APPENDIX A

Three different models were used to develop design flows for the primary and secondary systems. For each system analyzed, the hydrologic model(s) was selected based on the complexity of the stormwater conveyance system.

The US Army Corps of Engineers (USACE) HEC-HMS model was selected to model the primary systems defined as the main stems of Bells Branch and Meetinghouse Branch. HEC-HMS simulates the surface runoff response to precipitation for an interconnected system of surfaces, channels, and ponds. Input data for the HEC-HMS model was developed using topographic, land use, and soils maps in GIS to delineate and calculate the basin areas and SCS hydrologic parameters. The HEC-HMS model offers a variety of methods for simulating the rainfall-runoff response, hydrograph development, channel and pond routing. The selection of methods for the analyses is based on the study objectives, data availability, and watershed characteristics. The precipitation data for the 24-hour duration, NRCS Type III storm was used to represent the synthetic rainfall event. The NRCS curve number approach was selected to calculate runoff volumes from the precipitation data, and the sub-basin unit hydrographs for these flood volumes were developed using the NRCS lag times. Where appropriate, reservoir routing was selected to model attenuation behind culvert embankments.

For the larger secondary systems that may: (a) have significant backwater effects from rising water surface elevations within the Primary Systems, (b) have attenuation within drainage ditches or behind roadways, and (c) show a sensitivity to the timing response of runoff to rainfall, the Storm Water Management Model (SWMM) developed by the Environmental Protection Agency (EPA) was selected as the hydrologic and hydraulic model. The NRCS curve number approach was selected to calculate runoff volumes from the precipitation data, and the sub-basin unit hydrographs for these flood volumes were developed using the watershed width parameter. SWMM simulates the surface runoff response to precipitation for an interconnected system of surfaces, channels, and ponds. Input data for the SWMM model was developed using topographic data, land use data, and soils maps in GIS to delineate and calculate the basin areas and NRCS hydrologic parameters. The SWMM model offers a variety of methods for simulating the rainfall-runoff response, hydrograph development, and channel routing. One advantage to using SWMM to model both hydrology and hydraulics is that channel routing is modeled in the EXTRAN (hydraulics) block automatically based on the geometry and nature of the conveyance system. This eliminates the need to iterate between a hydrologic model and a hydraulic model to produce reasonable flows.

Some project areas with smaller drainage areas and less complex conveyance systems required a less rigorous approach. Hydraflow Storm Sewers, an extension of AutoCAD Civil 3D, was used to generate peak flows using the Rational Method. Table A-1 lists the different systems and the modeling methodology applied to each system.

Table A-1: Project Area Model Selection

Project Area	Model Selection
Bells Branch Primary System	HEC-HMS
Meetinghouse Branch Primary System	HEC-HMS
Grey Fox Trail System	Hydraflow Storm Sewers
Barnes Street – Paramore Drive – Rondo Drive System	SWMM
Fantasia Street – Sherwood Drive System	SWMM
Oakmont Drive system	Hydraflow Storm Sewers
Unnamed Tributary to Meetinghouse Branch	HEC-HMS

Watershed Delineation and Connectivity

Watersheds were delineated for the Primary Systems and for each of the five (5) secondary systems utilizing digital LiDAR data available from the State of North Carolina and the stormwater inventory. The preliminary watersheds were created using automated procedures in a GIS platform and then adjusted as necessary based on the conveyance system and known ridge lines. Each flood control project watershed for the Primary Systems was subdivided into sub-watersheds selected at hydrologically and hydraulically significant points, such as major roadway crossings, stream convergences, known problem areas, etc. Each sub-watershed for the secondary systems was selected as the area that drained to each inlet modeled on the secondary system. Sixteen (16) sub-watersheds were delineated for the Primary Systems ranging in size from 20 to 346 acres. Sub-watersheds were delineated as necessary for the secondary systems to accurately model the hydraulics of the system. The watershed maps included in Appendix C illustrate the sub-watershed and hydrologic connectivity for the primary system.

Soils

The NRCS curve number method uses basin characteristics, such as soil types and land use, to compute the runoff response. The infiltration rate of a soil influences the volume of surface runoff that results from given storm events. Soils with high infiltration rates produce lower runoff than soils with lower infiltration rates. The Soil Conservation Service has prepared soil maps for Pitt County that identify four primary soil groups. This data is available digitally and was obtained for the City of Greenville.

The groups (A, B, C, and D) correspond to decreasing rates of infiltration. A general description of the four soil groups taken from the USDA, SCS, NEH-4 (1972) is presented in Table A-2.

Table A-2: Hydrologic Soils Groups

Soil Group	Description
A	Group A soils have high infiltration rates even when thoroughly wetted and consist chiefly of deep, well to excessively drained sand or gravels. These soils have a high rate of water transmission. (greater than 0.3 inches per hour)
B	Group B soils have moderate infiltration rates even when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse texture. These soils have a moderate rate of water transmission. (0.15 to 0.3 inches per hour)
C	Group C soils have slow infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission. (0.5 to 0.15 inches per hour)
D	Group D soils have a very slow infiltration rate when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission. (0 to 0.05 inches per hour)
A/D	The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 60 centimeters (24 inches) below the surface.
B/D	The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 60 centimeters (24 inches) below the surface.

Soils within the watershed are predominantly NRCS hydrologic soil groups A and C soils, although six (6) different hydrologic soil groups are represented in some quantity in the Pilot watershed (See Table A-3 and Appendix C).

Table A-3: Area Distribution of Hydrologic Soil Groups

Soil Group	Total Area (acre)	Percent of Total Area
A	525	27%
B	180	9%
C	843	44%
D	261	14%
A/D	6	0.3%
B/D	105	5%

Land Use

Land use is the watershed cover condition as it relates to the actual type of development and zoning within the watershed. Land use influences the runoff characteristics of a watershed, and combined with other basin characteristics, is used to determine the SCS curve number for the basin.

The existing zoned land uses for the Pilot Watershed were provided by the City of Greenville. These zoning maps were used to develop peak flows for the watershed. Eight land use categories were delineated within the Pilot Watershed based on the information provided and field observation of the current uses (See Appendix C).

In its entirety, the Pilot Watershed covers an area of approximately 1,920 acres (3.0 square miles). The majority of the basin is developed currently to its zoned land use. While a few isolated parcels may be developed, it is unlikely they will significantly increase peak flows. Therefore, for the purposes of this study, the existing conditions land use was considered the same as the build-out conditions land use. Percentages of each existing land use group and the correlating acreage are listed in Table A-4 below.

Table A-4: Pilot Watershed Existing Land Use

Land Use Category	Area (acres)	Percent of Basin Area
Commercial	79	4%
Office/Institutional/Multifamily	268	14%
High Density Residential	188	10%
Medium Density Residential	685	36%
Low Density Residential	251	13%
Conservation/Open Space	151	8%
Agricultural/Cropland	206	11%
Right-of-Way	92	5%
TOTAL	1920	100%

NRCS Curve Numbers

The NRCS curve number approach was used in computing the runoff response. Runoff curve numbers (RCNs) were generated by using the NRCS document entitled Urban Hydrology for Small Watersheds, dated June 1986 and commonly referred to as TR-55. This method relates the drainage characteristics of the hydrologic soil group, land use category, and antecedent moisture conditions (AMC) to a runoff curve number. The runoff curve number and an estimate of the initial surface moisture storage capacity are used to calculate a total runoff depth for a storm in a basin.

The AMC refers to the total rainfall in a 5-day period preceding a storm and relates to the soil moisture condition at the beginning of the storm event. The AMC value can be used as a calibration tool in the hydrologic computations where AMC-1 represents "dry" conditions and AMC-3 represents "wet" conditions. The average antecedent moisture conditions (AMC-2) are generally considered most representative for the humid southeastern portion of the country and were used for the hydrologic calculations in this study.

Runoff curve numbers were determined for each sub-basin based on the soil group, land use, and average antecedent moisture condition for the area. The curve numbers calculated for this study are listed in Table A-5 below.

Table A-5: Curve Numbers Based on Land Use and Soil Groups

Land Use Category	Soil Group			
	A	B	C	D
Commercial	89	92	94	95
Office/Institutional/Multifamily	77	85	90	92
High Density Residential	61	75	83	87
Medium Density Residential	54	70	80	85
Low Density Residential	51	68	79	84
Conservation/Open Space	49	69	79	84
Agricultural/Cropland	67	78	85	89
Right-of-Way	83	89	92	93

For each sub-basin, the curve number was determined and weighted by area to calculate the composite curve number for each sub-basin. A summary of the hydrologic input data for the Primary Systems, including the runoff curve numbers, is shown in Table A-6. The detailed calculations are included in Appendix E (runoff curve numbers) and Appendix F (times of concentration).

Table A-6: Summary of Hydrologic Input Data

Drainage Basin ID	Drainage Area (acre)	RCN	Time of Concentration (minutes)
BB-1	62.04	81	165
BB-2	48.16	82	65
BB-3	19.57	82	56
BB-4	74.14	75	115
BB-5	24.54	69	90
BB-6	32.30	68	64
MHB-1	101.17	89	261
MHB-2	48.20	90	172
MHB-3	139.15	85	194
MHB-4	76.15	87	132
MHB-5	300.60	83	232
MHB-6	111.16	75	65
MHB-7	110.50	63	253
MHB-8	108.03	58	72
MHB-9	345.77	75	158
MHB-10	108.87	67	165
UTBB-1	204.37	73	308

Rainfall

Rainfall distributions for Greenville are derived using the NRCS Type III standard distribution. Total rainfall volumes for the modeled frequency storms were based on data published on the NOAA website, http://hdsc.nws.noaa.gov/hdsc/pfds/orb/nc_pfds.html. Table A-7 shows the total rainfall volumes used for this study based on precipitation data collected in Greenville, North Carolina

Table A-7: Design Storm Rainfall Depths

Design Storm	Rainfall Depth (in)
2-year, 24-hour	3.76
10-year, 24-hour	5.81
25-year, 24-hour	7.23
50-year, 24-hour	8.47
100-year, 24-hour	9.84

While the depth-duration-frequency curves are calculated based on real rainfall data, the rainfall data used for the SWMM and HEC-HMS models represent the Type III synthetic rainfall distribution. Actual runoff is based on several factors including rainfall intensity, duration and the antecedent moisture conditions of the watershed.

Hydrograph Translation

The lag time, as defined by the NRCS for use in the NRCS dimensionless unit hydrograph method, is the time, or lag, between the center of mass of rainfall excess and the peak of the unit hydrograph. The lag time is based on the sub-watershed time of concentration, or travel time, and is a function of the sub-watershed size, shape, slope, cover, and other basin characteristics. For the NRCS method, the sub-watershed lag time is calculated to be 0.6 times the time of concentration for each sub-watershed.

The times of concentration for the sub-watersheds were calculated from the methodology described in TR-55. A summary of the calculations is shown in Appendix F. The longest flow path is divided into three types of flow; overland flow, shallow concentrated flow, and channel flow. A spreadsheet was developed to tabulate the incremental travel times for each type of flow for each sub-basin. The incremental travel times were totaled and multiplied by 0.6 to compute the lag time for each sub-basin. The equation detailing the travel time for sheet flow is as follows:

$$T_t = \frac{.007\,(nL)^{0.8}}{(P_2)^{0.5}\,S^{0.4}}$$

T_t = Travel Time in hours
n = Manning Roughness Coefficient (Paved = 0.011, Unpaved = 0.24)
L = flow length in feet
P_2 = 2-year, 24 hour rainfall = 3.76 inches
S = slope of hydraulic grade line (land slope in ft/ft)

For shallow concentrated flow, the velocity (V) is calculated for either paved or unpaved sections by using the following equations:

$$\text{Unpaved } V = 16.1345\,(S)^{1/2}$$
$$\text{Paved } V = 20.3282\,(S)^{1/2}$$

The travel time for shallow flow is then calculated by dividing the flow length (L in feet) by velocity as follows:

T_t = Travel Time = L / (3600*V)

The open channel travel times are determined by a modified version of the Manning equation, which is as follows:

$$V = \frac{1.49\, R^{2/3}\, S^{0.5}}{n}$$

V = Average full-flow velocity (ft/s)
R = Hydraulic radius (ft)
S = Slope of hydraulic grade line (ft/ft)
n = Manning roughness coefficient

Instead of a time of concentration parameter, the SWMM model uses a watershed width parameter to create the unit hydrograph used in the model that will translate the rainfall into runoff. The watershed width is a parameter unique to SWMM that typically represents the watershed area divided by the longest flow path. The width parameter is typically calibrated to flow gauge data, if available. The Pilot Watershed lacks flow gauge data, so the peak flows from SWMM were compared to flows developed using the Rational Method. Based on the flow comparison, the watershed widths for each basin were increased in some instances to produce reasonable flows. Increasing the watershed width parameters is not an uncommon practice for calibrating models for areas with gradual slopes and moderate conveyance systems.

For the remainder of the smaller sub-watersheds of the secondary systems (Oakmont and Grey Fox), time of concentration values were assumed to be between 5 and 15 minutes.

Channel Elements

Flood peaks attenuate, or reduce, as they travel downstream due to the storage characteristic of the stream reach. The Muskingum-Cunge routing method in HEC-HMS was selected to define the storage characteristic of selected stream reaches in the Pilot Watersheds. It can be described as a hydrologic routing method based on physical parameters of the channel and floodplain. Input data for this method consists of representative channel/floodplain sections, reach length, Manning's roughness coefficient, and channel bed slope. This method provides advantages over other hydrologic techniques based on the relative size and slope of the channels and floodplains in the watershed.

Structure and Pond Routing

Reservoir storage routing was used for routing hydrographs through the storage areas upstream from undersized structures (culverts). HEC-HMS is able to model the effects of an undersized culvert through inputs defining the relationship between water volume or area and elevation and the relationship between outflow and water surface elevations. The relationship between outflow and water surface elevations is developed using an iterative process between HEC-HMS and HEC-RAS. A rating curve generated using HEC-RAS defines the outflow of the water leaving this system.

Structures having fill heights greater than or equal to 50% of the height of the structure were assumed to provide significant peak flow attenuation and, therefore, were routed in the HEC-HMS model. In addition, any structure which exhibited significant upstream floodplain storage or significant backwater from the HEC-RAS model output would be analyzed for providing peak flow attenuation.

For each structure, the cutoff point in the backwater pool was determined where the structure routing ends and upstream channel routing begins. This determination was necessary so that available storage areas calculated for channel and structure routing did not overlap. The following procedure was used for this determination:

- The approximate limit of the 100-year frequency flood backwater pool was delineated in the topographic map.
- The distance from the upstream face of the structure to the upstream limit of the pool was measured.
- From the upstream end of the backwater pool, a distance equal to 20% of the total pool length was measured in the downstream direction and the point marked on the topographic map.
- Through this point a line was drawn perpendicular to the contour lines.
- This line was then designated as the cutoff point to be used as the upstream limit of the channel routing.

For each structure, the elevation-storage relation for the Modified Puls method was derived by calculating the surface area of the topographic contours from the upstream face of the structure to the routing cutoff point associated with the structure. A pair of "SA" (storage area) – "SE" (elevation) records, the elevation-storage relation for each structure was input from the delineated information. To avoid interpolating storage areas for each stage-discharge point, a separate stage-discharge relation was entered into the HEC-HMS model on a pair of "SQ" (discharge) – "SE" (elevation) records based on the HEC-RAS model output.

However, the method described in the previous paragraph does not account for the reduction in tailwater on the structure due to the attenuation effects of the upstream storage, which in turn can affect the stage-discharge relation of the structure. Therefore, an iterative process for storage structures was followed with an objective to obtain a set of peak discharge values, runoff volumes, and water surface elevations that are "balanced" between the two models. The process was initiated by inputting a set of discharges into the HEC-RAS model to develop a set of discharge-storage relations for each reach. This initial set of relations was input into the HEC-HMS model. These values were supplemented by the depth-storage relation for each structure.

The HEC-HMS model was run with these values to derive new discharges at downstream locations. These new values were input into the HEC-RAS model and it was recomputed. The new discharges and water surface elevations listed in the HEC-HMS summary output were compared with the discharges listed in the previous HEC-RAS run. When the values stabilized, the model was considered "balanced". If not then additional iterations were performed. Typically, three iterations are adequate to derive a balanced model.

Summary of Hydrologic Model Results

The HEC-HMS model was used to compute peak runoff for the 2-, 10-, 25-, 50- and 100- year design storms for the existing conditions.

The results of the hydrologic model are summarized in Table A-8. The HEC-HMS input and output are included in Appendix H. Additionally, a CD is included in Appendix J and contains the digital files for the HEC-HMS model.

Table A-8: Existing Conditions Flows from HEC-HMS

HEC-HMS Node	Road Name / Location	HEC-RAS Station	Storm Event				
			2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
BELLS BRANCH							
BB – 1	U/S Limit of Bells Branch	11194	30	59	80	98	118
14th St – BB	14th Street	9780	45	109	149	183	220
Quail Ridge Rd	Quail Ridge Road	9132	50	138	189	230	271
York Road	York Road	7435	77	181	279	350	425
Railroad Crossing	Railroad Culvert	6760	81	188	242	281	327
ADD – 14	Kensington Drive	4687	113	272	366	446	533
MEETINGHOUSE BRANCH							
MHB-1	U/S Limit of Meetinghouse Branch	14470	48	83	108	129	152
ADD – 1_2	Charles Boulevard	13233	76	132	170	204	241
ADD – 3	Tucker Drive	11180	146	259	339	408	484
ADD – 7	King George Road	3507	309	583	772	937	1,119
ADD – 8	Railroad Bridge	2045	327	635	854	1,048	1,263
ADD – 15	Oxford Road	-532	508	1,143	1,570	1,935	2,351
OUTLET	D/S Limit of Meetinghouse Branch	-3630	484	1,124	1,552	1,914	2,331

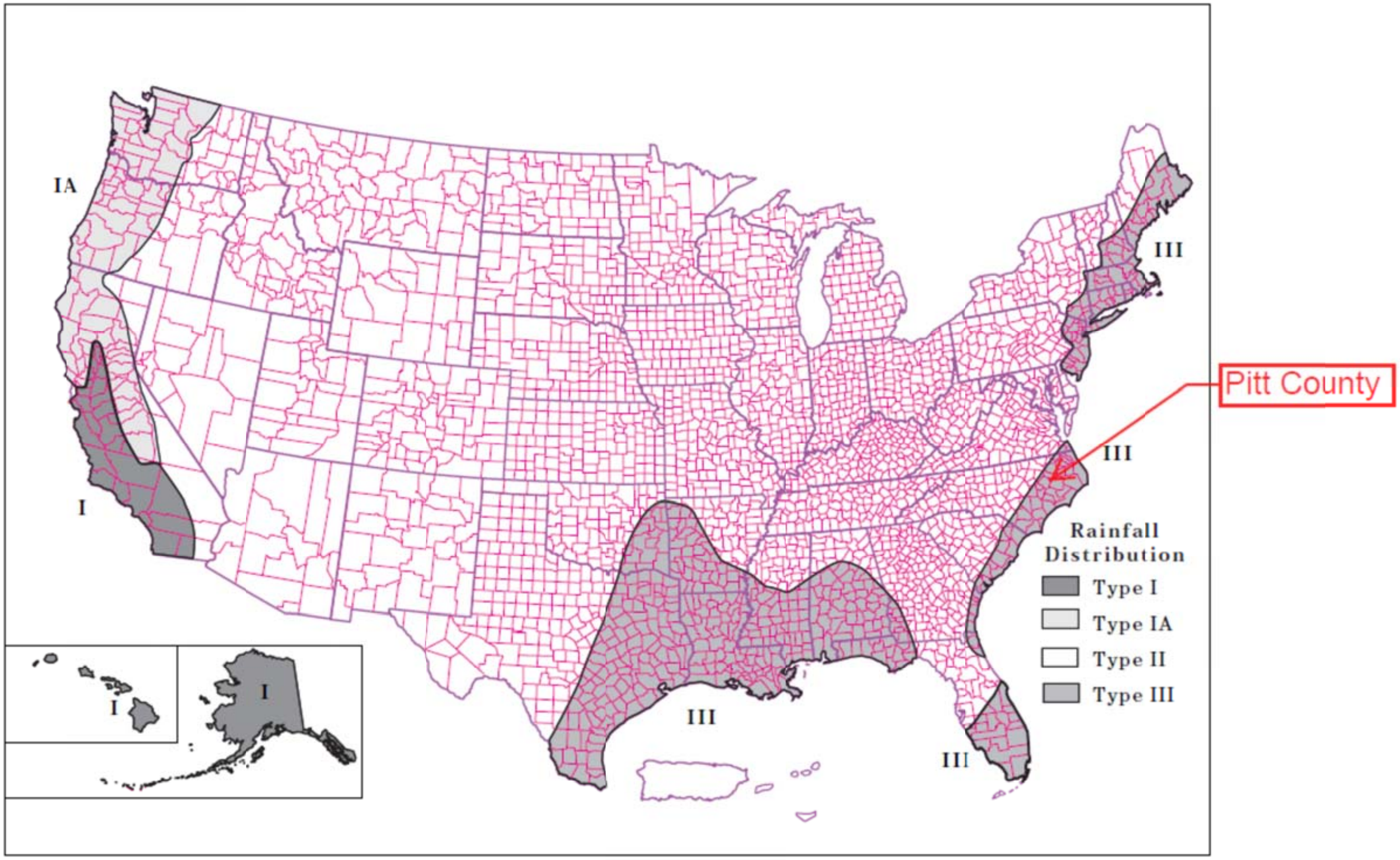
Comparison of Peak Flows

For comparison purposes, flood peaks were estimated using the U.S. Geological Survey (USGS) publication entitled "The National Flood-Frequency Program – Methods for Estimating Flood Magnitude and Frequency in Rural and Urban Areas in North Carolina – USGS Fact Sheet 007-00" (2001) at key locations within the watershed. Table A-9 compares the peak flows determined from the USGS regional regression equations the Coastal-Plain region versus the peak flows from HEC-HMS.

Table A-9: Comparison of Existing Conditions Peak Flows

Methodology	Location	2-Year (cfs)	10-Year (cfs)	25-Year (cfs)	50-Year (cfs)	100-Year (cfs)
HEC-HMS	U/S Limit of Bells Branch	30	59	80	98	118
	U/S Limit of Meetinghouse Branch	48	83	108	129	152
	D/S Limit of Meetinghouse Branch	484	1,124	1,552	1,914	2,331
USGS Regression Coastal-Plains (2001)	U/S Limit of Bells Branch	48	138	233	282	331
	U/S Limit of Meetinghouse Branch	116	281	432	503	570
	D/S Limit of Meetinghouse Branch	696	1,374	1,868	2,140	2,392

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Source: TR-55 (June, 1986)

APPENDIX B

The purpose of the hydraulic modeling analysis is to determine an existing level of flooding for the stormwater drainage network and to develop proposed solutions to mitigate flooding, on both the primary systems and the secondary systems. Three different modeling methodologies were used depending on the complexity and location of the conveyance system. For the primary systems comprised of Bells Branch and Meetinghouse Branch, the Hydrologic Engineering Center River Analysis System (HEC-RAS) was used for hydraulic modeling. For smaller less complex secondary systems, Hydraflow Storm Sewers was used to calculate the hydraulic grade lines using an energy grade based approach, while more complex secondary systems were modeled using SWMM. Table B-1 lists the project areas that were modeled using each approach.

Table B-1: Project Area Model Selection

Project Area	Model Selection
Bells Branch Primary System	HEC-RAS
Meetinghouse Branch Primary System	HEC-RAS
Grey Fox Trail System	Hydraflow Storm Sewers
Barnes Street – Paramore Drive – Rondo Drive System	SWMM
Fantasia Street – Sherwood Drive System	SWMM
Oakmont Drive system	Hydraflow Storm Sewers
Unnamed Tributary to Meetinghouse Branch	HEC-RAS

HEC-RAS Model

The HEC-RAS model calculates water surface profiles for steady, gradually varied flow, both sub-critical and supercritical, for user-specified discharges. The standard step backwater analysis for sub-critical flow was modeled for the Bells Branch and Meetinghouse Branch Primary System and the Unnamed Tributary to Meetinghouse Branch Secondary System. The model calculates the effect of obstructions, such as culverts, and building structures in the channel and floodplain on the water surface profile. The hydraulic computations are based on the solution of a one-dimensional energy equation with energy loss due to friction evaluated by Manning's equation.

Input data for the HEC-RAS computer model includes the following:

- Cross-section geometry of the channel and floodplain.
- Roughness coefficients to describe the characteristics of the channel and floodplain.
- Size, shape, and characteristics of culverts and roadways along the stream reach.
- Energy loss coefficients for flow in the channel and at roadway crossings.

Primary System Study Limits

As discussed with City of Greenville stormwater staff, study limits for the hydraulic evaluation of the primary systems include Bells Branch from its confluence with Meetinghouse Branch at the downstream end to approximately 1,500 feet upstream of East 14th Street and Meetinghouse Branch from its confluence with Hardee Creek at the downstream end to approximately 1,300 feet upstream of Charles Boulevard.

Stormwater Inventory
For the Pilot Watershed Master Plan, stormwater utility infrastructure throughout the watershed was collected by WK Dickson personnel to compile a Geographic Information System (GIS) stormwater inventory database for the City. This was accomplished by using Global Positioning Systems (GPS) as the primary means of data capture. WK Dickson employed survey grade GPS to locate the x, y, and z coordinates of each visible stormwater system structure and conventional surveying techniques to obtain other attributes including but not limited to size, material, slope, and length. Additionally, attributes were also collected for select streams and open channel. Data was obtained for those streams and open channels required to complete connectivity for modeling purposed. The data was collected using horizontal datum NAD 1983 and vertical datum NAVD 1988

Attributes collected as part of the inventory were used to populate the various models. Field visits and digital photographs for each structure and channel were used to estimate the roughness coefficients and energy loss coefficients. The topographic data used for the Pilot Watershed Master Plan was the State of North Carolina's LiDAR data.

Cross Sections
Cross section surveys had recently been completed for sections of both Bells Branch and Meetinghouse Branch as part of the State's floodplain mapping program. These surveyed cross sections were augmented with additional cross sections surveyed by WK Dickson. The surveyed cross section points were than merged with the digital elevation model based on the LiDAR data. Cross sections were located perpendicular to the flow and at intervals along the stream to characterize the flow capacity of the channel and floodplain for the primary system (and the Unnamed Tributary to Meetinghouse Branch). Along stream reaches where the shape, size, and geometry of the cross-section are varying, cross sections were cut at closer intervals than for reaches having little change in channel characteristic. Additional sections were cut as required by the HEC-RAS program to sufficiently model structures such as culverts.

Surveyed cross sections are identified by station number, which for the HEC-RAS model, refers to the approximate linear distance upstream from a reference point on the main channel or tributary reach. The cross sections depict the locations of cut sections from field topographic surveys. Similarly, the cross section at each road crossing represents the top-of-road cross section. The cross sections just upstream and just downstream of highest point of roadway (commonly referred to as the weir) represent the locations of the upstream and downstream faces, respectively, of the bridge or culvert in an area not impacted by roadway fill.

Roughness Coefficients
Manning's roughness coefficients, or 'n' values, represent the resistance to flow and influence the flow capacity of channels and floodplains. The HEC-RAS model uses these coefficients to compute friction loss longitudinally in the channel and floodplain. The roughness value is a function of the type and density of the vegetation, channel bottom and stream bank material, degree of channel meandering, and depth of flow.

Roughness coefficients were determined for all stream reaches for which hydraulic analyses were performed. The "horizontal variation in n-values" option was enabled to allow for correct modeling of the widely varied surfaces on a given cross-section. For example, many cross-sections sufficient to represent the roughness of the floodplain and channel in the study area, one for the channel section, one for the right overbank floodplain, and one for the left overbank floodplain. The right or left bank of the stream is referenced facing downstream. Roughness coefficients used in this study are listed in Table B-2.

Table B-2: Roughness Coefficients

Location	Range of 'n' values
Main Channel	0.025 - 0.08
Left Overbank	0.04 - 0.12
Right Overbank	0.04 - 0.12

All roughness coefficients were estimated through field observation and by referencing standard engineering manuals.

Culvert and Roadway Data

Culverts generally have different characteristics than the channel and floodplains away from roadway crossings. Often culverts constrict flood flows in the channel and floodplain, which may create backwater effects upstream of the structure. The constriction can produce increased velocities and result in localized scour.

For culvert analysis, the HEC-RAS model utilizes the concepts of "inlet" control and "outlet" control to simplify complicated culvert hydraulics. Inlet control flow occurs when the flow carrying capacity of the culvert entrance is less than the flow capacity of the culvert barrel. Outlet control flow occurs when the culvert carrying capacity is limited by downstream conditions or by the flow capacity of the culvert barrel.

During inlet control computations, the culvert inlet acts as either a weir or an orifice, and the resulting headwater is computed. The equations used by HEC-RAS are the same as those developed by the Federal Highway Administration during extensive laboratory testing, which describe the inlet control headwater under various conditions.

For outlet control flow conditions, the required headwater is computed considering various conditions. For culverts flowing full, a form of the Bernoulli Equation, which considers friction losses, entrance losses and exit losses is utilized. Friction losses are based on Manning's equation. Entrance losses are computed as a coefficient times the velocity head in the culvert at the upstream end. Exit losses are computed as a coefficient times the change in velocity head from just inside the culvert (at the downstream end) to outside the culvert.

When the culvert is not flowing full, the direct step backwater procedure is used to calculate the profile through the culvert up to the culvert inlet. An entrance loss is then computed and added to the energy inside the culvert to obtain the upstream headwater. Culvert input data for the HEC-RAS model include:

- Shape and dimensions of the structure openings;
- Culvert length;
- Entrance loss coefficient, exit loss coefficient and coefficient of discharge for weir flow during roadway overtopping;
- Upstream and downstream invert elevations;

- Federal Highway Administration chart number for the culvert type;
- Top-of-road elevations to describe the weir during roadway overtopping and the weir crest length; and
- Four cross sections are required; one cross section sufficiently downstream of the culvert that flow is not affected by the culvert, one at the downstream end of the culvert, one at the upstream end of the culvert, and one located far enough upstream that the culvert has no effect on flow.

Energy Loss Coefficients
Contraction and expansion of flow produces energy losses caused by the transition. The magnitude of these losses is related to the velocity and the estimated loss coefficient. Where the transitions are gradual, the losses are small. At abrupt changes in cross-sectional area, the losses are higher. Energy losses resulting from expansion are greater than losses associated with contraction. Energy loss coefficients used for the Pilot Watershed hydraulic models are presented in Table B-3.

Table B-3: Energy Loss Coefficients

Type of Transition	Expansion	Contraction
None	0	0
Gradual	0.3	0.1
Culvert sections	0.5	0.3

Starting Water Surface Elevation
The starting water surface elevations for the Bells Branch and Meetinghouse Branch HEC-RAS models were calculated using the slope-area method, which is based on normal depth. The calculated slopes are as follows:

- Bells Branch – 0.003 feet/feet; and
- Meetinghouse Branch – 0.008 feet/feet

For the Unnamed Tributary to Meetinghouse Branch, the starting water surface elevation was obtained directly from the Meetinghouse Branch HEC-RAS model.

Model Run Descriptions and Assumptions
The HEC-RAS model was used to compute flood elevations at each cross-section for Bells Branch and Meetinghouse Branch Primary System and the Unnamed Tributary to Meetinghouse Branch Secondary System for the 2-, 10-, 25-, 50- and 100-year floods. A hard copy of the HEC-RAS input and output is included in Appendix H, while a digital copy of the input and output is located on the CD in Appendix J.

The hydraulic analysis for this study is based only on the condition of unobstructed flow. Therefore, flood elevations shown on the profiles are considered valid only if hydraulic structures remain unobstructed and do not fail. Flood elevations may be raised by debris blockage of the culvert, channel, or floodplain.

Model Validation
Efforts were made to verify the models for various storm events. Feedback obtained from the questionnaires was reviewed for relevant information that could be used to verify the model. The comments and responses received were not specific enough to verify the model. Likewise, the information received during the public meetings was not useful for the purposes of verifying the models. The City Staff was able to provide some feedback that was useful during the model validation process.

During the validation process, the flows and water surface elevations calculated were determined to be significantly higher than the FEMA flow and base flood elevations. Furthermore, the results from the initial existing conditions model were not aligned with some of the feedback received from the City. At this point, the decision was made to use a Type III NRCS Storm versus a Type II. The Type III storm was selected based on the location of the City of Greenville. It is located close to the boundary of between Type II and III. The results presented in this report have incorporated this change.

Open Channel Systems and Roadway Flooding
Thirteen (13) crossings were analyzed for flooding potential in the Pilot Watershed Master Plan. All roadway crossings that were analyzed in this study are listed in Tables B-5A and B including the minimum top-of-road elevations and the 2-, 10-, 25-, 50- and 100-year flood elevations at the crossing for existing and proposed conditions.

Table B-5A: Overtopping Analysis of Roadway Crossings – Bells Branch

Location	Minimum Elevation at Top of Road (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)				
		2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Existing Conditions						
East 14th Street (Culvert)	63.90	62.59	**64.35**	**64.62**	**64.70**	**64.84**
Quail Ridge Road (Culvert)	62.75	57.23	59.24	60.49	61.50	62.61
York Road (Culvert)	52.00	47.80	**52.14**	**52.76**	**54.21**	**54.48**
Railroad Crossing (Culvert)	54.02	42.97	46.51	51.52	**54.20**	**54.44**
Kensington Drive(Bridge)	33.70	23.59	25.46	25.87	26.16	26.49
Oxford Road (Closed System)	24.04	23.17	**24.91**	**25.12**	**25.30**	**25.51**
Alternative #1						
East 14th Street (Culvert)	63.90	61.19	62.28	62.91	63.47	**64.19**
Quail Ridge Road (Culvert)	62.75	57.87	59.20	60.11	60.85	61.50
York Road (Culvert)	52.00	48.33	50.77	**52.50**	**54.17**	**54.40**
Railroad Crossing (Culvert)	54.02	43.92	47.54	51.16	**54.15**	**54.38**
Kensington Drive(Bridge)	33.70	23.37	24.81	25.43	25.78	26.12
Oxford Road (Closed System)	24.04	20.30	22.95	23.93	**24.29**	**24.52**
Alternative #2						
East 14th Street (Culvert)	63.90	61.19	62.27	62.91	63.46	**64.13**
Quail Ridge Road (Culvert)	62.75	57.88	59.20	60.10	60.86	61.50
York Road (Culvert)	52.00	47.77	49.98	51.79	**52.29**	**52.94**
Railroad Crossing (Culvert)	54.02	43.03	45.46	47.25	49.40	52.45
Kensington Drive(Bridge)	33.70	23.38	25.03	25.70	26.09	26.43
Oxford Road (Closed System)	24.04	20.30	23.20	**24.10**	**24.44**	**24.66**

***Bold print indicates overtopping.**

Table B-5B: Overtopping Analysis of Roadway Crossings – Meetinghouse Branch

Location	Minimum Elevation at Top of Road (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)				
		2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Existing Conditions						
Charles Boulevard (Culvert)	68.00	63.80	65.92	67.56	**68.16**	**68.31**
Tucker Drive (Culvert)	63.64	59.97	62.26	**63.98**	**64.48**	**64.80**
14th Street (Culvert)	53.83	**54.10**	**54.89**	**55.23**	**55.45**	**55.66**
King George Road (Bridge)	35.91	33.16	34.62	35.69	**36.68**	**38.14**
Railroad Crossing (Bridge)	43.41	32.22	32.71	33.01	33.25	33.52
Oxford Road South (3-Sided Arch Bridge)	25.96	22.76	24.93	25.95	**26.77**	**27.50**
Oxford Road North (Bridge)	18.16	12.68	14.45	15.51	16.82	**19.62**
Alternative #1						
Charles Boulevard (Culvert)	68.00	63.80	65.87	67.39	**68.15**	**68.30**
Tucker Drive (Culvert)	63.64	59.76	61.68	63.16	**64.15**	**64.57**
14th Street (Culvert)	53.83	51.70	52.43	53.82	**54.30**	**54.67**
King George Road (Bridge)	37.09	33.02	34.22	34.97	35.59	36.45
Railroad Crossing (Bridge)	43.41	32.23	32.72	33.02	33.26	33.52
Oxford Road South (3-Sided Arch Bridge)	25.96	22.94	25.04	**26.04**	**26.84**	**27.48**
Oxford Road North (Bridge)	18.16	12.74	14.58	15.65	16.95	**19.81**
Alternative #2						
Charles Boulevard (Culvert)	68.00	63.53	65.05	66.07	66.91	67.67
Tucker Drive (Culvert)	63.64	59.76	61.69	63.16	**64.15**	**64.58**
14th Street (Culvert)	53.83	50.04	51.48	52.45	**53.98**	**54.53**
King George Road (Bridge)	37.09	33.02	34.23	34.98	35.60	36.47
Railroad Crossing (Bridge)	43.41	32.23	32.73	33.02	33.26	33.53
Oxford Road South (3-Sided Arch Bridge)	25.96	22.34	24.56	25.63	**26.45**	**27.23**
Oxford Road North (Bridge)	18.16	12.74	14.58	15.73	17.05	**20.08**

***Bold print indicates overtopping.**

Hydraflow Storm Sewers

The purpose of the hydrologic analysis for the secondary systems, or closed systems, was to estimate the peak runoff that would flow to the catch basins and into the closed system. The rational method was used for the closed system hydrologic analysis. The rational method can be expressed as follows:

$$Q = CiA$$

Q = maximum rate of runoff (cfs)
C = runoff coefficient representing a ration of runoff to rainfall
i = average rainfall intensity for a duration equal to the time of concentration (in/hr)
A = drainage area contributing to the design location (acres)

SWMM

SWMM is a dynamic rainfall-runoff model capable of modeling the hydrologic response of a watershed and hydraulic routing throughout a stormwater conveyance system. The model calculates the effect of backwater, flat or negative slopes, energy losses, and minor headlosses associated with bends, entrances and exits.

Input data for the EPA SWMM (hydraulics) computer model include the following:

- Conveyance pipes including structure inverts, pipe sizes and lengths;
- Open channel cross section geometries;
- Roughness coefficients for pipes and channels;
- Energy loss coefficients for flow in the pipes and channels;
- Storage rating curves; and
- Overland flow characteristics.

SWMM provides an accurate evaluation of the existing and proposed conditions because it combines hydrology and hydraulics while accounting for the routing affects of the channel and over bank storage areas. Because hydrology and hydraulics are combined, changes to peak flows or water surface elevations resulting from proposed modifications to the existing channels or culverts are calculated in the model in one step. Additionally, changes to flows from proposed pipes and channel improvements are seen both upstream and downstream, reducing the potential for a stormwater system having increased flooding downstream.

Energy Loss Coefficients

Contraction and expansion of flow produces energy losses caused by the transition. The magnitude of these losses is related to the velocity and the estimated loss coefficient. Where the transitions are gradual, the losses are small. At abrupt changes in cross-sectional area, the losses are higher. Energy losses resulting from expansion are greater than losses associated with contraction. Energy loss coefficients used for the hydraulic SWMM models are presented in Table B-6 below:

Table B-6: Energy Loss Coefficients for SWMM Models

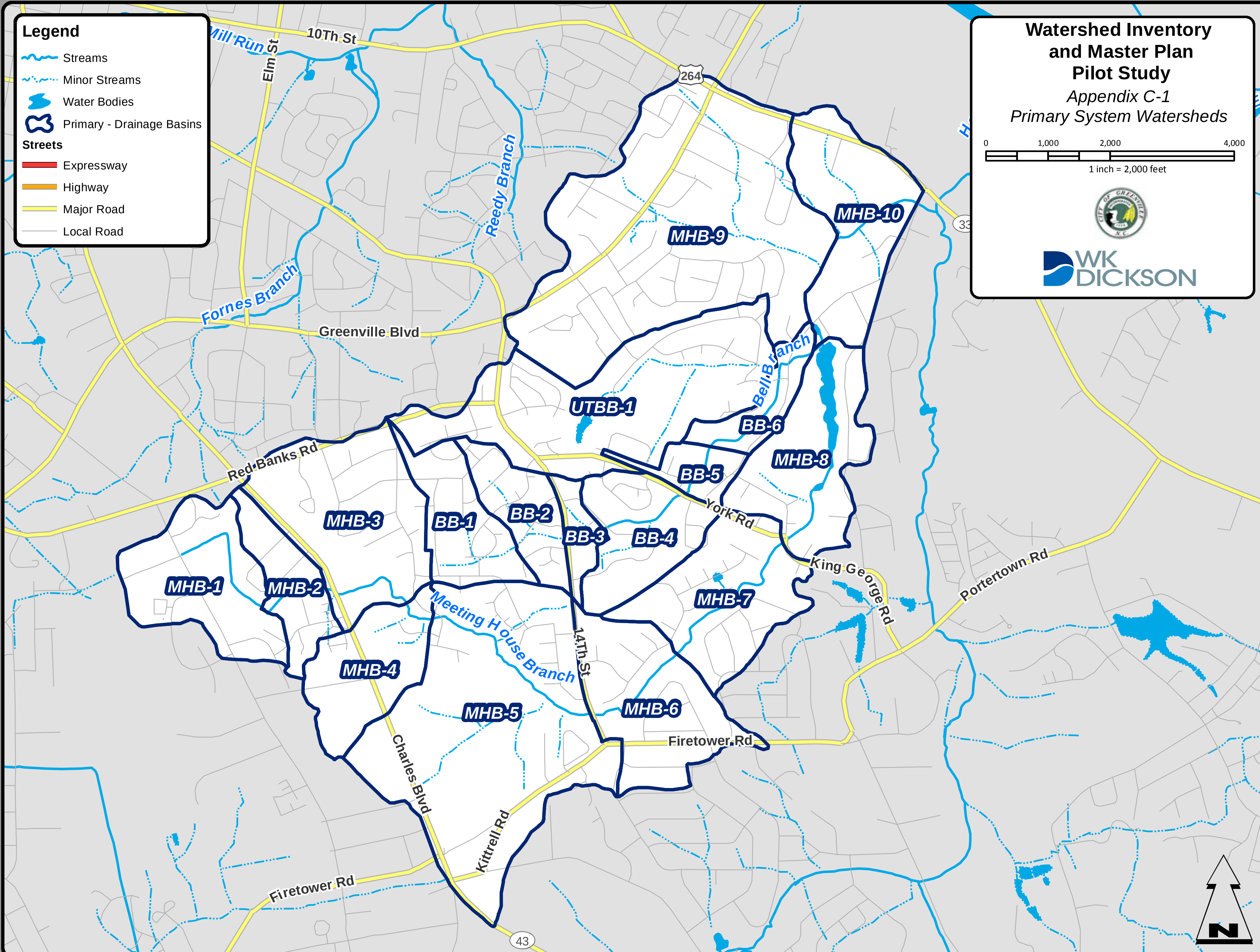
Type of Transition	Expansion	Contraction
None	0	0
Manhole/Inlet	0.7	0.5
Open Channel	1	0.5–Headwall/ 0.9 - Projecting

Additional energy losses for structures having bends were divided between the two joining pipes. The bend losses used for this project are based on NCDOT values, and are shown below in Table B-7.

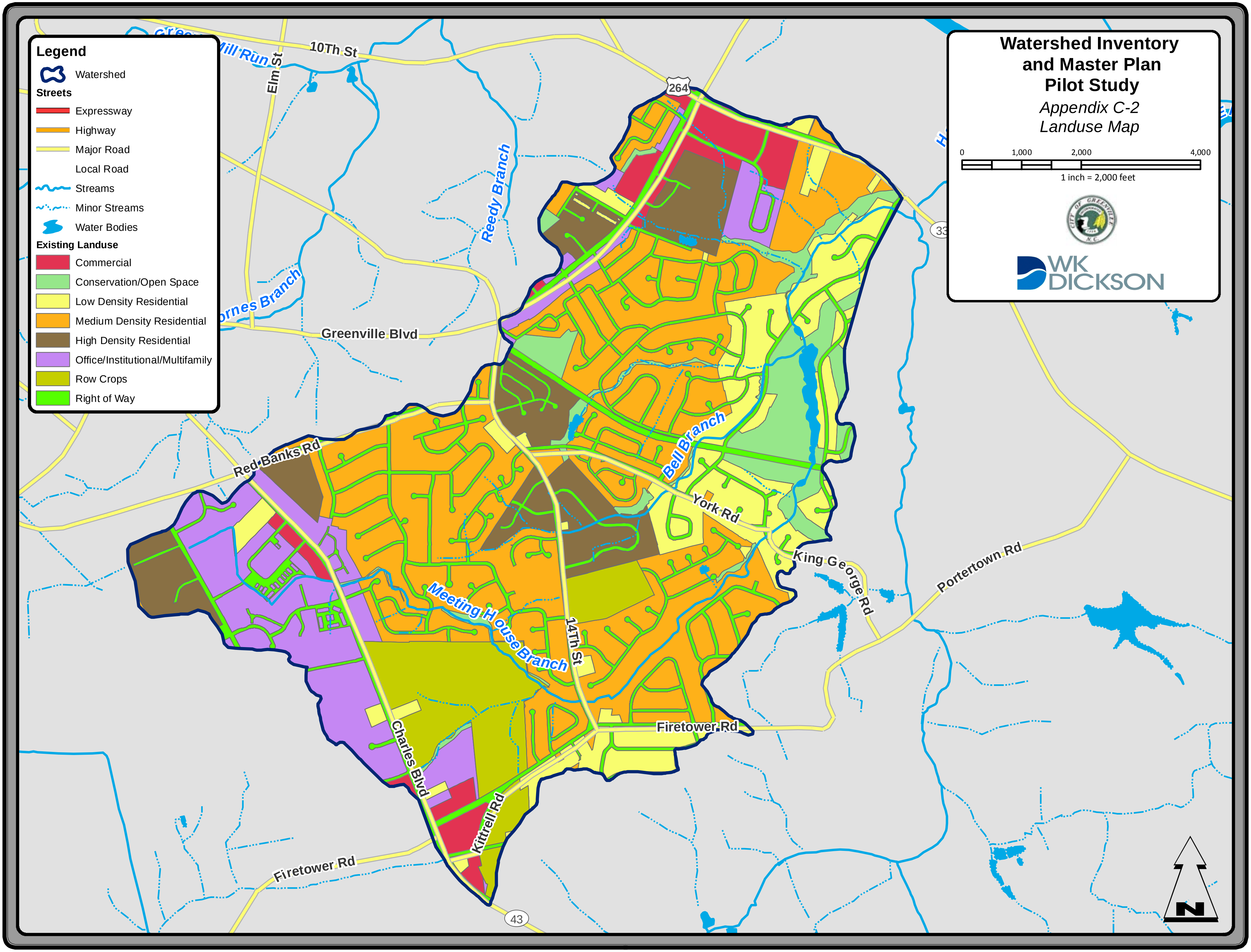
Table B-7: Bend Loss Coefficients

Angle (°)	Loss Coefficient	Angle (°)	Loss Coefficient
90	0.70	40	0.38
80	0.66	30	0.28
70	0.61	25	0.22
60	0.55	20	0.16
50	0.47	15	0.10

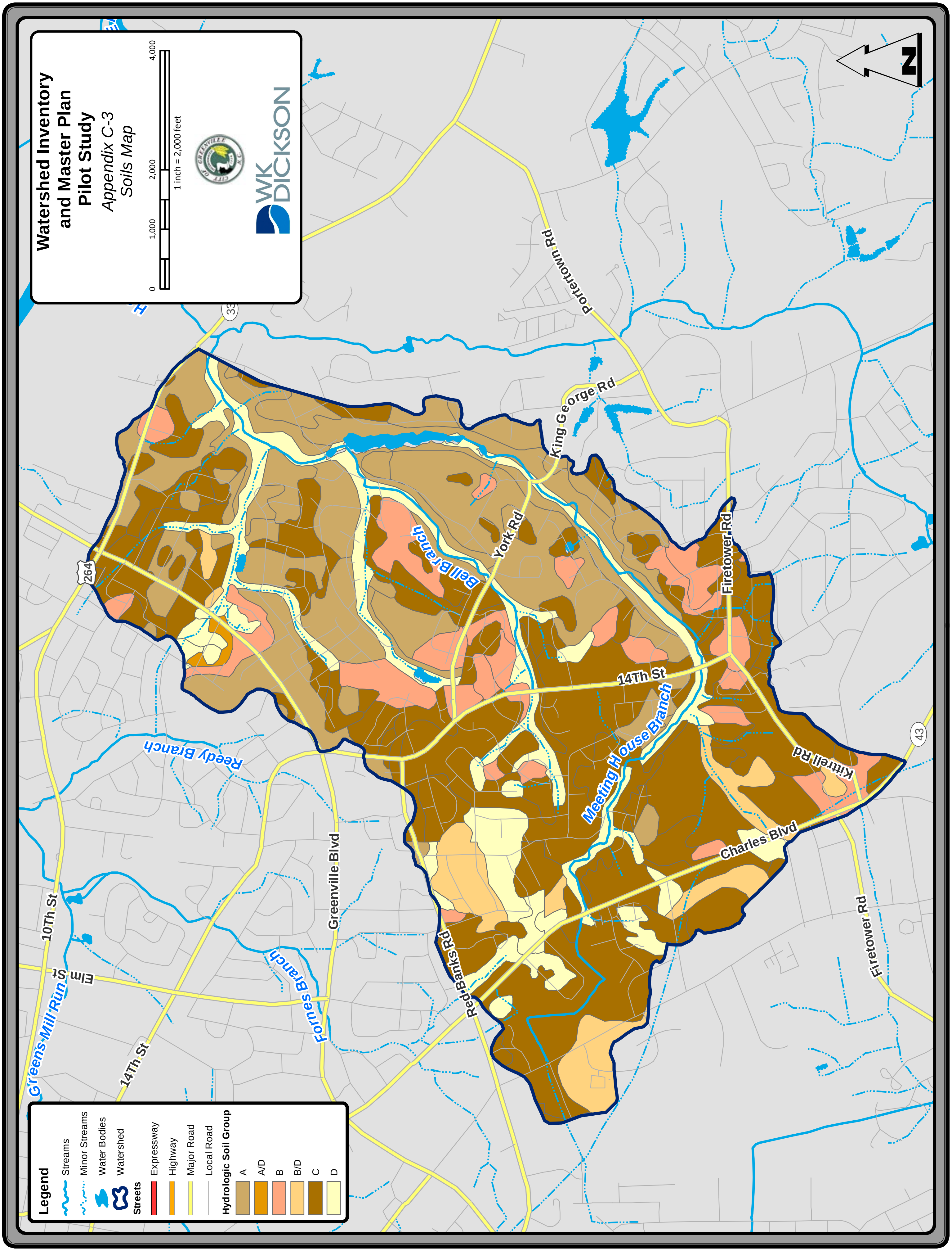
APPENDIX C



Watershed Inventory
and Master Plan
Pilot Study
Appendix C-1
Primary System Watersheds
0
1,000
2,000
4,000
1 inch = 2,000 feet
WK DICKSON
Legend
Streams
Minor Streams
Water Bodies
Primary - Drainage Basins
Streets
Expressway
Highway
Major Road
Local Road
MHB-1
MHB-2
MHB-3
MHB-4
MHB-5
MHB-6
MHB-7
MHB-8
MHB-9
MHB-10
BB-1
BB-2
BB-3
BB-4
BB-5
BB-6
UTBB-1
10Th St
Elm St
Mill Run
Reedy Branch
Fornes Branch
Greenville Blvd
Red Banks Rd
Meeting House Branch
Bell Branch
14Th St
York Rd
King George Rd
Portertown Rd
Firetower Rd
Charles Blvd
Kittrell Rd
264
43
33
N



Watershed Inventory
and Master Plan
Pilot Study
Appendix C-2
Landuse Map
0
1,000
2,000
4,000
1 inch = 2,000 feet
WK DICKSON
Legend
Watershed
Streets
Expressway
Highway
Major Road
Local Road
Streams
Minor Streams
Water Bodies
Existing Landuse
Commercial
Conservation/Open Space
Low Density Residential
Medium Density Residential
High Density Residential
Office/Institutional/Multifamily
Row Crops
Right of Way
10Th St
Elm St
Reedy Branch
Greenville Blvd
Red Banks Rd
Bell Branch
York Rd
King George Rd
Portertown Rd
Meeting House Branch
14Th St
Firetower Rd
Charles Blvd
Kittrell Rd
264
43
33
N


Watershed Inventory and Master Plan Pilot Study
Appendix C-3
Soils Map
0
1,000
2,000
4,000
1 inch = 2,000 feet
WK DICKSON
N
Legend
Streams
Minor Streams
Water Bodies
Watershed
Streets
Expressway
Highway
Major Road
Local Road
Hydrologic Soil Group
A
A/D
B
B/D
C
D
Bell Branch
York Rd
King George Rd
Portertown Rd
Firetower Rd
14Th St
Meeting House Branch
Kittrell Rd
Charles Blvd
Red Banks Rd
Greenville Blvd
Reedy Branch
Fornes Branch
10Th St
Elm St
Greens Mill Run
14Th St
Firetower Rd
264
43
33

APPENDIX D

Table D-1: General Survey Results

Survey Question Number	Question	Survey Response		
		Yes	No	Maybe
2	Have you ever experienced flooding on your system property during a (non-Hurricane) storm?	67	102	-
4	Have you ever noticed flooded streets in your neighborhood?	55	99	-
6	Has flooding increased on your property due to the filling of lots adjacent to, or near, your property?	26	123	1
9	If a cost-sharing program was made available along with training, would you be willing to install a stormwater BMP (e.g. rain garden, cistern, backyard wetland,etc.)?	21	45	79
12	Are you aware that the City of Greenville is currently analyzing and looking for possible solutions to erosion, flooding and water quality issues along Meetinghouse Branch?	58	106	-
13	Are you aware of how the City of Greenville currently spends or utilizes its stormwater utility fee?	15	145	-

Table D-2: Frequency and Location of Flooding Question Responses (Question 2)

Frequency of Flooding	Flooding Location						
	Storage Building	Air Conditioning	Crawl Space	Living Space	Yard flooding from stream/ditch	Yard flooding from street runoff	Yard flooding from adjacent property
Never	21	19	17	19	16	18	16
Less than once per year	3	4	4	3	2	0	3
Once per year	1	0	1	3	6	4	5
2-3 times per year	2	1	3	1	18	10	10
More than 3 times per year	2	1	1	0	13	6	10
Every time it rains	1	0	1	2	2	4	7

Table D-3: Threatened by Erosion (Question 7)

Item	Number of Responses
Street	13
Yard	51
Garage	4
Fence	12
Other	23

Table D-4: Willingness to Participate in a Stream Maintenance Program (Question 8)

Item	Number of Responses
Definitely	36
Maybe	56
Never	15
I need assistance	5
Allow access	16
Other	1

Table D-5: Prioritization of Concerns (Question 10)

Concern	Priority									
	1	2	3	4	5	6	7	8	9	10
Flooding	31	14	15	16	7	4	7	2	1	-
Erosion Sedimentation	23	9	13	18	10	11	5	4	3	1
Watershed Education	2	1	6	3	7	9	12	21	15	1
Stream Maintenance	19	13	16	7	17	10	3	3	3	-
Water Quality	35	12	8	6	10	7	3	7	4	-
Infrastructure Maintenance	19	18	16	3	13	9	13	5	1	1
Property Damage	24	19	13	17	3	7	7	7	1	-
Agency Coordination	1	6	12	3	4	13	6	9	28	-
Aquatic Plan and Animal Life	5	7	5	5	6	5	15	14	18	-
Other	1	-	-	-	-	-	1	-	1	32

Table D-6: Actions taken in last 5 years to reduce flooding/erosion (Question 11)

Item	Number of Responses
Riprap to stabilize stream bank	7
Planted trees to stabilize stream bank	25
Reduced or eliminated mowing near stream bank	16
Installed water harvesting	7
Moved structures away from stream channel	9
Other	21

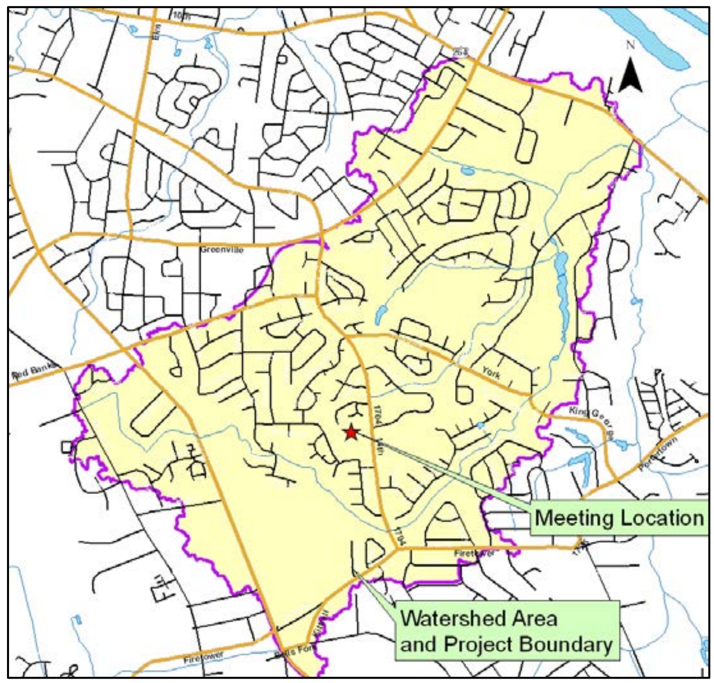
Table D-7: How should City utilize funds to address stormwater runoff issues? (Question 14)

Item	Number of Responses
Develop cost-share program for water harvesting	50
Develop incentives for replanting riparian areas	53
Develop program to address erosion on private property	66
Construct and maintain regional detention facilities	41
Stream restoration	70
Buyout of endangered properties	17
Other	17

PUBLIC MEETING NOTICE

The City of Greenville is currently working on a Stormwater Master Plan for Meetinghouse Branch in your area and is gathering information for preparation of the existing drainage system analysis including City maintained pipes and ditches. An open-house project kick-off meeting has been scheduled for **April 19, 2011** to discuss the scope of the master plan, the timeframe for completion of the project, and to answer any questions you may have. **Your input is critical to the success of the project!**

There are several ways to respond:



1. Complete the questionnaire located on the back of this notice and return it to the following address:

Tom Murray, PE
WK Dickson
720 Corporate Center Drive
Raleigh, NC 27607

2. Bring the completed questionnaire with you to the following open-house public meeting:

April 19, 2011

Meetinghouse Branch Stormwater Master Plan
Location: First Christian Church Family Life Center
2810 East 14th Street
Greenville, NC
Time: 5:30-7:30 p.m.

You are invited!

The meeting is an open-house format, so please arrive any time between 5:30 pm and 7:30 pm to discuss this project and address any questions or concerns you may have.

For more information, contact the Project Manager, Lisa Kirby, PE
252-329-4683 or LKirby@GREENVILLENC.GOV

or WK Dickson Project Manager, Tom Murray, PE
919-782-0495 or tmurray@wkdickson.com

The City of Greenville would like your input and assistance with Stormwater Master Planning. Our purpose is to obtain information about drainage and erosion problems and water quality concerns. Please take a few minutes to check the appropriate answer and write comments where needed. Then drop the survey in the nearest mail box at your convenience. Postage is paid; no stamp is necessary. Thank you in advance for your input.

Name: ____________________

Property Address: ____________________

____

Phone #: ____________________

1. How long have you owned or lived at this location?

2. Have you ever experienced flooding on your property during a (non-Hurricane) storm?
   - ❑ Yes ❑ No

   If yes, check all situations that apply and note the frequency by choosing the appropriate letter from legend.

Legend	
A	Never experienced
B	Less than once per year
C	Once per year
D	2-3 times per year
E	More than 3 times per year
F	Every time it rains

- ❑ Water in storage building ______
- ❑ Water on air condition units ______
- ❑ Water in crawl space ______
- ❑ Water up to, or in the living space ______
- ❑ Yard flooding from stream/ditch ______
- ❑ Yard flooding from street runoff ______
- ❑ Yard flooding from adjacent property ______

3. If flooding occurred, please list the approximate date(s), location, and indicate depth of flooding.

   Date ____________________
   Location ____________________
   Depth of water ____________________

   Date ____________________
   Location ____________________
   Depth of water ____________________

4. Have you ever noticed flooded streets in your neighborhood?
   - ❑ Yes ❑ No

5. If you noticed flooded streets, please provide the approximate date(s), location and depth of flooding.

   Date ____________________
   Location ____________________
   Depth of water ____________________

   Date ____________________
   Location ____________________
   Depth of water ____________________

6. Has flooding increased on your property due to the filling of lots adjacent to, or near, your property?
   - ❑ Yes ❑ No

7. What is threatened by erosion?
   - ❑ Street
   - ❑ Yard
   - ❑ Garage
   - ❑ Fence
   - ❑ Other ____________________

8. I would be willing to participate in a stream maintenance program (e.g. allowing for stream bank restoration, sampling for water quality, installing rain gauges, diverting stormwater to cisterns or rain barrels, etc.).
   - ❑ Definitely
   - ❑ Maybe
   - ❑ Never
   - ❑ I need assistance
   - ❑ I can't help but I will allow access to the creek through my property
   - ❑ Other ____________________

9. If a cost-sharing program was made available along with training, would you be willing to install a stormwater BMP (e.g. rain garden, cistern, backyard wetland, etc.)
   - ❑ Yes ❑ No ❑ Maybe

10. Please prioritize your concerns by placing the numbers from 1 through 10 next to the issue

____Flooding
____Erosion/Sedimentation
____Watershed Education
____Stream Maintenance (debris removal, bank stabilization, quantity control)
____Water Quality
____Infrastructure Maintenance (culvert, stormwater, detention ponds)
____Property Damage
____Agency coordination, such as Township, City, and or Road District
____Aquatic Plan and Animal Life
____Other:

11. What action, if any, have you taken in the last 5 years to lessen the threat of erosion and/or flooding? (Check all that apply)
    - ❑ Used rip-rap to stabilize the stream bank (either self-funded or provided by the City
    - ❑ Planted trees or other natural vegetation to stabilize the bank
    - ❑ Reduced or eliminated mowing near the stream bank to allow for plant growth in order to aid in bank stabilization
    - ❑ Installed rain barrels, cisterns, or other water harvesting practices to reduce runoff
    - ❑ Moved structures away from stream channel and/or elevated structures
    - ❑ Other ____________________

12. Are you aware that the City of Greenville is currently analyzing and looking for possible solutions to erosion, flooding and water quality issues along Meetinghouse Branch?
    - ❑ Yes ❑ No

13. Are you aware of how the City of Greenville currently spends or utilizes its stormwater utility fee?
    - ❑ Yes ❑ No

14. In what ways should the City of Greenville utilize funds to address excessive stormwater runoff, erosion and flooding issues along Meetinghouse Branch (or in your neighborhood)? (Check all that apply)
    - ❑ Develop cost-sharing program for installation of water harvesting practices to reduce stormwater flows
    - ❑ Develop incentives for replanting riparian areas (directly adjacent to streams)
    - ❑ Develop a program to address erosion on private property
    - ❑ Construct and maintain regional detention facilities to store stormwater
    - ❑ Stream restoration
    - ❑ Buyout of endangered properties
    - ❑ Other ____________________

Other comments: ____________________

720 Corporate Center Drive, Raleigh, North Carolina 27607 919.782.0495

DATE: April 20, 2011

TO: Lisa Kirby

FROM: Tom Murray

WKD #: 20100174.00.RA (City of Greenville Stormwater Master Plan)

City of Greenville Public Meeting – April 19, 2011
5:30 PM at First Christian Church Family Life Center

Design Team Participants:

- Tom Murray – Project Manager, WK Dickson
- Scott Whalen – Senior Project Manager, WK Dickson
- Ebony Hagans – Project Engineer, WK Dickson

Citizen Input

A copy of the sign-in sheet from the public meeting is attached. Below is a summary of the comments obtained from those in attendance.

- **102 Casual Court – Jean Soranno**
  - The Sorannos are experiencing minor flooding in back corner of property.
  - Mary Moody at 104 Casual Court, has experienced water in her living space.
  - The neighbor at 106 Casual Court has had water get under their house.

- **402 Tuckahoe Road – Donna Smith**
  - Mrs. Smith is experiencing backyard flooding.
  - The creek in her backyard is widening due to erosion; this has happened over the past 4 years.
  - She believes it is a channel capacity issue.
  - The water comes up to her garage but has not entered. She is afraid that it is only a matter of time before her garage will get wet.

- She is also afraid that one of the larger trees will fall over.
- Her neighbor has experienced water getting into garage and living space.

- **406 Tuckahoe Road – Mary Wesley Harvey**
  - Heavy rain floods creek adjacent to her property.
  - Originally, the lower 40 feet of backyard was flat; now there is a gully developing as a result of erosion.
  - Big trees with roots becoming exposed rapidly.
  - She questions if the new development in watershed near Walgreens is contributing to the problem.
  - There is street flooding that occurs at the intersection of Firetower and Arlington any time there is a constant heavy rain.
  - The pipe underneath 14th Street backs up on the upstream end. It washed away during Hurricane Floyd; not sure if or when they replaced it. An additional pipe was added to increase capacity.

- **3119 Cleere Court – Kevin Pate**
  - Mr. Pate will forward video with dates showing the amount of water that is flowing through the creek. Scott provided business card and pointed out Tom's email on front of questionnaire.
  - A dead tree has already fallen into his yard.
  - He has called the City on at least two occasions. He has had people come and say there is nothing that they could do. They informed him that his property is adjacent to what has been classified as a protected greenway.
  - There is lots of sediment being deposited as a result of erosion. The sediment depositions are decreasing the capacity of creek, pipes, etc.
  - In the main creek, there is a tree at a bend, during heavy rains some of the flow leaves at this location and is creating a side ditch.
  - Mr. Pate was interested in what he could do in the interim to minimize the impacts to his property. He wanted short–term solutions because he realizes this process would take time.

- **103 Nichols Drive – Deanne and Scott Hucks**
  - Drainage ditch between 103 Nichols Drive and 201 Kent Street is eroded causing loss of yard and potential for structural damage.
  - Water overtops Kent Street approximately once per year causing erosion on the downstream end of the road in addition to the flooding.

    - The City is currently working on a design to fix the erosion problem and a drainage study for the Eastwood subdivision project in general.
    - Mr. and Mrs. Hucks would like to speak with Lisa Kirby to talk specifically about the proposed design.

- **201 Kent Street – Evelyn Hinnant**
    - Similar issues to 103 Nichols Street except owner has had to have house jacked and structurally supported due to erosion in proximity to house.

- **129 King George Road – Julian Vainright**
    - The stream borders Mr. Vainright's property for approximately 150 feet along the back of his property. The stream gets out of bank with approximately 2-3 inches of rain. When the stream is out of bank significant sediment deposits and debris accumulates on his property.
    - The stream has significantly widened over the years.
    - The culverts at the maintenance road causes water to back up with approximately a 2' head difference between the upstream and downstream portions of the culvert.
    - Drainage from the new section of Brook Valley crosses at Oxford Road causing some flooding near the club house.
    - Mr. Vainright provided pictures of the flooding and erosion problems.

- **99 Nichols Street - John and Frances Hart**
    - Approximately 2 times a year has yard flooding
    - Property has streams on north side and east side. Both sides can cause yard flooding.
    - Opening up walking path will reduce a restriction in flow
    - Basement was flooded once during Floyd

- **215 Windsor Road – Don and Jean Broadbelt**
    - Sump pump in basement outfalls to yard and does not drain. Mr. Broadbelt wants to discharge to the sanitary sewer as there is no storm drainage structure in close proximity. Tom notified Mr. Broadbelt that they would not be allowed to discharge stormwater to the sanitary sewer system.
    - Near the 17th green Windsor Road slopes away from the lake causing standing water on the opposite side of the road.

- **335 Glenn Court – Joe Luczkovich**
    - 3-story home on culdesac. Bottom floor is protected by a bulkhead. The stream runs directly behind his house before discharging through a culvert under the railroad.
    - The railroad appears to back up water. During large storm events (approximately 4” of rain) water will back up behind the railroad and cause yard flooding.
    - Erosion has brought the stream closer to Mr. Luczkovich’s deck.
    - Runoff from Glenn Court has flooded crawl space in front of house.
    - There is a storm structure at the end of the culdesac.
    - Mr. Luczkovich will email Tom a video of the flooding.

- **3201 Meeting Place – Durk Tyson**
    - No drainage issues in neighborhood.
    - A couple of times a year, the water will come out of bank in the stream behind Mr. Tyson’s house causing backyard flooding.
    - The channel is incised behind the house.
    - Storm drainage from the street drains to an open ditch between Mr. Tyson’s house and the adjacent house causing minor erosion of Mr. Tyson’s yard.

APPENDIX E

SCS Runoff Curve Number - Primary System

Project: City of Greenville - Pilot Watershed
Conditions: Existing
Prepared by: EVH
Checked by: DJK
Date: March 9, 2012

Subbasin: BB - 1

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
High Density Residential	B	75	0.1	0.000	8
High Density Residential	C	83	1.0	0.002	80
High Density Residential	D	87	1.9	0.003	164
Medium Density Residential	A	54	0.0	0.000	1
Medium Density Residential	B	70	3.3	0.005	231
Medium Density Residential	B/D	85	3.9	0.006	331
Medium Density Residential	C	80	34.5	0.054	2758
Medium Density Residential	D	85	17.4	0.027	1478
ROW	A	83	0.0	0.000	1
ROW	D	93	0.0	0.000	0
		Totals =	62.0	0.097	5051.4

Total (weighted) RCN = total product/total area = 81.43

RCN used = 81

Subbasin: BB - 2

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
High Density Residential	B	75	1.3	0.002	96
High Density Residential	C	83	10.8	0.017	896
High Density Residential	D	87	2.0	0.003	172
Medium Density Residential	B	70	1.4	0.002	96
Medium Density Residential	C	80	25.3	0.040	2022
Medium Density Residential	D	85	6.1	0.009	514
ROW	B	89	0.3	0.000	24
ROW	C	92	1.1	0.002	97
ROW	D	93	0.1	0.000	9
		Totals =	48.2	0.075	3926.3

Total (weighted) RCN = total product/total area = 81.51

RCN used = 82

Subbasin: BB - 3

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
High Density Residential	B	75	5.9	0.009	444
High Density Residential	C	83	6.5	0.010	541
High Density Residential	D	87	3.9	0.006	341
Medium Density Residential	B	70	0.2	0.000	14
Medium Density Residential	C	80	0.1	0.000	5
Low Density Residential	B	68	0.4	0.001	27
Low Density Residential	D	84	0.1	0.000	8
Row Crops - Straight Row (Good)	C	85	1.0	0.002	88
ROW	B	89	0.3	0.000	27
ROW	C	92	1.0	0.002	93
ROW	D	93	0.1	0.000	10
		Totals =	19.6	0.031	1597.6

Total (weighted) RCN = total product/total area = 81.65

RCN used = 82

Subbasin: BB - 4

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
High Density Residential	A	61	3.4	0.005	206
High Density Residential	B	75	6.3	0.010	473
High Density Residential	C	83	11.5	0.018	956
High Density Residential	D	87	6.8	0.011	593
Medium Density Residential	A	54	0.8	0.001	44
Medium Density Residential	B	70	4.8	0.007	334
Medium Density Residential	C	80	7.1	0.011	567
Medium Density Residential	D	85	2.9	0.005	247
Low Density Residential	A	51	11.3	0.018	576
Low Density Residential	C	79	1.4	0.002	113
Low Density Residential	D	84	1.5	0.002	128
Conservation/Open Space (Fair)	B	69	0.6	0.001	43
Conservation/Open Space (Fair)	C	79	1.4	0.002	111
Conservation/Open Space (Fair)	D	84	1.0	0.001	80
Row Crops - Straight Row (Good)	A	67	2.9	0.005	195
Row Crops - Straight Row (Good)	B	78	0.3	0.000	22
Row Crops - Straight Row (Good)	C	85	6.5	0.010	549
Row Crops - Straight Row (Good)	D	89	2.5	0.004	223
ROW	A	83	0.4	0.001	35
ROW	C	92	0.6	0.001	56
ROW	D	93	0.1	0.000	11
		Totals =	74.1	0.116	5559.8

Total (weighted) RCN = total product/total area = 75.02

RCN used = 75

Subbasin: BB - 5

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Medium Density Residential	A	54	3.5	0.005	186
Medium Density Residential	B	70	1.0	0.002	73
Medium Density Residential	C	80	6.0	0.009	477
Low Density Residential	A	51	6.0	0.009	308
Low Density Residential	D	84	2.3	0.004	191
Conservation/Open Space (Fair)	A	49	1.0	0.002	48
Conservation/Open Space (Fair)	C	79	0.0	0.000	1
Conservation/Open Space (Fair)	D	84	0.8	0.001	69
ROW	A	83	2.4	0.004	202
ROW	B	89	0.3	0.000	28
ROW	C	92	0.9	0.001	83
ROW	D	93	0.3	0.000	29
		Totals =	24.54	0.038	1694.9

Total (weighted) RCN = total product/total area = 69.08

RCN used = 69

Subbasin: BB - 6

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Medium Density Residential	A	54	0.1	0.000	7
Medium Density Residential	B	70	2.5	0.004	172
Medium Density Residential	C	80	1.4	0.002	115
Medium Density Residential	D	85	0.0	0.000	1
Low Density Residential	A	51	7.0	0.011	356
Low Density Residential	B	68	0.7	0.001	50
Low Density Residential	C	79	0.1	0.000	9
Low Density Residential	D	84	5.6	0.009	471
Conservation/Open Space (Fair)	A	49	6.7	0.010	327
Conservation/Open Space (Fair)	D	84	3.9	0.006	329
ROW	A	83	2.2	0.003	184
ROW	B	89	0.2	0.000	17
ROW	C	92	0.1	0.000	12
ROW	D	93	1.5	0.002	143
Water	-	100	0.1	0.000	14
		Totals =	32.3	0.050	2208.4

Total (weighted) RCN = total product/total area = 68.38

RCN used = 68

Subbasin: MHB - 1

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Office/Institutional/Multi-Family	B/D	92	6.3	0.010	575
Office/Institutional/Multi-Family	C	90	56.7	0.089	5101
Office/Institutional/Multi-Family	D	92	1.3	0.002	121
High Density Residential	B/D	87	19.5	0.030	1694
High Density Residential	C	83	10.4	0.016	863
High Density Residential	D	87	0.0	0.000	0
Medium Density Residential	B/D	85	0.3	0.000	23
Medium Density Residential	C	80	0.0	0.000	0
Low Density Residential	C	79	2.5	0.004	196
ROW	B/D	93	2.8	0.004	256
ROW	C	92	1.5	0.002	141
		Totals =	101.2	0.158	8971.7

Total (weighted) RCN = total product/total area = 88.68

RCN used = 89

Subbasin: MHB - 2

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	C	94	3.9	0.006	364
Commercial	D	95	1.5	0.002	144
Office/Institutional/Multi-Family	C	90	28.8	0.045	2591
Office/Institutional/Multi-Family	D	92	9.8	0.015	898
Low Density Residential	C	79	4.1	0.006	322
Low Density Residential	D	84	0.2	0.000	16
ROW	C	92	0.0	0.000	1
		Totals =	48.21	0.075	4335.7

Total (weighted) RCN = total product/total area = 89.93

RCN used = 90

Subbasin: MHB - 3

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	C	94	0.6	0.001	57
Commercial	D	95	0.4	0.001	35
Office/Institutional/Multi-Family	B/D	92	1.5	0.002	137
Office/Institutional/Multi-Family	C	90	9.9	0.015	887
Office/Institutional/Multi-Family	D	92	12.0	0.019	1105
High Density Residential	B/D	89	0.0	0.000	4
High Density Residential	C	83	11.1	0.017	925
High Density Residential	D	87	4.2	0.007	368
Medium Density Residential	A	54	0.0	0.000	0
Medium Density Residential	B	70	1.9	0.003	134
Medium Density Residential	B/D	85	26.6	0.042	2258
Medium Density Residential	C	80	34.9	0.054	2789
Medium Density Residential	D	85	23.3	0.036	1981
Low Density Residential	C	79	0.5	0.001	40
Conservation/Open Space (Fair)	D	84	0.7	0.001	62
ROW	A	83	0.8	0.001	66
ROW	B	89	0.6	0.001	53
ROW	B/D	93	1.7	0.003	161
ROW	C	92	6.2	0.010	567
ROW	D	93	2.2	0.003	207
		Totals =	139.15	0.217	11836.1

Total (weighted) RCN = total product/total area = 85.06

RCN used = 85

Subbasin: MHB - 4

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Office/Institutional/Multi-Family	B/D	92	5.0	0.008	459
Office/Institutional/Multi-Family	C	90	30.3	0.047	2728
Office/Institutional/Multi-Family	D	92	6.5	0.010	597
Medium Density Residential	A	54	0.7	0.001	39
Medium Density Residential	C	80	9.3	0.015	746
Medium Density Residential	D	85	4.7	0.007	400
Low Density Residential	B/D	84	0.1	0.000	11
Low Density Residential	C	79	0.1	0.000	7
Conservation/Open Space (Fair)	D	84	0.0	0.000	2
Row Crops - Straight Row (Good)	A	67	1.7	0.003	115
Row Crops - Straight Row (Good)	B	78	0.0	0.000	3
Row Crops - Straight Row (Good)	C	85	13.0	0.020	1101
Row Crops - Straight Row (Good)	D	89	1.2	0.002	103
ROW	C	92	3.0	0.005	271
ROW	D	93	0.6	0.001	51
		Totals =	76.2	0.119	6633.3

Total (weighted) RCN = total product/total area = 87.11

RCN used = 87

Subbasin: MHB - 5

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	B	92	9.8	0.015	902
Commercial	B/D	95	3.4	0.005	321
Commercial	C	94	9.4	0.015	879
Commercial	D	95	1.2	0.002	117
Office/Institutional/Multi-Family	B/D	92	19.5	0.030	1790
Office/Institutional/Multi-Family	C	90	15.6	0.024	1407
Office/Institutional/Multi-Family	D	92	4.5	0.007	415
Medium Density Residential	A	54	12.8	0.020	692
Medium Density Residential	B	70	7.9	0.012	552
Medium Density Residential	B/D	85	1.0	0.002	82
Medium Density Residential	C	80	53.1	0.083	4245
Medium Density Residential	D	85	7.6	0.012	647
Low Density Residential	B	68	5.0	0.008	340
Low Density Residential	B/D	84	0.7	0.001	61
Low Density Residential	C	79	15.9	0.025	1259
Conservation/Open Space (Fair)	A	49	0.2	0.000	11
Conservation/Open Space (Fair)	B/D	84	1.7	0.003	145
Conservation/Open Space (Fair)	C	79	1.2	0.002	92
Conservation/Open Space (Fair)	D	84	1.9	0.003	160
Row Crops - Straight Row (Good)	A	67	4.2	0.007	279
Row Crops - Straight Row (Good)	B	78	4.8	0.007	372
Row Crops - Straight Row (Good)	B/D	89	11.6	0.018	1028
Row Crops - Straight Row (Good)	C	85	83.7	0.131	7113
Row Crops - Straight Row (Good)	D	89	7.3	0.011	649
ROW	A	83	0.5	0.001	39
ROW	B	89	4.7	0.007	414
ROW	B/D	93	0.8	0.001	71
ROW	C	92	9.4	0.015	861
ROW	D	93	1.5	0.002	136
		Totals =	300.61	0.470	25083.1

Total (weighted) RCN = total product/total area = 83.44

RCN used = 83

Subbasin: MHB - 6

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Medium Density Residential	A	54	15.9	0.025	861
Medium Density Residential	B	70	19.5	0.030	1364
Medium Density Residential	C	80	34.1	0.053	2730
Medium Density Residential	D	85	6.9	0.011	590
Low Density Residential	A	51	0.6	0.001	33
Low Density Residential	B	68	4.0	0.006	270
Low Density Residential	C	79	21.1	0.033	1665
Row Crops - Straight Row (Good)	B	78	0.1	0.000	4
Row Crops - Straight Row (Good)	C	85	4.4	0.007	373
ROW	A	83	0.3	0.000	26
ROW	B	89	0.7	0.001	63
ROW	C	92	3.4	0.005	314
ROW	D	93	0.1	0.000	12
		Totals =	111.17	0.174	8303.5

Total (weighted) RCN = total product/total area = 74.69

RCN used = 75

Subbasin: MHB - 7

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Medium Density Residential	A	54	52.6	0.082	2842
Medium Density Residential	B	70	9.7	0.015	676
Medium Density Residential	C	80	15.7	0.025	1259
Medium Density Residential	D	85	6.6	0.010	564
Low Density Residential	A	51	13.5	0.021	686
Low Density Residential	C	79	1.4	0.002	107
Low Density Residential	D	84	0.7	0.001	63
Conservation/Open Space (Fair)	A	49	0.9	0.001	45
Conservation/Open Space (Fair)	C	79	0.1	0.000	7
Conservation/Open Space (Fair)	D	84	0.7	0.001	58
Row Crops - Straight Row (Good)	A	67	3.2	0.005	216
Row Crops - Straight Row (Good)	B	78	2.4	0.004	191
Row Crops - Straight Row (Good)	C	85	0.9	0.001	76
Row Crops - Straight Row (Good)	D	89	0.0	0.000	3
ROW	A	83	1.8	0.003	153
ROW	D	93	0.1	0.000	8
Water	-	100	0.1	0.000	8
		Totals =	110.5	0.173	6960.4

Total (weighted) RCN = total product/total area = 62.99

RCN used = 63

Subbasin: MHB - 8

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Medium Density Residential	A	54	1.9	0.003	100
Medium Density Residential	B	70	0.0	0.000	0
Medium Density Residential	C	80	0.1	0.000	12
Medium Density Residential	D	85	0.0	0.000	0
Low Density Residential	A	51	38.9	0.061	1985
Low Density Residential	B	68	2.2	0.003	149
Low Density Residential	C	79	1.6	0.003	129
Low Density Residential	D	84	1.0	0.002	84
Conservation/Open Space (Fair)	A	49	43.7	0.068	2142
Conservation/Open Space (Fair)	B	69	0.2	0.000	13
Conservation/Open Space (Fair)	C	79	4.5	0.007	357
Conservation/Open Space (Fair)	D	84	3.8	0.006	317
ROW	A	83	3.2	0.005	268
ROW	C	92	0.4	0.001	32
ROW	D	93	0.4	0.001	39
Water	-	100	6.1	0.009	608
		Totals =	108.0	0.169	6234.9

Total (weighted) RCN = total product/total area = 57.72

RCN used = 58

Subbasin: MHB - 9

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	A	89	13.4	0.021	1192
Commercial	A/D	95	0.3	0.001	32
Commercial	B/D	95	0.3	0.001	30
Commercial	C	94	30.8	0.048	2896
Commercial	D	95	2.8	0.004	267
Office/Institutional/Multi-Family	A	77	17.9	0.028	1380
Office/Institutional/Multi-Family	A/D	92	0.9	0.001	84
Office/Institutional/Multi-Family	B	85	1.7	0.003	147
Office/Institutional/Multi-Family	C	90	16.4	0.026	1476
Office/Institutional/Multi-Family	D	92	6.9	0.011	634
High Density Residential	A	61	20.0	0.031	1222
High Density Residential	A/D	87	2.7	0.004	236
High Density Residential	B	75	5.0	0.008	375
High Density Residential	B/D	87	4.6	0.007	400
High Density Residential	C	83	14.1	0.022	1167
High Density Residential	D	87	13.0	0.020	1128
Medium Density Residential	A	54	72.5	0.113	3914
Medium Density Residential	B	70	16.1	0.025	1128
Medium Density Residential	C	80	36.9	0.058	2952
Medium Density Residential	D	85	10.5	0.016	897
Low Density Residential	A	51	7.1	0.011	363
Low Density Residential	A/D	84	0.9	0.001	77
Low Density Residential	B	68	0.3	0.001	24
Low Density Residential	C	79	3.3	0.005	261
Low Density Residential	D	84	5.6	0.009	469
Conservation/Open Space (Fair)	A	49	8.8	0.014	432
Conservation/Open Space (Fair)	B	69	1.4	0.002	99
Conservation/Open Space (Fair)	C	79	6.3	0.010	499
Conservation/Open Space (Fair)	D	84	7.5	0.012	630
ROW	A	83	6.1	0.010	508
ROW	A/D	93	1.0	0.002	96
ROW	B	89	1.5	0.002	134
ROW	C	92	7.8	0.012	714
ROW	D	93	0.8	0.001	71
Water	-	100	0.3	0.000	31
		Totals =	345.8	0.540	25964.9

Total (weighted) RCN = total product/total area = 75.09

RCN used = 75

Subbasin: MHB - 10

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	A	89	4.7	0.007	418
Commercial	C	94	2.1	0.003	202
Office/Institutional/Multi-Family	A	77	2.0	0.003	156
Office/Institutional/Multi-Family	C	90	0.2	0.000	20
Medium Density Residential	A	54	19.4	0.030	1050
Medium Density Residential	B	70	2.8	0.004	195
Medium Density Residential	C	80	9.0	0.014	723
Medium Density Residential	D	85	1.6	0.002	132
Low Density Residential	A	51	25.7	0.040	1313
Low Density Residential	B	68	2.6	0.004	180
Low Density Residential	C	79	4.1	0.006	322
Low Density Residential	D	84	12.0	0.019	1008
Conservation/Open Space (Fair)	A	49	11.0	0.017	537
Conservation/Open Space (Fair)	C	79	0.1	0.000	9
Conservation/Open Space (Fair)	D	84	3.6	0.006	302
ROW	A	83	4.5	0.007	370
ROW	B	89	1.2	0.002	108
ROW	C	92	1.5	0.002	140
ROW	D	93	0.4	0.001	42
Water	-	100	0.2	0.000	19
		Totals =	108.87	0.170	7244.6

Total (weighted) RCN = total product/total area = 66.54

RCN used = 67

Subbasin: UTBB - 1

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
High Density Residential	A	61	0.4	0.001	22
High Density Residential	B	75	9.2	0.014	689
High Density Residential	C	83	21.0	0.033	1744
High Density Residential	D	87	0.4	0.001	39
Medium Density Residential	A	54	46.0	0.072	2482
Medium Density Residential	B	70	29.4	0.046	2058
Medium Density Residential	B/D	85	0.8	0.001	65
Medium Density Residential	C	80	49.3	0.077	3947
Medium Density Residential	D	85	9.1	0.014	777
Low Density Residential	A	51	5.9	0.009	301
Low Density Residential	B	68	3.4	0.005	230
Low Density Residential	C	79	7.0	0.011	556
Low Density Residential	D	84	2.6	0.004	215
Conservation/Open Space (Fair)	A	49	0.1	0.000	4
Conservation/Open Space (Fair)	B	69	0.8	0.001	52
Conservation/Open Space (Fair)	C	79	0.5	0.001	40
Conservation/Open Space (Fair)	D	84	6.1	0.009	508
ROW	A	83	3.1	0.005	258
ROW	B	89	3.1	0.005	278
ROW	C	92	5.1	0.008	469
ROW	D	93	0.6	0.001	54
Water	-	100	0.6	0.001	56
		Totals =	204.37	0.319	14845.3

Total (weighted) RCN = total product/total area = 72.64

RCN used = 73

SCS Runoff Curve Number - Secondary System

Project: City of Greenville - Pilot Watershed
Conditions: Existing
Prepared by: ERB
Checked by: EVH
Date: March 22, 2012

Subbasin: MHUT 1

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	A	89	3.25	0.005	289
Commercial	C	94	1.60	0.002	150
Office/Institutional/Multi-Family	A	77	1.41	0.002	109
Office/Institutional/Multi-Family	C	90	0.75	0.001	67
Office/Institutional/Multi-Family	D	92	0.07	0.000	7
Medium Density Residential	A	54	8.60	0.013	464
Medium Density Residential	C	80	1.45	0.002	116
Medium Density Residential	D	85	0.96	0.001	81
Conservation/Open Space (Fair)	A	49	0.04	0.000	2
Conservation/Open Space (Fair)	D	84	3.19	0.005	268
ROW	A	83	1.28	0.002	106
ROW	C	92	0.27	0.000	25
ROW	D	93	0.04	0.000	4
		Totals =	22.9	0.036	1689.2

Total (weighted) RCN = total product/total area = 73.71

RCN used = 74

Subbasin: MHUT 2

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	A	89	0.80	0.001	71
Commercial	C	94	0.87	0.001	82
Office/Institutional/Multi-Family	A	77	4.82	0.008	371
Office/Institutional/Multi-Family	C	90	10.58	0.017	952
Office/Institutional/Multi-Family	D	92	0.77	0.001	70
High Density Residential	C	83	0.01	0.000	1
Medium Density Residential	A	54	3.61	0.006	195
Medium Density Residential	C	80	0.37	0.001	30
Medium Density Residential	D	85	0.64	0.001	54
Conservation/Open Space (Fair)	D	84	1.18	0.002	99
ROW	A	83	1.57	0.002	131
ROW	C	92	2.04	0.003	188
		Totals =	27.3	0.043	2243.4

Total (weighted) RCN = total product/total area = 82.32

RCN used = 82

Subbasin: MHUT 3

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	A	89	8.21	0.013	731
Commercial	C	94	20.84	0.033	1959
Commercial	D	95	0.13	0.000	12
Office/Institutional/Multi-Family	A	77	0.00	0.000	0
Office/Institutional/Multi-Family	C	90	0.65	0.001	59
Office/Institutional/Multi-Family	D	92	0.17	0.000	16
High Density Residential	A	61	8.30	0.013	506
High Density Residential	B/D	87	3.17	0.005	276
High Density Residential	C	83	7.83	0.012	650
High Density Residential	D	87	6.08	0.010	529
Medium Density Residential	A	54	2.87	0.004	155
Medium Density Residential	C	80	6.07	0.009	485
Medium Density Residential	D	85	0.10	0.000	8
Conservation/Open Space (Fair)	D	84	0.04	0.000	3
ROW	A	83	1.49	0.002	124
ROW	C	92	7.79	0.012	717
		Totals =	73.7	0.115	6229.3

Total (weighted) RCN = total product/total area = 84.49

RCN used = 84

Subbasin: MHUT 4

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
High Density Residential	A	61	0.75	0.001	46
High Density Residential	C	83	0.41	0.001	34
High Density Residential	D	87	1.55	0.002	134
High Density Residential	W	100	0.31	0.000	31
Medium Density Residential	A	54	8.91	0.014	481
Medium Density Residential	C	80	1.86	0.003	148
Medium Density Residential	D	85	0.22	0.000	19
ROW	A	83	1.69	0.003	140
ROW	C	92	0.29	0.000	26
		Totals =	16.0	0.025	1060.5

Total (weighted) RCN = total product/total area = 66.35

RCN used = 66

Subbasin: MHUT 5

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Office/Institutional/Multi-Family	A	77	2.70	0.004	208
High Density Residential	A	61	0.06	0.000	4
High Density Residential	B	75	1.15	0.002	86
High Density Residential	B/D	87	0.01	0.000	1
High Density Residential	C	83	1.65	0.003	137
High Density Residential	D	87	1.07	0.002	93
Medium Density Residential	A	54	25.98	0.041	1403
Medium Density Residential	B	70	5.78	0.009	404
Medium Density Residential	C	80	9.26	0.014	741
Medium Density Residential	D	85	6.06	0.009	515
Conservation/Open Space (Fair)	A	49	3.84	0.006	188
Conservation/Open Space (Fair)	B	69	1.43	0.002	99
Conservation/Open Space (Fair)	C	79	5.46	0.009	431
ROW	A	83	8.14	0.013	675
ROW	B	89	1.90	0.003	169
ROW	C	92	5.14	0.008	473
ROW	D	93	2.24	0.004	209
		Totals =	81.84	0.128	5833.7

Total (weighted) RCN = total product/total area = 71.28

RCN used = 71

Subbasin: MHUT 6

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial	A	89	3.71	0.006	330
Commercial	A/D	95	0.28	0.000	26
Commercial	B/D	95	0.29	0.000	27
Commercial	C	94	5.56	0.009	523
Commercial	D	95	2.55	0.004	242
Office/Institutional/Multi-Family	A	77	6.86	0.011	528
Office/Institutional/Multi-Family	A/D	92	0.63	0.001	58
Office/Institutional/Multi-Family	B	85	1.70	0.003	144
Office/Institutional/Multi-Family	C	90	2.10	0.003	189
Office/Institutional/Multi-Family	D	92	4.78	0.007	440
High Density Residential	A	61	9.02	0.014	550
High Density Residential	A/D	87	2.46	0.004	214
High Density Residential	B	75	4.23	0.007	317
High Density Residential	B/D	87	1.38	0.002	120
High Density Residential	C	83	5.18	0.008	430
High Density Residential	D	87	3.63	0.006	316
Medium Density Residential	A	54	7.10	0.011	383
Medium Density Residential	A/D	85	0.17	0.000	15
Medium Density Residential	B	70	6.98	0.011	489
Medium Density Residential	C	80	7.38	0.012	590
Medium Density Residential	D	85	2.11	0.003	180
Conservation/Open Space (Fair)	A	49	2.80	0.004	137
Conservation/Open Space (Fair)	B	69	0.19	0.000	13
Conservation/Open Space (Fair)	C	79	0.85	0.001	67
ROW	A	83	6.78	0.011	563
ROW	A/D	93	1.68	0.003	156
ROW	B	89	3.34	0.005	297
ROW	B/D	93	0.07	0.000	6
ROW	C	92	4.86	0.008	447
ROW	D	93	2.36	0.004	219
		Totals =	101.0	0.158	8018.1

Total (weighted) RCN = total product/total area = 79.37

RCN used = 79

APPENDIX F

Project: City of Greenville - Pilot Watershed
Prepared by :EVH
Checked by: DJK
Date: August 2, 2011

Time of Concentration - Primary System

Sub-basin	Sheet Flow						Shallow Concentration					Channel Flow										
	Description	n	Flow Length (ft)	P-2 (in)	Land Slope (ft/ft)	Tt (min)	Surface Description 0--Unpaved/1-Paved	Flow Length (ft)	Slope (ft/ft)	Velocity (ft/s)	Tt (min)	Channel Area (ft2)	Channel Perimeter (ft)	Hydraulic Radius (ft)	Slope (ft/ft)	n	Velocity (ft/s)	Flow Length (ft)	Tt (min)	Tc (min)	Lag (min)	Calibration (min)
MHB-1	Woods	0.4	180	3.76	0.002	83.48	1	306	0.001	0.67	7.64	8	7.7	1.04	0.001	0.035	1.29	2301	29.78	120.90	72.54	157
MHB-2	Woods	0.4	171	3.76	0.003	65.66	1	232	0.004	1.33	2.90	Pipe			0.005	0.013	5.00	864	2.88	72.51	43.50	103
												16.5	10.7	1.54	0.011	0.035	5.87	376	1.07			
MHB-3	Grass	0.24	242	3.76	0.003	57.02	1	516	0.002	0.89	9.61	Pipe			0.012	0.013	5.00	149	0.50	87.20	52.32	116
												8	7.7	1.04	0.004	0.05	1.86	960	8.61			
												Pipe			0.004	0.013	5.00	916	3.05			
												36	15.9	2.26	0.003	0.05	2.76	1394	8.42			
MHB-4	Grass	0.24	175	3.76	0.003	44.86	1	375	0.003	1.05	5.95	Pipe			0.011	0.013	5.00	426	1.42	60.16	36.10	79
												16.5	10.7	1.54	0.005	0.05	2.75	420	2.55			
												Pipe			0.002	0.013	5.00	1078	3.59			
												36	15.9	2.26	0.002	0.08	1.34	144	1.79			
MHB-5	Grass	0.24	199	3.76	0.002	64.21	0	563	0.004	0.96	9.76	Pipe			0.005	0.013	5.00	905	3.02	104.06	62.44	139
												8	7.7	1.04	0.006	0.06	2.04	936	7.65			
												16.5	10.7	1.54	0.008	0.06	2.98	1490	8.34			
												36	15.9	2.26	0.001	0.06	1.11	742	11.10			
MHB-6	Woods	0.4	150	3.76	0.040	20.77	0	191	0.021	2.33	1.36	36	15.9	2.26	0.005	0.06	3.12	1517	8.11	30.24	18.14	39
MHB-7	Woods	0.4	221	3.76	0.003	80.43	1	732	0.046	4.38	2.78	72	22.4	3.21	0.001	0.06	1.77	1887	17.79	101.00	60.60	152
MHB-8	Woods	0.4	211	3.76	0.095	19.32	0	306	0.033	2.92	1.75	90	25.4	3.54	0.003	0.035	5.01	1574	5.24	26.31	15.78	43
MHB-9	Woods	0.4	152	3.76	0.010	36.73	0	763	0.012	1.75	7.26	8	7.7	1.04	0.012	0.06	2.81	404	2.40	68.65	41.19	95
												Pipe			0.008	0.013	5.00	2716	9.05			
												36	15.9	2.26	0.007	0.06	3.60	2850	13.21			
MHB-10	Grass	0.24	132	3.76	0.004	31.98	0	508	0.018	2.15	3.94	Pipe			0.036	0.013	5.00	497	1.66	67.17	40.30	99
												36	15.9	2.26	0.003	0.06	2.38	4227	29.59			
BB-1	Woods	0.4	118	3.76	0.003	46.00	1	508	0.001	0.64	13.28	Pipe			0.001	0.013	5.00	297	0.99	75.81	45.49	99
												8	7.7	1.04	0.004	0.07	1.30	1213	15.55			
BB-2	Grass	0.24	100	3.76	0.005	22.92	1	297	0.007	1.67	2.97	Pipe			0.034	0.013	5.00	178	0.59	26.97	16.18	39
												36	15.9	2.26	0.011	0.045	6.05	179	0.49			
BB-3	Grass	0.24	100	3.76	0.010	17.37	1	198	0.003	1.02	3.23	8	7.7	1.04	0.011	0.045	3.59	536	2.49	25.65	15.39	34
												36	15.9	2.26	0.004	0.045	3.49	537	2.56			
BB-4	Grass	0.24	172	3.76	0.005	34.73	1	398	0.010	2.04	3.25	Pipe			0.006	0.013	5.00	1100	3.67	45.68	27.41	69
												36	15.9	2.26	0.008	0.06	3.77	909	4.02			
BB-5	Grass	0.24	130	3.76	0.004	31.40	0	247	0.024	2.51	1.64	Pipe			0.043	0.013	5.00	50	0.17	35.89	21.54	54
												8	7.7	1.04	0.024	0.04	5.95	235	0.66			
												36	15.9	2.26	0.015	0.06	5.18	631	2.03			
BB-6	Grass	0.24	184	3.76	0.022	20.82	0	366	0.065	4.12	1.48	48	18.9	2.54	0.009	0.08	3.26	912	4.67	26.97	16.18	38
UTBB-1	Woods	0.4	261	3.76	0.002	109.06	0	1255	0.012	1.80	11.63	16.5	10.7	1.54	0.010	0.04	4.96	3228	10.852	131.54	78.93	185

Project: City of Greenville - Pilot Watershed
Prepared by :ERB
Checked by: EVH
Date: March 23, 2012

Time of Concentration - Secondary System

Sub-basin	Sheet Flow						Shallow Concentration					Channel Flow									
	Description	n	Flow Length (ft)	P-2 (in)	Land Slope (ft/ft)	Tt (min)	Surface Description 0--Unpaved/1-Paved	Flow Length (ft)	Slope (ft/ft)	Velocity (ft/s)	Tt (min)	Channel Area (ft2)	Channel Perimeter (ft)	Hydraulic Radius (ft)	Slope (ft/ft)	n	Velocity (ft/s)	Flow Length (ft)	Tt (min)	Tc (min)	Lag (min)
MHUT_1	Grass	0.24	266	3.76	0.005	50.14	0	1733	0.018	2.16	13.34	184	78.5	2.34	0.006	0.07	2.92	601	3.43	66.91	40.15
MHUT_2	Grass	0.24	253	3.76	0.004	52.66	1	515	0.014	2.41	3.57	Pipe			0.016	0.013	5.00	911	3.04	59.38	35.63
												81.6	30.2	2.70	0.064	0.07	10.48	70	0.11		
MHUT_3	Grass	0.24	235	3.76	0.007	39.69	0	706	0.017	2.10	5.59	172.2	46.6	3.70	0.006	0.07	3.96	156	0.66	50.59	30.35
												Pipe			0.003	0.023	5.00	205	0.68		
												172.2	46.6	3.70	0.010	0.07	5.11	1216	3.97		
MHUT_4	Grass	0.24	117	3.76	0.021	14.64	0	387	0.005	1.14	5.65	Pipe			0.011	0.023	5.00	504	1.68	24.33	14.60
												83.9	26	3.23	0.027	0.07	7.67	96	0.21		
												Pipe			0.010	0.013	5.00	98	0.33		
												12	10.9	1.10	0.033	0.07	4.12	450	1.82		
MHUT_5	Grass	0.24	294	3.76	0.004	59.39	0	349	0.015	1.98	2.94	Pipe			0.022	0.013	5.00	210	0.70	77.53	46.52
							1	328	0.005	1.44	3.80	84	26.6	3.16	0.006	0.07	3.56	339	1.59		
												Pipe			0.005	0.028	5.00	77	0.26		
												81	51.4	1.58	0.017	0.07	3.76	216	0.96		
												Pipe			0.007	0.023	5.00	1984	6.61		
												62.5	23.7	2.64	0.023	0.07	6.18	477	1.29		
MHUT_6	Grass	0.24	296	3.76	0.020	31.37	0	301	0.016	2.04	2.46	Pipe			0.002	0.013	5.00	383	1.28	45.72	27.43
							1	942	0.007	1.70	9.23	190.8	42.1	4.53	0.008	0.07	5.24	214	0.68		
												Pipe			0.004	0.023	5.00	134	0.45		
												93.1	25.8	3.61	0.033	0.07	9.14	80	0.15		
												Pipe			0.006	0.013	5.00	35	0.12		

APPENDIX G

Unit Costs - Meetinghouse Branch Watershed Master Plan

	Item Description	*Unit*	*Unit Price*
1	Mobilization (10%)	LS	$ -
2	Excavation	CY	$ 25.00
3	Hauling	CY	$ 4.00
4	Clearing & Grubbing	AC	$ 5,000.00
5	Channel Grading	SY	$ 10.00
6	Construction Staking	LS	Varies
7	Select Material	CY	$ 25.00
8	Flowable Fill	CY	$ 350.00
9	12" R.C. Pipe Culvert, Class III	LF	$ 45.00
10	15" R.C. Pipe Culvert, Class III	LF	$ 50.00
11	18" R.C. Pipe Culvert, Class III	LF	$ 55.00
12	18" R.C. Pipe Culvert, Class IV	LF	$ 60.00
13	24" R.C. Pipe Culvert, Class III	LF	$ 65.00
14	24" R.C. Pipe Culvert, Class IV	LF	$ 70.00
15	30" R.C. Pipe Culvert, Class III	LF	$ 80.00
16	36" Steel Pipe Culvert (Tunnel Installation)	LF	$ 800.00
17	36" R.C. Pipe Culvert, Class III	LF	$ 110.00
18	36" R.C. Pipe Culvert, Class IV	LF	$ 120.00
19	42" R.C. Pipe Culvert, Class III	LF	$ 150.00
20	42" R.C. Pipe Culvert, Class IV	LF	$ 165.00
21	48" R.C. Pipe Culvert, Class III	LF	$ 180.00
22	48" R.C. Pipe Culvert, Class IV	LF	$ 195.00
23	48" Steel Pipe Culvert (Tunnel Installation)	LF	$ 1,100.00
24	54" R.C. Pipe Culvert, Class III	LF	$ 200.00
25	60" R.C. Pipe Culvert, Class III	LF	$ 225.00
26	60" Steel Pipe Culvert (Tunnel Installation)	LF	$ 1,500.00
27	72" Steel Pipe Culvert (Tunnel Installation)	LF	$ 1,800.00
28	72" R.C. Pipe Culvert, Class III	LF	$ 320.00
29	72" R.C. Pipe Culvert, Class IV	LF	$ 370.00
30	4' x 4' Precast R.C. Box Culvert	LF	$ 400.00
31	5' x 3' Precast R.C. Box Culvert	LF	$ 450.00
32	5' x 4' Precast R.C. Box Culvert	LF	$ 500.00
33	6' x 3' Precast R.C. Box Culvert	LF	$ 600.00
34	6' x 4' Precast R.C. Box Culvert	LF	$ 650.00
35	6' x 5' Precast R.C. Box Culvert	LF	$ 700.00
36	7' x 5' Precast R.C. Box Culvert	LF	$ 750.00
37	9' x 5' Precast R.C. Box Culvert	LF	$ 1,100.00
38	7' x 6' Precast R.C. Box Culvert	LF	$ 850.00
39	11' x 6' Precast R.C. Box Culvert	LF	$ 1,500.00
40	Drainage Structures, Manhole	EA	$ 3,000.00
41	Drainage Structures, Inlet	EA	$ 2,500.00
42	Drainage Structures, DOT Standard Endwall	EA	$ 5,000.00
43	Drainage Structures, Custom Junction Box	EA	$ 10,000.00
44	Drainage Structures, Custom Endwall	EA	$ 15,000.00
45	Flared End Section, 36 inch	EA	$ 2,500.00
46	Flared End Section, 42 inch	EA	$ 2,500.00
47	Custom Junction Box	EA	$ 15,000.00
48	Concrete Curb and Gutter	LF	$ 30.00
49	6" Concrete Driveway Replacement	EA	$ 1,200.00
50	4" Concrete Sidewalk	LF	$ 25.00
51	Concrete Pipe Plug	EA	$ 450.00
52	Asphalt Milling/Overlay	SY	$ 20.00
53	Asphalt Replacement (Surface, Base Course, & Milling)	SY	$ 55.00
54	Rip Rap Stone, Class B	TN	$ 60.00
55	Rip Rap Stone, Class 1	TN	$ 70.00
56	Rock Grade Control	EA	$ 8,000.00
57	Traffic Control	LS	Varies
58	Erosion Control	LS	Varies
59	Fence Removal / Replacement	LF	$ 50.00
60	Erosion Control Matting	SY	$ 7.00
61	Soil Media	CY	$ 30.00
62	BMP Plantings	SF	$ 2.00
63	Riparian Seed Mix	SY	$ 1.50
64	Live Staking	SY	$ 15.00
65	Seeding and Mulching	AC	$ 5,000.00
66	Wood Retaining Wall (4' high)	LF	$ 100.00
67	Log Grade Control Structure	EA	$ 1,000.00
68	Gabion Wall	LF	$ 300.00
69	Utility Relocations***	LS	Varies
70	Foundation Protection	EA	$ 15,000.00
	20% Contingency		**20%**

PRIMARY SYSTEM

East 14th Street (Bell Branch) - Alternative #1

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 9,300.00	$ 9,300.00
2	Comprehensive Grading	1	LS	$ 15,400.00	$ 15,400.00
3	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
4	Select Material	250	CY	$ 25.00	$ 6,250.00
5	42" R.C. Pipe Culvert, Class III	106	LF	$ 150.00	$ 15,900.00
6	Drainage Structures, DOT Standard Endwall	2	EA	$ 5,000.00	$ 10,000.00
7	Asphalt Replacement (Surface, Base Course, & Milling)	67	SY	$ 55.00	$ 3,666.67
8	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
9	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
10	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
11	Utility Relocations/Conflicts**	1	LS	$ 10,000.00	$ 10,000.00
				Subtotal	$ 102,000.00
				20% Contingency	$20,400.00
				Total	**$ 122,400.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				36,700.00
				Total Opinion of Project Cost	**$ 159,100.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

The Engineer’s opinions of probable construction costs are made on the basis of the Engineer’s experience and qualifications and represent the Engineer’s best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer’s cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

York Road & Railroad Crossing (Bells Branch) - Alternative #1

Item Number	***Item Description***	***Quantities***	***Unit***	***Unit Price***	***Amount***
1	Mobilization (10%)	1	LS	$ 10,700.00	$ 10,700.00
2	Comprehensive Grading	1	LS	$ 17,800.00	$ 17,800.00
3	Construction Staking	1	LS	$ 6,000.00	$ 6,000.00
4	Select Material	500	CY	$ 25.00	$ 12,500.00
5	72" R.C. Pipe Culvert, Class III	61	LF	$ 320.00	$ 19,520.00
6	Drainage Structures, DOT Standard Endwall	2	EA	$ 5,000.00	$ 10,000.00
7	Asphalt Replacement (Surface, Base Course, & Milling)	49	SY	$ 55.00	$ 2,688.89
8	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
9	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
10	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
11	Utility Relocations/Conflicts**	1	LS	$ 10,000.00	$ 10,000.00
				Subtotal	$ 117,700.00
				20% Contingency	$23,500.00
				Total	**$ 141,200.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				42,400.00
				Total Opinion of Project Cost	**$ 183,600.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

York Road & Railroad Crossing (Bells Branch) - Alternative #2

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 18,500.00	$ 18,500.00
2	Comprehensive Grading	1	LS	$ 30,800.00	$ 30,800.00
3	Construction Staking	1	LS	$ 6,000.00	$ 6,000.00
4	Select Material	500	CY	$ 25.00	$ 12,500.00
5	72" R.C. Pipe Culvert, Class III	61	LF	$ 320.00	$ 19,520.00
6	36" Steel Pipe Culvert (Tunnel Installation)	62	LF	$ 800.00	$ 49,600.00
7	Drainage Structures, DOT Standard Endwall	2	EA	$ 5,000.00	$ 10,000.00
8	Asphalt Replacement (Surface, Base Course, & Milling)	49	SY	$ 55.00	$ 2,688.89
9	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
10	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
11	Erosion Control	1	LS	$ 30,000.00	$ 30,000.00
12	Utility Relocations/Conflicts**	1	LS	$ 10,000.00	$ 10,000.00
				Subtotal	$ 203,100.00
				20% Contingency	$40,600.00
				Total	**$ 243,700.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				73,100.00
				Total Opinion of Project Cost	**$ 316,800.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Oxford Road Closed System (Bells Branch) - Alternative #1

Item Number	*Item Description*	*Quantities*	*Unit*	*Unit Price*	*Amount*
1	Mobilization (10%)	1	LS	$ 82,900.00	$ 82,900.00
2	Comprehensive Grading	1	LS	$ 138,200.00	$ 138,200.00
3	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
4	Select Material	250	CY	$ 25.00	$ 6,250.00
5	7' x 5' Precast R.C. Box Culvert	653	LF	$ 750.00	$ 489,750.00
6	Drainage Structures, Custom Endwall	1	EA	$ 15,000.00	$ 15,000.00
7	Custom Junction Box	6	EA	$ 20,000.00	$ 120,000.00
8	Asphalt Replacement (Surface, Base Course, & Milling)	93	SY	$ 55.00	$ 5,133.33
9	Rip Rap Stone, Class 1	100	TN	$ 70.00	$ 7,000.00
10	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
11	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
12	Utility Relocations/Conflicts**	1	LS	$ 20,000.00	$ 20,000.00
				Subtotal	$ 912,200.00
				20% Contingency	$182,400.00
				Total	**$ 1,094,600.00**

Design, Administration, Fiscal and Legal (30% of Construction Costs) 328,400.00

Total Opinion of Project Cost $ 1,423,000.00

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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Charles Boulevard (Meetinghouse Branch) - Alternative #2

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 32,000.00	$ 32,000.00
2	Comprehensive Grading	1	LS	$ 29,100.00	$ 29,100.00
3	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
4	48" Steel Pipe Culvert (Tunnel Installation)	180	LF	$ 1,100.00	$ 198,000.00
5	48" R.C. Pipe Culvert, Class III	100	LF	$ 180.00	$ 18,000.00
6	Drainage Structures, Custom Endwall	2	EA	$ 15,000.00	$ 30,000.00
7	Rip Rap Stone, Class 1	100	TN	$ 70.00	$ 7,000.00
8	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
9	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
10	Utility Relocations/Conflicts**	1	LS	$ 10,000.00	$ 10,000.00
				Subtotal	$ 352,100.00
				20% Contingency	$70,400.00
				Total	**$ 422,500.00**
				Design, Administration, Fiscal and Legal (30% of Construction Costs)	126,800.00
				Total Opinion of Project Cost	**$ 549,300.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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14th Street (Meetinghouse Branch) - Alternative #1

Item Number	*Item Description*	*Quantities*	*Unit*	*Unit Price*	*Amount*
1	Mobilization (10%)	1	LS	$ 32,200.00	$ 32,200.00
2	Comprehensive Grading	1	LS	$ 53,800.00	$ 53,800.00
3	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
4	Select Material	250	CY	$ 25.00	$ 6,250.00
5	11' x 6' Precast R.C. Box Culvert	120	LF	$ 1,500.00	$ 180,000.00
6	Drainage Structures, Custom Endwall	2	EA	$ 15,000.00	$ 30,000.00
7	Asphalt Replacement (Surface, Base Course, & Milling)	133	SY	$ 55.00	$ 7,333.33
8	Rip Rap Stone, Class 1	100	TN	$ 70.00	$ 7,000.00
9	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
10	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
11	Utility Relocations/Conflicts**	1	LS	$ 10,000.00	$ 10,000.00
12	Earthen Berm	1000	LF	$ 15.00	$ 15,000.00
				Subtotal	$ 369,600.00
				20% Contingency	$73,900.00
				Total	**$ 443,500.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				133,100.00
	Total Opinion of Project Cost				**$ 576,600.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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14th Street (Meetinghouse Branch) - Alternative #2

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 123,450.00	$ 123,450.00
2	Comprehensive Grading	1	LS	$ 80,500.00	$ 80,500.00
3	Excavation	14500	CY	$ 25.00	$ 362,500.00
4	Hauling	14500	CY	$ 4.00	$ 58,000.00
5	Construction Staking	1	LS	$ 10,000.00	$ 10,000.00
6	Select Material	500	CY	$ 25.00	$ 12,500.00
7	9' x 5' Precast R.C. Box Culvert	120	LF	$ 1,100.00	$ 132,000.00
8	Drainage Structures, Custom Endwall	2	EA	$ 15,000.00	$ 30,000.00
9	Clearing & Grubbing	4	AC	$ 5,000.00	$ 20,000.00
10	Channel Grading	1800	LF	$ 10.00	$ 18,000.00
11	Riparian Seed Mix	20000	SY	$ 1.50	$ 30,000.00
12	Asphalt Replacement (Surface, Base Course, & Milling)	133	SY	$ 55.00	$ 7,333.33
13	Rip Rap Stone, Class 1	100	TN	$ 70.00	$ 7,000.00
14	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
15	Erosion Control	1	LS	$ 20,000.00	$ 20,000.00
16	Utility Relocations/Conflicts**	1	LS	$ 25,000.00	$ 25,000.00
				Subtotal	$ 946,300.00
				20% Contingency	$189,300.00
				Total	**$ 1,135,600.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				340,700.00
				Total Opinion of Project Cost	**$ 1,476,300.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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Oxford Road Floodplain Bench (Meetinghouse Branch) - Alternative #2

Item Number	***Item Description***	***Quantities***	***Unit***	***Unit Price***	***Amount***
1	Mobilization (10%)	1	LS	$ 46,800.00	$ 46,800.00
2	Comprehensive Grading	1	LS	$ 16,000.00	$ 16,000.00
3	Excavation	8000	CY	$ 25.00	$ 200,000.00
4	Hauling	8000	CY	$ 4.00	$ 32,000.00
5	Construction Staking	1	LS	$ 5,000.00	$ 5,000.00
6	Clearing & Grubbing	2.5	AC	$ 5,000.00	$ 12,500.00
7	Channel Grading	1800	LF	$ 10.00	$ 18,000.00
8	Riparian Seed Mix	12000	SY	$ 1.50	$ 18,000.00
9	Erosion Control	1	LS	$ 10,000.00	$ 10,000.00
				Subtotal	$ 358,300.00
				20% Contingency	$71,700.00
				Total	**$ 430,000.00**
				Design, Administration, Fiscal and Legal (30% of Construction Costs)	129,000.00
				Total Opinion of Project Cost	**$ 559,000.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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SECONDARY SYSTEM

Grey Fox Trail System

Item Number	*Item Description*	*Quantities*	*Unit*	*Unit Price*	*Amount*
1	Mobilization (10%)	1	LS	$ 49,443.00	$ 49,443.00
2	Comprehensive Grading*	1	LS	$ 82,400.00	$ 82,400.00
3	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
4	Select Material	250	CY	$ 25.00	$ 6,250.00
5	18" R.C. Pipe Culvert, Class III	33	LF	$ 55.00	$ 1,815.00
6	24" R.C. Pipe Culvert, Class III	182	LF	$ 65.00	$ 11,830.00
7	30" R.C. Pipe Culvert, Class III	451	LF	$ 80.00	$ 36,080.00
8	36" R.C. Pipe Culvert, Class III	924	LF	$ 110.00	$ 101,640.00
9	Flared End Section, 36 inch	1	EA	$ 2,500.00	$ 2,500.00
10	Drainage Structures, Manhole	1	EA	$ 3,000.00	$ 3,000.00
11	Drainage Structures, Inlet	8	EA	$ 2,500.00	$ 20,000.00
12	Concrete Curb and Gutter	1096	LF	$ 30.00	$ 32,880.00
13	Asphalt Milling/Overlay**	2044	SY	$ 20.00	$ 40,888.89
14	Asphalt Replacement (Surface, Base Course, & Milling)***	2044	SY	$ 55.00	$ 112,444.44
15	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
16	6" Concrete Driveway Replacement	1	EA	$ 1,200.00	$ 1,200.00
17	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
18	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
19	Utility Relocations****	1	LS	$ 10,000.00	$ 10,000.00
				Subtotal	$ 543,900.00
				20% Contingency	$108,800.00
				Total	**$ 652,700.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				195,800.00
				Total Opinion of Project Cost	**$ 848,500.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

**Milling and overlay for pavement outside of pipe trench to provide new pavement across entire roadway section.

***Pavement replacement required for pipe replacement. Includes base course, intermediate course, and surface course.

**** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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Barnes Street - Paramore Drive - Rondo Drive System

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 34,655.00	$ 34,655.00
2	Comprehensive Grading*	1	LS	$ 57,800.00	$ 57,800.00
3	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
4	Select Material	250	CY	$ 25.00	$ 6,250.00
5	18" R.C. Pipe Culvert, Class III	415	LF	$ 55.00	$ 22,825.00
6	36" R.C. Pipe Culvert, Class III	292	LF	$ 110.00	$ 32,120.00
7	42" R.C. Pipe Culvert, Class III	755	LF	$ 150.00	$ 113,250.00
8	48" R.C. Pipe Culvert, Class III	134	LF	$ 180.00	$ 24,120.00
9	Drainage Structures, Inlet	14	EA	$ 2,500.00	$ 35,000.00
10	Asphalt Replacement (Surface, Base Course, & Milling)**	249	SY	$ 55.00	$ 13,688.89
11	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
12	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
13	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
14	Utility Relocations***	1	LS	$ 10,000.00	$ 10,000.00
				Subtotal	$ 381,200.00
				20% Contingency	$76,200.00
				Total	**$ 457,400.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				137,200.00
				Total Opinion of Project Cost	**$ 594,600.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

**Pavement replacement required for pipe replacement. Includes base course, intermediate course, and surface course.

*** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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Fantasia Street - Sherwood Drive System

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 102,601.00	$ 102,601.00
2	Comprehensive Grading*	1	LS	$ 171,000.00	$ 171,000.00
3	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
4	Select Material	250	CY	$ 25.00	$ 6,250.00
5	15" R.C. Pipe Culvert, Class III	562	LF	$ 50.00	$ 28,100.00
6	18" R.C. Pipe Culvert, Class III	714	LF	$ 55.00	$ 39,270.00
7	24" R.C. Pipe Culvert, Class III	2628	LF	$ 65.00	$ 170,820.00
8	30" R.C. Pipe Culvert, Class III	222	LF	$ 80.00	$ 17,760.00
9	42" R.C. Pipe Culvert, Class III	131	LF	$ 150.00	$ 19,650.00
10	48" R.C. Pipe Culvert, Class III	387	LF	$ 180.00	$ 69,660.00
11	Concrete Curb and Gutter	2000	LF	$ 30.00	$ 60,000.00
12	Drainage Structures, Manhole	7	EA	$ 3,000.00	$ 21,000.00
13	Drainage Structures, Inlet	17	EA	$ 2,500.00	$ 42,500.00
14	Drainage Structures, DOT Standard Endwall	1	EA	$ 5,000.00	$ 5,000.00
15	Asphalt Milling/Overlay**	4267	SY	$ 20.00	$ 85,333.33
16	Asphalt Replacement (Surface, Base Course, & Milling)***	4267	SY	$ 55.00	$ 234,666.67
17	Rip Rap Stone, Class 1	100	TN	$ 70.00	$ 7,000.00
18	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
19	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
20	Utility Relocations****	1	LS	$ 20,000.00	$ 20,000.00
				Subtotal	$ 1,128,600.00
				20% Contingency	$225,700.00
				Total	**$ 1,354,300.00**

Design, Administration, Fiscal and Legal (30% of Construction Costs) 406,300.00

Total Opinion of Project Cost $ 1,760,600.00

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

**Milling and overlay for pavement outside of pipe trench to provide new pavement across entire roadway section.

***Pavement replacement required for pipe replacement. Includes base course, intermediate course, and surface course.

**** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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Oakmont Drive System

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 28,570.00	$ 28,570.00
2	Comprehensive Grading*	1	LS	$ 47,600.00	$ 47,600.00
3	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
4	Select Material	150	CY	$ 25.00	$ 3,750.00
5	24" R.C. Pipe Culvert, Class III	33	LF	$ 65.00	$ 2,145.00
6	30" R.C. Pipe Culvert, Class III	205	LF	$ 80.00	$ 16,400.00
7	36" R.C. Pipe Culvert, Class III	17	LF	$ 110.00	$ 1,870.00
8	42" R.C. Pipe Culvert, Class III	244	LF	$ 150.00	$ 36,600.00
9	48" R.C. Pipe Culvert, Class III	346	LF	$ 180.00	$ 62,280.00
10	Drainage Structures, Inlet	12	EA	$ 2,500.00	$ 30,000.00
11	Drainage Structures, DOT Standard Endwall	1	EA	$ 5,000.00	$ 5,000.00
12	Asphalt Replacement (Surface, Base Course, & Milling)	156	SY	$ 55.00	$ 8,555.56
13	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
14	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
15	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
16	Utility Relocations**	1	LS	$ 10,000.00	$ 10,000.00
17	Foundation Protection	2	EA	$ 15,000.00	$ 30,000.00
				Subtotal	$ 314,300.00
				20% Contingency	$62,900.00
				Total	**$ 377,200.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				113,200.00
				Total Opinion of Project Cost	**$ 490,400.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

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Eastwood Subdivision System

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 125,788.20	$ 125,788.20
2	Clearing & Grubbing	2	AC	$ 5,000.00	$ 10,000.00
3	Comprehensive Grading*	1	LS	$ 209,647.00	$ 209,647.00
4	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
5	Select Material	6500	CY	$ 25.00	$ 162,500.00
6	15" R.C. Pipe Culvert, Class III	72	LF	$ 50.00	$ 3,600.00
7	24" R.C. Pipe Culvert, Class III	84	LF	$ 65.00	$ 5,460.00
8	30" R.C. Pipe Culvert, Class IV	250	LF	$ 95.00	$ 23,750.00
9	48" R.C. Pipe Culvert, Class III	281	LF	$ 180.00	$ 50,580.00
10	48" R.C. Pipe Culvert, Class IV	806	LF	$ 195.00	$ 157,170.00
11	54" R.C. Pipe Culvert, Class III	900	LF	$ 200.00	$ 180,000.00
12	Drainage Structures, Inlet	4	EA	$ 2,500.00	$ 10,000.00
13	Drainage Structures, Manhole	2	EA	$ 5,000.00	$ 10,000.00
14	Custom Junction Box	12	EA	$ 15,000.00	$ 180,000.00
15	Drainage Structures, DOT Standard Endwall	1	EA	$ 5,000.00	$ 5,000.00
16	Concrete Curb and Gutter	705	LF	$ 30.00	$ 21,150.00
17	Asphalt Milling/Overlay	2220	SY	$ 20.00	$ 44,400.00
18	Asphalt Replacement (Surface, Base Course, & Milling)	2220	SY	$ 55.00	$ 122,100.00
19	Rip Rap Stone, Class II	245	TN	$ 65.00	$ 15,925.00
20	6" Concrete Driveway Replacement	3	EA	$ 1,200.00	$ 3,600.00
21	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
22	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
23	Seeding & Mulching	1	AC	$ 5,000.00	$ 5,000.00
24	Utility Relocations	1	LS	$ 10,000.00	$ 10,000.00
				Subtotal	$ 1,383,700.00
				20% Contingency	$ 276,700.00
				Total	**$ 1,660,400.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				$ 498,100.00
	Total Opinion of Project Cost				**$ 2,158,500.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

** Cost for utility conflicts includes all utilities that need to be moved including sanitary sewer and potable water lines. Additional survey may be required to locate pressurized utilities.

The cost estimate for the Eastwood Subdivision System was provided by the City of Greenville.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

STREAM STABILIZATION

Stream Stabilization Project #1 - Charles Boulevard

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 8,908.00	$ 8,908.00
2	Comprehensive Grading*	1	LS	$ 14,800.00	$ 14,800.00
3	Construction Staking	1	LS	$ 1,500.00	$ 1,500.00
4	Channel Grading	1680	SY	$ 10.00	$ 16,800.00
5	Erosion Control Matting	1680	SY	$ 7.00	$ 11,760.00
6	Live Staking	1680	SY	$ 15.00	$ 25,200.00
7	Riparian Seed Mix	1680	SY	$ 1.50	$ 2,520.00
8	Rock Grade Control	1	EA	$ 8,000.00	$ 8,000.00
9	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
10	Erosion Control	1	LS	$ 5,000.00	$ 5,000.00
				Subtotal	$ 98,000.00
				20% Contingency	$19,600.00
				Total	**$ 117,600.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				35,300.00
				Total Opinion of Project Cost	**$ 152,900.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

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Stream Stabilization Project #2 - Crooked Creek Road

Item Number	*Item Description*	*Quantities*	*Unit*	*Unit Price*	*Amount*
1	Mobilization (10%)	1	LS	$ 4,965.00	$ 4,965.00
2	Comprehensive Grading*	1	LS	$ 8,200.00	$ 8,200.00
3	Construction Staking	1	LS	$ 1,500.00	$ 1,500.00
4	Channel Grading	700	SY	$ 10.00	$ 7,000.00
5	Erosion Control Matting	700	SY	$ 7.00	$ 4,900.00
6	Live Staking	700	SY	$ 15.00	$ 10,500.00
7	Riparian Seed Mix	700	SY	$ 1.50	$ 1,050.00
8	Rock Grade Control	1	EA	$ 8,000.00	$ 8,000.00
9	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
10	Erosion Control	1	LS	$ 5,000.00	$ 5,000.00
				Subtotal	$ 54,600.00
				20% Contingency	$10,900.00
				Total	**$ 65,500.00**
				Design, Administration, Fiscal and Legal (30% of Construction Costs)	19,700.00
				Total Opinion of Project Cost	**$ 85,200.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Stream Stabilization Project #3 - Brook Valley Golf Course

Item Number	Item Description	Quantities	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 7,893.00	$ 7,893.00
2	Comprehensive Grading*	1	LS	$ 13,200.00	$ 13,200.00
3	Construction Staking	1	LS	$ 1,500.00	$ 1,500.00
4	Channel Grading	900	SY	$ 10.00	$ 9,000.00
5	Erosion Control Matting	900	SY	$ 7.00	$ 6,300.00
6	Live Staking	900	SY	$ 15.00	$ 13,500.00
7	Riparian Seed Mix	900	SY	$ 1.50	$ 1,350.00
8	Buffer Plantings	1389	SY	$ 1.50	$ 2,083.33
9	Wood Retaining Wall (4' high)	200	LF	$ 100.00	$ 20,000.00
10	Rip Rap Stone, Class 1	100	TN	$ 70.00	$ 7,000.00
11	Erosion Control	1	LS	$ 5,000.00	$ 5,000.00
				Subtotal	$ 86,800.00
				20% Contingency	$17,400.00
				Total	**$ 104,200.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				31,300.00
	Total Opinion of Project Cost				**$ 135,500.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Stream Stabilization Project #4 - Bloomsbury Road

Item Number	***Item Description***	***Quantities***	***Unit***	***Unit Price***	***Amount***
1	Mobilization (10%)	1	LS	$ 3,474.00	$ 3,474.00
2	Comprehensive Grading*	1	LS	$ 5,800.00	$ 5,800.00
3	Construction Staking	1	LS	$ 1,500.00	$ 1,500.00
4	Channel Grading	610	SY	$ 10.00	$ 6,100.00
5	Erosion Control Matting	610	SY	$ 7.00	$ 4,270.00
6	Live Staking	610	SY	$ 15.00	$ 9,150.00
7	Riparian Seed Mix	610	SY	$ 1.50	$ 915.00
8	Log Grade Control Structures	2	EA	$ 1,000.00	$ 2,000.00
9	Erosion Control	1	LS	$ 5,000.00	$ 5,000.00
				Subtotal	$ 38,200.00
				20% Contingency	$7,600.00
				Total	**$ 45,800.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				13,700.00
	Total Opinion of Project Cost				**$ 59,500.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Stream Stabilization Project #5 - Kensington Drive

Item Number	***Item Description***	***Quantities***	***Unit***	***Unit Price***	***Amount***
1	Mobilization (10%)	1	LS	$ 10,154.00	$ 10,154.00
2	Comprehensive Grading*	1	LS	$ 17,000.00	$ 17,000.00
3	Construction Staking	1	LS	$ 1,500.00	$ 1,500.00
4	Channel Grading	210	SY	$ 10.00	$ 2,100.00
5	Erosion Control Matting	210	SY	$ 7.00	$ 1,470.00
6	Live Staking	210	SY	$ 15.00	$ 3,150.00
7	Riparian Seed Mix	210	SY	$ 1.50	$ 315.00
8	Gabion Wall	225	LF	$ 300.00	$ 67,500.00
9	Rip Rap Stone, Class 1	50	TN	$ 70.00	$ 3,500.00
10	Erosion Control	1	LS	$ 5,000.00	$ 5,000.00
				Subtotal	$ 111,700.00
				20% Contingency	$22,300.00
				Total	**$ 134,000.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				40,200.00
				Total Opinion of Project Cost	**$ 174,200.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

WATER QUALITY

First Free WIll Baptist - Biorentention Pond

Preliminary Opinion of Probable Construction Cost

	Item Description	*QUANTITIES*	*Unit*	*Unit Price*	*Amount*
1	Mobilization (10%)	1	LS	$ 4,840.00	$ 4,840.00
2	Comprehensive Grading*	1	LS	$ 8,000.00	$ 8,000.00
3	Sediment and Erosion Control	1	LS	$ 3,000.00	$ 3,000.00
4	Excavation	470	CY	$ 25.00	$ 11,750.00
5	Hauling	470	CY	$ 4.00	$ 1,880.00
6	Soil Media	470	CY	$ 30.00	$ 14,100.00
7	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
8	BMP Plantings	1000	SF	$ 2.00	$ 2,000.00
9	Seeding and Mulching	0.1	AC	$ 5,000.00	$ 500.00
10	18" R.C. Pipe Culvert, Class III	30	LF	$ 55.00	$ 1,650.00
11	Drainage Structures, Inlet	1	EA	$ 2,500.00	$ 2,500.00
				Subtotal	$ 53,220.00
				20% Contingency	$ 10,600.00
				Total	**$ 63,820.00**
				Design, Administration, Fiscal and Legal (30% of Construction Costs)	$ 19,100.00
				Total Opinion of Project Cost	**$ 82,900.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Oakmont Drive - Biorentention Area

Preliminary Opinion of Probable Construction Cost

	Item Description	*QUANTITIES*	*Unit*	*Unit Price*	*Amount*
1	Mobilization (10%)	1	LS	$ 2,400.00	$ 2,400.00
2	Comprehensive Grading*	1	LS	$ 4,000.00	$ 4,000.00
3	Sediment and Erosion Control	1	LS	$ 3,000.00	$ 3,000.00
4	Excavation	140	CY	$ 25.00	$ 3,500.00
5	Hauling	140	CY	$ 4.00	$ 560.00
6	Soil Media	140	CY	$ 30.00	$ 4,200.00
7	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
8	Plantings	1000	SF	$ 2.00	$ 2,000.00
9	Seeding and Mulching	0.1	AC	$ 5,000.00	$ 500.00
10	15" R.C. Pipe Culvert, Class III	15	LF	$ 50.00	$ 750.00
11	Drainage Structures, Inlet	1	EA	$ 2,500.00	$ 2,500.00
				Subtotal	$ 26,410.00
				20% Contingency	$ 5,300.00
				Total	**$ 31,710.00**
				Design, Administration, Fiscal and Legal (30% of Construction Costs)	$ 9,500.00
				Total Opinion of Project Cost	**$ 41,200.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Eleanor Street - Biorentention Area
Preliminary Opinion of Probable Construction Cost

	Item Description	*QUANTITIES*	*Unit*	*Unit Price*	*Amount*
1	Mobilization (10%)	1	LS	$ 3,350.00	$ 3,350.00
2	Comprehensive Grading*	1	LS	$ 5,600.00	$ 5,600.00
3	Sediment and Erosion Control	1	LS	$ 3,000.00	$ 3,000.00
4	Excavation	230	CY	$ 25.00	$ 5,750.00
5	Hauling	230	CY	$ 4.00	$ 920.00
6	Soil Media	230	CY	$ 30.00	$ 6,900.00
7	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
8	BMP Plantings	1000	SF	$ 2.00	$ 2,000.00
9	Seeding and Mulching	0.1	AC	$ 5,000.00	$ 500.00
10	18" R.C. Pipe Culvert, Class III	60	LF	$ 55.00	$ 3,300.00
11	Drainage Structures, Inlet	1	EA	$ 2,500.00	$ 2,500.00
				Subtotal	$ 36,820.00
				20% Contingency	$ 7,400.00
				Total	**$ 44,220.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				$ 13,300.00
	Total Opinion of Project Cost				**$ 57,500.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Brook Valley Country Club - Biorentention Area
Preliminary Opinion of Probable Construction Cost

	Item Description	QUANTITIES	Unit	Unit Price		Amount	
1	Mobilization (10%)	1	LS	$	3,240.00	$	3,240.00
2	Comprehensive Grading*	1	LS	$	5,400.00	$	5,400.00
3	Sediment and Erosion Control	1	LS	$	3,000.00	$	3,000.00
4	Excavation	220	CY	$	25.00	$	5,500.00
5	Hauling	220	CY	$	4.00	$	880.00
6	Soil Media	220	CY	$	30.00	$	6,600.00
7	Construction Staking	1	LS	$	3,000.00	$	3,000.00
8	BMP Plantings	1000	SF	$	2.00	$	2,000.00
9	Seeding and Mulching	0.1	AC	$	5,000.00	$	500.00
10	18" R.C. Pipe Culvert, Class III	55	LF	$	55.00	$	3,025.00
11	Drainage Structures, Inlet	1	EA	$	2,500.00	$	2,500.00
				Subtotal		$	35,645.00
				20% Contingency		$	7,100.00
				Total		**$**	**42,745.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)					$	12,800.00
	Total Opinion of Project Cost					**$**	**55,500.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Perkins Field - Biorentention Area
Preliminary Opinion of Probable Construction Cost

	Item Description	QUANTITIES	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 5,270.00	$ 5,270.00
2	Comprehensive Grading*	1	LS	$ 8,800.00	$ 8,800.00
3	Sediment and Erosion Control	1	LS	$ 3,000.00	$ 3,000.00
4	Excavation	520	CY	$ 25.00	$ 13,000.00
5	Hauling	520	CY	$ 4.00	$ 2,080.00
6	Soil Media	520	CY	$ 30.00	$ 15,600.00
7	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
8	BMP Plantings	1000	SF	$ 2.00	$ 2,000.00
9	Seeding and Mulching	0.1	AC	$ 5,000.00	$ 500.00
10	15" R.C. Pipe Culvert, Class III	45	LF	$ 50.00	$ 2,250.00
11	Drainage Structures, Inlet	1	EA	$ 2,500.00	$ 2,500.00
				Subtotal	$ 58,000.00
				20% Contingency	$ 11,600.00
				Total	**$ 69,600.00**
				Design, Administration, Fiscal and Legal (30% of Construction Costs)	$ 20,900.00
				Total Opinion of Project Cost	**$ 90,500.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Eastern Elementary School - Biorentention Area

Preliminary Opinion of Probable Construction Cost

	Item Description	*QUANTITIES*	*Unit*	*Unit Price*	*Amount*
1	Mobilization (10%)	1	LS	$ 4,670.00	$ 4,670.00
2	Comprehensive Grading*	1	LS	$ 7,800.00	$ 7,800.00
3	Sediment and Erosion Control	1	LS	$ 3,000.00	$ 3,000.00
4	Excavation	440	CY	$ 25.00	$ 11,000.00
5	Hauling	440	CY	$ 4.00	$ 1,760.00
6	Soil Media	440	CY	$ 30.00	$ 13,200.00
7	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
8	BMP Plantings	1000	SF	$ 2.00	$ 2,000.00
9	Seeding and Mulching	0.1	AC	$ 5,000.00	$ 500.00
10	18" R.C. Pipe Culvert, Class III	35	LF	$ 55.00	$ 1,925.00
11	Drainage Structures, Inlet	1	EA	$ 2,500.00	$ 2,500.00
				Subtotal	$ 51,355.00
				20% Contingency	$ 10,300.00
				Total	**$ 61,655.00**
				Design, Administration, Fiscal and Legal (30% of Construction Costs)	$ 18,500.00
				Total Opinion of Project Cost	**$ 80,200.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

Jaycee Park - Biorentention Area

Preliminary Opinion of Probable Construction Cost

	Item Description	QUANTITIES	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$ 8,800.00	$ 8,800.00
2	Comprehensive Grading*	1	LS	$ 14,600.00	$ 14,600.00
3	Sediment and Erosion Control	1	LS	$ 3,000.00	$ 3,000.00
4	Excavation	1020	CY	$ 25.00	$ 25,500.00
5	Hauling	1020	CY	$ 4.00	$ 4,080.00
6	Soil Media	1020	CY	$ 30.00	$ 30,600.00
7	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
8	BMP Plantings	1000	SF	$ 2.00	$ 2,000.00
9	Seeding and Mulching	0.1	AC	$ 5,000.00	$ 500.00
10	18" R.C. Pipe Culvert, Class III	40	LF	$ 55.00	$ 2,200.00
11	Drainage Structures, Inlet	1	EA	$ 2,500.00	$ 2,500.00
				Subtotal	$ 96,780.00
				20% Contingency	$ 19,400.00
				Total	**$ 116,180.00**
	Design, Administration, Fiscal and Legal (30% of Construction Costs)				$ 34,900.00
	Total Opinion of Project Cost				**$ 151,100.00**

* Cost for comprehensive grading includes roadway excavation, saw cutting, compaction of select material, geotechnical recommendations, home owner coordination, tree and structure protection, structure removal and disposal, shoring, and culvert excavation.

