Appendix E

Pollutant Loading Analysis

Appendix E

Pollutant Loading Analysis
North Branch Park River Watershed

Appendix E

Pollutant Loading Analysis
North Branch Park River Watershed

Tables

End of Report

1 Introduction

A pollutant loading analysis was performed for the North Branch Park River watershed in support of the Baseline Watershed Assessment Report to assess the potential for increases in nonpoint source (NPS) pollutant loads. The model was used to compare existing nonpoint source (NPS) pollutant loads from the watershed to projected future pollutant loads under a watershed buildout scenario. The predicted change in pollutant loads in each of the subwatersheds was used as an indicator of their relative vulnerability to future development. The pollutant loading model is used to identify and rank pollution sources, as well as assist in identifying, prioritizing, and evaluating subwatershed pollution control strategies.

2 Model Description

A pollutant loading model was applied to the North Branch Park River watershed using the land use/land cover data described in *Section 7.0* of the Baseline Watershed Assessment Report. The model was used to compare pollutant loadings from the watershed under existing land use conditions to future pollutant loadings under a watershed buildout scenario. It is important to note that the results of this screening-level analysis are intended for the purposes of comparing existing to future conditions and not to predict future water quality.

The Watershed Treatment Model (WTM), Version 3.1, developed by the Center for Watershed Protection, was used for this analysis. This model calculates watershed pollutant loads primarily based on nonpoint source (NPS) runoff from various land uses. The model was also used to estimate pollutant loads from other sources, including:

- Combined Sewer Overflows
- Illicit Discharges
- Septic Systems
- Sanitary Sewer Overflows
- Managed Turf
- Road Sanding

Reductions in future pollutant loads in the watershed can be estimated using a range of treatment measures, such as structural and nonstructural best management practices, that are included in the WTM.

Other similar screening-level pollutant loading models were considered for use in development of a watershed management plan for the North Branch Park River, including the Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), the Generalized Watershed Loading Function (GWLF) model, and other similar models. While STEPL was identified as a suitable choice for the North Branch Park River, it was determined that the WTM is better suited for modeling bacterial loads and provides a larger suite of best management practices for urban areas. The ArcView GIS version of the GWLF model was also considered for use in the evaluation, although the AVGWLF model has limited capability for modeling CSOs when using the urban runoff module RUNQUAL within the GWLF model. Again, the WTM model was determined to be better suited for modeling CSOs than the AVGWLF model.

The pollutants modeled in this analysis are the default pollutants contained in the WTM model: total phosphorus, total nitrogen, total suspended solids, and total fecal coliform bacteria. These pollutants are the major NPS pollutants of concern in environmental systems. Additional loading from the CSOs and SSOs during wet-weather was simulated in the subwatershed where such discharges are known to exist.

Nitrogen and phosphorus are nutrients that promote the growth of algae and plants in water. When this biomass dies and settles to the bottom of water bodies, its decomposition consumes oxygen which is needed by other organisms for survival. Nitrogen is generally present in relatively small quantities compared to other nutrients in salt water systems, such as Long Island Sound, so limiting its concentration limits the growth of algae. In fresh water systems, such as the streams and impoundments in the North Branch Park River watershed, phosphorus is the nutrient that is relatively scarce and thus limits algal growth.

Total suspended solids (TSS) is a measure of both biodegradable and mineral sediment. Its discharge to a water body results in turbidity and sedimentation. TSS may also have secondary effects; biodegradable TSS exerts a biological oxygen demand (BOD), and mineral TSS can be associated with particulate phosphorus.

Fecal coliform is commonly used as a surrogate parameter to indicate the possible presence of disease-causing bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in streams suggests that pathogenic microorganisms might also be present and that swimming or contact recreation might be a health risk. Fecal coliform is present in stormwater runoff due to contamination with the fecal material of humans or animals and can enter rivers through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from human sewage (EPA, 2006).

3 Model Inputs

3.1 Nonpoint Source Runoff

Land use/land cover data that is described in the Baseline Watershed Assessment Report was adapted for use in the WTM. Data were prepared in this manner for both the existing conditions and future conditions (watershed buildout) pollutant loading scenarios. The available land use data for the North Branch Park River have categories defined by the Capitol Region Council of Governments (CRCOG). The WTM allows the user to enter custom land use categories. The land use categories that are chosen for the model were selected based on the parameter-specific land use categories listed in *Table E-2*. *Table E-3* summarizes the assignment of WTM land use categories for each of the CRCOG land use categories. The Multi-family and Single-family residential land uses were further refined into three sub-categories of residential land use for the WTM since a large percentage of the watershed consists of residential use. Generally, Low-density/Single family residential is considered greater than 1 acre, Medium density between ¼ and 1 acre and High-density/Multi-family is less than ¼ acre. Exceptions were made for variable-sized lots within subdivisions of generally uniform lot sizes to maintain consistency within residential subdivisions.

