Coon Creek Water Quality Report

Wenck File #
1239-26

Prepared for:

COON CREEK WATERSHED DISTRICT
12301 Central Avenue Northeast, Suite 100
Blaine, Minnesota 55434

Prepared by:

WENCK ASSOCIATES, INC.
1800 Pioneer Creek Center
P.O. Box 249
Maple Plain, Minnesota 55359-0249
(763) 479-4200

June 2007

Wenck

Table of Contents

Table of Contents (Cont.)

1.0 Introduction

1.1 NPDES PHASE II AND NONDEGRADATION REGULATIONS

Municipal Separate Stormwater Systems (MS4s) in urbanized areas as defined by the 2000 Census are required to obtain a NPDES/SDS stormwater permit. An "urbanized area" is defined as a land area comprising one or more places ("central places") and the adjacent densely settled surrounding area ("urban fringe") that together have a residential population of at least 50,000 and a density of at least 1,000 people per square mile. The definition also includes any other public storm sewer system located fully or partially within an urbanized area.

MS4s are required to develop and implement a stormwater pollution prevention program (SWPPP) to reduce the discharge of pollutants from their storm sewer system to the maximum extent practicable. The SWPPP must cover six minimum control measures:

- Public education and outreach;
- Public participation/involvement;
- Illicit discharge, detection and elimination;
- Construction site runoff control;
- Post-construction site runoff control; and
- Pollution prevention/good housekeeping.

The MS4 must identify best management practices (BMPs) and measurable goals associated with each minimum control measure. An annual report on the implementation of the SWPPP must be submitted each year.

In addition, the Minnesota NPDES General Stormwater Permit has been revised to meet the requirements of a May 2003 Minnesota Court of Appeals decision in which the court required the MPCA to address nondegradation for all waters, and provide opportunity for public review of the SWPPP. This means that a group of 30 selected MS4s must provide a study to determine if there are new or expanded significant dischargers, and then to determine reasonable measures they can take to keep pollutant loading of receiving waters at levels no greater than 1988. This study, called a Nondegradation Report, must show that either the selected MS4 has not seen a significant increase in stormwater runoff and pollutant loading since 1988, or will demonstrate what past, present and future best management practices (BMPs) will be reasonably required to return stormwater runoff to 1988 levels.

One component of the Nondegradation Report is a load assessment modeling effort. An appropriate model will be used to show the relative change in the stormwater runoff volume, phosphorous levels, and levels of total suspended solids that appeared in 1988, compared to the present period, and the expectation for runoff in 2020.

1.2 PURPOSE

The Coon Creek Watershed District Comprehensive Plan states that it is the intent of the District to pursue and fulfill the following water quality objectives:

- to minimize public capital expenditures needed to correct flooding and water quality problems;
- to identify and plan for means to effectively protect and improve surface and groundwater quality;
- to secure the other benefits associated with the proper management of surface and groundwater; and
- to protect and enhance the water quality in watercourses or water basins.

The CCWD has identified five goals for the management of water quality in the District. (Figure 1 shows a map of the District.) Those goals are:

1. To control and minimize pollution caused by erosion and sedimentation
2. To reduce siltation to, and the pollution of, water bodies and streams
3. To preserve and improve the quality of the lakes and wetlands within the watershed
4. Improve the quality of the surface and subsurface discharges to the lakes and wetlands within the watershed by limiting nutrients and other contaminants
5. Reduce the amount of accumulated in-place nutrients contained in Crooked Lake.

To accomplish these goals the District employs a two-pronged approach that includes both a monitoring program and a land management program.

The purpose of establishing water quality goals is to provide targets or endpoints that protect the water resources and their benefits. The benefits that need protection can include recreation, habitat, flood control, and aesthetics. Goals should include State and local regulations including TMDL limits and NPDES nondegradation limits.

To help accomplish these goals, the District evaluated current water quality conditions to establish a baseline for future evaluations. This process included both a detailed analysis of available water quality data and the development of a P8 water quality model. The evaluation is intended to identify where water quality stands in terms of the identified goals including data gaps, and what factors are controlling water quality in the watershed. Additionally, the model provides a necessary tool for addressing current regulations such as NPDES Phase II or TMDLs that may be established in the future. The goal of the plan is to provide a process for meeting water quality objectives in the watershed and tracking progress toward meeting those objectives.

1.3 OBJECTIVES

With increased scrutiny of stormwater quality by regulatory agencies, there is a need to develop an action plan for addressing stormwater quality on a watershed basis. The water quality plan provides a “road map” for managing the quality of water resources and tracking the effectiveness of implemented actions. The plan provides a process for reaching established watershed goals, meeting local and State regulations, and tracking the effectiveness of implemented actions. The ultimate goal is to streamline both watershed and local activities addressing stormwater quality into an efficient and effective process that minimizes duplication of efforts.

The objectives of the water quality plan are:

1. Evaluate current water quality conditions in the Coon Creek Watershed

2. Develop a plan for tracking and achieving water quality goals

3. Streamline water quality regulation requirements including TMDLs and NPDES Phase II

2.0 Watershed Conditions

2.1 WETLANDS AND WATER BODIES

Wetlands are an important water resource in the Coon Creek Watershed District. To quantify the extent of wetland area in the CCWD, the National Wetland Inventory (NWI) maps were overlayed on the current land use. These data represent the best data available for wetland coverage in the District. The wetland areas were assumed to remain the same for each time period. Although some of the wetlands may have been filled or altered, this approach is consistent with the Wetlands Conservation Act (WCA), which requires a 2 to 1 replacement of filled wetlands.

