A. Z. Kelsey Avenue
Ecosystem Restoration Project
Stream Restoration and Stormwater BMP Retrofits
Basis for Design
100% Progress

Prepared for

City of Griffin
Stormwater Services

Prepared by

TETRA TECH

2110 Powers Ferry Road Southeast
Atlanta, GA 30339
(770) 850-0949

April 25, 2014

Table of Contents

Figures

Tables

1 Project Description

1.1 INTRODUCTION

The City of Griffin, Georgia (City) is planning an ecosystem restoration project in the vicinity of A. Z. Kelsey Avenue and North 3rd Street that includes 960 feet of stream restoration, two stormwater best management practices (BMPs) that will discharge into the restored stream segment, and replacement of two undersized culverts at North 3rd Street and A. Z. Kelsey Avenue, along the stream reach. The stream restoration and each of the stormwater BMPs were three individual watershed improvement projects recommended in the Cabin Creek Watershed Protection Plan (Tetra Tech 2012). The City is implementing these three projects together, along with the culvert replacements, to integrate the designs into a single plan set and to construct the project at one time, as a comprehensive ecosystem restoration project. A project location map is shown in Figure 1.

The stream is a tributary to Cabin Creek, and flows across the grounds of A. Z. Kelsey Academy within the project area. The proposed BMPs, which consist of a bioretention area and a vegetated dry detention basin, are designed to treat the water quality volume from the 1.2" rainfall event from 1.3 and 3.2 acre drainage areas, respectively.

The stream is currently entrenched with steep, eroding banks in some areas and heavily vegetated with invasive kudzu over much of the reach. The infrastructure that would be affected and the cost associated with significant grading prohibits the re-establishment of a meandering stream pattern. The proposed restoration will raise the stream bed where possible to provide gentler stream bank slopes while maintaining an entrenched condition to avoid increases in the floodplain. The channel size will be increased slightly and floodplain benches will be added to account for varied flow conditions from the urbanized watershed. Natural stream structures will be used to provide grade control and reduce stresses against banks and the invasive kudzu will be completely removed and the riparian area re-stabilized with native vegetation to prevent future bank erosion. This will create a safer stream reach and will provide improved habitat and aesthetic features.

The proposed Kelsey Avenue culvert is sized to handle the 100 year storm event flow rate for the drainage basin. The updated culvert alignment removes unnecessary bends in the current alignment and consists of (1) 10' x 6' precast concrete box culvert. The proposed North 3rd Street culvert is also sized to handle the 100 year storm event flow for the drainage basin and consists of (1) 12' x 5' precast box culvert.

The bioretention area will be constructed in the northeast corner of the A Z Kelsey Academy main parking lot, requiring the removal of over 9,000 sq.ft. of asphalt and the installation of approximately 500 feet of curb and gutter. Part of the proposed bioretention footprint will impact the managed grassed area on the east side of the parking lot, although appropriate setbacks for adjacent tree protection are provided. Runoff from the parking lot will enter the four-cell bioretention area via several curb cuts and a grassed pre-treatment swale, and discharge from the BMP through perforated underdrains and a concrete riser-structure with culvert outlet to the stream. Bioretention landscaping will include hardwood mulch with native plantings of recommended woody shrubs and herbaceous perennials.

The dry detention basin will be constructed on the opposite side of the creek in the flat grassed area to the southwest of a baseball field at Fairmont Park, a Spalding County parks and recreation facility. The area will be excavated to provide an 18" detention depth that will discharge through a concrete riser structure and culvert to the restored creek elevation. A rip-rap forebay will be installed to provide pre-treatment, and be planted with native grasses adapted to withstand temporary ponding and occasional mowing. Design plans for the A. Z. Kelsey Avenue ecosystem restoration project are provided as Attachment D to this design report.

