CHAPTER 5: FINDINGS AND OPPORTUNITIES

The purpose of this chapter is to capture and document the key findings from the previous sections of this master plan. This chapter will also document the opportunities for program enhancement that will keep the Town of Cary stormwater management program at the forefront of municipal programs.

A. Future Regulatory Direction

Determining the exact future and direction of Federal and State stormwater regulations is, by nature, difficult. Stormwater regulation is not developed by the USEPA and DWQ in a vacuum. Political trends, court actions, and developing research can all affect the eventual development (or lack of development) of new Rules and policies. However, both USEPA and DWQ appear to be interested in standardizing and augmenting current stormwater quality regulations. The three main mechanisms that the USEPA and DWQ are currently using to accomplish these changes are:

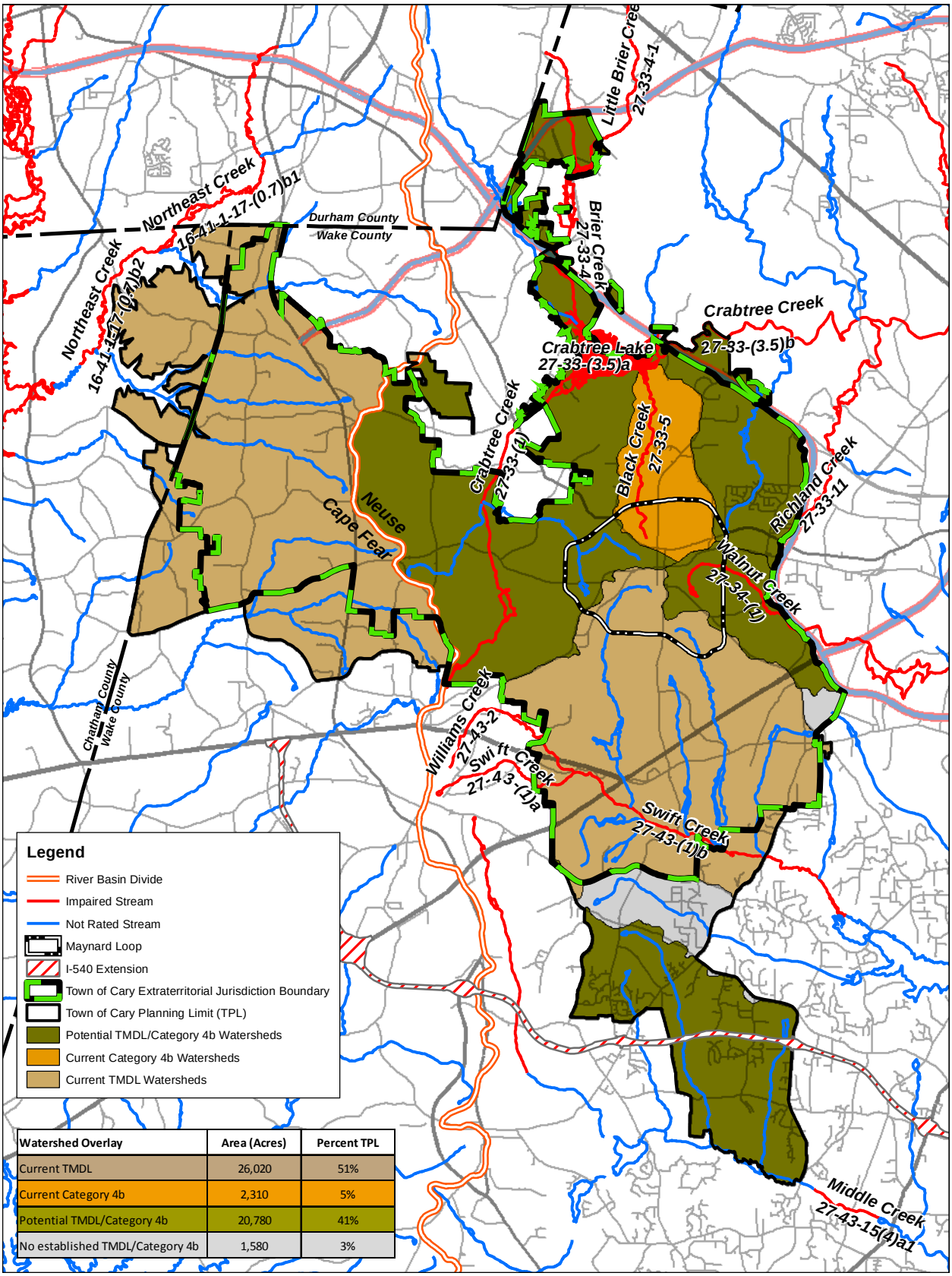
1. Phase I and II NPDES Stormwater Permit conditions

2. TMDLs or TMDL-type mechanisms (i.e. voluntary Category 4b plans),

3. New rule making and rule expansion/amendments.

New rule making is anticipated to have the least impact on stormwater regulation over the next five to ten years because of recent State legislation (SL 2011-398) that was passed that strongly limits NCDENR's ability to develop new Rules unless there is a direct Federal requirement to do so. Also, the new requirements in the proposed expansion of the NPDES Phase II Stormwater Rules by the USEPA are, for the most part, already incorporated by DWQ in its NPDES Phase II program. As such, most anticipated changes to stormwater requirements in North Carolina will likely occur through changes in NPDES Phase I and II Permits conditions, and creation of TMDLs and "voluntary" Category 4bs watershed plans. This directly affects the Town because the USEPA or DWQ can add new Permit conditions with each new cycle without necessarily having to create new Rules (as long as the existing Rules allow the agencies to make create such conditions). Also, since, much like most larger municipalities in North Carolina, many of the Town's watersheds have impaired streams, the Town could be strongly affected by the creation of TMDLs and Category 4b watershed plans (See Section 4D). A map of the potential future TMDL and 4b watersheds is provided in the figure below:

Figure 5.1 - Potential TMDL/Category 4b Watersheds



Watershed Overlay	Area (Acres)	Percent TPL
Current TMDL	26,020	51%
Current Category 4b	2,310	5%
Potential TMDL/Category 4b	20,780	41%
No established TMDL/Category 4b	1,580	3%

Federal (USEPA)

The following is a brief discussion of some the current trends in regulation as of the publication of this document in which the USEPA has expressed interest:

- The USEPA has shown interest in requiring more stringent construction and post construction controls as a condition of NPDES Phase II Permits for MS4s and through the USEPA Construction General Permit. Currently, USEPA is seeking to promulgate new NPDES Stormwater Rules to require these changes. The draft Rules are expected later in the year. The trend appears to be that North Carolina will also use the NPDES Phase II Permits and the General Construction Permit (NCG 010000) to strengthen the program to meet USEPA requirements both now and in the future. The USEPA is also attempting to develop turbidity limits for construction project runoff, but recent Federal Court decisions have caused it to revisit the proposed turbidity limit of 280 NTUs. It is likely, however, that there will eventually be limits that require sampling, monitoring, and reporting. These limits will also likely be enforceable.

  Effect on the Town: Currently DWQ and not the Town enforces the conditions of NCG 010000, but DWQ may look to the municipal programs to support them in this effort. Also, increased monitoring requirements and the addition of limitation requirements would directly affect the Town's capital projects and introduce the potential for additional violations and enforcement actions. In regards to post construction requirements, the rules proposed by USEPA would likely have little effect on the State NPDES program since the State has already implemented most of the proposed changes.

- USEPA is trending towards seeking to implement TMDLs, Category 4bs, and WQRPs, through NPDES Phase II Permits.

  Effect on the Town: Establishing these programs as part of the Town's NPDES Phase II Permit would make it easier for the USEPA and DWQ to establish new requirements as permit conditions and enforce them.

- USEPA is seeking strategies to reduce runoff volumes (as opposed to peak rates) and create groundwater recharge. As such, there is an increased focus on Low Impact Development (LID) strategies. The Town has been proactive by offering an LID approach alternative as part of its Southwest Area plan. Additionally, North Carolina developed a document named Low Impact Development, A Guidebook for North Carolina (2009). This guidebook should help establish the definition of LID in North Carolina in regards to stormwater practices. The USEPA is seeking to implement a strategy to require retention of 95% of the runoff from a 1-inch rain event as a condition of NPDES stormwater permits.

  Effect on the Town: The geology and soil conditions for the majority of the Town are not conducive to stormwater infiltration practices. Capturing and retaining 95% of the runoff from a 1-inch rain event through infiltration would be challenging for larger, high impervious cover development. As such, the

Town would most likely be required to require developers to provide stormwater harvesting infrastructure or alternative detention methods in lieu of infiltration practices, for instance.

State (DWQ)

Many of the regulatory trends regarding the State's stormwater program are driven by the USEPA's trends as described above. However, the State does have additional regulatory trends and directions discussed below:

- Session Law 2012-200 and 201 have delayed the implementation of the Jordan Lake "New Development Rule" - 15A NCAC 02B .0265 until August 10, 2014. The Law also requires that DENR develop a new Rule.
  Effect on the Town: The Town has already enacted its ordinance implementing the requirements of 15A NCAC 02B .0265. If the Rule changes, the Town could be required to change its current ordinance to meet the new requirements. If the new Rule has less restrictive requirements than current established in the Town's ordinance then the Town may not be required to change its ordinance. However, in that case, the Town's ordinance may be more restrictive than required.

- Session Law 2012-200 prohibits local governments, such as the Town, from treating land within a riparian buffer as if the land is property of the State. Additionally the Law makes additional provisions to allow residences on "existing lots" to be constructed within Zone 2 of the buffer under certain circumstances.
  Effect on the Town: This Law could impact the Town's ability to disallow the platting of lots within riparian buffers, or otherwise limit the construction of residences within Zone 2 of the buffer.

- As discussed above, DWQ and USEPA desire strategies that are based on volume reduction. This would signal a trend towards LID-type approaches and rainwater and runoff harvesting. With the new calculation methods for the Jordan Watershed, volume reduction results in nutrient load reductions, making stormwater strategies that reduce volume of runoff more attractive to developers.
  Effect on the Town: LID-type approaches based on infiltration are problematic since most of the soil types found within the Town do not have high infiltration rates. However, an increased use of rainwater harvesting strategies for large scale projects for irrigation (as opposed to individual residences) could help reduce potable water demand, especially during peak use periods. Also, in the Jordan Lake watershed, the use of BMPs that reduce volume other than by infiltration such as green roofs may also become more attractive to the development community.
- The new Mitigation Laws that are in effect could impact the Town's ability to require and provide mitigation on its own terms. DWQ's interpretation of these laws is summarized in the "Implementation of N.C. General Assembly Session Laws 2009-337 and 2011-343" guidance memo.
  Effect on the Town: It is possible that these laws may limit the Town's ability to set up its own program to sell mitigation credit for wetlands, streams, riparian buffers, and nutrient credits to third parties. This means that such mitigation would likely be established by private mitigation bankers outside the Town's planning boundary such that there would be no benefit to the Town's water quality; however, the laws

do not appear to preclude the Town from establishing a mitigation "credit union" to use for its own impacts.

- The Jordan Lake Rules have mechanisms to require stormwater BMP retrofits for existing development. The Stage II adaptive management program could require BMP retrofits for existing development in the Lower New Hope Basin if nutrient standards are not met in March 2017 or later.
  Effect on the Town: Because of this (and other) potential requirements, it is in the Town's best interest to consider the potential requirements retrofits of Town-owned BMPs as well as Town-owned areas that do not currently have BMPs. As part of this Master Plan, the Town is seeking to identify potential BMP retrofit and BMP upgrades sites (See Section 5C). This may help the Town by having a readily available list of sites that are both beneficial to water quality and cost effective. However, considering the above and the fact that current and future TMDLs require BMP retrofits, it may be in the Town's best interest to enumerate and record the specific pollutant reduction benefits of its existing BMPs.
- Municipalities have an ever increasing role in ensuring the water quality in their watersheds and streams. One important parameter for assessing water quality in North Carolina is the health of aquatic organisms. It is commonly understood that urban systems typically do not support the same numbers, diversity, and "intolerant" nature of aquatic species as do the reference streams that DWQ uses for comparison. These reference streams typically occur in undeveloped or less-developed, watersheds. For its aquatic species sampling, DWQ has always compared urban systems to reference systems to evaluate whether or not a particular stream reach should be considered to be impaired and subsequently placed on the 303(d) list. Municipalities are questioning the appropriateness of such a comparison in that no matter how much of the runoff from impervious cover is treated by stormwater BMPs, an urban system may never be able to accommodate the species mix that streams in reference systems do. As such, the Town may benefit from studying urban aquatic systems, or partnering with entities such as WECO to study such systems, to develop a more appropriate urban rating system, since under the current rating system, it may not be possible to reach unimpaired status based on currently used metrics.
  Effect on the Town: Developing new criteria for evaluating the impairment of urban streams could provide the Town with achievable means of addressing impairments (as required by TMDLs, for instance), as well as result in the removal of some impaired streams from DWQ's 303(d) list (See Section 4E).

B. Infrastructure Repair

Infrastructure assessment was discussed in Chapter 3. This section will expand on that discussion including looking at options for refining the assessment to aid with need prioritization and repair options.

Infrastructure Repair Overview

Section 3C looked at some of the most common parameters that are assessed when analyzing the overall condition of stormwater infrastructure components. These parameters include age, roadway crossing level of service, pipe capacity / sufficiency, pipe condition (from field assessment), and databases of property owner requests / complaints. Once a general "state of the infrastructure system" has been established, more detailed analysis is needed in order to identify individual problem areas and prioritize infrastructure repair. Two options for refining the closed system assessment include pipe video inspections, and developing stormwater management models (SWMM). General improvement alternatives include pipe replacements, pipe slip-lining, and culvert / bridge replacement.

Infrastructure Repair Approach

Similar to the infrastructure assessment section, the infrastructure repair approach section is subdivided into categories including TCAP study area, FEMA Roadway Level of Service, and Age / Pipe conflicts.

TCAP Area Improvements

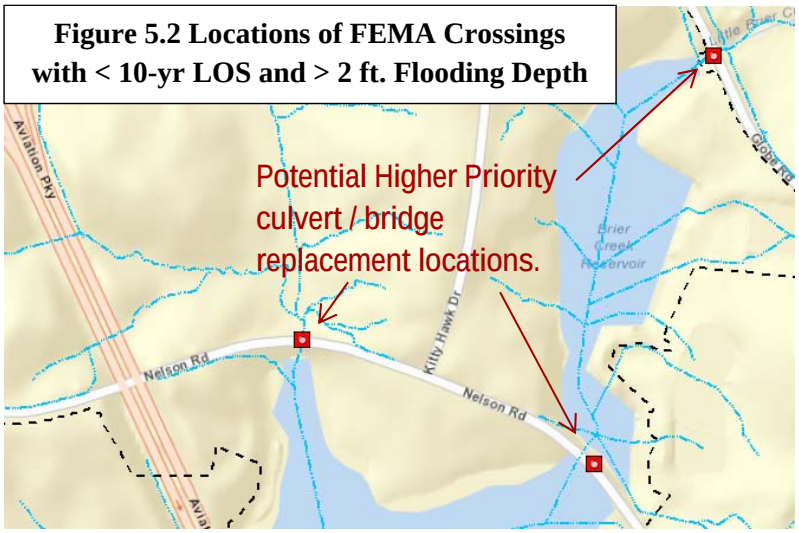
Improvements to address potential capacity issues under roads were identified in 2006 as part of a master plan for the TCAP area. The improvements consisted primarily of proposed culvert/pipe system upgrades and similar infrastructure improvements (i.e., capital improvement projects) to reduce flooding and bring roadways to their design level of service (LOS), if feasible. Although these improvements focused on roadway overtopping, the proposed improvements would significantly lower flood elevations and thus reduce flooding at many of the flood prone buildings as well. A summary of estimated improvement costs and associated LOS criteria are shown for each study stream below. As indicated in the last column of the table, the recommended improvements do not completely mitigate all undesirable road overtopping situations. This is due to the fact that several of the sites were deemed to be unfeasible to mitigate. However, there is marked improvement in LOS. The reader is referred to the report prepared for the 2006 study for more detailed description of improvement analysis.

Table 5.1 - Recommended Improvement Costs and LOS by Study Stream

Study Stream	Recommended Improvement Cost ($)	# of Crossings Meeting 25-yr LOS with Improvements	# of Crossings Not Meeting 25-yr LOS with Improvements	Percent Total Meeting 25-yr LOS
Coles Branch	$95,000	4	2	*66.7%*
Swift Creek Tributary 7	$4,100,000	3	3	*50.0%*
Walnut Creek	$3,400,000	5	3	*62.5%*
Walnut Creek Tributary	$15,000	0	1	*0.0%*
Total	***$7,610,000***	***12***	***9***	***57.1%***

FEMA Roadway LOS Improvements

Figure 5.2 Locations of FEMA Crossings with < 10-yr LOS and > 2 ft. Flooding Depth



In addition to the TCAP road crossings examined in the Dewberry & Davis study, there are 74 FEMA crossings that were identified and analyzed in Chapter 3, 33 of which were determined to provide less than the 100-year level of service. That is, the roads are estimated to be overtopped by flooding that occurs on less than a 100-year return interval. In order to prioritize the bridge and culvert replacements, one could identify those crossing that are currently the most "undersized". For example, the figure above identifies three FEMA / NCFMP crossings with less than 10-year level of service and more than 2 feet overtopping depth during the 100-year storm. It should be noted that the two crossings along Brier Creek Reservoir have more than 10 foot overtopping depth during the 100-year storm.

Culvert/bridge modification or replacement improvements were conceptually estimated to address the 33 problematic overtopping roadways (i.e. roadways that currently do not meet the100-yr level of service) along FEMA mapped streams identified in previous sections. Cursory improvement costs were estimated from a combined of major unit items and/or NCDOT bids for similar type projects. Most culvert upgrades were roughly estimated between $100,000 - $250,000 for construction (excludes design, real estate, and utility relocation), while bridges were generally estimated around $500,000 for construction. The total estimated cost, including a 25% contingency, for culvert and /bridge modifications is estimated at

approximately $10 million. It is important to reiterate that this cost estimate is based on general conceptual assumptions and is provided to give a rough estimate for master planning purposes only.

These estimates are meant to provide planning-level guidance on the cost of meeting the targeted level of service. The replacement costs are based on rough estimates of the sizes of the culverts or bridges needed; engineering calculations were not performed because that is beyond the scope of this study. Furthermore, the costs applied to the estimated culverts and bridges were also general and not specified according to the proposed remedy. For example, bridge estimates were based on an industry standard of about $150/sq. ft. of bridge deck for a standard bridge that would use a cored slab type construction. Larger structures that would most likely have a steel girder replacement used $200/sq. ft. For the roadway approach construction, $20/sq. ft. of roadway surface was applied.

For culverts, Baker looked at recent bid tabs for the City of Charlotte and RS Means to find cost estimates. RS Means is a company that annually publishes construction and building cost information. It's considered a standard cost estimating reference. A 6-foot by 7-foot precast box culvert was approximately $650 per linear foot. Unit costs for larger boxes or multiple boxes are less commonly used and more difficult to find. For this application, Baker used $800 per linear foot; however, culverts larger than 12-feet wide used $900 per linear foot. For a 25-foot wide arch culvert, $1,200 per linear foot was used. The cost of replacing roadway above the culverts was also included at $20/sq. ft.

Based on the assumptions listed above, the estimated cost of replacing 18 Town-owned crossings is $5.34 million. The estimated cost of replacing 14 NCDOT-owned crossings is $4.43 million. One privately-owned crossing is estimated to cost $122,000 to replace.

Address Pipe Conflicts

Section 3C of the master plan identified several instances where pipe diameters decreased moving downstream in the conveyance system and the PWUT work order database also included complaint reports in these same areas. DOT unit bid pricing (2009 for Division 5) plus contingencies to cover potential utility conflicts, paving cost, and design costs were applied to estimate the replacement costs for these areas. It was assumed that the smaller downstream pipe would be replaced by a pipe of the same size as the upstream pipe. The results are shown in the following table.

Table 5.2 - Pipe Conflicts and Infrastructure Reports

Pipe ID	Notes	Replacement Cost
0	Pipe conflict (30 inch into 24 inch) downstream of one PWUT and one complaint report of flooding and storm drain blockage. 745' of pipe replacement.	$175,000
3	Pipe conflict (15 inch into 12 inch) downstream several PWUT reports of storm drain blockage. 60' of pipe replacement	$16,000
4	Pipe conflict (18 inch into 15 inch) downstream of one PWUT report of storm drain blockage. 511' of pipe replacement.	$80,000
6	Pipe conflict (18 inch into 15 inch) near several PWUT reports of storm drain blockages. 150' of pipe replacement.	$29,000
	Total	**$300,000**

Improvements to Damaged and Older Town-Owned Pipes

Further analysis on the portion of the stormwater conveyance system within the public right of way was conducted to determine which pipes were owned by the Town, NCDOT, and other entities. The pipe ownership analysis first allocated the ownership attribute from the street centerline shape file to the ROW shape file. The ROW shape file was then intersected with the storm drain line shape file to add an attribute for ownership. The breakdown of stormwater conveyance pipe within the ROW by owner is provided in Table 5.3. The analysis included approximately 56% of the pipes within the Town since that is the portion located within the ROW.

Table 5.3 – Breakdown of Pipe Ownership within ROW

Ownership Entity	Number of Pipes	Pipe Length (LF)	Percentage of Total Length
Town	15,084	1,244,048	74%
NCDOT	3,682	358,752	21%
Private/Other	1,133	84,717	5%
Total	19,899	1,687,517	100%

There is an additional 1,335,924 feet of pipe within the Town limits that is outside of the ROW, of which 57,508 feet are located on Town-owned property.