The WTM uses the Simple Method to calculate nutrient, sediment, and bacteria loads from various land uses. The user specifies several model parameters for each land use in the watershed that are used to estimate runoff quantity and pollutant levels. These parameters include Event Mean Concentrations (EMCs), which are literature values for the mean concentration of a pollutant in stormwater runoff for each land use, and an average impervious cover percentage for each land use.

A literature review was conducted to determine EMC values and impervious percentage values for use in the evaluation. Since comparison between existing and proposed watershed conditions is the focus of this analysis, EMC values were selected to reflect the relative difference in NPS pollutant characteristics between existing and future land uses. *Table E-2* at the end of this report shows EMC values from several sources for the pollutants of interest, with the selected values displayed at the bottom of the table.

The default impervious cover coefficients in the WTM were adjusted to better reflect local conditions in the North Branch Park River watershed. Impervious cover estimates for each land use category were modified based on measured total impervious area (TIA) for representative parcels or areas within each land use. The default impervious cover coefficients, literature values, and the selected impervious cover coefficients are presented in *Table E-1*.

3.2 Other Pollutant Sources

In addition to nonpoint source runoff pollutant loads, the WTM also provides the capability to model other pollutant sources including point sources and subsurface contributions. The following sections describe the model inputs and parameter values for other pollutant sources within the North Branch Park River watershed.

3.2.1 Combined Sewer Overflows

The WTM uses a modification of the Simple Method to calculate annual loads from CSOs. The primary assumption is that CSO discharges occur when the combined volume of stormwater and wastewater exceeds the total system capacity. The MDC system experiences approximately 50 CSO discharge events annually in the North Branch Park River (MDC, 2009). Statistical analysis of 15 years of precipitation data at a nearby weather station reveals that the approximate critical depth of rainfall to cause 50 CSO discharge events per year is 0.3 inches.

The volume of a typical CSO is based on the median storm event. In the WTM, any rainfall beyond the system capacity contributes to the CSO volume. Thus, this volume is calculated as the runoff caused by the difference between the median storm event depth and the rainfall depth that causes CSOs (assumed to be 0.3 inch). The runoff volume from this storm event is determined using the Simple Method. The resulting CSO pollutant load is the product of the CSO volume, the number of CSO events, and typical CSO pollutant concentrations, summarized in *Table E-5*.

3.2.2 Illicit Discharges

The WTM default assumptions for illicit discharges were used (i.e., a fraction of the total sewage flow contributes to illicit connections). The WTM makes separate assumptions for residential and business illicit connections. For residential connections, the WTM's default assumption is that one in every 1,000 sewered individuals is connected to the sewer system via an illicit connection. This value is then multiplied by the number of individuals connected to the system, and then by typical per capita flow and pollutant concentrations for raw sewage. For businesses, it is assumed that 10% of businesses have illicit connections, and approximately 10% of those have direct sewage discharges.

3.2.3 Septic Systems

Although the majority of the North Branch Park River watershed is served by sanitary sewers, portions of the western and northwestern sections of Bloomfield are on private septic systems (Thiesse, pers. comm., December 18, 2009). The number of unsewered dwelling units in each subwatershed was estimated using GIS data including the mapped sewer service area, impervious cover, and aerial photographs. The approximate number of unsewered dwelling units in each subwatershed is provided as *Table E-6*. The WTM default values were used for septic system failure rate (30%) and effluent concentrations from both working and failing septic systems.

3.2.4 Sanitary Sewer Overflows

There is currently one sanitary sewer overflow (SSO) discharge location in the North Branch Park River subwatershed. WTM default assumptions were used since detailed information on the volume and frequency of overflow was not available.

The WTM estimates the SSO load as a product of total flow from SSOs and pollutant concentrations of raw sewage. Unlike most urban pollutant sources, which can be classified as either storm loads or non-storm loads, SSOs can occur both during and between storms. Some are initiated by storm events, such as when the cause of the overflow is lack of capacity, or infiltration of rainfall into the sanitary system. SSOs can also be caused by pipe breakage or blockage, resulting in flow between storm events. The WTM default assumption is that 50% of the load from SSOs occurs as a storm load, with the remainder as a non-storm load.

Based on the MDC GIS data, there are 82 miles of sanitary sewer that convey wastewater to the SSO location in the North Branch Park River subwatershed. An estimated 12 overflows occur per year by assuming the default rate of 140 SSOs per 1,000 miles of sewer.

3.2.5 Managed Turf

In urban watersheds, subsurface flow constitutes a relatively small fraction of total annual flow, and most constituents have a relatively low concentration in groundwater. One possible exception is nitrogen, which can leach from urban lawns and other managed turf grass. The annual nitrogen load from managed turf areas is calculated as the product of its concentration and the annual infiltration volume. The area of managed turf in each subwatershed is based on 2006 Center for Land use Education and Research (CLEAR) Land Cover Data and includes residential lawns, golf courses, parks, and other areas with grass or turf. Managed turf areas used in the WTM are summarized in *Table E-6*.