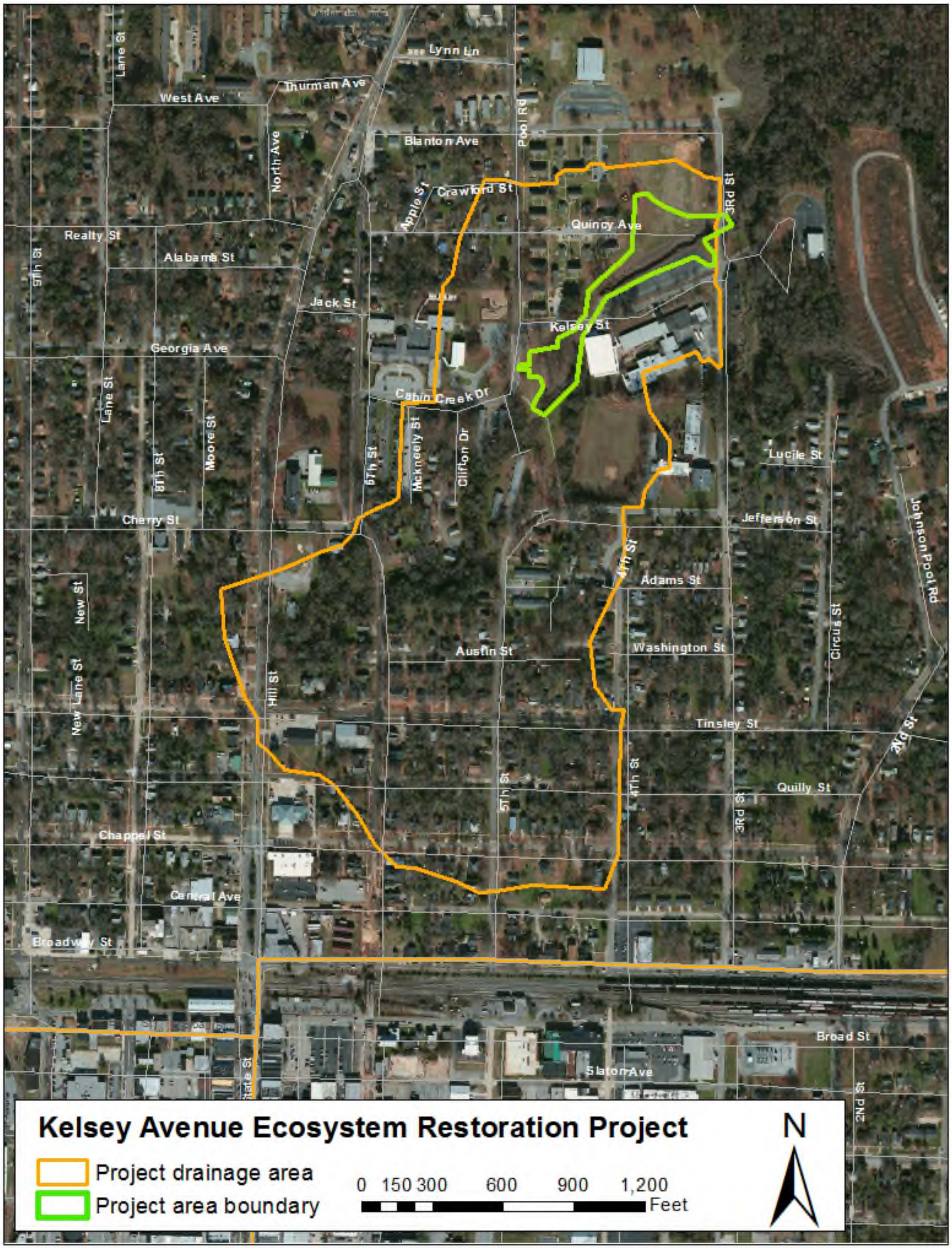

Figure 1. Project location map

1.2 CURRENT CONDITIONS

The Kelsey Avenue project is located on three different parcel properties. Both BMPs are located at A. Z. Kelsey Academy, which is owned by the Spalding County Board of Education (ITOS ID: 003-05002). The proposed stream restoration intersects this parcel, as well as two other parcels owned by Spalding County (ITOS IDs: 003-0500, 007-01002). The entire project reach between the pedestrian bridge and the N. 3rd St. culvert is channelized, entrenched, and disconnected from its floodplain. Based on site observations, the floodplain disconnection is more a result of historical infill from adjacent development rather than stream stresses and degradation. Invasive vegetation is present throughout the stream corridor, including a heavy stand of kudzu starting upstream of the A. Z. Kelsey Avenue culvert. Note that the first segment of this three-pipe culvert was recently replaced by the City of Griffin with a 48"HDPE pipe. The middle section under the roadway is parallel 36" RCPs and the downstream segment is a damaged 60" CMP that has areas of reduced width were failure has occurred.

The parking lot adjacent to the proposed bioretention area is aged and shows signs of degradation and sediment export. Currently, the parking lot is being encroached by kudzu along the north side adjacent to the stream corridor that has reduced the parking capacity along the north row of parking stalls. The proposed bioretention area will also impact the open grassed area to the east of the parking lot. This area contains several large hardwood trees that were designated for protection.

The flat grassed area where the detention basin will be constructed receives direct drainage via a HDPE pipe that discharges runoff from the adjacent Housing Authority neighborhood. A small delta of sediment has accumulated around the outlet of the culvert, and runoff appears to sheet flow and/or infiltrate prior to reaching the top of the stream channel. No signs of erosion are present in the grassed area.

The US Army Corp of Engineers (USACE) determined that the site is subject to provisions of Section 404 of the Clean Water Act due to the presence of jurisdictional wetlands within the drainage channel and will likely require a Nationwide Permit (NWP) #27 for Aquatic Habitat Restoration, and NWP #3 for increasing the culvert sizes. Additional information regarding the permitting requirements is provided in Section 5.

1.3 WATERSHED DESCRIPTION

Refer to Appendix A for a map of the stream restoration and BMP drainage areas, as well as an aerial overlay and the hydraulic flow paths.

Table 1 shows the main drainage area characteristics for each subwatershed. Note that the BMP subwatersheds are shown discretely but also embedded within the stream restoration drainage area parameters. The land use in the watershed is primarily single family residential, although multi-family residential, institution, and recreation open-space land uses also exist throughout. Most of the infrastructure in the watershed is older so many of the trees are mature, thus providing significant canopy, shading, and leaf litter. Open space conditions ranged from ‘good’ to ‘poor’ conditions.

Table 1. Drainage area characteristics

Parameter	STR-1	STR-2a	STR-2b	STR-2c	STR-3	BR-1[1]	DP-1[1]
Area (acres)	56.2	8.60	2.9	4.9	12.5	1.31	3.18
Total Imperviousness (%)	28.8%	17.4%	50.0%	31.4%	35.1%	89.7%	45.3%
Directly Connected Imperv. (%)	14.0%	12.2%	35.0%	22.0%	22.7%	89.7%	13.6%
Hydraulic Length (ft)	3,005	965	904	1,016	1,085	550	630
Hydraulic Slope (ft/ft)	0.036	0.057	0.053	0.031	0.053	0.014	0.059

[1] Contained within STR-3.

As shown in Appendix B, the soil series delineation for the proposed stream restoration reach is considered ‘Alluvial land, moderately wet.’ Although this soil series also underlays the bioretention area, the main soil series in the proposed BMP footprints is a ‘Cecil sandy clay loam, 6 to 10 percent slopes, severely eroded.’ The other major soil series in the watershed is a ‘Cecil-Urban land complex, 2 to 6 percent slopes.’ The only Hydrologic Soil Group in the watershed is type ‘B.’

2 Data Collection

2.1 SITE VISIT

An initial site visit was conducted on February 18-19, 2010 through field work associated with the Cabin Creek Watershed Protection Plan. Data collected during the initial site visit include site photographs, a verification of the watershed delineation, observed utility conflicts, and general observations about construction conflicts and feasibility. After selection as a combined retrofit and stream restoration project in the Cabin Creek Watershed, the Kelsey Avenue project site was revisited on June 18, 2013 to confirm construction suitability and note any site changes following the 2010 visit. The second site visit confirmed the suitability of the proposed BMP locations, refined the drainage area delineation, revealed discrepancies between the GIS drainage layer and actual conditions, and outlined the survey boundary. The stream restoration reach was also walked, including all three culvert locations.

2.2 SURVEY

Contracted by the City of Griffin, S.L. Colwell and Assoc., Inc. conducted a topographic survey of the site in July 2013 and collected the following information within the survey limits:

- general topography for 1-foot contour resolution, including detailed stream features
- parcel lines and parcel information,
- location and extent of above ground features such as buildings, sidewalks, roads, fences, signs, lightpoles, etc.,
- location, size and species of trees and shrubs over 4" diameter at breast height (DBH),
- location, size, and invert elevations of sanitary and storm sewer systems (including road culverts), and
- approximate location of other utilities as evidenced by above ground features

The survey data was incorporated into a detailed base map. The base map was used for the existing site conditions in the attached design plan set.

2.3 SOILS INVESTIGATION

Tetra Tech conducted a geotechnical investigation of the Kelsey Avenue project site on July 10, 2013. Two borings were collected using a 3.25 inch diameter hand auger. Boring #1 is east of the school parking lot, and boring #2 is on the north side of the creek from the school parking lot (Figure 2). Soil material from the borings was characterized by texture, color, saturation, and depth. Samples of the various soil textures were collected and saved for future reference. Boring #1 reached 131 inches deep, and boring #2 reached 113 inches deep. Both boring are located on a divide between mapped soil units, based on the NRCS soil survey. The mapped soil unit downslope of each boring is Alp (Alluvial land, moderately wet), which is a hydric soil. The mapped soil unit upslope of each boring is CZC3 (Cecil sandy clay loam, 6-10% slopes, severely eroded), which is not a hydric soil type. The water table was not reached in either boring. Soil sampling field forms are provided in Appendix F.

Figure 2. Soil boring locations

3 Design Calculations

3.1 INTRODUCTION

Design methodology was based on the City of Griffin's design standards as referenced in the City's "Stormwater Design Manual." Where relevant, the Georgia Stormwater Management Manual and the Manual for Erosion and Sediment Control in Georgia (GADNR, 2000) were also utilized as a basis for design. However, for BMP retrofit projects pre-development hydrology is not applicable since the targeted drainage area is already developed. For calculating reductions in runoff rates and volumes, the "pre" development scenario refers to existing land use and drainage area conditions while "post" development refers to changes in watershed hydrology incurred from implementing a BMP at the drainage area outlet. Appropriate methods and modeling tools for hydrologic and hydraulic calculations were utilized and discussed below. The hydrology for the stream restoration project was calculated at each of the three culvert locations for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year storms. Culvert 1 is under a footpath at the most upstream end of the project area; it includes drainage area STR-1. Culvert 2 is under A. Z. Kelsey Avenue; it includes drainage areas STR-1, STR-2a, STR-2b, and STR-2c. Culvert 3 is under North 3rd Street, at the most downstream end of the project area, and includes drainage areas STR-1, STR-2a, STR-2b, STR-2c, and STR-3. These drainage areas are depicted on the watershed map (Appendix A). Detailed calculation sheets are included in Appendix C.