The Town would also like to know the condition and the age of the pipe conveyance system that it owns. This information is provided in the Table 5.4 and Table 5.5.

Table 5.4 – Condition and Age of Town Pipes within ROW

Estimated Age (Year Range)	Number of Pipes	Pipe Length (LF)	Condition
1835 - 1965	652	42,777	Good
	152	10,221	Fair
	9	440	Poor
	30	2477	None listed
1966 - 1980	1,164	92,866	Good
	212	16,569	Fair
	8	517	Poor
	67	5844	None listed
1981 - 1990	2,709	233,452	Good
	68	4,861	Fair
	9	662	Poor
	80	6,649	None listed
1991 - 2000	4,869	417,364	Good
	27	2,127	Fair
	4	271	Poor
	86	7621	None listed
2001 - 2011	4,297	348,787	Good
	12	967	Fair
	1	28	Poor
	302	23,280	None Listed
Not available	228	18,695	Good
	15	1,442	Fair
	78	6,132	None listed
Total	15,084	1,244,048	

From the table above it is apparent that the vast majority of the pipes owned by the Town within the ROW are in good condition. The Town should plan to confirm and repair or replace all of the pipes in poor condition, as well as those in the oldest category (1835 – 1965) that are in fair condition. Pipes that fit this description include 183 pipes with a cumulative length of 12,139 feet.

As discussed in Section 3C, pipes older than 50 years may have exceeded their life expectancy. Consequently, pipes in the oldest category that are in good condition and those in the second oldest category (1966 - 1980) that are in fair condition should be investigated and replaced or repaired as needed. Pipes that fit this description include 864 pipes with a cumulative length of 59,346 feet.

To more closely investigate the condition of the pipes to determine if repair or replacement is required, it is a common practice to clean and inspect the storm drainage systems prior to condition assessment. Cleaning methods may consist of hydraulic high pressure jet machines, heavy duty power rodding machines, and heavy duty bucket machines if necessary. Inspection of the pipe networks can be done by visual inspection if the pipes are large enough and safe enough for entry. If not, closed circuit television (CCTV) video inspection is preferred. The information obtained by the video or visual inspection would be assessed for issues such as joint failures, root intrusions, collapsed segments, spalling of concrete, and erosion at the flowline. Surface indications, such as sinkholes, or slumping end sections, may also indicate that a pipe is reaching its life expectancy. Cleaning and inspection can be done in a cost effective manner with an estimated cost of $5 per linear foot. The Town of Cary could inspect 12 miles of pipe a year for a cost of $320,000. This would allow the Town to get through all the high and medium priority Town owned pipe systems within the first two years and then address all remaining pipes over a twenty year period. This would essentially become an annual enhancement to the maintenance program. For an additional $320,000 per year, the Town could clean, inspect, and assess all pipes outside the Town ROW.

The primary options to fix the identified segment failures from the pipe inspection and assessment process are pipe replacement or pipe repair. Pipe replacement is the more costly option because it involves excavation of the existing pipe and frequently repairs to other utilities and pavement. The practice of sliplining can be a lower cost alternative to repair damaged segments of pipe. Sliplining consists of inserting a high density poly-ethylene (HDPE) or equivalent flexible liner into the damaged section and then using heat and water pressure to form the liner to the existing pipe wall.

To add economic perspective to these estimates, consider that it may cost $70 per linear foot to replace the poor pipes, as well as the fair ones in the oldest category within the Town ROW. This is based on NCDOT unit costs plus contingency for a reinforced concrete pipe that is approximately 18 inches in diameter. The added cost accounts for design and replacing utilities as part of the work. This amounts approximately $425,000 for 12,139 feet of pipe (it is assumed only 50% will need repair). In this section, these will be considered the high priority pipes. The comparative cost for a sliplining solution is $303,000.

In twenty years, pipes in the second oldest category will all be 50 years old or greater. Thus, for planning purposes, the Town should consider that the oldest pipes in good condition and those in the second oldest category in fair condition may need to be replaced. This carries a considerably higher cost because the length of pipe increases to 59,346 feet. At $70 per linear foot, replacement of an assumed 20% of these pipes would total just under $830,000 in today's dollars (i.e., not accounting for inflation). In this section, these will be considered the medium priority pipes. The comparative cost for a sliplining solution is $593,000

In addition to pipes in the ROW, the Town owns pipes located on Town property. A GIS analysis was conducted to select the portion of the conveyance system located on Town property. The identified pipes were further segregated according to age and condition, as shown in Table 5.5.

Table 5.5 – Condition and Age of Town Pipes on Town Property

Estimated Age (Year Range)	Number of Pipes	Pipe Length (LF)	Condition
1835 - 1965	33	1,099	Good
	5	107	Fair
	0	0	Poor
	15	434	None listed
1966 - 1980	46	2,744	Good
	5	324	Fair
	0	0	Poor
	6	195	None listed
1981 - 1990	181	12,472	Good
	9	732	Fair
	0	0	Poor
	16	687	None listed
1991 - 2000	294	22,567	Good
	4	145	Fair
	0	0	Poor
	42	1,909	None listed
2001 - 2011	193	9,073	Good
	1	50	Fair
	0	0	Poor
	90	4,681	None Listed
Not available	3	139	Good
	0	0	Fair
	3	150	None listed
Total	946	57,508	

It is notable that none of the pipes on Town property were assessed as being in poor condition. Using the protocol discussed above for the ROW pipes, the Town should plan to confirm and repair or replace the pipes in the oldest category (1835 – 1965) that are in fair condition. This is limited to just five pipes totaling 107 feet.

As with the ROW, pipes older than 50 years may have exceeded their life expectancy. Thus, pipes in the oldest category that are in Good condition and those in the second oldest category (1966 - 1980) that are in Fair condition should be investigated and replaced or repaired as needed. Pipes that fit this description include 38 pipes with a cumulative length of 1,423 feet.

In economic terms, the pipes on Town property do not pose much of a burden. The initial need is estimated to be slightly more than $7,500 (107 feet at $70/ft.) and the longer term need (i.e., 20 years) is approximately $99,600 (1,423 feet at $70/ft.) in today's dollars.

Overall, the pipes on Town property are in good condition and few enough in number that they could be readily investigated.

Table 5.6 - Estimated Replacement Cost by Category

Category	Cost (millions)
TCAP Crossings	$7.61
FEMA Crossings	$5.34
Pipe Conflicts	$0.30
High Priority Aging and Damaged Pipes	$0.43
Medium Priority Aging and Damaged Pipes	$0.83
Total	$14.51

As noted above, the Town's general government budget includes $600,000 per year for Policy 146 from FY2014 through FY2023. This totals $6.0M and appears to be insufficient to meet the infrastructure needs identified in this study and the table above. However, the Town can prioritize the most urgent needs and address many of those. Aging pipes do not necessarily need to be replaced if they are functioning and within the expected life span. The expected life span of the older pipes will be analyzed to estimate which need to be field assessed and replaced as soon as possible, and which are in less urgent need of attention. It is recommended that a systematic replace/repair schedule be implemented to address these concerns.

Additionally, as discussed in Chapter 6A, the Town has added funding for street storm drainage rehabilitation under the Transportation Capital Improvements Fund at $500,000 per year. It may be necessary to continue to fund this capital improvement measure in order to address the infrastructure repairs identified in this Master Plan within a 20-year time frame. Further prioritization of these repairs is needed to determine which can wait and which should be addressed in the near term.

Improvements to Damaged and Older Pipes Outside ROW

The section above discussed the condition and age of the stormwater conveyance pipes within the ROW and Town-owned property. This section will briefly discuss the stormwater conveyance pipes outside of the ROW on private property, which sum to 1,335,924, or 44% of the total pipe length within the Town limits.

This category of pipe may be broken down by condition as follows:

Table 5.7 Estimated Condition of Pipe Outside of ROW

Condition	Length (LF)
Good	1,029,376
Fair	30,124
Poor	2,639
Unrated	273,488
Total	1,335,924

Table 5.8 Estimated Age of Pipe Outside of ROW

Age Range	Length (LF)
1835 – 1965	31,502
1966 – 1980	93,121
1981 – 1990	288,200
1991 - 2000	546,785
2001 - 2011	359,578
No Age Available	16,738
Total	1,335,924

In the following table estimated costs are provided for replacing the oldest pipes, using an average cost of $70/linear foot. Utility replacement and road paving costs have been included in these estimates as a contingency.

Table 59 - Pipe Age and Estimated Replacement Costs

Age Range	Length (LF)	Replacement Cost
1835 – 1965	31,502	$2,205,140
1966 – 1980	93,121	$6,518,470
Total	124,623	$8,723,610

Infrastructure Observations and Recommendations

Table 5.10 lists some general observations from the Town of Cary stormwater infrastructure system and recommendations to address these observations.

Table 5.10 - Infrastructure Observations and Recommendations

Observation	Recommendation
Roadway crossing below recommended level of service / Deep overtopping depth	Replace bridge / culvert
Drainage requests / complaints dealing with sinkholes or other items that would indicate pipe failure	Video inspections to further analyze the issue; “pipe slip-lining” or selective pipe replacement to repair leaking sections.
Pipe size decreasing (i.e. “neck downs”); drainage requests that would indicate insufficient pipe capacity	SWMM analysis to assess existing conditions and provide recommendations for CIP (drainage improvement) projects.
Current budget allocation is insufficient to fund all potential infrastructure improvement projects	Consider as one funding option the establishment of a stormwater utility (and associated fee) to help fund stormwater infrastructure improvement projects, as discussed in Chapter 6

C. Potential BMP Retrofits

The Jordan Lake Rules and Neuse Rules (See Section 2B) requires the Town to identify stormwater best management practice (BMP) retrofit opportunities. The purpose of the BMPs required by the NPDES Permit is primarily for water quality, but many BMPs can serve dual purposes by attenuating storm flows as well. When identifying potential opportunities, it is important for the retrofit to be feasible, cost effective, and specific to the watershed needs. The following are both identification and evaluation criteria used to rank retrofit sites identified in this Section:

- The site is located on readily available property owned or controlled by the Town (primarily PRCR controlled parcels).
- The site is located in a priority watershed (such as the Swift Creek or Black Creek sub-basins) and would address the primary water quality or flooding issues in that watershed.
- The specific location of the BMP retrofit site is of adequate size to support the appropriate BMP based on its drainage area and land use.
- The site contains an existing BMP that could be retrofitted for a relatively small construction cost in order to increase its pollutant removal or detention/retention effectiveness (for instance, converting a dry detention basin into a bioretention area).
- Sites where the BMP could have a dual use purpose, such as non-potable water use or an amenity.
- Sites that have degraded natural resources (an eroding stream, for instance) that could be restored in such a way to improve water quality, aquatic habitat, and reduce existing flooding problems.
- Sites that are tributaries to locations with recurring stormwater related complaints or PWUT work orders.

A total of 35 potential BMP sites were identified and reviewed using the above criteria. The majority of the sites are on property owned by the Town. The sites that are not on Town property were identified based on either Town staff knowledge of the sites or based on known issues downstream of the sites. It is also believed that the respective owners may be open to allowing the Town to obtain easements or otherwise acquire the property. The 35 sites were vetted to the 19 sites presented in this Section based on Town staff's specific knowledge of the sites. Each potential retrofit site described in this Section was field-verified for readily identifiable issues and benefits. Town Engineering Services, Stormwater, and PRCR staff reviewed the chosen sites and retrofit options to ensure that the proposed retrofits did not conflict with their respective programs. Conceptual designs and preliminary construction cost estimates were developed for four (4) of the sites based on the Town's priorities. More detailed information regarding the alternative funding opportunities described in this section can be found in Chapter 6A. Table 5.11 lists the BMP retrofits sites, locations, and relative ranking.

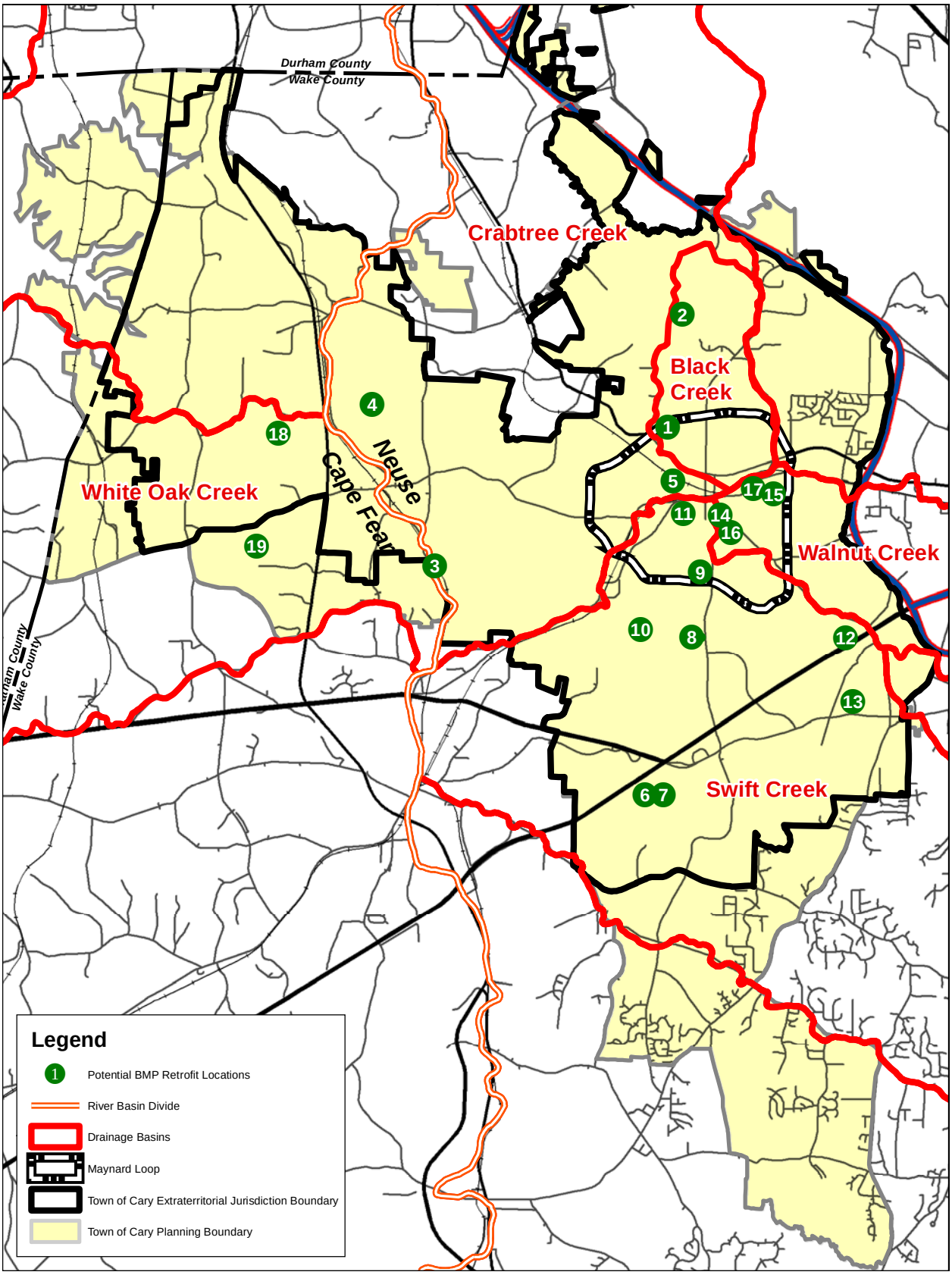
Retrofit Sites

Table 5.11 - Potential BMP Retrofit Sites

Figure #	Site Name	Watershed	Potential
1	Godbold Park*	Black Creek	Very High
2	North Cary Park*	Black Creek	Very High
3	Davis Drive Park*	Crabtree Creek	High
4	Green Hope Elementary	Crabtree Creek	High
5	Lexie Lane Park	Crabtree Creek	High
6	Regency Park*	Swift Creek	Very High
7	Swift Creek Slough	Swift Creek	High
8	Kildaire Farm Greenway	Swift Creek	Moderate
9	Rose Street Park	Swift Creek	Moderate
10	Kildaire Farm Lake	Swift Creek	Low
11	Ridgecrest Road Lot	Swift Creek	Low
12	Walnut Street and US-1	Swift Creek	Low
13	Macedonia Lake (Future Tryon Road Park)	Swift Creek	Low
14	Town Center Park	Walnut Creek	Very High
15	Walnut Creek	Walnut Creek	Very High
16	218 Byrum Street	Walnut Creek	High
17	Urban Park	Walnut Creek	Moderate
18	Sears Farm Road Park	White Oak Creek	Moderate
19	White Oak Creek Greenway	White Oak Creek	Low

* Site includes a conceptual design

Figure 5.3 - Potential BMP Retrofit Sites



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1 - Godbold Park			
Description	Retrofit skate park with concrete flumes and convert existing dry detention basin to bioretention		
Watershed	Black Creek	Potential	Very High
Benefits	▪ Nutrient reduction ▪ Peak flow attenuation	Estimated Project Cost	$30,000-$40,000
Challenges	▪ Increased maintenance		

Table 5.12 - Godbold Park Retrofit Site Summary

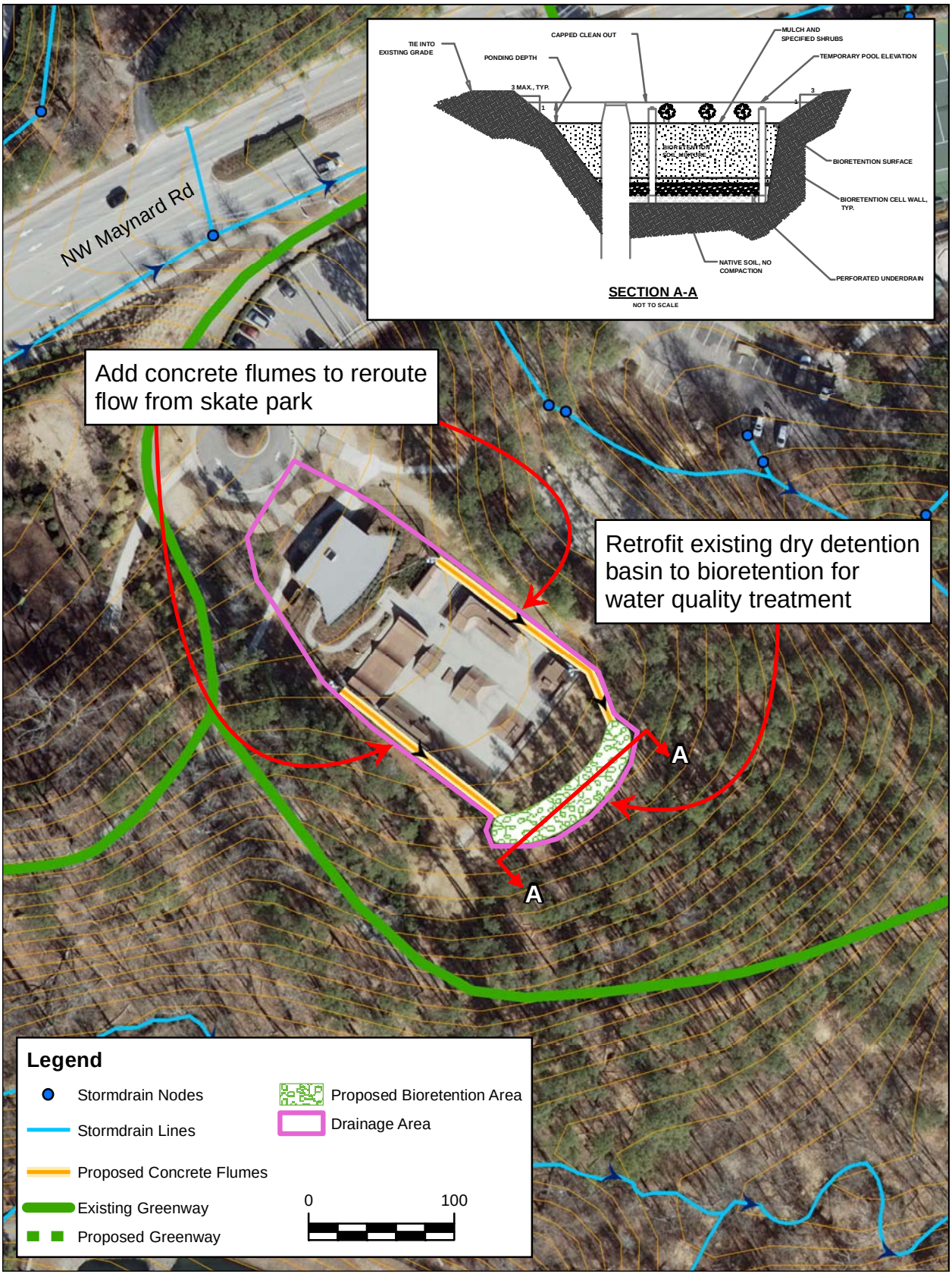
Godbold Park is located at the very upper ridge of the Black Creek watershed. The park includes a skateboard park (Sk8 Cary). Behind Sk8 Cary is an existing dry detention basin that appears to be receiving minimal drainage. The skate park includes a large paved area located on a high point; the paved area and building currently drain away from the existing dry detention basin. Concrete flumes could be installed on both sides of the pavement to capture runoff from the pavement and carry it to the detention basin. Additionally, the dry detention basin is of sufficient size to be easily converted into a bioretention area for nutrient reduction. The proposed stormwater improvements to Godbold Park could be partially funded by applying for a CWMTF grant. A partnership with WECO, BCWA, the Town Engineering Services/Stormwater, and PRCR could improve the likelihood of being awarded such a grant. It should be considered that the bioretention area would require more maintenance than the existing dry detention basin.