The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

APPENDIX H

PRIMARY SYSTEM EXISTING CONDITIONS: HEC-HMS OUTPUT

Project: Pilot Watershed Simulation Run: existing2

Start of Run: 04Aug2011, 01:00 Basin Model: Existing Conditions
End of Run: 05Aug2011, 01:30 Meteorologic Model: 2-Year Type III
Compute Time: 13Sep2013, 14:11:23 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	47.9	04Aug2011, 15:50	2.49
MHB-2	0.08	33.3	04Aug2011, 14:50	2.63
ADD-1_2	0.24	76.1	04Aug2011, 15:20	2.53
RT-1_2	0.24	76.0	04Aug2011, 15:25	2.53
MHB-3	0.22	70.3	04Aug2011, 15:05	2.18
ADD-3	0.46	145.6	04Aug2011, 15:15	2.36
RT-3	0.46	145.0	04Aug2011, 15:25	2.35
MHB-4	0.12	53.9	04Aug2011, 14:25	2.38
ADD-4	0.58	183.6	04Aug2011, 15:05	2.36
RT-4	0.58	183.4	04Aug2011, 15:05	2.35
MHB-5	0.47	122.1	04Aug2011, 15:35	1.99
ADD-5	1.05	301.5	04Aug2011, 15:20	2.19
RT-5	1.05	301.3	04Aug2011, 15:25	2.19
14th St-MHB	1.05	293.7	04Aug2011, 15:45	2.19
MHB-6	0.17	71.1	04Aug2011, 13:45	1.48
ADD-6	1.22	308.8	04Aug2011, 15:45	2.09
RT-6	1.22	308.4	04Aug2011, 16:00	2.08
MHB-7	0.17	13.5	04Aug2011, 16:20	0.73
ADD-7	1.39	321.8	04Aug2011, 16:00	1.92
RT-7	1.39	320.5	04Aug2011, 16:15	1.90
MHB-8	0.17	18.4	04Aug2011, 14:00	0.55
ADD-8	1.56	327.0	04Aug2011, 16:15	1.76
RT-8	1.56	326.7	04Aug2011, 16:20	1.75
Brook Valley	1.56	326.0	04Aug2011, 16:25	1.55
BB-1	0.10	30.3	04Aug2011, 14:50	1.87
RT-9	0.10	30.0	04Aug2011, 15:00	1.86

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	46.2	04Aug2011, 13:45	1.99
ADD-9	0.18	58.1	04Aug2011, 13:50	1.92
14th Street-BB	0.18	44.6	04Aug2011, 14:55	1.84
BB-3	0.03	18.7	04Aug2011, 13:40	1.99
ADD-10	0.21	49.4	04Aug2011, 14:55	1.86
RT-10	0.21	49.4	04Aug2011, 14:55	1.86
Quail Ridge Rd	0.21	50.1	04Aug2011, 14:50	1.86
BB-4	0.12	35.0	04Aug2011, 14:20	1.46
ADD-11	0.33	79.3	04Aug2011, 14:50	1.72
RT-11	0.33	77.9	04Aug2011, 14:50	1.72
York Road	0.33	76.9	04Aug2011, 14:55	1.72
BB-5	0.04	12.0	04Aug2011, 13:45	1.11
ADD-12	0.37	81.3	04Aug2011, 14:55	1.65
Railroad Crossing	0.37	81.2	04Aug2011, 14:55	1.65
BB-6	0.05	14.0	04Aug2011, 13:45	1.05
ADD-13	0.42	86.5	04Aug2011, 14:55	1.58
RT-12	0.42	84.6	04Aug2011, 15:10	1.57
UTBB-1	0.32	42.2	04Aug2011, 16:40	1.25
ADD-14	0.74	113.3	04Aug2011, 15:15	1.43
RT-13	0.74	113.3	04Aug2011, 15:15	1.43
MHB-9	0.54	126.5	04Aug2011, 14:50	1.45
MHB-10	0.17	23.9	04Aug2011, 15:00	0.96
ADD-15	3.01	508.2	04Aug2011, 16:15	1.47
RT-OUT	3.01	484.0	04Aug2011, 17:00	1.42
OUTLET	3.01	484.0	04Aug2011, 17:00	1.42

Project: Pilot Watershed Simulation Run: existing10

Start of Run: 04Aug2011, 01:00 Basin Model: Existing Conditions
End of Run: 05Aug2011, 01:30 Meteorologic Model: 10-Year Type III
Compute Time: 13Sep2013, 14:16:23 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	83.1	04Aug2011, 15:45	4.37
MHB-2	0.08	56.8	04Aug2011, 14:50	4.56
ADD-1_2	0.24	131.6	04Aug2011, 15:15	4.44
RT-1_2	0.24	131.5	04Aug2011, 15:20	4.43
MHB-3	0.22	129.1	04Aug2011, 15:05	4.01
ADD-3	0.46	259.3	04Aug2011, 15:10	4.23
RT-3	0.46	258.3	04Aug2011, 15:20	4.21
MHB-4	0.12	95.8	04Aug2011, 14:25	4.27
ADD-4	0.58	328.8	04Aug2011, 15:00	4.23
RT-4	0.58	328.5	04Aug2011, 15:00	4.22
MHB-5	0.47	231.2	04Aug2011, 15:30	3.77
ADD-5	1.05	552.0	04Aug2011, 15:15	4.02
RT-5	1.05	551.6	04Aug2011, 15:20	4.01
14th St-MHB	1.05	548.8	04Aug2011, 15:25	4.01
MHB-6	0.17	153.2	04Aug2011, 13:45	3.10
ADD-6	1.22	582.6	04Aug2011, 15:25	3.88
RT-6	1.22	582.0	04Aug2011, 15:35	3.87
MHB-7	0.17	38.6	04Aug2011, 16:00	1.93
ADD-7	1.39	619.3	04Aug2011, 15:35	3.64
RT-7	1.39	616.6	04Aug2011, 15:50	3.61
MHB-8	0.17	68.9	04Aug2011, 13:55	1.62
ADD-8	1.56	635.3	04Aug2011, 15:50	3.40
RT-8	1.56	634.0	04Aug2011, 15:55	3.39
Brook Valley	1.56	633.1	04Aug2011, 16:00	3.12
BB-1	0.10	59.1	04Aug2011, 14:45	3.63
RT-9	0.10	58.7	04Aug2011, 15:00	3.61

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	87.8	04Aug2011, 13:45	3.79
ADD-9	0.18	113.0	04Aug2011, 13:50	3.69
14th Street-BB	0.18	108.7	04Aug2011, 14:00	3.51
BB-3	0.03	35.5	04Aug2011, 13:40	3.80
ADD-10	0.21	135.2	04Aug2011, 13:55	3.55
RT-10	0.21	135.2	04Aug2011, 13:55	3.55
Quail Ridge Rd	0.21	137.7	04Aug2011, 13:55	3.55
BB-4	0.12	75.8	04Aug2011, 14:15	3.07
ADD-11	0.33	205.1	04Aug2011, 14:05	3.37
RT-11	0.33	204.7	04Aug2011, 14:05	3.37
York Road	0.33	180.9	04Aug2011, 14:30	3.37
BB-5	0.04	29.6	04Aug2011, 13:45	2.55
ADD-12	0.37	196.5	04Aug2011, 14:20	3.28
Railroad Crossing	0.37	188.0	04Aug2011, 14:45	3.28
BB-6	0.05	35.6	04Aug2011, 13:45	2.46
ADD-13	0.42	202.2	04Aug2011, 14:35	3.18
RT-12	0.42	201.3	04Aug2011, 14:55	3.17
UTBB-1	0.32	94.8	04Aug2011, 16:30	2.73
ADD-14	0.74	272.0	04Aug2011, 15:25	2.98
RT-13	0.74	272.0	04Aug2011, 15:25	2.98
MHB-9	0.54	274.6	04Aug2011, 14:45	3.05
MHB-10	0.17	62.4	04Aug2011, 14:55	2.32
ADD-15	3.01	1143.1	04Aug2011, 15:35	3.02
RT-OUT	3.01	1123.6	04Aug2011, 16:00	2.96
OUTLET	3.01	1123.6	04Aug2011, 16:00	2.96

Project: Pilot Watershed Simulation Run: existing25

Start of Run: 04Aug2011, 01:00 Basin Model: Existing Conditions
End of Run: 05Aug2011, 01:30 Meteorologic Model: 25-Year Type III
Compute Time: 13Sep2013, 14:17:40 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	107.6	04Aug2011, 15:45	5.71
MHB-2	0.08	73.0	04Aug2011, 14:50	5.93
ADD-1_2	0.24	170.1	04Aug2011, 15:15	5.78
RT-1_2	0.24	170.0	04Aug2011, 15:20	5.77
MHB-3	0.22	170.4	04Aug2011, 15:05	5.33
ADD-3	0.46	338.8	04Aug2011, 15:10	5.56
RT-3	0.46	337.3	04Aug2011, 15:15	5.54
MHB-4	0.12	124.8	04Aug2011, 14:25	5.62
ADD-4	0.58	430.3	04Aug2011, 15:00	5.56
RT-4	0.58	430.0	04Aug2011, 15:00	5.55
MHB-5	0.47	308.8	04Aug2011, 15:30	5.06
ADD-5	1.05	729.1	04Aug2011, 15:10	5.33
RT-5	1.05	728.7	04Aug2011, 15:15	5.32
14th St-MHB	1.05	725.4	04Aug2011, 15:25	5.32
MHB-6	0.17	213.8	04Aug2011, 13:45	4.33
ADD-6	1.22	771.7	04Aug2011, 15:20	5.18
RT-6	1.22	770.9	04Aug2011, 15:30	5.17
MHB-7	0.17	59.7	04Aug2011, 15:55	2.91
ADD-7	1.39	828.4	04Aug2011, 15:30	4.89
RT-7	1.39	825.1	04Aug2011, 15:45	4.87
MHB-8	0.17	113.7	04Aug2011, 13:50	2.55
ADD-8	1.56	853.8	04Aug2011, 15:40	4.61
RT-8	1.56	851.7	04Aug2011, 15:50	4.60
Brook Valley	1.56	850.6	04Aug2011, 15:55	4.31
BB-1	0.10	79.8	04Aug2011, 14:45	4.91
RT-9	0.10	79.2	04Aug2011, 14:55	4.89

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	117.3	04Aug2011, 13:45	5.11
ADD-9	0.18	150.5	04Aug2011, 13:50	4.99
14th Street-BB	0.18	149.2	04Aug2011, 13:55	4.72
BB-3	0.03	47.3	04Aug2011, 13:35	5.11
ADD-10	0.21	191.0	04Aug2011, 13:50	4.78
RT-10	0.21	191.0	04Aug2011, 13:50	4.78
Quail Ridge Rd	0.21	188.8	04Aug2011, 13:55	4.78
BB-4	0.12	106.2	04Aug2011, 14:15	4.29
ADD-11	0.33	285.3	04Aug2011, 14:00	4.60
RT-11	0.33	284.9	04Aug2011, 14:00	4.60
York Road	0.33	278.6	04Aug2011, 14:10	4.60
BB-5	0.04	43.3	04Aug2011, 13:45	3.68
ADD-12	0.37	308.7	04Aug2011, 14:10	4.50
Railroad Crossing	0.37	242.1	04Aug2011, 14:45	4.50
BB-6	0.05	52.4	04Aug2011, 13:45	3.58
ADD-13	0.42	262.8	04Aug2011, 14:30	4.39
RT-12	0.42	262.1	04Aug2011, 14:45	4.37
UTBB-1	0.32	134.9	04Aug2011, 16:25	3.87
ADD-14	0.74	365.6	04Aug2011, 15:35	4.15
RT-13	0.74	365.6	04Aug2011, 15:35	4.15
MHB-9	0.54	384.9	04Aug2011, 14:45	4.25
MHB-10	0.17	93.1	04Aug2011, 14:50	3.40
ADD-15	3.01	1574.7	04Aug2011, 15:25	4.21
RT-OUT	3.01	1556.6	04Aug2011, 15:50	4.13
OUTLET	3.01	1556.6	04Aug2011, 15:50	4.13

Project: Pilot Watershed Simulation Run: existing50

Start of Run: 04Aug2011, 01:00 Basin Model: Existing Conditions
End of Run: 05Aug2011, 01:30 Meteorologic Model: 50-Year Type III
Compute Time: 13Sep2013, 14:18:08 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	128.9	04Aug2011, 15:45	6.88
MHB-2	0.08	87.1	04Aug2011, 14:45	7.12
ADD-1_2	0.24	203.6	04Aug2011, 15:15	6.96
RT-1_2	0.24	203.5	04Aug2011, 15:20	6.95
MHB-3	0.22	206.5	04Aug2011, 15:05	6.50
ADD-3	0.46	408.0	04Aug2011, 15:10	6.74
RT-3	0.46	406.6	04Aug2011, 15:15	6.72
MHB-4	0.12	150.2	04Aug2011, 14:25	6.81
ADD-4	0.58	519.2	04Aug2011, 15:00	6.74
RT-4	0.58	518.9	04Aug2011, 15:00	6.74
MHB-5	0.47	376.9	04Aug2011, 15:30	6.21
ADD-5	1.05	884.3	04Aug2011, 15:10	6.50
RT-5	1.05	883.8	04Aug2011, 15:15	6.49
14th St-MHB	1.05	879.8	04Aug2011, 15:25	6.48
MHB-6	0.17	267.8	04Aug2011, 13:45	5.44
ADD-6	1.22	937.1	04Aug2011, 15:20	6.33
RT-6	1.22	936.3	04Aug2011, 15:25	6.32
MHB-7	0.17	79.5	04Aug2011, 15:50	3.84
ADD-7	1.39	1013.0	04Aug2011, 15:30	6.01
RT-7	1.39	1009.8	04Aug2011, 15:40	5.98
MHB-8	0.17	156.6	04Aug2011, 13:50	3.43
ADD-8	1.56	1048.1	04Aug2011, 15:40	5.70
RT-8	1.56	1045.8	04Aug2011, 15:45	5.69
Brook Valley	1.56	1044.5	04Aug2011, 15:50	5.40
BB-1	0.10	98.0	04Aug2011, 14:45	6.06
RT-9	0.10	97.3	04Aug2011, 14:55	6.04

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	143.2	04Aug2011, 13:40	6.28
ADD-9	0.18	184.3	04Aug2011, 13:50	6.15
14th Street-BB	0.18	182.9	04Aug2011, 13:55	5.82
BB-3	0.03	57.8	04Aug2011, 13:35	6.29
ADD-10	0.21	234.2	04Aug2011, 13:50	5.88
RT-10	0.21	234.2	04Aug2011, 13:50	5.88
Quail Ridge Rd	0.21	230.0	04Aug2011, 13:55	5.88
BB-4	0.12	133.4	04Aug2011, 14:15	5.39
ADD-11	0.33	354.2	04Aug2011, 14:00	5.70
RT-11	0.33	353.4	04Aug2011, 14:00	5.70
York Road	0.33	349.9	04Aug2011, 14:05	5.70
BB-5	0.04	55.6	04Aug2011, 13:45	4.73
ADD-12	0.37	392.4	04Aug2011, 14:05	5.60
Railroad Crossing	0.37	280.6	04Aug2011, 14:55	5.59
BB-6	0.05	67.8	04Aug2011, 13:45	4.61
ADD-13	0.42	304.2	04Aug2011, 14:30	5.48
RT-12	0.42	303.9	04Aug2011, 14:45	5.45
UTBB-1	0.32	171.2	04Aug2011, 16:25	4.91
ADD-14	0.74	446.2	04Aug2011, 15:40	5.22
RT-13	0.74	446.2	04Aug2011, 15:45	5.21
MHB-9	0.54	483.6	04Aug2011, 14:45	5.35
MHB-10	0.17	121.4	04Aug2011, 14:50	4.40
ADD-15	3.01	1958.8	04Aug2011, 15:20	5.29
RT-OUT	3.01	1936.5	04Aug2011, 15:45	5.19
OUTLET	3.01	1936.5	04Aug2011, 15:45	5.19

Project: Pilot Watershed Simulation Run: existing100

Start of Run: 04Aug2011, 01:00 Basin Model: Existing Conditions
End of Run: 05Aug2011, 01:30 Meteorologic Model: 100-Year Type III
Compute Time: 13Sep2013, 14:18:30 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	152.4	04Aug2011, 15:45	8.19
MHB-2	0.08	102.6	04Aug2011, 14:45	8.45
ADD-1_2	0.24	240.5	04Aug2011, 15:15	8.28
RT-1_2	0.24	240.3	04Aug2011, 15:20	8.27
MHB-3	0.22	246.4	04Aug2011, 15:00	7.80
ADD-3	0.46	484.3	04Aug2011, 15:10	8.04
RT-3	0.46	482.1	04Aug2011, 15:15	8.03
MHB-4	0.12	178.0	04Aug2011, 14:25	8.14
ADD-4	0.58	616.6	04Aug2011, 14:55	8.05
RT-4	0.58	615.8	04Aug2011, 15:00	8.04
MHB-5	0.47	452.3	04Aug2011, 15:25	7.50
ADD-5	1.05	1054.1	04Aug2011, 15:10	7.80
RT-5	1.05	1053.5	04Aug2011, 15:15	7.79
14th St-MHB	1.05	1048.8	04Aug2011, 15:25	7.77
MHB-6	0.17	328.1	04Aug2011, 13:45	6.70
ADD-6	1.22	1118.6	04Aug2011, 15:15	7.62
RT-6	1.22	1117.8	04Aug2011, 15:25	7.60
MHB-7	0.17	102.5	04Aug2011, 15:50	4.92
ADD-7	1.39	1216.5	04Aug2011, 15:25	7.27
RT-7	1.39	1212.4	04Aug2011, 15:40	7.24
MHB-8	0.17	206.7	04Aug2011, 13:50	4.47
ADD-8	1.56	1262.5	04Aug2011, 15:35	6.94
RT-8	1.56	1260.4	04Aug2011, 15:40	6.92
Brook Valley	1.56	1258.9	04Aug2011, 15:45	6.62
BB-1	0.10	118.2	04Aug2011, 14:45	7.34
RT-9	0.10	117.4	04Aug2011, 14:55	7.32

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	171.9	04Aug2011, 13:40	7.59
ADD-9	0.18	222.1	04Aug2011, 13:50	7.44
14th Street-BB	0.18	220.4	04Aug2011, 13:55	7.05
BB-3	0.03	69.4	04Aug2011, 13:35	7.60
ADD-10	0.21	281.8	04Aug2011, 13:45	7.13
RT-10	0.21	281.8	04Aug2011, 13:45	7.13
Quail Ridge Rd	0.21	270.9	04Aug2011, 14:00	7.13
BB-4	0.12	163.7	04Aug2011, 14:15	6.64
ADD-11	0.33	427.7	04Aug2011, 14:05	6.95
RT-11	0.33	427.4	04Aug2011, 14:05	6.95
York Road	0.33	424.6	04Aug2011, 14:10	6.95
BB-5	0.04	69.6	04Aug2011, 13:40	5.92
ADD-12	0.37	474.2	04Aug2011, 14:05	6.84
Railroad Crossing	0.37	326.5	04Aug2011, 15:00	6.83
BB-6	0.05	85.1	04Aug2011, 13:45	5.79
ADD-13	0.42	351.3	04Aug2011, 14:50	6.71
RT-12	0.42	350.5	04Aug2011, 15:05	6.68
UTBB-1	0.32	212.1	04Aug2011, 16:25	6.09
ADD-14	0.74	533.0	04Aug2011, 15:40	6.43
RT-13	0.74	532.9	04Aug2011, 15:40	6.42
MHB-9	0.54	594.2	04Aug2011, 14:40	6.59
MHB-10	0.17	153.7	04Aug2011, 14:50	5.55
ADD-15	3.01	2385.1	04Aug2011, 15:20	6.50
RT-OUT	3.01	2357.1	04Aug2011, 15:40	6.39
OUTLET	3.01	2357.1	04Aug2011, 15:40	6.39

SECONDARY SYSTEM EXISTING CONDITIONS: HEC-HMS OUTPUT

Project: MHUT Simulation Run: 2-Year

Start of Run: 04Aug2011, 01:00 Basin Model: MHUT
End of Run: 05Aug2011, 01:00 Meteorologic Model: 2-Year
Compute Time: 13Sep2013, 14:55:30 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHUT_6	0.158	98.9	04Aug2011, 13:32	1.40
ADD_6	0.158	98.9	04Aug2011, 13:32	1.40
RT_1	0.158	98.7	04Aug2011, 13:33	1.40
MHUT_5	0.128	34.4	04Aug2011, 13:55	0.92
ADD_5	0.286	123.0	04Aug2011, 13:36	1.19
RT_2	0.286	122.7	04Aug2011, 13:38	1.18
MHUT_4	0.025	9.3	04Aug2011, 13:20	0.69
ADD_4	0.311	127.9	04Aug2011, 13:37	1.14
RT_3	0.311	124.9	04Aug2011, 13:40	1.14
MHUT_3	0.115	85.9	04Aug2011, 13:34	1.75
ADD_3	0.426	208.5	04Aug2011, 13:38	1.30
RT_4	0.426	207.7	04Aug2011, 13:40	1.30
MHUT_2	0.043	26.3	04Aug2011, 13:40	1.60
ADD_2	0.469	234.0	04Aug2011, 13:40	1.33
RT_5	0.469	233.6	04Aug2011, 13:41	1.33
MHUT_1	0.036	11.5	04Aug2011, 13:48	0.98
ADD_1	0.505	244.7	04Aug2011, 13:42	1.30
RT_6	0.505	243.8	04Aug2011, 13:45	1.30
OUTLET	0.505	243.8	04Aug2011, 13:45	1.30

Project: MHUT Simulation Run: 10-Year

Start of Run: 04Aug2011, 01:00 Basin Model: MHUT
End of Run: 05Aug2011, 01:00 Meteorologic Model: 10-Year
Compute Time: 13Sep2013, 14:56:09 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHUT_6	0.158	221.7	04Aug2011, 13:31	3.42
ADD_6	0.158	221.7	04Aug2011, 13:31	3.42
RT_1	0.158	221.5	04Aug2011, 13:31	3.42
MHUT_5	0.128	99.7	04Aug2011, 13:53	2.64
ADD_5	0.286	298.5	04Aug2011, 13:35	3.07
RT_2	0.286	297.6	04Aug2011, 13:37	3.07
MHUT_4	0.025	31.1	04Aug2011, 13:18	2.24
ADD_4	0.311	314.2	04Aug2011, 13:36	3.00
RT_3	0.311	308.3	04Aug2011, 13:38	2.99
MHUT_3	0.115	173.2	04Aug2011, 13:33	3.92
ADD_3	0.426	478.8	04Aug2011, 13:36	3.24
RT_4	0.426	477.3	04Aug2011, 13:38	3.24
MHUT_2	0.043	55.9	04Aug2011, 13:39	3.71
ADD_2	0.469	533.2	04Aug2011, 13:38	3.28
RT_5	0.469	532.5	04Aug2011, 13:39	3.28
MHUT_1	0.036	32.0	04Aug2011, 13:46	2.74
ADD_1	0.505	563.5	04Aug2011, 13:40	3.24
RT_6	0.505	561.9	04Aug2011, 13:42	3.23
OUTLET	0.505	561.9	04Aug2011, 13:42	3.23

Project: MHUT Simulation Run: 25-Year

Start of Run: 04Aug2011, 01:00 Basin Model: MHUT
End of Run: 05Aug2011, 01:00 Meteorologic Model: 25-Year
Compute Time: 13Sep2013, 14:56:33 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHUT_6	0.158	286.6	04Aug2011, 13:30	4.75
ADD_6	0.158	286.6	04Aug2011, 13:30	4.75
RT_1	0.158	286.5	04Aug2011, 13:31	4.75
MHUT_5	0.128	138.9	04Aug2011, 13:52	3.84
ADD_5	0.286	396.4	04Aug2011, 13:35	4.34
RT_2	0.286	395.3	04Aug2011, 13:37	4.34
MHUT_4	0.025	43.8	04Aug2011, 13:17	3.37
ADD_4	0.311	419.0	04Aug2011, 13:35	4.26
RT_3	0.311	412.1	04Aug2011, 13:38	4.25
MHUT_3	0.115	217.7	04Aug2011, 13:33	5.31
ADD_3	0.426	626.9	04Aug2011, 13:36	4.53
RT_4	0.426	625.1	04Aug2011, 13:38	4.53
MHUT_2	0.043	71.5	04Aug2011, 13:39	5.07
ADD_2	0.469	696.6	04Aug2011, 13:38	4.58
RT_5	0.469	695.6	04Aug2011, 13:39	4.58
MHUT_1	0.036	44.0	04Aug2011, 13:45	3.96
ADD_1	0.505	738.5	04Aug2011, 13:39	4.53
RT_6	0.505	736.2	04Aug2011, 13:41	4.52
OUTLET	0.505	736.2	04Aug2011, 13:41	4.52

Project: MHUT Simulation Run: 50-Year

Start of Run:	04Aug2011, 01:00	Basin Model:	MHUT
End of Run:	05Aug2011, 01:00	Meteorologic Model:	50-Year
Compute Time:	13Sep2013, 14:56:53	Control Specifications:	24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHUT_6	0.158	338.2	04Aug2011, 13:30	5.88
ADD_6	0.158	338.2	04Aug2011, 13:30	5.88
RT_1	0.158	337.9	04Aug2011, 13:31	5.88
MHUT_5	0.128	171.3	04Aug2011, 13:52	4.89
ADD_5	0.286	475.6	04Aug2011, 13:35	5.44
RT_2	0.286	474.4	04Aug2011, 13:36	5.43
MHUT_4	0.025	54.0	04Aug2011, 13:17	4.36
ADD_4	0.311	504.2	04Aug2011, 13:35	5.35
RT_3	0.311	496.4	04Aug2011, 13:37	5.33
MHUT_3	0.115	252.8	04Aug2011, 13:33	6.48
ADD_3	0.426	746.2	04Aug2011, 13:36	5.64
RT_4	0.426	744.4	04Aug2011, 13:37	5.64
MHUT_2	0.043	83.9	04Aug2011, 13:39	6.22
ADD_2	0.469	828.0	04Aug2011, 13:37	5.69
RT_5	0.469	826.8	04Aug2011, 13:38	5.69
MHUT_1	0.036	53.9	04Aug2011, 13:45	5.02
ADD_1	0.505	879.3	04Aug2011, 13:39	5.64
RT_6	0.505	876.9	04Aug2011, 13:41	5.63
OUTLET	0.505	876.9	04Aug2011, 13:41	5.63

Project: MHUT Simulation Run: 100-Year

Start of Run: 04Aug2011, 01:00 Basin Model: MHUT
End of Run: 05Aug2011, 01:00 Meteorologic Model: 100-Year
Compute Time: 13Sep2013, 14:57:13 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHUT_6	0.158	389.1	04Aug2011, 13:30	7.17
ADD_6	0.158	389.1	04Aug2011, 13:30	7.17
RT_1	0.158	388.7	04Aug2011, 13:31	7.17
MHUT_5	0.128	205.1	04Aug2011, 13:52	6.10
ADD_5	0.286	556.1	04Aug2011, 13:35	6.69
RT_2	0.286	554.8	04Aug2011, 13:36	6.69
MHUT_4	0.025	64.2	04Aug2011, 13:17	5.53
ADD_4	0.311	591.0	04Aug2011, 13:35	6.59
RT_3	0.311	582.6	04Aug2011, 13:37	6.58
MHUT_3	0.115	287.4	04Aug2011, 13:33	7.80
ADD_3	0.426	866.9	04Aug2011, 13:35	6.91
RT_4	0.426	864.9	04Aug2011, 13:37	6.90
MHUT_2	0.043	96.2	04Aug2011, 13:39	7.53
ADD_2	0.469	960.9	04Aug2011, 13:37	6.96
RT_5	0.469	959.5	04Aug2011, 13:38	6.95
MHUT_1	0.036	64.1	04Aug2011, 13:44	6.25
ADD_1	0.505	1021.8	04Aug2011, 13:38	6.90
RT_6	0.505	1019.1	04Aug2011, 13:41	6.89
OUTLET	0.505	1019.1	04Aug2011, 13:41	6.89

PRIMARY SYSTEM ALTERNATIVE #1: HEC-HMS OUTPUT

Project: Pilot Watershed   Simulation Run: alt1-2

Start of Run: 04Aug2011, 01:00   Basin Model: Alternative #1
End of Run: 05Aug2011, 01:30   Meteorologic Model: 2-Year Type III
Compute Time: 13Sep2013, 14:19:09   Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	47.9	04Aug2011, 15:50	2.49
MHB-2	0.08	33.3	04Aug2011, 14:50	2.63
ADD-1_2	0.24	76.1	04Aug2011, 15:20	2.53
RT-1_2	0.24	76.0	04Aug2011, 15:25	2.53
MHB-3	0.22	70.3	04Aug2011, 15:05	2.18
ADD-3	0.46	145.6	04Aug2011, 15:15	2.36
RT-3	0.46	145.0	04Aug2011, 15:25	2.35
MHB-4	0.12	53.9	04Aug2011, 14:25	2.38
ADD-4	0.58	183.6	04Aug2011, 15:05	2.36
RT-4	0.58	183.5	04Aug2011, 15:05	2.36
MHB-5	0.47	122.1	04Aug2011, 15:35	1.99
ADD-5	1.05	301.1	04Aug2011, 15:15	2.19
RT-5	1.05	301.0	04Aug2011, 15:20	2.19
14th St-MHB	1.05	301.1	04Aug2011, 15:20	2.19
MHB-6	0.17	71.1	04Aug2011, 13:45	1.48
ADD-6	1.22	320.2	04Aug2011, 15:15	2.09
RT-6	1.22	320.0	04Aug2011, 15:15	2.09
MHB-7	0.17	13.5	04Aug2011, 16:20	0.73
ADD-7	1.39	331.3	04Aug2011, 15:20	1.92
RT-7	1.39	330.0	04Aug2011, 15:35	1.91
MHB-8	0.17	18.4	04Aug2011, 14:00	0.55
ADD-8	1.56	337.9	04Aug2011, 15:35	1.76
RT-8	1.56	337.6	04Aug2011, 15:40	1.76
Brook Valley	1.56	334.7	04Aug2011, 15:50	1.57
BB-1	0.10	30.3	04Aug2011, 14:50	1.87
RT-9	0.10	30.0	04Aug2011, 15:00	1.86

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	46.2	04Aug2011, 13:45	1.99
ADD-9	0.18	58.1	04Aug2011, 13:50	1.92
14th Street-BB	0.18	58.1	04Aug2011, 13:50	1.92
BB-3	0.03	18.7	04Aug2011, 13:40	1.99
ADD-10	0.21	75.4	04Aug2011, 13:45	1.93
RT-10	0.21	75.4	04Aug2011, 13:45	1.93
Quail Ridge Rd	0.21	75.3	04Aug2011, 13:45	1.93
BB-4	0.12	35.0	04Aug2011, 14:20	1.46
ADD-11	0.33	102.9	04Aug2011, 13:55	1.76
RT-11	0.33	102.7	04Aug2011, 13:55	1.76
York Road	0.33	101.8	04Aug2011, 14:05	1.76
BB-5	0.04	9.7	04Aug2011, 14:05	1.10
ADD-12	0.37	111.5	04Aug2011, 14:05	1.69
Railroad Crossing	0.37	111.0	04Aug2011, 14:10	1.69
BB-6	0.05	14.0	04Aug2011, 13:45	1.05
ADD-13	0.42	122.6	04Aug2011, 14:05	1.61
RT-12	0.42	122.0	04Aug2011, 14:15	1.60
UTBB-1	0.32	42.2	04Aug2011, 16:40	1.25
ADD-14	0.74	133.8	04Aug2011, 14:20	1.45
RT-13	0.74	133.7	04Aug2011, 14:20	1.45
MHB-9	0.54	126.5	04Aug2011, 14:50	1.45
MHB-10	0.17	23.9	04Aug2011, 15:00	0.96
ADD-15	3.01	549.0	04Aug2011, 15:45	1.48
RT-OUT	3.01	546.9	04Aug2011, 16:05	1.47
OUTLET	3.01	546.9	04Aug2011, 16:05	1.47

Project: Pilot Watershed Simulation Run: alt1-10

Start of Run: 04Aug2011, 01:00 Basin Model: Alternative #1
End of Run: 05Aug2011, 01:30 Meteorologic Model: 10-Year Type III
Compute Time: 13Sep2013, 14:19:40 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	83.1	04Aug2011, 15:45	4.37
MHB-2	0.08	56.8	04Aug2011, 14:50	4.56
ADD-1_2	0.24	131.6	04Aug2011, 15:15	4.44
RT-1_2	0.24	131.5	04Aug2011, 15:20	4.43
MHB-3	0.22	129.1	04Aug2011, 15:05	4.01
ADD-3	0.46	259.3	04Aug2011, 15:10	4.23
RT-3	0.46	258.3	04Aug2011, 15:20	4.21
MHB-4	0.12	95.8	04Aug2011, 14:25	4.27
ADD-4	0.58	328.8	04Aug2011, 15:00	4.23
RT-4	0.58	328.8	04Aug2011, 15:00	4.22
MHB-5	0.47	231.2	04Aug2011, 15:30	3.77
ADD-5	1.05	551.2	04Aug2011, 15:10	4.02
RT-5	1.05	551.1	04Aug2011, 15:15	4.02
14th St-MHB	1.05	550.5	04Aug2011, 15:20	4.02
MHB-6	0.17	153.2	04Aug2011, 13:45	3.10
ADD-6	1.22	587.6	04Aug2011, 15:15	3.89
RT-6	1.22	587.5	04Aug2011, 15:15	3.89
MHB-7	0.17	38.6	04Aug2011, 16:00	1.93
ADD-7	1.39	622.5	04Aug2011, 15:20	3.65
RT-7	1.39	620.0	04Aug2011, 15:35	3.63
MHB-8	0.17	68.9	04Aug2011, 13:55	1.62
ADD-8	1.56	640.7	04Aug2011, 15:35	3.41
RT-8	1.56	639.5	04Aug2011, 15:40	3.40
Brook Valley	1.56	638.7	04Aug2011, 15:45	3.13
BB-1	0.10	59.1	04Aug2011, 14:45	3.63
RT-9	0.10	58.7	04Aug2011, 15:00	3.61

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	87.8	04Aug2011, 13:45	3.79
ADD-9	0.18	113.0	04Aug2011, 13:50	3.69
14th Street-BB	0.18	111.5	04Aug2011, 13:55	3.69
BB-3	0.03	35.5	04Aug2011, 13:40	3.80
ADD-10	0.21	142.8	04Aug2011, 13:50	3.71
RT-10	0.21	142.8	04Aug2011, 13:50	3.71
Quail Ridge Rd	0.21	143.0	04Aug2011, 13:50	3.71
BB-4	0.12	75.8	04Aug2011, 14:15	3.07
ADD-11	0.33	207.2	04Aug2011, 14:00	3.48
RT-11	0.33	207.2	04Aug2011, 14:00	3.48
York Road	0.33	203.3	04Aug2011, 14:10	3.48
BB-5	0.04	23.9	04Aug2011, 14:00	2.54
ADD-12	0.37	227.1	04Aug2011, 14:05	3.37
Railroad Crossing	0.37	205.3	04Aug2011, 14:30	3.37
BB-6	0.05	35.6	04Aug2011, 13:45	2.46
ADD-13	0.42	224.1	04Aug2011, 14:20	3.27
RT-12	0.42	223.1	04Aug2011, 14:40	3.25
UTBB-1	0.32	94.8	04Aug2011, 16:30	2.73
ADD-14	0.74	281.2	04Aug2011, 15:10	3.03
RT-13	0.74	281.2	04Aug2011, 15:10	3.03
MHB-9	0.54	274.6	04Aug2011, 14:45	3.05
MHB-10	0.17	62.4	04Aug2011, 14:55	2.32
ADD-15	3.01	1195.3	04Aug2011, 15:20	3.04
RT-OUT	3.01	1194.9	04Aug2011, 15:30	3.03
OUTLET	3.01	1194.9	04Aug2011, 15:30	3.03

Project: Pilot Watershed Simulation Run: alt1-25

Start of Run: 04Aug2011, 01:00 Basin Model: Alternative #1
End of Run: 05Aug2011, 01:30 Meteorologic Model: 25-Year Type III
Compute Time: 13Sep2013, 14:21:15 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	107.6	04Aug2011, 15:45	5.71
MHB-2	0.08	73.0	04Aug2011, 14:50	5.93
ADD-1_2	0.24	170.1	04Aug2011, 15:15	5.78
RT-1_2	0.24	170.0	04Aug2011, 15:20	5.77
MHB-3	0.22	170.4	04Aug2011, 15:05	5.33
ADD-3	0.46	338.8	04Aug2011, 15:10	5.56
RT-3	0.46	337.3	04Aug2011, 15:15	5.54
MHB-4	0.12	124.8	04Aug2011, 14:25	5.62
ADD-4	0.58	430.3	04Aug2011, 15:00	5.56
RT-4	0.58	430.3	04Aug2011, 15:00	5.56
MHB-5	0.47	308.8	04Aug2011, 15:30	5.06
ADD-5	1.05	727.9	04Aug2011, 15:10	5.34
RT-5	1.05	727.4	04Aug2011, 15:15	5.33
14th St-MHB	1.05	726.7	04Aug2011, 15:15	5.33
MHB-6	0.17	213.8	04Aug2011, 13:45	4.33
ADD-6	1.22	777.6	04Aug2011, 15:10	5.19
RT-6	1.22	777.5	04Aug2011, 15:15	5.19
MHB-7	0.17	59.7	04Aug2011, 15:55	2.91
ADD-7	1.39	832.1	04Aug2011, 15:20	4.91
RT-7	1.39	828.9	04Aug2011, 15:30	4.88
MHB-8	0.17	113.7	04Aug2011, 13:50	2.55
ADD-8	1.56	861.0	04Aug2011, 15:30	4.63
RT-8	1.56	858.9	04Aug2011, 15:35	4.62
Brook Valley	1.56	857.9	04Aug2011, 15:40	4.33
BB-1	0.10	79.8	04Aug2011, 14:45	4.91
RT-9	0.10	79.2	04Aug2011, 14:55	4.89

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	117.3	04Aug2011, 13:45	5.11
ADD-9	0.18	150.5	04Aug2011, 13:50	4.99
14th Street-BB	0.18	144.7	04Aug2011, 14:00	4.99
BB-3	0.03	47.3	04Aug2011, 13:35	5.11
ADD-10	0.21	186.1	04Aug2011, 13:45	5.01
RT-10	0.21	186.1	04Aug2011, 13:45	5.01
Quail Ridge Rd	0.21	184.5	04Aug2011, 13:50	5.01
BB-4	0.12	106.2	04Aug2011, 14:15	4.29
ADD-11	0.33	281.4	04Aug2011, 14:05	4.75
RT-11	0.33	281.4	04Aug2011, 14:05	4.75
York Road	0.33	271.3	04Aug2011, 14:20	4.75
BB-5	0.04	35.1	04Aug2011, 14:00	3.67
ADD-12	0.37	303.4	04Aug2011, 14:15	4.63
Railroad Crossing	0.37	253.2	04Aug2011, 14:50	4.63
BB-6	0.05	52.4	04Aug2011, 13:45	3.58
ADD-13	0.42	272.3	04Aug2011, 14:35	4.50
RT-12	0.42	271.8	04Aug2011, 14:50	4.49
UTBB-1	0.32	134.9	04Aug2011, 16:25	3.87
ADD-14	0.74	376.7	04Aug2011, 15:30	4.22
RT-13	0.74	376.7	04Aug2011, 15:30	4.22
MHB-9	0.54	384.9	04Aug2011, 14:45	4.25
MHB-10	0.17	93.1	04Aug2011, 14:50	3.40
ADD-15	3.01	1635.1	04Aug2011, 15:15	4.24
RT-OUT	3.01	1634.3	04Aug2011, 15:25	4.22
OUTLET	3.01	1634.3	04Aug2011, 15:25	4.22

Project: Pilot Watershed Simulation Run: alt1-50

Start of Run: 04Aug2011, 01:00 Basin Model: Alternative #1
End of Run: 05Aug2011, 01:30 Meteorologic Model: 50-Year Type III
Compute Time: 13Sep2013, 14:22:15 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	128.9	04Aug2011, 15:45	6.88
MHB-2	0.08	87.1	04Aug2011, 14:45	7.12
ADD-1_2	0.24	203.6	04Aug2011, 15:15	6.96
RT-1_2	0.24	203.5	04Aug2011, 15:20	6.95
MHB-3	0.22	206.5	04Aug2011, 15:05	6.50
ADD-3	0.46	408.0	04Aug2011, 15:10	6.74
RT-3	0.46	406.6	04Aug2011, 15:15	6.72
MHB-4	0.12	150.2	04Aug2011, 14:25	6.81
ADD-4	0.58	519.2	04Aug2011, 15:00	6.74
RT-4	0.58	519.2	04Aug2011, 15:00	6.74
MHB-5	0.47	376.9	04Aug2011, 15:30	6.21
ADD-5	1.05	882.6	04Aug2011, 15:10	6.50
RT-5	1.05	882.1	04Aug2011, 15:10	6.50
14th St-MHB	1.05	880.0	04Aug2011, 15:20	6.50
MHB-6	0.17	267.8	04Aug2011, 13:45	5.44
ADD-6	1.22	941.6	04Aug2011, 15:10	6.35
RT-6	1.22	941.4	04Aug2011, 15:15	6.35
MHB-7	0.17	79.5	04Aug2011, 15:50	3.84
ADD-7	1.39	1015.3	04Aug2011, 15:20	6.04
RT-7	1.39	1012.1	04Aug2011, 15:30	6.01
MHB-8	0.17	156.6	04Aug2011, 13:50	3.43
ADD-8	1.56	1053.9	04Aug2011, 15:25	5.73
RT-8	1.56	1051.7	04Aug2011, 15:30	5.72
Brook Valley	1.56	1050.7	04Aug2011, 15:35	5.43
BB-1	0.10	98.0	04Aug2011, 14:45	6.06
RT-9	0.10	97.3	04Aug2011, 14:55	6.04

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	143.2	04Aug2011, 13:40	6.28
ADD-9	0.18	184.3	04Aug2011, 13:50	6.15
14th Street-BB	0.18	169.5	04Aug2011, 14:05	6.15
BB-3	0.03	57.8	04Aug2011, 13:35	6.29
ADD-10	0.21	215.5	04Aug2011, 13:50	6.17
RT-10	0.21	215.5	04Aug2011, 13:50	6.17
Quail Ridge Rd	0.21	214.3	04Aug2011, 13:55	6.17
BB-4	0.12	133.4	04Aug2011, 14:15	5.39
ADD-11	0.33	339.7	04Aug2011, 14:05	5.89
RT-11	0.33	339.5	04Aug2011, 14:05	5.88
York Road	0.33	335.5	04Aug2011, 14:15	5.88
BB-5	0.04	45.2	04Aug2011, 14:00	4.71
ADD-12	0.37	377.3	04Aug2011, 14:15	5.76
Railroad Crossing	0.37	285.1	04Aug2011, 15:10	5.76
BB-6	0.05	67.8	04Aug2011, 13:45	4.61
ADD-13	0.42	303.9	04Aug2011, 14:50	5.62
RT-12	0.42	303.8	04Aug2011, 15:05	5.59
UTBB-1	0.32	171.2	04Aug2011, 16:25	4.91
ADD-14	0.74	456.1	04Aug2011, 15:45	5.30
RT-13	0.74	456.0	04Aug2011, 15:45	5.30
MHB-9	0.54	483.6	04Aug2011, 14:45	5.35
MHB-10	0.17	121.4	04Aug2011, 14:50	4.40
ADD-15	3.01	2007.3	04Aug2011, 15:15	5.32
RT-OUT	3.01	2006.4	04Aug2011, 15:25	5.30
OUTLET	3.01	2006.4	04Aug2011, 15:25	5.30

Project: Pilot Watershed   Simulation Run: alt1-100

Start of Run: 04Aug2011, 01:00   Basin Model: Alternative #1
End of Run: 05Aug2011, 01:30   Meteorologic Model: 100-Year Type III
Compute Time: 13Sep2013, 14:22:48   Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	152.4	04Aug2011, 15:45	8.19
MHB-2	0.08	102.6	04Aug2011, 14:45	8.45
ADD-1_2	0.24	240.5	04Aug2011, 15:15	8.28
RT-1_2	0.24	240.3	04Aug2011, 15:20	8.27
MHB-3	0.22	246.4	04Aug2011, 15:00	7.80
ADD-3	0.46	484.3	04Aug2011, 15:10	8.04
RT-3	0.46	482.1	04Aug2011, 15:15	8.03
MHB-4	0.12	178.0	04Aug2011, 14:25	8.14
ADD-4	0.58	616.6	04Aug2011, 14:55	8.05
RT-4	0.58	616.5	04Aug2011, 14:55	8.05
MHB-5	0.47	452.3	04Aug2011, 15:25	7.50
ADD-5	1.05	1052.0	04Aug2011, 15:10	7.80
RT-5	1.05	1051.6	04Aug2011, 15:10	7.80
14th St-MHB	1.05	1049.1	04Aug2011, 15:15	7.80
MHB-6	0.17	328.1	04Aug2011, 13:45	6.70
ADD-6	1.22	1123.9	04Aug2011, 15:10	7.64
RT-6	1.22	1123.5	04Aug2011, 15:15	7.64
MHB-7	0.17	102.5	04Aug2011, 15:50	4.92
ADD-7	1.39	1219.1	04Aug2011, 15:20	7.30
RT-7	1.39	1215.3	04Aug2011, 15:30	7.27
MHB-8	0.17	206.7	04Aug2011, 13:50	4.47
ADD-8	1.56	1269.5	04Aug2011, 15:25	6.97
RT-8	1.56	1267.2	04Aug2011, 15:30	6.95
Brook Valley	1.56	1265.8	04Aug2011, 15:35	6.65
BB-1	0.10	118.2	04Aug2011, 14:45	7.34
RT-9	0.10	117.4	04Aug2011, 14:55	7.32

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	171.9	04Aug2011, 13:40	7.59
ADD-9	0.18	222.1	04Aug2011, 13:50	7.44
14th Street-BB	0.18	191.9	04Aug2011, 14:20	7.44
BB-3	0.03	69.4	04Aug2011, 13:35	7.60
ADD-10	0.21	241.7	04Aug2011, 13:50	7.46
RT-10	0.21	241.7	04Aug2011, 13:50	7.46
Quail Ridge Rd	0.21	237.9	04Aug2011, 14:00	7.46
BB-4	0.12	163.7	04Aug2011, 14:15	6.64
ADD-11	0.33	398.3	04Aug2011, 14:10	7.16
RT-11	0.33	398.2	04Aug2011, 14:10	7.16
York Road	0.33	396.7	04Aug2011, 14:15	7.16
BB-5	0.04	56.7	04Aug2011, 14:00	5.90
ADD-12	0.37	449.4	04Aug2011, 14:10	7.02
Railroad Crossing	0.37	323.2	04Aug2011, 15:10	7.02
BB-6	0.05	85.1	04Aug2011, 13:45	5.79
ADD-13	0.42	344.8	04Aug2011, 15:00	6.88
RT-12	0.42	344.3	04Aug2011, 15:15	6.85
UTBB-1	0.32	212.1	04Aug2011, 16:25	6.09
ADD-14	0.74	539.0	04Aug2011, 15:50	6.52
RT-13	0.74	538.9	04Aug2011, 15:50	6.52
MHB-9	0.54	594.2	04Aug2011, 14:40	6.59
MHB-10	0.17	153.7	04Aug2011, 14:50	5.55
ADD-15	3.01	2424.3	04Aug2011, 15:15	6.55
RT-OUT	3.01	2423.1	04Aug2011, 15:20	6.52
OUTLET	3.01	2423.1	04Aug2011, 15:20	6.52

PRIMARY SYSTEM ALTERNATIVE #2: HEC-HMS OUTPUT

Project: Pilot Watershed Simulation Run: alt2-2

Start of Run: 04Aug2011, 01:00 Basin Model: Alternative #2
End of Run: 05Aug2011, 01:30 Meteorologic Model: 2-Year Type III
Compute Time: 13Sep2013, 14:23:22 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	47.9	04Aug2011, 15:50	2.49
MHB-2	0.08	33.3	04Aug2011, 14:50	2.63
ADD-1_2	0.24	76.1	04Aug2011, 15:20	2.53
RT-1_2	0.24	76.0	04Aug2011, 15:25	2.53
MHB-3	0.22	70.3	04Aug2011, 15:05	2.18
ADD-3	0.46	145.6	04Aug2011, 15:15	2.36
RT-3	0.46	145.0	04Aug2011, 15:25	2.35
MHB-4	0.12	53.9	04Aug2011, 14:25	2.38
ADD-4	0.58	183.6	04Aug2011, 15:05	2.36
RT-4	0.58	183.5	04Aug2011, 15:05	2.36
MHB-5	0.47	122.1	04Aug2011, 15:35	1.99
ADD-5	1.05	301.1	04Aug2011, 15:15	2.19
RT-5	1.05	301.0	04Aug2011, 15:20	2.19
14th St-MHB	1.05	301.1	04Aug2011, 15:20	2.19
MHB-6	0.17	71.1	04Aug2011, 13:45	1.48
ADD-6	1.22	320.2	04Aug2011, 15:15	2.09
RT-6	1.22	320.0	04Aug2011, 15:15	2.09
MHB-7	0.17	13.5	04Aug2011, 16:20	0.73
ADD-7	1.39	331.3	04Aug2011, 15:20	1.92
RT-7	1.39	329.9	04Aug2011, 15:35	1.91
MHB-8	0.17	18.4	04Aug2011, 14:00	0.55
ADD-8	1.56	337.9	04Aug2011, 15:35	1.76
RT-8	1.56	337.6	04Aug2011, 15:40	1.76
Brook Valley	1.56	334.7	04Aug2011, 15:50	1.57
BB-1	0.10	30.3	04Aug2011, 14:50	1.87
RT-9	0.10	30.0	04Aug2011, 15:00	1.86

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	46.2	04Aug2011, 13:45	1.99
ADD-9	0.18	58.1	04Aug2011, 13:50	1.92
14th Street-BB	0.18	58.1	04Aug2011, 13:50	1.92
BB-3	0.03	18.7	04Aug2011, 13:40	1.99
ADD-10	0.21	75.4	04Aug2011, 13:45	1.93
RT-10	0.21	75.4	04Aug2011, 13:45	1.93
Quail Ridge Rd	0.21	75.3	04Aug2011, 13:45	1.93
BB-4	0.12	35.0	04Aug2011, 14:20	1.46
ADD-11	0.33	102.9	04Aug2011, 13:55	1.76
RT-11	0.33	102.7	04Aug2011, 13:55	1.76
York Road	0.33	101.8	04Aug2011, 14:05	1.76
BB-5	0.04	9.7	04Aug2011, 14:05	1.10
ADD-12	0.37	111.5	04Aug2011, 14:05	1.69
Railroad Crossing	0.37	111.5	04Aug2011, 14:05	1.69
BB-6	0.05	14.0	04Aug2011, 13:45	1.05
ADD-13	0.42	124.0	04Aug2011, 14:00	1.61
RT-12	0.42	123.4	04Aug2011, 14:10	1.60
UTBB-1	0.32	42.2	04Aug2011, 16:40	1.25
ADD-14	0.74	134.0	04Aug2011, 14:15	1.45
RT-13	0.74	133.9	04Aug2011, 14:15	1.45
MHB-9	0.54	126.5	04Aug2011, 14:50	1.45
MHB-10	0.17	23.9	04Aug2011, 15:00	0.96
ADD-15	3.01	548.9	04Aug2011, 15:45	1.48
RT-OUT	3.01	546.8	04Aug2011, 16:05	1.47
OUTLET	3.01	546.8	04Aug2011, 16:05	1.47

Project: Pilot Watershed Simulation Run: alt2-10

Start of Run: 04Aug2011, 01:00 Basin Model: Alternative #2
End of Run: 05Aug2011, 01:30 Meteorologic Model: 10-Year Type III
Compute Time: 13Sep2013, 14:24:08 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	83.1	04Aug2011, 15:45	4.37
MHB-2	0.08	56.8	04Aug2011, 14:50	4.56
ADD-1_2	0.24	131.6	04Aug2011, 15:15	4.44
RT-1_2	0.24	131.5	04Aug2011, 15:20	4.43
MHB-3	0.22	129.1	04Aug2011, 15:05	4.01
ADD-3	0.46	259.3	04Aug2011, 15:10	4.23
RT-3	0.46	258.3	04Aug2011, 15:20	4.21
MHB-4	0.12	95.8	04Aug2011, 14:25	4.27
ADD-4	0.58	328.8	04Aug2011, 15:00	4.23
RT-4	0.58	328.8	04Aug2011, 15:00	4.22
MHB-5	0.47	231.2	04Aug2011, 15:30	3.77
ADD-5	1.05	551.2	04Aug2011, 15:10	4.02
RT-5	1.05	551.1	04Aug2011, 15:15	4.02
14th St-MHB	1.05	551.1	04Aug2011, 15:15	4.02
MHB-6	0.17	153.2	04Aug2011, 13:45	3.10
ADD-6	1.22	589.5	04Aug2011, 15:10	3.89
RT-6	1.22	589.4	04Aug2011, 15:15	3.89
MHB-7	0.17	38.6	04Aug2011, 16:00	1.93
ADD-7	1.39	623.5	04Aug2011, 15:15	3.65
RT-7	1.39	620.9	04Aug2011, 15:35	3.63
MHB-8	0.17	68.9	04Aug2011, 13:55	1.62
ADD-8	1.56	642.5	04Aug2011, 15:30	3.41
RT-8	1.56	641.2	04Aug2011, 15:35	3.40
Brook Valley	1.56	640.5	04Aug2011, 15:40	3.13
BB-1	0.10	59.1	04Aug2011, 14:45	3.63
RT-9	0.10	58.7	04Aug2011, 15:00	3.61

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	87.8	04Aug2011, 13:45	3.79
ADD-9	0.18	113.0	04Aug2011, 13:50	3.69
14th Street-BB	0.18	111.5	04Aug2011, 13:55	3.69
BB-3	0.03	35.5	04Aug2011, 13:40	3.80
ADD-10	0.21	142.8	04Aug2011, 13:50	3.71
RT-10	0.21	142.8	04Aug2011, 13:50	3.71
Quail Ridge Rd	0.21	143.0	04Aug2011, 13:50	3.71
BB-4	0.12	75.8	04Aug2011, 14:15	3.07
ADD-11	0.33	207.2	04Aug2011, 14:00	3.48
RT-11	0.33	207.2	04Aug2011, 14:00	3.48
York Road	0.33	203.3	04Aug2011, 14:10	3.48
BB-5	0.04	23.9	04Aug2011, 14:00	2.54
ADD-12	0.37	227.1	04Aug2011, 14:05	3.37
Railroad Crossing	0.37	221.1	04Aug2011, 14:15	3.37
BB-6	0.05	35.6	04Aug2011, 13:45	2.46
ADD-13	0.42	245.3	04Aug2011, 14:05	3.27
RT-12	0.42	243.0	04Aug2011, 14:30	3.26
UTBB-1	0.32	94.8	04Aug2011, 16:30	2.73
ADD-14	0.74	287.9	04Aug2011, 14:40	3.03
RT-13	0.74	287.7	04Aug2011, 14:40	3.03
MHB-9	0.54	274.6	04Aug2011, 14:45	3.05
MHB-10	0.17	62.4	04Aug2011, 14:55	2.32
ADD-15	3.01	1196.5	04Aug2011, 15:10	3.05
RT-OUT	3.01	1195.7	04Aug2011, 15:20	3.03
OUTLET	3.01	1195.7	04Aug2011, 15:20	3.03

Project: Pilot Watershed Simulation Run: alt2-25

Start of Run: 04Aug2011, 01:00 Basin Model: Alternative #2
End of Run: 05Aug2011, 01:30 Meteorologic Model: 25-Year Type III
Compute Time: 13Sep2013, 14:24:38 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	107.6	04Aug2011, 15:45	5.71
MHB-2	0.08	73.0	04Aug2011, 14:50	5.93
ADD-1_2	0.24	170.1	04Aug2011, 15:15	5.78
RT-1_2	0.24	170.0	04Aug2011, 15:20	5.77
MHB-3	0.22	170.4	04Aug2011, 15:05	5.33
ADD-3	0.46	338.8	04Aug2011, 15:10	5.56
RT-3	0.46	337.3	04Aug2011, 15:15	5.54
MHB-4	0.12	124.8	04Aug2011, 14:25	5.62
ADD-4	0.58	430.3	04Aug2011, 15:00	5.56
RT-4	0.58	430.3	04Aug2011, 15:00	5.56
MHB-5	0.47	308.8	04Aug2011, 15:30	5.06
ADD-5	1.05	727.9	04Aug2011, 15:10	5.34
RT-5	1.05	727.4	04Aug2011, 15:15	5.33
14th St-MHB	1.05	727.5	04Aug2011, 15:15	5.33
MHB-6	0.17	213.8	04Aug2011, 13:45	4.33
ADD-6	1.22	779.7	04Aug2011, 15:10	5.19
RT-6	1.22	779.4	04Aug2011, 15:15	5.19
MHB-7	0.17	59.7	04Aug2011, 15:55	2.91
ADD-7	1.39	833.5	04Aug2011, 15:15	4.91
RT-7	1.39	830.2	04Aug2011, 15:30	4.88
MHB-8	0.17	113.7	04Aug2011, 13:50	2.55
ADD-8	1.56	863.3	04Aug2011, 15:25	4.63
RT-8	1.56	861.2	04Aug2011, 15:30	4.62
Brook Valley	1.56	860.3	04Aug2011, 15:35	4.33
BB-1	0.10	79.8	04Aug2011, 14:45	4.91
RT-9	0.10	79.2	04Aug2011, 14:55	4.89

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	117.3	04Aug2011, 13:45	5.11
ADD-9	0.18	150.5	04Aug2011, 13:50	4.99
14th Street-BB	0.18	144.7	04Aug2011, 14:00	4.99
BB-3	0.03	47.3	04Aug2011, 13:35	5.11
ADD-10	0.21	186.1	04Aug2011, 13:45	5.01
RT-10	0.21	186.1	04Aug2011, 13:45	5.01
Quail Ridge Rd	0.21	184.5	04Aug2011, 13:50	5.01
BB-4	0.12	106.2	04Aug2011, 14:15	4.29
ADD-11	0.33	281.4	04Aug2011, 14:05	4.75
RT-11	0.33	281.4	04Aug2011, 14:05	4.75
York Road	0.33	271.3	04Aug2011, 14:20	4.75
BB-5	0.04	35.1	04Aug2011, 14:00	3.67
ADD-12	0.37	303.4	04Aug2011, 14:15	4.63
Railroad Crossing	0.37	285.0	04Aug2011, 14:35	4.63
BB-6	0.05	52.4	04Aug2011, 13:45	3.58
ADD-13	0.42	309.8	04Aug2011, 14:25	4.50
RT-12	0.42	308.7	04Aug2011, 14:40	4.49
UTBB-1	0.32	134.9	04Aug2011, 16:25	3.87
ADD-14	0.74	394.8	04Aug2011, 15:05	4.22
RT-13	0.74	394.7	04Aug2011, 15:05	4.22
MHB-9	0.54	384.9	04Aug2011, 14:45	4.25
MHB-10	0.17	93.1	04Aug2011, 14:50	3.40
ADD-15	3.01	1666.4	04Aug2011, 15:10	4.24
RT-OUT	3.01	1665.5	04Aug2011, 15:20	4.22
OUTLET	3.01	1665.5	04Aug2011, 15:20	4.22

Project: Pilot Watershed Simulation Run: alt2-50

Start of Run: 04Aug2011, 01:00 Basin Model: Alternative #2
End of Run: 05Aug2011, 01:30 Meteorologic Model: 50-Year Type III
Compute Time: 13Sep2013, 14:25:12 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	128.9	04Aug2011, 15:45	6.88
MHB-2	0.08	87.1	04Aug2011, 14:45	7.12
ADD-1_2	0.24	203.6	04Aug2011, 15:15	6.96
RT-1_2	0.24	203.5	04Aug2011, 15:20	6.95
MHB-3	0.22	206.5	04Aug2011, 15:05	6.50
ADD-3	0.46	408.0	04Aug2011, 15:10	6.74
RT-3	0.46	406.6	04Aug2011, 15:15	6.72
MHB-4	0.12	150.2	04Aug2011, 14:25	6.81
ADD-4	0.58	519.2	04Aug2011, 15:00	6.74
RT-4	0.58	519.2	04Aug2011, 15:00	6.74
MHB-5	0.47	376.9	04Aug2011, 15:30	6.21
ADD-5	1.05	882.6	04Aug2011, 15:10	6.50
RT-5	1.05	882.1	04Aug2011, 15:10	6.50
14th St-MHB	1.05	881.8	04Aug2011, 15:15	6.50
MHB-6	0.17	267.8	04Aug2011, 13:45	5.44
ADD-6	1.22	945.5	04Aug2011, 15:10	6.35
RT-6	1.22	945.0	04Aug2011, 15:15	6.35
MHB-7	0.17	79.5	04Aug2011, 15:50	3.84
ADD-7	1.39	1018.1	04Aug2011, 15:15	6.04
RT-7	1.39	1014.7	04Aug2011, 15:25	6.01
MHB-8	0.17	156.6	04Aug2011, 13:50	3.43
ADD-8	1.56	1058.4	04Aug2011, 15:25	5.73
RT-8	1.56	1056.3	04Aug2011, 15:30	5.72
Brook Valley	1.56	1055.1	04Aug2011, 15:35	5.43
BB-1	0.10	98.0	04Aug2011, 14:45	6.06
RT-9	0.10	97.3	04Aug2011, 14:55	6.04

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	143.2	04Aug2011, 13:40	6.28
ADD-9	0.18	184.3	04Aug2011, 13:50	6.15
14th Street-BB	0.18	169.5	04Aug2011, 14:05	6.15
BB-3	0.03	57.8	04Aug2011, 13:35	6.29
ADD-10	0.21	215.5	04Aug2011, 13:50	6.17
RT-10	0.21	215.5	04Aug2011, 13:50	6.17
Quail Ridge Rd	0.21	214.3	04Aug2011, 13:55	6.17
BB-4	0.12	133.4	04Aug2011, 14:15	5.39
ADD-11	0.33	339.7	04Aug2011, 14:05	5.89
RT-11	0.33	339.5	04Aug2011, 14:05	5.88
York Road	0.33	335.5	04Aug2011, 14:15	5.88
BB-5	0.04	45.2	04Aug2011, 14:00	4.71
ADD-12	0.37	377.3	04Aug2011, 14:15	5.76
Railroad Crossing	0.37	327.6	04Aug2011, 14:45	5.76
BB-6	0.05	67.8	04Aug2011, 13:45	4.61
ADD-13	0.42	354.3	04Aug2011, 14:30	5.62
RT-12	0.42	353.6	04Aug2011, 14:45	5.60
UTBB-1	0.32	171.2	04Aug2011, 16:25	4.91
ADD-14	0.74	483.1	04Aug2011, 15:25	5.30
RT-13	0.74	483.0	04Aug2011, 15:25	5.30
MHB-9	0.54	483.6	04Aug2011, 14:45	5.35
MHB-10	0.17	121.4	04Aug2011, 14:50	4.40
ADD-15	3.01	2062.0	04Aug2011, 15:10	5.32
RT-OUT	3.01	2061.3	04Aug2011, 15:20	5.31
OUTLET	3.01	2061.3	04Aug2011, 15:20	5.31

Project: Pilot Watershed Simulation Run: alt2-100

Start of Run: 04Aug2011, 01:00 Basin Model: Alternative #2
End of Run: 05Aug2011, 01:30 Meteorologic Model: 100-Year Type III
Compute Time: 13Sep2013, 14:25:57 Control Specifications: 24-hour Storm

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MHB-1	0.16	152.4	04Aug2011, 15:45	8.19
MHB-2	0.08	102.6	04Aug2011, 14:45	8.45
ADD-1_2	0.24	240.5	04Aug2011, 15:15	8.28
RT-1_2	0.24	240.3	04Aug2011, 15:20	8.27
MHB-3	0.22	246.4	04Aug2011, 15:00	7.80
ADD-3	0.46	484.3	04Aug2011, 15:10	8.04
RT-3	0.46	482.1	04Aug2011, 15:15	8.03
MHB-4	0.12	178.0	04Aug2011, 14:25	8.14
ADD-4	0.58	616.6	04Aug2011, 14:55	8.05
RT-4	0.58	616.5	04Aug2011, 14:55	8.05
MHB-5	0.47	452.3	04Aug2011, 15:25	7.50
ADD-5	1.05	1052.0	04Aug2011, 15:10	7.80
RT-5	1.05	1051.6	04Aug2011, 15:10	7.80
14th St-MHB	1.05	1051.2	04Aug2011, 15:15	7.80
MHB-6	0.17	328.1	04Aug2011, 13:45	6.70
ADD-6	1.22	1128.7	04Aug2011, 15:05	7.64
RT-6	1.22	1128.4	04Aug2011, 15:10	7.64
MHB-7	0.17	102.5	04Aug2011, 15:50	4.92
ADD-7	1.39	1222.6	04Aug2011, 15:15	7.30
RT-7	1.39	1218.7	04Aug2011, 15:25	7.27
MHB-8	0.17	206.7	04Aug2011, 13:50	4.47
ADD-8	1.56	1274.8	04Aug2011, 15:20	6.97
RT-8	1.56	1272.4	04Aug2011, 15:25	6.95
Brook Valley	1.56	1271.1	04Aug2011, 15:30	6.65
BB-1	0.10	118.2	04Aug2011, 14:45	7.34
RT-9	0.10	117.4	04Aug2011, 14:55	7.32

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BB-2	0.08	171.9	04Aug2011, 13:40	7.59
ADD-9	0.18	222.1	04Aug2011, 13:50	7.44
14th Street-BB	0.18	191.9	04Aug2011, 14:20	7.44
BB-3	0.03	69.4	04Aug2011, 13:35	7.60
ADD-10	0.21	241.7	04Aug2011, 13:50	7.46
RT-10	0.21	241.7	04Aug2011, 13:50	7.46
Quail Ridge Rd	0.21	237.9	04Aug2011, 14:00	7.46
BB-4	0.12	163.7	04Aug2011, 14:15	6.64
ADD-11	0.33	398.3	04Aug2011, 14:10	7.16
RT-11	0.33	398.2	04Aug2011, 14:10	7.16
York Road	0.33	396.7	04Aug2011, 14:15	7.16
BB-5	0.04	56.7	04Aug2011, 14:00	5.90
ADD-12	0.37	449.4	04Aug2011, 14:10	7.02
Railroad Crossing	0.37	368.7	04Aug2011, 14:50	7.02
BB-6	0.05	85.1	04Aug2011, 13:45	5.79
ADD-13	0.42	398.5	04Aug2011, 14:30	6.88
RT-12	0.42	397.9	04Aug2011, 14:45	6.86
UTBB-1	0.32	212.1	04Aug2011, 16:25	6.09
ADD-14	0.74	570.4	04Aug2011, 15:35	6.53
RT-13	0.74	570.4	04Aug2011, 15:35	6.53
MHB-9	0.54	594.2	04Aug2011, 14:40	6.59
MHB-10	0.17	153.7	04Aug2011, 14:50	5.55
ADD-15	3.01	2489.9	04Aug2011, 15:10	6.55
RT-OUT	3.01	2488.3	04Aug2011, 15:20	6.52
OUTLET	3.01	2488.3	04Aug2011, 15:20	6.52

PRIMARY SYSTEM EXISTING CONDITIONS: HEC-RAS OUTPUT

Bells Branch - Existing Conditions

HEC-RAS Plan: Existing River: Bells Branch Reach: Reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	11194	2-Year	30.30	62.20	64.84		64.89	0.002780	1.83	19.47	15.39	0.23
Reach 1	11194	10-Year	59.10	62.20	65.62		65.68	0.002571	2.18	42.79	45.44	0.23
Reach 1	11194	25-Year	79.80	62.20	66.00		66.06	0.002360	2.28	63.17	60.73	0.23
Reach 1	11194	50-Year	98.00	62.20	66.27		66.33	0.002228	2.34	81.04	71.50	0.22
Reach 1	11194	100-Year	118.20	62.20	66.52		66.58	0.002129	2.40	100.32	81.53	0.22
Reach 1	10514	2-Year	30.30	60.20	63.52		63.55	0.001449	1.48	26.64	24.83	0.16
Reach 1	10514	10-Year	59.10	60.20	64.70		64.72	0.000872	1.46	71.31	51.08	0.13
Reach 1	10514	25-Year	79.80	60.20	65.04		65.07	0.000974	1.64	90.22	58.50	0.14
Reach 1	10514	50-Year	98.00	60.20	65.24		65.27	0.001133	1.82	102.30	63.60	0.15
Reach 1	10514	100-Year	118.20	60.20	65.48		65.51	0.001199	1.94	117.84	67.67	0.16
Reach 1	10229	2-Year	58.10	59.87	63.14		63.17	0.001295	1.38	54.53	58.10	0.17
Reach 1	10229	10-Year	113.00	59.87	64.54		64.56	0.000457	1.16	161.82	91.94	0.11
Reach 1	10229	25-Year	150.50	59.87	64.86		64.88	0.000535	1.33	192.26	98.38	0.12
Reach 1	10229	50-Year	184.30	59.87	65.02		65.05	0.000663	1.52	208.03	101.55	0.14
Reach 1	10229	100-Year	222.10	59.87	65.23		65.26	0.000757	1.69	229.50	105.71	0.15
Reach 1	9819	2-Year	58.10	58.85	62.67		62.72	0.000913	1.92	36.78	33.44	0.20
Reach 1	9819	10-Year	113.00	58.85	64.36		64.39	0.000374	1.66	156.34	100.97	0.14
Reach 1	9819	25-Year	150.50	58.85	64.64		64.67	0.000476	1.95	185.46	109.12	0.16
Reach 1	9819	50-Year	184.30	58.85	64.72		64.78	0.000643	2.29	195.10	110.67	0.18
Reach 1	9819	100-Year	222.10	58.85	64.87		64.94	0.000781	2.58	212.06	112.66	0.20
Reach 1	9780	2-Year	44.60	58.85	62.59	60.63	62.67	0.001259	2.36	18.86	31.75	0.24
Reach 1	9780	10-Year	108.70	58.85	64.35	61.61	64.37	0.000351	1.61	155.00	100.54	0.13
Reach 1	9780	25-Year	149.20	58.85	64.62	62.12	64.66	0.000478	1.95	183.38	108.63	0.16
Reach 1	9780	50-Year	182.90	58.85	64.70	62.51	64.75	0.000654	2.31	192.12	110.68	0.18
Reach 1	9780	100-Year	220.40	58.85	64.84	62.91	64.91	0.000804	2.61	208.54	114.45	0.20
Reach 1	9749		Culvert									
Reach 1	9724	2-Year	44.60	56.43	59.34	57.50	59.37	0.000962	1.42	31.33	14.06	0.17
Reach 1	9724	10-Year	108.70	56.43	61.00	58.18	61.06	0.001060	1.89	57.37	17.26	0.18
Reach 1	9724	25-Year	149.20	56.43	61.65	58.53	61.73	0.001173	2.16	70.02	31.64	0.20
Reach 1	9724	50-Year	182.90	56.43	62.22	58.78	62.30	0.001087	2.28	84.95	58.05	0.19
Reach 1	9724	100-Year	220.40	56.43	63.01	59.05	63.09	0.000857	2.27	111.44	81.45	0.18

HEC-RAS Plan: Existing River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	9700	2-Year	44.60	56.43	59.33		59.35	0.000554	1.13	39.33	16.06	0.13
Reach 1	9700	10-Year	108.70	56.43	60.99		61.03	0.000694	1.60	68.11	18.57	0.15
Reach 1	9700	25-Year	149.20	56.43	61.64		61.69	0.000806	1.85	82.04	32.04	0.16
Reach 1	9700	50-Year	182.90	56.43	62.21		62.27	0.000755	1.95	108.79	58.48	0.16
Reach 1	9700	100-Year	220.40	56.43	63.01		63.06	0.000563	1.87	165.06	81.52	0.14
Reach 1	9352	2-Year	49.40	56.19	57.95	57.95	58.60	0.045981	6.45	7.66	5.98	1.00
Reach 1	9352	10-Year	135.20	56.19	59.51	59.40	60.17	0.020278	6.83	25.89	23.17	0.74
Reach 1	9352	25-Year	191.00	56.19	60.72		60.98	0.006329	4.90	67.33	45.24	0.44
Reach 1	9352	50-Year	234.20	56.19	61.66		61.78	0.002602	3.63	115.57	57.20	0.29
Reach 1	9352	100-Year	281.80	56.19	62.70		62.77	0.001220	2.84	181.60	69.14	0.21
Reach 1	9132	2-Year	50.10	53.29	57.23	54.95	57.27	0.001022	1.62	31.49	14.89	0.17
Reach 1	9132	10-Year	137.70	53.29	59.24	56.03	59.31	0.000946	2.25	81.37	34.61	0.18
Reach 1	9132	25-Year	188.80	53.29	60.49	56.51	60.55	0.000647	2.18	133.78	52.46	0.16
Reach 1	9132	50-Year	230.00	53.29	61.50	56.84	61.55	0.000438	1.98	195.62	72.20	0.13
Reach 1	9132	100-Year	270.90	53.29	62.61	57.14	62.64	0.000275	1.73	271.29	107.37	0.11
Reach 1	9068		Culvert									
Reach 1	8990	2-Year	50.10	53.70	56.93	55.43	57.01	0.003575	2.41	27.46	24.30	0.26
Reach 1	8990	10-Year	137.70	53.70	58.50	56.84	58.57	0.002337	2.66	85.31	48.95	0.23
Reach 1	8990	25-Year	188.80	53.70	59.05	57.26	59.12	0.002230	2.82	114.61	58.78	0.23
Reach 1	8990	50-Year	230.00	53.70	59.31	57.51	59.39	0.002423	3.04	130.82	63.47	0.24
Reach 1	8990	100-Year	270.90	53.70	59.54	57.73	59.62	0.002609	3.25	145.46	67.34	0.25
Reach 1	8900	2-Year	50.10	53.70	56.08		56.34	0.017498	4.11	12.67	10.67	0.54
Reach 1	8900	10-Year	137.70	53.70	58.14		58.27	0.004553	3.49	68.45	43.31	0.31
Reach 1	8900	25-Year	188.80	53.70	58.70		58.83	0.004159	3.66	95.42	52.55	0.31
Reach 1	8900	50-Year	230.00	53.70	58.92		59.07	0.004779	4.05	107.20	56.46	0.33
Reach 1	8900	100-Year	270.90	53.70	59.09		59.27	0.005434	4.42	117.23	59.58	0.36
Reach 1	8494	2-Year	79.30	49.30	53.29		53.43	0.004686	2.97	28.57	12.57	0.29
Reach 1	8494	10-Year	205.10	49.30	53.83	52.77	54.46	0.018196	6.46	36.11	16.60	0.58
Reach 1	8494	25-Year	285.30	49.30	54.31	54.31	55.05	0.019893	7.31	60.08	62.13	0.62
Reach 1	8494	50-Year	354.20	49.30	54.79	54.64	55.36	0.015789	6.98	91.58	71.41	0.56
Reach 1	8494	100-Year	427.70	49.30	55.22		55.68	0.012769	6.65	124.51	79.97	0.51

HEC-RAS Plan: Existing River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	8113	2-Year	79.30	47.11	49.53		49.89	0.025888	4.79	16.55	11.29	0.70
Reach 1	8113	10-Year	205.10	47.11	52.32		52.41	0.002274	2.82	128.97	77.42	0.24
Reach 1	8113	25-Year	285.30	47.11	52.97		53.05	0.002029	2.94	183.75	91.25	0.24
Reach 1	8113	50-Year	354.20	47.11	54.32		54.36	0.000841	2.23	326.62	123.13	0.16
Reach 1	8113	100-Year	427.70	47.11	54.60		54.65	0.000969	2.47	363.15	132.41	0.17
Reach 1	7695	2-Year	79.30	43.34	47.80	45.37	47.86	0.001796	2.14	44.02	20.77	0.20
Reach 1	7695	10-Year	205.10	43.34	52.14	46.65	52.15	0.000221	1.27	372.83	148.27	0.08
Reach 1	7695	25-Year	285.30	43.34	52.76	47.32	52.78	0.000263	1.45	474.61	178.37	0.09
Reach 1	7695	50-Year	354.20	43.34	54.21	47.81	54.22	0.000139	1.18	793.54	263.23	0.07
Reach 1	7695	100-Year	427.70	43.34	54.48	48.22	54.49	0.000168	1.31	865.74	277.66	0.07
Reach 1	7630		Culvert									
Reach 1	7545	2-Year	79.30	42.21	45.55	43.87	45.68	0.005639	2.97	27.58	16.11	0.31
Reach 1	7545	10-Year	205.10	42.21	46.93	45.17	47.17	0.007011	4.32	70.66	46.38	0.37
Reach 1	7545	25-Year	285.30	42.21	51.55	46.14	51.56	0.000183	1.15	526.44	152.88	0.07
Reach 1	7545	50-Year	354.20	42.21	54.21	46.66	54.21	0.000057	0.76	1036.78	236.84	0.04
Reach 1	7545	100-Year	427.70	42.21	54.46	47.04	54.46	0.000074	0.88	1096.80	249.69	0.05
Reach 1	7435	2-Year	76.90	42.65	44.69		44.79	0.012160	2.65	29.07	20.04	0.38
Reach 1	7435	10-Year	180.90	42.65	46.68		46.71	0.001687	1.68	169.62	113.46	0.16
Reach 1	7435	25-Year	278.60	42.65	51.54		51.54	0.000045	0.49	864.56	164.59	0.03
Reach 1	7435	50-Year	349.90	42.65	54.21		54.21	0.000023	0.43	1448.12	268.31	0.02
Reach 1	7435	100-Year	424.60	42.65	54.45		54.46	0.000031	0.50	1515.10	276.67	0.03
Reach 1	7020	2-Year	81.30	39.75	43.00		43.04	0.002164	1.57	69.16	57.70	0.17
Reach 1	7020	10-Year	196.50	39.75	46.53		46.53	0.000200	0.83	372.54	112.95	0.06
Reach 1	7020	25-Year	308.70	39.75	51.53		51.53	0.000027	0.45	1122.72	184.47	0.02
Reach 1	7020	50-Year	392.40	39.75	54.20		54.20	0.000015	0.39	1662.86	219.83	0.02
Reach 1	7020	100-Year	474.20	39.75	54.44		54.45	0.000021	0.46	1716.84	225.70	0.02
Reach 1	6880	2-Year	81.30	39.05	42.97		42.98	0.000136	0.48	174.17	60.57	0.05
Reach 1	6880	10-Year	196.50	39.05	46.51		46.52	0.000059	0.51	463.27	109.11	0.03
Reach 1	6880	25-Year	308.70	39.05	51.53		51.53	0.000014	0.36	1215.11	185.68	0.02
Reach 1	6880	50-Year	392.40	39.05	54.20		54.20	0.000009	0.33	1768.23	229.15	0.02
Reach 1	6880	100-Year	474.20	39.05	54.44		54.44	0.000012	0.39	1824.31	233.19	0.02

HEC-RAS Plan: Existing River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	6830	2-Year	81.30	38.85	42.97	39.66	42.97	0.000155	0.51	164.74	57.43	0.05
Reach 1	6830	10-Year	196.50	38.85	46.51	40.10	46.51	0.000067	0.53	413.99	116.18	0.04
Reach 1	6830	25-Year	308.70	38.85	51.52	40.44	51.53	0.000022	0.44	790.04	207.84	0.02
Reach 1	6830	50-Year	392.40	38.85	54.20	40.66	54.20	0.000009	0.33	1900.26	266.86	0.02
Reach 1	6830	100-Year	474.20	38.85	54.44	40.86	54.44	0.000013	0.39	1966.23	277.33	0.02
Reach 1	6795		Culvert									
Reach 1	6760	2-Year	81.20	36.05	38.35	37.51	38.58	0.012406	3.84	21.12	27.95	0.47
Reach 1	6760	10-Year	188.00	36.05	39.46	38.46	39.99	0.016243	5.83	32.24	43.46	0.57
Reach 1	6760	25-Year	242.10	36.05	39.53	38.87	40.37	0.025143	7.36	32.92	43.80	0.71
Reach 1	6760	50-Year	280.60	36.05	39.82	39.13	39.98	0.007821	3.12	91.44	45.33	0.37
Reach 1	6760	100-Year	326.50	36.05	40.03	39.45	40.20	0.007757	3.30	101.08	46.41	0.38
Reach 1	6690	2-Year	81.20	34.85	36.19	36.19	36.72	0.077015	5.83	13.92	13.37	1.01
Reach 1	6690	10-Year	188.00	34.85	36.99	36.99	37.84	0.068420	7.37	25.50	15.33	1.01
Reach 1	6690	25-Year	242.10	34.85	37.34	37.34	38.29	0.063889	7.84	31.16	19.14	0.99
Reach 1	6690	50-Year	280.60	34.85	37.60	37.60	38.57	0.055306	7.94	37.14	26.17	0.94
Reach 1	6690	100-Year	326.50	34.85	37.90	37.90	38.86	0.047393	7.99	46.04	34.16	0.89
Reach 1	6370	2-Year	81.20	28.65	32.07		32.12	0.002313	1.70	54.23	31.05	0.18
Reach 1	6370	10-Year	188.00	28.65	33.31		33.39	0.002995	2.45	95.41	34.70	0.21
Reach 1	6370	25-Year	242.10	28.65	33.89		33.99	0.002931	2.65	116.04	36.01	0.22
Reach 1	6370	50-Year	280.60	28.65	34.26		34.36	0.002924	2.79	129.42	36.83	0.22
Reach 1	6370	100-Year	326.50	28.65	34.63		34.75	0.002994	2.96	143.28	37.67	0.22
Reach 1	5305	2-Year	86.50	22.05	23.61	23.61	24.26	0.101048	6.48	13.34	10.34	1.01
Reach 1	5305	10-Year	202.20	22.05	25.85		26.23	0.022926	4.95	40.87	14.20	0.51
Reach 1	5305	25-Year	262.80	22.05	26.40		26.85	0.023566	5.37	48.98	15.15	0.53
Reach 1	5305	50-Year	304.20	22.05	26.76	25.31	27.25	0.023495	5.58	54.56	15.85	0.53
Reach 1	5305	100-Year	351.30	22.05	27.14	25.61	27.64	0.022167	5.73	69.55	80.52	0.52
Reach 1	5004	2-Year	86.50	16.20	23.59	19.39	23.62	0.000389	1.46	59.35	14.90	0.13
Reach 1	5004	10-Year	202.20	16.20	25.46	20.67	25.54	0.000690	2.24	90.35	20.10	0.18
Reach 1	5004	25-Year	262.80	16.20	25.87	21.17	25.98	0.000917	2.69	99.78	25.91	0.21
Reach 1	5004	50-Year	304.20	16.20	26.16	21.49	26.30	0.001025	2.93	109.08	40.60	0.22
Reach 1	5004	100-Year	351.30	16.20	26.49	21.82	26.65	0.001105	3.17	126.20	60.97	0.23

HEC-RAS Plan: Existing River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4962		Bridge									
Reach 1	4907	2-Year	86.50	18.98	23.48	20.96	23.55	0.001021	2.11	40.91	13.25	0.21
Reach 1	4907	10-Year	202.20	18.98	25.30	22.08	25.43	0.001237	2.94	77.85	50.97	0.24
Reach 1	4907	25-Year	262.80	18.98	25.65	22.55	25.83	0.001567	3.48	89.86	58.15	0.28
Reach 1	4907	50-Year	304.20	18.98	25.91	22.84	26.12	0.001699	3.75	99.87	66.68	0.29
Reach 1	4907	100-Year	351.30	18.98	26.21	23.14	26.44	0.001806	4.02	111.01	70.99	0.30
Reach 1	4720	2-Year	86.50	18.85	23.20		23.25	0.002670	1.79	48.30	15.00	0.18
Reach 1	4720	10-Year	202.20	18.85	24.95		25.05	0.003404	2.59	86.53	35.03	0.21
Reach 1	4720	25-Year	262.80	18.85	25.19		25.34	0.004751	3.17	95.69	41.33	0.25
Reach 1	4720	50-Year	304.20	18.85	25.41		25.58	0.005345	3.46	105.39	47.10	0.27
Reach 1	4720	100-Year	351.30	18.85	25.67		25.87	0.005800	3.72	118.46	53.91	0.28
Reach 1	4687	2-Year	113.30	18.32	23.17	20.12	23.23	0.000265	1.99	65.29	34.59	0.18
Reach 1	4687	10-Year	272.00	18.32	24.91	21.30	25.03	0.000349	2.91	167.00	78.19	0.21
Reach 1	4687	25-Year	365.60	18.32	25.12	21.86	25.30	0.000537	3.69	183.77	82.50	0.27
Reach 1	4687	50-Year	446.20	18.32	25.30	22.31	25.54	0.000702	4.30	198.41	86.08	0.31
Reach 1	4687	100-Year	533.00	18.32	25.51	22.86	25.81	0.000857	4.86	217.03	90.43	0.34
Reach 1	4348		Culvert									
Reach 1	3887	2-Year	113.30	15.25	17.92	17.47	17.98	0.003005	3.22	84.59	81.07	0.35
Reach 1	3887	10-Year	272.00	15.25	18.73	17.88	18.80	0.003001	3.61	158.90	81.88	0.34
Reach 1	3887	25-Year	365.60	15.25	19.14	18.01	19.22	0.003000	3.77	192.28	82.29	0.34
Reach 1	3887	50-Year	446.20	15.25	19.46	18.14	19.54	0.003001	3.89	218.40	82.61	0.33
Reach 1	3887	100-Year	533.00	15.25	19.77	18.26	19.86	0.003003	4.00	244.54	82.92	0.33

Meetinghouse Branch - Existing Conditions

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	14470	2-year	48.00	62.82	65.28		65.37	0.001945	2.47	19.40	10.67	0.32
Reach 1	14470	10-year	83.00	62.82	66.61		66.69	0.001114	2.37	35.01	12.78	0.25
Reach 1	14470	25-year	108.00	62.82	67.89		67.96	0.000603	2.05	54.01	26.33	0.19
Reach 1	14470	50-year	129.00	62.82	68.46		68.52	0.000520	2.05	83.78	64.13	0.18
Reach 1	14470	100-year	152.00	62.82	68.65		68.73	0.000606	2.26	96.71	69.19	0.19
Reach 1	13600	2-year	48.00	61.40	64.26		64.31	0.000812	1.80	26.71	12.51	0.22
Reach 1	13600	10-year	83.00	61.40	66.13		66.17	0.000357	1.54	53.92	16.58	0.15
Reach 1	13600	25-year	108.00	61.40	67.67		67.70	0.000169	1.25	119.88	62.18	0.11
Reach 1	13600	50-year	129.00	61.40	68.27		68.29	0.000150	1.27	203.21	256.56	0.10
Reach 1	13600	100-year	152.00	61.40	68.43		68.46	0.000173	1.40	247.97	283.05	0.11
Reach 1	13285	2-year	48.00	60.29	63.99		64.02	0.001018	1.49	32.18	14.02	0.17
Reach 1	13285	10-year	83.00	60.29	66.02		66.04	0.000437	1.25	66.34	19.61	0.12
Reach 1	13285	25-year	108.00	60.29	67.61		67.63	0.000235	1.07	103.38	38.42	0.09
Reach 1	13285	50-year	129.00	60.29	68.21		68.23	0.000205	1.07	183.95	254.95	0.09
Reach 1	13285	100-year	152.00	60.29	68.37		68.39	0.000239	1.18	227.83	301.84	0.09
Reach 1	13233	2-year	76.00	60.29	63.80	62.23	63.90	0.003183	2.56	29.64	13.52	0.31
Reach 1	13233	10-year	132.00	60.29	65.92	62.85	65.99	0.001189	2.04	64.55	19.36	0.20
Reach 1	13233	25-year	170.00	60.29	67.56	63.20	67.60	0.000606	1.70	101.29	36.79	0.15
Reach 1	13233	50-year	204.00	60.29	68.16	63.48	68.20	0.000543	1.72	167.90	238.97	0.14
Reach 1	13233	100-year	241.00	60.29	68.31	63.74	68.36	0.000648	1.92	203.36	282.45	0.15
Reach 1	13137 Charles Blvd		Culvert									
Reach 1	13045	2-year	76.00	59.31	63.53	61.28	63.61	0.001036	2.27	33.52	12.21	0.24
Reach 1	13045	10-year	132.00	59.31	64.97	61.98	65.06	0.000917	2.49	53.12	15.11	0.23
Reach 1	13045	25-year	170.00	59.31	65.90	62.37	66.00	0.000784	2.49	68.17	17.01	0.22
Reach 1	13045	50-year	204.00	59.31	66.46	62.68	66.57	0.000791	2.62	77.95	18.13	0.22
Reach 1	13045	100-year	241.00	59.31	66.95	62.99	67.06	0.000825	2.77	86.98	19.11	0.23
Reach 1	12995	2-year	76.00	59.31	63.47		63.56	0.001096	2.32	32.83	12.09	0.25
Reach 1	12995	10-year	132.00	59.31	64.92		65.02	0.000953	2.52	52.36	15.01	0.24
Reach 1	12995	25-year	170.00	59.31	65.86		65.96	0.000806	2.52	67.46	16.92	0.22
Reach 1	12995	50-year	204.00	59.31	66.42		66.53	0.000812	2.64	77.18	18.05	0.23
Reach 1	12995	100-year	241.00	59.31	66.90		67.02	0.000847	2.80	86.13	19.02	0.23
Reach 1	12695	2-year	76.00	58.30	63.20		63.24	0.000952	1.62	46.96	16.88	0.17
Reach 1	12695	10-year	132.00	58.30	64.69		64.74	0.000814	1.75	75.39	21.27	0.16
Reach 1	12695	25-year	170.00	58.30	65.68		65.73	0.000674	1.74	97.86	24.19	0.15

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	12695	50-year	204.00	58.30	66.24		66.29	0.000681	1.82	111.80	25.83	0.15
Reach 1	12695	100-year	241.00	58.30	66.71		66.77	0.000714	1.94	124.48	27.24	0.16
Reach 1	12280	2-year	146.00	58.35	61.80		62.07	0.006988	4.16	35.09	12.36	0.44
Reach 1	12280	10-year	259.00	58.35	63.38		63.71	0.006030	4.61	56.23	14.36	0.41
Reach 1	12280	25-year	339.00	58.35	64.61		64.91	0.004344	4.46	84.23	33.60	0.36
Reach 1	12280	50-year	408.00	58.35	65.14		65.47	0.004383	4.71	104.36	43.03	0.36
Reach 1	12280	100-year	484.00	58.35	65.54		65.91	0.004544	5.04	124.88	57.92	0.37
Reach 1	12225	2-year	146.00	55.91	61.76		61.84	0.001699	2.36	61.93	19.95	0.24
Reach 1	12225	10-year	259.00	55.91	63.39		63.49	0.001532	2.63	98.65	26.09	0.23
Reach 1	12225	25-year	339.00	55.91	64.65		64.75	0.001091	2.55	142.98	44.45	0.20
Reach 1	12225	50-year	408.00	55.91	65.18		65.29	0.001129	2.73	168.65	52.63	0.21
Reach 1	12225	100-year	484.00	55.91	65.59		65.72	0.001232	2.95	194.45	72.23	0.22
Reach 1	12070	2-year	146.00	56.84	61.47		61.56	0.001934	2.42	60.24	21.37	0.25
Reach 1	12070	10-year	259.00	56.84	63.16		63.26	0.001439	2.56	101.77	28.20	0.23
Reach 1	12070	25-year	339.00	56.84	64.49		64.58	0.000988	2.44	144.12	37.54	0.20
Reach 1	12070	50-year	408.00	56.84	65.02		65.12	0.001040	2.62	165.33	43.42	0.21
Reach 1	12070	100-year	484.00	56.84	65.41		65.54	0.001163	2.86	183.33	47.85	0.22
Reach 1	11775	2-year	146.00	57.05	61.05		61.11	0.001209	1.98	74.84	28.30	0.21
Reach 1	11775	10-year	259.00	57.05	62.90		62.96	0.000732	1.98	148.92	57.98	0.17
Reach 1	11775	25-year	339.00	57.05	64.35		64.39	0.000402	1.80	263.46	92.61	0.13
Reach 1	11775	50-year	408.00	57.05	64.87		64.92	0.000407	1.92	314.15	100.36	0.14
Reach 1	11775	100-year	484.00	57.05	65.25		65.31	0.000448	2.09	353.60	106.01	0.15
Reach 1	11500	2-year	146.00	55.23	60.76		60.82	0.000918	1.98	74.52	20.75	0.18
Reach 1	11500	10-year	259.00	55.23	62.66		62.74	0.000827	2.29	122.13	33.59	0.17
Reach 1	11500	25-year	339.00	55.23	64.19		64.26	0.000562	2.23	198.61	66.60	0.15
Reach 1	11500	50-year	408.00	55.23	64.70		64.78	0.000608	2.44	235.27	76.49	0.16
Reach 1	11500	100-year	484.00	55.23	65.05		65.16	0.000703	2.70	263.68	83.36	0.17
Reach 1	11380	2-year	146.00	56.65	60.54		60.65	0.002210	2.64	58.43	25.23	0.27
Reach 1	11380	10-year	259.00	56.65	62.53		62.62	0.001080	2.54	140.41	67.46	0.21
Reach 1	11380	25-year	339.00	56.65	64.13		64.19	0.000558	2.22	279.51	123.97	0.16
Reach 1	11380	50-year	408.00	56.65	64.64		64.71	0.000552	2.33	347.86	140.57	0.16
Reach 1	11380	100-year	484.00	56.65	65.00		65.07	0.000605	2.52	399.46	151.63	0.17
Reach 1	11180	2-year	146.00	56.05	60.07		60.18	0.002459	2.71	53.84	18.79	0.28
Reach 1	11180	10-year	259.00	56.05	62.31		62.41	0.001032	2.57	126.21	51.66	0.20

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	11180	25-year	339.00	56.05	64.01		64.08	0.000540	2.25	255.94	100.67	0.15
Reach 1	11180	50-year	408.00	56.05	64.52		64.59	0.000578	2.45	317.36	142.61	0.16
Reach 1	11180	100-year	484.00	56.05	64.85		64.94	0.000657	2.69	369.91	171.01	0.17
Reach 1	11130	2-year	146.00	54.75	59.97	57.27	60.08	0.001737	2.77	64.15	28.48	0.24
Reach 1	11130	10-year	259.00	54.75	62.26	58.21	62.36	0.000952	2.75	155.93	54.99	0.19
Reach 1	11130	25-year	339.00	54.75	63.98	58.75	64.05	0.000565	2.48	280.36	89.73	0.15
Reach 1	11130	50-year	408.00	54.75	64.48	59.19	64.56	0.000644	2.75	332.56	121.56	0.16
Reach 1	11130	100-year	484.00	54.75	64.80	59.65	64.90	0.000772	3.09	375.22	151.36	0.18
Reach 1	11075 Tucker Dr		Culvert									
Reach 1	11000	2-year	146.00	54.41	59.49	56.71	59.59	0.001494	2.79	74.32	30.71	0.23
Reach 1	11000	10-year	259.00	54.41	60.64	57.66	60.81	0.001889	3.63	110.46	39.79	0.27
Reach 1	11000	25-year	339.00	54.41	61.24	58.23	61.45	0.002153	4.14	130.63	44.52	0.29
Reach 1	11000	50-year	408.00	54.41	61.68	58.68	61.94	0.002388	4.56	146.45	50.08	0.31
Reach 1	11000	100-year	484.00	54.41	62.14	59.11	62.43	0.002582	4.95	186.20	59.42	0.32
Reach 1	10940	2-year	146.00	54.41	59.38		59.50	0.001640	2.87	71.22	29.89	0.24
Reach 1	10940	10-year	259.00	54.41	60.49		60.68	0.002122	3.79	109.39	38.67	0.28
Reach 1	10940	25-year	339.00	54.41	61.08		61.31	0.002407	4.31	133.25	43.26	0.30
Reach 1	10940	50-year	408.00	54.41	61.51		61.78	0.002630	4.71	152.89	47.54	0.32
Reach 1	10940	100-year	484.00	54.41	61.94		62.26	0.002893	5.15	174.76	55.41	0.34
Reach 1	10670	2-year	146.00	52.63	58.97		59.05	0.001587	2.44	75.31	38.07	0.21
Reach 1	10670	10-year	259.00	52.63	59.97		60.10	0.002030	3.15	123.22	60.73	0.25
Reach 1	10670	25-year	339.00	52.63	60.51		60.67	0.002191	3.51	158.57	69.99	0.26
Reach 1	10670	50-year	408.00	52.63	60.92		61.10	0.002267	3.75	188.91	76.61	0.27
Reach 1	10670	100-year	484.00	52.63	61.34		61.52	0.002317	3.96	222.04	83.26	0.28
Reach 1	10500	2-year	184.00	55.05	58.59		58.71	0.002391	2.89	71.61	37.34	0.30
Reach 1	10500	10-year	329.00	55.05	59.48		59.69	0.002821	3.75	110.45	49.41	0.34
Reach 1	10500	25-year	430.00	55.05	59.97		60.21	0.003034	4.21	136.13	56.76	0.36
Reach 1	10500	50-year	519.00	55.05	60.34		60.62	0.003168	4.55	158.47	62.45	0.37
Reach 1	10500	100-year	617.00	55.05	60.73		61.04	0.003246	4.86	183.59	68.29	0.38
Reach 1	10250	2-year	184.00	54.45	57.08		57.46	0.014913	4.99	36.90	22.80	0.68
Reach 1	10250	10-year	329.00	54.45	58.26		58.58	0.007791	4.68	83.20	48.18	0.52
Reach 1	10250	25-year	430.00	54.45	58.88		59.18	0.005996	4.61	114.43	53.47	0.47
Reach 1	10250	50-year	519.00	54.45	59.34		59.63	0.005088	4.68	140.08	58.55	0.45
Reach 1	10250	100-year	617.00	54.45	59.78		60.09	0.004518	4.79	167.37	63.51	0.43

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	10125	2-year	184.00	52.75	56.83		56.93	0.001583	2.53	84.04	42.96	0.24
Reach 1	10125	10-year	329.00	52.75	58.01		58.14	0.001600	3.09	144.89	59.97	0.25
Reach 1	10125	25-year	430.00	52.75	58.63		58.78	0.001627	3.38	184.60	68.81	0.26
Reach 1	10125	50-year	519.00	52.75	59.09		59.26	0.001674	3.63	218.19	78.67	0.27
Reach 1	10125	100-year	617.00	52.75	59.54		59.72	0.001707	3.85	256.59	91.32	0.27
Reach 1	10000	2-year	184.00	52.55	56.64		56.73	0.001524	2.49	87.49	42.89	0.23
Reach 1	10000	10-year	329.00	52.55	57.82		57.94	0.001557	3.05	146.11	57.09	0.25
Reach 1	10000	25-year	430.00	52.55	58.43		58.58	0.001607	3.36	183.28	64.72	0.26
Reach 1	10000	50-year	519.00	52.55	58.88		59.05	0.001659	3.61	213.96	70.63	0.26
Reach 1	10000	100-year	617.00	52.55	59.32		59.51	0.001732	3.87	247.03	79.44	0.27
Reach 1	9930	2-year	184.00	51.47	56.58		56.64	0.000966	2.04	101.80	52.18	0.19
Reach 1	9930	10-year	329.00	51.47	57.76		57.85	0.000997	2.51	175.81	72.99	0.20
Reach 1	9930	25-year	430.00	51.47	58.37		58.47	0.001025	2.76	223.82	83.62	0.21
Reach 1	9930	50-year	519.00	51.47	58.83		58.94	0.001052	2.96	263.73	91.38	0.22
Reach 1	9930	100-year	617.00	51.47	59.27		59.39	0.001078	3.14	306.04	99.07	0.22
Reach 1	9745	2-year	184.00	52.15	56.35		56.43	0.001313	2.36	105.00	59.18	0.22
Reach 1	9745	10-year	329.00	52.15	57.52		57.63	0.001340	2.87	189.36	87.89	0.23
Reach 1	9745	25-year	430.00	52.15	58.13		58.25	0.001367	3.14	248.17	105.80	0.24
Reach 1	9745	50-year	519.00	52.15	58.58		58.72	0.001390	3.34	299.02	119.14	0.24
Reach 1	9745	100-year	617.00	52.15	59.02		59.17	0.001415	3.54	354.54	134.48	0.25
Reach 1	9400	2-year	184.00	51.45	56.02		56.07	0.000816	1.98	148.66	88.05	0.17
Reach 1	9400	10-year	329.00	51.45	57.20		57.26	0.000823	2.35	272.63	126.19	0.18
Reach 1	9400	25-year	430.00	51.45	57.80		57.87	0.000839	2.56	357.07	152.82	0.19
Reach 1	9400	50-year	519.00	51.45	58.25		58.33	0.000841	2.69	430.56	170.90	0.19
Reach 1	9400	100-year	617.00	51.45	58.70		58.77	0.000840	2.82	510.05	188.31	0.19
Reach 1	9050	2-year	302.00	50.85	55.52		55.63	0.001732	2.93	177.75	93.43	0.25
Reach 1	9050	10-year	552.00	50.85	56.64		56.78	0.001971	3.66	294.25	115.72	0.28
Reach 1	9050	25-year	729.00	50.85	57.19		57.37	0.002172	4.11	361.00	125.91	0.30
Reach 1	9050	50-year	884.00	50.85	57.60		57.80	0.002322	4.45	414.66	133.16	0.31
Reach 1	9050	100-year	1054.00	50.85	58.01		58.23	0.002467	4.78	469.89	140.23	0.33
Reach 1	8965	2-year	302.00	50.65	55.35		55.47	0.001892	3.04	166.54	94.06	0.26
Reach 1	8965	10-year	552.00	50.65	56.44		56.61	0.002151	3.78	278.67	111.51	0.29
Reach 1	8965	25-year	729.00	50.65	56.97		57.17	0.002414	4.27	339.59	120.83	0.31
Reach 1	8965	50-year	884.00	50.65	57.36		57.59	0.002627	4.66	388.78	130.05	0.33

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	8965	100-year	1054.00	50.65	57.75		58.00	0.002827	5.03	440.35	139.05	0.35
Reach 1	8885	2-year	302.00	49.71	54.90		55.21	0.005535	4.69	94.66	80.11	0.40
Reach 1	8885	10-year	552.00	49.71	55.98		56.33	0.005480	5.45	214.38	136.74	0.42
Reach 1	8885	25-year	729.00	49.71	56.55		56.88	0.005213	5.69	296.08	153.36	0.42
Reach 1	8885	50-year	884.00	49.71	56.97		57.29	0.005049	5.86	363.26	165.73	0.41
Reach 1	8885	100-year	1054.00	49.71	57.38		57.70	0.004899	6.03	434.13	177.70	0.41
Reach 1	8750	2-year	294.00	49.95	54.70		54.80	0.001505	2.74	193.84	133.33	0.23
Reach 1	8750	10-year	549.00	49.95	55.77		55.89	0.001678	3.33	346.98	153.01	0.25
Reach 1	8750	25-year	725.00	49.95	56.30		56.43	0.001801	3.67	431.30	162.84	0.26
Reach 1	8750	50-year	880.00	49.95	56.70		56.85	0.001903	3.94	497.61	169.66	0.27
Reach 1	8750	100-year	1049.00	49.95	57.09		57.25	0.001992	4.19	565.64	176.32	0.28
Reach 1	8469	2-year	294.00	47.54	54.38		54.45	0.001001	2.49	239.26	119.17	0.19
Reach 1	8469	10-year	549.00	47.54	55.34		55.45	0.001458	3.36	361.82	136.39	0.24
Reach 1	8469	25-year	725.00	47.54	55.80		55.94	0.001755	3.87	426.80	144.69	0.26
Reach 1	8469	50-year	880.00	47.54	56.14		56.30	0.002004	4.27	476.59	150.46	0.28
Reach 1	8469	100-year	1049.00	47.54	56.47		56.66	0.002236	4.65	528.05	155.89	0.30
Reach 1	7993	2-year	294.00	46.71	54.12		54.15	0.000410	1.78	431.58	192.41	0.12
Reach 1	7993	10-year	549.00	46.71	54.93		54.97	0.000684	2.49	593.71	209.87	0.16
Reach 1	7993	25-year	725.00	46.71	55.28		55.34	0.000894	2.94	668.57	216.80	0.19
Reach 1	7993	50-year	880.00	46.71	55.51		55.59	0.001098	3.32	719.63	221.34	0.21
Reach 1	7993	100-year	1049.00	46.71	55.74		55.83	0.001312	3.70	771.22	225.84	0.23
Reach 1	7943	2-year	294.00	46.71	54.10	49.99	54.13	0.000420	1.80	427.34	191.93	0.13
Reach 1	7943	10-year	549.00	46.71	54.89	51.54	54.94	0.000706	2.52	585.82	209.05	0.17
Reach 1	7943	25-year	725.00	46.71	55.23	52.37	55.29	0.000930	2.98	657.73	215.83	0.19
Reach 1	7943	50-year	880.00	46.71	55.45	52.86	55.53	0.001152	3.38	705.69	220.11	0.21
Reach 1	7943	100-year	1049.00	46.71	55.66	53.31	55.76	0.001388	3.78	753.98	224.35	0.24
Reach 1	7897 14th St		Culvert									
Reach 1	7843	2-year	294.00	45.75	52.02	48.68	52.10	0.001207	2.61	258.55	205.12	0.19
Reach 1	7843	10-year	549.00	45.75	52.90	49.87	53.00	0.001506	3.21	456.07	242.05	0.22
Reach 1	7843	25-year	725.00	45.75	53.35	50.84	53.45	0.001631	3.49	568.74	257.88	0.23
Reach 1	7843	50-year	880.00	45.75	53.70	51.30	53.80	0.001714	3.69	660.03	270.03	0.24
Reach 1	7843	100-year	1049.00	45.75	54.04	52.23	54.14	0.001786	3.89	752.68	281.06	0.25
Reach 1	7788	2-year	294.00	45.75	51.95		52.03	0.001305	2.68	243.28	190.52	0.20

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	7788	10-year	549.00	45.75	52.80		52.91	0.001691	3.36	431.17	238.41	0.23
Reach 1	7788	25-year	725.00	45.75	53.24		53.36	0.001826	3.65	540.51	254.01	0.25
Reach 1	7788	50-year	880.00	45.75	53.58		53.70	0.001912	3.86	629.27	266.00	0.25
Reach 1	7788	100-year	1049.00	45.75	53.92		54.04	0.001988	4.06	719.52	277.19	0.26
Reach 1	7522	2-year	294.00	45.77	51.55		51.60	0.001987	2.49	279.93	179.49	0.21
Reach 1	7522	10-year	549.00	45.77	52.29		52.35	0.002526	3.10	419.40	198.77	0.24
Reach 1	7522	25-year	725.00	45.77	52.68		52.76	0.002780	3.42	499.67	208.45	0.25
Reach 1	7522	50-year	880.00	45.77	52.99		53.07	0.002951	3.65	565.02	215.99	0.26
Reach 1	7522	100-year	1049.00	45.77	53.29		53.38	0.003116	3.87	631.09	223.35	0.27
Reach 1	7281	2-year	294.00	45.67	50.70		50.85	0.005526	3.79	192.63	236.52	0.35
Reach 1	7281	10-year	549.00	45.67	51.44		51.55	0.004499	3.87	383.91	274.57	0.32
Reach 1	7281	25-year	725.00	45.67	51.85		51.95	0.004141	3.93	499.44	295.19	0.32
Reach 1	7281	50-year	880.00	45.67	52.17		52.26	0.003864	3.96	595.97	307.04	0.31
Reach 1	7281	100-year	1049.00	45.67	52.48		52.57	0.003693	4.03	691.43	316.97	0.30
Reach 1	7088	2-year	294.00	44.73	49.90		50.00	0.003468	3.21	212.14	174.95	0.29
Reach 1	7088	10-year	549.00	44.73	50.64		50.75	0.003882	3.81	350.08	194.34	0.31
Reach 1	7088	25-year	725.00	44.73	51.04		51.16	0.004056	4.12	428.95	202.96	0.32
Reach 1	7088	50-year	880.00	44.73	51.38		51.50	0.004042	4.29	498.67	210.28	0.33
Reach 1	7088	100-year	1049.00	44.73	51.67		51.80	0.004180	4.53	562.52	216.76	0.34
Reach 1	6769	2-year	294.00	43.69	47.44	47.44	47.94	0.014672	6.47	98.23	130.33	0.74
Reach 1	6769	10-year	549.00	43.69	48.07	48.07	48.59	0.014022	7.40	202.09	195.49	0.75
Reach 1	6769	25-year	725.00	43.69	48.33	48.33	48.88	0.014914	8.05	252.56	201.45	0.79
Reach 1	6769	50-year	880.00	43.69	48.46	48.46	49.11	0.017159	8.88	280.59	204.62	0.85
Reach 1	6769	100-year	1049.00	43.69	48.65	48.65	49.33	0.017807	9.38	319.38	208.92	0.87
Reach 1	6315	2-year	294.00	36.65	41.13		41.29	0.002878	3.22	91.22	29.67	0.32
Reach 1	6315	10-year	549.00	36.65	42.73		42.96	0.002873	3.82	143.87	35.95	0.34
Reach 1	6315	25-year	725.00	36.65	43.50		43.78	0.002988	4.20	173.67	45.74	0.35
Reach 1	6315	50-year	880.00	36.65	44.03		44.35	0.003116	4.54	201.82	61.95	0.36
Reach 1	6315	100-year	1049.00	36.65	44.52		44.89	0.003249	4.86	242.85	101.26	0.37
Reach 1	6004	2-year	294.00	34.68	40.06		40.27	0.003706	3.68	79.87	24.55	0.36
Reach 1	6004	10-year	549.00	34.68	41.57		41.89	0.004117	4.53	124.81	39.93	0.39
Reach 1	6004	25-year	725.00	34.68	42.24		42.63	0.004493	5.07	154.23	47.94	0.42
Reach 1	6004	50-year	880.00	34.68	42.71		43.17	0.004619	5.48	192.15	89.30	0.43
Reach 1	6004	100-year	1049.00	34.68	43.17		43.67	0.004672	5.85	235.35	100.09	0.44

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	5630	2-year	294.00	33.32	38.94		39.11	0.002606	3.23	91.17	27.06	0.31
Reach 1	5630	10-year	549.00	33.32	40.40		40.64	0.002675	4.02	178.28	111.43	0.33
Reach 1	5630	25-year	725.00	33.32	41.09		41.35	0.002590	4.33	262.15	133.37	0.33
Reach 1	5630	50-year	880.00	33.32	41.59		41.87	0.002537	4.55	333.44	149.52	0.33
Reach 1	5630	100-year	1049.00	33.32	42.10		42.38	0.002437	4.71	413.82	164.83	0.33
Reach 1	5260	2-year	294.00	31.95	38.05		38.17	0.002333	2.84	140.43	100.04	0.25
Reach 1	5260	10-year	549.00	31.95	39.78		39.87	0.001467	2.85	378.65	173.08	0.21
Reach 1	5260	25-year	725.00	31.95	40.52		40.61	0.001382	3.00	518.07	209.84	0.21
Reach 1	5260	50-year	880.00	31.95	41.05		41.14	0.001336	3.10	636.62	235.69	0.21
Reach 1	5260	100-year	1049.00	31.95	41.60		41.69	0.001260	3.17	773.16	262.31	0.20
Reach 1	4765	2-year	294.00	30.39	36.84		36.97	0.002514	3.02	117.74	48.68	0.25
Reach 1	4765	10-year	549.00	30.39	39.00		39.12	0.001583	3.10	304.17	115.54	0.21
Reach 1	4765	25-year	725.00	30.39	39.72		39.86	0.001670	3.41	394.40	135.12	0.22
Reach 1	4765	50-year	880.00	30.39	40.23		40.38	0.001781	3.68	466.82	153.26	0.23
Reach 1	4765	100-year	1049.00	30.39	40.78		40.94	0.001811	3.89	558.57	178.37	0.24
Reach 1	4230	2-year	294.00	28.77	34.28		34.40	0.002900	3.07	154.11	125.34	0.27
Reach 1	4230	10-year	549.00	28.77	35.96		36.03	0.001606	2.73	433.40	234.72	0.21
Reach 1	4230	25-year	725.00	28.77	36.96		37.01	0.000983	2.39	702.11	280.21	0.17
Reach 1	4230	50-year	880.00	28.77	37.85		37.89	0.000667	2.15	961.54	301.58	0.14
Reach 1	4230	100-year	1049.00	28.77	38.89		38.91	0.000441	1.90	1282.52	319.66	0.12
Reach 1	3840	2-year	294.00	26.71	33.75		33.81	0.000883	1.99	200.30	78.02	0.15
Reach 1	3840	10-year	549.00	26.71	35.52		35.58	0.000842	2.35	394.58	128.13	0.16
Reach 1	3840	25-year	725.00	26.71	36.61		36.67	0.000739	2.43	546.14	148.60	0.15
Reach 1	3840	50-year	880.00	26.71	37.57		37.63	0.000634	2.42	696.83	165.55	0.14
Reach 1	3840	100-year	1049.00	26.71	38.67		38.72	0.000513	2.35	888.98	183.04	0.13
Reach 1	3610	2-year	294.00	27.30	33.34		33.56	0.001145	3.80	92.82	29.15	0.29
Reach 1	3610	10-year	549.00	27.30	34.93		35.30	0.001453	5.11	183.08	81.14	0.34
Reach 1	3610	25-year	725.00	27.30	36.05		36.42	0.001288	5.32	292.57	114.50	0.33
Reach 1	3610	50-year	880.00	27.30	37.09		37.42	0.001062	5.24	432.81	157.64	0.31
Reach 1	3610	100-year	1049.00	27.30	38.31		38.56	0.000772	4.87	657.45	208.85	0.27
Reach 1	3507	2-year	309.00	27.30	33.16	30.49	33.42	0.001437	4.15	87.53	27.99	0.33
Reach 1	3507	10-year	583.00	27.30	34.62	31.86	35.10	0.001985	5.78	147.70	71.76	0.40
Reach 1	3507	25-year	772.00	27.30	35.69	32.68	36.22	0.001882	6.23	199.05	103.50	0.40
Reach 1	3507	50-year	937.00	27.30	36.68	33.32	37.22	0.001686	6.41	246.72	140.26	0.39
Reach 1	3507	100-year	1119.00	27.30	38.14	34.29	38.45	0.000963	5.38	623.36	202.97	0.30

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	3490 King George Rd		Bridge									
Reach 1	3401	2-year	309.00	27.65	32.83	30.91	33.17	0.002447	4.76	78.87	38.81	0.42
Reach 1	3401	10-year	583.00	27.65	33.97	32.36	34.59	0.003386	6.61	141.37	70.22	0.51
Reach 1	3401	25-year	772.00	27.65	34.68	33.22	35.38	0.003402	7.22	194.65	82.86	0.52
Reach 1	3401	50-year	937.00	27.65	35.28	33.92	36.01	0.003263	7.54	240.25	93.40	0.52
Reach 1	3401	100-year	1119.00	27.65	35.91	34.55	36.67	0.003125	7.85	297.27	103.15	0.52
Reach 1	3280	2-year	322.00	26.55	32.77		32.90	0.000855	3.33	240.44	122.65	0.26
Reach 1	3280	10-year	619.00	26.55	33.97		34.16	0.001123	4.39	404.11	151.13	0.31
Reach 1	3280	25-year	828.00	26.55	34.71		34.92	0.001149	4.78	521.73	165.16	0.32
Reach 1	3280	50-year	1013.00	26.55	35.33		35.54	0.001141	5.04	627.01	178.40	0.32
Reach 1	3280	100-year	1217.00	26.55	35.97		36.19	0.001106	5.23	747.22	192.42	0.32
Reach 1	2850	2-year	327.00	26.15	32.35		32.52	0.000883	3.35	105.44	27.18	0.26
Reach 1	2850	10-year	635.00	26.15	32.98		33.47	0.002195	5.71	123.34	29.77	0.42
Reach 1	2850	25-year	854.00	26.15	33.31		34.08	0.003252	7.21	133.19	31.10	0.52
Reach 1	2850	50-year	1048.00	26.15	33.52		34.59	0.004314	8.50	139.92	31.98	0.60
Reach 1	2850	100-year	1263.00	26.15	33.68		35.14	0.005699	9.94	145.20	32.66	0.69
Reach 1	2590	2-year	327.00	25.38	32.38		32.40	0.000159	1.54	438.00	204.51	0.12
Reach 1	2590	10-year	635.00	25.38	33.14		33.18	0.000273	2.21	602.74	226.78	0.16
Reach 1	2590	25-year	854.00	25.38	33.62		33.67	0.000320	2.52	714.88	240.76	0.17
Reach 1	2590	50-year	1048.00	25.38	34.01		34.06	0.000349	2.73	810.94	252.12	0.18
Reach 1	2590	100-year	1263.00	25.38	34.41		34.47	0.000376	2.95	914.87	267.27	0.19
Reach 1	2280	2-year	327.00	24.65	32.32		32.35	0.000123	1.58	366.73	122.27	0.11
Reach 1	2280	10-year	635.00	24.65	33.01		33.08	0.000293	2.61	458.04	145.18	0.17
Reach 1	2280	25-year	854.00	24.65	33.45		33.55	0.000391	3.14	524.08	155.38	0.20
Reach 1	2280	50-year	1048.00	24.65	33.81		33.93	0.000462	3.51	581.10	162.28	0.22
Reach 1	2280	100-year	1263.00	24.65	34.18		34.32	0.000528	3.87	642.76	169.50	0.23
Reach 1	2145	2-year	327.00	23.85	32.24		32.32	0.000416	2.29	146.28	42.85	0.18
Reach 1	2145	10-year	635.00	23.85	32.76		33.00	0.001086	3.96	181.93	93.61	0.30
Reach 1	2145	25-year	854.00	23.85	33.06		33.43	0.001577	4.95	214.59	122.92	0.36
Reach 1	2145	50-year	1048.00	23.85	33.31		33.78	0.001956	5.67	247.25	134.00	0.41
Reach 1	2145	100-year	1263.00	23.85	33.58		34.15	0.002288	6.31	284.37	138.24	0.45
Reach 1	2045	2-year	327.00	23.25	32.22	26.80	32.26	0.000375	1.67	195.74	61.99	0.17
Reach 1	2045	10-year	635.00	23.25	32.71	27.94	32.83	0.001053	2.75	231.66	82.06	0.28

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	2045	25-year	854.00	23.25	33.01	28.61	33.18	0.001422	3.36	257.39	93.25	0.33
Reach 1	2045	50-year	1048.00	23.25	33.25	29.15	33.48	0.001704	3.83	281.14	102.50	0.36
Reach 1	2045	100-year	1263.00	23.25	33.52	29.69	33.80	0.001952	4.26	309.60	112.58	0.39
Reach 1	2037 Railroad Crossin		Bridge									
Reach 1	1970	2-year	327.00	23.05	32.19	26.60	32.23	0.000356	1.58	207.14	69.19	0.16
Reach 1	1970	10-year	635.00	23.05	32.64	27.75	32.74	0.000931	2.64	241.01	85.51	0.26
Reach 1	1970	25-year	854.00	23.05	32.89	28.41	33.06	0.001313	3.27	261.61	94.32	0.32
Reach 1	1970	50-year	1048.00	23.05	33.11	28.95	33.33	0.001632	3.78	278.64	101.51	0.36
Reach 1	1970	100-year	1263.00	23.05	33.33	29.49	33.62	0.001951	4.27	297.11	109.21	0.39
Reach 1	1890	2-year	326.00	23.05	32.19		32.21	0.000066	1.23	387.34	128.09	0.08
Reach 1	1890	10-year	633.00	23.05	32.63		32.69	0.000191	2.17	446.05	138.48	0.13
Reach 1	1890	25-year	851.00	23.05	32.89		32.98	0.000297	2.76	482.12	144.40	0.17
Reach 1	1890	50-year	1045.00	23.05	33.09		33.23	0.000397	3.24	512.58	149.22	0.20
Reach 1	1890	100-year	1259.00	23.05	33.32		33.49	0.000508	3.73	546.46	154.40	0.22
Reach 1	1727	2-year	326.00	26.56	32.18		32.20	0.000096	1.14	303.10	105.94	0.09
Reach 1	1727	10-year	633.00	26.56	32.59		32.65	0.000271	2.01	348.26	110.98	0.16
Reach 1	1727	25-year	851.00	26.56	32.83		32.93	0.000424	2.55	374.59	114.68	0.20
Reach 1	1727	50-year	1045.00	26.56	33.01		33.15	0.000573	3.01	396.13	117.79	0.23
Reach 1	1727	100-year	1259.00	26.56	33.21		33.39	0.000741	3.46	419.75	121.10	0.26
Reach 1	1590	2-year	326.00	26.53	32.18	27.35	32.19	0.000021	0.57	609.56	159.29	0.04
Reach 1	1590	10-year	633.00	26.53	32.61	27.76	32.63	0.000059	1.02	679.43	166.93	0.08
Reach 1	1590	25-year	851.00	26.53	32.85	28.00	32.88	0.000092	1.31	720.68	170.89	0.10
Reach 1	1590	50-year	1045.00	26.53	33.05	28.21	33.09	0.000124	1.55	754.48	174.06	0.11
Reach 1	1590	100-year	1259.00	26.53	33.26	28.41	33.31	0.000159	1.79	791.44	177.47	0.13
Reach 1	100		Inl Struct									
Reach 1	-50	2-year	326.00	17.55	22.76		22.78	0.000578	1.85	301.93	83.61	0.14
Reach 1	-50	10-year	633.00	17.55	24.94		24.96	0.000469	1.96	520.06	154.94	0.13
Reach 1	-50	25-year	851.00	17.55	25.96		25.99	0.000446	2.08	716.63	228.01	0.13
Reach 1	-50	50-year	1045.00	17.55	26.78		26.81	0.000405	2.11	927.38	286.34	0.12
Reach 1	-50	100-year	1259.00	17.55	27.51		27.54	0.000378	2.14	1154.96	338.21	0.12
Reach 1	-172	2-year	326.00	13.25	22.76		22.77	0.000014	0.67	610.83	164.84	0.04
Reach 1	-172	10-year	633.00	13.25	24.93		24.94	0.000019	0.93	1117.74	317.15	0.05
Reach 1	-172	25-year	851.00	13.25	25.95		25.97	0.000022	1.07	1483.86	391.60	0.06

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	-172	50-year	1045.00	13.25	26.77		26.79	0.000024	1.16	1819.23	429.01	0.06
Reach 1	-172	100-year	1259.00	13.25	27.50		27.51	0.000026	1.26	2142.59	461.88	0.06
Reach 1	-267	2-year	326.00	13.25	22.76	15.73	22.76	0.000015	0.69	493.59	122.53	0.04
Reach 1	-267	10-year	633.00	13.25	24.92	16.45	24.94	0.000023	1.03	653.80	209.96	0.06
Reach 1	-267	25-year	851.00	13.25	25.94	16.84	25.96	0.000030	1.24	729.19	313.00	0.07
Reach 1	-267	50-year	1045.00	13.25	26.75	17.16	26.78	0.000035	1.41	789.22	357.11	0.07
Reach 1	-267	100-year	1259.00	13.25	27.47	17.48	27.51	0.000042	1.60	842.39	396.18	0.08
Reach 1	-332		Culvert									
Reach 1	-347	2-year	326.00	16.55	22.66	19.39	22.74	0.002583	2.33	154.09	53.93	0.19
Reach 1	-347	10-year	633.00	16.55	24.71	20.61	24.78	0.001842	2.53	407.91	186.10	0.18
Reach 1	-347	25-year	851.00	16.55	25.54	21.14	25.62	0.001700	2.64	584.57	239.59	0.17
Reach 1	-347	50-year	1045.00	16.55	26.15	21.60	26.22	0.001616	2.71	743.19	284.95	0.17
Reach 1	-347	100-year	1259.00	16.55	26.75	22.11	26.82	0.001502	2.74	928.31	330.09	0.17
Reach 1	-532	2-year	508.00	15.15	22.00		22.15	0.003580	3.17	187.56	50.86	0.24
Reach 1	-532	10-year	1143.00	15.15	23.91		24.15	0.004703	4.41	409.43	154.65	0.28
Reach 1	-532	25-year	1570.00	15.15	24.71		24.97	0.005046	4.88	535.92	162.86	0.30
Reach 1	-532	50-year	1935.00	15.15	25.28		25.57	0.005294	5.23	631.03	170.06	0.31
Reach 1	-532	100-year	2351.00	15.15	25.84		26.16	0.005620	5.61	729.83	181.48	0.32
Reach 1	-2127	2-year	508.00	12.35	17.38		17.43	0.002747	2.41	365.43	162.67	0.21
Reach 1	-2127	10-year	1143.00	12.35	19.13		19.20	0.002508	2.91	674.28	189.61	0.21
Reach 1	-2127	25-year	1570.00	12.35	20.17		20.24	0.002241	3.06	880.16	205.61	0.20
Reach 1	-2127	50-year	1935.00	12.35	21.05		21.12	0.001981	3.12	1080.03	256.10	0.20
Reach 1	-2127	100-year	2351.00	12.35	22.12		22.19	0.001609	3.06	1386.72	310.37	0.18
Reach 1	-3322	2-year	508.00	8.65	14.31		14.36	0.002405	2.46	379.91	143.98	0.19
Reach 1	-3322	10-year	1143.00	8.65	16.70		16.75	0.001702	2.68	750.28	165.98	0.17
Reach 1	-3322	25-year	1570.00	8.65	18.02		18.07	0.001500	2.81	976.48	177.89	0.17
Reach 1	-3322	50-year	1935.00	8.65	19.15		19.20	0.001325	2.86	1184.88	190.24	0.16
Reach 1	-3322	100-year	2351.00	8.65	20.57		20.62	0.001078	2.83	1467.31	205.81	0.15
Reach 1	-3552	2-year	508.00	7.25	13.30		13.49	0.006316	4.20	180.18	56.28	0.32
Reach 1	-3552	10-year	1143.00	7.25	15.66		15.99	0.007676	5.88	338.31	94.02	0.37
Reach 1	-3552	25-year	1570.00	7.25	17.05		17.39	0.007002	6.27	515.50	160.22	0.36
Reach 1	-3552	50-year	1935.00	7.25	18.44		18.67	0.004532	5.54	781.90	223.00	0.30
Reach 1	-3552	100-year	2351.00	7.25	20.13		20.26	0.002472	4.52	1220.34	294.12	0.23