3.2.6 Road Sanding

Sediment loads from road sanding are calculated based on the quantity of sand applied to roads in a typical year. Data from the West Hartford Public Works Department was extrapolated to the rest of the watershed since more detailed data was unavailable. A sanding application rate for typical roads was calculated based on the average rate in West Hartford in pounds per mile per year. The local roads GIS layer was used to calculate the total length of roads in each subwatershed and the total amount of sand applied to the roads in an average year. Note that winter road application is typically a 50/50 mixture of road sand and salt. The volume of salt is not included in this calculation, so the result is for total suspended solids only. Since road sand consists of relatively large sediment particle sizes, not all of the sediment will reach the receiving water body due to gravity settling. The default WTM assumption is that 90% of road sand is delivered to the receiving water in closed section roads, while only 35% is delivered in open section roads.

4 Existing Pollutant Loads

Table E-7 presents the existing modeled pollutant loads for the North Branch Park River watershed. Nonpoint source runoff accounts for approximately 71% of the total nitrogen load, 89% of the total phosphorus load, 33% of the total suspended solids load, and 7% of the fecal coliform bacteria load for the entire watershed. Road sanding accounts for nearly the entire balance of the total suspended solids load, while CSOs and SSOs contribute more than 90% of the fecal coliform load for the watershed. *Table E-8* presents a breakdown of estimated annual loadings of total nitrogen, total phosphorus, TSS, and fecal coliform by subwatershed.

Because the study subwatersheds vary in size, pollutant loads were also evaluated in terms of loading rates (i.e., pollutant loads per acre of land area, as shown in *Table E-8*). A higher loading rate indicates relatively greater pollutant sources per unit area, which suggests that implementation of best management practices (BMPs) in these areas may be more effective in reducing pollutant loads. The highest loading rates for nitrogen and phosphorus are associated with the North Branch Park River, Filley Brook, Wash Brook South, Tumbledown Brook, and Wash Brook North subwatersheds. Filley Brook has the loading rates of total suspended solids, while the North Branch Park River subwatershed has the largest fecal coliform loading rate due to contributions from CSOs and SSOs.

- *North Branch Park River*. The North Branch Park River subwatershed is the largest subwatershed by area. It also has the largest amount of commercial/industrial, institutional, and transportation land uses. The nutrient loads in this subwatershed are approximately 3 times greater than the next highest subwatershed, primarily due to the comparatively large size and highly urban nature of the subwatershed. The estimated nitrogen loading rate (excluding CSO and SSO contributions) is the second highest of the subwatersheds at 9.4 lb/ac-year, while the phosphorus loading rate is the highest of the subwatersheds at 1.3 lb/ac-year. The estimated fecal coliform loading due to nonpoint source runoff is 279,377 billion per year, while the contribution of fecal coliform from sewer overflows is significantly larger (approximately 6 orders of magnitude) than the nonpoint source runoff contribution.

- *Wash Brook South*. Wash Brook South ranks among the top four subwatersheds in annual pollutant loading and loading rates. The high loading is due to the proportionally high commercial/industrial, residential, and roadway land uses in this subwatershed.

- *Filley Brook*. The Filley Brook subwatershed has the highest TSS loading rate in the watershed and is among the 4 highest subwatersheds in terms of pollutant loading rates for nitrogen, phosphorus, and fecal coliform bacteria. However, the total loading of each pollutant is among the lowest in the watershed due to its small size. The high pollutant loading rates reflect the large percentage of medium density residential (50%) and commercial/industrial (20%) development in the subwatershed.

Table E-9 summarizes the contribution of nonpoint source pollutant loads by land use for the entire watershed. The majority of the nitrogen and phosphorus loads are from roadway, commercial/industrial, and residential land uses. The majority of the TSS loads is due to roadway (41.8%) and commercial/industrial (31.1%) land use. Residential land use accounts for approximately 83% of the nonpoint source bacterial load. Other modeled pollutant sources contribute significantly to the watershed pollutant loads, particularly CSOs and SSOs, which are the predominant source of the fecal coliform loads in the watershed.

5 Future Pollutant Loads

Anticipated future land use due to new development and redevelopment within the watershed (*Table E-10)* was used in the WTM model to simulate potential future pollutant loads under a watershed buildout scenario. The predicted changes in land use under a watershed buildout scenario are presented in *Table E-11.* Future land use categories were derived from the watershed buildout scenario presented in the Baseline Watershed Assessment Report. Future controls or best management practices were not considered in the calculation of future pollutant loads. Therefore, the predicted future pollutant loads reflect a potential worst-case scenario against which potential watershed management pollution control strategies may be evaluated. Additionally, future pollutant loads were modeled with and without CSO and SSO mitigation to evaluate the potential reductions in pollutant loads that could be achieved by the MDC's ongoing and planned sewer overflow mitigation projects.