The Town would benefit from this stormwater runoff treatment by receiving a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 35% and 45%, respectively. This basin is also located at the top of the Black Creek watershed increasing the benefits of both its detention and water quality improvement potential.

Because the property is already owned by the Town and has a high probability of receiving funding, the project will be relatively inexpensive to the Town. Although the bioretention area will require more maintenance than the existing basin, water quality and quantity will benefit from this retrofit. With this combination of factors, this BMP retrofit was designated with an implementation ranking of “very high” potential.

Existing dry detention basin in Godbold Park.

Figure 5.4 - Godbold Park Concept



2 – North Cary Park			
Description	Create terraced bioretention areas behind volleyball courts		
Watershed	Black Creek	Potential	Very High
Benefits	▪ Nutrient reduction ▪ Peak flow attenuation	Estimated Project Cost	$50,000-$80,000
Challenges	▪ Construction access		

Table 5.13 - North Cary Park Retrofit Summary

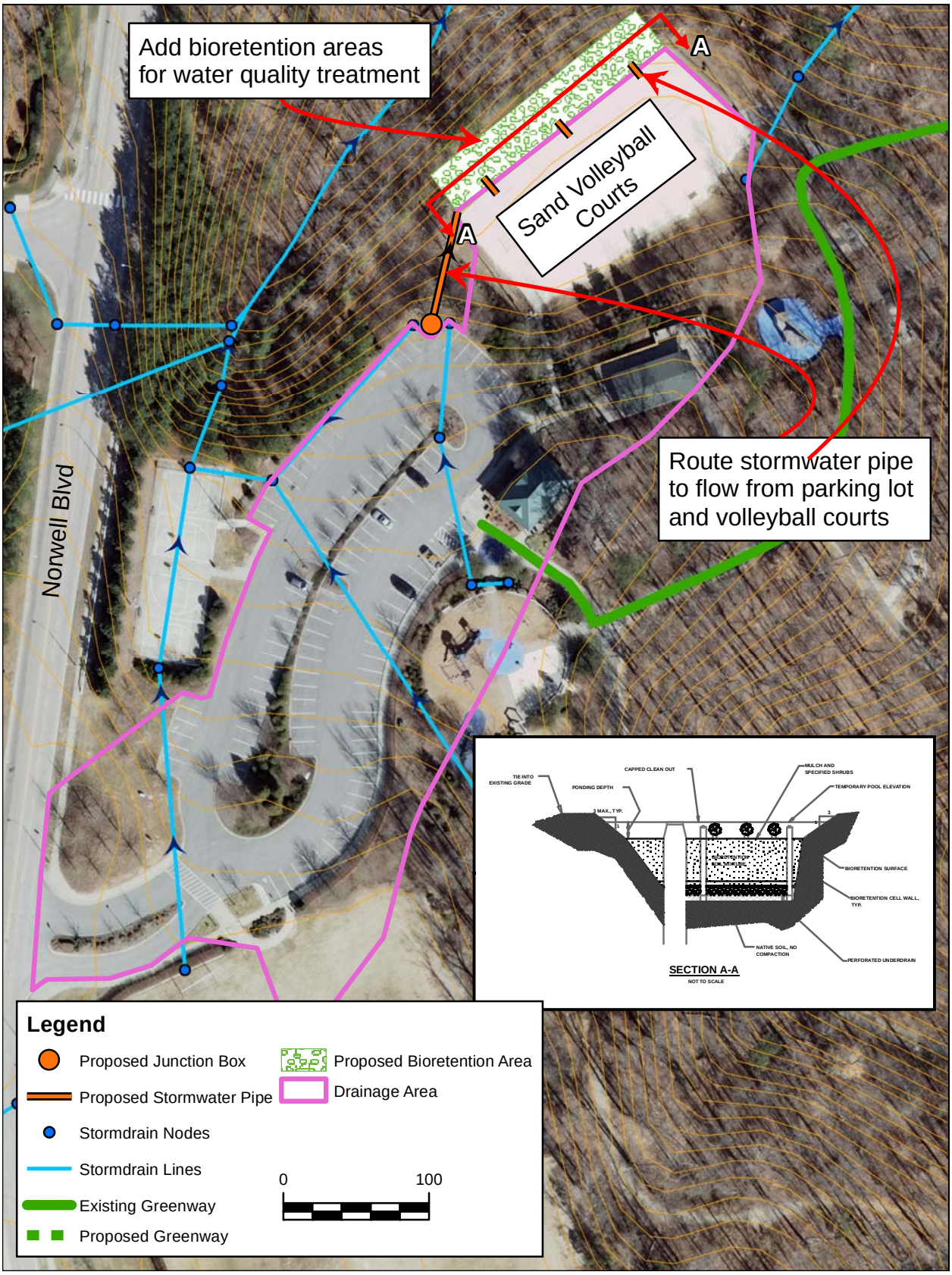
The North Cary Park has been identified by WECO and BCWA as a good location for a BMP retrofit in the Black Creek watershed. One of the best potential retrofit locations is an open area between the receiving channel and sand-volley ball court. There is a shelf on the cut slope behind the pits which could be converted to a series of bioretention areas which would receive most of the runoff from the parking lot and volleyball courts, thus reducing nutrients and attenuating peak flow rates in the receiving stream and Black Creek. Accessing this area during construction could present a challenge and increase estimated construction costs.

The Town could partially fund the bioretention areas by partnering with WECO and BCWA to apply for a CWMTF grant. The Town would benefit from this stormwater runoff treatment by receiving a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 35% and 45%, respectively. The bioretention area could also be designed to include peak flow attenuation which could serve to alleviate erosion issues in Black Creek.

The North Cary Park Retrofit would provide benefits to both water quality and water quantity. These bioretention areas will have a relatively low cost and although accessing the site may present a challenge, this site has an overall “very high” potential for implementation.

Shelf behind volleyball court for potential bioretention area.

Figure 5.5 - North Cary Park Concept



3 – Davis Drive Park			
Description	Convert riprap lined swale to bioretention area or bioswale		
Watershed	Crabtree Creek	Potential	High
Benefits	▪ Nutrient reduction	Estimated Project Cost	$40,000-$60,000
Challenges	▪ Increased maintenance		

Table 5.14 - Davis Drive Park Retrofit Summary

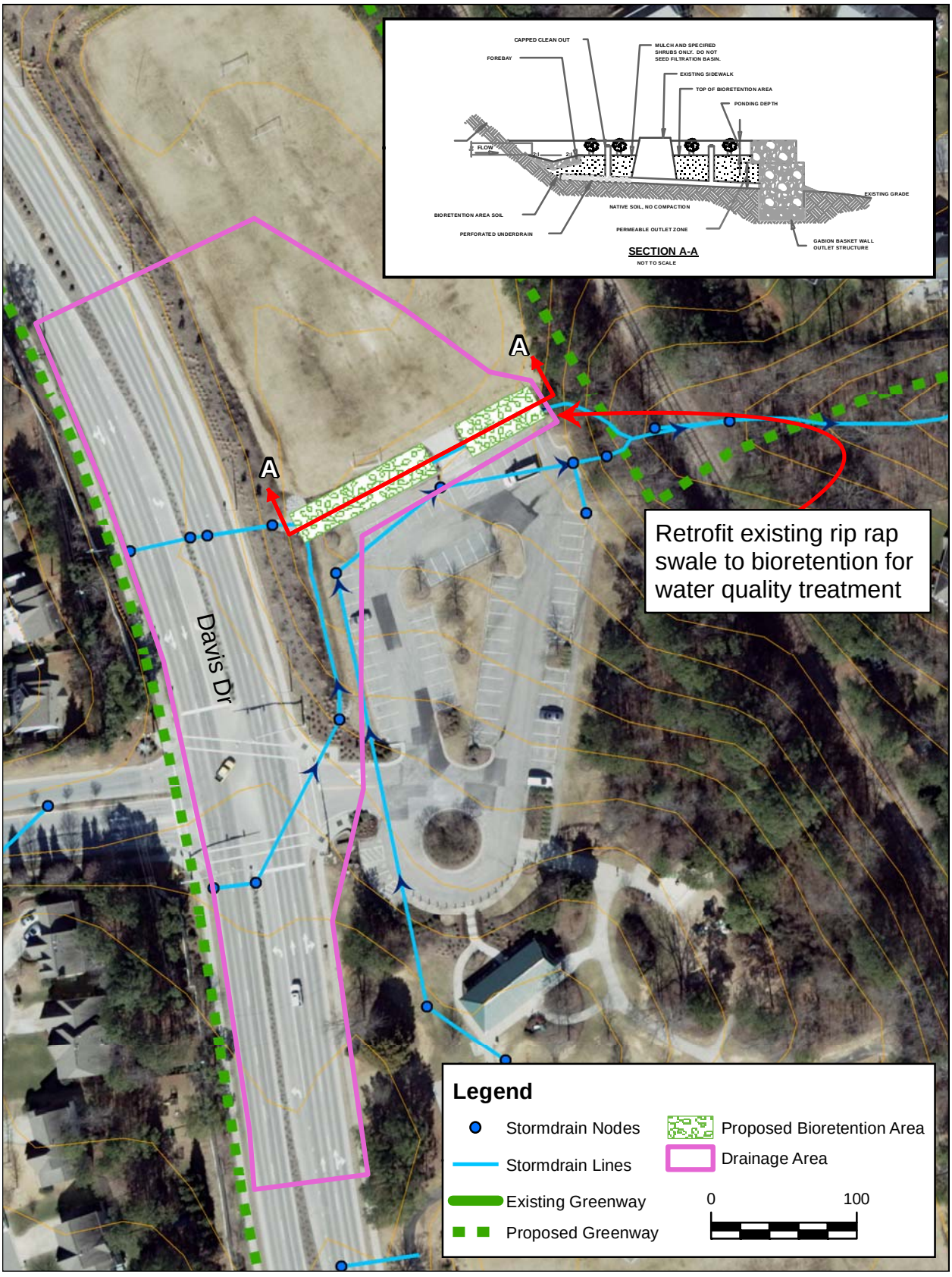
Converting the riprap channel between the northern-most soccer field and parking lot at Davis Drive Park would provide a relatively simple and cost effective means to achieve a BMP retrofit credit. The channel is fed by a 24" pipe that receives runoff from Davis Drive and a small portion of the neighborhood to the west. The site also receives runoff from a portion of the parking lot and soccer field. Immediately downstream of the swale is a railroad track and neighborhood with lots that back up directly to a small headwater stream. Retrofitting the rip rap channel into a bio-swale (a series of bioretention cells) would provide nutrient reduction and attenuate peak flow in the receiving stream. The bio-swale could be funded through a partnership between PRCR and the Town Engineering Services/Stormwater. The BMP could be counted as a retrofit under the Town's NPDES Phase II Stormwater Permit and function to improve the aesthetics of the park. Additionally, PRCR plans to extend the greenway in the neighborhood adjacent to the receiving stream under the railroad and connect it to Davis Drive.

The Town could benefit from some cost-efficiencies and minimize disruption to the park by including the retrofit with the construction of this proposed greenway. The Town would benefit from this stormwater runoff treatment by receiving a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 35% and 45%, respectively; however, more maintenance is required with a bioretention area than a riprap swale.

This retrofit could be easily implemented, and although it will require more maintenance, it will be a cost effective way to reduce nutrients and peak flow for small storm events. These characteristics give the Davis Drive Park Retrofit a "high" potential for implementation.

Existing riprap swale between parking lot and soccer field at Davis Drive Park.

Figure 5.6 Davis Drive Park Concept



4 – Green Hope Elementary School Park			
Description	Add rainwater cistern for ball field irrigation, create bioretention/bio-swales, and convert dry detention basin into a constructed wetland		
Watershed	Crabtree Creek	Potential	High
Benefits	▪ Nutrient reduction ▪ Peak flow attenuation ▪ Reduced water demand	Estimated Project Cost	$600,000-$800,000
Challenges	▪ Possible utility conflicts ▪ Perimeter Buffer Conflict		

Table 5.15 - Green Hope Elementary School Park Retrofit Summary

Green Hope Elementary School Park is located adjacent to and north of Green Hope Elementary School. The school and the park present four potential BMP retrofit opportunities: adding rainwater harvesting cisterns for ball field irrigation, converting a riprap swale into a stormwater wetland for detention and nutrient removal, retrofit a low spot/swale into a bio-swale for nutrient reduction, and retrofit an existing dry detention basin into a stormwater wetland to provide additional nutrient removal and habitat.

The first opportunity includes installing cisterns to harvest rainwater for irrigation use. PRCR is seeking funding for this opportunity and there appears to be adequate room and roof area to supply such features. In order to reach the fields, the harvesting cisterns would also require a pumping system.

Existing depression between Louis Stephens Road and parking lot

The second opportunity includes creating a wetland on the west side of the site. A majority of the north parking lot (which is part of the park) collects in storm drains and outlets into a small rip rap swale just before crossing underneath Louis Stephens Road. The swale is in a low area that appears to be partially connected to the groundwater table. The area presents a good opportunity for a small stormwater wetland. The area appears to have minimal conflicts with utilities, and little disturbance would be necessary to implement the design. The wetland would provide treatment for the runoff coming from the parking lot area.

The third opportunity would retrofit the existing dry basin that serves the majority of the school into a stormwater wetland to provide nutrient removal as well as habitat. The basin already appears to have a groundwater connection based on the observed wetland vegetation. The dry basin also appears to be in need of maintenance based on the erosion around the outlet structure. The stormwater wetland could be funded through a partnership with Wake County Schools and the Town Engineering Services/Stormwater Division. The Stormwater Division would provide the means to convert the BMP in order to improve the stormwater runoff treatment for the school, and the BMP could also be counted as a retrofit under the Town's NPDES Phase II Stormwater Permit. Maintenance of the BMP would need to be negotiated through Wake County Schools.

Existing dry detention basin serving Green Hope Elementary

These retrofit opportunities will provide a large amount of benefit to water quality and quantity while also reducing water demand. To maximize effectiveness, all three locations would need to be constructed which results in a higher cost. Utility conflicts may also be an issue. Additionally, the wetland retrofit may require a variance if constructed in the limits of the streetscape. Despite some challenges, the many benefits give this retrofit an implementation ranking of "high."

Figure 5.7 Green Hope Elementary School Park

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5 – Lexie Lane Park			
Description	Constructed wetlands		
Watershed	Crabtree Creek	Potential	High (if Town has easement)
Benefits	▪ Nutrient reduction ▪ Peak flow attenuation	Estimated Project Cost	$200,000 - $300,000
Challenges	▪ Property acquisition		

Table 5.16 - Lexie Lane Park Retrofit Summary

Immediately northeast of Lexie Lane Park, there is a large, open area that receives a significant amount of untreated runoff from the park and other developed areas (currently carried in a ditch). The parcel layer indicates that this area is not owned by the Town; however, it is possible that the Town owns an easement in this area (which needs to be verified by the Town). Based on the fact that the retrofit site appears to be close to the groundwater table, stormwater wetlands would provide nutrient reduction and peak flow attenuation for a large drainage area that is currently untreated.

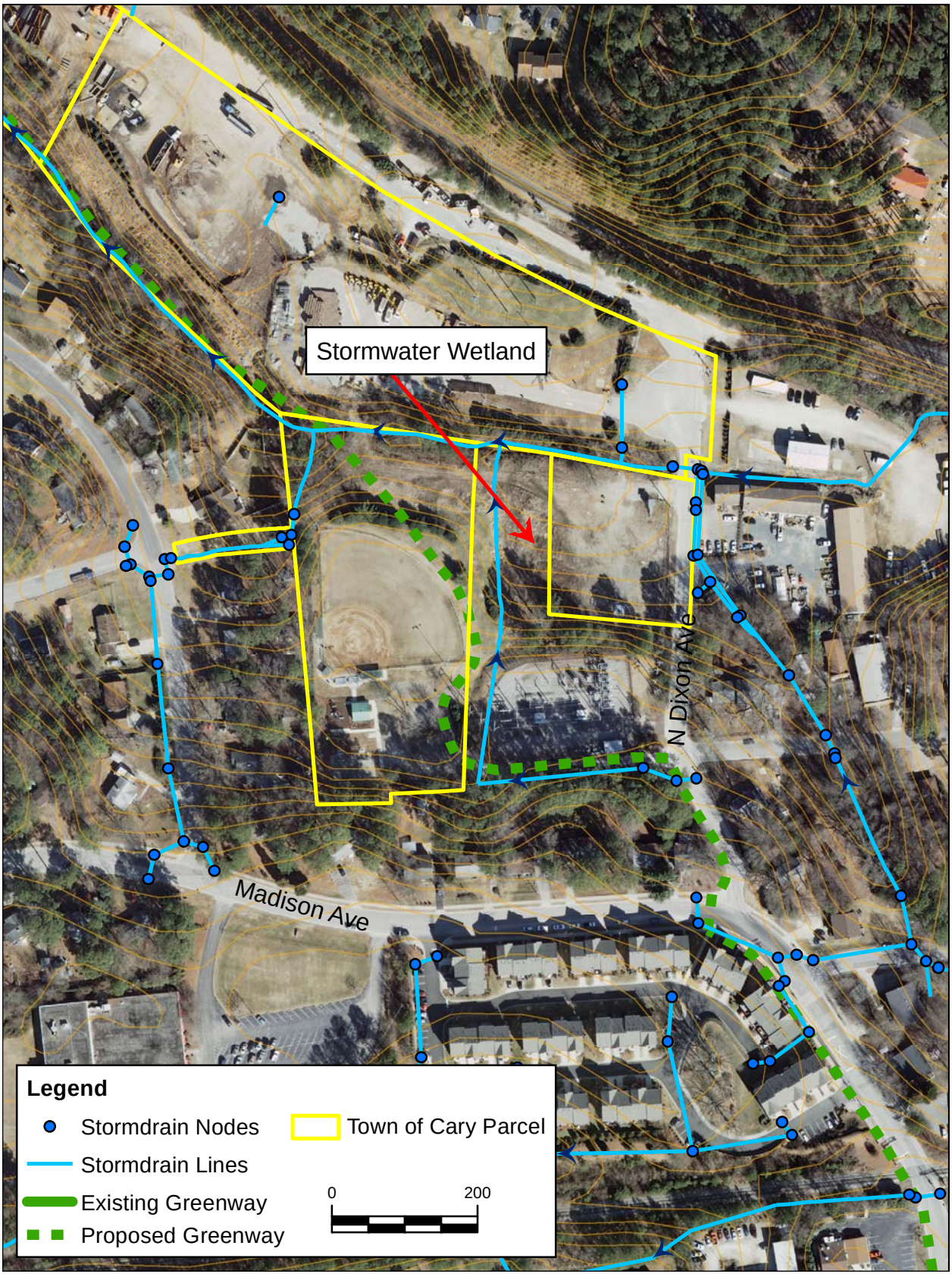
Drainage ditch looking upstream

The Town would benefit from a stormwater wetland in this location by a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 40% and 40%, respectively. This basin is also located at the top of the Crabtree Creek watershed (303(d) stream) which increases the benefits of its detention and water quality improvement potential. The stormwater improvements to the park could partially be funded by applying for a CWMTF grant. In order to pursue this alternative funding source, it would be essential to secure land and/or an easement that could be used as matching funds for the grant.

Drainage ditch looking downstream

Although this BMP has a relatively high cost, it has the ability to treat a large drainage area for both water quality and quantity and funding may be available. This retrofit has been ranked as having a “high” potential for implementation as long as the Town has an easement on the property.

Figure 5.8 - Lexie Lane Park



6 – Regency Park			
Description	Constructed wetland retrofitted within existing forebay		
Watershed	Swift Creek	Potential	Very High
Benefits	▪ Nutrient reduction ▪ Parks amenity	Estimated Project Cost	$140,000-$160,000
Challenges	▪ Increased surface area ▪ Increased maintenance		

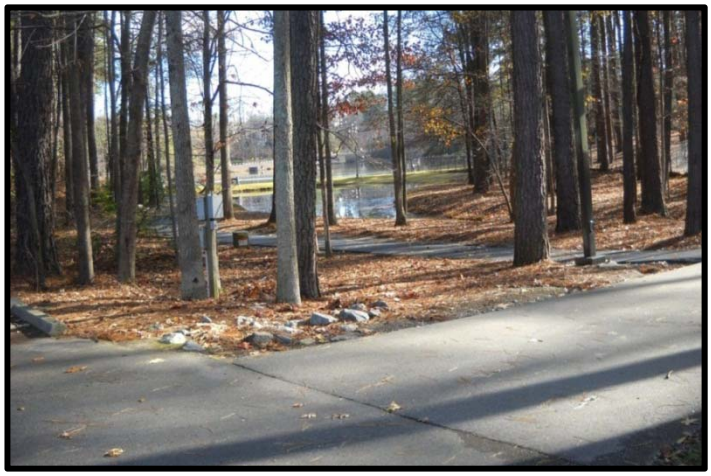
Table 5.17 – Regency Park Retrofit Summary

Adjacent to the Koka Booth Amphitheater is a forebay that drains to Symphony Lake which drains directly to Swift Creek and provides flood attenuation and some pollutant removal. The forebay can be converted to a constructed wetland for additional nutrient reduction. The forebay receives runoff from Regency Parkway and the amphitheater. Beyond the additional nutrient reduction of converting the forebay to a wetland, the wetland can be made less attractive to geese which are a problem in the area and contribute fecal coliform pollution. The wetland would provide a dual-usage benefit to the Town by using landscaping to improve the appearance of the area and be counted as a retrofit under the Town's NPDES Phase II Stormwater Permit. The area could also serve as an educational opportunity given its location to the greenway and amphitheater. This multi-usage benefit could present a funding opportunity through a partnership with PRCR and the Town Engineering Services/Stormwater Division.