HEC-RAS Plan: Existing River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	-3604	2-year	508.00	7.05	12.68	10.70	13.09	0.006700	5.14	98.76	26.98	0.47
Reach 1	-3604	10-year	1143.00	7.05	14.45	12.87	15.36	0.010318	7.63	149.79	29.00	0.59
Reach 1	-3604	25-year	1570.00	7.05	15.51	13.77	16.69	0.011280	8.70	180.36	29.00	0.62
Reach 1	-3604	50-year	1935.00	7.05	16.82	14.43	18.04	0.009879	8.86	218.30	29.00	0.57
Reach 1	-3604	100-year	2351.00	7.05	19.62	15.15	20.03	0.002941	5.82	563.06	246.43	0.32
Reach 1	-3617		Bridge									
Reach 1	-3630	2-year	484.00	7.05	12.40	10.62	12.83	0.007397	5.30	91.34	25.77	0.50
Reach 1	-3630	10-year	1124.00	7.05	13.63	12.82	14.87	0.016812	8.94	125.78	29.00	0.76
Reach 1	-3630	25-year	1552.00	7.05	14.08	13.76	16.02	0.023743	11.16	139.03	29.00	0.90
Reach 1	-3630	50-year	1914.00	7.05	14.42	14.42	16.99	0.029467	12.86	148.87	29.00	1.00
Reach 1	-3630	100-year	2331.00	7.05	15.14	15.14	18.07	0.029730	13.74	169.66	29.00	1.00
Reach 1	-3682	2-year	484.00	7.05	12.10	10.42	12.31	0.008593	3.96	161.48	88.38	0.36
Reach 1	-3682	10-year	1124.00	7.05	13.24	12.13	13.68	0.014039	6.06	282.03	123.09	0.49
Reach 1	-3682	25-year	1552.00	7.05	13.76	12.81	14.33	0.016685	7.07	350.39	141.20	0.54
Reach 1	-3682	50-year	1914.00	7.05	14.12	13.24	14.79	0.018553	7.79	403.69	153.84	0.57
Reach 1	-3682	100-year	2331.00	7.05	14.48	13.68	15.25	0.020348	8.50	462.10	166.60	0.61
Reach 1	-3897	2-year	484.00	6.75	10.43	9.65	10.48	0.008007	2.84	334.26	291.71	0.32
Reach 1	-3897	10-year	1124.00	6.75	11.27	10.18	11.34	0.008004	3.39	610.30	347.39	0.33
Reach 1	-3897	25-year	1552.00	6.75	11.69	10.46	11.78	0.008011	3.68	759.10	355.54	0.34
Reach 1	-3897	50-year	1914.00	6.75	12.01	10.62	12.11	0.008003	3.89	873.39	361.67	0.34
Reach 1	-3897	100-year	2331.00	6.75	12.35	10.78	12.45	0.008004	4.10	995.36	368.10	0.35

PRIMARY SYSTEM ALTERNATIVE #1: HEC-RAS OUTPUT

Bells Branch - Alternative #1

HEC-RAS Plan: Alt #1 River: Bells Branch Reach: Reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	11194	2-Year	30.00	62.20	64.84		64.89	0.002733	1.81	19.44	15.37	0.23
Reach 1	11194	10-Year	59.00	62.20	65.64		65.70	0.002476	2.15	43.66	46.20	0.23
Reach 1	11194	25-Year	80.00	62.20	66.00		66.06	0.002366	2.28	63.24	60.78	0.23
Reach 1	11194	50-Year	98.00	62.20	66.26		66.32	0.002272	2.36	80.22	71.04	0.22
Reach 1	11194	100-Year	118.00	62.20	66.51		66.57	0.002157	2.41	99.48	81.12	0.22
Reach 1	10514	2-Year	30.00	60.20	63.45		63.49	0.001597	1.52	24.95	23.27	0.17
Reach 1	10514	10-Year	59.00	60.20	64.21		64.25	0.001824	1.93	48.87	40.46	0.19
Reach 1	10514	25-Year	80.00	60.20	64.61		64.66	0.001819	2.08	66.88	49.19	0.19
Reach 1	10514	50-Year	98.00	60.20	64.93		64.98	0.001713	2.14	83.89	56.12	0.19
Reach 1	10514	100-Year	118.00	60.20	65.25		65.30	0.001620	2.19	103.00	63.88	0.18
Reach 1	10229	2-Year	58.00	59.87	62.91		62.95	0.002079	1.62	41.98	47.10	0.21
Reach 1	10229	10-Year	113.00	59.87	63.74		63.78	0.001569	1.80	94.56	74.96	0.20
Reach 1	10229	25-Year	151.00	59.87	64.19		64.23	0.001356	1.86	130.39	84.77	0.19
Reach 1	10229	50-Year	184.00	59.87	64.55		64.59	0.001194	1.88	162.76	92.14	0.18
Reach 1	10229	100-Year	222.00	59.87	64.90		64.94	0.001119	1.94	195.46	99.03	0.18
Reach 1	9819	2-Year	58.00	58.85	61.56		61.71	0.004615	3.15	18.53	10.49	0.41
Reach 1	9819	10-Year	113.00	58.85	62.56		62.80	0.003970	3.91	33.43	31.28	0.41
Reach 1	9819	25-Year	151.00	58.85	63.22		63.43	0.002904	3.84	63.89	60.97	0.36
Reach 1	9819	50-Year	184.00	58.85	63.81		63.96	0.001986	3.52	105.71	82.40	0.31
Reach 1	9819	100-Year	222.00	58.85	64.24		64.37	0.001672	3.46	144.44	97.11	0.29
Reach 1	9780	2-Year	58.00	58.85	61.19	60.69	61.43	0.009600	3.99	14.53	10.20	0.57
Reach 1	9780	10-Year	112.00	58.85	62.28	61.30	62.59	0.005803	4.47	25.19	15.06	0.49
Reach 1	9780	25-Year	145.00	58.85	62.91	61.59	63.25	0.004688	4.65	31.65	49.59	0.46
Reach 1	9780	50-Year	170.00	58.85	63.47	61.81	63.80	0.003778	4.63	37.76	70.00	0.42
Reach 1	9780	100-Year	192.00	58.85	64.19	61.99	64.30	0.001321	3.05	140.20	95.70	0.25
Reach 1	9749		Culvert									
Reach 1	9724	2-Year	58.00	56.43	59.95	57.66	59.98	0.000803	1.44	40.29	15.24	0.16
Reach 1	9724	10-Year	112.00	56.43	61.11	58.21	61.17	0.001031	1.89	59.23	17.46	0.18
Reach 1	9724	25-Year	145.00	56.43	61.56	58.49	61.63	0.001205	2.16	67.77	26.49	0.20
Reach 1	9724	50-Year	170.00	56.43	61.90	58.69	61.98	0.001224	2.30	76.00	45.90	0.20
Reach 1	9724	100-Year	192.00	56.43	62.26	58.85	62.34	0.001163	2.37	85.70	59.22	0.20

HEC-RAS Plan: Alt #1 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	9700	2-Year	58.00	56.43	59.94		59.96	0.000486	1.17	49.46	16.99	0.12
Reach 1	9700	10-Year	112.00	56.43	61.10		61.14	0.000679	1.60	70.11	18.73	0.15
Reach 1	9700	25-Year	145.00	56.43	61.54		61.60	0.000821	1.84	79.21	27.02	0.16
Reach 1	9700	50-Year	170.00	56.43	61.89		61.95	0.000852	1.98	91.79	46.11	0.17
Reach 1	9700	100-Year	192.00	56.43	62.25		62.31	0.000806	2.03	111.06	59.61	0.16
Reach 1	9352	2-Year	75.00	56.19	58.39	58.39	59.19	0.044943	7.19	10.43	6.63	1.01
Reach 1	9352	10-Year	143.00	56.19	59.50	59.49	60.24	0.022985	7.26	25.70	23.04	0.79
Reach 1	9352	25-Year	186.00	56.19	60.39		60.78	0.009635	5.70	53.42	39.37	0.53
Reach 1	9352	50-Year	216.00	56.19	61.08		61.29	0.004782	4.52	84.52	49.94	0.39
Reach 1	9352	100-Year	242.00	56.19	61.67		61.80	0.002753	3.74	116.01	57.29	0.30
Reach 1	9132	2-Year	75.00	53.29	57.87	55.31	57.93	0.001087	1.93	43.06	21.17	0.18
Reach 1	9132	10-Year	143.00	53.29	59.20	56.08	59.27	0.001063	2.37	79.77	34.16	0.19
Reach 1	9132	25-Year	185.00	53.29	60.11	56.47	60.18	0.000826	2.35	115.20	44.54	0.17
Reach 1	9132	50-Year	214.00	53.29	60.85	56.71	60.91	0.000635	2.24	153.86	59.47	0.16
Reach 1	9132	100-Year	238.00	53.29	61.50	56.90	61.55	0.000470	2.06	195.37	72.12	0.14
Reach 1	9068		Culvert									
Reach 1	8990	2-Year	75.00	53.70	57.49	55.87	57.57	0.003096	2.55	43.57	33.31	0.25
Reach 1	8990	10-Year	143.00	53.70	58.36	56.89	58.45	0.003019	2.96	78.72	46.45	0.26
Reach 1	8990	25-Year	185.00	53.70	58.75	57.23	58.84	0.003084	3.17	97.89	53.39	0.27
Reach 1	8990	50-Year	214.00	53.70	58.98	57.42	59.08	0.003113	3.30	110.60	57.54	0.27
Reach 1	8990	100-Year	238.00	53.70	59.15	57.56	59.25	0.003124	3.38	120.96	60.70	0.27
Reach 1	8945.*	2-Year	75.00	53.70	57.27		57.39	0.004632	2.97	36.80	29.86	0.30
Reach 1	8945.*	10-Year	143.00	53.70	58.15		58.28	0.004475	3.47	69.03	43.48	0.31
Reach 1	8945.*	25-Year	185.00	53.70	58.53		58.66	0.004527	3.72	86.54	49.40	0.32
Reach 1	8945.*	50-Year	214.00	53.70	58.75		58.89	0.004585	3.87	98.09	53.46	0.32
Reach 1	8945.*	100-Year	238.00	53.70	58.93		59.07	0.004603	3.98	107.62	56.59	0.33
Reach 1	8900	2-Year	75.00	53.70	56.86		57.07	0.009562	3.86	25.79	23.17	0.43
Reach 1	8900	10-Year	143.00	53.70	57.74		57.97	0.008663	4.48	52.30	37.30	0.43
Reach 1	8900	25-Year	185.00	53.70	58.12		58.36	0.008433	4.74	67.65	43.07	0.43
Reach 1	8900	50-Year	214.00	53.70	58.34		58.59	0.008299	4.88	77.78	46.08	0.43
Reach 1	8900	100-Year	238.00	53.70	58.51		58.77	0.008328	5.03	85.77	49.12	0.43

HEC-RAS Plan: Alt #1 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	8764.66*	2-Year	75.00	52.23	55.45		55.69	0.010741	4.02	20.83	14.58	0.44
Reach 1	8764.66*	10-Year	143.00	52.23	56.49		56.77	0.009004	4.63	46.27	34.30	0.43
Reach 1	8764.66*	25-Year	185.00	52.23	56.90		57.19	0.008814	4.92	61.67	41.80	0.43
Reach 1	8764.66*	50-Year	214.00	52.23	57.13		57.43	0.008759	5.09	72.12	46.77	0.44
Reach 1	8764.66*	100-Year	238.00	52.23	57.32		57.62	0.008632	5.20	81.03	50.63	0.44
Reach 1	8629.33*	2-Year	75.00	50.77	54.36		54.53	0.006823	3.38	24.06	12.73	0.35
Reach 1	8629.33*	10-Year	143.00	50.77	55.55		55.77	0.006002	3.99	53.23	40.90	0.35
Reach 1	8629.33*	25-Year	185.00	50.77	55.97		56.19	0.006006	4.26	72.62	52.07	0.35
Reach 1	8629.33*	50-Year	214.00	50.77	56.24		56.46	0.005710	4.33	87.93	58.98	0.35
Reach 1	8629.33*	100-Year	238.00	50.77	56.49		56.69	0.005239	4.28	103.17	65.22	0.34
Reach 1	8494	2-Year	103.00	49.30	53.29		53.52	0.007924	3.86	28.54	12.56	0.37
Reach 1	8494	10-Year	207.00	49.30	54.51		54.80	0.007961	4.76	72.58	65.97	0.39
Reach 1	8494	25-Year	281.00	49.30	55.01		55.27	0.007311	4.89	108.00	75.80	0.38
Reach 1	8494	50-Year	340.00	49.30	55.38		55.62	0.006539	4.85	137.81	83.18	0.37
Reach 1	8494	100-Year	398.00	49.30	55.65		55.88	0.006437	4.97	160.72	88.43	0.37
Reach 1	8367.*	2-Year	103.00	48.57	52.35		52.55	0.007190	3.69	29.75	14.27	0.38
Reach 1	8367.*	10-Year	207.00	48.57	53.42		53.76	0.008407	4.90	61.16	49.14	0.43
Reach 1	8367.*	25-Year	281.00	48.57	53.93		54.28	0.008344	5.28	89.78	65.09	0.44
Reach 1	8367.*	50-Year	340.00	48.57	54.69		54.90	0.004913	4.49	148.70	90.18	0.34
Reach 1	8367.*	100-Year	398.00	48.57	54.97		55.17	0.004821	4.61	174.73	96.23	0.34
Reach 1	8240.*	2-Year	103.00	47.84	51.49		51.67	0.006587	3.50	31.78	19.39	0.38
Reach 1	8240.*	10-Year	207.00	47.84	52.41		52.71	0.007988	4.69	64.34	50.94	0.43
Reach 1	8240.*	25-Year	281.00	47.84	53.11		53.36	0.005920	4.55	106.64	69.00	0.39
Reach 1	8240.*	50-Year	340.00	47.84	54.38		54.48	0.002073	3.19	213.68	100.38	0.24
Reach 1	8240.*	100-Year	398.00	47.84	54.64		54.75	0.002185	3.38	240.92	107.12	0.25
Reach 1	8113	2-Year	103.00	47.11	49.96		50.31	0.019776	4.77	21.80	13.43	0.63
Reach 1	8113	10-Year	207.00	47.11	51.41		51.68	0.008148	4.53	68.13	55.30	0.44
Reach 1	8113	25-Year	281.00	47.11	52.74		52.84	0.002547	3.19	163.72	86.58	0.26
Reach 1	8113	50-Year	340.00	47.11	54.26		54.30	0.000809	2.18	320.36	121.50	0.16
Reach 1	8113	100-Year	398.00	47.11	54.51		54.56	0.000901	2.36	351.67	129.56	0.17
Reach 1	7695	2-Year	103.00	43.34	48.33	45.65	48.41	0.001789	2.34	56.23	26.77	0.20
Reach 1	7695	10-Year	207.00	43.34	50.77	46.67	50.82	0.000764	2.08	159.57	98.63	0.14

HEC-RAS Plan: Alt #1 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	7695	25-Year	281.00	43.34	52.50	47.29	52.51	0.000314	1.56	428.68	165.46	0.10
Reach 1	7695	50-Year	340.00	43.34	54.17	47.71	54.18	0.000133	1.14	781.33	260.71	0.06
Reach 1	7695	100-Year	398.00	43.34	54.40	48.08	54.41	0.000153	1.25	844.27	273.45	0.07
Reach 1	7630		Culvert									
Reach 1	7545	2-Year	103.00	42.21	45.87	44.16	46.05	0.006360	3.40	34.00	23.27	0.34
Reach 1	7545	10-Year	207.00	42.21	47.71	45.19	47.82	0.002898	3.11	113.66	63.56	0.25
Reach 1	7545	25-Year	281.00	42.21	51.19	46.10	51.20	0.000229	1.25	473.38	144.43	0.08
Reach 1	7545	50-Year	340.00	42.21	54.16	46.57	54.16	0.000054	0.74	1025.26	234.29	0.04
Reach 1	7545	100-Year	398.00	42.21	54.40	46.89	54.40	0.000066	0.83	1081.59	246.49	0.04
Reach 1	7435	2-Year	102.00	42.65	44.80		44.96	0.017243	3.27	31.48	23.99	0.45
Reach 1	7435	10-Year	203.00	42.65	47.64		47.65	0.000558	1.14	284.03	126.50	0.10
Reach 1	7435	25-Year	271.00	42.65	51.18		51.19	0.000052	0.51	806.13	162.08	0.03
Reach 1	7435	50-Year	336.00	42.65	54.16		54.16	0.000022	0.41	1435.09	266.65	0.02
Reach 1	7435	100-Year	397.00	42.65	54.39		54.39	0.000028	0.47	1498.31	274.60	0.02
Reach 1	7020	2-Year	112.00	39.75	43.95		43.97	0.000913	1.25	132.39	73.83	0.11
Reach 1	7020	10-Year	227.00	39.75	47.55		47.56	0.000126	0.73	496.40	128.55	0.05
Reach 1	7020	25-Year	303.00	39.75	51.17		51.17	0.000030	0.47	1057.23	179.71	0.03
Reach 1	7020	50-Year	377.00	39.75	54.15		54.15	0.000014	0.38	1652.27	219.19	0.02
Reach 1	7020	100-Year	449.00	39.75	54.38		54.39	0.000019	0.44	1703.38	223.21	0.02
Reach 1	6880	2-Year	112.00	39.05	43.93		43.93	0.000108	0.50	236.77	70.47	0.04
Reach 1	6880	10-Year	227.00	39.05	47.54		47.55	0.000045	0.49	584.78	127.11	0.03
Reach 1	6880	25-Year	303.00	39.05	51.17		51.17	0.000016	0.37	1149.14	180.88	0.02
Reach 1	6880	50-Year	377.00	39.05	54.15		54.15	0.000009	0.32	1757.22	228.34	0.01
Reach 1	6880	100-Year	449.00	39.05	54.38		54.38	0.000011	0.37	1810.41	232.19	0.02
Reach 1	6830	2-Year	112.00	38.85	43.92	39.79	43.93	0.000128	0.53	224.68	69.50	0.05
Reach 1	6830	10-Year	227.00	38.85	47.54	40.20	47.54	0.000053	0.52	491.19	134.76	0.03
Reach 1	6830	25-Year	303.00	38.85	51.16	40.42	51.17	0.000023	0.44	763.03	201.19	0.02
Reach 1	6830	50-Year	377.00	38.85	54.15	40.62	54.15	0.000009	0.32	1887.47	264.78	0.01
Reach 1	6830	100-Year	449.00	38.85	54.38	40.80	54.38	0.000012	0.37	1949.75	274.75	0.02
Reach 1	6795		Culvert									

HEC-RAS Plan: Alt #1 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	6760	2-Year	111.00	36.05	38.72	37.80	39.03	0.013553	4.47	24.81	32.83	0.50
Reach 1	6760	10-Year	205.00	36.05	39.60	38.59	40.18	0.016804	6.10	33.62	44.16	0.59
Reach 1	6760	25-Year	253.00	36.05	39.66	38.95	40.51	0.023973	7.38	34.28	44.51	0.70
Reach 1	6760	50-Year	285.00	36.05	39.85	39.17	40.00	0.007813	3.14	92.39	45.44	0.37
Reach 1	6760	100-Year	323.00	36.05	40.02	39.43	40.19	0.007759	3.29	100.37	46.34	0.38
Reach 1	6690	2-Year	111.00	34.85	36.44	36.44	37.07	0.073542	6.38	17.41	13.99	1.01
Reach 1	6690	10-Year	205.00	34.85	37.10	37.10	37.99	0.067841	7.55	27.15	15.59	1.01
Reach 1	6690	25-Year	253.00	34.85	37.41	37.41	38.37	0.061728	7.89	32.61	20.97	0.98
Reach 1	6690	50-Year	285.00	34.85	37.63	37.63	38.60	0.054337	7.94	37.95	27.00	0.94
Reach 1	6690	100-Year	323.00	34.85	37.87	37.87	38.84	0.047878	7.99	45.33	33.59	0.90
Reach 1	6370	2-Year	111.00	28.65	32.59		32.64	0.002251	1.87	71.03	33.08	0.18
Reach 1	6370	10-Year	205.00	28.65	33.61		33.69	0.002682	2.44	106.04	35.38	0.20
Reach 1	6370	25-Year	253.00	28.65	34.04		34.13	0.002834	2.66	121.35	36.34	0.21
Reach 1	6370	50-Year	285.00	28.65	34.32		34.42	0.002887	2.79	131.50	36.96	0.22
Reach 1	6370	100-Year	323.00	28.65	34.64		34.75	0.002908	2.92	143.67	37.69	0.22
Reach 1	5305	2-Year	123.00	22.05	23.97	23.97	24.76	0.097547	7.16	17.19	10.96	1.01
Reach 1	5305	10-Year	224.00	22.05	25.55		26.13	0.037803	6.10	36.73	13.69	0.66
Reach 1	5305	25-Year	272.00	22.05	26.20		26.75	0.029988	5.91	45.99	14.80	0.59
Reach 1	5305	50-Year	304.00	22.05	26.56		27.10	0.027698	5.92	51.36	15.42	0.57
Reach 1	5305	100-Year	345.00	22.05	26.93	25.57	27.50	0.026199	6.03	57.31	17.15	0.56
Reach 1	5004	2-Year	123.00	16.20	23.37	19.85	23.44	0.000917	2.19	56.04	14.51	0.20
Reach 1	5004	10-Year	224.00	16.20	24.81	20.85	24.93	0.001226	2.84	78.81	17.02	0.23
Reach 1	5004	25-Year	272.00	16.20	25.43	21.25	25.58	0.001266	3.03	89.90	19.78	0.24
Reach 1	5004	50-Year	304.00	16.20	25.78	21.49	25.93	0.001291	3.16	97.57	24.68	0.24
Reach 1	5004	100-Year	345.00	16.20	26.12	21.78	26.30	0.001355	3.36	107.38	37.51	0.25
Reach 1	4962		Bridge									
Reach 1	4907	2-Year	123.00	18.98	23.07	21.37	23.25	0.003024	3.46	35.55	12.56	0.36
Reach 1	4907	10-Year	224.00	18.98	24.45	22.26	24.71	0.003134	4.11	54.68	18.66	0.38
Reach 1	4907	25-Year	272.00	18.98	25.10	22.62	25.37	0.002643	4.17	71.74	47.10	0.35
Reach 1	4907	50-Year	304.00	18.98	25.44	22.84	25.72	0.002470	4.25	82.79	53.93	0.35
Reach 1	4907	100-Year	345.00	18.98	25.76	23.10	26.06	0.002459	4.43	94.26	61.95	0.35

HEC-RAS Plan: Alt #1 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4720	2-Year	123.00	18.85	21.24	20.81	21.72	0.048483	5.58	22.04	11.73	0.72
Reach 1	4720	10-Year	224.00	18.85	23.18		23.52	0.018215	4.67	48.00	14.97	0.46
Reach 1	4720	25-Year	272.00	18.85	24.17		24.45	0.011794	4.28	64.58	21.96	0.38
Reach 1	4720	50-Year	304.00	18.85	24.61		24.88	0.010170	4.26	75.70	28.67	0.36
Reach 1	4720	100-Year	345.00	18.85	24.93		25.23	0.010085	4.45	85.77	34.45	0.36
Reach 1	4687	2-Year	134.00	18.32	20.30	20.30	21.10	0.009612	7.19	18.64	11.54	1.00
Reach 1	4687	10-Year	281.00	18.32	22.95	21.36	23.38	0.001982	5.25	58.36	29.46	0.48
Reach 1	4687	25-Year	377.00	18.32	23.93	21.93	24.34	0.001497	5.30	96.27	57.35	0.43
Reach 1	4687	50-Year	456.00	18.32	24.29	22.35	24.77	0.001624	5.80	122.35	65.51	0.45
Reach 1	4687	100-Year	539.00	18.32	24.52	22.89	25.10	0.001874	6.42	138.02	70.13	0.49
Reach 1	4348		Culvert									
Reach 1	3887	2-Year	134.00	15.25	18.01	17.54	18.06	0.002994	3.26	99.48	81.16	0.35
Reach 1	3887	10-Year	281.00	15.25	18.78	17.90	18.84	0.003000	3.63	162.29	81.93	0.34
Reach 1	3887	25-Year	377.00	15.25	19.19	18.03	19.26	0.003000	3.79	196.10	82.34	0.34
Reach 1	3887	50-Year	456.00	15.25	19.49	18.15	19.58	0.003001	3.90	221.45	82.64	0.33
Reach 1	3887	100-Year	539.00	15.25	19.79	18.27	19.88	0.003003	4.00	246.29	82.94	0.33

Meetinghouse Branch - Alternative #1

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	14470	2-year	48.00	62.82	65.27		65.37	0.001956	2.48	19.36	10.66	0.32
Reach 1	14470	10-year	83.00	62.82	66.58		66.67	0.001148	2.40	34.63	12.73	0.26
Reach 1	14470	25-year	108.00	62.82	67.77		67.84	0.000669	2.12	51.21	19.59	0.20
Reach 1	14470	50-year	129.00	62.82	68.45		68.51	0.000524	2.05	83.25	63.91	0.18
Reach 1	14470	100-year	152.00	62.82	68.65		68.72	0.000609	2.26	96.39	69.07	0.19
Reach 1	13600	2-year	48.00	61.40	64.26		64.31	0.000815	1.80	26.68	12.50	0.22
Reach 1	13600	10-year	83.00	61.40	66.09		66.12	0.000372	1.56	53.12	16.48	0.15
Reach 1	13600	25-year	108.00	61.40	67.52		67.54	0.000192	1.31	110.54	60.05	0.11
Reach 1	13600	50-year	129.00	61.40	68.25		68.28	0.000152	1.28	200.49	254.86	0.10
Reach 1	13600	100-year	152.00	61.40	68.43		68.45	0.000174	1.40	246.26	282.09	0.11
Reach 1	13285	2-year	48.00	60.29	63.98		64.02	0.001021	1.49	32.14	14.01	0.17
Reach 1	13285	10-year	83.00	60.29	65.96		65.99	0.000456	1.27	65.29	19.47	0.12
Reach 1	13285	25-year	108.00	60.29	67.45		67.47	0.000264	1.11	97.69	30.74	0.10
Reach 1	13285	50-year	129.00	60.29	68.20		68.22	0.000208	1.07	181.09	251.60	0.09
Reach 1	13285	100-year	152.00	60.29	68.36		68.38	0.000241	1.18	225.88	299.91	0.09
Reach 1	13233	2-year	76.00	60.29	63.80	62.23	63.90	0.003198	2.57	29.59	13.51	0.31
Reach 1	13233	10-year	132.00	60.29	65.87	62.85	65.93	0.001246	2.08	63.45	19.20	0.20
Reach 1	13233	25-year	170.00	60.29	67.39	63.20	67.44	0.000684	1.77	95.95	26.25	0.15
Reach 1	13233	50-year	204.00	60.29	68.15	63.48	68.19	0.000549	1.73	165.26	235.44	0.14
Reach 1	13233	100-year	241.00	60.29	68.30	63.74	68.35	0.000653	1.93	201.54	280.38	0.15
Reach 1	13137 Charles Blvd		Culvert									
Reach 1	13045	2-year	76.00	59.31	63.53	61.28	63.61	0.001040	2.27	33.48	12.20	0.24
Reach 1	13045	10-year	132.00	59.31	64.91	61.98	65.01	0.000956	2.52	52.29	15.00	0.24
Reach 1	13045	25-year	170.00	59.31	65.74	62.37	65.85	0.000874	2.60	65.44	16.68	0.23
Reach 1	13045	50-year	204.00	59.31	66.39	62.68	66.50	0.000828	2.66	76.60	17.98	0.23
Reach 1	13045	100-year	241.00	59.31	66.90	62.99	67.02	0.000847	2.80	86.13	19.02	0.23
Reach 1	12995	2-year	76.00	59.31	63.47		63.55	0.001100	2.32	32.78	12.09	0.25
Reach 1	12995	10-year	132.00	59.31	64.86		64.96	0.000995	2.56	51.51	14.89	0.24
Reach 1	12995	25-year	170.00	59.31	65.69		65.80	0.000903	2.63	64.65	16.58	0.23
Reach 1	12995	50-year	204.00	59.31	66.34		66.45	0.000852	2.69	75.80	17.89	0.23
Reach 1	12995	100-year	241.00	59.31	66.85		66.98	0.000870	2.83	85.26	18.93	0.23
Reach 1	12695	2-year	76.00	58.30	63.19		63.24	0.000957	1.62	46.87	16.87	0.17
Reach 1	12695	10-year	132.00	58.30	64.62		64.67	0.000858	1.79	73.92	21.07	0.17
Reach 1	12695	25-year	170.00	58.30	65.49		65.54	0.000766	1.82	93.25	23.62	0.16

HEC-RAS Plan: Alternative #1   River: Meeting House   Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	12695	50-year	204.00	58.30	66.15		66.20	0.000718	1.86	109.57	25.57	0.16
Reach 1	12695	100-year	241.00	58.30	66.66		66.72	0.000736	1.96	123.06	27.08	0.16
Reach 1	12280	2-year	146.00	58.35	61.77		62.04	0.007182	4.20	34.74	12.32	0.44
Reach 1	12280	10-year	259.00	58.35	63.19		63.55	0.006905	4.84	53.50	14.11	0.44
Reach 1	12280	25-year	339.00	58.35	64.15		64.53	0.005990	5.00	70.61	25.31	0.42
Reach 1	12280	50-year	408.00	58.35	64.93		65.30	0.005043	4.96	95.94	39.36	0.39
Reach 1	12280	100-year	484.00	58.35	65.41		65.80	0.005042	5.22	117.22	52.77	0.39
Reach 1	12225	2-year	146.00	55.91	61.73		61.81	0.001743	2.38	61.34	19.86	0.24
Reach 1	12225	10-year	259.00	55.91	63.19		63.31	0.001771	2.76	93.67	24.41	0.25
Reach 1	12225	25-year	339.00	55.91	64.18		64.31	0.001482	2.84	124.03	37.64	0.23
Reach 1	12225	50-year	408.00	55.91	64.98		65.10	0.001278	2.85	158.54	49.19	0.22
Reach 1	12225	100-year	484.00	55.91	65.46		65.60	0.001338	3.04	185.20	65.88	0.23
Reach 1	12070	2-year	146.00	56.84	61.43		61.53	0.002009	2.46	59.39	21.23	0.26
Reach 1	12070	10-year	259.00	56.84	62.92		63.04	0.001739	2.73	95.06	27.09	0.25
Reach 1	12070	25-year	339.00	56.84	63.97		64.09	0.001382	2.74	126.06	31.89	0.23
Reach 1	12070	50-year	408.00	56.84	64.79		64.91	0.001188	2.75	155.96	40.93	0.22
Reach 1	12070	100-year	484.00	56.84	65.26		65.39	0.001268	2.95	176.28	46.17	0.23
Reach 1	11775	2-year	146.00	57.05	60.98		61.05	0.001293	2.03	73.01	27.90	0.21
Reach 1	11775	10-year	259.00	57.05	62.57		62.64	0.000976	2.16	132.03	46.65	0.20
Reach 1	11775	25-year	339.00	57.05	63.74		63.81	0.000631	2.08	210.07	83.59	0.16
Reach 1	11775	50-year	408.00	57.05	64.62		64.68	0.000481	2.03	289.55	96.66	0.15
Reach 1	11775	100-year	484.00	57.05	65.09		65.15	0.000498	2.17	335.96	103.52	0.15
Reach 1	11500	2-year	146.00	55.23	60.68		60.74	0.000980	2.02	72.79	20.44	0.18
Reach 1	11500	10-year	259.00	55.23	62.27		62.36	0.001047	2.48	110.24	28.25	0.19
Reach 1	11500	25-year	339.00	55.23	63.51		63.60	0.000838	2.54	158.10	51.84	0.18
Reach 1	11500	50-year	408.00	55.23	64.42		64.52	0.000711	2.57	214.73	71.12	0.17
Reach 1	11500	100-year	484.00	55.23	64.86		64.98	0.000780	2.80	248.22	79.70	0.18
Reach 1	11380	2-year	146.00	56.65	60.44		60.55	0.002490	2.74	55.79	24.58	0.29
Reach 1	11380	10-year	259.00	56.65	62.08		62.21	0.001587	2.88	112.45	57.77	0.25
Reach 1	11380	25-year	339.00	56.65	63.40		63.50	0.000916	2.62	207.47	86.40	0.20
Reach 1	11380	50-year	408.00	56.65	64.35		64.43	0.000685	2.52	307.84	131.14	0.17
Reach 1	11380	100-year	484.00	56.65	64.79		64.88	0.000697	2.66	369.66	145.34	0.18
Reach 1	11180	2-year	146.00	56.05	59.88		60.01	0.002953	2.90	50.36	18.28	0.31
Reach 1	11180	10-year	259.00	56.05	61.76		61.89	0.001571	2.94	101.88	38.80	0.24

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	11180	25-year	339.00	56.05	63.20		63.31	0.000935	2.72	184.06	77.66	0.20
Reach 1	11180	50-year	408.00	56.05	64.20		64.29	0.000703	2.62	276.03	115.99	0.17
Reach 1	11180	100-year	484.00	56.05	64.63		64.73	0.000758	2.83	333.98	152.16	0.18
Reach 1	11130	2-year	146.00	54.75	59.76	57.27	59.89	0.002102	2.95	58.43	26.45	0.26
Reach 1	11130	10-year	259.00	54.75	61.68	58.21	61.82	0.001393	3.13	127.49	45.28	0.23
Reach 1	11130	25-year	339.00	54.75	63.16	58.75	63.26	0.000881	2.89	205.27	73.35	0.19
Reach 1	11130	50-year	408.00	54.75	64.15	59.19	64.25	0.000757	2.91	296.68	100.22	0.18
Reach 1	11130	100-year	484.00	54.75	64.57	59.65	64.69	0.000861	3.21	344.71	127.98	0.19
Reach 1	11075 Tucker Dr		Culvert									
Reach 1	11000	2-year	146.00	54.41	59.49	56.71	59.59	0.001493	2.78	74.33	30.71	0.23
Reach 1	11000	10-year	259.00	54.41	60.64	57.66	60.81	0.001890	3.63	110.44	39.78	0.27
Reach 1	11000	25-year	339.00	54.41	61.24	58.23	61.45	0.002156	4.14	130.58	44.51	0.29
Reach 1	11000	50-year	408.00	54.41	61.68	58.68	61.94	0.002392	4.56	146.36	50.04	0.31
Reach 1	11000	100-year	484.00	54.41	62.14	59.11	62.43	0.002587	4.96	185.99	59.36	0.32
Reach 1	10940	2-year	146.00	54.41	59.38		59.50	0.001639	2.87	71.23	29.90	0.24
Reach 1	10940	10-year	259.00	54.41	60.49		60.68	0.002123	3.79	109.37	38.66	0.28
Reach 1	10940	25-year	339.00	54.41	61.08		61.31	0.002410	4.31	133.18	43.24	0.30
Reach 1	10940	50-year	408.00	54.41	61.51		61.78	0.002634	4.71	152.77	47.51	0.32
Reach 1	10940	100-year	484.00	54.41	61.94		62.26	0.002899	5.15	174.55	55.32	0.34
Reach 1	10670	2-year	146.00	52.63	58.97		59.05	0.001586	2.44	75.33	38.08	0.21
Reach 1	10670	10-year	259.00	52.63	59.97		60.10	0.002032	3.15	123.17	60.71	0.25
Reach 1	10670	25-year	339.00	52.63	60.51		60.66	0.002196	3.51	158.37	69.94	0.26
Reach 1	10670	50-year	408.00	52.63	60.92		61.09	0.002275	3.75	188.58	76.54	0.27
Reach 1	10670	100-year	484.00	52.63	61.33		61.52	0.002329	3.97	221.50	83.15	0.28
Reach 1	10500	2-year	184.00	55.05	58.59		58.71	0.002389	2.89	71.64	37.35	0.30
Reach 1	10500	10-year	329.00	55.05	59.48		59.68	0.002825	3.76	110.38	49.39	0.34
Reach 1	10500	25-year	430.00	55.05	59.96		60.21	0.003048	4.22	135.84	56.68	0.36
Reach 1	10500	50-year	519.00	55.05	60.33		60.62	0.003189	4.56	157.99	62.33	0.37
Reach 1	10500	100-year	617.00	55.05	60.71		61.03	0.003279	4.87	182.75	68.10	0.38
Reach 1	10250	2-year	184.00	54.45	57.06		57.46	0.015294	5.03	36.57	22.34	0.69
Reach 1	10250	10-year	329.00	54.45	58.23		58.56	0.008120	4.75	81.73	47.97	0.53
Reach 1	10250	25-year	430.00	54.45	58.84		59.15	0.006266	4.68	112.59	53.09	0.48
Reach 1	10250	50-year	519.00	54.45	59.30		59.61	0.005305	4.74	137.88	58.14	0.46
Reach 1	10250	100-year	617.00	54.45	59.74		60.06	0.004691	4.85	164.95	63.09	0.44

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	10125	2-year	184.00	52.75	56.81		56.91	0.001620	2.55	83.12	42.57	0.24
Reach 1	10125	10-year	329.00	52.75	57.97		58.11	0.001657	3.13	142.49	59.40	0.26
Reach 1	10125	25-year	430.00	52.75	58.58		58.74	0.001687	3.42	181.50	68.17	0.26
Reach 1	10125	50-year	519.00	52.75	59.04		59.21	0.001733	3.67	214.47	77.33	0.27
Reach 1	10125	100-year	617.00	52.75	59.49		59.68	0.001767	3.90	252.24	89.97	0.28
Reach 1	10000	2-year	184.00	52.55	56.61		56.71	0.001570	2.51	86.32	42.62	0.24
Reach 1	10000	10-year	329.00	52.55	57.77		57.90	0.001625	3.09	143.35	56.48	0.25
Reach 1	10000	25-year	430.00	52.55	58.37		58.53	0.001677	3.41	179.80	64.04	0.26
Reach 1	10000	50-year	519.00	52.55	58.83		59.00	0.001727	3.66	210.03	69.69	0.27
Reach 1	10000	100-year	617.00	52.55	59.27		59.46	0.001800	3.92	242.59	78.32	0.28
Reach 1	9930	2-year	184.00	51.47	56.55		56.61	0.000997	2.06	100.27	51.66	0.19
Reach 1	9930	10-year	329.00	51.47	57.71		57.80	0.001043	2.55	172.07	72.08	0.21
Reach 1	9930	25-year	430.00	51.47	58.31		58.42	0.001073	2.81	219.07	82.65	0.21
Reach 1	9930	50-year	519.00	51.47	58.77		58.88	0.001099	3.00	258.36	90.37	0.22
Reach 1	9930	100-year	617.00	51.47	59.21		59.34	0.001124	3.19	300.21	98.02	0.23
Reach 1	9745	2-year	184.00	52.15	56.31		56.39	0.001371	2.39	102.69	58.48	0.22
Reach 1	9745	10-year	329.00	52.15	57.46		57.57	0.001419	2.93	183.74	85.98	0.24
Reach 1	9745	25-year	430.00	52.15	58.06		58.19	0.001450	3.21	240.72	103.71	0.24
Reach 1	9745	50-year	519.00	52.15	58.51		58.65	0.001471	3.41	290.38	116.98	0.25
Reach 1	9745	100-year	617.00	52.15	58.95		59.10	0.001489	3.60	344.96	131.38	0.25
Reach 1	9400	2-year	184.00	51.45	55.96		56.01	0.000871	2.02	143.45	86.41	0.18
Reach 1	9400	10-year	329.00	51.45	57.10		57.17	0.000891	2.42	261.42	122.21	0.19
Reach 1	9400	25-year	430.00	51.45	57.70		57.78	0.000910	2.63	342.38	148.53	0.19
Reach 1	9400	50-year	519.00	51.45	58.15		58.24	0.000911	2.77	413.75	166.98	0.20
Reach 1	9400	100-year	617.00	51.45	58.60		58.68	0.000904	2.89	492.13	184.53	0.20
Reach 1	9050	2-year	301.00	50.85	55.41		55.53	0.001936	3.04	167.77	91.27	0.27
Reach 1	9050	10-year	551.00	50.85	56.48		56.64	0.002257	3.84	276.22	112.56	0.30
Reach 1	9050	25-year	728.00	50.85	57.01		57.21	0.002491	4.31	339.50	122.88	0.32
Reach 1	9050	50-year	883.00	50.85	57.43		57.65	0.002645	4.66	391.55	130.08	0.33
Reach 1	9050	100-year	1052.00	50.85	57.84		58.08	0.002765	4.98	446.81	137.32	0.34
Reach 1	8965	2-year	301.00	50.65	55.22		55.36	0.002186	3.20	154.01	91.90	0.28
Reach 1	8965	10-year	551.00	50.65	56.25		56.44	0.002556	4.02	257.16	108.38	0.32
Reach 1	8965	25-year	728.00	50.65	56.76		56.98	0.002864	4.54	314.17	116.50	0.34
Reach 1	8965	50-year	883.00	50.65	57.14		57.40	0.003097	4.94	360.74	124.88	0.36

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	8965	100-year	1052.00	50.65	57.54		57.82	0.003274	5.30	411.68	134.12	0.37
Reach 1	8885	2-year	301.00	49.71	54.70		55.05	0.006583	4.95	79.68	68.97	0.44
Reach 1	8885	10-year	551.00	49.71	55.78		56.13	0.005816	5.47	187.66	129.80	0.43
Reach 1	8885	25-year	728.00	49.71	56.37		56.68	0.005064	5.49	270.05	148.29	0.41
Reach 1	8885	50-year	883.00	49.71	56.82		57.10	0.004595	5.50	339.42	161.45	0.39
Reach 1	8885	100-year	1052.00	49.71	57.26		57.52	0.004234	5.53	412.47	174.19	0.38
Reach 1	8750	2-year	301.00	49.95	54.32		54.48	0.002467	3.31	145.52	126.48	0.29
Reach 1	8750	10-year	551.00	49.95	55.44		55.60	0.002345	3.78	297.39	146.93	0.29
Reach 1	8750	25-year	727.00	49.95	56.02		56.19	0.002318	4.04	386.67	157.71	0.29
Reach 1	8750	50-year	880.00	49.95	56.47		56.64	0.002300	4.22	458.90	165.75	0.30
Reach 1	8750	100-year	1049.00	49.95	56.90		57.08	0.002307	4.42	532.05	173.06	0.30
Reach 1	8469	2-year	301.00	47.54	53.71		53.85	0.002068	3.28	164.86	100.20	0.27
Reach 1	8469	10-year	551.00	47.54	54.75		54.93	0.002462	4.09	284.77	125.84	0.30
Reach 1	8469	25-year	727.00	47.54	55.30		55.50	0.002641	4.50	356.55	135.69	0.32
Reach 1	8469	50-year	880.00	47.54	55.73		55.94	0.002741	4.80	415.92	143.33	0.33
Reach 1	8469	100-year	1049.00	47.54	56.13		56.36	0.002865	5.10	475.33	150.33	0.34
Reach 1	7993	2-year	301.00	46.71	52.07	50.02	52.40	0.004770	4.70	88.90	137.93	0.40
Reach 1	7993	10-year	551.00	46.71	53.48	51.47	53.68	0.002830	4.36	313.29	177.01	0.32
Reach 1	7993	25-year	727.00	46.71	54.04		54.22	0.002729	4.55	415.59	190.60	0.32
Reach 1	7993	50-year	880.00	46.71	54.49		54.67	0.002577	4.64	504.68	200.46	0.31
Reach 1	7993	100-year	1049.00	46.71	54.86		55.04	0.002640	4.86	580.08	208.45	0.32
Reach 1	7943	2-year	301.00	46.71	51.70	50.04	52.10	0.006423	5.15	68.55	34.59	0.45
Reach 1	7943	10-year	551.00	46.71	52.43	51.48	53.24	0.011021	7.53	100.65	149.91	0.61
Reach 1	7943	25-year	727.00	46.71	53.82	52.46	54.05	0.003408	4.97	374.86	185.38	0.35
Reach 1	7943	50-year	880.00	46.71	54.30	52.92	54.52	0.003074	4.97	467.35	196.39	0.34
Reach 1	7943	100-year	1049.00	46.71	54.67	53.33	54.89	0.003111	5.18	541.18	204.36	0.35
Reach 1	7897 14th St		Culvert									
Reach 1	7843	2-year	301.00	45.75	51.92	48.72	52.01	0.001415	2.78	237.71	187.88	0.21
Reach 1	7843	10-year	551.00	45.75	52.72	49.88	52.84	0.001867	3.50	411.98	235.57	0.25
Reach 1	7843	25-year	727.00	45.75	53.14	50.95	53.27	0.002038	3.82	515.24	250.49	0.26
Reach 1	7843	50-year	880.00	45.75	53.47	51.38	53.60	0.002147	4.05	598.01	261.84	0.27
Reach 1	7843	100-year	1049.00	45.75	53.79	52.23	53.92	0.002243	4.26	683.66	272.96	0.28
Reach 1	7788	2-year	301.00	45.75	51.82		51.93	0.001577	2.91	220.18	179.33	0.22

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	7788	10-year	551.00	45.75	52.58		52.72	0.002191	3.74	379.82	230.73	0.27
Reach 1	7788	25-year	727.00	45.75	52.99		53.14	0.002390	4.08	478.30	245.26	0.28
Reach 1	7788	50-year	880.00	45.75	53.31		53.47	0.002509	4.31	557.81	256.39	0.29
Reach 1	7788	100-year	1049.00	45.75	53.63		53.79	0.002611	4.53	640.33	267.45	0.30
Reach 1	7522	2-year	301.00	45.77	51.43		51.47	0.001727	2.28	258.47	176.18	0.19
Reach 1	7522	10-year	551.00	45.77	52.06		52.12	0.002162	2.79	375.88	193.31	0.22
Reach 1	7522	25-year	727.00	45.77	52.43		52.49	0.002342	3.04	447.93	202.28	0.23
Reach 1	7522	50-year	880.00	45.77	52.72		52.79	0.002449	3.22	506.87	209.30	0.24
Reach 1	7522	100-year	1049.00	45.77	53.00		53.08	0.002548	3.39	567.98	216.32	0.25
Reach 1	7281	2-year	301.00	45.67	50.69		50.81	0.004821	3.53	191.88	236.36	0.33
Reach 1	7281	10-year	551.00	45.67	51.39		51.47	0.003472	3.37	369.70	271.93	0.28
Reach 1	7281	25-year	727.00	45.67	51.78		51.85	0.003099	3.37	477.91	291.46	0.27
Reach 1	7281	50-year	880.00	45.67	52.09		52.15	0.002833	3.36	570.02	304.29	0.26
Reach 1	7281	100-year	1049.00	45.67	52.38		52.45	0.002673	3.39	662.20	313.96	0.26
Reach 1	7088	2-year	301.00	44.73	49.93		50.02	0.003479	3.23	216.94	176.77	0.29
Reach 1	7088	10-year	551.00	44.73	50.65		50.76	0.003884	3.82	351.01	194.45	0.31
Reach 1	7088	25-year	727.00	44.73	51.04		51.16	0.004056	4.12	429.85	203.05	0.32
Reach 1	7088	50-year	880.00	44.73	51.38		51.50	0.004042	4.29	498.67	210.28	0.33
Reach 1	7088	100-year	1049.00	44.73	51.67		51.80	0.004180	4.53	562.52	216.76	0.34
Reach 1	6769	2-year	301.00	43.69	47.47	47.47	47.97	0.014654	6.51	101.13	132.83	0.74
Reach 1	6769	10-year	551.00	43.69	48.08	48.08	48.59	0.014027	7.40	202.76	195.58	0.75
Reach 1	6769	25-year	727.00	43.69	48.33	48.33	48.88	0.014938	8.06	252.99	201.50	0.79
Reach 1	6769	50-year	880.00	43.69	48.46	48.46	49.11	0.017159	8.88	280.59	204.62	0.85
Reach 1	6769	100-year	1049.00	43.69	48.65	48.65	49.33	0.017807	9.38	319.38	208.92	0.87
Reach 1	6315	2-year	301.00	36.65	41.18		41.34	0.002873	3.24	92.85	29.88	0.32
Reach 1	6315	10-year	551.00	36.65	42.74		42.97	0.002874	3.82	144.22	35.99	0.34
Reach 1	6315	25-year	727.00	36.65	43.51		43.79	0.002983	4.20	174.16	46.05	0.35
Reach 1	6315	50-year	880.00	36.65	44.03		44.35	0.003109	4.53	202.05	62.18	0.36
Reach 1	6315	100-year	1049.00	36.65	44.53		44.89	0.003245	4.86	243.07	101.31	0.37
Reach 1	6004	2-year	301.00	34.68	40.11		40.32	0.003721	3.71	81.16	24.74	0.36
Reach 1	6004	10-year	551.00	34.68	41.58		41.90	0.004120	4.53	125.17	40.03	0.39
Reach 1	6004	25-year	727.00	34.68	42.26		42.65	0.004469	5.06	154.98	50.56	0.42
Reach 1	6004	50-year	880.00	34.68	42.73		43.18	0.004570	5.47	193.40	89.63	0.43
Reach 1	6004	100-year	1049.00	34.68	43.18		43.68	0.004643	5.83	236.21	100.29	0.44

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	5630	2-year	301.00	33.32	38.99		39.16	0.002622	3.26	92.45	28.06	0.31
Reach 1	5630	10-year	551.00	33.32	40.41		40.65	0.002671	4.02	179.40	111.75	0.33
Reach 1	5630	25-year	727.00	33.32	41.13		41.39	0.002511	4.29	268.05	134.78	0.32
Reach 1	5630	50-year	880.00	33.32	41.64		41.91	0.002433	4.48	341.45	151.22	0.32
Reach 1	5630	100-year	1049.00	33.32	42.13		42.41	0.002382	4.67	418.79	165.44	0.33
Reach 1	5260	2-year	301.00	31.95	38.10		38.22	0.002327	2.86	145.14	102.13	0.25
Reach 1	5260	10-year	551.00	31.95	39.80		39.89	0.001461	2.85	380.82	173.55	0.21
Reach 1	5260	25-year	727.00	31.95	40.59		40.68	0.001310	2.94	533.34	213.35	0.20
Reach 1	5260	50-year	880.00	31.95	41.14		41.22	0.001249	3.03	657.35	239.92	0.20
Reach 1	5260	100-year	1049.00	31.95	41.64		41.73	0.001218	3.13	785.40	264.57	0.20
Reach 1	4765	2-year	301.00	30.39	36.87		37.01	0.002570	3.07	119.30	49.06	0.26
Reach 1	4765	10-year	551.00	30.39	39.02		39.13	0.001577	3.10	305.96	115.91	0.21
Reach 1	4765	25-year	727.00	30.39	39.85		39.97	0.001545	3.32	411.34	138.59	0.21
Reach 1	4765	50-year	880.00	30.39	40.38		40.52	0.001626	3.56	490.36	160.08	0.22
Reach 1	4765	100-year	1049.00	30.39	40.86		41.01	0.001726	3.82	572.97	181.95	0.23
Reach 1	4230	2-year	301.00	28.77	34.17		34.32	0.003430	3.29	141.57	120.49	0.29
Reach 1	4230	10-year	551.00	28.77	35.65		35.75	0.002218	3.11	370.64	190.58	0.24
Reach 1	4230	25-year	727.00	28.77	36.45		36.53	0.001644	2.92	562.24	267.61	0.21
Reach 1	4230	50-year	880.00	28.77	37.07		37.13	0.001310	2.79	732.23	282.85	0.19
Reach 1	4230	100-year	1049.00	28.77	37.78		37.82	0.001012	2.62	937.81	300.15	0.17
Reach 1	3840	2-year	301.00	26.71	33.53		33.60	0.001092	2.16	184.69	69.87	0.17
Reach 1	3840	10-year	551.00	26.71	35.04		35.12	0.001181	2.66	335.16	118.53	0.18
Reach 1	3840	25-year	727.00	26.71	35.89		35.99	0.001155	2.85	444.35	135.73	0.18
Reach 1	3840	50-year	880.00	26.71	36.55		36.65	0.001125	2.98	537.90	147.61	0.18
Reach 1	3840	100-year	1049.00	26.71	37.33		37.42	0.001028	3.03	657.09	161.25	0.18
Reach 1	3610	2-year	301.00	27.30	33.02		33.29	0.001498	4.17	83.85	27.15	0.33
Reach 1	3610	10-year	551.00	27.30	34.17		34.71	0.002380	6.04	129.41	58.67	0.43
Reach 1	3610	25-year	727.00	27.30	34.88		35.55	0.002632	6.84	178.91	79.60	0.46
Reach 1	3610	50-year	880.00	27.30	35.49		36.21	0.002663	7.28	232.37	97.51	0.47
Reach 1	3610	100-year	1049.00	27.30	36.35		37.03	0.002275	7.25	328.77	126.85	0.44
Reach 1	3507	2-year	320.00	28.00	33.02	30.27	33.11	0.000620	2.52	145.32	57.98	0.22
Reach 1	3507	10-year	588.00	28.00	34.22	31.23	34.40	0.000797	3.41	227.10	80.53	0.27
Reach 1	3507	25-year	778.00	28.00	34.97	31.73	35.19	0.000839	3.84	284.81	97.19	0.28
Reach 1	3507	50-year	942.00	28.00	35.59	32.12	35.83	0.000847	4.12	335.31	109.98	0.29
Reach 1	3507	100-year	1124.00	28.00	36.45	32.52	36.69	0.000756	4.23	409.74	127.65	0.28

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	3490 King George Rd		Bridge									
Reach 1	3401	2-year	320.00	28.00	32.94	30.26	33.05	0.000662	2.57	137.06	50.96	0.23
Reach 1	3401	10-year	588.00	28.00	34.11	31.23	34.30	0.000879	3.54	206.18	67.63	0.28
Reach 1	3401	25-year	778.00	28.00	34.84	31.73	35.08	0.000944	4.02	259.92	79.57	0.30
Reach 1	3401	50-year	942.00	28.00	35.44	32.11	35.71	0.000961	4.33	310.28	89.33	0.30
Reach 1	3401	100-year	1124.00	28.00	36.07	32.51	36.38	0.000973	4.64	371.22	108.07	0.31
Reach 1	3280	2-year	331.00	26.55	32.81		32.94	0.000871	3.38	245.22	123.60	0.26
Reach 1	3280	10-year	623.00	26.55	33.99		34.18	0.001119	4.39	407.27	151.63	0.31
Reach 1	3280	25-year	832.00	26.55	34.73		34.94	0.001143	4.78	525.35	165.57	0.32
Reach 1	3280	50-year	1015.00	26.55	35.34		35.56	0.001133	5.03	630.13	178.78	0.32
Reach 1	3280	100-year	1219.00	26.55	35.99		36.21	0.001097	5.22	751.01	192.85	0.32
Reach 1	2850	2-year	338.00	26.15	32.37		32.55	0.000933	3.45	105.91	27.25	0.27
Reach 1	2850	10-year	641.00	26.15	32.99		33.49	0.002223	5.75	123.64	29.81	0.43
Reach 1	2850	25-year	861.00	26.15	33.32		34.10	0.003288	7.26	133.47	31.14	0.52
Reach 1	2850	50-year	1054.00	26.15	33.53		34.60	0.004349	8.54	140.10	32.01	0.60
Reach 1	2850	100-year	1270.00	26.15	33.69		35.16	0.005749	9.99	145.34	32.67	0.70
Reach 1	2590	2-year	338.00	25.38	32.40		32.42	0.000166	1.58	442.06	205.09	0.12
Reach 1	2590	10-year	641.00	25.38	33.15		33.19	0.000274	2.22	605.88	227.18	0.16
Reach 1	2590	25-year	861.00	25.38	33.63		33.68	0.000321	2.53	718.39	241.18	0.17
Reach 1	2590	50-year	1054.00	25.38	34.02		34.07	0.000349	2.74	813.92	252.46	0.18
Reach 1	2590	100-year	1270.00	25.38	34.42		34.48	0.000376	2.95	918.17	267.76	0.19
Reach 1	2280	2-year	338.00	24.65	32.34		32.37	0.000130	1.63	368.80	122.66	0.11
Reach 1	2280	10-year	641.00	24.65	33.03		33.10	0.000296	2.63	459.84	145.72	0.17
Reach 1	2280	25-year	861.00	24.65	33.47		33.56	0.000394	3.15	526.16	155.64	0.20
Reach 1	2280	50-year	1054.00	24.65	33.82		33.94	0.000464	3.52	582.88	162.49	0.22
Reach 1	2280	100-year	1270.00	24.65	34.19		34.33	0.000530	3.88	644.70	169.72	0.23
Reach 1	2145	2-year	338.00	23.85	32.25		32.34	0.000440	2.36	146.78	43.96	0.19
Reach 1	2145	10-year	641.00	23.85	32.77		33.01	0.001100	3.99	182.76	94.47	0.30
Reach 1	2145	25-year	861.00	23.85	33.07		33.44	0.001592	4.97	215.71	123.80	0.37
Reach 1	2145	50-year	1054.00	23.85	33.32		33.79	0.001966	5.69	248.33	134.13	0.41
Reach 1	2145	100-year	1270.00	23.85	33.59		34.16	0.002298	6.33	285.53	138.38	0.45
Reach 1	2045	2-year	338.00	23.25	32.23	26.85	32.27	0.000400	1.72	196.37	62.41	0.17
Reach 1	2045	10-year	641.00	23.25	32.72	27.96	32.84	0.001064	2.76	232.36	82.38	0.28

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	2045	25-year	861.00	23.25	33.02	28.64	33.19	0.001433	3.38	258.22	93.58	0.33
Reach 1	2045	50-year	1054.00	23.25	33.26	29.17	33.49	0.001711	3.84	281.94	102.79	0.36
Reach 1	2045	100-year	1270.00	23.25	33.52	29.71	33.81	0.001959	4.27	310.51	112.89	0.39
Reach 1	2037 Railroad Crossin		Bridge									
Reach 1	1970	2-year	338.00	23.05	32.20	26.64	32.24	0.000379	1.63	207.72	69.54	0.17
Reach 1	1970	10-year	641.00	23.05	32.64	27.76	32.75	0.000942	2.66	241.61	85.77	0.26
Reach 1	1970	25-year	861.00	23.05	32.90	28.43	33.07	0.001325	3.29	262.23	94.58	0.32
Reach 1	1970	50-year	1054.00	23.05	33.11	28.97	33.34	0.001641	3.79	279.21	101.75	0.36
Reach 1	1970	100-year	1270.00	23.05	33.34	29.51	33.62	0.001961	4.29	297.67	109.45	0.39
Reach 1	1890	2-year	335.00	23.05	32.20		32.22	0.000069	1.26	388.43	128.29	0.08
Reach 1	1890	10-year	639.00	23.05	32.64		32.70	0.000194	2.18	447.10	138.65	0.14
Reach 1	1890	25-year	858.00	23.05	32.89		32.99	0.000301	2.78	483.20	144.58	0.17
Reach 1	1890	50-year	1051.00	23.05	33.10		33.23	0.000400	3.26	513.59	149.38	0.20
Reach 1	1890	100-year	1266.00	23.05	33.32		33.50	0.000512	3.75	547.49	154.56	0.22
Reach 1	1727	2-year	335.00	26.56	32.19		32.21	0.000101	1.17	303.93	106.04	0.09
Reach 1	1727	10-year	639.00	26.56	32.60		32.66	0.000275	2.02	349.03	111.06	0.16
Reach 1	1727	25-year	858.00	26.56	32.83		32.93	0.000429	2.57	375.37	114.79	0.20
Reach 1	1727	50-year	1051.00	26.56	33.02		33.16	0.000578	3.02	396.85	117.89	0.23
Reach 1	1727	100-year	1266.00	26.56	33.22		33.40	0.000747	3.48	420.45	121.20	0.26
Reach 1	1590	2-year	335.00	26.53	32.19	27.36	32.20	0.000022	0.59	610.85	159.45	0.05
Reach 1	1590	10-year	639.00	26.53	32.62	27.77	32.63	0.000060	1.03	680.65	167.05	0.08
Reach 1	1590	25-year	858.00	26.53	32.86	28.01	32.89	0.000093	1.32	721.91	171.00	0.10
Reach 1	1590	50-year	1051.00	26.53	33.06	28.21	33.09	0.000125	1.55	755.61	174.17	0.11
Reach 1	1590	100-year	1266.00	26.53	33.27	28.42	33.32	0.000160	1.80	792.53	177.57	0.13
Reach 1	100		Inl Struct									
Reach 1	-50	2-year	335.00	17.55	22.95		22.97	0.000522	1.77	317.31	83.80	0.13
Reach 1	-50	10-year	639.00	17.55	25.05		25.08	0.000444	1.92	538.71	163.29	0.12
Reach 1	-50	25-year	858.00	17.55	26.07		26.09	0.000425	2.05	740.64	235.39	0.12
Reach 1	-50	50-year	1051.00	17.55	26.87		26.90	0.000389	2.08	952.15	292.43	0.12
Reach 1	-50	100-year	1266.00	17.55	27.52		27.55	0.000379	2.15	1158.47	338.95	0.12
Reach 1	-172	2-year	335.00	13.25	22.94		22.95	0.000013	0.67	641.77	172.18	0.04
Reach 1	-172	10-year	639.00	13.25	25.05		25.06	0.000019	0.92	1155.53	326.68	0.05
Reach 1	-172	25-year	858.00	13.25	26.06		26.07	0.000022	1.06	1524.70	396.44	0.06

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	-172	50-year	1051.00	13.25	26.86		26.87	0.000023	1.15	1856.13	432.89	0.06
Reach 1	-172	100-year	1266.00	13.25	27.51		27.52	0.000026	1.26	2147.31	462.34	0.06
Reach 1	-267	2-year	335.00	13.25	22.94	15.75	22.95	0.000014	0.69	507.18	126.52	0.04
Reach 1	-267	10-year	639.00	13.25	25.04	16.46	25.06	0.000023	1.02	662.47	215.12	0.06
Reach 1	-267	25-year	858.00	13.25	26.04	16.86	26.07	0.000030	1.24	736.84	318.63	0.07
Reach 1	-267	50-year	1051.00	13.25	26.84	17.16	26.87	0.000035	1.41	795.54	361.76	0.07
Reach 1	-267	100-year	1266.00	13.25	27.48	17.49	27.52	0.000042	1.61	843.13	396.73	0.08
Reach 1	-332		Culvert									
Reach 1	-347	2-year	335.00	16.55	22.85	19.43	22.93	0.002338	2.28	163.08	56.72	0.19
Reach 1	-347	10-year	639.00	16.55	24.82	20.62	24.89	0.001708	2.47	429.23	192.16	0.17
Reach 1	-347	25-year	858.00	16.55	25.64	21.16	25.71	0.001605	2.59	608.01	246.82	0.17
Reach 1	-347	50-year	1051.00	16.55	26.23	21.62	26.30	0.001542	2.67	765.66	290.80	0.17
Reach 1	-347	100-year	1266.00	16.55	26.80	22.12	26.87	0.001468	2.72	943.91	333.62	0.16
Reach 1	-532	2-year	549.00	15.15	22.18		22.34	0.003704	3.29	196.79	52.06	0.24
Reach 1	-532	10-year	1198.00	15.15	24.02		24.26	0.004756	4.48	426.91	155.81	0.29
Reach 1	-532	25-year	1627.00	15.15	24.80		25.07	0.005075	4.94	551.92	163.87	0.30
Reach 1	-532	50-year	1985.00	15.15	25.36		25.65	0.005308	5.27	644.78	171.70	0.31
Reach 1	-532	100-year	2386.00	15.15	25.89		26.21	0.005636	5.64	738.39	182.43	0.32
Reach 1	-2127	2-year	549.00	12.35	17.51		17.56	0.002734	2.46	387.19	164.71	0.21
Reach 1	-2127	10-year	1198.00	12.35	19.27		19.33	0.002475	2.94	700.54	191.72	0.21
Reach 1	-2127	25-year	1627.00	12.35	20.31		20.38	0.002207	3.08	907.86	207.67	0.20
Reach 1	-2127	50-year	1985.00	12.35	21.17		21.24	0.001951	3.12	1109.64	263.85	0.19
Reach 1	-2127	100-year	2386.00	12.35	22.21		22.27	0.001585	3.06	1413.08	313.81	0.18
Reach 1	-3322	2-year	549.00	8.65	14.47		14.52	0.002381	2.50	402.58	145.52	0.19
Reach 1	-3322	10-year	1198.00	8.65	16.88		16.93	0.001666	2.70	780.51	167.43	0.17
Reach 1	-3322	25-year	1627.00	8.65	18.18		18.23	0.001485	2.83	1005.30	179.65	0.17
Reach 1	-3322	50-year	1985.00	8.65	19.29		19.34	0.001312	2.88	1211.12	191.74	0.16
Reach 1	-3322	100-year	2386.00	8.65	20.68		20.73	0.001067	2.83	1488.74	206.94	0.15
Reach 1	-3552	2-year	549.00	7.25	13.44		13.65	0.006605	4.36	188.14	57.32	0.33
Reach 1	-3552	10-year	1198.00	7.25	15.83		16.18	0.007844	6.03	355.11	102.15	0.38
Reach 1	-3552	25-year	1627.00	7.25	17.24		17.57	0.006717	6.22	546.38	168.92	0.36
Reach 1	-3552	50-year	1985.00	7.25	18.60		18.82	0.004329	5.47	818.16	230.20	0.29
Reach 1	-3552	100-year	2386.00	7.25	20.24		20.37	0.002387	4.47	1254.64	298.74	0.22

HEC-RAS Plan: Alternative #1 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	-3604	2-year	549.00	7.05	12.74	10.87	13.20	0.007502	5.47	100.43	27.24	0.50
Reach 1	-3604	10-year	1198.00	7.05	14.58	13.02	15.53	0.010566	7.81	153.39	29.00	0.60
Reach 1	-3604	25-year	1627.00	7.05	15.65	13.89	16.86	0.011338	8.82	184.51	29.00	0.62
Reach 1	-3604	50-year	1985.00	7.05	16.95	14.55	18.19	0.009906	8.94	222.03	29.00	0.57
Reach 1	-3604	100-year	2386.00	7.05	19.81	15.23	20.17	0.002573	5.51	611.71	259.35	0.30
Reach 1	-3617		Bridge									
Reach 1	-3630	2-year	547.00	7.05	12.40	10.87	12.95	0.009463	5.99	91.28	25.76	0.56
Reach 1	-3630	10-year	1197.00	7.05	13.60	13.02	15.02	0.019457	9.58	124.94	29.00	0.81
Reach 1	-3630	25-year	1626.00	7.05	14.07	13.90	16.21	0.026305	11.73	138.60	29.00	0.95
Reach 1	-3630	50-year	1984.00	7.05	14.55	14.55	17.18	0.029445	13.00	152.56	29.00	1.00
Reach 1	-3630	100-year	2385.00	7.05	15.23	15.23	18.21	0.029729	13.84	172.33	29.00	1.00
Reach 1	-3682	2-year	547.00	7.05	11.94		12.26	0.013124	4.76	148.29	83.78	0.45
Reach 1	-3682	10-year	1197.00	7.05	12.97	12.25	13.59	0.020732	7.09	249.69	114.47	0.58
Reach 1	-3682	25-year	1626.00	7.05	13.47	12.90	14.25	0.023623	8.12	311.92	131.31	0.63
Reach 1	-3682	50-year	1984.00	7.05	13.85	13.32	14.73	0.025009	8.76	364.40	144.63	0.66
Reach 1	-3682	100-year	2385.00	7.05	14.25	13.74	15.20	0.025722	9.31	424.76	158.56	0.68
Reach 1	-3897	2-year	547.00	6.75	11.11	9.73	11.13	0.002501	1.83	554.59	344.29	0.18
Reach 1	-3897	10-year	1197.00	6.75	12.20	10.21	12.23	0.002502	2.24	940.86	365.24	0.19
Reach 1	-3897	25-year	1626.00	6.75	12.77	10.49	12.81	0.002501	2.44	1152.23	376.20	0.20
Reach 1	-3897	50-year	1984.00	6.75	13.19	10.65	13.24	0.002503	2.58	1313.64	384.37	0.20
Reach 1	-3897	100-year	2385.00	6.75	13.63	10.79	13.68	0.002502	2.73	1483.82	392.79	0.20

PRIMARY SYSTEM ALTERNATIVE #2: HEC-RAS OUTPUT

Bells Branch - Alternative #2

HEC-RAS Plan: Alternative #2   River: Bells Branch   Reach: Reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	11194	2-Year	30.30	62.20	64.85		64.90	0.002726	1.81	19.65	15.48	0.23
Reach 1	11194	10-Year	59.10	62.20	65.64		65.70	0.002475	2.15	43.76	46.28	0.23
Reach 1	11194	25-Year	79.80	62.20	66.00		66.06	0.002367	2.28	63.06	60.66	0.23
Reach 1	11194	50-Year	98.00	62.20	66.26		66.32	0.002272	2.36	80.22	71.03	0.22
Reach 1	11194	100-Year	118.20	62.20	66.52		66.57	0.002162	2.41	99.54	81.15	0.22
Reach 1	10514	2-Year	30.30	60.20	63.46		63.49	0.001619	1.53	25.04	23.36	0.17
Reach 1	10514	10-Year	59.10	60.20	64.21		64.25	0.001831	1.94	48.86	40.45	0.19
Reach 1	10514	25-Year	79.80	60.20	64.60		64.65	0.001822	2.08	66.66	49.10	0.19
Reach 1	10514	50-Year	98.00	60.20	64.93		64.98	0.001716	2.14	83.84	56.10	0.19
Reach 1	10514	100-Year	118.20	60.20	65.24		65.29	0.001651	2.20	102.22	63.56	0.19
Reach 1	10229	2-Year	58.10	59.87	62.91		62.95	0.002078	1.62	42.07	47.20	0.21
Reach 1	10229	10-Year	113.00	59.87	63.74		63.78	0.001574	1.80	94.42	74.91	0.20
Reach 1	10229	25-Year	150.50	59.87	64.18		64.22	0.001358	1.86	129.96	84.67	0.19
Reach 1	10229	50-Year	184.30	59.87	64.55		64.59	0.001203	1.89	162.46	92.08	0.18
Reach 1	10229	100-Year	222.10	59.87	64.88		64.92	0.001149	1.96	193.39	98.61	0.18
Reach 1	9819	2-Year	58.10	58.85	61.56		61.72	0.004614	3.15	18.56	10.49	0.41
Reach 1	9819	10-Year	113.00	58.85	62.55		62.79	0.004034	3.93	33.06	31.03	0.41
Reach 1	9819	25-Year	150.50	58.85	63.22		63.42	0.002907	3.84	63.54	60.76	0.36
Reach 1	9819	50-Year	184.30	58.85	63.79		63.95	0.002034	3.56	104.40	81.82	0.31
Reach 1	9819	100-Year	222.10	58.85	64.18		64.32	0.001797	3.55	138.96	95.28	0.30
Reach 1	9780	2-Year	58.10	58.85	61.19	60.69	61.44	0.009585	3.99	14.55	10.20	0.57
Reach 1	9780	10-Year	111.50	58.85	62.27	61.29	62.58	0.005823	4.46	25.10	11.17	0.49
Reach 1	9780	25-Year	144.70	58.85	62.91	61.59	63.24	0.004698	4.64	31.59	49.37	0.46
Reach 1	9780	50-Year	169.50	58.85	63.46	61.80	63.79	0.003803	4.64	37.61	69.49	0.42
Reach 1	9780	100-Year	191.90	58.85	64.13	61.99	64.25	0.001424	3.14	134.46	93.75	0.26
Reach 1	9749		Culvert									
Reach 1	9724	2-Year	58.10	56.43	59.89	57.66	59.93	0.000859	1.48	39.37	15.12	0.16
Reach 1	9724	10-Year	111.50	56.43	60.92	58.21	60.98	0.001194	1.99	55.96	17.10	0.19
Reach 1	9724	25-Year	144.70	56.43	61.36	58.49	61.44	0.001408	2.27	63.74	17.95	0.21
Reach 1	9724	50-Year	169.50	56.43	61.74	58.68	61.83	0.001399	2.40	72.02	36.74	0.21
Reach 1	9724	100-Year	191.90	56.43	62.13	58.85	62.22	0.001288	2.45	82.11	55.42	0.21

HEC-RAS Plan: Alternative #2 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	9700	2-Year	58.10	56.43	59.88		59.90	0.000426	1.09	58.43	35.25	0.12
Reach 1	9700	10-Year	111.50	56.43	60.92		60.95	0.000498	1.42	96.38	38.08	0.13
Reach 1	9700	25-Year	144.70	56.43	61.37		61.40	0.000558	1.59	113.66	39.31	0.14
Reach 1	9700	50-Year	169.50	56.43	61.75		61.79	0.000547	1.67	131.97	57.49	0.14
Reach 1	9700	100-Year	191.90	56.43	62.14		62.18	0.000500	1.69	158.10	73.11	0.13
Reach 1	9352	2-Year	75.40	56.19	58.40	58.40	59.20	0.044940	7.21	10.46	6.63	1.01
Reach 1	9352	10-Year	142.80	56.19	59.50	59.48	60.24	0.022912	7.25	25.71	23.04	0.78
Reach 1	9352	25-Year	186.10	56.19	60.38		60.77	0.009771	5.74	53.08	39.21	0.54
Reach 1	9352	50-Year	215.50	56.19	61.09		61.29	0.004713	4.50	84.86	50.03	0.38
Reach 1	9352	100-Year	241.70	56.19	61.67		61.79	0.002754	3.74	115.87	57.26	0.30
Reach 1	9132	2-Year	75.30	53.29	57.88	55.31	57.93	0.001088	1.93	43.20	21.23	0.18
Reach 1	9132	10-Year	143.00	53.29	59.20	56.08	59.27	0.001063	2.37	79.77	34.16	0.19
Reach 1	9132	25-Year	184.50	53.29	60.10	56.47	60.17	0.000827	2.35	114.81	44.34	0.17
Reach 1	9132	50-Year	214.30	53.29	60.86	56.72	60.92	0.000633	2.24	154.33	59.63	0.16
Reach 1	9132	100-Year	237.90	53.29	61.50	56.89	61.54	0.000471	2.06	195.18	72.07	0.14
Reach 1	9068		Culvert									
Reach 1	8990	2-Year	75.30	53.70	57.49	55.87	57.57	0.003095	2.55	43.74	33.40	0.25
Reach 1	8990	10-Year	143.00	53.70	58.36	56.89	58.45	0.003019	2.96	78.72	46.45	0.26
Reach 1	8990	25-Year	184.50	53.70	58.74	57.23	58.84	0.003084	3.17	97.66	53.32	0.27
Reach 1	8990	50-Year	214.30	53.70	58.98	57.42	59.08	0.003113	3.30	110.73	57.58	0.27
Reach 1	8990	100-Year	237.90	53.70	59.15	57.56	59.25	0.003124	3.38	120.92	60.69	0.27
Reach 1	8945.*	2-Year	75.30	53.70	57.28		57.39	0.004630	2.98	36.96	29.94	0.30
Reach 1	8945.*	10-Year	143.00	53.70	58.15		58.28	0.004475	3.47	69.03	43.48	0.31
Reach 1	8945.*	25-Year	184.50	53.70	58.52		58.66	0.004526	3.71	86.34	49.33	0.32
Reach 1	8945.*	50-Year	214.30	53.70	58.75		58.90	0.004585	3.87	98.22	53.50	0.32
Reach 1	8945.*	100-Year	237.90	53.70	58.92		59.07	0.004603	3.98	107.59	56.58	0.33
Reach 1	8900	2-Year	75.30	53.70	56.86		57.07	0.009552	3.87	25.91	23.25	0.43
Reach 1	8900	10-Year	143.00	53.70	57.74		57.97	0.008664	4.48	52.30	37.30	0.43
Reach 1	8900	25-Year	184.50	53.70	58.11		58.36	0.008437	4.73	67.47	43.01	0.43
Reach 1	8900	50-Year	214.30	53.70	58.35		58.59	0.008299	4.89	77.88	46.12	0.43
Reach 1	8900	100-Year	237.90	53.70	58.51		58.77	0.008327	5.03	85.74	49.11	0.43

HEC-RAS Plan: Alternative #2   River: Bells Branch   Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	8764.66*	2-Year	75.30	52.23	55.46		55.70	0.010739	4.02	20.91	14.69	0.44
Reach 1	8764.66*	10-Year	143.00	52.23	56.49		56.77	0.009003	4.63	46.27	34.31	0.43
Reach 1	8764.66*	25-Year	184.50	52.23	56.89		57.18	0.008807	4.91	61.52	41.72	0.43
Reach 1	8764.66*	50-Year	214.30	52.23	57.13		57.43	0.008763	5.10	72.21	46.81	0.44
Reach 1	8764.66*	100-Year	237.90	52.23	57.31		57.62	0.008637	5.20	80.97	50.60	0.44
Reach 1	8629.33*	2-Year	75.30	50.77	54.36		54.53	0.006879	3.39	24.05	12.73	0.35
Reach 1	8629.33*	10-Year	143.00	50.77	55.55		55.77	0.005995	3.99	53.27	40.93	0.35
Reach 1	8629.33*	25-Year	184.50	50.77	55.97		56.19	0.005965	4.25	72.68	52.10	0.35
Reach 1	8629.33*	50-Year	214.30	50.77	56.24		56.46	0.005733	4.33	87.87	58.96	0.35
Reach 1	8629.33*	100-Year	237.90	50.77	56.49		56.69	0.005256	4.29	102.95	65.13	0.34
Reach 1	8494	2-Year	102.90	49.30	53.29		53.52	0.007933	3.86	28.51	12.54	0.37
Reach 1	8494	10-Year	207.20	49.30	54.51		54.80	0.007954	4.76	72.71	66.01	0.39
Reach 1	8494	25-Year	281.40	49.30	55.01		55.28	0.007301	4.89	108.23	75.86	0.38
Reach 1	8494	50-Year	339.70	49.30	55.32		55.58	0.007058	5.01	132.77	81.98	0.38
Reach 1	8494	100-Year	398.30	49.30	55.59		55.84	0.006952	5.13	155.26	87.20	0.38
Reach 1	8367.*	2-Year	102.90	48.57	52.34		52.55	0.007233	3.69	29.65	14.23	0.38
Reach 1	8367.*	10-Year	207.20	48.57	53.43		53.76	0.008366	4.90	61.43	49.32	0.43
Reach 1	8367.*	25-Year	281.40	48.57	53.91		54.27	0.008572	5.34	88.51	64.45	0.44
Reach 1	8367.*	50-Year	339.70	48.57	54.21		54.58	0.008592	5.59	109.88	74.67	0.45
Reach 1	8367.*	100-Year	398.30	48.57	54.51		54.87	0.008290	5.71	133.35	84.38	0.44
Reach 1	8240.*	2-Year	102.90	47.84	51.46		51.65	0.006791	3.53	31.31	18.69	0.38
Reach 1	8240.*	10-Year	207.20	47.84	52.44		52.73	0.007719	4.63	65.74	51.71	0.43
Reach 1	8240.*	25-Year	281.40	47.84	52.93		53.23	0.007518	4.97	94.13	64.32	0.43
Reach 1	8240.*	50-Year	339.70	47.84	53.26		53.56	0.007219	5.13	117.00	72.45	0.43
Reach 1	8240.*	100-Year	398.30	47.84	53.68		53.95	0.006022	4.98	149.89	82.75	0.40
Reach 1	8113	2-Year	102.90	47.11	50.12		50.42	0.014795	4.35	24.18	16.30	0.55
Reach 1	8113	10-Year	207.20	47.11	51.18		51.54	0.011411	5.11	56.43	48.13	0.52
Reach 1	8113	25-Year	281.40	47.11	52.32		52.48	0.004279	3.87	128.99	77.43	0.34
Reach 1	8113	50-Year	339.70	47.11	52.71		52.86	0.003875	3.91	160.75	85.84	0.32
Reach 1	8113	100-Year	398.30	47.11	53.28		53.40	0.002826	3.62	213.08	97.73	0.28
Reach 1	7695	2-Year	102.90	43.34	47.77	45.65	47.89	0.003103	2.80	43.52	20.60	0.26
Reach 1	7695	10-Year	207.20	43.34	49.98	46.67	50.06	0.001489	2.66	123.10	72.26	0.20

HEC-RAS Plan: Alternative #2 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	7695	25-Year	281.40	43.34	51.79	47.29	51.84	0.000689	2.17	206.46	134.52	0.14
Reach 1	7695	50-Year	339.70	43.34	52.29	47.71	52.32	0.000538	2.00	395.93	155.61	0.12
Reach 1	7695	100-Year	398.30	43.34	52.94	48.09	52.97	0.000445	1.92	507.49	187.05	0.11
Reach 1	7630		Culvert									
Reach 1	7545	2-Year	102.90	42.21	45.92	44.16	46.08	0.006026	3.34	35.01	24.20	0.33
Reach 1	7545	10-Year	207.20	42.21	46.79	45.19	47.08	0.008459	4.64	64.38	43.31	0.41
Reach 1	7545	25-Year	281.40	42.21	47.63	46.10	47.85	0.005862	4.38	108.58	61.78	0.35
Reach 1	7545	50-Year	339.70	42.21	49.51	46.57	49.56	0.001311	2.57	263.29	104.00	0.17
Reach 1	7545	100-Year	398.30	42.21	52.48	46.90	52.49	0.000194	1.26	680.65	178.70	0.07
Reach 1	7435	2-Year	101.80	42.65	45.17		45.27	0.008609	2.59	42.92	37.00	0.33
Reach 1	7435	10-Year	203.30	42.65	46.03		46.14	0.007001	2.97	98.20	104.50	0.31
Reach 1	7435	25-Year	271.30	42.65	47.47		47.49	0.001231	1.64	262.59	124.16	0.14
Reach 1	7435	50-Year	335.50	42.65	49.48		49.48	0.000258	0.97	539.39	150.12	0.07
Reach 1	7435	100-Year	396.70	42.65	52.47		52.48	0.000066	0.64	1034.14	209.35	0.04
Reach 1	7020	2-Year	111.50	39.75	43.10		43.15	0.003445	2.03	74.83	60.24	0.21
Reach 1	7020	10-Year	227.10	39.75	45.50		45.52	0.000645	1.32	264.93	97.38	0.10
Reach 1	7020	25-Year	303.40	39.75	47.28		47.29	0.000272	1.04	461.86	124.40	0.07
Reach 1	7020	50-Year	377.30	39.75	49.41		49.42	0.000113	0.80	761.78	156.45	0.05
Reach 1	7020	100-Year	449.40	39.75	52.45		52.46	0.000038	0.57	1299.30	196.73	0.03
Reach 1	6880	2-Year	111.50	39.05	43.05		43.05	0.000237	0.64	178.69	61.34	0.06
Reach 1	6880	10-Year	227.10	39.05	45.47		45.48	0.000146	0.72	359.04	90.86	0.05
Reach 1	6880	25-Year	303.40	39.05	47.26		47.27	0.000093	0.68	549.53	122.16	0.04
Reach 1	6880	50-Year	377.30	39.05	49.40		49.41	0.000051	0.60	850.73	157.35	0.03
Reach 1	6880	100-Year	449.40	39.05	52.45		52.45	0.000022	0.46	1393.18	200.01	0.02
Reach 1	6830	2-Year	111.50	38.85	43.03	39.80	43.04	0.000273	0.68	168.68	58.26	0.06
Reach 1	6830	10-Year	227.10	38.85	45.46	40.20	45.47	0.000165	0.74	346.14	97.28	0.05
Reach 1	6830	25-Year	303.40	38.85	47.25	40.42	47.26	0.000105	0.71	493.01	129.61	0.05
Reach 1	6830	50-Year	377.30	38.85	49.40	40.62	49.40	0.000063	0.65	668.76	168.53	0.04
Reach 1	6830	100-Year	449.40	38.85	52.45	40.80	52.45	0.000033	0.56	918.89	224.92	0.03
Reach 1	6795		Culvert									

HEC-RAS Plan: Alternative #2 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	6760	2-Year	111.50	36.05	38.55	37.67	38.72	0.010047	3.32	33.60	30.58	0.42
Reach 1	6760	10-Year	221.10	36.05	39.51	38.31	39.82	0.010508	4.42	49.99	43.72	0.45
Reach 1	6760	25-Year	285.00	36.05	39.90	38.64	40.29	0.011585	5.04	56.54	45.70	0.49
Reach 1	6760	50-Year	327.60	36.05	40.10	38.83	40.56	0.012612	5.47	59.92	46.73	0.51
Reach 1	6760	100-Year	368.70	36.05	40.26	39.02	40.79	0.013774	5.89	62.64	47.56	0.54
Reach 1	6690	2-Year	111.50	34.85	36.45	36.45	37.08	0.073496	6.39	17.46	14.00	1.01
Reach 1	6690	10-Year	221.10	34.85	37.20	37.20	38.12	0.066479	7.69	28.77	16.67	1.00
Reach 1	6690	25-Year	285.00	34.85	37.63	37.63	38.60	0.054337	7.94	37.95	27.00	0.94
Reach 1	6690	50-Year	327.60	34.85	37.90	37.90	38.87	0.047247	7.99	46.27	34.34	0.89
Reach 1	6690	100-Year	368.70	34.85	38.13	38.13	39.09	0.042790	8.06	54.83	40.53	0.86
Reach 1	6370	2-Year	111.50	28.65	32.60		32.65	0.002243	1.87	71.38	33.11	0.18
Reach 1	6370	10-Year	221.10	28.65	33.79		33.87	0.002682	2.50	112.15	35.76	0.21
Reach 1	6370	25-Year	285.00	28.65	34.35		34.45	0.002814	2.77	132.73	37.03	0.21
Reach 1	6370	50-Year	327.60	28.65	34.71		34.81	0.002862	2.92	146.01	37.83	0.22
Reach 1	6370	100-Year	368.70	28.65	34.99		35.11	0.003063	3.12	157.02	40.80	0.23
Reach 1	5305	2-Year	124.00	22.05	23.98	23.98	24.78	0.097486	7.17	17.29	10.97	1.01
Reach 1	5305	10-Year	245.30	22.05	25.82		26.39	0.034625	6.06	40.49	14.15	0.63
Reach 1	5305	25-Year	309.80	22.05	26.56		27.12	0.028829	6.04	51.32	15.41	0.58
Reach 1	5305	50-Year	354.30	22.05	26.97	25.63	27.55	0.026806	6.13	58.01	27.50	0.57
Reach 1	5305	100-Year	398.50	22.05	27.33	25.86	27.86	0.022423	5.96	85.47	82.73	0.53
Reach 1	5004	2-Year	124.00	16.20	23.38	19.86	23.46	0.000922	2.20	56.28	14.54	0.20
Reach 1	5004	10-Year	245.30	16.20	25.03	21.04	25.17	0.001298	2.97	82.58	17.40	0.24
Reach 1	5004	25-Year	309.80	16.20	25.70	21.54	25.87	0.001402	3.27	95.72	23.59	0.25
Reach 1	5004	50-Year	354.30	16.20	26.09	21.84	26.28	0.001455	3.47	106.33	35.46	0.26
Reach 1	5004	100-Year	398.50	16.20	26.43	22.12	26.63	0.001487	3.64	122.15	58.49	0.27
Reach 1	4962		Bridge									
Reach 1	4907	2-Year	124.00	18.98	23.08	21.37	23.27	0.003028	3.47	35.75	12.58	0.36
Reach 1	4907	10-Year	245.30	18.98	24.66	22.42	24.94	0.003179	4.25	59.39	28.45	0.38
Reach 1	4907	25-Year	309.80	18.98	25.33	22.87	25.63	0.002826	4.46	78.92	51.62	0.37
Reach 1	4907	50-Year	354.30	18.98	25.70	23.16	26.02	0.002730	4.63	91.84	59.88	0.37
Reach 1	4907	100-Year	398.50	18.98	26.01	23.43	26.35	0.002703	4.80	103.53	68.29	0.37

HEC-RAS Plan: Alternative #2 River: Bells Branch Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4720	2-Year	124.00	18.85	21.23	20.82	21.73	0.049745	5.64	21.97	11.72	0.73
Reach 1	4720	10-Year	245.30	18.85	23.33		23.70	0.019224	4.88	50.29	15.22	0.47
Reach 1	4720	25-Year	309.80	18.85	24.25		24.61	0.014176	4.76	66.58	23.31	0.42
Reach 1	4720	50-Year	354.30	18.85	24.68		25.04	0.013009	4.88	77.83	29.79	0.41
Reach 1	4720	100-Year	398.50	18.85	25.00		25.38	0.012732	5.05	88.23	36.28	0.41
Reach 1	4687	2-Year	134.00	18.32	20.30	20.30	21.10	0.009612	7.19	18.64	11.54	1.00
Reach 1	4687	10-Year	287.90	18.32	23.20	21.40	23.58	0.001678	5.01	66.08	35.27	0.44
Reach 1	4687	25-Year	394.80	18.32	24.10	22.03	24.50	0.001433	5.31	103.87	61.41	0.42
Reach 1	4687	50-Year	483.10	18.32	24.44	22.51	24.93	0.001611	5.89	132.33	68.44	0.45
Reach 1	4687	100-Year	570.40	18.32	24.66	23.07	25.25	0.001873	6.53	148.08	73.03	0.49
Reach 1	4348		Culvert									
Reach 1	3887	2-Year	134.00	15.25	18.08	17.54	18.13	0.002501	3.02	105.75	81.23	0.32
Reach 1	3887	10-Year	287.90	15.25	18.93	17.91	18.99	0.002502	3.37	174.81	82.08	0.31
Reach 1	3887	25-Year	394.80	15.25	19.41	18.06	19.47	0.002501	3.53	214.09	82.56	0.31
Reach 1	3887	50-Year	483.10	15.25	19.76	18.19	19.83	0.002502	3.64	243.43	82.91	0.30
Reach 1	3887	100-Year	570.40	15.25	20.09	18.32	20.17	0.002501	3.74	270.60	83.24	0.30

Meetinghouse Branch - Alternative #2

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	14470	2-year	48.00	62.82	65.27		65.36	0.001972	2.49	19.31	10.65	0.33
Reach 1	14470	10-year	83.00	62.82	66.26		66.38	0.001603	2.70	30.69	12.23	0.30
Reach 1	14470	25-year	108.00	62.82	66.99		67.11	0.001301	2.70	40.07	13.40	0.27
Reach 1	14470	50-year	129.00	62.82	67.63		67.74	0.001076	2.64	48.94	14.41	0.25
Reach 1	14470	100-year	152.00	62.82	68.23		68.34	0.000887	2.60	70.00	58.26	0.23
Reach 1	13600	2-year	48.00	61.40	64.12		64.18	0.000979	1.92	24.96	12.20	0.24
Reach 1	13600	10-year	83.00	61.40	65.45		65.51	0.000655	1.93	43.11	15.10	0.20
Reach 1	13600	25-year	108.00	61.40	66.37		66.43	0.000499	1.86	58.40	23.25	0.18
Reach 1	13600	50-year	129.00	61.40	67.15		67.20	0.000379	1.76	89.55	54.97	0.16
Reach 1	13600	100-year	152.00	61.40	67.88		67.92	0.000282	1.66	132.89	65.03	0.14
Reach 1	13285	2-year	48.00	60.29	63.77		63.82	0.001312	1.64	29.28	13.44	0.20
Reach 1	13285	10-year	83.00	60.29	65.23		65.27	0.000852	1.61	51.69	17.44	0.16
Reach 1	13285	25-year	108.00	60.29	66.20		66.24	0.000640	1.54	70.05	20.13	0.15
Reach 1	13285	50-year	129.00	60.29	67.02		67.06	0.000504	1.47	87.49	22.39	0.13
Reach 1	13285	100-year	152.00	60.29	67.77		67.81	0.000414	1.44	113.06	89.80	0.12
Reach 1	13233	2-year	76.00	60.29	63.53	62.23	63.66	0.004520	2.92	26.04	12.76	0.36
Reach 1	13233	10-year	132.00	60.29	65.05	62.85	65.16	0.002532	2.71	48.68	16.95	0.28
Reach 1	13233	25-year	170.00	60.29	66.07	63.20	66.16	0.001764	2.53	67.30	19.75	0.24
Reach 1	13233	50-year	204.00	60.29	66.91	63.46	67.00	0.001368	2.40	84.88	22.06	0.22
Reach 1	13233	100-year	241.00	60.29	67.67	63.74	67.75	0.001125	2.35	105.55	40.05	0.20
Reach 1	13137 Charles Blvd		Culvert									
Reach 1	13045	2-year	76.00	59.31	63.53	61.28	63.61	0.001040	2.27	33.48	12.20	0.24
Reach 1	13045	10-year	132.00	59.31	64.91	61.98	65.01	0.000956	2.52	52.29	15.00	0.24
Reach 1	13045	25-year	170.00	59.31	65.74	62.37	65.85	0.000874	2.60	65.44	16.68	0.23
Reach 1	13045	50-year	204.00	59.31	66.39	62.68	66.50	0.000828	2.66	76.60	17.98	0.23
Reach 1	13045	100-year	241.00	59.31	66.90	62.99	67.02	0.000847	2.80	86.14	19.02	0.23
Reach 1	12995	2-year	76.00	59.31	63.47		63.55	0.001100	2.32	32.78	12.09	0.25
Reach 1	12995	10-year	132.00	59.31	64.86		64.96	0.000995	2.56	51.51	14.89	0.24
Reach 1	12995	25-year	170.00	59.31	65.69		65.80	0.000902	2.63	64.65	16.58	0.23
Reach 1	12995	50-year	204.00	59.31	66.34		66.45	0.000852	2.69	75.80	17.89	0.23
Reach 1	12995	100-year	241.00	59.31	66.86		66.98	0.000870	2.83	85.27	18.93	0.23
Reach 1	12695	2-year	76.00	58.30	63.19		63.24	0.000957	1.62	46.87	16.87	0.17
Reach 1	12695	10-year	132.00	58.30	64.62		64.67	0.000858	1.79	73.92	21.07	0.17
Reach 1	12695	25-year	170.00	58.30	65.49		65.54	0.000766	1.82	93.25	23.62	0.16

HEC-RAS Plan: Alternative #2   River: Meeting House   Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	12695	50-year	204.00	58.30	66.15		66.20	0.000718	1.86	109.57	25.57	0.16
Reach 1	12695	100-year	241.00	58.30	66.66		66.72	0.000736	1.96	123.08	27.08	0.16
Reach 1	12280	2-year	146.00	58.35	61.77		62.04	0.007182	4.20	34.74	12.32	0.44
Reach 1	12280	10-year	259.00	58.35	63.19		63.55	0.006905	4.84	53.50	14.11	0.44
Reach 1	12280	25-year	339.00	58.35	64.15		64.53	0.005988	5.00	70.62	25.31	0.42
Reach 1	12280	50-year	408.00	58.35	64.93		65.30	0.005043	4.96	95.95	39.37	0.39
Reach 1	12280	100-year	484.00	58.35	65.41		65.80	0.005034	5.22	117.32	52.84	0.39
Reach 1	12225	2-year	146.00	55.91	61.73		61.81	0.001743	2.38	61.34	19.86	0.24
Reach 1	12225	10-year	259.00	55.91	63.19		63.31	0.001771	2.76	93.67	24.41	0.25
Reach 1	12225	25-year	339.00	55.91	64.19		64.31	0.001481	2.84	124.04	37.64	0.23
Reach 1	12225	50-year	408.00	55.91	64.98		65.10	0.001278	2.85	158.56	49.19	0.22
Reach 1	12225	100-year	484.00	55.91	65.46		65.60	0.001336	3.04	185.33	65.97	0.23
Reach 1	12070	2-year	146.00	56.84	61.43		61.53	0.002009	2.46	59.39	21.23	0.26
Reach 1	12070	10-year	259.00	56.84	62.92		63.04	0.001739	2.73	95.06	27.09	0.25
Reach 1	12070	25-year	339.00	56.84	63.97		64.09	0.001382	2.74	126.07	31.89	0.23
Reach 1	12070	50-year	408.00	56.84	64.79		64.91	0.001188	2.75	155.98	40.93	0.22
Reach 1	12070	100-year	484.00	56.84	65.26		65.40	0.001266	2.95	176.38	46.19	0.23
Reach 1	11775	2-year	146.00	57.05	60.98		61.05	0.001293	2.03	73.01	27.90	0.21
Reach 1	11775	10-year	259.00	57.05	62.57		62.64	0.000976	2.16	132.03	46.65	0.20
Reach 1	11775	25-year	339.00	57.05	63.74		63.81	0.000630	2.08	210.12	83.60	0.16
Reach 1	11775	50-year	408.00	57.05	64.62		64.68	0.000481	2.03	289.58	96.67	0.15
Reach 1	11775	100-year	484.00	57.05	65.09		65.15	0.000498	2.17	336.22	103.56	0.15
Reach 1	11500	2-year	146.00	55.23	60.68		60.74	0.000980	2.02	72.79	20.44	0.18
Reach 1	11500	10-year	259.00	55.23	62.27		62.36	0.001047	2.48	110.25	28.25	0.19
Reach 1	11500	25-year	339.00	55.23	63.51		63.60	0.000838	2.54	158.14	51.86	0.18
Reach 1	11500	50-year	408.00	55.23	64.42		64.52	0.000711	2.57	214.76	71.13	0.17
Reach 1	11500	100-year	484.00	55.23	64.87		64.98	0.000779	2.80	248.45	79.75	0.18
Reach 1	11380	2-year	146.00	56.65	60.44		60.55	0.002490	2.74	55.79	24.58	0.29
Reach 1	11380	10-year	259.00	56.65	62.08		62.21	0.001587	2.88	112.46	57.77	0.25
Reach 1	11380	25-year	339.00	56.65	63.40		63.50	0.000916	2.62	207.53	86.41	0.20
Reach 1	11380	50-year	408.00	56.65	64.35		64.43	0.000685	2.52	307.88	131.16	0.17
Reach 1	11380	100-year	484.00	56.65	64.80		64.88	0.000695	2.65	370.09	145.44	0.18
Reach 1	11180	2-year	146.00	56.05	59.88		60.01	0.002953	2.90	50.36	18.28	0.31
Reach 1	11180	10-year	259.00	56.05	61.76		61.89	0.001570	2.94	101.89	38.80	0.24

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	11180	25-year	339.00	56.05	63.20		63.31	0.000934	2.72	184.13	77.69	0.20
Reach 1	11180	50-year	408.00	56.05	64.20		64.29	0.000703	2.62	276.07	116.02	0.17
Reach 1	11180	100-year	484.00	56.05	64.63		64.74	0.000756	2.83	334.49	152.45	0.18
Reach 1	11130	2-year	146.00	54.75	59.76	57.27	59.89	0.002102	2.95	58.43	26.45	0.26
Reach 1	11130	10-year	259.00	54.75	61.69	58.21	61.82	0.001393	3.13	127.50	45.28	0.23
Reach 1	11130	25-year	339.00	54.75	63.16	58.75	63.26	0.000881	2.89	205.32	73.37	0.19
Reach 1	11130	50-year	408.00	54.75	64.15	59.19	64.25	0.000757	2.91	296.72	100.24	0.18
Reach 1	11130	100-year	484.00	54.75	64.58	59.65	64.69	0.000859	3.20	345.14	128.20	0.19
Reach 1	11075 Tucker Dr		Culvert									
Reach 1	11000	2-year	146.00	54.41	59.49	56.71	59.59	0.001493	2.78	74.33	30.71	0.23
Reach 1	11000	10-year	259.00	54.41	60.64	57.66	60.81	0.001890	3.63	110.45	39.78	0.27
Reach 1	11000	25-year	339.00	54.41	61.24	58.23	61.45	0.002154	4.14	130.60	44.52	0.29
Reach 1	11000	50-year	408.00	54.41	61.68	58.68	61.94	0.002390	4.56	146.40	50.06	0.31
Reach 1	11000	100-year	484.00	54.41	62.14	59.11	62.43	0.002584	4.95	186.11	59.39	0.32
Reach 1	10940	2-year	146.00	54.41	59.38		59.50	0.001640	2.87	71.23	29.89	0.24
Reach 1	10940	10-year	259.00	54.41	60.49		60.68	0.002122	3.79	109.38	38.66	0.28
Reach 1	10940	25-year	339.00	54.41	61.08		61.31	0.002409	4.31	133.22	43.25	0.30
Reach 1	10940	50-year	408.00	54.41	61.51		61.78	0.002632	4.71	152.83	47.53	0.32
Reach 1	10940	100-year	484.00	54.41	61.94		62.26	0.002896	5.15	174.67	55.37	0.34
Reach 1	10670	2-year	146.00	52.63	58.97		59.05	0.001586	2.44	75.33	38.08	0.21
Reach 1	10670	10-year	259.00	52.63	59.97		60.10	0.002031	3.15	123.19	60.72	0.25
Reach 1	10670	25-year	339.00	52.63	60.51		60.67	0.002193	3.51	158.48	69.97	0.26
Reach 1	10670	50-year	408.00	52.63	60.92		61.09	0.002271	3.75	188.75	76.57	0.27
Reach 1	10670	100-year	484.00	52.63	61.33		61.52	0.002322	3.97	221.80	83.21	0.28
Reach 1	10500	2-year	184.00	55.05	58.59		58.71	0.002389	2.89	71.64	37.35	0.30
Reach 1	10500	10-year	329.00	55.05	59.48		59.68	0.002824	3.75	110.41	49.40	0.34
Reach 1	10500	25-year	430.00	55.05	59.97		60.21	0.003040	4.22	136.00	56.72	0.36
Reach 1	10500	50-year	519.00	55.05	60.34		60.62	0.003178	4.56	158.24	62.39	0.37
Reach 1	10500	100-year	617.00	55.05	60.72		61.03	0.003261	4.86	183.19	68.20	0.38
Reach 1	10250	2-year	184.00	54.45	57.07		57.46	0.015245	5.03	36.61	22.40	0.69
Reach 1	10250	10-year	329.00	54.45	58.24		58.57	0.007964	4.71	82.42	48.07	0.53
Reach 1	10250	25-year	430.00	54.45	58.86		59.16	0.006112	4.64	113.62	53.31	0.48
Reach 1	10250	50-year	519.00	54.45	59.32		59.62	0.005189	4.71	139.04	58.36	0.45
Reach 1	10250	100-year	617.00	54.45	59.77		60.08	0.004597	4.82	166.25	63.32	0.43

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	10125	2-year	184.00	52.75	56.81		56.91	0.001616	2.55	83.24	42.62	0.24
Reach 1	10125	10-year	329.00	52.75	57.99		58.12	0.001630	3.11	143.62	59.67	0.25
Reach 1	10125	25-year	430.00	52.75	58.61		58.76	0.001653	3.40	183.25	68.53	0.26
Reach 1	10125	50-year	519.00	52.75	59.07		59.24	0.001701	3.65	216.44	78.04	0.27
Reach 1	10125	100-year	617.00	52.75	59.52		59.70	0.001734	3.87	254.59	90.70	0.27
Reach 1	10000	2-year	184.00	52.55	56.62		56.71	0.001564	2.51	86.47	42.66	0.24
Reach 1	10000	10-year	329.00	52.55	57.79		57.92	0.001593	3.07	144.65	56.77	0.25
Reach 1	10000	25-year	430.00	52.55	58.40		58.55	0.001637	3.38	181.77	64.42	0.26
Reach 1	10000	50-year	519.00	52.55	58.86		59.02	0.001689	3.63	212.12	70.11	0.27
Reach 1	10000	100-year	617.00	52.55	59.30		59.48	0.001763	3.90	245.00	78.93	0.28
Reach 1	9930	2-year	184.00	51.47	56.55		56.61	0.000993	2.06	100.47	51.72	0.19
Reach 1	9930	10-year	329.00	51.47	57.73		57.82	0.001021	2.53	173.83	72.51	0.21
Reach 1	9930	25-year	430.00	51.47	58.35		58.45	0.001045	2.78	221.76	83.20	0.21
Reach 1	9930	50-year	519.00	51.47	58.80		58.91	0.001073	2.98	261.22	90.91	0.22
Reach 1	9930	100-year	617.00	51.47	59.24		59.37	0.001099	3.16	303.37	98.59	0.22
Reach 1	9745	2-year	184.00	52.15	56.32		56.40	0.001363	2.39	102.99	58.57	0.22
Reach 1	9745	10-year	329.00	52.15	57.49		57.60	0.001381	2.90	186.38	86.89	0.23
Reach 1	9745	25-year	430.00	52.15	58.10		58.23	0.001402	3.17	244.94	104.90	0.24
Reach 1	9745	50-year	519.00	52.15	58.55		58.69	0.001427	3.37	294.99	118.14	0.25
Reach 1	9745	100-year	617.00	52.15	58.99		59.14	0.001448	3.57	350.15	133.07	0.25
Reach 1	9400	2-year	184.00	51.45	55.96		56.02	0.000863	2.02	144.12	86.63	0.18
Reach 1	9400	10-year	329.00	51.45	57.15		57.22	0.000858	2.39	266.73	124.11	0.19
Reach 1	9400	25-year	430.00	51.45	57.76		57.83	0.000868	2.59	350.74	150.98	0.19
Reach 1	9400	50-year	519.00	51.45	58.21		58.29	0.000872	2.73	422.77	169.09	0.19
Reach 1	9400	100-year	617.00	51.45	58.65		58.73	0.000868	2.85	501.90	186.60	0.19
Reach 1	9050	2-year	301.00	50.85	55.43		55.55	0.001904	3.03	169.15	91.58	0.26
Reach 1	9050	10-year	551.00	50.85	56.56		56.71	0.002106	3.75	285.11	114.12	0.29
Reach 1	9050	25-year	728.00	50.85	57.12		57.30	0.002292	4.19	352.15	124.67	0.31
Reach 1	9050	50-year	883.00	50.85	57.52		57.73	0.002455	4.54	404.34	131.79	0.32
Reach 1	9050	100-year	1052.00	50.85	57.93		58.17	0.002585	4.86	459.86	138.97	0.33
Reach 1	8965	2-year	301.00	50.65	55.24		55.37	0.002139	3.17	155.81	92.21	0.28
Reach 1	8965	10-year	551.00	50.65	56.35		56.52	0.002336	3.90	267.95	109.96	0.30
Reach 1	8965	25-year	728.00	50.65	56.88		57.09	0.002577	4.37	329.33	118.82	0.32
Reach 1	8965	50-year	883.00	50.65	57.27		57.51	0.002817	4.77	376.43	127.80	0.34

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	8965	100-year	1052.00	50.65	57.66		57.93	0.002999	5.13	428.14	136.98	0.36
Reach 1	8885	2-year	301.00	49.71	54.68		55.06	0.007050	5.11	78.26	67.82	0.45
Reach 1	8885	10-year	551.00	49.71	55.75		56.20	0.007071	6.00	183.72	128.74	0.47
Reach 1	8885	25-year	728.00	49.71	56.37		56.77	0.006257	6.10	269.32	148.15	0.45
Reach 1	8885	50-year	883.00	49.71	56.79		57.17	0.006003	6.27	333.82	160.43	0.45
Reach 1	8885	100-year	1052.00	49.71	57.23		57.60	0.005592	6.34	407.78	173.42	0.44
Reach 1	8750	2-year	301.00	49.95	54.30		54.46	0.002546	3.35	142.28	126.01	0.29
Reach 1	8750	10-year	551.00	49.95	55.44		55.60	0.002340	3.78	297.71	146.97	0.29
Reach 1	8750	25-year	728.00	49.95	56.06		56.22	0.002251	3.99	392.24	158.36	0.29
Reach 1	8750	50-year	882.00	49.95	56.46		56.63	0.002336	4.25	456.71	165.53	0.30
Reach 1	8750	100-year	1051.00	49.95	56.89		57.08	0.002329	4.44	530.75	172.94	0.30
Reach 1	8469	2-year	301.00	47.54	53.66		53.80	0.002191	3.35	159.34	97.70	0.28
Reach 1	8469	10-year	551.00	47.54	54.76		54.94	0.002451	4.08	285.38	125.92	0.30
Reach 1	8469	25-year	728.00	47.54	55.37		55.56	0.002500	4.41	365.96	136.93	0.31
Reach 1	8469	50-year	882.00	47.54	55.69		55.92	0.002826	4.85	411.19	142.73	0.33
Reach 1	8469	100-year	1051.00	47.54	56.11		56.35	0.002920	5.14	472.31	150.00	0.34
Reach 1	7993	2-year	301.00	46.71	51.77	50.02	52.15	0.006032	5.04	70.93	35.81	0.44
Reach 1	7993	10-year	551.00	46.71	53.56	51.49	53.74	0.002577	4.20	328.29	179.09	0.31
Reach 1	7993	25-year	728.00	46.71	54.32	52.78	54.47	0.002064	4.08	471.30	196.82	0.28
Reach 1	7993	50-year	882.00	46.71	54.26		54.48	0.003212	5.06	459.31	195.50	0.35
Reach 1	7993	100-year	1051.00	46.71	54.75		54.95	0.002915	5.05	557.24	206.06	0.34
Reach 1	7943	2-year	301.00	46.71	50.04	50.04	51.29	0.035234	8.95	33.63	13.40	1.00
Reach 1	7943	10-year	551.00	46.71	51.48	51.48	53.03	0.026412	10.06	61.48	30.70	0.91
Reach 1	7943	25-year	728.00	46.71	52.45	52.45	53.85	0.018951	9.90	100.46	150.59	0.80
Reach 1	7943	50-year	882.00	46.71	53.98	52.91	54.27	0.004243	5.65	405.31	189.38	0.40
Reach 1	7943	100-year	1051.00	46.71	54.53	53.33	54.78	0.003551	5.46	512.23	201.27	0.37
Reach 1	7897 14th St		Culvert									
Reach 1	7843	2-year	301.00	45.75	50.06	48.88	50.22	0.004096	3.60	112.42	174.25	0.33
Reach 1	7843	10-year	551.00	45.75	50.69	49.55	51.00	0.006839	5.18	141.73	178.69	0.44
Reach 1	7843	25-year	728.00	45.75	51.05	49.91	51.46	0.008531	6.10	158.07	181.92	0.50
Reach 1	7843	50-year	882.00	45.75	51.31	50.20	51.83	0.009919	6.82	170.36	188.04	0.54
Reach 1	7843	100-year	1051.00	45.75	51.76	50.49	51.81	0.001363	2.68	641.47	198.51	0.20
Reach 1	7788	2-year	301.00	45.75	50.04		50.06	0.000847	1.63	327.07	174.10	0.15

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	7788	10-year	551.00	45.75	50.71		50.74	0.001126	2.11	444.13	178.78	0.18
Reach 1	7788	25-year	728.00	45.75	51.09		51.13	0.001264	2.36	513.44	182.97	0.19
Reach 1	7788	50-year	882.00	45.75	51.39		51.43	0.001367	2.56	568.83	189.85	0.20
Reach 1	7788	100-year	1051.00	45.75	51.68		51.74	0.001465	2.75	625.80	196.67	0.21
Reach 1	7522	2-year	301.00	45.77	49.73		49.75	0.001755	1.88	279.61	199.15	0.19
Reach 1	7522	10-year	551.00	45.77	50.31		50.35	0.002002	2.27	398.13	204.22	0.21
Reach 1	7522	25-year	728.00	45.77	50.67		50.71	0.002090	2.47	470.43	207.71	0.22
Reach 1	7522	50-year	882.00	45.77	50.94		50.99	0.002154	2.63	527.51	210.42	0.23
Reach 1	7522	100-year	1051.00	45.77	51.21		51.27	0.002218	2.78	585.38	213.13	0.23
Reach 1	7281	2-year	301.00	45.67	49.23		49.25	0.002391	2.08	283.91	277.64	0.23
Reach 1	7281	10-year	551.00	45.67	49.85		49.88	0.001920	2.15	460.87	292.49	0.21
Reach 1	7281	25-year	728.00	45.67	50.21		50.24	0.001787	2.22	567.41	299.56	0.21
Reach 1	7281	50-year	882.00	45.67	50.49		50.52	0.001722	2.29	651.34	304.06	0.20
Reach 1	7281	100-year	1051.00	45.67	50.76		50.80	0.001685	2.37	735.57	308.51	0.20
Reach 1	7088	2-year	301.00	44.75	48.74		48.78	0.002489	2.38	227.86	168.59	0.24
Reach 1	7088	10-year	551.00	44.75	49.38		49.43	0.002728	2.84	340.22	183.00	0.26
Reach 1	7088	25-year	728.00	44.75	49.73		49.80	0.002870	3.10	407.17	191.06	0.27
Reach 1	7088	50-year	882.00	44.75	50.01		50.08	0.002982	3.30	460.16	197.21	0.28
Reach 1	7088	100-year	1051.00	44.75	50.27		50.36	0.003104	3.51	513.23	201.64	0.29
Reach 1	6769	2-year	301.00	43.69	46.83	46.83	47.16	0.014474	5.91	112.58	168.30	0.74
Reach 1	6769	10-year	551.00	43.69	47.17	47.17	47.59	0.017973	7.30	171.27	183.50	0.85
Reach 1	6769	25-year	728.00	43.69	47.35	47.35	47.83	0.020024	8.10	204.81	191.65	0.90
Reach 1	6769	50-year	882.00	43.69	47.49	47.49	48.02	0.021370	8.68	231.99	198.00	0.94
Reach 1	6769	100-year	1051.00	43.69	47.63	47.63	48.21	0.022263	9.19	261.51	204.68	0.97
Reach 1	6315	2-year	301.00	36.65	41.18		41.35	0.002866	3.24	92.93	29.89	0.32
Reach 1	6315	10-year	551.00	36.65	42.73		42.96	0.002895	3.83	143.84	35.95	0.34
Reach 1	6315	25-year	728.00	36.65	43.50		43.78	0.003017	4.22	173.58	45.68	0.35
Reach 1	6315	50-year	882.00	36.65	44.02		44.34	0.003144	4.56	201.42	61.54	0.36
Reach 1	6315	100-year	1051.00	36.65	44.51		44.88	0.003285	4.89	241.69	101.02	0.38
Reach 1	6004	2-year	301.00	34.68	40.12		40.33	0.003696	3.70	81.36	24.77	0.36
Reach 1	6004	10-year	551.00	34.68	41.55		41.87	0.004210	4.57	123.99	39.69	0.40
Reach 1	6004	25-year	728.00	34.68	42.21		42.61	0.004622	5.13	152.81	47.56	0.42
Reach 1	6004	50-year	882.00	34.68	42.67		43.13	0.004799	5.56	188.22	88.25	0.44
Reach 1	6004	100-year	1051.00	34.68	43.10		43.62	0.004926	5.95	228.68	98.50	0.45

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	5630	2-year	301.00	33.32	39.02		39.18	0.002559	3.23	93.24	28.66	0.30
Reach 1	5630	10-year	551.00	33.32	40.28		40.54	0.002999	4.18	164.95	107.53	0.34
Reach 1	5630	25-year	728.00	33.32	40.90		41.20	0.003053	4.59	237.92	127.42	0.36
Reach 1	5630	50-year	882.00	33.32	41.37		41.69	0.003051	4.86	300.50	142.28	0.36
Reach 1	5630	100-year	1051.00	33.32	41.81		42.15	0.003056	5.11	366.71	156.48	0.37
Reach 1	5260	2-year	301.00	31.95	38.18		38.29	0.002132	2.77	153.76	105.85	0.24
Reach 1	5260	10-year	551.00	31.95	39.50		39.61	0.001920	3.15	330.77	161.88	0.24
Reach 1	5260	25-year	728.00	31.95	40.14		40.26	0.001887	3.37	443.40	188.80	0.24
Reach 1	5260	50-year	882.00	31.95	40.62		40.75	0.001882	3.53	539.87	214.83	0.24
Reach 1	5260	100-year	1051.00	31.95	41.08		41.21	0.001862	3.68	643.65	237.13	0.24
Reach 1	4765	2-year	301.00	30.39	37.14		37.25	0.002087	2.84	132.79	54.35	0.23
Reach 1	4765	10-year	551.00	30.39	38.31		38.49	0.002687	3.75	229.94	98.89	0.27
Reach 1	4765	25-year	728.00	30.39	38.84		39.07	0.003123	4.28	286.36	111.77	0.30
Reach 1	4765	50-year	882.00	30.39	39.24		39.50	0.003454	4.68	331.94	121.50	0.32
Reach 1	4765	100-year	1051.00	30.39	39.63		39.92	0.003740	5.06	381.80	132.49	0.33
Reach 1	4230	2-year	301.00	28.77	33.97		34.02	0.001648	2.22	254.69	208.75	0.20
Reach 1	4230	10-year	551.00	28.77	35.33		35.35	0.000706	1.70	544.33	217.66	0.13
Reach 1	4230	25-year	728.00	28.77	36.14		36.16	0.000525	1.59	732.48	274.78	0.12
Reach 1	4230	50-year	882.00	28.77	36.77		36.79	0.000433	1.55	910.75	284.64	0.11
Reach 1	4230	100-year	1051.00	28.77	37.52		37.54	0.000342	1.49	1128.26	296.22	0.10
Reach 1	3840	2-year	301.00	26.71	33.52		33.56	0.000853	1.91	212.82	83.89	0.15
Reach 1	3840	10-year	551.00	26.71	35.00		35.05	0.000798	2.18	374.55	123.43	0.15
Reach 1	3840	25-year	728.00	26.71	35.85		35.91	0.000754	2.30	485.16	135.71	0.15
Reach 1	3840	50-year	882.00	26.71	36.52		36.57	0.000725	2.38	578.68	146.92	0.15
Reach 1	3840	100-year	1051.00	26.71	37.30		37.36	0.000652	2.41	699.25	160.77	0.14
Reach 1	3610	2-year	301.00	27.30	33.02		33.29	0.001498	4.17	83.85	27.15	0.33
Reach 1	3610	10-year	551.00	27.30	34.17		34.71	0.002369	6.03	129.82	58.87	0.43
Reach 1	3610	25-year	728.00	27.30	34.89		35.56	0.002627	6.84	179.48	79.81	0.46
Reach 1	3610	50-year	882.00	27.30	35.50		36.22	0.002657	7.28	233.46	97.84	0.47
Reach 1	3610	100-year	1051.00	27.30	36.37		37.04	0.002259	7.24	331.30	127.67	0.44
Reach 1	3507	2-year	320.00	28.00	33.02	30.27	33.11	0.000620	2.52	145.32	57.98	0.22
Reach 1	3507	10-year	590.00	28.00	34.23	31.24	34.40	0.000799	3.42	227.53	80.66	0.27
Reach 1	3507	25-year	780.00	28.00	34.98	31.74	35.19	0.000840	3.84	285.34	97.33	0.28
Reach 1	3507	50-year	946.00	28.00	35.60	32.13	35.84	0.000849	4.13	336.18	110.19	0.29
Reach 1	3507	100-year	1129.00	28.00	36.47	32.53	36.71	0.000755	4.23	411.34	128.02	0.28

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	3490 King George Rd		Bridge									
Reach 1	3401	2-year	320.00	28.00	32.94	30.26	33.05	0.000662	2.57	137.06	50.96	0.23
Reach 1	3401	10-year	590.00	28.00	34.12	31.23	34.31	0.000882	3.55	206.55	67.72	0.28
Reach 1	3401	25-year	780.00	28.00	34.85	31.73	35.09	0.000945	4.02	260.43	79.68	0.30
Reach 1	3401	50-year	946.00	28.00	35.45	32.12	35.72	0.000964	4.34	311.15	89.49	0.30
Reach 1	3401	100-year	1129.00	28.00	36.09	32.52	36.40	0.000975	4.65	372.70	108.72	0.31
Reach 1	3280	2-year	331.00	26.55	32.81		32.94	0.000871	3.38	245.22	123.60	0.26
Reach 1	3280	10-year	624.00	26.55	34.00		34.19	0.001117	4.39	408.31	151.79	0.31
Reach 1	3280	25-year	834.00	26.55	34.74		34.95	0.001143	4.78	526.43	165.69	0.32
Reach 1	3280	50-year	1018.00	26.55	35.35		35.57	0.001132	5.03	631.96	179.00	0.32
Reach 1	3280	100-year	1223.00	26.55	36.01		36.23	0.001094	5.22	753.80	193.14	0.32
Reach 1	2850	2-year	338.00	26.15	32.37		32.55	0.000933	3.45	105.91	27.25	0.27
Reach 1	2850	10-year	643.00	26.15	33.00		33.49	0.002232	5.77	123.75	29.82	0.43
Reach 1	2850	25-year	863.00	26.15	33.32		34.10	0.003298	7.27	133.55	31.15	0.52
Reach 1	2850	50-year	1058.00	26.15	33.53		34.61	0.004372	8.57	140.22	32.02	0.61
Reach 1	2850	100-year	1275.00	26.15	33.69		35.17	0.005791	10.03	145.37	32.68	0.70
Reach 1	2590	2-year	338.00	25.38	32.40		32.42	0.000166	1.58	442.06	205.09	0.12
Reach 1	2590	10-year	643.00	25.38	33.16		33.20	0.000275	2.22	606.92	227.32	0.16
Reach 1	2590	25-year	863.00	25.38	33.64		33.69	0.000321	2.53	719.40	241.31	0.17
Reach 1	2590	50-year	1058.00	25.38	34.03		34.08	0.000350	2.74	815.90	252.69	0.18
Reach 1	2590	100-year	1275.00	25.38	34.43		34.49	0.000377	2.96	920.14	268.05	0.19
Reach 1	2280	2-year	338.00	24.65	32.34		32.37	0.000130	1.63	368.80	122.66	0.11
Reach 1	2280	10-year	643.00	24.65	33.03		33.10	0.000297	2.63	460.45	145.89	0.17
Reach 1	2280	25-year	863.00	24.65	33.47		33.57	0.000395	3.15	526.76	155.71	0.20
Reach 1	2280	50-year	1058.00	24.65	33.83		33.95	0.000466	3.53	584.07	162.63	0.22
Reach 1	2280	100-year	1275.00	24.65	34.20		34.34	0.000532	3.89	645.80	169.85	0.24
Reach 1	2145	2-year	338.00	23.85	32.25		32.34	0.000440	2.36	146.78	43.96	0.19
Reach 1	2145	10-year	643.00	23.85	32.77		33.02	0.001104	4.00	183.04	94.75	0.30
Reach 1	2145	25-year	863.00	23.85	33.07		33.44	0.001596	4.98	216.03	124.05	0.37
Reach 1	2145	50-year	1058.00	23.85	33.32		33.80	0.001972	5.70	249.05	134.21	0.41
Reach 1	2145	100-year	1275.00	23.85	33.60		34.16	0.002311	6.35	285.93	138.42	0.45
Reach 1	2045	2-year	338.00	23.25	32.23	26.84	32.27	0.000400	1.72	196.37	62.41	0.17
Reach 1	2045	10-year	643.00	23.25	32.73	27.97	32.85	0.001067	2.77	232.60	82.49	0.28

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	2045	25-year	863.00	23.25	33.02	28.64	33.20	0.001436	3.38	258.45	93.68	0.33
Reach 1	2045	50-year	1058.00	23.25	33.26	29.17	33.49	0.001716	3.85	282.48	102.99	0.36
Reach 1	2045	100-year	1275.00	23.25	33.53	29.73	33.81	0.001971	4.29	310.79	112.98	0.39
Reach 1	2037 Railroad Crossin		Bridge									
Reach 1	1970	2-year	338.00	23.05	32.20	26.65	32.24	0.000379	1.63	207.72	69.54	0.17
Reach 1	1970	10-year	643.00	23.05	32.65	27.77	32.76	0.000945	2.66	241.82	85.86	0.27
Reach 1	1970	25-year	863.00	23.05	32.90	28.44	33.07	0.001328	3.30	262.40	94.66	0.32
Reach 1	1970	50-year	1058.00	23.05	33.12	28.97	33.34	0.001647	3.80	279.58	101.90	0.36
Reach 1	1970	100-year	1275.00	23.05	33.34	29.52	33.63	0.001975	4.30	297.75	109.48	0.39
Reach 1	1890	2-year	335.00	23.05	32.20		32.22	0.000069	1.26	388.43	128.29	0.08
Reach 1	1890	10-year	641.00	23.05	32.64		32.70	0.000195	2.19	447.45	138.71	0.14
Reach 1	1890	25-year	860.00	23.05	32.89		32.99	0.000302	2.78	483.52	144.63	0.17
Reach 1	1890	50-year	1055.00	23.05	33.10		33.24	0.000402	3.27	514.27	149.48	0.20
Reach 1	1890	100-year	1271.00	23.05	33.32		33.50	0.000516	3.76	547.62	154.58	0.22
Reach 1	1727	2-year	335.00	26.56	32.19		32.21	0.000101	1.17	303.93	106.04	0.09
Reach 1	1727	10-year	641.00	26.56	32.60		32.67	0.000276	2.03	349.29	111.09	0.16
Reach 1	1727	25-year	860.00	26.56	32.84		32.94	0.000431	2.58	375.59	114.83	0.20
Reach 1	1727	50-year	1055.00	26.56	33.02		33.16	0.000581	3.03	397.33	117.96	0.23
Reach 1	1727	100-year	1271.00	26.56	33.22		33.40	0.000753	3.49	420.44	121.20	0.26
Reach 1	1590	2-year	335.00	26.53	32.19	27.36	32.20	0.000022	0.59	610.85	159.45	0.05
Reach 1	1590	10-year	641.00	26.53	32.62	27.77	32.64	0.000061	1.03	681.05	167.09	0.08
Reach 1	1590	25-year	860.00	26.53	32.86	28.01	32.89	0.000094	1.32	722.26	171.04	0.10
Reach 1	1590	50-year	1055.00	26.53	33.06	28.22	33.10	0.000125	1.56	756.36	174.24	0.11
Reach 1	1590	100-year	1271.00	26.53	33.27	28.42	33.32	0.000161	1.81	792.59	177.58	0.13
Reach 1	100		Inl Struct									
Reach 1	-50	2-year	335.00	17.55	22.34		22.37	0.000900	2.24	266.92	83.19	0.18
Reach 1	-50	10-year	641.00	17.55	24.57		24.60	0.000606	2.15	468.32	129.01	0.14
Reach 1	-50	25-year	860.00	17.55	25.65		25.69	0.000552	2.26	649.60	206.03	0.14
Reach 1	-50	50-year	1055.00	17.55	26.47		26.51	0.000499	2.29	842.48	264.40	0.14
Reach 1	-50	100-year	1271.00	17.55	27.26		27.29	0.000449	2.30	1070.94	320.04	0.13
Reach 1	-172	2-year	335.00	13.25	22.34		22.35	0.000018	0.73	545.23	148.06	0.05
Reach 1	-172	10-year	641.00	13.25	24.56		24.58	0.000023	1.00	1007.24	287.49	0.06
Reach 1	-172	25-year	860.00	13.25	25.64		25.66	0.000026	1.14	1364.91	374.33	0.06

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	-172	50-year	1055.00	13.25	26.46		26.48	0.000027	1.23	1688.65	415.01	0.06
Reach 1	-172	100-year	1271.00	13.25	27.24		27.26	0.000029	1.32	2025.61	450.27	0.07
Reach 1	-267	2-year	335.00	13.25	22.34	15.76	22.35	0.000019	0.75	462.54	113.43	0.05
Reach 1	-267	10-year	641.00	13.25	24.56	16.47	24.57	0.000027	1.08	626.73	193.85	0.06
Reach 1	-267	25-year	860.00	13.25	25.63	16.86	25.66	0.000034	1.29	706.25	296.14	0.07
Reach 1	-267	50-year	1055.00	13.25	26.45	17.17	26.48	0.000032	1.33	1361.14	340.79	0.07
Reach 1	-267	100-year	1271.00	13.25	27.23	17.49	27.26	0.000034	1.44	1642.47	383.06	0.07
Reach 1	-332		Culvert									
Reach 1	-347	2-year	335.00	16.55	22.21	19.43	22.32	0.004040	2.72	132.51	47.19	0.24
Reach 1	-347	10-year	641.00	16.55	24.34	20.62	24.44	0.002583	2.88	342.71	166.18	0.21
Reach 1	-347	25-year	860.00	16.55	25.23	21.17	25.33	0.002218	2.93	512.40	215.82	0.19
Reach 1	-347	50-year	1055.00	16.55	25.84	21.63	25.94	0.002080	3.00	659.17	261.90	0.19
Reach 1	-347	100-year	1271.00	16.55	26.45	22.13	26.54	0.001908	3.02	832.80	307.63	0.19
Reach 1	-532	2-year	549.00	15.15	21.60		21.70	0.002971	2.85	274.49	88.52	0.22
Reach 1	-532	10-year	1200.00	15.15	23.67		23.83	0.003642	3.93	513.21	152.20	0.26
Reach 1	-532	25-year	1655.00	15.15	24.53		24.72	0.003858	4.36	648.31	161.09	0.27
Reach 1	-532	50-year	2025.00	15.15	25.12		25.32	0.004050	4.67	744.10	167.10	0.28
Reach 1	-532	100-year	2435.00	15.15	25.68		25.92	0.004343	5.04	841.75	178.28	0.29
Reach 1	-2127	2-year	549.00	12.35	17.56		17.60	0.002591	2.41	394.78	165.42	0.20
Reach 1	-2127	10-year	1200.00	12.35	19.09		19.16	0.002855	3.09	666.59	188.98	0.22
Reach 1	-2127	25-year	1655.00	12.35	20.08		20.16	0.002643	3.30	861.64	204.22	0.22
Reach 1	-2127	50-year	2025.00	12.35	20.95		21.03	0.002299	3.33	1055.10	249.39	0.21
Reach 1	-2127	100-year	2435.00	12.35	22.09		22.16	0.001753	3.19	1377.78	309.19	0.19
Reach 1	-3322	2-year	549.00	8.65	13.97		14.02	0.003520	2.84	369.33	160.21	0.23
Reach 1	-3322	10-year	1200.00	8.65	16.32		16.37	0.001947	2.77	771.94	181.87	0.18
Reach 1	-3322	25-year	1655.00	8.65	17.76		17.81	0.001518	2.77	1042.00	192.98	0.17
Reach 1	-3322	50-year	2025.00	8.65	19.06		19.11	0.001179	2.69	1301.02	203.06	0.15
Reach 1	-3322	100-year	2435.00	8.65	20.69		20.73	0.000863	2.55	1641.35	215.59	0.13
Reach 1	-3552	2-year	549.00	7.25	13.45		13.49	0.001603	2.15	420.27	117.66	0.16
Reach 1	-3552	10-year	1200.00	7.25	15.91		15.97	0.001534	2.69	733.36	142.74	0.17
Reach 1	-3552	25-year	1655.00	7.25	17.40		17.46	0.001457	2.93	966.25	176.27	0.17
Reach 1	-3552	50-year	2025.00	7.25	18.76		18.82	0.001355	3.09	1246.80	237.32	0.17
Reach 1	-3552	100-year	2435.00	7.25	20.47		20.52	0.000985	2.90	1714.85	307.79	0.14

HEC-RAS Plan: Alternative #2 River: Meeting House Reach: Reach 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	-3604	2-year	549.00	7.05	12.74	10.87	13.20	0.007502	5.47	100.43	27.24	0.50
Reach 1	-3604	10-year	1200.00	7.05	14.58	13.03	15.53	0.010571	7.82	153.54	29.00	0.60
Reach 1	-3604	25-year	1655.00	7.05	15.73	13.95	16.95	0.011310	8.86	186.85	29.00	0.61
Reach 1	-3604	50-year	2025.00	7.05	17.05	14.62	18.31	0.009906	8.99	225.16	29.00	0.57
Reach 1	-3604	100-year	2435.00	7.05	20.08	15.31	20.37	0.002138	5.11	683.12	277.21	0.27
Reach 1	-3617		Bridge									
Reach 1	-3630	2-year	547.00	7.05	12.40	10.87	12.95	0.009463	5.99	91.28	25.76	0.56
Reach 1	-3630	10-year	1200.00	7.05	13.60	13.02	15.03	0.019501	9.60	125.05	29.00	0.81
Reach 1	-3630	25-year	1654.00	7.05	14.09	13.95	16.28	0.026805	11.87	139.31	29.00	0.95
Reach 1	-3630	50-year	2024.00	7.05	14.62	14.62	17.28	0.029512	13.10	154.52	29.00	1.00
Reach 1	-3630	100-year	2434.00	7.05	15.31	15.31	18.33	0.029859	13.95	174.49	29.00	1.00
Reach 1	-3682	2-year	547.00	7.05	11.94		12.26	0.013124	4.76	148.29	83.78	0.45
Reach 1	-3682	10-year	1200.00	7.05	12.97	12.26	13.60	0.020756	7.10	250.13	114.59	0.58
Reach 1	-3682	25-year	1654.00	7.05	13.50	12.93	14.29	0.023762	8.17	315.99	132.39	0.64
Reach 1	-3682	50-year	2024.00	7.05	13.89	13.36	14.78	0.025113	8.82	370.35	146.06	0.66
Reach 1	-3682	100-year	2434.00	7.05	14.30	13.78	15.25	0.025765	9.37	432.24	160.21	0.68
Reach 1	-3897	2-year	547.00	6.75	11.11	9.73	11.13	0.002501	1.83	554.59	344.29	0.18
Reach 1	-3897	10-year	1200.00	6.75	12.20	10.21	12.23	0.002502	2.24	942.42	365.32	0.19
Reach 1	-3897	25-year	1654.00	6.75	12.80	10.50	12.84	0.002501	2.45	1165.32	376.87	0.20
Reach 1	-3897	50-year	2024.00	6.75	13.24	10.67	13.28	0.002502	2.60	1331.24	385.25	0.20
Reach 1	-3897	100-year	2434.00	6.75	13.68	10.81	13.73	0.002502	2.74	1503.83	393.77	0.20

SECONDARY SYSTEM EXISTING CONDITIONS: HEC-RAS OUTPUT

HEC-RAS Plan: MHUT_Existing River: MHUT Reach: Alignment - (4)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (4)	2496.9	2-Year	98.90	22.86	25.54		25.87	0.017128	4.60	21.49	10.02	0.55
Alignment - (4)	2496.9	10-Year	221.70	22.86	27.63		28.00	0.011022	4.85	45.70	13.16	0.46
Alignment - (4)	2496.9	25-Year	286.60	22.86	28.34		28.76	0.010964	5.17	55.45	14.23	0.46
Alignment - (4)	2496.9	50-Year	338.20	22.86	28.81		29.27	0.011194	5.43	62.29	14.93	0.47
Alignment - (4)	2496.9	100-Year	389.10	22.86	29.19		29.70	0.011124	5.72	69.68	25.33	0.47
Alignment - (4)	2341.87	2-Year	123.00	20.11	24.56		24.70	0.004383	2.96	41.55	12.67	0.29
Alignment - (4)	2341.87	10-Year	298.50	20.11	26.41		26.71	0.006723	4.42	68.86	24.55	0.37
Alignment - (4)	2341.87	25-Year	396.40	20.11	27.00		27.40	0.007524	5.08	89.30	43.82	0.40
Alignment - (4)	2341.87	50-Year	475.60	20.11	27.42		27.86	0.007874	5.48	110.29	57.21	0.41
Alignment - (4)	2341.87	100-Year	556.10	20.11	27.81		28.28	0.007925	5.75	134.94	67.76	0.42
Alignment - (4)	2113.58	2-Year	123.00	18.06	24.09		24.15	0.001401	1.94	63.54	19.35	0.17
Alignment - (4)	2113.58	10-Year	298.50	18.06	26.02		26.08	0.001237	2.34	251.97	138.75	0.17
Alignment - (4)	2113.58	25-Year	396.40	18.06	26.71		26.77	0.001103	2.37	355.38	156.68	0.16
Alignment - (4)	2113.58	50-Year	475.60	18.06	27.19		27.24	0.001025	2.39	431.63	164.21	0.16
Alignment - (4)	2113.58	100-Year	556.10	18.06	27.62		27.67	0.000974	2.42	503.65	171.14	0.15
Alignment - (4)	1932.27	2-Year	127.90	17.47	23.87		23.92	0.001136	1.84	73.75	39.01	0.15
Alignment - (4)	1932.27	10-Year	314.20	17.47	25.77		25.85	0.001348	2.53	217.82	104.43	0.17
Alignment - (4)	1932.27	25-Year	419.00	17.47	26.47		26.55	0.001341	2.70	296.99	120.48	0.18
Alignment - (4)	1932.27	50-Year	504.20	17.47	26.94		27.03	0.001327	2.80	356.48	127.75	0.18
Alignment - (4)	1932.27	100-Year	591.00	17.47	27.38		27.46	0.001327	2.91	413.29	135.71	0.18
Alignment - (4)	1725.07	2-Year	127.90	17.36	23.69		23.73	0.000720	1.68	105.74	44.37	0.12
Alignment - (4)	1725.07	10-Year	314.20	17.36	25.51		25.59	0.001180	2.59	209.22	69.58	0.17
Alignment - (4)	1725.07	25-Year	419.00	17.36	26.17		26.26	0.001370	2.95	258.14	78.74	0.18
Alignment - (4)	1725.07	50-Year	504.20	17.36	26.62		26.73	0.001526	3.22	295.27	87.89	0.19
Alignment - (4)	1725.07	100-Year	591.00	17.36	27.03		27.15	0.001660	3.47	333.35	97.56	0.20
Alignment - (4)	1488.39	2-Year	208.50	16.61	23.46		23.51	0.001070	2.08	173.23	72.55	0.15
Alignment - (4)	1488.39	10-Year	478.80	16.61	25.18		25.26	0.001504	2.90	319.31	97.31	0.18
Alignment - (4)	1488.39	25-Year	626.90	16.61	25.80		25.89	0.001715	3.26	381.79	106.16	0.20
Alignment - (4)	1488.39	50-Year	746.20	16.61	26.21		26.32	0.001873	3.52	427.14	112.14	0.21
Alignment - (4)	1488.39	100-Year	866.90	16.61	26.59		26.71	0.002020	3.76	470.14	117.53	0.22
Alignment - (4)	1259.55	2-Year	208.50	17.44	22.89		23.07	0.004310	3.50	77.48	51.78	0.28
Alignment - (4)	1259.55	10-Year	478.80	17.44	24.41		24.66	0.005307	4.68	191.67	98.11	0.33

HEC-RAS Plan: MHUT_Existing River: MHUT Reach: Alignment - (4) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (4)	1259.55	25-Year	626.90	17.44	24.96		25.23	0.005495	5.04	250.92	114.98	0.34
Alignment - (4)	1259.55	50-Year	746.20	17.44	25.35		25.62	0.005524	5.25	297.34	124.91	0.35
Alignment - (4)	1259.55	100-Year	866.90	17.44	25.70		25.97	0.005527	5.42	342.69	133.64	0.35
Alignment - (4)	1090.72	2-Year	208.50	16.74	22.18		22.35	0.004140	3.43	84.60	62.59	0.28
Alignment - (4)	1090.72	10-Year	478.80	16.74	23.51		23.75	0.005398	4.62	192.85	92.64	0.33
Alignment - (4)	1090.72	25-Year	626.90	16.74	24.04		24.29	0.005592	4.97	242.48	96.74	0.34
Alignment - (4)	1090.72	50-Year	746.20	16.74	24.40		24.67	0.005733	5.22	278.44	99.55	0.35
Alignment - (4)	1090.72	100-Year	866.90	16.74	24.74		25.01	0.005854	5.45	312.08	101.55	0.36
Alignment - (4)	843.87	2-Year	234.00	15.86	21.07		21.24	0.004906	3.61	122.36	132.72	0.30
Alignment - (4)	843.87	10-Year	533.20	15.86	22.76		22.84	0.002554	3.22	366.52	155.20	0.23
Alignment - (4)	843.87	25-Year	696.60	15.86	23.27		23.35	0.002594	3.43	447.33	161.31	0.23
Alignment - (4)	843.87	50-Year	828.00	15.86	23.62		23.70	0.002661	3.59	504.15	165.29	0.24
Alignment - (4)	843.87	100-Year	960.90	15.86	23.93		24.02	0.002737	3.75	556.74	168.69	0.24
Alignment - (4)	713.86	2-Year	234.00	15.90	20.42		20.61	0.004690	3.51	73.78	45.81	0.30
Alignment - (4)	713.86	10-Year	533.20	15.90	22.25		22.43	0.003822	4.00	256.26	127.44	0.28
Alignment - (4)	713.86	25-Year	696.60	15.90	22.73		22.92	0.004071	4.34	319.55	133.58	0.30
Alignment - (4)	713.86	50-Year	828.00	15.90	23.05		23.26	0.004299	4.60	363.28	137.66	0.31
Alignment - (4)	713.86	100-Year	960.90	15.90	23.34		23.56	0.004523	4.85	403.64	141.32	0.32
Alignment - (4)	484.82	2-Year	234.00	15.19	18.71		19.04	0.010736	4.61	50.77	14.88	0.44
Alignment - (4)	484.82	10-Year	533.20	15.19	20.39	18.70	20.94	0.012430	6.29	135.78	126.02	0.49
Alignment - (4)	484.82	25-Year	696.60	15.19	20.84		21.39	0.012334	6.64	196.54	140.11	0.50
Alignment - (4)	484.82	50-Year	828.00	15.19	21.16		21.69	0.012029	6.81	242.25	148.55	0.50
Alignment - (4)	484.82	100-Year	960.90	15.19	21.45		21.96	0.011688	6.93	286.59	156.30	0.49
Alignment - (4)	275.5	2-Year	234.00	12.95	16.65		16.95	0.009207	4.37	53.54	14.93	0.41
Alignment - (4)	275.5	10-Year	533.20	12.95	18.25		18.64	0.009369	5.54	170.25	118.17	0.43
Alignment - (4)	275.5	25-Year	696.60	12.95	18.70		19.09	0.009433	5.88	224.19	121.87	0.44
Alignment - (4)	275.5	50-Year	828.00	12.95	19.00		19.40	0.009653	6.15	260.52	124.30	0.45
Alignment - (4)	275.5	100-Year	960.90	12.95	19.25		19.67	0.010006	6.44	292.38	126.39	0.46
Alignment - (4)	80.49	2-Year	244.70	11.04	14.75	13.14	15.07	0.010007	4.56	53.65	15.95	0.42
Alignment - (4)	80.49	10-Year	563.50	11.04	16.35	14.68	16.75	0.010002	5.73	185.01	145.83	0.44
Alignment - (4)	80.49	25-Year	738.50	11.04	16.80	16.05	17.20	0.010003	6.06	258.94	177.72	0.45
Alignment - (4)	80.49	50-Year	879.30	11.04	17.08	16.50	17.48	0.010001	6.26	310.84	188.41	0.45

HEC-RAS Plan: MHUT_Existing River: MHUT Reach: Alignment - (4) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (4)	80.49	100-Year	1021.80	11.04	17.32	16.78	17.71	0.010015	6.43	357.58	193.47	0.46

SECONDARY SYSTEM EXISTING CONDITIONS: HYDRAFLOW STORM SEWERS

Storm Sewer Inventory Report

System A - Grey Fox Trail System
System B - Oakmont Drive System

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	231.19	-117.36	MH	0.00	0.00	0.00	0.0	31.10	3.37	38.90	30	Cir	0.013	1.00	49.80	A1-30" RCP
2	1	157.52	-21.26	Comb	0.00	0.79	0.55	5.0	45.80	1.08	47.50	30	Cir	0.013	1.00	53.90	A2-30" RCP
3	2	393.91	-69.54	Comb	0.00	0.58	0.55	5.0	47.50	0.46	49.30	30	Cir	0.013	1.50	54.20	A3-30" RCP
4	3	140.78	1.73	Comb	0.00	0.59	0.55	5.0	49.30	0.64	50.20	24	Cir	0.013	1.50	54.60	A4-24" RCP
5	4	451.22	-0.02	Comb	0.00	0.44	0.55	5.0	50.20	0.75	53.60	24	Cir	0.013	1.50	57.70	A5-24" RCP
6	5	33.06	90.41	Comb	0.00	2.33	0.55	15.0	55.10	2.12	55.80	18	Cir	0.013	1.48	57.80	A6-18" RCP
7	6	116.37	-78.78	Comb	0.00	0.82	0.55	5.0	55.80	0.60	56.50	15	Cir	0.013	0.60	59.10	A7-15" RCP
8	7	32.88	-12.04	Comb	0.00	0.53	0.55	5.0	56.50	2.13	57.20	15	Cir	0.013	1.00	59.50	A8-15" RCP
9	2	33.27	8.20	Comb	0.00	1.44	0.55	10.0	49.90	1.80	50.50	15	Cir	0.013	1.00	54.00	A9-15" RCP
10	3	33.19	92.22	Comb	0.00	2.46	0.55	15.0	50.30	0.60	50.50	15	Cir	0.013	1.00	54.00	A10-15" RCP
11	4	33.19	90.06	Comb	0.00	1.90	0.55	10.0	50.60	2.11	51.30	15	Cir	0.013	1.00	54.50	A11-15" RCP
12	End	147.59	-136.48	DrGrt	0.00	0.31	0.81	5.0	61.30	1.56	63.60	24	Cir	0.013	0.60	68.10	B1-24" RCP
13	12	137.08	-0.39	Comb	0.00	0.43	0.90	5.0	63.60	0.29	64.00	24	Cir	0.013	0.60	67.30	B2-24" RCP
14	13	61.32	-0.36	Comb	0.00	0.27	0.90	5.0	64.00	0.33	64.20	24	Cir	0.013	0.60	67.30	B3-24" RCP
15	14	10.91	0.14	Comb	0.00	0.40	0.90	5.0	64.20	-0.92	64.10	24	Cir	0.024	0.60	67.10	B4-24" CMP
16	15	32.87	0.08	DrGrt	0.00	3.16	0.76	5.0	64.10	0.61	64.30	24	Cir	0.024	0.50	66.80	B5-24" CMP
17	16	200.09	1.50	DrCrb	0.00	1.00	0.60	5.0	64.30	0.30	64.90	18	Cir	0.024	1.13	68.60	B6-18" CMP
18	17	16.59	45.51	DrCrb	0.00	0.89	0.61	5.0	64.90	0.60	65.00	18	Cir	0.024	1.15	68.70	B7-18" CMP
19	18	145.29	-46.61	DrGrt	0.00	0.36	0.85	5.0	65.00	0.41	65.60	18	Cir	0.024	0.60	68.90	B8-18" CMP
20	19	59.85	-1.18	Comb	0.00	1.80	0.85	5.0	65.60	1.17	66.30	18	Cir	0.024	0.60	68.00	B9-18" CMP
21	20	33.05	5.16	Comb	0.00	1.01	0.85	5.0	66.30	-1.21	65.90	15	Cir	0.013	1.00	67.90	B10-15" RCP

Project File: Greenville_EC.stm | Existing Conditions - 10 Year | Number of lines: 21 | Date: 10/15/2012

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	A1-30" RCP	29.38	30	Cir	231.19	31.10	38.90	3.374	35.49	40.71	n/a	42.21 i	End	Manhole
2	A2-30" RCP	29.70	30	Cir	157.52	45.80	47.50	1.079	47.34	49.32	n/a	50.84 i	1	Combination
3	A3-30" RCP	24.93	30	Cir	393.91	47.50	49.30	0.457	50.84*	52.30*	0.60	52.90	2	Combination
4	A4-24" RCP	17.26	24	Cir	140.78	49.30	50.20	0.639	52.90*	53.72*	0.70	54.42	3	Combination
5	A5-24" RCP	11.37	24	Cir	451.22	50.20	53.60	0.754	54.69*	55.83*	0.31	56.14	4	Combination
6	A6-18" RCP	10.18	18	Cir	33.06	55.10	55.80	2.117	56.14	57.02	n/a	58.18 i	5	Combination
7	A7-15" RCP	5.15	15	Cir	116.37	55.80	56.50	0.602	58.18*	58.93*	0.16	59.09	6	Combination
8	A8-15" RCP	2.05	15	Cir	32.88	56.50	57.20	2.129	59.32*	59.35*	0.04	59.40	7	Combination
9	A9-15" RCP	4.63	15	Cir	33.27	49.90	50.50	1.803	50.84	51.36	n/a	52.00 i	2	Combination
10	A10-15" RCP	6.81	15	Cir	33.19	50.30	50.50	0.603	52.90*	53.27*	0.48	53.75	3	Combination
11	A11-15" RCP	6.11	15	Cir	33.19	50.60	51.30	2.109	54.51*	54.80*	0.39	55.19	4	Combination
12	B1-24" RCP	50.53	24	Cir	147.59	61.30	63.60	1.558	65.82*	73.19*	n/a	75.06 i	End	DropGrate
13	B2-24" RCP	49.14	24	Cir	137.08	63.60	64.00	0.292	75.06*	81.53*	2.28	83.82	12	Combination
14	B3-24" RCP	46.64	24	Cir	61.32	64.00	64.20	0.326	84.19*	86.80*	2.06	88.86	13	Combination
15	B4-24" CMP	45.01	24	Cir	10.91	64.20	64.10	-0.917	89.09*	90.57*	1.91	92.48	14	Combination
16	B5-24" CMP	42.63	24	Cir	32.87	64.10	64.30	0.608	92.81*	96.79*	1.43	98.22	15	DropGrate
17	B6-18" CMP	26.46	18	Cir	200.09	64.30	64.90	0.300	98.22*	141.54*	3.94	145.48	16	DropCurb
18	B7-18" CMP	22.35	18	Cir	16.59	64.90	65.00	0.603	146.48*	149.05*	2.86	151.90	17	DropCurb
19	B8-18" CMP	18.77	18	Cir	145.29	65.00	65.60	0.413	152.63*	168.47*	1.05	169.52	18	DropGrate
20	B9-18" CMP	16.71	18	Cir	59.85	65.60	66.30	1.170	169.88*	175.05*	0.83	175.89	19	Combination
21	B10-15" RCP	6.04	15	Cir	33.05	66.30	65.90	-1.210	176.90*	177.19*	0.38	177.57	20	Combination

Project File: Greenville_EC.stm | Number of lines: 21 | Run Date: 10/15/2012

NOTES: Return period = 10 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control.