3.2 EXISTING HYDROLOGY

3.2.1 Time of Concentration

Time of concentration (TOC), which is used to estimate the lag time for peak flow calculations, was calculated using two different methods. For the three large stream restoration subwatersheds, the simplified Kirpich (1940) equation was utilized to calculate the TOC from the most upstream drainage point to the inlet of each culvert. For the two BMP subwatersheds, the TR-55 segmented approach (US-SCS, 1986) was utilized because outlet structure sizing warranted a more accurate calculation of peak flow timing. With the TR-55 approach, TOC values were calculated separately for each flow type and summed to determine the total TOC for the drainage area. Appendix C shows the TOC calculations for each subwatershed and flow regime, as well as the calculated lag time. For both BMP drainage areas, the estimated TOC is less than the minimum allowable TOC value of 5 minutes, so a 3 minute lag time was used. The Kirpich estimated TOC values for STR-1, STR-2, and STR-3 were 13.7, 4.7, and 9.3 minutes, respectively. The watershed map in Appendix A shows the TOC flow paths, which include sheet flow, shallow concentrated flow, and channel (pipe) flow.

3.2.2 Peak Flow

The City's Stormwater Design Manual provides a suite of methods for determining peak flow for various return intervals. These methods include the Rational Method, Soil Conservation Service (SCS) Curve Number Method, and United States Geological Survey (USGS) regression equations. For this project, each method was initially used to calculate peak flow and the results were compared. The comparison revealed significant variation in the estimated flows between the different methods. Therefore, a decision on which method should be used was required. While the SCS CN method is generally considered preferable to the rational or regression equation methods for small urban streams, our analysis concluded that the peak flows calculated using the SCS CN method were too high, and thus too conservative. Application of the SCS CN method, via a multi-basin HEC-HMS model linked to the existing HEC-RAS model, showed overtopping of the roadway at each culvert during the 2-year storm event for the existing geometric conditions. A discussion with city staff revealed that overtopping at the culvert locations had not been observed despite significant storm events greater than the 2-year event having occurred in recent years. In contrast, the USGS regression equations calculated mean peak flows that were lower than those used in the existing HEC-RAS model. However, the 95% confidence interval peak flows calculated with the USGS regression equations were just slightly lower than the values calculated using the rational method. As a result, it was determined that the rational method provides a conservative peak flow estimate for stream and culvert designs that will also pass the 95th confidence interval flows calculated using the USGS regression equations. Therefore, the rational method was selected as the appropriate peak discharge estimation tool for the design of the stream reach and culvert replacement. The following sections describe each of the methods in more detail and summarize the results.

3.2.2.1 USGS Regression

USGS has developed regression equations based on gauging stations throughout central Georgia and applicable to the City of Griffin. These equations provide peak discharge for a range of return intervals as a function of watershed size and imperviousness. USGS equations are not generally recommended for watersheds less than 0.10 sq mi. (64 acres) and therefore may not be appropriate for the upper reaches of the proposed stream restoration. Peak discharge values are provided in Table 2 for comparison purposes.

Table 2. USGS regression equation calculated peak discharges

	Culvert 1	Culvert 2	Culvert 3
Watershed Size (ac)	56.2	72.63	85.1
Imperviousness (%)	28.8%	28.5%	29.5%
2-yr peak (cfs)	*66*	*71*	*92*
10-yr peak (cfs)	*99*	*108*	*137*
25-yr peak (cfs)	*115*	*126*	*159*
50-yr peak (cfs)	*126*	*139*	*175*
100-yr peak (cfs)	*137*	*152*	*191*

3.2.2.2 SCS-Curve number (HEC-HMS)

The SCS Curve number method can be utilized to estimate runoff depth and peak discharge based on rainfall statistics, land use characteristics, and hydrologic soil groups within a watershed. When utilized as part of the HEC-HMS package, the impact of routing of discrete sub-watersheds and hydrologic storage can be used to further refine peak discharge estimates. For the Kelsey Ave project, peak runoff discharges for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year storms were calculated using HEC-HMS, which was run using the SCS Curve Number (CN) Method and the SCS Unit Hydrograph to model watershed loss and direct runoff. Table 3 (and Appendix C) shows the calculated composite Curve Numbers for the component drainage areas, as well as the calculated initial abstraction values used to determine the hydrologic 'Loss' in HEC-HMS.

Table 3. SCS curve number inputs

Parameter	STR-1	STR-2a	STR-2b	STR-2c	STR-3	BR-1	DP-1
Composite Curve Number	81.6	79.5	82.8	78.4	80.5	78.4	78.4
Initial Abstractions (in)	0.45	0.52	0.42	0.55	0.48	0.55	0.55

Meteorological inputs were based on Table 2-2 in the City's Stormwater Design Manual. All of the design storm rainfall intensities were converted to partial duration precipitation values for a range of storm durations up to 24-hours. Table 4 shows the HEC-HMS results for the three culverts within the stream restoration reach and the two proposed BMP's.

Table 4. HEC-HMS estimated peak discharge

	Culvert 1	Culvert 2	Culvert 3	Detention Basin	Bioretention
Watershed Size (ac)	56.2	187.5	85.1	3.18	1.31
1-yr peak (cfs)	*129*	*150*	*167*	*11.1*	*5.8*
2-yr oeak (cfs)	*161*	*188*	*208*	*13.3*	*6.5*
5-yr peak (cfs)	*207*	*244*	*273*	*16.2*	*7.5*
10-yr peak (cfs)	*241*	*285*	*318*	*18.6*	*8.4*
25-yr peak (cfs)	*290*	*343*	*385*	*21.8*	*9.6*
50-yr peak (cfs)	*323*	*384*	*432*	*24.1*	*10.4*
100-yr peak (cfs)	*360*	*429*	*482*	*26.4*	*11.3*

3.2.3 Rational Method

The Rational Method provides peak flows as a function of a rational coefficient (expression of land use characteristics) and time of concentration within the watershed. Peak discharges were computed for specific return intervals using the rational method and are provided in Table 5.

Table 5. Rational method results

	Culvert 1	Culvert 2	Culvert 3
Watershed Size (ac)	56.2	72.63	85.1
Time of Conc. (min)	13.4	15.1	18.0

	Culvert 1	Culvert 2	Culvert 3
Rational Coeff	0.44	0.44	0.44
1-yr peak (cfs)	94	110	123
2-yr peak (cfs)	107	127	142
10-yr peak (cfs)	138	167	187
50-yr peak (cfs)	209	253	286
100-yr peak (cfs)	237	288	325

3.2.4 Water Quality Volume

The water quality volume, which is based on the 1.2” design storm for the City of Griffin, was calculated using the Simple Method as described by Schueler (1987). The required water quality volume for the bioretention area, which had a 1.3-acre, 90% impervious drainage area, is 4,900 cubic feet. The 3.2-acre, 45% impervious drainage area for the detention pond yielded a water quality volume of 5,820 cubic feet.

