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Technical Memorandum

To: *City of Franklin IWRP Team*

From: *CDM*

Date: *July 29, 2011*

Subject: *Integrated Water Resources Plan – Stormwater Technical Analysis - Evaluation of Stormwater Basin Plans*

1.0 Introduction

In April 1999, the City of Franklin selected Camp Dresser & McKee Inc. (CDM) to develop a Comprehensive Stormwater Management Program (SWMP) to proactively address stormwater needs related to rapid growth and the City's regulatory requirements. A phased approach was outlined to maximize the City's resources and to minimize incremental program costs. In the years following, CDM developed individual plans for each of the major basins in the City, which are shown in **Figure 1**. The primary focus of the plans was to address water quantity/flooding issues which had become increasingly problematic as the City continued to develop. Water quality consideration was part of the analysis, but water quality modeling was not performed for these original studies.

Since the original development of these plans, water quality has evolved as a significant driver in stormwater management planning. The first major water quality driver was the City's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit, which was issued in 2003. This permit was recently re-issued in October of 2010 and includes additional requirements to address water quality within the City's MS4 jurisdiction.

In addition to the NPDES MS4 permit, significant attention has been focused on identifying impaired waters throughout the State. The State performs routine sampling of streams to identify which streams do not meet State Water Quality Standards for their intended use. Streams that do not meet their intended use are placed on the State 303(d) list of impaired waters. Once a waterbody is on the list, the State works through a priority schedule that ultimately results in the development of a Total Maximum Daily Load (TMDL), which is essentially a "pollution diet" for a river or stream. The TMDL plan quantifies the amount of pollutant in the stream, identifies the source of the pollutant, and recommends regulatory or other actions that may need to be taken in