The footprint of the wetland area will need to be approximately 20,000 square feet or approximately 7,000 square feet (~0.16 acres) larger than the current normal pool area of the existing forebay. Much of the expanded area could be above the normal pool of the wetland in a zone called "shallow land" which is 0 to 12 inches above the wetland normal pool.

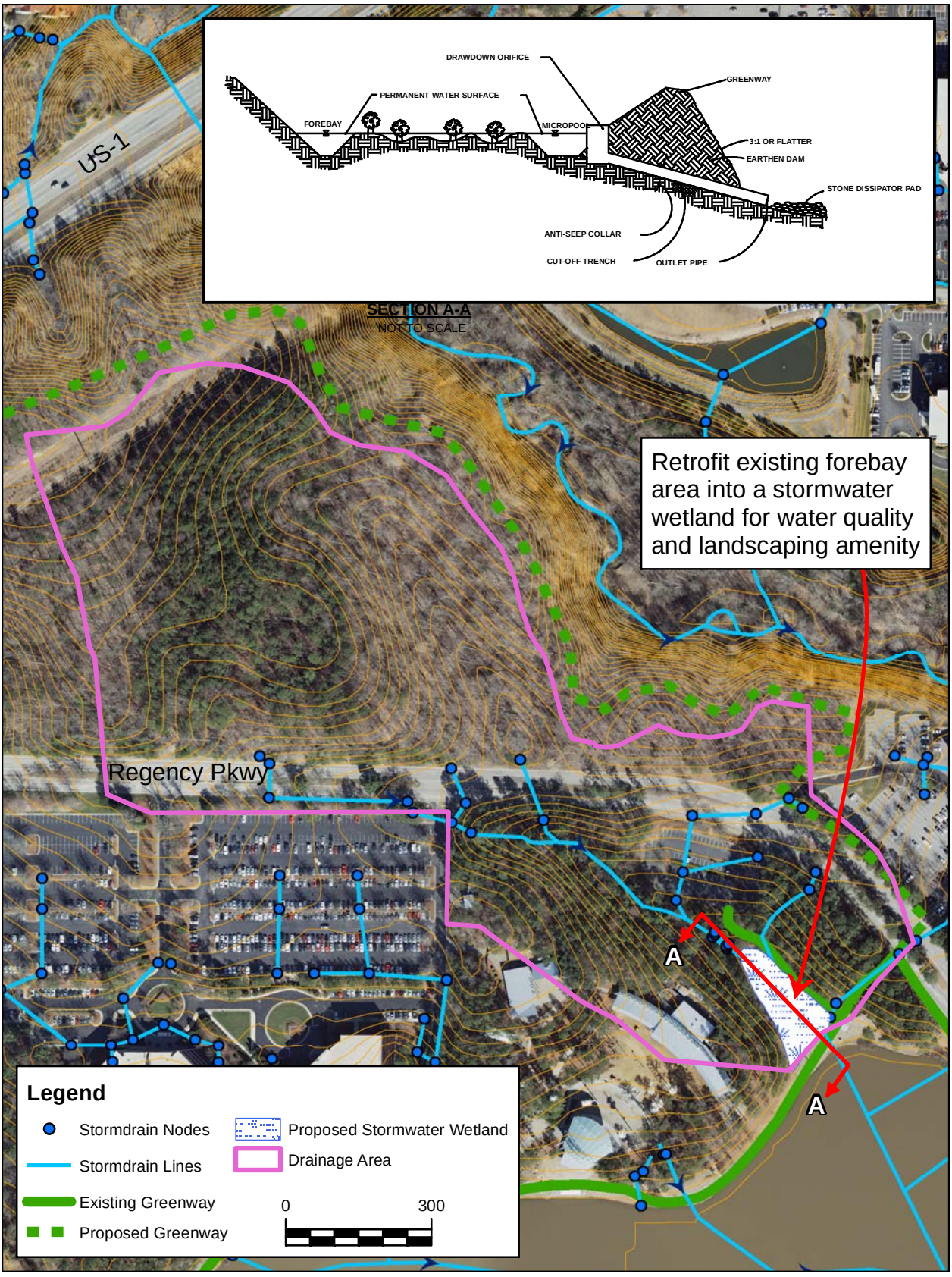
The Town would benefit from this stormwater runoff treatment by receiving a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 40% and 40%, respectively.

This retrofit will provide nutrient reduction and also act as an amenity to the park. This project is relatively inexpensive and funding may also be available. Even though the retrofit will require a larger surface area than the existing feature, it has been given an implementation rating of "very high."



Existing forebay at Regency Lake.

Figure 5.9 – Regency Park Concept



7 – Swift Creek Slough			
Description	Create natural floodplain slough in undeveloped area of the Swift Creek floodplain.		
Watershed	Swift Creek	Potential	High
Benefits	▪ Flood control ▪ Water quality improvement	Estimated Project Cost	$800,000 to $1,200,000
Challenges	▪ Land acquisition ▪ Soil disposal		

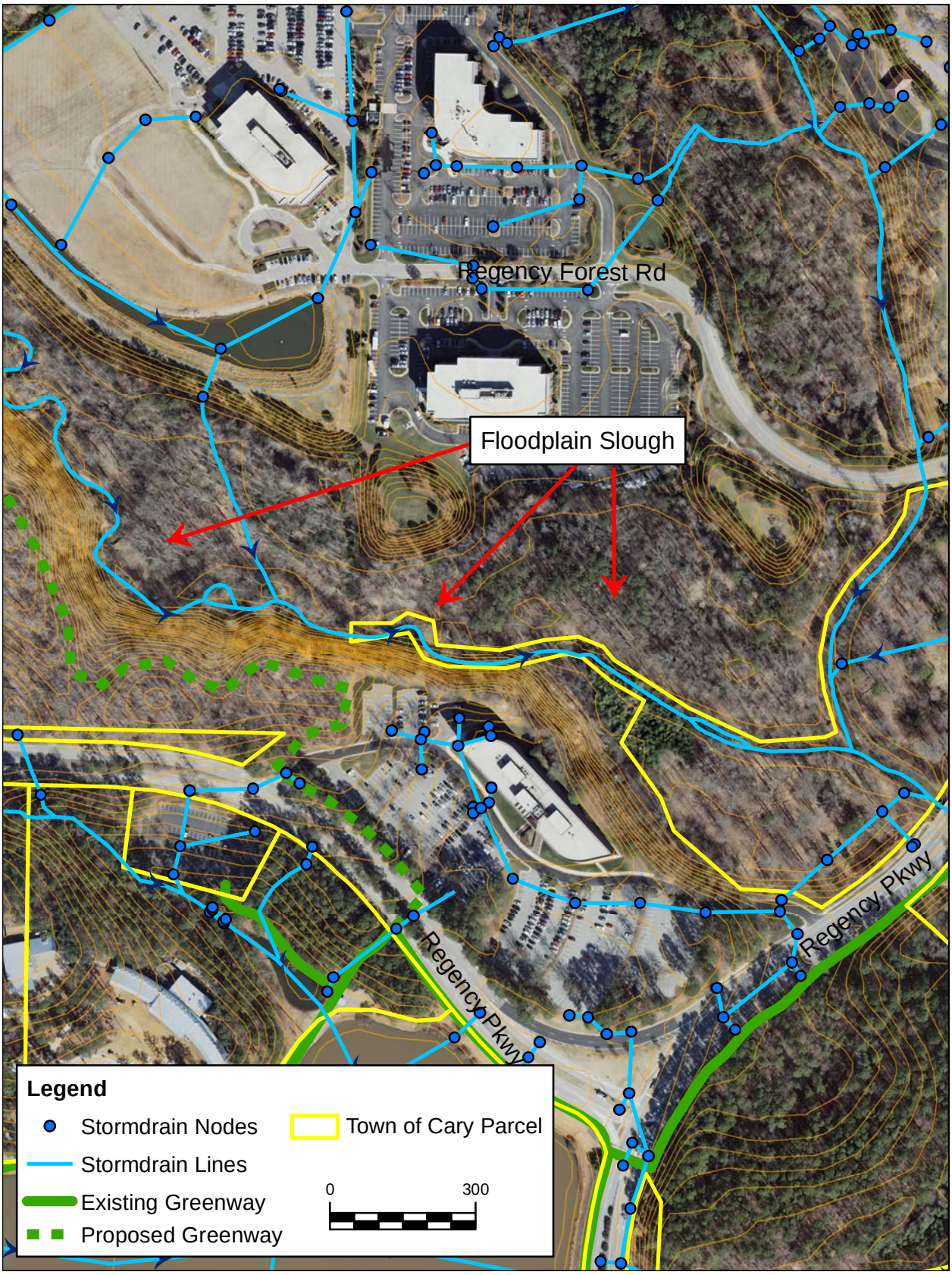
Table 5.18 - Swift Creek Slough Retrofit Summary

Currently, there are flooding complaints along Swift Creek in the vicinity of Kildaire Farm Road and Ritter Park. As such, it is beneficial to identify and provide additional flood storage upstream of this location. One such area is immediately above Regency Parkway. In this location, the Town owns some large and essentially undevelopable areas within the floodplain of Swift Creek; these areas are good candidates for creating floodplain sloughs. Sloughs are side channels which are slightly higher than the bottom of the existing stream. These channels fill during flood events and temporarily store flood waters. Sloughs also create opportunities for wetland habitat and pollutant reduction. By creating a larger hydraulic area during flood events, the slough could reduce bank erosion by reducing localized shear stress and velocities in Swift Creek. There is an existing floodplain slough along Swift Creek in Hemlock Bluffs State Natural Area which indicates that a created slough is viable.

The Town would benefit from the proposed slough by creating flood storage, water quality via a more frequently flooded overbank area, and creating wetland habitat. A slough would also replace pervious cover functions in a way that it could be considered as impervious cover reduction per the Swift Creek TMDL. In order to make this project feasible, the Town would need to secure the necessary land through communicating with land owners as well as have the ability to properly dispose of excess spoil material created from the excavation of the sloughs. This slough creation project could be partially funded by applying for a CWMTF grant. It is notable that the CWMTF has awarded grants to at least two other slough creation projects (South Buffalo Creek in Greensboro and Stoney Creek in Goldsboro). The DWR and 319 grants could also be considered as secondary funding possibilities because of the project's location in the Swift Creek Watershed.

The slough retrofits will provide several benefits. Although this project has a high cost and challenges with land acquisition and soil disposal have laced this retrofit as a "high" implementation potential because of its funding possibilities and amount of benefit that could be seen.

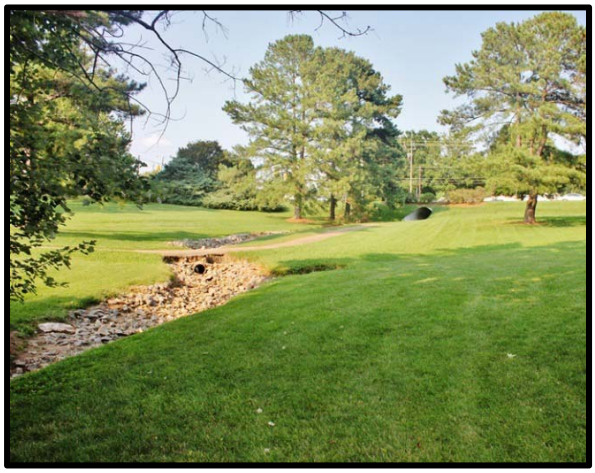
Figure 5.10 - Swift Creek Slough



8 – Kildaire Farm Greenway			
Description	Create stormwater wetland and restore stream near greenway.		
Watershed	Swift Creek	Potential	Moderate
Benefits	▪ Nutrient reduction ▪ Stormwater detention	Estimated Project Cost	$400,000 - $800,000
Challenges	▪ Land acquisition ▪ Establishing O&M responsibilities		

Table 5.19 - Kildaire Farm Greenway Retrofit Summary

The Kildaire Farm I subdivision owns a significant parcel of open space immediately west of Kildaire Farm Road. There is a large strip mall located to the east of Kildaire Farm Road that drains to this area. Within the open space, there are two eroded channels that meet to form a headwater stream. There is ample space to provide a stormwater wetland or wet detention basin at this location that would treat a large amount of untreated runoff from the strip mall. There is also potential for stream restoration opportunities for this highly eroded headwater stream. The Town would benefit from a stormwater wetland retrofit by a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 40% and 40%, respectively. The area is located in the upper watershed of Swift Creek which has a TMDL. Providing detention and nutrient reduction would help water quality for the 303(d) impaired stream. Restoring the stream would decrease sedimentation and allow for a better functioning riparian area.

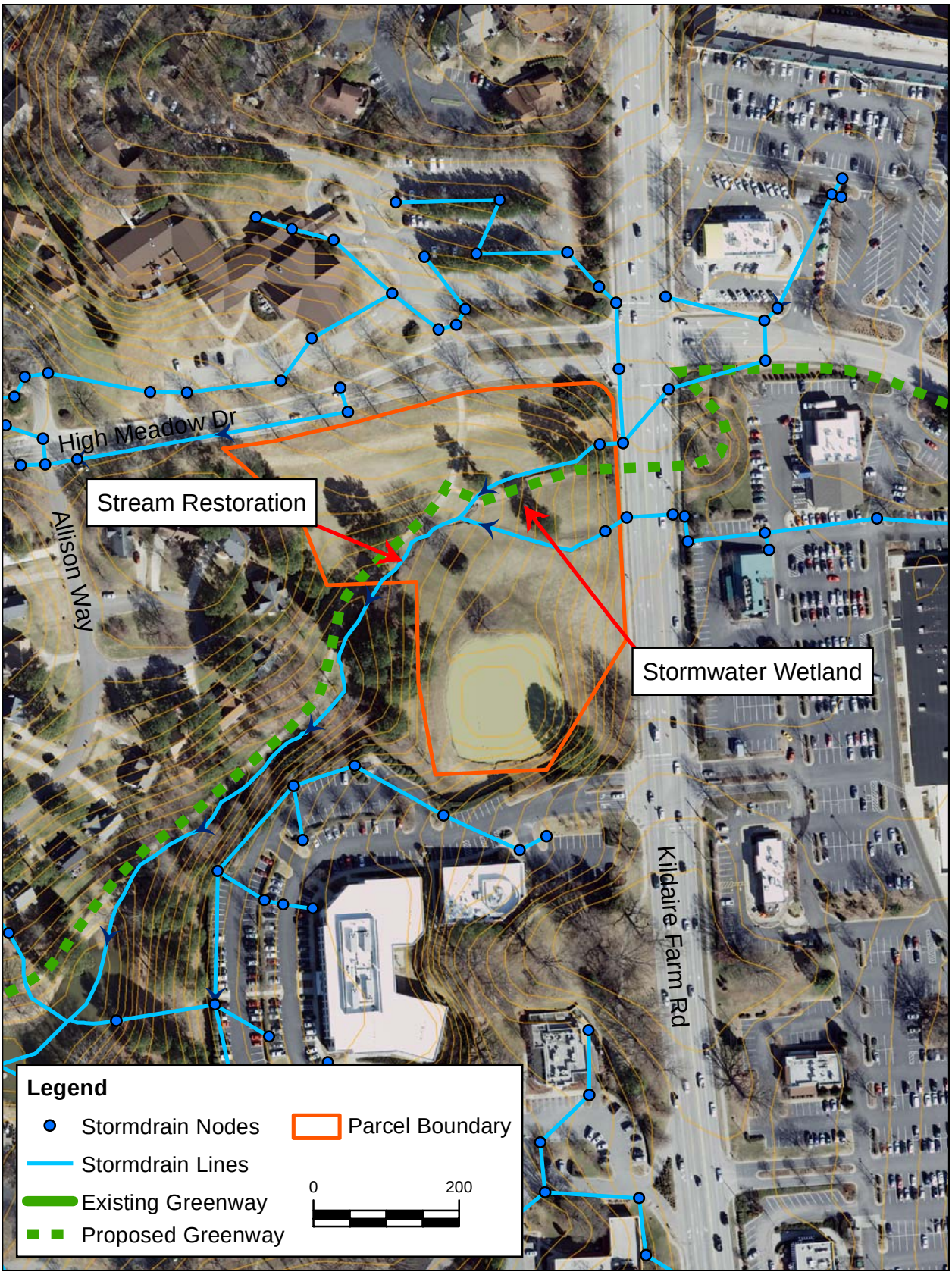


Open space and eroded riprap lined ditch.

The improvement costs could be decreased through a partnership with the Kildaire Farm I subdivision and the Town Engineering Services/Stormwater Division. The costs could be decreased if the Kildaire Farm I subdivision were to allow the Town to complete the work without having to pay to acquire an easement, requiring further communication with the land owners. Pursuing a CWMTF, DWR, or a 319 grant could also be considered as secondary funding opportunities. A proper O&M agreement would be essential to determine the maintenance responsibilities of the BMP post-construction.

This stream restoration and wetland creation would benefit both water quality and water quantity in a TMDL watershed. Alternative funding is a possibility and cost could be decreased further with cooperation from the subdivision. This retrofit would still be relatively expensive and require an agreement with the subdivision to ensure that the wetland and stream continue to function properly; therefore, it has been giving a “moderate” potential ranking for implementation.

Figure 5.11 - Kildaire Farm Greenway



9 – Rose Street Park			
Description	Create gabion wall bioretention area.		
Watershed	Swift Creek	Potential	Moderate
Benefits	▪ Nutrient reduction	Estimated Project Cost	$50,000 - $60,000
Challenges	▪ Utility conflicts ▪ Future plans for park ▪ Perimeter buffer conflict		

Table 5.20 - Rose Street Park Retrofit Summary

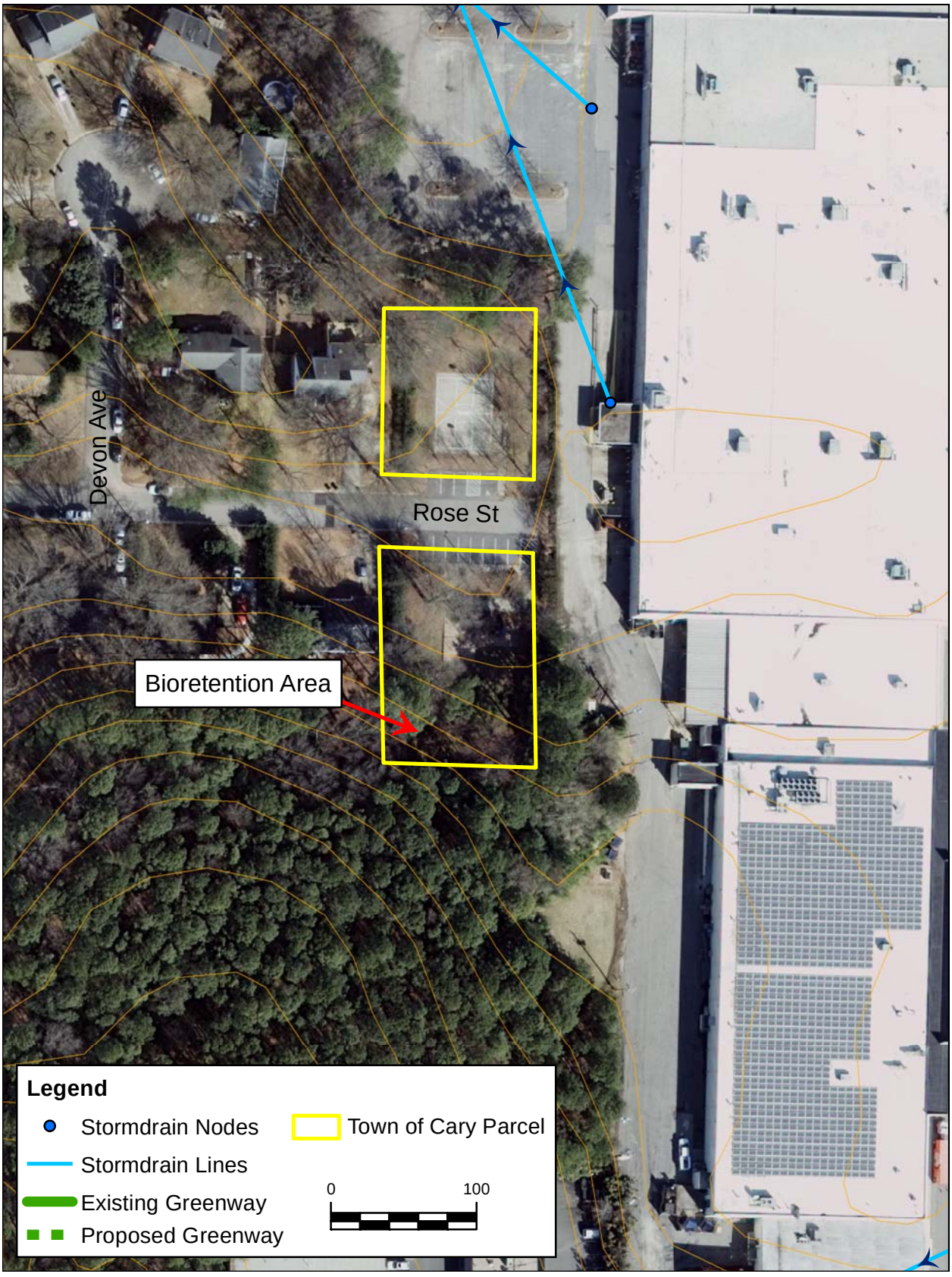
Rose Street Park is a neighborhood park with a small parking area and playground equipment. The parking lot sheet flows towards the southwest corner of the site. The sloped nature of this area would serve as good location for a raised bioretention area to reduce nutrients and provide runoff attenuation. There is also potential that the park may be redeveloped or expanded which could provide opportunity for more integrated BMPs that provide dual-usage. The site is spatially constrained and may have utility conflicts. The proposed stormwater improvements to the park could be partially funded as part of the development of the park. The stormwater improvements would be incorporated into the landscape of the park, as well as be counted as a retrofit under the Town's NPDES Phase II Stormwater Permit. Pursuing a DWR or a 319 grant could also be considered as secondary funding opportunities.