3.3 PROPOSED DESIGN

The design for the proposed BMPs, and stream restoration project, and road culvert replacements are described below, including hydrology and structure hydraulics, as well as other physical design elements. The hydraulic calculations used to size the outlet structures and road culvert replacements are included in Appendix C. Design plans for the project are provided as Attachment D.

3.3.1 Stream Restoration

The design for the stream restoration reach includes a multistage trapezoidal cross section to account for varying flow conditions and necessary channel capacity. A lower floodplain, located within the entrenched channel, provides relief of the higher velocities and shear stresses without sacrificing sediment conveyance and base flow levels. The inner floodplain is sized to overtop in the 1- to 2-year flow event while the entire channel area is sized to lower or maintain the existing overall 100-year flood elevations. Cross sections surveyed from the existing stream upstream and downstream of Kelsey Street within the proposed restoration area indicate a channel cross section area that is smaller than the 1-year design storm. It is expected that the restored channel will adjust dynamically to create the appropriate low-flow channel dimensions; the larger channel cross section will help establish varied stream habitat while maintaining channel protection at the design flows.

The lower stream and valley slopes present seem more indicative of a meandering stream with a wider floodplain. The existing entrenched stream appears to be more likely created by infill and straightening of the channel rather than natural stream morphology. Because of the restrictions in the area, the proposed restoration will need to remain entrenched. The proposed restoration design will mimic features of a Rosgen B-type stream. The bank slopes above the design channel will be graded back at a 3:1 slope where possible and the channel invert will be raised to limit the amount of disturbance caused by the bank grading. The stream will be dominated by riffles, as it is currently, but additional sinuousity will be added and stream structures included to create pools for habitat variability and oxygenation of the water. Where bank grading is limited due to constraints, such as along the parking lot area, imbricated rock walls will be used to increase the bank slopes to near vertical. Step pools, cross vanes, and constructed riffles will also be used to maintain grades throughout the reach.

Hydrologic Analysis - As discussed in section 3.2.2, a hydrologic analysis was performed to determine the peak flow values for the watershed to facilitate the channel design and floodplain impact analysis. Peak flows were calculated for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year storm events. The points chosen for the hydrologic analysis are located at each of the three culverts. Peak flow calculations at the most downstream culvert represent the entire drainage area, while the other two locations were calculated based on their subareas. Combined, the chosen locations represent changes in flow for the main stream channel and culverts based on the natural and constructed drainage network. Figure 3 shows the locations of the flow points and

Table 6 (and Appendix C) shows the flow values calculated for each subarea.

The multistage channel was designed for the capacity of the 1-year flow event. The upstream reach (south of Kelsey Street) was designed using Flow Point #1 and the downstream reach (north of Kelsey Street) was designed using Flow Point #2. Design channel dimensions of the first stage attempted to match a W/D ratio of 12, which is typical for B-type streams, while minimizing the amount of impact to the surrounding area.

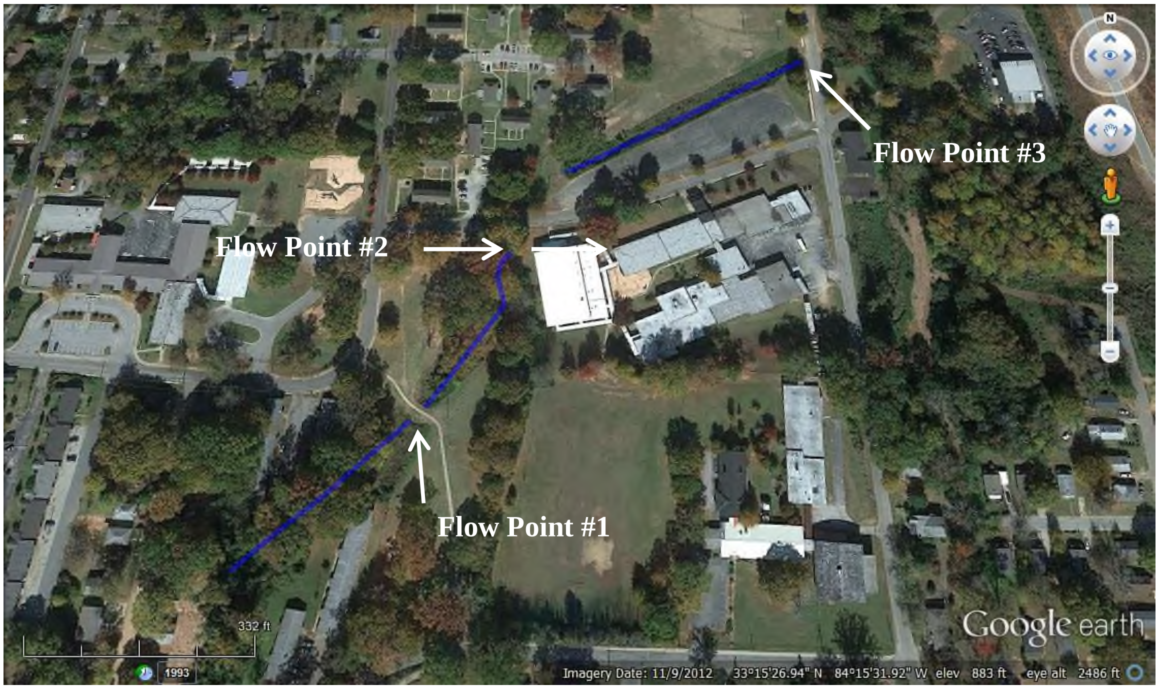

Figure 3. Flow points

Table 6. Flow values calculated for each subarea

Location	1-Yr	2-Yr	10-Yr	50-Yr	100-Yr
Flow Point #1	94	107	138	209	237
Flow Point #2	110	127	167	253	288
Flow Point #3	123	142	187	286	325

Hydraulic Analysis - After flows were determined in the hydrologic analysis, a hydraulic analysis of the stream restoration design was performed that includes channel hydraulics for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year storm events and its impact to the 100-yr floodplain using HEC-RAS. Results from the hydraulic model along with a comparison of hydraulic flow characteristics between the existing and stream restoration conditions will be included in the 90% submittal.

Geomorphic Assessment, Reference Reach, and Standard Channel Cross Section Design - A geomorphic assessment, survey information, and reference reach were utilized to initially develop a standard channel cross section design. The geomorphic assessment was performed during the Spring of 2008 for the project stream and reference reach based on accepted industry standards. Survey information collected in the summer of 2013 was used to refine the geomorphic assessment of the project stream.

A reference reach is a stable stream flowing through a similar topography and similar soils as the project stream. The primary assumption is that the reference reach has stable geometric characteristics that can be used to aid in the design and/or be replicated in the project stream. A reference reach was identified based on characteristics described in the 2008 Cabin Creek stream assessment (Tetra Tech, 2008). The reach is located immediately east of 3rd street and immediately north of Kelsey Avenue (Figure 4).

