Amendment to the
Lower Raritan/Middlesex Water Quality Management Plan, Mercer County Water Quality Management Plan, Monmouth County Water Quality Management Plan, Northeast Water Quality Management Plan, Upper Raritan Water Quality Management Plan, and Sussex County Water Quality Management Plan

Total Maximum Daily Loads for Fecal Coliform to Address 48 Streams in the Raritan Water Region

Watershed Management Area 7
(Arthur Kill, Newark Bay, Elizabeth River,
Rahway River / Woodbridge Creek, Morses Creek)
Watershed Management Area 8
(North and South Branch Raritan)
Watershed Management Area 9
(Lower Raritan, South River, and Lawrence and Manalapan Brooks)
Watershed Management Area 10
(Stony Brook, Millstone River)

Proposed:	April 21, 2003
Established:	
Approved (by EPA Region 2):	
Adopted:	

New Jersey Department of Environmental Protection
Division of Watershed Management
P.O. Box 418
Trenton, New Jersey 08625-0418

Contents

1.0 Executive Summary 5
2.0 Introduction 7
3.0 Background 7
4.0 Pollutant of Concern and Area of Interest 8
4.1. Description of the Raritan Water Region and Sublist 5 Waterbodies 11
4.1.1. Watershed Management Area 7 11
4.1.2. Watershed Management Area 8 13
4.1.3. Watershed Management Area 9 17
4.1.4. Watershed Management Area 10 21
4.2. Data Sources 24
5.0 Applicable Water Quality Standards 25
5.1. New Jersey Surface Water Quality Standards for Fecal Coliform 25
5.2. Pathogen Indicators in New Jersey's Surface Water Quality Standards (SWQS) 25
6.0 Source Assessment 26
6.1. Assessment of Point Sources other than Stormwater 26
6.2. Assessment of Nonpoint and Stormwater Point Sources 26
7.0 Water Quality Analysis 28
7.1. Seasonal Variation / Critical Conditions 31
7.2. Margin of Safety 32
8.0 TMDL Calculations 33
8.1. Wasteload Allocations and Load Allocations 34
8.2. Reserve Capacity 36
9.0 Follow - up Monitoring 36
10.0 Implementation 36
10.1. Source Trackdown 39
10.2. Short Term Management Strategies 39
10.3. Long–Term Management Strategies 41
10.4. Segment Specific Recommendations 43
10.4.1. Watershed Management Area 7 43
10.4.2. Watershed Management Area 8 44
10.4.3. Watershed Management Area 9 47
10.4.4. Watershed Management Area 10 49
10.5. Pathogen Indicators and Bacterial Source Tracking 52
10.6. Reasonable Assurance 53
11.0 Public Participation 54
References 57
Appendix A: Explanation of stream segments in Sublist 5 of the *2002 Integrated List of Waterbodies* for which TMDLs will not be developed in this report. 59
Appendix B: Municipal POTWs Located in the TMDLs' Project Areas 60
Appendix C: TMDL Calculations 62
Appendix D: Load Duration Curves for selected listed waterbodies 65

Figures

Figure 1 Spatial extent of Sublist 5 segments for which TMDLs are being developed in WMA 7 12
Figure 2 Spatial extent of Sublist 5 segments for which TMDLs are being developed in WMA 8 15
Figure 3 Spatial extent of Sublist 5 segments for which TMDLs are being developed in WMA 9 19
Figure 4 Spatial extent of Sublist 5 segments for which TMDLs are being developed in WMA 10 22
Figure 5 Example Load Duration Curve (LDC) 27
Figure 6 Percent of summer values over 400 CFU/100ml as a function of summer geometric mean values 30
Figure 7 Statewide monthly fecal coliform geometric means during water years 1994-1997 using USGS/NJDEP data. 32