2.2 LAND USE AND LAND COVER

Land use data was collected from the Metropolitan Council and the Cities of Andover, Blaine, Coon Rapids, and Ham Lake. However, each of the key time periods and data sets had different land use categories. These data were combined into a representative group of categories for years 1990, 2000, and 2020 (Table 2.1 and Figures 2, 3 and 4). (Individual city land use data is presented in Appendix A.) 1990 data was selected as a surrogate for 1988 because land use data was readily available for 1990 and not 1988. Little change occurred in the District between 1988 and 1990. In the 1990 coverage, agriculture and vacant lands were not uniquely identified. Since the conversion of agricultural land to developed land has significantly different implications, it was assumed the agricultural land in 2000 was also agriculture in 1990 and converted the land use accordingly. The Metropolitan Council's coverage also included a mixed-use category that was dissected using City data into the appropriate category such as commercial or single family residential. The resultant coverages are the best estimate of land use for the three critical time periods including 1990, 2000 (present) and 2020 (future).

Table 2.1. Aggregated land use categories for the Coon Creek Watershed District

Land Use Categories	1990 Land Use	2000 Land Use	2020 Planned Land Use
Agricultural	2000 Agricultural [1]	Agricultural	Agricultural, 2000 Agricultural [1]
Airport	Airport	Airport	Airport
Commercial	Commercial	Retail and Other Commercial, Office, Mixed Use	Commercial
Industrial	Industrial	Industrial	Industrial
Major Highway	Major Highway	Major Highway	Roadway
Multi-Family Residential	Multi-Family Residential	Single Family Attached, Multi-Family	Multi-Family Residential
NWI Wetlands	All Classes	All Classes	All Classes
Open Water	Open Water	Water	Open Water
Parks and Recreation	Parks and Recreation	Golf Course and Parks and Recreation	Parks and Recreation, Mixed Use
Public/Semi Public	Public/Semi Public	Institutional	Institutional
Railway	None	Railway	Railway
Single Family Residential	Single Family Residential, Farmstead	Farmstead, Seasonal/ Vacation, Single Family Detached, Manufactured Housing Park	Single Family Residential
Vacant	Vacant/Agricultural	Undeveloped (Includes Ag and Vacant)	Vacant, Open Space
Various	NA	NA	Mixed Use [2]
Various	NA	NA	Rural Residential [2]

Notes:

1	For 1990 and 2020 Land Use, the 2000 agriculture class updated into the undeveloped, vacant or rural residential.
2	The mixed use category that was defined as SFR, MFR, COM, or IND in 2000 coverage were changed to 2000 classifications. The rural residential category that was defined as AG, SFR, MFR, COM, or IND in 2000 coverage were changed to 2000 classification. Where available, the 2020 coverage was updated with City future land use.
3	Overlayed the NWI and classified the 1990, 2000 and 2020 landuse as NWI Wetland.

Results of the land use assessment are presented in Table 2.2. Development occurring in the District will convert approximately 1,540 acres of agricultural land and 11,451 acres of vacant land to a mix of commercial, multifamily, and single family residential.

Table 2.2. Land use in the Coon Creek Watershed District for 1990, 2000, and 2020.

Land Use Category	1990 Land Use (Acres)	2000 Land Use (Acres)	2020 Land Use (Acres)
Agricultural	6,482	6,234	4,942
Airport	730	720	699
Commercial	695	948	2,566
Industrial	558	790	893
Major Highway	534	604	854
Multi-Family Residential	429	971	1,880
NWI Wetlands (Types 1,2,6,7,8)	8,635	8,635	8,635
NWI Wetlands (Types 3,4,5)	7,108	7,108	7,108
Open Water	234	234	234
Parks and Recreation	3,683	4,532	4,376
Public/Semi Public	706	914	1,091
Railway	202	202	202
Single Family Residential	10,313	13,714	18,277
Vacant/ Rural Residential	17,622	12,322	6,171
TOTAL	57,929	57,929	57,929

2.3 IMPERVIOUSNESS

To assess the imperviousness in the District, assumed percent imperviousness from literature and LANDSAT imagery were assessed (Table 2.3; Figures 5 and 6). The percent impervious values were selected based on knowledge of the area and to provide a conservative approach. The largest differences between the literature values and LANDSAT data were observed in the multifamily and public semi-public land use. These values were adjusted based on measured imperviousness conducted by the Cities of Blaine and Andover (Jim Hafner pers. comm.; Dave Berkowitz pers. comm.). Blaine used aerial photo interpretation to evaluate imperviousness for public and semipublic land uses. Results found the impervious fraction ranged from 5 to 55%. However, most were 30% impervious or less. Andover also measured churches and high schools at 33% and 23% impervious respectively. Multifamily in Andover was measured at an average of 35%.

Table 2.3. Impervious fractions by land use from literature, LANDSAT analysis, and those fractions used in this study.

Land Use	LANDSAT Impervious Fractions	Literature Impervious Fractions	Selected Impervious Fractions
Agricultural	16	3	5
Airport	33	30	20
Commercial	65	85	75
Industrial	63	75	70
Major Highway	50	50	50
Multi-Family Residential	39	65	40
Parks and Recreation	14	2	5
Public/Semi Public	40	5	30
Railway	30		35
Single Family Residential	24	30	25
Vacant/Rural Residential	13	3	5

3.0 WATER QUALITY RULES AND BMPS

3.1 COON CREEK WATERSHED DISTRICT RULES

The District's regulatory program was formally established in 1988. Since that time, a stormwater management plan is required for projects that create 1 acre or greater of impervious surface. Among other requirements, the plan must satisfy certain rate control and water quality standards.