The Town would benefit from this BMP upgrade by a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 35% and 45%, respectively. This basin is also located at the top of the Swift Creek watershed increasing the benefits of both its detention and water quality improvement potential.

This BMP has a relatively low cost and could be easily implemented along with redevelopment of the park. Funding opportunities may be available. Because of the small area and potential utility conflicts, this retrofit has been giving an implementation ranking of "moderate." Additionally, the bioretention area would need to be constructed outside of the perimeter buffer or receive a variance.

Parking lot and play area.

Figure 5.12 – Rose Street Park



10 – Kildaire Farm Lake			
Description	Create irrigation system in lake for surrounding neighborhood.		
Watershed	Swift Creek	Potential	Low
Benefits	▪ Source of non-potable water	Estimated Project Cost	$1,500,000 - $10,000,000
Challenges	▪ Land acquisition ▪ Cost-effectiveness ▪ Lack of infrastructure		

Table 5.21 - Kildaire Farm Lake Retrofit Summary

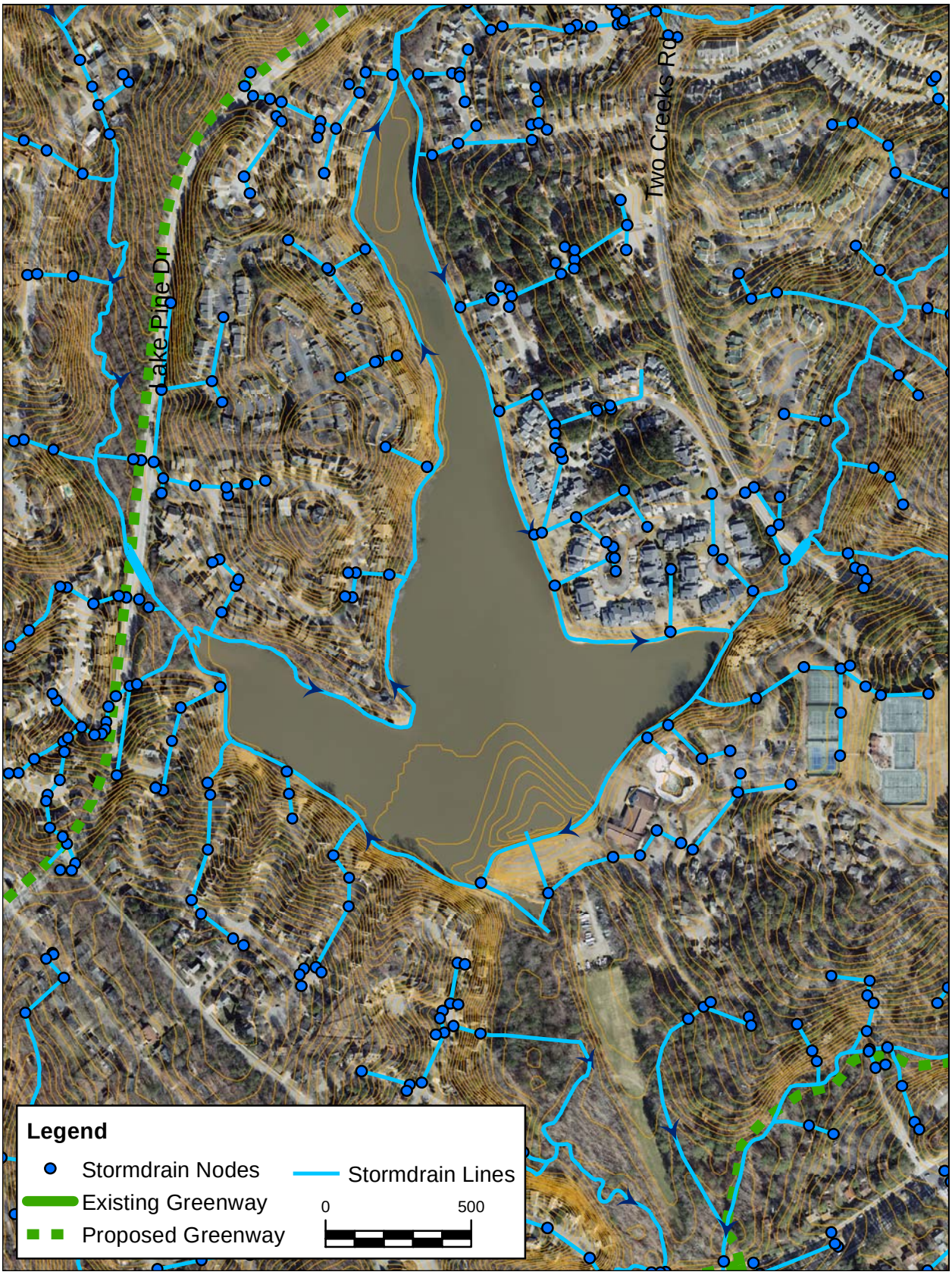
The Kildaire Farm Lake was constructed in the mid-1980's as part of the Kildaire Farm PUD. It is currently owned by the Kildaire Farms II Homeowners Association. The lake primarily serves as an amenity; however, it probably also provides some flood attenuation. It has been suggested that the lake could be used as a source of non-potable water for irrigation. In order to make use of this non-potable source, a separate distribution system would need to be constructed. Additionally, the lake is, for the most part, very shallow and water level fluctuations would be apparent in the summer which may result in large portions of the lake bottom being exposed. This exposure means that additional land adjacent to the lake may be required to reach necessary volume requirements which would involve coordination with land owners. It may be more practical to extend reclaimed water lines from the North Cary Water Reclamation Facility instead.

If the Town used Kildaire Farm Lake as a source of non-potable irrigation water, it would potentially reduce potable water demands during periods of highest demand. This would result in a reduction in potable water costs, for which the Town could eventually recover the cost of the project. A DWR or a 319 grant could also be considered as a secondary funding source. Additionally, nutrients in the water would be removed from the system as the water is used for irrigation.

This lake could provide some irrigation for the surrounding area, which would decrease the potable water demand. However, this retrofit has been given an implementation ranking of "low" because it would require much coordination and construction, and may not be aesthetically pleasing if used for irrigation during summer months. Other options would be more practical.

Kildaire Farm Lake.

Figure 5.13 - Kildaire Farm Lake



11 – Ridgecrest Road Lot			
Description	Create dry detention basin.		
Watershed	Swift Creek	Potential	Low
Benefits	▪ Peak flow attenuation	Estimated Project Cost	$220,000 - $380,000
Challenges	▪ Obtaining permits ▪ Land acquisition		

Table 5.22 - Ridgecrest Road Lot Retrofit Summary

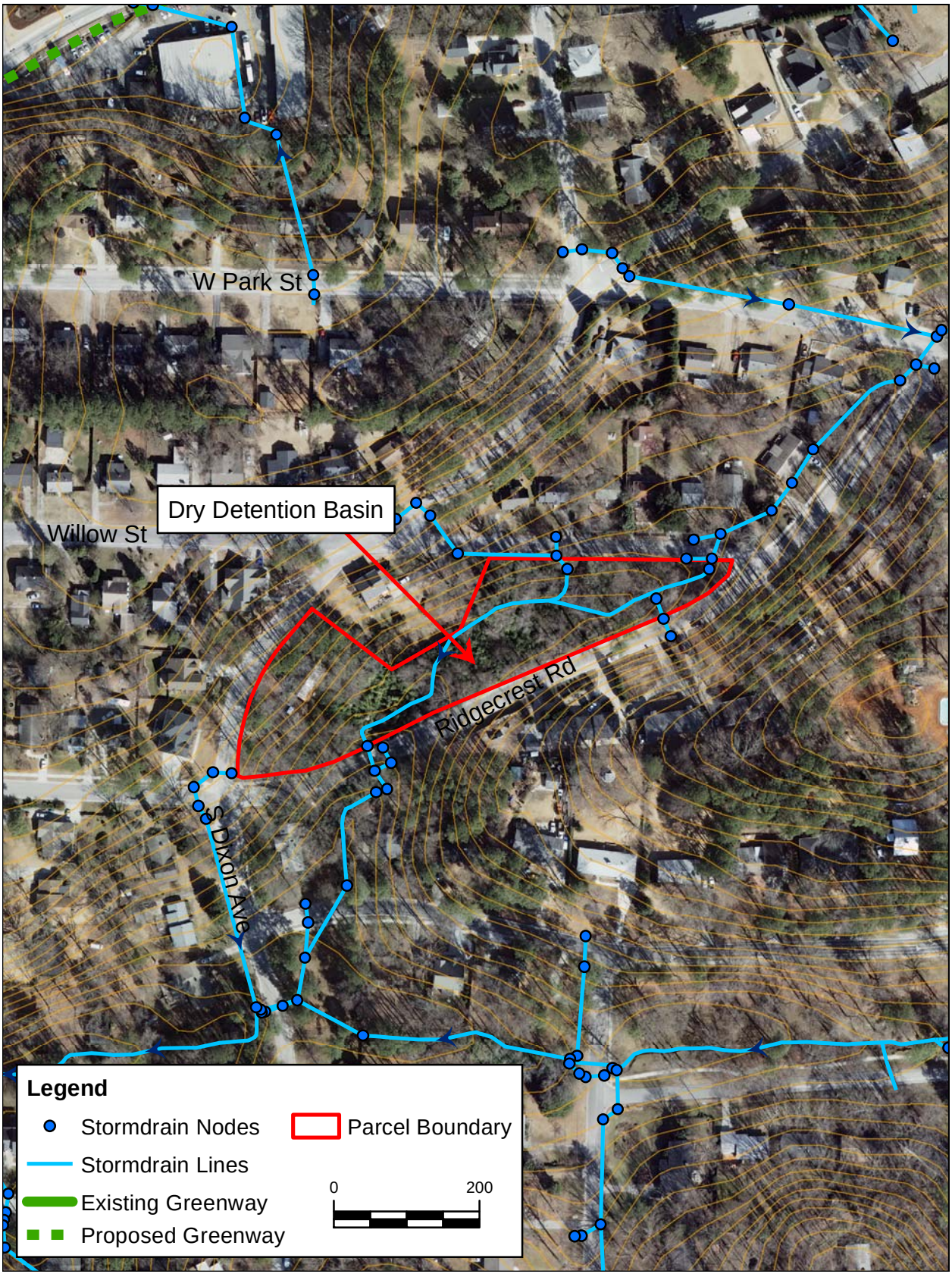
To the northeast of Ridgecrest Road and South Dixon Avenue is a forested residential lot with a natural depression adjacent to Ridgecrest Road. This lot is situated at the uppermost ridge in the Swift Creek watershed making it an excellent location for controlling peak discharges and downstream flooding. Converting this area into a dry detention basin could potentially be achieved without necessarily removing the forest; however, since the area is located on private property, the Town would either need to purchase the site or obtain an easement. Additionally, the property appears to have a stream and possible historic structure, potentially making it difficult to obtain permits.

Benefits to the Town from this BMP include a reduction in peak flow providing some protection to a downstream stream restoration project and alleviating known flooding issues. The dry detention basin would not provide significant water quality benefits. A DWR or a 319 grant could be pursued to partially fund the cost of the BMP.

The location of this site provides a good opportunity for controlling water quantity and could be implemented at a relatively low cost; however, the small amount of benefit combined with the difficulty of acquiring land and permits gives this retrofit location an implementation ranking of “low.”

Wooded depression in lot

Figure 5.14 - Ridgecrest Road Lot



12– US 1 and Walnut Street Interchange			
Description	Detention and Stormwater Wetland		
Watershed	Swift Creek	Potential	Low
Benefits	▪ Detention to help downstream flooding ▪ Nutrient reduction ▪ Reduced erosion and sedimentation downstream	Estimated Project Cost	$250,000 - $400,000
Challenges	▪ Capturing runoff from upstream impervious cover		

Table 5.23 - Walnut Street and US-1 Retrofit Summary

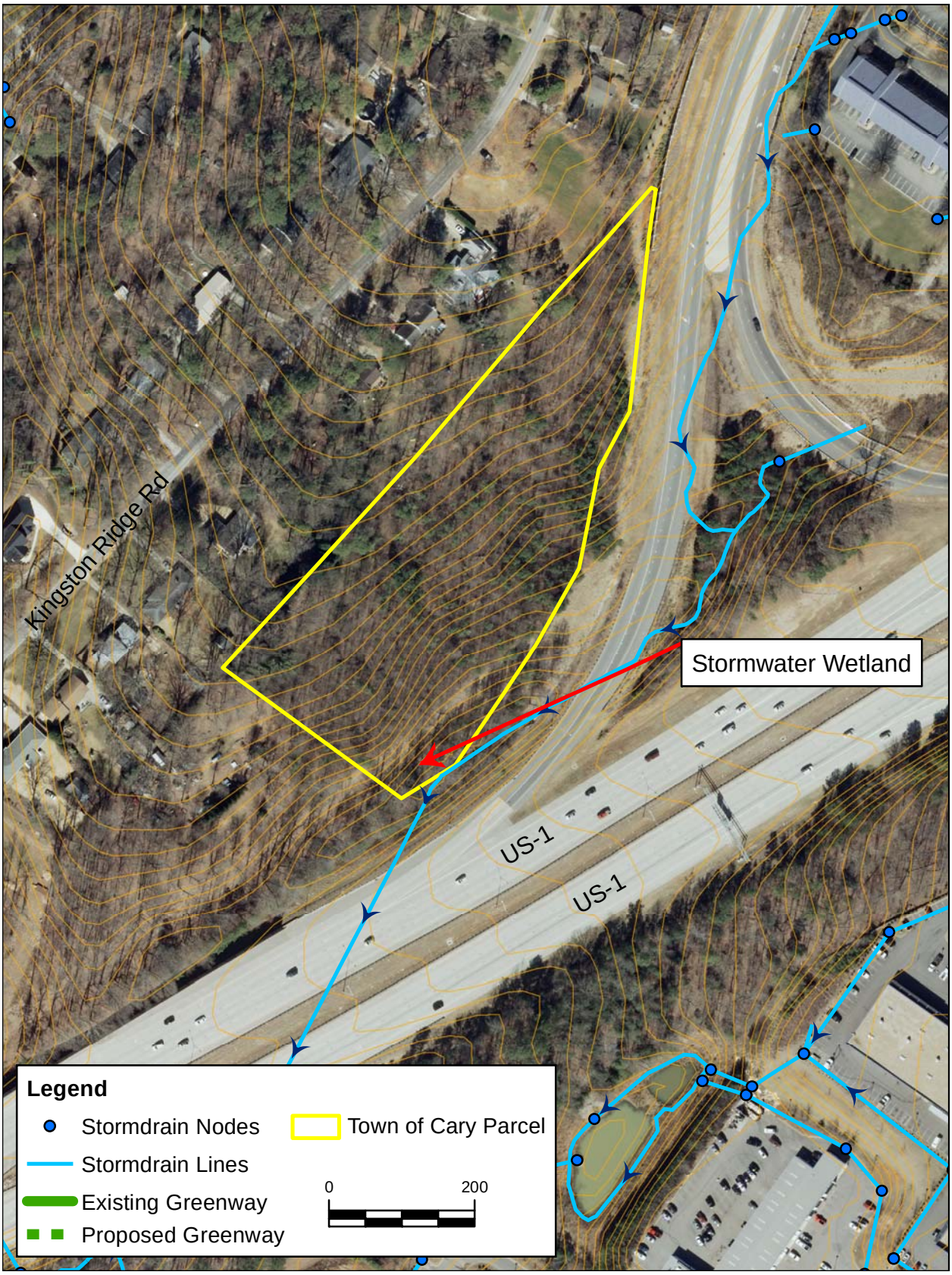
The Town owns an undeveloped parcel at in the northwest quadrant of the Walnut Street and US-1 interchange. This parcel is located high in the Swift Creek watershed above areas with known flooding issues. Its situation in the watershed makes it an excellent location to control runoff from the Kingston Ridge Road residential area. However, the majority of the runoff from the interchange and higher density multifamily area is carried along the southern most corner of the property via a stream mapped as having buffers. Nevertheless, if detention were provided using a stormwater wetland, it would not only provide stormwater runoff detention which could be designed to reduce flooding and erosion downstream, but would also provide a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 40% and 40%, respectively.

The site is currently owned by the Town so there would be no costs associated with acquiring the property; however, the tributary area to the site is relatively small yielding a low amount of runoff that can be captured. The buffered stream, which the site review revealed likely no longer exists, carrying the majority of the runoff is located in the extreme southern corner of the parcel in a relatively low position and is probably located within NCDOT right-of-way. Since the site is steeply sloped towards US-1, diverting runoff from the stream onto the parcel would be difficult. It may be possible to partner with NCDOT into order to access the stream.

This retrofit is in a good location for affecting Swift Creek; however, it captures a fairly drainage area. Coordination with NCDOT may be required and stream buffers and right-of-way are likely to pose challenges giving this site an implementation rating of “low.”

Walnut Street and US-1 Potential Stormwater Wetland Location

Figure 5.15 - Walnut Street and US-1



13 – Macedonia Lake (Future Tryon Road Park)			
Description	Create multiple vegetated shelves.		
Watershed	Swift Creek	Potential	Low
Benefits	▪ Improve nutrient removal ▪ Discourage geese (fecal coliform reduction)	Estimated Project Cost	$100,000-$700,000
Challenges	▪ Disruption of neighboring properties ▪ Lack of benefits		

Table 5.24 - Macedonia Lake Retrofit Summary

Macedonia Lake is owned by the Town and currently functions as a flood control BMP. As a large impoundment, it provides some nutrient removal capabilities; however, these capabilities could be improved by adding vegetative shelves around the lake. The presence of such shelves improves nutrient cycling and assimilation opportunities. Another added benefit in this location is that geese prefer not to utilize impoundments that are surrounded by a strip of higher growing vegetation. Geese avoidance improves water quality by reducing nutrient input and fecal coliform.

Adding vegetated shelves to the lake would benefit the Town by providing an opportunity for additional nitrogen and phosphorous removal and reducing a large fecal coliform and nutrient source by deterring geese. A DWR or a 319 grant could be pursued to partially fund cost of the vegetative shelves.

These vegetated shelves would be relatively simple to install and provide water quality benefits; however, the small impact of benefits and the high cost give this retrofit an implementation ranking of “low.”

Macedonia Lake

Figure 5.16 - Macedonia Lake (Future Tryon Park)

14 – Town Center Park			
Description	Create dual-use detention and nutrient reduction stormwater BMP.		
Watershed	Walnut Creek	Potential	Very High
Benefits	▪ Flood reduction ▪ Nutrient reduction	Estimated Project Cost	$100,000-$400,000
Challenges	▪ Integration with Town plans		

Table 5.25 - Town Center Park Retrofit Summary

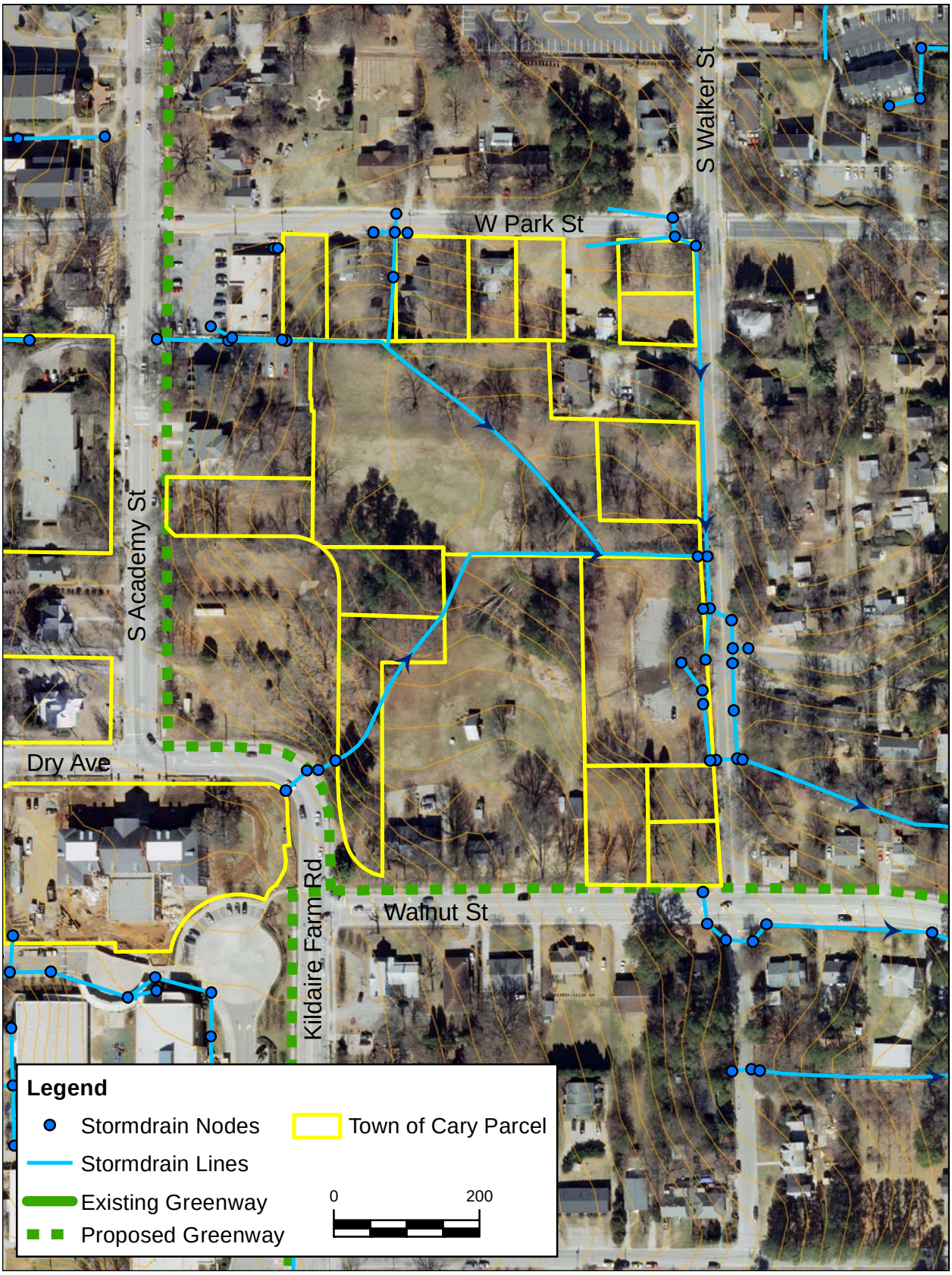
Currently, land continues to be acquired and concepts developed for the Town Center Park area. As part of these plans, it is anticipated that a stormwater BMP will be provided as part of the plan for this area. At a minimum, some type of detention facility will need to be provided. It would be possible to provide underground detention, but it may also be possible to provide some sort of "hardscape" detention facility that becomes an amenity to the project, such as a water feature. If nutrient removal is required, BMPs such as bioretention (or a proprietary equivalent) should be considered as it can be provided within planter-type features that have aesthetic potential. Such features would also be excellent opportunities for public education because of the high human interaction potential.