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	231.19	0.00	11.88	0.00	0.00	6.53	0.0	19.4	4.5	29.38	75.33	6.85	30	3.37	31.10	38.90	35.49	40.71	34.10	49.80	A1-30" RCP
2	1	157.52	0.79	11.88	0.55	0.43	6.53	5.0	18.9	4.5	29.70	42.61	8.57	30	1.08	45.80	47.50	47.34	49.32	49.80	53.90	A2-30" RCP
3	2	393.91	0.58	9.65	0.55	0.32	5.31	5.0	17.6	4.7	24.93	27.72	5.08	30	0.46	47.50	49.30	50.84	52.30	53.90	54.20	A3-30" RCP
4	3	140.78	0.59	6.61	0.55	0.32	3.64	5.0	17.2	4.7	17.26	18.08	5.50	24	0.64	49.30	50.20	52.90	53.72	54.20	54.60	A4-24" RCP
5	4	451.22	0.44	4.12	0.55	0.24	2.27	5.0	15.1	5.0	11.37	19.63	3.62	24	0.75	50.20	53.60	54.69	55.83	54.60	57.70	A5-24" RCP
6	5	33.06	2.33	3.68	0.55	1.28	2.02	15.0	15.0	5.0	10.18	15.28	7.23	18	2.12	55.10	55.80	56.14	57.02	57.70	57.80	A6-18" RCP
7	6	116.37	0.82	1.35	0.55	0.45	0.74	5.0	5.3	6.9	5.15	5.01	4.20	15	0.60	55.80	56.50	58.18	58.93	57.80	59.10	A7-15" RCP
8	7	32.88	0.53	0.53	0.55	0.29	0.29	5.0	5.0	7.0	2.05	9.42	1.67	15	2.13	56.50	57.20	59.32	59.35	59.10	59.50	A8-15" RCP
9	2	33.27	1.44	1.44	0.55	0.79	0.79	10.0	10.0	5.8	4.63	8.67	4.91	15	1.80	49.90	50.50	50.84	51.36	53.90	54.00	A9-15" RCP
10	3	33.19	2.46	2.46	0.55	1.35	1.35	15.0	15.0	5.0	6.81	5.01	5.55	15	0.60	50.30	50.50	52.90	53.27	54.20	54.00	A10-15" RCP
11	4	33.19	1.90	1.90	0.55	1.05	1.05	10.0	10.0	5.8	6.11	9.38	4.98	15	2.11	50.60	51.30	54.51	54.80	54.60	54.50	A11-15" RCP
12	End	147.59	0.31	9.63	0.81	0.25	7.48	5.0	6.0	6.8	50.53	28.23	16.08	24	1.56	61.30	63.60	65.82	73.19	63.40	68.10	B1-24" RCP
13	12	137.08	0.43	9.32	0.90	0.39	7.23	5.0	5.8	6.8	49.14	12.22	15.64	24	0.29	63.60	64.00	75.06	81.53	68.10	67.30	B2-24" RCP
14	13	61.32	0.27	8.89	0.90	0.24	6.84	5.0	5.8	6.8	46.64	12.92	14.85	24	0.33	64.00	64.20	84.19	86.80	67.30	67.30	B3-24" RCP
15	14	10.91	0.40	8.62	0.90	0.36	6.60	5.0	5.7	6.8	45.01	0.00	14.33	24	-0.92	64.20	64.10	89.09	90.57	67.30	67.10	B4-24" CMP
16	15	32.87	3.16	8.22	0.76	2.40	6.24	5.0	5.7	6.8	42.63	9.56	13.57	24	0.61	64.10	64.30	92.81	96.79	67.10	66.80	B5-24" CMP
17	16	200.09	1.00	5.06	0.60	0.60	3.84	5.0	5.5	6.9	26.46	3.11	14.98	18	0.30	64.30	64.90	98.22	141.54	66.80	68.60	B6-18" CMP
18	17	16.59	0.89	4.06	0.61	0.54	3.24	5.0	5.4	6.9	22.35	4.42	12.65	18	0.60	64.90	65.00	146.48	149.05	68.60	68.70	B7-18" CMP
19	18	145.29	0.36	3.17	0.85	0.31	2.69	5.0	5.2	7.0	18.77	3.66	10.62	18	0.41	65.00	65.60	152.63	168.47	68.70	68.90	B8-18" CMP
20	19	59.85	1.80	2.81	0.85	1.53	2.39	5.0	5.1	7.0	16.71	6.15	9.46	18	1.17	65.60	66.30	169.88	175.05	68.90	68.00	B9-18" CMP
21	20	33.05	1.01	1.01	0.85	0.86	0.86	5.0	5.0	7.0	6.04	0.00	4.92	15	-1.21	66.30	65.90	176.90	177.19	68.00	67.90	B10-15" RCP

Project File: Greenville_EC.stm | Number of lines: 21 | Run Date: 10/15/2012

NOTES:Intensity = 84.35 / (Inlet time + 15.10) ^ 0.83; Return period =Yrs. 10 ; c = cir e = ellip b = box

Inlet Report

Line No	Inlet ID	Q = CIA (cfs)	Q carry (cfs)	Q capt (cfs)	Q Byp (cfs)	Junc Type	Curb Inlet		Grate Inlet			Gutter							Inlet			Byp Line No
							Ht (in)	L (ft)	Area (sqft)	L (ft)	W (ft)	So (ft/ft)	W (ft)	Sw (ft/ft)	Sx (ft/ft)	n	Depth (ft)	Spread (ft)	Depth (ft)	Spread (ft)	Depr (in)	
1	MHMB0098	0.00	0.00	0.00	0.00	MH	0.0	0.00	0.00	0.00	0.00	Sag	0.00	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.0	Off
2	MHMB0099	3.05	0.40	3.45	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.18	4.62	0.31	4.62	2.0	Off
3	MHMB0101	2.24	0.40	2.24	0.40	Comb	6.0	3.00	2.80	3.00	2.00	0.080	2.00	0.050	0.031	0.013	0.18	4.58	0.25	2.72	2.0	2
4	MHMB0103	2.28	0.36	2.24	0.40	Comb	6.0	3.00	2.80	3.00	2.00	0.080	2.00	0.050	0.031	0.013	0.18	4.58	0.25	2.72	2.0	3
5	MHMB0105	1.70	0.00	1.34	0.36	Comb	6.0	3.00	0.00	3.00	2.00	0.008	2.00	0.050	0.031	0.013	0.23	6.16	0.32	4.85	2.0	4
6	MHMB0106	6.45	0.00	3.66	2.78	Comb	6.0	3.00	0.00	3.00	2.00	0.010	2.00	0.050	0.031	0.013	0.35	10.03	0.45	9.27	2.0	11
7	MHMB0107	3.17	0.00	3.17	0.00	Comb	6.0	3.00	1.08	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.15	3.66	0.28	3.66	2.0	6
8	MHMB0108	2.05	0.00	1.56	0.49	Comb	6.0	3.00	0.00	3.00	2.00	0.010	2.00	0.050	0.031	0.013	0.24	6.35	0.32	5.08	2.0	Off
9	MHMB0100	4.63	0.00	4.63	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.24	6.56	0.37	6.56	2.0	Off
10	MHMB0102	6.81	0.00	6.81	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.000	0.35	10.11	0.48	10.11	2.0	Off
11	MHMB0104	6.11	2.78	8.90	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.44	13.01	0.57	13.01	2.0	Off
12	MHMB0498	1.77	0.00	1.32	0.45	DrGrt	0.0	0.00	0.00	3.00	2.00	0.015	2.00	0.015	0.015	0.050	0.18	26.00	0.18	26.00	0.0	Off
13	MHMB0499	2.72	0.00	2.72	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.13	3.01	0.26	3.01	2.0	Off
14	MHMB0500	1.71	0.00	1.71	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.06	1.23	0.19	1.66	2.0	Off
15	MHMB0501	2.53	0.00	2.53	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.12	2.69	0.25	2.69	2.0	Off
16	MHMB0502	16.88	0.00	16.88	0.00	DrGrt	0.0	0.00	2.80	3.00	2.00	Sag	2.00	0.031	0.031	0.013	1.26	83.24	1.26	83.24	0.0	Off
17	MHMB0503	4.22	0.00	4.22	0.00	DrCrb	6.0	8.40	0.00	0.00	0.00	Sag	0.00	0.031	0.031	0.013	0.30	9.74	0.30	9.74	0.0	Off
18	MHMB0504	3.82	0.00	3.82	0.00	DrCrb	6.0	8.40	0.00	0.00	0.00	Sag	0.00	0.031	0.031	0.013	0.28	9.11	0.28	9.11	0.0	Off
19	MHMB0505	2.15	0.00	2.15	0.00	DrGrt	0.0	0.00	2.92	2.50	2.50	Sag	2.00	0.031	0.031	0.013	0.17	13.63	0.17	13.63	0.0	Off
20	MHMB0506	10.76	0.00	10.76	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.52	15.59	0.65	15.59	2.0	Off
21	MHMB0507	6.04	0.00	6.04	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.31	8.82	0.44	8.82	2.0	Off

Project File: Greenville_EC.stm | Number of lines: 21 | Run Date: 10/15/2012

NOTES: Inlet N-Values = 0.016; Intensity = 84.35 / (Inlet time + 15.10) ^ 0.83; Return period = 10 Yrs. ; * Indicates Known Q added. All curb inlets are Horiz throat.

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf		Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf	Ave Sf	Enrgy loss		
(1)	(in) (2)	(cfs) (3)	(ft) (4)	(ft) (5)	(ft) (6)	(sqft) (7)	(ft/s) (8)	(ft) (9)	(ft) (10)	(%) (11)	(ft) (12)	(ft) (13)	(ft) (14)	(ft) (15)	(sqft) (16)	(ft/s) (17)	(ft) (18)	(ft) (19)	(%) (20)	(%) (21)	(ft) (22)	(K) (23)	(ft) (24)
1	30	29.38	31.10	35.49	2.50	4.91	5.99	0.56	36.05	n/a	231.19	38.90	40.71 j	1.81**	3.81	7.71	0.92	41.64i	n/a	n/a	n/a	1.00	n/a
2	30	29.70	45.80	47.34	1.54*	3.17	9.38	1.37	48.71	n/a	157.52	47.50	49.32	1.82**	3.83	7.75	0.93	50.26i	n/a	n/a	n/a	1.00	n/a
3	30	24.93	47.50	50.84	2.50	4.91	5.08	0.40	51.24	0.370	393.91	49.30	52.30	2.50	4.91	5.08	0.40	52.70	0.369	0.370	1.456	1.50	0.60
4	24	17.26	49.30	52.90	2.00	3.14	5.50	0.47	53.37	0.583	140.78	50.20	53.72	2.00	3.14	5.50	0.47	54.19	0.583	0.583	0.820	1.50	0.70
5	24	11.37	50.20	54.69	2.00	3.14	3.62	0.20	54.89	0.253	451.22	53.60	55.83	2.00	3.14	3.62	0.20	56.03	0.253	0.253	1.141	1.50	0.31
6	18	10.18	55.10	56.14	1.04	1.30	7.83	0.95	57.09	n/a	33.06	55.80	57.02	1.22**	1.54	6.63	0.68	57.70i	n/a	n/a	n/a	1.48	n/a
7	15	5.15	55.80	58.18	1.25	1.23	4.20	0.27	58.46	0.636	116.37	56.50	58.93	1.25	1.23	4.20	0.27	59.20	0.636	0.636	0.740	0.60	0.16
8	15	2.05	56.50	59.32	1.25	1.23	1.67	0.04	59.36	0.101	32.88	57.20	59.35	1.25	1.23	1.67	0.04	59.40	0.101	0.101	0.033	1.00	0.04
9	15	4.63	49.90	50.84	0.94	0.99	4.67	0.34	51.18	n/a	33.27	50.50	51.36 j	0.86**	0.90	5.14	0.41	51.77i	n/a	n/a	n/a	1.00	n/a
10	15	6.81	50.30	52.90	1.25	1.23	5.55	0.48	53.38	1.112	33.19	50.50	53.27	1.25	1.23	5.55	0.48	53.75	1.112	1.112	0.369	1.00	0.48
11	15	6.11	50.60	54.51	1.25	1.23	4.98	0.39	54.89	0.896	33.19	51.30	54.80	1.25	1.23	4.98	0.39	55.19	0.896	0.896	0.297	1.00	0.39
12	24	50.53	61.30	65.82	2.00	3.14	16.09	4.02	69.84	n/a	147.59	63.60	73.19	2.00	3.14	16.08	4.02	77.21i	n/a	n/a	3.346	0.60	n/a
13	24	49.14	63.60	75.06	2.00	3.14	15.64	3.80	78.87	4.722	137.08	64.00	81.53	2.00	3.14	15.64	3.80	85.34	4.720	4.721	6.471	0.60	2.28
14	24	46.64	64.00	84.19	2.00	3.14	14.85	3.43	87.62	4.255	61.32	64.20	86.80	2.00	3.14	14.85	3.43	90.23	4.253	4.254	2.609	0.60	2.06
15	24	45.01	64.20	89.09	2.00	3.14	14.33	3.19	92.28	13.504	10.91	64.10	90.57	2.00	3.14	14.33	3.19	93.76	13.499	13.502	1.473	0.60	1.91
16	24	42.63	64.10	92.81	2.00	3.14	13.57	2.86	95.67	12.113	32.87	64.30	96.79	2.00	3.14	13.57	2.86	99.65	12.108	12.110	3.981	0.50	1.43
17	18	26.46	64.30	98.22	1.50	1.77	14.98	3.49	101.71	21.654	200.09	64.90	141.54	1.50**	1.77	14.98	3.49	145.03	21.646	21.650	43.32	1.13	3.94
18	18	22.35	64.90	146.48	1.50	1.77	12.65	2.49	148.97	15.440	16.59	65.00	149.05	1.50	1.77	12.65	2.49	151.53	15.434	15.437	2.561	1.15	2.86
19	18	18.77	65.00	152.63	1.50	1.77	10.63	1.76	154.39	10.898	145.29	65.60	168.47	1.50	1.77	10.62	1.75	170.22	10.894	10.896	15.83	0.60	1.05
20	18	16.71	65.60	169.88	1.50	1.77	9.46	1.39	171.27	8.637	59.85	66.30	175.05	1.50	1.77	9.46	1.39	176.44	8.634	8.636	5.169	0.60	0.83
21	15	6.04	66.30	176.90	1.25	1.23	4.92	0.38	177.28	0.874	33.05	65.90	177.19	1.25	1.23	4.92	0.38	177.57	0.874	0.874	0.289	1.00	0.38

Project File: Greenville_EC.stm | Number of lines: 21 | Run Date: 10/15/2012

Notes: * Normal depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

Hydraflow HGL Computation Procedure

General Procedure:

Hydraflow computes the HGL using the Bernoulli energy equation. Manning's equation is used to determine energy losses due to pipe friction. In a standard step, iterative procedure, Hydraflow assumes upstream HGLs until the energy equation balances. If the energy equation cannot balance, supercritical flow exists and critical depth is temporarily assumed at the upstream end. A supercritical flow Profile is then computed using the same procedure in a downstream direction using momentum principles.The computed HGL is checked against inlet control.

Col. 1 The line number being computed. Calculations begin at Line 1 and proceed upstream.

Col. 2 The line size. In the case of non-circular pipes, the line rise is printed above the span.

Col. 3 Total flow rate in the line.

Col. 4 The elevation of the downstream invert.

Col. 5 Elevation of the hydraulic grade line at the downstream end. This is computed as the upstream HGL + Minor loss of this line's downstream line.

Col. 6 The downstream depth of flow inside the pipe (HGL - Invert elevation) but not greater than the line size

Col. 7 Cross-sectional area of the flow at the downstream end.

Col. 8 The velocity of the flow at the downstream end, (Col. 3 / Col. 7).

Col. 9 Velocity head (Velocity squared / 2g).

Col. 10 The elevation of the energy grade line at the downstream end, HGL + Velocity head, (Col. 5 + Col. 9).

Col. 11 The friction slope at the downstream end (the S or Slope term in Manning's equation).

Col. 12 The line length.

Col. 13 The elevation of the upstream invert.

Col. 14 Elevation of the hydraulic grade line at the upstream end.

Col. 15 The upstream depth of flow inside the pipe (HGL - Invert elevation) but not greater than the line size.

Col. 16 Cross-sectional area of the flow at the upstream end.

Col. 17 The velocity of the flow at the upstream end, (Col. 3 / Col. 16).

Col. 18 Velocity head (Velocity squared / 2g).

Col. 19 The elevation of the energy grade line at the upstream end, HGL + Velocity head, (Col. 14 + Col. 18) .

Col. 20 The friction slope at the upstream end (the S or Slope term in Manning's equation).

Col. 21 The average of the downstream and upstream friction slopes.

Col. 22 Energy loss. Average Sf/100 x Line Length (Col. 21/100 x Col. 12). Equals (EGL upstream - EGL downstream) +/- tolerance.

Col. 23 The junction loss coefficient (K).

Col. 24 Minor loss. (Col. 23 x Col. 18). Is added to upstream HGL and used as the starting HGL for the next upstream line(s).

SECONDARY SYSTEM ALTERNATIVE #1: HYDRAFLOW STORM SEWERS

Storm Sewer Inventory Report

System A - Grey Fox Trail System
System B - Oakmont Drive System

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	231.19	-117.36	MH	0.00	0.00	0.00	0.0	29.70	6.47	44.65	36	Cir	0.013	1.00	49.80	A1-36" RCP (PROP)
2	1	157.52	-21.26	Comb	0.00	0.79	0.55	5.0	44.65	1.33	46.75	36	Cir	0.013	1.00	53.90	A2-36" RCP (PROP)
3	2	393.91	-69.54	Comb	0.00	0.58	0.55	5.0	46.75	0.51	48.75	36	Cir	0.013	1.50	54.20	A3-36" RCP (PROP)
4	3	140.78	1.73	Comb	0.00	0.59	0.55	5.0	48.75	0.50	49.45	36	Cir	0.013	1.50	54.60	A4-36" RCP (PROP)
5	4	451.22	-0.02	Comb	0.00	0.44	0.55	5.0	49.55	0.75	52.95	30	Cir	0.013	1.50	57.70	A5-30" RCP (PROP)
6	5	33.06	90.41	Comb	0.00	2.33	0.55	15.0	53.05	2.12	53.75	24	Cir	0.013	1.48	57.80	A6-24" RCP (PROP)
7	6	116.37	-78.78	Comb	0.00	0.82	0.55	5.0	53.75	1.12	55.05	24	Cir	0.013	0.60	59.10	A7-24" RCP (PROP)
8	7	32.88	-12.04	Comb	0.00	0.53	0.55	5.0	55.05	1.22	55.45	24	Cir	0.013	1.00	59.50	A8-24" RCP (PROP)
9	2	33.27	8.20	Comb	0.00	1.44	0.55	10.0	49.90	1.80	50.50	15	Cir	0.013	1.00	54.00	A9-15" RCP
10	3	33.19	92.22	Comb	0.00	2.46	0.55	15.0	50.25	0.90	50.55	18	Cir	0.013	1.00	54.00	A10-18" RCP (PROP
11	4	33.19	90.06	Comb	0.00	1.90	0.55	10.0	50.60	2.11	51.30	15	Cir	0.013	1.00	54.50	A11-15" RCP
12	End	147.59	-136.48	DrGrt	0.00	0.31	0.81	5.0	57.50	0.68	58.50	48	Cir	0.013	0.60	68.10	B1-48" RCP (PROP)
13	12	137.08	-0.39	Comb	0.00	0.43	0.90	5.0	58.50	1.13	60.05	48	Cir	0.013	0.60	67.30	B2-48" RCP (PROP)
14	13	61.32	-0.36	Comb	0.00	0.27	0.90	5.0	60.05	0.57	60.40	48	Cir	0.013	0.60	67.30	B3-48" RCP (PROP)
15	14	10.91	0.14	Comb	0.00	0.40	0.90	5.0	60.40	0.55	60.46	48	Cir	0.013	0.60	67.10	B4-48" RCP (PROP)
16	15	32.87	0.08	DrGrt	0.00	3.16	0.83	5.0	60.56	1.79	61.15	42	Cir	0.013	0.50	66.80	B5-42" RCP (PROP)
17	16	200.09	1.50	DrCrb	0.00	1.00	0.83	5.0	61.15	0.52	62.20	42	Cir	0.013	1.13	68.60	B6-42" RCP (PROP)
18	17	16.59	45.51	DrCrb	0.00	0.89	0.78	5.0	62.20	2.41	62.60	36	Cir	0.013	1.15	68.70	B7-36" RCP (PROP)
19	18	145.29	-46.61	DrGrt	0.00	0.36	0.85	5.0	62.70	0.55	63.50	30	Cir	0.013	0.60	68.90	B8-30" RCP (PROP)
20	19	59.85	-1.18	Comb	0.00	1.80	0.85	5.0	63.50	1.17	64.20	30	Cir	0.013	0.60	68.00	B9-30" RCP(PROP)
21	20	33.05	5.16	Comb	0.00	1.01	0.85	5.0	64.30	1.82	64.90	24	Cir	0.013	1.00	67.90	B10-24" RCP (PROP

Alternative #1 Alternative #1 - 10 Year

Number of lines: 21

Date: 10/15/2012

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	A1-36" RCP (PROP)	27.68	36	Cir	231.19	29.70	44.65	6.467	31.38	46.33	n/a	47.36 i	End	Manhole
2	A2-36" RCP (PROP)	28.09	36	Cir	157.52	44.65	46.75	1.333	47.36	48.44	n/a	49.49 i	1	Combination
3	A3-36" RCP (PROP)	23.85	36	Cir	393.91	46.75	48.75	0.508	49.49	50.31	n/a	51.21 i	2	Combination
4	A4-36" RCP (PROP)	16.73	36	Cir	140.78	48.75	49.45	0.497	51.21	51.24	0.34	51.58	3	Combination
5	A5-30" RCP (PROP)	11.35	30	Cir	451.22	49.55	52.95	0.753	51.72	54.08	n/a	54.65 i	4	Combination
6	A6-24" RCP (PROP)	10.18	24	Cir	33.06	53.05	53.75	2.117	54.65	54.88	n/a	55.57 i	5	Combination
7	A7-24" RCP (PROP)	5.05	24	Cir	116.37	53.75	55.05	1.117	55.57	55.85	n/a	56.21 i	6	Combination
8	A8-24" RCP (PROP)	2.05	24	Cir	32.88	55.05	55.45	1.217	56.21	56.19	0.06	56.25	7	Combination
9	A9-15" RCP	4.63	15	Cir	33.27	49.90	50.50	1.803	50.55	51.38	n/a	51.96 i	2	Combination
10	A10-18" RCP (PROP)	6.81	18	Cir	33.19	50.25	50.55	0.904	51.21	51.55	n/a	52.26 i	3	Combination
11	A11-15" RCP	6.11	15	Cir	33.19	50.60	51.30	2.109	51.58	52.29	n/a	53.19 i	4	Combination
12	B1-48" RCP (PROP)	49.77	48	Cir	147.59	57.50	58.50	0.678	59.59	60.59	n/a	61.82 i	End	DropGrate
13	B2-48" RCP (PROP)	49.25	48	Cir	137.08	58.50	60.05	1.131	61.82	62.13	n/a	63.35 i	12	Combination
14	B3-48" RCP (PROP)	47.28	48	Cir	61.32	60.05	60.40	0.571	63.35	63.35	0.21	63.56	13	Combination
15	B4-48" RCP (PROP)	45.82	48	Cir	10.91	60.40	60.46	0.550	63.62	63.62	0.17	63.80	14	Combination
16	B5-42" RCP (PROP)	43.72	42	Cir	32.87	60.56	61.15	1.795	63.80	63.67	n/a	63.82 i	15	DropGrate
17	B6-42" RCP (PROP)	28.15	42	Cir	200.09	61.15	62.20	0.525	63.82	63.88	n/a	64.58 i	16	DropCurb
18	B7-36" RCP (PROP)	22.69	36	Cir	16.59	62.20	62.60	2.411	64.58	64.45	n/a	64.52 i	17	DropCurb
19	B8-30" RCP (PROP)	18.50	30	Cir	145.29	62.70	63.50	0.551	64.52	64.94	n/a	65.84 i	18	DropGrate
20	B9-30" RCP(PROP)	16.59	30	Cir	59.85	63.50	64.20	1.169	65.84	65.75	n/a	66.06 i	19	Combination
21	B10-24" RCP (PROP)	6.04	24	Cir	33.05	64.30	64.90	1.816	66.06	65.99	0.18	66.17	20	Combination

Alternative #1 | Number of lines: 21 | Run Date: 10/15/2012

NOTES: Return period = 10 Yrs. ; i - Inlet control.

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	231.19	0.00	11.88	0.00	0.00	6.53	0.0	22.0	4.2	27.68	169.6	6.80	36	6.47	29.70	44.65	31.38	46.33	34.10	49.80	A1-36" RCP (PRO
2	1	157.52	0.79	11.88	0.55	0.43	6.53	5.0	21.3	4.3	28.09	77.01	5.51	36	1.33	44.65	46.75	47.36	48.44	49.80	53.90	A2-36" RCP (PRO
3	2	393.91	0.58	9.65	0.55	0.32	5.31	5.0	19.4	4.5	23.85	47.52	4.98	36	0.51	46.75	48.75	49.49	50.31	53.90	54.20	A3-36" RCP (PRO
4	3	140.78	0.59	6.61	0.55	0.32	3.64	5.0	18.4	4.6	16.73	47.03	3.25	36	0.50	48.75	49.45	51.21	51.24	54.20	54.60	A4-36" RCP (PRO
5	4	451.22	0.44	4.12	0.55	0.24	2.27	5.0	15.2	5.0	11.35	35.60	3.90	30	0.75	49.55	52.95	51.72	54.08	54.60	57.70	A5-30" RCP (PRO
6	5	33.06	2.33	3.68	0.55	1.28	2.02	15.0	15.0	5.0	10.18	32.91	4.68	24	2.12	53.05	53.75	54.65	54.88	57.70	57.80	A6-24" RCP (PRO
7	6	116.37	0.82	1.35	0.55	0.45	0.74	5.0	5.8	6.8	5.05	23.91	3.01	24	1.12	53.75	55.05	55.57	55.85	57.80	59.10	A7-24" RCP (PRO
8	7	32.88	0.53	0.53	0.55	0.29	0.29	5.0	5.0	7.0	2.05	24.95	1.52	24	1.22	55.05	55.45	56.21	56.19	59.10	59.50	A8-24" RCP (PRO
9	2	33.27	1.44	1.44	0.55	0.79	0.79	10.0	10.0	5.8	4.63	8.67	6.09	15	1.80	49.90	50.50	50.55	51.38	53.90	54.00	A9-15" RCP
10	3	33.19	2.46	2.46	0.55	1.35	1.35	15.0	15.0	5.0	6.81	9.98	5.60	18	0.90	50.25	50.55	51.21	51.55	54.20	54.00	A10-18" RCP (PR
11	4	33.19	1.90	1.90	0.55	1.05	1.05	10.0	10.0	5.8	6.11	9.38	5.90	15	2.11	50.60	51.30	51.58	52.29	54.60	54.50	A11-15" RCP
12	End	147.59	0.31	9.63	0.81	0.25	8.08	5.0	8.5	6.2	49.77	118.2	7.50	48	0.68	57.50	58.50	59.59	60.59	63.40	68.10	B1-48" RCP (PRO
13	12	137.08	0.43	9.32	0.90	0.39	7.83	5.0	7.9	6.3	49.25	152.7	5.95	48	1.13	58.50	60.05	61.82	62.13	68.10	67.30	B2-48" RCP (PRO
14	13	61.32	0.27	8.89	0.90	0.24	7.44	5.0	7.6	6.4	47.28	108.5	4.51	48	0.57	60.05	60.40	63.35	63.35	67.30	67.30	B3-48" RCP (PRO
15	14	10.91	0.40	8.62	0.90	0.36	7.20	5.0	7.6	6.4	45.82	106.5	4.26	48	0.55	60.40	60.46	63.62	63.62	67.30	67.10	B4-48" RCP (PRO
16	15	32.87	3.16	8.22	0.83	2.62	6.84	5.0	7.5	6.4	43.72	134.8	5.31	42	1.79	60.56	61.15	63.80	63.67	67.10	66.80	B5-42" RCP (PRO
17	16	200.09	1.00	5.06	0.83	0.83	4.22	5.0	6.3	6.7	28.15	72.88	4.88	42	0.52	61.15	62.20	63.82	63.88	66.80	68.60	B6-42" RCP (PRO
18	17	16.59	0.89	4.06	0.78	0.69	3.39	5.0	6.2	6.7	22.69	103.6	4.36	36	2.41	62.20	62.60	64.58	64.45	68.60	68.70	B7-36" RCP (PRO
19	18	145.29	0.36	3.17	0.85	0.31	2.69	5.0	5.6	6.9	18.50	30.43	5.59	30	0.55	62.70	63.50	64.52	64.94	68.70	68.90	B8-30" RCP (PRO
20	19	59.85	1.80	2.81	0.85	1.53	2.39	5.0	5.3	6.9	16.59	44.35	4.33	30	1.17	63.50	64.20	65.84	65.75	68.90	68.00	B9-30" RCP(PRO
21	20	33.05	1.01	1.01	0.85	0.86	0.86	5.0	5.0	7.0	6.04	30.48	2.75	24	1.82	64.30	64.90	66.06	65.99	68.00	67.90	B10-24" RCP (PR

Alternative #1 | Number of lines: 21 | Run Date: 10/15/2012

NOTES:Intensity = 84.35 / (Inlet time + 15.10) ^ 0.83; Return period =Yrs. 10 ; c = cir e = ellip b = box

Inlet Report

Line No	Inlet ID	Q = CIA (cfs)	Q carry (cfs)	Q capt (cfs)	Q Byp (cfs)	Junc Type	Curb Inlet		Grate Inlet			Gutter							Inlet			Byp Line No
							Ht (in)	L (ft)	Area (sqft)	L (ft)	W (ft)	So (ft/ft)	W (ft)	Sw (ft/ft)	Sx (ft/ft)	n	Depth (ft)	Spread (ft)	Depth (ft)	Spread (ft)	Depr (in)	
1	MHMB0098	0.00	0.00	0.00	0.00	MH	0.0	0.00	0.00	0.00	0.00	Sag	0.00	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.0	Off
2	MHMB0099	3.05	0.40	3.45	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.18	4.62	0.31	4.62	2.0	Off
3	MHMB0101	2.24	0.40	2.24	0.40	Comb	6.0	3.00	2.80	3.00	2.00	0.080	2.00	0.050	0.031	0.013	0.18	4.58	0.25	2.72	2.0	2
4	MHMB0103	2.28	0.36	2.24	0.40	Comb	6.0	3.00	2.80	3.00	2.00	0.080	2.00	0.050	0.031	0.013	0.18	4.58	0.25	2.72	2.0	3
5	MHMB0105	1.70	0.00	1.34	0.36	Comb	6.0	3.00	0.00	3.00	2.00	0.008	2.00	0.050	0.031	0.013	0.23	6.16	0.32	4.85	2.0	4
6	MHMB0106	6.45	0.00	3.66	2.78	Comb	6.0	3.00	0.00	3.00	2.00	0.010	2.00	0.050	0.031	0.013	0.35	10.03	0.45	9.27	2.0	11
7	MHMB0107	3.17	0.00	3.17	0.00	Comb	6.0	3.00	1.08	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.15	3.66	0.28	3.66	2.0	6
8	MHMB0108	2.05	0.00	1.56	0.49	Comb	6.0	3.00	0.00	3.00	2.00	0.010	2.00	0.050	0.031	0.013	0.24	6.35	0.32	5.08	2.0	Off
9	MHMB0100	4.63	0.00	4.63	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.24	6.56	0.37	6.56	2.0	Off
10	MHMB0102	6.81	0.00	6.81	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.000	0.35	10.11	0.48	10.11	2.0	Off
11	MHMB0104	6.11	2.78	8.90	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.44	13.01	0.57	13.01	2.0	Off
12	MHMB0498	1.77	0.00	1.32	0.45	DrGrt	0.0	0.00	0.00	3.00	2.00	0.015	2.00	0.015	0.015	0.050	0.18	26.00	0.18	26.00	0.0	Off
13	MHMB0499	2.72	0.00	2.72	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.13	3.01	0.26	3.01	2.0	Off
14	MHMB0500	1.71	0.00	1.71	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.06	1.23	0.19	1.66	2.0	Off
15	MHMB0501	2.53	0.00	2.53	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.12	2.69	0.25	2.69	2.0	Off
16	MHMB0502	18.44	0.00	18.44	0.00	DrGrt	0.0	0.00	2.80	3.00	2.00	Sag	2.00	0.031	0.031	0.013	1.50	98.89	1.50	98.89	0.0	Off
17	MHMB0503	5.83	0.00	5.83	0.00	DrCrb	6.0	8.40	0.00	0.00	0.00	Sag	0.00	0.031	0.031	0.013	0.38	12.10	0.38	12.10	0.0	Off
18	MHMB0504	4.88	0.00	4.88	0.00	DrCrb	6.0	8.40	0.00	0.00	0.00	Sag	0.00	0.031	0.031	0.013	0.33	10.74	0.33	10.74	0.0	Off
19	MHMB0505	2.15	0.00	2.15	0.00	DrGrt	0.0	0.00	2.92	2.50	2.50	Sag	2.00	0.031	0.031	0.013	0.17	13.63	0.17	13.63	0.0	Off
20	MHMB0506	10.76	0.00	10.76	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.52	15.59	0.65	15.59	2.0	Off
21	MHMB0507	6.04	0.00	6.04	0.00	Comb	6.0	3.00	2.80	3.00	2.00	Sag	2.00	0.050	0.031	0.013	0.31	8.82	0.44	8.82	2.0	Off

Alternative #1 | Number of lines: 21 | Run Date: 10/15/2012

NOTES: Inlet N-Values = 0.016; Intensity = 84.35 / (Inlet time + 15.10) ^ 0.83; Return period = 10 Yrs. ; * Indicates Known Q added. All curb inlets are Horiz throat.

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf		Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf	Ave Sf	Enrgy loss		
	(in)	(cfs)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(%)	(ft)	(K)	(ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	36	27.68	29.70	31.38	1.68	4.07	6.80	0.72	32.10	n/a	231.19	44.65	46.33 j	1.68**	4.06	6.81	0.72	47.05i	n/a	n/a	n/a	1.00	n/a
2	36	28.09	44.65	47.36	2.71	6.73	4.18	0.27	47.64	n/a	157.52	46.75	48.44 j	1.69**	4.10	6.85	0.73	49.17i	n/a	n/a	n/a	1.00	n/a
3	36	23.85	46.75	49.49	2.74	6.77	3.52	0.19	49.69	n/a	393.91	48.75	50.31 j	1.56**	3.70	6.44	0.64	50.95i	n/a	n/a	n/a	1.50	n/a
4	36	16.73	48.75	51.21	2.46	6.19	2.70	0.11	51.32	0.063	140.78	49.45	51.24	1.79	4.40	3.81	0.23	51.46	0.142	0.103	0.144	1.50	0.34
5	30	11.35	49.55	51.72	2.17	4.52	2.51	0.10	51.82	n/a	451.22	52.95	54.08 j	1.13**	2.14	5.29	0.44	54.51i	n/a	n/a	n/a	1.50	n/a
6	24	10.18	53.05	54.65	1.60	2.69	3.79	0.22	54.87	n/a	33.06	53.75	54.88 j	1.13**	1.83	5.56	0.48	55.36i	n/a	n/a	n/a	1.48	n/a
7	24	5.05	53.75	55.57	1.82	3.00	1.68	0.04	55.61	n/a	116.37	55.05	55.85 j	0.80**	1.16	4.33	0.29	56.14i	n/a	n/a	n/a	0.60	n/a
8	24	2.05	55.05	56.21	1.16	1.88	1.09	0.02	56.23	0.020	32.88	55.45	56.19	0.74	1.05	1.95	0.06	56.25	0.098	0.059	0.019	1.00	0.06
9	15	4.63	49.90	50.55	0.65*	0.64	7.18	0.80	51.35	n/a	33.27	50.50	51.38	0.88	0.92	5.01	0.39	51.77i	n/a	n/a	0.029	1.00	n/a
10	18	6.81	50.25	51.21	0.96	1.19	5.73	0.51	51.72	n/a	33.19	50.55	51.55	1.00**	1.25	5.47	0.46	52.01i	n/a	n/a	n/a	1.00	n/a
11	15	6.11	50.60	51.58	0.98	1.03	5.94	0.55	52.13	n/a	33.19	51.30	52.29	0.99**	1.04	5.87	0.54	52.82i	n/a	n/a	n/a	1.00	n/a
12	48	49.77	57.50	59.59	2.09	6.64	7.49	0.87	60.46	n/a	147.59	58.50	60.59 j	2.09**	6.63	7.51	0.88	61.46i	n/a	n/a	n/a	0.60	n/a
13	48	49.25	58.50	61.82	3.32	11.16	4.41	0.30	62.13	n/a	137.08	60.05	62.13 j	2.08**	6.59	7.48	0.87	63.00i	n/a	n/a	n/a	0.60	n/a
14	48	47.28	60.05	63.35	3.30	11.09	4.26	0.28	63.63	0.107	61.32	60.40	63.35	2.95	9.95	4.75	0.35	63.70	0.135	0.121	0.074	0.60	0.21
15	48	45.82	60.40	63.62	3.22	10.85	4.22	0.28	63.90	0.105	10.91	60.46	63.62	3.16	10.66	4.30	0.29	63.91	0.109	0.107	0.012	0.60	0.17
16	42	43.72	60.56	63.80	3.24	9.29	4.71	0.34	64.14	n/a	32.87	61.15	63.67	2.52	7.40	5.91	0.54	64.21i	n/a	n/a	-0.475	0.50	n/a
17	42	28.15	61.15	63.82	2.67	7.87	3.58	0.20	64.02	n/a	200.09	62.20	63.88	1.68	4.56	6.18	0.59	64.47i	n/a	n/a	-0.141	1.13	n/a
18	36	22.69	62.20	64.58	2.38	6.02	3.77	0.22	64.80	n/a	16.59	62.60	64.45	1.85	4.58	4.95	0.38	64.83i	n/a	n/a	-0.351	1.15	n/a
19	30	18.50	62.70	64.52	1.82	3.82	4.84	0.36	64.88	n/a	145.29	63.50	64.94	1.44**	2.92	6.33	0.62	65.56i	n/a	n/a	n/a	0.60	n/a
20	30	16.59	63.50	65.84	2.34	4.78	3.47	0.19	66.03	n/a	59.85	64.20	65.75	1.55	3.20	5.18	0.42	66.17i	n/a	n/a	-0.276	0.60	n/a
21	24	6.04	64.30	66.06	1.76	2.93	2.06	0.07	66.13	0.064	33.05	64.90	65.99	1.09	1.75	3.45	0.18	66.17	0.214	0.139	0.046	1.00	0.18

Alternative #1 | Number of lines: 21 | Run Date: 10/15/2012

Notes: * Normal depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

Hydraflow HGL Computation Procedure

General Procedure:

Hydraflow computes the HGL using the Bernoulli energy equation. Manning's equation is used to determine energy losses due to pipe friction. In a standard step, iterative procedure, Hydraflow assumes upstream HGLs until the energy equation balances. If the energy equation cannot balance, supercritical flow exists and critical depth is temporarily assumed at the upstream end. A supercritical flow Profile is then computed using the same procedure in a downstream direction using momentum principles.The computed HGL is checked against inlet control.

Col. 1 The line number being computed. Calculations begin at Line 1 and proceed upstream.

Col. 2 The line size. In the case of non-circular pipes, the line rise is printed above the span.

Col. 3 Total flow rate in the line.

Col. 4 The elevation of the downstream invert.

Col. 5 Elevation of the hydraulic grade line at the downstream end. This is computed as the upstream HGL + Minor loss of this line's downstream line.

Col. 6 The downstream depth of flow inside the pipe (HGL - Invert elevation) but not greater than the line size

Col. 7 Cross-sectional area of the flow at the downstream end.

Col. 8 The velocity of the flow at the downstream end, (Col. 3 / Col. 7).

Col. 9 Velocity head (Velocity squared / 2g).

Col. 10 The elevation of the energy grade line at the downstream end, HGL + Velocity head, (Col. 5 + Col. 9).

Col. 11 The friction slope at the downstream end (the S or Slope term in Manning's equation).

Col. 12 The line length.

Col. 13 The elevation of the upstream invert.

Col. 14 Elevation of the hydraulic grade line at the upstream end.

Col. 15 The upstream depth of flow inside the pipe (HGL - Invert elevation) but not greater than the line size.

Col. 16 Cross-sectional area of the flow at the upstream end.

Col. 17 The velocity of the flow at the upstream end, (Col. 3 / Col. 16).

Col. 18 Velocity head (Velocity squared / 2g).

Col. 19 The elevation of the energy grade line at the upstream end, HGL + Velocity head, (Col. 14 + Col. 18) .

Col. 20 The friction slope at the upstream end (the S or Slope term in Manning's equation).

Col. 21 The average of the downstream and upstream friction slopes.

Col. 22 Energy loss. Average Sf/100 x Line Length (Col. 21/100 x Col. 12). Equals (EGL upstream - EGL downstream) +/- tolerance.

Col. 23 The junction loss coefficient (K).

Col. 24 Minor loss. (Col. 23 x Col. 18). Is added to upstream HGL and used as the starting HGL for the next upstream line(s).

SECONDARY SYSTEM EXISTING CONDITIONS: SWMM INPUT

Project: Greenville Pilot Watershed Study
Location: Rondo Drive (Existing)
Prepared by :ERB/EVH
Checked by: DJK
Date: May 2012

SWMM Sub-Basin ID	Curve Number	Area (acres)	Area (sq. ft.)	Flow Length (ft.)	Width (ft.)	Elevation Change (ft.)	Basin Slope (%)
Basin_BBMB0113	86	1.44	62726	346	181	2	0.69
Basin_BBMB0114	85	1.78	77537	472	164	2	0.44
Basin_BBMB0115	83	3.38	147233	657	224	3	0.44
Basin_BBMB0116	91	0.56	24394	306	80	3	0.85
Basin_BBMB0117	86	0.35	15246	215	71	2	0.79
Basin_BBMB0118	86	0.63	27443	284	97	4	1.34
Basin_BBMB0119	85	0.41	17860	227	79	3	1.37
Basin_BBMB0120	86	0.41	17860	185	97	2	1.19
Basin_BBMB0121	86	0.41	17860	155	115	2	1.48
Basin_BBMB0122	81	0.18	7841	175	45	3	1.43
Basin_BBMB0123	82	0.58	25265	232	109	2	0.69
Basin_BBMB0124	85	0.50	21780	311	70	2	0.68
Basin_BBMB0125	85	1.07	46609	369	126	3	0.76
Basin_BBMB0126	84	0.64	27878	336	83	3	1.01
Basin_BBMB0127	84	0.15	6534	131	50	2	1.30
Basin_BBMB0128	82	0.63	27443	349	79	2	0.46
Basin_BBMB0129	83	0.25	10890	205	53	2	0.88
Basin_BBMB0130	83	0.28	12197	186	66	2	0.86
Basin_BBMB0131	85	0.28	12197	207	59	2	0.92
Basin_BBMB0132	88	0.22	9583	212	45	1	0.42
Basin_BBMB0133	80	0.67	29185	250	117	2	0.64
Basin_BBMB0134	81	1.91	83200	650	128	3	0.40
Basin_BBMB0135	75	0.53	23087	245	94	1	0.41
Basin_BBMB0136	84	0.98	42689	275	155	2	0.73
Basin_BBMB0137	84	1.21	52708	636	83	3	0.53
Basin_BBMB0138	82	1.07	46609	576	81	2	0.33
Basin_BBMB0139	82	1.77	77101	404	191	3	0.77
Basin_BBMB0140	85	0.92	40075	334	120	1	0.18
Basin_BBMB0223	85	1.40	60984	248	246	1	0.35
Basin_BBMB0224	85	0.57	24829	146	170	3	1.86

*For basin with slope less than 0.2 %, increased slope to 0.2%.

Project: Greenville Pilot Watershed Study
Location: Sherwood Drive (Existing)
Prepared by :ERB/EVH
Checked by: DJK
Date: May 2012

SWMM Sub-Basin ID	Curve Number	Area (acres)	Area (sq. ft.)	Flow Length (ft.)	Width (ft.)	Elevation Change (ft.)	Basin Slope (%)
Basin_MHMB0458	87	0.55	23958	367	65	2	0.44
Basin_MHMB0460	88	0.82	35719	211	169	1	0.62
Basin_MHMB0461	87	1.46	63598	425	150	1	0.33
Basin_MHMB0464	87	1.48	64469	419	154	2	0.50
Basin_MHMB0465	86	4.18	182081	551	330	3	0.45
Basin_MHMB0467	86	3.13	136343	554	246	0	0.07
Basin_MHMB0470	84	1.38	60113	640	94	2	0.30
Basin_MHMB0471	81	2.76	120226	705	171	2	0.26
Basin_MHMB0472	87	0.39	16988	251	68	2	0.76
Basin_MHMB0473	89	0.27	11761	226	52	2	0.71
Basin_MHMB0474	84	1.36	59242	283	209	0	0.14
Basin_MHMB0475	85	0.91	39640	269	147	0	0.04
Basin_MHMB0476	88	0.88	38333	373	103	2	0.51
Basin_MHMB0477	82	3.70	161172	622	259	2	0.31
Basin_MHMB0478	85	0.48	20909	166	126	0	0.06
Basin_MHMB0479	85	0.56	24394	210	116	1	0.33
Basin_MHMB0480	85	1.30	56628	340	167	0	0.09
Basin_MHMB0482	87	3.96	172498	1026	168	0	0.03
Basin_MHMB0483	87	4.30	187308	1018	184	1	0.05
Basin_MHMB0486	87	2.03	88427	506	175	1	0.20
Basin_MHMB0487	87	5.09	221720	669	331	1	0.16
*For basin with slope less than 0.2 %, increased slope to 0.2%.							

SECONDARY SYSTEM EXISTING CONDITIONS: SWMM OUTPUT

Existing Conditions:Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

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EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
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Existing Conditions:Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Starting Date ............ MAY-20-2010 00:00:00
Ending Date .............. MAY-22-2010 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:10:00
Dry Time Step ............ 00:10:00
Routing Time Step ........ 15.00 sec


WARNING 04: minimum elevation drop used for Conduit 9_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 14_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 18_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 24_EX30RCP

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......        11.241         5.812
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         2.177         1.125
Surface Runoff ...........         8.985         4.645
Final Surface Storage ....         0.092         0.048
Continuity Error (%) .....        -0.115


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         8.985         2.928
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.791         0.258
External Outflow .........         9.026         2.941
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.011         0.004
Final Stored Volume ......         0.266         0.087
Continuity Error (%) .....         5.049


*************************
Highest Continuity Errors
```

Existing Conditions:Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

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*************************
Node BBMB0121 (2.03%)
Node BBMB0124 (1.62%)
Node BBMB0122 (1.47%)
Node BBMB0120 (1.20%)
Node BBMB0123 (1.13%)


***************************
Time-Step Critical Elements
***************************
Link 24_EX30RCP (29.83%)
Link 22_EX36RCP (2.03%)
Link 20_EX15RCP (1.11%)
Link 19_EX18RCP (1.02%)


********************************
Highest Flow Instability Indexes
********************************
Link 29_EX24RCP (2)
Link 14_EX18RCP (2)
Link 13_EX30RCP (2)
Link 17_EX15RCP (2)
Link 16_EX24RCP (2)


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.73 sec
Average Time Step           :    13.11 sec
Maximum Time Step           :    15.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.01


***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
Basin_BBMB0113	5.81	0.00	0.00	0.97	4.80	0.19	3.29	0.825
Basin_BBMB0114	5.81	0.00	0.00	1.04	4.73	0.23	3.48	0.813
Basin_BBMB0115	5.81	0.00	0.00	1.17	4.60	0.42	5.83	0.791
Basin_BBMB0116	5.81	0.00	0.00	0.65	5.13	0.08	1.43	0.882
Basin_BBMB0117	5.81	0.00	0.00	0.97	4.80	0.05	0.89	0.827
Basin_BBMB0118	5.81	0.00	0.00	0.97	4.80	0.08	1.61	0.827
Basin_BBMB0119	5.81	0.00	0.00	1.03	4.74	0.05	1.07	0.816
Basin_BBMB0120	5.81	0.00	0.00	0.97	4.81	0.05	1.11	0.827
Basin_BBMB0121	5.81	0.00	0.00	0.96	4.81	0.05	1.14	0.828
Basin_BBMB0122	5.81	0.00	0.00	1.27	4.51	0.02	0.46	0.775
Basin_BBMB0123	5.81	0.00	0.00	1.21	4.56	0.07	1.37	0.784
Basin_BBMB0124	5.81	0.00	0.00	1.04	4.74	0.06	1.15	0.815
Basin_BBMB0125	5.81	0.00	0.00	1.04	4.73	0.14	2.40	0.815
Basin_BBMB0126	5.81	0.00	0.00	1.10	4.68	0.08	1.49	0.805
Basin_BBMB0127	5.81	0.00	0.00	1.09	4.69	0.02	0.41	0.807
Basin_BBMB0128	5.81	0.00	0.00	1.22	4.55	0.08	1.29	0.782
Basin_BBMB0129	5.81	0.00	0.00	1.16	4.61	0.03	0.55	0.793
Basin_BBMB0130	5.81	0.00	0.00	1.15	4.62	0.04	0.71	0.795
Basin_BBMB0131	5.81	0.00	0.00	1.03	4.74	0.04	0.72	0.816
Basin_BBMB0132	5.81	0.00	0.00	0.84	4.93	0.03	0.54	0.848
Basin_BBMB0133	5.81	0.00	0.00	1.33	4.44	0.08	1.50	0.763
Basin_BBMB0134	5.81	0.00	0.00	1.30	4.47	0.23	3.16	0.770
Basin_BBMB0135	5.81	0.00	0.00	1.62	4.15	0.06	1.05	0.714
Basin_BBMB0136	5.81	0.00	0.00	1.10	4.68	0.12	2.30	0.805
Basin_BBMB0137	5.81	0.00	0.00	1.11	4.66	0.15	2.20	0.802

Basin_BBMB0138	5.81	0.00	0.00	1.24	4.53	0.13	1.81	0.780
Basin_BBMB0139	5.81	0.00	0.00	1.22	4.55	0.22	3.72	0.783
Basin_BBMB0140	5.81	0.00	0.00	1.04	4.73	0.12	1.78	0.813

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Node Depth Summary
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Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	Time of Max Occurrence hr:min
BBMB0113	JUNCTION	4.99	6.08	68.48	0	13:17
BBMB0114	JUNCTION	2.91	3.99	68.49	0	13:18
BBMB0115	JUNCTION	2.81	3.89	68.49	0	13:16
BBMB0116	JUNCTION	4.69	5.79	68.49	0	13:17
BBMB0117	JUNCTION	4.89	5.99	68.49	0	13:18
BBMB0118	JUNCTION	5.19	6.30	68.50	0	13:19
BBMB0119	JUNCTION	4.39	5.48	68.48	0	13:19
BBMB0120	JUNCTION	3.80	4.99	68.59	0	13:16
BBMB0121	JUNCTION	3.60	4.81	68.61	0	13:13
BBMB0122	JUNCTION	4.40	5.66	68.66	0	13:13
BBMB0123	JUNCTION	3.21	4.69	68.89	0	13:07
BBMB0124	JUNCTION	2.22	3.74	68.94	0	13:09
BBMB0125	JUNCTION	1.82	3.34	68.94	0	13:08
BBMB0126	JUNCTION	1.42	2.99	68.99	0	13:06
BBMB0127	JUNCTION	1.03	2.61	69.01	0	13:06
BBMB0128	JUNCTION	0.63	2.21	69.01	0	13:06
BBMB0129	JUNCTION	0.63	2.25	69.05	0	13:02
BBMB0130	JUNCTION	0.13	1.70	69.10	0	13:01
BBMB0131	JUNCTION	0.13	1.64	69.14	0	13:01
BBMB0132	JUNCTION	0.06	1.24	69.14	0	13:01
BBMB0133	JUNCTION	2.52	4.07	68.97	0	13:07
BBMB0134	JUNCTION	2.22	3.91	69.11	0	13:06
BBMB0135	JUNCTION	2.23	3.98	69.18	0	13:06
BBMB0136	JUNCTION	1.63	3.49	69.29	0	13:07
BBMB0137	JUNCTION	0.55	2.45	69.35	0	13:06
BBMB0138	JUNCTION	0.25	2.21	69.41	0	13:00
BBMB0139	JUNCTION	1.44	3.30	69.30	0	13:09
BBMB0140	JUNCTION	1.24	3.11	69.31	0	13:07
BBMB0112	OUTFALL	7.43	7.43	67.33	0	00:00

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Node Inflow Summary
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Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal
BBMB0113	JUNCTION	3.28	44.08	0	00:01	0.188	3.201
BBMB0114	JUNCTION	3.48	4.41	0	00:02	0.228	0.489
BBMB0115	JUNCTION	5.82	6.67	0	13:00	0.422	0.446
BBMB0116	JUNCTION	1.43	27.98	0	00:01	0.078	2.565
BBMB0117	JUNCTION	0.89	27.59	0	00:02	0.046	2.241
BBMB0118	JUNCTION	1.60	29.80	0	12:53	0.082	2.432
BBMB0119	JUNCTION	1.07	30.25	0	12:55	0.053	2.317
BBMB0120	JUNCTION	1.10	20.55	0	13:05	0.054	2.014
BBMB0121	JUNCTION	1.14	10.76	0	00:09	0.054	0.878
BBMB0122	JUNCTION	0.46	19.17	0	13:06	0.022	1.867
BBMB0123	JUNCTION	1.36	18.90	0	13:06	0.072	1.787
BBMB0124	JUNCTION	1.15	7.45	0	13:01	0.064	0.535
BBMB0125	JUNCTION	2.39	2.39	0	13:00	0.138	0.141
BBMB0126	JUNCTION	1.49	5.31	0	13:00	0.081	0.320
BBMB0127	JUNCTION	0.41	3.93	0	13:00	0.019	0.235
BBMB0128	JUNCTION	1.29	1.29	0	13:00	0.078	0.079

BBMB0129	JUNCTION	0.55	2.34	0	13:00	0.031	0.133
BBMB0130	JUNCTION	0.71	1.86	0	13:00	0.035	0.101
BBMB0131	JUNCTION	0.72	1.22	0	13:00	0.036	0.066
BBMB0132	JUNCTION	0.54	0.54	0	12:59	0.029	0.029
BBMB0133	JUNCTION	1.49	13.75	0	12:50	0.081	1.160
BBMB0134	JUNCTION	3.16	12.50	0	12:50	0.232	1.069
BBMB0135	JUNCTION	1.04	9.86	0	12:49	0.060	0.830
BBMB0136	JUNCTION	2.30	9.18	0	12:48	0.124	0.765
BBMB0137	JUNCTION	2.20	4.01	0	13:00	0.153	0.287
BBMB0138	JUNCTION	1.81	1.81	0	13:00	0.132	0.132
BBMB0139	JUNCTION	3.71	5.35	0	12:58	0.219	0.344
BBMB0140	JUNCTION	1.77	1.86	0	13:00	0.118	0.121
BBMB0112	OUTFALL	0.00	44.08	0	00:01	0.000	3.199

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Node Surcharge Summary
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Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Feet	Min. Depth Below Rim Feet
BBMB0113	JUNCTION	0.54	0.080	1.920

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Node Flooding Summary
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No nodes were flooded.

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Outfall Loading Summary
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Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS	Total Volume 10^6 gal
BBMB0112	98.04	3.41	44.08	3.199
System	98.04	3.41	44.08	3.199

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Link Flow Summary
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Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days	hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
1_EX36CMP	CONDUIT	44.08	0	00:01	6.71	0.89	1.00
2_EX18RCP	CONDUIT	4.41	0	00:02	3.05	0.64	1.00
2_OVERLAND	CONDUIT	2.41	0	12:48	0.58	0.01	0.79
3_EX15RCP	CONDUIT	3.49	0	00:03	3.23	0.98	1.00
3_OVERLAND	CONDUIT	6.52	0	12:59	1.01	0.03	0.79
4_EX36CMP	CONDUIT	27.98	0	00:01	4.65	1.99	1.00
4_OVERLAND	CONDUIT	23.71	0	13:21	1.98	0.28	1.00
5_EX36CMP	CONDUIT	27.59	0	00:02	6.31	0.94	1.00
5_OVERLAND	CONDUIT	16.33	0	13:16	1.13	0.04	0.65
6_EX36CMP	CONDUIT	24.80	0	00:03	5.95	0.78	1.00
6_OVERLAND	CONDUIT	16.36	0	13:08	0.91	0.08	0.72
7_EX36CMP	CONDUIT	18.18	0	00:08	3.37	0.61	1.00
7_OVERLAND	CONDUIT	28.33	0	12:53	2.52	0.10	0.67

Existing Conditions:Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

8_EX36RCP	CONDUIT	20.00	0	12:55	3.79	0.43	1.00
8_OVERLAND	CONDUIT	4.79	0	13:16	0.81	0.02	0.54
9_EX36RCP	CONDUIT	8.64	0	12:55	3.01	0.10	1.00
9_OVERLAND	CONDUIT	0.94	0	13:14	0.90	0.07	0.09
10_EX36RCP	CONDUIT	13.12	0	00:07	5.51	0.27	1.00
10_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.09
11_EX36RCP	CONDUIT	8.42	0	13:07	1.20	0.15	1.00
11_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.11
12_EX36RCP	CONDUIT	18.87	0	13:07	2.67	0.29	1.00
12_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
13_EX30RCP	CONDUIT	6.21	0	13:10	1.27	0.16	1.00
13_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.47
14_EX18RCP	CONDUIT	1.82	0	12:46	1.43	0.16	1.00
14_OVERLAND	CONDUIT	1.50	0	13:09	0.50	0.05	0.27
15_EX24RCP	CONDUIT	5.24	0	13:00	1.67	0.28	1.00
15_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.14
16_EX24RCP	CONDUIT	3.87	0	13:00	1.23	0.26	1.00
16_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
17_EX15RCP	CONDUIT	1.25	0	13:00	1.02	0.18	1.00
17_OVERLAND	CONDUIT	0.16	0	13:07	0.05	0.00	0.28
18_EX18RCP	CONDUIT	2.32	0	13:01	1.31	0.33	1.00
18_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
19_EX18RCP	CONDUIT	1.82	0	13:01	1.03	0.23	1.00
19_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
20_EX15RCP	CONDUIT	1.17	0	13:01	1.48	0.40	1.00
20_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
21_EX15RCP	CONDUIT	0.51	0	13:02	1.23	0.06	1.00
21_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
22_EX36RCP	CONDUIT	13.69	0	12:50	1.94	0.28	1.00
22_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
23_EX30RCP	CONDUIT	12.47	0	12:50	2.54	0.51	1.00
23_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
24_EX30RCP	CONDUIT	9.80	0	12:49	2.39	3.64	1.00
24_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
25_EX30RCP	CONDUIT	8.99	0	12:49	1.83	0.33	1.00
25_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.04
26_EX24RCP	CONDUIT	4.01	0	13:00	1.28	0.29	1.00
26_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.04
27_EX15RCP	CONDUIT	1.82	0	13:00	1.48	0.30	1.00
27_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.14
28_EX24RCP	CONDUIT	4.29	0	13:25	1.80	0.24	1.00
28_OVERLAND	CONDUIT	1.15	0	13:11	0.62	0.00	0.09
29_EX24RCP	CONDUIT	1.70	0	12:58	1.53	0.12	1.00
29_OVERLAND	CONDUIT	0.41	0	13:21	0.30	0.00	0.10

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Flow Classification Summary
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Conduit	Adjusted /Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
		--- Fraction of Time in Flow Class ----								
1_EX36CMP	1.88	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0002
2_EX18RCP	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0004
2_OVERLAND	17.05	0.02	0.92	0.00	0.06	0.00	0.00	0.00	0.00	0.0000
3_EX15RCP	4.19	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0007
3_OVERLAND	17.05	0.02	0.91	0.00	0.08	0.00	0.00	0.00	0.01	0.0000
4_EX36CMP	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0005
4_OVERLAND	9.29	0.02	0.82	0.00	0.08	0.00	0.08	0.00	0.06	0.0000
5_EX36CMP	7.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0003
5_OVERLAND	16.43	0.01	0.00	0.00	0.98	0.00	0.00	0.00	0.05	0.0000
6_EX36CMP	5.54	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0002
6_OVERLAND	10.73	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.03	0.0000
7_EX36CMP	1.80	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0003
7_OVERLAND	13.04	0.01	0.86	0.00	0.13	0.00	0.00	0.00	0.03	0.0000
8_EX36RCP	1.94	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0002
8_OVERLAND	20.87	0.87	0.11	0.00	0.02	0.00	0.00	0.00	0.00	0.0000
9_EX36RCP	24.63	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0001

Existing Conditions:Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

9_OVERLAND	7.40	0.98	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.0000
10_EX36RCP	2.16	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0001
10_OVERLAND	9.04	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
11_EX36RCP	2.39	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0001
11_OVERLAND	9.04	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
12_EX36RCP	2.20	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.0001
12_OVERLAND	10.84	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
13_EX30RCP	2.17	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.0001
13_OVERLAND	23.25	0.95	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
14_EX18RCP	6.03	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.0002
14_OVERLAND	6.09	0.97	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.0000
15_EX24RCP	1.75	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.0001
15_OVERLAND	24.58	0.97	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
16_EX24RCP	2.12	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.0001
16_OVERLAND	10.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
17_EX15RCP	5.41	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.0002
17_OVERLAND	17.05	0.97	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
18_EX18RCP	1.88	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.02	0.0001
18_OVERLAND	4.48	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
19_EX18RCP	1.59	0.01	0.12	0.00	0.87	0.00	0.00	0.00	0.05	0.0000
19_OVERLAND	14.64	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
20_EX15RCP	2.65	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.37	0.0001
20_OVERLAND	17.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
21_EX15RCP	7.86	0.02	0.01	0.00	0.96	0.00	0.00	0.00	0.32	0.0000
21_OVERLAND	11.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
22_EX36RCP	1.90	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.01	0.0001
22_OVERLAND	7.19	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
23_EX30RCP	2.49	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.0002
23_OVERLAND	7.38	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
24_EX30RCP	6.15	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.0011
24_OVERLAND	9.59	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
25_EX30RCP	1.61	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.0001
25_OVERLAND	11.51	0.99	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
26_EX24RCP	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.02	0.0001
26_OVERLAND	20.00	0.99	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
27_EX15RCP	5.14	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.08	0.0001
27_OVERLAND	21.98	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
28_EX24RCP	6.11	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.0002
28_OVERLAND	16.84	0.98	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
29_EX24RCP	3.43	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.0002
29_OVERLAND	16.43	0.98	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.0000

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Conduit Surcharge Summary
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Conduit	--------- Hours Full -------- Both Ends	Upstream	Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
1_EX36CMP	47.98	47.98	47.98	0.01	0.01
2_EX18RCP	47.95	47.95	47.95	0.01	0.01
3_EX15RCP	47.95	47.95	47.95	0.01	0.01
4_EX36CMP	47.92	47.92	47.92	0.26	0.01
4_OVERLAND	0.54	0.54	0.55	0.01	0.01
5_EX36CMP	47.92	47.92	47.92	0.01	0.01
6_EX36CMP	47.92	47.92	47.92	0.01	0.01
7_EX36CMP	47.77	47.77	47.77	0.01	0.01
8_EX36RCP	47.67	47.67	47.67	0.01	0.01
9_EX36RCP	47.62	47.62	47.62	0.01	0.01
10_EX36RCP	47.67	47.67	47.67	0.01	0.01
11_EX36RCP	47.62	47.62	47.62	0.01	0.01
12_EX36RCP	47.47	47.47	47.47	0.01	0.01
13_EX30RCP	2.72	2.72	2.72	0.01	0.01
14_EX18RCP	47.52	47.52	47.52	0.01	0.01
15_EX24RCP	1.93	1.93	1.93	0.01	0.01
16_EX24RCP	1.36	1.36	1.36	0.01	0.01
17_EX15RCP	1.85	1.85	1.85	0.01	0.01
18_EX18RCP	1.47	1.47	1.47	0.01	0.01

19_EX18RCP	0.50	0.50	0.51	0.01	0.01
20_EX15RCP	0.86	0.86	0.86	0.01	0.01
22_EX36RCP	2.13	2.13	2.14	0.01	0.01
23_EX30RCP	2.82	2.82	2.82	0.01	0.01
24_EX30RCP	2.82	2.82	2.82	3.16	2.82
25_EX30RCP	1.61	1.61	1.62	0.01	0.01
26_EX24RCP	0.88	0.88	0.88	0.01	0.01
27_EX15RCP	1.50	1.50	1.50	0.01	0.01
28_EX24RCP	2.07	2.07	2.07	0.01	0.01
29_EX24RCP	1.77	1.77	1.77	0.01	0.01

Analysis begun on: Mon Oct 15 11:23:19 2012
Analysis ended on: Mon Oct 15 11:23:20 2012
Total elapsed time: 00:00:01

Existing Conditions: Fantasia Street-Sherwood Drive System (10-year)

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------

Existing Conditions: Fantasia Street-Sherwood Drive System (10-year)

*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Starting Date ............ MAY-20-2010 00:00:00
Ending Date .............. MAY-22-2010 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:10:00
Dry Time Step ............ 00:10:00
Routing Time Step ........ 30.00 sec


WARNING 04: minimum elevation drop used for Conduit 5_EX24CMP

WARNING 04: minimum elevation drop used for Conduit 9_EX15CMP

WARNING 04: minimum elevation drop used for Conduit 11_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 12_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 16_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 18_EX15CMP

WARNING 04: minimum elevation drop used for Conduit 19_EX15CMP

WARNING 04: minimum elevation drop used for Conduit CHANNEL_UPST

WARNING 02: maximum depth increased for Node MHMB0460

WARNING 02: maximum depth increased for Node MHMB0461

WARNING 02: maximum depth increased for Node MHMB0463

WARNING 02: maximum depth increased for Node MHMB0467

WARNING 02: maximum depth increased for Node MHMB0468

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......        19.853         5.812
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         3.416         1.000
Surface Runoff ...........        16.244         4.755
Final Surface Storage ....         0.217         0.064
Continuity Error (%) .....        -0.118
```

Existing Conditions: Fantasia Street-Sherwood Drive System (10-year)

```
**************************        Volume         Volume
Flow Routing Continuity         acre-feet      10^6 gal
**************************      ---------      ---------
Dry Weather Inflow .......          0.000          0.000
Wet Weather Inflow .......         16.243          5.293
Groundwater Inflow .......          0.000          0.000
RDII Inflow ..............          0.000          0.000
External Inflow ..........          0.000          0.000
External Outflow .........         16.246          5.294
Internal Outflow .........          0.000          0.000
Storage Losses ...........          0.000          0.000
Initial Stored Volume ....          0.000          0.000
Final Stored Volume ......          0.008          0.003
Continuity Error (%) .....         -0.070


*************************
Highest Continuity Errors
*************************
Node MHMB0483 (-1.41%)


***************************
Time-Step Critical Elements
***************************
Link 7_EX24CMP (14.74%)
Link 6_EX24CMP (10.60%)
Link 10_EX24CMP (8.25%)
Link 9_EX15CMP (5.72%)
Link 13_EX18CMP (3.52%)


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     1.21 sec
Average Time Step           :    21.50 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.01


***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
Basin_MHMB0458	5.81	0.00	0.00	0.91	4.86	0.07	1.18	0.836
Basin_MHMB0460	5.81	0.00	0.00	0.84	4.93	0.11	2.11	0.848
Basin_MHMB0461	5.81	0.00	0.00	0.91	4.85	0.19	2.91	0.835
Basin_MHMB0464	5.81	0.00	0.00	0.91	4.86	0.20	3.14	0.836
Basin_MHMB0465	5.81	0.00	0.00	0.98	4.79	0.54	7.97	0.824
Basin_MHMB0467	5.81	0.00	0.00	0.98	4.78	0.41	5.28	0.822
Basin_MHMB0470	5.81	0.00	0.00	1.11	4.65	0.17	2.30	0.801
Basin_MHMB0471	5.81	0.00	0.00	1.30	4.46	0.33	4.18	0.768
Basin_MHMB0472	5.81	0.00	0.00	0.91	4.87	0.05	0.98	0.837
Basin_MHMB0473	5.81	0.00	0.00	0.78	5.00	0.04	0.70	0.860
Basin_MHMB0474	5.81	0.00	0.00	1.11	4.67	0.17	2.71	0.803
Basin_MHMB0475	5.81	0.00	0.00	1.04	4.73	0.12	1.86	0.814
Basin_MHMB0476	5.81	0.00	0.00	0.85	4.92	0.12	1.95	0.847
Basin_MHMB0477	5.81	0.00	0.00	1.24	4.53	0.46	6.07	0.780

Basin_MHMB0478	5.81	0.00	0.00	1.04	4.74	0.06	1.11	0.815
Basin_MHMB0479	5.81	0.00	0.00	1.04	4.74	0.07	1.30	0.815
Basin_MHMB0480	5.81	0.00	0.00	1.04	4.73	0.17	2.50	0.813
Basin_MHMB0482	5.81	0.00	0.00	0.91	4.81	0.52	5.60	0.827
Basin_MHMB0483	5.81	0.00	0.00	0.91	4.81	0.56	6.10	0.828
Basin_MHMB0486	5.81	0.00	0.00	0.91	4.84	0.27	3.57	0.833
Basin_MHMB0487	5.81	0.00	0.00	0.91	4.83	0.67	8.22	0.832

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	hr:min
MHMB0457	JUNCTION	0.60	1.64	68.44	0	13:07
MHMB0458	JUNCTION	0.65	2.63	70.03	0	13:35
MHMB0459	JUNCTION	0.64	2.88	70.48	0	13:38
MHMB0460	JUNCTION	0.54	3.21	71.01	0	13:33
MHMB0461	JUNCTION	0.61	3.25	70.95	0	13:49
MHMB0462	JUNCTION	0.66	2.48	70.68	0	13:52
MHMB0463	JUNCTION	0.91	2.61	71.01	0	13:50
MHMB0464	JUNCTION	0.69	2.32	71.02	0	13:23
MHMB0465	JUNCTION	0.75	2.38	70.98	0	13:48
MHMB0466	JUNCTION	0.68	2.38	71.18	0	14:07
MHMB0467	JUNCTION	0.44	1.87	73.27	0	13:09
MHMB0468	JUNCTION	0.90	2.03	68.83	0	13:05
MHMB0469	JUNCTION	0.67	1.84	69.64	0	13:03
MHMB0470	JUNCTION	0.48	1.82	69.92	0	13:02
MHMB0471	JUNCTION	0.70	2.34	70.24	0	13:06
MHMB0472	JUNCTION	0.55	1.53	69.73	0	13:02
MHMB0473	JUNCTION	0.93	1.95	70.15	0	13:01
MHMB0474	JUNCTION	0.98	2.31	70.81	0	15:00
MHMB0475	JUNCTION	1.57	3.74	72.04	0	15:13
MHMB0476	JUNCTION	1.20	3.38	72.18	0	15:43
MHMB0477	JUNCTION	1.22	3.38	72.18	0	15:44
MHMB0478	JUNCTION	1.55	4.27	72.77	0	15:02
MHMB0479	JUNCTION	1.77	4.63	73.23	0	15:00
MHMB0480	JUNCTION	1.93	4.62	73.32	0	14:56
MHMB0481	JUNCTION	2.09	4.51	73.31	0	15:02
MHMB0482	JUNCTION	1.13	2.71	73.31	0	14:57
MHMB0483	JUNCTION	1.35	2.94	73.34	0	13:05
MHMB0484	JUNCTION	2.01	4.41	73.31	0	15:01
MHMB0485	JUNCTION	1.52	3.51	73.31	0	14:57
MHMB0486	JUNCTION	1.46	3.41	73.31	0	14:53
MHMB0487	JUNCTION	1.51	3.41	73.31	0	15:00
MHMB0425	OUTFALL	0.58	1.57	66.17	0	13:07

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal
MHMB0457	JUNCTION	0.00	25.69	0	13:04	0.000	5.294
MHMB0458	JUNCTION	1.18	11.50	0	13:38	0.073	1.774
MHMB0459	JUNCTION	0.00	11.03	0	13:57	0.000	1.701
MHMB0460	JUNCTION	2.11	4.14	0	13:26	0.110	0.291
MHMB0461	JUNCTION	2.91	7.17	0	13:03	0.192	0.603
MHMB0462	JUNCTION	0.00	3.54	0	17:08	0.000	0.806
MHMB0463	JUNCTION	0.00	5.66	0	12:53	0.000	0.953
MHMB0464	JUNCTION	3.14	8.10	0	13:07	0.195	0.442
MHMB0465	JUNCTION	7.97	7.97	0	13:00	0.543	0.666

Existing Conditions: Fantasia Street-Sherwood Drive System (10-year)

MHMB0466	JUNCTION	0.00	2.64	0	12:39	0.000	0.440
MHMB0467	JUNCTION	5.28	7.99	0	13:08	0.406	0.668
MHMB0468	JUNCTION	0.00	14.86	0	13:02	0.000	3.521
MHMB0469	JUNCTION	0.00	14.97	0	13:00	0.000	3.521
MHMB0470	JUNCTION	2.30	5.13	0	13:00	0.174	0.509
MHMB0471	JUNCTION	4.18	4.18	0	13:00	0.334	0.334
MHMB0472	JUNCTION	0.98	10.01	0	13:00	0.052	3.013
MHMB0473	JUNCTION	0.70	9.46	0	15:00	0.037	2.961
MHMB0474	JUNCTION	2.71	9.33	0	14:59	0.172	2.925
MHMB0475	JUNCTION	1.86	8.69	0	15:29	0.117	2.762
MHMB0476	JUNCTION	1.95	6.30	0	13:00	0.118	0.592
MHMB0477	JUNCTION	6.07	6.07	0	13:00	0.455	0.465
MHMB0478	JUNCTION	1.11	7.04	0	14:41	0.062	2.064
MHMB0479	JUNCTION	1.30	6.83	0	14:30	0.072	2.002
MHMB0480	JUNCTION	2.50	6.93	0	14:29	0.167	1.953
MHMB0481	JUNCTION	0.00	7.29	0	13:42	0.000	1.856
MHMB0482	JUNCTION	5.60	7.55	0	13:00	0.517	0.863
MHMB0483	JUNCTION	6.10	7.08	0	13:00	0.562	0.600
MHMB0484	JUNCTION	0.00	3.70	0	13:38	0.000	0.693
MHMB0485	JUNCTION	0.00	5.58	0	13:04	0.000	0.668
MHMB0486	JUNCTION	3.57	4.24	0	13:00	0.267	0.291
MHMB0487	JUNCTION	8.22	8.22	0	13:00	0.668	0.688
MHMB0425	OUTFALL	0.00	25.59	0	13:07	0.000	5.294

****
Node Surcharge Summary
****

No nodes were surcharged.

****
Node Flooding Summary
****

No nodes were flooded.

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS	Total Volume 10^6 gal
MHMB0425	96.38	6.63	25.59	5.294
System	96.38	6.63	25.59	5.294

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days	hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
1_EX30CMP	CONDUIT	14.86	0	13:02	3.66	0.77	0.77
1_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
2_EX18CMP	CONDUIT	5.09	0	13:00	2.88	0.78	1.00
2_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
3_EX15CMP	CONDUIT	3.29	0	12:46	2.68	1.21	1.00
3_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.04
4_EX30CMP	CONDUIT	9.91	0	13:01	3.76	0.24	0.67
4_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
5_EX24CMP	CONDUIT	9.47	0	15:00	3.57	17.59	0.87

5_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
6_EX24CMP	CONDUIT	9.33	0	15:00	2.99	1.53	0.99
6_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
7_EX24CMP	CONDUIT	8.70	0	15:35	2.77	2.39	1.00
7_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
8_EX18CMP	CONDUIT	2.70	0	18:10	1.53	0.85	1.00
8_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.21
9_EX15CMP	CONDUIT	1.53	0	21:00	1.24	9.10	1.00
9_OVERLAND	CONDUIT	3.33	0	13:00	0.71	0.00	0.41
10_EX24CMP	CONDUIT	7.03	0	14:42	2.24	1.83	1.00
10_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
11_EX18CMP	CONDUIT	5.12	0	17:18	2.90	2.98	1.00
11_OVERLAND	CONDUIT	3.23	0	15:01	1.30	0.50	0.16
12_EX18CMP	CONDUIT	4.31	0	18:47	2.44	2.77	1.00
12_OVERLAND	CONDUIT	5.10	0	14:54	1.37	0.47	0.19
13_EX18CMP	CONDUIT	3.63	0	21:43	2.05	3.07	1.00
13_OVERLAND	CONDUIT	6.12	0	14:53	2.10	0.02	0.18
14_EX15CMP	CONDUIT	1.72	0	12:55	1.40	0.50	1.00
14_OVERLAND	CONDUIT	5.42	0	13:13	1.01	0.00	0.22
15_EX15CMP	CONDUIT	2.28	0	13:03	1.86	0.83	1.00
15_OVERLAND	CONDUIT	4.49	0	13:09	0.61	0.00	0.33
16_EX18CMP	CONDUIT	2.59	1	01:25	1.46	0.89	1.00
16_OVERLAND	CONDUIT	1.48	0	13:41	1.16	0.05	0.15
17_EX18CMP	CONDUIT	2.56	1	01:28	1.45	0.69	1.00
17_OVERLAND	CONDUIT	2.65	0	13:35	0.56	0.00	0.33
18_EX15CMP	CONDUIT	2.55	1	02:06	2.08	6.38	1.00
18_OVERLAND	CONDUIT	1.12	0	14:56	0.22	0.00	0.42
19_EX15CMP	CONDUIT	3.28	0	13:06	2.67	14.85	1.00
19_OVERLAND	CONDUIT	3.70	0	13:57	0.41	0.00	0.29
20_EX24CMP	CONDUIT	11.50	0	13:38	3.87	1.61	0.91
20_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
21_EX24CMP	CONDUIT	11.04	0	14:04	3.51	1.16	1.00
21_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
22_EX15CMP	CONDUIT	3.50	0	14:54	2.85	1.47	1.00
22_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.06
23_EX18CMP	CONDUIT	6.72	0	13:10	3.80	1.87	1.00
23_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.13
24_EX18CMP	CONDUIT	3.56	0	17:04	2.32	1.08	1.00
24_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
25_EX18CMP	CONDUIT	3.54	0	17:08	2.05	2.48	1.00
25_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.14
26_EX15CMP	CONDUIT	2.27	0	12:47	1.85	0.58	1.00
26_OVERLAND	CONDUIT	3.28	0	13:26	0.66	0.00	0.13
27_EX15CMP	CONDUIT	3.19	0	12:53	2.60	0.62	1.00
27_OVERLAND	CONDUIT	5.48	0	13:24	1.28	0.01	0.20
28_EX18CMP	CONDUIT	2.53	0	12:40	1.43	0.68	1.00
28_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.06
29_EX15CMP	CONDUIT	2.64	0	12:39	2.15	1.00	1.00
29_OVERLAND	CONDUIT	5.46	0	13:09	1.52	0.01	0.29
CHANNEL_DNST	CONDUIT	25.59	0	13:07	3.11	0.15	0.40
CHANNEL_UPST	CONDUIT	14.74	0	13:05	1.51	3.64	0.46

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
		--- Fraction of Time in Flow Class ----								
1_EX30CMP	2.96	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.44	0.0002
1_OVERLAND	13.90	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
2_EX18CMP	13.90	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.16	0.0002
2_OVERLAND	41.74	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
3_EX15CMP	7.75	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.08	0.0004
3_OVERLAND	62.83	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
4_EX30CMP	45.49	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.73	0.0001
4_OVERLAND	10.80	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
5_EX24CMP	4.74	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.47	0.0045

Existing Conditions: Fantasia Street-Sherwood Drive System (10-year)

5_OVERLAND	8.96	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
6_EX24CMP	2.46	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.28	0.0004
6_OVERLAND	13.90	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
7_EX24CMP	1.21	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.14	0.0006
7_OVERLAND	7.81	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
8_EX18CMP	1.61	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.02	0.0005
8_OVERLAND	49.66	0.71	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
9_EX15CMP	4.47	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.08	0.0095
9_OVERLAND	53.69	0.67	0.05	0.00	0.28	0.00	0.00	0.00	0.01	0.0000
10_EX24CMP	1.36	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.07	0.0005
10_OVERLAND	16.46	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
11_EX18CMP	2.17	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.09	0.0010
11_OVERLAND	9.90	0.87	0.00	0.00	0.00	0.00	0.13	0.00	0.05	0.0001
12_EX18CMP	1.75	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.09	0.0011
12_OVERLAND	11.20	0.79	0.00	0.00	0.10	0.00	0.00	0.11	0.08	0.0001
13_EX18CMP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.08	0.0017
13_OVERLAND	26.35	0.75	0.00	0.00	0.19	0.00	0.00	0.06	0.17	0.0000
14_EX15CMP	1.48	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.12	0.0004
14_OVERLAND	64.35	0.61	0.12	0.00	0.23	0.00	0.04	0.00	0.02	0.0000
15_EX15CMP	7.83	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.06	0.0006
15_OVERLAND	62.83	0.57	0.22	0.00	0.02	0.00	0.19	0.00	0.01	0.0000
16_EX18CMP	6.76	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.04	0.0007
16_OVERLAND	12.19	0.75	0.00	0.00	0.23	0.00	0.02	0.00	0.04	0.0000
17_EX18CMP	1.27	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.11	0.0006
17_OVERLAND	52.25	0.61	0.13	0.00	0.25	0.00	0.01	0.00	0.01	0.0000
18_EX15CMP	26.04	0.02	0.00	0.00	0.68	0.00	0.00	0.31	0.18	0.0072
18_OVERLAND	204.53	0.54	0.08	0.00	0.38	0.00	0.00	0.00	0.00	0.0000
19_EX15CMP	7.81	0.02	0.00	0.00	0.57	0.00	0.00	0.42	0.18	0.0122
19_OVERLAND	77.51	0.55	0.18	0.00	0.24	0.00	0.02	0.00	0.01	0.0000
20_EX24CMP	1.75	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.37	0.0004
20_OVERLAND	36.81	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
21_EX24CMP	10.09	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.38	0.0003
21_OVERLAND	14.76	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
22_EX15CMP	5.78	0.02	0.06	0.00	0.92	0.00	0.00	0.00	0.05	0.0005
22_OVERLAND	13.50	0.95	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
23_EX18CMP	10.80	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.10	0.0005
23_OVERLAND	15.83	0.93	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
24_EX18CMP	1.48	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.34	0.0004
24_OVERLAND	44.97	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
25_EX18CMP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.19	0.0009
25_OVERLAND	56.00	0.81	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
26_EX15CMP	12.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.04	0.0005
26_OVERLAND	69.63	0.75	0.14	0.00	0.05	0.00	0.06	0.00	0.01	0.0000
27_EX15CMP	34.74	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.10	0.0005
27_OVERLAND	45.19	0.77	0.06	0.00	0.05	0.00	0.11	0.00	0.04	0.0000
28_EX18CMP	2.91	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.09	0.0004
28_OVERLAND	42.32	0.87	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
29_EX15CMP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.34	0.0003
29_OVERLAND	83.43	0.75	0.11	0.00	0.14	0.00	0.00	0.00	0.02	0.0000
CHANNEL_DNST	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.43	0.0000
CHANNEL_UPST	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.18	0.0009

****
Conduit Surcharge Summary
****

Conduit	Hours Full: Both Ends	Hours Full: Upstream	Hours Full: Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
2_EX18CMP	0.79	0.79	0.80	0.01	0.01
3_EX15CMP	2.65	2.65	2.66	0.80	0.01
5_EX24CMP	0.01	0.01	0.01	21.13	0.01
6_EX24CMP	0.01	0.01	0.01	7.89	0.01
7_EX24CMP	4.40	4.40	4.40	13.71	0.01
8_EX18CMP	9.86	9.86	9.86	0.01	0.01
9_EX15CMP	12.80	12.80	12.81	9.13	6.06
10_EX24CMP	9.37	9.37	9.38	7.63	8.54
11_EX18CMP	15.18	15.18	15.18	16.28	15.18

Existing Conditions: Fantasia Street-Sherwood Drive System (10-year)

12_EX18CMP	15.54	15.54	15.55	14.84	14.26
13_EX18CMP	15.69	15.69	15.70	11.39	10.35
14_EX15CMP	13.72	13.72	13.73	0.01	0.01
15_EX15CMP	13.72	13.72	13.73	0.01	0.01
16_EX18CMP	15.77	15.77	15.78	0.01	0.89
17_EX18CMP	14.94	14.94	14.95	0.01	0.01
18_EX15CMP	15.05	15.05	15.05	2.10	3.05
19_EX15CMP	15.05	15.05	15.05	12.83	8.98
20_EX24CMP	0.01	0.01	0.01	3.36	0.01
21_EX24CMP	2.65	2.65	2.66	2.40	2.65
22_EX15CMP	3.91	3.91	3.92	2.13	2.30
23_EX18CMP	3.63	3.63	3.63	2.95	3.51
24_EX18CMP	3.58	3.58	3.58	1.65	0.21
25_EX18CMP	3.68	3.68	3.68	8.51	3.68
26_EX15CMP	7.08	7.08	7.09	0.01	0.01
27_EX15CMP	7.34	7.34	7.34	0.01	0.01
28_EX18CMP	6.10	6.10	6.10	0.01	0.01
29_EX15CMP	4.04	4.04	4.04	0.01	0.03
CHANNEL_UPST	0.01	0.01	0.01	13.53	0.01

```
Analysis begun on:  Mon Oct 15 11:25:53 2012
Analysis ended on:  Mon Oct 15 11:25:53 2012
Total elapsed time: < 1 sec
```

SECONDARY SYSTEM ALTERNATIVE #1: SWMM INPUT

Project: Greenville Pilot Watershed Study
Location: Sherwood Drive (Alternative 1)
Prepared by :ERB/EVH
Checked by: DJK
Date: June 2012

SWMM Sub-Basin ID	Curve Number	Area (acres)	Area (sq. ft.)	Flow Length (ft.)	Width (ft.)	Elevation Change (ft.)	Basin Slope (%)
Basin_MHMB0458	87	0.55	23958	367	65	2	0.44
Basin_MHMB0460	88	1.38	60113	530	113	1	0.09
Basin_MHMB0461	87	1.23	53579	425	126	0	0.02
Basin_MHMB0464	87	0.92	40075	370	108	1	0.30
Basin_MHMB0465	86	0.9	39204	375	105	1	0.14
Basin_MHMB0467	86	2.18	94961	385	247	0	0.06
Basin_PR_3	86	2.16	94090	460	205	0	0.03
Basin_MHMB0470	84	1.38	60113	640	94	2	0.30
Basin_MHMB0471	85	0.61	26572	165	161	0	0.18
Basin_PR_10	85	1.09	47480	451	105	1	0.22
Basin_PR_11	85	1.07	46609	456	102	1	0.18
Basin_MHMB0472	87	0.39	16988	251	68	2	0.76
Basin_MHMB0473	89	0.27	11761	226	52	2	0.71
Basin_PR_8	88	1.08	47045	370	127	2	0.46
Basin_PR_9	87	3.16	137650	504	273	0	0.08
Basin_MHMB0474	84	1.36	59242	283	209	0	0.14
Basin_MHMB0475	85	0.91	39640	269	147	0	0.04
Basin_MHMB0476	88	0.88	38333	373	103	2	0.51
Basin_MHMB0477	82	3.70	161172	622	259	2	0.31
Basin_MHMB0478	85	0.48	20909	166	126	0	0.06
Basin_MHMB0479	85	0.56	24394	210	116	1	0.33
Basin_MHMB0480	85	1.30	56628	340	167	0	0.09
Basin_MHMB0482	87	0.2	8712	82	106	0	0.37
Basin_PR_4	87	0.21	9148	80	114	1	0.69
Basin_PR_5	87	0.27	11761	155	76	1	0.32
Basin_PR_6	87	0.56	24394	312	78	1	0.20
Basin_PR_7	87	1.53	66647	345	193	1	0.42
Basin_MHMB0483	87	0.60	26136	194	135	0	0.10
Basin_PR_1	87	0.77	33367	340	98	1	0.27
Basin_PR_2	87	0.84	36590	191	192	0	0.02
Basin_MHMB0486	87	0.98	42689	460	93	1	0.22
Basin_MHMB0487	87	1.06	46174	438	105	1	0.25

*For basin with slope less than 0.2 %, increased slope to 0.2%.

SECONDARY SYSTEM ALTERNATIVE #1: SWMM OUTPUT

Alt 1: Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------

Alt 1: Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Starting Date ............ MAY-20-2010 00:00:00
Ending Date .............. MAY-22-2010 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:10:00
Dry Time Step ............ 00:10:00
Routing Time Step ........ 15.00 sec


WARNING 04: minimum elevation drop used for Conduit 4_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 14_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 18_OVERLAND

WARNING 02: maximum depth increased for Node BBMB0125

WARNING 02: maximum depth increased for Node BBMB0128

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......        12.196         5.812
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         2.346         1.118
Surface Runoff ...........         9.763         4.653
Final Surface Storage ....         0.100         0.048
Continuity Error (%) .....        -0.116


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         9.763         3.181
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         9.763         3.182
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....        -0.002
```

Alt 1: Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

```
***************************
Time-Step Critical Elements
***************************
Link 3_EX15RCP (6.10%)


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     9.42 sec
Average Time Step           :    14.86 sec
Maximum Time Step           :    15.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
Basin_BBMB0113	5.81	0.00	0.00	0.97	4.80	0.19	3.29	0.825
Basin_BBMB0114	5.81	0.00	0.00	1.04	4.73	0.23	3.48	0.813
Basin_BBMB0115	5.81	0.00	0.00	1.17	4.60	0.42	5.83	0.791
Basin_BBMB0116	5.81	0.00	0.00	0.65	5.13	0.08	1.43	0.882
Basin_BBMB0117	5.81	0.00	0.00	0.97	4.80	0.05	0.89	0.827
Basin_BBMB0118	5.81	0.00	0.00	0.97	4.80	0.08	1.61	0.827
Basin_BBMB0119	5.81	0.00	0.00	1.03	4.74	0.05	1.07	0.816
Basin_BBMB0120	5.81	0.00	0.00	0.97	4.81	0.05	1.11	0.827
Basin_BBMB0121	5.81	0.00	0.00	0.96	4.81	0.05	1.14	0.828
Basin_BBMB0122	5.81	0.00	0.00	1.27	4.51	0.02	0.46	0.775
Basin_BBMB0123	5.81	0.00	0.00	1.21	4.56	0.07	1.37	0.784
Basin_BBMB0124	5.81	0.00	0.00	1.04	4.74	0.06	1.15	0.815
Basin_BBMB0125	5.81	0.00	0.00	1.04	4.73	0.14	2.40	0.815
Basin_BBMB0126	5.81	0.00	0.00	1.10	4.68	0.08	1.49	0.805
Basin_BBMB0127	5.81	0.00	0.00	1.09	4.69	0.02	0.41	0.807
Basin_BBMB0128	5.81	0.00	0.00	1.22	4.55	0.08	1.29	0.782
Basin_BBMB0129	5.81	0.00	0.00	1.16	4.61	0.03	0.55	0.793
Basin_BBMB0130	5.81	0.00	0.00	1.15	4.62	0.04	0.71	0.795
Basin_BBMB0131	5.81	0.00	0.00	1.03	4.74	0.04	0.72	0.816
Basin_BBMB0132	5.81	0.00	0.00	0.84	4.93	0.03	0.54	0.848
Basin_BBMB0133	5.81	0.00	0.00	1.33	4.44	0.08	1.50	0.763
Basin_BBMB0134	5.81	0.00	0.00	1.30	4.47	0.23	3.16	0.770
Basin_BBMB0135	5.81	0.00	0.00	1.62	4.15	0.06	1.05	0.714
Basin_BBMB0136	5.81	0.00	0.00	1.10	4.68	0.12	2.30	0.805
Basin_BBMB0137	5.81	0.00	0.00	1.11	4.66	0.15	2.20	0.802
Basin_BBMB0138	5.81	0.00	0.00	1.24	4.53	0.13	1.81	0.780
Basin_BBMB0139	5.81	0.00	0.00	1.22	4.55	0.22	3.72	0.783
Basin_BBMB0140	5.81	0.00	0.00	1.04	4.73	0.12	1.78	0.813
5	5.81	0.00	0.00	1.02	4.75	0.07	1.59	0.818
6	5.81	0.00	0.00	1.04	4.73	0.18	3.15	0.815

```
******************
Node Depth Summary
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Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days hr:min

BBMB0113	JUNCTION	0.22	1.81	61.61	0	13:02
BBMB0114	JUNCTION	0.10	0.65	64.93	0	13:00
BBMB0115	JUNCTION	0.17	1.35	65.80	0	13:00
BBMB0116	JUNCTION	0.29	2.18	62.98	0	13:02
BBMB0117	JUNCTION	0.30	2.49	63.44	0	13:03
BBMB0118	JUNCTION	0.29	2.65	63.80	0	13:03
BBMB0119	JUNCTION	0.26	2.37	64.16	0	13:03
BBMB0120	JUNCTION	0.24	2.15	64.57	0	13:03
BBMB0122	JUNCTION	0.24	2.11	65.11	0	13:03
BBMB0123	JUNCTION	0.24	2.03	65.68	0	13:02
BBMB0124	JUNCTION	0.12	0.93	66.13	0	13:00
BBMB0125	JUNCTION	0.07	0.63	66.23	0	13:00
BBMB0126	JUNCTION	0.10	0.84	66.84	0	13:00
BBMB0127	JUNCTION	0.10	0.80	67.20	0	13:00
BBMB0128	JUNCTION	0.05	0.43	67.23	0	13:00
BBMB0129	JUNCTION	0.08	0.67	67.47	0	13:00
BBMB0130	JUNCTION	0.06	0.54	67.94	0	13:00
BBMB0131	JUNCTION	0.08	0.65	68.15	0	13:00
BBMB0132	JUNCTION	0.03	0.25	68.15	0	13:00
BBMB0133	JUNCTION	0.20	1.46	66.36	0	13:01
BBMB0134	JUNCTION	0.25	1.85	66.95	0	13:01
BBMB0135	JUNCTION	0.23	1.98	67.18	0	13:01
BBMB0136	JUNCTION	0.17	1.63	67.43	0	13:01
BBMB0137	JUNCTION	0.12	0.74	67.64	0	13:00
BBMB0138	JUNCTION	0.08	0.62	67.82	0	13:00
BBMB0139	JUNCTION	0.13	1.51	67.51	0	13:01
BBMB0140	JUNCTION	0.09	1.32	67.52	0	13:00
PROP_INLET	JUNCTION	0.08	0.52	63.92	0	13:00
BBMB0223	JUNCTION	0.07	0.54	65.79	0	13:00
BBMB0224	JUNCTION	0.09	0.40	67.65	0	12:59
BBMB0112	OUTFALL	0.20	1.30	58.15	0	13:02

****

Node Inflow Summary

****

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal
BBMB0113	JUNCTION	3.28	49.00	0	13:02	0.188	3.181
BBMB0114	JUNCTION	3.48	9.28	0	12:59	0.228	0.650
BBMB0115	JUNCTION	5.83	5.83	0	12:59	0.422	0.422
BBMB0116	JUNCTION	1.43	43.03	0	13:02	0.078	2.773
BBMB0117	JUNCTION	0.89	36.25	0	13:03	0.046	2.266
BBMB0118	JUNCTION	1.61	35.48	0	13:03	0.082	2.220
BBMB0119	JUNCTION	1.07	34.24	0	13:02	0.053	2.137
BBMB0120	JUNCTION	2.25	29.12	0	13:02	0.107	1.831
BBMB0122	JUNCTION	0.46	27.28	0	13:02	0.022	1.724
BBMB0123	JUNCTION	1.37	27.02	0	13:01	0.072	1.702
BBMB0124	JUNCTION	1.15	9.07	0	13:00	0.064	0.512
BBMB0125	JUNCTION	2.40	2.40	0	12:59	0.138	0.138
BBMB0126	JUNCTION	1.49	5.58	0	13:00	0.081	0.310
BBMB0127	JUNCTION	0.41	4.14	0	13:00	0.019	0.229
BBMB0128	JUNCTION	1.29	1.29	0	12:59	0.078	0.078
BBMB0129	JUNCTION	0.55	2.48	0	13:00	0.031	0.132
BBMB0130	JUNCTION	0.71	1.94	0	12:59	0.035	0.101
BBMB0131	JUNCTION	0.72	1.25	0	12:59	0.036	0.066
BBMB0132	JUNCTION	0.54	0.54	0	12:59	0.029	0.029
BBMB0133	JUNCTION	1.50	16.72	0	13:01	0.081	1.118
BBMB0134	JUNCTION	3.16	15.34	0	13:01	0.232	1.038
BBMB0135	JUNCTION	1.05	12.37	0	13:00	0.060	0.806
BBMB0136	JUNCTION	2.30	11.54	0	13:00	0.124	0.746
BBMB0137	JUNCTION	2.20	4.00	0	12:59	0.153	0.285
BBMB0138	JUNCTION	1.81	1.81	0	12:59	0.132	0.132
BBMB0139	JUNCTION	3.72	5.42	0	12:59	0.219	0.337
BBMB0140	JUNCTION	1.78	1.78	0	12:59	0.118	0.118

PROP_INLET	JUNCTION	0.00	3.17	0	13:00	0.000	0.221
BBMB0223	JUNCTION	3.15	4.73	0	12:59	0.180	0.254
BBMB0224	JUNCTION	1.59	1.59	0	12:59	0.074	0.074
BBMB0112	OUTFALL	0.00	49.03	0	13:02	0.000	3.181

****
Node Surcharge Summary
****

No nodes were surcharged.

****
Node Flooding Summary
****

No nodes were flooded.