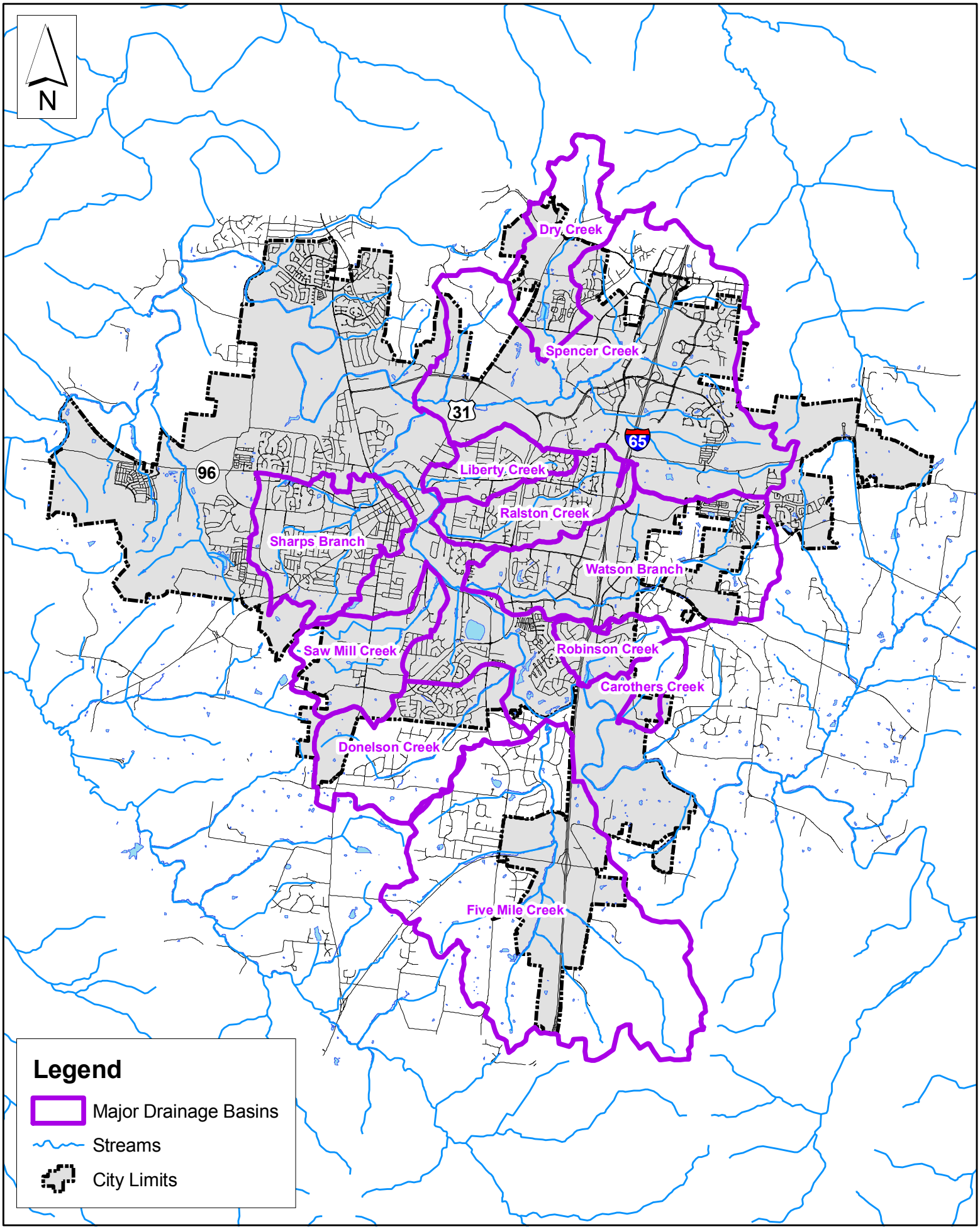

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Figure 1
City of Franklin, TN
Major Drainage Basins

order for the stream to cease being polluted. The requirements of these two regulatory programs have led the City to consider a re-evaluation of the previous studies to consider additional water quality improvements.

CDM has met with the City's stormwater staff to review the previous plans in order to identify potential improvements, including water quality enhancements to existing projects as well as to develop estimates of the pollutant removal potential for these projects.

2.0 Data Collection and Evaluation

CDM performed a review of each of the previous stormwater plans developed for the City. From each plan, CDM compiled a list of proposed flood-control projects. **Table 1** summarizes the list of projects. The location of each proposed project is shown on **Figure 2.**

Table 1 – Summary of Proposed Stormwater Projects from Previous Plans

ID	Stream	Watershed	Tributary Area (acres)	Watershed Plan Notes
W1	Sharps Branch	Sharps Branch	210	Detention Facility, 40 ac-ft of storage, Tributary 2 near Birchwood Circle
W2	Quarry Branch	Sharps Branch	107	Detention Facility, 30 ac-ft of storage, Tributary 3 near Downs Blvd and Figures Dr
W3	North Ewingville Creek	Ralston Creek	20	Detention Facility, retrofit existing facility at junction 10600
W4	North Ewingville Creek	Ralston Creek	66	Detention Facility, Junction 32450 upstream of Stanwick Dr.
W5	Liberty Creek	Liberty Creek	88	Detention Facility, 10 ac-ft of storage. Main stem, upstream of Jordan Rd
W6	Saw Mill Creek	Saw Mill Creek	700	Detention facility in the vicinity of Model Junction 90420
W7	Donelson Creek	Donelson Creek	880	Detention facility in the vicinity of model junction 90851
W8	Goose Creek	Five Mile Creek	290	Detention facility, 10 ac-ft storage, retrofit recommendation

Because Franklin has continued to grow at a rapid pace throughout the development of these plans, it was important to review the location of each project to verify if the project was still viable. Using the most recent aerial photography and location information from the plans, CDM