The Town would benefit from a detention facility in this location because of its position at the top of a watershed with known downstream flooding issues. By planning ahead, the facility could serve a dual-use as a stormwater control structure and parks amenity. Upgrading the BMP to have pollutant removal characteristics could also reduce total suspended solids, nitrogen, and phosphorous. The BMP could be partially funded as part of the development of the park through a partnership with PRCR and the Town Engineering Services/Stormwater Division.

Multi-use detention facilities would provide water quality and quantity benefits, as well as educational and aesthetic properties. The combination of benefits along with the relatively simple implementation has given this retrofit a ranking of "very high" potential.

eloped.

Figure 5.17 – Town Center Park



15 – Walnut Creek Stream Restoration			
Description	Restore reach of Walnut Creek upstream of SE Maynard Rd and downstream of Clay St.		
Watershed	Walnut Creek	Potential	Very High
Benefits	▪ Flood reduction ▪ Bank stabilization (erosion reduction)	Estimated Project Cost	$4,000,000 - $11,000,000
Challenges	▪ Land acquisition		

Table 5.26 – Walnut Creek Stream Restoration Summary

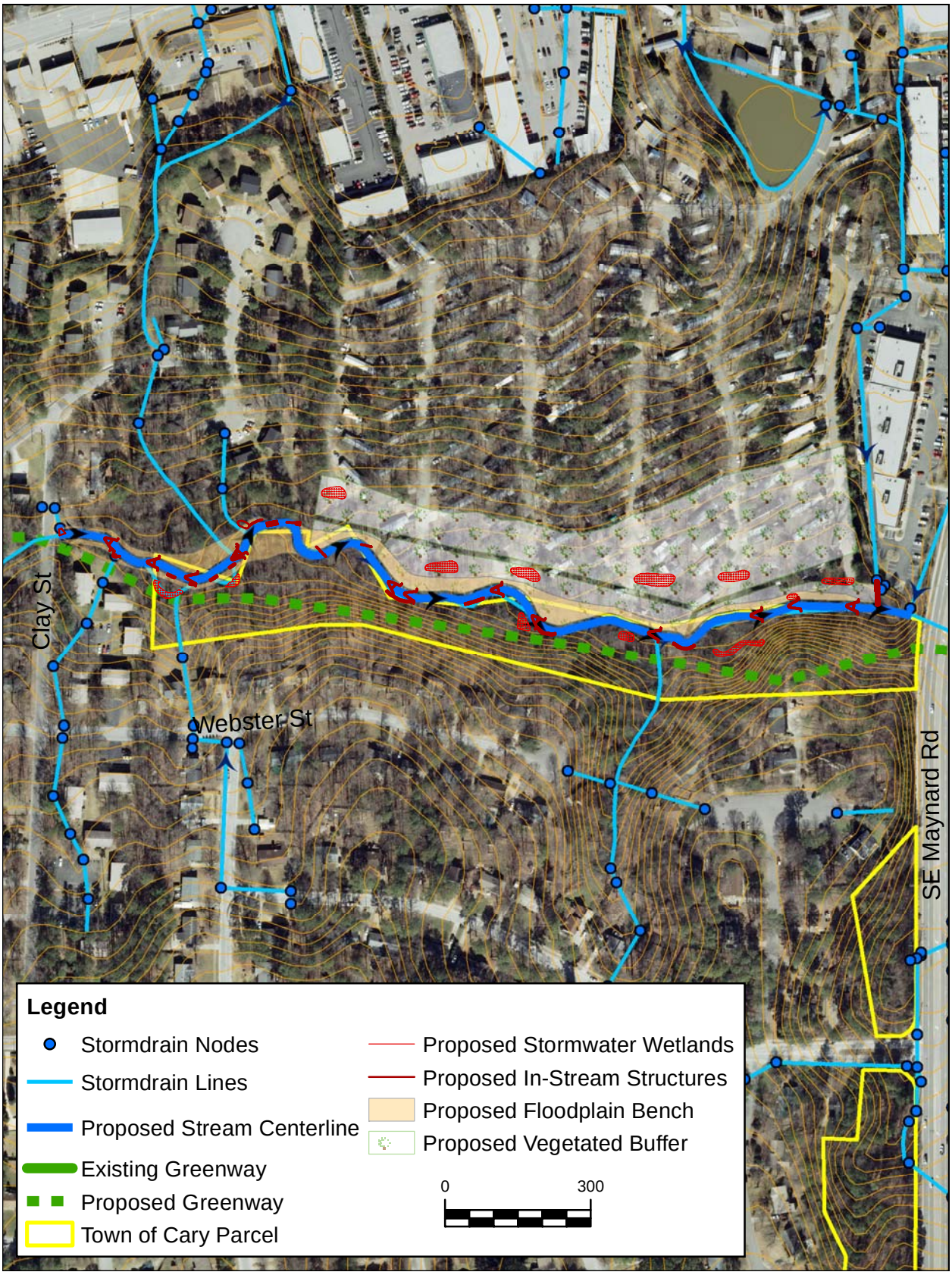
Restoring the portion of Walnut Creek upstream of Southeast Maynard Road to Clay Street would provide meaningful improvements to water quality by reducing and significantly addressing known flooding issues. This area has had frequent flooding complaints and the project was initiated primarily to address the existing flooding issues. The Town has developed plans and specifications, and has received a 404/401 Permit, a CLOMR, and an Erosion and Sedimentation Control Permit. This project also has potential dual-usage as greenway/open space since the Town already owns the south side of the stream and the project proposes purchasing or obtaining easements for the north side of the stream.

Restoring the stream would benefit the Town by addressing known flooding issues, reducing total suspended solids, and reducing sedimentation (from bank erosion) in the stream; reducing nitrogen and phosphorous by means of a better functioning stream and riparian buffer. This stream restoration opportunity could be partially funded through the Section 401/404 compensatory mitigation credit the Town would receive as a part of the restoration.

This stream restoration could provide water quality and quantity benefits, while also serving as a recreational area. Plans and permits have already been acquired, giving this site an implementation potential of “very high”.

Eroded stream bank adjacent to existing residence

Figure 5.18 – Walnut Creek Stream Restoration



16 – 218 Byrum Street			
Description	Detention and Stormwater Wetland		
Watershed	Walnut Creek	Potential	High
Benefits	▪ Detention to address downstream flooding ▪ Nutrient reduction ▪ Reduced erosion and sedimentation downstream	Estimated Project Cost	$550,000 - $650,000
Challenges	▪ Property acquisition ▪ Site may contain stream and wetlands		

Table 5.27 - 218 Byrum Street Retrofit Summary

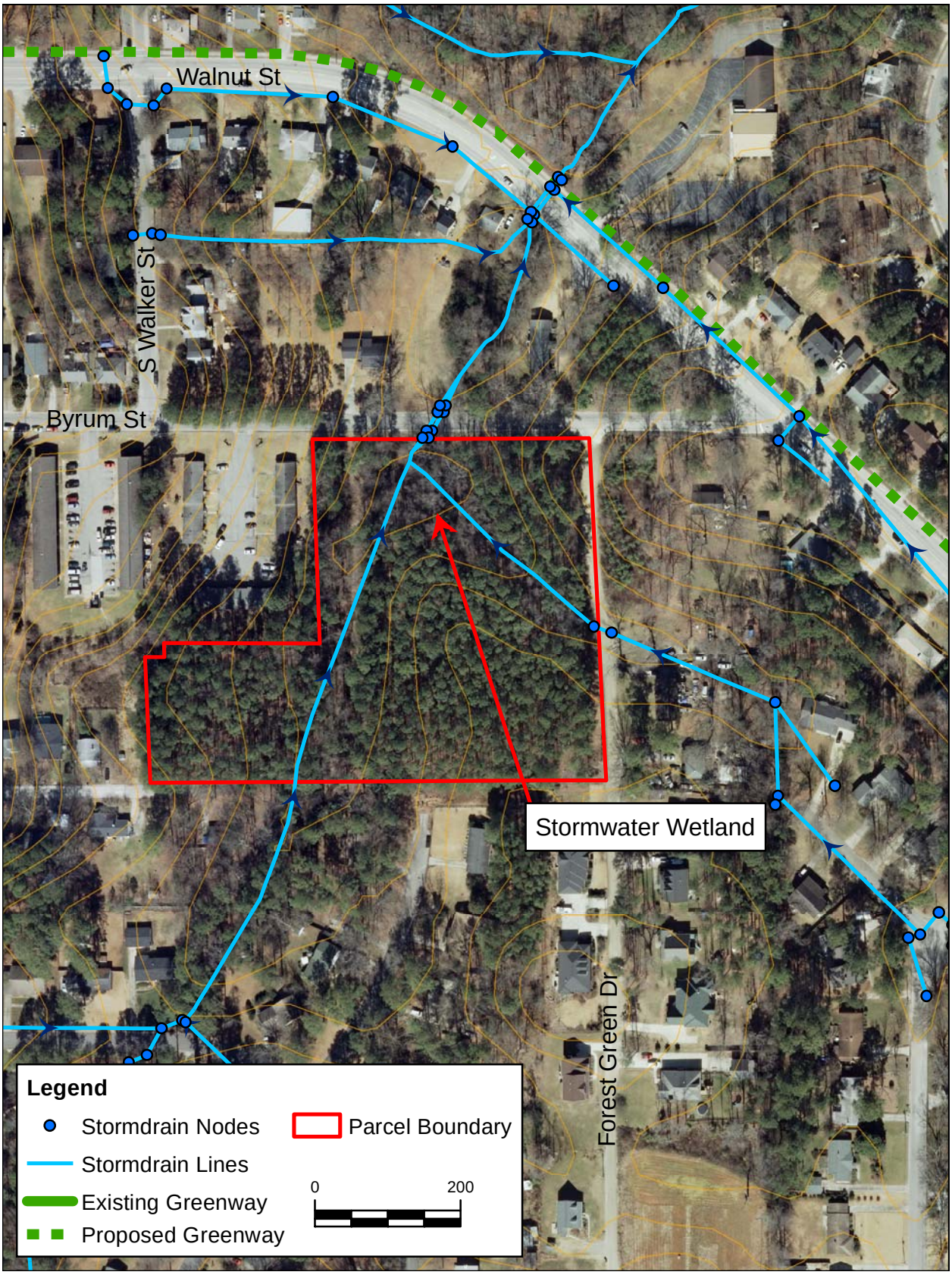
An undeveloped parcel at 218 Byrum Street presents an opportunity to provide detention in the upper portion of the Walnut Creek watershed to serve the downtown area. There are known flooding and erosion issues downstream of this area. This site is situated high up in the Walnut Creek watershed of the downtown area making it a prime location to reduce peak runoff flow through detention. If the detention were provided using a stormwater wetland, it would not only provide stormwater runoff detention which could be designed to reduce flooding and erosion downstream, but would also provide a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 40% and 40%, respectively. The area is also located near an elementary school and could provide educational opportunities for the students.

The potential challenges to using this site is that it is currently privately owned and the Town would need to acquire the property. There also appears to be a stream and potentially wetland areas that would be impacted by a BMP. If so, it would be difficult to obtain permits to impacts such feature for stormwater attenuation purposes. However, there are few such critically located undeveloped parcels that would serve the downtown area, making this a prime location for a BMP retrofit. PRCR may also be interested in the site for a potential “pocket park” location.

Byrum Street Potential Retrofit Location

This retrofit is at an ideal location to provide water quantity and quality improvements and could provide educational opportunities. Since property acquisition may pose a problem as well as possible streams and wetlands on site give this retrofit a “high” ranking for implementation.

Figure 5.19 - 218 Byrum Street



17 – Urban Park			
Description	Create bioretention area and underground detention.		
Watershed	Walnut Creek	Potential	Moderate
Benefits	▪ Nutrient reduction ▪ Peak flow attenuation	Estimated Project Cost	$250,000 - $350,000
Challenges	▪ Utility conflicts ▪ Other physical constraints		

Table 5.28 - Urban Park Retrofit Summary

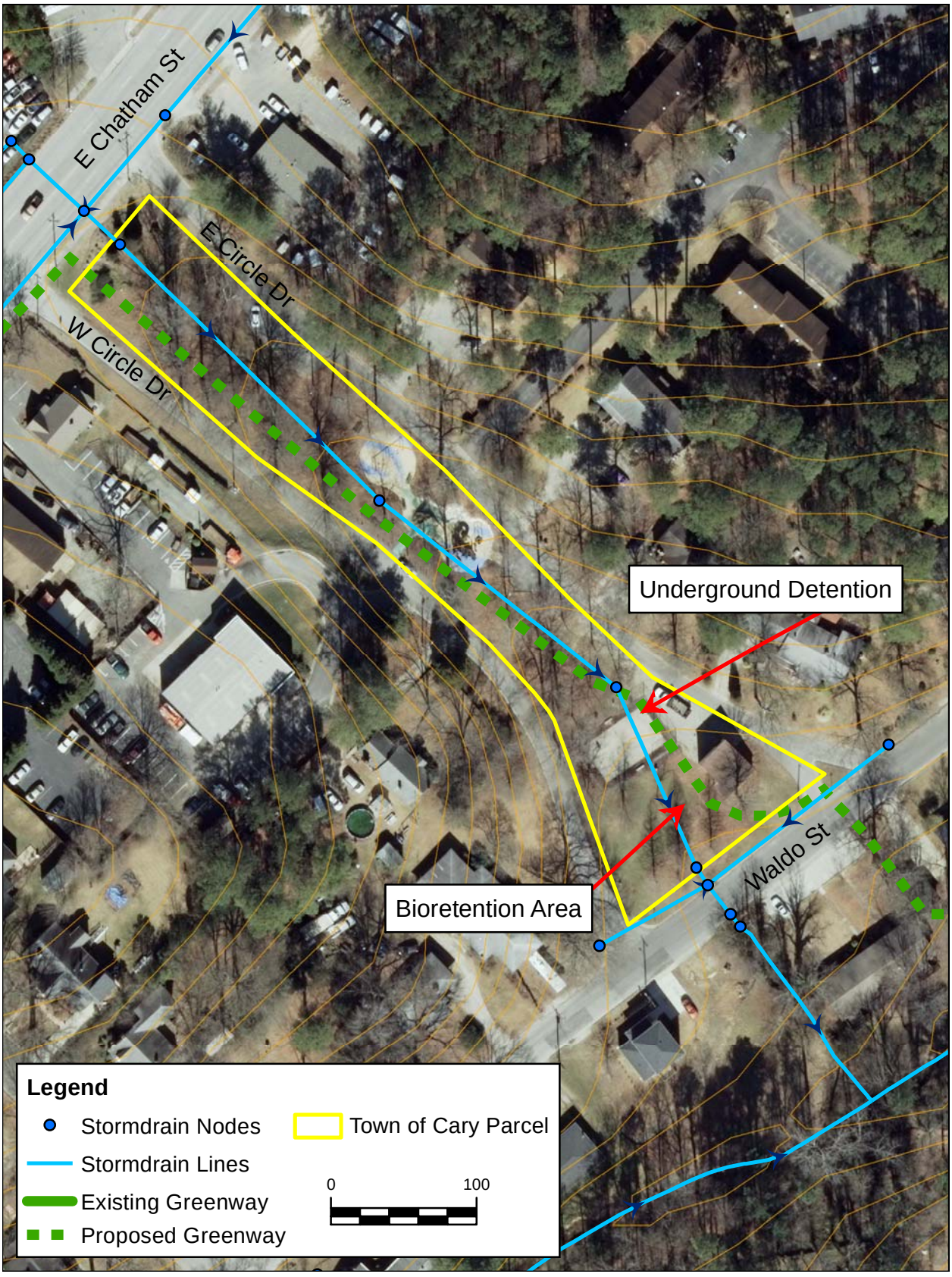
Urban Park is a linear neighborhood park located in one of the older parts of the Town of Cary. There are known flooding issues downstream of the park and the watershed above the park is planned for substantial re-development. Between the playground and the basketball courts at the park is an open area receiving sheet flow from the adjacent streets that could be converted into a bioretention area. Also, a large storm drainage pipe runs underneath the park which could provide a relatively simple means of connecting the bioretention area under-drain system to an outfall structure. Additionally, the pipe itself could also be increased in size to provide storage for peak flow attenuation. The site is significantly constrained due to existing infrastructure and there is a high potential for utility conflicts in this area.

The Town would benefit from this BMP upgrade by a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 35% and 45%, respectively. The park is also located in a sub-watershed of Walnut Creek with known downstream flooding issues increasing the benefits of providing detention to this watershed. The bioretention area could be partially funded as part of the development of the park through a partnership with PRCR and the Town Engineering Services/Stormwater Division. A CWMTF grant could also be pursued as a secondary funding opportunity.

Urban Park looking down-gradient toward BMP retrofit sites

This potential bioretention area is at a critical location between proposed development and downstream flooding to provide relief for both water quality and quantity. Challenges with this site including utility conflicts and size constraints, however, place this retrofit to a “moderate” potential ranking.

Figure 5.20 - Urban Park



18 – Sears Farm Road Park			
Description	Convert existing dry detention basin to bioretention area.		
Watershed	White Oak Creek	Potential	Moderate
Benefits	▪ Nutrient reduction	Estimated Project Cost	$35,000-$45,000
Challenges	▪ Increased maintenance		

Table 5.29 - Sears Farm Road Park Retrofit Summary

A significant portion of the Sears Farm Road Park drains to an existing dry detention basin which discharges to a level spreader. The dry detention basin is well situated to be upgraded to a bioretention area that would provide additional nutrient reduction for a relatively low cost since there is already a basin and outlet structure in place. The bioretention area could be funded through a partnership between PRCR and the Town Engineering Services/Stormwater. The retrofit would also have dual-usage benefits, as the BMP could be counted as a retrofit under the Town's NPDES Phase II Stormwater Permit and function to improve the aesthetics of the park.

The Town would benefit from a reduction in total suspended solids, nitrogen, and phosphorous loading of approximately 85%, 35% and 45%, respectively. This basin is also located at the top of the White Oak Creek watershed increasing the benefits of its water quality improvement potential. Bioretention areas require more maintenance than dry detention basins and would pose an increased annual operating cost to the Town.

The current structure could easily be converted to a bioretention area to provide more water quality benefits and would increase the aesthetics of the park. The increased cost of maintenance and low priority of the White Oak Creek watershed for retrofit opportunities give the Sears Farm Road Park an implementation potential of "moderate."