Tables

Table 1 Fecal coliform-impaired stream segments in the Raritan Water Region, identified in Sublist 5 of the 2002 Integrated List of Waterbodies, for which fecal coliform TMDLs are being established. 5
Table 2 Abridged Sublist 5 of the 2002 Integrated List of Waterbodies, listed for fecal coliform impairment in the Raritan Water Region. 9
Table 3 Description of the spatial extent for each Sublist 5 segment, listed for fecal coliform, in WMA 7. 12
Table 4 River miles, Watershed size, and Anderson Landuse classification for seven Sublist 5 segments, listed for fecal coliform, in WMA 7. 13
Table 5 Description of the spatial extent for each Sublist 5 segment, listed for fecal coliform, in WMA 8. 16
Table 6 River miles, Watershed size, and Anderson Landuse classification for eighteen Sublist 5 segments, listed for fecal coliform, in WMA 8. 16
Table 7 Description of the spatial extent for each Sublist 5 segment, listed for fecal coliform, in WMA 9. 20
Table 8 River miles, Watershed size, and Anderson Landuse classification for thirteen Sublist 5 segments, listed for fecal coliform, in WMA 9. 20
Table 9 Description of the spatial extent for each Sublist 5 segment, listed for fecal coliform, in WMA 10. 23
Table 10 River miles, Watershed size, and Anderson Landuse classification for ten Sublist 5 segments, listed for fecal coliform, in WMA 10. 23
Table 11 TMDLs for fecal coliform-impaired stream segments in the Raritan Water Region as identified in Sublist 5 of the 2002 Integrated List of Waterbodies. The reductions reported in this table represent the higher, or more stringent, percent reduction required of the two fecal colifom criteria. 34

1.0 Executive Summary

In accordance with Section 305(b) of the Federal Clean Water Act (CWA), the State of New Jersey developed the *2002 Integrated List of Waterbodies*, addressing the overall water quality of the State's waters and identifying impaired waterbodies for which Total Maximum Daily Loads (TMDLs) may be necessary. The *2002 Integrated List of Waterbodies* identified several waterbodies in the Raritan Water Region as being impaired by pathogens, as indicated by the presence of fecal coliform concentrations in excess of standards. This report, developed by the New Jersey Department of Environmental Protection (NJDEP), establishes 48 TMDLs addressing fecal coliform loads to the waterbodies identified in Table 1.

Table 1 Fecal coliform-impaired stream segments in the Raritan Water Region, identified in Sublist 5 of the 2002 Integrated List of Waterbodies, for which fecal coliform TMDLs are being established.

TMDL Number	WMA	Station Name/Waterbody	Site ID	County(s)	River Miles
1	7	WB Elizabeth River near Union	01393350	Essex Union	4.2
2	7	Elizabeth River at Ursino Lake at Elizabeth	01393450	Union	5.7
3	7	West Branch Rahway River at Northfield Ave. at West Orange	01393960	Essex	4.4
4	7	Rahway River near Springfield	01394500	Essex	26.3
5	7	Rahway River at Rahway	01395000	Union	8.6
6	7	Robinson Branch at Scotch Plains	01395200	Union	3.3
7	7	Robinson Branch at St Georges Ave at Rahway	01396003	Middlesex Union	20.7
8	8	Stony Brook at Fairview Avenue at Naughright	01396219	Morris	3.4
9	8	South Branch Raritan River at Middle Valley	01396280	Morris	15.2
10	8	South Branch Raritan River Arch St at High Bridge	01396535	Hunterdon	4.3
11	8	Spruce Run at Newport	01396550	Hunterdon	8.6
12	8	Spruce Run near Glen Gardner	01396588	Hunterdon	3.6
13	8	Mulhockaway Creek at Van Syckel	01396660	Hunterdon	16.5
14	8	South Branch Raritan River at Stanton Station	01397000	Hunterdon	8.3
15	8	South Branch Raritan River at Three Bridges	01397400	Hunterdon	7.4
16	8	Neshanic River at Reaville	01398000	Hunterdon	37.0
17	8	South Branch Raritan River at South Branch	01398102	Somerset	7.1
18	8	North Branch Raritan River near Chester	01398260	Morris	8.5
19	8	North Branch Raritan River at Burnt Mills	01399120	Somerset	5.8
20	8	Lamington River near Ironia	01399200	Morris	2.7
21	8	Lamington River near Pottersville	01399500	Morris	12.8
22	8	Rockaway Creek at Whitehouse	01399700	Hunterdon	3.6
23	8	Lamington River at Burnt Mills	01399780	Somerset	10.0
24	8	Chambers Brook at North Branch Depot	01399900	Somerset	8.5
25	8	North Branch Raritan River near Raritan	01400000	Somerset	7.9
26	9	Peters Brook at Rt 28 at Somerville	01400395	Somerset	12.2
27	9	Raritan River at Manville	01400500	Somerset	10.8