Table E-12 presents projected future pollutant loads and load increases under a watershed buildout scenario. Not considering ongoing and planned CSO and SSO mitigation efforts, a significant increase in nutrient and bacteria pollutant loads is predicted in many of the subwatersheds. *Table E-13* presents the projected future pollutant loads in terms of the projected load increase based on existing loads (percent increase) and loading rate increase for each subwatershed.

The watershed as a whole is predicted to experience a 13% increase in nitrogen loads, a 16% increase in phosphorus loads, and a 20% increase in TSS loads under a future buildout scenario and assuming completion of the ongoing and planned CSO and SSO mitigation projects. Overall fecal coliform loads for the entire watershed are predicted to decrease by 64%, primarily as a result of the MDC sewer overflow mitigation projects. However, these projects will only affect pollutant loads in the North Branch Park River subwatershed. Almost all of the other subwatersheds are predicted to experience significant increases in fecal coliform loads (generally 20% to 80% increases) under a watershed buildout scenario due to nonpoint source runoff. Several of the subwatersheds are predicted to experience significantly higher increases in pollutant loads and loading rates under a watershed buildout scenario. These subwatersheds, which include the Beamans Brook East, Wash Brook North, Wash Brook West, and Wintonbury Reservoir subwatersheds, correspond to areas with significant developable land.

6 References

CH2M HILL (2001). *PLOAD version 3.0: An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects - User's Manual.* Data from Appendix IV.

Environmental Protection Agency [EPA] (2006). "Monitoring and Assessing Water Quality: Fecal Bacteria" http://www.epa.gov/volunteer/stream/vms511.html

Haith, Douglas A. (1993). *Runoff Quality from Development Sites (RUNQUAL) Users Manual.*

Metropolitan District Commission [MDC]. (2009). "Clean Water Project" Available at http://thecleanwaterproject.com/aboutus.htm

NSQD (2004). *Findings from the National Stormwater Quality Database*, Research Progress Report. Prepared by the Center for Watershed Protection.

NURP (1983). *Results of the Nationwide Urban Runoff Program.* U.S. Environmental Protection Agency Water Planning Division, PB 84-185552, Washington, D.C.

Tetra Tech., Inc. *Spreadsheet Tool for the Estimation of Pollutant Load (STEPL). Version 4.0.* Developed for the U.S. EPA

Thiesse, Jonathan. (2009). Town Engineer, Town of Bloomfield, Connecticut. Personal communication with Kristine Baker of Fuss & O'Neill, Inc. December 18, 2009.

University of Connecticut Center for Land Use Education and Research (CLEAR). Connecticut's Changing Landscape – Statewide Land Cover. URL: www.clear.uconn.edu/projects/landscape/statewide_landcover.htm.

WTM (2001). *Watershed Treatment Model User's Guide - Version 3.1.* Prepared by the Center for Watershed Protection.

Tables

Table E-1. Impervious Cover Coefficients

Land Use	Impervious Cover Coefficients			
	STEPL	NEMO[1]	WTM	Selected
Agriculture	-	-	-	0
Open Space	0.01	0.001 - 0.094		0.01
Commercial/Industrial	0.85	0.205 - 0.557	0.72	0.7
Multi-family/High Density Residential	0.75	0.09 - 0.39	0.44	0.44
Medium Density Residential	-	-	0.33	0.33
Single-family/Low Density Residential	0.3	0.065 - 0.12	0.21	0.21
Institutional	0.5	-	-	0.3
Forest	-	-	-	0
Roadway	0.95	0.433	0.8	0.8

[1] *Sleavin et al. (2000) and Prisloe et al. (2003)*

Table E-2. Runoff Event Mean Concentrations (EMCs)