3.1.1 Rate Control

On-site detention for rate control is required to maintain predevelopment rates of runoff for the 25- or the 100-year storm event. The predevelopment runoff rate from the 25-year storm event is the standard in areas identified as having "drainage sensitive uses" (all drainage areas upstream of agricultural or a land use sensitive to flooding like a golf course). The predevelopment runoff rate from the 100-year storm event is the standard for all other areas. No volume control is required.

3.1.2 Water Quality Treatment

The type of downstream receiving body determines the level of water quality treatment required for development. Areas that discharge to Type 1, 2, 6, or 7 wetlands and ditches must provide treatment for the runoff from a 0.5-inch storm and include skimming of floatable materials. Areas draining to Type 3, 4, or 5 wetlands and lakes must meet National Urban Runoff Program (NURP) design requirements and include skimming of floatable materials. For this study, downstream receiving bodies were identified by observation using NWI and aerial photos.

Many subwatersheds in the District drain to Type 1, 2, 6, and 7 wetlands or ditches and are subject to drainage sensitive uses runoff rate control. Stormwater ponds in these subwatersheds are typically constructed with a larger permanent pool than required because a larger flood pool volume is needed to satisfy the drainage sensitive uses criteria. Therefore, the combination of these two requirements indirectly results in greater water quality treatment than required for a subwatershed discharging to a Type 1, 2, 6, or 7 wetland or ditch.

3.1.3 Treatment Device Quantification

The most common treatment device throughout the District is a stormwater pond. Therefore, three subwatersheds were chosen to determine the removal efficiency of stormwater ponds designed to the required rate control and water quality standards. A P8 model was built to include all stormwater ponds within each of the three subwatersheds. (The P8 modeling software is described below.) Drainage areas, outlet devices, and permanent and flood pool volumes were obtained from plans submitted to the District when the development was permitted. Table 3.1 lists the results of the evaluation. (Refer to Appendix B for a summary of the test subwatershed analysis.)

Table 3.1. Results of average stormwater pond performance in three subwatersheds.

Rate Control Standard	Water Quality Standard	% TSS Removal	% TP Removal
Drainage sensitive uses	NURP standards	85	50
No drainage sensitive uses	NURP standards	85	50
Drainage sensitive uses	0.5-inch standard	65	40
No drainage sensitive uses	0.5-inch standard	45	20

3.1.4 Application of Rules

Because District stormwater management rules became effective in 1988, it was assumed that water quality treatment from stormwater ponds did not occur prior to 1990. From 1990 to 2020, though, all development is subject to District rules and thus, the above removal efficiencies were applied.

3.2 STREET SWEEPING AND SUMP MANHOLES

Street sweeping aims to control urban runoff pollution at one of the major source areas – streets. The ultimate sources of nutrients and TSS in urban watersheds are actually poorly understood. Soil erosion, leaf litter, grass clippings, lawn fertilizers, pet waste, air pollution and other sources all contribute to urban runoff pollution. Many of these urban sources accumulate on streets and can therefore be controlled to some degree. Consequently, Cities put a significant amount of money and resources into reducing pollutant build-up and wash off from roads. The most direct efforts include street sweeping to remove pollutants from the road surface. Another BMP used is the inclusion of sump manholes to collect the pollutants and prevent them from entering local surface waters. These practices are critical for maintaining urban lakes by preventing the build-up of nutrient rich organic material in lake sediments that can ultimately lead to internal nutrient loads and changed oxygen dynamics.

The cities within the District (except Columbus) have street sweeping and vacuuming programs to remove accumulated sediment from streets and sump manholes/catch basins. Each city reported the amount of material removed from streets and sumps in 2006 (Tables 3.2 and 3.3). The annual removal of TSS was allocated among the subwatersheds based on the impervious acres in that subwatershed. This assumes that the subwatersheds with more impervious acres had more road surface that was swept. The current frequency of sweeping and vacuuming occurs approximately three times per year (spring, summer and fall) with summer sweeping occurring as needed or when City staff have time. Sweeping and vacuuming data reported for leaf removal was not included in the removal volumes or loads since leaves are not considered sediment.

Table 3.2. 2006 sweeping data.

City	Total Swept (CY)	Total Swept[1] (lb)	Impervious Area in District (ac)	Total Swept (lb/impervious acre)	% Of City in the District	Total Swept in the District (lb)
Andover	1,140	3,385,800	1,092	3,101	45.1	1,526,996
Blaine	2,160	6,415,200	1,769	3,627	54.4	3,489,869
Columbus	0	0	149	0	24.7	0
Coon Rapids	1,734	5,149,980	2,062	2,498	65.5	3,373,237
Ham Lake	500	1,485,000	1,931	769	91.6	1,360,260
Total	5,534	16,435,980	7,003	--	--	9,750,362

[1]Assumes there are 1.485 tons material per cubic yard of material (Coduto, Donald. *Geotechnical Engineering*. Prentice Hall. 1999).

Table 3.3. 2006 sump manhole vacuuming data.

City	Total Vacuumed (CY)	Total Vacuumed[1] (lb)	Impervious Area in District (ac)	% Of City in the District	Total Vacuumed in the District (lb)
Andover	130	386,100	1,092	45.1	174,131
Blaine	120	356,400	1,769	54.4	193,882
Columbus	0	0	149	24.7	0
Coon Rapids	0	0	2,062	65.5	0
Ham Lake	100	297,000	1,931	91.6	272,052
Total	350	1,039,500	7,003	--	640,065

[1]Assumes there are 1.485 tons material per cubic yard of material (Coduto).

These data represent the gross amount of material picked up from streets as a result of the sweeping and vacuuming sump manholes. However, only a fraction of this load contributes to the TSS measured at the end of pipe. This is not to say that street sweeping and vacuuming of sump manholes are ineffective. Rather, sweeping and vacuuming can have a large influence on water quality since much of the larger material can be bed load that reduces the effectiveness of current stormwater treatment devices by quickly filling them in. Additionally, the organic fraction of the gross load can contribute to nutrient enrichment of lake and wetland sediments as well as change the oxygen dynamics of the receiving water.

