4.0 BMP Assessment

4.1 Methods

The approach to BMP evaluation in the Crooked Creek watershed included:

- A records search of existing BMP facilities
- A field survey and inventory of identified BMPs
- A field survey to identify additional BMPs
- A follow-up reconnaissance of inventoried BMPs to evaluate their potential for water quality protection
- A map and field search for potential sites for future BMPs
- An evaluation of the estimated pollutant load reduction benefits from existing and potential BMPs

4.1.1 Initial Records Search

Many development plans were available from the Gwinnett County DPU. Copies of these plans were reviewed to identify existing BMP facilities. This research served as the starting point for the BMP inventory.

4.1.2 Field Survey of Existing BMPs

A field survey was conducted to identify existing BMP facilities that were not apparent from the development plans. Topographic maps and aerial photos were reviewed for clues to identifying existing BMPs, based on topography or land use. Reconnaissance crews checked areas likely to have BMPs, such as commercial or industrial sites. Additional BMPs were identified in the course of the drainage inventory.

4.1.3 Evaluation of Existing and Potential BMPs

An evaluation of existing and potential BMPs was completed, which was designed to identify:

- Existing BMPs with significant water quality benefits
- Existing flood control BMPs with potential for water quality and/or channel protection retrofit
- Sites with suitable area and storage volume where runoff from commercial or densely developed areas could be routed for water quality treatment
- Commercial or densely developed areas with no coverage from identified BMPs
- Other BMP opportunities based on suitable site characteristics

- Flood control BMPs with little or no opportunity for water quality retrofit

4.2 Results

4.2.1 Inventory

A total of 81 existing BMPs were identified within the Crooked Creek watershed and catalogued in the inventory. The type and condition are shown in Table 8.

TABLE 8
Number of Inventory BMPs in Indicated Condition

BMP Type	Good	Fair	Poor
Wet Detention Pond	12	1	0
Dry Detention Pond	56	5	7

The BMPs identified in the Crooked Creek drainage inventory are shown in Figure 14. Basic data on each BMP was uploaded to the County GIS.

Additional existing BMPs and sites for potential future BMPs were located from stream surveys and other watershed site visits (see Figure 15). Table 9 provides basic information concerning existing BMPs that may have watershed-wide benefits. These sites were evaluated as described in the following sections to identify the BMPs to be included in the recommended CIP. Potential sites for new BMPs were also evaluated; and these are described in Section 4.2.3.2.

4.2.2 BMP Evaluation

Each BMP was screened, based on the initial data available, to identify those that may have a meaningful benefit to water quality or hydrologic control. In general, BMPs identified in "Good" condition appear to be functioning as they were originally designed. However, most facilities serve small drainage areas and thus have limited benefits on a watershed basis. In addition, the dry detention ponds provide little water quality benefit.

A follow-up field reconnaissance was conducted for those BMPs that had potential watershed-wide benefits. The goal was to determine if they provided meaningful water quality benefits, as measured by their potential for reducing loads of TSS.

There were two conditions under which existing BMPs were judged to have significant water quality benefits:

- Provide extended detention for the water quality storm (1.2 inches of rainfall), such that the runoff is released over a 24 hour period.

Or

- Provide permanent pool storage volume equal to the water quality volume, defined as the runoff from the 1.2-inch water quality storm.

TABLE 9
Characteristics of Existing BMPs[1]

BMP	Type	Drainage Area (acres)	Pool Volume (ac-ft))	Water Quality Volume (ac-ft)	Water Quality Benefit[2]	Channel Protection Benefit[3]	Detailed Evaluation	Comment
A	Existing wet pond with extended detention	62.2	12.86	1.53	Yes	Yes	No	Meets both water quality and channel protection criteria. There is no need for further evaluation.
B	Existing wet pond	196.5		8.67	Drains to AL	Drains to AL	No	Upstream of AL, see evaluation of AL.
C	Existing wet pond	4.4	0.6	0.25	Yes	No	No	Does not meet channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
D	Existing wet pond with extended detention	9		0.15	Yes	Yes	No	Meets both water quality and channel protection criteria. There is no need for further evaluation.
F	Existing wet pond	19.7	1.5	1.04	Yes	No	No	Does not meet channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
G	Dam with small pool				Drains to AL	Drains to AL	No	Upstream of AL, see evaluation of AL.
H	Dry pond	33.2	0	1.84	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
I	Existing wet pond	86.7	6.25	4.07	Yes	No	Yes	Detailed evaluation completed. See section 4.2.3.1.
J	Existing dry pond	41.3	0	1.83	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
K	New dry pond	6.5	0	0.17	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further

TABLE 9
Characteristics of Existing BMPs[1]

BMP	Type	Drainage Area (acres)	Pool Volume (ac-ft))	Water Quality Volume (ac-ft)	Water Quality Benefit[2]	Channel Protection Benefit[3]	Detailed Evaluation	Comment
								for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
L	Dry pond	9.7	0	0.39	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
M	Dry pond. Not accessible	57.4	0	1.19	No	No	No	Does not meet water quality or channel protection criteria, but there was a site and/or permitting constraint. This may be a candidate for further evaluation if the constraint can be resolved.
O	Wet pond with multi-stage riser	298.4	3.60	13.97	No	No	Yes	Detailed evaluation completed. See section 4.2.3.1.
P	Dry pond on private property	67	0	3.75	No	No	Yes	Detailed evaluation completed. See section 4.2.3.1.
Q	Small dry pond		0		No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
R	Small dry pond	5.1	0	0.27	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
S	Overgrown dry pond	64	0	2.83	No	No	No	Does not meet water quality or channel protection criteria, but there was a site and/or permitting constraint. This may be a candidate for further evaluation if the constraint can be resolved.
T	Dry pond with breached embankment.	13.8	0	0.75	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for

TABLE 9
Characteristics of Existing BMPs[1]

BMP	Type	Drainage Area (acres)	Pool Volume (ac-ft))	Water Quality Volume (ac-ft)	Water Quality Benefit[2]	Channel Protection Benefit[3]	Detailed Evaluation	Comment
								further evaluation of local benefits.
V	Small wet pond for construction site with extended detention	7	1.0	0.41	Yes	No	No	Does not meet channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
W	Dry pond		0		No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
X	Old and not maintained detention pond	9.8	0	0.49	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
Y	Dry pond	12	0	0.22	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
Z	Site for potential new BMP; but contributory to AL				No	No	No	Upstream of AL, see evaluation of AL.
AA	Small dry detention	6.9	0	0.37	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
AB	Dry pond; looks like forebay for Lake Siskey (AH).	41.7	0	2.49	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further. This would be a candidate for further evaluation.
AC	Small wet pond; overgrown. Drains to AL				Included in AL	No	No	Does not meet channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation

TABLE 9
Characteristics of Existing BMPs[1]

BMP	Type	Drainage Area (acres)	Pool Volume (ac-ft))	Water Quality Volume (ac-ft)	Water Quality Benefit[2]	Channel Protection Benefit[3]	Detailed Evaluation	Comment
								of local benefits.
AD	Old dry detention	8.6	0	0.43	No	No	No	Does not meet water quality or channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
AE	Old dry detention						No	Since this BMP treated a small watershed it was not evaluated any further. This would be a candidate for further evaluation.
AG	No potential at this site	23.9		1.05			No	Since this BMP treated a small watershed it was not evaluated any further. This would be a candidate for further evaluation.
AH	Wet pond	204.9	10.20	6.58	Yes	No	Yes	Detailed evaluation completed. See section 4.2.3.1.
AI	Existing Pond	85	24.8	5.78	Yes	No	Yes	Detailed evaluation completed. See section 4.2.3.1.
AJ	Existing Pond	89	69	1.68	Yes	No	No	Does not meet channel protection criteria, but there was a site and/or permitting constraint. This may be a candidate for further evaluation if the constraint can be resolved.
AK	Existing Pond	78	40.24	2.83	Yes	No	No	Does not meet channel protection criteria, but there was a site and/or permitting constraint. This may be a candidate for further evaluation if the constraint can be resolved.
AL	Existing Pond	414	41	20.26	Yes	No	Yes	Detailed evaluation completed. See section 4.2.3.1.
AM	Existing Pond	52	6.75	2.13	Yes	No	No	Does not meet channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits. A relatively small reach of stream would be protected because of the proximity of the BMP to the main channel.
AN	Existing Pond	28	8	1.148	Yes	No	No	Does not meet channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation

TABLE 9
Characteristics of Existing BMPs[1]

BMP	Type	Drainage Area (acres)	Pool Volume (ac-ft))	Water Quality Volume (ac-ft)	Water Quality Benefit[2]	Channel Protection Benefit[3]	Detailed Evaluation	Comment
								of local benefits.
AO	Existing Pond	40	8.5	2.00	Yes	No	Yes	Detailed evaluation completed. See section 4.2.3.1.
AP	Existing Pond	65	6	3.25	Yes	No	Yes	Detailed evaluation completed. See section 4.2.3.1.
AQ	Existing Pond	65	4.8	3.25	Yes	No	No	Does not meet channel protection criteria, but since it was a small watershed it was not evaluated any further for watershed-wide benefits. This would be a candidate for further evaluation of local benefits.
AR	Existing Pond	155	5.1	6.36	No	No	No	Does not meet water quality or channel protection criteria, but there was a site and/or permitting constraint. This may be a candidate for further evaluation if the constraint can be resolved.

Notes:
1 Based on existing conditions of BMPs
2 Column denotes if a BMP meets water quality protection criteria described in Section 4.2.2.
3 Column denotes if a BMP meets the channel protection criteria described in Section 4.2.2.

In addition, BMPs were screened to determine if they provided protection against downstream channel erosion. The criterion for the channel protection follows Gwinnett County guidelines of 24-hour detention of the 1-year storm (3.36 inches of precipitation). If a BMP provided such extended detention, it was considered to provide channel protection against scour and erosion due to runoff from its contributory area. This protection was assumed to cover stream channels to a point downstream where the drainage area was equal to five times the area contributory to the BMP.

In general, existing BMPs identified in the BMP inventory have limited impact on watershed pollutant loads. While some may be quite effective on a small scale, the gross drainage area controlled by the BMPs is minimal compared to the Crooked Creek watershed as a whole. Greater geographic coverage by small-scale BMPs or larger scale facilities will be needed to meet Gwinnett County's goal for TSS load reduction from the Crooked Creek watershed.

4.2.3 Existing, Retrofit, and Potential New BMPs

4.2.3.1 Screening of Existing Facilities

Inventoried BMPs with potential for significant water quality benefits and existing lakes and ponds were evaluated for water quality and channel protection benefits. Table 9 lists the characteristics of BMPs that were evaluated. The column entitled "Water Quality Benefit" indicates if the BMP meets one of the criteria for the water quality storm control under existing conditions. Pollutant load reductions associated with existing facilities were included in the existing conditions model; therefore, no further TSS reduction benefits can be allocated to these facilities.