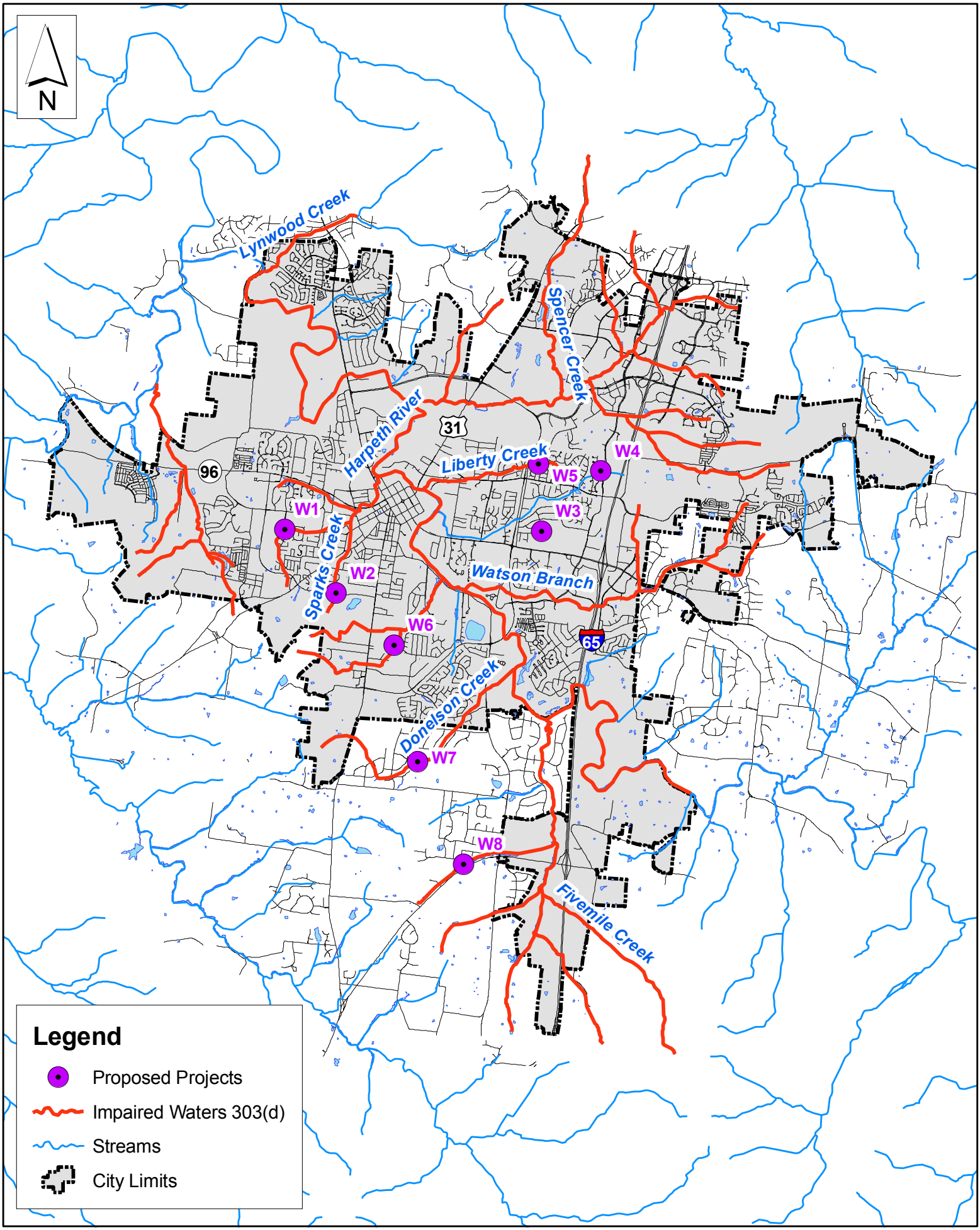

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Figure 2
City of Franklin, TN
Capital Projects and Impaired Waters

mapped each of the proposed projects and performed a desktop review of the location compared to existing landuse/development. Based on this review, CDM eliminated Project ID W2 in Sharps Branch due to the existence of development at the previously proposed site. All other projects appear to be feasible based on the results of this review.

3.0 Current Water Quality Conditions

Because water quality is a key component of this reassessment, it is important to understand the current water quality conditions in the City. CDM performed a review of the State's 303(d) list of impaired waters to identify water quality impairments within the City limits. The most current list of impaired waters provided by the State is from 2010, although the list has not been finalized. However, a comparison between the 2010 draft and the 2008 final list did not reveal significant changes. A map of the impaired waters in the City (shown in BOLD red) is shown in Figure 2. As indicated, the majority of stream segments in the City have been identified by the State as impaired for one or more pollutants. **Table 2** summarizes the listed impairments, identified pollution sources, and TMDL status.