The goal of this study, however, is to assess the fraction of the gross load removed that would contribute to TSS loads. To accomplish this comparison, particle size distributions of sump and swept materials were measured by the City of Andover (Appendix C). Approximately 15% of the gross street sweepings were particles smaller than 120 microns in size (Table 3.4). This corresponds to the P8 NURP50 particle distribution, which includes 120-micron particles and smaller.

Table 3.4 Fraction of samples collected of street sweeping and vacuumed material for each P8 particle class.

Particle Size	% of Sample			Average
	Sample 1	Sample 2	Sample 3	
< 120 micron	12	15	18	15

The TP content of the removed material was based on a proportion of 215 mg TP per kg of sediment reported by the City of Andover (11% of the sample). The relationship of 3,850 mg/kg (4% of the sample) was maintained for the smaller particles to remain consistent with the P8 model. Like TSS, the annual removal of TP was allocated among the watersheds based on the impervious acres in that subwatershed assuming that the subwatersheds with more impervious acres had more road surface that were swept.

Results of the street sweeping and sump vacuuming assessment suggest that although more than 10 million tons of material are removed from the road surfaces and sump manholes only approximately 1.5 million pounds are removed that would contribute to TSS in the receiving water (Table 3.5). Approximately, 1,850 pounds of phosphorous associated with that fraction are removed. However, a much greater amount of phosphorus is removed with the gross load (~6,000 pounds). Removal of this phosphorus load is critical in reducing phosphorus release from water resources. For example, long-term phosphorus loading to a lake in the form of gross organic material can lead to increased internal loading and eutrophication. This assessment represents a conservative approach to determining compliance with nondegradation requirements.

Table3.5. TSS removal from 2006 sweeping and vacuuming data.

City	Total Swept in District (lb)	Total Vacuumed in District (lb)	TSS Removed by Sweeping (lb)[1]	TSS Removed by Vacuuming (lb)[1]	TP Removed by Sweeping (lb)[2]	TP Removed by Vacuuming (lb)[2]
Andover	1,526,996	174,131	229,049	26,120	271	31
Blaine	3,489,869	193,882	523,480	29,082	620	34
Columbus	0	0	0	0	0	0
Coon Rapids	3,373,237	0	505,986	0	599	0
Ham Lake	1,360,260	272,052	204,039	40,808	242	48
Total	9,750,362	640,065	1,462,554	96,010	1,732	114

[1] 15% of total swept and vacuumed

[2] 11% of total swept and vacuumed with a concentration of 215 mg TP per kg and 4% of total swept and vacuumed with a concentration of 3,850 mg TP per kg

4.0 WATER QUALITY MODELING

P8 is an industry standard water quality model developed to assess pollutant loading in urban watersheds. P8 was developed using NURP data and provides loading estimates based on data collected as a part of the NURP program. P8 was designed to assess the effectiveness of BMP implementation in reducing runoff loads from impervious surfaces and provides a tool for evaluating other nonstructural practices such as street sweeping. The model requires two key pieces of information: the drainage area percent impervious and the pervious curve number.

4.1 MODEL CONSTRUCTION

4.1.1 Model organization

The Coon Creek Watershed District maintains an XP-SWMM for the entire watershed for planning purposes. As a part of this modeling effort, the District has already assessed drainage patterns in the district and delineated the watershed into 285 subwatersheds. To remain consistent with other District models, these subwatersheds were used for the P8 model (Figure 7).

4.1.2 Model inputs

Imperviousness was input into the model based on data described in Section 2.3.

The second key piece of information for the P8 model is a curve number for the pervious areas in the model. The SCS curve number reflects an area-weighted average of the pervious areas considering soil types, land use and hydrologic groups. All pervious, undeveloped areas were assigned a curve number of 60. All pervious, developed areas were assigned a curve number of 74. Curve number selection is discussed further in the model verification section.

Other model inputs are the particle, precipitation and temperature files. As discussed below in the model validation section, monitoring data indicated that the NURP50 particle file was appropriate for TSS and TP loading. The precipitation file consists of hourly data from Minneapolis-St. Paul International Airport. This was the closest location to the District that had hourly precipitation data available. Temperature files were created for the model by averaging daily maximum and minimum temperatures obtained from the Cedar weather station in Anoka County. All models were run for the same 10-year period (1993 to 2002) with 5 passes through the precipitation file.

4.1.3 Incorporating Developed and Undeveloped Land into the Loading Assessment

A critical component in using the model output to complete the loading assessment was to accurately account for pollutant loading from land that developed before District rules and from undeveloped land that remains in 2000 and 2020. It was assumed that runoff from land that developed before District rules received no treatment from stormwater ponds. Therefore, this portion of the overall load in the 1990 condition remained constant through 2000 and 2020 conditions. Similarly, it was assumed that runoff from undeveloped land in 2000 and 2020 was not routed to stormwater ponds for treatment.

The loading assessment accounted for these situations by calculating the loading from undeveloped land in 1990, 2000, and 2020. The TSS and TP runoff loads were calculated by first determining the amount of undeveloped land within each subwatershed and then calculating the load based on loading rates of 40 lb/ac for TSS and 0.1 lb/ac for TP (discussed within Section 4.2). The difference between the modeled load and the undeveloped load yielded the developed load for 1990. This load was carried through all calculations for 2000 and 2020.

Additionally, the undeveloped loads calculated for each subwatershed in 2000 and 2020 were subtracted from the modeled load so as to not over-count for treatment within the stormwater ponds. In the end, the only runoff for which treatment was taken credit from stormwater ponds was from land that had developed since 1990.