Table 9 (Comment column) also lists existing BMPs with potential for retrofit to meet water quality control at existing sites that do not currently qualify, or to increase TSS reduction benefits through control of the channel protection storm. Existing BMPs evaluated for additional TSS reduction benefits are shown in Figure 16 and include the following:

Engineering Drive – I
The existing pond at Engineering Drive near Peachtree Industrial Boulevard has adequate permanent pool volume (6.4 acre-feet) to satisfy the criterion for water quality control. For channel protection, about 5 feet of additional storage would be needed to control the 1-year storm. Shoreline constraints may limit the feasibility of this retrofit option.

Wet Pond at Atlantic Blvd – O
The wet detention pond at Atlantic Boulevard (designated as BMP O) in Figure 15 appears to provide flood peak attenuation, but does not meet the criteria for the water quality control or channel protection. However, the existing multi-stage outlet control may be suitable for retrofit to provide the necessary storage for water quality benefits. The water quality storm over the 300-acre drainage area would produce about 14 acre-feet of runoff, and increase the pool elevation by about 7 feet. Extended detention of the channel protection storm seems infeasible at this location given the storage volume that wold be necessary.

Private Dry Pond – P
A dry pond on private property serves a drainage area of about 67 acres. Retrofit outlet works could be built to provide control of the 3.8 acre-feet water quality storm. Extended

detention of the channel protection storm (10.5 acre-feet) seems infeasible due to site constraints.

Lake Siskey—AH

Lake Siskey along Governor's Lake Parkway has a surface area of about 3.4 acres and an average depth of 5 feet. The permanent pool includes about 17 acre-feet of water, which is well above the required water quality volume of 4 acre-feet from the 218-acre drainage area. There is a broad overflow weir that provides no extended detention for additional water quality or channel protection benefits.

This lake has adequate permanent pool to provide water quality benefits. However, the hydraulic control for the pool is a 20-foot weir, which does not provide extended detention for the channel protection storm. The 1-year storm (with a 24-hour rainfall of 3.36 inches over 24 hours) would create about 17 acre-feet of runoff. This volume could be stored at a depth of about 5 feet. Temporary inundation of the lake shoreline to a depth of 5 feet seems feasible and this retrofit BMP is included in the recommended CIP.

Gateway Drive—AI

The wet pond near Gateway Drive has a surface area of about 2.2 acres and an average depth of about 5 feet, producing a permanent pool volume of about 11 acre-feet, which is adequate to satisfy the water quality volume criterion.

This lake has adequate permanent pool for water quality benefits, but provides almost no channel protection or flood control benefit. There is only about 1 to 2 feet of freeboard before the entire embankment overtops. Shoreline amenities may preclude the feasibility of building up the embankment. Retrofit for channel protection does not appear feasible at this location.

Technology Parkway—AL

This is a relatively new lake with a large surface area and plenty of room for flood storage. With 8.3 acres surface area, the pool's depth is 5 feet, resulting in a permanent pool volume of 40 acre-feet. The water quality volume for the drainage area of 414 acres is 20 acre-feet. The permanent pool is adequate for water quality benefits, but the outlet does not provide adequate control for the channel protection storm. The channel protection storm could be stored at a depth of about 7 feet with some spillway retrofit. Such an additional storage depth appears feasible with minimal disturbance to shoreline activities.

Private Community – AO

The lake at AO is within an apartment community near Winterbrook Court and has a permanent pool of adequate size for water quality protection. However, the embankment does not appear to be well-maintained, as there are large trees growing on it and the spillway is simply an earthen cut in the embankment. There is 1 to 3 feet of freeboard between the water level and the embankment overtopping elevation. Without substantial improvements to the embankment and the spillway, this facility does not appear amenable to retrofit for channel protection.

Private Community – AP

Between Jones Mill Road and Lake View Lane, an existing wet pond provides adequate permanent pool volume to qualify for water quality benefits. This pond may be suitable for retrofit for channel protection by providing extended detention of the 9 acre-feet of runoff from the channel protection storm.

4.2.3.2 Potential New BMPs

Opportunities for new BMPs were evaluated for potential water quality benefits. Reductions in TSS loads were evaluated in terms of capture and treatment of the water quality storm volume and extended detention of the channel protection storm (1-year). New facilities evaluated for potential TSS reduction benefits are shown in Figure 16 and described below.

Potential locations BC, BD, BE and BH (shown in Figure 15) were not considered further because of limited opportunities and site constraints.

BB – Potential site at Atlantic Blvd and Jimmy Carter Boulevard

This is a low-lying corner lot with a stream that drains storm water from about 102 acres of commercial property. It is currently for sale, but the low-lying nature and possible flood threats make this a less desirable commercial lot. A water quality wet pond or extended detention dry pond could be located at this corner, which would impound the water quality storm of 5.9 acre-feet about to the current road elevation of Jimmy Carter Boulevard. Extended detention of the channel protection storm seems infeasible, due to the elevation constraints of the site.

Overexcavation of the site may be considered to provide the water quality volume below the normal pool elevation. However, the required channel protection volume would require a wet-weather storage volume of about 14 acre-feet of runoff. The site constraints are unlikely to accommodate this volume, as the surface area is limited to under an acre.

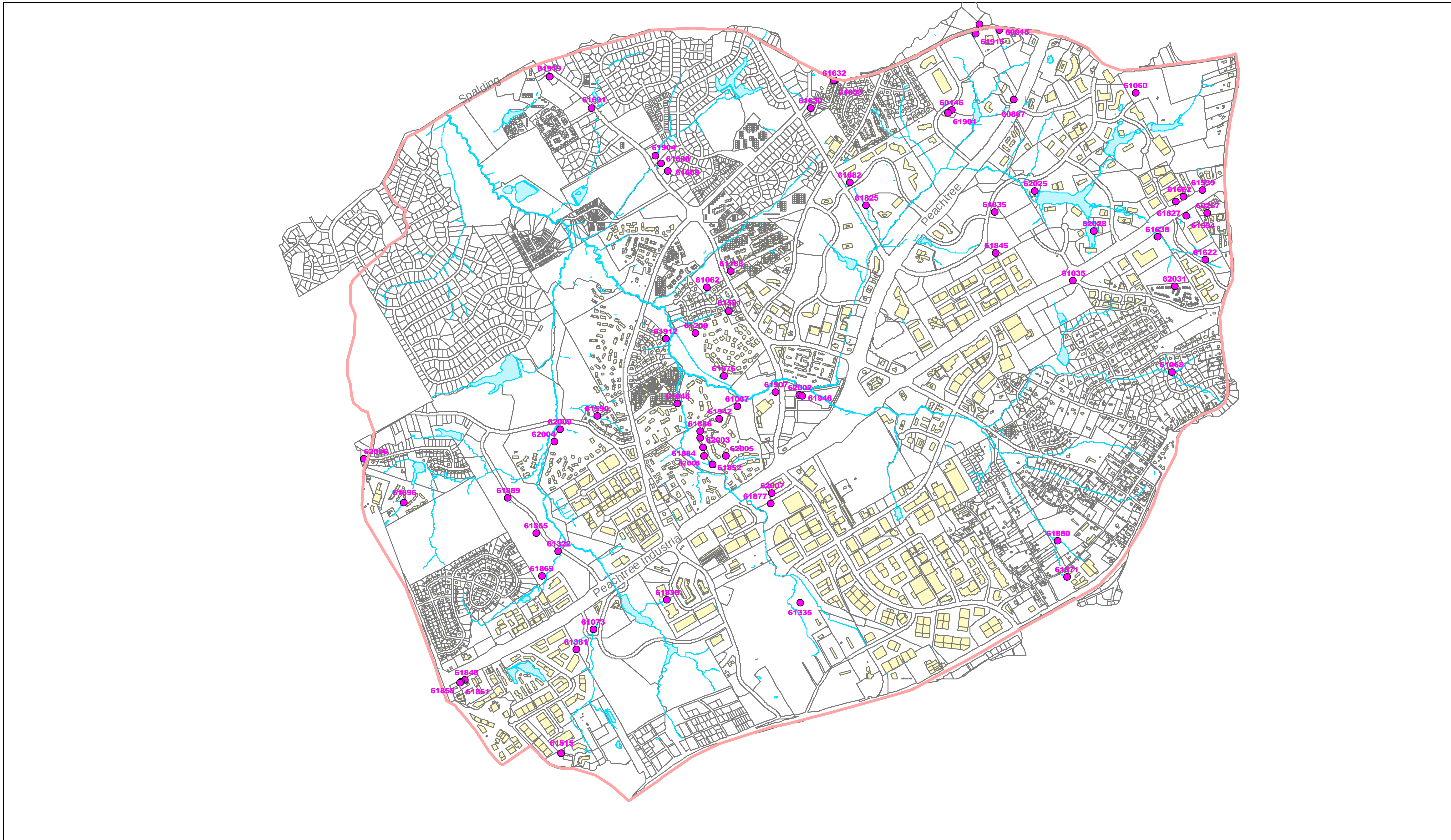
BF – Conifer Crossing

About 52 acres drain through and from the Conifer Crossing community. Near Crooked Creek, there is a wide floodplain area that serves as a vegetative filter/infiltration area. At two locations there are hydraulic controls (small embankments with V-notch weirs) that enhance detention and infiltration. The water quality volume for this drainage area is about 1.6 acre-feet, and the land area available for detention is more than 4 acres. Retrofits for water quality and channel protection seem feasible at this location.

BG – Franklin Office Park near Peachtree Industrial Boulevard

This is an intensely developed office park with little or no storm water facilities that provide water quality or channel protection. The area of about 28 acres has a water quality volume of about 1.92 acre-feet of runoff. No convenient location is available to provide this amount of storage volume, and so a series of on-site BMPs would be needed to meet the cumulative storage need. Conceptual designs and specific BMPs for this area would depend on site constraints

A summary of the existing retrofit or potential new upland BMPs evaluated for the recommended storm water master plan (see Section 6) is shown in Figure 16. These BMPs were further evaluated (in Section 6) based on their benefits for meeting the Crooked Creek watershed needs (Section 5) and overall costs for implementation.