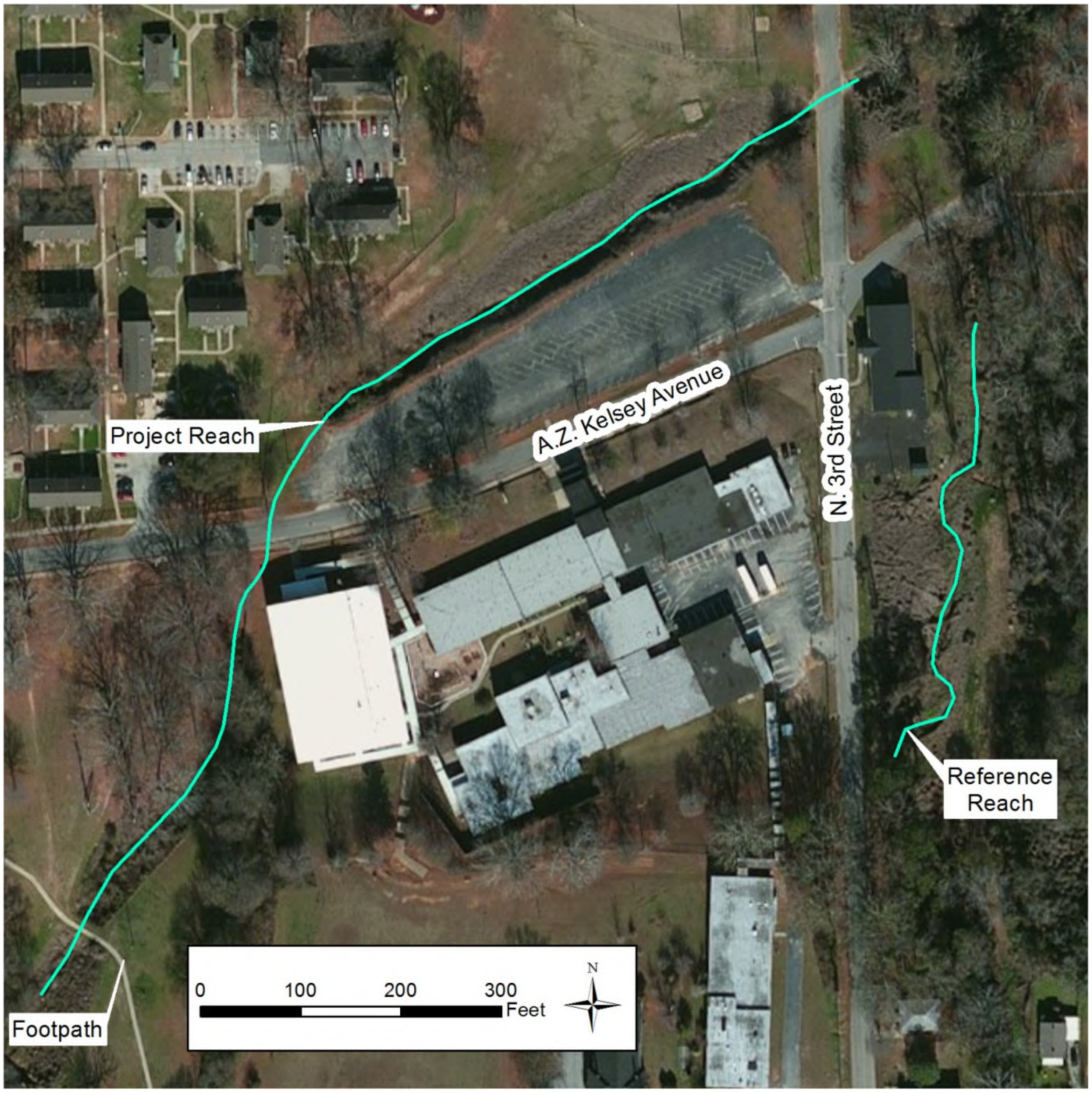

Figure 4. Reference reach

The channel geometry of the reference reach was derived from several sources including; field measurements made in 2008, measurements made from recent aerial photographs, and measurements made using 2-foot contour data provided by the city of Griffin (

Table 7). In order to apply the reference reach geometry to the design of the project reach, modifications were required due to bounding conditions which included three stream crossings, a school parking lot, and a sanitary sewer line. The reference reach data was used to calibrate the design channel dimensions, which will be included in the 90% submittal.

Table 7. Stream channel and valley morphology

Morphological Variable	Reference Reach
Drainage area (acres)	112
Bankfull width (ft)	5.6
Bankfull depth (ft)	2.0
Bankfull xs area (sq-ft)	11.2
Radius of curvature (ft)	49
Meander belt width (ft)	55
Sinuosity (ft/ft)	1.14
Valley slope (ft/ft)	.023

Material Sizing and Particle Mobility - A sediment transport analysis was conducted to insure that the materials used to construct the grade controls, provide bank erosion protection, and to create the stream bed surface remain in place during high flows. Standard rock sizing methods, described in the Stream Restoration Design section of the National Engineering Handbook (NRCS, 2007) and the Georgia Soil and Water Conservation Commission (GaSWCC, 2000), were applied to size the material for grade controls, bank protection, and bed material.

Material sizing was performed for both the in-stream rock structures and the stream bed mix used within riffle sections of the stream. To ensure stability under extreme flow conditions the analyses for the in-stream structures were applied using the 100-year recurrence flows derived from the HEC-HMS results. Channel bed material used in the riffles was sized using a shear stress analysis of the 10-year recurrence flows to create a stable bed that supports aquatic habitat.

Grade Control and Bank Material Sizing - The Ishbash relation (Appendix G) between flow velocity and stable stone size was used to select stone sizes for grade controls and for rip-rap. To provide a conservative design, the highest in-channel flow velocity from the HEC-RAS model for the 100 year storm event was used. This velocity was used to determine the intermediate axis dimension of the stone using the Ishbash curve (dimension B in Figure 5). Stacked stone grade controls may use rectangular stones as shown in Figure 5, whereas rip-rap composed of crushed granite would likely have a more rounded forms with the A, B, and C axis more equal in length. The minimum and maximum stone dimensions, the A-axis and C-axis, are determined by using a factor of 1.25 times the B-axis dimension (Table 8).

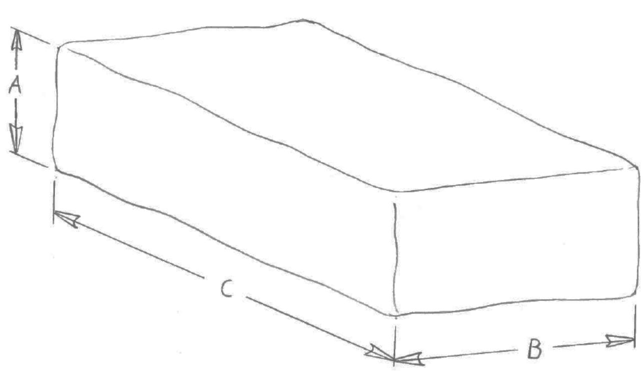

Figure 5. Three axes of a stone (shown as rectangular for clarity).

Table 8. In-stream structure material size.

Feature	100-year velocity (feet/sec)	Minimum Stone Dimension (inches)		
		A Axis	B Axis	C Axis
In-Stream Structures	9.28	9	12	15

Channel Bed Material Sizing - The goal of the bed material sizing analysis is to select a size distribution of stones that will remain stable during high flows but will also prevent subsurface baseflow and create a positive habitat for aquatic life. A shear stress analysis was conducted, using the HEC-RAS output for the 10-year recurrence flow, to determine a median particle diameter that would be stable for the largest 10-year shear stress modeled within a design riffle section. The largest 10-year shear stress within a riffle section was found to be 2.5 lb/ft^2; using a safety factor of 1.25 results in a shear stress of 3.1 lb/ft^2. Using critical shear stress methods developed by Andrews (1994) and Shields (1936) results in a median particle diameter of 5.0 inches and a D30 of 3.3 inches. These particle sizes were distributed to establish an stable bed mix to be used within riffle sections.