Existing dry detention pond

Figure 5.21– Sears Farm Road Park

19 – White Oak Creek Greenway			
Description	Stream and wetland restoration.		
Watershed	White Oak Creek	Potential	Low
Benefits	▪ Enhanced nutrient cycling ▪ Reduced erosion and sedimentation	Estimated Project Cost	$800,000 - $2,000,000
Challenges	▪ Site accessibility ▪ Benefits		

Table 5.30 - White Oak Creek Greenway Retrofit Summary

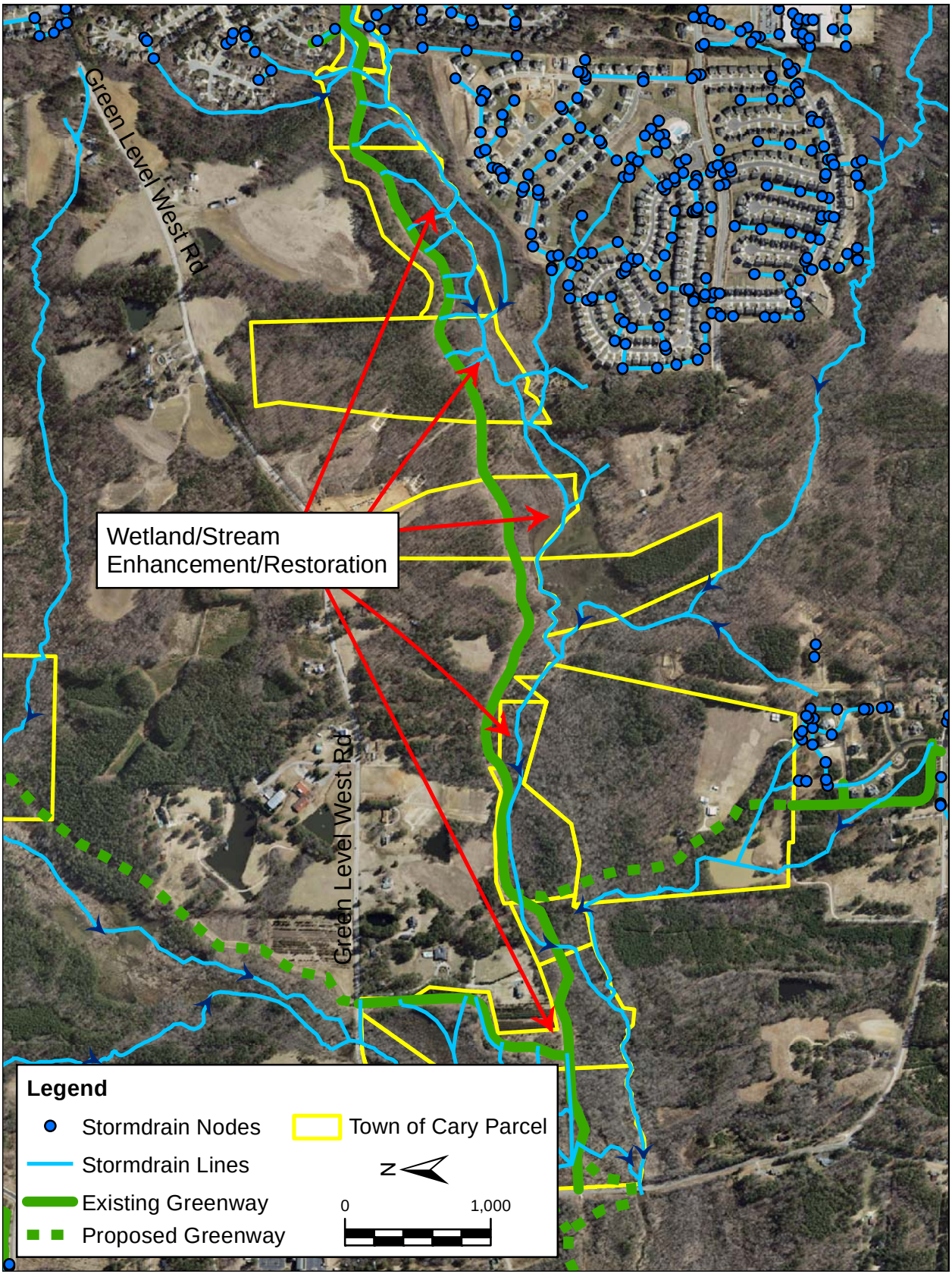
There is opportunity to restore or enhance streams and wetlands along this corridor. Natural streams and wetlands are able to provide nutrient cycling and pollutant removal as well as flood storage and attenuation. Since the corridor is already wooded and contains significant wetlands, this opportunity may not make it a high priority for restoration compared to more degraded systems such as Black Creek, Walnut Creek, or some reaches of Swift Creek and its tributaries.

The benefits to the Town are less obvious in this situation as the improvements realized from stabilizing the stream and enhancing the wetlands may be somewhat incremental based on the existing conditions. Accessibility to the site would not be possible without significant impacts to the surrounding forest and permitting efforts for a project of this size would be significant. The proposed stormwater improvements could be partially funded by pursuing a CWMTF, DWR, or a 319 grant through a partnership with the PRCR and the Town Engineering Services/Stormwater Division.

This restoration location would provide water quality and quantity benefits, but they are of a lower priority than other areas because the site is located in the White Oak Creek watershed. Permitting and site accessibility present significant challenges to this project as well. This combination of characteristics gives this retrofit a “low” potential for implementation.

Eroded stream bank by White Oak Creek Greenway

Figure 5.22 - White Oak Greenway



D. Flood Mitigation

Flooding issues related to buildings and property were identified and evaluated in Chapter 3. This section discusses potential flood mitigation improvement options and recommendations.

Flood Mitigation Improvement Options Overview

There are a number of improvement alternatives that can be used to mitigate flooding and risk in flood prone areas, however, they can typically be categorized in two general groups: improvements that reduce or remove the hazard, and improvements that reduce or mitigate the risk.

Improvements in each group can be further sub-divided into "structural" or "non-structural" improvements. Structural improvements involve construction or modification of a physical feature (e.g. pipe, channel, pond, etc.). Non-structural improvements tend to be changes to operational procedures, policies, or human practices (e.g. zoning changes to implement maximum percent impervious for developments).

In the context of this section, the hazard is flooding - waters that come out of channel banks and/or pipe systems during large storm events. The risk is the damage and loss of function to buildings, property, and roadways as a result of this flooding. Thus, improvements in the first category (i.e. reduce or mitigate hazard) would involve some measure to reduce the amount of flooding such that it diminishes or removes the hazard for the items at risk. General improvement options to reduce or remove flood hazard include structural measures such as but not limited to:

- Infrastructure improvements (e.g. upsizing pipe systems)
- Channel improvements (e.g. flood benches, channel modifications, etc.)
- Detention (e.g. detention ponds)

Non-structural measures related to new or re-development restrictions could be implemented as well to prevent problems from worsening in the future; however, they may not significantly reduce existing problems.
General improvement options associated with the second category (i.e. reduce or mitigate risk) include structural measures such as but not limited to:

- Property demolition, acquisition, or relocation
- Structure elevation
- Flood proofing
- Construction of flood barriers

Non-structural measures such as development regulation, public education, flood insurance, and flood warning systems are options that also may be implemented to either reduce the risk or lesson the impacts. For example, educating citizens that are in the floodplain of flood risks or providing automated alerts based

on predictive models may encourage citizens to reduce potential damage to their property by permanently locating or moving items of value during storm events to higher locations on their property. The table below summarizes general flood mitigation options.

Table 5.32 - Flood Mitigation Options Summary

Mitigation Option	Description	Applications	Pros / Cons
Property Acquisition / Relocation	Purchase of property and demolition or relocation of structure. Purchased property is generally returned to open space.	• Applicable to structures/property. • Especially applicable if property experiences severe flooding or is in a floodway, where other improvements may not be feasible.	• Considered "safest" alternative • Removes subject structure(s) at risk. • Can be grouped together to create public open spaces/amenities. • Can be more costly depending on land values.
Structure Elevation	Elevate structure and utilities above flood elevation.	• Typically accomplished using fill, columns, piles, or extending foundation walls. • Most appropriate for smaller, single-story, non slab-on-grade structure (e.g. residences) in areas outside of floodway (or high velocity zone).	Even though structure can be protected, need to consider lack of ingress/egress if structure is surrounded by floodplain.
Flood Barriers	Construction of berm, levee, flood wall, or other physical barrier between flooding source and structure.	• Can be used for protecting individual properties or groups of properties. • Most applicable in areas outside floodway with relative low flood depths where barrier can be "tied-into" higher ground without surrounding properties.	• May reduce natural flow and storage of flood waters which can create adverse flooding and environmental impacts (e.g. higher flood elevations, velocities, etc.). • May also have more complex design and regulatory requirements.

Flood Proofing	Improvements to a structure to make it "watertight".	• Typically involves installation of flood doors/shields, waterproof coatings, and utility valves to keep flood water from entering structure up to a given elevation. • Most appropriate for non-inhabited masonry or concrete in areas outside of floodway (or high velocity zone) with flood depths less than 3 ft.	• Can be cost-effective • Typically requires human interaction to install flood doors/shields once flooding is imminent • Response plan with defined roles/responsibilities is required.
Infrastructure Improvements	Modification to infrastructure (e.g. culverts, roadways, streams, etc.) to increase capacity in order to lower flood levels.	Most appropriate in areas where existing infrastructure is undersized and is causing flood water to "back up". Can also entail stream modifications (e.g. floodplain benching, relocation, etc.).	Can be very cost-effective and implementable in certain areas where upsizing of a culvert or bridge has beneficial impact to many upstream structures and improvements are within existing right-of-way.
Detention	Installation of detention ponds or similar structure to reduce flood elevations. Flood waters are held and released at a slower rate over a longer period of time.	Most applicable on small to mid-sized drainage areas (i.e. < 5 sq. mi.) where land is available and topography forms a natural pond type area.	• Can have beneficial impacts on flood flows / elevations • Often requires a significant amount of land. • May have more complex design and regulatory requirements.
Public Outreach	Education of citizens to increase awareness of flood hazards and risks. Provide steps they can take to reduce the risk and impact of a flood event: (e.g. purchase flood insurance, install audible warning system, stay out of areas during floods, etc.)	Applicable in all situations.	Educating citizens can be a very cost-effective technique and improve public safety.
Regulatory / Policy Controls	Implementation of regulations (e.g. zoning, development regulations, etc.) or policies that help reduce risk.	Most often reduces future flood risk by preventing actions that would be subject to risk.	Often require extensive stakeholder involvement and political motivation to be enacted.

Flood Improvement Alternative Approach

The evaluation and ultimate selection of a flood improvement alternative for a given problem area is dependent on a number of technical and logistical considerations that are often specific to that area. Examples of considerations include:

- type and scale of flooding
- magnitude and frequency of flooding
- costs and anticipated benefits of an improvement
- constructability (physical, regulatory, and political).

The type and scale of flooding relate to the cause and severity of flooding. In general, the type of flooding can be divided into two categories:

1) Flooding from larger-scale sources
2) Localized flooding

In areas that are subject to larger-scale flooding, such as areas within FEMA mapped floodplains, there is a significant upstream drainage area that contributes the majority of flood flow. Thus, improvements that are typically most effective in these situations are those that reduce flooding by improving the hydraulic efficiency and capacity of the major drainage system (e.g. culvert improvements) or that directly reduce or mitigate the risk (e.g. property acquisition). Areas that are subject to localized flooding often have more direct influence on the amount of flooding, thus, modifications to the infrastructure of minor drainage systems (inlets, pipes, etc.), detention ponds, diversions, and similar techniques are often most effective for reducing flooding. Considerations on the applicability of specific common mitigation improvement alternatives are provided in the previous table.

The ideal improvement alternative is one that provides the maximum hazard and risk reduction for the most properties, is limited to a minimum number of properties and constraints (e.g. public parcels that are undeveloped or lightly developed), has fewer regulatory challenges (i.e. wetlands, floodplains, etc.), is cost-effective, and provides secondary benefits (e.g. water quality benefits, aesthetics, etc.).

Building and Property Hot Spot Improvements Evaluation

Potential flood improvement alternatives were evaluated for hot spots identified in the previous section using the general logic as presented above. The improvement evaluation was conducted at a very conceptual level, based on general information that could be gleaned from the floodplain mapping and other data sources mentioned above. No calculations, detailed analyses, or field data collection were performed. Thus, specific potential project costs were not developed. However, it is noted that costs presented in Sections 6A for maintenance and in Section 5B for infrastructure improvements would likely completely or partially cover potential costs for projects listed below, as maintenance related activities and replacement of undersized infrastructure is a significant cause in building and property flooding. In addition, planning-level unit costs for many flood mitigation improvement alternatives can be found in FEMA

documents P-312 (2009), Publication 259 (2001), and Publication 102 (1986) as cited in the References section of this report.

Table 5.33 - Potential Mitigation Improvement Alternatives for Building and Property Hot Spots

ID	Location Description	Flood Category	Potential Alternatives	Notes
1	Swift Creek U/S of Holly Springs Rd.	Larger Scale	Spillway / Outlet improvements on Lochmere dam; Culvert upsizing at Holly Springs Rd.	NCDOT maintained roadway.
2	Swift Creek at Kildaire Farm Rd.	Larger Scale	Property acquisition; Infrastructure Improvements; Flood barrier	Large number of affected houses; Likely involve combination of listed improvement alternatives
3	Brittany Pl. and Versailles Dr.	Localized	Flood Barrier; Channel Improvements; Elevation	City offered cost-share (Policy 35) support for a floodwall, however, rejected by home owner association.
4	Jodhpur Dr. in Parkway Homeowners Neighborhood	Localized	Channel Improvements and/or Maintenance	There is a current Policy 146 project underway in this area.
5	Swift Creek Tributary #7 near Lake Pine Dr.	Larger Scale	Property Acquisition; Detention	Possible detention pond on land owned by the Town just U/S of SW Maynard Rd.
6	Walnut Creek near SE Maynard Rd.	Larger Scale	Property Acquisition; Elevation; Flood barrier	If not acquired, likely involve combination of multiple improvement types
7	Swift Creek Tributary #7 near South Dixon Av.	Larger Scale	Infrastructure Improvements	Located in 2006 TCAP study area - alternatives discussed in report
8	Pamlico Dr. and Dorset Dr.	Larger Scale	Infrastructure Improvements	Located in 2006 TCAP study area - alternatives discussed in report
9	Urban Dr. and Webster St.	Larger Scale	Infrastructure Improvements; Elevation; Flood Barrier	Located in 2006 TCAP study area - alternatives discussed in report

Overview of Current Flood Mitigation Policies

The Town of Cary maintains a progressive flood mitigation program with several ordinances / policies that go above and beyond the minimum FEMA and typical municipality / state requirements. The table below lists out a few of the more prevalent examples of the Town's progressive flood mitigation policies / initiatives.

Table 5.34 - Progressive Flood Mitigation Policies

Town of Cary Standard	Typical Minimum Regulations
Full flood study to establish 100-yr flood elevations and flooding limits required for any development with a drainage area 50 acres or greater	No flood study or regulation required for development outside of a FEMA mapped floodplain. Typical FEMA floodplain stops at one (1) square mile (640 acres) drainage.
Flood study analysis conducted using Future Conditions hydrology	Flood study analysis conducted using Existing Conditions hydrology
No development allowed within either the Existing or Future conditions Floodway or Flood Fringe with limited exceptions (e.g. Roads, greenways, public utilities, etc.)	Development allowed within "Floodway" with engineering study verifying no-impact to flood elevations
	Development allowed within "Flood Fringe" without any analysis of impacts
2 foot freeboard required above Base Flood Elevation (i.e. Lowest floor of a structure must be minimum of 2 feet above the Base Flood Elevation)	No freeboard required above Base Flood Elevation (i.e. Lowest floor of a structure must only be at or above the Base Flood Elevation)
New or improved roadway crossings located within FEMA floodplain shall provide 100-yr Level of Service	Roadway crossing Level of Service dependent on type of roadway (e.g. highway, secondary, etc.) but typically 25-yr or less

In addition, the Town has an active public outreach program and maintains a website that provides current floodplain data and links to relevant State and Federal resources. As noted earlier, much of the flood risk in a community is located upstream of the mapped FEMA floodplains (which typically stop at a drainage area of one (1) square mile). Therefore, in addition to requiring flood studies for developments with a drainage area of 50 acres or more, the Town of Cary has taking the initiative to fund flood studies and establish flood elevations upstream of the FEMA limits in and around the TCAP area where development tends to be concentrated and risk from flooding is greater.

In addition to the policies and initiatives mentioned above, the Town is continually improving its stormwater infrastructure through Capital Improvement Projects (CIP). In addition to maintaining the stormwater infrastructure throughout the Town, these projects often have the added benefit of flood mitigation through reduced flood elevations. As flood mitigation projects are identified throughout a fiscal year, they are placed on a "to-do" list and addressed with funds from current appropriations.

General Flood Mitigation Observations and Recommendations

In addition to the more specific flood mitigation improvements discussed above, the following general opportunities and recommendations are offered:

Table 5.35 - Flood Mitigation Observations and Recommendations

Observation	Recommendation / Opportunity
The Town already has progressive floodplain-related regulations (e.g. limit development in floodplain, regulate to future conditions, etc.) to help reduce future flood risks, however, significant current flood risks still exist.	Leverage alternative funding (discussed in Section 6D) to pursue property acquisitions and other mitigation improvements for floodprone buildings and properties.
The Town has an active web page dedicated to floodplains with links to various Federal and State resources.	Expand web presence and other public outreach materials to educate citizens on graduated risk (rather than “in” / “out”), specific hazards during flooding, and opportunity for all to buy insurance.
As indicated by drainage complaints and risk assessment results of the 2006 TCAP study area, a significant amount of flood risk is undetermined and undocumented upstream of FEMA floodplain mapping	Conduct additional studies similar to the 2006 TCAP study to analyze and map flood hazards upstream of existing FEMA boundaries.
The finished floor and adjacent ground elevation information for buildings are key data elements to assessing the flood risk at buildings. This study demonstrated that there is new technology that allows this information to be collected quickly, accurately, and in a cost-effective manner.	Utilize mobile LiDAR or similar technologies to obtain flood and ground elevations at buildings close to flood sources.

E. Stormwater Enhancement Opportunities

Known Infrastructure Issues

One priority when considering the existing and future stormwater needs of the Town is, by nature, the known stormwater infrastructure issues. Chapter 3 of this master plan identified known and potential infrastructure issues based on condition, function, and level of service by analyzing the Town's GIS stormwater infrastructure database, the stormwater complaints database, the maintenance calls database provided by PWUT, as well as previous studies such as the TCAP study. Overall, infrastructure not providing an adequate level of service at road crossings was identified as a key issue, as less than half of all roadway crossings currently meet level of service standards. In addition, there are approximately forty (40) locations that were identified as having capacity, function, or some of insufficiency not related to level of service. A plan to address these issues would be a first step to provide improved performance to the Town's stormwater facilities. Infrastructure improvement options are described in Section B of this Chapter.

Aging Stormwater Infrastructure in TCAP

A priority for the existing and future stormwater needs is the aging stormwater infrastructure, the oldest of which exists within the TCAP area. As part of the conveyance inventories conducted by Dewberry and Withers & Ravenel, 72 pipes were identified as being in 'Poor' condition. The total length represented by the 72 pipes is 5,342 linear feet. There are also 930 pipes in 'Fair' condition. Not all of the 'Fair' condition pipes will need to be replaced; however, the ones in the oldest ranges (50 to 100 years) are more likely to need replacement in the future. It should be noted that some of the known stormwater issues discussed above are the same ones identified by Dewberry and Withers & Ravenel. Replacing stormwater infrastructure that has exceeded its service life and is no longer functioning properly should be a top priority for the Town.

Peak Magnification on Receiving Streams

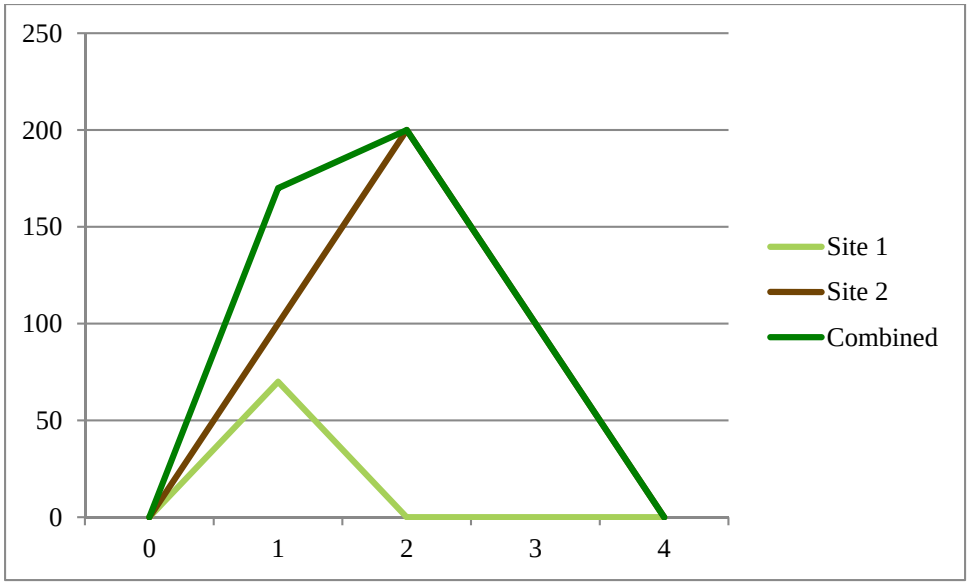
As the industry moves forward with the science of BMP design and implementation, the issue of managing runoff volume becomes more and more relevant. Retention of the up to 95% of the first inch of runoff is desired by many municipalities throughout the country and supported by the EPA in its rulemaking. In addition, many municipalities employ detention requirements for storm events as high as the 25-year event. Currently, the Town of Cary requires no net increase in runoff from the pre-development condition for the 1-year design storm and requires evaluation of detention for the 2, 5, and 10-year events.

While the implementation of BMP's to reach these requirements provide many water quality and quantity benefits, there is a potential negative impact from employing methods that modify the hydrograph post development, even if the peak is reduced or held the same. This is the issue of compounding peak hydrographs or peak magnification. To explain this, an example situation is provided using a triangular hydrograph for ease of understanding:

- A 10 acre site with an existing 10-year peak discharge of 70 cfs and a time to peak of 1 hour and duration of 2 hours flows into a receiving watershed of 30 acres with a discharge of 200 cfs and a time

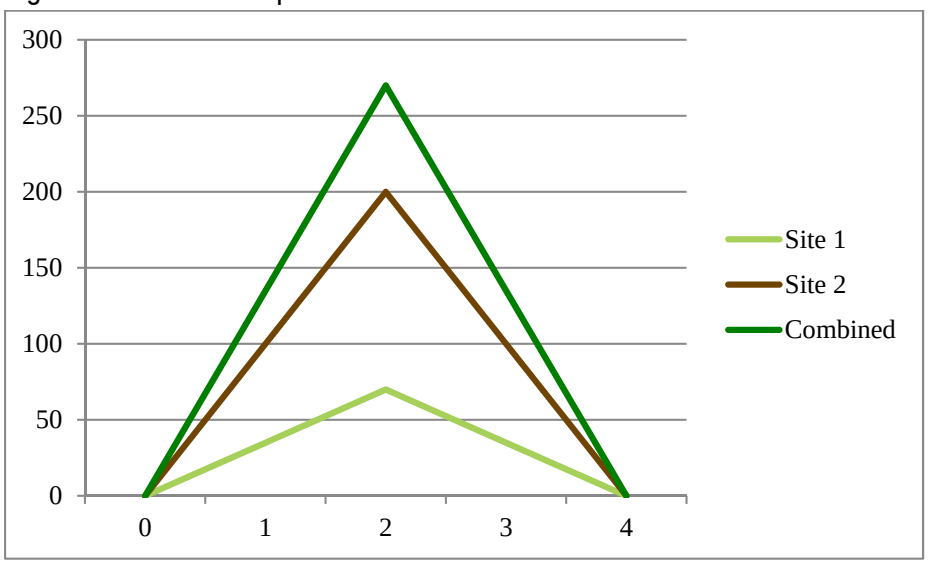
to peak of 2 hours on a 4 hour duration. In the existing condition for the 10-year event, the 10 acre site will peak an hour before the 30 acre site and the combined hydrograph will only have a combined peak of 200 cfs at the 2 hour mark.