- BMP Identified and Catalogued in BMP Inventory
- Streams
- Underground Conduit
- Crooked Creek Watershed
- Water Bodies
- Building
- Parcels

Figure 14
BMPs Identified From Drainage Inventory
Crooked Creek Storm Water Master Plan
Gwinnett County DPU

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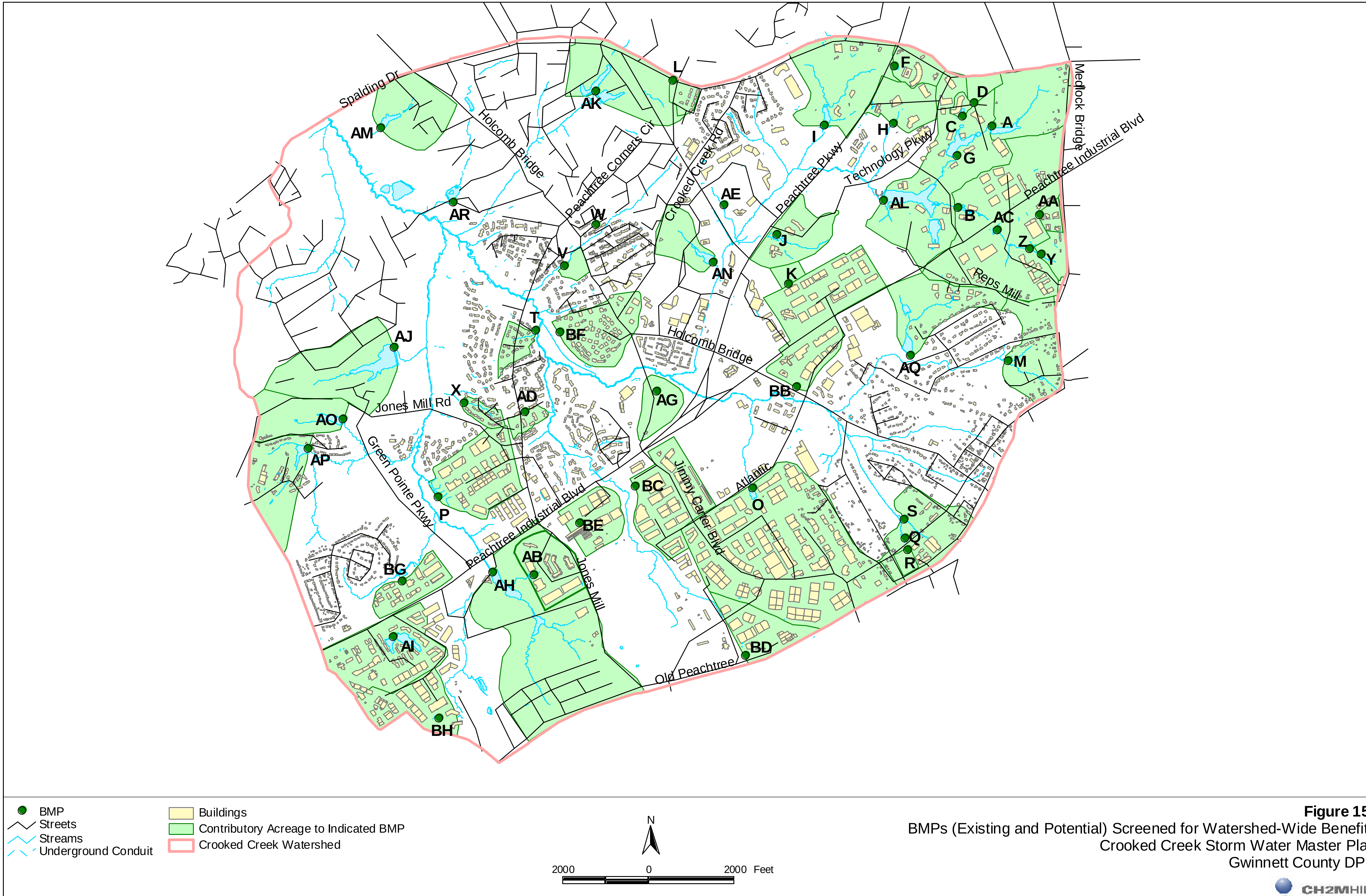

Figure 15
BMPs (Existing and Potential) Screened for Watershed-Wide Benefits
Crooked Creek Storm Water Master Plan
Gwinnett County DPU

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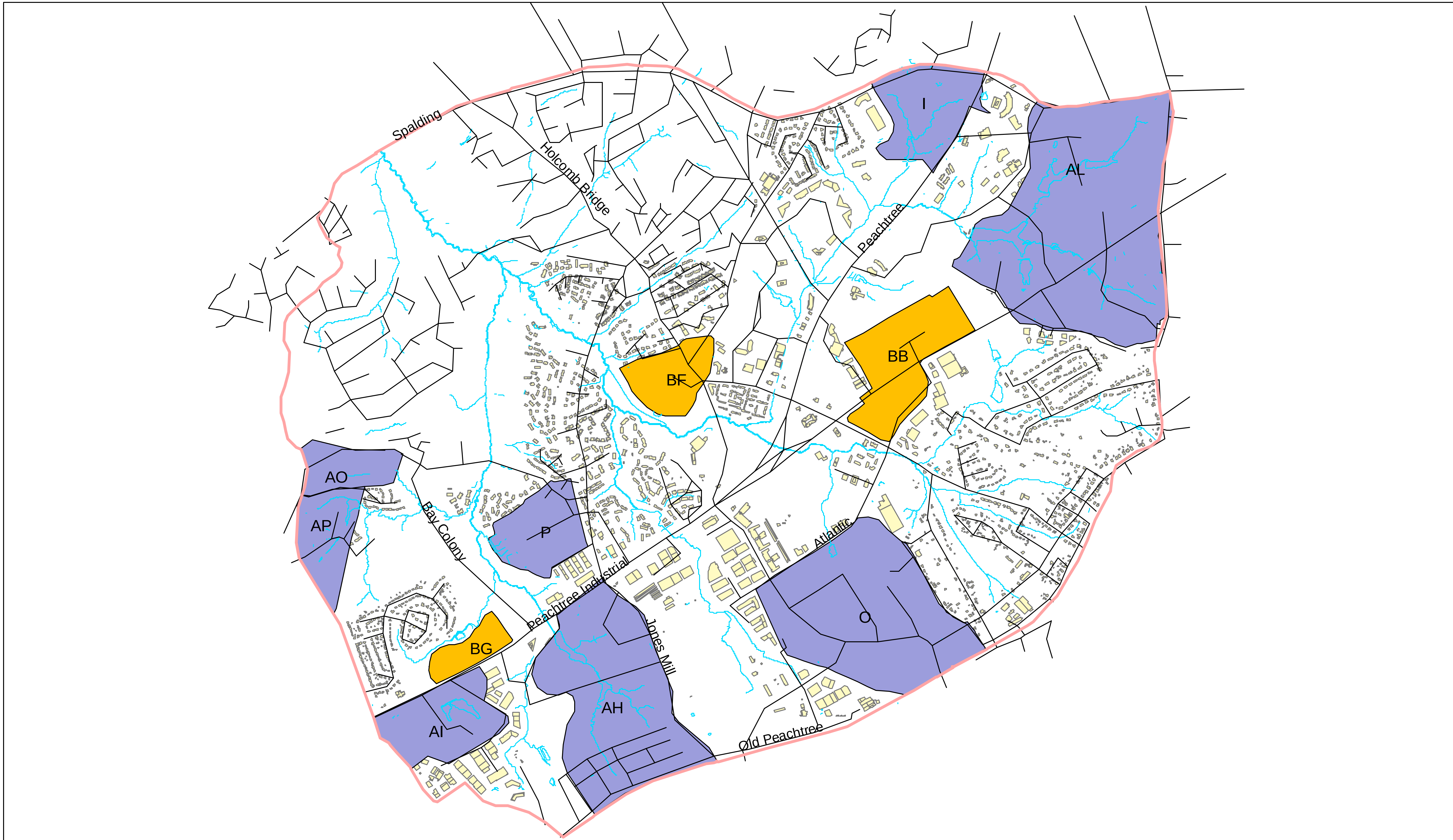

Streets
Streams
Underground Conduit
Bulidings
Potential New BMP for Water Quality Benefit
Existing BMPs considered for water quality and/or channel protection retrofit
Crooked Creek Watershed

Figure 16
New and Retrofit Upland BMPs
Crooked Creek Storm Water Master Plan
Gwinnett County DPU

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5.0 Watershed Needs

5.1 Flooding

The watershed needs related to flooding include proper floodplain management and potential upgrades of road crossings where flooding is indicated. Floodplain maps have been prepared and are now in use for managing floodplain activities in the Crooked Creek watershed. A submittal has been made to the FEMA to adopt the results of the current study as the regulatory floodplain for insurance and management purposes.

The flood study indicated 6 road crossings that are subject to overtopping during the 100-year flood under existing conditions. Flood potential at each road crossing included in the current study is shown in Table 10.

TABLE 10
Flood Potential at Road Crossings

				Roadway Overtopping Depth (ft)		
Stream	**Road Name**	**HEC-RAS Section**	**Top of Road Elevation (ft)**	**10-year Existing**	**100-Year Existing**	**100-year Future**
Crooked Creek	Spalding Drive	90	889.6	0	0	0
	Meadow Rue Drive	4376	893.9	0.03	1.3	1.6
	Pineland Wood Drive	6627	904.7	0	0	0
	Peachtree Corners West	7402	914.3	0	0	0
	Peachtree Industrial Blvd	13361	967.1	0	0	0
Tributary A	Pineland Wood Drive	1252	903.4	0	0	0.4
	Jones Mill Road	4440	920.6	0	0.6	1.2
Tributary 2	Jimmy Carter Blvd	2751	934.9	0	0	0
	Woodhill drive – Holcomb Bridge Road	5837	942.3	0	0	0
	Jay Bird Alley	7452	947.5	0.3	0.7	0.8
	Parkway Lane	8687	951.3	0	0	0
	Engineering Drive	10340	964.6	0	0	0
Tributary 2.1	Peachtree Parkway (s/b)	798	933.6	0	0	0
	Access Road	1109	930.9	0	0	0.7
	Peachtree Industrial Blvd (s/b)	1381	942.7	0	0	0

TABLE 10 (CONT'D)
Flood Potential at Road Crossings

Stream	Road Name	HEC-RAS Section	Top of Road Elevation (ft)	Roadway Overtopping Depth (ft)		
				10-year Existing	100-Year Existing	100-year Future
	Bridge @ Crossing Park	3173	934.2	0	3.1	4.0
	Atlantic Blvd	3768	941.3	1.0	2.5	3.0
	Holcomb Bridge Road	4503	945.0	2.0	2.7	2.9
	Sunset Drive	5496	961.3	0	0	0.1
	Sunset Drive	5990	971.9	0	0	0
Tributary 2.1.1	Langford Drive	690	954.4	0	0	0
	Bridge to United Consultants	1251	965.8	0	0	0

For Atlantic Boulevard and Holcomb Bridge Road over Tributary 2.1, alternate routes are available to provide access around flooded roads. However, Meadow Rue Drive provides the only access across Crooked Creek to a residential neighborhood, and could isolate the area in times of extreme flooding. This information will be turned over to the Gwinnett County Transportation Department for consideration in future transportation improvement plans.