In total, approximately 87 miles of stream within the City are impaired. The most common impairments include habitat loss from lack of vegetation, siltation, nutrients, low dissolved oxygen and bacteria. The sources of pollution include land development, the City's MS4 and wastewater operations, and cattle grazing (i.e., agricultural practices). The US Environmental Protection Agency (EPA) has already approved TMDLs for some of the streams, including the main stem of the Harpeth River. The City's wastewater treatment plant has been restricted to a discharge of 300 lbs/day of Total Nitrogen (TN), 1,000 lbs/day of Total Suspended Solids (TSS) in the winter and 3,000 lbs/day of TSS in the summer, which are referred to as Waste Load Allocations (WLAs) in the TMDL. These WLAs provide a point of comparison for potential benefits of pollutant reduction from stormwater BMPs. Additional information on approved TMDLs can be found on the State's website (http://www.tn.gov/environment/wpc/tmdl/).

4.0 Water Quality Evaluation

CDM reevaluated the projects in the existing basin plans considering the potential for water quality improvements. Based on a review of the list of water quality impairments, CDM identified the following pollutants to include in this evaluation: 1) TN or total nitrogen, 2) TP or total phosphorus, and 3) TSS or sediment. It should be noted that no additional design calculations or modeling were performed for this task. However, a literature search was conducted to identify potential pollutant removal capabilities of common stormwater BMPs, which included dry detention ponds, wet detention ponds, and constructed stormwater wetlands. It was assumed that minor changes could be made to the outlet configurations of the proposed ponds to provide the desired water quality treatment with minimal impact to the original cost estimates identified in the plans.

Table 2
City of Franklin, TN
Integrated Water Resources Plan
Summary of Impaired Waters

Waterbody	Miles Impaired	Cause of Impairment	Pollutant Source	Comments
HATCHER SPRING CREEK	6.5	Habitat loss due to alteration in stream-side or littoral vegetative cover; Loss of biological integrity due to siltation	Pasture Grazing	Category 5. TMDLs needed.
LYNWOOD CREEK	5.4	Alteration in stream-side or littoral vegetative cover; Loss of biological integrity due to siltation	Pasture Grazing Land Development	Category 4a. Impaired, but EPA has approved a siltation/ habitat alteration TMDL for the known pollutants.
SPENCER CREEK	19.9	Loss of biological integrity due to siltation; Escherichia coli	Land Development Discharges from MS4 Area	Category 5. EPA approved a siltation TMDL for some of the known pollutants.
LIBERTY CREEK	0.54	Toluene; Acetone; Low Dissolved Oxygen; Loss of biological integrity due to siltation; Alteration of stream-side or littoral vegetative cover	Industrial Point Source Discharges from MS4 Area	Liberty Creek is impacted in part due to accidental releasesof toluene and acetone. Thesesubstances indirectly affect fish and aquatic life and directly impact the aesthetics of the stream. Category 5. One or more uses impaired.
LIBERTY CREEK	1.31	Loss of biological integrity due to siltation; Alteration of stream-side or littoral vegetation	Discharges from MS4 area	This stream is Category 5. One or more uses impaired.
WATSON BRANCH	6.8	Loss of biological integrity due to siltation	Land Development	Category 4a. EPA approved a siltation TMDL for the known pollutant.
HARPETH RIVER	6.8	Low dissolved oxygen; Phosphorus	Municipal Point Source Discharges from MS4 area	Category 4a. EPA approved DO and nutrient TMDLs for the known pollutants.
FIVEMILE CREEK	14.4	Loss of biological integrity due to siltation; Escherichia coli	Pasture Grazing	Category 4a. EPA approved siltation and pathogen TMDLs for the known pollutants.
DONELSON CREEK	3.4	Loss of biological integrity due to siltation	Land Development	Category 4a. EPA approved a siltation TMDL for the known pollutant.
UNNAMED TRIB TO HARPETH RIVER	4	Habitat loss due to alteration in stream-side or littoral vegetative cover; Loss of biological integrity due to siltation	Land Development	Category 4a. The stream is impaired, but EPA approved a siltation/ habitat alteration TMDL for the known pollutants.
SHARPS CREEK	4.9	Habitat loss due to alteration in stream-side or littoral vegetative cover; Loss of biological integrity due to siltation	Discharges from MS4 area	Category 4a. The stream is impaired, but EPA approved a siltation/ habitat alteration TMDL for the known pollutants.
HARPETH RIVER	3.9	Low Dissolved Oxygen; Phosphorus; Loss of biological integrity due to siltation; Escherichia coli	Discharges from MS4 area Highways, Roads, Bridges, Infrastructure Construction Pasture Grazing	Category 4a. Impaired, but EPA has approved pathogen, siltation/ habitat alteration, and organic enrichment TMDLs for the known pollutants.
HARPETH RIVER	9	Low Dissolved Oxygen; Loss of biological integrity due to siltation	Pasture Grazing	Category 4a. EPA approved DO and siltation TMDLs for the known pollutants.