As an example, Subwatershed 3703 (one of the test subwatersheds) is located in a drainage sensitive uses area and drains to Type 1 and 2 wetlands and Anoka County Ditch 37. Therefore, District rules require a permanent pool sized for the runoff from a 0.5-inch storm and live storage sufficient to discharge the proposed 100-year runoff at the 25-year existing runoff rate. As discussed earlier, this situation results in TSS and TP removal throughout the subwatershed at approximately 65 and 40%, respectively. The total area of Subwatershed 3703 is approximately 417.3 acres. Table 4.1 uses Subwatershed 3703 as an example of the calculations discussed in this section.

Table 4.1. Summary of total suspended solids loading calculations for Subwatershed 3703.

Year	Undeveloped Area (ac)	Undeveloped Load (lb/yr)	Total P8 Load (lb/yr)	Pre-1990 Developed Load (lb/yr)	Untreated Load (lb/yr)	Treated Load (lb/yr)	Load Removed by Rules (lb/yr)
1990	400.7	16,028	17,009	981	17,009	0	0
2000	326.1	13,044	28,906	981	14,025	14,881	9,672
2020	77.9	3,116	72,665	981	4,097	68,568	44,569

Based on the amount of undeveloped land (400.7 acres) and an undeveloped land TSS loading rate of 40 lb/ac, the total load from undeveloped land in 1990 is 16,028 lb/yr. The total load for the subwatershed includes both undeveloped and developed land. The predicted total load from the P8 model is 17,009 lb/yr. Therefore, the difference between the two loading rates yields the loading rate from developed land in 1990 (981 lb/yr). Because District rules were not in effect in 1990, the total load (17,009 lb/yr) is untreated and there is no load removed by the rules.

In 2000, the amount of undeveloped land decreased to 326.1 acres. Again, based on an undeveloped loading rate of 40 lb/ac, this undeveloped area corresponds to a load of 13,044 lb/yr. The total load predicted by the P8 model is 28, 906 lb/yr, and the developed load from 1990 is maintained at 981 lb/yr. Therefore, the untreated load is the sum of the undeveloped and Pre-1990 loads (13,044 lb/yr and 981 lb/yr), and the treated load is the difference between the total P8 load and the untreated load (14,881 lb/yr). Finally, the load removed by pond treatment (9,672 lb/yr) is calculated by multiplying the treated load (14,881 lb/yr) by the TSS removal efficiency (65%).

The untreated, treated and pond removal loads were calculated in the same manner for the year 2020. Note that the Pre-1990 developed load remains the same for that area that developed prior to District rules and that the untreated load decreased dramatically because of the reduction in undeveloped land.

A similar methodology was followed for TP, and the results are presented in Table 4.2. The complete load assessment data for TSS and TP and 1990, 2000, and 2020 are presented in Appendix D.

Table 4.2. Summary of total phosphorus loading calculations for Subwatershed 3703.

Year	Undeveloped Area (ac)	Undeveloped Load (lb/yr)	Total P8 Load (lb/yr)	Pre-1990 Developed Load (lb/yr)	Untreated Load (lb/yr)	Treated Load (lb/yr)	Load Removed by Rules (lb/yr)
1990	400.7	40	60	20	60	0	0
2000	326.1	33	99	20	53	46	19
2020	77.9	8	242	20	28	214	86

4.2 MODEL ASSUMPTIONS AND VALIDATION

One of the critical aspects of using P8 is to analyze the change in loading that occurs as land is converted from open or agriculture to developed land. To test how P8 calculates loading from open space, a test watershed (100 acres) was run for an average precipitation year (Table 4.3). Curve numbers in the model for open space and agriculture typically ranged from 60 to 75. Because of the low annual runoff (<1.9 inches), the loading rates for open land with these curve numbers is very low. This may be artificially lowering the runoff from these areas, especially if the current land use is agriculture. However, to maintain a conservative approach, these numbers were maintained in the model.

Table 4.3. Runoff and loading by curve number from a test watershed in P8 (29 in. of precipitation).

Curve Number	Runoff (in)	TSS load (lbs./ac/yr)	TSS (ppm)	TP load (lbs./ac/yr)	TP (ppm)
50	0.3	0.7	12	0.01	0.127
55	0.5	2	17	0.01	0.138
60	0.7	4	22	0.02	0.150
65	1.0	7	29	0.04	0.167
70	1.4	13	40	0.06	0.193

Curve Number	Runoff (in)	TSS load (lbs./ac/yr)	TSS (ppm)	TP load (lbs./ac/yr)	TP (ppm)
75	1.9	24	55	0.10	0.226
80	2.7	44	71	0.16	0.263
85	4.0	82	89	0.28	0.305
90	6.3	163	114	0.52	0.363
95	11.0	366	148	1.09	0.440
Imp. (NURP 50)	26.1	649	110	2.09	0.354
Imp. (NURP 90)	26.1	1947	330	4.43	0.750

To validate the model, results were compared to stream data collected as a part of the Watershed Outlet Monitoring Program (WOMP). For the WOMP data, monitoring results from 1998 were selected because the annual precipitation total was close to average. Because the P8 model is a watershed runoff model, base flow was removed from the 1998 watershed monitoring data to develop an estimate of watershed runoff. Results indicate that the model slightly over predicted runoff for 1998, predicting an additional 0.9 inches of runoff from the watershed (Table 4.4). These results were considered reasonable for predicting changes between the identified time periods.

Table 4.4. Volume comparison of 1990 and 2000 land use for 1998 precipitation and monitored data.