Source	Pollutant	Land Use									
		Agriculture	Open Space (Urban)	Commercial	Multi-family/High Density Residential	Medium Density Residential	Single-family/Low Density Residential	Institutional	Forest	Roadway	Units
STEPL	N	1.9	1.5	2	2.2	-	2.2	1.8	0.2	3	mg/L
	P	0.3	0.15	0.2	0.4	-	0.4	0.3	0.1	0.5	mg/L
	FC	-	-	-	-	-	-	-	-	-	#/100mL
	TSS	-	70	75	100	-	100	67	-	150	mg/L
NSQD	N*	-	1.2	2.2	2	-	-	-	-	2.3	mg/L
	P	-	0.25	0.22	0.3	-	-	-	-	0.25	mg/L
	FC	-	-	-	-	-	-	-	-	-	#/100mL
	TSS	-	51	43	48	-	-	-	-	99	mg/L
NURP	N*	-	1.5	1.75	2.6	-	-	-	-	-	mg/L
	P	-	0.1	0.201	0.38	-	-	-	-	-	mg/L
	FC	-	-	-	-	-	-	-	-	-	#/100mL
	TSS	-	70	57	101	-	-	-	-	-	mg/L
WTM	N*	-	-	2	2	-	2	-	-	2	mg/L
	P	-	-	0.26	0.26	-	0.26	-	-	0.26	mg/L
	FC	-	-	20,000	20,000	-	20,000	-	-	20,000	#/100mL
	TSS	-	-	55	55	-	55	-	-	55	mg/L
RUNQUAL	N	-	-	-	-	-	-	-	-	-	mg/L
	P	-	-	-	-	-	-	-	-	-	mg/L
	FC	-	-	9,600	9,600	9,600	9,600	9,600	-	-	#/100mL
	TSS	-	-	-	-	-	-	-	-	-	mg/L
CH2M HILL	N*	1.1	1.1	-	2.7	1.7	1.2	-	-	-	mg/L
	P	0.2	0.2	-	0.3	0.2	0.2	-	-	-	mg/L
	FC	-	500	1,400	8,700	8,700	8,700	1,400	500	1,400	#/100mL
	TSS	19.2	20	-	47.7	30.5	22.1	-	70	-	mg/L
Selected	**N**	**1.5**	**1.5**	**2.2**	**2.7**	**1.7**	**1.2**	**1.8**	**0.2**	**3**	**mg/L**
	P	**0.2**	**0.15**	**0.4**	**0.3**	**0.2**	**0.2**	**0.3**	**0.1**	**0.5**	**mg/L**
	FC	**500†**	**500**	**1,400**	**8,700**	**8,700**	**8,700**	**1,400**	**500**	**1,400**	**#/100mL**
	TSS	**19.2**	**20**	**100**	**47.7**	**30.5**	**22.1**	**67**	**70**	**150**	**mg/L**

N=Total Nitrogen; P=Total Phosphorus; FC=Fecal Coliform; TSS=Total Suspended Solids *Nitrate and nitrite only

† No data - selected same value as forest and open space to model non-animal agricultural land use

See References for Source Information

Table E-3. Modeled Land Use Categories

North Branch Park River Land Use Category (CRCOG)	WTM Land Use Category
Agriculture	Agriculture
Cemetery	Open Space (Urban)
Commercial	Commercial (includes Industrial uses)
Government/Non-Profit	Institutional
Group Quarters	Institutional
Health/Medical	Institutional
Mixed Use	High Density Residential
Multi-Family	Residential Low, Medium, High Density based on parcel size and impervious cover
One Family	Residential Low, Medium, High Density based on parcel size and impervious cover
Resource/Recreation	Open Space (Urban)
ROW	Roadway
Undeveloped	Forest
Unknown	Forest

Table E-4. Existing Land Use Composition by Subwatershed

Subwatershed	Existing Modeled Land Use Composition (acres)								
	Agriculture	Commercial/ Industrial	Forest	Institutional	Medium Density Residential	Multi-family/High Density Residential	Open Space (Urban)	Roadway	Single-family/Low Density Residential
Beaman Brook East	0.0	0.0	18.7	0.0	26.2	0.0	14.6	5.1	98.3
Beaman Brook West	0.0	92.4	128.8	215.2	359.4	0.0	234.7	110.2	44.3
Blue Hills Reservoir	32.5	325.3	97.9	72.7	21.6	0.0	385.1	47.8	52.1
Cold Spring Reservoir	23.6	13.5	352.6	0.0	22.4	0.0	90.8	72.8	579.3
Filley Brook	19.5	75.7	27.8	21.3	201.1	0.0	1.0	57.5	0.2
North Branch Park River	0.0	394.0	426.5	733.0	813.9	748.9	300.0	580.2	36.8
Tumbledown Brook	32.9	293.8	122.4	64.8	527.6	0.0	336.6	115.5	66.9
Tumbledown Brook South	4.8	2.6	498.0	81.6	515.1	0.0	323.8	105.9	90.1
Tunxis Reservoir	38.0	83.0	68.1	24.1	30.1	0.0	371.1	56.6	202.7
Wash Brook North	128.7	202.8	190.0	39.8	73.9	0.0	25.8	62.3	38.7
Wash Brook South	25.9	271.3	240.9	101.2	587.3	0.0	57.0	148.4	127.3
Wash Brook West	38.9	1.4	217.0	0.0	190.5	0.0	248.8	56.7	275.6
West Hartford Reservoir	0.0	4.3	1774.2	25.9	2.5	0.0	17.9	24.5	198.1
Wintonbury Reservoir	63.3	125.0	187.7	0.0	185.3	0.0	256.2	50.4	25.7
Total (Watershed)	408	1885	4351	1380	3557	749	2663	1494	1836