5.2 Drainage Systems

The drainage inventory documented the locations, dimensions, and conditions of various parts of the drainage network in the Crooked Creek watershed. The condition of facilities was generally described as follows:

- Good – the facility or structure seems to be operating as designed
- Fair – there may be some structural damage or clogging, but the performance of the facility does not appear to be significantly impaired.
- Poor – there is structural damage or debris clogging to the point that the structure appears not to function as designed.

The types of structures included in the inventory and the condition of each structure is shown in Table 11.

TABLE 11
Condition Summary of Drainage Inventory Items

Category	Total	Good	Fair	Poor
BMP	85	72	6	7
Catch Basin	729	729	0	0
Closed Conduit	1278	819	446	13
Ditch	186	186	0	0
Flume	24	22	2	0
Headwall	485	473	4	8
Junction	157	156	1	0
Standpipe	10	9	0	1
Trench Drain	5	5	0	0
Weir	46	37	8	1
Yard Inlet	236	236	0	0

Inventory data, such as the age, condition, or degree of clogging of a structure can be used to indicate maintenance or repair needs of the inventory items. Routine inventory results were used to generate service requests for those areas rated in poor condition. These areas will be evaluated and prioritized according to standard County policies.

5.3 Pollutant Loadings

In the WPP, watershed modeling established a current loading of 2438 lb/ac/yr and a future loading of 2,466 lb/ac/yr for TSS in the Crooked Creek watershed. The total loading rate was comprised of upland loads due to washoff from the contributing area and channel sources from bed and bank scour. The channel component of the total load was estimated to be 85 percent. It was demonstrated through correlation analysis that the current total TSS load and associated sedimentation in Crooked Creek are the primary factors contributing to loss of the aquatic biota and stream habitat. The primary factors identified that affect the TSS loading include:

- **Changes in hydrology** – due to an increasing percentage of impervious ground cover
- **Disturbance of the riparian corridor** -- due to removal of trees and natural vegetation along the stream banks.
- **Degradation of aquatic habitat** – due mainly to the erosion and sedimentation process including historic channelization and intensive agriculture practices.

To improve the biotic and habitat integrity of Crooked Creek, it was estimated in the Watershed Assessment that the TSS loading rate needed to be reduced to 1,600 lb/ac/yr or less. The stream improvement program in the CIP resulting from this study is designed to achieve this target rate, and was developed from an evaluation of the following projects:

- 68 stream improvement projects proposed to reduce TSS loading by stabilizing the stream banks and beds,

- 11 BMP projects (8 retrofit of existing facilities and 3 new potential new sites) to reduce the peak flows and erosive forces of uncontrolled storm water runoff.

5.4 Stream Habitat

The results of the Phase 1 and 2 surveys in the Crooked Creek watershed demonstrated that the stream habitat and riparian zone are severely degraded throughout most of the mainstem and tributaries. The extensive loss of aquatic habitat in the Crooked Creek watershed streams is due to several factors:

- Historic channel alteration (dredging and straightening) for flood prevention and to recover land for agriculture.
- Removal of the natural vegetation from the riparian buffer zone up to the edge of the creek banks resulting in unstable and highly erodible banks that, along with hydrologic changes, contribute to the considerable TSS loading.
- Extensive development and associated impervious area that has altered the hydrology of the watershed causing an increase in the peak velocity and erosive flow energy in the channels contributing to severe bed and bank erosion.

The mostly "poor" to "fair" habitat and biotic ratings demonstrate that the habitat and biota of Crooked Creek are generally degraded. Gwinnett County is aware of these conditions and, in addition to this CIP, is working with the State through its storm water and NPDES programs toward the goal that the aquatic systems in the County will support the designated use of "Fishing". The Index of Biotic Integrity (IBI) rating of the fish community in lower Crooked Creek was "poor," indicative of a community dominated by tolerant, habitat-generalist species and thus, seems to reflect the observed physical habitat degradation. The low rating was attributable to lower-than-expected metric scores for species richness, number of sensitive species, trophic structure balance, and relative abundance and health of fish (CH2M HILL, 2000).

The stream improvement program, including 68 individual stream projects, integrates hydrogeomorphic and soil bioengineering techniques for restoring stream channels stability (i.e., no long-term aggradation or degradation) and includes various habitat features. The habitat features may include a riffle/run/pool complex with in-stream structures such as cobbles and boulders that provide surface and interstitial habitat for macroinvertebrates (e.g., insects and mussels) and fish. Specially designed fluvial structures will be used to enhance stream habitat and reduce erosive forces.

Specific benefits of habitat improvement to native communities of macroinvertebrates and fish include:

- Enhanced species diversity of benthic macroinvertebrates due to increases in pool depth variability, increased availability of stable bottom and stream-bank substrates for colonization, and reduced sedimentation of bottom substrates.
- Overall increased species richness of fish and increased distribution of sensitive fish species in the watershed, including mottled sculpin and longnose shiner.

- Increased trophic balance of the fish community, as reflected by increased relative abundance of insectivorous minnows, decreased relative abundance of omnivores, and increased relative abundance of top carnivores such as largemouth bass and spotted bass.
- Increased abundance and condition of the stream fish community. Reduced stream bank erosion and sediment deposition would increase spawning area and enhance reproductive success of native species. Reproductive success could also be enhanced for species inhabiting the Chattahoochee River that spawn in tributary habitats (e.g., suckers and bullheads).
- Reduced sedimentation of riverine habitats in the mainstem Chattahoochee River.

6.0 Capital Improvement Program

6.1 Goals

From a water quality standpoint, the goal of the CIP is to reduce annual pollutant loads of TSS to target levels identified in the WPP (1,600 lb/ac/yr). Watershed modeling associated with the County-wide Watershed Assessment indicates a current Crooked Creek watershed TSS load of 2,438 lb/ac/yr. A reduction of 34 percent (or 4.8 million pounds per year) is needed to achieve the goal of the Watershed Protection Plan.

This loading level was established as a management guideline to protect and restore aquatic habitats to support a fish population that meets or exceeds the minimum level to support the designated use assigned by the Georgia EPD (IBI score of fair or better). Although this guideline was established for preparing long-term preliminary management strategies to improve stream aquatic integrity, this CIP identifies the need for site-specific stream TSS and sediment loading criteria to minimize further stream degradation. The programmatic goals are described in more detail in the County-wide Watershed Protection Plan report.

6.2 Watershed Improvement Strategies

The proposed watershed improvement strategy for Crooked Creek is to develop a master plan of CIP projects that addresses the goals of pollutant reduction and habitat improvement. Elements of the master plan will be implemented as funding becomes available or, when cost-sharing may be realized through multi-purpose projects.

Two types of CIP projects have been identified:

- Channel restoration projects, designed to reduce erosion of the bed and bank of streams, as well as improve the aquatic habitat
- Upland BMP facilities, including both retrofits and new facilities, designed to attenuate peak flow rates and reduce TSS loads to downstream reaches.

In addition to the proposed CIP projects, the drainage and BMP inventories will be used to identify facilities that are currently serving the Crooked Creek watershed and that need protection or maintenance to ensure continuing benefits.

6.3 Management Opportunities and Alternatives

6.3.1 BMP Project Selection

There are numerous types of upland BMPs that may be considered to help Gwinnett County meet the TSS load reductions targeted in the Watershed Protection Plan. Opportunities include:

- Maintenance and repair of existing BMPs to optimize performance

- Retrofit of existing BMPs for additional water quality or flood control benefits.
- Locations where the construction of larger-scale BMP facilities may be appropriate to serve multiple properties.
- Areas of existing development where little or no water quality BMPs exist, and where the construction of smaller-scale on-site BMPs may be appropriate to protect or improve water quality conditions.

From a watershed perspective, the larger scale projects would probably produce the best benefit in terms of TSS load reductions. Initially, project sites with large drainage areas were prioritized. In addition, retrofits of existing facilities can reduce the level of effort required for design, permitting and construction, and so were also ranked high.

6.3.2 Stream Project Selection

6.3.2.1 Background

As described in Section 3 of this report, Stream Assessment, the mainstem and tributaries in the Crooked Creek watershed (Figure 3) were evaluated using a two-part process. First, the streams were walked and degraded conditions were documented using prepared assessment forms and protocols. After a preliminary ranking of stream reaches based on the initial assessment data, the streams were re-walked. This second phase of field investigations focused on confirming the initial assessment data, noting site constraints that might affect engineering design, and developing restoration concepts for each stream reach.

6.3.2.2 Restoration Concepts

During the second phase of field investigations, conceptual plans were developed for each stream reach. In all, 68 restoration projects of various types totaling more than 79,000 linear feet of stream, have been identified along Crooked Creek and its tributaries as shown in Figure 17.

6.3.2.3 Restoration Activities

The concept for each reach is unique; however, each plan involves combinations and variations of similar restoration activities. Nine basic types of stream restoration activities are proposed for Crooked Creek and its tributaries. These activities are:

- Type 1 and 2 Stream Restoration
- Type 3 and 4 Stream Restoration
- Spot Repair – Culvert
- Spot Repair – Stream Bank
- Buffer Restoration/Enhancement
- Selective Vegetation Management
- Preservation
- Levee Removal
- In-Stream Structures

Conceptual design sketches were developed for typical CIP projects recommended for the Crooked Creek Watershed. The locations of the representative projects and the accompanying conceptual sketches are shown in Appendix E.

Stream Restoration

Stream restoration refers to the alteration of stream channel pattern, form, and/or profile to a point where the channel is stable – that is, the channel is neither aggrading nor degrading.

Rosgen (1997) describes a "priority system" or range of stream restoration design concepts that considers numerous factors including returning an incised stream to its original elevation and re-connecting floodplains, widening the overall stream corridor width to construct a new channel at the existing elevation, changing stream types, and stabilizing the existing channel in place. Rosgen's range of restoration concepts is termed a "priority" system because some of the concepts return the stream to a more natural state than others. For example, elevating a stream to its original grade and reclaiming an abandoned floodplain is returning the stream to a natural state where the floodplain can perform its highest and best function in the watershed (i.e., a frequently-flooded floodplain removes more pollutants than an infrequently-flooded one), therefore it is a Priority 1, restoration activity.

Rosgen's priority system is presented below in Table 12 and Figure 18. For purposes of the Crooked Creek CIP, conceptual sketches using Rosgen Priority 1 and 2 restoration concepts are termed Type 1 and 2 Stream Restoration; similarly, conceptual sketches using Priority 3 and 4 restoration concepts are termed Type 3 and 4 Stream Restoration. The term "Type" is used for restoration concepts so they are not confused with project prioritization, which will be developed later. Figures 19 and 20 provide photographs of a Type 1 and 2 and Type 3 and 4 Stream Restoration project, respectively. A general description of improvement project types follows, and specific restoration projects are listed in Appendix F. Appendix E presents conceptual sketches of channel improvement types.

