210,000.00
2.	Surveying				$ 25,000.00
3.	Engineering Services During Construction				$ 100,000.00
4.	Permitting				$ 40,000.00
5.	Geotechnical				$ 40,000.00
6.	Inspection				$ 75,000.00
7.	Bidding Services				$ 10,000.00
				PROJECT CONTINGENCY	$ 250,000.00
				TOTAL ESTIMATED PROJECT COST	$ 6,250,000.00

TABLE VII – 10

SUMMARY OF PROJECTS

Priority	Description	Cost	Benefit to Downtown Area
1	Purchase Land	$7,500,000.00	This allows the projects to proceed and affected properties to be city owned.
2	Minor Improvements	$ 500,000.00	Negligible benefits for small storms (5-year frequency or less) No Benefit for larger storms.
3	Carver Park Detention	$2,500,000.00	Limited benefit for small storms (2-year frequency or less).
4	West King Street Detention	$1,200,000.00	Moderate benefit for small storms (2-year frequency or less). Negligible benefits for larger storms.
5	King Creek Main Stem Detention	$2,750,000.00	Limited additional benefit in the downtown area but will improve water quantity level of service in the upper watershed of King Creek.* Protects intersection.
6	Brush Creek Detention (Main Stem) Upstream of State of Franklin Road	$3,700,000.00	Moderate benefit for small storms (2-year frequency or less) Limited benefit for larger storms. * A more narrow flood plain
7	Downtown Detention Facility	$3,700,000.00	Significant benefit for small and large storms with exception of street flooding.*
8	Channel Improvements (Carver Park to Downtown Detention Pond)	$3,300,000.00	Significant benefit for small and large storms with exception of street flooding in Brush Creek in the vicinity of Watauga and Kelly's Market.*
9	Channel Improvements (Watauaga to Downtown Detention Pond)	$4,200,000.00	Significant benefit for small and large storms.*
10	Greenway Amenities Downtown to Tennessee Street	$ 275,000.00	Limited water quantity benefit. Will provide maintenance and recreational access to King and Brush Creek.
11	Brush Creek Tributary Detention (Upstream of ETSU Ball Field)	$6,250,000.00	Limited additional benefit in the downtown area but will improve water quantity level of service in the upper watershed of Brush Creek in the vicinity of ETSU.*

*Assumes previous improvement has been implemented.

CONCLUSIONS AND RECOMMENDATIONS

VIII

SECTION VIII

CONCLUSIONS AND RECOMMENDATIONS

Johnson City's Historic District and downtown area dates to the mid 1800's. Over the past century and half, there have been numerous documented floods in the area. This area is at the confluence of Brush Creek and King Creek. Even before the upper reaches of the drainage areas experienced flooding, the downtown area experienced flooding because of development. As development continues, with more roof and paved areas, storm water runoff resulting from heavy rainfall events will have a more severe impact.

The United States Environmental Protection Agency (EPA) has mandated that communities with populations greater than 10,000 develop a storm water management program. Johnson City has embarked on that mandated effort. As a part of that program a Stormwater utility (rate structure) is being considered by the City. If adopted, monies from that program can be used to maintain drainage structures and other useful activities relating to storm water management. Independent of the EPA mandated program the City initiated a study of flooding in the downtown area. The study reviewed the affects of rainfall events of varying frequencies on the downtown area. A computer model was developed to analyze these events. After the model was developed it was calibrated to match actual observed conditions.

In order to eliminate or minimize flooding in the downtown area, various alternatives were reviewed The study team assisted the City in conducting various public meetings to engage the stakeholders. After the alternatives had been developed, they were presented to the public on September 1, 2004. It was the consensus of the stakeholders, present, that the most attractive alternate to pursue was the greenway alternative.

A few years ago a downtown Historic District was designated. Many of the structures affected by flooding in the downtown area are within the historic district. However, the affected area is only a small portion of the district. Implementing meaningful alternatives could be a challenge due to the historic designation.