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS	Total Volume 10^6 gal
BBMB0112	95.95	2.85	49.03	3.181
System	95.95	2.85	49.03	3.181

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days hr:min		Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
1_PROP48RCP	CONDUIT	49.03	0	13:02	10.82	0.23	0.39
2A_PROP24RCP	CONDUIT	3.15	0	13:01	5.09	0.13	0.25
2A_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
2B_PROP24RCP	CONDUIT	3.17	0	13:00	4.12	0.20	0.29
2B_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
3_EX15RCP	CONDUIT	5.82	0	13:00	5.81	1.26	0.76
3_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
4_PROP42RCP	CONDUIT	43.04	0	13:03	7.62	0.60	0.57
4_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
5_PROP42RCP	CONDUIT	36.34	0	13:04	5.37	0.51	0.67
5_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
6_PROP42RCP	CONDUIT	35.51	0	13:03	4.70	0.49	0.73
6_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
7_PROP42RCP	CONDUIT	34.12	0	13:03	4.63	0.46	0.72
7_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
8_PROP42RCP	CONDUIT	29.07	0	13:03	4.43	0.41	0.64
8_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
10_PROP42RCP	CONDUIT	27.20	0	13:03	4.45	0.38	0.61
10_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
12_PROP42RCP	CONDUIT	26.87	0	13:02	4.56	0.38	0.59
12_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
13_EX30RCP	CONDUIT	9.06	0	13:01	4.55	0.24	0.48
13_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
14_EX18RCP	CONDUIT	2.38	0	13:00	2.57	0.21	0.52
14_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
15_EX24RCP	CONDUIT	5.57	0	13:00	4.15	0.30	0.44
15_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
16_EX24RCP	CONDUIT	4.13	0	13:01	3.39	0.27	0.41

Alt 1: Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

16_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
17_EX15RCP	CONDUIT	1.28	0	13:00	2.17	0.18	0.49
17_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
18_EX18RCP	CONDUIT	2.47	0	13:00	2.85	0.35	0.49
18_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
19_EX18RCP	CONDUIT	1.94	0	13:00	2.90	0.25	0.40
19_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
20_EX15RCP	CONDUIT	1.24	0	13:00	2.16	0.43	0.47
20_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
21_EX15RCP	CONDUIT	0.53	0	13:00	1.39	0.07	0.36
21_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
22_EX36RCP	CONDUIT	16.71	0	13:01	5.20	0.34	0.49
22_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
23_EX30RCP	CONDUIT	15.32	0	13:01	4.45	0.77	0.66
23_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
24_EX30RCP	CONDUIT	12.35	0	13:01	3.06	0.46	0.77
24_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
25_EX30RCP	CONDUIT	11.37	0	13:01	3.00	0.42	0.72
25_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
26_EX24RCP	CONDUIT	3.98	0	13:00	2.26	0.29	0.59
26_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
27_EX15RCP	CONDUIT	1.80	0	13:00	2.66	0.29	0.54
27_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
28_EX24RCP	CONDUIT	5.30	0	13:00	2.23	0.30	0.78
28_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
29_EX24RCP	CONDUIT	1.71	0	13:00	1.16	0.12	0.71
29_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
30_PROP36RCP	CONDUIT	4.72	0	13:00	3.91	0.07	0.39
30_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
31_EX15RCP	CONDUIT	1.59	0	13:00	4.06	0.17	0.36
31_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
32_EX18RCP	CONDUIT	6.10	0	13:00	4.50	0.39	0.72

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	--- Fraction of Time in Flow Class ---- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
1_PROP48RCP	3.17	0.02	0.00	0.00	0.17	0.81	0.00	0.00	1.58	0.0000
2A_PROP24RCP	1.62	0.02	0.00	0.00	0.00	0.00	0.00	0.98	1.35	0.0000
2A_OVERLAND	37.23	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
2B_PROP24RCP	1.13	0.02	0.00	0.00	0.61	0.37	0.00	0.00	0.84	0.0000
2B_OVERLAND	13.95	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
3_EX15RCP	4.59	0.02	0.00	0.00	0.16	0.82	0.00	0.00	1.09	0.0002
3_OVERLAND	17.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
4_PROP42RCP	1.36	0.02	0.00	0.00	0.30	0.68	0.00	0.00	1.04	0.0001
4_OVERLAND	4.48	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
5_PROP42RCP	9.01	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.65	0.0001
5_OVERLAND	11.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
6_PROP42RCP	7.01	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.73	0.0001
6_OVERLAND	7.38	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
7_PROP42RCP	2.36	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.78	0.0001
7_OVERLAND	9.20	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
8_PROP42RCP	2.14	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.78	0.0001
8_OVERLAND	20.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
10_PROP42RCP	2.34	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.77	0.0001
10_OVERLAND	14.64	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
12_PROP42RCP	2.09	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.78	0.0001
12_OVERLAND	15.91	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
13_EX30RCP	2.17	0.02	0.00	0.00	0.02	0.02	0.00	0.94	0.99	0.0000
13_OVERLAND	23.25	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
14_EX18RCP	6.03	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.51	0.0000
14_OVERLAND	4.48	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
15_EX24RCP	1.75	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.62	0.0001
15_OVERLAND	17.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
16_EX24RCP	2.12	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.58	0.0000

Alt 1: Barnes Street–Paramore Drive–Rondo Drive System (10-Year)

16_OVERLAND	14.64	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
17_EX15RCP	5.41	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.51	0.0000
17_OVERLAND	17.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
18_EX18RCP	1.88	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.47	0.0001
18_OVERLAND	4.48	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
19_EX18RCP	1.59	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.52	0.0000
19_OVERLAND	14.64	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
20_EX15RCP	2.65	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.40	0.0001
20_OVERLAND	17.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
21_EX15RCP	7.86	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.33	0.0000
21_OVERLAND	11.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
22_EX36RCP	1.90	0.02	0.00	0.00	0.01	0.00	0.00	0.96	1.00	0.0001
22_OVERLAND	5.93	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
23_EX30RCP	2.33	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.62	0.0001
23_OVERLAND	6.75	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
24_EX30RCP	9.33	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.46	0.0001
24_OVERLAND	6.75	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
25_EX30RCP	1.61	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.65	0.0001
25_OVERLAND	11.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
26_EX24RCP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.52	0.0001
26_OVERLAND	20.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
27_EX15RCP	5.14	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.62	0.0001
27_OVERLAND	20.87	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
28_EX24RCP	6.11	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.48	0.0001
28_OVERLAND	11.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
29_EX24RCP	3.43	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.44	0.0000
29_OVERLAND	11.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
30_PROP36RCP	1.00	0.02	0.00	0.00	0.06	0.01	0.00	0.91	0.99	0.0000
30_OVERLAND	35.65	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
31_EX15RCP	2.19	0.02	0.15	0.00	0.71	0.12	0.00	0.00	0.47	0.0000
31_OVERLAND	23.98	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
32_EX18RCP	1.50	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.55	0.0001

****
Conduit Surcharge Summary
****

Conduit	Hours Full Both Ends	Hours Full Upstream	Hours Full Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
3_EX15RCP	0.01	0.01	0.01	0.32	0.01

Analysis begun on: Mon Oct 15 11:25:11 2012
Analysis ended on: Mon Oct 15 11:25:12 2012
Total elapsed time: 00:00:01

Alt 1: Fantasia Street-Sherwood Drive System (10-Year)

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EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)
--------------------------------------------------------------

Alt 1: Fantasia Street-Sherwood Drive System (10-Year)

*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ YES
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Starting Date ............ MAY-20-2010 00:00:00
Ending Date .............. MAY-22-2010 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:10:00
Dry Time Step ............ 00:10:00
Routing Time Step ........ 15.00 sec


WARNING 04: minimum elevation drop used for Conduit 5_EX24CMP

WARNING 04: minimum elevation drop used for Conduit 11_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 12_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 16_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 18_OVERLAND

WARNING 04: minimum elevation drop used for Conduit 41_OVERLAND

**************************        Volume         Depth
Runoff Quantity Continuity     acre-feet        inches
**************************     ---------       -------
Total Precipitation ......        16.753         5.812
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         2.849         0.988
Surface Runoff ...........        13.769         4.777
Final Surface Storage ....         0.154         0.054
Continuity Error (%) .....        -0.115