TABLE 12
Stream Restoration Project Types, Descriptions, and Summary for Incised River Restoration

Description	Methods	Advantages	Disadvantages
Type 1			
Convert G and/or F stream types to C or E at previous elevation with floodplain (example shown in Figure 18a)	Re-establish channel on previous floodplain using relic channel or construction of new bankfull discharge channel. Design new channel for dimension, pattern, and profile characteristic of stable form. Fill in existing incised channel or with discontinuous oxbow lakes level with new floodplain elevation.	Re-establishment of floodplain and stable channel: reduces bank height and streambank erosion Reduces land loss, Raises water table, Decreases sediment, Improves aquatic and terrestrial habitats, Improves land productivity, and Improves aesthetics.	Floodplain re-establishment could cause flood damage to urban agricultural, and industrial development. Downstream end of project could require grade control from new to previous channel to prevent head-cutting.

TABLE 12 (CONT'D)
Stream Restoration Project Types, Descriptions, and Summary for Incised River Restoration

Description	Methods	Advantages	Disadvantages
Type 2			
Convert F and/or G stream types to C or E. Re-establishment of floodplain at existing level or higher, but not at original level (examples shown in Figures 18b and 18c)	If belt width provides for the minimum meander width ratio for C or E stream types, construct channel in bed of existing channel, convert existing bed to new floodplain. If belt width is too narrow, excavate streambank walls. End-haul material or place in streambed to raise bed elevation and create new floodplain in the deposition.	Decreases bank height and streambank erosion Allows for riparian vegetation to help stabilize banks Establishes floodplain to help take stress off of channel during flood Improves aquatic habitat Prevents wide-scale flooding of original and surface Reduces sediment Downstream grade transition for grade control is easier	does not raise water table back to previous elevation shear stress and velocity higher during flood due to narrower floodplain upper banks needs to be sloped and stabilized to reduce erosion during flood.
Type 3			
Convert to a new stream type without an active floodplain, but containing a floodprone area. Convert G to B stream type, or F to Bc (Examples shown in Figures 18d and 18e)	Excavation of channel to change stream type involves establishing proper dimension, pattern, and profile. To convert a G to B stream involves an increase in width/depth and entrenchment ratio, shaping upper slopes and stabilizing both bed and banks. A conversion from F to Bc stream type involves a decrease in width/depth ratio and an increase in entrenchment ratio.	Reduces the amount of land needed to return the river to a stable form. Developments next to river need not be relocated due to flooding potential Decreases flood stage for the same magnitude flood Improves aquatic habitat	high cost of materials for bed and streambank stabilization does not create the diversity of aquatic habitat does not raise water table to previous levels
Type 4			
Stabilize stream in place using structural techniques (see Figure 18f)	A long list of stabilization materials and methods have been used to decrease stream bed and streambank erosion, including concrete, gabions, boulders and bio-engineering methods.	Excavation volumes are reduced Land needed for restoration is minimal	High cost for stabilization High risk due to excessive shear stress and velocity Limited aquatic habitat depending on nature of stabilization methods used.

Source: Rosgen, David L., "A Geomorphological Approach to Restoration of Incised Rivers," *Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision*, 1997

Spot Repair
Spot repairs refer to the localized use of stabilization measures (soil bioengineering preferably) to stabilize stream banks. Spot Repair - Culvert addresses those erosion areas caused by scour at roadway culvert inlets and/or outlets. Figure 21 shows an example of a Spot Repair – Culvert. Spot Repair - Stream Bank addresses localized erosion areas along stream banks on stream reaches outside of the vicinity of roadway culverts.

Buffer Restoration/Enhancement
Buffers refer to the corridor of land adjacent to each side of a stream that separates the upland land use from the waters of the stream (see Figure 22). Well vegetated buffers that create sheet flow from overland storm water runoff have been shown to provide the highest levels of pollution removal. Buffer Enhancement/Restoration projects are those that focus on establishing or supplementing an improved mixture of vegetation and creating opportunities for sheet flow.

Selective Vegetation Management
Many streams in the Crooked Creek watershed have been degraded from scour caused by large woody debris blockages. Also, many non-native plant species (i.e., privet) can be found growing along streams, crowding out native plants. Selective Vegetation Management refers to the practice of removing blockages from the streams, removing trees and other vegetation in imminent danger of collapsing into the stream and causing a blockage, removing non-native species from the stream banks and buffer, and selectively pruning and/or removing trees and shrubs to relieve crowding and provide opportunities for desirable vegetation to mature and thrive.

Preservation
Streams that exhibit stable geomorphology and have intact and functional buffers are proposed for Preservation. Preservation areas are recommended to be purchased by the County or otherwise deeded or conserved via an easement such that the land use in the easement remains the same from this point forward and the stream and its buffer remain unaltered from their present state.

Levee Removal
Berms or other structures adjacent to watercourses with top elevations higher than the land surrounding the watercourse act as levees – preventing floodwaters from spilling over into the adjacent land. These levees act to prevent floodplains from performing their function of slowing down runoff velocities promoting sediment removal from storm water and infiltration runoff and removing pollutants. Levee Removal projects propose to remove levees to reconnect the stream channel to its floodplain.

In-Stream Structures
A wide variety of structures can be placed in streams to provide stream bank protection, grade control, and fish and benthic macroinvertebrate habitat (see Figure 23). In-Stream Structures projects refer to those reaches where the concept involves predominantly the use of such structures for restoration.

Project Types

The "project type" specified for each reach of Crooked Creek and its tributaries refers to the most predominant type of restoration activity proposed for the reaches, not necessarily the only activity proposed for the reach.

6.4 Project Prioritization

6.4.1 Project Selection Criteria

Each potential watershed improvement project was evaluated with respect to a set of 15 Project Selection Criteria in six major categories:

1. Water Quality Benefits
2. Hydrologic controls
3. Property Protection
4. Habitat and Biological Integrity
5. Implementation
6. Benefit/Cost Considerations

The Project Selection Criteria and scoring guidance are presented in Table 13.

TABLE 13
Project Selection Criteria and Scoring Guidance

Issue	5 – High	3 - Medium	1 – Low	0 - Not applicable
		Water Quality Benefits		
Fecal Coliform	Very effective at addressing this issue	Somewhat effective	Incidental benefits	Issue score = 0 if no benefits
TSS	Very effective at addressing this issue	Somewhat effective	Incidental benefits	Issue score = 0 if no benefits
Phosphorus	Very effective at addressing this issue	Somewhat effective	Incidental benefits	Issue score = 0 if no benefits
Metals	Very effective at addressing this issue	Somewhat effective	Incidental benefits	Issue score = 0 if no benefits
		Hydrologic Control		
Flood Problem Mitigation due to hydrologic controls	Provides substantial reduction in flood threats	Part of a larger program to alleviate flooding	Incidental flood control benefits	Issue score = 0 if no benefits
Reduction in channel protection storm	24-hour detention of channel protection storm for contributory area	Detention of channel protection storm less than optimal	Incidental reduction in peak of channel protection storm	No reduction in channel protection storm
		Property Protection		
Property protection	Provides significant reduction in flooding threat to property		Minimal flood control benefit	No flood control benefit
		Habitat and Biological Integrity		
Habitat/Biology	Substantial increase in habitat and fish score anticipated	Moderate increase in habitat and fish score	Minimal increase in habitat and fish score	Issue score = 0 if no benefits

TABLE 13 (CONT'D)
Project Selection Criteria and Scoring Guidance

Issue	5 – High	3 - Medium	1 – Low	0 - Not applicable
		Implementation		
Site Constraints (land acquisition and conflicts with existing facilities)	Little or no constraints to meeting design and performance criteria	Project will have less than optimal efficiency due to site constraints	Cost-effective design and construction appear unlikely	Site constraints may render project infeasible
Compatibility with other County Programs	Potential cost-sharing by other programs (such as Greenways)	Compatible with plans for other County programs	Minor conflicts with other programs	Conflicts with other County projects could render project infeasible
Neighborhood acceptance	Embraced by neighborhood	No opinion by neighborhood	Likely objections from neighborhood	Known opposition to project
Environmental Impacts	Minimal environmental impacts anticipated	Possibly significant environmental impacts	Significant environmental impacts anticipated	Very significant -- Environmental opposition expected
		Benefit Cost Considerations		
Reduction in TSS annual load (lb per $)	Most cost-effective	Average	Least cost-effective	Relatively expensive
Habitat feet Protected or Restored per $	Most cost-effective	Average	Least cost-effective	Relatively expensive
Relative ease of Operation & Maintenance	Little or no effort anticipated	Occasional routine O&M	Frequent O&M	Significant O&M on regular basis

6.4.2 Project Evaluation Scoring

Each project was given a score between 0 and 5 for each criterion, then that score was weighted depending upon its importance toward achieving the goals of the Gwinnett County Watershed Protection Plan. The Project Selection Criteria worksheet for each project reach is included in Appendix F. While the scoring guidelines in Table 13 generally explain how a numerical score is to be assigned for each criterion, the following narrative provides more information regarding how elements of each project were viewed with respect to the Water Quality Project Selection Criteria and the scoring guidelines.

6.4.2.1 Water Quality Benefits

Fecal Coliform

For purposes of this evaluation, all of the conceptual stream channel restoration plans were given a score of 1 indicating that fecal coliform removal rates would be incidental to activities proposed. The restoration activities do have an impact on the amount of fecal coliform in waters, mostly via the action of storm water infiltration enhanced by sheet flow through a properly vegetated buffer. All of the proposed stream channel projects assume the presence of an intact buffer or the creation/enhancement of one, and therefore, receive the same score of 1.

Upland BMP projects achieved a somewhat higher score for fecal coliform management, due to the “capture and treat” nature of the facilities. Wet pond BMPs that satisfy design requirements in the *Gwinnett County Storm Water Design Manual* and/or the *Georgia Storm Water Management Manual* are assigned a score of up to 5 depending on the degree that the *Water Quality* and *Channel Protection* requirements are believed to be satisfied (volume and residence time).

Total Suspended Solids (TSS)

In previous work, watershed modeling established TSS loading rates by land use type. The total loading rate was comprised of upland loads due to washoff from the contributing area and channel sources from bed and bank scour. The channel component of the total load was estimated at 85 percent of the total.

As documented in the 2000 Watershed Protection Plan report, previous watershed modeling estimated an annual load of about 14 million ponds per year of TSS from the Crooked Creek watershed. This total load has been partitioned into 2.1 million pounds from upland sources and 11.9 million pounds from channel sources. The channel load was apportioned among stream reaches in the watershed according to their relative cross sectional area (represented by their drainage area) and their erosion score from the field surveys. The upland load was apportioned to areas based on the land use.