Bed material size distribution.

Percent (%) Less Than	B-axis Diameter (in)
10	1.0
30	3.3
50	5.0
60	5.5
84	6.7
100	7.5

Bank Vegetation - Banks are currently stabilized in many areas by invasive kudzu, which has choked out native vegetation. The proposed design includes adjustments of the planform and grading back of steep banks, which will remove the invasive plants but will leave most of the reach length unvegetated and exposed to erosional flows. The exposed banks will be initially stabilized using coir fiber matting along the lower channel banks and by establishing fast-growing annual grasses. A riparian seed mix with perennial grasses and other native vegetation will be added to provide long term stability and prevent the re-establishment of kudzu. Live stakes or other woody material will be placed along the baseflow channel to protect against local scour and native trees and shrubs will be included throughout the restoration to create a varied riparian habitat.

Sewer Realignment - An eight-inch clay sanitary sewer line currently crosses the upper reach of the stream (south of Kelsey Avenue) three times, including one aerial crossing (where the sewer line is exposed), and two crossings with only one foot of cover. Due to grading limitations, it is not possible to sufficiently protect these pipes through the stream restoration measures alone. In order to sufficiently protect sewer infrastructure, the design incorporates a sewer realignment that will eliminate two of the sewer crossings (those with only one foot of cover) by re-routing the sewer line. The aerial crossing will remain exposed, but the pipe will be reinforced through bank stabilization. The new segment of sewer will be constructed of ductile iron pipe. The original segment of sewer line will be abandoned.

3.3.2 Culverts

The performance of the existing culverts under Kelsey Avenue and North 3rd Street were evaluated to analyze its effect on Cabin Creek and the surrounding area. The existing conditions for Kelsey Avenue consist of a recently replaced section of (1) 48" HDPE pipe, (2) 36" RCP pipes, junction boxes, and a deteriorated 60" CMP pipe and at North 3rd Street a deteriorated squashed 66" x 42" CMP, both under paved roadways. Using the recent study entitled "Magnitude and Frequency of Floods for Urban and Small Rural Streams in Georgia" in 2008, the flow rate for the10-year storm event overtops both Kelsey and North 3rd Street. A more detailed discussion of the basin analysis and methodology is found in Section 3.3.

The sizing, alignment, and components of the proposed culverts were chosen to improve the culvert performance and pass the flow rate seen during the 100 year storm event. The proposed culvert at A. Z. Kelsey Avenue updates the alignment by removing unnecessary junction boxes and changes in direction. The A. Z. Kelsey Avenue culvert consists of (1) 10' x 6' precast concrete culvert designed to pass the 100 year design storm flows without over topping. Other features that are integral with the Kelsey Avenue culvert are the drop inlets that will be installed to receive flows from the roadway.

The proposed culvert at North 3rd Street keeps the same alignment as the existing culvert, but is now sized to convey the 100 year design storm flows without over topping. The selected culvert includes (1) 12' x 5' precast concrete culvert.

Both culvert selections were modeled in both HEC-RAS and HY-8 for performance based on the 2, 10, 25, 50, and 100 year storm events using both the Rational Method and the USGS Regression method for determining peak flow rates. Both culverts are designed to meet the USACE requirements for the pre-construction notification checklist for regional permits. Each is designed to be buried 20% of the culvert's height to allow natural substrate to colonize the structure's bottom and encourage fish movement.

3.3.3 Dry Detention Basin

As shown in the attached set of 50% design plans provided in Appendix D, the extended dry detention basin is sized to treat 5,865 cubic feet of runoff, which is just over the required water quality volume. This treatment volume does not include the additional storage provided by the proposed pretreatment forebay. The bottom of the basin will incorporate 18 inches of extended detention storage and drain though a 1.5" diameter adjustable orifice that is sized to provide a drawdown time of approximately 2.0 days. The concrete riser outlet structure will have internal dimensions of 4'x4'x4' with 0.5' tall weir slots on four sides. The proposed outlet culvert is 18" Class III reinforced concrete pipe (RCP) and discharge onto an armored stone pad on the constructed floodplain in the stream. The emergency spillway at the lower basin will be 30 feet wide to ensure safe passage of the 100-year, 24-hour storm event while maintaining at least 1-foot of freeboard between the top of the embankment and the 100-yr peak water elevation in the wetland. Major feature elevations of the dry detention basin are shown in Table 9. The 2-year, 24-hour storm routing results for the dry detention basin are shown in Figure 6. The 100-year, 24-hour storm routing results for the dry detention basin are shown in Figure 7.

3.3.4 Bioretention Area

The proposed bioretetention area, which is composed of four hydraulically-connected cells, is designed to treat approximately 3,750 cu.ft. of runoff – or 76% of the required water quality volume. Runoff from the existing parking lot will enter the bioretention area via six curb cuts installed along a proposed curb-and-gutter system. The three most-upstream curb cuts will direct runoff to a grassed pretreatment swale, while the lower three curb cuts will discharge directly to the bioretention cells via a grass filter strip and stone energy-dissipation pad. The 4'x'4'x9' concrete riser structure located in the lower bioretention cell will pond runoff to a maximum depth of 9 inches before discharging peak flow through the 0.5' tall slot weirs located on all four sides of the structure. Approximately 400 feet of 6" perforated Schedule 40 PVC underdrain pipe will be installed below the 4' of bioretention media and connect to the concrete riser. Major feature elevations of the bioretention area are shown in Table 9.

Table 9. Major feature elevations for BMPs

Feature	Dry Detention Basin	Bioretention Area (Lower Cell)
Top of Bed	862.0	
Extended detention depth		
Slot weirs	863.5	
Emergency spillway	865.0	NA
Top of embankment	866.0	

A calculated stage-storage-discharge table was developed from the preliminary plans and utilized in a HEC-HMS model to route the design storms through the two BMPs and their associated outlet structures. Table 10 reports the hydraulic performance of the BMP system for 2-yr and 100-yr, 24-hour storms since these events are most critical to the design requirements. Figures 1 and 2 below provide hydrograph examples for the hydrologic impact from the detention basin for the 2-yr and 100-yr storms. As shown, the 2-yr peak discharge is reduced to 11.5 cfs, yielding a 75% reduction. Note that the 100-yr storm event will over-top the service road (elev. 910.0), although the actual peak stage will be less than 910.4 since the topography above the road is not represented by the stage-storage relationship in the model. The 100-yr peak elevation in the lower basin will reach a peak of stage of 907.2 as currently designed, which is 0.8 feet below the top of the embankment.