**************************        Volume        Volume
Flow Routing Continuity        acre-feet      10^6 gal
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......        13.769         4.487
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........        13.766         4.486
Internal Outflow .........         0.000         0.000
Storage Losses ...........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.003         0.001
Continuity Error (%) .....        -0.002
```

Alt 1: Fantasia Street-Sherwood Drive System (10-Year)

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***************************
Time-Step Critical Elements
***************************
Link 5_EX24CMP (8.81%)
Link 11_EX18CMP (2.68%)


********************************
Highest Flow Instability Indexes
********************************
All links are stable.


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.91 sec
Average Time Step           :    14.44 sec
Maximum Time Step           :    15.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00


***************************
Subcatchment Runoff Summary
***************************
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Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
Basin_MHMB0458	5.81	0.00	0.00	0.91	4.86	0.07	1.18	0.836
Basin_MHMB0460	5.81	0.00	0.00	0.85	4.91	0.18	2.43	0.844
Basin_MHMB0461	5.81	0.00	0.00	0.91	4.85	0.16	2.28	0.834
Basin_MHMB0464	5.81	0.00	0.00	0.91	4.85	0.12	1.88	0.835
Basin_MHMB0465	5.81	0.00	0.00	0.98	4.79	0.12	1.71	0.824
Basin_MHMB0467	5.81	0.00	0.00	0.98	4.79	0.28	4.10	0.824
Basin_MHMB0470	5.81	0.00	0.00	1.11	4.65	0.17	2.30	0.801
Basin_MHMB0471	5.81	0.00	0.00	1.03	4.74	0.08	1.42	0.815
Basin_MHMB0472	5.81	0.00	0.00	0.91	4.87	0.05	0.98	0.837
Basin_MHMB0473	5.81	0.00	0.00	0.78	5.00	0.04	0.70	0.860
Basin_MHMB0474	5.81	0.00	0.00	1.11	4.67	0.17	2.71	0.803
Basin_MHMB0475	5.81	0.00	0.00	1.04	4.73	0.12	1.86	0.814
Basin_MHMB0476	5.81	0.00	0.00	0.85	4.92	0.12	1.95	0.847
Basin_MHMB0477	5.81	0.00	0.00	1.24	4.53	0.46	6.07	0.780
Basin_MHMB0478	5.81	0.00	0.00	1.04	4.74	0.06	1.11	0.815
Basin_MHMB0479	5.81	0.00	0.00	1.04	4.74	0.07	1.30	0.815
Basin_MHMB0480	5.81	0.00	0.00	1.04	4.73	0.17	2.50	0.813
Basin_MHMB0482	5.81	0.00	0.00	0.91	4.85	0.16	2.40	0.835
Basin_MHMB0483	5.81	0.00	0.00	0.91	4.84	0.28	3.70	0.833
Basin_MHMB0486	5.81	0.00	0.00	0.91	4.85	0.13	1.80	0.834
Basin_MHMB0487	5.81	0.00	0.00	0.91	4.85	0.14	2.01	0.835
Basin_PR_1	5.81	0.00	0.00	0.91	4.86	0.10	1.59	0.835
Basin_PR_2	5.81	0.00	0.00	0.91	4.86	0.11	1.93	0.836
Basin_PR_3	5.81	0.00	0.00	0.98	4.78	0.28	3.86	0.823
Basin_PR_8	5.81	0.00	0.00	0.85	4.92	0.14	2.11	0.846
Basin_PR_9	5.81	0.00	0.00	0.91	4.84	0.42	5.57	0.833
Basin_PR_10	5.81	0.00	0.00	1.04	4.72	0.14	1.95	0.812
Basin_PR_11	5.81	0.00	0.00	1.04	4.72	0.14	1.89	0.812

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******************
Node Depth Summary
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	Average Depth	Maximum Depth	Maximum HGL	Time of Max Occurrence

Alt 1: Fantasia Street-Sherwood Drive System (10-Year)

Node	Type	Feet	Feet	Feet	days	hr:min
MHMB0457	JUNCTION	0.68	3.89	64.19	0	13:05
MHMB0458	JUNCTION	0.22	1.20	64.35	0	13:01
MHMB0459	JUNCTION	0.28	1.75	65.30	0	13:01
MHMB0460	JUNCTION	0.13	0.80	68.55	0	13:00
MHMB0461	JUNCTION	0.25	1.88	69.13	0	13:00
MHMB0462	JUNCTION	0.28	1.74	65.94	0	13:03
MHMB0463	JUNCTION	0.25	1.83	66.98	0	13:03
MHMB0464	JUNCTION	0.06	0.94	66.99	0	13:03
MHMB0465	JUNCTION	0.18	1.73	66.98	0	13:03
MHMB0466	JUNCTION	0.24	1.82	67.27	0	13:03
MHMB0467	JUNCTION	0.21	1.34	69.29	0	13:00
MHMB0468	JUNCTION	0.26	2.29	64.29	0	13:05
MHMB0469	JUNCTION	0.28	1.96	64.62	0	13:03
MHMB0470	JUNCTION	0.24	1.49	66.16	0	13:01
MHMB0471	JUNCTION	0.23	1.57	66.41	0	13:01
MHMB0472	JUNCTION	0.08	0.48	68.68	0	12:58
MHMB0473	JUNCTION	0.34	1.73	69.93	0	13:01
MHMB0474	JUNCTION	0.31	2.40	70.90	0	13:01
MHMB0475	JUNCTION	0.55	3.28	71.58	0	13:01
MHMB0477	JUNCTION	0.16	1.05	68.00	0	13:00
MHMB0478	JUNCTION	0.38	3.40	71.90	0	13:01
MHMB0479	JUNCTION	0.35	3.78	72.38	0	13:01
MHMB0480	JUNCTION	0.32	3.93	72.63	0	13:01
MHMB0481	JUNCTION	0.11	0.76	70.66	0	13:01
MHMB0482	JUNCTION	0.16	1.22	70.57	0	13:01
MHMB0483	JUNCTION	0.19	1.25	70.50	0	13:00
MHMB0484	JUNCTION	0.11	0.78	70.83	0	13:01
MHMB0485	JUNCTION	0.19	1.03	71.18	0	13:00
MHMB0486	JUNCTION	0.16	1.04	71.24	0	13:00
MHMB0487	JUNCTION	0.16	1.07	71.27	0	13:00
PR_INLET1	JUNCTION	0.17	1.02	70.12	0	13:00
PR_INLET2	JUNCTION	0.18	1.16	69.66	0	13:01
PR_INLET3	JUNCTION	0.19	1.11	68.86	0	13:01
PR_INLET_10	JUNCTION	0.19	1.24	67.20	0	13:00
PR_INLET_11	JUNCTION	0.22	1.43	66.79	0	13:00
MHMB0425	OUTFALL	0.67	3.82	63.82	0	13:05

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Node Inflow Summary
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Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal
MHMB0457	JUNCTION	0.00	60.01	0	13:02	0.000	4.486
MHMB0458	JUNCTION	1.18	35.77	0	13:01	0.073	2.706
MHMB0459	JUNCTION	0.00	34.61	0	13:00	0.000	2.633
MHMB0460	JUNCTION	2.42	2.42	0	12:59	0.184	0.184
MHMB0461	JUNCTION	9.95	9.95	0	12:59	0.722	0.722
MHMB0462	JUNCTION	0.00	23.14	0	13:03	0.000	1.728
MHMB0463	JUNCTION	0.00	23.31	0	13:01	0.000	1.728
MHMB0464	JUNCTION	1.88	1.88	0	12:59	0.121	0.121
MHMB0465	JUNCTION	1.71	1.71	0	12:59	0.117	0.117
MHMB0466	JUNCTION	0.00	20.44	0	13:01	0.000	1.490
MHMB0467	JUNCTION	4.10	16.77	0	13:00	0.283	1.209
MHMB0468	JUNCTION	0.00	25.46	0	13:02	0.000	1.780
MHMB0469	JUNCTION	0.00	25.78	0	13:00	0.000	1.780
MHMB0470	JUNCTION	2.30	13.31	0	13:00	0.174	0.985
MHMB0471	JUNCTION	1.42	11.14	0	13:00	0.078	0.810
MHMB0472	JUNCTION	0.98	12.42	0	13:00	0.052	0.795
MHMB0473	JUNCTION	0.70	11.50	0	13:00	0.037	0.744
MHMB0474	JUNCTION	4.66	10.88	0	13:00	0.290	0.707
MHMB0475	JUNCTION	1.86	6.41	0	13:00	0.117	0.418
MHMB0477	JUNCTION	6.06	6.06	0	12:59	0.455	0.455
MHMB0478	JUNCTION	1.11	4.70	0	13:00	0.062	0.301

MHMB0479	JUNCTION	1.30	3.71	0	13:00	0.072	0.239
MHMB0480	JUNCTION	2.50	2.50	0	12:59	0.167	0.167
MHMB0481	JUNCTION	0.00	3.69	0	13:01	0.000	0.269
MHMB0482	JUNCTION	2.40	5.94	0	13:01	0.165	0.433
MHMB0483	JUNCTION	3.70	9.51	0	13:00	0.280	0.713
MHMB0484	JUNCTION	0.00	3.74	0	13:00	0.000	0.269
MHMB0485	JUNCTION	0.00	3.79	0	13:00	0.000	0.269
MHMB0486	JUNCTION	1.80	1.80	0	12:59	0.129	0.129
MHMB0487	JUNCTION	2.01	2.01	0	12:59	0.140	0.140
PR_INLET1	JUNCTION	1.58	11.03	0	13:00	0.102	0.815
PR_INLET2	JUNCTION	1.93	12.87	0	13:00	0.111	0.926
PR_INLET3	JUNCTION	3.86	20.48	0	13:00	0.281	1.490
PR_INLET_10	JUNCTION	1.95	7.99	0	13:00	0.140	0.595
PR_INLET_11	JUNCTION	1.88	9.81	0	13:00	0.137	0.732
MHMB0425	OUTFALL	0.00	58.50	0	13:05	0.000	4.486

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Node Surcharge Summary
****

No nodes were surcharged.

****
Node Flooding Summary
****

No nodes were flooded.

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS	Total Volume 10^6 gal
MHMB0425	96.60	4.77	58.50	4.486
System	96.60	4.77	58.50	4.486

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days	hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
1_PROP42RCP	CONDUIT	25.46	0	13:02	5.21	0.36	0.60
1_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
2_PROP30RCP	CONDUIT	13.29	0	13:01	5.01	0.45	0.53
2_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
3_PROP30RCP	CONDUIT	11.10	0	13:01	3.53	0.38	0.61
3_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
4_EX30CMP	CONDUIT	12.55	0	13:00	5.52	0.08	0.48
4_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
5_EX24CMP	CONDUIT	11.48	0	13:01	6.50	21.35	0.55
5_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
6_EX24CMP	CONDUIT	10.82	0	13:00	3.55	1.78	0.93
6_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
7_EX24CMP	CONDUIT	6.43	0	13:02	2.05	1.77	1.00
7_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
10_EX24CMP	CONDUIT	4.64	0	13:01	1.48	1.21	1.00
10_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
11_EX18CMP	CONDUIT	3.61	0	13:00	2.04	2.10	1.00

Alt 1: Fantasia Street-Sherwood Drive System (10-Year)

11_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
12_EX18CMP	CONDUIT	2.42	0	13:00	1.37	1.56	1.00
12_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
14_PROPTWIN18RCP	CONDUIT	3.74	0	13:02	1.62	0.33	0.66
14_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
15_PROPTWIN18RCP	CONDUIT	5.99	0	13:02	1.94	0.52	0.82
15_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
16_PROPTWIN15RCP	CONDUIT	3.69	0	13:01	2.61	0.46	0.62
16_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
17_PROPTWIN15RCP	CONDUIT	3.74	0	13:00	1.97	1.34	0.72
17_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
18_PROP15RCP	CONDUIT	1.79	0	13:00	1.65	0.34	0.83
18_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
19_PROP15RCP	CONDUIT	2.00	0	13:00	1.82	0.69	0.84
19_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
20_PROP48RCP	CONDUIT	35.74	0	13:01	4.31	0.20	0.63
20_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
21_PROP48RCP	CONDUIT	34.66	0	13:01	8.23	0.22	0.37
21_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
22_PROP15RCP	CONDUIT	2.41	0	13:00	3.35	0.55	0.57
22_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
23_PROP18RCP	CONDUIT	9.93	0	13:00	5.91	1.22	0.90
23_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
24_PROP48RCP	CONDUIT	23.17	0	13:04	4.50	0.27	0.44
24_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
25_PROPTWIN24RCP	CONDUIT	23.14	0	13:03	3.91	0.93	0.89
25_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
26_PROP24RCP	CONDUIT	1.73	0	13:00	1.58	0.04	0.69
26_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
27_PROP24RCP	CONDUIT	1.61	0	13:00	0.71	0.07	0.89
27_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
28_PROPTWIN24RCP	CONDUIT	20.19	0	13:02	3.39	0.79	0.91
28_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
29_PROPTWIN24RCP	CONDUIT	20.44	0	13:01	4.24	0.60	0.73
29_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
30_PROP18RCP	CONDUIT	6.05	0	13:00	4.18	0.72	0.76
30_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
31_PROP24RCP	CONDUIT	7.96	0	13:00	3.58	0.54	0.67
31_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
32_PROP30RCP	CONDUIT	9.77	0	13:00	3.19	0.43	0.60
32_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
40_PROPTWIN18RCP	CONDUIT	9.48	0	13:00	3.30	0.82	0.76
41_PROPTWIN24RCP	CONDUIT	11.00	0	13:01	3.15	0.43	0.54
41_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
42_PROPTWIN24RCP	CONDUIT	12.82	0	13:01	3.12	0.50	0.62
42_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
43_PROPTWIN24RCP	CONDUIT	16.76	0	13:01	4.14	0.60	0.61
43_OVERLAND	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
CHANNEL_DNST	CONDUIT	58.50	0	13:05	1.86	0.91	0.96
CHANNEL_UPST	CONDUIT	24.47	0	13:03	1.41	0.15	0.77

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Flow Classification Summary
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Conduit	Adjusted /Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Avg. Froude Number	Avg. Flow Change
		--- Fraction of Time in Flow Class ----								
1_PROP42RCP	2.07	0.02	0.00	0.00	0.33	0.65	0.00	0.00	0.98	0.0001
1_OVERLAND	26.69	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
2_PROP30RCP	9.81	0.02	0.00	0.00	0.00	0.00	0.00	0.98	1.01	0.0001
2_OVERLAND	20.87	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
3_PROP30RCP	6.77	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.65	0.0001
3_OVERLAND	21.70	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
4_EX30CMP	55.55	0.02	0.00	0.00	0.55	0.43	0.00	0.00	0.81	0.0000
4_OVERLAND	2.62	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
5_EX24CMP	2.37	0.02	0.00	0.00	0.77	0.21	0.00	0.00	0.51	0.0049
5_OVERLAND	4.48	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000

Alt 1: Fantasia Street-Sherwood Drive System (10-Year)

6_EX24CMP	1.23	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.22	0.0003
6_OVERLAND	6.95	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
7_EX24CMP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.07	0.0003
7_OVERLAND	3.90	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
10_EX24CMP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.05	0.0002
10_OVERLAND	8.23	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
11_EX18CMP	1.09	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.12	0.0004
11_OVERLAND	4.95	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
12_EX18CMP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.13	0.0003
12_OVERLAND	5.60	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
14_PROPTWIN18RCP	1.00	0.02	0.01	0.00	0.97	0.00	0.00	0.00	0.44	0.0001
14_OVERLAND	19.08	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
15_PROPTWIN18RCP	4.67	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.41	0.0002
15_OVERLAND	19.08	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
16_PROPTWIN15RCP	3.79	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.64	0.0002
16_OVERLAND	4.48	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
17_PROPTWIN15RCP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.31	0.0004
17_OVERLAND	17.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
18_PROP15RCP	20.67	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.28	0.0001
18_OVERLAND	11.97	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
19_PROP15RCP	5.21	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.25	0.0001
19_OVERLAND	17.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
20_PROP48RCP	2.20	0.02	0.00	0.00	0.94	0.04	0.00	0.00	0.58	0.0000
20_OVERLAND	12.85	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
21_PROP48RCP	10.92	0.02	0.00	0.00	0.06	0.92	0.00	0.00	1.32	0.0000
21_OVERLAND	7.92	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
22_PROP15RCP	3.46	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.93	0.0001
22_OVERLAND	16.13	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
23_PROP18RCP	6.95	0.02	0.00	0.00	0.00	0.00	0.00	0.98	1.00	0.0002
23_OVERLAND	14.98	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
24_PROP48RCP	1.53	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.71	0.0000
24_OVERLAND	18.10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
25_PROPTWIN24RCP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.60	0.0003
25_OVERLAND	22.49	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
26_PROP24RCP	13.84	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.22	0.0000
26_OVERLAND	19.08	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
27_PROP24RCP	25.58	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.16	0.0000
27_OVERLAND	14.64	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
28_PROPTWIN24RCP	1.94	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.62	0.0003
28_OVERLAND	13.21	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
29_PROPTWIN24RCP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.77	0.0002
29_OVERLAND	34.40	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
30_PROP18RCP	1.15	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.81	0.0001
30_OVERLAND	14.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
31_PROP24RCP	1.38	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.66	0.0001
31_OVERLAND	17.05	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
32_PROP30RCP	1.23	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.65	0.0001
32_OVERLAND	18.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
40_PROPTWIN18RCP	3.06	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.62	0.0003
41_PROPTWIN24RCP	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.63	0.0001
41_OVERLAND	4.48	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
42_PROPTWIN24RCP	1.06	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.59	0.0002
42_OVERLAND	9.29	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
43_PROPTWIN24RCP	3.60	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.70	0.0002
43_OVERLAND	9.29	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000
CHANNEL_DNST	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.16	0.0002
CHANNEL_UPST	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.11	0.0000

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Conduit Surcharge Summary
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Conduit	--------- Hours Full -------- Both Ends	Upstream	Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
5_EX24CMP	0.01	0.01	0.01	10.31	0.01
6_EX24CMP	0.01	0.01	0.01	0.72	0.01
7_EX24CMP	0.29	0.29	0.29	0.69	0.01

Alt 1: Fantasia Street-Sherwood Drive System (10-Year)

10_EX24CMP	0.57	0.57	0.57	0.32	0.37
11_EX18CMP	1.23	1.23	1.23	1.02	1.08
12_EX18CMP	1.14	1.14	1.14	0.56	0.61
15_PROPTWIN18RCP	0.01	0.01	0.01	0.08	0.01
17_PROPTWIN15RCP	0.01	0.01	0.01	1.92	0.01
23_PROP18RCP	0.01	0.01	0.01	0.29	0.01
25_PROPTWIN24RCP	0.01	0.01	0.01	1.00	0.01
28_PROPTWIN24RCP	0.01	0.01	0.01	0.62	0.01
29_PROPTWIN24RCP	0.01	0.01	0.01	0.30	0.01
40_PROPTWIN18RCP	0.01	0.01	0.01	0.68	0.01
43_PROPTWIN24RCP	0.01	0.01	0.01	0.30	0.01

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Analysis begun on:  Mon Oct 15 11:27:40 2012
Analysis ended on:  Mon Oct 15 11:27:41 2012
Total elapsed time: 00:00:01
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APPENDIX I

Bioretention Pond - First Free Will Baptist Church

Project: City of Greenville - Pilot Watershed Master Plan
Prepared by: EVH
Checked by: TLM
Date: 10/10/12

DRAINAGE AREA INPUT PARAMETERS

Water Quality Event (in)	1.00		Input
	Pervious	**Impervious**	
Drainage Area (sq ft)	49,661	18,464	Input
Sub-basin CN	74	98	Input
S (in)	3.51	0.20	Calculated
R/O (in)	0.02	0.79	Calculated
Sub-basin WQ Volume (sf*in)	1152	14603	Calculated
Sub-basin WQ Volume (cf)	96	1217	Calculated
Summary Calculations			
Total Watershed area (sq ft)	68,125		Calculated
Total Watershed area (acres)	1.56		Calculated
Total WQ Runoff Volume (sf*in)	15,755		Calculated
Total WQ Runoff Volume (cf)	1,313		Calculated
Surface area of bioretention			
Average depth of water (in)	10		Input
Surface area of bioretention (sf)	1,576		Calculated
Surface area of bioretention (ac)	0.04		Calculated
Depth of Bioretention (in)	36		Input
Length of Bioretention (ft)	69		Input
Width of Bioretention (ft) *Assuming 3:1 Ratio (L:W)*	23		Calculated

Bioretention Area - Oakmont Dive

Project: City of Greenville - Pilot Watershed Master Plan
Prepared by: EVH
Checked by: TLM
Date: 10/10/12

DRAINAGE AREA INPUT PARAMETERS

Water Quality Event (in)	1.00		Input
	Pervious	**Impervious**	
Drainage Area (sq ft)	5,876	9,098	Input
Sub-basin CN	74	98	Input
S (in)	3.51	0.20	Calculated
R/O (in)	0.02	0.79	Calculated
Sub-basin WQ Volume (sf*in)	136	7196	Calculated
Sub-basin WQ Volume (cf)	11	600	Calculated
Summary Calculations			
Total Watershed area (sq ft)	14,974		Calculated
Total Watershed area (acres)	0.34		Calculated
Total WQ Runoff Volume (sf*in)	7,332		Calculated
Total WQ Runoff Volume (cf)	611		Calculated
Surface area of bioretention			
Average depth of water (in)	10		Input
Surface area of bioretention (sf)	733		Calculated
Surface area of bioretention (ac)	0.02		Calculated
Depth of Bioretention (in)	36		Input
Length of Bioretention (ft)	47		Input
Width of Bioretention (ft) *Assuming 3:1 Ratio (L:W)*	16		Calculated

Bioretention Area - Eleanor Street

Project: City of Greenville - Pilot Watershed Master Plan
Prepared by: EVH
Checked by: TLM
Date: 10/10/12

DRAINAGE AREA INPUT PARAMETERS

Water Quality Event (in)	1.00		Input
	Pervious	**Impervious**	
Drainage Area (sq ft)	10,890	15,503	Input
Sub-basin CN	69	98	Input
S (in)	4.49	0.20	Calculated
R/O (in)	0.00	0.79	Calculated
Sub-basin WQ Volume (sf*in)	24	12261	Calculated
Sub-basin WQ Volume (cf)	2	1022	Calculated
Summary Calculations			
Total Watershed area (sq ft)	26,393		Calculated
Total Watershed area (acres)	0.61		Calculated
Total WQ Runoff Volume (sf*in)	12,286		Calculated
Total WQ Runoff Volume (cf)	1,024		Calculated
Surface area of bioretention			
Average depth of water (in)	10		Input
Surface area of bioretention (sf)	1,229		Calculated
Surface area of bioretention (ac)	0.03		Calculated
Depth of Bioretention (in)	36		Input
Length of Bioretention (ft)	61		Input
Width of Bioretention (ft) *Assuming 3:1 Ratio (L:W)*	20		Calculated

Bioretention Area - Brook Vallley County Club

Project: City of Greenville - Pilot Watershed Master Plan
Prepared by: EVH
Checked by: TLM
Date: 10/10/12

DRAINAGE AREA INPUT PARAMETERS

Water Quality Event (in)	1.00		Input
	Pervious	**Impervious**	
Drainage Area (sq ft)	45,550	15,268	Input
Sub-basin CN	67	98	Input
S (in)	4.93	0.20	Calculated
R/O (in)	0.00	0.79	Calculated
Sub-basin WQ Volume (sf*in)	2	12076	Calculated
Sub-basin WQ Volume (cf)	0	1006	Calculated
Summary Calculations			
Total Watershed area (sq ft)	60,818		Calculated
Total Watershed area (acres)	1.40		Calculated
Total WQ Runoff Volume (sf*in)	12,078		Calculated
Total WQ Runoff Volume (cf)	1,006		Calculated
Surface area of bioretention			
Average depth of water (in)	10		Input
Surface area of bioretention (sf)	1,208		Calculated
Surface area of bioretention (ac)	0.03		Calculated
Depth of Bioretention (in)	36		Input
Length of Bioretention (ft)	61		Input
Width of Bioretention (ft) *Assuming 3:1 Ratio (L:W)*	20		Calculated

Bioretention Area - Perkins Field

Project: City of Greenville - Pilot Watershed Master Plan
Prepared by: EVH
Checked by: TLM
Date: 10/10/12

DRAINAGE AREA INPUT PARAMETERS

Water Quality Event (in)	1.00		Input
	Pervious	**Impervious**	
Drainage Area (sq ft)	50,690	30,897	Input
Sub-basin CN	79	98	Input
S (in)	2.66	0.20	Calculated
R/O (in)	0.07	0.79	Calculated
Sub-basin WQ Volume (sf*in)	3556	24437	Calculated
Sub-basin WQ Volume (cf)	296	2036	Calculated
Summary Calculations			
Total Watershed area (sq ft)	81,587		Calculated
Total Watershed area (acres)	1.87		Calculated
Total WQ Runoff Volume (sf*in)	27,993		Calculated
Total WQ Runoff Volume (cf)	2,333		Calculated
Surface area of bioretention			
Average depth of water (in)	10		Input
Surface area of bioretention (sf)	2,799		Calculated
Surface area of bioretention (ac)	0.06		Calculated
Depth of Bioretention (in)	36		Input
Length of Bioretention (ft)	92		Input
Width of Bioretention (ft) *Assuming 3:1 Ratio (L:W)*	31		Calculated

Bioretention Area - Eastern Elementary School

Project: City of Greenville - Pilot Watershed Master Plan
Prepared by: EVH
Checked by: TLM
Date: 10/10/12

DRAINAGE AREA INPUT PARAMETERS

Water Quality Event (in)	1.00		Input
	Pervious	**Impervious**	
Drainage Area (sq ft)	81,151	29,255	Input
Sub-basin CN	65	98	Input
S (in)	5.38	0.20	Calculated
R/O (in)	0.00	0.79	Calculated
Sub-basin WQ Volume (sf*in)	90	23138	Calculated
Sub-basin WQ Volume (cf)	8	1928	Calculated
Summary Calculations			
Total Watershed area (sq ft)	110,406		Calculated
Total Watershed area (acres)	2.53		Calculated
Total WQ Runoff Volume (sf*in)	23,228		Calculated
Total WQ Runoff Volume (cf)	1,936		Calculated
Surface area of bioretention			
Average depth of water (in)	10		Input
Surface area of bioretention (sf)	2,323		Calculated
Surface area of bioretention (ac)	0.05		Calculated
Depth of Bioretention (in)	36		Input
Length of Bioretention (ft)	84		Input
Width of Bioretention (ft) *Assuming 3:1 Ratio (L:W)*	28		Calculated

Bioretention Area - Jaycee Park

Project: City of Greenville - Pilot Watershed Master Plan
Prepared by: EVH
Checked by: TLM
Date: 10/10/12

DRAINAGE AREA INPUT PARAMETERS

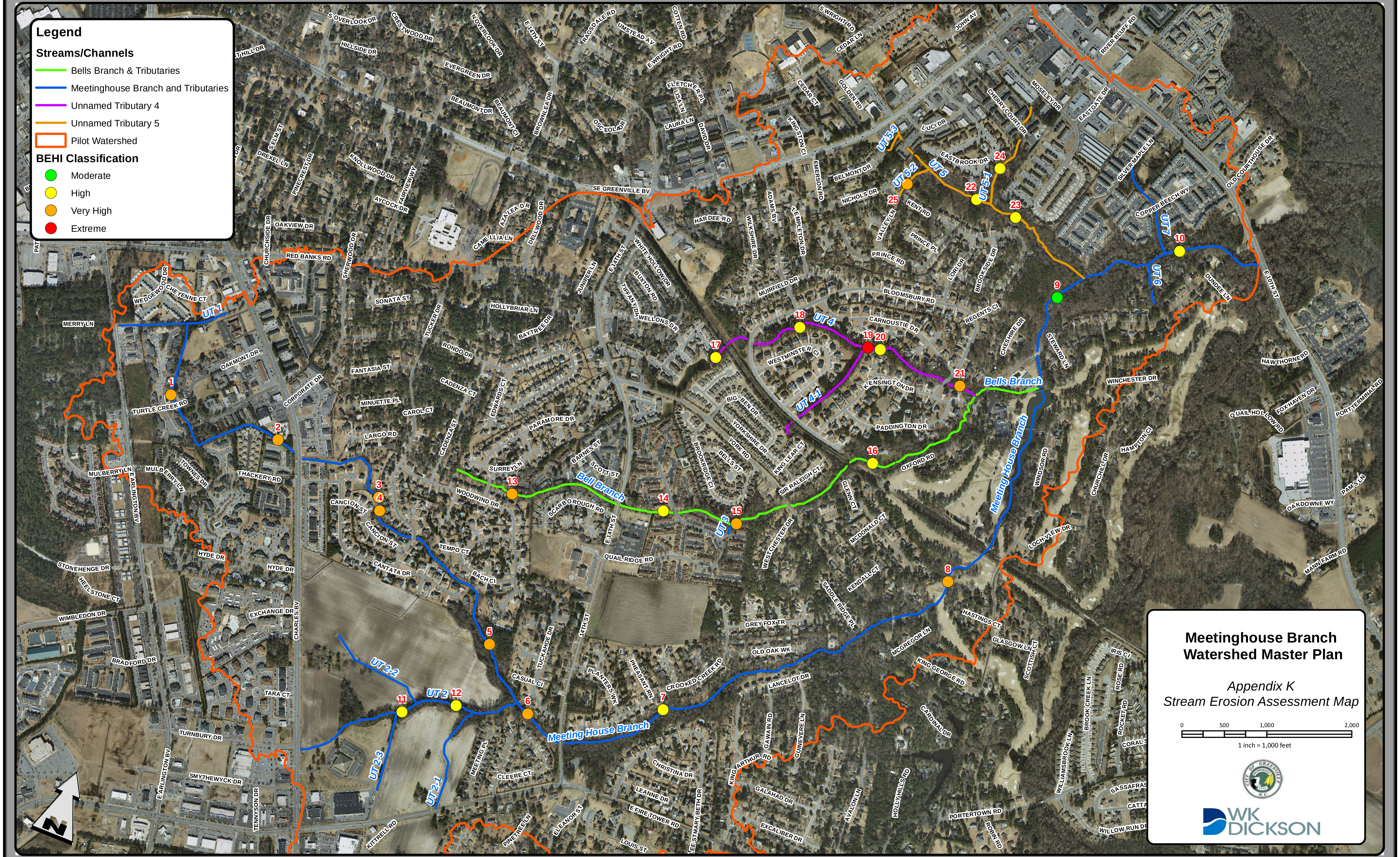
Water Quality Event (in)	1.00		Input
	Pervious	**Impervious**	
Drainage Area (sq ft)	58,637	60,267	Input
Sub-basin CN	49	98	Input
S (in)	10.41	0.20	Calculated
R/O (in)	0.13	0.79	Calculated
Sub-basin WQ Volume (sf*in)	7355	47666	Calculated
Sub-basin WQ Volume (cf)	613	3972	Calculated
Summary Calculations			
Total Watershed area (sq ft)	118,904		Calculated
Total Watershed area (acres)	2.73		Calculated
Total WQ Runoff Volume (sf*in)	55,021		Calculated
Total WQ Runoff Volume (cf)	4,585		Calculated
Surface area of bioretention			
Average depth of water (in)	10		Input
Surface area of bioretention (sf)	5,502		Calculated
Surface area of bioretention (ac)	0.13		Calculated
Depth of Bioretention (in)	36		Input
Length of Bioretention (ft)	129		Input
Width of Bioretention (ft) *Assuming 3:1 Ratio (L:W)*	43		Calculated

APPENDIX J

(Digital files on CD included with hardcopy report)

APPENDIX K

Assessment Number	BEHI Score	BEHI Classification	Stream Reach
19	45.1	Extreme	UT 4
15	44.5	Very High	Bell Branch
8	43.4	Very High	Meeting House Branch
6	42.5	Very High	Meeting House Branch
21	42.5	Very High	UT 4
4	42.1	Very High	Meeting House Branch
5	42.1	Very High	Meeting House Branch
2	41.5	Very High	Meeting House Branch
3	41.2	Very High	Meeting House Branch
1	40.7	Very High	Meeting House Branch
25	40.6	Very High	UT 5-2
13	39.8	Very High	Bell Branch
20	39.5	High	UT 4
24	39.2	High	UT 5-1
17	39	High	UT 4
10	38	High	Meeting House Branch
14	37.1	High	Bell Branch
23	36.7	High	UT 5
18	36.6	High	UT 4
11	36	High	UT 2
7	35.5	High	Meeting House Branch
12	35.3	High	UT 2
22	35.3	High	UT 5
16	34.1	High	Bell Branch
9	27.7	Moderate	Meeting House Branch


Legend
Streams/Channels
Bells Branch & Tributaries
Meetinghouse Branch and Tributaries
Unnamed Tributary 4
Unnamed Tributary 5
Pilot Watershed
BEHI Classification
Moderate
High
Very High
Extreme
Bells Branch
Meeting House Branch
UT 1
UT 2
UT 2-1
UT 2-2
UT 2-3
UT 3
UT 4
UT 4-1
UT 5
UT 5-1
UT 5-2
UT 5-3
UT 6
UT 7
Meetinghouse Branch
Watershed Master Plan
Appendix K
Stream Erosion Assessment Map
0 500 1,000 2,000
1 inch = 1,000 feet
WK DICKSON

Bank Erosion Hazard Rating Guide

Stream Meetinghouse **Assessment Number** 1 **Date** **Crew**

Bank Erosion Potential

Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value	1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value	1.11-1.19		0.89-0.5	0.89	79-55		21-60		79-55	
	Index	2.0-3.9	0.00	2.0-3.9	2.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00
MODERATE	Value	1.2-1.5		0.49-0.3		54-30		61-80	70.00	54-30	
	Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	4.90	4.0-5.9	0.00
HIGH	Value	1.6-2.0		0.29-0.15		29-15	15.00	81-90		29-15	15.00
	Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	7.90	6.0-7.9	0.00	6.0-7.9	7.90
VERY HIGH	Value	2.1-2.8		0.14-0.05		14-5.0		91-119		14-10	
	Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value	>2.8	5.33	<0.05		<5		>119		<10	
	Index	10	10.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index						SUB-TOTAL (Sum one index from each column):				**32.7**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **8**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **40.7**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream Meetinghouse **Assessment Number** 2 **Date** **Crew**

Bank Erosion Potential	Bank Height (ft): Bankfull Height (ft):		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW		Value	1.0-1.1		1.0-0.9	0.98	100-80		0-20		100-80	
		Index	1.0-1.9	0.00	1.0-1.9	1.23	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5		79-55		21-60		79-55	
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00
MODERATE		Value	1.2-1.5		0.49-0.3		54-30		61-80	70.00	54-30	
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	4.90	4.0-5.9	0.00
HIGH		Value	1.6-2.0		0.29-0.15		29-15	15.00	81-90		29-15	18.00
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	7.90	6.0-7.9	0.00	6.0-7.9	7.49
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0		91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME		Value	>2.8	4.00	<0.05		<5		>119		<10	
		Index	10	10.00	10	0.00	10	0.00	10	0.00	10	0.00
	V = value, I = index								SUB-TOTAL (Sum one index from each column):		31.5	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **41.5**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **Meetinghouse** **Assessment Number** **3** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW		Value	1.0-1.1		1.0-0.9	0.92	100-80		0-20		100-80	
		Index	1.0-1.9	0.00	1.0-1.9	1.72	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5		79-55		21-60	45.00	79-55	
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.17	2.0-3.9	0.00
MODERATE		Value	1.2-1.5		0.49-0.3		54-30		61-80		54-30	
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH		Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	15.00
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	7.90
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0	10.00	91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.44	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME		Value	>2.8	3.00	<0.05		<5		>119		<10	
		Index	10	10.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index							SUB-TOTAL (Sum one index from each column):				**31.2**	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **41.2**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **Meetinghouse** **Assessment Number** **4** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value		1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index		1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value		1.11-1.19		0.89-0.5	0.70	79-55		21-60	50.00	79-55	
	Index		2.0-3.9	0.00	2.0-3.9	2.93	2.0-3.9	0.00	2.0-3.9	3.41	2.0-3.9	0.00
MODERATE	Value		1.2-1.5		0.49-0.3		54-30		61-80		54-30	
	Index		4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH	Value		1.6-2.0		0.29-0.15		29-15		81-90		29-15	
	Index		6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value		2.1-2.8		0.14-0.05		14-5.0	9.00	91-119		14-10	13.00
	Index		8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.56	8.0-9.0	0.00	8.0-9.0	8.25
EXTREME	Value		>2.8	3.33	<0.05		<5		>119		<10	
	Index		10	10.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index									SUB-TOTAL (Sum one index from each column):		**33.1**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **9**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **42.1**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **Meetinghouse** **Assessment Number** **5** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value		1.0-1.1	1.03	1.0-0.9		100-80		0-20		100-80	
	Index		1.0-1.9	1.27	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value		1.11-1.19		0.89-0.5		79-55		21-60	50.00	79-55	
	Index		2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.41	2.0-3.9	0.00
MODERATE	Value		1.2-1.5		0.49-0.3		54-30		61-80		54-30	
	Index		4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH	Value		1.6-2.0		0.29-0.15		29-15		81-90		29-15	
	Index		6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value		2.1-2.8		0.14-0.05	0.05	14-5.0	10.00	91-119		14-10	
	Index		8.0-9.0	0.00	8.0-9.0	9.00	8.0-9.0	8.44	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value		>2.8		<0.05		<5		>119		<10	9.00
	Index		10	0.00	10	0.00	10	0.00	10	0.00	10	10.00
V = value, I = index									SUB-TOTAL (Sum one index from each column):		**32.1**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **42.1**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **Meetinghouse** **Assessment Number** **6** **Date** **Crew**

Bank Erosion Potential			Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
Bank Height (ft): Bankfull Height (ft):												
VERY LOW		Value	1.0-1.1		1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5		79-55		21-60	60.00	79-55	
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.90	2.0-3.9	0.00
MODERATE		Value	1.2-1.5		0.49-0.3	0.39	54-30		61-80		54-30	43.00
		Index	4.0-5.9	0.00	4.0-5.9	5.02	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	4.87
HIGH		Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0	8.00	91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.67	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME		Value	>2.8	2.90	<0.05		<5		>119		<10	
		Index	10	10.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index									SUB-TOTAL (Sum one index from each column):		32.5	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **42.5**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **Meetinghouse** **Assessment Number 7** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW		Value	1.0-1.1	1.00	1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	1.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5		79-55		21-60		79-55	
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00
MODERATE		Value	1.2-1.5		0.49-0.3		54-30	40.00	61-80	60.00	54-30	35.00
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	5.11	4.0-5.9	3.90	4.0-5.9	5.50
HIGH		Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0		91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME		Value	>2.8		<0.05	0.01	<5		>119		<10	
		Index	10	0.00	10	10.00	10	0.00	10	0.00	10	0.00
V = value, I = index							SUB-TOTAL (Sum one index from each column):				**25.5**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **35.5**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream Meetinghouse **Assessment Number** 8 **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value		1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index		1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value		1.11-1.19		0.89-0.5		79-55		21-60	50.00	79-55	
	Index		2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.41	2.0-3.9	0.00
MODERATE	Value		1.2-1.5		0.49-0.3		54-30		61-80		54-30	
	Index		4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH	Value		1.6-2.0		0.29-0.15	0.25	29-15		81-90		29-15	25.00
	Index		6.0-7.9	0.00	6.0-7.9	6.54	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	6.54
VERY HIGH	Value		2.1-2.8	2.67	0.14-0.05		14-5.0	13.00	91-119		14-10	
	Index		8.0-9.0	8.81	8.0-9.0	0.00	8.0-9.0	8.11	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value		>2.8		<0.05		<5		>119		<10	
	Index		10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index								SUB-TOTAL (Sum one index from each column):			33.4	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **43.4**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream Meetinghouse **Assessment Number** 9 **Date** **Crew**

Bank Erosion Potential	Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
	VERY LOW	Value	1.0-1.1	1.00	1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	1.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
	LOW	Value	1.11-1.19		0.89-0.5		79-55		21-60	45.00	79-55	
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.17	2.0-3.9	0.00
	MODERATE	Value	1.2-1.5		0.49-0.3	0.42	54-30	35.00	61-80		54-30	50.00
		Index	4.0-5.9	0.00	4.0-5.9	4.70	4.0-5.9	5.50	4.0-5.9	0.00	4.0-5.9	4.32
	HIGH	Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
	VERY HIGH	Value	2.1-2.8		0.14-0.05		14-5.0		91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
	EXTREME	Value	>2.8		<0.05		<5		>119		<10	
		Index	10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
	V = value, I = index								SUB-TOTAL (Sum one index from each column):		**18.7**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **9**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **27.7**

BEHI RATING: **MODERATE**

Bank Erosion Hazard Rating Guide

Stream **Meetinghouse** **Assessment Number 10** **Date** **Crew**

Bank Erosion Potential		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
Bank Height (ft): Bankfull Height (ft):											
VERY LOW	Value	1.0-1.1	1.00	1.0-0.9		100-80		0-20		100-80	
	Index	1.0-1.9	1.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value	1.11-1.19		0.89-0.5		79-55		21-60	50.00	79-55	
	Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.41	2.0-3.9	0.00
MODERATE	Value	1.2-1.5		0.49-0.3		54-30		61-80		54-30	43.00
	Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	4.87
HIGH	Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	
	Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value	2.1-2.8		0.14-0.05		14-5.0	8.00	91-119		14-10	
	Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.67	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value	>2.8		<0.05	0.02	<5		>119		<10	
	Index	10	0.00	10	10.00	10	0.00	10	0.00	10	0.00
V = value, I = index						SUB-TOTAL (Sum one index from each column):				**28.0**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **38.0**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream UT 2 **Assessment Number** 11 **Date** **Crew**

Bank Erosion Potential

Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value	1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value	1.11-1.19		0.89-0.5	0.50	79-55		21-60		79-55	65.00
	Index	2.0-3.9	0.00	2.0-3.9	3.90	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.11
MODERATE	Value	1.2-1.5		0.49-0.3		54-30	33.00	61-80	70.00	54-30	
	Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	5.66	4.0-5.9	4.90	4.0-5.9	0.00
HIGH	Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	
	Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value	2.1-2.8	2.40	0.14-0.05		14-5.0		91-119		14-10	
	Index	8.0-9.0	8.43	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value	>2.8		<0.05		<5		>119		<10	
	Index	10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index								SUB-TOTAL (Sum one index from each column):		**26.0**	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **36.0**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream UT 2 **Assessment Number** 12 **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
	VERY LOW	Value	1.0-1.1	1.01	1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	1.09	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
	LOW	Value	1.11-1.19		0.89-0.5		79-55		21-60	45.00	79-55	
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.17	2.0-3.9	0.00
	MODERATE	Value	1.2-1.5		0.49-0.3		54-30	30.00	61-80		54-30	40.00
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	5.90	4.0-5.9	0.00	4.0-5.9	5.11
	HIGH	Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
	VERY HIGH	Value	2.1-2.8		0.14-0.05		14-5.0		91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
	EXTREME	Value	>2.8		<0.05	0.02	<5		>119		<10	
		Index	10	0.00	10	10.00	10	0.00	10	0.00	10	0.00
	V = value, I = index								SUB-TOTAL (Sum one index from each column):		25.3	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **35.3**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream **Bells Branch** **Assessment Number** **13** **Date** **Crew**

Bank Erosion Potential	Bank Height (ft): Bankfull Height (ft):		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
	VERY LOW	Value	1.0-1.1		1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
	LOW	Value	1.11-1.19		0.89-0.5	0.63	79-55		21-60	45.00	79-55	
		Index	2.0-3.9	0.00	2.0-3.9	3.29	2.0-3.9	0.00	2.0-3.9	3.17	2.0-3.9	0.00
	MODERATE	Value	1.2-1.5		0.49-0.3		54-30		61-80		54-30	
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
	HIGH	Value	1.6-2.0	2.00	0.29-0.15		29-15		81-90		29-15	
		Index	6.0-7.9	7.90	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
	VERY HIGH	Value	2.1-2.8		0.14-0.05		14-5.0	10.00	91-119		14-10	10.00
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.44	8.0-9.0	0.00	8.0-9.0	9.00
	EXTREME	Value	>2.8		<0.05		<5		>119		<10	
		Index	10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
	V = value, I = index								SUB-TOTAL (Sum one index from each column):		**31.8**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **8**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **39.8**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **Bells Branch** **Assessment Number** **14** **Date** **Crew**

Bank Erosion Potential			Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
Bank Height (ft): Bankfull Height (ft):												
VERY LOW	Value		1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index		1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value		1.11-1.19		0.89-0.5	0.53	79-55		21-60	45.00	79-55	58.00
	Index		2.0-3.9	0.00	2.0-3.9	3.78	2.0-3.9	0.00	2.0-3.9	3.17	2.0-3.9	3.66
MODERATE	Value		1.2-1.5		0.49-0.3		54-30		61-80		54-30	
	Index		4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH	Value		1.6-2.0		0.29-0.15		29-15	15.00	81-90		29-15	
	Index		6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	7.90	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value		2.1-2.8	2.50	0.14-0.05		14-5.0		91-119		14-10	
	Index		8.0-9.0	8.57	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value		>2.8		<0.05		<5		>119		<10	
	Index		10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index									SUB-TOTAL (Sum one index from each column):		**27.1**	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **37.1**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream **Bells Branch** **Assessment Number** **15** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value		1.0-1.1	1.01	1.0-0.9		100-80		0-20		100-80	
	Index		1.0-1.9	1.09	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value		1.11-1.19		0.89-0.5		79-55		21-60		79-55	
	Index		2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00
MODERATE	Value		1.2-1.5		0.49-0.3		54-30		61-80	80.00	54-30	
	Index		4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	5.90	4.0-5.9	0.00
HIGH	Value		1.6-2.0		0.29-0.15		29-15		81-90		29-15	
	Index		6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value		2.1-2.8		0.14-0.05		14-5.0	9.00	91-119		14-10	10.00
	Index		8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.56	8.0-9.0	0.00	8.0-9.0	9.00
EXTREME	Value		>2.8		<0.05	0.02	<5		>119		<10	
	Index		10	0.00	10	10.00	10	0.00	10	0.00	10	0.00
V = value, I = index							SUB-TOTAL (Sum one index from each column):				**34.5**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **44.5**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **Bells Branch** **Assessment Number** **16** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value		1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index		1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value		1.11-1.19		0.89-0.5	0.81	79-55		21-60	50.00	79-55	
	Index		2.0-3.9	0.00	2.0-3.9	2.38	2.0-3.9	0.00	2.0-3.9	3.41	2.0-3.9	0.00
MODERATE	Value		1.2-1.5	1.33	0.49-0.3		54-30		61-80		54-30	
	Index		4.0-5.9	4.82	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH	Value		1.6-2.0		0.29-0.15		29-15		81-90		29-15	18.00
	Index		6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	7.49
VERY HIGH	Value		2.1-2.8		0.14-0.05		14-5.0	14.00	91-119		14-10	
	Index		8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value		>2.8		<0.05		<5		>119		<10	
	Index		10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index									SUB-TOTAL (Sum one index from each column):		**26.1**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **8**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **34.1**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream UT 4 **Assessment Number** 17 **Date** **Crew**

Bank Erosion Potential	Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
	VERY LOW	Value	1.0-1.1		1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
	LOW	Value	1.11-1.19		0.89-0.5	0.85	79-55		21-60		79-55	
		Index	2.0-3.9	0.00	2.0-3.9	2.19	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00
	MODERATE	Value	1.2-1.5	1.20	0.49-0.3		54-30		61-80	65.00	54-30	
		Index	4.0-5.9	4.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	4.40	4.0-5.9	0.00
	HIGH	Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
	VERY HIGH	Value	2.1-2.8		0.14-0.05		14-5.0	10.00	91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.44	8.0-9.0	0.00	8.0-9.0	0.00
	EXTREME	Value	>2.8		<0.05		<5		>119		<10	5.00
		Index	10	0.00	10	0.00	10	0.00	10	0.00	10	10.00
	V = value, I = index								SUB-TOTAL (Sum one index from each column):		**29.0**	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **39.0**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream **UT 4** **Assessment Number** **18** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW		Value	1.0-1.1	1.05	1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	1.45	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5	0.74	79-55		21-60		79-55	
		Index	2.0-3.9	0.00	2.0-3.9	2.73	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00
MODERATE		Value	1.2-1.5		0.49-0.3		54-30		61-80	80.00	54-30	
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	5.90	4.0-5.9	0.00
HIGH		Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	15.00
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	7.90
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0	8.00	91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.67	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME		Value	>2.8		<0.05		<5		>119		<10	
		Index	10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index									SUB-TOTAL (Sum one index from each column):		**26.6**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **36.6**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream **UT 4** **Assessment Number** **19** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW		Value	1.0-1.1		1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5	0.53	79-55		21-60	60.00	79-55	
		Index	2.0-3.9	0.00	2.0-3.9	3.75	2.0-3.9	0.00	2.0-3.9	3.90	2.0-3.9	0.00
MODERATE		Value	1.2-1.5		0.49-0.3		54-30		61-80		54-30	
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH		Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0	10.00	91-119		14-10	10.00
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.44	8.0-9.0	0.00	8.0-9.0	9.00
EXTREME		Value	>2.8	5.33	<0.05		<5		>119		<10	
		Index	10	10.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index							SUB-TOTAL (Sum one index from each column):				**35.1**	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **45.1**

BEHI RATING: **EXTREME**

Bank Erosion Hazard Rating Guide

Stream UT 4 **Assessment Number** 20 **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW		Value	1.0-1.1	1.00	1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	1.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5		79-55		21-60	45.00	79-55	
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.17	2.0-3.9	0.00
MODERATE		Value	1.2-1.5		0.49-0.3		54-30		61-80		54-30	
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH		Value	1.6-2.0		0.29-0.15		29-15		81-90		29-15	23.00
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	6.81
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0	9.00	91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.56	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME		Value	>2.8		<0.05	0.04	<5		>119		<10	
		Index	10	0.00	10	10.00	10	0.00	10	0.00	10	0.00
V = value, I = index							SUB-TOTAL (Sum one index from each column):				**29.5**	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)
Boulders (Banks composed of boulders have low bank erosion potential)
Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **39.5**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **UT 4** **Assessment Number** **21** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value		1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index		1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value		1.11-1.19		0.89-0.5		79-55		21-60	45.00	79-55	
	Index		2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.17	2.0-3.9	0.00
MODERATE	Value		1.2-1.5		0.49-0.3		54-30		61-80		54-30	30.00
	Index		4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	5.90
HIGH	Value		1.6-2.0		0.29-0.15	0.25	29-15	15.00	81-90		29-15	
	Index		6.0-7.9	0.00	6.0-7.9	6.54	6.0-7.9	7.90	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value		2.1-2.8	2.80	0.14-0.05		14-5.0		91-119		14-10	
	Index		8.0-9.0	9.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value		>2.8		<0.05		<5		>119		<10	
	Index		10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index									SUB-TOTAL (Sum one index from each column):		**32.5**	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **42.5**

BEHI RATING: **VERY HIGH**

Bank Erosion Hazard Rating Guide

Stream **UT 5** **Assessment Number** **22** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW		Value	1.0-1.1	1.00	1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	1.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5		79-55		21-60	60.00	79-55	55.00
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.90	2.0-3.9	3.90
MODERATE		Value	1.2-1.5		0.49-0.3		54-30		61-80		54-30	
		Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00
HIGH		Value	1.6-2.0		0.29-0.15		29-15	25.00	81-90		29-15	
		Index	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	6.54	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0		91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME		Value	>2.8		<0.05	0.03	<5		>119		<10	
		Index	10	0.00	10	10.00	10	0.00	10	0.00	10	0.00
V = value, I = index							SUB-TOTAL (Sum one index from each column):				25.3	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)
Boulders (Banks composed of boulders have low bank erosion potential)
Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	**EXTREME**
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **35.3**
BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream UT 5 **Assessment Number** 23 **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value		1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index		1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value		1.11-1.19		0.89-0.5	0.60	79-55		21-60		79-55	
	Index		2.0-3.9	0.00	2.0-3.9	3.41	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00
MODERATE	Value		1.2-1.5		0.49-0.3		54-30	35.00	61-80	70.00	54-30	50.00
	Index		4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	5.50	4.0-5.9	4.90	4.0-5.9	4.32
HIGH	Value		1.6-2.0		0.29-0.15		29-15		81-90		29-15	
	Index		6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value		2.1-2.8	2.50	0.14-0.05		14-5.0		91-119		14-10	
	Index		8.0-9.0	8.57	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value		>2.8		<0.05		<5		>119		<10	
	Index		10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index									SUB-TOTAL (Sum one index from each column):		**26.7**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL: **36.7**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream **UT 5-1** **Assessment Number** **24** **Date** **Crew**

Bank Erosion Potential		Bank Height (ft): / Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW		Value	1.0-1.1		1.0-0.9		100-80		0-20		100-80	
		Index	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW		Value	1.11-1.19		0.89-0.5		79-55		21-60		79-55	
		Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00
MODERATE		Value	1.2-1.5		0.49-0.3	0.31	54-30	35.00	61-80	70.00	54-30	40.00
		Index	4.0-5.9	0.00	4.0-5.9	5.80	4.0-5.9	5.50	4.0-5.9	4.90	4.0-5.9	5.11
HIGH		Value	1.6-2.0	2.00	0.29-0.15		29-15		81-90		29-15	
		Index	6.0-7.9	7.90	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH		Value	2.1-2.8		0.14-0.05		14-5.0		91-119		14-10	
		Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME		Value	>2.8		<0.05		<5		>119		<10	
		Index	10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index							SUB-TOTAL (Sum one index from each column):				**29.2**	

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **10**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach　　Outside of Bend

GRAND TOTAL: **39.2**

BEHI RATING: **HIGH**

Bank Erosion Hazard Rating Guide

Stream **UT 5-2** **Assessment Number** **25** **Date** **Crew**

Bank Erosion Potential		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
Bank Height (ft): Bankfull Height (ft):											
VERY LOW	Value	1.0-1.1		1.0-0.9		100-80		0-20		100-80	
	Index	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00	1.0-1.9	0.00
LOW	Value	1.11-1.19		0.89-0.5		79-55		21-60	60.00	79-55	
	Index	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	0.00	2.0-3.9	3.90	2.0-3.9	0.00
MODERATE	Value	1.2-1.5		0.49-0.3		54-30		61-80		54-30	48.00
	Index	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	0.00	4.0-5.9	4.48
HIGH	Value	1.6-2.0	2.00	0.29-0.15	0.15	29-15		81-90		29-15	
	Index	6.0-7.9	7.90	6.0-7.9	7.90	6.0-7.9	0.00	6.0-7.9	0.00	6.0-7.9	0.00
VERY HIGH	Value	2.1-2.8		0.14-0.05		14-5.0	10.00	91-119		14-10	
	Index	8.0-9.0	0.00	8.0-9.0	0.00	8.0-9.0	8.44	8.0-9.0	0.00	8.0-9.0	0.00
EXTREME	Value	>2.8		<0.05		<5		>119		<10	
	Index	10	0.00	10	0.00	10	0.00	10	0.00	10	0.00
V = value, I = index						SUB-TOTAL (Sum one index from each column):				**32.6**	

Bank Material Description:

Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT: **8**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT:

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach   Outside of Bend

GRAND TOTAL: **40.6**

BEHI RATING: **VERY HIGH**

APPENDIX L

NC DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
BRIDGE MANAGEMENT UNIT

ATTENTION

BRIDGE INSPECTION REPORT

INSPECTION TYPE: Routine Inspection - Municipal

COUNTY PITT | BRIDGE NUMBER 730469 | INSPECTION CYCLE 0 YRS

ROUTE KENSINGTON RD. | ACROSS BELLS BRANCH | M.P. 0

LOCATION 100' W.JCT.OXFORD RD.

SUPERSTRUCTURE REINFORCED CONCRETE FLOOR ON CONT.I-BEAM

SUBSTRUCTURE E.BTS&BT:STEEL CAPS/TIMBER PILES

1@23'-9"; 1@23'-3" CONT.

SPANS 2@23'-8 CONT.

LONGITUDE	77° 19' 54.4"	LATITUDE	35° 35' 15.3"
PRESENT CONDITION	GOOD	INVENTORY RATING	
INSPECTION DATE	03/20/2012	OPERATING RATING	
PRESENT POSTING	SV 17 TTST 23 SV 17 TTST 23	PROPOSED POSTING	
COMPUTER UPDATE		ANALYSIS DATE	
POSTING LETTER DATE		SUFFICIENCY RATING	

OTHER SIGNS PRESENT NONE

LOOKING EAST

SIGN NOTICE ISSUED FOR		NUMBERED REOUIRED
No	WEIGHT LIMIT	
No	DELINEATORS	
No	NARROW BRIDGE	
No	ONE LANE BRIDGE	
No	LOW CLEARANCE	

BRIDGE I & A FORM1 (90)A

BRIDGE INSPECTION RECORD AND SUMMARY

INSPECTION TYPE Routine Inspection - Municipal
BRIDGE NO. 730469 COUNTY PITT ROUTE KENSINGTON RD. OVER BELLS BRANCH
STRUCTURE TYPE REINFORCED CONCRETE FLOOR ON CONT.I-BEAM
ROUTE ORIENTATION W - E SPANS 2@23'-8 CONT.

EVALUATION CODES: CRITICAL (C, 0 - 3); POOR (P, 4); FAIR (F, 5, 6); GOOD (G, 7 - 9)

INSPECTION ITEM			
DECK ITEMS			GRADES
1. WEARING SURFACE			G
2. DECK NO. OF EA TYPE SPN GRADE RATES SI & A ITEM 58	a. CONCRETE	2	G
	b. TIMBER		
	c. STEEL PLANK		
	d. OPEN GRID		
3. RAILING	a. CONCRETE		
	b. TIMBER		
	c. ALUMINUM		
	d. STEEL		G
4. CURBS, WHEELGUARDS, PARAPETS, MEDIANS			G
5. WALKWAYS (ON OR ATTACHED TO STRUCTURE)			G
6. DECK EXP JTS. OR DEVICES. NO. OF EACH	a. STEEL PL OR FINGER		
	b. MISC PREFAB		
	c. COMPRESSION SEAL		
	d. STANDARD JOINTS	2	G
	e. OPEN JOINTS		
7. DECK DEBRIS (INCLUDES EXCESS SAND/GRAVEL)			G
SUPER STR. (FM. 1 (90)B TRUSS) ITEM 59			
10. LONGITUDINAL BEAMS OR GIRDERS			G
11. LONGITUDINAL JOIST OR STRINGERS			
12. INT. DIAP'S, X-FRAMES, BRACING & CONN'S			
13. END DIAP'S, CURTAIN WALLS, & CONN'S			F
14. FLOOR BEAMS AND CONNECTIONS			
15. BEARING ASSEMBLIES (INCLUDING MISALIGN)			G
16. DRAINAGE SYSTEM (ON STRUCTURE)			G
17. MOVABLE SPAN MACHINERY			
SUB STR. ITEMS. ITEM 60 (INCLUDE SCOUR)			
35. TIM SUB STR.	a. ABUT. & INT. BENT CAPS & RISERS		
	b. PILES, POST, SILLS, & BRACING		G
	c. BULKHEADS, WING'S, & TIE BACKS		G
36. CONC SUB STR.	a. ABUT. & INT. BENT CAPS		
	b. ABUT. & BENT COL'S BREASTWALLS		
	c. ABUT. & INT. BENT PILES		
	d. BACKWALLS, WING'S, RETAIN. WALLS		
	e. ABUT. & BENT FOOTINGS & SILLS		
37. STEEL SUB STR.	a. ABUT. & INT. BENT CAPS & RISERS		F
	b. PILES, BRACING, AND BULKHEADS		
38. FOUNDATION PILES TYPE MATERIAL			
39. SLOPE PROT., RIP-RAP (INCLUDE DRAINAGE)			G
40. FENDER SYSTEMS			
41. DRIFT			G

ITEM 61			
45. CHANNEL & CHANNEL PROT.	a. WATERWAY		G
	b. ALIGNMENT		F
	c. SCOUR		G
	d. SLOPE PROT., RIP-RAP, DIKES, ETC.		G
50. APPROACH ROADWAY CONDITION			G
51. APPROACH SLABS			G
52. PAINT SYSTEM	CODE	Y	G
53. UTILITIES			G
54. RESPONSE TO LIVE LOAD			G
55. ESTIMATED REMAINING LIFE			18
60. REGULATORY SIGN NOTICE ISSUED			NO
61. PROMPT-ACTION NOTICE ISSUED			NO
62. PRESENTLY POSTED			YES
63. TOT. FIELD INSP TIME (INCLUDE WRITE UP)(MAN HR)			6
64. TOTAL SNOOPER INSP. TIME (HRS)			
65. TOTAL TRAFFIC CONTROL TIME (MAN HRS)			
70. SI&A GENERAL CONDITION RATINGS			
a. DECK	ITEM 58		7
b. SUPERSTRUCTURE	ITEM 59		7
c. SUBSTRUCTURE	ITEM 60		7
d. CHANNEL & CHANNEL PROT.	ITEM 61		7
71. SI&A FIELD APPRAISAL RATINGS			
a. WATERWAY ADAQUACY			7
b. APPR. RDWY. ALIGNMENT			7
72. FIELD SCOUR EVALUATION			O
USE OF INSP. ACCESSIBILITY EQUIPMENT			
SNOOPER (CODE S, 4, OR N)		HRS	NO
LADDER			NO
BUCKET TRUCK			NO
BOAT			NO
OTHER			NO
SPECIAL INSPECTION REQUESTED FOR			
NOTE			
80. INSPECTED BY:	Karen Mobley		
81. REVIEWED BY:			

Bridge I&A Form 1(82)H State of North Carolina Dept. of Transportation Division of Highways	FIELD INSPECTION REPORT Bridge Inspecion & Analysis	

Team Leader K. Mobley

Assisted By MTM

Item No.	Grade	
2a	G	RANDOM LOCATIONS OF SCALING AND RUSTING IN THE BOTTOM OF THE SIP FORM THROUGHOUT THE STRUCTURE. SEE PHOTO OF THE CONDITION OF THE SIP FORM IN BAY 1 AT END BENT 2.
4	G	HAIRLINE MAP CRACKING WITH EFFLORESCENCE IN BOTH PARAPETS THROUGHOUT THE STRUCTURE. SEE PHOTO OF THE CRACKS IN THE WEST FACE OF THE DOWNSTREAM END POST AT END BENT 1. VERTICAL HAIRLINE CRACK WITH EFFLORESCENCE IN THE FACE OF THE DOWNSTREAM PARAPET EXTENDING INTO TRANSVERSE HAIRLINE CRACKS IN THE TOP OF THE DECK AT THE RAIL POST ATTACHMENTS. SEE PHOTO OF THE CRACKS AT RAIL POST 4 ATTACHMENT.
5	G	HAIRLINE MAP CRACKING WITH EFFLORESCENCE IN THE TOP OF THE UPSTREAM SIDEWALK. SEE PHOTO OF THE CRACKS IN THE SIDEWALK NEAR THE WEST APPROACH.
10A	NO	NO CURVED GIRDERS.
13	F	PAINT FLAKING AND PEELING AND SURFACE RUST ON THE END BENT DIAPRHAGMS. SEE PHOTO OF THE CONDITION OF END BENT 2 DIAPHRAGM IN BAY 4.
35b	G	CHECKS AND SPLITS IN THE PILES THROUGHOUT THE STRUCTURE. SEE PHOTO OF THE CHECKS AND SPLITS IN PILE 3 AT END BENT 1.
37a	F	SCALING AND RUST PACKING IN THE CAPS. SEE PHOTO OF THE SCALING IN END BENT 1 WEB BETWEEN PILES 4 AND 5.
45b	F	THE STREAM CURVES TO THE WEST AROUND THE BENT ON THE UPSTREAM AND DOWNSTREAM SIDES.
50	G	TRANSVERSE CRACKS IN THE ASPHALT WEARING SURFACE ALONG BOTH END BENT FILL FACES. SEE PHOTO OF THE CRACK ALONG END BENT 1 FILL FACE. LONGITUDINAL CRACK IN THE ASPHALT WEARING SURFACE IN THE EASTBOUND LANE AT THE EAST APPROACH (SEE PHOTO).
62	YES	SV17 TTST 23

BRIDGE INSPECTOR'S RECOMMENDATION FOR MAINTENANCE REPAIRS

Bridge: 730469 County PITT Date: 03/20/2012

These Repairs Should Be Made Within Twelve Months From Date Of This Inspection

MMS Code	Description of Function	Unit	Quantity	Remarks	Est. Cost
0	No Maintenance Required	NA	0	NONE	

Key

Priority Maintenance Item Critical Finding Item Priority Maintenance Level Not Determined

TRANSVERSE CRACK IN ASPHALT WEARING SURFACE ALONG END BENT 1 FILL FACE

HAIRLINE MAP CRACKING WITH EFFLORESCENCE IN TOP OF UPSTREAM SIDEWALK NEAR WEST APPROACH

LONGITUDINAL CRACK IN ASPHALT WEARING SURFACE IN EASTBOUND LANE AT EAST APPROACH

HAIRLINE MAP CRACKING WITH EFFLORESCENCE IN WEST FACE OF DOWNSTREAM END POST AT END BENT 1

VERTICAL HAIRLINE CRACK WITH EFFLORESCENCE IN FACE OF DOWNSTREAM PARAPET EXTENDING INTO TRANSVERSE HAIRLINE CRACK IN TOP OF DECK AT RAIL POST 4

CHECKS AND SPLITS IN PILE 3 AT END BENT 1

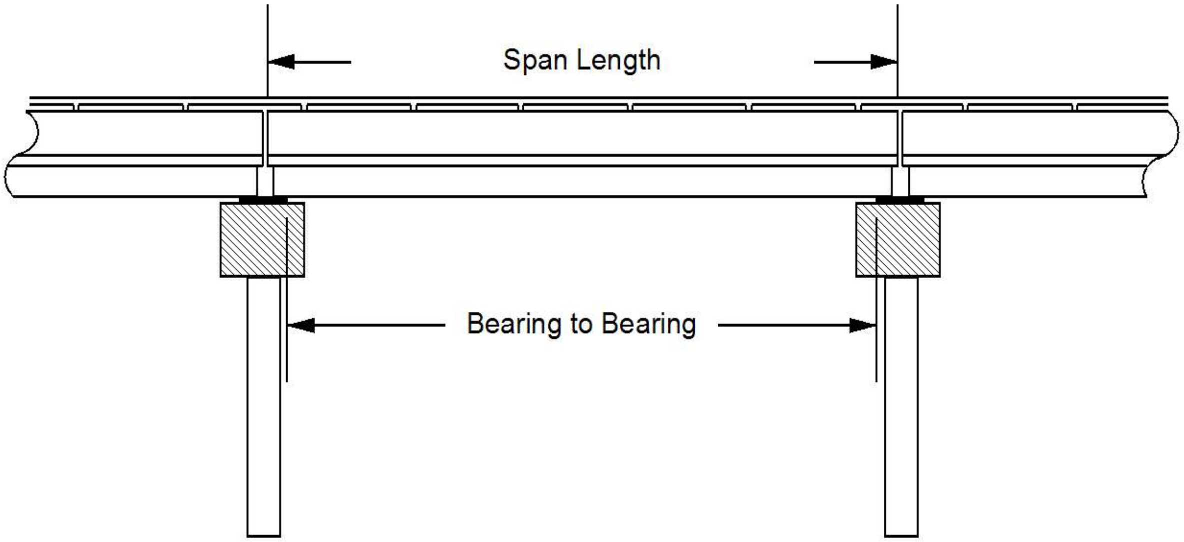
SCALING AND RUST PACKING IN END BENT 1 WEB BETWEEN PILES 4 AND 5

SCALING AND RUSTING IN BOTTOM OF SIP FORM IN BAY 1 AT END BENT 2

PAINT FLAKING AND PEELING AND SURFACE RUST ON END BENT 2 DIAPHRAGM IN BAY 4

Structure Data Worksheet

County: PITT Structure No: 730469 Date: 03/20/2012 Inspected By: KMM



Span No	Span Length	Bearing to Bearing	Comments
1	23.75 FT	21.417 FT	NBIS: 41.083 FT
2	23.25 FT	20.917 FT	

Stream Bed Soundings

(See next sheet for profile sketch)

Bridge No: 730469 County: PITT Date: 03/20/2012 By: KMM

Record sounding from top of rail. Other location if needed:

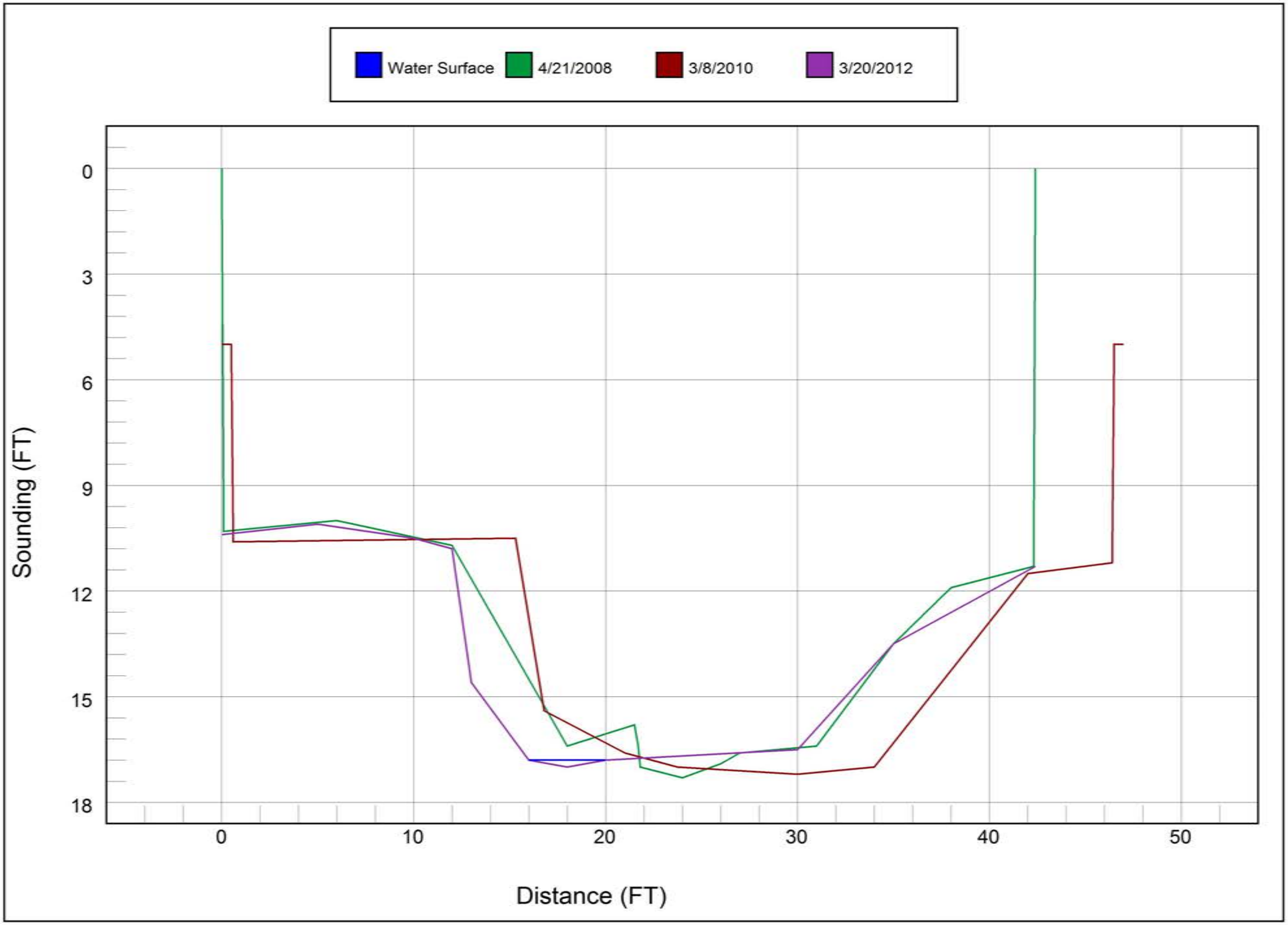
Distance from Highwater Mark to top of rail: 14 Location of Highwater Mark: DRIFT ON BANK

DOWNSTREAM			UPSTREAM		
Distance (Station) (ft)	Sounding (ft)	Description	Distance (Station) (ft)	Sounding (ft)	Description
0	10.4	GROUND AT CAP	0	10.7	GROUND AT CAP
5	10.1	GROUND			
10	10.5	GROUND			
12	10.8	GROUND			
13	14.6	GROUND			
16	16.8	Water Surface/Water Edge (WSWE)			
18	17	STREAMBED			
20	16.8	Water Surface/Water Edge (WSWE)			
30	16.5	GROUND			
35	13.5	GROUND			
42.4	11.3	GROUND AT CAP	42.4	11.2	GROUND AT CAP

Bridge: 730469 County PITT Date: 03/20/2012

STREAMBED PROFILE (Downstream)

Top of Rail = 0 FT (Sounding)



Bridge Inspection Field Sketch

Roadway	24ft Wide	2 Paved Lanes	Looking East
Left Shoulder	2.5ft Wide	2.5ft Curb & Gutter	
Right Shoulder	2.5ft Wide	2.5ft Curb & Gutter	
Left Guardrail			
Right Guardrail			

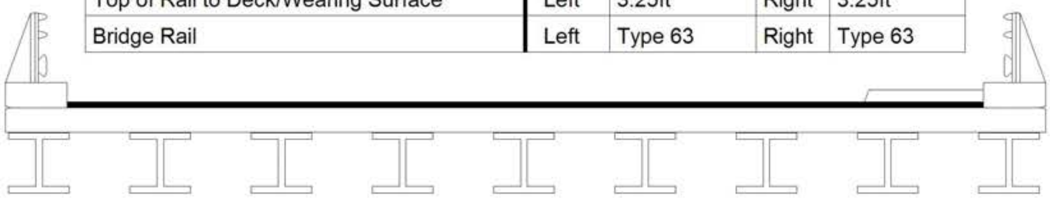
SKETCH REVISED BY MTM ON 3.20.12

Title	**Description**
APPROACH ROADWAY	LOOKING EAST

Bridge No: 730469	**Drawn By:** FCJ	**Date:** 3/08/2010	**File Name:** S0254000324

Bridge Inspection Field Sketch

Deck Width/Out to Out	34.667ft	Between Rails			32ft
Clear Roadway	27ft	Wearing Surface			0.167ft
Median Width		Median Height			
Curb Height		Left	0.75ft	Right	0.167ft
Sidewalk Width		Left		Right	5ft
Clear Roadway (Rail to Median)		Left		Right	
Guardrail Width		Left	1.333ft	Right	1.333ft
Top of Rail to Deck/Wearing Surface		Left	3.25ft	Right	3.25ft
Bridge Rail		Left	Type 63	Right	Type 63



Measurements for Span #	1	Span 2 Similar	
Deck Thickness	0.729ft	Left Overhang	1.125ft
Top of Rail to Bottom of Beam	7.083ft	Right Overhang	1.125ft

Beam Number	Beam Type	Spacing	Comments
1	Steel I Beam	4.042ft	W 18 X 50
2	Steel I Beam	4.042ft	W 18 X 50
3	Steel I Beam	4.042ft	W 18 X 50
4	Steel I Beam	4.042ft	W 18 X 50
5	Steel I Beam	4.042ft	W 18 X 50
6	Steel I Beam	4.042ft	W 18 X 50
7	Steel I Beam	4.042ft	W 18 X 50
8	Steel I Beam	4.042ft	W 18 X 50
9	Steel I Beam		W 18 X 50

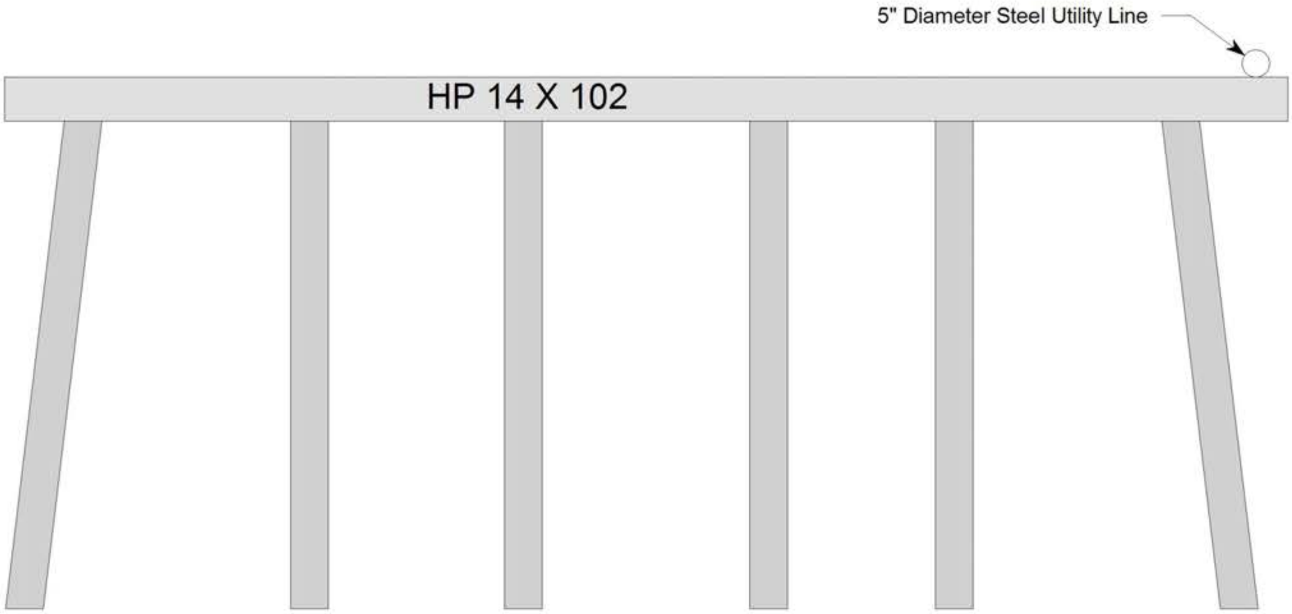
2 CONTINUOUS SPANS

SKETCH VERIFIED BY MTM ON 3.20.12

Title	**Description**
TYPICAL SECTION	9 LINES OF STEEL I-BEAMS

Bridge No:	**Drawn By:**	**Date:**	**File Name:**
730469	FCJ	3/08/2010	S0254000325

Bridge Inspection Field Sketch



Cap Information			Material Steel			
Length	Width	Height	Left Overhang	Right Overhang	Left Beam to End of Cap.	Right Beam to End of Cap.
34.000 ft.	1.250 ft.	1.167 ft.	2.083 ft.	2.667 ft.	.833 ft.	.833 ft.

Subcap Information			Material		
Length	Width	Height	Left Overhang	Right Overhang	Left Pile to Splice.

Sill Information			Material
Length	Width	Height	

Pile #	Material	Spacing	Width/Dia.	Height	Length	Orientation	Driven?	Replacement?	Removed?	Collar?
1	Timber	6.0 ft.	1.0 ft.			Battered	Yes	No	No	No
2	Timber	5.667 ft.	1.0 ft.			Vertical	Yes	No	No	No
3	Timber	6.5 ft.	1.0 ft.			Vertical	Yes	No	No	No
4	Timber	4.917 ft.	1.0 ft.			Vertical	Yes	No	No	No
5	Timber	6.0 ft.	1.0 ft.			Vertical	Yes	No	No	No
6	Timber		1.0 ft.			Battered	Yes	No	No	No

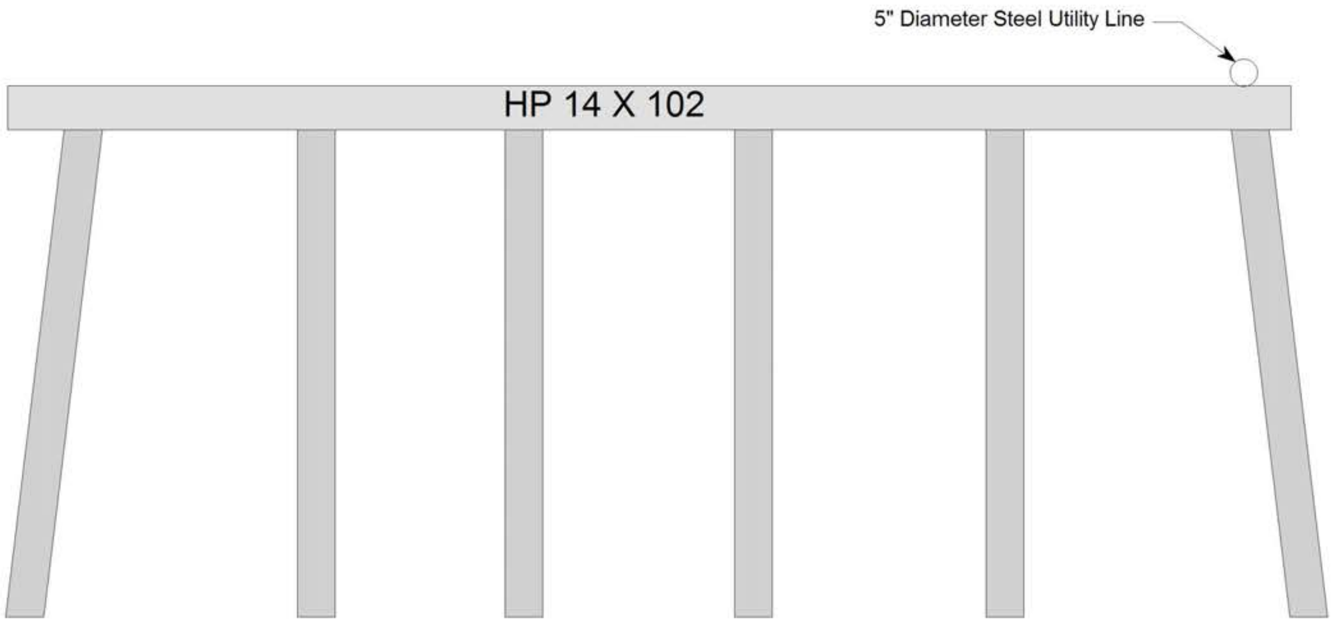
End Bent #: 1

SKETCH VERIFIED BY MTM ON 3.20.12

Title	Description
END BENT PROFILE	END BENT 1

Bridge No:	Drawn By:	Date:	File Name:
730469	FCJ	3/08/2010	S0254000326

Bridge Inspection Field Sketch



Cap Information			Material Steel			
Length	Width	Height	Left Overhang	Right Overhang	Left Beam to End of Cap.	Right Beam to End of Cap.
34.000 ft.	1.250 ft.	1.167 ft.	2.000 ft.	1.250 ft.	.833 ft.	.833 ft.

Subcap Information			Material		
Length	Width	Height	Left Overhang	Right Overhang	Left Pile to Splice.

Sill Information			Material
Length	Width	Height	

Pile #	Material	Spacing	Width/Dia.	Height	Length	Orientation	Driven?	Replacement?	Removed?	Collar?
1	Timber	6.167 ft.	1.0 ft.			Battered	Yes	No	No	No
2	Timber	5.5 ft.	1.0 ft.			Vertical	Yes	No	No	No
3	Timber	6.083 ft.	1.0 ft.			Vertical	Yes	No	No	No
4	Timber	6.667 ft.	1.0 ft.			Vertical	Yes	No	No	No
5	Timber	6.5 ft.	1.0 ft.			Vertical	Yes	No	No	No
6	Timber		1.0 ft.			Battered	Yes	No	No	No

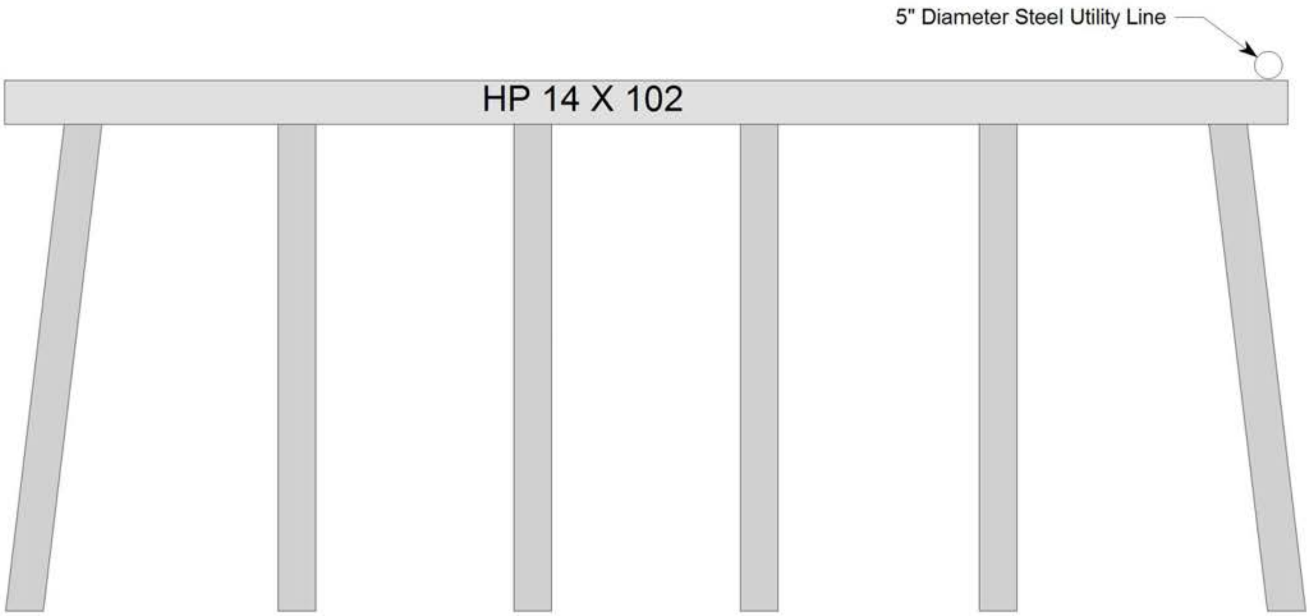
Bent #: 1

SKETCH VERIFIED BY MTM ON 3.20.12

Title	**Description**
BENT PROFILE	BENT

Bridge No: 730469	**Drawn By:** FCJ	**Date:** 3/08/2010	**File Name:** S0254000327

Bridge Inspection Field Sketch



Cap Information			Material Steel			
Length	Width	Height	Left Overhang	Right Overhang	Left Beam to End of Cap.	Right Beam to End of Cap.
34.000 ft.	1.250 ft.	1.167 ft.	2.083 ft.	1.750 ft.	.833 ft.	.833 ft.

Subcap Information			Material		
Length	Width	Height	Left Overhang	Right Overhang	Left Pile to Splice.

Sill Information			Material
Length	Width	Height	

Pile #	Material	Spacing	Width/Dia.	Height	Length	Orientation	Driven?	Replacement?	Removed?	Collar?
1	Timber	5.667 ft.	1.0 ft.			Battered	Yes	No	No	No
2	Timber	6.25 ft.	1.0 ft.			Vertical	Yes	No	No	No
3	Timber	6.0 ft.	1.0 ft.			Vertical	Yes	No	No	No
4	Timber	6.333 ft.	1.0 ft.			Vertical	Yes	No	No	No
5	Timber	6.083 ft.	1.0 ft.			Vertical	Yes	No	No	No
6	Timber		1.0 ft.			Battered	Yes	No	No	No

End Bent #: 2

SKETCH VERIFIED BY MTM ON 3.20.12

Title	**Description**
END BENT PROFILE 1	END BENT 2

Bridge No: 730469 **Drawn By:** FCJ **Date:** 3/08/2010 **File Name:** S0254000328

LOOKING EAST

ROADWAY DRAIN ON NORTH SIDE AT WEST APPROACH, ROADWAY DRAIN ON SOUTH SIDE SIMILAR

DOWNSTREAM RAIL

UPSTREAM RAIL

POSTING SIGN AT WEST APPROACH, POSTING SIGN AT EAST APPROACH SIMILAR

EAST APPROACH, LOOKING WEST

NORTHWEST WINGWALL, OTHERS SIMILAR

5" DIAMETER STEEL UTILITY LINE ON UPSTREAM SIDE

BENT, LOOKING NORTHEAST

SPAN 2 UNDERDECK, SPAN 1 UNDERDECK SIMILAR

END BENT 2, END BENT 1 SIMILAR

UPSTREAM PROFILE, LOOKING NORTHWEST

LOOKING UPSTREAM, SOUTH

LOOKING DOWNSTREAM, NORTH

DOWNSTREAM PROFILE, LOOKING SOUTHWEST

NC DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
BRIDGE MANAGEMENT UNIT

ATTENTION: PRIORITY MAINTENANCE
TEMPORARY REPAIRS

BRIDGE INSPECTION REPORT

INSPECTION TYPE: Routine Inspection - Municipal

COUNTY: PITT
BRIDGE NUMBER: 730421
INSPECTION CYCLE: 0 YRS

ROUTE: KING GEORGE RD.
ACROSS: MEETING HOUSE BRANCH
M.P.: 0

100'S.JCT.YORK RD.

LOCATION: 50'S.JCT.YORK RD.

SUPERSTRUCTURE: PRESTRESSED CONCRETE CHANNELS

SUBSTRUCTURE: E.BTS:RC CAPS/TIM.PILES

1@30'

SPANS: 1@30'-3

LONGITUDE	77° 19' 53.7"	LATITUDE	35° 34' 48.9"
PRESENT CONDITION	FAIR	INVENTORY RATING	
INSPECTION DATE	03/20/2012	OPERATING RATING	
PRESENT POSTING	SV 21 TTST 27 SV 21 TTST 27	PROPOSED POSTING	
COMPUTER UPDATE		ANALYSIS DATE	
POSTING LETTER DATE		SUFFICIENCY RATING	

OTHER SIGNS PRESENT: FOUR (4) DELINEATORS

SIGN NOTICE ISSUED FOR		NUMBERED REQUIRED
No	WEIGHT LIMIT	
No	DELINEATORS	
No	NARROW BRIDGE	
No	ONE LANE BRIDGE	
No	LOW CLEARANCE	

LOOKING NORTH

BRIDGE I & A FORM1 (90)A

BRIDGE INSPECTION RECORD AND SUMMARY

INSPECTION TYPE Routine Inspection - Municipal
BRIDGE NO. 730421 COUNTY PITT ROUTE KING GEORGE RD. OVER MEETING HOUSE BRANCH
STRUCTURE TYPE PRESTRESSED CONCRETE CHANNELS
ROUTE ORIENTATION S - N SPANS 1@30'-3

EVALUATION CODES: CRITICAL (C, 0 - 3); POOR (P, 4); FAIR (F, 5, 6); GOOD (G, 7 - 9)

INSPECTION ITEM			
DECK ITEMS			GRADES
1. WEARING SURFACE			F
2. DECK NO. OF EA TYPE SPN GRADE RATES SI & A ITEM 58	a. CONCRETE	1	G
	b. TIMBER		
	c. STEEL PLANK		
	d. OPEN GRID		
3. RAILING	a. CONCRETE		
	b. TIMBER		
	c. ALUMINUM		
	d. STEEL		F
4. CURBS, WHEELGUARDS, PARAPETS, MEDIANS			G
5. WALKWAYS (ON OR ATTACHED TO STRUCTURE)			G
6. DECK EXP JTS. OR DEVICES. NO. OF EACH	a. STEEL PL OR FINGER		
	b. MISC PREFAB		
	c. COMPRESSION SEAL		
	d. STANDARD JOINTS	2	F
	e. OPEN JOINTS		
7. DECK DEBRIS (INCLUDES EXCESS SAND/GRAVEL)			F
SUPER STR. (FM. 1 (90)B TRUSS) ITEM 59			
10. LONGITUDINAL BEAMS OR GIRDERS			F
11. LONGITUDINAL JOIST OR STRINGERS			
12. INT. DIAP'S, X-FRAMES, BRACING & CONN'S			
13. END DIAP'S, CURTAIN WALLS, & CONN'S			G
14. FLOOR BEAMS AND CONNECTIONS			
15. BEARING ASSEMBLIES (INCLUDING MISALIGN)			G
16. DRAINAGE SYSTEM (ON STRUCTURE)			F
17. MOVABLE SPAN MACHINERY			
SUB STR. ITEMS. ITEM 60 (INCLUDE SCOUR)			
35. TIM SUB STR.	a. ABUT. & INT. BENT CAPS & RISERS		
	b. PILES, POST, SILLS, & BRACING		F
	c. BULKHEADS, WING'S, & TIE BACKS		F
36. CONC SUB STR.	a. ABUT. & INT. BENT CAPS		G
	b. ABUT. & BENT COL'S BREASTWALLS		
	c. ABUT. & INT. BENT PILES		
	d. BACKWALLS, WING'S, RETAIN. WALLS		
	e. ABUT. & BENT FOOTINGS & SILLS		
37. STEEL SUB STR.	a. ABUT. & INT. BENT CAPS & RISERS		
	b. PILES, BRACING, AND BULKHEADS		
38. FOUNDATION PILES TYPE MATERIAL			
39. SLOPE PROT., RIP-RAP (INCLUDE DRAINAGE)			G
40. FENDER SYSTEMS			
41. DRIFT			G

ITEM 61			
45. CHANNEL & CHANNEL PROT.	a. WATERWAY		F
	b. ALIGNMENT		G
	c. SCOUR		G
	d. SLOPE PROT., RIP-RAP, DIKES, ETC.		G
50. APPROACH ROADWAY CONDITION			F
51. APPROACH SLABS			
52. PAINT SYSTEM	CODE		
53. UTILITIES			F
54. RESPONSE TO LIVE LOAD			F
55. ESTIMATED REMAINING LIFE			5
60. REGULATORY SIGN NOTICE ISSUED			NO
61. PROMPT-ACTION NOTICE ISSUED			YES
62. PRESENTLY POSTED			YES
63. TOT. FIELD INSP TIME (INCLUDE WRITE UP)(MAN HR)			7
64. TOTAL SNOOPER INSP. TIME (HRS)			
65. TOTAL TRAFFIC CONTROL TIME (MAN HRS)			
70. SI&A GENERAL CONDITION RATINGS			
a. DECK		ITEM 58	7
b. SUPERSTRUCTURE		ITEM 59	5
c. SUBSTRUCTURE		ITEM 60	5
d. CHANNEL & CHANNEL PROT.		ITEM 61	7
71. SI&A FIELD APPRAISAL RATINGS			
a. WATERWAY ADAQUACY			7
b. APPR. RDWY. ALIGNMENT			7
72. FIELD SCOUR EVALUATION			G
USE OF INSP. ACCESSIBILITY EQUIPMENT			
SNOOPER (CODE S, 4, OR N)		HRS	NO
LADDER			NO
BUCKET TRUCK			NO
BOAT			NO
OTHER			NO
SPECIAL INSPECTION REQUESTED FOR			
NOTE			
80. INSPECTED BY:			
81. REVIEWED BY:			

Bridge I&A Form 1(82)H State of North Carolina Dept. of Transportation Division of Highways	FIELD INSPECTION REPORT Bridge Inspecion & Analysis	

Team Leader K. Mobley

Assisted By MTM

Item No.	Grade	
1	F	LONGITUDINAL CRACK IN THE ASPHALT WEARING SURFACE IN THE NORTHBOUND LANE (SEE PHOTO). SIMILAR CRACK ALONG THE CENTERLINE OF THE ROADWAY.
3d	F	DAMAGE TO THE UPSTREAM RAIL ALONG THE LENGTH OF THE RAIL (SEE PHOTO).
7	F	DEBRIS ACCUMULATION ALONG BOTH CURB LINES. SEE PHOTO OF THE ACCUMULATION ALONG THE DOWNSTREAM CURB.
10	F	THE CHANNELS HAVE BEEN REPAIRED AT THE FOLLOWING LOCATIONS: 1) LEG 2 OF CHANNEL 2, 10' FROM END BENT 1; 2) LEG 2 OF CHANNEL 4 AT END BENT 1 BEARING; 3) LEGS 1 AND 2 OF CHANNEL 5 AT END BENT 1 BEARING; 4) LEG 2 OF CHANNEL 11 AT END BENT 2 BEARING; 5) LEGS 1 AND 2 OF CHANNEL 12 AT END BENT 2 BEARING (SEE PHOTO). PRIORITY MAINTENANCE: 11' X 3" X 2" DEEP SPALL WITH EXPOSED STRAND IN LEG 2 OF CHANNEL 5 (SEE PHOTO). PRIORITY MAINTENANCE: 30" X 3" X 2" DEEP SPALL WITH EXPOSED STRAND IN LEG 2 OF CHANNEL 5 AT END BENT 2 (SEE PHOTO). 66" X 3" AREA OF DELAMINATION AND 1/8" HORIZONTAL CRACK IN LEG 2 OF CHANNEL 5 NEAR END BENT 2 (SEE PHOTO).
10A	NO	NO CURVED GIRDERS.
16	F	CLOGGED DECK DRAINS ALONG THE UPSTREAM CURB. SEE PHOTO OF THE DECK DRAIN NEAR THE SOUTH END.
35b	F	24" X 3" X 1/2" DEEP AREA OF DECAY IN PILE 4 AT END BENT 1 (SEE PHOTO). CHECKS AND SPLITS IN THE PILES AT BOTH END BENTS. SEE PHOTO OF PILE 5 AT END BENT 1. UP TO 1/4" SPLIT IN PILE 2 AT END BENT 2 (SEE PHOTO).
35c	F	AREAS OF DECAY IN THE SOUTHEAST WINGWALL (SEE PHOTO). 12" X 8" X 2" DEEP AREA OF DECAY IN THE NORTHWEST WINGWALL BEHIND THE WING PILE (SEE PHOTO).
50	F	TRANSVERSE CRACKS IN THE ASPHALT WEARING SURFACE ALONG END BENT 1 FILL FACE (SEE PHOTO). 5" X 2" X 1" DEEP POTHOLE AND TRANSVERSE CRACK IN THE ASPHALT WEARING SURFACE ALONG END BENT 2 FILL FACE (SEE PHOTO).

Bridge I&A Form 1(82)H State of North Carolina Dept. of Transportation Division of Highways	FIELD INSPECTION REPORT Bridge Inspecion & Analysis	

Team Leader K. Mobley

Assisted By MTM

Item No.	Grade	
53	F	12" LONG SECTION OF DETERIORATION OF 4" DIAMETER STEEL UTILITY CONDUIT ON THE UPSTREAM SIDE (SEE PHOTO).
61	YES	1) 11' X 3" X 2" DEEP SPALL WITH EXPOSED STRAND IN LEG 2 OF CHANNEL 5. 2) 30" X 3" X 2" DEEP SPALL WITH EXPOSED STRAND IN LEG 2 OF CHANNEL 5 AT END BENT 2.
62	YES	SV 21 TTST 27

BRIDGE INSPECTOR'S RECOMMENDATION FOR MAINTENANCE REPAIRS

Bridge: 730421 County PITT Date: 03/20/2012

These Repairs Should Be Made Within Twelve Months From Date Of This Inspection

MMS Code	Description of Function	Unit	Quantity	Remarks	Est. Cost
3306	Maintain Concrete Superstructure Components	SF	4	TWO SPALLS WITH EXPOSED STRAND IN LEG 2 OF CHANNEL 5: 11' X 3" X 2" DEEP SPALL ALONG MIDSPAN AND 30" X 3" X 2" SPALL AT END BENT 2.	
2816	Asphalt Surface Repair or Replacement	SY	7	LONGITUDINAL CRACK IN THE ASPHALT WEARING SURFACE IN THE NORTHBOUND LANE AND ALONG THE CENTERLINE OF THE ROADWAY. TRANSVERSE CRACKS IN THE ASPHALT WEARING SURFACE ALONG END BENT 1 FILL FACE. 5" X 2" X 1" DEEP POTHOLE AND TRANSVERSE CRACK IN THE ASPHALT WEARING SURFACE ALONG END BENT 2 FILL FACE.	
3332	Maint Drainage System - Bridge	LF	30	CLOGGED DECK DRAINS ALONG THE UPSTREAM CURB.	
3322	Maint to Steel Handrail	LF	30	DAMAGE TO THE UPSTREAM RAIL ALONG THE LENGTH OF THE RAIL.	
3346	Repair / Maintain Timber Wings & Blkhds	SF	3	AREAS OF DECAY IN THE SOUTHEAST WINGWALL. 12" X 8" X 2" DEEP AREA OF DECAY IN THE NORTHWEST WINGWALL BEHIND THE WING PILE.	
3376	Clean/Wash Bridge Decks	SF	60	DEBRIS ACCUMULATION ALONG BOTH CURB LINES.	

Key

Priority Maintenance Item Critical Finding Item Priority Maintenance Level Not Determined

BRIDGE INSPECTOR'S RECOMMENDATION FOR PRIORITY MAINTENANCE REPAIRS

Bridge: 730421 County PITT

THE FOLLOWING MAINTENANCE ITEMS HAVE BEEN SUBMITTED IN CONJUNCTION WITH A PRIORITY MAINTENANCE REQUEST

MMS Code	MMS Description	Quantity
3306	Maintain Concrete Superstructure Components	4 SF

Location:		
Beams and Girders	Bent/Span No. 1	LEG 2 OF CHANNEL 5

Priority Level	Status
Priority Maintenance	Awaiting Municipal Repairs

Submitted Date:	Submitted By:	Assisted By:
03/22/2012	K. Mobley	M. Mobley

Details
TWO SPALLS WITH EXPOSED STRAND IN LEG 2 OF CHANNEL 5: 11' X 3" X 2" DEEP SPALL ALONG MIDSPAN AND 30" X 3" X 2" SPALL AT END BENT 2.

TRANSVERSE CRACKS IN ASPHALT WEARING SURFACE ALONG END BENT 1 FILL FACE

LONGITUDINAL CRACK IN ASPHALT WEARING SURFACE IN NORTHBOUND LANE

CLOGGED DECK DRAIN AT UPSTREAM CURB NEAR SOUTH END

DAMAGE TO UPSTREAM RAIL

DEBRIS ACCUMULATION ALONG DOWNSTREAM CURB

5" X 2" X 1" DEEP POTHOLE AND TRANSVERSE CRACK IN ASPHALT WEARING SURFACE ALONG END BENT 2 FILL FACE

AREAS OF DECAY IN SOUTHEAST WINGWALL

11' X 3" X 2" DEEP SPALL WITH EXPOSED STRAND IN LEG 2 OF CHANNEL 5 (PRIORITY MAINTENANCE)

30" X 3" X 2" DEEP SPALL WITH EXPOSED STRAND IN LEG 2 OF CHANNEL 5 AT END BENT 2 (PRIORITY MAINTENANCE)

66" X 3" AREA OF DELAMINATION AND 1/8" HORIZONTAL CRACK IN LEG 2 OF CHANNEL 5 NEAR END BENT 2

UP TO 1/4" SPLIT IN PILE 2 AT END BENT 2

24" X 3" X 1/2" DEEP AREA OF DECAY IN PILE 4 AT END BENT 1

CHECKS AND SPLITS IN PILE 5 AT END BENT 1

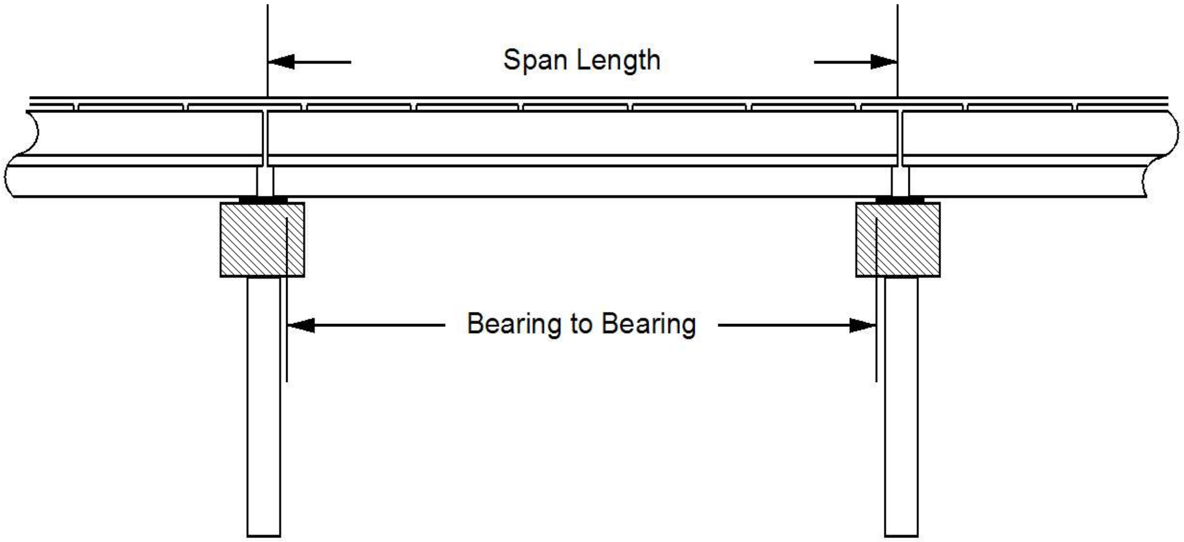
12" LONG SECTION OF DETERIORATION OF 4" DIAMETER STEEL UTILITY CONDUIT ON UPSTREAM SIDE

12" X 8" X 2" DEEP AREA OF DECAY IN NORTHWEST WINGWALL BEHIND WING PILE

Structure Data Worksheet

Spans

County: PITT Structure No: 730421 Date: 03/20/2012 Inspected By: KMM



Span No	Span Length	Bearing to Bearing	Comments
1	30.0 FT	29.0 FT	NBIS: 28.0 FT

Stream Bed Soundings

(See next sheet for profile sketch)

Bridge No: 730421 County: PITT Date: 03/20/2012 By: KMM

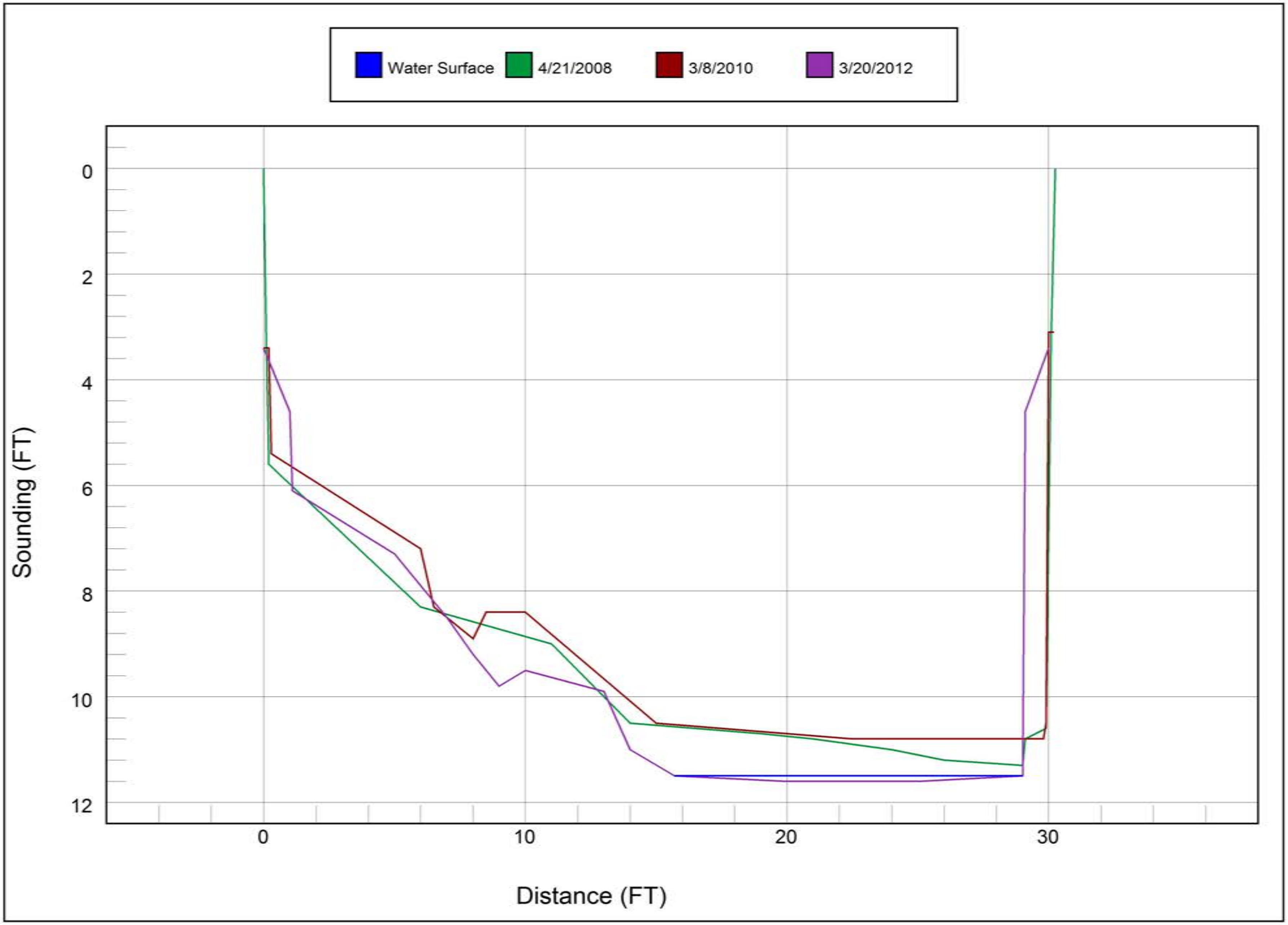
Record sounding from top of rail. Other location if needed:

Distance from Highwater Mark to top of rail: 7 Location of Highwater Mark: WATER STAINS ON PILES

DOWNSTREAM			UPSTREAM		
Distance (Station) (ft)	Sounding (ft)	Description	Distance (Station) (ft)	Sounding (ft)	Description
0	3.4	TOP OF WINGWALL			
1	4.6	Top of Cap			
1.1	6.1	GROUND AT CAP	1.1	7.5	GROUND AT CAP
5	7.3	GROUND			
7	8.5	GROUND			
8	9.2	GROUND			
9	9.8	GROUND			
10	9.5	GROUND			
13	9.9	GROUND			
14	11	GROUND			
15.7	11.5	Water Surface/Water Edge (WSWE)			
20	11.6	STREAMBED			
25	11.6	STREAMBED			
29	11.5	Water Surface/Water Edge (WSWE)	29	8.5	GROUND
29.1	4.6	Top of Cap			
30	3.4	TOP OF WINGWALL			

STREAMBED PROFILE (Downstream)

Top of Rail = 0 FT (Sounding)



Bridge Inspection Field Sketch

Roadway	23ft Wide	2 Paved Lanes	Looking North
Left Guardrail			
Right Guardrail			

NOTE: No shoulder width due to private properties adjacent to roadway.

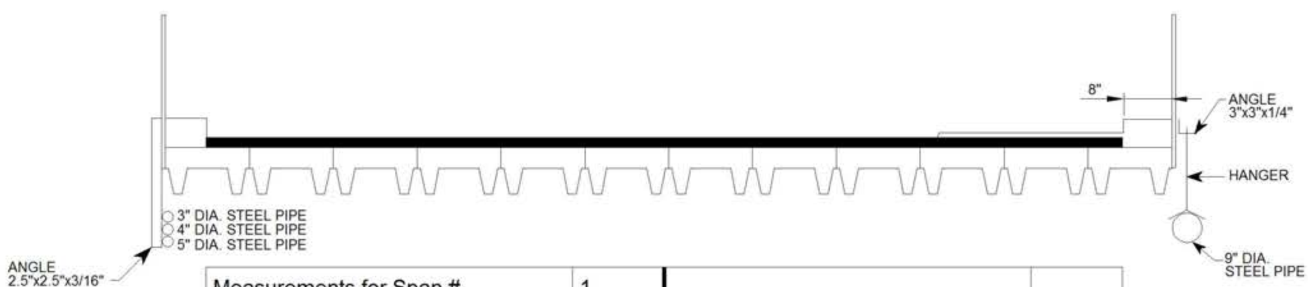
SKETCH REVISED BY MTM ON 3.20.12

Title	**Description**
APPROACH ROADWAY	LOOKING NORTH

Bridge No: 730421	**Drawn By:** FCJ	**Date:** 3/08/2010	**File Name:** S0254000320

Bridge Inspection Field Sketch

Deck Width/Out to Out	30.75ft	Between Rails			30.75ft
Clear Roadway	24.25ft	Wearing Surface			0.25ft
Median Width		Median Height			
Curb Height		Left	0.583ft	Right	0.417ft
Sidewalk Width		Left		Right	5ft
Clear Roadway (Rail to Median)		Left		Right	
Guardrail Width		Left	0.125ft	Right	0.125ft
Top of Rail to Deck/Wearing Surface		Left	2.750ft	Right	2.833ft
Bridge Rail		Left	Type 36	Right	Type 36



Measurements for Span #	1		
Deck Thickness		Left Overhang	0.25ft
Top of Rail to Bottom of Beam	4.5ft	Right Overhang	0.25ft

Number of Channels	12
Leg Width	0.208ft
Leg Height	1.0ft
Leg to Leg (Centers)	2.0ft
Channel Width	2.542ft
Channel Height	1.417ft
Comments	

SKETCH REVISED BY MTM ON 3.20.12

Title	**Description**
TYPICAL SECTION	12 LINES OF PPC CHANNELS

Bridge No: 730421	**Drawn By:** FCJ	**Date:** 3/08/2010	**File Name:** S0254000321

Bridge Inspection Field Sketch

Cap Information			Material	Cast-in-Place Concrete		
Length	Width	Height	Left Overhang	Right Overhang	Left Beam to End of Cap.	Right Beam to End of Cap.
31.500 ft.	1.333 ft.	1.000 ft.	1.583 ft.	1.333 ft.	.500 ft.	.500 ft.

Subcap Information			Material		
Length	Width	Height	Left Overhang	Right Overhang	Left Pile to Splice.

Sill Information			Material
Length	Width	Height	

Pile #	Material	Spacing	Width/Dia.	Height	Length	Orientation	Driven?	Replacement?	Removed?	Collar?
1	Timber	6.0 ft.	1.0 ft.			Vertical	Yes	No	No	No
2	Timber	5.417 ft.	1.0 ft.			Vertical	Yes	No	No	No
3	Timber	5.917 ft.	1.0 ft.			Vertical	Yes	No	No	No
4	Timber	5.75 ft.	1.0 ft.			Vertical	Yes	No	No	No
5	Timber	5.5 ft.	1.0 ft.			Vertical	Yes	No	No	No
6	Timber		1.0 ft.			Vertical	Yes	No	No	No

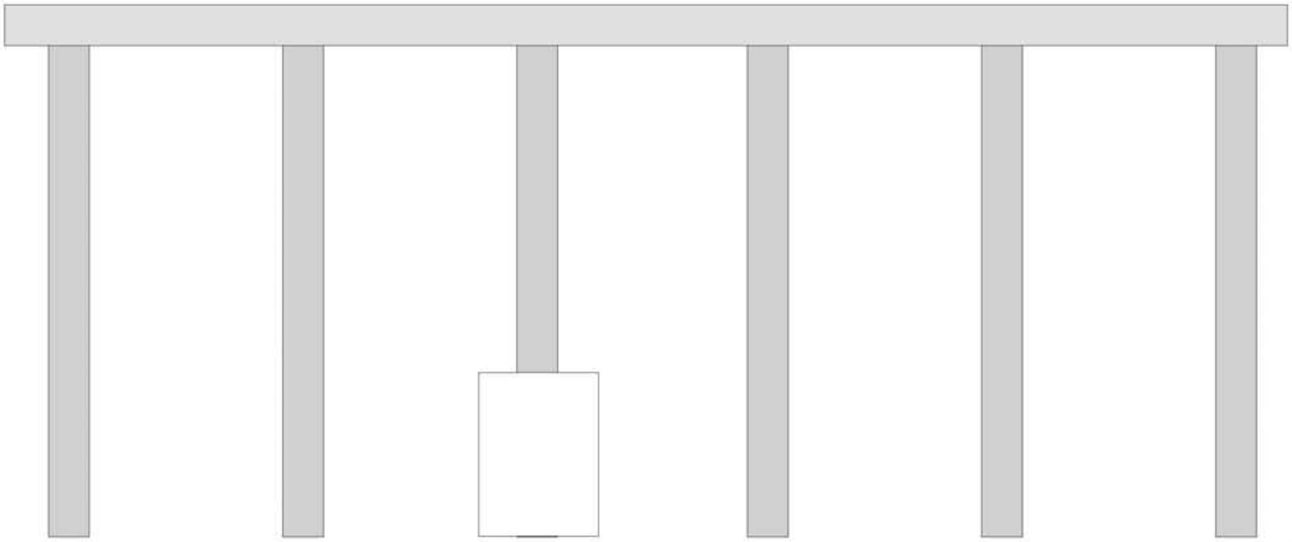
End Bent #: 1

SKETCH VERIFIED BY MTM ON 3.20.12

Title	Description
END BENT PROFILE	END BENT 1

Bridge No:	Drawn By:	Date:	File Name:
730421	FCJ	3/08/2010	S0254000322

Bridge Inspection Field Sketch



Cap Information			Material	Cast-in-Place Concrete		
Length	Width	Height	Left Overhang	Right Overhang	Left Beam to End of Cap.	Right Beam to End of Cap.
31.500 ft.	1.333 ft.	1.000 ft.	1.583 ft.	1.583 ft.	.500 ft.	.500 ft.

Subcap Information			Material		
Length	Width	Height	Left Overhang	Right Overhang	Left Pile to Splice.

Sill Information			Material
Length	Width	Height	

Pile #	Material	Spacing	Width/Dia.	Height	Length	Orientation	Driven?	Replacement?	Removed?	Collar?
1	Timber	5.75 ft.	1.0 ft.			Vertical	Yes	No	No	No
2	Timber	5.75 ft.	1.0 ft.			Vertical	Yes	No	No	No
3	Timber	5.667 ft.	1.0 ft.			Vertical	Yes	No	No	Yes
4	Timber	5.75 ft.	1.0 ft.			Vertical	Yes	No	No	No
5	Timber	5.75 ft.	1.0 ft.			Vertical	Yes	No	No	No
6	Timber		1.0 ft.			Vertical	Yes	No	No	No

End Bent #: 2

SKETCH VERIFIED BY MTM ON 3.20.12

Title	**Description**
END BENT PROFILE 1	END BENT 2

Bridge No: 730421	**Drawn By:** FCJ	**Date:** 3/08/2010	**File Name:** S0254000323

LOOKING NORTH

POSTING SIGN AT SOUTH APPROACH, POSTING SIGN AT NORTH APPROACH SIMILAR

DOWNSTREAM RAIL, UPSTREAM RAIL SIMILAR

LOOKING UPSTREAM, WEST

LOOKING DOWNSTREAM, EAST

NORTH APPROACH, LOOKING SOUTH

DOWNSTREAM PROFILE, LOOKING WEST

9" DIAMETER STEEL UTILITY LINE ATTACHED TO DOWNSTREAM SIDE

RAIL POST AND 9" DIAMETER STEEL UTILITY LINE ATTACHMENT TO DOWNSTREAM SIDE

END BENT 1

REPAIR TO LEGS 1 AND 2 OF CHANNEL 12 AT END BENT 2, LEG 2 OF CHANNEL 11 SIMILAR

UNDERDECK

3" DIAMETER, 4" DIAMETER AND 5" DIAMETER STEEL CONDUITS ATTACHED TO UPSTREAM SIDE

END BENT 2

UPSTREAM PROFILE, LOOKING EAST

NC DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
BRIDGE MANAGEMENT UNIT

ATTENTION: TEMPORARY REPAIRS

BRIDGE INSPECTION REPORT

INSPECTION TYPE: Routine Inspection - Municipal

COUNTY: PITT
BRIDGE NUMBER: 730419
INSPECTION CYCLE: 0 YRS

ROUTE: OXFORD ROAD
ACROSS: BELLS BRANCH
M.P.: 0

LOCATION: 0.1 MI.S.JCT.10TH ST.

SUPERSTRUCTURE: PRESTRESSED CONCRETE CHANNELS

SUBSTRUCTURE: E.BTS:RC CAPS/TIM.PILES

SPANS: 1@30'

LONGITUDE	77° 19' 26.9"	LATITUDE	35° 35' 42.4"
PRESENT CONDITION	FAIR	INVENTORY RATING	
INSPECTION DATE	03/19/2012	OPERATING RATING	
PRESENT POSTING	SV 21 TTST 27 SV 21 TTST 27	PROPOSED POSTING	
COMPUTER UPDATE		ANALYSIS DATE	
POSTING LETTER DATE		SUFFICIENCY RATING	

OTHER SIGNS PRESENT: FOUR (4) DELINEATORS

SIGN NOTICE ISSUED FOR		NUMBERED REQUIRED
No	WEIGHT LIMIT	
No	DELINEATORS	
No	NARROW BRIDGE	
No	ONE LANE BRIDGE	
No	LOW CLEARANCE	

LOOKING NORTH

BRIDGE I & A FORM1 (90)A

BRIDGE INSPECTION RECORD AND SUMMARY

INSPECTION TYPE Routine Inspection - Municipal
BRIDGE NO. 730419 COUNTY PITT ROUTE OXFORD ROAD OVER BELLS BRANCH
STRUCTURE TYPE PRESTRESSED CONCRETE CHANNELS
ROUTE ORIENTATION S - N SPANS 1@30'

EVALUATION CODES: CRITICAL (C, 0 - 3); POOR (P, 4); FAIR (F, 5, 6); GOOD (G, 7 - 9)

INSPECTION ITEM			
DECK ITEMS			GRADES
1. WEARING SURFACE			G
2. DECK NO. OF EA TYPE SPN GRADE RATES SI & A ITEM 58	a. CONCRETE	1	G
	b. TIMBER		
	c. STEEL PLANK		
	d. OPEN GRID		
3. RAILING	a. CONCRETE		
	b. TIMBER		
	c. ALUMINUM		
	d. STEEL		G
4. CURBS, WHEELGUARDS, PARAPETS, MEDIANS			F
5. WALKWAYS (ON OR ATTACHED TO STRUCTURE)			
6. DECK EXP JTS. OR DEVICES. NO. OF EACH	a. STEEL PL OR FINGER		
	b. MISC PREFAB		
	c. COMPRESSION SEAL		
	d. STANDARD JOINTS	2	G
	e. OPEN JOINTS		
7. DECK DEBRIS (INCLUDES EXCESS SAND/GRAVEL)			G
SUPER STR. (FM. 1 (90)B TRUSS) ITEM 59			
10. LONGITUDINAL BEAMS OR GIRDERS			F
11. LONGITUDINAL JOIST OR STRINGERS			
12. INT. DIAP'S, X-FRAMES, BRACING & CONN'S			
13. END DIAP'S, CURTAIN WALLS, & CONN'S			G
14. FLOOR BEAMS AND CONNECTIONS			
15. BEARING ASSEMBLIES (INCLUDING MISALIGN)			G
16. DRAINAGE SYSTEM (ON STRUCTURE)			G
17. MOVABLE SPAN MACHINERY			
SUB STR. ITEMS. ITEM 60 (INCLUDE SCOUR)			
35. TIM SUB STR.	a. ABUT. & INT. BENT CAPS & RISERS		
	b. PILES, POST, SILLS, & BRACING		F
	c. BULKHEADS, WING'S, & TIE BACKS		F
36. CONC SUB STR.	a. ABUT. & INT. BENT CAPS		G
	b. ABUT. & BENT COL'S BREASTWALLS		
	c. ABUT. & INT. BENT PILES		
	d. BACKWALLS, WING'S, RETAIN. WALLS		
	e. ABUT. & BENT FOOTINGS & SILLS		
37. STEEL SUB STR.	a. ABUT. & INT. BENT CAPS & RISERS		
	b. PILES, BRACING, AND BULKHEADS		
38. FOUNDATION PILES TYPE MATERIAL			
39. SLOPE PROT., RIP-RAP (INCLUDE DRAINAGE)			F
40. FENDER SYSTEMS			
41. DRIFT			G

ITEM 61		
45. CHANNEL & CHANNEL PROT.	a. WATERWAY	G
	b. ALIGNMENT	F
	c. SCOUR	F
	d. SLOPE PROT., RIP-RAP, DIKES, ETC.	F
50. APPROACH ROADWAY CONDITION		F
51. APPROACH SLABS		
52. PAINT SYSTEM	CODE	
53. UTILITIES		G
54. RESPONSE TO LIVE LOAD		G
55. ESTIMATED REMAINING LIFE		2
60. REGULATORY SIGN NOTICE ISSUED		NO
61. PROMPT-ACTION NOTICE ISSUED		NO
62. PRESENTLY POSTED		YES
63. TOT. FIELD INSP TIME (INCLUDE WRITE UP)(MAN HR)		6
64. TOTAL SNOOPER INSP. TIME (HRS)		
65. TOTAL TRAFFIC CONTROL TIME (MAN HRS)		
70. SI&A GENERAL CONDITION RATINGS		
a. DECK	ITEM 58	7
b. SUPERSTRUCTURE	ITEM 59	5
c. SUBSTRUCTURE	ITEM 60	5
d. CHANNEL & CHANNEL PROT.	ITEM 61	5
71. SI&A FIELD APPRAISAL RATINGS		
a. WATERWAY ADAQUACY		7
b. APPR. RDWY. ALIGNMENT		7
72. FIELD SCOUR EVALUATION		U
USE OF INSP. ACCESSIBILITY EQUIPMENT		
SNOOPER (CODE S, 4, OR N)	HRS	NO
LADDER		NO
BUCKET TRUCK		NO
BOAT		NO
OTHER		NO
SPECIAL INSPECTION REQUESTED FOR		
NOTE		
80. INSPECTED BY:	Karen Medley	
81. REVIEWED BY:		

Bridge I&A Form 1(82)H State of North Carolina Dept. of Transportation Division of Highways	FIELD INSPECTION REPORT Bridge Inspecion & Analysis	

Team Leader K. Mobley

Assisted By MTM

Item No.	Grade	
1	G	CRACK IN THE ASPHALT WEARING SURFACE IN THE NORTHBOUND LANE AT END BENT 1 (SEE PHOTO). LONGITUDINAL REFLECTIVE CRACKS IN THE ASPHALT WEARING SURFACE IN THE SOUTHBOUND LANE (SEE PHOTO).
3d	G	33" LONG X 2" DEEP AREA OF IMPACT DAMAGE TO THE UPSTREAM RAIL BETWEEN RAIL POSTS 2 AND 3 (SEE PHOTO).
4	F	30" X 8" X 3" DEEP SPALL IN THE TOP AND 5" X 3" X 1/2" DEEP SPALL IN THE FACE OF THE UPSTREAM CURB AT THE NORTH END (SEE PHOTO).
10	F	REPAIR TO LEG 1 IN CHANNEL 6 AT MIDSPAN (SEE STRUCTURE PHOTO). SIMILAR REPAIRS TO LEG 1 OF CHANNELS 1, 2, 4 AND 5 AT END BENT 2. TWO 5" X 4" X 1/8" DEEP SPALLS WITH EXPOSED STIRRUP IN THE UPSTREAM FACE OF LEG 1 IN CHANNEL 2 (SEE PHOTO). SIMILAR SPALLS AT THE FOLLOWING LOCATIONS: 1) DOWNSTREAM FACE OF LEG 2 IN CHANNEL 1, APPROXIMATELY 4', 8' AND 10' FROM END BENT 1; 2) UPSTREAM FACE OF LEG 1 IN CHANNEL 2, APPROXIMATELY 4' FROM END BENT 1; 3) LEG 2 IN CHANNEL 2 AT END BENT 1 BEARING.
10A	NO	NO CURVED GIRDERS.
35b	F	UP TO 1 1/2" WIDE X 4" DEEP SPLIT IN PILE 5 ON THE DOWNSTREAM AND UPSTREAM FACES FROM THE TOP OF THE CONCRETE COLLAR TO THE BOTTOM OF THE CAP AT END BENT 1 (SEE PHOTO). CHECKS AND SPLITS IN THE PILES AT BOTH END BENTS. UP TO 1/8" HORIZONTAL CRACK IN THE UPSTREAM FACE OF THE CONCRETE ENCASEMENT AT PILE 1 AT END BENT 1. UP TO 1/16" HORIZONTAL CRACK IN THE FACE OF THE CONCRETE ENCASEMENT AT PILE 6 AT END BENT 2.
35c	F	78" X 4" WIDE AREA OF DECAY IN THE NORTHWEST WINGWALL (SEE PHOTO).
39	F	UP TO 12" DEEP SHOULDER EROSION BEHIND THE SOUTHWEST WINGWALL (SEE PHOTO). SIMILAR EROSION BEHIND THE SOUTHEAST WINGWALL.
45b	F	THE WATER FLOWS DIRECTLY AGAINST THE UPSTREAM END OF END BENT 1 AND THE DOWNSTREAM END OF END BENT 2.

Bridge I&A Form 1(82)H State of North Carolina Dept. of Transportation Division of Highways	FIELD INSPECTION REPORT Bridge Inspecion & Analysis	

Team Leader K. Mobley

Assisted By MTM

Item No.	Grade	
45c	F	EROSION OF THE STREAMBANK ALONG THE END BENTS. SCOUR REPORT DATED 2/17/2011 RECOMMENDS A RATING OF 5.
50	F	TRANSVERSE CRACK IN THE ASPHALT WEARING SURFACE ALONG END BENT 1 FILL FACE IN THE SOUTHBOUND LANE (SEE PHOTO). SIMILAR CRACK ALONG END BENT 2 FILL FACE IN THE SOUTHBOUND LANE. REPAIR: THE TRANSVERSE CRACKS ALONG BOTH END BENT FILL FACES IN THE NORTHBOUND LANE HAVE BEEN RESURFACED (SEE APPROACH STRUCTURE PHOTOS).
62	YES	SV 21 TTST 27

BRIDGE INSPECTOR'S RECOMMENDATION FOR MAINTENANCE REPAIRS

Bridge: 730419 County PITT Date: 03/19/2012

These Repairs Should Be Made Within Twelve Months From Date Of This Inspection

MMS Code	Description of Function	Unit	Quantity	Remarks	Est. Cost
3322	Maint to Steel Handrail	LF	3	33" LONG X 2" DEEP AREA OF IMPACT DAMAGE TO THE UPSTREAM RAIL BETWEEN RAIL POSTS 2 AND 3.	
3344	Repair / Replace Timber Substructure Components	LF	3	UP TO 1 1/2" WIDE X 4" DEEP SPLIT IN PILE 5 ON THE DOWNSTREAM AND UPSTREAM FACES FROM THE TOP OF THE CONCRETE COLLAR TO THE BOTTOM OF THE CAP AT END BENT 1.	
3346	Repair / Maintain Timber Wings & Blkhds	SF	3	78" X 4" WIDE AREA OF DECAY IN THE NORTHWEST WINGWALL.	
2816	Asphalt Surface Repair or Replacement	SY	5	LONGITUDINAL REFLECTIVE CRACKS IN THE ASPHALT WEARING SURFACE IN THE SOUTHBOUND LANE.	

Key

Priority Maintenance Item Critical Finding Item Priority Maintenance Level Not Determined

TRANSVERSE CRACK IN ASPHALT WEARING SURFACE ALONG END BENT 1 FILL FACE IN SOUTHBOUND LANE

CRACK IN ASPHALT WEARING SURFACE IN NORTHBOUND LANE AT END BENT 1

LONGITUDINAL REFLECTIVE CRACKS IN ASPHALT WEARING SURFACE IN SOUTHBOUND LANE

30" X 8" X 3" DEEP SPALL IN TOP AND 5" X 3" X 1/2" DEEP SPALL IN FACE OF UPSTREAM CURB AT NORTH END

33" LONG X 2" DEEP AREA OF IMPACT DAMAGE TO UPSTREAM RAIL BETWEEN RAIL POSTS 2 AND 3

UP TO 12" DEEP SHOULDER EROSION BEHIND SOUTHWEST WINGWALL

UP TO 1 1/2" WIDE X 4" DEEP SPLIT IN PILE 5 ON UPSTREAM AND DOWNSTREAM FACES FROM TOP OF CONCRETE COLLAR TO BOTTOM OF CAP AT END BENT 1

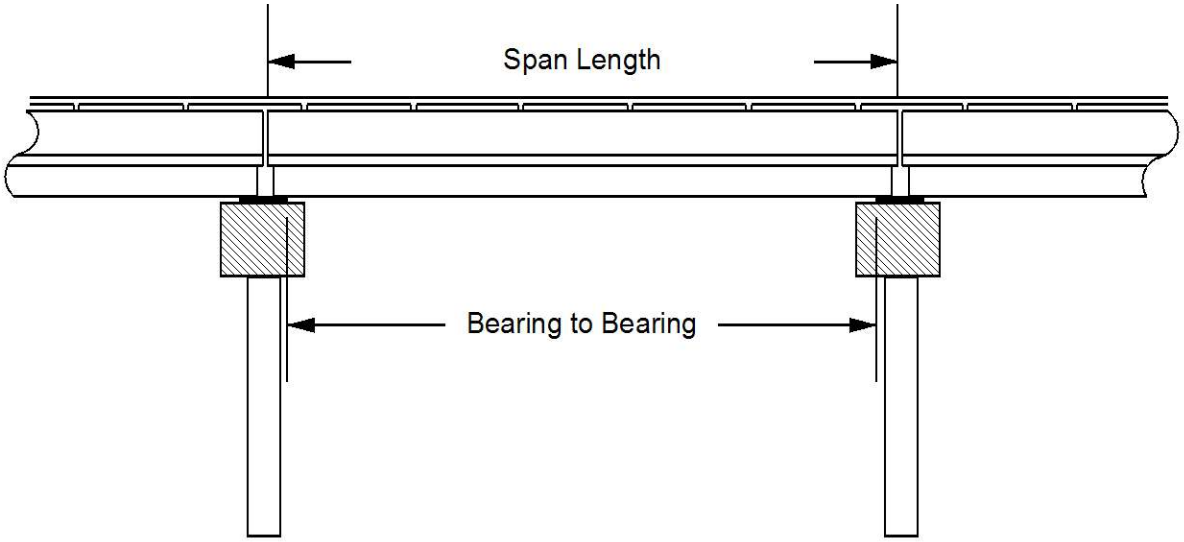
78" X 4" WIDE AREA OF DECAY IN NORTHWEST WINGWALL

Structure 730419 County PITT Date: 03/19/2012 Condition Photos

TWO 5" X 4" X 1/8" DEEP SPALLS WITH EXPOSED STIRRUP IN UPSTREAM FACE OF LEG 1 IN CHANNEL 2

Structure Data Worksheet

County: PITT Structure No: 730419 Date: 03/19/2012 Inspected By: KMM



Span No	Span Length	Bearing to Bearing	Comments
1	30 FT	29.333 FT	NBIS: 28.333 FT

Stream Bed Soundings

(See next sheet for profile sketch)

Bridge No: 730419 County: PITT Date: 03/19/2012 By: KMM

Record sounding from top of rail. Other location if needed:

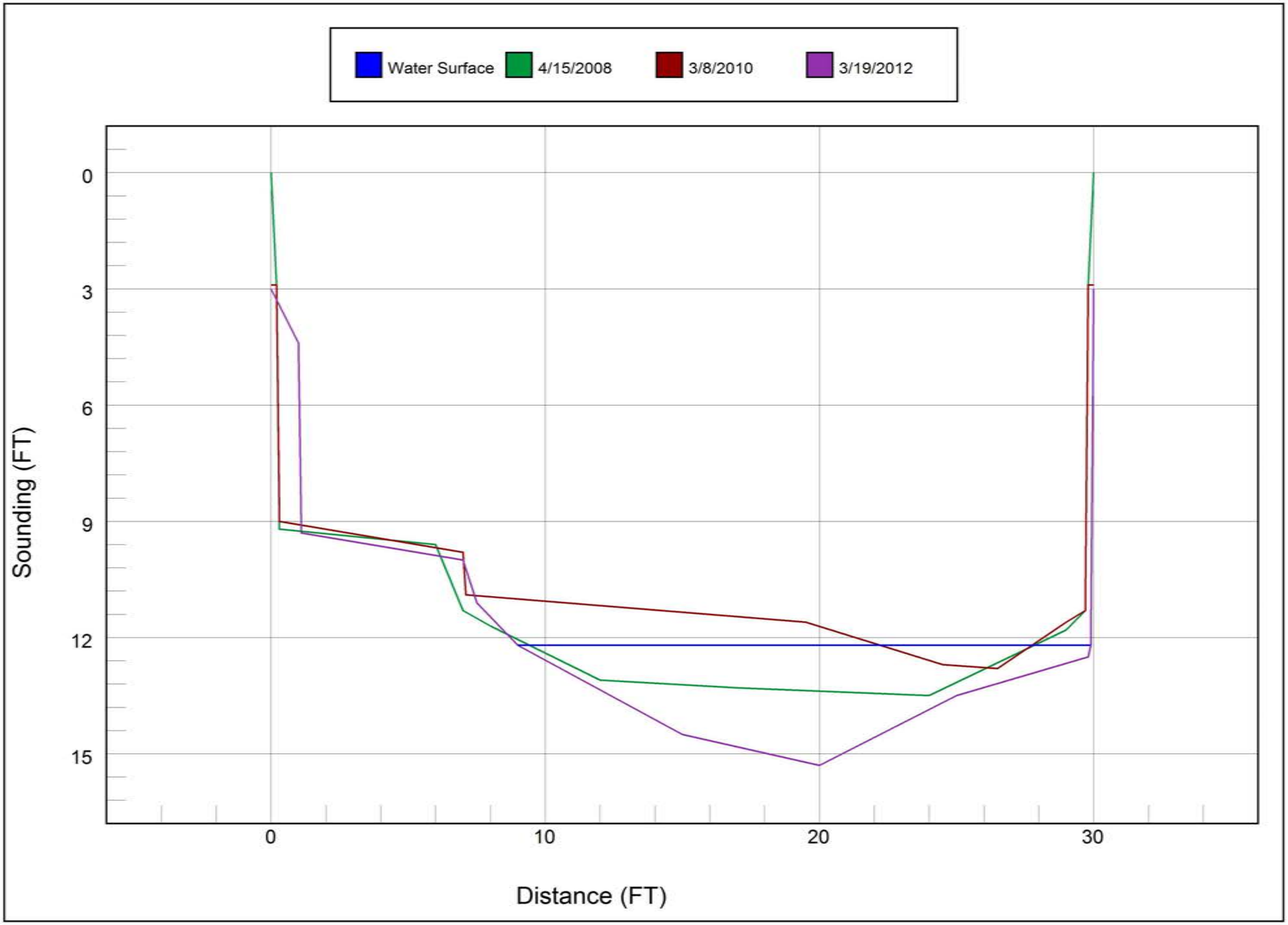
Distance from Highwater Mark to top of rail: 9 Location of Highwater Mark: WATER STAINS ON PILES

DOWNSTREAM			UPSTREAM		
Distance (Station) (ft)	Sounding (ft)	Description	Distance (Station) (ft)	Sounding (ft)	Description
0	3	TOP OF WINGWALL			
1	4.4	Top of Cap			
1.1	9.3	GROUND AT CAP	1.1	12.2	STREAMBED
7	10	GROUND			
7.5	11.1	GROUND			
9	12.2	Water Surface/Water Edge (WSWE)			
15	14.5	STREAMBED			
20	15.3	STREAMBED			
25	13.5	STREAMBED			
29.8	12.5	STREAMBED	29.8	7.2	GROUND
29.9	12.2	Water Surface/Water Edge (WSWE)			
30	3	TOP OF WINGWALL			

Bridge: 730419 County PITT Date: 03/19/2012

STREAMBED PROFILE (Downstream)

Top of Rail = 0 FT (Sounding)



Bridge Inspection Field Sketch

Roadway	24ft Wide	2 Paved Lanes	Looking North
Left Shoulder	4ft Wide		4ft Unpaved
Right Shoulder	4ft Wide		4ft Unpaved
Left Guardrail			
Right Guardrail			

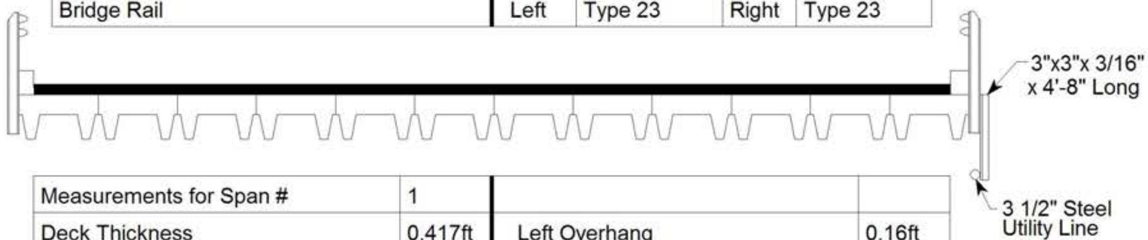
SKETCH REVISED BY MTM ON 3.22.12

Title	**Description**
APPROACH ROADWAY	LOOKING NORTH

Bridge No: 730419	**Drawn By:** LGH	**Date:** 3/08/2010	**File Name:** S0266000074

Bridge Inspection Field Sketch

Deck Width/Out to Out	30.5ft	Between Rails			30.083ft
Clear Roadway	29.25ft	Wearing Surface			0.333ft
Median Width		Median Height			
Curb Height		Left	0.583ft	Right	0.583ft
Sidewalk Width		Left		Right	
Clear Roadway (Rail to Median)		Left		Right	
Guardrail Width		Left	0.5ft	Right	0.5ft
Top of Rail to Deck/Wearing Surface		Left	2.667ft	Right	2.667ft
Bridge Rail		Left	Type 23	Right	Type 23



Measurements for Span #	1		
Deck Thickness	0.417ft	Left Overhang	0.16ft
Top of Rail to Bottom of Beam	4.333ft	Right Overhang	0.16ft

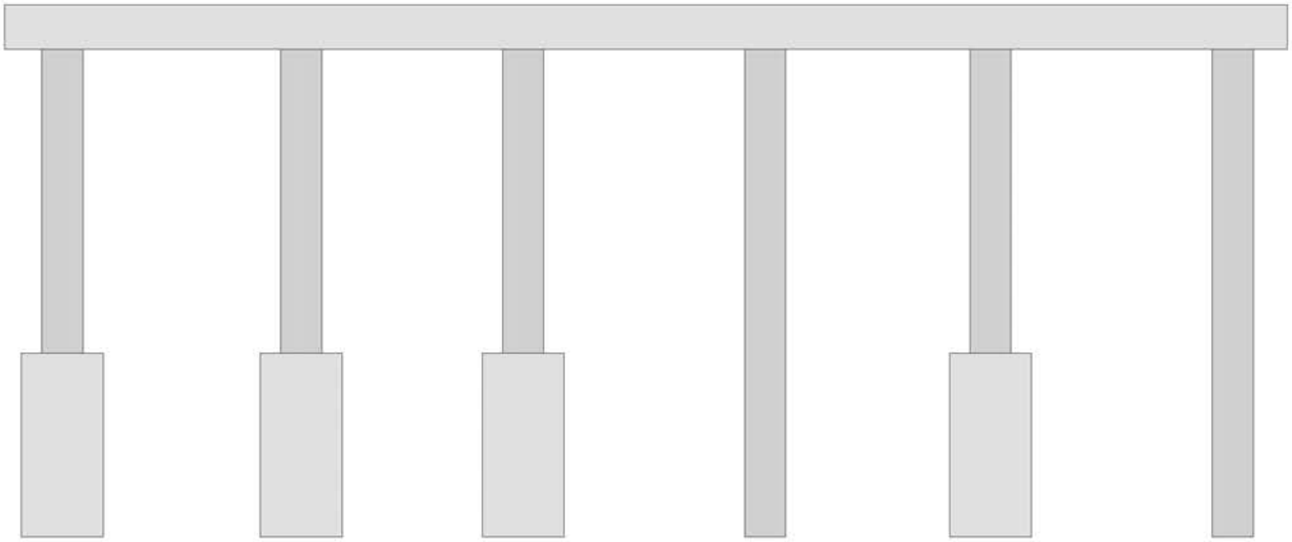
Number of Channels	12
Leg Width	0.167ft
Leg Height	1.0ft
Leg to Leg (Centers)	2.0ft
Channel Width	2.54ft
Channel Height	1.42ft
Comments	

SKETCH VERIFIED BY MTM ON 3.22.12

Title	Description
TYPICAL SECTION	12 LINES OF PPC CHANNELS

Bridge No: 730419	Drawn By: LGH	Date: 3/08/2010	File Name: S0266000075

Bridge Inspection Field Sketch



Cap Information			Material	Precast Concrete		
Length	Width	Height	Left Overhang	Right Overhang	Left Beam to End of Cap.	Right Beam to End of Cap.
31.250 ft.	1.250 ft.	1.083 ft.	1.417 ft.	1.250 ft.	.750 ft.	.750 ft.

Subcap Information			Material		
Length	Width	Height	Left Overhang	Right Overhang	Left Pile to Splice.

Sill Information			Material
Length	Width	Height	

Pile #	Material	Spacing	Width/Dia.	Height	Length	Orientation	Driven?	Replacement?	Removed?	Collar?
1	Timber	5.833 ft.	1 ft			Vertical	Yes	No	No	Yes
2	Timber	5.417 ft.	1 ft			Vertical	Yes	No	No	Yes
3	Timber	5.917 ft.	1 ft			Vertical	Yes	No	No	Yes
4	Timber	5.500 ft.	1 ft			Vertical	Yes	No	No	No
5	Timber	5.917 ft.	1 ft			Vertical	Yes	No	No	Yes
6	Timber		1 ft			Vertical	Yes	No	No	No

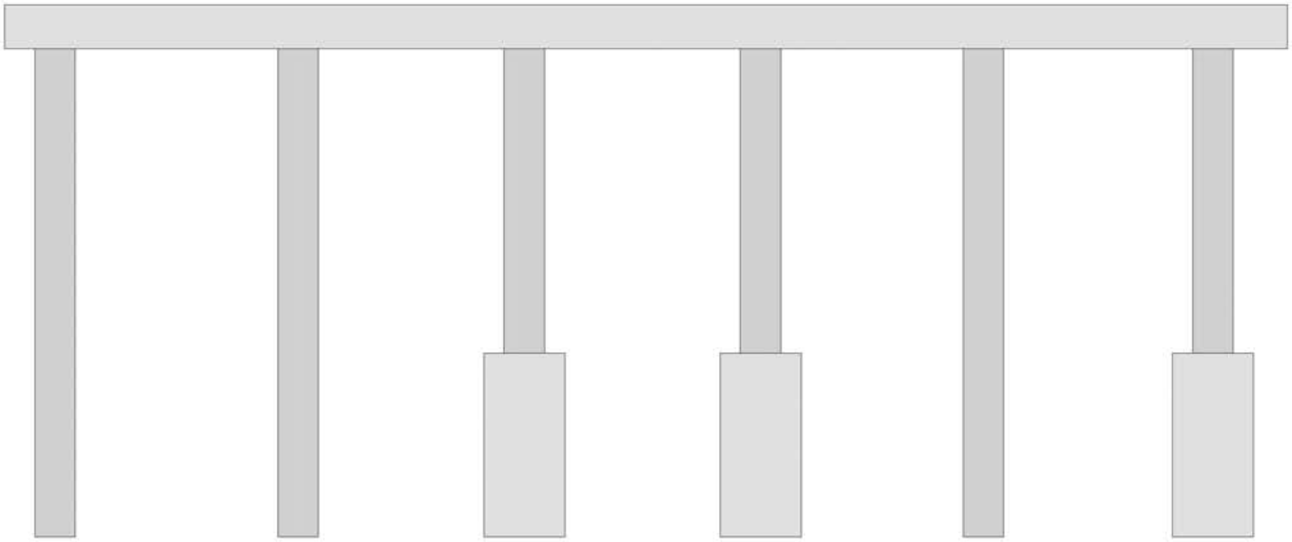
End Bent #: 1

SKETCH VERIFIED BY MTM ON 3.22.12

Title	Description
END BENT PROFILE	END BENT 1

Bridge No:	Drawn By:	Date:	File Name:
730419	LGH	3/08/2010	S0266000076

Bridge Inspection Field Sketch



Cap Information			Material	Precast Concrete		
Length	Width	Height	Left Overhang	Right Overhang	Left Beam to End of Cap.	Right Beam to End of Cap.
31.167 ft.	1.250 ft.	1.083 ft.	1.250 ft.	1.333 ft.	.750 ft.	.750 ft.

Subcap Information			Material		
Length	Width	Height	Left Overhang	Right Overhang	Left Pile to Splice.

Sill Information			Material
Length	Width	Height	

Pile #	Material	Spacing	Width/Dia.	Height	Length	Orientation	Driven?	Replacement?	Removed?	Collar?
1	Timber	6.000 ft.	1.000 ft.			Vertical	Yes	No	No	No
2	Timber	5.583 ft.	1.000 ft.			Vertical	Yes	No	No	No
3	Timber	5.833 ft.	1.000 ft.			Vertical	Yes	No	No	Yes
4	Timber	5.500 ft.	1.000 ft.			Vertical	Yes	No	No	Yes
5	Timber	5.667 ft.	1.000 ft.			Vertical	Yes	No	No	No
6	Timber		1.000 ft.				Yes	No	No	Yes

End Bent #: 2

SKETCH VERIFIED BY MTM ON 3.22.12

Title	**Description**
END BENT PROFILE 1	END BENT 2

Bridge No: 730419	**Drawn By:** LGH	**Date:** 3/08/2010	**File Name:** S0266000077

LOOKING NORTH

POSTING SIGN AT SOUTH APPROACH, POSTING SIGN AT NORTH APPROACH SIMILAR

DOWNSTREAM RAIL, UPSTREAM RAIL SIMILAR

ROADWAY DRAIN ON WEST SIDE AT NORTH APPROACH, ROADWAY DRAIN ON EAST SIDE SIMILAR

NORTH APPROACH, LOOKING SOUTH

LOOKING UPSTREAM, WEST

LOOKING DOWNSTREAM, EAST

DOWNSTREAM PROFILE, LOOKING WEST

SOUTHWEST WINGWALL, OTHERS SIMILAR

RAIL POST 2 ATTACHMENT TO DOWNSTREAM SIDE, OTHERS SIMILAR

3 1/2" DIAMETER STEEL UTILITY LINE ON DOWNSTREAM SIDE

UNDERDECK

REPAIR TO LEG 1 IN CHANNEL 6 AT MIDSPAN

END BENT 2

END BENT 1

UPSTREAM PROFILE, LOOKING SOUTHEAST

APPENDIX M

Project Prioritization Matrix

CATEGORY	Public Health and Safety		Severity of Street Flooding (Public ROW)		Cost Effectiveness		Effect of Improvements		Water Quality - BMP		Water Quality - Erosion Control		Implementation Constraints		Grant Funding		Constructibility		TOTAL WEIGHTED SCORE
Primary System Projects																			
East 14th Street (Bells Branch) - Alternative #1	1	10	3	30	3	30	1	6	0	0	0	0	3	18	0	0	3	9	**116**
York Road & Railroad Crossing (Bells Branch) - Alternative #1	3	30	5	50	5	50	1	6	0	0	0	0	1	6	0	0	1	3	**158**
York Road & Railroad Crossing (Bells Branch) - Alternative #2	3	30	5	50	3	30	5	30	0	0	0	0	1	6	0	0	1	3	**164**
Oxford Road Closed System (Bells Branch)	5	50	5	50	1	10	3	18	0	0	0	0	3	18	0	0	3	9	**170**
14th Street (Meetinghouse Branch) - Alternative #1	3	30	5	50	3	30	1	6	0	0	0	0	3	18	0	0	3	9	**158**
14th Street (Meetinghouse Branch) - Alternative #2	3	30	5	50	1	10	3	18	0	0	1	6	3	18	1	6	3	9	**164**
Charles Boulevard (Meetinghouse Branch) - Alternative #2	3	30	3	30	3	30	5	30	0	0	0	0	1	6	0	0	3	9	**150**
Oxford Road Floodplain Bench (Meetinghouse Branch) - Alternative #2	3	30	3	30	3	30	3	18	0	0	1	6	1	6	1	6	3	9	**150**
Secondary System Projects																			
Grey Fox Trail	3	30	3	30	1	10	1	6	0	0	0	0	5	30	1	6	3	9	**135**
Barnes Street- Paramore Drive -Rondo Drive	1	10	1	10	1	10	1	6	0	0	0	0	3	18	1	6	3	9	**79**
Fantasia Street - Sherwood Drive	3	30	0	0	1	10	1	6	0	0	0	0	3	18	1	6	3	9	**88**
Oakmont Drive	3	30	3	30	3	30	1	6	0	0	0	0	3	18	1	6	1	3	**135**
Eastwood Subdivision	1	10	3	30	1	10	3	18	5	30	0	0	3	18	3	18	1	3	**156**
Stream Stabilization Projects																			
Project #1 – Charles Boulevard	1	10	0	0	3	30	1	6	0	0	5	30	3	18	3	18	3	9	**139**
Project #2 – Crooked Creek Road	0	0	0	0	1	10	3	18	0	0	5	30	1	6	3	18	3	9	**107**
Project #3 – Brook Valley Golf Course	0	0	0	0	3	30	1	6	0	0	5	30	1	6	3	18	3	9	**115**
Project #4 – Bloomsbury Road	0	0	0	0	3	30	1	6	0	0	5	30	1	6	3	18	3	9	**115**
Project #5 – Kensington Drive	0	0	0	0	0	0	1	6	0	0	5	30	1	6	3	18	3	9	**82**
Water Quality Projects																			
Free First Baptist Church - Bioretention	0	0	0	0	1	10	0	0	3	18	0	0	1	6	3	18	3	9	**72**
Oakmont Drive - Bioretention	0	0	0	0	5	50	0	0	3	18	0	0	1	6	3	18	3	9	**116**
Eleanor Street - Bioretention	0	0	0	0	3	30	0	0	3	18	0	0	1	6	3	18	3	9	**94**
Brook Valley Country Club - Bioretention	0	0	0	0	3	30	0	0	3	18	0	0	1	6	3	18	3	9	**94**
Perkins Field - Bioretention	0	0	0	0	3	30	0	0	3	18	0	0	5	30	3	18	3	9	**122**
Eastern Elementary School - Bioretention	0	0	0	0	3	30	0	0	3	18	0	0	5	30	3	18	3	9	**122**
Jaycee Park - Bioretention	0	0	0	0	1	10	0	0	3	18	0	0	5	30	3	18	3	9	**100**

*Raw numbers are shown in left side of column and weighted numbers are provided in right side of column. Totals are based on weighted numbers.

Category	General Description	Score	Evaluation Criteria
Public Health and Safety	Evaluates potential impact of flooding on public health and safety. Generally, refers to flooding in and around habitable structures.	5	Flood water depth and/or velocity completely surrounds and threatens the structural integrity of habitable structures or vehicles. Finished Floor Flooding Occurs during the design storm.
		3	Flood water surrounds structure but does not cause imminent danger. Crawl space and HVAC units are flooded.
		1	Yard flooding occurs and flood waters are near HVAC, crawl spaces or foundations.
		0	Minor yard flooding may occur but habitable structure is not directly affected.
Severity of Street Flooding (City Owned)	Evaluates impact of flood depths to or through an area	5	Street spread requirements are not met and are so severe that the street becomes impassable during the design storm or street flooding has spread into private property.
			Flooding is noted on NCDOT roads as a result spread issues on adjacent city owned street.
		3	Street spread requirements are not met and the streets are passable only through the center of the street.
			Flooding noted on collector and local streets.
		1	Spread requirements exceeded but street flooding is considered minor nuisance for traffic.
		0	Spread requirements are met.
Cost Effectiveness	Evaluates the benefit/cost of the proposed improvements	5	Project benefit ratio is greater than 1.5
		3	Project benefit ratio is between 0.5 and 1.5
		1	Project benefit ratio is between 0.075 and 0.5
		0	Project ratio is less than 0.075
Effect of Improvements	Evaluates the number of drainage issues resolved and the number of citizens positively affected	5	Multiple major drainage issues are being resolved through the proposed improvements such as street spread and increased drainage capacity.
			Proposed improvements would resolve major drainage issues for more than 5 properties.
		3	Single drainage issue is being resolved and it is considered major. Proposed improvements would resolve drainage issues for 3-5 properties.
		1	Single drainage issue is being resolved and it is considered major.
			Proposed improvements would resolve drainage issues for 2-3 properties.
		0	Single drainage issue is being resolved and it is considered minor.
			Proposed improvements would resolve drainage issue(s) for a single property at most.
Water Quality/Quantity	Evaluates the impact a BMP would have on water quality, water quantity and NPDES Phase II Compliance	5	Provides both water quantity and water quality benefits. Does not use manufactured or proprietary BMP technology. Incorporates some form of green solution such as infiltration, LID, sustainability etc. Is considered a BMP retrofit.
		3	Provides water quality benefits but does not provide water quantity benefit.
			Is considered a BMP retrofit
		1	Improvements will have minimal impacts on water quality and would primarily serve as a demonstration project.
			Is considered a BMP retrofit.
		0	Improvements will have no measurable impact on water quality and would serve only as a demonstration project.
Open Channel - Erosion Control	Evaluates the severity of erosion control issues and impact on water quality	5	Severe erosion problems are evident and are contributing significantly to water quality issues.
		3	Moderate erosion problems are evident and are contributing to water quality issues.
		1	Minor erosion control issues are evident and are contributing to water quality issues.
		0	Minor erosion control issues are evident and are not contributing to water quality issues in a significant way.

Implementation Constraints	Considers potential constraints that may either delay or make the project too difficult to construct. Some examples would include significant permitting issues, high mitigation costs, numerous easement needs, required partnering with other communities, the NCDOT, or railroads.	5	Only minor local or state permits required. Does not involve ACOE, DWQ or FEMA. Proposed improvements can be completed without permanent or temporary easements. Project can proceed independent of other stormwater improvements identified in the master plan.
		3	Requires State and Federal permits that are typically easy to obtain such as Nationwide permits, FEMA No Rise etc. Primarily requires temporary easements with only a few permanent easements needed to build the project. Improvements may have limited coordination with other projects such as DOT widening, GUC utility improvements or down stream drainage improvements. Significant delays in the schedule due to this coordination is not anticipated. Project can proceed independent of other stormwater improvements identified in the master plan. Project is self mitigating or requires very minor mitigation.
		1	Numerous permits required including federal, state and local agencies. Examples would include an individual permit or FEMA CLOMR/LOMR. Extensive permanent and temporary easements are required. Project can not proceed independent of other stormwater improvements identified in the master plan.
Grant Funding	Evaluates the availability and potential to receive grant funding	5	Project qualifies for multiple grants. Grant does not require significant match (20% match or less) City does not have an open grant from the agency providing the funding. Project meets all ranking criteria and will score highly in most if not all categories.
		3	Project qualifies for only one type of grant funding. Grant requires match between 20% and 50% range. City has an open grant from agency providing the funding. Project meets most if not all of the ranking criteria and will score high in key categories.
		1	Project qualifies for only one type of grant funding. Grant requires match equal to or greater than 50%. City has an open grant from agency providing the funding. Project meets some of the ranking criteria and may score high in one or two categories.
		0	Project does not qualify for any type of grant funding
Constructability	Evaluates relative constructability of the project including site constraints, traffic and neighborhood impacts, and impacts on adjacent property owners.	5	Limited to no site constraints. Limited to no utility conflicts. Limited to no impacts on adjacent property owners. Limited to no impacts on traffic or surround neighborhoods.
		3	Some site constraints exist but are considered fairly minor. Some utility conflicts exist but are routine and do not require major utility relocation. Some traffic and neighborhood impacts occur but are fairly minor. Examples include temporary lane closures, occasional hauling or traffic detours though adjacent neighborhoods.
		1	Site constraints exist and are fairly major. Utility conflicts exist and require rerouting or relocation of existing utilities. Traffic and neighborhood impacts occur and are fairly major. Examples included extended road closures or hauling operations.

To calculate the project benefit ratio used in evaluating the cost effectiveness, the following steps were taken for each project location:

1. The weighted scores for the Public Health and Safety, Severity of Street Flooding, and Effect of Improvements categories were added together.
2. The sum of the three categories was divided by the total project cost.
3. The quotient was multiplied by a common multiplier, 5,000, to determine the benefit ratio.
4. The value was then assigned a score based on the evaluation criteria shown below for the cost effectiveness criteria.

Score	Evaluation Criteria
5	Project benefit ratio is greater than 1.5
3	Project benefit ratio is between 0.5 and 1.5
1	Project benefit ratio is between 0.075 and 0.5
0	Project ratio is less than 0.075

5. The applicable weighting factor is then applied to the score. The final number obtained is listed in the project prioritization matrix.

Weight Factor	Criteria
10	Public Health and Safety
	Severity of Street Flooding (Town Owned)
	Cost Effectiveness
6	Effect of Improvements
	Water Quality - BMP and Erosion Control
	Implementation Constraints
	Grant Funding
3	Construction Impacts
	Constructability

The above table presents the weighting factors that will be applied to the prioritization criteria, with the reason being that some criteria are viewed as more important (i.e. deserve a higher weighting) than others. So each score of each prioritization criteria will be multiplied by the assigned weight factor for that prioritization criteria category as shown in the Priority Matrix.

APPENDIX N

Final Report
Ecosystem Enhancement Grant

Water Quality Restoration for Meeting House Branch:

Plan and Implementation

Prepared by:

Heather Jacobs Deck, Pamlico-Tar River Foundation

In collaboration with:
Dr. Michael O'Driscoll, East Carolina University
Dr. Charles Humphrey, East Carolina University
Dr. Eban Bean, East Carolina University
Colin Walker, Master Degree Candidate, East Carolina University

Submitted
October 30, 2012

Pamlico~Tar River
FOUNDATION

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Executive Summary

PTRF was awarded a $50,000 two-year grant to develop a comprehensive water quality restoration plan for Meeting House Branch (MHB) located in the Tar-Pamlico River Basin in Pitt County. The MHB watershed was targeted because it has undergone rapid urban expansion since the 1970s and is showing signs of impairment due to urban stormwater inputs (channel erosion) and elevated nitrogen inputs possibly due to the legacy of agricultural land-use, lawn fertilizers, septic systems and/or pet waste.

PTRF contracted with researchers from East Carolina University to accomplish the goals of the grant. The goals of this study were to characterize the Meeting House Branch watershed and it primary water quality issues and develop potential solutions. All seven grant objectives were successfully completed.

Water quality impairments within the Meeting House Branch (8 km^2) watershed were identified by a multidisciplinary team. The approach included literature reviews, analyses of pre-existing data, field reconnaissance, water quality, and channel geomorphological monitoring. This work was used to identify impaired sites and develop priorities for restoration, conservation, and BMP implementation. A total of 21 restoration sites were identified and a simple BMP prioritization methodology was developed.

Overall, the stream channels within the MHB watershed are enlarged as a result of past channelization and stream channel incision and widening. Nitrogen levels were elevated in the middle of the watershed. The research indicates that a likely possible source for this elevated nutrient content is agricultural fertilizer transported via groundwater. Urban runoff is the main cause of these problems. The golf course pond in the lower section of the watershed has actually functioned as a sink for nutrients and sediment and nutrient content reduces downstream.

The grant's educational objectives were exceeded. In total more than 300 students and adults were reached via 13 educational presentations. Furthermore, in collaboration with the City of Greenville, all 3600 residents within the Meeting House Branch Watershed received a stormwater survey with 4.5% responding. The results of the survey were used to develop a watershed specific Education & Outreach Plan, with specific activities to be completed over the next 2-3 years. Finally, PTRF in collaboration with the City of Greenville's Public Works Department and East Carolina University held an Urban Stormwater Tour for elected officials, city staff and citizen commission members.

The project's cost totaled $41,467.97. PTRF and the project partners were able to reduce the initial expected costs by the donation of additional in-kind services as well as project objective collaborations with the City of Greenville.

Narrative of Work Completed

All seven of the project's grant objectives were completed. The grant's objectives were to:

a) Gather and evaluate existing water quality, land use, and hydrologic data for Meeting House Branch. **Completed**
b) Design and implement monitoring to collect data needed for production of the restoration plan. **Completed**
c) Analyze all collected data. **Completed**
d) Identify impairment and its causes. **Completed**
e) Identify and prioritize stormwater BMP projects that would enhance the quality of the streams. **Completed**
f) Develop educational materials and outreach plan. **Completed**
g) Seek additional grant support from other funding agencies for BMP implementation. **Completed**

The results of grant objectives *a* through *e* above can be found in the enclosed Final Project Report, "Water Quality Restoration for Meeting House Branch: Plan & Implementation."

Below is a bulleted list of the work completed by this grant:

Evaluation of existing data:

- Restoration plan completed that summarizes all past data, including water quality issues, soils, historical landuse and population changes and impervious area and land-use maps generated. Also characterized past and current stormwater policies.
- Compiled all past research and water quality data and compared to current data.

Monitoring, Analysis and Evaluation:

- Water level recorders installed at 6 sites to monitor stream flow
- 26 locations were monitored for water quality
- Sampling was conducted at 4 baseflow (seasonal samples) and 2 storm events at the 26 sites, plus selected outfalls during storm events.
- Analyzed a total of 129 baseflow and 35 stormwater samples.
- Additional sampling run was conducted in May, 2012 at all sites to determine spatial nitrogen content (11 surface samples and 18 riparian groundwater samples taken)
- Cross-sectional stream channel profiles were collected monthly at monitoring stations along MHB and its selected tributaries from June, 2011 until February, 2012 to assess how channel dimensions changed seasonally. In addition to stream channel profiles being recorded monthly at each monitoring site, channel dimensions were measured prior to and after Hurricane Irene
- Assessment of riparian zone quality for 93, 300-foot buffer segments.
- Land use was also evaluated across the riparian buffers during the assessment. For each riparian buffer segment (180 ft x 300 ft or 55 m x 90 m) a site sketch was performed, identifying and delineating any impervious surfaces, housing density, or vegetative growth.
- Identified and mapped all stormwater outfalls, ditches and other drainage pipes.
- Stormwater survey sent to all 3600 residents in MHB watershed.

- Survey results analyzed and included in the Final Project Report.
- A total of 21 potential BMP sites were selected

Education& BMP Prioritization

- Distributed urban stormwater guide and fact sheets
- Developed BMP ranking methodology
- Developed Education and Outreach Plan
- Published 10 copies of restoration plan
- Conducted urban stormwater tour for 10 elected officials, members of advisory commissions, and members of city staff, including the Public works director and City Manager.
- In total, PTRF and ECU presented 13 educational events reaching approximately 350 persons, targeting grades 9-12, undergraduate and graduate courses, adult civic organizations and the general public.
- Seven ECU students participated in data collection and analysis.

Additional Funding

- A grant proposal was developed and finalized to fund three stormwater BMP retrofits for the MHB Watershed. The proposal was ultimately pulled for consideration by the project partners to allow for more time to reach out to landowners (including the Greenville Utilities Commission) and seek more information on required state and federal permits.
- The project partners plan to initiate talks with the City of Greenville, the Greenville Utilities Commission and other prioritized BMP site location landowners to develop shovel-ready stormwater BMP projects.

Estimate of Environmental impact

The funds from this grant allowed us to complete phase I, which is the development of a comprehensive water quality restoration plan for MHB based on both historical and current water quality and hydrologic data. The project partners have identified 21 BMP sites and will seek funding to implement Phase II, which is the construction of stormwater BMPs.

Work is currently underway to develop new partnerships with the City of Greenville as well as the Greenville Utilities Commission, who owns numerous access easements along MHB, to prepare shovel-ready projects within the MHB watershed for the purposes of stormwater improvements. The funding from this current grant has allowed us to complete the restoration planning that will be the basis of all future work. We anticipate within the next 5 years having stormwater BMPs in the ground, of course depending on funding. Budget cuts to the 319 and Clean Water Management Trust Funds have slowed progress on implementation of beneficial projects.

Educational impact

The educational objectives of the grant were exceeded. In total, approximately 350 students and adults were reached via 13 educational presentations held by PTRF and ECU project partners. Seven undergraduate and graduate students participated in the water quality data collection for the restoration plan and one graduate student utilized the project for his thesis.

In collaboration with the City of Greenville, all 3600 residents within the Meeting House Branch Watershed received a stormwater survey with 4.5% responding. The results of the survey were used to develop a watershed specific Education & Outreach Plan, with specific activities to be completed over the next 2-3 years. This plan incorporates activities by PTRF and ECU in collaboration with the City of Greenville and the Pitt County Division of Soil and Water Conservation.

The MHB watershed is almost completely built-out. This information, along with the clear signs of stream impairment, provided the project partners with a unique educational opportunity for city leaders. Much of the development within the MHB watershed occurred when stormwater regulations were less restrictive than current new development post-construction requirements. The erosion and flooding issues now plaguing Meeting House Branch can only be alleviated by retrofits, which can be an expensive after-the-fact fix where the cost burden falls on local governments. Several other urban watersheds within the City of Greenville's jurisdiction are not completely built-out yet. Educating our elected officials regarding the impacts of less than adequate stormwater regulations may in fact result in policy improvements that seek to prevent stream damage in other portions of the city.

The project partners collaborated with the City of Greenville's public works department to hold an urban stormwater tour and presentation for ten elected officials, city staff and citizen commission members. It is the collaborators plan to conduct more urban stormwater tours in the future, as outlined in the Education and Outreach Plan (Appendix B).

Meeting of Benchmarks

a. Finalized restoration planning document that identifies causes of stream impairment and identifies and prioritizes restoration activities. **(Task completed)**
b. Maps and other planning documents and tools created to drive further restoration activities. **(Task completed)**
c. Simple prioritization methodology for BMP site selection that can be easily replicated for use in other watersheds. **(Task completed)**
d. Educational materials provided to watershed landowners **(Task completed - Ongoing)**
e. A minimum of 5 sites identified for future water restoration activities. **(Task Completed)**
f. A minimum of 2 Educational Outreach presentations **(Task completed)**
g. Additional funding leveraged to implement restoration plan activities **(Pending)**

Final accounting of EEG money spent

PTRF was able to complete all of the grant objectives while remaining under budget. This was partially due to additional donated services from our contract partners, East Carolina University, including travel costs, monitoring equipment and analysis. We were also fortunate to be able to partner with the City of Greenville to reduce costs on the stakeholder survey and public meeting.

In total, the final project cost was $41,467.97.

Final Report Enclosures

Final Project Report," Water Quality Restoration for Meeting House Branch: Plan & Implementation"
Education & Outreach Plan
BMP Prioritization Methodology and Schematic
Urban Stormwater Tour Agenda
Urban Stormwater Tour Fact Sheets
Final Budget Accounting

Acknowledgements

PTRF is grateful for funding from the Ecosystem Enhancement Program to aid in implementation of beneficial projects that will ultimately lead to improved water quality and stream habitat as well as improvements in public attitudes toward clean water.

We would like to acknowledge the excellent work, as well as additional donated time and services by our East Carolina University partners, Dr. Michael O'Driscoll, Dr. Eban Bean and Dr. Charles Humphrey. A special thanks to all of the ECU students who participated in data collection, especially master's degree candidate, Colin Walker for all of his hard work and dedication, especially for slogging in the streams collecting data during the heat of summer.

PTRF would also like to thank the City of Greenville for a well planned urban stormwater tour and their consultants WK Dickson for collaborating with us on the stakeholder survey and providing us with the results.

And finally a special thanks and recognition for our colleague Dr. Mark Brinson, whose untimely death affected many. His work was instrumental in developing an effective riparian buffer survey that was utilized for this project.

Appendix A

Final Project Report: “Water Quality Restoration for Meeting House Branch: Plan & Implementation

Water Quality Restoration for Meeting House Branch-Plan and Implementation

Final Project Report

(October 31, 2012)

By M. O'Driscoll, M.C. Walker, C. Humphrey, H. Jacobs-Deck, and E. Bean

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Executive Summary

Past studies and water quality, channel morphology, and stream discharge data collected during the current study suggest that increased urban runoff, stream channel erosion, elevated stream nitrate, and total suspended sediment concentrations have impacted Meeting House Branch watershed. Based on historical aerial photographs and maps of the watershed, most of land was either forested or agricultural in the 1970s. Sections of the headwaters were channelized to facilitate agriculture, prior to the 1970s. Predominantly during the 1980s-1990s, rapid urban and suburban development of the watershed occurred and these land-use changes resulted in increased stormwater generation, which has affected stream channel stability and in some cases caused stream channel incision. Overall, the stream channels are enlarged in this watershed as a result of past channelization and stream channel incision and widening. Total dissolved nitrogen levels were elevated in the middle of the watershed. Nitrate was the dominant nitrogen species in stream water and is commonly present in Meeting House Branch at elevated concentrations (> 1.5 mg/l) between 14th street and the golf course pond. Possible sources for elevated dissolved nitrogen and nitrate include fertilizer, pet waste, wastewater, organic soils, and atmospheric deposition. Based on the data collected in this study it appears that agricultural fertilizer transported via groundwater flowpaths may play an important role. Fortunately, a combination of dilution and nutrient uptake/transformations in the golf course pond, channel and pond sediments, and possible in-stream processing, help to reduce nitrate and total dissolved nitrogen concentrations downstream of the pond at Brook Valley Golf Course. If the golf course pond has not been dredged, it likely holds a record of sediment deposition over the last 50 years. Future work on the treatment efficiency of the pond could help elucidate the mechanisms responsible for improving water quality. Healthy riparian buffers can help reduce nitrogen inputs to streams. Along some reaches the riparian buffers are of poor quality and may have reduced ability to retain/remove nitrogen from groundwater. In some cases, urban runoff flows directly through buffers as overland flow, bypassing the potential for subsurface treatment. Improvements in buffer condition can help improve water quality. Throughout the Meeting House Branch watershed, segments of the stream channel have high densities of discharge pipes and culverts that can discharge runoff with little to no treatment. During storm events total suspended sediments and phosphorus concentrations become elevated throughout the watershed. These data, along with stream channel cross-sections and channel observations suggest that bank sediment erosion is a problem along some reaches. Since urban stormwater runoff is the root cause of these problems, efforts to reduce urban runoff inputs to channels could improve stream health. Although we did not assess stream ecological metrics, it is likely that stream organisms respond to the changes in habitat (due to the spatial variability of water quality and stream bank erosion) and future work could assess the biological response to urbanization within this watershed. In this report, over 20 potential restoration sites were identified and other restorative actions are recommended to improve water quality, reduce stormwater-related erosion, and mitigate flooding issues.

Introduction

The Tar-Pamlico River basin is home to numerous endangered and threatened aquatic organisms. The Pamlico River estuary continues to show signs of significant nutrient impairment, indicated by NC DWQ sampling (NC DENR 2010). The main-stem of the Pamlico River is noted on the draft 303(d) list as impaired for exceeding chlorophyll *a* water quality standards. Even though the regulated communities (new development, wastewater treatment plants, agriculture, etc.) have reached their nutrient reduction goals, impairment continues (NC DENR 2010). Reducing nutrient inputs from existing developed areas will be critical for removing the Pamlico River estuary from the impaired waters list. Greens Mill Run, a tributary to the Tar River that runs through the heart of the City of Greenville, is classified as an impaired stream (NC DENR 303D, 2010). Impairment of urbanized Coastal Plain watersheds is evidenced by severe bank erosion, scour, and poor water quality (Hardison et al. 2009). Highly urbanized watersheds such as Greens Mill Run pose a significant challenge for restoration due to severe impairment, multiple landowners, and limited riparian buffers. Tributaries, such as Meeting House Branch (MHB), that are currently experiencing urbanization but do not yet show many of the symptoms of the urban stream syndrome (Walsh et al. 2005), may provide some of the most cost-effective opportunities for improving water quality in this rapidly urbanizing region.

Study Objectives

The goals of this study were to characterize the Meeting House Branch watershed (Figure 1) and its primary water quality issues and develop potential solutions. The study objectives were to:

a) Gather and evaluate existing water quality, land-use and hydrologic data for Meeting House Branch.

b) Identify monitoring needs and implement monitoring to collect data needed for production of a restoration plan.

c) Identify causes of impairment.

d) Identify potential BMP projects.

e) Develop educational materials (e.g. signage, pamphlets, etc.).

g) Seek additional grant support for BMP implementation.

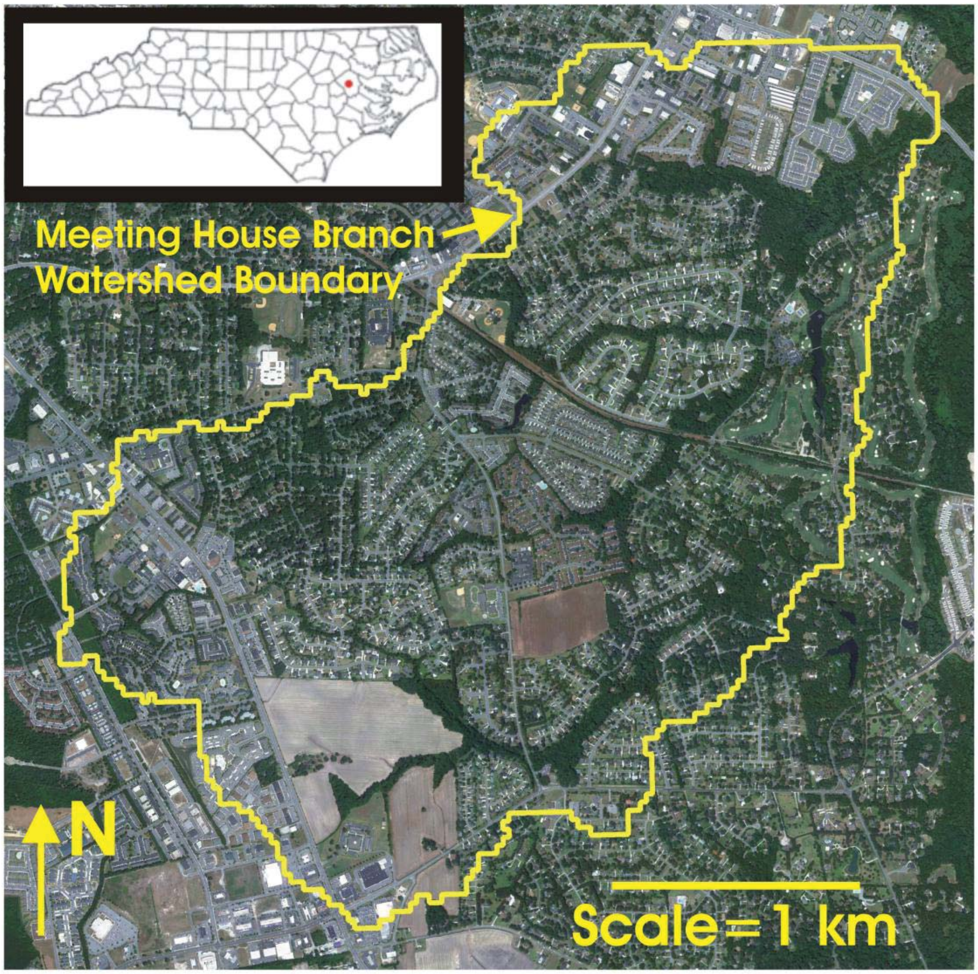


Figure 1. Aerial photograph of the Meeting House Branch watershed (source: Google Earth, 2011).

History of Development

The city of Greenville (0.4 km^2) was founded in 1787 on the banks of the Tar River. Growth of Greenville has been due to its role as an agricultural, industrial, and educational hub for eastern North Carolina. Cotton and tobacco industries were strong in the late 1800s and the establishment of the railroad (1889) and East Carolina Teachers Training School (now East Carolina University) in 1907 also resulted in growth and development of the Greenville area (Williams 1974, Kammerer and Pearce 2001). Population and urban development has expanded as the University has grown, particularly over the last quarter century (Williams 1974, LINC 2008, McCann et al. 2008).

Since Greenville was first settled a variety of land-use changes have occurred in the region that have altered the landscape and drainage network. The conversion of forest to agricultural land in the North Carolina Coastal Plain has resulted in significant erosion from upland areas (Phillips, 1997). Many of the floodplain forests along the Atlantic Coastal Plain experienced substantial sediment deposition due to the erosion of upstream sediments in the eighteenth and nineteenth centuries. Deforestation and agricultural conversion and subsequent channel incision led to floodplains that are relatively “high and dry” (Hupp, 2000). Estuarine sediments in the Neuse and Pamlico Estuaries, NC, suggest that sedimentation rates and nutrient loads to the estuary were much higher over the last 50 years than in any other period after 1720 (Cooper et al., 2004). This implies that more recent activities land-use conversion has intensified in comparison to the initial conversion from forest to agriculture.