As the options are explored, the City should consider the opportunity to solve the flooding situation as a way to revitalize downtown from both a social and economic perspective.

Recently, communities have rediscovered their town centers and have redeveloped these historic areas to attract new mixed use projects that bring businesses, residents, and consumers back downtown. Often times these redeveloped town centers include public spaces and provisions for alternative transportation connections to nearby population centers. These amenities attract consumers by providing a village center atmosphere where they can shop, eat, or seek entertainment opportunities. In addition, these village centers have attracted new residents seeking opportunities to live, work, and play while minimizing vehicular trips from one location to another. The Johnson City downtown has the Tipton Street project as an example where the tax base can get a boost from redevelopment. With the new library already nearby, a properly planned and executed program for downtown Johnson City could bring private funds to augment a much needed public project (flood reduction).

Communities that have implemented these efforts successfully have developed master plans for redevelopment of their town centers in order to provide a "road map" to their future village center. These "road maps" may then be utilized to attract new privately funded redevelopment projects to the town center. Development of successful community improvements plans includes stakeholder and public involvement throughout the process. In addition, master planning efforts include identification of these general components:

1. Existing features in the town center to be preserved and enhanced.
2. Existing features in the town center that could be targeted for redevelopment opportunities.
3. Nearby population centers (ETSU, VA and others).
4. Alternative transportation modes to connect these population centers to the town center (such as the university, the veterans facilities, and medical complex).

5. Enhancements to the town center to create public spaces that provide an inviting and comfortable atmosphere for pedestrians, greenways with bike/walking paths, picnic tables, etc., enhance the environmental aesthetics.

6. Necessary modifications to local development regulations to encourage consistency with the master plan as the town center is redeveloped (possibly adjusted to the current historic district ordinance).

7. Project priorities and funding opportunities to implement the public elements of the master plan.

It is strongly recommended that the City develop a grantsmanship taskforce to assist with funding for this much needed project. There are numerous federal and state agencies that have grant and loan funds which could be applied to the execution of this project. Not all of the various programs would have funds for a flood project; however, funds can be secured for other activities which would result in being a component of the over-all project. An example would be the Tennessee Department of Environment and Conservation (TDEC) has monies for recreational use. Those monies could possibly be used to do earthwork to prepare ballfields at Carver Park (the result would be a part of the King Creek Storage). Other ways to use TDEC funds would be for bike/walking paths along the greenway. Department of Transportation has available funds which might be incorporated into the program. Also, there is the possibility of getting a direct federal appropriation.

It is recommended that the following activities be initiated relative to reducing flood damage in the downtown area and enhancing its environmental and economic condition:

1. Purchase the affected properties.
2. Using funds from the Stormwater utility to perform certain minor improvements such as opening up the pipe network downtown for better and more efficient use of that infrastructure, and minor grade changes and some flood proofing.
3. Develop a storage facility on City owned property at Carver Park along King Creek.
4. Construct additional storage along King Creek downstream of Carver Park.
5. Regrade Kiwanis Park such that it can act as a storage facility along King Creek.
6. Develop storage on Brush Creek upstream of State of Franklin Road (property owned by City).
7. Construct the downtown detention facility with the water amenity with a park-like atmosphere.

8. Construct channel improvement along King Creek to connect to the downtown storage.

9. Construct channel improvements along Brush Creek to connect to the downtown storage.

10. Develop greenway amenities with recreation facilities along Brush and King Creeks.

11. Construct storage upstream of the university baseball fields to aid with flood along Brush Creek upstream of the downtown area.

The eleven above mentioned projects and their execution should be over time with funding from various sources. Even though the earlier mentioned EPA mandated storm water program is separate, it and this program should be approached as complimentary to each other.

The city should authorize a redevelopment study for the downtown area. This effort would be a road map for the economic revitalization of the downtown area to build on things already happening.