Pollutant Loads

The first step in the evaluation process was the development of estimated pollutant loadings delivered to each of the proposed BMP sites. Using the City's GIS data, CDM delineated an approximate tributary area to each site. Next, CDM reviewed the City's aerial photography within each tributary area to estimate the fraction of various land uses that would need to be treated by the BMP. **Table 3** summarizes the total area and land use basis for each of the BMP locations identified in Figure 2.

Table 3 – Land Use Distribution for Each Candidate BMP Site

ID	Total Area (ac.)	Comm. %	Indust. %	Instit. %	Trans. %	Multi-Fam %	Single-Fam %	Open Space %
W1	210			15	10	15	35	25
W2	0							
W3	20	70			10			20
W4	65			35	15		10	40
W5	90			3	15		82	
W6	700	15	30	5	15			35
W7	880			5	15		45	35
W8	290			5	10		40	45

The EPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) was used to generate desktop estimates of pollutant loads delivered to each candidate BMP site. This tool uses a combination of annual rainfall estimates, land use information and event mean concentration (EMC) data to estimate annual pollutant loads. The spreadsheet tool used average annual rainfall data from the closest weather gage (Nashville BNA airport), which was estimated at approximately 59 inches annually. Land use information for each sub-watershed was generated by CDM using the City's existing GIS data. The standard, default EMC values provided in the spreadsheet tool (**Table 4**) used for this evaluation were consistent with national averages.

Table 4 – EMC Values for Various Pollutants and Land Uses (mg/L)

Pollutant	Comm.	Indust.	Instit.	Trans.	Multi-Fam	Single-Fam	Open Space
TN	0.62	0.75	0.62	0.28	0.58	0.58	0.85
TP	0.23	0.27	0.23	0.25	0.31	0.31	0.33
TSS	48	90	48	99	50	50	72

Using the STEPL tool with the values defined in Tables 3 and 4, CDM generated total pollutant loads for each of the candidate sites. The initial pollutant loads were based on the assumption that no BMPs already exist within the watersheds. The loads were generated in units of lbs/year of TN and TP and in tons/yr of sediment for each site (**Table 5**).

Table 5 – Total Pollutant Loads Delivered to BMP Sites

ID	TN Load (lb/yr)	TP Load (lb/yr)	Sediment Load (tons/yr)
W1	1,948	325	45
W2	-	-	-
W3	215	26	5
W4	595	96	14
W5	939	164	22
W6	6,093	935	150
W7	6,192	1,041	155
W8	916	176	29
Total	**16,898**	**2,763**	**420**

Pollutant Load Reduction Potential

The final step in the analysis was to estimate the pollutant load reduction potential for each of the identified sites. Because sizing and design calculations for each site were not performed as part of this analysis, CDM performed a literature search to identify pollutant removal capabilities of selected BMP alternatives. The BMPs used for this analysis included dry detention ponds, wet detention ponds and constructed stormwater wetlands. The primary reference used to estimate pollutant removal capabilities was the National Pollutant Removal Performance Database (September 2007) by the Center for Watershed Protection. The study summarized sampling data from a variety of BMPs in a variety of locations to generate expected pollutant removal efficiencies. Pollutant removal efficiencies used for this analysis are provided in **Table 6**.