Table E-5. Model Parameters - CSOs, SSOs, and Illicit Connections

Pollutant Source	Parameter	Description (Source)
Combined Sewer Overflows (NBP subwatershed only)	Median Storm Event (inches) = 0.685 Sewershed Area (acres) = 1594 Sewershed Impervious Cover (%) = 29.7% # of CSOs/year = 50 Critical CSO value (rainfall depth in inches) = 0.3	WTM, 2001- Model default values; MDC, 2009
Sanitary Sewer Overflows (NBP subwatershed only)	82 miles of sanitary sewer up-gradient of SSO location 140 SSOs per 1,000 miles of sewer	MDC, 2009; WTM, 2001- Model default values
Household and Business Illicit Connections	Household Fraction of Population Illicitly Connected = 0.001 Business Fraction of Businesses with Illicit Connections = 0.1 Fraction of Business Connections that are Wash Water Only = 0.9	WTM, 2001; Model default values

Table E-6. Model Parameters - Septic Systems, Managed Turf, and Road Sanding

Subwatershed	Approximate Number of Unsewered Dwelling Units	Turf and Grass Area (acres)	Length of Roads (mi)	Road Sand Applied (lbs/yr)
Beaman Brook East	0	45	1.8	68,264
Beaman Brook West	150	328	22.4	835,105
Blue Hills Reservoir	0	86	8.0	298,198
Cold Spring Reservoir	300	205	13.0	484,205
Filley Brook	0	201	11.4	426,367
North Branch Park River	0	838	81.7	3,041,953
Tumbledown Brook	130	786	26.0	970,130
Tumbledown Brook South	100	592	24.5	912,539
Tunxis Reservoir	175	255	8.7	324,045
Wash Brook North	0	72	11.1	413,436
Wash Brook South	20	529	30.1	1,121,120
Wash Brook West	150	277	8.0	297,972
West Hartford Reservoir	30	12	5.3	198,151
Wintonbury Reservoir	0	143	8.2	305,421

Table E-7. Modeled Existing Pollutant Loads by Source Type

Source	N lb/yr	P lb/yr	TSS lb/yr	Fecal Coliform billion/yr
Nonpoint Source Runoff	97,441	15,234	3,686,296	883,935
Other Sources	38,949	1,874	7,487,076	11,170,230
Septic Systems	14,487	182	7,274	0
SSOs	516	86	3,441	390,550
CSOs	3,653	731	73,054	10,654,285
Illicit Discharges	1,004	586	9,416	125,395
Managed Turf	19,288	289	0	0
Road Sanding	0	0	7,393,891	0
Total	**136,389**	**17,108**	**11,173,372**	**12,054,165**

FUSS & O'NEILL

Table E-8. Modeled Existing Pollutant Loads

Subwatershed	N (lb/yr)	P (lb/yr)	TSS (lb/yr)	Fecal Coliform (billion/yr)	N (lb/ac-yr)	P (lb/ac-yr)	TSS (lb/ac-yr)	Fecal Coliform (billion/ ac-yr)
Beaman Brook East (163 ac)	778	112	65,702	18,530	4.8	0.7	403	113.8
Beaman Brook West (1,185 ac)	8,917	1,096	892,088	63,816	7.5	0.9	753	53.9
Blue Hills Reservoir (1,035 ac)	6,740	1,115	500,837	27,292	6.5	1.1	484	26.4
Cold Spring Reservoir (1,155 ac)	8,825	822	499,416	95,667	7.6	0.7	432	82.8
Filley Brook (404 ac)	4,349	543	454,764	30,696	10.8	1.3	1,126	76.0
North Branch Park River (4,033 ac) (excluding CSOs and SSOs)	37,808	5,121	3,537,838	279,377	9.4	1.3	877	69.3
CSOs and SSO	4,169	817	76,495	11,044,834	1.0	0.2	19.0	2,738.4
Tumbledown Brook (1,561 ac)	15,486	1,660	1,112,424	93,446	9.9	1.1	713	59.9
Tumbledown Brook South (1,622 ac)	10,149	937	895,817	84,370	6.3	0.6	552	52.0
Tunxis Reservoir (874 ac)	7,142	672	381,828	41,445	8.2	0.8	437	47.4
Wash Brook North (762 ac)	5,187	845	527,067	26,722	6.8	1.1	692	35.1
Wash Brook South (1,559 ac)	13,603	1,778	1,263,600	111,061	8.7	1.1	810	71.2
Wash Brook West (1,029 ac)	6,680	602	329,983	68,767	6.5	0.6	321	66.8
West Hartford Reservoir (2,048 ac)	1,839	332	246,421	33,749	0.9	0.2	120	16.5
Wintonbury Reservoir (894 ac)	4,719	657	389,091	34,393	5.3	0.7	435	38.5
Watershed Total (18,323 ac)	136,389	17,108	11,173,372	12,054,165	7.4	0.9	610	657.9