Figure 5.23 - Pre-Development Condition



- In the post development condition, a detention BMP has been employed that maintains the pre-development discharge of 70 cfs, but does this by extending the hydrograph and the time to peak by 1 hour. Now, at the 2 hour mark the combined peak increases to 270 cfs for the 10-year event. So even though design requirements are met for the site, the receiving stream has now received a negative impact of a 35% increase in peak runoff.

Figure 5.24 Post Development Condition



It is recognized that the Town of Cary does require a Downstream Impact Analysis for sites that generate post development discharges greater than 10% of the pre-development discharges for the 2, 5, and 10-year events. This analysis does require identification of a point downstream where the impact becomes less than 10% and an analysis of what impact the increased discharge will have between the two locations. Mitigation of that impact is required. This analysis will not necessarily catch or address the above stated condition on compounding peaks.

Under the Cary LDO, the above scenario would actually meet the pre-equals-post criteria and no further analysis would have been required although downstream impacts on the receiving stream would have occurred. One solution to deal with this is that adopted by the City of Raleigh. Their design guide requires the following:

> "The "ten percent rule" may be used to determine the downstream extent of design considerations for new detention. This rule recognizes that in addition to controlling the peak discharge from the outlet works, storage facilities change the timing of the entire outflow hydrograph.
>
> Where required, channel routing calculations must proceed downstream to a confluence point where the drainage area being analyzed represents ten percent or less of the total drainage area. At this point, the effect of the hydrograph routed through the proposed storage facility on the downstream hydrograph is assessed and shown not to have detrimental effects on downstream hydrographs. If detrimental impacts are suspected, then backwater calculations and determination of flood elevations for the areas impacted by increased flows, if any, must be prepared."

We recommend the Town of Cary further investigate this issue and consider amending the LDO Section 7.3.3 under the Downstream Impact Analysis with language and requirements similar to the City of Raleigh example. The mitigation requirements the Town has set forth for the Downstream Impact Analysis should be sufficient to cover this situation.

Consider Establishment of a Town-wide Stormwater System Infrastructure Inspection/Monitoring Program

The SWMP is currently only highlighting issues for the infrastructure that fall within the Town ROW. There are approximately 1,275,316 linear feet of pipe outside the Town ROW. Since it may not be feasible for the Town to expand its LOS to cover these systems, we recommend the Town consider at a minimum an inspection/monitoring program to evaluate these systems and notify the owners of any issues and their responsibility towards maintenance. As shown below the City of Seattle implements a program of this type that could be considered by the Town:

- "The City of Seattle regularly inspects all privately owned stormwater detention, treatment, and conveyance systems in the city. Under the Seattle Municipal Code (Chapter 22.800), owners of private drainage systems are responsible for maintaining the systems to ensure that they continue to function over the long term.

- Property owners are notified with a letter in advance of the inspection and are welcome to accompany the inspector. The facility is inspected for high sediment levels, missing or broken components, and drainage issues. Within two weeks of the inspection, a letter is sent to the property owner with a report detailing any problems and explaining how the facility needs to be maintained or repaired. The city also provides a list of drainage contractors and information on best management practices (BMPs) for stormwater drainage systems. In addition, the city provides checklists for how to inspect and maintain many different types of facilities on its Web site.

- Site re-inspections occur 60 days after the follow-up letter and report. If compliance is not achieved during that time, a Notice of Violation, which may result in a $300 fine for each day the violation continues, may be issued. The city also coordinates with the property owner to inspect after a drainage contractor has completed any work and before the contractor has been paid to ensure that the job was performed adequately."

The format for how to do this would be to emulate the Towns' successful BMP Inspection Program or expand that program to include inspections of the stormwater systems as a whole. Obviously, working with PWUT would be necessary as this type of inspection falls within their core capabilities.

Compliance with the NPDES Phase II Stormwater Permit

The Town is required by NCDWQ and the USEPA to comply with all the provisions of its NPDES Phase II Stormwater Permit. The Town is currently meeting all of its Permit requirements and already has the mechanisms, ordinances and procedures in place to continue to meet the current requirements, but the requirements are expected to increase. As such, it is important for the Town to manage the anticipated changes by coordinating closely with NCDWQ and the USEPA. Addressing the current and anticipated future requirements of the Permit is a high priority for the Town's stormwater program (See Sections 2B and 5A).

Compliance with TMDLs and Category 4bs

Currently, there are three TMDLs that affect the Town: the Jordan Lake TMDL, the Neuse Estuary TMDL, and the Swift and Williams Creek TMDL. A result of the Jordan Lake TMDL is the Jordan Lake Rules which affect all of the municipalities that drain to the Haw River and Jordan Lake. The Neuse Estuary TMDL affects most municipalities that drain to the Neuse River. The Swift and Williams Creeks TMDL (a sub-basin of the Neuse) affects a number of municipalities in Wake County, but primarily affects the Town of Cary. Because the Swift Creek TMDL primarily affects the Town, most of the burden of complying with that TMDL falls on the Town and the Town could be held accountable if the compliance is not achieved.

Recently, NCDWQ is leaning towards a "voluntary" means of addressing impaired waters called "Category 4b" waters. The concept is to avoid a full-scale TMDL by enacting a WQRP-type plan to resolve the impairment issues. However, on a practical scale, implementing such a plan could result in a similar burden that a full-scale TMDL would impose. Additionally, the USEPA has been trending towards assimilating TMDL and Category 4b requirements into the NPDES Phase II Permits. These methods of implementing TMDL-type requirements could result in higher regulatory burdens on the Town. However, the Town's

partnership with the BCWA to address water quality issues in Black Creek may be a model for alternative means of addressing water quality in the watersheds of impaired streams. Because of development of the BCWA Plan to improve water quality in Black Creek, DWQ has indicated that that stream now has a very low priority for the development of a TMDL or Category 4b WQRP-type plan. Using the BCWA as a model, the Town could encourage the development of similar associations and partner with them to develop plans for impaired watersheds listed on DWQ's 303(d) list. The Town could prioritize listed streams that DWQ or the USEPA consider to be a high priority for the development of a TMDL or Category 4b-type plan. This would keep the Town on the forefront of establishing creative, proactive means of addressing water quality, as well as delay (possibly indefinitely) the need for DWQ or the USEPA to establish formal requirements for such watersheds. The BCWA and BCWA Plan are discussed in detail in Sections 2B and 4F.

Downtown Redevelopment Flexibility

The Town of Cary intends to redevelop the downtown center. Since the Town center is at the top of several watersheds, including Swift Creek, Walnut Creek, and Crabtree Creek, it is located in a critical area in regards to water quality and flooding. From a stormwater perspective, redevelopment of the downtown will present water quality and water quantity challenges due to increased amounts of impervious cover. There are known flooding issues downstream of downtown (See Chapter 3D) and all of the downstream areas have streams that are listed on NCDWQ's 303(d) list for impaired water quality. There are also a number of State requirements that mandate certain water quality and quantity goals as well as a limit on impervious cover. In order for the Town to meet its development goals and address stormwater needs and requirements, an innovative approach to stormwater may be required.

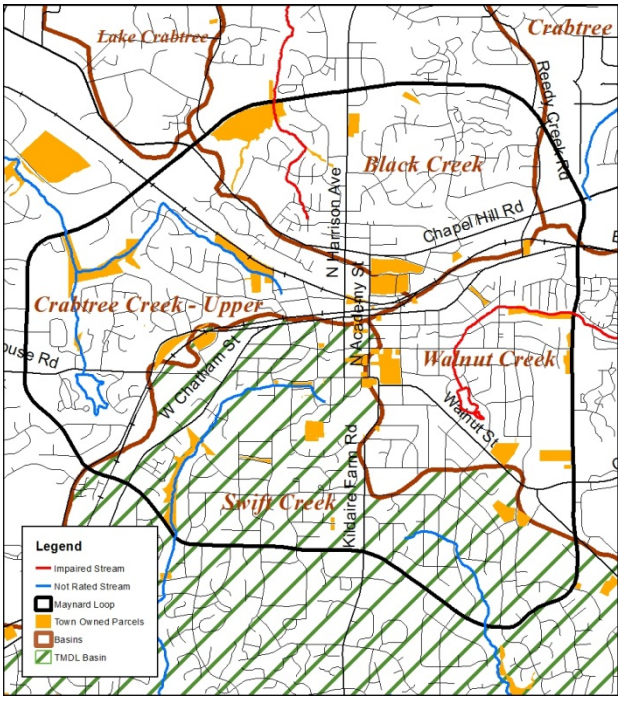


Figure 5.25 - Maynard Loop

The Town of Cary Town Center Area Stormwater Management Plan Final Report (March 2005) study suggests the best way to address stormwater needs and requirements in the TCAP area is on a site-by-site basis. Under current NCDWQ requirements, this may be the only viable alternative; however, for this specific situation, it is possible to approach NCDWQ and the Environmental Management Commission (EMC) to request a change in the Towns LDO that would provide the Town with flexibility to implement its downtown center plan while still meeting State requirements. This flexibility could be achieved by implementing the following:

- Develop a program to provide density transfers in the Swift Creek watershed which has development density limits. A density transfer program would involve setting aside undeveloped areas in the upper portions of the Swift Creek watershed that could be used to compensate for higher density

development in the downtown area. Recent legislation (SL 2012-200) allows density averaging between two non-contiguous properties in the same watershed in Water Supply Watersheds.

- Re-evaluate the downtown area based on the updated development plan to identify variety of treatment and detention opportunities in the TCAP versus simply defaulting to the "site-by-site" approach. An example is providing underground detention beneath proposed parking decks that would provide runoff volume storage in excess of what would be required for the deck by itself.
- A SWMM model could be used to develop a system-wide stormwater plan to further provide flexibility for TCAP area in regards to stormwater. The model could be used to assist in managing stormwater for the entire TCAP, eliminate peak magnification, and reduce the need for costly detention practices by looking at timing versus simple detention. Detention on a site-by-site basis has been shown to have the potential to cause peak magnification. A system that requires developers to update the effective SWMM model to show no net impact downstream, similar in manner as the requirement to obtain effective models when performing detailed hydraulic analyses, could satisfy NCDWQ's requirement for detention. Creating a comprehensive SWWM model has the added capacity to assess pollutant loading and removal as well as analyze flooding and drainage infrastructure performance in a single model. . If the unified model approach provides benefit for the TCAP area, it is also recommended that the modeling approach be expanded to all the Town watersheds on a watershed by watershed basis.
- Redevelopment policies can be as much a technical as a political/ economic decision for municipal leaders. Consider an incentives-based program for developers that would encourage them to add more progressive design elements that limit impact to the environment, such as green roofs that would exceed regulations. Between incentives and enabling developers to have a PR benefit, this may help to reduce the impact of existing impervious cover and improve the site, not just meet existing condition. A positive example for this was the decision by the local McDonald's franchisee at Saltbox Village to rebuild the McDonalds as a sustainable LEED certified structure. It was a public relations benefit to the Town and to the corporation. This type of model can be employed within the TCAP for water quality as well. The incentives do not need to increase municipality costs as they can involve:

    - Granting permission for the redeveloper to increase building height and thereby useable floor space.
    - Municipal improvements to the older roadways of the neighborhood using green infrastructure – the older roadways are likely not managed to existing stormwater standards and the improved appearance of the rights of way will provide a "sense of place" that can improve property values and promote additional redevelopment of neighboring underutilized properties.
    - Some form of payment in kind to support the design, construction or maintenance process.

As long as the Town can demonstrate that water quality is being protected in an equal or better manner than could be achieved by site-by-site BMPs then NCDWQ would likely accept the Town's approval and allow a modification to the Town's LDO. Other units of government such as Maryland and Tampa are now focused on a "regional" approach. This approach could be extended to the remainder of the Swift, Walnut, and Black Creek watersheds.

Flood Risk Awareness / Outreach and Mitigation

Much of the public's understanding of flood risk is limited to media coverage of flooded areas in large events and/or possibly regulatory floodplain maps used for development and insurance rating purposes (i.e. FEMA/NCFMP FIRMs). This perception often leads to an "in" or "out" mentality that if one is not in a mapped floodplain or other high profile flooding area, then there is no risk of flooding. In reality, every part of a watershed has some risk of flooding; therefore, flood risk should be viewed on more of a "sliding scale" of lower to higher risk based on a number of factors. Flooding can, and does, occur outside identified/mapped flood hazard areas. A high percentage of flood insurance claims and drainage requests are outside of mapped flood areas. Educating the public to increase their awareness of flood risks and enabling them with information so they can take steps/actions to either reduce the risk from flooding (e.g. building to higher standards) and/or the consequences should flooding occur (e.g. purchasing flood insurance to ease damages from flooding) is integral to a flood mitigation strategy.

It is recommended that the Town of Cary build upon the Flood Risk Assessments for the TCAP and look at other areas where this methodology can be applied and hold a Public Outreach session with impacted property owners to go over their options to reduce risk.

Future Flood Control

Chapter 3 of this master plan identified a number of existing and potential building/property and roadway flooding locations based on flood insurance claims, drainage requests, floodplain mapping, and information from previous studies. There were nearly 750 primary buildings that were identified within a mapped flood hazard area. As part of a detailed risk assessment conducted in the TCAP area, approximately 95 buildings were identified as have moderate flood risk. In addition, approximately 14 building flooding "hot spots" were identified in the Town. These problem areas present potential issues related to flood damage, public safety, and/or loss of use/function. Identifying regulatory, policy, and/or structural flood control improvements to address/reduce these issues is a goal of the overall flood mitigation strategy. The risk assessment using Mobile LiDAR technology and depth grids combined with the risk analysis methods developed by NCFMP at a reduced level provided the Town with a cost effective method to evaluate risk to property owners beyond the FEMA SFHA. This information if acted upon, will give the Town and property owners the opportunity to mitigate future flooding impact and the costs associated with recovering from an event.

Enhanced Public Awareness Program

With the ever increasing use of electronic media and the internet for communication, it would be advantageous to both citizens and staff to continually enhance and improve public awareness of the stormwater program as well as the benefits and services it provides. The objective should be to further educate the residents, businesses and city staff on protecting water quality through the reduction of stormwater pollution, including understanding where it comes from, knowing which pollutants are the biggest problems (and why), and being aware of and motivated to take specific steps to reduce or eliminate it. For properties that are in or near FEMA or Town Floodplains, outreach for flood risk awareness could also be enhanced.

One option recommended in this Stormwater Master Plan is to develop a Stormwater Communications Plan, including recommendations for specific Education and Outreach Programs and Activities that will educate existing and future residents and businesses and city staff on methods to accomplish the aforementioned objective.

This Plan can be a stand-alone Communications Plan by the Engineering Department/Stormwater Division, and referenced in the Sustainability Communications Plan (under development by Town Council's Environmental Advisory Board). It should build upon the public outreach and education efforts currently underway to support the Town of Cary's Phase II Stormwater Permit, and be reviewed by the Town's Internal Public Education Group and Environmental Advisory Board. And, the Plan should evaluate successful flood risk awareness and stormwater pollution prevention education and outreach programs across the country to recommend the most effective public education tools in use today.

At the minimum, the Plan will consider the following methods –

1. Work with the Town Sustainability Manager and the Town Council's Environmental Advisory Board to review ongoing Cary environmental campaigns to evaluate opportunities to combine outreach materials and activities to ensure no duplication of effort.

2. Review and amend/update (if needed) all other Town outreach materials to reinforce water quality protection. For example, existing solid waste management information may not specifically mention the harm done to water quality/wildlife from littering, not picking up animal waste or illegally disposing waste.

3. Design and implement targeted education campaigns (including specific materials and trained staff) for specific groups, including –

    a. Town staff (to ensure town activities and facilities don't pollute)

    b. Elementary and middle school classes

    c. Programs for civic and business groups

    d. HOA newsletters

    e. Mass mailings (via utility bills or other means)

    f. Outreach at Town events (*Earth Day*)

    g. Newspaper advertising (*The Cary News, The N&O)*

    h. HOA newsletters

    i. Instructional Videos

    j. BUD TV

4. Partner with the business and development community to promote water quality protection messages, programs and initiatives.

5. Utilize Block Leader program participants to disseminate stormwater pollution prevention information.

6. Better utilize the Town's Website as the primary environmental education vehicle.

   a. Stormwater Management Page –

      i. Should be the main portal for all Stormwater Pollution education and outreach efforts.

         1. Elevate visibility of the page (currently it is very difficult to find: only accessible via the Engineering Department main page or the overall Site Index; and, not listed on the "Alphabetical Listings of Items in Guide to Services").

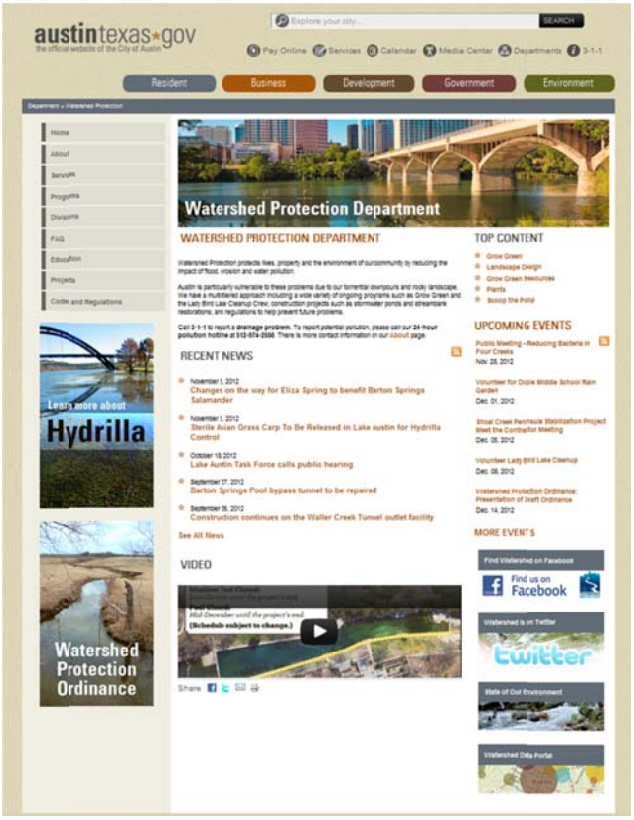


Figure 5.26 - Website Example from Austin, TX
For Additional Examples, See Appendix D

      ii. Update to better describe the Town's Stormwater Management Program (including this Master Plan) and include link to separate Stormwater Pollution Prevention page.

   b. Stormwater Pollution Prevention Page –

      i. Create new page specifically for this program.

      ii. Page should be easy to navigate and understand, with clear links to all education and outreach materials and activities.

      iii. Should be fun and interesting and interactive

      iv. Should contain links to -

         1. DWQ maps for including drainage area/watershed maps, wetland info, pollution information, etc.

         2. DWQ's Environmental Sensitivity Maps

3. Existing stormwater education websites, including EPA's Stormwater Pollution Prevention and Clean Water Education Partnership

4. DENR's NC Environmental Education resources

5. Other educational sites such as Environmental Management and Watershed Planning in NC

c. Flood Risk Awareness Page

   i. Enhance/update the current Floodplain Page to make it easier to navigate and find information related to an individual property owners risk.

   ii. Once the NC Emergency Management Division has its "iRisk" page operational, link to this to leverage the benefit of the State resources.

   iii. Consider the addition of Town floodplains that have been analyzed for risk within this master plan to educate those who are still at risk outside the FEMA floodplain.

   iv. Refine the links to FEMA pages to refer to the latest data.

   v. Link to the Town Hazard Mitigation Plan

d. Other Pages – All Cary environmental-related pages, including Sustainability, Environmental Advisory Board, Guide to Services, etc. should have links to the Stormwater Management Page.

7. Develop educational/interactive kiosks to be placed at select creeks, lakes, natural and stormwater ponds, restored wetlands, etc. within Town owned Parks and Greenways to showcase the value of natural systems in improving water quality and their harm if not protected by the public.

F. Conclusions

Based upon the findings of this chapter and this SWMP in general, it is evident that the Town of Cary has managed to meet or exceed the regulatory requirements that it adheres to, been responsive to the needs and issues of the citizenry as feasibly possible, has worked actively to identify capital projects within the budget that would improve water quantity and quality in troubled areas, looked to manage its floodplains and buffers in a progressive manner, and has laid a solid foundation for the future of the stormwater program.

The opportunities for program enhancement provided throughout this chapter are meant to build on the foundation that the Town has laid. It is recommended that stormwater staff review these opportunities and decide which ones will fit the vision for the future of the program. The next chapter will summarize the enhancement opportunities and provide economic basis for these enhancements and provide funding alternatives that could be pursued to supplement the budget cycle.