Table 6 – BMP Pollutant Removal Efficiencies

BMP Type	% TN Reduction	% TP Reduction	% Sediment Reduction
Dry Detention Pond	15%	15%	70%
Wet Detention Pond	35%	45%	80%
Constructed Wetland	25%	30%	70%

The pollutant removal efficiencies in Table 6 were applied to the predicted loadings from Table 5 to determine the total pollutant removal potential of the designated BMP sites. For each site, pollutant removals were estimated for the three different BMP types. Summaries of the pollutant load reduction estimates are shown in Tables 7a (dry pond), 7b (wet pond), and 7c (wetland). Total estimated pollutant reductions that may be achieved if all sites are built are reported as follows:

- Total Nitrogen Reduction Potential: 2,500 to 5,900 lbs/yr of TN (or, 7 to 16 lbs/day)
- Total Phosphorus Reduction Potential: 400 to 1,200 lbs/yr of TP (or, 1.1 to 3.3 lbs/day)
- Total Sediment Reduction Potential: 290 to 350 tons/yr of Sediment (or, 1,600 to 1,900 lbs/d)

Cost Evaluation

Each of the original basin plans included an estimated cost for construction for the identified flood control facilities. The original cost estimates and designs primarily focused on the flood control benefits of the projects, therefore CDM applied a factor of 1.25 to each of the project costs to adjust for design changes that may be necessary to provide the desired pollutant removal noted in the previous sections. Additionally, costs were converted to 2011 dollars. Excluding project W2, which was determined to not be feasible, the total cost of all projects is estimated to be in the range of $14 to $15 million as summarized in **Table 8**.

Tables 7a - 7c
City of Franklin, TN
Pollutant Removal Estimates for Various BMPs

POLLUTANT REMOVAL via DRY POND										
BMP ID	Creek Location	Watershed Name	N Load (no BMP) lb/year	P Load (no BMP) lb/year	Sediment Load (no BMP) t/year	N Reduction lb/year	P Reduction lb/year	Sediment Reduction t/year	N Load (with BMP) lb/year	P Load (with BMP) lb/year	Sediment Load (with BMP) t/year
W1	Sharps Branch	Sharps Branch	1,948	325	45	292	49	32	1,655	276	14
W2	Quarry Branch	Sharps Branch	-	-	-	-	-	-	-	-	-
W3	North Ewingville Creek	Ralston Creek	215	26	5	32	4	3	183	22	1
W4	North Ewingville Creek	Ralston Creek	595	96	14	89	14	10	506	81	4
W5	Liberty Creek	Liberty Creek	939	164	22	141	25	16	798	139	7
W6	Saw Mill Creek	Saw Mill Creek	6,093	936	150	914	140	105	5,179	795	45
W7	Donelson Creek	Donelson Creek	6,193	1,041	155	929	156	108	5,264	885	46
W8	Goose Creek	Five Mile Creek	916	176	29	137	26	21	779	150	9
Total			**16,899**	**2,763**	**420**	**2,535**	**415**	**294**	**14,364**	**2,349**	**126**

POLLUTANT REMOVAL via WET POND										
BMP ID	Creek Location	Watershed Name	N Load (no BMP) lb/year	P Load (no BMP) lb/year	Sediment Load (no BMP) t/year	N Reduction lb/year	P Reduction lb/year	Sediment Reduction t/year	N Load (with BMP) lb/year	P Load (with BMP) lb/year	Sediment Load (with BMP) t/year
W1	Sharps Branch	Sharps Branch	1,948	325	45	682	146	36	1,266	179	9
W2	Quarry Branch	Sharps Branch	-	-	-	-	-	-	-	-	-
W3	North Ewingville Creek	Ralston Creek	215	26	5	75	12	4	140	14	1
W4	North Ewingville Creek	Ralston Creek	595	96	14	208	43	11	387	53	3
W5	Liberty Creek	Liberty Creek	939	164	22	329	74	18	610	90	4
W6	Saw Mill Creek	Saw Mill Creek	6,093	936	150	2,133	421	120	3,961	515	30
W7	Donelson Creek	Donelson Creek	6,193	1,041	155	2,167	469	124	4,025	573	31
W8	Goose Creek	Five Mile Creek	916	176	29	321	79	23	596	97	6
Total			**16,899**	**2,763**	**420**	**5,914**	**1,244**	**336**	**10,984**	**1,520**	**84**