River channelization is the modification of river channels for flood control, land drainage, navigation or erosion prevention and has been documented as one of the greatest and most widespread forms of human alterations to rivers throughout the world (Brookes 1988). Stream channelization has been widespread in the Coastal Plain of North Carolina and it has been estimated that over 5 million acres (20,000 km^2) of rural Coastal Plain lands have been drained (Stone et al. 1992, Dukes et al., 2003). In the Atlantic Coastal Plain, the primary purpose of channelization has been to drain lands for agriculture. In addition, the Flood Control Act of 1936 provided the Army Corps of Engineers the authority to clear streams and resulted in a project that removed in-channel and bank vegetation along the Tar River and some of its larger tributaries that was completed in 1946 and was documented to reduce flooding (USACE 1975). In 1971, a successful lawsuit filed by the National Resources Defense Council and other groups versus the Soil Conservation Service prevented the channelization along nearby Chicod Creek, Pitt Co., NC (Brookes 1988). After this lawsuit in the 1970s, negative attention, and a growing realization that channelization severely altered stream ecology, large scale federal government channelization projects declined (Wohl 2004). Based on the last county scale survey of agricultural drainage (1978), it was estimated that approximately 43% of Pitt County has been drained for agriculture (US Bureau of Census, 1980).

The Southeast Drainage Commission (Greenville, NC) maintains records of channelization projects in Pitt County (http://gis.pittcountync.gov/website/opis/) and other counties throughout eastern North Carolina. Their records show that most of Meeting House Branch and its tributaries were not channelized as part of the agricultural drainage improvement projects conducted during the 1940-1970s (Vandiford 2008). However, small tributaries in the headwaters of Meeting House Branch fall within the drainage districts. Aerial photos and site visits revealed that several hundred meters of headwater reaches along Meeting House Branch (adjacent to Charles Boulevard) were channelized. The drainage district does not extend into the lower portions of the watershed and there is no evidence that extensive channelization of the mainstem stream occurred, although small local projects may have occurred.

The most recent major land-use change in the region has been the conversion of forested and agricultural lands to urban/suburban land-use. In 1974, the Pitt County Soil Survey mapped the region (Karnowski et al. 1974). Within the Survey, Plates 42 and 50 cover the majority of the Meeting House Branch watershed and reveal that the watershed was predominantly agricultural at that point in time (Figure 2). Since the 1970s, the watershed has undergone a transformation from predominantly agricultural land-use, to urban and suburban land-use. Hardison et al. (2009)

developed an urban development model (based on time series of local maps and aerial photos; details are provided by R. Howard in Appendix A) for the Greenville area from 1930 to 2000 which indicated that Meeting House Branch watershed was relatively undeveloped prior to the 1974 soil survey. Meeting House Branch watershed began to experience suburban development between 1965 and 1975 (Figure 3).

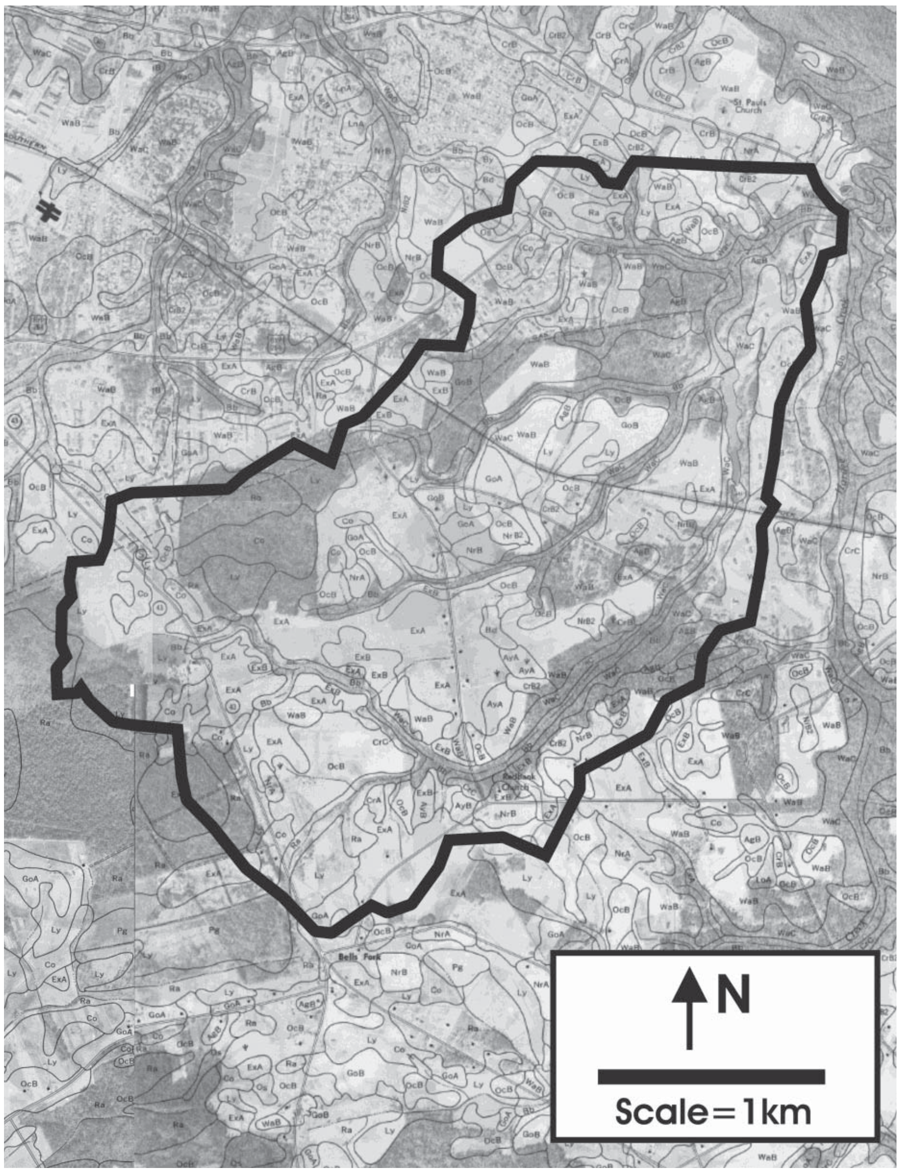


Figure 2. Aerial photos and soils map from the 1974 Soil Survey of Pitt County. Black line is the approximate watershed boundary for the Meeting House Branch watershed.

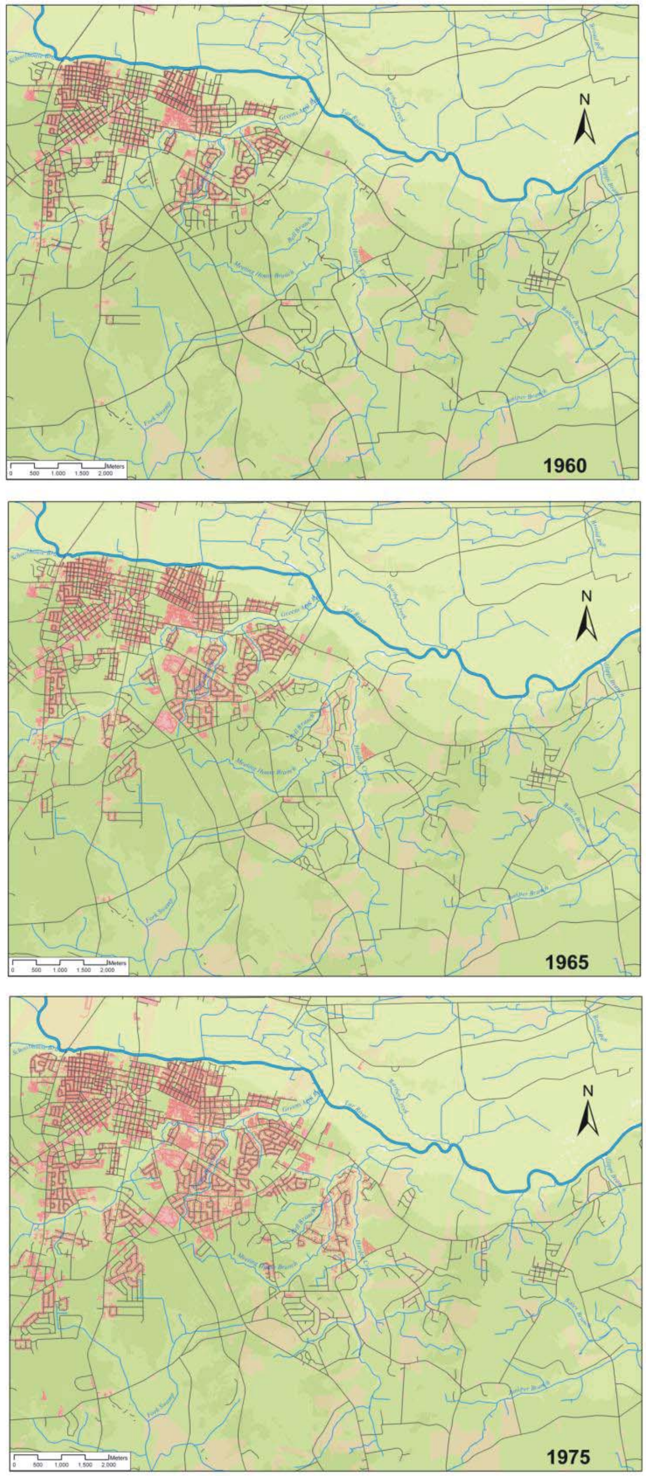


Figure 3. Urban development model developed by R. Howard for the Greenville area (modified from Hardison et al. 2009). Meeting House Branch watershed began developing around 1965. Appendix A includes more details on the development of the model.

Based on the 1982 USGS Topographic Quadrangle (Greenville SE), the Pitt County Soil Survey (1974), and historic maps analyzed by Hardison et al. (2009), much of the suburban and urban development in the watershed took place over the previous 30 years (1982-2012). This corresponds with a period of rapid population growth and urban expansion in Greenville, related to the expansion of East Carolina University. Although population density in Greenville has remained relatively constant since the 1980s, the municipal land area has expanded from 39 km^2 in 1980 to 90 km^2 in 2010, to accommodate an increase in population from 35,740 (1980) to 85,152 (2010) (North Carolina Office of State Budget and Management, 2011). The 1982 USGS Topographic Quadrangle (Figure 4) shows that the Bell Branch sub-watershed was relatively undeveloped in 1982 with most development occurring off 14th street at a housing complex off of Scott and Barnes Streets. Along the mainstem of Meeting House Branch most of the development in 1982 was centered in Brook Valley (Oxford, York, and Windsor Roads) and some development (Windy Ridge) off 14th street (Wellcome Drive and Tuckahoe Drive). At this time there was minimal development along Charles Boulevard in the headwaters. The green areas on the map represent forested areas and the white areas are generally open fields and agricultural lands. The USGS updated the Greenville SE Quadrangle in 1998. A comparison of the two quadrangles reveals a period of rapid urbanization between 1982 and 1998 (Figure 3). In the late 1960s a small dam was put in place in the lower portion of the watershed to create a lake for a golf course for the Brook Valley Country Club. The lake dimensions are approximately 500m by 50 m. The USGS maps suggest that sediment from upstream may be slowly filling the lake, for example there is a small island on the 1998 map that was absent in 1982 (Figure 4). In addition, recent aerial photos from Google Earth reveal large sand bars in the channel upstream of the lake (Figure 5).

Although USGS does not have topographic quadrangles for this watershed that have been updated within the last decade, Google Earth has historic aerial photos available for various years from 1993 through 2011. A comparison of the 1998 and 2011 photos revealed that urban development has also occurred over the last decade but to a lesser extent than for the period of 1982-1998 (Figure 5). Most of the land-use change between 1998 and 2011 occurred as farmland conversion to housing developments in the Meeting House Branch watershed. Based on the earliest Google Earth images (1993), farmland (row crops) extent in the watershed was approximately 210 ha or approximately 30% of the watershed. The latest aerial photos collected in 2011 reveal approximately 57 ha of farmland remaining in the watershed or 8% of the watershed area. Currently, only three remaining farm plots exist, two off of Charles Boulevard near the headwaters, and one off of 14th Street, in the middle of the watershed. Overall, when contrasted with the 1974 aerial photos (Figure 2), these data suggest that the predominant land-use in the watershed shifted from farmland to urban/suburban development over the past four decades.

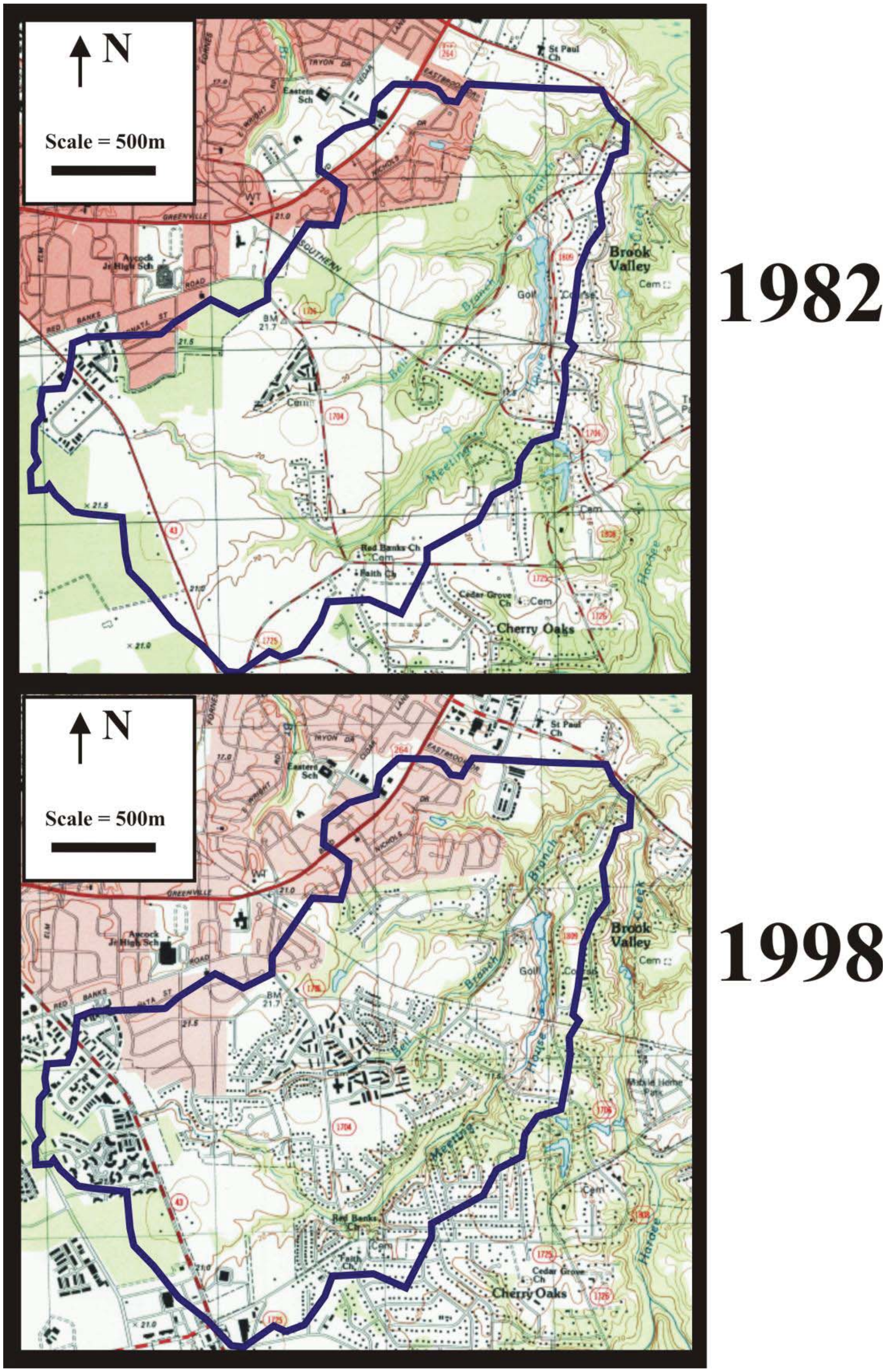


Figure 4. A comparison of the 1982 USGS Topographic Quadrangle (Greenville SE) with the 1998 revised version suggests a period of rapid urban expansion between 1982 and 1998. Source: USGS (2012).

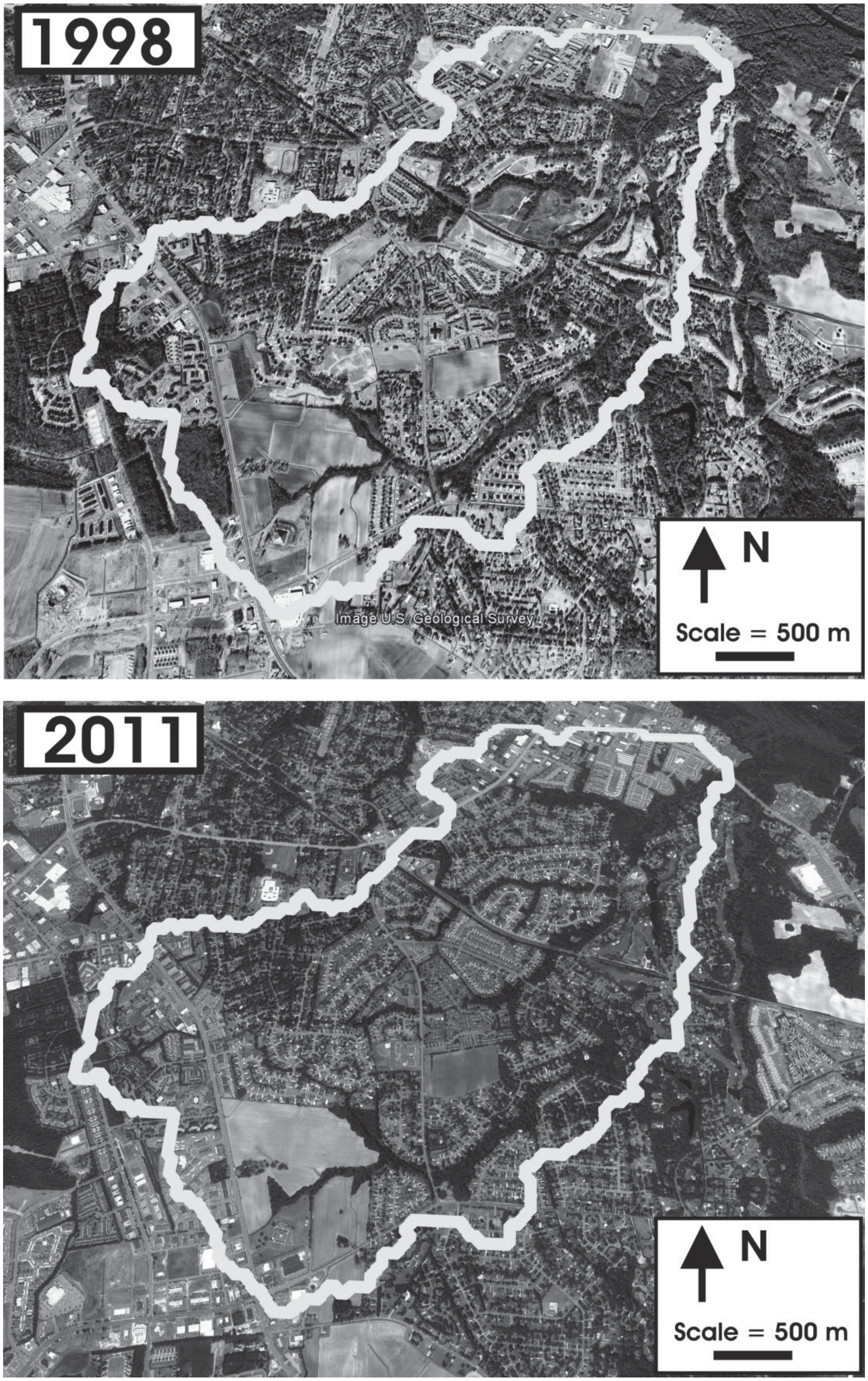


Figure 5. Aerial photographs showing changes in land cover from 1998 to 2011 (source: Google Earth).

History of Stormwater Management and Regulations in Greenville

In 1973, the North Carolina Sedimentation and Pollution Control Act was passed which required construction projects adjacent to water bodies to preserve a buffer between the land disturbance and the waterway and that practices be put in place to retain sediment on site (NCS 1973). While no post-construction stormwater requirements were specifically included in the Act, Greenville (GCC 1973) and Pitt County (PCC 1991) enacted similar ordinances around the same time that required post-construction peak discharge from the 10-year event either not to exceed the pre-development peak by 10% or be controlled to or below the pre-development peak discharge. Through the 1970's and 1980's control of the ten-year event remained the standard for stormwater control within the Meeting House Branch watershed. While the NC Environmental Management Commission implemented a set of stormwater management rules in 1988 and 1994 that required capture and treatment of runoff from varying event sizes, these rules only applied to water bodies with a high priority for water quality protection (e.g. shellfish waters, high quality waters, or outstanding resource waters) and did not apply within the Meeting House Branch watershed (NCAC 2012).

During the 1980's, algal blooms and fish kills within the Tar-Pamlico River were attributed to increasing nutrients within the Tar-Pamlico watershed. As a result, the entire basin was designated as Nutrient Sensitive Waters in 1989 (NCDENR 1989), allowing the state Environmental Management Commission to develop rules for stormwater control within the basin (NC Administrative Code: 15A:02H.0258), although they did not go into effect until 2001. These rules required the more populated municipalities and counties within the basin, including Greenville and Pitt County, to develop a stormwater management program to comply with nutrient loading reductions. Each of these programs requires implementation of stormwater control measures to limit runoff nutrient loadings to 4.0 lbs N/ac/yr and 0.4 lbs P/ac/yr and no increase in peak runoff between pre-developed and post-developed land uses, unless the increase was less than 10% (Pitt County 2006; COG 2004). Implementing these programs brought Pitt County (eff. October 12, 2004) and Greenville municipality (eff. September 10, 2004) into compliance with the Tar-Pamlico River Basin Stormwater Requirements.

Session Law 2006-246, which became effect July 1, 2007, required communities to comply with Phase II of the National Pollution Discharge Elimination System (NPDES) rules (small Municipal Separate Storm Sewer Systems, < 100,000), a federal program initiated under the 1972 Federal Water Pollution Control Act that became effective in 2003 and regulates municipal stormwater discharge (EPA 2005). However, since the Tar-Pamlico Stormwater Rules meet or exceed the requirements for coverage by the North Carolina small general permit, stormwater requirements within Meeting House Branch were not affected by the Session Law.

In summary, during initial settlement Meeting House Branch watershed was drained to alleviate flooding and conversion of lands for agriculture. In the early 1970's state laws and local ordinances were enacted to reduce sedimentation and erosion in streams and water bodies by not allowing increased peak discharge velocities from the 10-year event for construction and post-construction compared to pre-construction. It was not until 2004 that rules and ordinances required control of peak discharge from the one-year, 24-hour event and nutrient loadings using stormwater control measures. By this time, most of the now existing development had occurred within the Meeting House Branch watershed. Since then, build out and an economic downturn have limited new development within the watershed. The recent (2004) regulations can limit increased stormwater impacts in the future but since the majority of development occurred prior to these rules, reducing stormwater impacts in Meeting House Branch will require retrofits to deal with earlier development that had minimal stormwater management.

Year	Source	Effect
1973	North Carolina Sedimentation and Pollution Control Act	Land Disturbing Activities: Sedimentation and erosion control devices must retain sediment within construction site. Buffers: Must preserve a buffer between land disturbance projects and lake or natural watercourses. Siltation in buffers must be limited to the landward 25% of the buffer.
1973*	Greenville City Ordinance: 26A-8: Permanent Downstream Protection of Stream Banks and Channels 28-23.1b1: Construction Requirements: Storm Drainage	Construction and Post-Construction Condition: peak discharge rate for the 10-year event must not exceed the pre-developed peak discharge rate, if development is shown to cause erosion or sedimentation in stream channel; measures must be implemented during construction to prevent accelerated stream erosion. Subdivisions: All laterals and cross drains must have adequate capacity to convey the 25-yr event.
1973*	Pitt County Ordinances: Soil Erosion and Sedimentation Control	Stormwater Outlet Protection: prevent erosion and sedimentation for the 10-year event by limiting velocities to pre-developed or soil texture dependent velocities.
1989	Greenville City Ordinance: 9-5-125: All Subdivisions to be Adequately Drained	Subdivision Drainage: prevent inundation of public and private lands for events up to the 10-year event.
2004 (September)	City of Greenville Stormwater Management Program implementation (Approved in compliance with 15A NCAC 02B .0258).	Enacted to comply with "Tar-Pamlico Stormwater Rules" for post-construction stormwater and development: Nutrient Loadings: Greater than 1 acre single family development or ½ acre multifamily, commercial, industrial or institutional development, required to limit runoff loadings to 4 lbs. N/ac/y and 0.4 lbs. P/ac/y through use of stormwater control measures; higher loadings allowed if off-site treatment used. Post-Development Peak Stormwater Flows: Must be less than or equal to pre-development peak rate for the one-year 24-hr event, if post- exceeds pre- by at least 10%. Required Buffer width: 50 ft. buffers.
2007 (July 1)	Session Law 2006 – 246: Requires compliance with federal National Pollution Discharge Elimination System Program: Phase II.	Compliance: Assumed under compliance with Tar-Pamlico Stormwater Rules, via enacting the City of Greenville Stormwater Management Plan. Buffers: 30 ft required; defer to Tar-Pamlico Stormwater Rules where appropriate, 50 ft.

* Approximate year enacted.

Table 1. Historical statutes, rules, and ordinances concerning drainage, stormwater control, and stream protection applicable to Meeting House Branch watershed since 1970.

Meeting House Branch Watershed Characteristics

Watershed Characteristics and Land-Use

Meeting House Branch watershed area is approximately 710 ha. The main trunk of the stream is approximately 5 km long from the headwaters near Charles Boulevard and the confluence with Hardee Creek near Route 33. Bell Branch, a tributary to MHB, is approximately 1.7 km long and feeds into MHB directly below the golf course dam through a culvert that runs underground below Oxford Rd. and the golf course. The watershed is asymmetrical, with most of the drainage area located to the east of the main trunk stream, particularly after the channel changes course and heads in a more northerly direction after crossing 14^{th} street (Figure 4). Land-use across the watershed largely consists of various mixes of low to high intensity development, agriculture, and forest. A golf course (Brook Valley Country Club) comprises approximately 62 ha in the lower portion of the watershed and at this site the mainstem of MHB is regulated by a dam. Hardison et al. (2009) estimated land use for the MHB watershed as 51% developed (urban/suburban land-use consisting of approximately 22% watershed Total Impervious Area), 31% agricultural, and 18% forested, based on the 2001 National Land Cover Database. However, as mentioned previously, since the 2001 estimate much of the agricultural land within the watershed has been converted to housing developments. Based on approximations from 2011 aerial photos, updated land-use for 2011 should be approximately 74% developed, 18% forested, and 8% agricultural.

Soils

Soils information for the Meeting House Branch Watershed was obtained from the Soil Survey of Pitt County (USDA, 1974) and the Web Soil Survey (United States Department of Agriculture, 2012). There are 15 different soil series mapped in the Meeting House Branch watershed (Table 2, Figure 2). However, four soil series comprise nearly 65% of watershed area. These soils include the well-drained Wagram (26.1%), moderately well drained Exum (18%), somewhat poorly drained Lynchburg (12.3%), and the poorly drained Bibb (8.5%) (Table 1). The Wagram soils (Loamy, kaolinitic, thermic Arenic Kandiudults) formed from the deposition of fluviomarine and marine deposits and have moderate permeability (Appendix B). Wagram soils formed in upland areas on the summit, shoulder or back slopes. Exum soils (Fine-silty, siliceous, subactive, thermic Aquic Paleudults) formed from loamy marine sediments and have moderate permeability. Exum soils are found on broad, smooth divides on uplands (Appendix B). Lynchburg soils (Fine-loamy, siliceous, semiactive, thermic Aeric Paleaquults) formed from marine and fluviomarine marine deposits and have moderate permeability. Lynchburg soils occur on marine terraces and flats (Appendix B). Bibb soils (Coarse-loamy, siliceous, active, acid, thermic Typic Fluvaquent) form from alluvium and have moderate permeability. Bibb soils are located along floodplains, and in draws and depressions in uplands (Appendix B).

Most of the soils in the Meeting House Branch watershed are characterized as at least moderately well drained. More specifically, 3.5% of the watershed soils are classified as somewhat excessively drained, 30.8% are well drained, and 24.3% of soils are moderately well drained

(Table 2). There are nearly equal percentages of land classified as poorly drained (19.1%) and somewhat poorly drained (21.8%) (Table 2). However, the dominant soils and drainage classes

MHB				
Soil	**Acres**	**ha**	**%**	**Drainage**
Alaga (AgB) 0-6% slopes	62.0	25.1	3.5	SED
Aycock (AyA) 0-1% slopes	10.1	4.1	0.6	WD
Aycock (AyB)	18.9	7.7	1.1	WD
Bibb (Bb)	152.1	61.6	8.5	PD
Bladen (Bd)	7.0	2.8	0.4	PD
Coxville (Co)	85.9	34.8	4.8	PD
Craven (CrA) 0-1% slopes	2.9	1.2	0.2	MWD
Craven (CrB) 1-6% slopes	5.6	2.3	0.3	MWD
Craven (CrB2) 1-6% slopes, eroded	27.5	11.1	1.5	MWD
Craven (CrC) 6-10% slopes	5.5	2.2	0.3	MWD
Exum (ExA) 0-1 % slopes	272.5	110.3	15.2	MWD
Exum (ExB) 1-6% slopes	50.4	20.4	2.8	MWD
Goldsboro (GoA) 0-6% slopes	27.3	11.1	1.5	MWD
Goldsbororo (GoB) 1-6 % slopes	45.2	18.3	2.5	MWD
Lynchburg (Ly)	220.9	89.4	12.3	SWP
Norfolk (NrA) 0-1% slopes	21.5	8.7	1.2	WD
Norfolk (NrB) 1-6% slopes	23.9	9.7	1.3	WD
Norfolk (NrB2) 1-6% slopes, eroded	11.0	4.5	0.6	WD
Ocilla (OcB) 0-4% slopes	170.5	69.0	9.5	SWP
Osier (Os)	5.3	2.1	0.3	PD
Pantego (Pg)	2.3	0.9	0.1	VPD
Rains (Ra)	93.7	37.9	5.2	PD
Wagram (WaB) 0-6% slopes	351.7	142.4	19.6	WD
Wagram (WaC) 6-10% slopes	116.4	47.1	6.5	WD
Water (W)	7.0	2.8	0.4	
Totals	**1797.1**	**727.6**	**100.0**	

Table 2. Soil series for Meeting House Branch. Drainage classes include: somewhat excessively drained (SED); well drained (WD); moderately well drained (MWD); somewhat poorly drained (SWP); poorly drained (PD) and very poorly drained (VPD).

differ for the upper, middle, and lower portions of the watershed. For example, for the upper portion of Meeting House Branch watershed, 3 of the 4 most frequently occurring soils are somewhat poorly drained or wetter (poorly drained or very poorly drained). These soils include Lynchburg (24.2%), Rains (12.3%) and Coxville (10.6%) (Table 2, Figure 2). Over 61% of the soils are considered somewhat poorly drained or wetter in the upper section of the watershed. This is in contrast to the middle portion of the watershed, where 79% of the soils are at least moderately well drained (Appendix B). An estimated 51.8% of soils in the middle portion of the watershed are well drained, 24.9% moderately well drained, and 2.5% somewhat excessively drained (Appendix B). The 3 dominant soil series in the middle portion of the watershed are all at least moderately well drained. These include the well-drained Wagram (40.6%), moderately well drained Exum (14.3%), and well drained Norfolk (9%) (Appendix B). The majority of the lower portion of the watershed is also at least moderately well drained (67%) (Appendix B). In the lower portion of the watershed, the dominant soils in area include Wagram (43.2%), Ocilla (12.7%), Bibb (12.3%) and Alaga (8.3%).

Geology and Hydrology

The North Carolina Coastal Plain is underlain by an eastward dipping and thickening wedge of sediments and sedimentary rocks that range in age from Recent through the Cretaceous (Lautier, 2002; Winner and Coble, 1996). The strata are composed of layers and lenses of sand, clay, silt, gravel, and shell hash material deposited during the rise and fall of sea level (Lautier, 2002). The hydrogeologic system in the study area from basement rock to the land surface consists of a series of aquifers and confining units. The surficial aquifer in Pitt County is composed of sandy and clayey Quaternary sediments, often overlying the Yorktown Formation (Maddry, 1979). Annual recharge to the surficial aquifer in the Coastal Plain of North Carolina at the USGS Lizzie Research Station (approximately 25 km southwest of the study area) was estimated to be approximately 74 cm/yr (Coes et al., 2007).

The Inner Coastal Plain of NC, located from the fall line to the Suffolk Scarp, is characterized by a low topographic relief and a temperate climate with generally warm, humid summers and cool, mild winters (Orr Jr and Stuart 2000). On average, Pitt County receives 125 cm of precipitation per year (NCSCO 2012). Summer thunderstorms and tropical depressions are common in eastern North Carolina and can bring substantial rainfall that may cause flash flooding (Orr Jr and Stuart 2000). During the current study (March 20011-2012), the total annual rainfall was 113 cm (44.5 inches) (USGS, 2012). The region was suffering from drought during the summer of 2011 and was impacted by flooding due to Hurricane Irene on August 28, 2011 (approximately 10 inches of rainfall) (see Figure 15).

Due to their low gradients and relatively high precipitation inputs, Coastal Plain streams in North Carolina flood more frequently (5 times/year) than Mountain or Piedmont streams (flood approximately 1.5 years) (Sweet and Geratz, 2003). Following precipitation events, natural Coastal Plain streams are predominantly fed by groundwater inputs to stream flow (Williams and Pinder, 1990). A strong seasonal variation in stream discharge occurs along most streams in response to evapotranspiration and rainfall, with minimal discharge typically occurring in the late summer (Hupp, 2000). Maximum stream flow typically occurs during the winter and spring months, but may occur in the fall if tropical storms deliver excessive rainfall to the region (Williams and Pinder, 1990). Previous work in the NC Coastal Plain by Spruill et al. (2005) has documented the nature of stream-groundwater interactions in a Coastal Plain setting in Lizzie, NC, a similar setting to Meeting House Branch watershed (approximately 25 km southwest of the study area). They reported that the majority of groundwater inputs to stream baseflow comes from the surficial aquifer and that deeper groundwater from the Pliocene-Cretaceous aquifers is restricted by the Yorktown confining unit. The surficial aquifer can act as both a recharge and discharge area, depending on the prevailing hydrologic condition and recent weather patterns (Spruill et al., 2005).

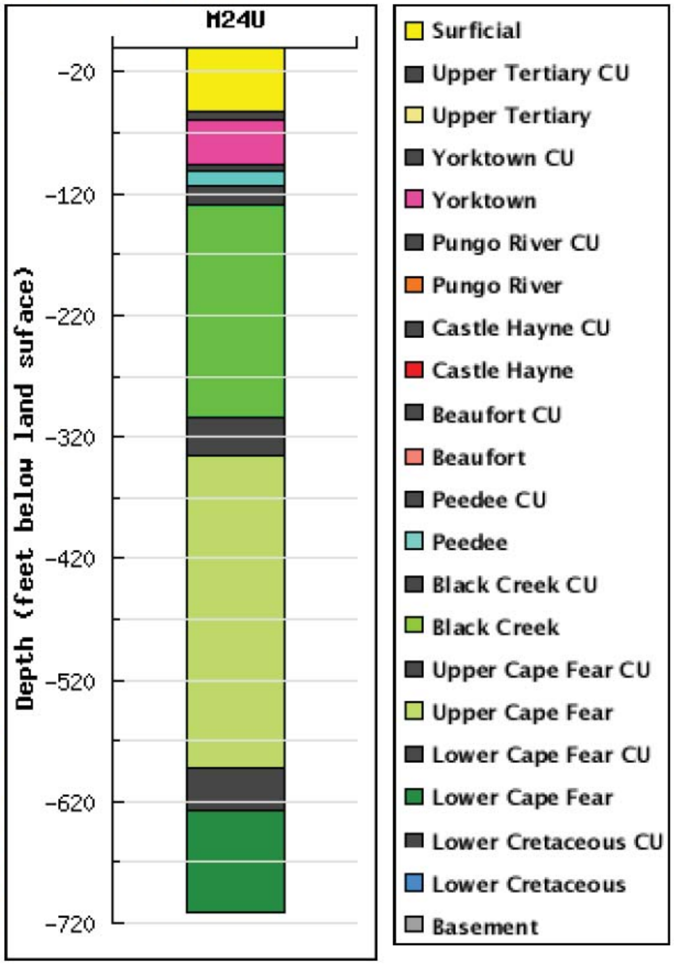
Based on hand-augering during well installation for several studies in the Greenville area (DeLoatch 2009; Hardison et al. 2009; and Harnsberger and O'Driscoll 2010), the unconfined surficial aquifer observed in the floodplains in the Greenville area is composed of mixed organic and mineral sediments, mainly silt and clayey sand. A marine clay confining unit exists below the surficial aquifer across the study area (approximately 4 m deep), presumably the Pliocene Yorktown Formation (Harnsberger, 2009). The dense, blue clay contains shell material in some locations and acts as a confining unit below the surficial aquifer. Due to the common presence of this shallow confining unit it is expected that groundwater moves laterally across the riparian zones until it discharges into the stream. The estimated mean hydraulic conductivities of floodplain sediments at five Greenville sites (DeLoatch 2009) was estimated by slug tests (Bouwer and Rice, 1976) and ranged from $1.34 *10^{-4}$ to $2.66*10^{-6}$ cm/s. According to Heath (2004), these values are in the range of clayey sand to clay. Harnsberger and O'Driscoll (2010) also found extensive buried peat layers in these floodplains, which may affect groundwater flowpaths and groundwater quality.

The NCDENR-DWR (Division of Water Resources) maintains a hydrogeologic database and has one well located near the headwaters of Meeting House Branch watershed, the NCDENR City of Greenville Well 3 (at the corner of 14th and Greenville Blvd) (Figure 6). The sediment information collected during well installation suggests that at the top of the watershed the surficial aquifer is approximately 50 feet thick (16 m) and underlain by the confining unit of the Yorktown formation at approximately 13 feet above sea level (4 m). At this location the confining unit is approximately 6 feet (2 m) thick. The elevation of the Meeting House Branch and Bell Branch channels range from 20 m in the headwaters to 2m above sea level at the confluence with Hardee Creek. At the King George Rd. Bridge, the channel is at approximately 10 m elevation above mean sea level and Harnsberger and O'Driscoll (2010) found the top of the Yorktown confining unit to be at approximately 3 to 4 m below the floodplain or at approximately 7 m elevation above mean sea level (Figure 7). These data suggest that the baseflow discharge to the channel is predominantly derived from the surficial aquifer at locations where the channel base is higher than 2m above sea level. However it is possible that lower down in the watershed (generally below the golf course pond) there is a greater likelihood that the Yorktown confining unit may be breached and confined groundwater from the Yorktown aquifer could contribute to baseflow. Further studies would be needed to verify this and determine the presence of the Yorktown confining unit adjacent to the channel and the spatial variability of its thickness. This may be important for evaluating water quality patterns because it is likely that the Yorktown groundwater would have lower nitrate concentrations and could have a diluting effect on upstream waters.

DWR Hydrogeologic Framework Detail for City of Greenville 3

Field	Data
County	Pitt
Latitude	35.590556
Longitude	-77.347500
Location Accuracy	Map Show Map
Quad	M 24U
Name link to logs	City of Greenville 3
Depth	711.00
Land Surface	65.00
Upper Tertiary CU	10001
Upper Tertiary	10001
Yorktown CU	13
Yorktown	6
Pungo River CU	10001
Pungo River	10001
Castle Hayne CU	10001
Castle Hayne	10001
Beaufort CU	10001
Beaufort	10001
Peedee CU	-31
Peedee	-36
Black Creek CU	-49
Black Creek	-65
Upper Cape Fear CU	-239
Upper Cape Fear	-271
Lower Cape Fear CU	-527
Lower Cape Fear	-563
Lower Cretaceous CU	10000
Lower Cretaceous	10000
Basement	10003

Unit top elevations are shown in table,
depths are shown in plot,
cross-hatched where casing occurs



- 10002 - unit likely exists, but there is no data to pick elevation or correlation is uncertain;
- 10001 - unit does not exist;
- 10000 - unit does not exist and is not penetrated;
- 10003 - unit likely exists, but is not penetrated.

Figure 6. Sediment core obtained from NCDENR (2012). The core indicates baseflow to the stream is predominantly fed by groundwater discharge from the surficial aquifer.

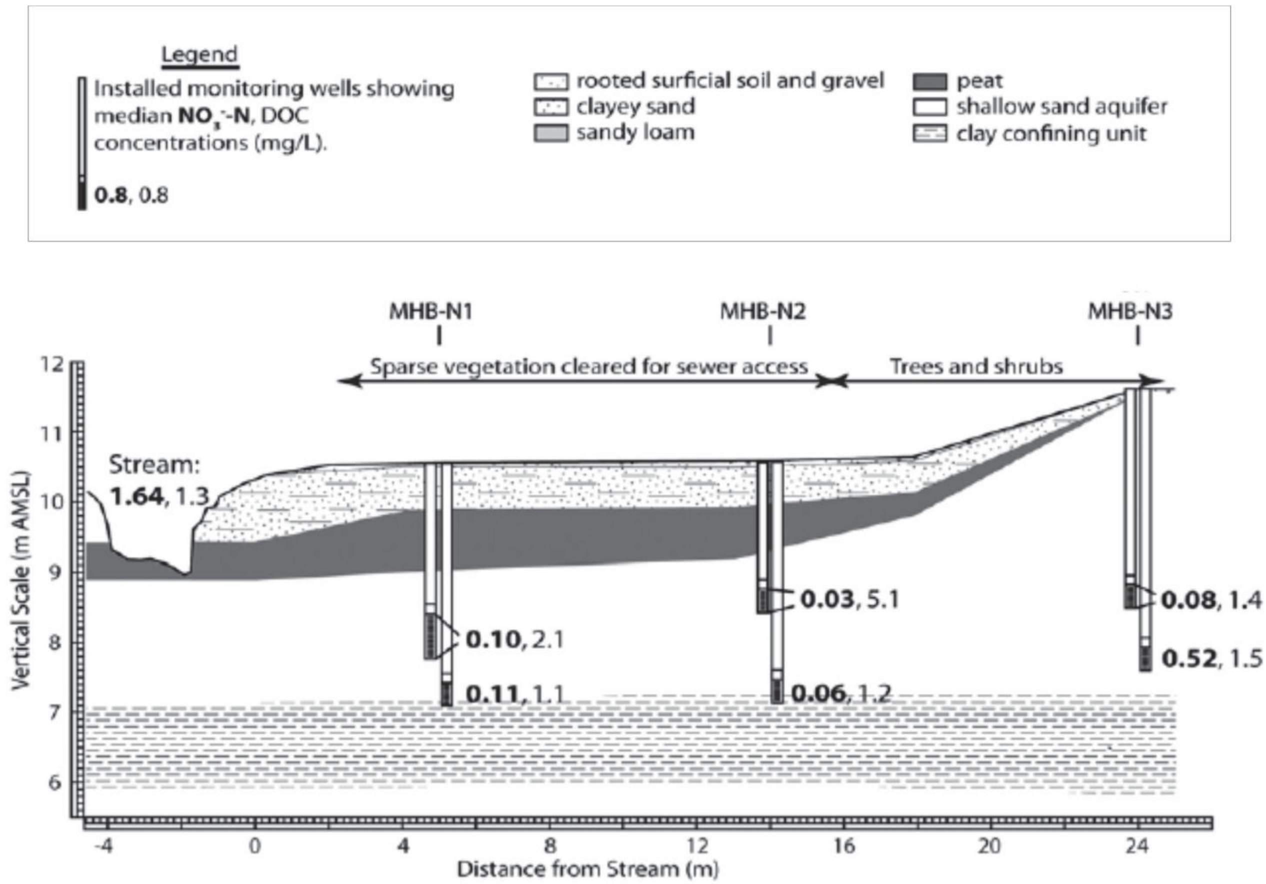


Figure 7. Geologic cross-section and median annual nitrate and dissolved organic concentrations for a study performed by Harnsberger and O'Driscoll (2010). The site is located at the floodplain directly upstream of the King George Road Bridge in Brook Valley and shows the presence of peat and a clay confining unit (presumably the Yorktown confining unit). The surficial aquifer was approximately 3-4 m thick at this location.

Background: Summary of Previous Literature and Relevant Studies

Numerous studies have documented various physical, chemical, and biological responses of streams to urbanization. Compared with streams in unaltered forested watersheds, urban streams consistently exhibit stream degradation associated with increased watershed imperviousness, recently referred to as the ''urban stream syndrome'' (Meyer et al., 2005; Walsh et al., 2005). Symptoms include altered hydrology (McMahon et al., 2003), elevated stream nutrient concentrations (Mallin et al., 2001), altered channel morphology and channel instability (Bledsoe and Watson, 2001), increased water temperature variability (Krause et al., 2004), shallow ground-water quality degradation (Bruce and McMahon, 1996), reduced biotic richness, altered species compositions (Sudduth and Meyer, 2006), and altered nutrient processing and ecosystem functioning (Meyer et al., 2005). Due to rapid population growth and urbanization in the southeastern U.S. over the last three decades, urban impairments to streams in the southeastern U.S. have become more widespread (O'Driscoll et al. 2010).

In the Meeting House Branch watershed and similar watersheds in the Greenville area, several studies over the past three decades have documented water quality and discharge responses to land-use change (see O'Driscoll et al. 2010). In one of the first hydrological studies on Meeting House Branch, the US Army Corps of Engineers evaluated flood risk along the main channel and for other streams in the Greenville area in 1975 (USACE 1975). This study is useful because it provides several cross-sections along Meeting House Branch that can be compared to current cross-sections to evaluate the changes in channel dimensions since 1975, providing channel dimensions before the watershed became dominated by urban/suburban land-use. Based on the study, they estimated various flood discharges at King George Rd. along Meeting House Branch, they estimated 1240 cfs for the 100 yr flood and 2070 cfs for the 500 yr flood.

A cross section of Meeting House Branch channel was surveyed immediately below King George Rd. and the channel was approximately 3.5 feet deep (1.1 m) at that time (1975). Cross-sectional surveys taken during the current study suggest the channel has incised and is currently approximately 5.5 ft deep (1.7 m). At this site the watershed area is approximately 3.4 km^2 (1.3 mi^2). In a recent study, Sweet and Geratz (2003) developed empirical curves for estimating bankfull depth for natural Coastal Plain streams in eastern North Carolina. Their bankfull depth equation ((bankfull depth (ft) = 0.98*(watershed area (sq. miles)$^{0.36}$) suggests that the bankfull channel depth should be approximately 1 ft. deep (0.3 m) for an undisturbed watershed of this size. This suggests that stormwater inputs have resulted in channel erosion and incision which has led to a deeper channel along Meeting House Branch. Based on the earlier data from the USACE (1975), it is estimated that channel incision has occurred at an average rate of approximately 1.5 cm/yr over the last several decades. Since urban development, associated stormwater generation, and weather patterns are variable, it is likely that channel erosion has not progressed steadily over time but at variable rates. Nevertheless, these estimates are not inconsistent with other estimates in the region provided by Hardison et al. (2009). In their study they showed slightly higher rates of channel incision (3-4 cm/yr) for two more urbanized streams (Reedy Branch and Fornes Branch) in the Greenville area.

Several studies have documented the effects of urban runoff on stream hydrology in low-order Coastal Plain watersheds in the Greenville area. In a recent stormwater study, six low-order Coastal Plain watersheds (including Meeting House Branch) were selected across an urban gradient (3.8% to 36.7% TIA) to quantify urban stormwater inputs using oxygen-18 (^{18}O) and deuterium (^{2}H) isotopes (Hutchinson 2007). Impervious area showed a strong correlation to stormflow $\delta^{18}O$ signatures (R^2=0.82) and the percentage of stormflow in total event discharge (R^2=0.884). Percentage of catchment stormflow during storm events could be predicted with percentage of watershed impervious area using the equation: % Catchment Stormflow =

1.24*(Impervious Area %) +10.0. This study showed that during storm events, streamflow in Meeting House Branch was fed by approximately 25% stormwater and 75% groundwater.

At the same sites, Hardison et al. (2009) evaluated the effects of urban land use on stream channels and riparian ground-water levels. They found that stream drainage density decreased with urbanization, presumably because segments of low-order streams were buried by urban infrastructure. They found that channel incision (related to increased urban stormwater inputs) caused groundwater levels to decline in urban riparian areas. In urban floodplains (>15% TIA), the median ground-water level was 0.84 m deeper than for the rural settings (<15% TIA). This resulted in a shift to drier conditions in the urban riparian zones, particularly during the summer months. Because of greater channel incision along urban streams, the riparian areas are measurably drier and suffer from ‘‘riparian hydrologic drought’’ in these settings (Figure 8).

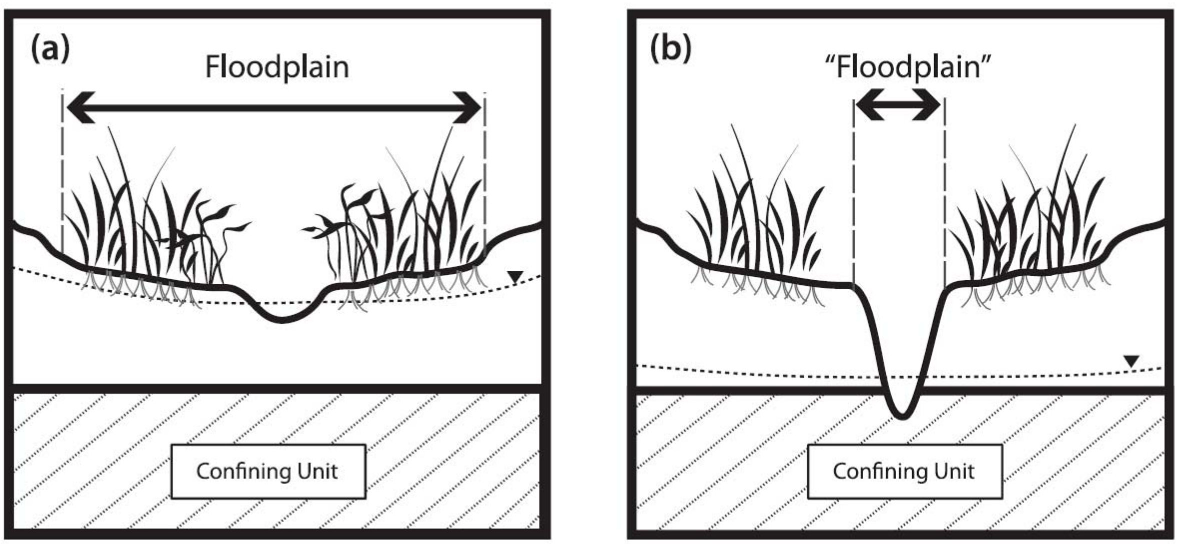


Figure 8. a). riparian area along a typical low-order Coastal Plain stream, in contrast to b) a riparian area along an incised urban stream. The deeper water table and reduced interactions between the incised stream and its floodplain results in "riparian hydrologic drought" (Hardison et al. 2009).

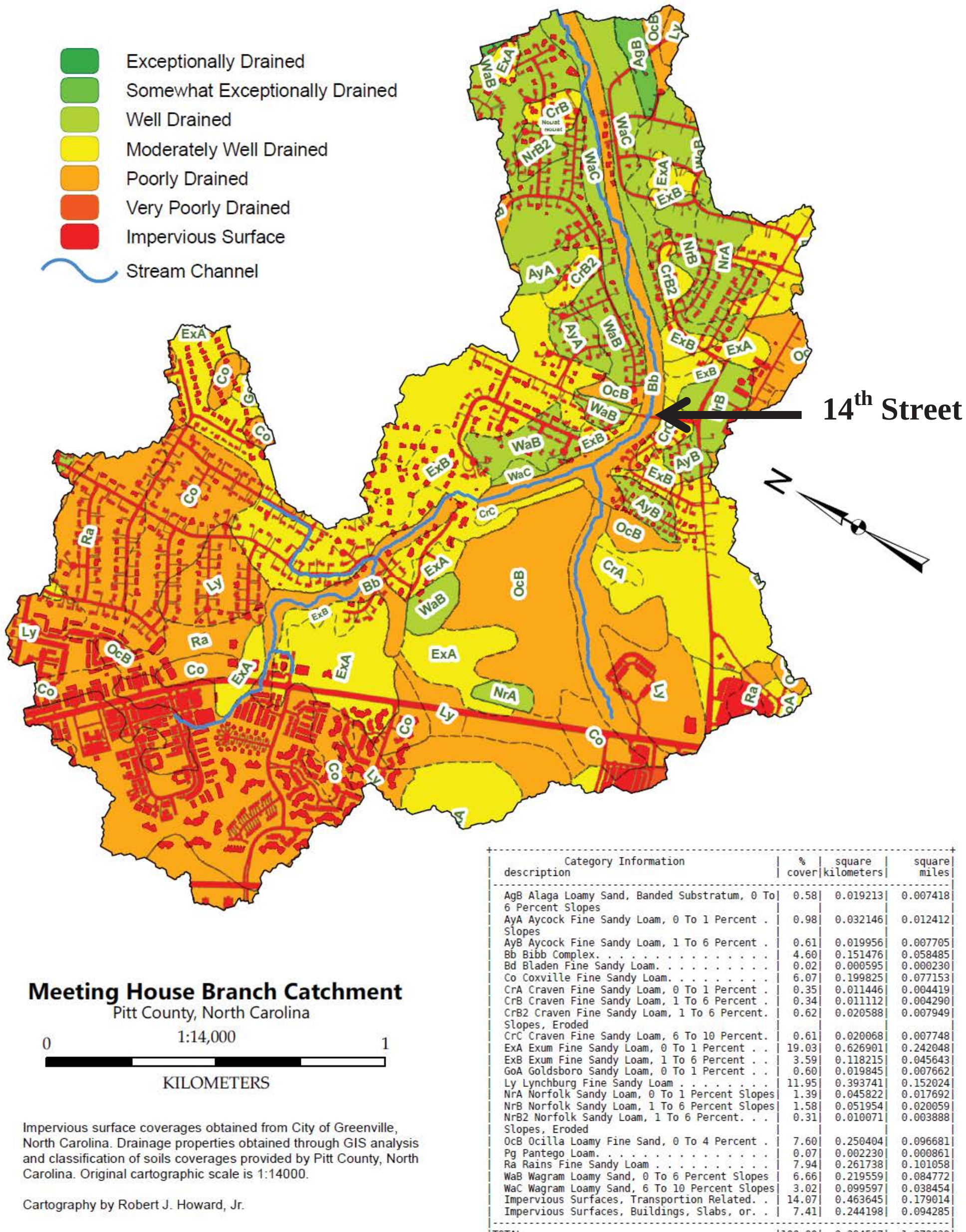
Urban stream channel incision has been shown to be a common occurrence along sandy coastal plain streams. In a recent study, O'Driscoll et al. (2009) evaluated urban channel response in small Inner Coastal Plain watersheds (<5 km^2) in eastern North Carolina. Fifty reaches were selected across a range of watershed total impervious area (0–67% TIA). Urban cross-sectional area, channel incision ratio, and channel grain size (gravel%, D50, and D84) were greater, relative to rural channels. Bankfull cross-sectional areas were approximately 1.78 times greater for urban watersheds than for rural watersheds. Channels in urban watersheds, including Meeting House Branch watershed, were incised and had median full-channel capacities approximately 3.4 times greater than channels draining rural watersheds. Watershed TIA explained 65–72% of channel capacity enlargement. Urban expansion in the region began in the 1960s, with major urbanization occurring over the last 25 years. Channels draining urban watersheds are still responding to this land use change by downcutting and widening. This study concluded that urban channel incision in the Inner Coastal Plain of North Carolina has frequently cut off streams from their floodplains, reducing floodplain sediment retention and water quality functions.

DeLoatch (2009) evaluated the effects of urban channel incision on stream-groundwater interactions along low-order Coastal Plain streams in the Greenville, NC area. He showed that increases in stormwater inputs were directly related to catchment impervious area and linked with stream channel incision. Although stormwater runoff was greatest at the most urbanized site, channel incision (2.13 m) resulted in no overbank flow during the year of study. The least urbanized site exhibited little channel incision (0.5 m) and flooded 7 times (the King George Road site featured in the current study was also used in his study and it flooded 3 times during the year of study). The reduction in overbank events at the urban site led to a reduction in floodplain recharge. None of the floodplain recharge at the most urban site could be attributed to overbank flow, whereas at the least urban site, 23.3% of the total recharge was contributed by overbank flow. This study showed that urban channel incision can alter groundwater recharge processes along Coastal Plain streams. Overall, the results showed that urbanization affects stream-groundwater interactions by increasing stormwater runoff and channel incision, which results in a decline of stream-floodplain connections and floodplain recharge. These changes can affect the stream and floodplain's ability to enhance water quality and to store floodwaters.

DeLoatch (2009) also performed seepage runs along Meeting House Branch to estimate groundwater inputs along the channel (every 365 m at 8 sites upstream of King George Rd site (MHB 2075 site in current study)- 3 times during August 2007, December 2007, and June 2008). He found there was a 61% increase in discharge along Meeting House Branch in the Planters Walk neighborhood, below 14th Street. Due to drought conditions during the study, the channel ceased to flow for most of the streamlength upstream of 14th street. These data suggest that groundwater inputs to the stream are greater in the lower portions of the watershed. In the previous soils section (p.16) and in an unpublished study (Howard 2009), it was shown that soils in the lower portion of the watershed are more permeable (Figure 9; Appendix B), which may in part explain the increased groundwater inputs below 14th Street.

In a recent study focused on land-use and nitrogen transport to low-order Coastal Plain streams, Harnsberger and O'Driscoll (2010) studied riparian buffers along several Greenville streams, including Meeting House Branch. Based on groundwater quality and hydraulic head data, they concluded that urban channel incision can decrease the riparian buffer's ability to reduce nitrogen concentrations in groundwater. At a rural site, the buffer reduced nitrate concentrations by 99% but at Meeting House Branch and another incised urban stream site, the buffers only reduced nitrate concentrations by 58-46%. They found that the presence of buried peats in the floodplains and the heterogeneity of sediments (and their hydraulic conductivities) in riparian zones could have a large influence on the quantity and quality of groundwater discharging to the stream channels. In addition to these studies, several water quality studies have included natural streams in the region (Kuenzler et al. 1977) and Meeting House Branch (Stewart 2003 and Hardison 2009). More recently, NCDENR has published their Tar-Pamlico Basinwide Water

Quality Management Plan (2010) which focuses on water quality issues in the Tar-Pamlico watershed.



Category Information description	% cover	square kilometers	square miles
AgB Alaga Loamy Sand, Banded Substratum, 0 To 6 Percent Slopes	0.58	0.019213	0.007418
AyA Aycock Fine Sandy Loam, 0 To 1 Percent . Slopes	0.98	0.032146	0.012412
AyB Aycock Fine Sandy Loam, 1 To 6 Percent .	0.61	0.019956	0.007705
Bb Bibb Complex.	4.60	0.151476	0.058485
Bd Bladen Fine Sandy Loam.	0.02	0.000595	0.000230
Co Coxville Fine Sandy Loam.	6.07	0.199825	0.077153
CrA Craven Fine Sandy Loam, 0 To 1 Percent .	0.35	0.011446	0.004419
CrB Craven Fine Sandy Loam, 1 To 6 Percent .	0.34	0.011112	0.004290
CrB2 Craven Fine Sandy Loam, 1 To 6 Percent. Slopes, Eroded	0.62	0.020588	0.007949
CrC Craven Fine Sandy Loam, 6 To 10 Percent.	0.61	0.020068	0.007748
ExA Exum Fine Sandy Loam, 0 To 1 Percent . .	19.03	0.626901	0.242048
ExB Exum Fine Sandy Loam, 1 To 6 Percent . .	3.59	0.118215	0.045643
GoA Goldsboro Sandy Loam, 0 To 1 Percent . .	0.60	0.019845	0.007662
Ly Lynchburg Fine Sandy Loam	11.95	0.393741	0.152024
NrA Norfolk Sandy Loam, 0 To 1 Percent Slopes	1.39	0.045822	0.017692
NrB Norfolk Sandy Loam, 1 To 6 Percent Slopes	1.58	0.051954	0.020059
NrB2 Norfolk Sandy Loam, 1 To 6 Percent. . . Slopes, Eroded	0.31	0.010071	0.003888
OcB Ocilla Loamy Fine Sand, 0 To 4 Percent .	7.60	0.250404	0.096681
Pg Pantego Loam.	0.07	0.002230	0.000861
Ra Rains Fine Sandy Loam	7.94	0.261738	0.101058
WaB Wagram Loamy Sand, 0 To 6 Percent Slopes	6.66	0.219559	0.084772
WaC Wagram Loamy Sand, 6 To 10 Percent Slopes	3.02	0.099597	0.038454
Impervious Surfaces, Transportion Related. .	14.07	0.463645	0.179014
Impervious Surfaces, Buildings, Slabs, or. .	7.41	0.244198	0.094285
TOTAL	100.00	3.294567	1.272039

Figure 9. Soils and their drainage characteristics in the upper and middle portions of Meeting House Branch Watershed, upstream of the King George Road site (MHB 2075 in the current study) (Howard 2009). In the segment of the watershed below 14th Street the soils adjacent to the stream are more permeable than in upstream areas.

Kuenzler et al. (1977) conducted a water quality study of channelized and unchannelized streams in Pitt County. Their data revealed a range of nitrate-N concentrations of 0.03-0.63 mg/l and showed that natural streams generally had low NH4-N and were dominated by dissolved organic nitrogen (0.2-0.35 mg/l). The highest nitrate concentrations (0.63 mg/l) along a natural stream were attributed to hog farming in the Chicod Creek basin. Their work suggests that in natural streams in the region, NO3-N should be <0.63 mg/l and elevated concentrations would indicate anthropogenic contributions. In addition, recent precipitation chemistry data collected by the National Atmospheric Deposition Program suggests that nitrogen deposition in rainfall can be elevated in eastern North Carolina (Source: NADP - http://nadp.sws.uiuc.edu/data/ntndata.aspx). Based on average data for the last decade at the Beaufort and Lewiston stations, rainfall in the region has a mean NO3-N concentration of approximately 0.65 mg/l. Based on the Kuenzler et al. (1977) study and the NADP rainfall chemistry data, stream NO3-N concentrations above 0.65 mg/l generally suggest anthropogenic N inputs to Meeting House Branch. In the Tar-Pamlico Basinwide Water Quality Management Plan (NC DENR 2010), it is mentioned that NC currently does not have nutrient standards for surface waters but normal nutrient levels for Class C waters (freshwaters for protection of aquatic life and recreational purposes) are <0.8 mg/l total dissolved nitrogen.

The NCDENR Tar-Pamlico Basinwide Water Quality Management Plan (2010) and monitoring did not cover the Meeting House Branch watershed but did contain water quality data for streams in the region. Their data showed that for the Lower Tar River Basin streams studied, mean TDN concentrations were approximately 0.9 mg/l in 1997 and have steadily increased to approximately 1.2 mg/l in 2008, predominately due to increases in organic nitrogen inputs. Although those data did not include Meeting House Branch, attached to the report in appendix 3E is a report from the Volunteer Water Information Network (Westphal and Patch 2009) that contains Meeting House Branch water quality data. Samples were collected monthly from 2005-2009. The sampling site was located at Oxford Road, downstream of the golf course dam. Overall, these data suggest that Meeting House Branch had higher than average total suspended sediments and zinc concentrations, relative to other streams in Pitt County. The zinc concentrations (>25 ug/l) were higher than those found in any of the 30 streams studied in Pitt, Edgecombe, and Nash Counties. Nitrate was the dominant inorganic nitrogen species and median nitrate concentrations were 0.7 mg/l, similar to other watersheds in the region. The long-term data series generally revealed a pattern of increased nitrate concentrations during the dormant season (late fall-winter) (Figure 10) and elevated nitrate concentrations during periods of higher discharge (Figure 11). However, during periods of extremely high discharge (>10 cfs) during spring and fall, nitrate concentrations for several sampling dates were lower, presumably from dilution effects (Figure 12).

In the Hardison (2009) study, four storm events were sampled along Meeting House Branch (King George Rd- Site MHB 2075 in the current study) and at 5 other local streams. Watershed impervious area was directly related to NH4-N and TSS. In comparison to the other streams studied in the Greenville area, MHB had the highest NO3-N and TSS concentrations during storm events and baseflow sampling.

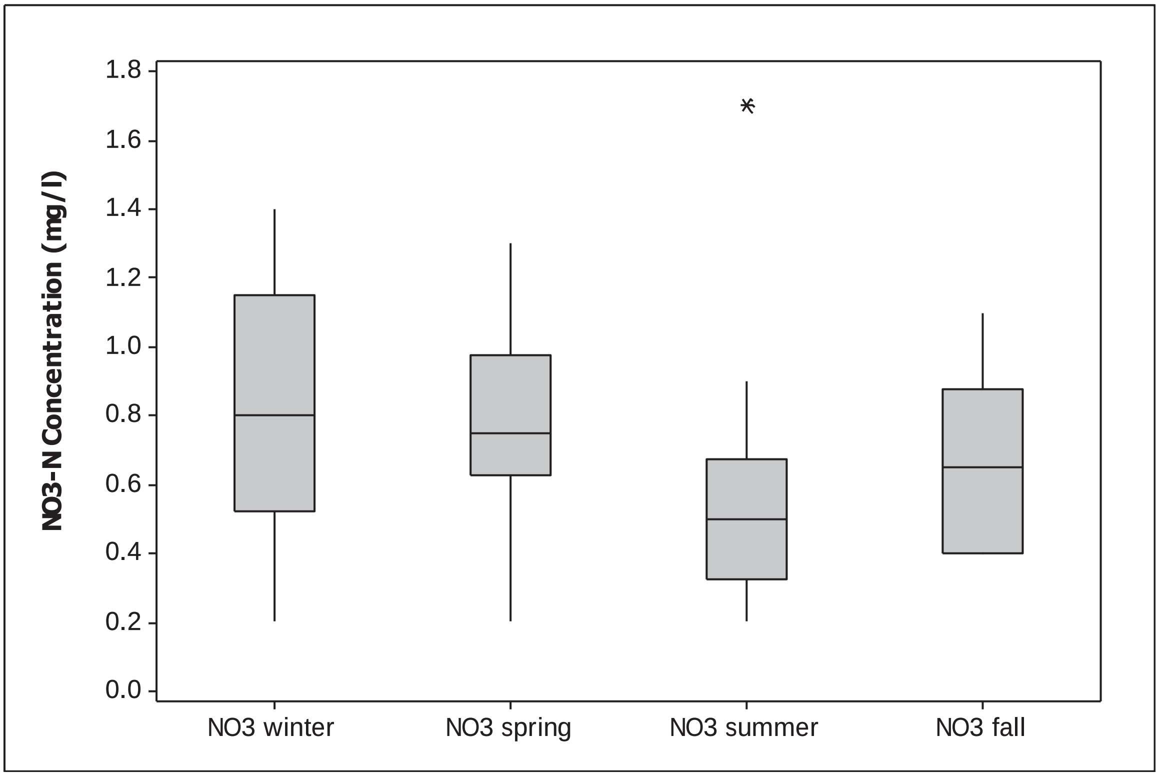


Figure 10. Seasonal variation in stream nitrate concentrations at Meeting House Branch –Oxford Road site from 2005-2009 (Data Source: Pamlico-Tar River Foundation and Volunteer Water Information Network; Westphal and Patch 2009).

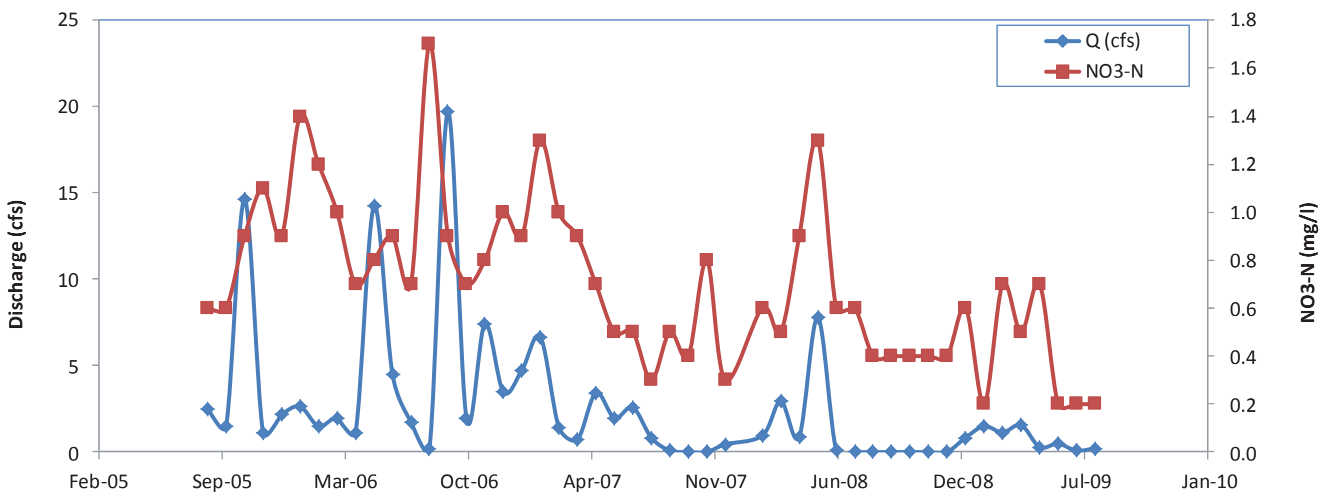


Figure 11. Discharge and stream nitrate concentrations at Meeting House Branch –Oxford Road site from 2005-2009 (Data Source: Pamlico-Tar River Foundation and Volunteer Water Information Network; Westphal and Patch 2009).

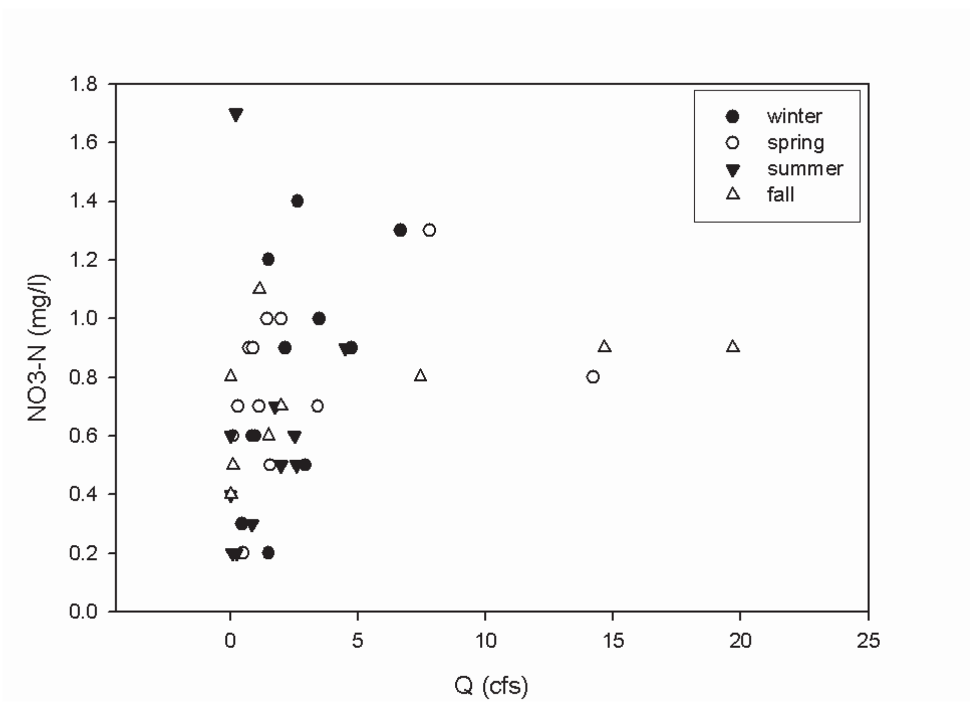


Figure 12. Seasonal relationships between discharge and stream nitrate concentrations at Meeting House Branch – Oxford Road site from 2005-2009 (Data Source: Pamlico-Tar River Foundation and Volunteer Water Information Network; Westphal and Patch 2009).

In the Stewart (2003) study, 6 sites within the Meeting House Branch watershed were selected for water quality analyses during 2001-2002. Sites were located below the golf course pond at Oxford Road: BCC (near site MHB 1000 for current study), at the bridge at King George Road: YKG (site MHB 2075 for current study), behind Planters Walk along Crooked Creek Drive: CCD (site MHB 2775 for current study), at 14th street: 14st (near site MHB 3375 for current study), and 200 m upstream of 14th Street: MPL, and along a tributary: EBA (near site BB3 700 for current study). Samples were collected every 2-3 weeks for a year. Stream inorganic N was dominated by nitrate. Mean stream nitrate-N concentrations ranged from 1.68 mg/l at CCD to 0.60 mg/l at BCC. The nitrate concentrations were elevated in the middle of the watershed at the CCD and YKG sites (similar to the 2075 and 2775 sites in the current study). Interestingly, this pattern was present during the current study and will be discussed later in the text (Figure 13).

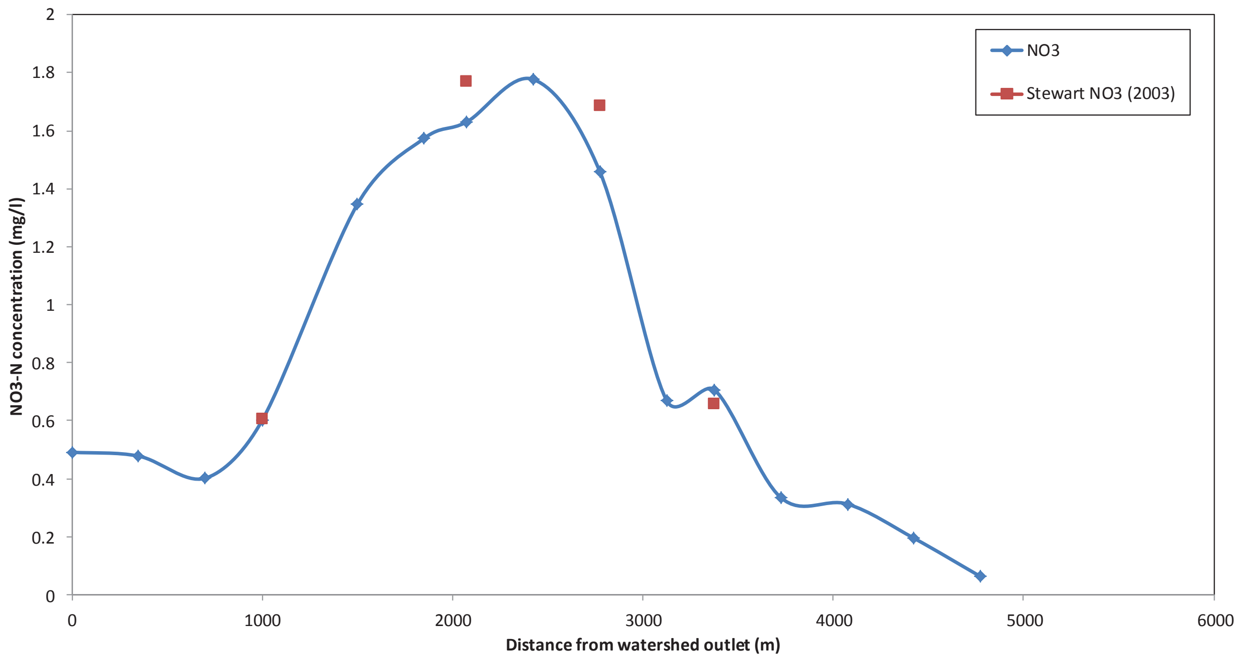


Figure 13. Spatial variability of stream nitrate concentrations along the mainstem of Meeting House Branch during the current study (median values in blue) and compared to 4 sites (in red) along Meeting House Branch that were studied by Stewart (2003). The elevated nitrate concentrations in stream water in the mid-watershed have been present for at least a decade.

Overall, these studies suggest that increased urban runoff, stream channel erosion, and elevated stream nitrogen and total suspended sediment concentrations have impacted stream water quality, runoff processes, riparian buffers, and channel morphology along streams within the Meeting House Branch watershed.

Methods

Water Quality and Discharge

Water level recorders were installed at four locations along Meeting House Branch and two locations along Bell Branch (one on the Bell Branch channel and one on a tributary to Bell Branch) (Figure 14). Water levels were recorded by pressure transducers (Hobo loggers-Onset Computer Corp.) on a half hourly basis and a rating curve was developed at the watershed outlet site by gaging stream flow with a Global Water Flow probe. At this site the rating curve related the discharge to the recorded stage to approximate an annual flow record for the watershed. Median discharge for the year was 2.44 cfs (0.07 cms) and discharge ranged from approximately 0 (during July 2011) to 519 cfs (14.7 cms) during Hurricane Irene (August 2011**) (Appendix C).** Detailed analyses of the relationships between discharge and water quality are currently being conducted and will be published in a thesis by M. Colin Walker. At the six water level monitoring sites and twenty other discrete monitoring points (a total of 26 monitoring locations) water quality was sampled seasonally during baseflow (groundwater-fed) conditions (March 2011, July 2011, Oct. 2011, and Feb 2012). In addition to baseflow sampling, two storm events were sampled on September 23, 2011 and March 3, 2012. During storm events, additional sampling was conducted at select stormwater outfalls. Locations for all sample collections are provided in Figure 14. During this study the sampling conditions varied seasonally. Water levels (and discharge) were generally below average during a drought period that extended throughout the summer of 2011 (Figure 15). Then on August 27, 2011, Hurricane Irene deposited approximately 10 inches (25 cm) of rain across the region, resulting in widespread flooding and above average discharge and water level conditions.

Water samples were hand collected and placed on ice then delivered to the ECU Central Environmental Laboratory for filtration and analyses of dissolved NO_3, NH_4, Total Kjeldahl Nitrogen, Chloride, and Orthophosphate (PO_4). For storm samples, additional analysis was conducted to quantify total suspended sediments. Analytical methods are provided in **Appendix D.**

In addition to seasonal surface water quality sampling, a detailed surface and groundwater quality monitoring event was conducted on May 18, 2012 to help identify the spatial variability of groundwater nitrogen inputs in the middle of the watershed. On this date, eleven surface water samples and eighteen riparian groundwater samples were collected (Figures 14 and 20) to evaluate the nitrogen inputs to the stream via groundwater flowpaths and the effectiveness of riparian buffers to retain/remove nitrogen from groundwater.

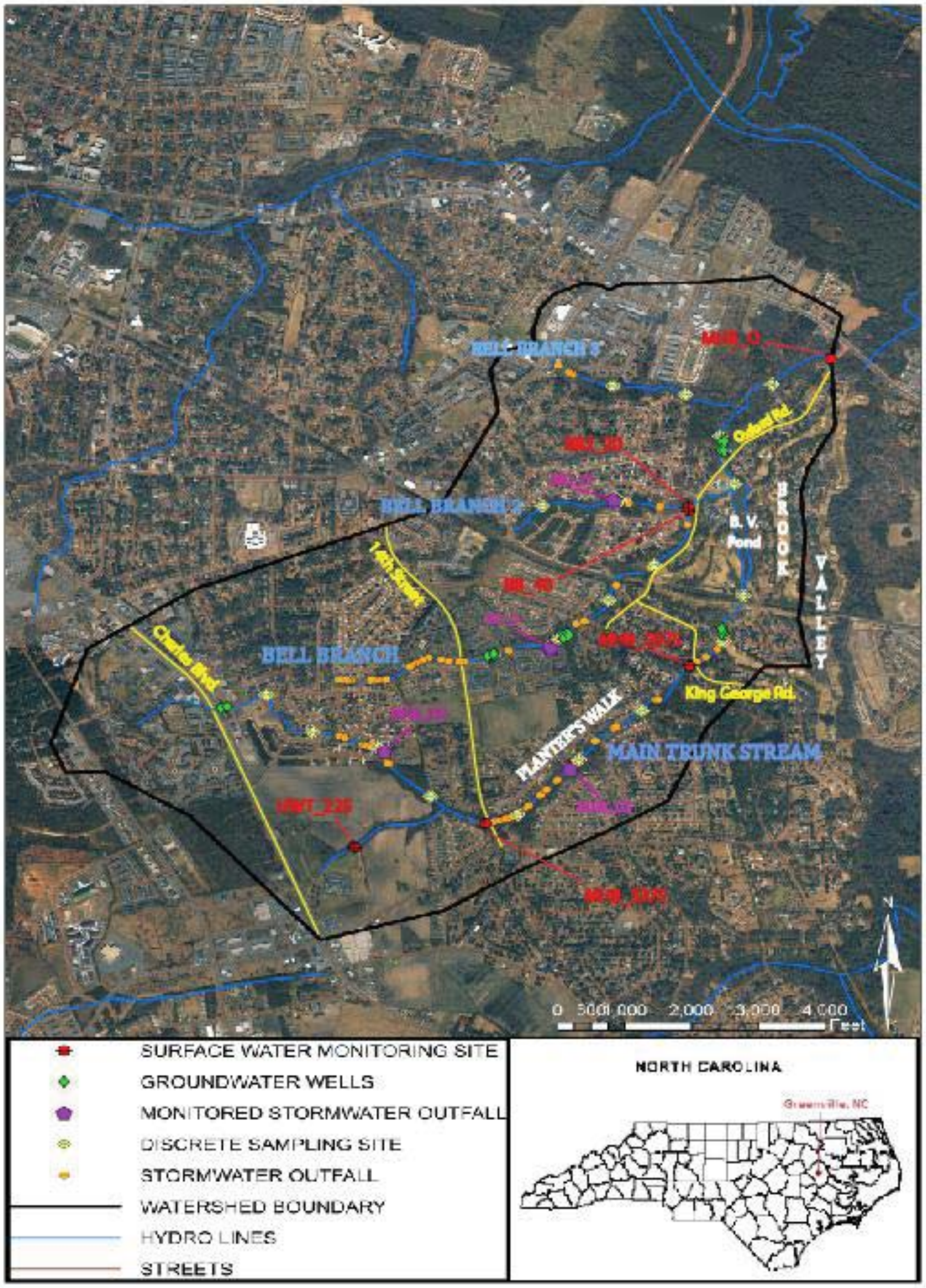


Figure 14. Surface water and groundwater sampling map and locations of stormwater outfalls in MHB watershed.

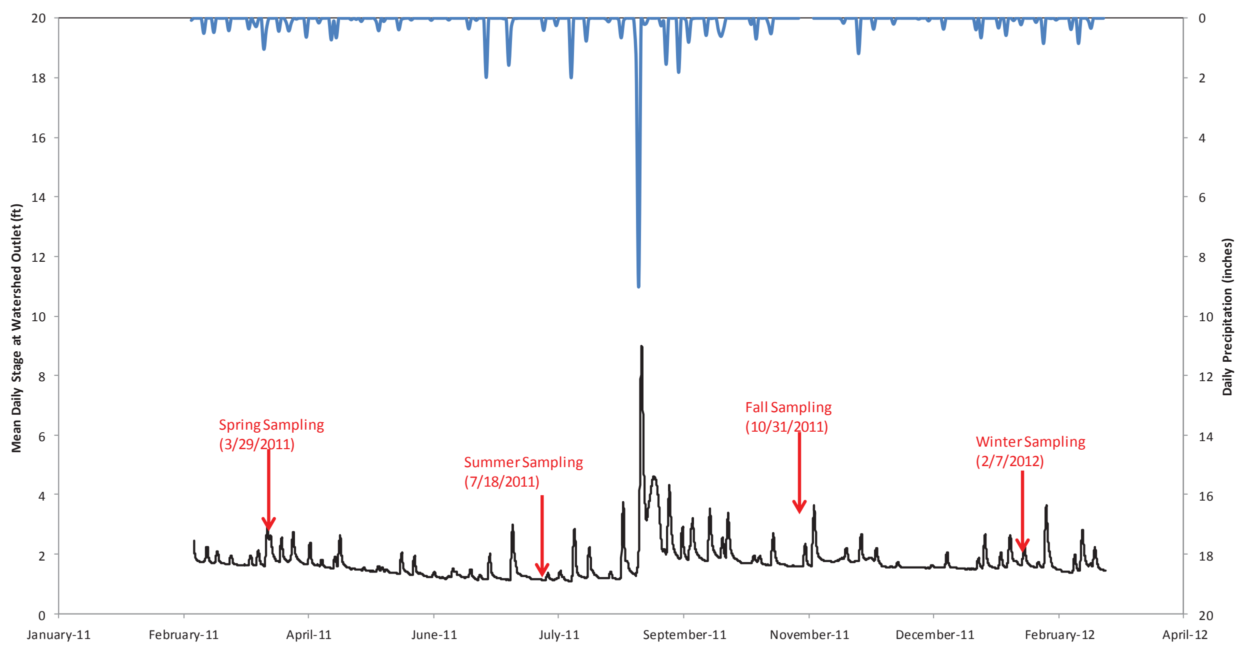


Figure 15. Surface water level conditions varied during seasonal sampling with the lowest stages and corresponding flows occurring in the summer of 2011. Groundwater depths for the surficial aquifer were monitored by the U.S. Geological Survey at a nearby site (Simpson NC-160 site) and these data showed that the water table was deepest on the 7/18/2011 sampling date (7.59 ft or 2.3 m) but for other dates groundwater depths ranged from approximately 3-4 ft. deep (1-1.3 m).

Channel Morphology and Riparian Buffers

Cross-sectional stream channel profiles were collected monthly at monitoring stations along MHB and its selected tributaries from June, 2011 until February, 2012 to assess how channel dimensions changed seasonally. In addition to stream channel profiles being recorded monthly at each monitoring site, channel dimensions were measured prior to and after Hurricane Irene (August 27, 2011). To measure a channel cross-section, a datum was established above and perpendicular to the stream channel at each of the six monitoring stations. Metal rods (0.5"x 4') were driven into the berm or floodplain immediately adjacent to both sides of the stream channel. A tape reel was stretched between the rods and was held static, perpendicular, and overlying the stream channel. Measuring vertically downward from the datum, moving in half-foot increments across the width of the stream channel, the cross-sectional channel profile was recorded. Collecting records of stream channel geomorphology over time at the monitoring sites was used to estimate the percent change in cross-sectional area at multiple points along MHB. Changes in channel dimensions helped to characterize the average rate of erosion over time for multiple points in the watershed.

A detailed assessment of the physical condition of the in-stream and riparian buffer zones was conducted using rapid field-based observation methods developed specifically for low-order coastal plain streams; formulated by Rheinhardt et al. (2007). Meeting House Branch and the riparian buffers adjacent to MHB were divided into 300 foot (approximately 100 m) segments moving upstream from the watershed outlet. In each buffer segment, a near stream zone was established by delineating parallel lines 0 and 10 feet (0-3 m) from the stream channel. A riparian buffer zone was established by delineating parallel lines 10 and 90 feet (3 and 27.4 m) from the stream channel. In total, 93 buffer segments were assessed within MHB watershed.

The riparian buffer field assessment included indicator classes, proposed by Rheinhardt and others, which describe and grade the physical condition of the near stream zone (In-stream woody structure; sediment regime; channel riparian connection; pollution affecting the stream; stream bank stability) and adjacent riparian buffer zone (pollution/erosion affecting the riparian zone; habitat quality of the riparian zone). Each indicator class contains sub-classes and corresponding grades; grading is determined based on conditions observed during field assessments. For some indicator classes, right and left sides are distinguished between and graded separately. The full assessment methodology and field sheets are presented in **Appendix E.**

Land use was also evaluated across the riparian buffers during the assessment. For each riparian buffer segment (180 ft x 300 ft or 55 m x 90 m) a site sketch was performed, identifying and delineating any impervious surfaces, housing density, or vegetative growth. Each land cover type corresponds to a weighted numerical grade. Using Microsoft Excel tables previously formulated by Rheinhardt et al. (2005, 2007), indicator class grades were combined with weighted land-use grades. This combination was designed to better characterize the overall quality of each stream reach. The midpoint along each 100 meter section was located using a handheld GPS unit (Garmin eTrex Vista HCx, 2010 model). From the midpoint, stream channel geometry was measured (width; bank height; cross sectional area; bank full height; channel incision ratio; reach sinuosity). Forms developed by Reinhardt et al. (2005) and used during the riparian buffer assessment (modified by Mark Brinson for low order coastal plain streams) are provided in **Appendix E.**

Stormwater outfalls and pipes draining to streams

Field surveys were conducted to obtain the GPS coordinates of stormwater outfalls, drainage pipes, and drainage ditches intersecting MHB stream. Surveys were performed using hand held GPS units (Garmin eTrex Vista HCx, 2010 model). Additionally, a categorical checklist was employed to identify the diameter, material used, and present discharge for each pipe intersecting the stream. After locating and identifying an outfall, the coordinates were mapped using GIS software (ArcMap 10). The highest density of outfalls occurred near middle sections of the main trunk stream and headwater sections of Bell Branch tributary (Figure 15). Mapping with GIS software also helped to pinpoint potential areas of concern in the watershed pertaining to stormwater discharges. Locating and identifying these outfalls intersecting MHB helped aid the stormwater sampling scheme (Sept. 23, 2011, March 3, 2012) by constraining the best potential candidates (the five largest outfalls) for sampling on the two dates. All outfalls found during this study that drained to MHB and tributaries can be found in Figure 14.

Stakeholder Survey Methods

The City of Greenville embarked on a project in 2010 that sought to evaluate the existing City stormwater program and develop a watershed master plan for Meeting House Branch. PTRF, ECU, City staff and their consultants WK Dickson met to discuss how the two projects could work in tandem to reduce duplicability. One such collaborative project was the development and implementation of a water quality survey for Meeting House Branch residents.

PTRF in collaboration with the City of Greenville and their consultants WK Dickson designed a homeowner water quality survey (**Appendix F**). The survey included 14 questions relating to flooding, erosion, water quality concerns, City stormwater program awareness and willingness to participate in restoration projects. A public meeting notice was included with the survey. A total of 3600 surveys were mailed in April, 2011 by the city to every residence in the Meeting House Branch Watershed. WK Dickson compiled the survey results into ArcGis shapefile with point features that include the survey responses in their attribute tables. Maps can be generated demonstrating how each survey respondent answered each of the questions. This allows for a graphical representation of where stormwater and flooding problems are occurring or most likely to occur.

A public meeting was held by the City on April 19, 2011 to gather more input from affected landowners in the watershed. The meeting setting was informal to allow homeowners to ask questions and relay important stormwater related information to the City and their consultants. Meeting minutes were compiled by WK Dickson and will be included in the City of Greenville’s final report (pending).

Results and Discussion

Survey Results[1]

A total of 169 surveys were returned, a 4.5% response rate. **Appendix G** (map) depicts the location of households that returned the survey within the MHB watershed.[2] Of the 169

[1] Survey results provided by WK Dickson, Raleigh, NC and the City of Greenville, NC.

responses, 67 or 40% of households had experienced flooding in the past on their property. Of those surveyed, 15% (26) indicated that flooding has increased on their property due to the filling and development of adjacent lots. Of the 102 that responded to the question regarding what is threatened by erosion, almost half noted their yard (49%). A total of 10 responses indicated that the stream or ditch banks are threatened by erosion.

Regarding a stream maintenance program, 73% indicated they would either definitely or potentially be willing to allow access for restoration, water quality sampling, installation of rain gauges, diverting stormwater, etc. with the majority of responses indicating “maybe” at 45%. Of the remaining responses, 11% stated they would not participate in a stream maintenance program and 13% said they could not help, but would allow access via their property. Several of the respondents noted they do not live along the creek or live in multi-family housing that requires outside permission. Question 11 of the survey asked: What action, if any, have you taken in the last 5 years to lessen the threat of erosion and/or flooding? The responses are summarized in Table 3, with the most popular response being to plant trees or other vegetation.

As for BMP installation, the majority of responses at 54% indicated they may be willing to install BMPs via a cost-share program. Only 14% said yes with 31% stating they would not install a stormwater BMP. A total of 86 respondents indicated they have taken an action in the past 5 years to lessen the threat of erosion and/or flooding., with their responses included in the table below. Some of the responses in the “other” column in included installing drains, sump pumps, digging trenches, removing debris and bulkhead repair.

Type of Action	**# of responses**	**% of responses (total = 86)**
Used Rip-Rap	7	8%
Planted Trees or other vegetation	26	30%
Reduced or eliminated Mowing	16	19%
Installed BMPs	7	8%
Moved structures away from the stream channel and/or elevated structures	10	12%
Other	20	23%

Table 3: Responses to Question 11 of the Public Survey.

[2] Greenville Pilot Watershed Study, Public Input Map. WK Dickson, Raleigh, NC.

Regarding watershed priorities, respondents were asked to rank their top 10 concerns (Table 4). The top 5 concerns noted were: flooding, property damage, erosion or sedimentation, stream maintenance and water quality.

1	Flooding
2	Property Damage
3	Erosion and sedimentation
4	Stream maintenance
5	Water quality
6	Infrastructure maintenance
7	Agency Coordination
8	Aquatic plant and aquatic life
9	Watershed Education

Table 4: Ranked watershed concerns

The final question asked respondents to indicate in what ways the City of Greenville should utilize funds to address stormwater runoff, erosion and flooding issues. The most popular response (73) indicated support for stream restoration. Other top responses included an erosion program to address problems on private property, a cost-share program to install BMPs, and incentives for replanting riparian areas. Less support was indicated for regional detention facilities and a buy-out program of endangered properties.

A total of 16 persons, representing 11 home sites, attended the public meeting. Meeting minutes can be found in **Appendix H**. [3] Relevant information from homeowners included experiences of flooding of property, testimony of creek channel widening and incision, erosion along the creek channel and property loss, and sediment deposition on stream bank after high flows.

Survey Discussion

The public survey results indicated that numerous properties were impacted by erosion, flooding, and stormwater runoff within the Meeting House Branch watershed. Survey responses indicate support and willingness on the part of property owners to work with the City and/or outside organizations or agencies for stream restoration and other maintenance programs. Educational efforts need to target the benefits of stormwater BMPs in existing impervious surface areas, including information on available cost-share programs. Educational efforts regarding BMP installation may best be served by targeting residences in the upper portion of the watershed to install BMPs that can capture and treat stormwater closer to the source rather than downstream. Replanting or reducing mowing to reduce stream bank erosion and improve water quality should target all residences that border the stream channels.

[3] Meeting minutes, City of Greenville Public Meeting- April 19, 2011. City of Greenville Stormwater Master Plan. Produced by WK Dickson, Raleigh, NC.

An educational effort also needs to target the natural characteristics of streams and flooding and include BMPs that allow for retention and infiltration as opposed to quick drainage solutions that may add to the erosion and flooding problems.

Both the watershed monitoring and survey responses indicate that the stormwater requirements when development occurred may not have been sufficient to avoid downstream impacts including flooding, erosion, water quality and aquatic habitat degradation within the Meeting House Branch Watershed. The city may wish to revisit the existing stormwater ordinance and program for new development and evaluate whether changes are warranted to reduce downstream (and upstream) problems. When stormwater-related erosion causes an increase in stream channel depth and slope, the knickpoint can migrate upstream causing erosion problems to be displaced upstream.

Riparian Buffers and Total Impervious Area

Within the Meeting House Branch watershed there was evidence of significant variation in the physical condition of riparian buffer zones. The criteria for grading each riparian buffer segment consisted of evaluating land-use (left and right sides of the stream) and physical stream/ riparian zone condition. The percent area of coverage for each land-use type was calculated along a buffer segment (100 meters long). Each land-use type was assigned a weighted value based on the Rheinhardt et al. (2005) protocol **(Appendix E)**. Percent area of each land-use type within a given buffer segment, multiplied by the corresponding land-use weighted value would produce one half of a composite buffer condition score. In addition to land-use, each riparian buffer zone was evaluated based on seven physical indicator classes, which were categorically subdivided based on physical symptoms evident during field surveys. The number of symptoms/impairments evident for a stream reach constrained the grading to a numerical scale. Both scores from land use and physical condition scores were averaged to establish a composite riparian buffer score for each 100 meter buffer segment. Riparian buffer scores are based on a 100 point scale with unimpaired buffers receiving a grade of 80 or higher, slightly impaired buffers receiving a grade of 60 to 79, and significantly impaired buffers receiving a grade of 59 or less. Moving upstream from the watershed outlet, riparian buffer scores stay consistently unimpaired until 1000 meters upstream (Figure 16). Between nine hundred to one thousand meters upstream from the watershed outlet (just downstream of the Brook Valley Dam) the riparian buffer zone was evaluated as slightly impaired. The Brook Valley Pond extends approximately 500 meters above the dam before the main trunk stream is re-encountered. Four riparian buffer sections between 1500 and 1900 meters upstream of the watershed outlet and directly upstream of the pond, are either graded as slightly impaired or significantly impaired. These buffer segments are within the boundaries of Brook Valley golf course, where land use has significantly changed from forested areas adjacent to the stream to manicured lawns and golf course fairways. Near the middle portions of the main trunk stream, from the 1900 meter mark, several buffer segments exhibit impaired physical conditions but many segments are in good condition. Riparian buffer condition declines upon reaching 3900 meters from the watershed outlet on the main trunk stream, with all remaining upstream portions having moderate to significant impairment. The greatest evidence for impairment is suggested to encompass buffer segments 4000 and 4100 meters upstream from the watershed outlet. Three tributaries drain the north western portion of the watershed (Bell Branch, Bell Branch 2, Bell Branch 3). These tributaries exhibited less variation than buffer segments on the main trunk stream, but some tributaries still had segments with different grades. Bell Branch exhibited the most variation of the three tributaries. Riparian buffer condition remained largely unaltered until 1700 to 2200 meters upstream from the confluence with the main trunk stream. This area of impairment on Bell Branch encompassed the headwater regions of Bell Branch tributary. Land-use in this headwater section is characterized by high density residential complexes bordering the stream. In contrast to Bell Branch tributary, Bell Branch 2 and Bell Branch 3 showed little variation in riparian buffer condition. Many buffer segments along the two smallest tributaries were graded among the highest within the entire watershed. Riparian buffers received consistently high grades along Bell Branch 3 due to the percent area of unaltered forest adjacent to the stream. Areas bordering Bell Branch 2 and Bell Branch 3 tributaries and their respective buffer zones can be characterized as having low to high density residential housing, similar to much of the land use surrounding all three of the Meeting House Branch tributaries. Overall, approximately 28% of Meeting House Branch watershed is comprised of impervious surfaces (Figure 17). The high density of impervious surfaces at the headwaters along Charles Boulevard likely has an influence on the low riparian buffer grades in that region.

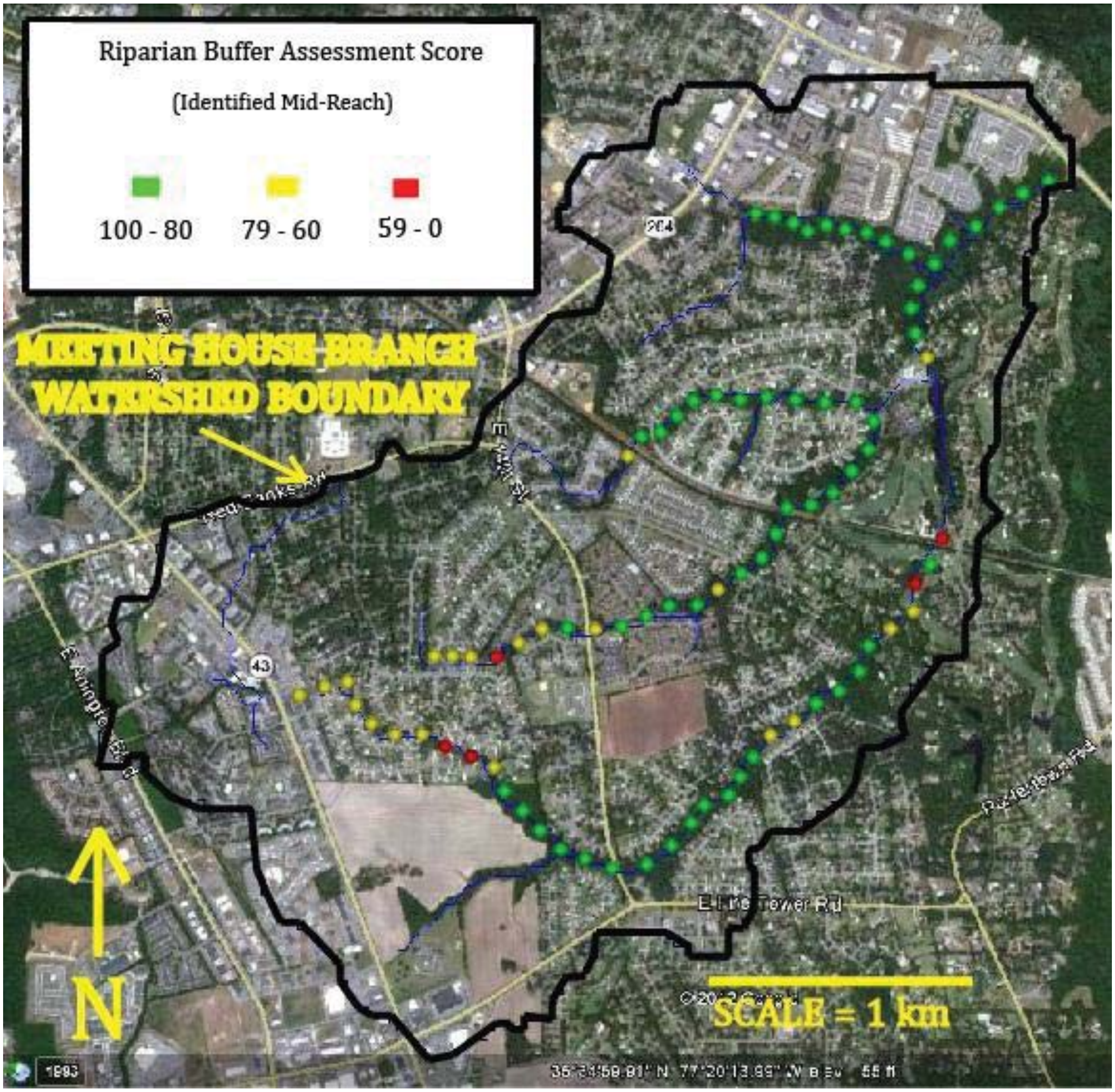


Figure 16. Variability in riparian buffer condition along MHB and its tributaries based on the Rheinhardt et al. 2005 assessment protocol.

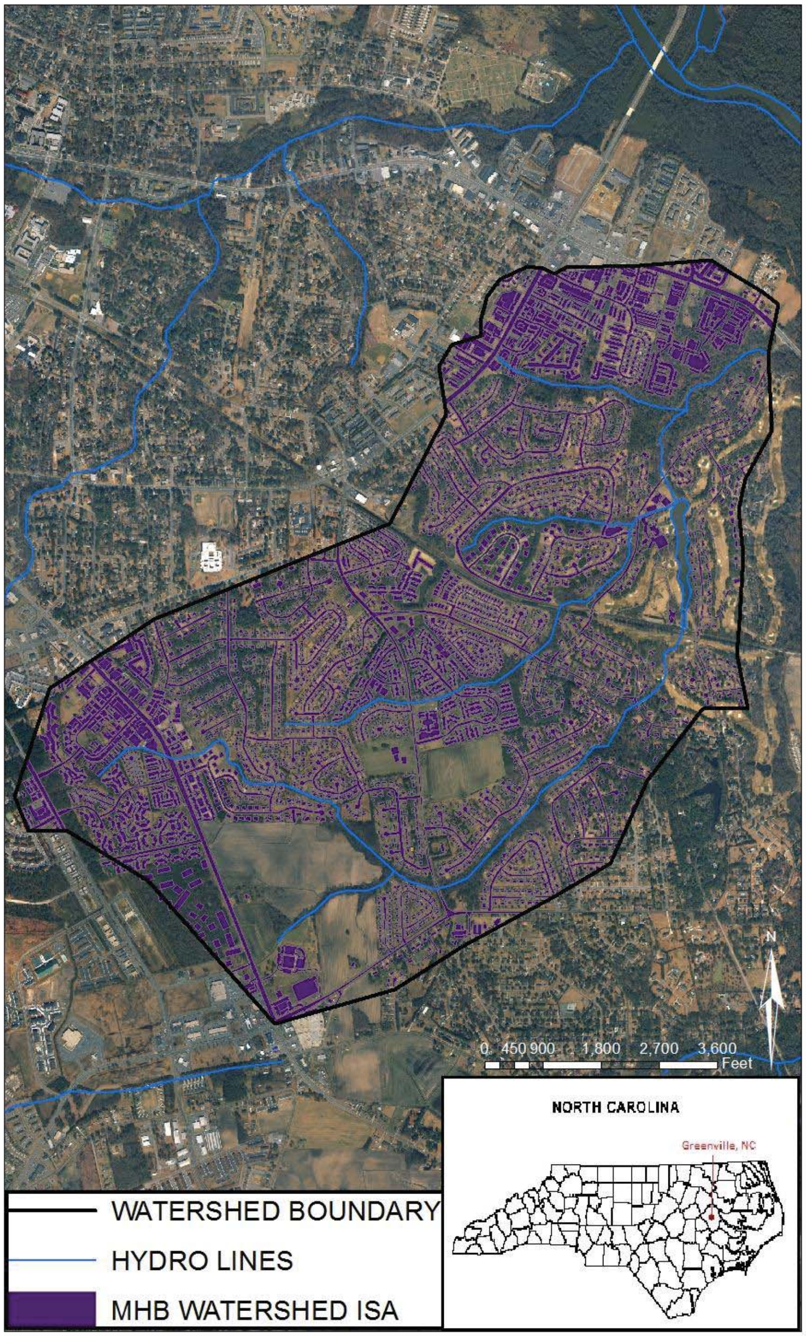


Figure 17. Impervious surface area (in purple) throughout the Meeting House Branch watershed. Total watershed impervious area is approximately 28%.

Changes in Stream Channel Dimensions

Stream channel cross-sectional area at most surface water monitoring sites (Figure 14) had significant variation during the study period. Results from monthly cross-sectional measurements showed that monitoring sites would often shift from a net gain in channel area one month, to a net loss in channel area the following month. The disparity between records of channel area at most sites, from month to month, suggests an alternating pattern of sediment scouring and sediment sequestering during a majority of the study period. These variations in channel morphology on a monthly basis show that MHB had been actively reworking channel sediments throughout the study period. Records showing the general shift of aggrading to eroding channel bed and bank sediment at monitoring sites on a monthly basis most likely represents channel reworking due to stormwater inputs and not solely attributable to baseflow conditions. After channel cross-sectional dimensions were recorded at each site monthly from June, 2011 to March, 2012 the monthly difference in channel profile area at monitoring sites were evaluated. Additionally, monthly records from Jun, 2011 to March, 2012 aided in estimating the total net change for sites along MHB. The most significant change in channel cross-sectional area over the monitoring period (June 2011-March 2012) occurred in the upper watershed. Records at monitoring site MHB_3375 showed a total net change in channel area of 7.3 ft^2 (0.09 m^2), which was the largest net loss of channel area for any monitoring site evaluated in the study. This correlates with a high density of stormwater inputs, the largest concentrations of which are located upstream and downstream of MHB_3375.

Monitoring site MHB_2075, located halfway down the main trunk stream of Meeting House Branch, showed a minimal net change in cross-sectional area of 0.04ft^2 (0.003 m^2). This small difference in net channel area suggests that MHB_2075 is scouring and sequestering sediment at similar rates and alternating monthly. The monthly switch in sediment transport regimes exhibited at MHB_2075, along with a low total net change for the site, could suggest that this is an area of sediment bypass on the main trunk stream. Approximately 500 meters downstream of MHBN_2075 the main trunk stream intersects a pond within Brook Valley Golf Course. The Brook Valley pond is approximately 50 meters in width by 500 meters in length. The pond was constructed in the late 1960's which presumably, has been sequestering sediment from upstream portions of the watershed for decades (assuming the pond has not been dredged). The Brook Valley pond dam represents an interruption in sediment flux from upper portions of the watershed to stream reaches below the dam. The only monitoring site located below the dam on the main trunk stream of MHB (MHB_O) occurs at the watershed outlet. Total cross-sectional area change at monitoring site MHB_O was calculated to be 6.06ft^2 (0.56 m^2). After evaluating the monthly difference in channel cross-sectional area at monitoring site MHB_O, records suggest that MHB_O had a more active role in scouring and sequestering sediment during the first half of the study period (June, 2011- Dec. 2011). In contrast, MHB_O during the latter half of the study period exhibited rates more characteristic of sediment bypass. Sediment flux is interrupted approximately one kilometer upstream of MHB_O due to a dam constructed for the Brook Valley Golf Course Pond. The upstream sources of sediment remaining to MHB_O are delivered via the confluence of Bell Branch and Bell Branch (2) tributaries which intersect with the main trunk stream approximately 10 meters below the Brook Valley Pond Dam. Bell Branch and Bell Branch (2) tributaries both exhibit similar monthly trends in sediment transport as MHB_O. Bell Branch and Bell Branch (2) both displayed a more active role in scouring and sequestering sediment during the first half of the study period, in contrast to the latter half of the study period when results were more distinctive of sediment bypass or deposition. Overall, the median channel change data for all sites revealed a period of net deposition (median channel size decreased) during the summer of 2011 and a period of net scour (median channel size increased) from fall 2011 to spring 2012 at the monitored sites (Table 5). Monthly and total variations in channel cross-sectional area for all monitoring sites between June, 2011 and March, 2012 are illustrated in Table 5. Overall, the differences exhibit significant variability over time but for the short monitoring period they do not show significant differences between channel enlargement and channel deposition. Longer term comparisons, mentioned earlier (p.22) suggest net channel erosion over time. Since these estimates suggest the channel was deepening at approximately 1.5 cm/yr (0.6 in or 0.05 ft/yr) near King George Road, it may take several years of monitoring cross-sectional areas to notice net changes in channel dimensions. There is a high degree of spatial and temporal variability in erosion and depositional processes within Meeting House Branch and a higher density of sampling locations that are sampled over longer timeframes and additional floodplain and pond sampling would be needed to characterize the sediment budget of the watershed. In the future, terrestrial LiDAR could be used to develop 3-dimensional baseline data that could be tracked over time to create a record of changes in channel dimensions and channel migration.

	MHB CHURCH	MHB 14TH ST.	MHB KING GEORGE RD.	BELL BRANCH	BELL BRANCH 2	MHB WATERSHED OUTLET	
Month	X-sect. Area (ft^2)	X-sect. Area (ft^2)	X-sect. Area (ft^2)	X-sect. Area (ft^2)	X-sect. Area (ft^2)	X-sect. Area (ft^2)	
June	12.65	23.64	46.845	36.74	22.735	27.75	
August	11.705	28.805	46.275	35.03	22.09	33.19	
September	12.32	28.765	42.18	32.19	20.105	36.765	
October	12.025	28.985	46.235	36.115	22.505	33.555	
November	12.32	28.845	47.17	34.44	22.815	39.125	
December	11.985	29.345	47.188	35.205	23.265	33.185	
January	11.83	29.635	44.465	35.365	23.385	33.715	
February	12.03	30.61	46.43	35.845	23.6	33.545	
March	12.33	30.985	46.805	36.02	24.135	33.81	
	Difference (ft^2)	Difference (ft^2)	Difference (ft^2)	Difference (ft^2)	Difference (ft^2)	Difference (ft^2)	Median difference
Jun-Aug	-0.945	5.165	-0.57	-1.71	-0.645	5.44	-0.6075
Aug-Sep	0.615	-0.04	-4.095	-2.84	-1.985	3.575	-1.0125
Sep-Oct	-0.295	0.22	4.055	3.925	2.4	-3.21	1.31
Oct-Nov	0.295	-0.14	0.935	-1.675	0.31	5.57	0.3025
Nov-Dec	-0.335	0.5	0.018	0.765	0.45	-5.94	0.234
Dec-Jan	-0.155	0.29	-2.723	0.16	0.12	0.53	0.14
Jan-Feb	0.2	0.975	1.965	0.48	0.215	-0.17	0.3475
Feb-Mar	0.3	0.375	0.375	0.175	0.535	0.265	0.3375
median	0.0225	0.3325	0.1965	0.1675	0.2625	0.3975	0.26825
net difference	-0.2975	7.345	-0.04	-0.72	1.4	6.06	1.0515

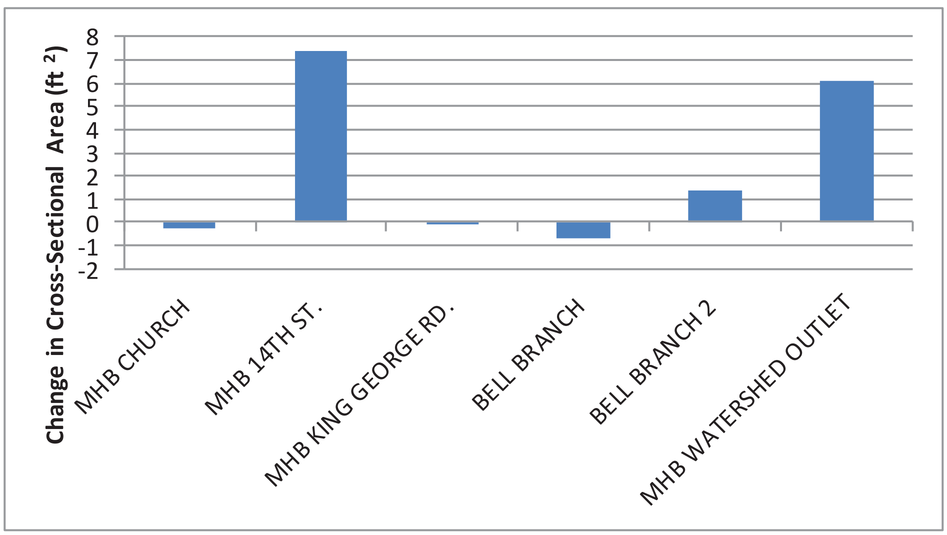


TABLE 5. Channel cross-sectional areas (ft^2) at monitoring stations and differences in channel cross-sectional area between sampling dates. Negative differences (occurred 17 times, median decrease=0.95ft^2) indicated deposition and a reduction in channel size, positive differences (occurred 31 times, median increase=0.48 ft^2) indicated erosion and an increase in channel size. Since the change data were quite variable, there was not a significant difference between the negative and positive changes. The lower bar graph shows the net differences.

Water Quality Patterns

Spatial Variability of Water Quality

Surface water quality varied temporally and spatially throughout the watershed. During baseflow conditions, PO4 (<0.05 mg/l) and NH4-N concentrations (<0.25 mg/l) in stream water were generally low throughout the watershed **(Appendix J).** Total dissolved nitrogen (TDN) was generally elevated in the middle of the watershed and lower in the headwaters and at the bottom of the watershed (Figure 17). Nitrate (NO_3- referred to as NO_3-N when considering the concentration of only the N component of the NO_3 molecule in water) was generally the dominant N species in surface waters throughout the watershed (Figure 18). Spatially, median stream NO_3-N concentrations increased along the mainstem of Meeting House Branch after the 3725 m sampling site causing an increase in TDN concentrations. The largest increase in stream NO_3-N concentrations occurred downstream of site MH 3125 and upstream of MH 2775, based on seasonal surface water sampling. Along this reach, chloride (a conservative tracer) concentrations remained relatively stable. Below the golf course pond (around 1000 m upstream from the watershed outlet) the chloride concentrations declined, suggesting there is some dilution effect that reduces nitrate concentrations in the lower portion of the watershed. However, the nitrate concentration declines are much larger than the chloride concentration declines below the dam, suggesting dilution is not the primary cause of nitrate reduction. Therefore, denitrification or assimilation of nitrate must be occurring to reduce nitrate concentrations along this portion of the stream.

When comparing the N-speciation along the main channel, a few trends appear (Figure 19). In the headwaters, NO_3-N concentrations are generally low and increase downstream, NH_4-N is also low (<0.5 mg/l) but generally higher than DON (dissolved organic nitrogen) along the headwater reach between 4775 and 3725 m. After this segment, nitrate in surface water increases between 3725 and 3375 m. DON and NH4-N also increase along this reach but DON has a larger increase and becomes elevated relative to NH4-N. There is a large increase in nitrate and DON along the next reach between 3125 and 2775. Between 2775 and 1500 m, the nitrate concentrations are at their highest and DON concentrations are elevated relative to those found upstream, NH4-N concentrations are similar to those found upstream. Below site 1500m is the large pond located at the golf course. At 1000m the nitrate declines dramatically and DON increases. Along the lower reaches (1000-0 m) the DON is elevated relative to the rest of the watershed. These patterns suggest that the headwaters and lower portions of the watershed are more effective at processing nitrogen or there are more N input sources in the middle of the watershed. Berman and Bronk (2003) showed that in lakes DON can be the dominant N species. In MHB watershed, DON increases downstream of the pond (site 1000 near golf course dam). Overall, nitrate is the dominant N-species in MHB watershed and the large increase in NO_3-N during baseflow conditions between 3175 and 2775 suggests an anthropogenic source, possibly fertilizer or wastewater. Since these samples were collected during baseflow conditions, groundwater transport is the likely cause of the elevated nitrates. In their nutrient criteria technical guidance manual, the EPA provide some general TDN concentration guidelines and suggest that TDN concentrations above 1.5 mg/l generally result in eutrophic conditions. The stream reach between 2775m-1500 m upstream of the watershed outlet consistently exhibited TDN concentrations that were greater than 1.5 mg/l for each seasonal sampling round, indicating a chronic nutrient problem along this reach.

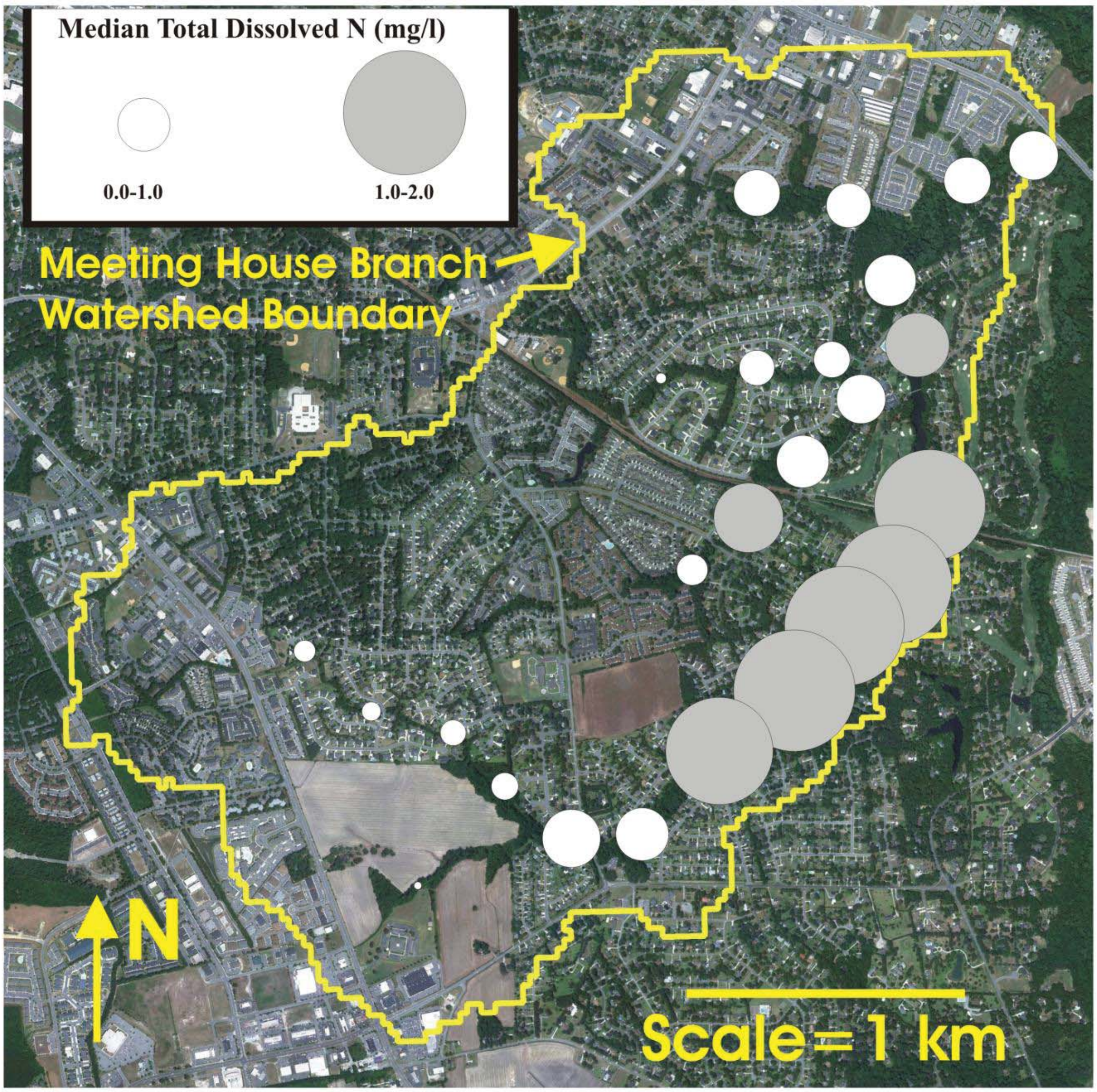


Figure 18. Median surface water total dissolved nitrogen (TDN; mg/l) for four seasonal sampling dates (2011-2012). Total dissolved nitrogen was elevated along the mainstem of Meeting House Branch, generally from the reach between 14th street downstream to the golf course. TDN levels declined below the golf course dam.

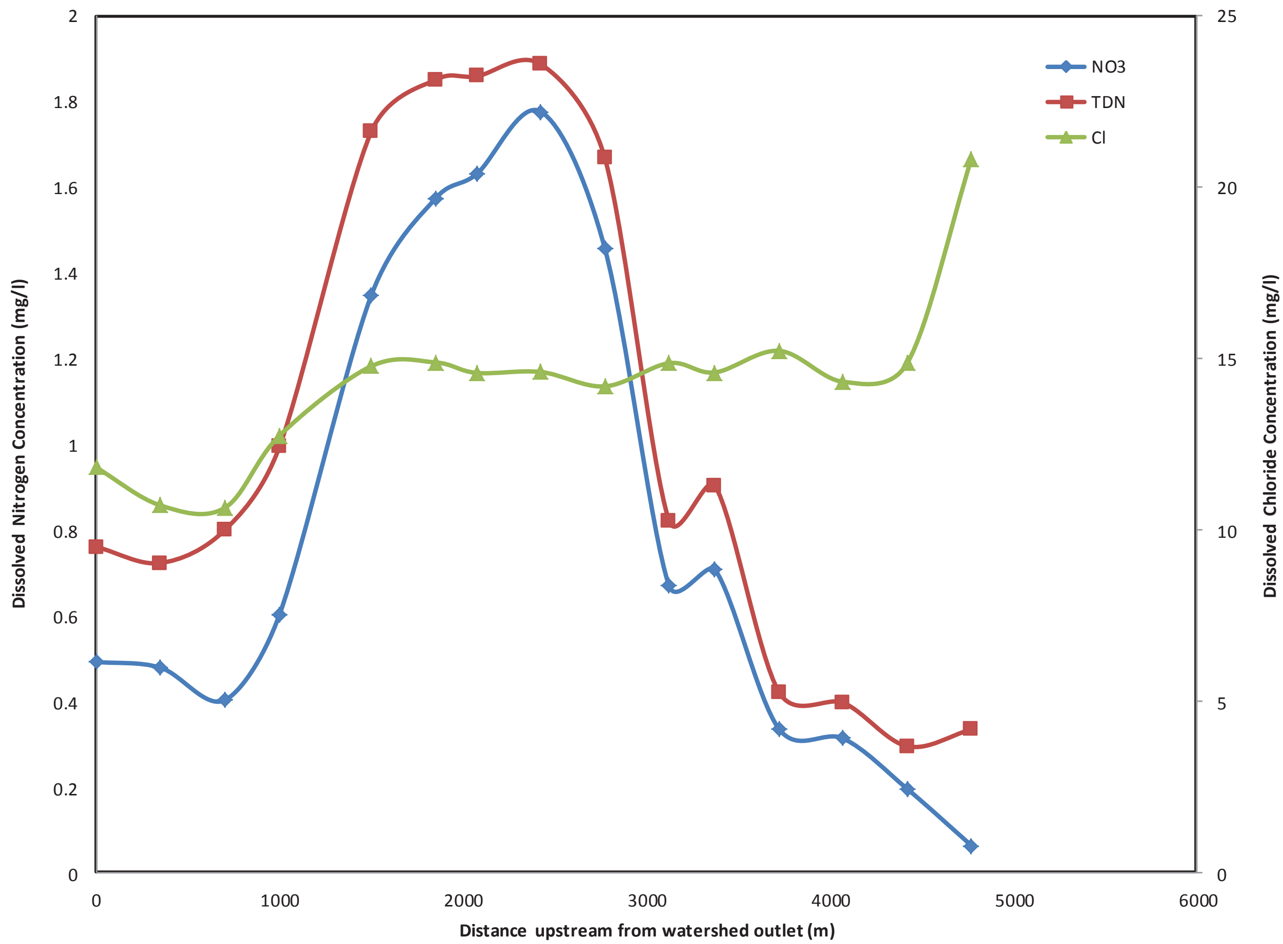


Figure 19. Median surface water dissolved nitrate, total dissolved nitrogen, and chloride concentration variations with distance from the watershed outlet. As distance along the main channel increases the stream order declines and the sampling points are closer to the headwaters. The majority of nitrate inputs appear to occur between 3725 and 2425 m upstream of the watershed outlet. Although nitrate concentrations vary along this reach, the chloride concentrations are relatively stable. Usually, wastewater contains elevated chloride concentrations. These data suggest that wastewater is not the main cause of elevated nitrates but more investigation would be needed to verify.

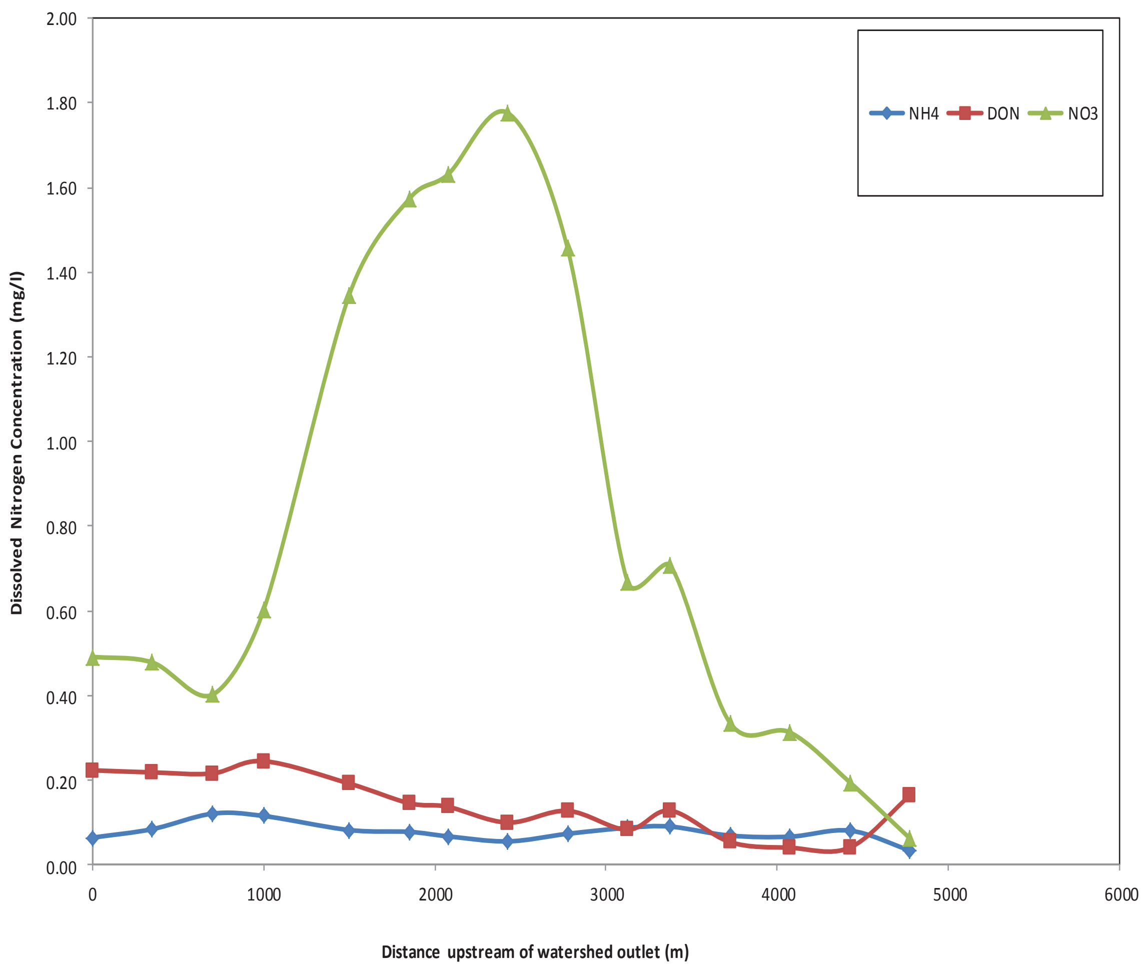


Figure 20. A comparison of median surface water dissolved nitrate-N, dissolved organic nitrogen, and ammonium-N concentration variations with distance from the watershed outlet. The largest increase in nitrate concentrations occurs between 3375 m and 2775 m upstream of the watershed outlet. The largest decrease in nitrate concentrations corresponds with a large increase in dissolved organic nitrogen that occurs downstream of the golf course dam (near 1000 m). Generally speaking, ammonium is usually present at low concentrations and nitrate and dissolved organic nitrogen are present at relatively higher concentrations.

Nitrogen and oxygen isotopes in nitrate can help to determine the source of nitrogen. At the sampling site MHB 3375 on November 4-7, 2012, stream samples were collected before, during, and after a storm event, and analyzed at the UC-Davis Laboratory. Results at this site revealed 7.5 $\delta^{15}N$ (o/oo) and 11.08 $\delta^{18}O$ (o/oo) (before the storm); 2.78 $\delta^{15}N$ (o/oo) and 15.62 $\delta^{18}O$ (o/oo) (during the storm); and 7.61 $\delta^{15}N$ (o/oo) and 11.17 $\delta^{18}O$ (o/oo) (after the storm). These data are presented as black circles in Figure 20. Similar results were found for samples collected along Bell Branch, these data are presented as hollow circles in Figure 20. These data are overlain on Kendall and McDonnell's figure (1998) to help determine the source of nitrate (Figure 20). The isotopic composition of the nitrate during baseflow and storm events falls in the possible range of fertilizer and soil nitrogen. Because denitrification tends to enrich ^{15}N in the remaining nitrate, it is possible to have nitrate with enriched ^{15}N that originated as a fertilizer source but as that nitrate was transported through the soils, surficial aquifer, riparian buffers, and stream channels, the denitrification process caused the $\delta^{15}N$ to become progressively enriched (more positive or to the right on Figure 20) . These data point towards fertilizer or soil organic matter as the likely source of N upstream of MHB 3375 and along Bell Branch. However, mixing of waters with different isotopic signatures could occur so it is not possible to entirely rule out any manure or wastewater sources. Septic systems are not currently used to dispose of wastewater in the MHB watershed, so any wastewater discharged to the channel would have to originate in the sanitary sewer pipes that are located adjacent to stream reaches. It is possible that these lines may leak along some reaches and could contribute nitrogen to the channel (photos in **Appendix I**). To further determine nitrate sources, we collected several samples for isotopic analyses at MHB 2075 on May 21, 2012, downstream from the reach that we measured high nitrate concentrations in the stream on that date. In addition, nitrate isotopic samples were collected along MHB at site 3375 and at Bell Branch on May 7-10, 2012, and we are awaiting results from the UC-Davis Laboratory.

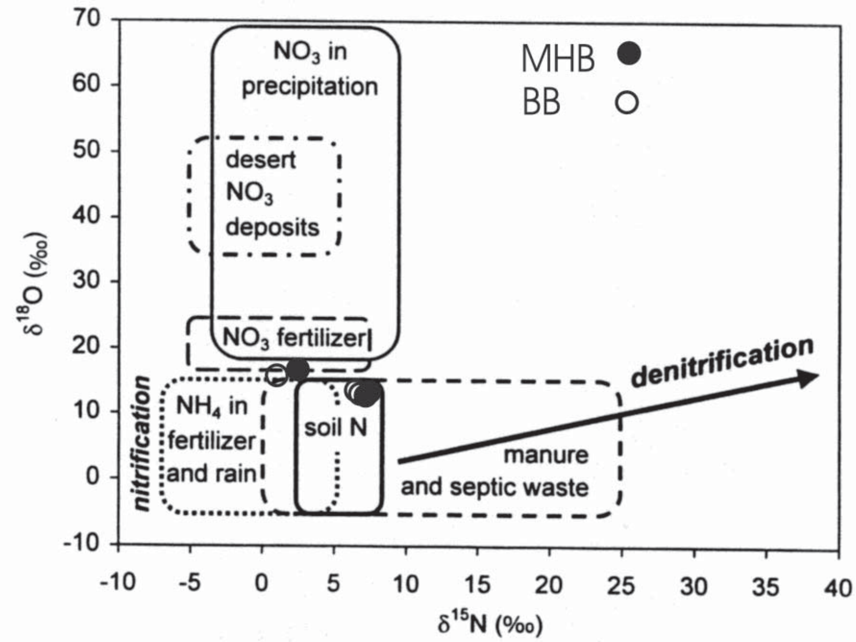


Figure 21. δ^{15}N (o/oo) and δ^{18}O (o/oo) composition of nitrate in stream water collected in December 2011 along Meeting House Branch (MHB 3375 site- black circles) and Bell Branch (blue circles) during baseflow (samples cluster to the right) and storm runoff (samples cluster to the left) conditions. The base figure was modified from Kendall and McDonnell (1998) and helps to indicate the source of nitrate. These data suggest that the nitrate source is likely soils and fertilizer.

To determine the cause of high nitrate and TDN levels in the middle of the watershed (Figures 17 and 18), we conducted an additional water quality survey along the mainstem of Meeting House Branch in May 2012. Since the pattern of elevated nitrate concentrations between 14th street and the golf course was present for all sampling dates during the current study and also present in 2002 when Stewart (2003) performed a water quality study on MHB (See Figure 13 and Stewart 2003), this suggests that there is a long-term source of nitrate that is discharging to the stream during baseflow conditions and this pattern must relate to land-use and stream channel conditions that were present at least a decade ago.

We sampled surface water at 11 points along the mainstem of Meeting House Branch on May 21, 2012. Each point was spaced approximately 200 m apart and sampling began at the downstream point adjacent to the golf course pond (approximately 1500 m upstream from the watershed outlet station). Sampling locations and total dissolved nitrogen concentrations are shown in Figure 20. The total dissolved nitrogen in stream water on May 21 showed a similar spatial pattern as observed in the seasonal data (Figure 17), with the most elevated levels occurring downstream of 14th Street. The smaller spacing between sampling points (relative to seasonal sampling) allowed us to better isolate the source of high dissolved nitrogen (predominantly nitrate) to the reach along Crooked Creek Road (Planters Walk neighborhood). Since the increase in dissolved nitrogen occurred upstream of the 2775 m seasonal sampling site (based on seasonal data- see Figure 18) and was not noticeable at the 2900 m sampling site in May 2012, the input must be between the reach that exists between 2900 and 2775 m upstream of the watershed outlet (Figure 21). The large increase in TDN along this reach suggests a large input of nitrogen to the stream in this area. If the TDN concentration increase was due to a leaking sewer line, presumably there would be a corresponding increase in chloride concentrations here. However, the stream chloride concentration data are similar to background groundwater concentrations, suggesting that wastewater alone could not be the primary cause of the large increase in dissolved nitrogen along this reach. Since this sampling and the seasonal sampling were conducted during predominantly baseflow conditions it is likely that the source of elevated nitrogen along this reach is related to groundwater inputs that contain elevated nitrogen. The question remains: what is the source of these elevated nitrogen concentrations in this stream reach?

If it is assumed that the groundwater table and groundwater hydraulic gradients mimic the land surface topography, then it is possible to determine an approximate source area for groundwater recharge that could feed this stream reach. Based on these assumptions, the possible land area that groundwater recharge originates in and flows to this stream reach is indicated in Figure 22. Based on the land use in this drainage area, there are a few possible sources of nitrogen to this reach including a sewer line, residential fertilizer, pet waste, agricultural fertilizer, and organic sediments along the incised reach. The seasonal TDN concentrations approximately double between the 2900 and 2700 m sampling points suggesting a large discrete input of nitrogen, which would not be likely from residential fertilizer alone (also, the increase is present year round and residential fertilizer is generally applied seasonally). Along the reach there are three residences on the west side of the stream at 2008, 2010, and 2012 Crooked Creek Road. These homes were built in 1988 (2008 and 2012) and 1997 (2010). It is less likely the inputs are coming from the east side where there is only one residence on 313 Mary Beth Road and there is an extensive forested buffer between the residence and the stream. Although it is possible that residential fertilizer could contribute nitrogen to this reach, the elevated high dissolved nitrogen levels that persist along the reach suggest a larger source. Based on the evidence, these high nitrogen levels may originate in the farmfield upgradient from the reach. Assuming the groundwater underlying that field discharges to the stream and based on an approximation that the hydraulic gradient mimics the land surface slope, some simple calculations based on Darcy's Law ($V=K/n(dh/dl)$) for a sandy surficial aquifer suggest that it could take groundwater from that field on the order of 10 years to discharge to this stream reach. As mentioned earlier, this region has relatively permeable sediments (Figure 9) and elevated groundwater inputs. It is also possible that stream channel incision along this reach has resulted in deeper groundwater tables and groundwater may bypass riparian buffers, less treatment and uptake of nitrogen can occur for these incised buffers. Future work will aim to isolate the source of this nutrient impairment.

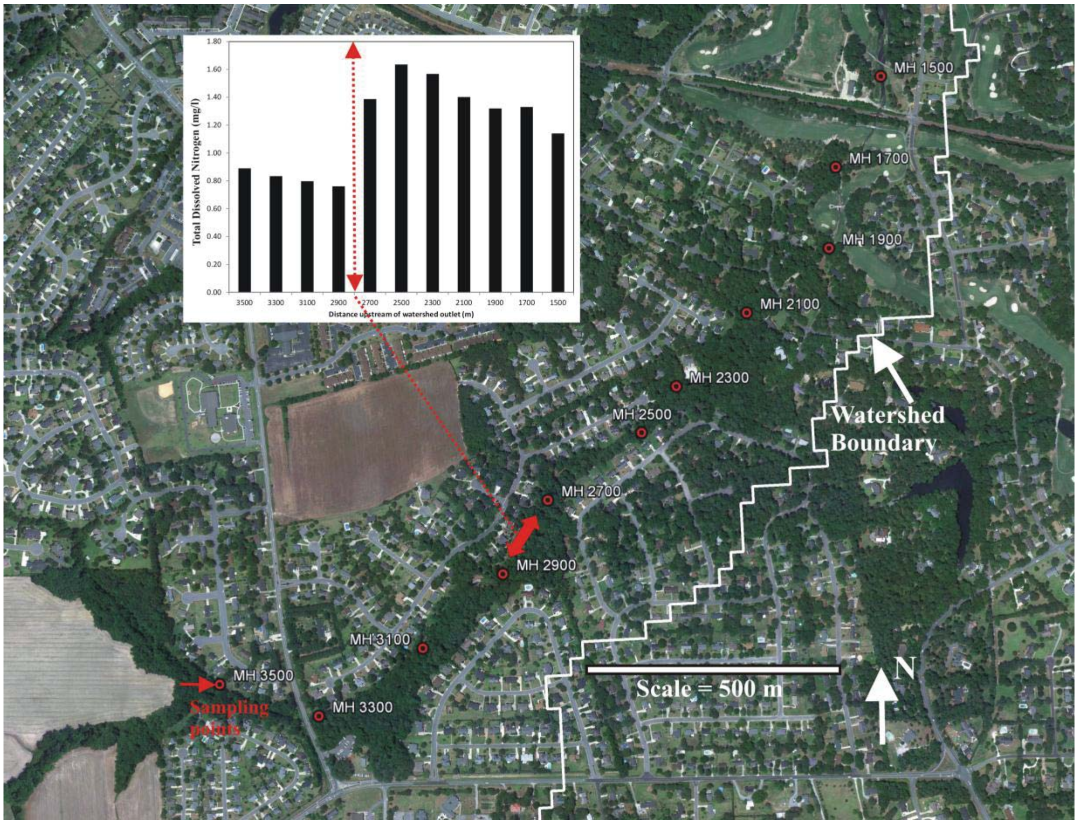


Figure 22. Spatial sampling to help isolate area of high nitrogen loading to stream. The reach between 2900 and 2700 is where the nitrogen concentrations increased almost two-fold.

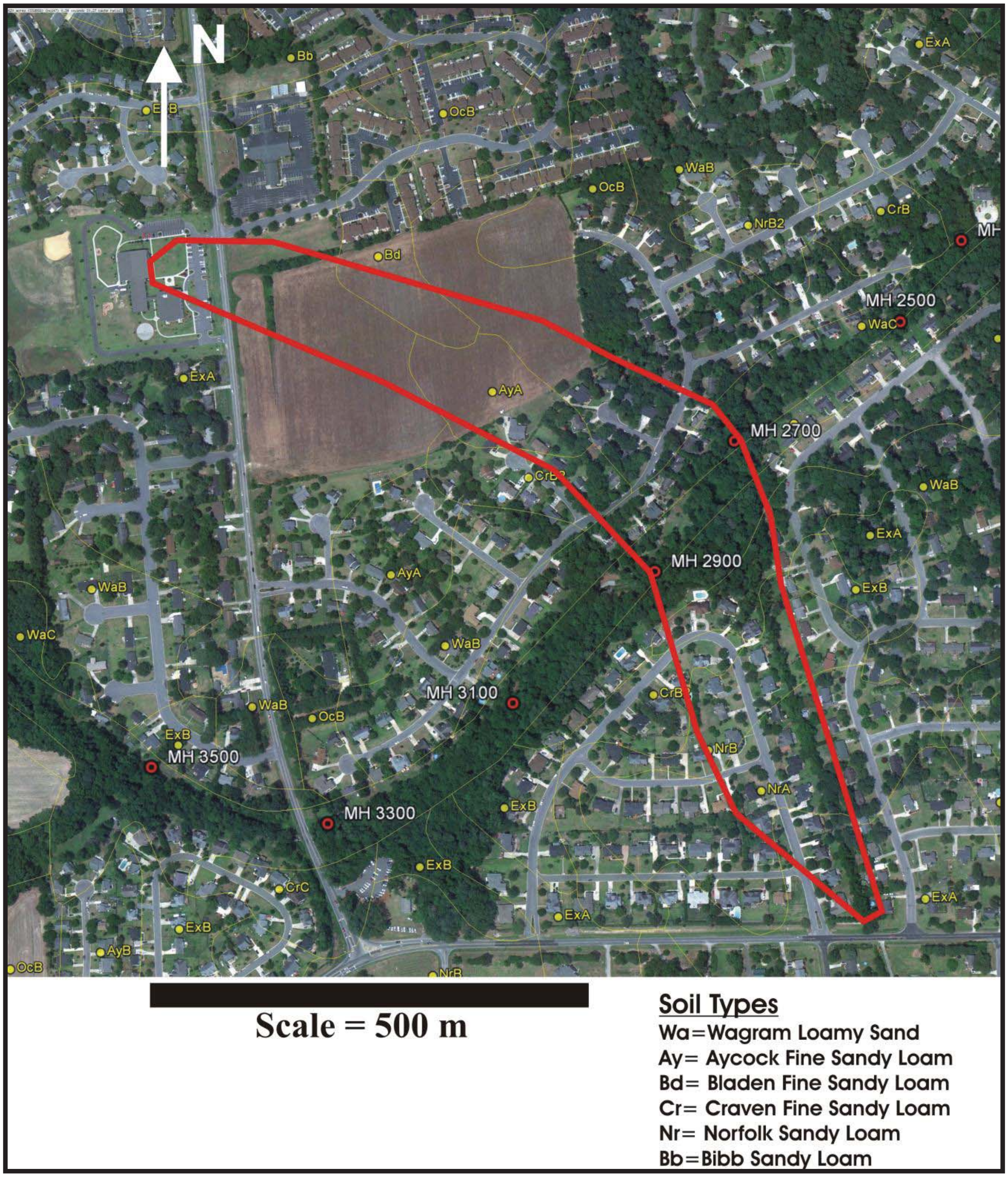


Figure 23. Approximate potential drainage area for the stream reach between 2900 and 2700. This is based on the land surface topography from the USGS topographic quadrangle. The large farm field off of 14th street falls within the drainage area and is one possible source for elevated nitrogen in groundwater draining to the stream.

To evaluate the effectiveness of riparian buffers to reduce nitrogen inputs to streams in the watershed we installed temporary piezometers in a variety of buffers (locations are shown in Figure 14). Buffers were characterized based on the Rheinhardt et al. (2007) approach (modified in O'Driscoll et al. 2008) and ten piezometers were installed in buffers that received low scores (range: 42.8-79.4) and were considered "bad" or poor quality riparian buffers and ten were installed along buffers that received high scores (range: 85.5-96.6) and were considered "good" buffers. The groundwater underlying buffers was sampled on May 21, 2012 and analyzed at the Central Environmental Laboratory. Overall, the median groundwater TDN concentration for all sites was 1.39 mg/l and the stream TDN was 1.31 mg/l on this date, indicating that the groundwater discharging from these sites has dissolved nitrogen levels that are elevated enough to explain the stream water dissolved nitrogen concentrations. Although in-stream processing of nitrogen is likely, the groundwater inputs are exerting a dominant control on surface water dissolved nitrogen levels, at least during baseflow conditions. Along stream reaches that have impaired buffers, it is likely that elevated nitrogen inputs can occur (Figure 23). However, the source groundwater nitrogen concentrations may vary across the watershed, if groundwater nitrogen concentrations are low prior to entering a poorly functioning buffer this is less of a problem than if groundwater nitrogen levels are elevated.

In general, there is a lack of shallow groundwater quality data for the Greenville area and for the Coastal Plain surficial aquifer, therefore it is difficult to quantify the extent of nutrient enrichment in the surficial aquifer without more groundwater quality data. Because groundwater in the surficial aquifer may take decades to drain to regional streams a better understanding of shallow groundwater quality, age dating of groundwater and surface water, stream-groundwater interactions, riparian buffer effectiveness, and in-stream processing is needed to understand the spatial variation in surface water quality in the region. Urban development of the watershed has likely affected groundwater recharge over the last several decades and more work is needed to characterize these changes, since groundwater ultimately discharges to the stream and changes in recharge processes can affect stream water quality and quantity. Our data suggests that past land-use, specifically agriculture, may still have a large influence on stream water quality, even though residential and urban land-use currently dominate the watershed. If this is the case, better characterization of the history of land-use change is needed to understand water quality in recently urbanized Coastal Plain watersheds. Puckett et al. (2011) recently published a paper on the legacy effect of agricultural fertilizer on nitrogen concentrations in surficial aquifers throughout the U.S. and their results suggest that it could take decades to centuries for the effects of intense application of agricultural fertilizers to migrate through surficial aquifers and these effects will likely influence stream nitrogen concentrations for long periods into the future.

Figure 24. Groundwater total dissolved nitrogen concentrations measured for riparian buffers that scored high (85.5-96.6) and were considered to be in "good" functional condition and for those that scored low (42.8-79.4) and were considered to be in "bad" functional condition.

Temporal Variability of Water Quality

For the four seasonal sampling events, median stream NO_3-N concentrations were the highest during the dormant season (October=0.65 mg/l; February=0.61 mg/l) and lowest during the growing season (March=0.41 mg/l; July 0.48 mg/l). Total dissolved nitrogen showed similar patterns of higher medians during the dormant season and the greatest variability across sites occurred during the fall (Figure 24). Temporally, TDN concentrations showed more seasonal variability than chloride concentrations (Figure 25), suggesting biological controls on TDN. Other studies in the region suggest the chloride concentrations along MHB are similar to natural streams in the region (Kuenzler et al. 1977, Stewart 2003) and groundwater chloride concentrations found in the surficial aquifer in the region. Wastewater generally has elevated levels of chloride, leaking sewer lines may be indicated by reaches with elevated chlorides. However, along the reaches with elevated nitrate concentrations, chloride concentrations were generally stable, suggesting that wastewater inputs are not the primary reason for elevated nitrates along the reach. However, minor leaks of wastewater may be difficult to detect because of dilution by groundwater inputs and future work could aim to better quantify the potential of leaking sewer lines to affect water quality in MHB watershed.

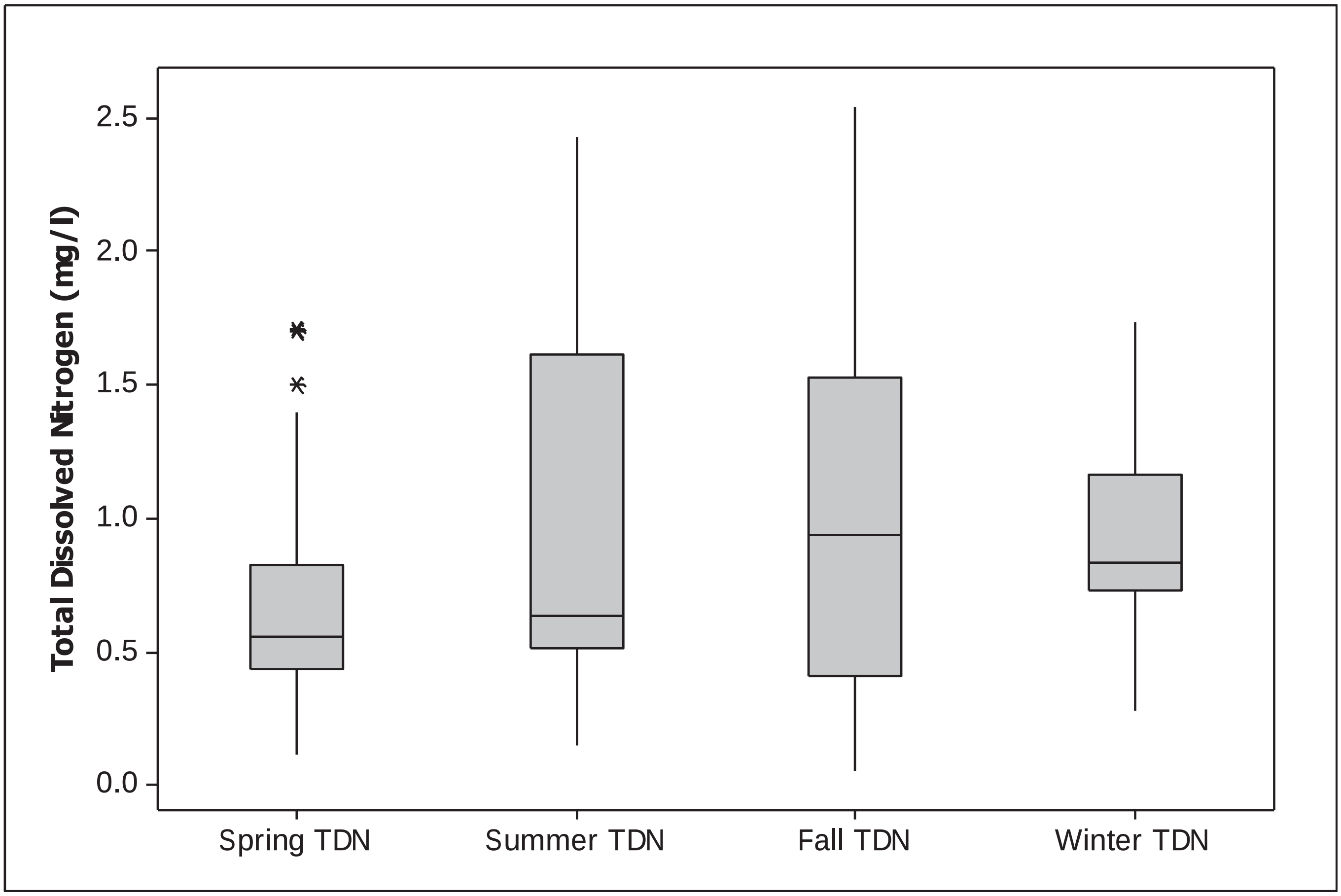


Figure 25. Seasonal variations in surface water total dissolved nitrogen concentrations.

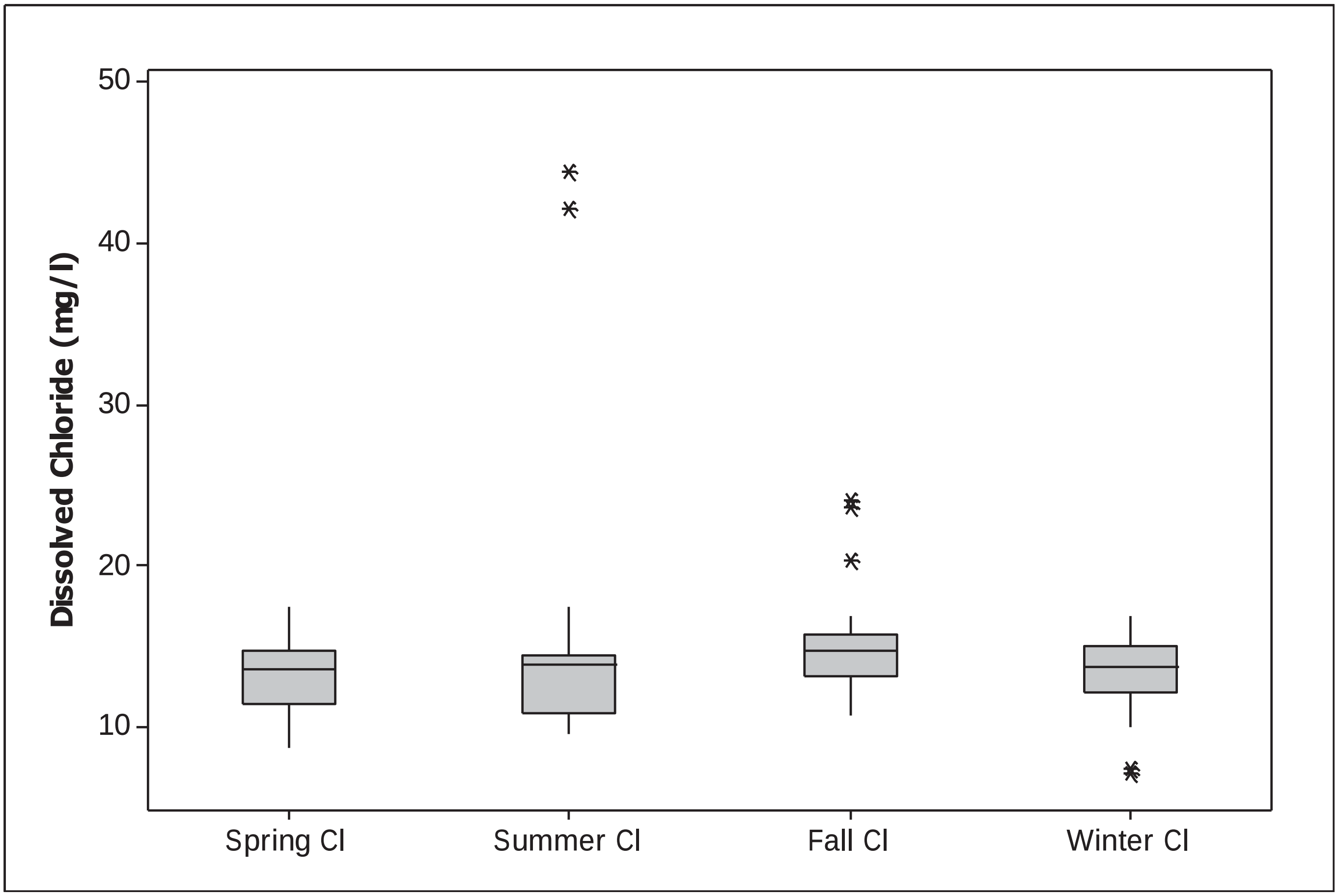


Figure 26. Seasonal variations in surface water chloride concentrations.

Stormwater data collected during two storms in September 2011 and March 2012 suggest that the source of total dissolved nitrogen (mainly nitrate) is predominantly from groundwater, since the rainfall inputs generally diluted the dissolved nitrogen during both storm events (Figure 26). The median baseflow total dissolved nitrogen concentration was 1.08 mg/l and the median stormflow total dissolved nitrogen concentration was 0.80 mg/l for these events. It is important to mention that even when diluted by incoming precipitation, the stream water still contained elevated nitrogen concentrations. As mentioned previously, in this region atmospheric deposition may also contain elevated levels of nitrogen (NADP, 2012). A Mann-Whitney test showed the median stormflow and baseflow total dissolved nitrogen concentrations were significantly different (at p=0.06). Although most stormwater outfalls remain dry during baseflow conditions, at one site (MHB Upper Outfall) close to the farm field on Charles Boulevard and 50 m downstream of the monitoring station (MHB 4075), the stormwater outfall flowed during dry conditions prior to the storms and the concentrations of total dissolved nitrogen were elevated (1.1-2.1 mg/l TDN). It is possible that former (or active) farmfields in the watershed are still draining groundwater with elevated nitrogen concentrations to the streams, and this problem may be exacerbated by old tile drains that short-circuit riparian buffers.

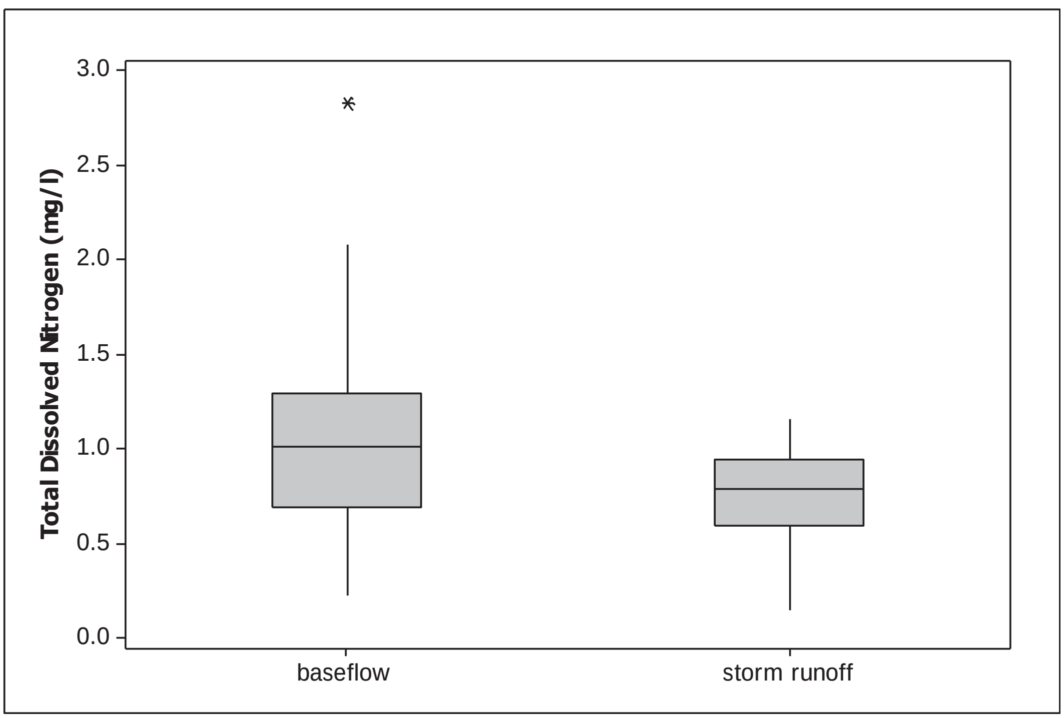


Figure 27. Storm runoff was sampled at ten locations (8 along the streams and two stormwater outfalls) during two storms in September 2011 and March 2012. Prior to storm events baseflow was sampled at the same locations. Total dissolved nitrogen was elevated during baseflow (groundwater-fed) conditions, in contrast to storm runoff conditions following precipitation events. These data suggest a groundwater source for elevated nitrogen inputs to the stream.

Although PO_4 was typically present at low concentrations in stream water throughout the watershed, stormwater sampling revealed that it became elevated during storm events (Figure 27) and differences between baseflow and storm runoff concentrations were statistically significant (at $p<0.05$). Other studies have shown that PO_4 tends to bind to sediments and is more mobile during storm events (e.g. Sharpley et al. 2008). Assuming phosphorus limitation, the boundary for mesotrophic to eutrophic conditions in freshwater is 0.075 mg/l (US EPA 2000). During baseflow conditions, median phosphorus concentrations were 0.01 mg/l for all sites. However, for six of the 19 storm samples PO_4 concentrations were greater than 0.075 mg/l. Similarly, total suspended sediment (TSS) concentrations were elevated during storm events. The median TSS concentration measured in streams and stormwater outfalls during storm events (in September 2011 and March 2012) was 0.19 mg/l and during baseflow (prior to storms) the median TSS concentration at these sites was 0.006 mg/l.

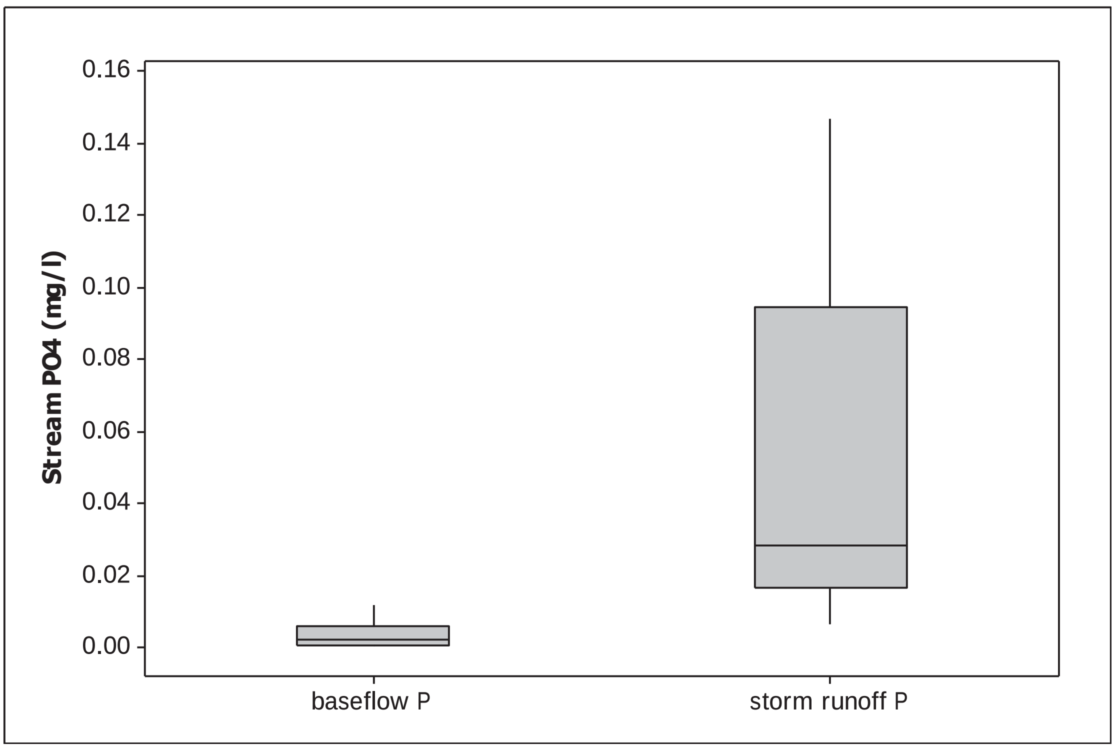


Figure 28. Storm runoff was sampled at ten locations (8 along the streams and two stormwater outfalls) during two storms in September 2011 and March 2012. Prior to storm events baseflow was sampled at the same locations. Orthophosphate (PO4) was elevated during storm runoff conditions following precipitation events, in contrast to baseflow (groundwater-fed) conditions. These data suggest that phosphorus is more mobile during runoff events.

Summary of Problem Areas and Potential Restoration Sites

On June 20, 2012, we performed a field survey to identify potential restoration and BMP sites. Overall, we visited 21 potential sites and these are documented in Figure 28 and the accompanying Table 6. Site photos are included in **Appendix I**. There are numerous opportunities in the watershed to reduce stormwater inputs, improve water quality, improve channel stability and reduce erosion and sediment transport. In addition to the opportunities specified in Table 6, many residences in the watershed have rooftops that drain directly to driveways and generate runoff that is delivered directly to streams, resulting in elevated stormwater runoff. In these cases, disconnecting impervious areas (e.g. roofs to driveways) and allowing for diffused flow over vegetated areas would allow for infiltration and water quality improvement. In addition, rain gardens or rainwater cisterns can help to hold more storm runoff on sites and/or increase groundwater recharge and can also reduce the use of potable water for irrigation within the watershed.

Most neighborhoods in the Meeting House Branch watershed have wide roadways, "Green Streets" could reduce runoff in these neighborhoods. These usually include narrowing the roadway in short sections to create bioretention cells on the sides of the road. This has also been shown to effectively calm traffic. Permeable pavement can also be incorporated into the roadway edges to infiltrate runoff directly from the roadway. These "Green Streets" tend to also be aesthetic, though likely more expensive than the other suggestions we have listed.

At site 10 (Figures 28 and 29), the effects of urban runoff on sandy stream channels is most evident. Extreme erosion has resulted in an extensive stabilization effort that includes tons of riprap to impede further migration of a nickpoint and reduce channel migration and bank erosion in the Planters Walk neighborhood. Based on the extreme degradation of this reach, an intense restoration effort would be required and the root cause of the erosion (urban stormwater runoff) would need to be reduced to provide a reasonable chance of restoration success. Slightly downstream of this reach, the stream dissolved nitrogen levels increased by approximately two-fold. It is possible that a stream reach restoration along this reach (between 2900 and 2700 m upstream of the watershed outlet) could help reduce groundwater nitrogen inputs to the stream and improve the riparian buffer's ability to regulate nitrogen inputs to the channel. This type of restoration could have multiple benefits and could help lower nitrogen exports from the basin.

Healthy riparian buffers can help reduce nitrogen inputs to streams. Along some reaches the riparian buffers are of poor quality and may have reduced ability to retain/remove nitrogen from groundwater. In some cases, urban runoff flows directly through buffers as overland flow, bypassing the potential for subsurface treatment. Improvements in buffer condition can help improve water quality.

Along many stream reaches it is evident that bank vegetation has been mowed or cut and this practice likely reduces channel stability, increases bank sediment transport, and may affect vegetative uptake of nutrients. A policy of limited removal/mowing of riparian vegetation could reduce some bank erosion, but may slightly increase flood risk.

Fortunately, a combination of dilution and nutrient uptake/transformations in the golf course pond, channel and pond sediments, and possible in-stream processing, help to reduce nitrate and total dissolved nitrogen concentrations downstream of the pond at Brook Valley Golf Course. If the golf course pond has not been dredged, it likely holds a record of sediment deposition over the last 50 years. Future work on the treatment efficiency of the pond could help elucidate the mechanisms responsible for improving water quality. Small ponds or in-stream wetlands along the main channel or tributaries may have similar water quality effects and may be useful BMPs.

Throughout the Meeting House Branch watershed, segments of the stream channel have high densities of discharge pipes and culverts that can discharge runoff with little to no treatment. During storm events total suspended sediments and phosphorus concentrations become elevated throughout the watershed. These pipes short circuit the riparian buffer systems and water is delivered directly to the stream with minimal treatment. Many of the pipes are of unknown origin and removal of these pipes would improve water quality and could reduce stormwater inputs. Since the origin of the pipes is often unknown, their removal may affect property owners. A characterization of the pipes could help to determine the consequences of their removal.

Stream channel cross-sections and channel observations suggest that bank sediment erosion is a problem along some reaches. Since urban stormwater runoff is the root cause of these problems, efforts to reduce urban runoff inputs to channels could improve stream health. Although we did not assess stream ecological metrics, it is likely that stream organisms respond to the changes in habitat (due to the spatial variability of water quality and stream bank erosion) and future work could assess the biological response to urbanization within this watershed.

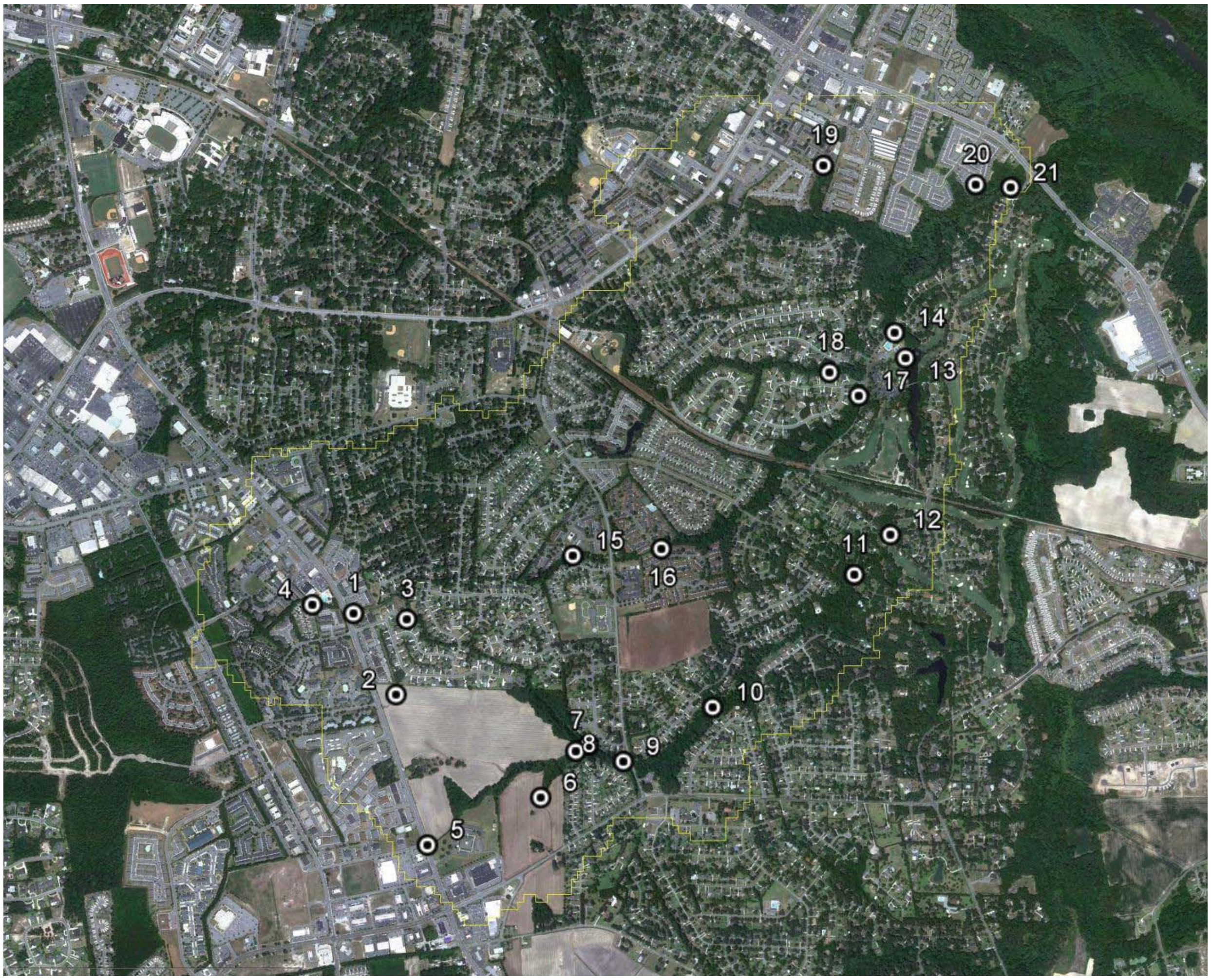


Figure 29. Twenty one potential restoration sites identified throughout the Meeting House Branch watershed. Coordinates and potential restoration actions are found in Table 1.

Site	Description	Latitude	Longitude	Potential Restoration Action	Potential Effect of Restoration
1	Upper Headwaters-parking lot near Charles Blvd.	35° 34.697	77° 21.327	Floodplain wetlands, parking lot BMPs	sediment and floodwater storage, water quality improvements
2	Upper Headwaters- cropfield near Charles Blvd.	35° 34.512	77° 21.193	Flashboard risers, agricultural BMPS, offline storage, floodplain wetlands	sediment and floodwater storage, water quality improvements
3	Upper Headwaters-Cantata neighborhood	35° 34.686	77° 21.175	Floodplain wetlands	sediment and floodwater storage, water quality improvements
4	Upper Headwaters-Colindale apartments	35° 34.715	77° 21.445	Enlarge bioretention	reduce stormwater inputs, water quality improvements, reduce erosion
5	Upper Headwaters-near church and Charles Blvd.	35° 34.168	77° 21.100	Flashboard risers, agricultural BMPS, offline storage, floodplain wetlands	sediment and floodwater storage, water quality improvements
6	Upper Headwaters-cropfield off Firetower	35° 34.283	77° 20.782	Flashboard risers, agricultural BMPS, offline storage, floodplain wetlands	sediment and floodwater storage, water quality improvements
7	Upper Headwaters-below cropfield off Firetower	35° 34.391	77° 20.685	Flashboard risers, agricultural BMPS, offline storage, floodplain wetlands	sediment and floodwater storage, water quality improvements
8	Mid Watershed-near Tuckahoe Rd.	35° 34.405	77° 20.650	Level spreaders, reduce concentrated flows	reduce stormwater inputs, water quality improvements, reduce erosion
9	Mid Watershed-near 14th St.	35° 34.369	77° 20.550	Level spreaders, reduce concentrated flows	reduce stormwater inputs, water quality improvements, reduce erosion
10	Mid Watershed-Planters Walk	35° 34.498	77° 20.299	Rip rap at nickpoints (already in place)	stabilize channel, reduce erosion
11	Mid Watershed-near King George Rd.	35° 34.811	77° 19.904	Level spreaders, reduce concentrated flows. Plug holes in bridge.	reduce stormwater inputs, water quality improvements, reduce erosion
12	Mid Watershed-Golf Course	35° 34.905	77° 19.803	Bank stabilization and tree planting	stabilize channel, reduce erosion
13	Lower Watershed-Bell Branch confluence	35° 35.315	77° 19.769	Daylight buried channel, construct floodplain wetlands	reduce stormwater inputs, water quality improvements, reduce erosion
14	Lower Watershed-Oxford Rd. and Golf Course	35° 35.374	77° 19.802	Level spreaders, reduce concentrated flows	reduce stormwater inputs, water quality improvements, reduce erosion
15	Bell Branch Headwaters- Windy Ridge	35° 34.841	77° 20.707	Floodplain wetlands or bioretention	reduce stormwater inputs, water quality improvements, reduce erosion
16	Bell Branch Headwaters- Quail Ridge	35° 34.861	77° 20.455	Floodplain wetlands or bioretention	reduce stormwater inputs, water quality improvements, reduce erosion
17	Bell Branch - Mid Watershed-Oxford Rd.	35° 35.225	77° 19.901	Channel stabilization, floodplain wetlands, reduce concentrated flows	reduce stormwater inputs, water quality improvements, reduce erosion
18	Bell Branch Trib. - Kensington and Bloomburg	35° 35.278	77° 19.986	Floodplain wetlands, bioretention, offline storage	reduce stormwater inputs, water quality improvements, reduce erosion
19	Bell Branch Trib. - Cherry Court	35° 35.760	77° 20.015	Floodplain wetlands, bioretention, offline storage	reduce stormwater inputs, water quality improvements, reduce erosion
20	Copper Beech	35° 35.723	77° 19.577	Repair gully near downed tree near detentionn pond	reduce stormwater inputs, water quality improvements, reduce erosion
21	Lower Watershed-sewer line	35° 35.718	77° 19.477	Film observed near exposed sewer line- survey to determine if leaks	water quality improvements

Table 6. Potential restoration sites and restoration actions for Meeting House Branch sites shown in Figure 27.

Figure 30. Photos taken on June 21, 2012 of a stream stabilization effort along Meeting House Branch (site 10 in Table 2). This reach along Crooked Creek Road in the Planters Walk subdivision is likely the most impaired in the watershed.

Recommendations and Future Work

Overall, it is evident that urban runoff generated from impervious areas in the Meeting House Branch watershed has resulted in stream impairment including: bank erosion, channel migration, channel aggradation, channel degradation, increased suspended sediment loads, increased flood risk, and water quality impairment. In addition, a past long-term monitoring study revealed that zinc was elevated in the lower portion of the watershed. Future work could aim to explain this problem.

Increased nutrient loading during baseflow conditions in the middle of the watershed is possibly related to fertilizer, wastewater inputs, poor riparian buffers, and/or impaired in-stream processing. It appears that past agricultural activities still have a legacy effect on groundwater nitrogen transport to the stream and it may take decades for this effect to naturally attenuate. Further studies would be needed to better isolate the cause of elevated nitrates in the mid-watershed and determine the age of affected groundwater and the residence time, to help develop solutions for this problem.

As previously mentioned, there are numerous opportunities in the watershed to reduce stormwater inputs, improve water quality, improve channel stability, reduce erosion and sediment transport, and develop a better understanding of the causes of stream impairment. These approaches include:

- Floodplain wetlands
- Offline storage and bioretention areas
- Parking lot BMPs
- Green streets
- Flash board risers and other agricultural BMPs
- Level spreaders
- Bank stabilization and tree planting
- Daylighting buried channels
- Stream reach and riparian buffer restorations
- Vegetation management along buffers
- Disconnecting rain gutters from driveways; rain gardens and cisterns
- Groundwater and surface water quality monitoring
- Biological assessment and monitoring
- Golf course pond monitoring and sediment study
- Sewer line leak detection surveys
- Illicit pipe and stormwater outfall characterization and removal

The scope of this study was to evaluate potential impairments to Meeting House Branch and its tributaries and identify potential restoration approaches. The City of Greenville recently commissioned a pilot watershed study of the Meeting House Branch watershed that will be published in the coming year and can complement the current study. This study was conducted by W.K. Dickson and Co., Inc. (Raleigh, NC) to evaluate stormwater management in the MHB watershed and to serve as a guide for assessing other watersheds in the Greenville area. A draft water quality monitoring plan has been developed through this City of Greenville project that can provide a basis for long-term monitoring in this watershed and surrounding watersheds. A long-term monitoring network can provide baseline data to better isolate, characterize, and manage the effects of current and future land-use change on water resources. Once finalized, this report can be obtained from the City of Greenville.

Future work will aim to implement some of the recommended restoration efforts documented in the current study. We will work with the City of Greenville to determine the feasibility of these actions and seek external funding for their implementation.

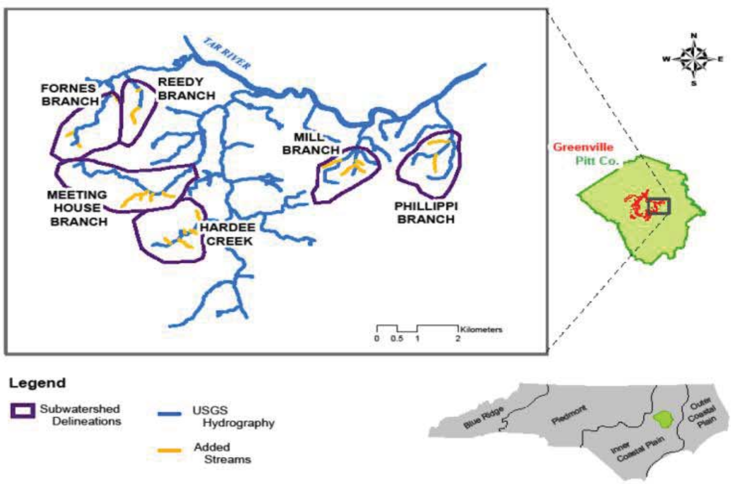
Acknowledgments

First, we would like to thank Dr. Mark Brinson. During the project he passed away unexpectedly on January 3, 2011. He helped to develop this project and without his inspiration, guidance, and expertise it could not have been accomplished. He contributed greatly to advancing wetlands science across the globe and was at the forefront of linking the science of wetlands with wetland management. This project is another example of his numerous contributions to watershed and wetland management in eastern North Carolina. Working with Mark was a great pleasure and he is sorely missed. A number of earlier projects in collaboration with Mark focused on urban land-use effects on Greenville streams and several graduate students deserve recognition for their field work and research contributions including: Rob Howard, Emma Hardison, John DeLoatch, Heather Hutchinson, Jason Soban, and Cassandra Horton. On the current project, Colin Walker, performed most of the field and lab work and put a great effort into this research as a component of his M.S. thesis project. Undergraduate interns Wade Hopfer and Erica McCarthy also helped with field and lab work. Our technicians Jim Watson and John Woods were pivotal in providing technical support. The Pamlico Tar River Foundation provided field and administrative assistance that helped the project run smoothly. We owe gratitude to the City of Greenville, and W.K. Dickson for providing advice and sharing data. In addition, we thank the City of Greenville and homeowners in the MHB watershed for allowing site access on numerous occasions throughout the study. Finally, we thank the EEG program for funding and supporting this project, we are confident it will lead to improved watershed management.

URBAN LAND-USE EFFECTS ON COASTAL PLAIN RIPARIAN ZONE HYDROLOGY

EAST CAROLINA UNIVERSITY— GEOLOGICAL SCIENCES AND BIOLOGY DEPARTMENTS

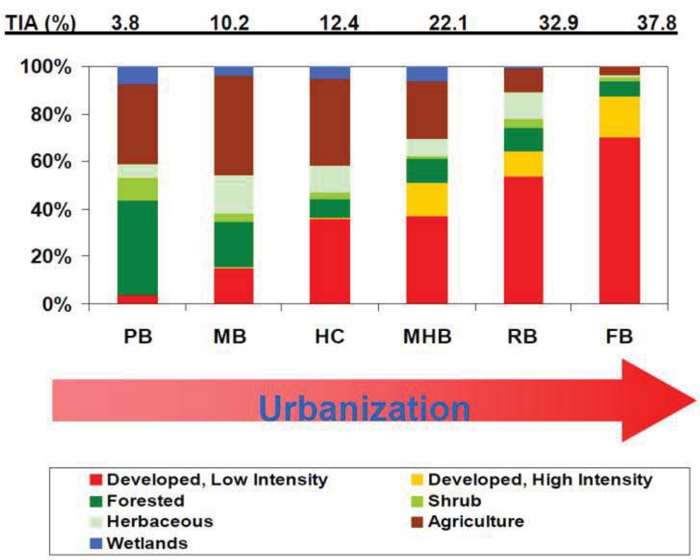
STUDY SITES



URBAN STREAM

Fornes Branch, Total Impervious Area (36.7%)

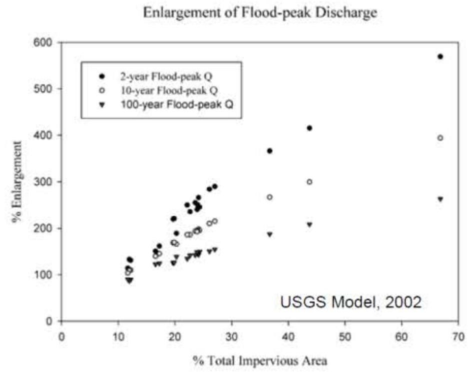
LAND-USE

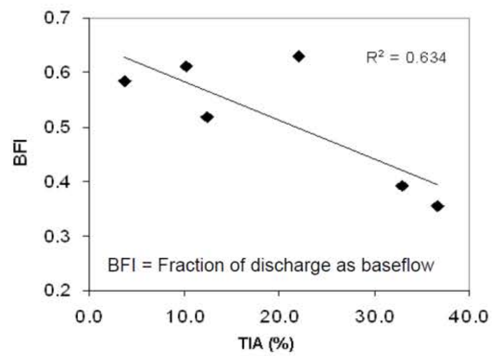


RURAL STREAM

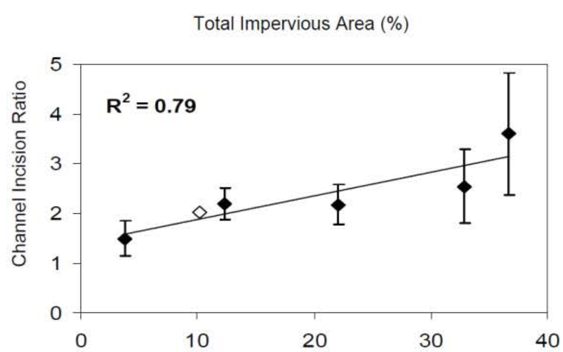
Hardee Creek, Total Impervious Area 12.4%

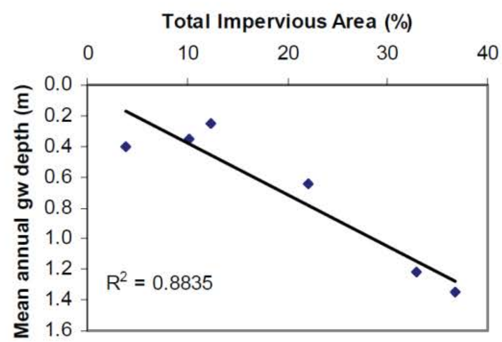
STORM PEAK INCREASE & BASEFLOW DECREASE WITH URBANIZATION





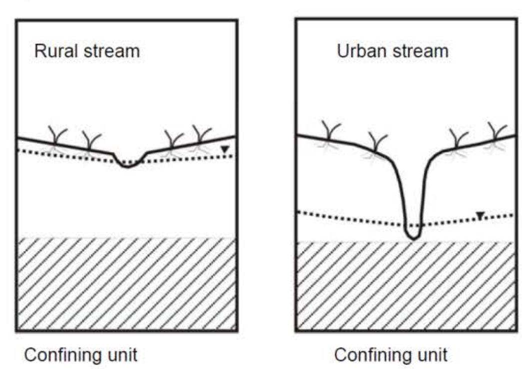
CHANNEL INCISION & DECLINE OF FLOODPLAIN GROUNDWATER LEVELS





Floodplain groundwater levels have declined in direct response to stormwater induced channel incision. The result is "riparian drought", a condition where floodplains are measurably drier. This condition affects floodplain function and along these low-order Coastal Plain streams is directly related to the magnitude of watershed impervious area.

Typical stream cross-section for low-order Coastal Plain streams



Outreach:

Community presentation: Pitt Community College, July 26, 2012

Fork Swamp/Swift Creek Workshop

Thursday, July 26, 2012
5:00 p.m. – 7:30 p.m.

Pitt Community College
Leslie Building, Room 143

5:00	Open House
6:00	Welcome/Introductions **James Rhodes, Pitt County Planning**
6:10	Project Overview **Chris Roessler, Baker Engineering**
6:40	Homeowner Best Management Practices **Mitch Woodward, NC Cooperative Extension**
7:10	Comparison of Stream Flow and Water Quality in Pitt County Watersheds **Charlie Humphrey, East Carolina University**

Water Quality Patterns in Meeting House Branch Watershed, Pitt County, NC

MEETING HOUSE BRANCH, GREENVILLE, NC

Funded through NC Department of Justice, Environmental Enhancement Grant

East Carolina University

M. O'Driscoll, Dept. of Geological Sciences, ECU
C. Walker, Dept. of Geological Sciences, ECU
C. Humphrey, Environmental Health Sciences , ECU
E. Bean, Dept. of Engineering, ECU
H. Jacobs-Deck, Pamlico-Tar River Foundation

Sediment and Nutrient Pollution in MHB Watershed

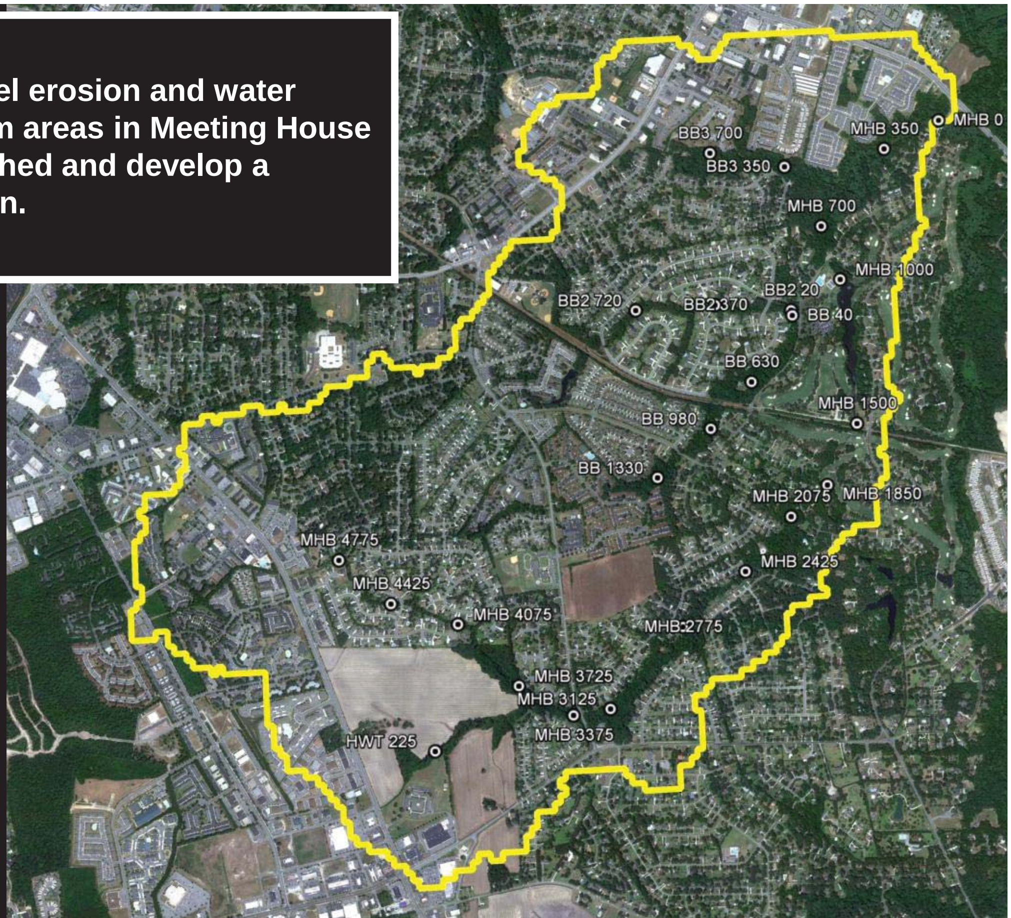
- **Sediment Problems-** Greatest pollutant in streams
- Sources: agriculture; urban development
  - chokes streams
  - fills in ponds, ditches, and streams
  - buries aquatic vegetation and prevents sunlight penetration

- **Nutrient Problems-** Nitrogen (N) and Phosphorous (P)
- Sources: fertilizers; detergents; wastewater
- **Eutrophication:** nutrients increase algal growth, algal blooms block sunlight, dead algae consume oxygen during decomposition
  - kills off submerged vegetation
  - lowers dissolved oxygen, affects aquatic life

- Problems in MHB watershed- Related to urban stormwater inputs and non-point sources.

Goal:

Identify channel erosion and water quality problem areas in Meeting House Branch watershed and develop a restoration plan.



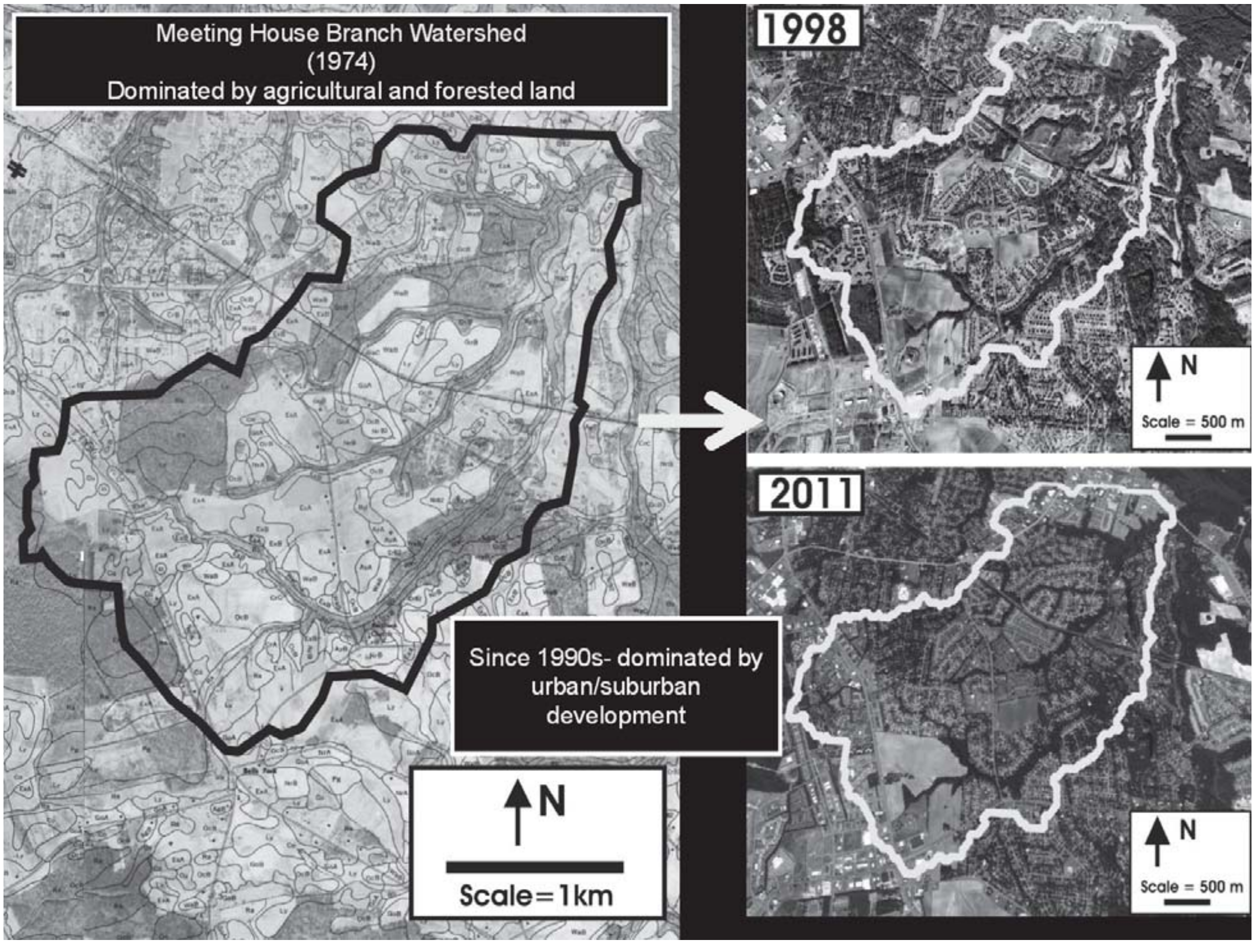
Water Quality Sampling:

Seasonal (2011-2012)
(4 times)

Storm-events
(Sep 2011, March 2012)

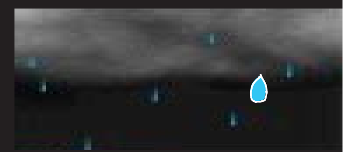
25 locations

Sampled for nutrients and other variables


Meeting House Branch Watershed
(1974)
Dominated by agricultural and forested land
Since 1990s- dominated by urban/suburban development
N
Scale=1km
1998
N
Scale = 500 m
2011
N
Scale = 500 m

Urban Land Use Effects on Stream Hydrology

- Expansion of impervious surfaces
  - alters sediment and water supply to stream.
- Increases storm discharge peak.
- Stream channel incision/widening is common.
- Loss of aquatic habitat, degraded stream ecology and water quality, and channel enlargement.

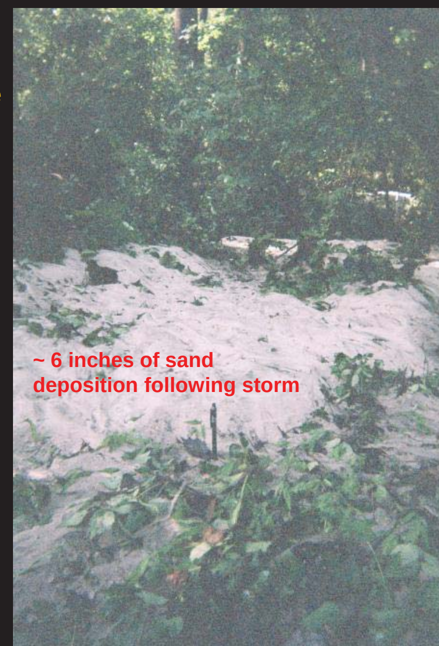


W. Wright Rd.
Greenville, NC

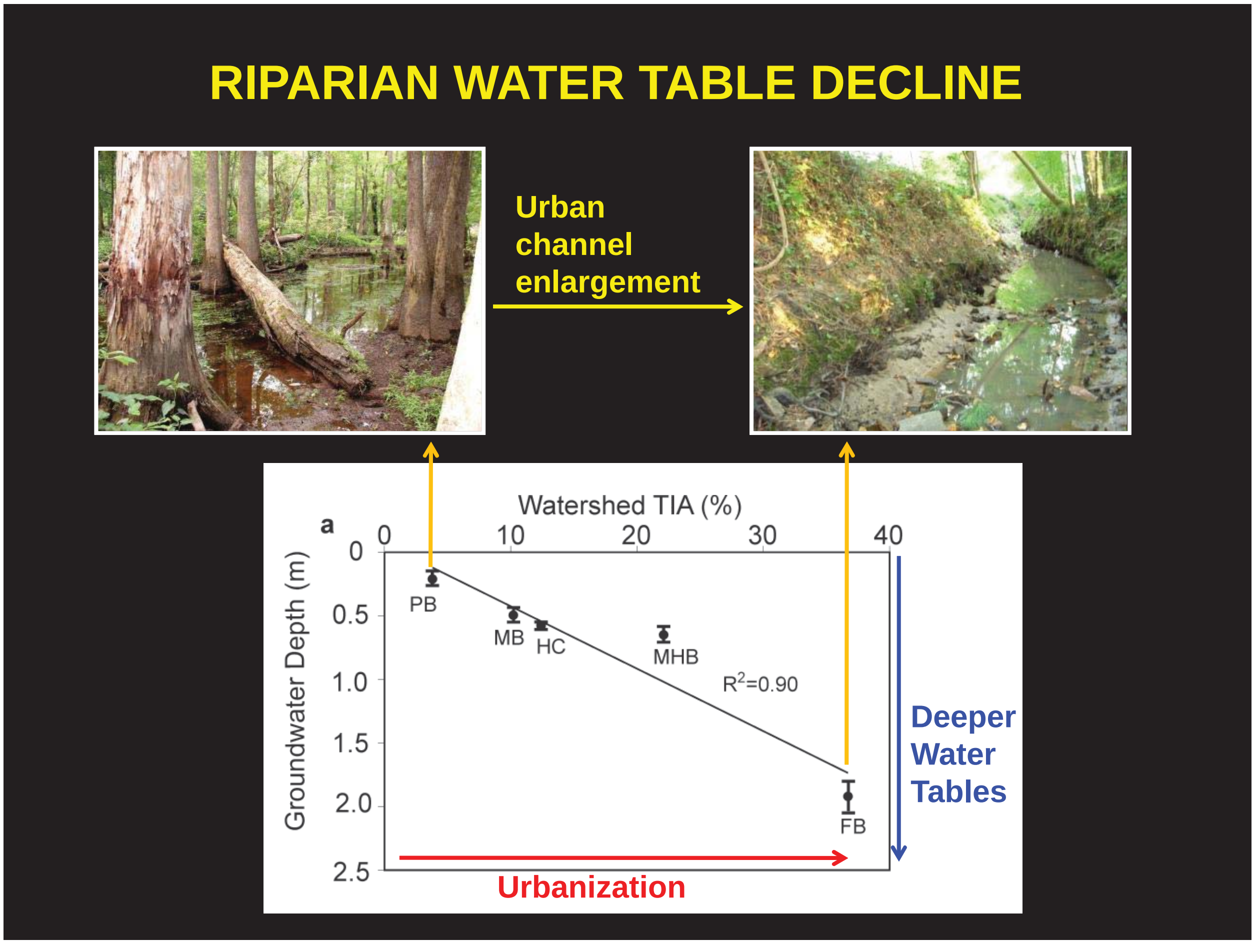
Reedy Branch,
Greenville, NC

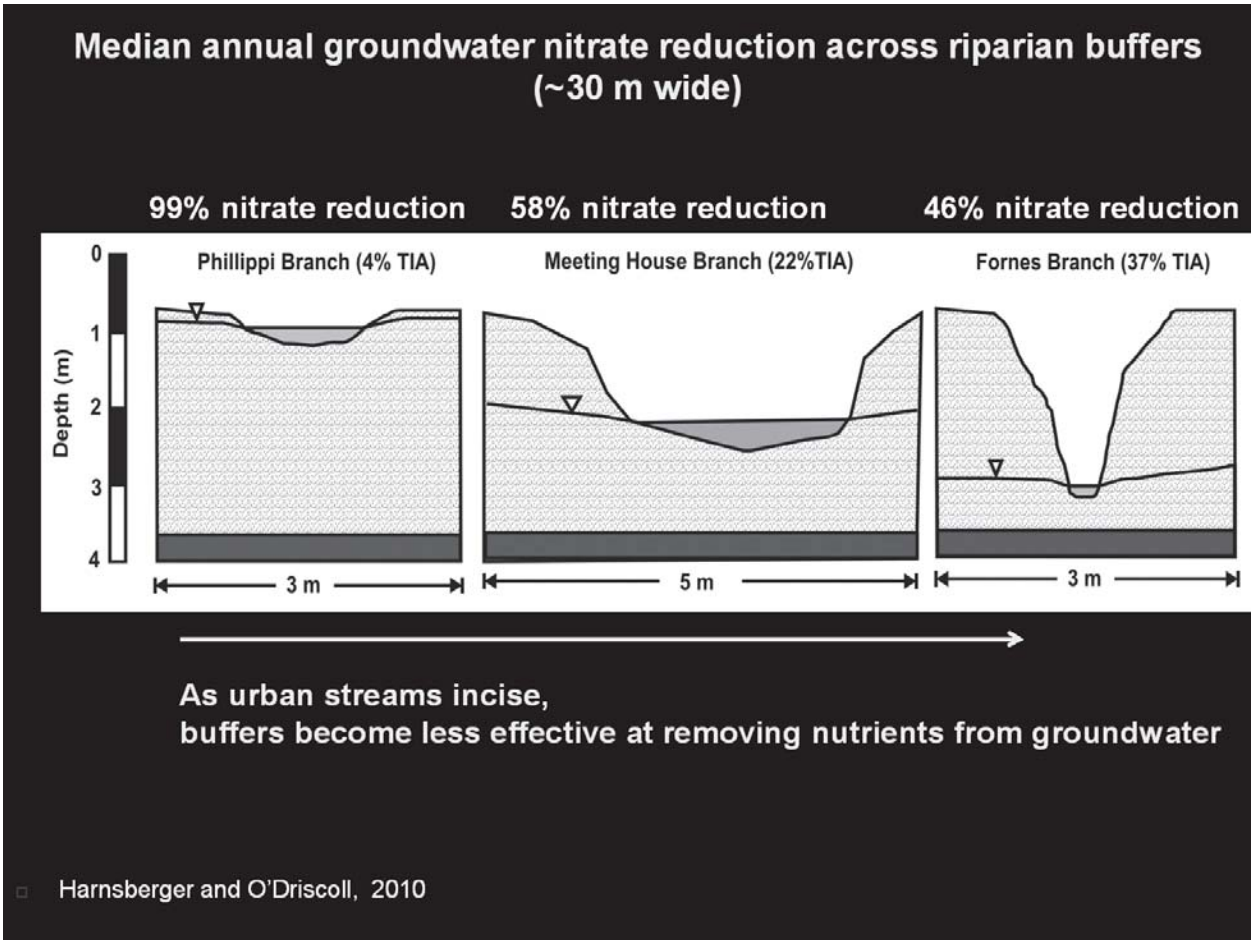
Active Erosion in MHB Watershed- Related to stormwater inputs

Erosion near 14th street



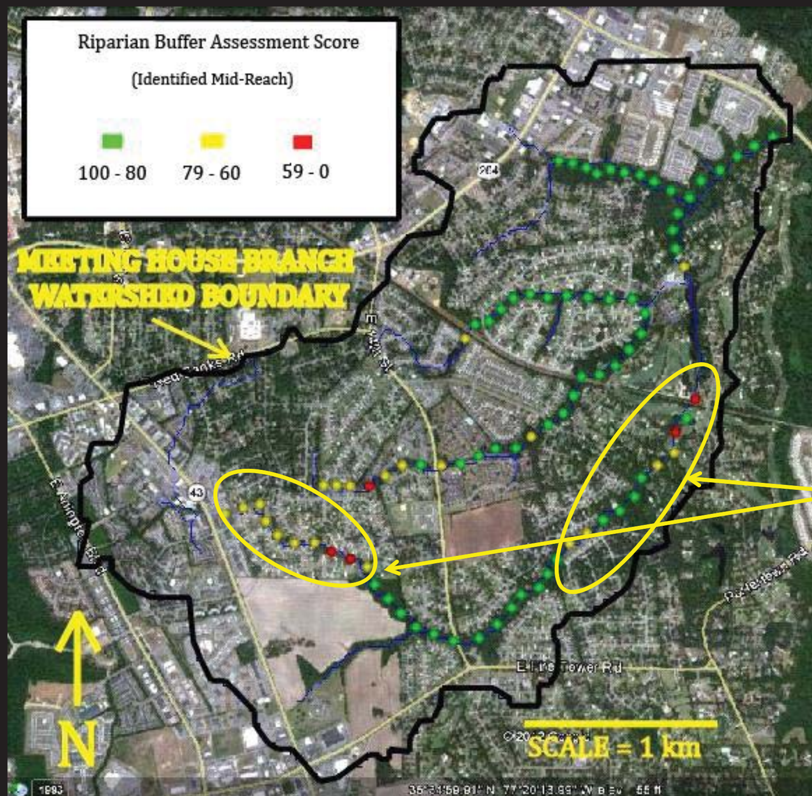
Deposition in floodplain downstream


RIPARIAN WATER TABLE DECLINE
Urban channel enlargement
Watershed TIA (%)
Groundwater Depth (m)
a
0
10
20
30
40
0
0.5
1.0
1.5
2.0
2.5
PB
MB
HC
MHB
FB
R2=0.90
Deeper Water Tables
Urbanization

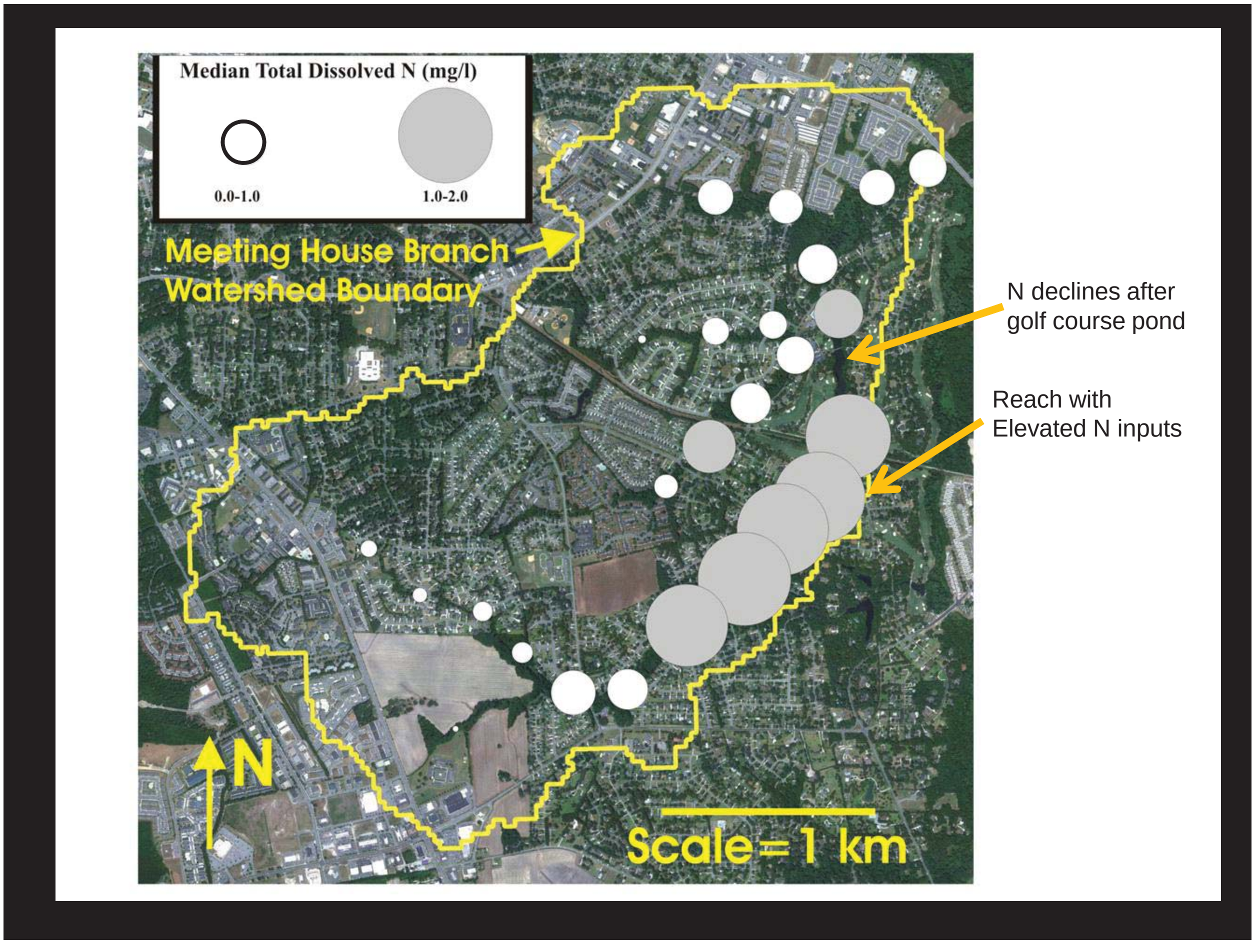

Median annual groundwater nitrate reduction across riparian buffers (~30 m wide)
99% nitrate reduction
58% nitrate reduction
46% nitrate reduction
Phillippi Branch (4% TIA)
Meeting House Branch (22%TIA)
Fornes Branch (37% TIA)
Depth (m)
0
1
2
3
4
3 m
5 m
3 m
As urban streams incise,
buffers become less effective at removing nutrients from groundwater
Harnsberger and O'Driscoll, 2010

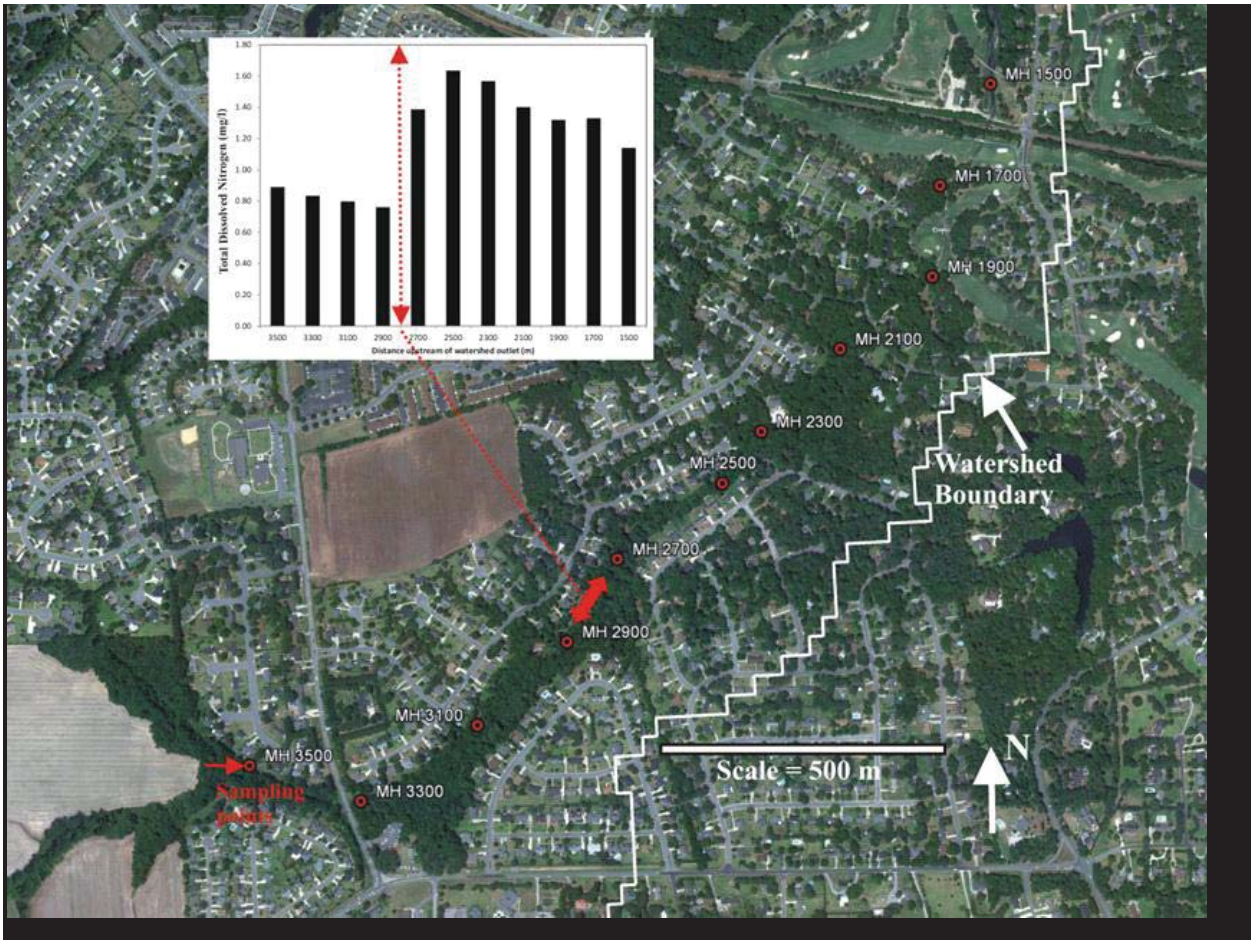
Riparian Buffers

Assessment using Rheinhardt et al. 2005 method



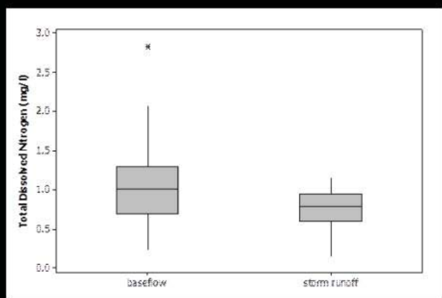
Poor
Buffers
Along MHB


Median Total Dissolved N (mg/l)
0.0-1.0
1.0-2.0
Meeting House Branch
Watershed Boundary
N declines after golf course pond
Reach with Elevated N inputs
N
Scale=1 km



Total Dissolved Nitrogen (mg/l)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
3500
3300
3100
2900
2700
2500
2300
2100
1900
1700
1500
MH 1500
MH 1700
MH 1900
MH 2100
MH 2300
MH 2500
MH 2700
MH 2900
MH 3100
MH 3500
MH 3300
Watershed Boundary
Scale = 500 m
N

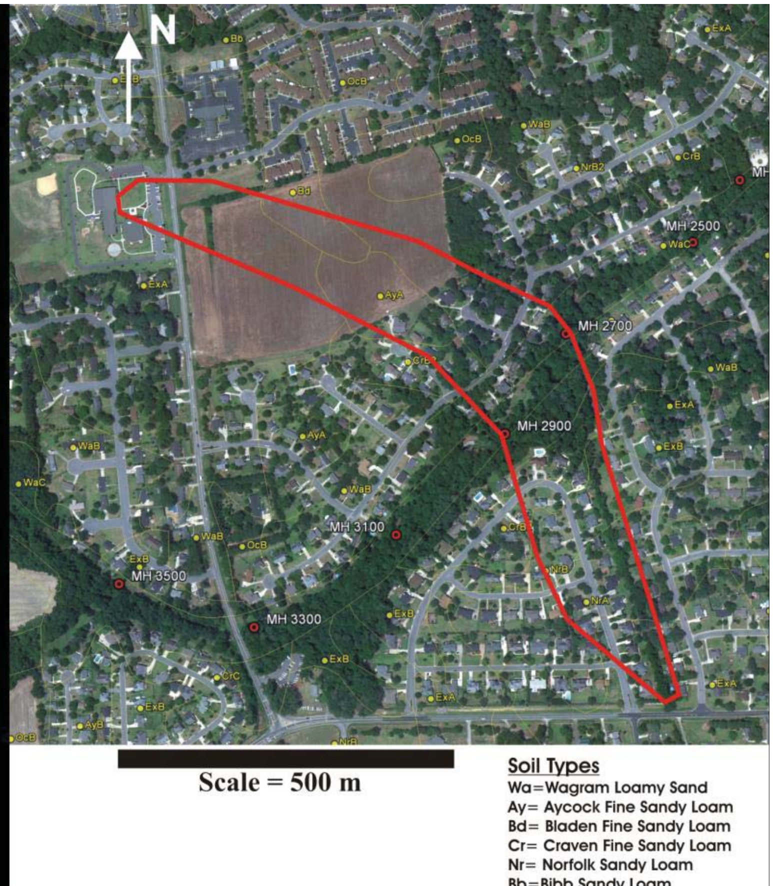
Possible sources of Elevated Nitrogen in MHB



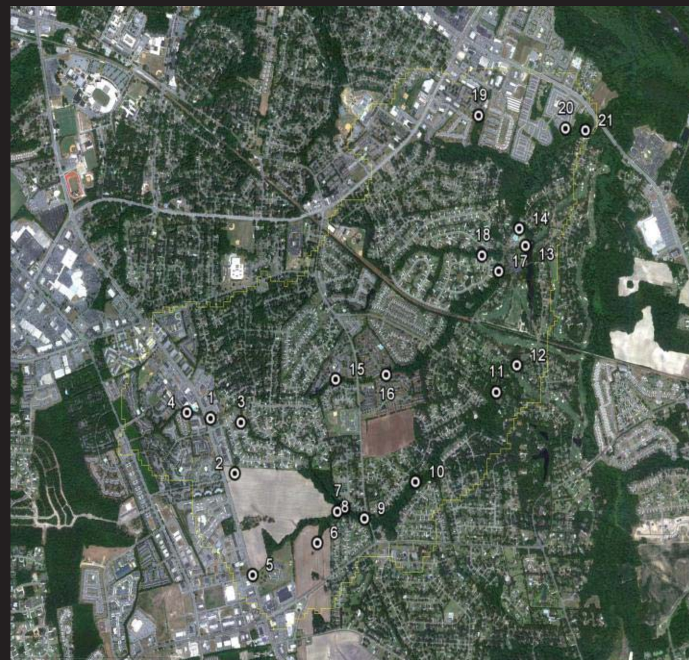
- Groundwater is source of N

Possibly derived from:

- Agricultural fertilizer
- Residential fertilizer
- Leaking sewer lines?
- Exposed organic soils
- Poor riparian buffers

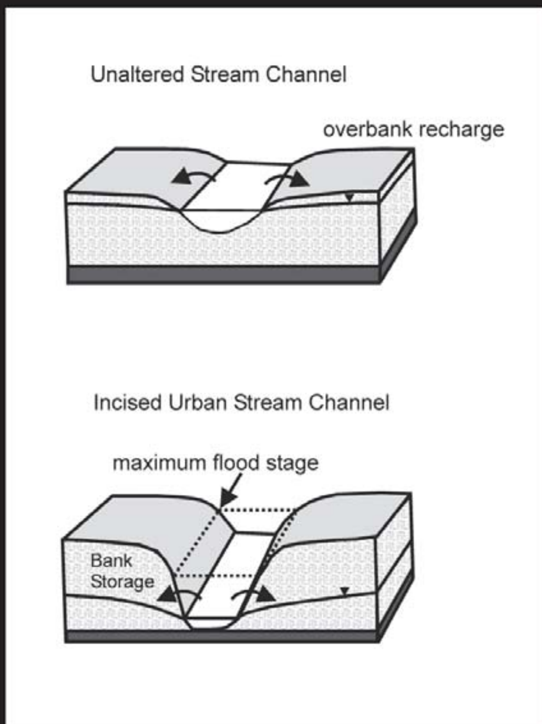


Improving Water Quality and Reducing Erosion in Meeting House Branch Watershed



- Identified 21 potential restoration sites (draft EEG report)
- Future work will aim to implement BMPs and restoration efforts

CONCLUSIONS



- Urban channel incision can :
  - reduce sediment and nutrient retention
  - reduce riparian stormwater storage
- Nutrient concentrations in urban streams related to:
  - Non-point source pollution from current and past land-use
  - Impaired riparian buffers
  - Impoundments
- Urbanization can impair stream water quality- restoration is expensive and sometimes impractical.
- Improved stormwater management and LID can help reduce future problems -less costly over long-term.

THANKS FOR YOUR ATTENTION!
QUESTIONS?

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APPENDIX O

CITY OF GREENVILLE

CITYWIDE WATER QUALITY MONITORING PROGRAM FRAMEWORK

WKD # 20100074.00.RA

May 4, 2012

Prepared for

City of Greenville
1500 Beatty Street
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Prepared by
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919/782/0495

Appendices

1. Introduction

The City of Greenville (City) is currently taking proactive measures to address flooding issues and stormwater concerns that may be intensified by their recent rapid growth and development. The City plans to identify and prioritize existing flooding, water quality, maintenance and improvement needs through the development and implementation of Stormwater Master Plans. The primary goal of this Watershed Inventory and Master Plan - Pilot Study Project is to create standard operating procedures (SOPs) for Master Plan development.

As part of this project, the City has requested that a city-wide water quality monitoring program framework be developed that can be implemented following funding and/or grant award, or as changes in regulatory requirements develop. Monitoring programs are essential to determining water quality trends and assessing impacts on a targeted water body associated with changes in a watershed. A water quality monitoring plan will allow the City to evaluate water quality and its response to development, land use changes, stormwater runoff or other nonpoint source issues. The data gathered will also be useful for developing or refining watershed management strategies that address water quality.

The purpose of the framework is to measure and characterize status and long-term water quality trends and to assess watershed conditions within the City. In conjunction with the monitoring, it is also important to track precipitation and land use or land management activities to determine potential variability in monitoring results. This document outlines the program objectives, framework design and components, monitoring parameters, and recommended sampling equipment needed to implement the program.

Objectives and Goals
The goal of this framework is to develop a city-wide water quality monitoring plan that will:

- establish baseline water quality conditions;
- measure and identify trends in water quality;
- detect new and emerging water quality problems;
- help meet regulatory compliance;
- provide data for developing future water quality models; and
- provide funding support (e.g. NC CWMTF and EPA 319)

2. Study Area and Background Information

There are 20 primary drainage features (named streams) located within Greenville's city limits and ETJ (study area). Of these, 16 drain into the Tar-Pamlico River Basin, and four drain into the Neuse River Basin (**Figure 1**). Nearly 81% of the total area encompassing the City of Greenville and its ETJ is located within the Lower Tar River Subbasin (HUC 03020103). The remaining 19% is located within the Neuse River Basin (HUCs 03020203 and 03020202). Much of the land within the study area is developed, with 41% of the area classified as residential. **Table 1** provides the results of a GIS analysis of land use for the study area based on City GIS data.

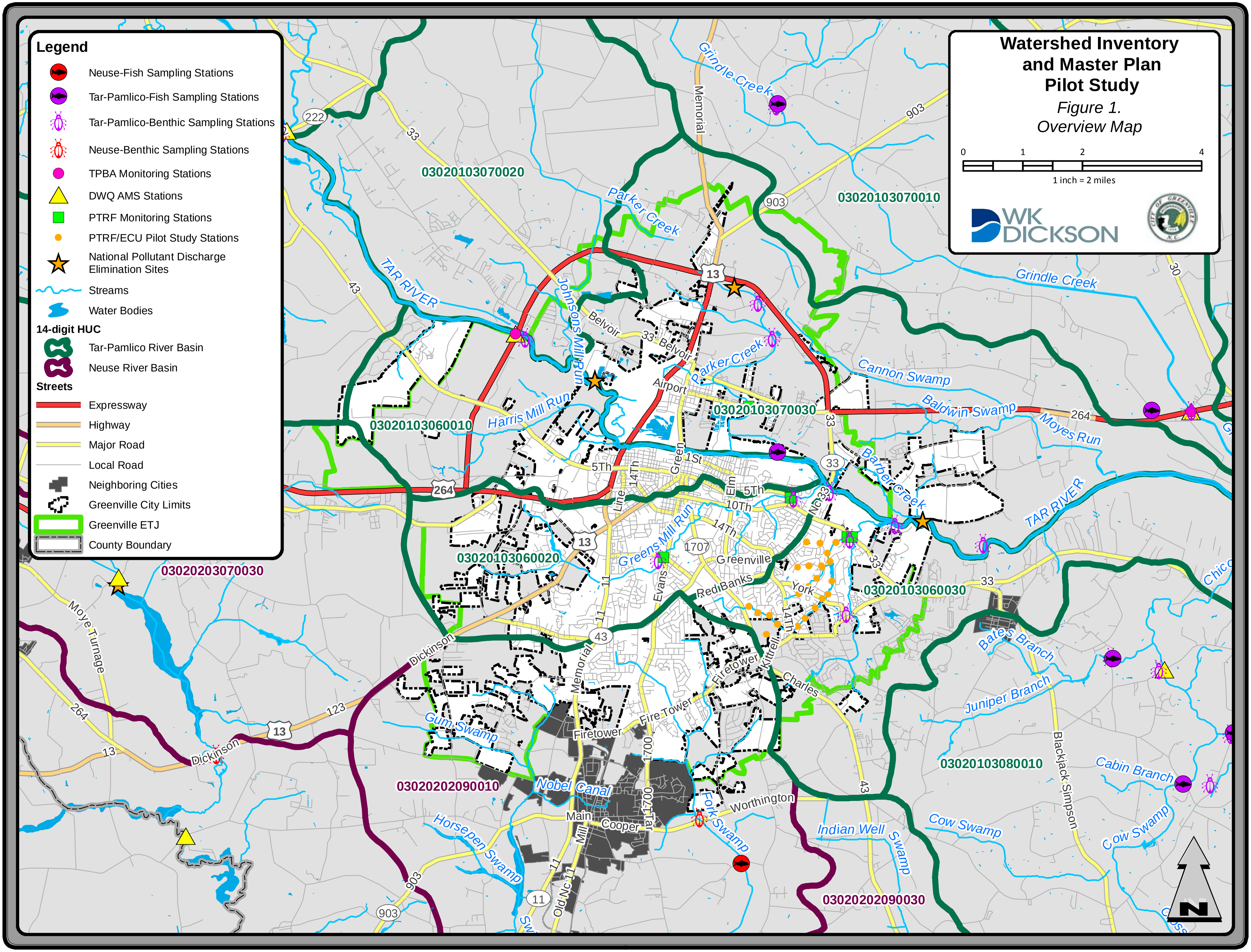

Watershed Inventory and Master Plan Pilot Study
Figure 1.
Overview Map
0 1 2 4
1 inch = 2 miles
WK DICKSON
Legend
Neuse-Fish Sampling Stations
Tar-Pamlico-Fish Sampling Stations
Tar-Pamlico-Benthic Sampling Stations
Neuse-Benthic Sampling Stations
TPBA Monitoring Stations
DWQ AMS Stations
PTRF Monitoring Stations
PTRF/ECU Pilot Study Stations
National Pollutant Discharge Elimination Sites
Streams
Water Bodies
14-digit HUC
Tar-Pamlico River Basin
Neuse River Basin
Streets
Expressway
Highway
Major Road
Local Road
Neighboring Cities
Greenville City Limits
Greenville ETJ
County Boundary
03020103070020
03020103070010
03020103070030
03020103060010
03020103060020
03020103060030
03020103080010
03020203070030
03020202090010
03020202090030
TAR RIVER
Grindle Creek
Parker Creek
Johnsons Mill Run
Harris Mill Run
Greens Mill Run
Cannon Swamp
Baldwin Swamp
Moyes Run
Barber Creek
Bates Branch
Juniper Branch
Cabin Branch
Cow Swamp