Table 10. 2-Yr and 100-Yr storm routing results for BMPs

Hydraulic Component	Detention Basin	Bioretention Area
2-Yr Discharge (cfs)	12.2	6.2
2-Yr % Reduction	8.3%	4.6%
2-Yr Peak Stage (ft)	860.0	863.9

Hydraulic Component	Detention Basin	Bioretention Area
100-Yr Discharge (cfs)	15.4	11.0
100-Yr % Reduction	41.7%	2.7%
100-Yr Peak Stage (ft)	865.0	860.1

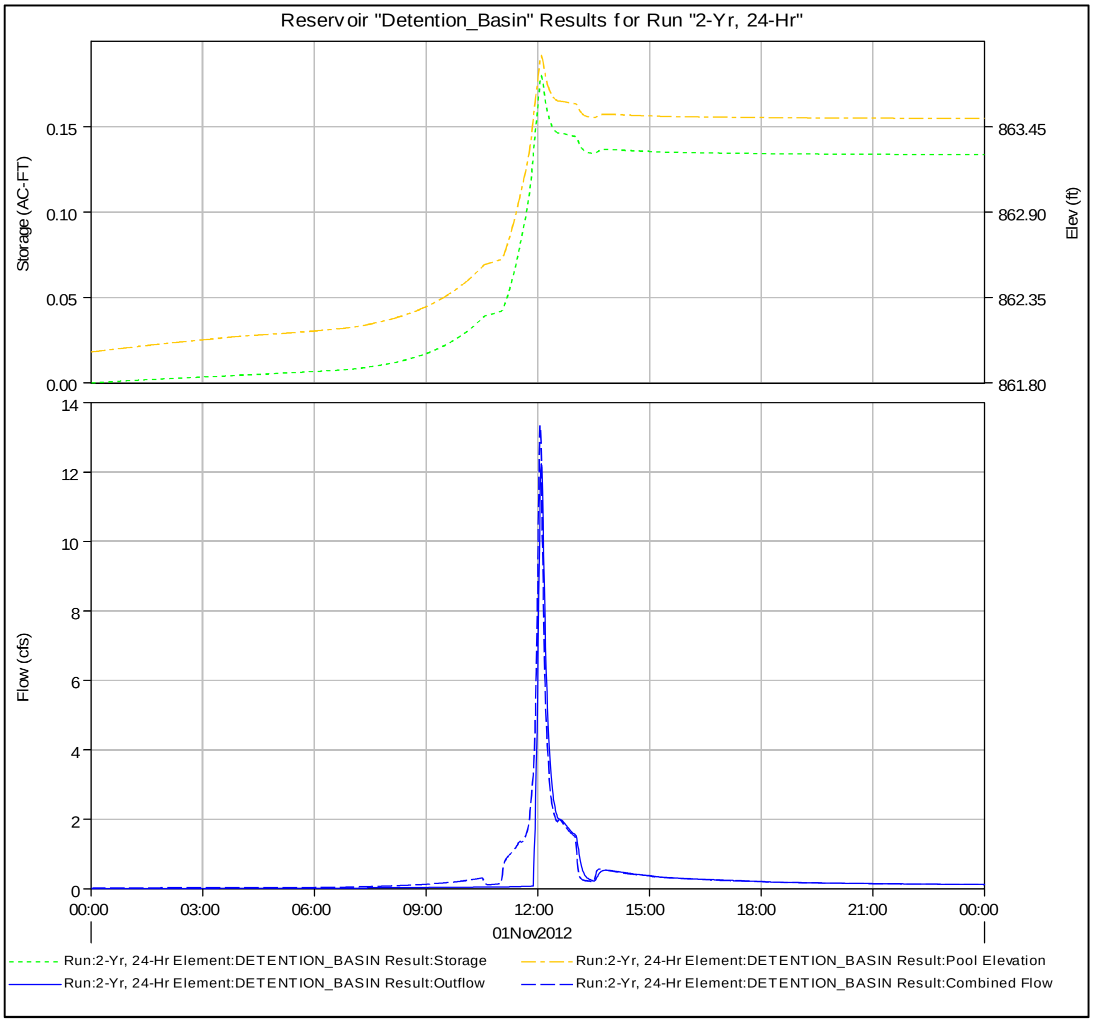

Figure 6. 2-Yr, 24-Hr Storm Routing Results for the Dry Detention Basin

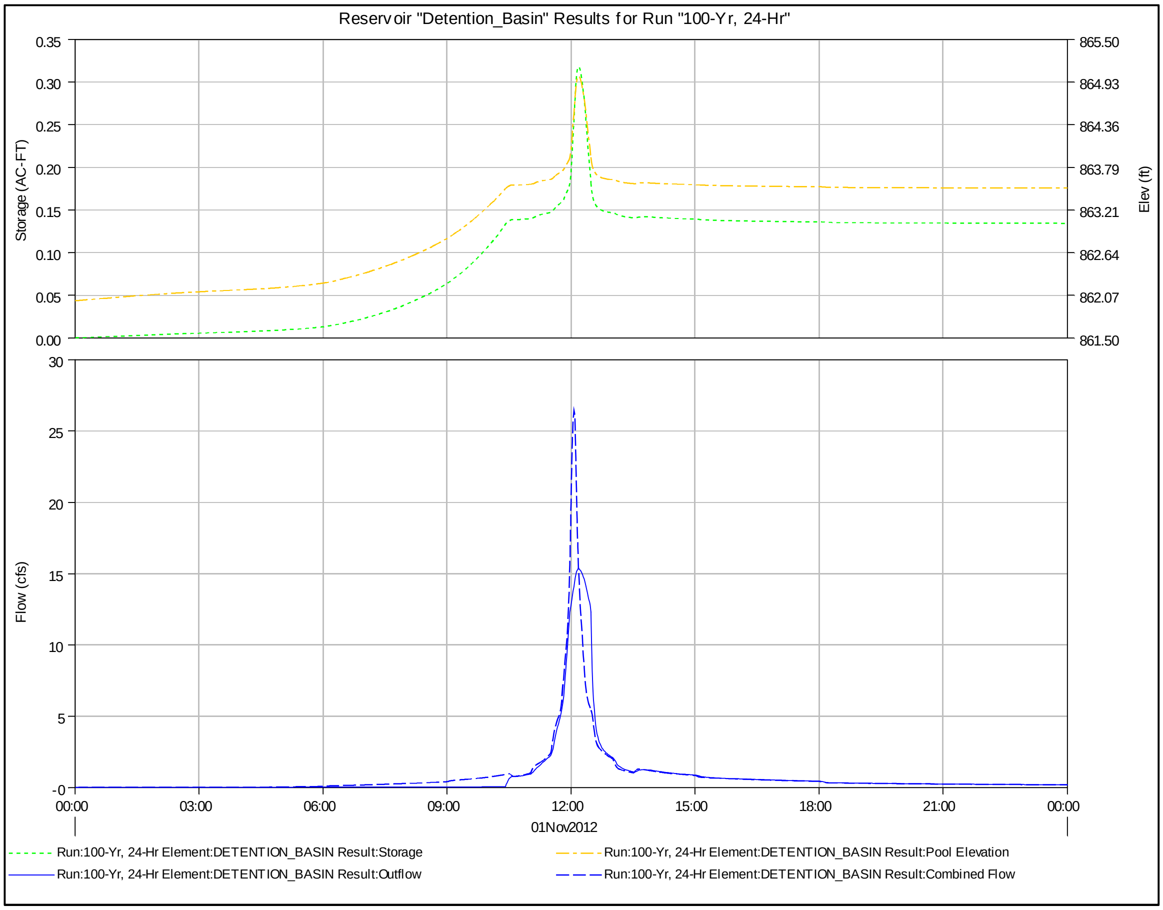

Figure 7. 100-Yr, 24-Hr Storm Routing Results for the Dry Detention Basin

3.4 Pollutant Load Reductions

As part of the Cabin Creek Protection Plan, LSPC results from the 2010 Watershed Hydrology and Water Quality Modeling Report for the City of Griffin Watersheds were utilized to estimate the potential pollutant load reductions associated with the two BMP retrofits at Kelsey Avenue (Tetra Tech, 2011). Refer to Chapter 8.3 in the Cabin Creek Protection Plan for further details and assumptions used for the conceptual BMP load reduction estimates. Since the drainage area delineations, BMP footprint areas and size calculations presented in the Protection Plan were based on conceptual-level field investigations, pollutant load reductions were re-calculated for both BMPs using the final design volumes presented within this report. Note that the final bioretention area is considered undersized (77% of water quality volume) for its contributing drainage area, and the final load reduction was adjusted by the 83% undersizing factor.