	1990 Land Use	2000 Land Use	Monitored
% Impervious	11	14	NA
Precipitation (in)	30.8	30.8	32.4
Runoff Volume (acre-feet)	17,572	20,931	17,850*
Runoff Depth (in)	4.8	5.8	4.9

*Data calculated from WOMP station for entire watershed excluding base flow

Because the model is not calibrated and is used only for comparison purposes, it is useful to test the sensitivity of model to selected inputs, especially as we compare model results to real-world measured removals. However, because the model does not account for receiving water processes, it is not appropriate to compare monitoring loads to land surface loads. Instead, runoff depth and loading rates were compared for each land use to determine reasonableness of the loading factors (Table 4.5). To accomplish this assessment, model output from watersheds in the Coon Creek Watershed District with a predominant land use were compiled for the primary land use classes in this study. None of the subwatersheds were predominantly commercial, so a watershed that was commercial and major highway was used in the assessment.

A parameter that may affect the results of the model is the selection of the particle file. The particle files typically used in P8 represent either median NURP study concentrations (NURP50; 100 ppm TSS) or the 90th percentile concentrations (NURP90; 300 ppm TSS). Comparison of the loading rates for the two files demonstrates that NURP90 loading rates would be extremely high – with TP loadings from industrial areas at almost 5 pounds per acre. Based on this comparison, the NURP50 particle distribution was selected as the best representation of land loading in the Coon Creek watershed.

Table 4.5. Land use loading rates based on P8 model results in the Coon Creek watershed.

Primary Land Use	Land Use Impervious %	Pervious CN	Area (ac)	Runoff Depth (in./yr)	NURP 50 TSS (lbs/ac/ year)	NURP 90 TSS (lbs/ac/ year)	NURP 50 TP (lbs/ac/ year)	NURP 90 TP (lbs/ac/ year)
Agriculture	5	74	19.0	3.2	64	191	0.2	0.5
Rural Residential	5	60	4.8	2.0	40	119	0.1	0.3
Single Family Residential	25	74	32.1	8.7	203	610	0.7	1.4
Parks	5	60	20.6	2.0	40	120	0.1	0.3
Commercial	75	74	7.7	17.1	417	1252	1.3	2.9
Major Highway	50	74						
Vacant	5	60	4.8	2.0	40	119	0.1	0.3
Industrial	70	74	65.4	20.2	689	2066	2.2	4.7

5.0 MODEL RESULTS

5.1 ADEQUACY OF STORMWATER MANAGEMENT RULES AND BMPS

Changes to impervious area, volume, TSS, and TP for the District between 1990, 2000, and 2020 are presented in Table 5.1. The P8 model was executed for a ten-year period (1993-2002) to obtain an average year value.

Between 1990 and 2000 the District added approximately 1,304 impervious acres resulting in an increased discharge of 3,174 acre-feet of water. The increased discharge includes an additional 886,386 pounds of TSS and 2,901 pounds of total phosphorus. Between 1990 and 2020 the District is expected to add approximately 3,935 impervious acres resulting in an increased discharge of 10,153 acre-feet of water. The increased volume includes 2.8 million pounds of TSS and 9,295 pounds of total phosphorus.

Table 5.1. Predicted runoff volumes and loads from the Coon Creek Watershed District based on past, present and future land use data.

	1990 Land Use	2000 Land Use	2020 Land Use
% Impervious	11	14	19
Volume (ac-ft/yr)	17,689	20,863	27,842
TSS (lb/yr)	4,358,286	5,244,673	7,199,292
TP (lb/yr)	14,827	17,729	24,122

5.2 VOLUME

Predicted volume increases for each city within the District are presented in Table 5.2. Although there is potential for increased loss through evaporation from constructed ponds, no BMPs or losses have been quantified for this study. However, calculations to approximate this loss indicate that it is likely incidental to the magnitude of the overall volume increase. The largest increases in volume are expected to occur in Andover, Blaine and Ham Lake due to the larger increases in imperviousness.

Table 5.2. Predicted runoff volume increase for each city within the Coon Creek Watershed District.

City	1990 (ac-ft)	2000 (ac-ft)	2020 (ac-ft)	2000 Increase from 1990 (ac-ft)	2020 Increase from 2000 (ac-ft)
Andover	2,849	3,380	4,956	531	1,576
Blaine	4,385	5,157	7,494	772	2,337
Columbus	594	596	827	2	231
Coon Rapids	4,793	5,618	6,482	824	864
Ham Lake	5,068	6,112	8,083	1,044	1,971
Total	17,689	20,863	27,842	3,173	6,979

5.3 TSS LOADING

The total predicted increase in TSS loading throughout the watershed was compared to removals by active BMPs in each city to assess compliance with nondegradation. The removals are based on city records for street sweeping and sump manhole maintenance, while development removals were based on assumed treatment efficiency achieved by District rules. Sweeping and vacuuming removal rates for 2020 were extrapolated based on the pounds per impervious acre swept in 2006, the increase in impervious surface, and the percentage of each city within the District.

Between 1990 and 2000, BMPs from District development rules removed approximately 84% of the increased TSS load associated with new development (Table 5.3). Removals from both street sweeping and sump manholes provided an additional treatment level that suggests that removals from the watershed are greater than the increase from 1990. Figure 8 indicates the subwatersheds with the greatest increase in TSS load from 1990 to 2000.

Table 5.3. Predicted TSS loads from the Coon Creek Watershed District for the 1990 to 2000 period.

TSS	2000 Land Use
Increase from 1990 (lb/yr)	886,386
Removal by Dev. Rules (lb/yr)	748,632
Sweeping Removal (lb/yr)	1,462,554
Vacuuming Removal (lb/yr)	96,010
Net Removal versus Increase (lb/yr)	-1,420,809

For future conditions, Watershed District rules alone will be sufficient to prevent increased TSS loading as a result of new development (Table 5.4). Treatment will account for slightly more than the increase. The extra treatment is a result of currently untreated discharge being routed through a treatment device after development. Figure 9 indicates the subwatersheds with the greatest increase in TSS load from 2000 to 2020.