The stream restoration activities proposed for the streams in the Crooked Creek watershed should all be very effective of addressing the issue of annual TSS loadings. Stream banks have been identified as the major source of TSS in the Crooked Creek watershed; and the channel restoration projects will significantly reduce this source. Appendix G describes the approach used to determine the relative benefits and costs of each proposed project relative to reduction in TSS loads.

The efficiency of each stream improvement type was assigned based on how well it is expected to control the sources of TSS. The scores for each project type included:

- Type 1, 2, or 3 channel restoration – 5
- Spot repair – 5
- Buffer restoration or enhancement – 3
- In-stream grade controls – 3
- Selective vegetative management -- 2
- Preservation – 1

For upland BMPs, a TSS score of 5 was assigned if the facility could provide adequate control for both the Water Quality storm and the Channel Protection storm. BMPs that satisfy design requirements in the *Gwinnett County Storm Water Design Manual* and/or the *Georgia Storm Water Management Manual* may be assigned a score of up to 5 depending on the degree that the *Water Quality* and *Channel Protection* requirements are believed to be satisfied (volume and residence time). A score of 3 was assigned if only the water quality storm was addressed or if the channel protection storm was addressed at facilities that already control the water quality storm.

Phosphorus

All of the conceptual stream restoration activities in the Crooked Creek watershed received a score of 1 with respect to the phosphorus removal criterion. There will be incidental benefits related to all of the proposed activities, primarily due to the use or preservation of vegetation common to all of the concepts and the removal of phosphorus via plant biological uptake.

Upland BMPs received a higher score for phosphorus removal, since these projects will capture and treat runoff associated with the major sources of phosphorus. Facilities that could adequately control the water quality storm and the channel protection storm were assigned a score of 5. A score of 3 was assigned if the new or retrofit BMP only addressed one of the design storms.

Metals

For the purposes of this evaluation, all of the conceptual stream restoration designs were given a score of 1, indicating that they would have incidental benefits to metals removal in the watershed. Metals in soluble form can adsorb to sediment particles and particulate forms have a close affinity with suspended sediment. The sediment settling and filtering activities of vegetated buffers therefore remove metals. Since buffers are planned or already existing on all of the stream reaches, all proposed projects receive the same score.

Upland BMPs, which can actively capture and treat runoff associated with sources of metals, received higher scores for this issue. Facilities that met the criteria for control of the water quality storm and the channel protection storm were assigned a score of 5. A new or retrofit BMP that only addressed one of these design storms was assigned a score of 3.

6.4.2.2 Hydrologic Controls

Flood Problem Mitigation

Improvement projects that would substantially reduce flood threats to existing facilities would be given a score of 5 for this issue. Upland BMPs, which provide a level of flood storage and peak flow reduction, were given a lesser score if they contribute to mitigating flood conditions in identified problem areas. Stream restoration projects do not generally have a significant benefit to flood protection; however, they can enhance channel and floodplain storage of flood volume, providing downstream benefits.

Projects that provide protection from the 25-year storm would receive a score of 5 in this category. BMPs designed to mitigate flood peaks but that could not meet this criterion, received a lesser score depending on the degree of mitigation provided. Channel restoration projects, which provide minimal enhancements in channel and floodplain storage were assigned a score of 1.

Channel Protection

For this issue, projects were assigned a score based on how well they performed at reducing the frequency of minor flooding. Upland BMP projects that provide 24-hour detention for the channel protection (1-year) storm were given a score of 5 for this issue. Projects that increased flood storage, but fell short of the channel protection volume, were scored somewhat less. Stream channel restoration projects were assigned a minimal hydrologic benefit, due to the enhanced channel or floodplain storage associated with these projects. BMPs that satisfy design requirements in the *Gwinnett County Storm Water Design Manual* and/or the *Georgia Storm Water Management Manual* may be assigned a score of up to 5 depending on the degree that the *Channel Protection* requirements are believed to be satisfied (volume and residence time).

6.4.2.3 Property Protection

Projects that address property protection by preventing bank erosion were scored in this category. Maximum scores were assigned where active erosion was threatening significant loss of property or damage to other facilities.

For channel restoration projects, spot repairs were assigned the maximum score of 5, since they are specifically intended to protect property from imminent erosion threat. Where channel stabilization projects are located in areas without immediate threats, the score was reduced to 3.

Upland BMPs that provide both water quality and channel protection storm controls were assigned a value of 3; and upland BMPs that only address the water quality storm were assigned a 1.

6.4.2.4 Habitat and Biological Integrity

The recommended projects will provide varying levels of aquatic habitat improvement or protection. Scores were assigned as follows:

- Type 1 or 2 channel restoration – 5
- Spot repairs along stream banks – 5
- Spot repairs at culverts or bridges – 4
- Upland BMPs with 24-hour detention for the channel protection storm – 3
- In-stream grade controls – 3
- Upland BMPs that provide water quality storm control – 2
- Type 3 or 4 channel restoration – 2
- Buffer restoration or enhancement – 2
- Preservation of stream buffer areas – 2

While aquatic biology cannot be managed directly, a correlation has been shown between biology and habitat. Restoration or preservation of habitat is assumed to have a direct benefit for aquatic biology.

6.4.2.5 Implementation Issues

Site Constraints

Site constraints are unique to each project and include physical barriers to being able to properly design and/or construct a project in a way such that its goals are met in a cost-effective manner. For example, a project that needs sinuosity added to a channel might have to be designed straighter than optimal due to the proximity of a sanitary sewer line to the stream. Shoreline activities or landscaping around existing lakes or ponds could prevent using flood storage above the current design for hydrologic controls. Projects with no apparent site constraints received a maximum score of 5. If land acquisition or conflicts with existing facilities appeared likely, a lower score was assigned.

Compatibility

Projects proposed that were deemed especially compatible with other, non-storm water projects (such as greenways) were given a score of 5 for this criterion. Projects with no influence, positive or negative, on other non-storm water projects scored a 3. Projects that conflicted with other non-storm water efforts received a 1 or a 0, depending upon the severity of the incompatibility.

Neighborhood Acceptance

For purposes of this evaluation, if the improvement project is generally seen as an amenity, and is likely to be supported by the local neighborhood, the maximum score of 5 was assigned. In areas where the neighbors are not likely to either support or object to the project, a lower score of 3 was assigned. If objections are anticipated from the neighborhood, a 1 or 0 was assigned.

Environmental Impacts

The majority of the proposed stream restoration projects in the Crooked Creek watershed will likely have minimal environmental impacts. Preservation projects and spot repairs of erosion problems received a maximum score of 5. Projects with short-term impacts from the construction phase received scores of 3; and projects that may have lasting environmental impacts were scored as 1 or 0.

Retrofits to existing lakes and ponds scored the maximum 5 for this criterion, because minimal impact is anticipated. New wet ponds, which may impact wetlands or stream channels, would score lower.

6.4.2.6 Benefit/Cost Considerations

A site-specific cost estimate was developed for each project area depending on the type of project, a linear estimate of the project length, the size of the stream, and respective constraints. These cost estimates were used to develop the issue scores for TSS and Habitat for each project. These costs estimates are intended only to illustrate the potential differences in magnitude of project cost, based on the type of improvements proposed, as well as the identified constraints at the site. The approach to evaluating benefit/cost scores for TSS and habitat is described in Appendix G.

Pounds of TSS Reduced Per Dollar

The stream restoration activities proposed for the streams in the Crooked Creek watershed are assumed to change eroding banks to stable stream systems. The amount of sediment that would be reduced by a specific project was calculated using bank erosion estimates made during field studies and other site-specific data including the amount (area) of eroded bank, stream size (magnitude), and a modeled TSS channel load (pounds/acre/year). The reduced TSS load per dollar equals the load per individual project divided by the corresponding project cost.

For upland BMPs, the annual load of TSS captured and treated was estimated, along with an allowance for mitigating downstream bank erosion where the channel protection storm is adequately controlled. Well-designed and maintained upland BMPs were assumed 80 percent effective at reducing TSS loads from upland areas and channels. In addition, protection of downstream channels was assumed based on the number of acres for which the channel protection storm was adequately managed. For example, an upland BMP that controlled the channel protection storm for 5 percent of the Crooked Creek watershed acreage would reduce the 11.9-million-pound stream channel load by 5 percent times the estimated effectiveness (generally 80 percent).

Relative Degree of Habitat Protected or Restored per Dollar

Habitat conditions were evaluated in the field using modified Barbour and Stribling procedures for estimating stream and riparian zone condition. Each stream improvement project was assumed to improve habitat conditions to the maximum extent practicable for the area. The habitat improved per dollar reflects the length and degree of habitat improved for each individual project divided by the corresponding project cost. (Habitat improved per $= (length X Habitat improvement score)/cost). For upland BMPs, minimal habitat improvement was assumed. However, due to the attenuation of peak flows, a small benefit will be realized, and a minimal score was assigned. For upland BMPs designed to provide adequate management of the channel protection storm, the relative degree of habitat protected was calculated as the potential improvement for reaches downstream of the BMP to a point that has five times the drainage area of the BMP itself. The factor of 5 was selected because, in general, the benefits of an upland BMP are fully reflected just downstream of the facility; and the benefits are slowly reduced until they are near zero at a point with 10 times the drainage area. A factor of 5 represents the average over this range of stream reaches.

Ease of Operation and Maintenance

Projects were rated on a relative scale according to the estimated level of effort for operation and maintenance. Projects planned for little or no maintenance scored 5 for this criterion. Projects requiring occasional maintenance were scored as 3; and those with more intensive maintenance requirements scored 1 or 0.

Project Ranking

The weighted scores for each criterion were totaled in each category. The higher the total project benefit score, the higher the project's ranking in the CIP.

6.5 Recommended CIP Elements

One of the underlying principles of the watershed approach for managing aquatic habitat improvement is a flexible process that allows for adjustments at virtually any time during the planning and implementation of the program. However, this flexibility to make adjustments does not mean compromising the overall goal of the Gwinnett WPP (CH2M HILL, 2000). As in the WPP, an "adaptive management" strategy is suggested for planning and implementing the BMP and stream improvement projects recommended in the CIP of this Crooked Creek Storm Water Master Plan. "Adaptive management" is a process of making plans and taking actions on those plans based on recent data and information to continuously improve the understanding of the problems and their solutions, while at the same time making progress toward attaining the goals of the County's WPP.