Table 11 shows the BMP pollutant load reduction estimates for TSS, TP, and TN based on the final designs at Kelsey Avenue.

Table 11. Final BMP Load Reduction Values

Hydraulic Component	Dry Detention Basin		Bioretention Area	
	Conceptual	Final Design	Conceptual	Final Design
Undersized WQ volume?	No	No	No	Yes
TSS Load (lbs/yr)	2940	2013	2013	1480
TP Load (lbs/yr)	0.89	0.61	0.60	0.33
TN Load (lbs/yr)	21.7	14.9	14.0	6.4

4 Construction Constraints and Challenges

No significant challenges are foreseen regarding construction of the dry detention basin. Several constraints should be noted regarding the culvert replacement and construction of the bioretention site. Because culvert replacements will involve roadway work in close proximity to A. Z. Kelsey Academy (including road closures), and construction of the bioretention areas will impact an active parking lot for the school, construction activities will need to accommodate traffic usage and public safety issues. Scheduling construction during the school holidays and vacations could help alleviate traffic conflicts.

Also note that the large willow oak trees located at the northeast corner of the bioretention site are allocated for tree protection. Appropriate tree protection practices shall be implemented as specified in the attached plan set.

The proposed restoration reach is constrained by local infrastructure, namely the surrounding buildings, fences, and buried sanitary sewer. The surrounding buildings limit any increases to the existing floodplain, which is resolved by grading back the banks and increasing the channel dimensions. The sanitary sewer pipes and manholes were addressed by raising the channel invert and redirecting the channel away from the above ground infrastructure. The sanitary sewer is being realigned to eliminate two existing stream crossings. Grading of the channel banks will impact existing trees, many of which will need to be removed, as well as existing fence. The fence will be temporarily removed during construction and then replaced along the new surface at completion of the project. An extensive planting plan is proposed to restore areas where tree removal is required.

5 Permitting Requirements

Nationwide Permits – Tetra Tech conducted a wetland investigation and wetland delineation for the project area on July 10, 2013. The perennial stream that flows through the project area is likely to be a jurisdictional water of the United States, and would require Clean Water Act Section 404 permitting through the USACE. No other wetlands or potentially jurisdictional waters were identified on the site. Preliminary discussions with United States Army Corps of Engineers (USACE) Savannah District regulatory specialist Ms. Maya Odeh-Adimah have indicated that the project could be permitted through a Nationwide Permit (NWP) #27 (Aquatic Ecosystem Restoration) for the stream restoration and NWP #3 (Maintenance) for increasing the culverts sizes. A pre-construction notification form and supporting information must be submitted to the Savannah District in order to receive authorization under these permits.

CLOMR/LOMR – The channel that is affected by this project is within a Zone A floodplain according to the FEMA map. A comparison of existing and proposed 100-yr profiles indicate that overall 100-year flood elevations decrease through the project reach but there is a section downstream where the floodplain elevation increases over 1 foot. It is typically up to the community to make the determination if they want to go through the LOMR process. Typically, this is only performed if the floodplain map changes. Because this project is in an incised channel and the 100-year event is contained within that channel, and restoration design raises the bed and lays back the banks to make a bigger channel, an expansion of the floodplain is nearly unavoidable. However, it will only increase in width by about 25 feet. The scale of FEMA floodplain maps will not likely capture a difference that small. So while it is ultimately up to the City, this change isn't necessary to submit through FEMA.

Tetra Tech utilized the existing HEC-RAS model for the City of Griffin to compare water surface elevations for the existing conditions versus the with-project conditions. The existing HEC-RAS model was updated to include additional cross-sections and adjusted existing cross-sections to represent the restoration reach. In total, 72 additional cross-sections were added to 6 existing cross-sections to represent changes in channel geometry. The FEMA 100-year flood stage was used to evaluate the with- and with-out project conditions. Although Base Flood Elevations are not shown on FEMA maps, the City of Griffin does have BFE data for this stream.

Stream Buffer Variance – A stream buffer variance will need to be obtained from Georgia Environmental Protection Division (GAEPD) prior to construction.

NPDES – A National Pollution Discharge Elimination System (NPDES) Construction Storm Water General Permit GAR1000001 will need to be obtained from GAEPD prior to construction. In order for this permit to be issued, the Towaliga Soil and Water Conservation District must approve the Erosion and Sediment Control Plans, and a Notice of Intent (NOI) must be submitted

6 Construction Quantities and Cost Estimates

Cost estimates for the three project components were developed utilizing a list of construction items and associated unit costs. Construction items were identified based on the current design configuration and a professional judgment of likely construction pay items. Where possible, construction quantities were determined from the design dimensions. For example, the quantity of 18-inch RCP was defined by the dimensions provided in the plans. For those items which were not quantified in the plans, such as silt fence, an estimate of likely quantity was determined based on the engineer’s professional judgment.

Construction unit costs were developed using a number of sources including; RS Means published construction costs, bid summaries of recent related projects in the area, and the engineer’s professional judgment of likely cost. Refer to Appendix E for a preliminary opinion of probable cost for this site.

7 References

Andrews, E. D. 1994. Marginal bed load transport in a gravel bed stream, Sagehen Creek, California. *Water Resources Research,* 30(7), 2241-2250.

GADNR. 2000. Manual for Erosion and Sediment Control in Georgia.

GaSWCC. 2000. Manual for Erosion and Sediment Control in Georgia. 5th Edition. Georgia Soil and Water Conservation Commission, Athens, GA.

Kirpich, Z. P. 1940. Time of concentration of small agricultural watersheds. Civil Engineering 10 (6), 362. The original source for the Kirpich equation. (In PDF).

NRCS, 2007. Technical Supplement 14C, Stone Sizing Critera. USDA NRCS National Engineering Handbook, Part 654, Stream Restoration Design. 210-VI-NEH, August 2007.

Schueler, T.R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Department of Environmental Programs, Metropolitan Washington Council of Governments .

Shields, A. 1936. Application of Similarity Principles, and Turbulence Research to Bed-Load Movement. California Institute of Technology, Pasadena (translated from German).

Tetra Tech, 2008. Stream Channel Erosion Activity Assessment of the Cabin Creek Watershed. Griffin, Georgia. May 2008. Tetra Tech, Inc., Atlanta, Georgia.

Tetra Tech, 2012. Cabin Creek Watershed Protection Plan. Tetra Tech, Inc., Atlanta, Georgia.

US Soil Conservation Service. 1986. Urban Hydrology for Small Watersheds, Technical Release 55. Washington, DC.

Appendix A. Watershed Map

Appendix B. Soil Series Delineation

Appendix C. Design Calculations

Appendix D. Final Design Plans

Appendix E. Cost Estimate

Appendix F. Soil Sampling Field Forms

Appendix G. Grade Control Stone, Rip-rap, and Riffle Stone Sizing