Table 5.4. Predicted TSS loads from the Coon Creek Watershed District for the 2000 to 2020 period.

TSS	2020 Land Use
Increase from 2000 (lb/yr)	1,954,619
Removal by Dev. Rules (lb/yr)	2,304,002
Sweeping Removal (lb/yr)	2,030,561
Vacuuming Removal (lb/yr)	134,414
Net Removal versus Increase (lb/yr)	-2,514,358

Predicted increases in TSS were also assessed by municipal boundary in the Coon Creek Watershed District. For the 1990 to 2000 period, Table 5.5 indicates that each of the Cites had greater removals than increases except for Columbus.

Table 5.5. Predicted TSS loads from each city based for the 1990 to 2000 period.

	Increase From 1990 (lb/yr)	TSS Removal (lb/yr)			Net Removal (-) vs. Net Increase (+) (lb/yr)
		Development Rules	Sweeping	Vacuuming	
Andover	146,474	135,501	229,049	26,120	-244,196
Blaine	216,212	204,664	523,480	29,082	-541,015
Columbus	444	146		0	+298
Coon Rapids	233,634	146,748	505,986	0	-419,099
Ham Lake	289,622	261,572	204,039	40,808	-216,797
Total	886,386	748,632	1,462,554	96,010	-1,420,809

As development moves forward, District rules appear to be sufficient to prevent TSS increases within each city except for Columbus (Table 5.6). Because the impervious area increase in the City of Columbus is so small, the rules may be sufficient but within the uncertainty in the model.

Table 5.6. Predicted TSS loads from each city based for the 2000 to 2020 period.

	Increase From 2000 (lb/yr)	TSS Removal (lb/yr)			Net Removal (-) vs. Net Increase (+) (lb/yr)
		Development Rules	Sweeping	Vacuuming	
Andover	442,953	504,144	354,673	36,568	-452,431
Blaine	659,886	772,611	812,754	40,715	-966,194
Columbus	60,940	48,905	0	0	+12,035
Coon Rapids	243,325	280,790	591,579	0	-629,045
Ham Lake	547,516	697,552	271,555	57,131	-478,722
Total	1,954,619	2,304,002	2,030,561	134,414	-2,514,357

5.4 TP LOADING

The total predicted increase in TP loading throughout the watershed was compared to removals by active BMPs in the watershed to assess compliance with nondegradation. Tables 5.7 and 5.8 indicate that the nondegradation standard is satisfied for present and future conditions.

The removals are based on city records for street sweeping and sump manhole maintenance, while development removals were based on assumed treatment efficiency achieved by District rules (see Section 3). Based on the modeling results, District rules removed less than one-half of the increased loads while street sweeping and sump manholes removed slightly more than half of the increase. Figure 10 indicates the subwatersheds with the greatest increase in TP load from 1990 to 2000.

Table 5.7. Predicted TP loads from the Coon Creek Watershed District based for the 1990 to 2000 period.

TP	2000 Land Use
Increase from 1990 (lb/yr)	2,901
Removal by Dev. Rules (lb/yr)	1,388
Sweeping Removal (lb/yr)	1,732
Vacuuming Removal (lb/yr)	114
Net Removal versus Increase (lb/yr)	-333

From 2000 to 2020, the calculations indicate that nondegredation is satisfied as BMP implementation (rules, sweeping and vacuuming) removes an excess of 447 pounds of TP (Table 5.8). District rules play a critical role in the removals moving forward removing approximately two-thirds of the increased load. Assuming that sweeping and vacuuming practices remain the same, another two-fifths of the increased load will be removed. Figure 11 indicates the subwatersheds with the greatest increase in TP load from 2000 to 2020.

Table 5.8. Predicted TP loads from the Coon Creek Watershed District based for the 2000 to 2020 period.

TP	2020 Land Use
Increase from 2000 (lb/yr)	6,393
Removal by Development Rules (lb/yr)	4,276
Sweeping Removal (lb/yr)	2,405
Vacuuming Removal (lb/yr)	159
Net Removal versus Increase (lb/yr)	-447

Assessment of the load increases by municipal boundary indicates that Ham Lake accounted for the majority of the increase from 1990 to 2000 (Table 5.9). The increase is likely a result of less active street sweeping and sump manhole programs compared to Andover, Blaine and Coon Rapids.

Table 5.9. Predicted TP loads from each city based for the 1990 to 2000 period.

	Increase from 1990 (lb/yr)	TP Removal (lb/yr)			Net Removal (-) vs. Net Increase (+) (lb/yr)
		Development Rules	Sweeping	Vacuuming	
Andover	481	257	271	32	-78
Blaine	707	397	620	34	-345
Columbus	2	0	0	0	+1
Coon Rapids	761	226	599	0	-64
Ham Lake	950	507	242	48	+153
Total	2,901	1,388	1,732	114	-333

For development between 2000 and 2020, the predicted increases are associated with Andover, Ham Lake, and City of Columbus (Table 5.10).

Table 5.10. Predicted TP loads from each city based for the 2000 to 2020 period.