For purposes of planning, the list of prioritized BMP and stream improvement projects presented in the CIP are expected to achieve the TSS guidelines of 1,600 lb/ac/yr established in the WPP for the watersheds in Gwinnett County. In the WPP, it was demonstrated, through correlation analysis, that improvements in the biota and habitat could be achieved if the TSS was reduced to this level. A listing of projects included in the recommended CIP program is shown in Table 14. The locations of these recommended projects are shown in Figure 24, along with the recommended upland BMP projects.

Projects ranked 1 through 33 in Table 14 are designed to limit the TSS load in the Crooked Creek Watershed to the County-wide target of 1,600 pounds/acre/year – that is, an annual watershed-wide load reduction of 4.8 million pounds of TSS. However, the recommended "adaptive management" strategy allows for making adjustments not only in the selection of projects and the implementation sequence, but also in the level of service provided such that it may be necessary to use greater (i.e., Type 1 and 2) or lesser (i.e., Type 3 and 4) levels of stream protection, depending on the stream and watershed conditions at the time a specific project is to be started.

Preservation projects ranked low in the overall ranking (Appendix F) because they are generally in areas where bank erosion and sedimentation are minimal and stream improvements would not likely contribute to substantial sediment control or removal. However, this ranking should not diminish their value to the watershed protection program; failure to protect these areas could lead to increased TSS loads if they are allowed to degrade.

The stream ranking that was prepared in Section 3 was based on habitat conditions alone. Whereas, the project prioritization includes several other factors, including habitat condition. Thus the prioritized projects do not correspond to the reaches ranked by the habitat score. For example, Reach TR-3.2 was ranked lowest (severe habitat degradation) by habitat score in Table 6 on page 3-9, but two of the three projects within Reach TR-3.2 were not ranked as high priority in Table 14 because of issues such as the relative amount of erosion, minimal infrastructure problems, few infrastructure constraints, and other site-specific project ranking issues that are not related to habitat.

TABLE 14
Recommended CIP Project Rankings

Rank	Segment	Composite Score	Project Type	TSS Benefit (lb/yr)	Cumulative TSS Benefit (lb/yr)	Estimated Cost
1	TR3.2-01 #1	71.74	Spot Repair - Culvert	18,375	18,375	$33,750
2	TR2.1.1-01 #1	71.58	Spot Repair - Culvert	17,776	36,151	$18,750
3	CC-03 #5	71.21	Spot Repair - Stream Bank	105,802	141,952	$155,000
4	TR2.1-02 #2	70.02	Spot Repair - Culvert	34,739	176,691	$45,000
5	TR2.1-02 #3	70.02	Spot Repair - Culvert	23,159	199,851	$30,000
6	BMP O	68.83	Retrofit for Water Quality and Channel Protection	464,116	663,967	$200,000
7	CC-03 #3	68.45	Spot Repair - Stream Bank	151,876	815,843	$222,500
8	BMP AL	68.37	Retrofit for Channel Protection and Flood Control	685,584	1,501,427	$200,000
9	TR2.1-02 #1	68.04	Spot Repair - Stream Bank	56,740	1,558,168	$122,500
10	TR3-01 #1	67.74	Spot Repair - Stream Bank	130,017	1,688,185	$320,000
11	TR2.1.2-01 #1	66.24	Spot Repair - Stream Bank	100,728	1,788,913	$247,913
12	BMP AH	66.01	Retrofit for Channel Protection	339,480	2,128,393	$200,000
13	TR2.1.1-01 #2	65.22	Spot Repair - Stream Bank	20,148	2,148,540	$49,588
14	TR3-01 #3	64.35	Spot Repair - Culvert	52,820	2,201,360	$130,000
15	TR3-01 #4	63.36	Spot Repair - Stream Bank	207,215	2,408,575	$918,000
16	BMP AP	63.34	Retrofit for Channel Protection	107,640	2,516,215	$100,000
17	CC-02 #2	63.27	Spot Repair - Stream Bank	255,890	2,772,105	$938,000

TABLE 14 (CONT'D)
Recommended CIP Project Rankings

Rank	Segment	Composite Score	Project Type	TSS Benefit	Cumulative TSS Benefit	Estimated Cost
18	CC-05 #1	63.12	Type 1 and 2 Stream Restoration	146,269	2,918,375	$288,000
19	TR3.1-01 #1	62.90	Type 1 and 2 Stream Restoration	79,067	2,997,441	$243,250
20	TR3-02 #1	62.31	Spot Repair - Stream Bank	113,054	3,110,495	$357,750
21	TR1-01 #1	62.02	Type 1 and 2 Stream Restoration	27,304	3,137,799	$73,500
22	CC-02 #1	61.59	Spot Repair - Culvert	51,560	3,189,359	$135,000
23	BMP I	60.40	Retrofit for Channel Protection	97,704	3,287,063	$100,000
24	TR4-01 #1	59.60	Type 1 and 2 Stream Restoration	47,538	3,334,601	$182,000
25	CC-01 #2	59.31	Type 1 and 2 Stream Restoration	280,626	3,615,227	$620,000
26	BMP AO	57.00	Retrofit for Channel Protection	66,240	3,681,467	$100,000
27	TR7-01 #1	57.98	Type 1 and 2 Stream Restoration	82,886	3,764,353	$178,500
28	TR3-01 #5	57.75	Type 1 and 2 Stream Restoration	62,977	3,827,330	$217,000
29	CC-03 #2	57.71	Type 1 and 2 Stream Restoration	37,542	3,864,872	$66,000
30	CC-03 #4	57.53	Type 1 and 2 Stream Restoration	168,941	4,033,813	$396,000
31	CC-01 #1	57.06	Type 1 and 2 Stream Restoration	488,832	4,522,646	$1,944,000
32	TR2-00 #1	56.79	Type 1 and 2 Stream Restoration	231,756	4,754,402	$868,000
33	TR2-02 #2	56.55	Type 1 and 2 Stream Restoration	114,882	4,869,284	$304,500

Note: A complete list of project scores is presented in Appendix F.

Table 17 and Figure 24 summarize the 33 upland and stream channel projects included in the recommended CIP for Crooked Creek watershed. Because streams are naturally dynamic, changes are expected to occur and "adaptive management" provides a mechanism to respond to these changes. Thus, the number, type, and sequence of projects may change as additional information is collected and analyzed. The project priority rankings described earlier were used to rank the potential projects, and a set of CIP projects is recommended that meet the minimum TSS target. This minimum set of CIP projects is listed in Table 14 and summarized in Table 15. With the exception of preservation projects, lower ranking projects (Projects 34 through 79 listed in Appendix F) that are not included in the recommended minimal plan should be considered for implementation if opportunities for multi-purpose projects are identified, land or site becomes more readily available, or if other conditions change to affect the ranking.

Many upland BMP projects are considered cost-effective because they take advantage of existing facilities where retrofit designs can improve their performance. New upland BMPs are generally not as cost-effective as these opportunistic retrofits.

TABLE 15
Minimum Recommended CIP Projects

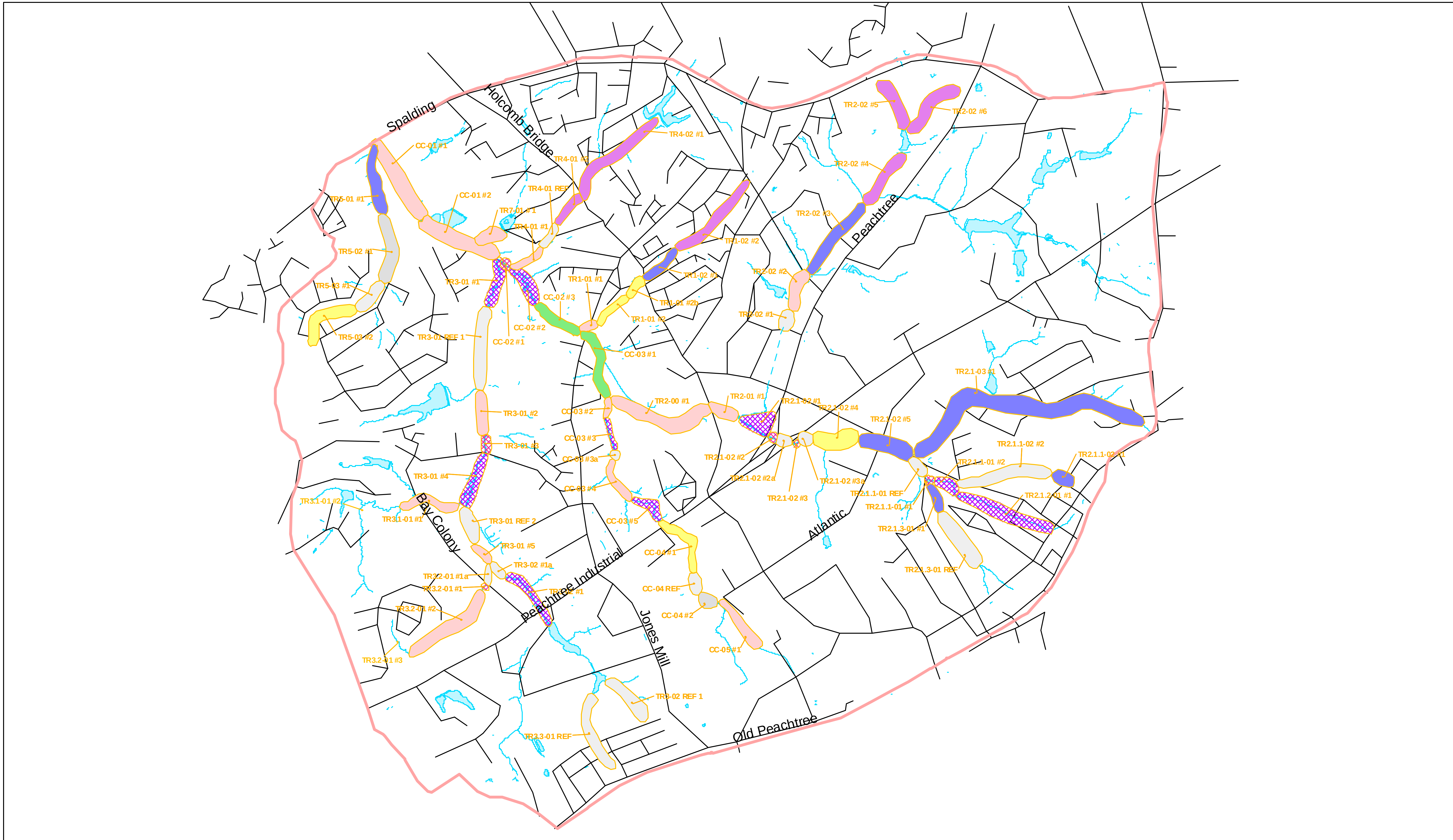
Project Type	Number of Projects	Estimated Total Cost	TSS Benefits (estimated reduction in annual load in lb/yr)
Stream restoration	27	$9,100,000	4,100,000
Upland BMP	6	$900,000	800,000
Crooked Creek Total	33	$10,000,000	4,900,000

6.5.1 Monitoring

Success of the proposed restoration measures and BMPs relative to the expected outputs and benefits to habitat and native aquatic communities would be measured using habitat and biological community monitoring of benthic macroinvertebrates and fish at representative stations. The objective of this monitoring would be to characterize changes in habitat and biotic integrity through time in the restored reaches compared to pre-restoration conditions and least-disturbed reference streams for the ecoregion.