Indian Well Swamp
Fork Swamp
Nobel Canal
Gum Swamp
Horsepen Swamp
Memorial
Belvoir
Airport
Green
1St
5Th
14Th
Line
Elm
10Th
Greenville
Evans
RedBanks
York
Kittrell
Charles
Firetower
Fire Tower
Worthington
Main
Cooper
Mill
Tar
Old Nc 11
Dickinson
Moye Turnage
Blackjack Simpson
Nc 33
33
43
13
11
30
264
222
903
123
1700
1707

Table 1. Land Use

Landuse Category	Description	% of Total Area
Industrial		11%
Commercial		8%
Mixed Use/Office/Institutional		< 1%
Medical Core		< 1%
Medical Transition		< 1%
Office/Institutional/Medical		< 1%
Office/Institutional/Multi-Family		10%
High Density Residential	</=1/8 acre/parcel	6%
Medium Density Residential	1/4 acre/parcel	32%
Low Density Residential	1/2 acre/parcel	1%
Very Low Density Residential	2 acres/parcel	2%
Conservation/Open Space		22%
Right-Of-Way		5%

Physiography, Topography, and Relief

The study area is located in the Atlantic Coastal Plain Physiographic province, where the northeast portion is classified as alluvial/estuarine valleys, and the southwest portion is classified as terraces of the middle coastal plain. This region is characterized by flat land with gently rolling hills and elevations ranging from 154 to 0 feet. This province is underlain by shallow-marine, estuarine, shoreline and fluvial sediments and sedimentary rocks that have been deposited during changes in sea level (Horton 1991). The area is predominantly underlain by the Yorktown Formation, consisting of fossiliferous clay with varying amounts of fine sand.

Water Quality and Related Studies

DWQ Classifications

The North Carolina Division of Water Quality (DWQ) assigns surface water classifications to all waters within the state that are most appropriate for their best use. These classifications have associated water quality standards that state and federal agencies use as a tool to protect and manage surface waters. DWQ also assigns Integrated Reporting Categories that correspond to different levels of water quality standards attainment. DWQ assigns an Integrated Reporting Category to every assessed water body that ranges from Category 1(water quality standards are met), to Category 5 (impaired waters that requiring Total Maximum Daily Load (TMDL)). **Table 2** lists each stream located within the city limits and ETJ, their classifications, Integrated Reporting Categories, existing impairments, and bioclassifications.

Table 2. DWQ Classifications

Waterbody	River Basin	Classification[1,3]	Overall Integrated Report Category[2,3]	Bioclassification[4,5]
Baldwin Swamp	Tar-Pamlico	C; NSW	3c	
Barber Creek	Tar-Pamlico	C; NSW	3c	
Bell Branch	Tar-Pamlico	C; NSW	3c	
Bryan Creek	Tar-Pamlico	WS-IV; NSW	3c	
Cannon Swamp	Tar-Pamlico	C; NSW	3	
Fornes Branch	Tar-Pamlico	C; NSW	3c	
Greens Mill Run	**Tar-Pamlico**	**C; NSW**	**5**	**Severe**
Hardee Creek	Tar-Pamlico	C; NSW	3	Natural
Harris Mill Run	Tar-Pamlico	C; NSW	3c	
Johnsons Mill Run	Tar-Pamlico	WS-IV; NSW	3c	
Meeting House Branch	Tar-Pamlico	C; NSW	2	
Parker Creek	Tar-Pamlico	C; NSW	3	Poor
Reedy Branch	Tar-Pamlico	C; NSW	3c	
Sams Branch	Tar-Pamlico	WS-IV; NSW	3c	
Schoolhouse Branch	Tar-Pamlico	C; NSW	3c	
Tar River (From 030303/030305 boundary to Johnsons Mill Creek)	Tar-Pamlico	WS-IV; NSW	2	Excellent
Tar River (From Johnsons Mill Run to Greenville Raw Water Supply Intake)	Tar-Pamlico	WS-IV; NSW, CA	3c	
Tar River (From Greenville Raw Water Supply Intake to a point 1.2 miles downstream of the mouth of Broad Run)	Tar-Pamlico	C; NSW	2	
Fork Swamp	Neuse	C; Sw, NSW	3c	
Gum Swamp	Neuse	C; Sw, NSW	3c	
Pinelog Branch	Neuse	C; Sw, NSW	3c	
Swift Creek	**Neuse**	**C; Sw, NSW**	**5**	

[1] *C*: Aquatic Life, Secondary Recreation, Fres; *CA*: Critical Area; *NSW*: Nutrient Sensitive Waters; *Sw*: Swamp Waters; *WS-IV*: Water Supply IV - Highly Developed

[2] *Category 2*: All monitored uses are supporting or not rated and there are no impaired assessments in the AU.; *Category 3*: Monitored uses are not rated and there are no impaired assessments.; *Category 3c*: No data available to make any water quality assessments.; *Category 5*: There is at least one impaired assessment that requires development of a TMDL (s).

[3] *Source*: 2012 Draft Overall Integrated Report Categories GIS Data (http://portal.ncdenr.org/web/wq/ps/mtu/assessment#6)

[4] Bioclassification: Supporting = Excellent, Good, Natural, Good-Fair, Not Impaired or Moderate Stress; Impaired = Fair, Severe, Severe Stress or Poor

[5] *Source*: 2010 Tar-Pamlico Basinwide Water Quality Plan

DWQ's Biological Assessment Unit evaluates the water quality of rivers and streams using the biological communities of fish and benthic macroinvertebrates. Bioclassifications are assigned to sampled waters based on biocriteria developed from the sensitivity, diversity, and quantity of organisms that are found within flowing waters. The resulting bioclassifications range from Excellent to Poor, and are used to assess pollutant impacts, document water quality trends, and supplement other monitoring efforts and programs. The Biological Assessment Unit has collected samples within the study area along Greens Mill Run, Hardee Creek, Parker Creek, and the Tar River since 1985. Greens Mill Run and Parker Creek are classified as impaired due to bioclassifications of severe and poor, respectively. Bioclassifications of the four sampled streams are summarized in (**Table 2**)

DWQ Basinwide Planning

Basinwide planning is a watershed-based approach to managing and protecting the waters of North Carolina. A few of the primary goals of the planning are to identify water quality problems, restore impaired waters, and protect high value and unimpaired waters. DWQ develops basinwide water quality plans on a continuous basis for each of the major river basins in North Carolina. Water quality studies performed for the Neuse River and Tar-Pamlico Basinwide Water Quality Plans indicate that three of the twenty streams listed in **Table 2** received a poor impaired rating/classification. The following are excerpts from these plans that describe water quality from DWQ's "2010 Tar-Pamlico Basinwide Water Quality Plan" for Greens Mill Run and Parker Creek, and from the "Neuse River Basinwide Water Quality Plan" (2009) for Swift Creek:

> **Greens Mill Run** (HUC 030201030403), AU# 28-96, from source to Tar River, 7.3 miles is Impaired due to a Severe benthos bioclassification in 2004. Stream habitat conditions represent typical conditions in highly urbanized watersheds with very severe bank erosion and scour. Stream flow flashiness is apparent (e.g., high wrack lines, scour, severe bank erosion) and is indicative of highly impervious watersheds. Restoration efforts for Green Mill Run need to focus on both habitat and water quality improvements to significantly improve benthic bioclassifications. This stream is part of an EEP local watershed plan; more information can be found at: http://www.nceep.net/services/lwps/Tar-Pamlico/Middle_Tar_LWP_Files/Middle_Tar_Rehabilitation_Plans_Appendices/Green_Mill_Run_Rehabilitation_Plan.pdf. (p. 3.16)
>
> **Parker Creek** (HUC 030201030404), AU# 28-95, from source to Tar River, 7.3 miles are Not Rated based on a 2007 fish community sample (OF31). This site is Not Rated because criteria are still being developed to rate coastal plain streams; when these criteria are finalized this stream can then be back-rated based on the 2007 sample. The sample indicated an improvement in riparian vegetation and bank stability since the 2002 sample; a diverse and abundant fish community was seen for such a small channelized stream.
>
> In the summer of 2009, two benthic samples were taken upstream of OF31 to determine if stormwater from a specific property was contributing to water quality degradation. The samples indicated Poor ratings both upstream (SR 1579) and downstream (SR 1591) of the facility with impacted habitat in-stream and riparian

limitations likely caused by historic channelization and extreme fluctuations in hydrology (flashiness). The poor aquatic macroinvertebrate habitat conditions could not be directly linked to the property of interest. Stormwater runoff and altered hydrology are likely the main reason for degraded water quality in this subwatershed. This subwatershed drains the Pitt-Greenville Airport and Greenville's industrial areas. Parkers Creek will likely be listed as impaired on the 2012 303(d) list. (p. 3.16)

Swift Creek [AU# 27-97-(0.5)a1; C; Sw; NSW] from source to 5.3 miles upstream of Clayroot Swamp (19.3 miles) remains impaired for aquatic life due to a historic poor benthic assessment at station JB241. Fish site JF57 was sampled for the first time about 8 miles downstream from the historic JB241 station (NC 102). Fish could not be sampled at that NC 102 because the macrophytic growth was historically too dense to sample. The site could not be rated due to the fact that the criteria for Coastal Plain streams have not been completed. This segment of the stream was also channelized and received the second lowest habitat score of any fish community site in the Coastal Plain in 2005. Despite the habitat alterations, the fauna collected included many typical species found in Coastal Plain streams, however, no intolerant species were collected during this assessment period. This site should be ratable during the next assessment period. (p. 228)

Greens Mill Run Rehabilitation Plan

The Greens Mill Run Rehabilitation Plan was generated in 2005 for Phases 2 and 3 of the Local Watershed Plan for the Lower Tar River Subbasin as selected by the North Carolina Ecosystem Enhancement Program (EEP). The purpose of the plan was to develop a framework for watershed rehabilitation through investigations of land use trending, watershed modeling, and riparian field investigations. The plan identified potential restoration, enhancement, preservation, and BMP project locations.

DWQ Ambient Monitoring System

Statewide water quality data are collected through the DWQ Ambient Monitoring System (AMS), which follows the trend monitoring approach. This program has been active for over 30 years and consists of 323 active monitoring stations that provide long-term water quality information on specific water bodies. This network of stations is relatively static and covers 95 of the 100 North Carolina counties and all major river basins. Most stations are along rivers or streams and are generally located at bridge crossings or other locations that are easily accessible. The primary objectives of the AMS, as stated in NCDENR's (2004) Quality Assurance Project Plan (QAPP), are to:

- Monitor waterbodies of interest for determination of levels of chemical, physical, and bacterial pathogen indicators for comparison to a selection of the state's water quality standards and action levels;
- Identify locations where exceedances of water quality standards and action levels for physical and chemical indicators occur in more than 10% of samples/measurement (20% for coliforms);
- And identify long-term temporal or spatial patterns. (p.15, Section A)

A secondary objective of the AMS is to provide data, primarily as background or supplemental, to various Sections within DWQ to provide support for their respective programs. Such programs include, but are not limited to: Basinwide Water Quality Management Plan development, TMDL development, 303(d) and 305(b) reporting, and development of NPDES permit limits.

The Ambient Monitoring System measures a basic group of water quality indicators at each station that center on chemical, physical and bacterial pathogen characteristics of the subject water body. The core indicators include chemicals that can be cost effectively analyzed and that have current water quality standards in place. These standards may include numeric and narrative statements or criteria, and use designations (classifications). Additional site-specific indicators may be measured at a station, depending on known issues or concerns at the site. **Table 3** lists the core and site-specific water quality indicators measured at AMS stations.

Table 3. AMS Water Quality Indicators

Indicator Type	Core indicators	Site-specific indicators
Physical	Temperature Specific conductance Turbidity Total suspended solids (TSS) Stream flow severity	Salinity Secchi depth (transparency) Flow
Chemical	Dissolved oxygen (DO) Metals (arsenic, cadmium, chromium, copper, iron, lead, nickel, zinc, aluminum, and mercury)	Nutrients ($NH3$, $NO2 + NO3$, TKN, Total P) Fluoride Sulfate Manganese Color Oil and grease
Biological	Fecal coliform	Chlorophyll a
Other	Air temperature Cloud cover Wind velocity and direction 24 hour precipitation	

(Source: Table A6.1: Water Quality Indicators; NC AMS QAPP, December 2004)

Currently, there is only one active AMS station within the study area. This station is located along the Tar River at the US Highway 264 Bypass. However, DWQ did perform water quality sampling between 2003 and 2005 on Greens Mill Run at four different locations, for a total of twelve samples.

NPDES Discharge Monitoring Coalition Program

The Monitoring Coalition Program is a voluntary ambient monitoring program comprised of NPDES dischargers. The group of dischargers combines resources to collectively perform instream monitoring in lieu of the instream monitoring required by their respective individual permits. Members of the coalition work with NCDWQ to develop a network that strategically identifies monitoring locations downstream of outfalls. Additionally, sites are selected such that they fit in with the State’s AMS network without duplicating efforts. The two programs that cover the portions of the Neuse and Tar-Pamlico Basins affecting the City are the Tar-

Pamlico Basin Association (TPBA) and the Lower Neuse Basin Association (LNBA).

The TPBA has been monitoring thirty-seven stations within the Tar-Pamlico River Basin since March 2007. The Greenville Utilities Commission is a member of the association in regards to the Greenville WWTP; however, the City of Greenville is not a member. The sites are monitored monthly and include, but not limited to, collection of, the following parameters: temperature, dissolved oxygen, pH, fecal coliform, metals, nutrients, and turbidity. For a more detailed description of the monitoring plan, see the Memorandum of Agreement between the DWQ and the TPBA in **Appendix A**. Of the thirty-seven stations, only one is located within the study area, which coincides with the AMS station on the Tar River at the US Highway 264 Bypass.

The LNBA has been monitoring forty-eight stations within the Neuse River Basin downstream of Falls Lake since December 1994. The sites are monitored monthly and include collecting such parameters as fecal coliform, nutrients, dissolved oxygen, and metals. For a more detailed description of the monitoring plan, see the Memorandum of Agreement between the DWQ and the LNBA in **Appendix B**. There are currently no LNBA stations located on any streams within Greenville's city limits or ETJ.

Pamlico-Tar River Foundation (PTRF)
PTRF is a private, non-profit organization whose objectives are to protect, preserve, and promote the environmental quality of the Tar-Pamlico River and associated watershed. In 2010, the organization, in conjunction with East Carolina University (ECU), was awarded a contract to develop a comprehensive water quality restoration plan for the Meeting House Branch watershed. The project includes gathering and evaluating existing data, monitoring and analyzing collected data, identifying areas of impairment and causes, and indentifying and prioritizing potential stormwater BMP projects. It is anticipated that after completion of this project, all the remaining watersheds within the City of Greenville will be assessed using the same criteria as developed for Meeting House Branch.

PTRF has also been monitoring water quality at ten to thirty stations located within the Tar-Pamlico River Basin since 2005. Five of those stations have been located on streams within the city limits and ETJ of Greenville, with two stations located on Greens Mill Run, and one each on Meeting House Branch, Hardee Creek, and Parker Creek. The parameters sampled at these sites include: flow, rainfall, air temperature, water temperature, DO, pH, turbidity, TSS, conductivity, alkalinity, NH_3, NO_3, PO_4, copper, zinc, and lead. See **Figure 1** for station locations.

3. Monitoring Design

Monitoring Approach

The design of a successful monitoring program is dependent on the monitoring goals and objectives, availability of resources and funds, timeframe, and an understanding of the variability in the system being monitored. These factors must be considered when selecting a monitoring approach. A water quality monitoring framework may be based upon one of seven types of monitoring (MacDonald, 1991):

1. *Trend monitoring* – determines the long-term trend of a specific parameter, using measurements that are made at regular time intervals;
2. *Baseline monitoring* – used to characterize existing water quality characteristics and establish a data set for future comparisons;
3. *Implementation monitoring* – assesses whether proposed activities were carried out as intended; however, this monitoring does not include any actual water quality measurements;
4. *Effectiveness monitoring* –evaluates whether a specific activity had the desired effect;
5. *Project monitoring* – assesses the impact of a specific project;
6. *Validation monitoring* – evaluates data gathered to predict the effectiveness a specific parameter of a proposed water quality model ; and
7. *Compliance monitoring* –determines if specific water quality standards or criteria are being met.

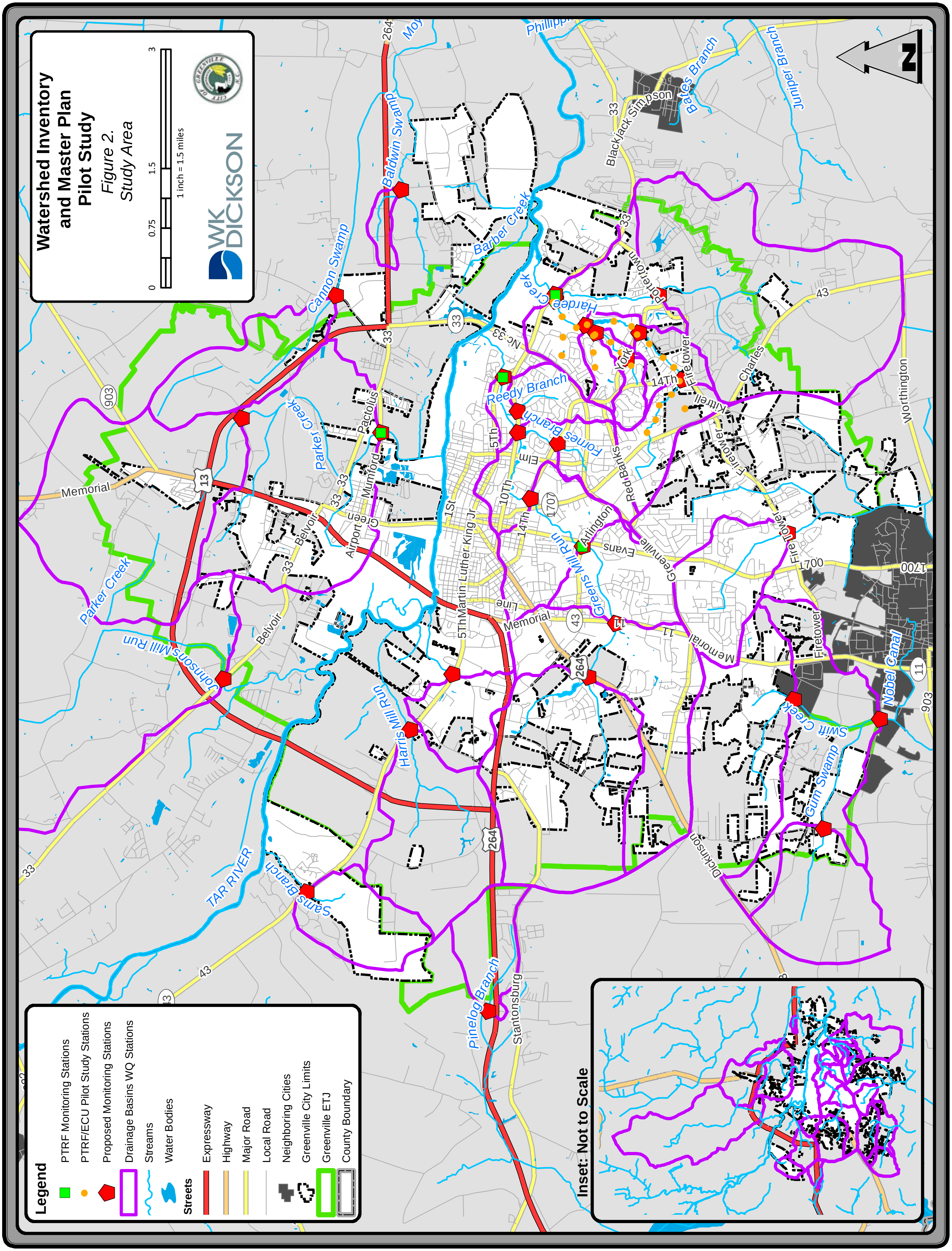
Because the primary objectives are to determine baseline conditions and trends in water quality, the most appropriate approach for this watershed is trend monitoring. This approach is intended to measure the physical and chemical conditions of water body at a specific point in time at regular intervals over time. It is also important to carefully monitor or track land use and management activities as to provide a basis for explaining measurable temporal or spatial variations in water quality. Precipitation and discharge are additional factors that may cause variability among parameter measurements, and therefore, should also be tracked.

Monitoring Locations

Long-term monitoring is often performed at a permanent or relatively static network of stations, based on judgmental design. When selecting site locations, accessibility, watershed size, land use, and flow conditions should be considered. For ease of access, sites should be established in close proximity to a road, generally at bridge or culvert crossings. Stations should also be selected to monitor specific effects from land use changes, non-point sources, or point sources, or to monitor known impairments. Other factors that may affect actual sampling points are proximity to outfalls, stream characteristics including impoundments or debris blockages, and flow or hydraulic conditions. When sampling at a station, the following guidelines should be followed:

- Take measurements and samples at the same location or as close to the same location as possible during subsequent monitoring trips to reduce sources of variation.
- Document any changes to sampling location resulting from stream conditions, safety issues, accessibility, or other concerns.
- Sample on the upstream side of bridges, culverts,or other road crossing structures.
- Sample within the stream thalweg (lowest point) and away from any outfalls, obstructions, or other structures, to ensure that a well-mixed sample is collected.

A total of 29 monitoring locations were identified within the Greenville city limits and ETJ (**Figure 2)**. Ultimately, the number and location of monitoring stations may vary in response to available City funds,resources, and goals. Many stations were selected at sites where water quality or other stream characteristics have previously been recorded by DWQ, the City, or



Watershed Inventory and Master Plan Pilot Study
Figure 2.
Study Area
0 0.75 1.5 3
1 inch = 1.5 miles
WK DICKSON
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Proposed Monitoring Stations
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Greens Mill Run
Harris Mill Run
Sams Branch
Pinelog Branch
Swift Creek
Gum Swamp
Nobel Canal
Bates Branch
Juniper Branch
Memorial
Greenville
Evans
Arlington
Fire Tower
Dickinson
Stantonsburg
Belvoir
Airport
Mumford
Pactolus
Charles
Worthington
Blackjack Simpson
Portertown
York
Kittrell
Red Banks
Martin Luther King Jr
10Th
14Th
5Th
Elm
Line

PTRF. **Table 4** lists the recommended stations and their dominant land use and drainage area. At least one station was selected per major drainage feature within the study area, generally located near the downstream limits of the stream or study area boundary. However, no sites were identified along the Tar River. Currently, there is an AMS station located on the Tar River at the upstream limits of the study area and one located downstream near Grimesland. This proposed group of sites provides a network of stations that will provide comprehensive water quality data for the study area. Multiple stations were selected along Greens Mill Run, Swift Creek, Meeting House Branch, Bell Branch, and Hardee Creek.

Table 4. Proposed Monitoring Sites

Station ID	Stream	Primary Landuse	Secondary Landuse	Drainage Area (mi^2)
BB-1	Bell Branch	Medium Density Residential	High Density Residential	0.39
BB-2	Bell Branch	Medium Density Residential	High Density Residential	0.28
BS	Baldwin Swamp	Commercial	Very Low Density Residential	0.25
CS	Cannon Swamp	Industrial	Very Low Density Residential	1.79
FM	Fomes Branch	Medium Density Residential	Commercial	0.79
FS	Fork Swamp	Medium Density Residential	Commercial	1.68
GMR-1	Greens Mill Run	Medium Density Residential	Office/Institutional/Multi-Family	13.21
GMR-2	Greens Mill Run	Medium Density Residential	Office/Institutional/Multi-Family	12.35
GMR-3	Greens Mill Run	Medium Density Residential	Office/Institutional/Multi-Family	10.77
GMR-4	Greens Mill Run	Medium Density Residential	Office/Institutional/Multi-Family	9.24
GMR-5	Greens Mill Run	Medium Density Residential	Office/Institutional/Multi-Family	7.87
GMR-6	Greens Mill Run	Industrial & Office/Institutional/Multi-Family	Medium Density Residential	4.45
GS	Gum Swamp	Medium Density Residential	Conservation/Open Space	2.04
HC-1	Hardee Creek	Medium Density Residential	Conservation/Open Space	10.31
HC-2	Hardee Creek	Medium Density Residential	Medical Care	6.30
HMR	Harris Mill Run	Medium Density Residential	Office/Institutional/Multi-Family	2.87
JMR	Johnsons Mill Run	Forest	Cultivated Crops	23.52
MHB-1	Meeting House Branch	Medium Density Residential	Office/Institutional/Multi-Family	3.06
MHB-2	Meeting House Branch	Medium Density Residential	Office/Institutional/Multi-Family	2.43
MHB-3	Meeting House Branch	Medium Density Residential	Office/Institutional/Multi-Family	1.55
MHB-4	Meeting House Branch	Medium Density Residential & Office/Institutional/Multi-Family	High Density Residential	0.99
PB	Pinelog Branch	Medium Density Residential	Conservation/Open Space	1.02
PC-1	Parker Creek	Industrial	Medium Density Residential	10.23
PC-2	Parker Creek	Industrial & Medium Density Residential	Office/Institutional/Multi-Family	5.42
RB	Reedy Branch	Medium Density Residential	High Density Residential	0.62
SAMB	Sams Branch	Medium Density Residential	Very Low Density Residential	1.37
SF-1	Swift Creek	Medium Density Residential	Conservation/Open Space	8.18
SF-2	Swift Creek	Medium Density Residential	Commercial	3.19
SHB	Schoolhouse Branch	Office/Institutional/Multi-Family	Medical Transition	1.07

Multiple stations were identified on both Greens Mill Run and Swift Creek, since both streams are classified as impaired and are 303(d) listed. It is likely that a TMDL will be required in the future, and the additional stations will provide data needed for TMDL development and subsequent water quality modeling. A total of six stations were selected along Greens Mill Run, four of which correspond to locations sampled by DWQ from 2003 to 2005. Two stations within the study area were identified along Swift Creek.

The four sites selected on Meeting House Branch and one of the two on Bell Branch coincide with stations that PTRF monitored for four years, ending in July 2009. If the PTRF sites are selected for future monitoring, the City should coordinate with the organization and ECU. The two stations along Hardee Creek are located near sites DWQ has previously sampled for benthos.

Sampling Parameters

The parameters monitored and analyzed under the monitoring program focus on physical, chemical, and biological indicators consistent with DWQ's Ambient Monitoring System (NCDENR 2004). By following the guidelines described in the QAPP and SOP for the AMS, the City may submit results of the monitoring program to DWQ or other entities for use in the local, regional, or national studies. A list of the primary or core parameters to be sampled is provided below in **Table 5**. This list includes parameters for which NC water quality standards have been established, provides information helpful in the interpretation of other measurements, and can be sampled and analyzed cost efficiently. Additional or supplemental parameters, presented in **Table 5**, may be sampled at the monitoring stations if determined to be necessary by site-specific conditions.

Table 5. Core and Supplemental Indicators

Indicator (unit)	Type, Core (C) or Supplemental (S)	Minimum Frequency	Numerical Instream Standard (S) or Action Level (AL)?
Field Measurements			
Water temperature (°C)	C	monthly	S
Specific conductance (μmhos/cm at 25°C)	C	monthly	none
Dissolved oxygen (DO) (mg/L)	C	monthly	S
pH (SU)	C	monthly	S
Air temperature (°C)	C	monthly	none
Salinity (ppt)[4]	S	monthly	none
Secchi depth (m)[5]	S	monthly	none
Reference point reading (linear ft.)[6]	S	monthly	none
Field Observations			
Cloud cover (%)[1]	C	monthly	none
Wind velocity (mi./hr.)[1]	C	monthly	none
Wind direction (degrees from North)	C	monthly	none
Stream flow severity[2]	C	monthly	none
Secondary Data Sources			

Table 5. Core and Supplemental Indicators

Indicator (unit)	Type, Core (C) or Supplemental (S)	Minimum Frequenc y	Numerical Instream Standard (S) or Action Level (AL)?
24 hr. precipitation (in.)[3]	C	monthly	none
Samples			
Fecal coliform (colonies/100mL)	C	monthly	S
Turbidity (NTU)	C	monthly	S
Total suspended solids (TSS) (mg/L)	C	quarterly	S
Aluminum, total (Al) (μg/L)	C	quarterly	none
Arsenic, total (As) (μg/L)	C	quarterly	S
Cadmium, total (Cd) (μg/L)	C	quarterly	S
Chromium, total (Cr) (μg/L)	C	quarterly	S
Copper, total (Cu) (μg/L)	C	quarterly	AL
Iron, total (Fe) (μg/L)	C	quarterly	AL
Lead, total (Pb) (μg/L)	C	quarterly	S
Mercury, total (Hg) (μg/L)	C	quarterly	S
Nickel, total (Ni) (μg/L)	C	quarterly	S
Zinc, total (Zn) (μg/L)	C	quarterly	AL
Total coliforms (colonies/100mL)[7]	S	monthly	S
NH_3 as N (mg/L)	S	monthly	none
TKN as N (mg/L)	S	quarterly	none
$NO_2 + NO_3$ as N (mg/L)	S	quarterly	S
Total Phosphorus (mg/L)	S	quarterly	none
Sulfate (mg/L)	S	quarterly	S
Fluoride (mg/L)	S	quarterly	S
Manganese, total (Mn)[8]	S	quarterly	S
Chlorophyll a (ug/L)	S	quarterly	S
Color (Pt-Co & ADMI units)	S	quarterly	none
Oil & Grease (mg/L)	S	quarterly	none

Source: Table B1.1 & B1.2 (NC AMS QAPP, December 2004)

[1] Estimated value

[2] Subjective scale of 1-4

[3] Obtained from NC Climate Office or local news weather networks

[4] Estuarine stations only

[5] Boat access stations only

[6] At stations that are part of cooperative agreement with USGS to maintain reference points for flow measurements

[7] WS-I classifications only

[8] Water supply classifications (WS-I, WS-II, WS-III, WS-IV, WS-V) only

Sampling Criteria and Frequency

Wet Weather Monitoring

Wet weather (storm event) sampling isolates the effect of discrete rainfall events to characterize the impact of stormwater runoff on water quality. Pollutant loadings and concentrations from nonpoint sources may be determined from the resulting data. A representative storm event requires a minimum of 0.2 inches of precipitation within a three hour time period, and a minimum antecedent dry period (< 0.1 inches of rainfall) of three days. Each station will be sampled manually or with automated systems that collect at first flush and thereafter hourly for a minimum of five hours to adequately document turbidity over time.

Stream flow measurements must be recorded during wet weather monitoring events in order to determine pollutant loadings. Therefore, a stage-discharge rating curve must be developed at each monitoring location. Stage-discharge measurements and rating curve development should follow the guidance and instructions provided in the USGS documents *Discharge Measurements at Gaging Stations* and *Discharge Ratings at Gaging Stations* and DWQ's *Intensive Survey Unit Standard Operating Procedures Manual* (ISU SOP).

Dry Weather Monitoring

Dry weather (baseflow) sampling characterizes in-stream water quality, where dry weather is defined as less than 0.10 inches per day of rain during a three day (72 hours) time period.

Frequency

Minimum sampling frequencies as required by the AMS are included in **Table 6** and are based on dry weather conditions. All field parameters and chemical and biological indicators are measured on a monthly basis, except for metals, which are to be sampled quarterly. For wet weather sampling, stations should be sampled on a quarterly basis, when feasible.

Sample Collection Methods

All sampling methods and field activities are to be carried out in accordance with DWQ's *Ambient Monitoring System Quality Assurance Project Plan* (QAPP) which includes the ISU SOP and the *Quality Assurance Manual* (QAM) for the Laboratory Section. Another document that should be referenced is DWQ's *NPDES Discharge Monitoring Coalition Program Field Monitoring Guidance*.

Field Measurements

Field parameters are to be measured in situ during routine station visits using an electronic field meter or probe. Measurements are discrete and should be taken approximately six inches below the water surface without letting the probe disturb sediment or touch the channel bed. If measurements are not able to be made easily from a bridge or channel bank, an extension pole, wading, or combination of the two may be necessary to acquire samples from the middle of the stream. Field parameters to be measured include:

- Temperature
- Conductivity (if accessibility prevents an in situ measurement, conductivity may be analyzed in a lab within 28 days of collecting the water sample)
- Dissolved oxygen
- pH (if accessibility prevents an in situ measurement, pH may be measured from a water sample within 15 minutes of collection)
- Air temperature, wind speed and direction, cloud cover, and stream flow severity

Refer to the QAPP and ISU SOP for instructions and guidance regarding field meter maintenance, calibration, calibration verification, and data validation.

Grab Samples
Grab samples are used to characterize the stream at a particular point and involves collecting samples in the same location where field parameters are measured. Samples should be collected within the stream thalweg, where water is well mixed, and stored in an appropriate container for submittal to a laboratory for analysis. Samples may be collected by hand or by using an extension pole, intermediate grab sampling device, or wading, depending on stream conditions and/or accessibility. Parameters to be sampled include:

- Turbidity
- TSS
- Fecal coliform
- Metals (Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, and Zn)
- Nutrients (NH_3, TKN, NO_3 + NO_2, TP, and PO_4)

Composite Samples
Composite samples are samples collected over time when water flow is continuous and include the same parameters as grab samples. The samples may be formed by either mixing discrete samples or by continuous sampling. Composite sampling is used to determine average pollutant concentrations, calculate pollutant loadings, associate flows data to parameter concentrations, or when analytical capabilities are limited. Samples may be collected at equal time intervals for time integrated sampling, or proportional to flow rates for flow proportional integrated sampling. Composite sampling may be performed using either automatic samplers or grab samples.

4. Sample Analyses and Reporting

Sample Collection and Analyses
Sample collection shall be performed by appropriately trained personnel and shall follow procedures and guidance in accordance with the DWQ's QAPP, ISU SOP, QAM and subsequent documents regarding sample collection, handling and custody, preservation and analytical methods. Laboratory analyses shall be performed at a DWQ-certified laboratory using approved methods as certified by the DWQ Laboratory Certification Branch. Reporting levels should be at least as stringent as those used by the DWQ laboratories. Refer to the QAPP, ISU SOP, and QAM for target reporting levels.

Monthly Reporting
Monthly reporting should involve updating a master spreadsheet or database with sampling results from the month's monitoring activities. The spreadsheet should include the site ID, date, time, comments, and all parameters measured or sampled and their respective units. Any associated data remark codes (refer to QAPP, ISU SOP, and QAM) should also be included for any samples analyzed at a laboratory.

Annual Reporting
An annual report will be generated and will include general descriptive statistics (minimum, maximum, median, 25th percentile and 75th percentile) of any field measurements or sample results received from the designated laboratory. The number of state standard exceedances (if any) will be included for all parameters measured or analyzed. The current year's results will also be compared to previous years, identifying any trends in water quality. These reports will be made available to the public and any other interested agencies.

5. BMP Monitoring

The purpose of this monitoring is to collect and analyze stormwater runoff at BMP locations to assess pollutant removal efficiency of the selected BMP. The monitoring includes the collection of flow-weighted composite samples during storm events from both the influent and effluent of each BMP, in accordance with the QAPP, ISU SOP, and QAM. Samples are to be collected with an automatic sampler. Parameters to be sampled include:

- Field parameters (temperature, flow, conductivity, DO, pH, rainfall, event duration)
- Turbidity
- TSS
- Fecal coliform
- Metals (Cu, Pb, and Zn)
- Nutrients (NH_3, TKN, NO_3 + NO_2, and TP)

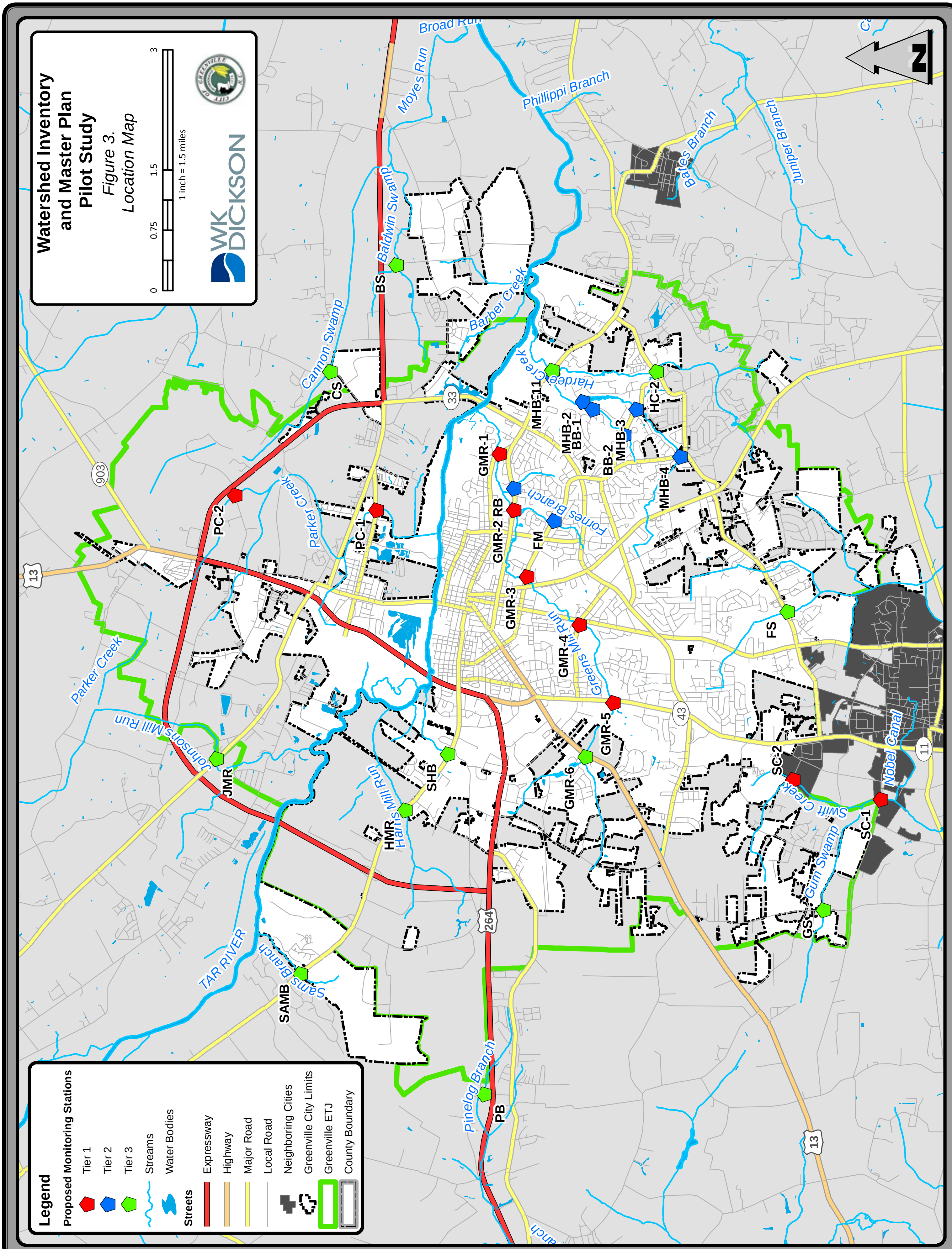
In-stream field measurements are to be collected if appropriate (i.e. if the BMP outlets to a regulated stream).

6. Recommendations

Monitoring Locations
Potential sites for water quality sampling are presented in **Figures 2 & 3**. These sites were primarily located to gather baseline data and to monitor water quality trends over time. Other factors considered were future needs to develop TMDLs for Greens Mill Run and Swift Creek. The locations and number of stations may be adjusted per the monitoring needs of the City and available funds, resources, and personnel.

The monitoring sites are divided into tiers, signifying the priority for which the stations should be established; where Tier 1 is the highest priority and Tier 3 is the lowest (see **Figure 3**). Tier 1 stations include those along Greens Mill Run and Swift Creek, where it is likely that TMDLs will be developed. Therefore, there is a more immediate or urgent need to begin monitoring along these streams. Two stations along Parkers Creek were also included in Tier 1 because it has received a "Poor" bioclassification rating from benthic monitoring.

Tier 2 stations include those along Meeting House Branch and Bell Branch. These were selected in an effort to continue monitoring the two streams after completion of the pilot study by PTRF and ECU. Finally, Tier 3 monitoring locations include all other sites and consist of one site per named/major drainage feature, except Hardee Creek, where two sites have been



Watershed Inventory and Master Plan Pilot Study
Figure 3.
Location Map
0
0.75
1.5
3
1 inch = 1.5 miles
WK DICKSON
Legend
Proposed Monitoring Stations
Tier 1
Tier 2
Tier 3
Streams
Water Bodies
Streets
Expressway
Highway
Major Road
Local Road
Neighboring Cities
Greenville City Limits
Greenville ETJ
County Boundary
N
Broad Run
Moyes Run
Phillippi Branch
Bates Branch
Juniper Branch
Baldwin Swamp
Barber Creek
Cannon Swamp
Hardee Creek
Parker Creek
Fornes Branch
Greens Mill Run
Johnsons Mill Run
Harris Mill Run
Swift Creek
Nobel Canal
Gum Swamp
TAR RIVER
Sams Branch
Pinelog Branch
BS
CS
PC-1
PC-2
MHB-1
MHB-2
MHB-3
MHB-4
BB-1
BB-2
HC-2
GMR-1
GMR-2
GMR-3
GMR-4
GMR-5
GMR-6
RB
FM
FS
JMR
SHB
HMR
SAMB
PB
SC-1
SC-2
GS
13
903
33
43
11
264

identified. These sites will provide a comprehensive water quality dataset for the study area.

Parameters and Frequency

Parameters and sampling frequency recommended for monitoring include the core indicators sampled by AMS, with a few modifications. The final selection of parameters will be dependent upon the resources and needs of the City. PTRF monitoring efforts include the sampling of Alkalinity and orthophosphate, commonly associated with agricultural land use changes, and have therefore been added to the parameter list for additional comparisons of water quality. **Table 6** provides the recommended list of parameters and associated frequencies to be monitored at baseflow conditions. Wet weather monitoring should be performed quarterly at all stations, in addition to the monthly dry weather monitoring.

Table 6. Recommended Indicators and Frequency

Indicator (unit)	Minimum Frequency	Required*
Field Measurements		
Water temperature (°C)	monthly	1
Specific conductance (μmhos/cm at 25°C)	monthly	1
Dissolved oxygen (DO) (mg/L)	monthly	1
pH (SU)	monthly	1
Air temperature (°C)	monthly	1
Field Observations		
Cloud cover (%)	monthly	1
Wind velocity (mi./hr.)	monthly	1
Wind direction (degrees from North)	monthly	1
Stream flow severity	monthly	1
Secondary Data Sources		
24 hr. precipitation (in.)	monthly	1
Samples		
Alkalinity (mg/L)	monthly	1
Fecal coliform (colonies/100mL)	monthly	1
Turbidity (NTU)	monthly	1
Total suspended solids (TSS) (mg/L)	quarterly	1
Copper, total (Cu) (μg/L)	quarterly	1
Lead, total (Pb) (μg/L)	quarterly	1
Zinc, total (Zn) (μg/L)	quarterly	1
NH_3 as N (mg/L)	monthly	1
TKN as N (mg/L)	quarterly	1
$NO_2 + NO_3$ as N (mg/L)	quarterly	1
Total Phosphorus (mg/L)	quarterly	1
PO_4 (Orthophosphate) (mg/L)	monthly	1
Manganese, total (Mn)	quarterly	1
Aluminum, total (Al) (μg/L)	quarterly	2
Arsenic, total (As) (μg/L)	quarterly	2
Cadmium, total (Cd) (μg/L)	quarterly	2
Chromium, total (Cr) (μg/L)	quarterly	2
Iron, total (Fe) (μg/L)	quarterly	2

Table 6. Recommended Indicators and Frequency

Indicator (unit)	Minimum Frequency	Required*
Mercury, total (Hg) (µg/L)	quarterly	2
Nickel, total (Ni) (µg/L)	quarterly	2
Sulfate (mg/L)	quarterly	2
Fluoride (mg/L)	quarterly	2
Chlorophyll a (ug/L)**	quarterly	2
Color (Pt-Co & ADMI units)	quarterly	2
Oil & Grease (mg/L)	quarterly	2

* 1 - Parameter is recommended for monitoring at all stations; 2 - Paramter is recommended for monitoring if funds and resources allow or if there is a specific need.

** not sampled in lotic stream sites

Equipment

A general list of equipment needed to perform water quality sampling at monitoring locations includes:

- Field meters
- Automated samplers
- Flowmeter
- Sample bottle rack and rope
- Long-handled dipper
- Data sheets/fieldbook
- Sharpie, pen, pencil
- Air thermometer
- Sample bottles
- Pre-preserved sample bottles
- Sample labels
- Lab chain of custody form/sample submission sheets
- pH standards
- Conductivity standards
- Distilled or deionized water
- 100-ft tape
- Ice
- Cooler
- Gloves
- Hip waders, rubber boots
- Hand sanitizer
- Orange safety vest
- Acid handling equipment
- First aid kit
- Fire extinguisher
- Vehicle

Note: The list will vary depending on the number of stations sampled, the location of the stations, and which parameters are measured.

Personnel

Well-trained, dedicated field staff are mandatory for maintaining a successful water quality monitoring program. All field personnel should be trained in equipment (field meters, automatic samplers, etc.) operation, calibration, and general maintenance; sampling methods; sample collection; sample documentation; QA/QC methodology; safety; and any other relevant field activities. At a minimum, staff should receive training in accordance with the appropriate methods described in the QAPP, ISU SOP, and QAM. New staff should receive training at the time of hiring, and all staff should receive annual refresher training. Personnel will be required to visit sites frequently to collect samples and measurements and must allocate enough time for sampling and any necessary repairs or maintenance.

Laboratory

It is recommended that laboratory analyses be performed at a DWQ-certified laboratory using approved methods, as certified by the DWQ Laboratory Certification Branch. As of 2011, there is one DWQ certified laboratory in Greenville:*Environment-I Inc*

114 Oakmont Dr
Greenville, NC 27858
Phone: (252)756-6208
Fax: (252)756-0633

If constraints involving funds, resources, or other issues prevent the City from using a DWQ-certified lab, then any lab used must follow EPA and State standards, at a minimum.

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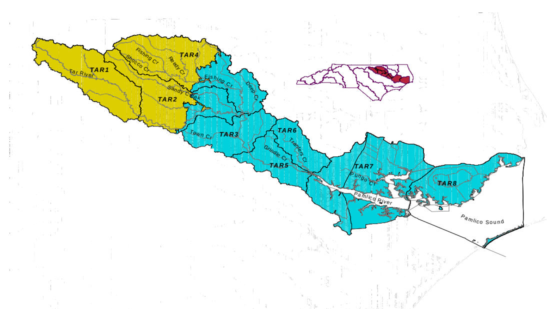
APPENDIX A.

Memorandum of Agreement
Between
The State of North Carolina’s Division of Water Quality
And
The Tar Pamlico Basin Association (TPBA) Permittees



Effective:
March 1, 2012 through February 28, 2017

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MEMORANDUM OF AGREEMENT

This Memorandum of Agreement (MOA) is made by and between the NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES'S DIVISION OF WATER QUALITY (DWQ), the NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) DISCHARGERS in the Tar/Pamlico River basin who have voluntarily executed this MOA (the TPBA PERMITTEES), and the TAR/PAMLICO BASIN ASSOCIATION (the TPBA), a non-profit corporation whose members include the TPBA PERMITTEES. The MOA includes all the attached tables and appendices. This MOA does not affect any influent or effluent monitoring requirement or any other NPDES permit requirements of individual permit holders with the one exception of performing upstream and downstream water quality monitoring. The TPBA PERMITTEES are exempted from instream monitoring as specified in their individual NPDES permits beginning on the effective date of this MOA and continuing for the duration of each permittee's participation in this MOA. Subsequent to the execution of this MOA, the DWQ will issue a letter to each TPBA PERMITTEE notifying the permittee that the instream monitoring requirements of its permit are not effective for as long as this MOA is in place and the permittee remains a party to this MOA.

The purpose of this MOA is to establish a formal agreement between the DWQ, the TPBA PERMITTEES, and the TPBA. This MOA authorizes the TPBA to act on behalf of the TPBA PERMITTEES as described herein. This MOA identifies the responsibilities of the TPBA PERMITTEES and the TPBA for surface water monitoring and reporting within the Tar/Pamlico River Basin. The water quality monitoring will occur at strategically located surface water sites to obtain information on water quality in the basin. Monitoring sites and parameters, listed in Appendix A, were established by the DWQ such that the instream monitoring is efficient, effective, and basin-oriented.

The TPBA will perform the monitoring activities described herein on behalf of TPBA PERMITTEES who are members in good standing of the TPBA. Each TPBA PERMITTEE agrees to remain a member in good standing of the TPBA. The TPBA will contract for the performance of the monitoring activities described herein and in Appendix B with a laboratory appropriately certified by the DWQ for the required laboratory and field analyses. Sample collection and field measurements will be made by the TPBA PERMITTEES, the TPBA, or a sub-contractor who will act as agent(s) of the TPBA PERMITTEES for the sole purpose of performing monitoring services required by this MOA. It will be the responsibility of the TPBA to coordinate the collection and analyses of the water quality monitoring data for the locations, parameters, and frequencies specified in Appendix A of this MOA. Sample collection, field measurement, and target reporting limits are specified in Appendix B of this MOA. Monthly and annual reporting requirements, including data format and data summaries are described in Appendix C of this MOA.

The TPBA shall submit the water quality data to the DWQ using the format documented in Appendix C of this MOA preferably in Microsoft® Excel 2003, a subsequent version, or the equivalent. The TPBA shall submit the water quality data to the DWQ within 90 days of the end of the month in which the sampling was performed. All data shall be archived by the TPBA for a period of 5 years. Each TPBA PERMITTEE has the right to review and comment on work, data or reports prepared by any contractor on behalf of the TPBA PERMITTEES and to notify the DWQ of any objection or disagreement with any portion of the work, data, or reports. Unless such notice is made within thirty (30) days of submission of data or other reports to the DWQ, it shall be deemed to be waived and the work, data and reports submitted shall be deemed to be approved by the TPBA PERMITTEES. Failure by the TPBA PERMITTEES or the TPBA to collect or analyze the water quality data as described in this MOA, or to provide the data to the DWQ in the required format, may result in the revocation of this MOA by the DWQ and the return to individual upstream and downstream monitoring requirements, as specified in the individual NPDES permits of the TPBA PERMITTEES.

The TPBA shall submit an annual written report that summarizes the previous calendar year's sampling results and formally finalizes the water quality data. The report shall be submitted no later than April 30th each year that this MOA is in effect. The annual report shall include the NPDES permit number of each actively participating permit holder and a contact name, email address and phone number for each member. Appendix C of this MOA describes the required annual report content. Two copies, signed by the TPBA chairman, of these and any other reports required herein shall be submitted to the DWQ Coalition Coordinators at 1621 Mail Service Center, Raleigh, NC 27699-1621.

Stream sampling may be discontinued at such times as flow conditions in the receiving waters or extreme weather conditions will result in a substantial risk of injury or death to persons collecting samples. Sampling may also be discontinued when environmental conditions, such as a dry stream, prevent sample collection. In such cases, on each day that sampling is discontinued, the DWQ Coalition Coordinators shall be notified within one week of the discontinuance and written justification for the discontinuance shall be submitted with the monthly data submittal. This provision shall not be utilized to avoid the requirements of this MOA when performance of these requirements is attainable. When there is a sampling discontinuance pursuant to this provision, sampling shall be resumed at the first opportunity.

This MOA may be modified by the written consent of the DWQ and the TPBA. The DWQ or the TPBA may determine that it is necessary to request changes in monitoring frequency, parameters or sites to be sampled. Any such changes can only be made by a written amendment to this MOA agreed to by the DWQ and the TPBA. The amendment shall be signed by the TPBA chairman and by the DWQ. Such amendments may be entered into at any time.

The TPBA has historically monitored total metals at 8 sites as specified in the 2007 – 2012 MOA. However, routine ambient data collection for total recoverable metals has been suspended since April 3, 2007, via annual memorandums from the DWQ Director. For this reason, the TPBA has forgone metals monitoring and accumulated resources for future monitoring. No requirements for metals monitoring are included in this MOA, as the DWQ is currently in the process of reviewing metals water quality assessment techniques, evaluation criteria and relevant standards. However, the DWQ expects to conclude the review within the life cycle of this MOA. At such time, or when the DWQ Director mandates, the TPBA is expected to resume monitoring at a similar level of effort to that historically performed. Within 60 days of the release of relevant documentation, the TPBA will finalize an amendment to the MOA, which includes metals monitoring.

The following additional dischargers may enter into this MOA subsequent to the effective date hereof:

1) Dischargers who receive a NPDES permit within the Tar/Pamlico River Basin, or
2) Dischargers who have NPDES permits within the Tar/Pamlico River Basin but are not parties to this Agreement.

The addition of such dischargers to this MOA may be made only with the consent of the DWQ and the TPBA and shall require a written amendment to this MOA signed by the TPBA chairman, by the DWQ, and by an authorized representative of any such discharger who wishes to enter into the MOA. The DWQ will not unreasonably withhold consent to the addition of a discharger to the MOA. The DWQ will consider modification of the existing monitoring program described in this MOA for the addition of a discharger to the MOA. Such amendments may be made at any time that this MOA is in effect. The TPBA PERMITTEES included in this MOA are listed in Table 1.

This MOA shall be effective until February 28, 2017 unless extended by the consent of both the DWQ and the TPBA. Upon sixty (60) days written notice, the DWQ or the TPBA may terminate this MOA for any reason. Upon termination of this MOA, the monitoring requirements contained in the individual NPDES permit of each TPBA PERMITTEE shall become effective immediately. An individual permit holder may terminate and cancel its participation in this MOA by providing ninety (90) days written notice to the TPBA, and sixty (60) days written notice to the DWQ Coalition Coordinator(s), the appropriate DWQ Regional Office, and the DWQ NPDES Unit. The monitoring requirements contained in the individual NPDES permit shall become effective immediately upon such cancellation or termination. In the event a permit holder terminates or cancels its participation in this MOA or its membership in the TPBA is terminated for any reason, the TPBA may request that DWQ review the monitoring plan described in this MOA for a possible reduction in sampling effort or requirements.

IN WITNESS WHEREOF, the parties have caused the execution of this instrument by authority duly given, to be effective as of the date executed by the DWQ

DIVISION OF WATER QUALITY

By: signature received 2/29/12

Charles Wakild, P.E.
Director
Division of Water Quality

Date: ______________________________

TAR PAMLICO BASIN ASSOCIATION

By: signature received 2/7/12

Larry Thomas
Chairman
Tar Pamlico Basin Association

Date: ______________________________

Table 1
TPBA Permittees

NPDES Permit Number	Tar Pamlico Basin Association Permittees Ownership & Facility	Authorized Representative and title	County	Region	Sub-basin
NC0020231	Town of Louisburg Louisburg WWTP	Mr. Mark Warren Town Manager	Franklin	Raleigh	030301
NC0069311	Franklin County Franklin County Public Utilities	Mr. Bryce Mendenhall Public Utilities Director	Franklin	Raleigh	030301
NC0042269	Town of Bunn Bunn WWTP	Ms. Marsha W. Strawbridge Mayor	Franklin	Raleigh	030301
NC0025054	Town of Oxford Oxford WWTP	Mr. Mark Donham Town Manager	Granville	Raleigh	030301
NC0020061	Town of Spring Hope Spring Hope WWTP	Mr. John Holpe Town Manager	Nash	Raleigh	030302
NC0030317	City of Rocky Mount Tar River WWTP	Mr. Charles Penny City Manager	Edgecombe	Raleigh	030302
NC0072125	City of Rocky Mount Tar River WTP	Mr. Charles Penny City Manager	Nash	Raleigh	030302
NC0072133	City of Rocky Mount Sunset Ave. WTP	Mr. Charles Penny City Manager	Nash	Raleigh	030302
NC0020435	Town of Pinetops Pinetops WWTP	Mr. Greg Bethea Town Administrator	Edgecombe	Raleigh	030303
NC0020605	Town of Tarboro Tarboro WWTP	Mr. M Alan Thorton Town Manager	Edgecombe	Raleigh	030303
NC0023337	Town of Scotland Neck Scotland Neck WWTP	Ms. Nancy Jackson Town Manager	Halifax	Raleigh	030304
NC0025402	Town of Enfield Enfield WWTP	Ms. Barbara Simmons Mayor	Halifax	Raleigh	030304
NC0084034	Town of Enfield Enfield WTP	Ms. Barbara Simmons Mayor	Halifax	Raleigh	030304
NC0020834	Town of Warrenton Warrenton WWTP	Mr. Jeffery W. Parrott Town Administrator	Warren	Raleigh	030304
NC0023931	Greenville Utilities Commission Greenville WWTP	Mr. Ron Elks General Manager	Pitt	Washington	030305
NC0026042	Town of Robersonville Robersonville WWTP	Ms. Elizabeth Jenkins Town Manager	Martin	Washington	030306
NC0026492	Town of Belhaven Belhaven WWTP	Mr. Guinn Leverett Town Manager	Beaufort	Washington	030307
NC0020648	City of Washington Washington WWTP	Mr. Josh Kay City Manager	Beaufort	Washington	030307
NC0081191	City of Washington Washington WTP	Mr. Josh Kay City Manager	Beaufort	Washington	030307

TPBA PERMITTEE SIGNATURES

NPDES Permit Number	Permittee	Signature	Date
NC0020231	Town of Louisburg Louisburg WWTP	signature received 2/15/12 Mark Warren Town Manager	
NC0069311	Franklin County Franklin County Public Utilities	signature received 2/26/12 Bryce Mendenhall Public Utilities Director	
NC0042269	Town of Bunn Bunn WWTP	signature received 2/29/12 Marsha Strawbridge Mayor	
NC0025054	Town of Oxford Oxford WWTP	signature received 2/7/12 Mark Donham Town Manager	
NC0020061	Town of Spring Hope Spring Hope WWTP	signature received 2/24/12 John Holpe Town Manager	
NC0030317	City of Rocky Mount Tar River WWTP	signature received 2/9/12 Charles Penny City Manager	
NC0072125	City of Rocky Mount Tar River WTP	signature received 2/9/12 Charles Penny City Manager	
NC0072133	City of Rocky Mount Sunset Ave. WTP	signature received 2/9/12 Charles Penny City Manager	

TPBA PERMITTEE SIGNATURES

NPDES Permit Number	Permittee	Signature	Date
NC0020435	Town of Pinetops Pinetops WWTP	signature received 1/24/12 Greg Bethea Town Administrator	
NC0020605	Town of Tarboro Tarboro WWTP	signature received 2/7/12 M. Alan Thorton Town Manager	
NC0023337	Town of Scotland Neck Scotland Neck WWTP	signature received 2/29/12 Nancy Jackson Town Manager	
NC0025402	Town of Enfield Enfield WWTP	signature received 2/14/12 Barbara Simmons Mayor	
NC0084034	Town of Enfield Enfield WTP	signature received 2/14/12 Barbara Simmons Mayor	
NC0020834	Town of Warrenton Warrenton WWTP	signature received 1/25/12 JefferyParrott Town Administrator	
NC0023931	Greenville Utilities Commission Greenville WWTP	signature received 2/10/12 Ron Elks General Manager	
NC0026042	Town of Robersonville Robersonville WWTP	signature received 2/28/12 Elizabeth Jenkins Town Manager	

TPBA PERMITTEE SIGNATURES

NPDES Permit Number	Permittee	Signature	Date
NC0026492	Town of Belhaven Belhaven WWTP	signature received 2/7/12 Guinn Leverett Town Manager	
NC0020648	City of Washington Washington WWTP	signature received 2/29/12 JoshKay City Manager	
NC0081191	City of Washington Washington WTP	signature received 2/29/12 JoshKay City Manager	

APPENDIX A

TPBA MONITORING PROGRAM

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Table A-1
TPBA Sampling Stations, Parameters & Frequencies

Station Number	Location	Station Description	Latitude	Longitude	County	Region	8 Digit HUC	Stream Index	Stream Class	[1]Field Parameters	Fecal Coliform	Turbidity	TSS	[2]Nutrients	[3]Metals
O0057000	TAR RIV AT US 158 NR BEREA	Tar headwaters, DWQ benthic and fish station, rare and threatened species area. Excellent fish community	36.33379	-78.76825	GRANVILLE	RRO	03020101	28-(1)	WS-IV NSW	M+2SM	M	M	M	M	
O0320000	FISHING CRK AT SR 1607 KNOTTS GROVE RD NR OXFORD	ups of Oxford WWTP	36.27703	-78.59133	GRANVILLE	RRO	03020101	28-11	C NSW	M+2SM	M	M		M	
O1025000	TAR RIV AT SR 1003 SIMS BRIDGE RD NR LOUISBURG	Ups Louisburg WWTP, USGS gage, Benthic Stn (GF-G)	36.14222	-78.37218	FRANKLIN	RRO	03020101	28-(15.5)	WS-IV NSW	M+2SM	M	M	M	M	
O1030000	TABBS CRK AT SR 1100 EGYPT MOUNTAIN RD NR KITTRELL	Tabbs Creek near mouth, Loading information for Nutrient Transport Model, Fish Stn (Good, but declining), 5 rare mollusks	36.18229	-78.45562	VANCE	RRO	03020101	28-17-(0.5)	C NSW	M+2SM	M	M	M	M	
O1600000	CEDAR CRK AT SR 1116 CEDAR CREEK RD NR FRANKLINTON	ups Franklin County WWTP, federally listed Dwarf Wedgemussel	36.06615	-78.43130	FRANKLIN	RRO	03020101	28-29-(2)	C NSW	M+2SM	M	M		M	
O1920000	CEDAR CRK AT SR 1109 TIMBERLAKE RD NR LOUISBURG	dns Franklin County WWTP, federally listed Dwarf Wedgemussel	36.06024	-78.35373	FRANKLIN	RRO	03020101	28-29-(2)	C NSW	M+2SM	M	M		M	
O2000000	TAR RIV AT SR 1001 NR BUNN	dns Louisburg WWTP, DWQ ambient station	36.00228	-78.24334	FRANKLIN	RRO	03020101	28-(24.7)	WS-V NSW	M+2SM	M	M		M	
O2015000	CROOKED CRK AT SR 1719 BUNN ELEMENTARY SCHOOL RD NR BUNN	ups Bunn WWTP, 5 rare mussels	35.94504	-78.26054	FRANKLIN	RRO	03020101	28-30	C NSW	M+2SM	M	M		M	
O2020000	CROOKED CRK AT NC 98 NR BUNN	dns Bunn WWTP, just ups Tar River. Benthic and Fish Stn (GF), 5 rare mussels in watershed	35.93863	-78.20892	FRANKLIN	RRO	03020101	28-30	C NSW	M+2SM	M	M		M	
O2101000	TAR RIV AT SR 1145 OLD SPRING HOPE RD NR SPRING HOPE	ups Spring Hope WWTP	35.90506	-78.11319	NASH	RRO	03020101	28-(24.7)	WS-V NSW	M+2SM	M	M		M	
O2102000	TAR RIV AT NC 581 NR STANHOPE	dns Spring Hope WWTP	35.88205	-78.08932	NASH	RRO	03020101	28-(24.7)	WS-V NSW	M+2SM	M	M		M	
O2140000	TAR RIV AT SR 1981 TAR RIVER CHURCH RD NR CLIFTONVILLE	ups Tar River Reservoir.	35.84663	-77.96394	NASH	RRO	03020101	28-(35.5)	WS-IV NSW CA	M+2SM	M	M		M	
O2320000	SAPONY CRK AT SR 1704 BATCHELOR DR NR NASHVILLE	ups Tar River Reservoir	35.93201	-77.93478	NASH	RRO	03020101	28-55-(5.5)	WS-IV NSW	M+2SM	M	M			
O2360000	TAR RIV AT US 301 BYP AT ROCKY MOUNT	between reservoir and Rocky Mount, USGS gage.	35.92549	-77.83098	NASH	RRO	03020101	28-(64.5)	WS-IV NSW	M+2SM	M	M	M	M	
O3140000	STONY CRK AT WINSTEAD AVE NR LITTLE EASONBURG	For Nutrient Transport Model, 5 rare mussels, biological impairment 303d, USGS gage	35.96880	-77.84967	NASH	RRO	03020101	28-68	C NSW	M+2SM	M	M	M	M	
O3189000	TAR RIV AT SR 1250 SPRINGFIELD RD AT ROCKY MOUNT	ups Rocky Mount WWTP	35.97789	-77.75769	EDGECOMBE	RRO	03020101	28-(69)	C NSW	M+2SM	M	M	M	M	
O3600000	TAR RIV AT SR 1252 NR HARTSEASE	dns Rocky Mount WWTP, DWQ ambient station	35.94090	-77.65511	EDGECOMBE	RRO	03020101	28-(74)	WS-IV NSW	M+2SM	M	M	M	M	
O4100000	TAR RIV AT NC 33 NR TARBORO	Tar River dns of Swift Creek and ups of Fishing Creek.	35.92844	-77.54984	EDGECOMBE	RRO	03020101	28-(74)	WS-IV NSW	M+2SM	M	M		M	
O4300000	FISHING CRK AT SR 1001 DR KING BLVD NR WARRENTON	ups Warrenton WWTP	36.38402	-78.18135	WARREN	RRO	03020102	28-79-(1)	C NSW	M+2SM	M	M		M	
O4400500	FISHING CRK AT SR 1600 BALTIMORE RD NR WARRENTON	dns Warrenton WWTP, Fish Stn (Exc)	36.35735	-78.14494	WARREN	RRO	03020102	28-19-(1)	C NSW	M+2SM	M	M		M	
O4480000	FISHING CRK AT NC 561 NR WOOD	Just dns of confluence with Shocco Creek, 8 rare mussels and 4 rare fish in watershed.	36.20105	-78.00401	NASH	RRO	03020102	28-79-(21)	WS-V NSW	M+2SM	M	M	M	M	
O4630000	LITTLE FISHING CRK AT NC 481 NR WHITE OAK	ups of confluence with Porter Creek, large numbers of rare aquatic animals in watershed, USGS gage. Nutrient transp. model stn.	36.18620	-77.87601	HALIFAX	RRO	03020102	28-79-25	C NSW	M+2SM	M	M	M	M	

Station Number	Location	Station Description	Latitude	Longitude	County	Region	8 Digit HUC	Stream Index	Stream Class	[1]Field Parameters	Fecal Coliform	Turbidity	TSS	[2]Nutrients	[3]Metals
O4670000	FISHING CRK AT SR 1222 BELLAMY MILL RD NR ENFIELD	ups Enfield WWTP, 8 rare mussels and 4 rare fish in watershed, first bridge ups of US 301, just dns of old mill impoundment	36.15490	-77.74036	HALIFAX	RRO	03020102	28-79-(25.5)	WS-IV NSW	M+2SM	M	M		M	
O4690000	FISHING CRK AT SR 1109 ETHERIDGE FARM RD NR ENFIELD	dns Enfield WWTP, 8 rare mussels and 4 rare fish in watershed, first bridge dns of US 301.	36.11342	-77.62704	HALIFAX	RRO	03020102	28-79-(29)	C NSW	M+2SM	M	M		M	
O4899000	FISHING CRK AT NC 97 NR LAWRENCE	USGS Gage, nr confluence with Tar, 8 rare mussels and 4 rare fish in watershed. Nutrient transp. model station.	36.00828	-77.52518	EDGECOMBE	RRO	03020102	28-79-(30.5)	WS-IV NSW	M+2SM	M	M	M	M	
O4995000	DEEP CRK AT SR 1104 BYNUMS BRIDGE RD NR SCOTLAND NECK	ups Scotland Neck WWTP	36.13551	-77.48517	HALIFAX	RRO	03020102	28-79-32-(0.5)	C NSW	M+2SM	M	M		M	
O5100000	DEEP CRK AT US 258 NR SCOTLAND NECK	dns Scotland Neck WWTP	36.10964	-77.43827	HALIFAX	RRO	03020102	28-79-32-(0.5)	C NSW	M+2SM	M	M		M	
O5250000	TAR RIV AT NC 33 US 64 BUS AT TARBORO	ups Tarboro WWTP, USGS gage, DWQ ambient station, Benthic Stn (Good). Modelers want twice monthly sampling here. Nutrient transport model station.	35.89352	-77.53233	EDGECOMBE	RRO	03020103	28-(80)	C NSW	M+2SM	M	M	M	M	
O5600000	TOWN CRK AT NC 111 SR 1202 NR WIGGINS CROSSROADS	ups Pinetops WWTP	35.82238	-77.63390	EDGECOMBE	RRO	03020103	28-83	C NSW	M+2SM	M	M			
O5990000	TOWN CRK AT US 258 NR COBBS CROSSRAODS	dns Pinetops WWTP, USGS gage	35.79828	-77.59144	EDGECOMBE	RRO	03020103	28-83	C NSW	M+2SM	M	M			
O6000000	TAR RIV AT NC 42 AT OLD SPARTA	dns Tarboro WWTP, just dns of Town Creek, Benthic Stn (Exc).	35.79030	-77.55067	EDGECOMBE	RRO	03020103	28-(80)	C NSW	M+2SM	M	M	M	M	
O6201000	BALLAHACK CANAL AT SR 1526 NR CONETOE	Agricultural land use site, Cropland, no point source dischargers	35.86447	-77.44383	EDGECOMBE	RRO	03020103	28-87-1.2	C NSW	M+2SM	M	M	M	M	
O6240000	TAR RIV AT US 264 BYP NR GREENVILLE	ups Greenville WWTP, USGS gage.	35.64598	-77.42212	PITT	WARO	03020103	28-(84)	WS-IV NSW	M+2SM	M	M	M	M	
O6700000	GRINDLE CRK AT SR 1427 NR BETHEL	Agricultural land use site, Cropland, no point source dischargers	35.76324	-77.37805	PITT	WARO	03020103	28-100	C NSW	M+2SM	M	M	M	M	
O6798000	GRINDLE CRK AT US 264 AT PACTOLUS	Last bridge crossing ups of Tar, Benthic Stn (D-F), Fish Stn, Modeler request	35.62426	-77.22118	PITT	WARO	03020103	28-100	C NSW	M+2SM	M	M	M	M	
O7000000	FLAT SWAMP AT SR 1159 THIRD ST AT ROBERSONVILLE	ups Robersonville WWTP	35.81602	-77.26421	MARTIN	WARO	03020103	28-103-2	C Sw NSW	M+2SM	M	M		M	
O7100000	FLAT SWAMP AT SR 1157 NR ROBERSONVILLE	dns Robersonville WWTP	35.78183	-77.25683	MARTIN	WARO	03020103	28-103-2	C Sw NSW	M+2SM	M	M		M	

[1] Field Parameters include: Dissolved Oxygen (DO), pH, Temperature and Conductivity
[2] Nutrients include: Ammonia (NH_3) as N, Nitrite/Nitrate (NO_2/NO_3) as N, Total Kjeldahl Nitrogen (TKN) as N, and Total Phosphorus (TP) as P
[3] No requirements for metals monitoring are included in this MOA, as the DWQ is currently in the process of reviewing metals water quality assessment techniques, evaluation criteria and relevant standards. However, the DWQ expects to conclude the review within the life cycle of this MOA. At such time, or when the DWQ Director mandates, the TPBA is expected to resume monitoring at a level of effort similar to that in the 2007-2012 MOA. Within 60 days of the release of relevant documentation, the TPBA will finalize an amendment to the MOA, which includes metals monitoring.

M = Sampling once a month
M + 2SM = Monthly Sampling January, February, March, April, October, November, and December and Twice Monthly Sampling May, June, July, August, and September. At least a 10 day interval should exist between Twice Monthly sampling events.

APPENDIX B

SAMPLE COLLECTION AND ANALYSIS

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Sample Collection Procedures
Sample collection shall be performed by trained personnel employed by NC DWQ certified laboratories in accordance with the DWQ NPDES Monitoring Coalition Program Field Monitoring Guidance Document (May 2008) and subsequent documents. The Field Monitoring Guidance Document can be found on the web at: http://portal.ncdenr.org/web/wq/ess/eco/coalition. Alternate collection procedures require the approval of the DWQ coalition coordinators prior to use.

Laboratory Analysis
All laboratory analyses shall be performed at a DWQ certified laboratory using approved methods as prescribed by section 40 of the Code of Federal Regulations part 136 (40CFR136) or other methods certified by the DWQ Laboratory Certification Branch (http://portal.ncdenr.org/web/wq/lab/cert/nonfield/methods) or the Director of DWQ. 40CFR136 can be accessed on the web at http://portal.ncdenr.org/web/wq/lab/cert/nonfield/rules.

Reporting levels will be at least as stringent as the reporting levels used by the DWQ Laboratory. For guidance purposes Table B-1 lists target reporting levels for each parameter based on the reporting levels of the DWQ Laboratory. The lowest possible analytical limits for all the parameters should be pursued.

TABLE B-1
DWQ Laboratory Reporting Limits

Parameters	Target Reporting Level	Comments
Temperature		Resolution to 0.1 degree Celsius
Dissolved Oxygen		Report results to the nearest 0.1 mg/l.
pH		Report results to the nearest 0.1 SU.
Specific Conductivity		Report results to the nearest whole µmho/cm at 25 ºC.
Turbidity	1.0 NTU	
TSS	2.5 mg/L	
Fecal Coliform	1 colony/100 mL	At least 3 dilutions should be used to achieve optimum colony counts per membrane filter of 20-60 colonies.
Chlorophyll *a*	1 µg/L	Report Chlorophyll *a* values free from pheophytin and other chlorophyll pigments. Analysis by HPLC is not approved by DWQ.
Ammonia (NH_3 as N)	0.02 mg/L	Address distillation requirement. See 40CFR136 Table II footnote.
Nitrate+Nitrite as N	0.02 mg/L	
Total Kjeldahl Nitrogen as N	0.20 mg/L	
Total Phosphorus as P	0.02 mg/L	
Al*		
As*		
Cu*		
Cd*		
Cr*		
Fe*		
Pb*		
Hg*		
Ni*		
Zn*		

*No requirements for metals monitoring are included in this MOA, as the DWQ is currently in the process of reviewing metals water quality assessment techniques, evaluation criteria and relevant standards. However, the DWQ expects to conclude the review within the life cycle of this MOA. At such time, or when the DWQ Director mandates, the TPBA is expected to resume monitoring at a level of effort similar to that in the 2007 – 2012 MOA. Within 60 days of the release of relevant documentation, the TPBA will finalize an amendment to the MOA, which includes metals monitoring.

Data Qualification Codes

When reporting data, the DWQ's data qualifier codes must be used to provide additional information regarding data quality and interpretation. The current set of qualifier codes to be used is provided in Table B-2. Review the data remark codes at least annually and utilize the most current set, as codes are subject to change. A copy of this table can be found at http://portal.ncdenr.org/web/wq/lab/qualityassurance.

Table B-2
Data Qualification Codes for Use With Coalition Data

Data Remark Code	Code Definition
A	Value reported is the mean (average) of two or more determinations. This code is to be used if the results of two or more discrete and separate samples are averaged. These samples shall have been processed and analyzed independently (e.g. field duplicates, different dilutions of the same sample). This code is not required for BOD or coliform reporting since averaging multiple dilutions for these parameters is fundamental to those methods.
B	Results based upon colony counts outside the acceptable range and should be used with caution. This code applies to microbiological tests and specifically to membrane filter (MF) colony counts. It is to be used if less than 100% sample was analyzed and the colony count is generated from a plate in which the number of colonies exceeds the ideal ranges indicated by the method. These ideal ranges are defined in the method as: *Fecal coliform or Enterococcus bacteria: 20-60 colonies* *Total coliform bacteria: 20-80 colonies* 1. Countable membranes with less than 20 colonies. Reported value is estimated or is a total of the counts on all filters reported per 100 mL. 2. Counts from all filters were zero. The value reported is based on the number of colonies per 100 mL that would have been reported if there had been one colony on the filter representing the largest filtration volume (reported as a less than "<" value). 3. Countable membranes with more than 60 or 80 colonies. The value reported is calculated using the count from the smallest volume filtered and reported as a greater than ">" value. 4. Filters have counts of both >60 or 80 and <20. Reported value is a total of the counts from all countable filters reported per 100 mL. 5. Too many colonies were present; too numerous to count (TNTC). TNTC is generally defined as > 150 colonies. The numeric value represents the maximum number of counts typically accepted on a filter membrane (60 for fecal and 80 for total), multiplied by 100 and then divided by the smallest filtration volume analyzed. This number is reported as a greater than value. 6. Estimated Value. Blank contamination evident. 7. Many non-coliform colonies or interfering non-coliform growths are present. In this competitive situation, the reported coliform value may under-represent actual coliform density. Note: A "B" value shall be accompanied by justification for its use denoted by the numbers listed above (e.g., B1, B2, etc.). Note: A "J2" should be used for spiking failures.
BB	This code applies to most probable number (MPN) microbiological tests. 1. No wells or tubes gave a positive reaction. Value based upon the appropriate MPN Index and reported as a less than "<" value. 2. All wells or tubes gave positive reactions. Value based upon the MPN Index and reported as a greater than ">" value. Note: A "BB" value shall be accompanied by justification for its use denoted by the numbers listed above (e.g., BB1, BB2, etc.).

Data Remark Code	Code Definition
C	Total residual chlorine was present in sample upon receipt in the laboratory; value is estimated. Generally applies to cyanide, phenol, NH_3, TKN, coliform, and organics)
G	A single quality control failure occurred during biochemical oxygen demand (BOD) analysis. The sample results should be used with caution. G1. The dissolved oxygen (DO) depletion of the dilution water blank exceeded 0.2 mg/L. G2. The bacterial seed controls did not meet the requirement of a DO depletion of at least 2.0 mg/L and/or a DO residual of at least 1.0 mg/L. G3. No sample dilution met the requirement of a DO depletion of at least 2.0 mg/L and/or a DO residual of at least 1.0 mg/L. G4. Evidence of toxicity was present. This is generally characterized by a significant increase in the BOD value as the sample concentration decreases. The reported value is calculated from the highest dilution representing the maximum loading potential and should be considered an estimated value. G5. The glucose/glutamic acid standard exceeded the range of 198± 30.5 mg/L. G6. The calculated seed correction exceeded the range of 0.6 to 1.0 mg/L. G7. Less than 1 mg/L DO remained for all dilutions set. The reported value is an estimated greater than value and is calculated for the dilution using the least amount of sample. G8. Oxygen usage is less than 2 mg/L for all dilutions set. The reported value is an estimated less than value and is calculated for the dilution using the most amount of sample. G9. The DO depletion of the dilution water blank produced a negative value.
J	Estimated value; value may not be accurate. This code is to be used in the following instances: J1. Surrogate recovery limits have been exceeded; J2. The reported value failed to meet the established quality control criteria for either precision or accuracy; J3. The sample matrix interfered with the ability to make any accurate determination; J4. The data is questionable because of improper laboratory or field protocols (e.g. composite sample was collected instead of grab, plastic instead of glass container) J5. Temperature limits exceeded (samples frozen or >6° C) during transport or not verifiable (e.g., no temperature blank provided);, non-reportable for NPDES compliance monitoring. J6. The laboratory analysis was from an unpreserved or improperly chemically preserved sample. The data may not be accurate. J7. This qualifier is used to identify analyte concentration exceeding the upper calibration range of the analytical instrument/method. The reported value should be considered estimated. J8. Temperature limits exceeds (samples frozen or >6°C during storage. The data may not be accurate. J9. The reported value is determined by a one-point estimation rather than against a regression equation. The estimated concentration is less than the laboratory practical quantitation limit and greater than the laboratory method detection limit. J10. Unidentified peak; estimated value. J11. The reported value is determined by a one-point estimation rather than against a regression equation. The estimated concentration is less than the laboratory practical quantitation limit and greater than the laboratory method detection limit. *This code is used when an MDL has not been established for the analyte in question.* J12. The calibration verification did not meet the calibration acceptance criterion for field parameters. Note: A "J" value shall not be used if another code applies (ex. N, V, M).

Data Remark Code	Code Definition
M	Sample and duplicate results are "out of control." The sample is non-homogenous (e.g. VOA soil). The reported value is the lower value of duplicate analyses of a sample.
N	Presumptive evidence of presence of material; estimated value. This code is to be used if: N1. The component has been tentatively identified based on mass spectral library search; N2. There is an indication that the analyte is present, but quality control requirements for confirmation were not met (i.e., presence of analyte was not confirmed by alternate procedures). N3. This code shall be used if the level is too low to permit accurate quantification, but the estimated concentration is less than the laboratory practical quantitation limit and greater than the laboratory method detection limit. This code is not routinely used for most analyses. N4. This code shall be used if the level is too low to permit accurate quantification, but the estimated concentration is less than the laboratory practical quantitation limit and greater than the instrument noise level. This code is used when an MDL has not been established for the analyte in question. N5. The component has been tentatively identified based on a retention time standard.
P	Elevated practical quantitation limit (PQL)* due to matrix interference and/or sample dilution.
Q	Holding time exceeded. These codes shall be used if the value is derived from a sample that was received, prepared and/or analyzed after the approved holding time restrictions for sample preparation and analysis. The value does not meet NPDES requirements. Q1. Holding time exceeded prior to receipt by lab Q2. Holding time exceeded following receipt by lab
S	Not enough sample provided to prepare and/or analyze a method-required matrix spike (MS) and/or duplicate (MSD).
U	Indicates that the analyte was analyzed for but not detected above the reported practical quantitation limit (PQL)*. The number value reported with the "U" qualifier is equal to the laboratory's PQL*.
V	Indicates the analyte was detected in both the sample and the associated method blank. Note: The value in the blank shall not be subtracted from the associated samples.
X	Sample not analyzed for this constituent. This code is to be used if: X1. Sample not screened for this compound. X2. Sampled, but analysis lost or not performed-field error X3. Sampled, but analysis lost or not performed-lab error
Y	Elevated PQL* due to insufficient sample size
Z	The presence or absence of the analyte cannot be verified. The sample analysis/results are not reported due to: Z1. Inability to analyze the sample. Z2. Questions concerning data reliability.

*PQL, The Practical Quantitation Limit (PQL), is defined as the lowest level achievable among laboratories within specified limits during routine laboratory operation. The Practical Quantitation Limit (PQL) is "about three to five times the method detection limit (MDL) and represents a practical and routinely achievable detection level with a relatively good certainty that any reported value is reliable." (APHA, AWWA, WEF. 1992. Standard Methods for the Examination of Water and Wastewater, 18th ed.)

** Data remarks are current as of December 7, 2011

APPENDIX C

DATA FORMAT AND REPORTING REQUIREMENTS

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Data Format for Monthly submittals

Table C-1 provides the required data submittal spreadsheet format. Do not use commas, tabs, pipes or other common file delimiters anywhere in the table. The first row should contain the column headings only. Column headings must include appropriate information on measurement units (mg/l, µg/l, cfu/100ml, etc.). The second row must contain the method code. It is very important that the format of the headings and the number and order of columns is consistent among all monthly submissions. The DWQ station number must be provided (e.g. B6140000). An additional column containing the location description is acceptable as long as it is consistently included. Include a comment column for describing pertinent information related to the sampling event or specific samples. Ensure that there are no missing values for station, date, time, and depth. Place all remark codes in a separate column as demonstrated in Table C-1. If there is no result for a particular parameter leave the cell blank. Screen all data for inappropriate or improbable values, such as a pH of 21.2.

Annual Report

The TPBA is required to submit an annual report by April 30th for each year the Agreement is in effect. The annual report will summarize all data collected in the past calendar year and contain the following elements:

- Monitoring Station List to include station number, station description, county, accurate coordinates (in decimal degrees to 4 decimal places using NAD83), stream classification, and 8 digit hydrologic unit code (HUC).
- List of all certified laboratories that conducted work for the coalition in the past year and laboratory methods used for all parameters. Summarize any laboratory certification issues for individual parameters.
- Submit a CD that includes all monitoring data for the past year with a statistical summary for each station. These data should be combined into a single table containing the year's reviewed and finalized data, which may be placed on the DWQ web site. The annual statistical summary must describe for each parameter at each location:
  - Number of observations (N)
  - Number of observations less than the laboratory reporting level (N<RL)
  - Identify the water quality standard, action level, or other reference level (Ref)
  - Identify the number of observations that do not meet the reference level (N>Ref) or (N<Ref)
  - Maximum observed value and Minimum observed value
  - Annual arithmetic mean (use a geometric mean for fecal coliform data)
- Include a list of active TPBA members with authorized representative updates, contact names, email addresses and phone numbers. Identify the facility name and permit number. Provide a list of members that are no longer active in the TPBA.
- Provide a list of changes in members' names, ownerships, and discharge locations.
- Summarize all quality assurance and quality control issues and any field audits conducted.
- Summarize any significant issues, special studies, or projects.
- Describe any required data collection that was missed and provide an explanation.
- Review the monitoring program and suggest potential MOA modifications.
- Provide the Coalition's Website Address.

Table C-1
File Format for Coalition Data Reporting

				Temp (°C)	Temp_rmk	DO (mg/l)	DO_rmk	pH (su)	pH_rmk	Conductivity (uohm/cm)	Conductivity_rmk	Fecal Coliform (#colonies/100ml)	Fecal Coliform_rmk	Suspended Residue (mg/l)	Suspended Residue_rmk	Turbidity (NTU)	Turbidity_rmk	Chlorophyll a (µg/l)	Chlorophyll_rmk	NH3_N (mg/l)	NH3_N_rmk	TKN_N (mg/l)	TKN_N_rmk	NO2_NO3_N (mg/l)	NO2_NO3_N_rmk	TP_P (mg/l)	TP_P_rmk
Station	**Date (m/d/yyyy)**	**Time (hh:mm)**	**Depth (m)**	**10**	**10 rmk**	**300**	**300 rmk**	**400**	**400 rmk**	**94**	**94 rmk**	**31613**	**31613 rmk**	**530**	**530 rmk**	**82079**	**82079 rmk**	**70953**	**70953 rmk**	**610**	**610 rmk**	**625**	**625 rmk**	**630**	**630 rmk**	**665**	**665 rmk**
A1234567	8/19/2002	15:30	0.1	25.2		7.8		6.9		133		110		45		22		23	Q1	0.1		0.2		0.3			
B9876543	8/20/2002	11:50	0.1	27.2		7.1		7.2		125		30		4		5.6		5		0.14		0.6		0.31			
B9876543	8/20/2002	11:50	1	28		6.5		7		122																	
B9876543	8/20/2002	11:50	2	25		6.7		6.9		119																	
B9876543	8/20/2002	11:50	3	17		5.5		6.7		120																	
C1357924	8/21/2002	16:10	0.1	22.1		3.1		6.2		233		15	B1	55		11											
C0246813	9/1/2002	9:30	0.1	19.7		8.3		7		99		6000	B5	410		36				0.26		0.4		0.57			
C0246813	10/1/2002	11:30	0.1	12		8.9		7.3		115		1200	B3	95	A		X3			0.16	J2	0.2		0.09			

Table C-1 Cont'd
File Format For Coalition Data Reporting

Cadmium, Cd (µg/L)	Cadmium, Cd_rmk	Chromium, Cr (µg/L)	Chromium, Cr_rmk	Copper, Cu (µg/L)	Copper, Cu_rmk	Nickel, Ni (µg/L)	Nickel, Ni_rmk	Lead, Pb (µg/L)	Lead, Pb_rmk	Zinc, Zn (µg/L)	Zinc, Zn_rmk	Aluminum, Al (µg/L)	Aluminum, Al_rmk	Iron, Fe (µg/L)	Iron, Fe_rmk	Manganese, Mn (µg/L)	Manganese, Mn_rmk	Arsenic, As (µg/L)	Arsenic, As_rmk	Mercury, Hg (µg/L)	Mercury, Hg_rmk	Comments
1027	1027 rmk	1034	1034 rmk	1042	1042 rmk	1067	1067 rmk	1051	1051 rmk	1092	1092 rmk	1105	1105 rmk	1045	1045 rmk	1055	1055 rmk	1002	1002 rmk	71900	71900 rmk	
130			11	3		27		4.4		610		10				0.21		12		12		
120		10	U	2	U	25	U	2	U	510		10	U	10	U	0.2	U	10	U	10	U	
																						Secchi depth 1.2 meters
333		10	U	2	U	25	U	2	U	624		10	U	10	U	0.2	U	10	U	10	U	Nutrient Sample Spilled
120		10	U	2	U	25	U	2	U	510		10	U	10	U	0.2	U	10	U	10	U	2.5" of rain on 8/31/2002
120		10	U	2	U	25	U	2	U	510		10	U	10	U	0.2	U	10	U	10	U	

APPENDIX B.

Memorandum of Agreement
Between
The State of North Carolina's Division of Water Quality
And
The Lower Neuse Basin Association Permittees

Effective:
August 1, 2009 through July 31, 2014

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MEMORANDUM OF AGREEMENT

This Memorandum of Agreement (MOA) is made by and between the NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES'S DIVISION OF WATER QUALITY (DWQ), the NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) DISCHARGERS in the Lower Neuse River basin who have voluntarily executed this MOA (the LNBA PERMITTEES), and the LOWER NEUSE BASIN ASSOCIATION (the LNBA), a non-profit corporation whose members include the LNBA PERMITTEES. The MOA includes all the attached tables and appendices. This MOA does not affect any influent or effluent monitoring requirement or any other of the NPDES permit requirements of individual permit holders with the one exception of performing upstream and downstream water quality monitoring. The LNBA PERMITTEES are exempted from instream monitoring as specified in their individual NPDES permits beginning on the effective date of this MOA and continuing for the duration of each permittee's participation in this MOA. Subsequent to the execution of this MOA, the DWQ will issue a letter to each PERMITTEE notifying the permittee that the instream monitoring requirements of its permit are not effective for as long as this MOA is in place and the permittee remains a party to this MOA.

The purpose of this MOA is to establish a formal agreement between the DWQ, the LNBA PERMITTEES, and the LNBA. This MOA authorizes the LNBA to act on behalf of the PERMITTEES as described herein. This MOA identifies the responsibilities of the LNBA Permittees and the LNBA for surface water monitoring and reporting within the Lower Neuse River Basin. The water quality monitoring will occur at strategically located surface water sites to obtain information on water quality in the basin. Monitoring sites and parameters were established by the DWQ and are listed in Table A-1, such that the instream monitoring is efficient, effective, and basin-oriented.

The LNBA will perform the monitoring activities described herein on behalf of LNBA PERMITTEES who are members in good standing of the LNBA. Each LNBA PERMITTEE agrees to remain a member in good standing of the LNBA. The LNBA will contract for the performance of the monitoring activities described herein with a laboratory appropriately certified by the DWQ for the required laboratory and field analyses. Sample collection and field measurements will be made by the LNBA PERMITTEES, the LNBA, or a sub-contractor who will act as agent(s) of the LNBA PERMITTEES for the sole purpose of performing monitoring services required by this MOA. It will be the responsibility of the LNBA to coordinate the collection and analyses of the water quality monitoring data for the locations, parameters, and frequencies specified in Table A-1 of this MOA. Sample collection, field measurement, and target reporting limits are specified in Appendix B of this MOA. Monthly and annual reporting requirements, including data format and data summaries are described in Appendix C of this MOA.

The LNBA shall submit the water quality data to the DWQ using the format documented in Appendix C of this MOA preferably in Microsoft® Excel 2000, a subsequent version, or the equivalent. The LNBA shall submit the water quality data to the DWQ within 90 days of the end of the month in which the sampling was performed. All data shall be archived by the LNBA for a period of 5 years. Each LNBA PERMITTEE has the right to review and comment on work, data or reports prepared by any contractor on behalf of the LNBA PERMITTEES and to notify the DWQ of any objection or disagreement with any portion of the work, data, or reports. Unless such notice is made within thirty (30) days of submission of each annual report (or other reports) to the DWQ, it shall be deemed to be waived and the work, data and reports submitted shall be deemed to be approved by the LNBA PERMITTEES. Failure by the LNBA PERMITTEES or the LNBA to collect or analyze the water quality data as described in this MOA or to provide the data to the DWQ in the required format may result in the revocation of this MOA by the DWQ and the return to individual upstream and downstream monitoring requirements, as specified in the individual NPDES permits of the LNBA PERMITTEES.

The LNBA shall submit an annual written report that summarizes the previous calendar year's sampling results and formally finalizes the water quality data. The report shall be submitted no later than April 30th each year that this MOA is in effect. The annual report shall include the NPDES permit number of each actively participating permit holder and a contact name and phone number for each member. Appendix C of this MOA describes the required annual report content. Two copies, signed by the LNBA chairman, of these and any other reports required herein shall be submitted to the DWQ Coalition Coordinators at 1621 Mail Service Center, Raleigh, NC 27699-1621.

Stream sampling may be discontinued at such times as flow conditions in the receiving waters or extreme weather conditions will result in a substantial risk of injury or death to persons collecting samples. Sampling may also be discontinued when environmental conditions, such as a dry stream, prevent sample collection. In such cases, on each day that sampling is discontinued, the DWQ Coalition Coordinators shall be notified within one week of the discontinuance and written justification for the discontinuance shall be submitted with the monthly data submittal. This provision shall not be utilized to avoid the requirements of this MOA when performance of these requirements is attainable. When there is a sampling discontinuance pursuant to this provision, sampling shall be resumed at the first opportunity.

This MOA may be modified by the written consent of the DWQ and the LNBA. The DWQ or the LNBA may determine that it is necessary to request changes in monitoring frequency, parameters or sites to be sampled. Any such changes can only be made by a written amendment to this MOA agreed to by the DWQ and the LNBA. The amendment shall be signed by the LNBA chairman and by the DWQ. Such amendments may be entered into at any time.

The following additional dischargers may enter into this MOA subsequent to the effective date hereof:

1) Dischargers who receive a NPDES permit within the Lower Neuse River Basin, or
2) Dischargers who have NPDES permits within the Lower Neuse River Basin but are not parties to this Agreement.

The addition of such dischargers to this MOA may be made only with the consent of the DWQ and the LNBA and shall require a written amendment to this MOA signed by the LNBA chairman, by the DWQ, and by an authorized representative of any such discharger who wishes to enter into the MOA. The DWQ will not unreasonably withhold consent to the addition of a discharger to the MOA. The DWQ will consider modification of the existing monitoring program described in this MOA for the addition of a discharger to the MOA. Such amendments may be made at any time that this MOA is in effect. The LNBA PERMITTEES included in this MOA are listed in Table 1.

This MOA shall be effective until July 31, 2014 unless extended by the consent of both the DWQ and the LNBA. Upon sixty (60) days written notice, the DWQ or the LNBA may terminate this MOA for any reason. Upon termination of this MOA, the monitoring requirements contained in the individual NPDES permit of each LNBA PERMITTEE shall become effective immediately. An individual permit holder may terminate and cancel its participation in this MOA by providing sixty (60) day written notice to the LNBA, the DWQ Coalition Coordinators, the appropriate DWQ Regional Office, and the DWQ NPDES Unit. The monitoring requirements contained in the individual NPDES permit shall become effective immediately upon such cancellation or termination. In the event a permit holder terminates or cancels its participation in this MOA or its membership in the LNBA is terminated for any reason, the LNBA may request that DWQ review the monitoring plan described in this MOA for a possible reduction in sampling effort or requirements.

IN WITNESS WHEREOF, the parties have caused the execution of this instrument
by authority duly given, to be effective as of the date executed by the DWQ

DIVISION OF WATER QUALITY	**LOWER NEUSE BASIN ASSOCIATION**
By: signed 7/29/2009	By: signed 7/28/2009
Coleen Sullins **Director** **Division of Water Quality**	**Daniel F. McLawhorn** **Chairman** **Lower Neuse Basin Association**
Date: ______________________	Date: ______________________

LNBA PERMITEE SIGNATURES

Permittee	NPDES Number	Signature
Carolina Power and Light (CP&L) d/b/a Progress Energy Carolinas, Inc. Lee Steam Electric Plant	NC0003417	received 6/09/2009 Kris Edmondson Plant Manager

Permittee	NPDES Number	Signature
EI DuPont Kinston Facility	NC0003760	received 6/30/2009 Harold Thomas Plant Manager

Permittee	NPDES Number	Signature
Town of Benson Benson WWTP	NC0020389	received 6/02/2009 Keith Langdon Town Manager

Permittee	NPDES Number	Signature
City of Havelock Havelock WWTP	NC0021253	received 6/04/2009 Jim Freeman City Manager

Permittee	NPDES Number	Signature
Town of La Grange La Grange WWTP	NC0021644	received 6/02/2009 John Craft Town Manager

LNBA PERMITEE SIGNATURES

Permittee	NPDES Number	Signature
City of Wilson Wilson WWTP	NC0023906	received 6/04/2009 Grant Goings City Manager

Permittee	NPDES Number	Signature
City of Goldsboro Goldsboro WWTP	NC0023949	received 6/08/2009 Joseph Huffman City Manager

Permittee	NPDES Number	Signature
City of Kinston Kinston Regional WRF	NC0024236	received 6/19/2009 Scott Stevens City Manager

Permittee	NPDES Number	Signature
City of New Bern New Bern WWTP	NC0025348	received 6/16/2009 Walter B. Hartman, Jr. City Manager

Permittee	NPDES Number	Signature
Town of Clayton Little Creek WWTP	NC0025453	received 6/09/2009 Steve Biggs Town Manager

LNBA PERMITEE SIGNATURES

Permittee	NPDES Number	Signature
City of Raleigh Neuse River WWTP	NC0029033	received 7/2/2009 Dale Crisp Public Utilities Director

Permittee	NPDES Number	Signature
Town of Farmville Farmville WWTP	NC0029572	received 6/08/2009 Richard Hicks Town Manager

Permittee	NPDES Number	Signature
Johnston County Central Johnston County WWTP	NC0030716	received 6/11/2009 Rick J. Hester County Manager

Permittee	NPDES Number	Signature
City of Raleigh Smith Creek WWTP	NC0030759	received 7/2/2009 Dale Crisp Public Utilities Director

Permittee	NPDES Number	Signature
Contentnea Metropolitan Sewerage District Contentnea MSD WWTP	NC0032077	received 6/03/2009 Charles M. Smithwick, Jr. District Manager

LNBA PERMITEE SIGNATURES

Permittee	NPDES Number	Signature
Town of Cary North Cary WRF	NC0048879	received 6/03/2009 Benjamin T. Shivar Town Manager

Permittee	NPDES Number	Signature
Town of Apex Apex WRF	NC0064050	received 6/10/2009 Bruce Radford Town Manager

Permittee	NPDES Number	Signature
Town of Kenly Kenly Regional WWTP	NC0064891	received 6/11/2009 Scott Shelton Town Manager

Permittee	NPDES Number	Signature
Town of Cary South Cary WRF	NC0065102	received 6/03/2009 Benjamin T. Shivar Town Manager

Permittee	NPDES Number	Signature
Town of Fuquay-Varina Terrible Creek WWTP	NC0066516	received 7/24/2009 Andy Hedrick Town Manager

LNBA PERMITEE SIGNATURES

Permittee	NPDES Number	Signature
City of Raleigh Little Creek WWTP	NC0079316	received 7/2/2009 Dale Crisp Public Utilities Director

Permittee	NPDES Number	Signature
Johnston County Johnston County WTP	NC0084735	received 6/11/2009 Rick J. Hester County Manager

Table 1. LNBA PERMITTEES

NPDES Permit Number	Lower Neuse Basin Association Permittees Ownership and Facility	Authorized Representative and Title	County	Region	8 Digit HUC
NC0003417	Carolina Power and Light (CP&L) d/b/a Progress Energy Carolinas, Inc. ─ Lee Steam Plant	Kris Edmondson Plant Manager	Wayne	WaRO	03020201
NC0003760	E. I. DuPont ─ Kinston Plant	Harold Thomas Plant Manager	Lenoir	WaRO	03020202
NC0020389	Town of Benson ─ Benson WWTP	Keith Langdon Town Manager	Johnston	RRO	03020201
NC0021253	City of Havelock ─ Havelock WWTP	Jim Freeman City Manager	Craven	WaRO	03020204
NC0021644	Town of La Grange ─ La Grange WWTP	John Craft Town Manager	Lenoir	WaRO	03020202
NC0023906	City of Wilson ─ Wilson WWTP	Grant Goings City Manager	Wilson	RRO	03020203
NC0023949	City of Goldsboro ─ Goldsboro WWTP	Joseph Huffman City Manager	Wayne	WaRO	03020202
NC0024236	City of Kinston ─ Regional Water Reclamation Facility	Scott Stevens City Manager	Lenoir	WaRO	03020202
NC0025348	City of New Bern ─ New Bern WWTP	William B. Hartman, Jr. City Manager	Craven	WaRO	03020204
NC0025453	Town of Clayton ─ Little Creek WWTP	Steve Biggs Town Manager	Johnston	RRO	03020201
NC0029033	City of Raleigh ─ Neuse River WWTP	Dale Crisp Public Utilities Director	Wake	RRO	03020201
NC0029572	Town of Farmville ─ Farmville WWTP	Richard N. Hicks Town Manager	Pitt	WaRO	03020203
NC0030716	Johnston County ─ Central Johnston County WWTP	Rick J. Hester County Manager	Johnston	RRO	03020201
NC0030759	City of Raleigh ─ Smith Creek WWTP	Dale Crisp Public Utilities Director	Wake	RRO	03020201
NC0032077	Contentnea Metropolitan Sewerage District ─ Contentnea MSD WWTP	Charles M. Smithwick, Jr. District Manager	Pitt	WaRO	03020203
NC0048879	Town of Cary ─ North WWTP	Benjamin T. Shivar Town Manager	Wake	RRO	03020201
NC0064050	Town of Apex ─ Apex WRF	Bruce Radford Town Manager	Wake	RRO	03020201
NC0064891	Town of Kenly ─ Kenly Regional WWTP	Scott Shelton Town Manager	Johnston	RRO	03020201
NC0065102	Town of Cary ─ South WWTP	Benjamin T. Shivar Town Manager	Wake	RRO	03020201
NC0066516	Town of Fuquay Varina ─ Terrible Creek WWTP	Andy Hedrick Town Manager	Wake	RRO	03020201
NC0079316	City of Raleigh ─ Little Creek WWTP	Dale Crisp Public Utilities Director	Wake	RRO	03020203
NC0084735	Johnston County ─ Johnston County WTP	Rick J. Hester County Manager	Johnston	RRO	03020201

APPENDIX A - LNBA MONITORING PROGRAM

Table A-1 LNBA Sampling Stations, Parameters and Sampling Frequency

STATION NUMBER	LOCATION	Station Comments	LATITUDE (dd.dddd)	LONGITUDE (dd.dddd)	COUNTY	8 Digit HUC	STREAM CLASS	Field Measurements (Temp, DO, pH, Conductivity)	*Nutrients	**Metals	Turbidity	Suspended Residue	Fecal Coliform	Chlorophyll a
J2230000	SMITH CRK AT SR 2045 BURLINGTON MILL RD NR WAKE FOREST	DWQ benthic and fish station.	35.9182	-78.5348	WAKE	03020201	C NSW	M+2SM	M		M	M	M	
J2330000	NEUSE RIV AT SR 2215 BUFFALO RD NR NEUSE	dns Smith Creek WWTP	35.8479	-78.5302	WAKE	03020201	C NSW	M+2SM	M		M	M	M	
J2360000	NEUSE RIV ABOVE MILBURNIE DAM NR RALEIGH	sample upstream of dam	35.8022	-78.5386	WAKE	03020201	C NSW	M+2SM	M		M	M	M	
J3210000	CRABTREE CRK AT LASSITER MILL DAM AT RALEIGH	dns North Cary WRF	35.8272	-78.6508	WAKE	03020201	C NSW	M+2SM	M		M	M	M	
J3970000	WALNUT CRK AT SR 2551 BARWELL RD NR RALEIGH	DWQ benthic station	35.7493	-78.5345	WAKE	03020201	C NSW	M+2SM	M	M	M	M	M	
J4050000	NEUSE RIV AT SR 2555 AUBURN KNIGHTDALE RD NR RALEIGH	ups Neuse River WWTP	35.7266	-78.5139	WAKE	03020201	C NSW	M+2SM	M	M	M	M	M	
J4080000	POPLAR CRK AT SR 2049 BETHLEHEM RD NR KNIGHTDALE	last bridge before Neuse	35.7309	-78.4776	WAKE	03020201	C NSW	M+2SM	M		M	M	M	
J4130000	NEUSE RIV AT SR 1700 COVERED BRIDGE RD NR ARCHERS LODGE	dns Neuse River WWTP, ups Little Creek (Clayton) WWTP	35.6749	-78.4364	JOHNSTON	03020201	WS-V NSW	M+2SM	M	M	M	M	M	
J4170000	NEUSE RIV AT NC 42 NR CLAYTON	dns Little Creek (Clayton) WWTP, DWQ benthic station, DWQ AMS station, USGS gage	35.6473	-78.4056	JOHNSTON	03020201	WS-IV NSW	M+2SM	M	M	M	M	M	
J4190000	NEUSE RIV AT SR 1908 FIRE DEPT DR NR WILSONS MILLS	ups Johnston County WTP	35.6067	-78.3374	JOHNSTON	03020201	WS-IV NSW	M+2SM	M		M	M	M	
J4414000	SWIFT CRK AT SR 1152 HOLLY SPRINGS RD NR MACEDONIA	ups Lake Wheeler, DWQ benthic station, USGS gage	35.7187	-78.7527	WAKE	03020201	WS-III NSW	M+2SM	M		M	M	M	
J4590000	SWIFT CRK AT NC 210 NR SMITHFIELD		35.5186	-78.3819	JOHNSTON	03020201	C NSW	M+2SM	M		M	M	M	
J4619000	MIDDLE CRK AT LUFKIN RD NR APEX	ups Apex WWTP, dns Hwy 1	35.71311	-78.8381	WAKE	03020201	C NSW	M+2SM	M		M	M	M	
J4690000	MIDDLE CRK AT SR 1152 HOLLY SPRINGS RD NR HOLLY SPRINGS	ups South Cary WRF, dns Apex WWTP	35.6609	-78.8042	WAKE	03020201	C NSW	M+2SM	M		M	M	M	
J4868000	MIDDLE CRK AT SR 1375 LAKE WHEELER RD NR BANKS	dns South Cary WRF, ups Terrible Creek	35.6356	-78.7279	WAKE	03020201	C NSW	M+2SM	M	M	M	M	M	
J4980000	MIDDLE CRK AT SR 1006 OLD STAGE ROAD NR WILLOW SPRINGS	dns of Terrible Creek	35.6091	-78.6866	WAKE	03020201	C NSW	M+2SM	M		M	M	M	
J5010000	MIDDLE CRK AT NC 210 NR SMITHFIELD	ups of Neuse River	35.5075	-78.4013	JOHNSTON	03020201	C NSW	M+2SM	M		M	M	M	
J5170000	BLACK CRK AT SR 1162 BLACK CREEK RD NR FOUR OAKS	dns Holts Lake, ups Neuse River, USGS gage	35.46925	-78.45681	JOHNSTON	03020201	C NSW	M+2SM	M		M	M	M	
J5250000	NEUSE RIV AT SR 1201 RICHARDSON BRIDGE RD NR COX MILL	dns for Johnston County WWTP, ups for Progress Energy and Goldsboro WWTP, DWQ benthic station	35.3741	-78.1962	JOHNSTON	03020201	WS-IV NSW	M+2SM	M	M	M	M	M	
J5390000	HANNAH CRK AT SR 1158 ALLENS CROSSROADS DR NR BENSON	ups Benson WWTP	35.3868	78.5110	JOHNSTON	03020201	C NSW	M+2SM	M		M	M	M	
J5390800	HANNAH CRK AT SR 1227 IVEY RD NR BENSON	dns Benson WWTP	35.4025	-78.4952	JOHNSTON	03020201	C NSW	M+2SM	M		M	M	M	
J5410000	MILL CRK AT SR 1200 RICHARDSON BRIDGE RD NR BENTONVILLE	USGS gage	35.3420	-78.2162	JOHNSTON	03020201	C NSW	M+2SM	M		M	M	M	
J5500000	FALLING CRK AT SR 1219 OLD GRANTHAM RD NR GRANTHAM		35.3224	-78.1282	WAYNE	03020201	WS-IV NSW	M+2SM	M		M	M	M	
J5620000	LITTLE RIV AT SR 2333 SMITHFIELD RD NR ZEBULON		35.8577	-78.3665	WAKE	03020201	WS-II HQW NSW	M+2SM	M		M	M	M	

*Nutrients include Ammonia as N (NH_3), Nitrate/Nitrite as N (NO_2/NO_3), Total Kjeldahl Nitrogen (TKN), and Total Phosphorus as P (TP)

**Metals analysis will include the following metals: Aluminum (Al), Arsenic (As), Cadmium (Cd), Chromium (Cr) (total), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), and Zinc (Zn) - Metals monitoring was suspended per DWQ's March 2009 letter at the agreement of DWQ and LNBA

*** These nutrient and chlorophyll *a* samples shall be collected as a composite sample over the photic zone (photic zone = twice the secchi depth)

M=Monthly, M+2SM=Monthly with Twice Monthly Summer Sampling during May, June, July, August, and September. Samples are to be collected at least ten days apart except when extenuating conditions arise.

ups=upstream, dns=downstream

Table A-1 Continued LNBA Sampling Stations, Parameters and Sampling Frequency

STATION NUMBER	LOCATION	Station Comments	LATITUDE (dd.dddd)	LONGITUDE (dd.dddd)	COUNTY	8 Digit HUC	STREAM CLASS	Field Measurements (Temp, DO, pH, Conductivity)	*Nutrients	**Metals	Turbidity	Suspended Residue	Fecal Coliform	Chlorophyll a
J5690000	LITTLE RIV AT US 301 NR KENLY	ups Kenly Regional WWTP	35.5829	-78.1593	JOHNSTON	03020201	WS-V NSW	M+2SM	M		M	M	M	
J5750000	LITTLE RIV AT SR 2339 BAGLEY RD NR LOWELL MILL	dns Kenly Regional WWTP	35.5613	-78.1594	JOHNSTON	03020201	WS-V NSW	M+2SM	M		M	M	M	
J5900000	LITTLE RIV AT SR 1234 CAPPS BRIDGE RD NR CROSSROADS		35.4662	-78.0942	WAYNE	03020201	WS-IV NSW	M+2SM	M		M	M	M	
J5930000	LITTLE RIV AT NC 581 NR ASYLUM	DWQ benthic station	35.3930	-78.0258	WAYNE	03020201	C NSW	M+2SM	M		M	M	M	
J6010950	WALNUT CRK AT SR 1730 SAINT JOHNS CHURCH RD NR WALNUT CREEK	significant tributary	35.2817	-77.8686	WAYNE	03020202	C NSW	M+2SM	M		M	M	M	
J6024000	NEUSE RIV AT SR 1731 PINEY GROVE RD NR SEVEN SPRINGS	dns Goldsboro WWTP	35.2290	-77.8460	WAYNE	03020202	C NSW	M+2SM	M		M	M	M	
J6044500	BEAR CRK AT SR 1311 BEAR CREEK RD NR KINSTON	DWQ benthic and fish stations	35.2489	-77.7843	LENOIR	03020202	WS IV Sw NSW	M+2SM	M		M	M	M	
J6055000	MOSLEY CRK AT SR 1327 WILLEY MEASLEY RD NR LA GRANGE	dns LaGrange WWTP	35.3119	-77.7313	LENOIR	03020202	C Sw NSW	M+2SM	M		M	M	M	
J6150000	NEUSE RIV AT NC 11 BYPASS AT KINSTON	DWQ AMS station, ups Kinston Regional WRF	35.2587	-77.5835	LENOIR	03020202	C NSW	M+2SM	M		M	M	M	
J6250000	NEUSE RIV AT NC 55 NR GRAINGERS	dns Kinston Regional WRF, ups DuPont	35.2957	-77.4962	LENOIR	03020202	C NSW	M+2SM	M		M	M	M	
J6410000	LITTLE CRK AT NC 97 AT ZEBULON	ups Little Creek (Raleigh) WWTP	35.8279	-78.3025	WAKE	03020203	C NSW	M+2SM	M		M	M	M	
J6450000	LITTLE CRK AT NC 39 AT ZEBULON	dns Little Creek (Raleigh) WWTP	35.8125	-78.2681	WAKE	03020203	C NSW	M+2SM	M		M	M	M	
J6500000	MOCCASIN CRK AT SR 1131 ANTIOCH CHURCH RD NR CONNER		35.7301	-78.1895	WILSON	03020203	C NSW	M+2SM	M		M	M	M	
J6680000	TURKEY CRK AT SR 1101 CLAUDE LEWIS RD NR MIDDLESEX	load to Buckhorn Reservoir	35.7519	-78.1597	NASH	03020203	C NSW	M+2SM	M		M	M	M	
J6764000	CONTENTNEA CRK AT US 301 WARD BLVD NR DIXIE	ups Wilson WWTP, dns Wiggins Mill Reservoir	35.6879	-77.9477	WILSON	03020203	C Sw NSW	M+2SM	M		M	M	M	
J6890000	CONTENTNEA CRK AT SR 1622 EVANSDALE RD NR WILSON	dns Wilson WWTP	35.6429	-77.8902	WILSON	03020203	C Sw NSW	M+2SM	M		M	M	M	
J7210000	CONTENTNEA CRK AT NC 58 NR STANTONSBURG	DWQ benthic station	35.5861	-77.8111	WILSON	03020203	C Sw NSW	M+2SM	M		M	M	M	
J7240000	TOISNOT SWAMP AT SR 1539 SAND PIT RD NR STANTONSBURG	major trib to Contentnea Creek	35.5976	-77.7947	WILSON	03020203	C Sw NSW	M+2SM	M		M	M	M	
J7325000	NAHUNTA SWAMP AT NC 58 NR CONTENTNEA	major trib to Contentnea Creek	35.5081	-77.7455	GREENE	03020203	C Sw NSW	M+2SM	M		M	M	M	
J7330000	CONTENTNEA CRK AT US 13 AT SNOW HILL		35.4585	-77.6753	GREENE	03020203	C Sw NSW	M+2SM	M		M	M	M	
J7690000	LITTLE CONTENTNEA CRK AT SR 1218 CHINQUAPIN RD NR FARMVILLE	ups Farmville WWTP	35.5881	-77.5416	PITT	03020203	C Sw NSW	M+2SM	M		M	M	M	
J7740000	LITTLE CONTENTNEA CRK AT SR 1110 HWY 903 AT SCUFFLETON	ups of Contentnea Ck	35.4567	-77.4854	PITT	03020203	C Sw NSW	M+2SM	M		M	M	M	
J7850000	NEUSE RIV AT SR 1470 MAPLE CYPRESS RD NR FORT BARNWELL	dns Contentnea Creek and Contentnea MSD WWTP, DWQ AMS station, ups New Bern WWTP	35.3124	-77.3022	CRAVEN	03020202	C Sw NSW	M+2SM	M		M	M	M	M
J8870000	TRENT RIV AT SHERATON MARINA DOCK A		35.1013	-77.0412	CRAVEN	03020204	SB Sw NSW	M+2SM	M***		M	M	M	M***
J9330000	SLOCUM CRK AT SLOCUM RD AT CHERRY POINT	dns Havelock and Cherry Pt. WWTPs	34.9177	-76.9115	CRAVEN	03020204	SC Sw NSW	M+2SM	M***		M	M	M	M***

*Nutrients include Ammonia as N (NH_3), Nitrate/Nitrite as N (NO_2/NO_3), Total Kjeldahl Nitrogen (TKN), and Total Phosphorus as P (TP)

**Metals analysis will include the following metals: Aluminum (Al), Arsenic (As), Cadmium (Cd), Chromium (Cr) (total), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), and Zinc (Zn) - Metals monitoring was suspended per DWQ's March 2009 letter at the agreement of DWQ and LNBA

*** These nutrient and chlorophyll *a* samples shall be collected as a composite sample over the photic zone (photic zone = twice the secchi depth)

M=Monthly, M+2SM=Monthly with Twice Monthly Summer Sampling during May, June, July, August, and September. Samples are to be collected at least ten days apart except when extenuating conditions arise.

ups=upstream, dns=downstream

APPENDIX B- SAMPLE COLLECTION AND ANALYSIS

Sample Collection Procedures

Sample collection shall be performed by trained personnel employed with NC DWQ certified laboratories in accordance with the DWQ NPDES Discharge Monitoring Coalition Program Field Monitoring Guidance Document (May 2008) and subsequent documents. Alternate collection procedures require the approval of the DWQ coalition coordinators prior to use. Nutrient and chlorophyll-*a* samples should be collected as a composite sample from the photic zone (photic zone = twice the secchi depth) at stations J8870000 (Trent River at Sheraton Marina Dock A at New Bern) and J9330000 (Slocum Creek at Slocum Rd at Cherry Point).

Laboratory Analysis

All laboratory analyses shall be performed at a DWQ certified laboratory using approved methods as prescribed by section 40 of the Code of Federal Regulations part 136 (40CFR136) or other methods certified by the DWQ Laboratory Certification Branch (http://h2o.enr.state.nc.us/lab/cert.htm) or the Director of DWQ. 40CFR136 can be accessed on the web at http://h2o.enr.state.nc.us/lab/MethodsUpdateRuleMUR.htm.

Reporting levels will be at least as stringent as the reporting levels used by the DWQ Laboratory. For guidance purposes Table B-1 lists target reporting levels for each parameter based on the reporting levels of the DWQ Laboratory. The lowest possible analytical limits for all the parameters should be pursued.

Table B-1 DWQ Laboratory Reporting Limits

Parameters	Target Reporting Level	Comments
Water Temperature		Resolution to 0.1 degree Celsius
Dissolved Oxygen		Report results to the nearest 0.1 mg/l.
pH		Meters should be calibrated to measure a pH range of at least 4.01 to 9.18. Report results to the nearest 0.1 pH units.
Specific Conductivity		Report results to the nearest whole µmho/cm at 25 ºC.

Table B-1 Continued -DWQ Laboratory Reporting Limits

Parameters	Target Reporting Level	Comments
Turbidity	1.0 NTU	
TSS	6.2 mg/L	
Fecal Coliform	1 colony/100 mL	At least 3 dilutions should be used to achieve optimum colony counts per membrane filter of 20-60 colonies.
Chlorophyll *a*	1 µg/L	Report Chlorophyll *a* values free from pheophytin and other chlorophyll pigments. Analysis by HPLC is not approved by DWQ.
Ammonia (NH_3 as N)	0.02 mg/L	Address distillation requirement. See 40CFR136 Table II footnote.
Nitrate+Nitrite as N	0.02 mg/L	
Total Kjeldahl Nitrogen as N	0.20 mg/L	
Total Phosphorus as P	0.02 mg/L	
Al	50 µg/L	
As	2 µg/L	A reporting level of 5 µg/L is acceptable.
Cd	1 µg/L	
Cr	10 µg/L	
Cu	2 µg/L	
Fe	50 µg/L	
Pb	10 µg/L	
Mn	10 µg/L	
Hg	0.2 µg/L	
Ni	10 µg/L	
Zn	10 µg/L	

Data Qualification Codes

When reporting data, the DWQ's data qualifier codes must be used to provide additional information regarding data quality and interpretation. The current set (codes are subject to change) of qualifier codes to be used is provided in Table B-2. Review the data remark codes at least annually and utilize the most current set. A copy of this table can be found at http://h2o.enr.state.nc.us/lab/qa.htm .

Table B-2 Data Remark Codes for Use with Coalition Data (current as of May 21, 2009)

Data Remark Code	Code Definition
A	Value reported is the mean (average) of two or more determinations. This code is to be used if the results of two or more discrete and separate samples are averaged. These samples shall have been processed and analyzed independently (e.g. field duplicates, different dilutions of the same sample). This code is not required for BOD or coliform reporting since averaging multiple dilutions for these parameters is fundamental to those methods.
B	Results are based upon colony counts outside the acceptable range and should be used with caution. This code applies to microbiological tests and specifically to membrane filter (MF) colony counts. It is to be used if less than 100% sample was analyzed and the colony count is generated from a plate in which the number of coliform colonies exceeds the ideal ranges indicated by the method. These ideal ranges are defined in the method as: *Fecal coliform bacteria: 20-60 colonies* *Total coliform bacteria: 20-80 colonies* B1. Countable membranes with less than 20 colonies. Reported value is estimated or is a total of the counts on all filters reported per 100 mL. B2. Counts from all filters were zero. The value reported is based on the number of colonies per 100 mL that would have been reported if there had been one colony on the filter representing the largest filtration volume (reported as a less than "<" value). B3. Countable membranes with more than 60 or 80 colonies. The value reported is calculated using the count from the smallest volume filtered and reported as a greater than ">" value. B4. Filters have counts of both >60 or 80 and <20. Reported value is a total of the counts from all countable filters reported per 100 mL. B5. Too many colonies were present; too numerous to count (TNTC). TNTC is generally defined as > 150 colonies. The numeric value represents the maximum number of counts typically accepted on a filter membrane (60 for fecal and 80 for total), multiplied by 100 and then divided by the smallest filtration volume analyzed. This number is reported as a greater than value. B6. Estimated Value. Blank contamination evident. B7. Many non-coliform colonies or interfering non-coliform growths are present. In this competitive situation, the reported coliform value may under-represent actual coliform density.
C	Total residual chlorine was present in sample upon receipt in the laboratory; value is **estimated**. Generally applies to cyanide, phenol, NH_3, TKN, coliform, and organics)

Table B-2 Data Remark Codes For Use With Coalition Data (current as of January 16, 2009)

Data Remark Code	Code Definition
G	A single quality control failure occurred during biochemical oxygen demand (BOD) analysis. The sample results should be used with caution. G1. The dissolved oxygen (DO) depletion of the dilution water blank exceeded 0.2 mg/L. G2. The bacterial seed controls did not meet the requirement of a DO depletion of at least 2.0 mg/L and/or a DO residual of at least 1.0 mg/L. G3. No sample dilution met the requirement of a DO depletion of at least 2.0 mg/L and/or a DO residual of at least 1.0 mg/L. G4. Evidence of toxicity was present. This is generally characterized by a significant increase in the BOD value as the sample concentration decreases. The reported value is calculated from the highest dilution representing the maximum loading potential and should be considered an **estimated** value. G5. The glucose/glutamic acid standard exceeded the range of 198± 30.5 mg/L. G6. The calculated seed correction exceeded the range of 0.6 to 1.0 mg/L. G7. Less than 1 mg/L DO remained for all dilutions set. The reported value is an **estimated** greater than value and is calculated for the dilution using the least amount of sample. G8. Oxygen usage is less than 2 mg/L for all dilutions set. The reported value is an **estimated** less than value and is calculated for the dilution using the most amount of sample. G9. The DO depletion of the dilution water blank produced a negative value.
J	**Estimated** value; value may not be accurate. This code is to be used in the following instances: J1. Surrogate recovery limits have been exceeded; J2. The reported value failed to meet the established quality control criteria for either precision or accuracy; J3. The sample matrix interfered with the ability to make any accurate determination; J4. The data is questionable because of improper laboratory or field protocols (e.g. composite sample was collected instead of grab, plastic instead of glass container) J5. Temperature limits exceeded (samples frozen or >6° C) during transport or not verifiable (e.g., no temperature blank provided);, non-reportable for NPDES compliance monitoring. J6. The laboratory analysis was from an unpreserved or improperly chemically preserved sample. The data may not be accurate. J7. This qualifier is used to identify analyte concentration exceeding the upper calibration range of the analytical instrument/method. The reported value should be considered estimated. J8. Temperature limits exceeds (samples frozen or >6°C during storage. The data may not be accurate. J9. The reported value is determined by a **one-point estimation** rather than against a regression equation. The estimated concentration is less than the laboratory practical quantitation limit and greater than the laboratory method detection limit. J10. Unidentified peak; estimated value. J11. The reported value is determined by a **one-point estimation** rather than against a regression equation. The estimated concentration is less than the laboratory practical quantitation limit and greater than the laboratory method detection limit. *This code is used when an MDL has not been established for the analyte in question.* J12. The calibration verification did not meet the calibration acceptance criterion for **field parameters**. Note: A "J" value shall not be used if another code applies (ex. N, V, M).

Table B-2 Data Remark Codes For Use With Coalition Data (current as of January 16, 2009)

Data Remark Code	Code Definition
M	Sample and duplicate results are "out of control." The sample is non-homogenous (e.g. VOA soil). The reported value is the lower value of duplicate analyses of a sample.
N	Presumptive evidence of presence of material; **estimated** value. This code is to be used if: N1. The component has been tentatively identified based on mass spectral library search; N2. There is an indication that the analyte is present, but quality control requirements for confirmation were not met (i.e., presence of analyte was not confirmed by alternate procedures). N3. This code shall be used if the level is too low to permit accurate quantification, but the **estimated** concentration is less than the laboratory practical quantitation limit and greater than the laboratory method detection limit. *This code is not routinely used for most analyses.* N4. This code shall be used if the level is too low to permit accurate quantification, but the estimated concentration is less than the laboratory practical quantitation limit and greater than the instrument noise level. *This code is used when an MDL has not been established for the analyte in question.* N5. The component has been tentatively identified based on a retention time standard.
P	Elevated practical quantitation limit (PQL)* due to matrix interference and/or sample dilution.
Q	Holding time exceeded. These codes shall be used if the value is derived from a sample that was received, prepared and/or analyzed after the approved holding time restrictions for sample preparation and analysis. The value does not meet NPDES requirements. Q1. Holding time exceeded prior to receipt by lab Q2. Holding time exceeded following receipt by lab
S	Not enough sample provided to prepare and/or analyze a method-required matrix spike (MS) and/or duplicate (MSD).
U	Indicates that the analyte was analyzed for but not detected above the reported practical quantitation limit (PQL)*. The number value reported with the "U" qualifier is equal to the laboratory's PQL*.
V	Indicates the analyte was detected in both the sample and the associated method blank. Note: The value in the blank shall not be subtracted from the associated samples.
X	Sample not analyzed for this constituent. This code is to be used if: X1. Sample not screened for this compound. X2. Sampled, but analysis lost or not performed-field error X3. Sampled, but analysis lost or not performed-lab error
Y	Elevated PQL* due to insufficient sample size
Z	The presence or absence of the analyte cannot be verified. The sample analysis/results are not reported due to: Z1. Inability to analyze the sample. Z2. Questions concerning data reliability.

*PQL The Practical Quantitation Limit (PQL) is defined as the lowest level achievable among laboratories within specified limits during routine laboratory operation. The Practical Quantitation Limit (PQL) is "about three to five times the method detection limit (MDL) and represents a practical and routinely achievable detection level with a relatively good certainty that any reported value is reliable." (APHA, AWWA, WEF. 1992. Standard Methods for the Examination of Water and Wastewater, 18th ed.)

APPENDIX C - DATA FORMAT AND REPORTING REQUIREMENTS

Data Format for Monthly submittals

Table C-1 provides the required data submittal spreadsheet format with sample data. Do not use commas, tabs, pipes or other common file delimiters anywhere in the table. The first row should contain the column headings only. Column headings must include appropriate information on measurement units (mg/l, µg/l, cfu/100ml, etc.). The second row must contain the method code. It is very important that the format of the headings and the number and order of columns is consistent among all monthly submissions. The DWQ station number must be provided (e.g. B6140000). An additional column containing the location description is acceptable as long as it is consistently included. Include a comment column for describing pertinent information related to the sampling event or specific samples. Ensure no missing values for station, date, time, and depth. Place all remark codes in a separate column as demonstrated in Table C-1. If there is no result for a particular parameter leave the cell blank. Screen all data for inappropriate or improbable values, such as a pH of 21.2.

Annual Report

The LNBA will be required to submit an annual report by April 30th for each year the MOA is in effect. The annual report will summarize all data collected in the past calendar year and contain the following elements:

- Monitoring Station List to include station number, station description, county, accurate coordinates (in decimal degrees to 4 decimal places), stream classification, and 8 digit hydrologic unit code (HUC).
- List of all certified laboratories that conducted work for the coalition in the past year. Identify time frames for all laboratories and analysis methods used during the year. Summarize any laboratory certification issues for individual parameters.
- Submit a CD that includes all monitoring data for the past year with a statistical summary for each station. These data should be combined into a single table containing the year's reviewed and finalized data. The annual statistical summary must describe for each parameter at each location:
    - Number of observations (N)
    - Number of observations less than the laboratory reporting level (N<RL)
    - Identify the water quality standard, action level, or other reference level (Ref)
    - Identify the number of observations that do not meet the reference level (N>Ref) or (N<Ref)
    - Maximum observed value (Max) and Minimum observed value (Min)
    - Annual arithmetic mean value (except for fecal coliform where geometric mean values should be calculated and pH)
- Include a list of active LNBA members with authorized representative updates, contact names, email addresses and phone numbers. Identify the facility name and permit number.
- Provide a list of members that are no longer active in the LNBA and their permit numbers.
- Provide a list of changes in members' names, ownerships, and discharge locations.
- Summarize all quality assurance and quality control issues and any field audits conducted.
- Summarize any significant issues, special studies, or projects.
- Describe any required data collection that was missed and provide an explanation.
- Review and update the monitoring program and suggest potential MOA modifications.
- Provide the Coalition's Website Address.

Table C-1 File Format For Coalition Data Reporting

				Temp (ºC)	Temp_rmk	DO (mg/l)	DO_rmk	pH (su)	pH_rmk	Conductivity (µS/cm)	Conductivity_rmk	Fecal Coliform	Fecal Coliform_rmk	Suspended Residue (mg/l)	Suspended Residue_rmk	Turbidity (NTU)	Turbidity_rmk	Chlorophyll a (µg/l)	Chlorophyll_rmk	NH3_N (mg/l)	NH3_N_rmk	TKN_N (mg/l)	TKN_N_rmk	NO2_NO3_N (mg/l)	NO2_NO3_N_rmk	TP_P (mg/l)	TP_P_rmk
Station	**Date (m/d/yyyy)**	**Time (hh:mm)**	**Depth (m)**	**10**	**10 rmk**	**300**	**300 rmk**	**400**	**400 rmk**	**94**	**94 rmk**	**31616**	**31616 rmk**	**530**	**530 rmk**	**82079**	**82079 rmk**	**32230**	**32230 rmk**	**610**	**610 rmk**	**625**	**625 rmk**	**630**	**630 rmk**	**665**	**665 rmk**
A1234567	8/19/2002	15:30	0.1	25.2		7.8		6.9		133		110		45		22		23	Q1	0.1		0.2		0.3			
B9876543	8/20/2002	11:50	0.1	27.2		7.1		7.2		125		30		4		5.6		5		0.14		0.6		0.31			
B9876543	8/20/2002	11:50	1	28		6.5		7		122																	
B9876543	8/20/2002	11:50	2	25		6.7		6.9		119																	
B9876543	8/20/2002	11:50	3	17		5.5		6.7		120																	
C1357924	8/21/2002	16:10	0.1	22.1		3.1		6.2		233		15	B1	55		11											
C0246813	9/1/2002	9:30	0.1	19.7		8.3		7		99		6000	B5	410		36				0.26		0.4		0.57			
C0246813	10/1/2002	11:30	0.1	12		8.9		7.3		115		1200	B3	95	A		X3			0.16	J2	0.2		0.09			

The reporting format table continues with metals and comment columns on the next page.

Table C-1 Continued. File Format For Coalition Data Submittals

Cadmium, Cd (µg/l)	Cadmium, Cd_rmk	Chromium, Cr (µg/l)	Chromium, Cr_rmk	Copper, Cu (µg/l)	Copper, Cu_rmk	Nickel, Ni (µg/l)	Nickel, Ni_rmk	Lead, Pb (µg/l)	Lead, Pb_rmk	Zinc, Zn (µg/l)	Zinc, Zn_rmk	Aluminum, Al (µg/l)	Aluminum, Al_rmk	Iron, Fe (µg/l)	Iron, Fe_rmk	Manganese, Mn (µg/l)	Manganese, Mn_rmk	Arsenic, As (µg/l)	Arsenic, As_rmk	Mercury, Hg (µg/l)	Mercury, Hg_rmk	Comments
1027	1027 rmk	1034	1034 rmk	1042	1042 rmk	1067	1067 rmk	1051	1051 rmk	1092	1092 rmk	1105	1105 rmk	1045	1045 rmk	1055	1055 rmk	1002	1002 rmk	71900	71900 rmk	
130		11		3		27		4.4		610		10				0.21		12		12		
120		10	U	2	U	25	U	2	U	510		10	U	10	U	0.2	U	10	U	10	U	
																						Secchi depth 1.2 meters
333		10	U	2	U	25	U	2	U	624		10	U	10	U	0.2	U	10	U	10	U	Nutrient Sample Spilled
120		10	U	2	U	25	U	2	U	510		10	U	10	U	0.2	U	10	U	10	U	2.5” of rain on 8/31/2002
120		10	U	2	U	25	U	2	U	510		10	U	10	U	0.2	U	10	U	10	U	