POLLUTANT REMOVAL via CONSTRUCTED WETLANDS										
BMP ID	Creek Location	Watershed Name	N Load (no BMP) lb/year	P Load (no BMP) lb/year	Sediment Load (no BMP) t/year	N Reduction lb/year	P Reduction lb/year	Sediment Reduction t/year	N Load (with BMP) lb/year	P Load (with BMP) lb/year	Sediment Load (with BMP) t/year
W1	Sharps Branch	Sharps Branch	1,948	325	45	487	98	32	1,461	228	14
W2	Quarry Branch	Sharps Branch	-	-	-	-	-	-	-	-	-
W3	North Ewingville Creek	Ralston Creek	215	26	5	54	8	3	161	18	1
W4	North Ewingville Creek	Ralston Creek	595	96	14	149	29	10	446	67	4
W5	Liberty Creek	Liberty Creek	939	164	22	235	49	16	704	115	7
W6	Saw Mill Creek	Saw Mill Creek	6,093	936	150	1,523	281	105	4,570	655	45
W7	Donelson Creek	Donelson Creek	6,193	1,041	155	1,548	312	108	4,644	729	46
W8	Goose Creek	Five Mile Creek	916	176	29	229	53	21	687	123	9
Total			**16,899**	**2,763**	**420**	**4,225**	**829**	**294**	**12,674**	**1,934**	**126**

Table 8 – Estimated Total Project Costs for Identified BMPs

ID	Stream	Watershed	Project Description	Cost
W1	Sharps Branch	Sharps Branch	Detention Facility, 40 ac-ft of storage	$ 1,800,000
W2	Quarry Branch	Sharps Branch	Detention Facility, 30 ac-ft of storage	n/a
W3	North Ewingville Creek	Ralston Creek	Detention Facility, retrofit existing facility	$ 2,400,000
W4	North Ewingville Creek	Ralston Creek	Detention Facility, upstream of Stanwick Dr.	$ 800,000
W5	Liberty Creek	Liberty Creek	Detention Facility, 10 ac-ft of storage	$ 1,200,000
W6	Saw Mill Creek	Saw Mill Creek	Detention facility	$ 2,400,000
W7	Donelson Creek	Donelson Creek	Detention facility	$ 4,700,000
W8	Goose Creek	Five Mile Creek	Detention facility, 10 ac-ft storage, retrofit	$ 800,000
			ESTIMATED TOTAL CONSTRUCTION COST =	**$ 14,100,000**

5.0 Summary and Conclusions

The analyses presented in this memorandum include estimates of the potential for pollutant removal at seven previously identified BMP sites across the City. While the original projects were designed primarily to address flooding concerns, relatively minor changes in the outlet configurations of these BMPs may be included to achieve pollutant reductions goals stated in the TMDL. By comparing the total estimated cost of the projects to the estimated pollutant removal, estimates of unit costs and benefits of these projects may be developed.

- Cost per lb of TN removed: $10 per lb per day TN
- Cost per lb of TP removed: $25 per lb per day TP
- Cost per ton of Sediment removed: $0.06 per lb per day Sediment

These unit costs may be used for comparison of other pollutant removal strategies being considered as part of the Integrated Water Resources Plan to determine the most cost effective water quality improvement strategies.

6.0 References

Center for Watershed Protection (September 2007). National Pollutant Removal Performance Database, Version 3.0. Retrieved from: http://www.stormwaterok.net/CWP%20Documents/CWP-07%20Natl%20Pollutant%20Removal%20Perform%20Database.pdf