The measurement of improvements to physical habitat and biotic integrity would focus on the particular metrics and community attributes that scored poorly in the original assessments for the WPP, as well as on specific indicator species or species guilds, such as EPT taxa of macroinvertebrates, benthic species of fish (e.g., sculpins, darters, madtoms), and sensitive species of fish (certain minnows).

Monitoring recommendations are described in the County-wide Watershed Protection Plan Report.



Project Areas

- In-Stream Structures
- Remove Levee
- Selective Vegetation Management
- Buffer Restoration / Enhancement
- Type 1 Stream Restoration
- Type 3 Restoration
- Preservation
- Spot Repair Culvert
- Spot Repair Stream Bank
- Streams
- Underground Conduit
- Streets
- Water Bodies
- Crooked Creek Watershed

N

2000 0 2000 Feet

Figure 17
Stream Improvement Project Areas
Crooked Creek Storm Water Master Plan
Gwinnett County DPU

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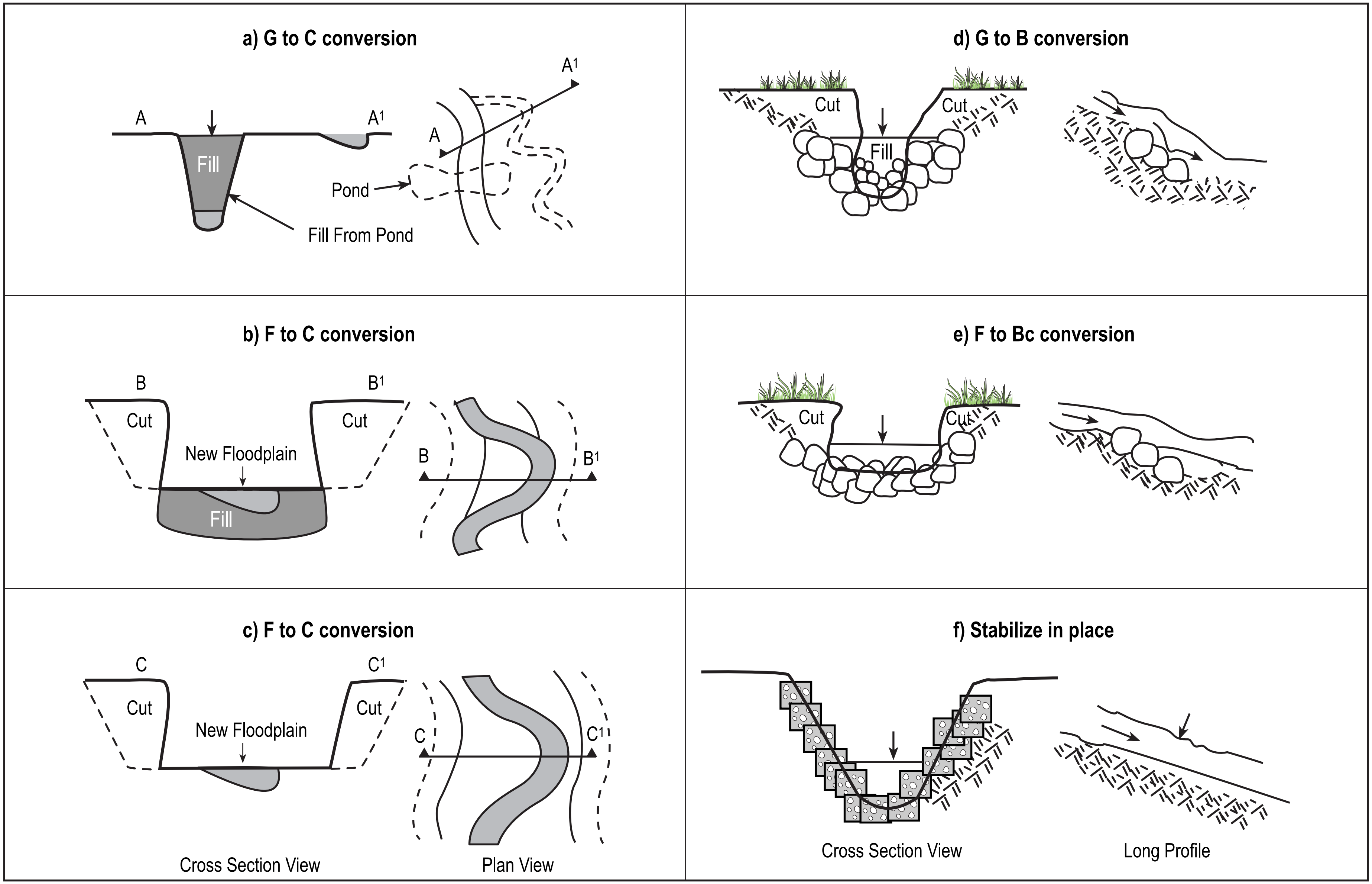


Source: Rosgen, David L., "A Geomorphological Approach to Restoration of Incised Rivers," *Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision*, 1997.

Figure 18
Various Restoration/Stabilization Options for Incised Channels
Stream Improvement Projects and Prioritization
Crooked Creek Storm Water Master Plan
Gwinnett County DPU

FIGURE 19
Example Type 2 Stream Improvement Project

Before, during, and after photos of a Type 2 restoration project depicts the construction of a bench for the stream re-establishing the floodplain at the existing elevation of the stream.

FIGURE 20
Example Type 4 Stream Improvement Project

Before, during, and after at a Type 4 restoration project depicts stabilization of the stream bank in place.

FIGURE 21
Example Spot Repair Project

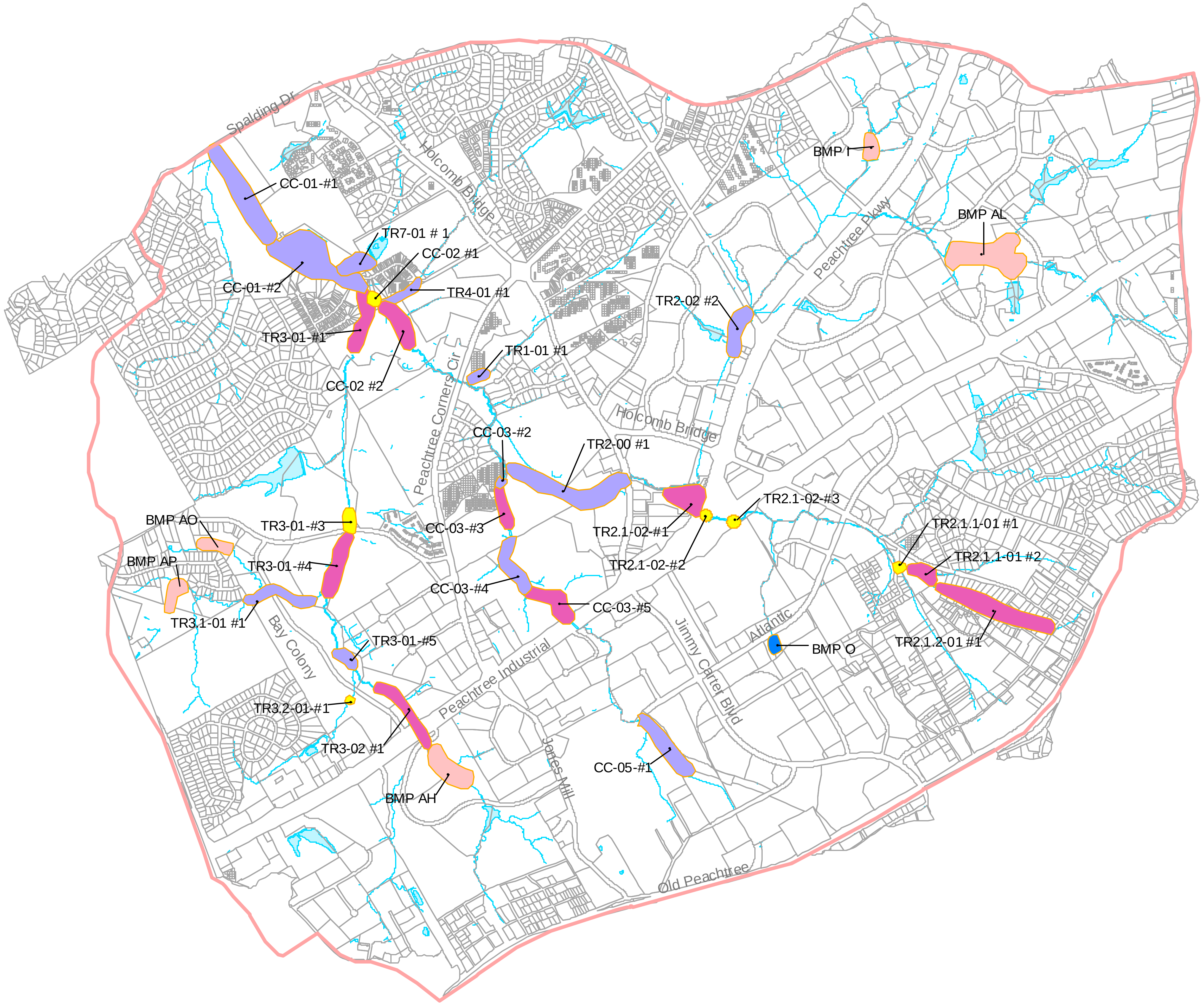
Stream bank scour at the approach to a stream crossing is repaired using a vegetated lift soil bioengineering technique.

FIGURE 22
Example Buffer Restoration Project

The buffer shown here contains a mixture of trees, shrubs, and grasses, and separates a mowed, fertilized lawn from the creek.

FIGURE 23
Example In-Stream Structure Project

A J-Hook Vane structure provides stream bank protection, preventing erosion.



Project Areas

- Type 1 and 2 Stream Restoration
- Buffer Restoration / Enhancement
- Retrofit BMP for Channel Protection
- Retrofit BMP for Water Quality and Channel Protection
- Spot Repair - Culvert
- Spot Repair - Stream Bank
- Streets
- Streams
- Water Bodies
- Crooked Creek Watershed

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2000 0 2000 Feet

Figure 24
Locations of Recommended CIP Projects
Crooked Creek Storm Water Master Plan
Gwinnett County DPU

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