Table E-9. Modeled Existing Pollutant Loads by Land Use

Land Use	N (lb/yr)	P (lb/yr)	TSS (lb/yr)	Fecal Coliform (billion/yr)	N (%)	P (%)	TSS (%)	Fecal Coliform (%)
Agriculture	274	37	3,506	416	0.3%	0.2%	0.1%	0.0%
Commercial/Industrial	25,239	4,589	1,147,223	73,199	25.9%	30.1%	31.1%	8.3%
Forest	389	195	136,280	4,436	0.4%	1.3%	3.7%	0.5%
Institutional	7,112	1,185	264,709	25,209	7.3%	7.8%	7.2%	2.9%
Medium Density Residential	18,778	2,209	336,905	437,981	19.2%	14.5%	9.1%	49.5%
Multi-family/High Density Residential	8,071	897	142,590	118,528	8.3%	5.9%	3.9%	13.4%
Open Space (Urban)	2,109	211	28,126	3,205	2.2%	1.4%	0.8%	0.4%
Roadway	30,887	5,148	1,544,327	65,691	31.7%	33.7%	41.8%	7.4%
Single-family/Low Density Residential	4,713	785	86,793	155,719	4.8%	5.1%	2.4%	17.6%
Total	**97,572**	**15,256**	**3,690,458**	**884,382**	**100%**	**100%**	**100%**	**100%**

Table E-10. Modeled Future Land Use Composition

Subwatershed	Future Land Use Composition (acres)								
	Agriculture	Commercial/ Industrial	Forest	Institutional	Medium Density Residential	Multi-family/ High Density Residential	Open Space (Urban)	Roadway	Single-family/ Low Density Residential
Beamans Brook East	0.0	0.0	1.3	0.0	49.4	91.5	14.6	5.1	1.0
Beamans Brook West	0.0	119.8	12.9	215.2	456.0	16.2	234.6	110.2	20.1
Blue Hills Reservoir	0.0	404.9	16.8	72.7	73.9	23.1	385.1	47.8	10.8
Cold Spring Reservoir	0.0	13.5	92.5	0.0	34.5	18.9	90.8	72.8	832.0
Filley Brook	0.0	115.9	0.0	21.3	209.2	0.0	0.0	57.5	0.2
North Branch Park River	0.0	561.0	66.3	733.0	1,153.7	803.4	129.6	580.2	6.1
Tumbledown Brook	0.0	329.0	20.1	64.8	546.3	131.7	335.1	115.5	18.1
Tumbledown Brook South	4.8	2.6	236.8	81.6	692.5	4.4	163.9	105.9	329.3
Tunxis Reservoir	7.7	86.6	21.8	24.1	167.8	0.0	328.4	56.6	180.6
Wash Brook North	47.3	424.8	48.7	39.8	74.7	0.0	25.8	62.3	38.7
Wash Brook South	23.9	285.0	28.6	101.2	828.3	57.0	39.7	148.4	47.1
Wash Brook West	0.0	1.4	4.5	0.0	466.9	0.0	54.5	56.7	444.9
West Hartford Reservoir	0.0	4.3	1,490.1	0.0	2.5	0.0	17.9	24.5	508.2
Wintonbury Reservoir	0.0	299.1	15.2	0.0	233.3	39.4	256.2	50.4	0.0
Total (Watershed)	**83.7**	**2,647.8**	**2,055.6**	**1,353.6**	**4,989.0**	**1,185.6**	**2,076.2**	**1,494.0**	**2,437.2**

Table E-11. Modeled Change in Land Use Composition by Subwatershed

Subwatershed	Change in Land Use Composition (acres)								
	Agriculture	Commercial/ Industrial	Forest	Institutional	Medium Density Residential	Multi-family/ High Density Residential	Open Space (Urban)	Roadway	Single-family/ Low Density Residential
Beamans Brook East	0.0	0.0	-17.4	0.0	23.2	91.5	0.0	0.0	-97.3
Beamans Brook West	0.0	27.4	-115.9	0.0	96.6	16.2	0.0	0.0	-24.3
Blue Hills Reservoir	-32.5	79.6	-81.1	0.0	52.2	23.1	0.0	0.0	-41.2
Cold Spring Reservoir	-23.6	0.0	-260.1	0.0	12.1	18.9	0.0	0.0	252.7
Filley Brook	-19.5	40.2	-27.8	0.0	8.1	0.0	-1.0	0.0	0.0
North Branch Park River	0.0	167.0	-360.2	0.0	339.8	54.5	-170.5	0.0	-30.6
Tumbledown Brook	-32.9	35.2	-102.3	0.0	18.8	131.7	-1.6	0.0	-48.8
Tumbledown Brook South	0.0	0.0	-261.2	0.0	177.4	4.4	-159.9	0.0	239.2
Tunxis Reservoir	-30.3	3.6	-46.3	0.0	137.7	0.0	-42.7	0.0	-22.0
Wash Brook North	-81.4	221.9	-141.3	0.0	0.8	0.0	0.0	0.0	0.0
Wash Brook South	-2.0	13.7	-212.3	0.0	241.0	57.0	-17.3	0.0	-80.2
Wash Brook West	-38.9	0.0	-212.6	0.0	276.3	0.0	-194.2	0.0	169.3
West Hartford Reservoir	0.0	0.0	-310.0	0.0	0.0	0.0	0.0	0.0	310.0
Wintonbury Reservoir	-63.3	174.1	-172.4	0.0	48.0	39.4	0.0	0.0	-25.7
Total (Watershed)	**-324.4**	**762.7**	**-2321.1**	**0.0**	**1432.0**	**436.7**	**-587.1**	**0.0**	**601.1**