	Increase from 2000 (lb/yr)	TP Removal (lb/yr)			Net Removal (-) vs. Net Increase (+) (lb/yr)
		Development Rules	Sweeping	Vacuuming	
Andover	1,447	959	420	43	+25
Blaine	2,153	1,439	962	48	-296
Columbus	203	102	0	0	+101
Coon Rapids	795	426	701	0	-332
Ham Lake	1,795	1,351	322	68	+55
Total	6,393	4,276	2,405	159	-447

6.0 Conclusions

6.1 RELATIONSHIP TO STORMWATER REGULATIONS

6.1.1 Stormwater Management Planning Requirements

The Metropolitan Surface Water Management Act requires watershed management organizations such as the Coon Creek Watershed District to make and implement a plan to protect and improve surface and groundwater quality. This plan must be consistent with federal and state water resources planning requirements and standards. The Act also requires that these planning efforts "…establish more uniform local policies and official controls for surface and groundwater management."

There is a significant amount of overlap between the various federal, state, regional, and local water management requirements and standards. The federal Clean Water Act requires states to monitor waters and to identify those that do not meet water quality standards as Impaired Waters. As described below, those waters are then required to undergo a Total Maximum Daily Load (TMDL) study, and on completion and approval, those waters must be actively managed to make progress toward meeting those standards.

In addition, the federal National Pollutant Discharge Elimination System (NPDES) Stormwater Program general permit for Minnesota requires permit holders such as cities to reduce the quantity of pollutants reaching public waters. In certain of these cities, the state requires the cities to not only reduce pollutants, but to reduce pollutants and water volumes to at least the levels in place in 1988 so as to avoid further degrading water quality.

With this context, this Water Quality Plan should wherever possible avoid conflict between the various levels of planning and management standards, and attempt to establish more uniform standards.

6.1.2 NPDES Phase II

Three of the four Cities in the District are required to assess their compliance with the state's NPDES Phase II nondegradation requirements, it is in the interest of the Coon Creek Watershed District to consider the role of District rules in achieving and maintaining compliance with nondegradation requirements.

6.1.3 Total Maximum Daily Loads (TMDLs)

Total Maximum Daily Load (TMDL) studies are similar to the nondegradation assessment process except that the endpoints are State standards designed to protect designated beneficial uses of water bodies. MS4s that contribute stormwater to impaired waters will be required to address TMDL wasteload allocations for that water body. If these allocations are more stringent that the 1988 conditions endpoint, the MS4 would need to develop an approach to meet the stricter end point.

Coon Creek is listed for biotic impairment based on a macroinvertebrate index of biotic integrity. A TMDL for a biotic impairment involves a stressor identification study to identify the factors most likely causing the biotic impairment. These factors can be habitat, flow, dissolved oxygen, turbidity, and numerous other water quality conditions.

6.2 MANAGEMENT ALTERNATIVES

6.2.1 Volume

The results of this study indicate an increase in runoff volume on a watershed basis. To address this increase, the District may wish to consider adopting volume management standards. These standards typically result in a reduction of runoff volume, an increase in groundwater recharge, a reduction in TSS and TP load, and likely aid in mimicking pre-development hydrology. Typically, volume reduction is accomplished through surface or underground infiltration practices. However, newer technologies include capturing and holding runoff to be used in irrigation systems or as gray water for bathroom fixtures.

The Minnehaha Creek Watershed District (MCWD) recently completed their 3rd Generation Comprehensive Water Resources Management Plan. A portion of the plan addresses the potential benefit of volume management strategies within certain subwatersheds of the MCWD. The plan indicates that capturing the runoff from a 0.5-inch storm results in a 53% reduction in runoff volume. Similarly, the plan indicates that capturing runoff from the 0.75-inch and 1.0-inch storm events result in volume reductions of 63% and 70%, respectively.

Table 5.2 indicates the increase in runoff volume between 2000 and 2020 is approximately 6,979 acre-feet. Based on the MCWD data, the District could expect a reduction in runoff volume of approximately 3,700 acre-feet if a volume management standard to capture the runoff from a 0.5-inch storm event were enacted.

The volume management standard also serves to reduce future TSS and TP loading in the District. Although this study indicates that nondegredation is satisfied, TMDLs and resource protection may necessitate future reductions in TSS and TP. Assuming an average total phosphorus runoff concentration of 300 ppm, a reduction in runoff volume of 3,700 acre-feet corresponds to approximately 3,000 lb/yr reduction in TP load. Therefore, a 0.5-inch volume reduction standard is beneficial for water quality as well.

Based on this discussion, it is recommended that the District consider amending its rules to include a volume management standard.

6.2.2 Total Suspended Solids

Watershed District rules provide sufficient treatment to reduce TSS loads by 85% or more. These removals combined with street sweeping and sump manholes are sufficient to prevent increased loadings from current conditions. Only 15% of the gross street sweeping removals were of a particle size that would contribute to TSS. However, street sweeping provides many benefits beyond this small TSS removal. Street sweeping removes organic material that can contribute to future phosphorus release from wetlands and lakes and also helps maintain treatment efficiencies in ponds by slowing the sediment accumulation rate.

6.2.3 Total Phosphorus

Watershed District rules were also sufficient for preventing increases in TP loading in the District. Construction of stormwater ponds through District rules and implementation of sweeping and vacuuming programs by the Cities were necessary to control phosphorus loads. Street sweeping removed a gross phosphorus mass of approximately 2,500 pounds with less than half of this associated with the smaller particles of the mass. However, the overall TP mass removed can provide a long-term benefit to water resources.

Additionally, this study did not quantify the effects of the phosphorus fertilizer ban throughout the state of Minnesota. A paired watershed study conducted by the Three Rivers Park District suggests that as much as a 15% reduction can be achieved through this ban. This additional reduction reinforces our findings that the District is compliant with nondegredation for TP.

Street sweeping practices remove some of the TSS and TP load, however mechanical sweepers are considered limited in their effectiveness for affecting TSS and TP in the water column. Data suggests that street sweeping does play an important role in controlling TSS and TP. Increased frequency and newer technologies can especially improve this benefit.