Table E-12. Modeled Future Pollutant Loads and Load Increases*

Subwatershed	N (lb/yr)	P (lb/yr)	TSS (lb/yr)	Fecal Coliform (billion/yr)	Projected Load Increase* N (lb/yr)	Projected Load Increase* P (lb/yr)	Projected Load Increase* TSS (lb/yr)	Projected Load Increase* Fecal Coliform (billion/yr)
Beamans Brook East (163 ac)	1,824	197	103,961	27,600	1,046	84	38,259	9,070
Beamans Brook West (1,185 ac)	9,895	1,227	1,001,484	77,163	979	131	109,396	13,347
Blue Hills Reservoir (1,035 ac)	8,113	1,342	601,382	36,848	1,374	227	100,545	9,556
Cold Spring Reservoir (1,155 ac)	9,621	934	575,831	121,300	796	112	76,415	25,633
Filley Brook (404 ac)	4,832	641	531,371	33,202	483	98	76,607	2,506
North Branch Park River (4,033 ac) (excluding CSOs and SSOs)	42,098	5,749	3,991,783	333,157	4,290	628	453,945	53,780
CSOs and SSOs	1,429	269	21,705	3,054,121	-2,740	-548	-54,791	-7,990,714
Tumbledown Brook (1,561 ac)	17,236	1,885	1,254,746	113,685	1,750	224	142,323	20,239
Tumbledown Brook South (1,622 ac)	11,516	1,118	1,127,110	126,752	1,367	181	231,293	42,382
Tunxis Reservoir (874 ac)	7,722	748	439,446	56,544	579	75	57,617	15,099
Wash Brook North (762 ac)	8,013	1,363	837,496	35,206	2,827	518	310,429	8,484
Wash Brook South (1,559 ac)	15,352	1,982	1,422,426	143,257	1,749	204	158,826	32,196
Wash Brook West (1,029 ac)	6,234	779	466,272	116,664	-447	178	136,289	47,897
West Hartford Reservoir (2,048 ac)	2,525	439	334,238	59,727	687	107	87,817	25,978
Wintonbury Reservoir (894 ac)	7,523	1,126	654,922	50,871	2,804	469	265,831	16,478
Watershed Total* (18,323 ac)	**153,934**	**19,797**	**13,364,172**	**4,386,097**	**17,545**	**2,689**	**2,190,801**	**-7,668,068**

*Reflects completion of ongoing and planned CSO and SSO mitigation projects.

Table E-13. Modeled Future Pollutant Loading Rate Increases and Load Increases

Subwatershed	Projected Future Loading Rate*				Projected Load Increase* (%)			
	N	P	TSS	Fecal Coliform	N	P	TSS	Fecal Coliform
	lb/ac-yr	lb/ac-yr	lb/ac-yr	billion/yr				
Beamans Brook East (163 ac)	11.2	1.2	638	169	134%	75%	58%	49%
Beamans Brook West (1,185 ac)	8.4	1.0	845	65	11%	12%	12%	21%
Blue Hills Reservoir (1,035 ac)	7.8	1.3	581	36	20%	20%	20%	35%
Cold Spring Reservoir (1,155 ac)	8.3	0.8	499	105	9%	14%	15%	27%
Filley Brook (404 ac)	12.0	1.6	1315	82	11%	18%	17%	8%
North Branch Park River (4,033 ac) (excluding CSOs and SSOs)	10.4	1.4	990	83	11%	12%	13%	19%
CSOs and SSOs	0.4	0.1	5.4	757	-66%	-67%	-72%	-72%
Tumbledown Brook (1,561 ac)	11.0	1.2	804	73	11%	13%	13%	22%
Tumbledown Brook South (1,622 ac)	7.1	0.7	695	78	13%	19%	26%	50%
Tunxis Reservoir (874 ac)	8.8	0.9	503	65	8%	11%	15%	36%
Wash Brook North (762 ac)	10.5	1.8	1099	46	54%	61%	59%	32%
Wash Brook South (1,559 ac)	9.8	1.3	912	92	13%	11%	13%	29%
Wash Brook West (1,029 ac)	6.1	0.8	453	113	-7%	30%	41%	70%
West Hartford Reservoir (2,048 ac)	1.2	0.2	163	29	37%	32%	36%	77%
Wintonbury Reservoir (894 ac)	8.4	1.3	733	57	59%	71%	68%	48%
Watershed Total* (18,323 ac)	**8.4**	**1.1**	**729**	**239**	**13%**	**16%**	**20%**	**-64%**

*Reflects completion of ongoing and planned CSO and SSO mitigation projects.