TMDL Number	WMA	Station Name/Waterbody	Site ID	County(s)	River Miles
28	9	Raritan River at Queens Bridge	01403300	Somerset	12.0
29	9	Bound Brook at Route 28 at Middlesex	01403385	Middlesex	17.8
30	9	Green Brook at North Plainfield	01403470	Middlesex Somerset	17.8
31	9	Bound Brook at Middlesex	01403900	Somerset	2.8
32	9	Matchaponix Brook at Englishtown	01405195	Middlesex	4.9
33	9	Manalapan Brook at Federal Rd near Manalapan	01405340	Middlesex	14.6
34	9	Manalapan Brook near Spotswood	01405400[a]	Middlesex	5.7
35	9	McGolliard Brook at Main St In Englishtown	22	Middlesex	1.1
36	9	Lake Topanemus at Pond Rd In Freehold	61	Middlesex	5.7
37	9	Wemrock Brook at Rt #9 (Before Pipes) In Freeh	68	Middlesex	2.9
38	9	Weemaconk Creek at Main St In Manalapan	9	Middlesex	6.7
39	10	Millstone River near Manalapan	01400540	Mercer Middlesex Monmouth	11.3
40	10	Millstone River at Grovers Mill	01400650	Mercer Middlesex Monmouth	27.3
41	10	Cranbury Book near Prospect Plains	01400690	Middlesex Monmouth	13.9
42	10	Stony Brook at Princeton	01401000	Mercer	8.3
43	10	Duck Pond Run at Clarksville	01401200	Mercer	2.8
44	10	Heathcote Brook at Kingston	01401400	Middlesex Somerset	13.7
45	10	Bedens Brook near Rocky Hill	01401600	Somerset	2.4
46	10	Pike Run near Rocky Hill	01401700	Somerset	2.8
47	10	Millstone River at Blackwells Mills	01402000	Somerset	10.5
48	10	Millstone River at Weston	01402540	Somerset	1.5
Total River Miles:					453.9

[a] This station was incorrectly labeled "01405440" in the *2002 Integrated List of Waterbodies.*

These forty-eight TMDLs will serve as management approaches or restoration plans aimed at identifying the sources of fecal coliform and for setting goals for fecal coliform load reductions in order to attain applicable surface water quality standards (SWQS).

As stated in N.J.A.C. 7:9B-1.14(c) of the New Jersey Surface Water Quality Standards, "Fecal coliform levels shall not exceed a geometric average of 200 CFU/100 ml nor should more than 10 percent of the total sample taken during any 30-day period exceed 400 CFU/100 ml in FW2 waters." Nonpoint and stormwater point sources are the primary contributors to fecal coliform loads in these streams and can include storm-driven loads transporting fecal coliform from sources such as geese, farms, and domestic pets to the receiving water. Nonpoint sources also include steady-inputs from sources such as failing sewage conveyance systems and failing or inappropriately located septic systems. Because the total point source contribution other than stormwater (i.e. Publicly-Owned Treatment Works, POTWs) is an insignificant fraction of a percent of the total load, these fecal coliform TMDLs will not impose any change in current practices for POTWs and will not result in changes to existing effluent limits.

Using ambient water quality data monitoring conducted by USGS/NJDEP and the Monmouth County Health Department during water years 1994-2002, summer and all season geometric means were determined for each Category 5 listed segment. Given the two surface water quality criteria of 200 CFU/100 ml and 400 CFU/100 ml in FW2 waters, computations were necessary for both criteria and resulted in two values for percent reduction for each stream segment. The higher (more stringent) percent reduction value was selected as the TMDL and will be applied to nonpoint and stormwater point sources as a whole or apportioned to categories of nonpoint and stormwater point sources within the study area. The extent to which nonpoint and stormwater point sources have been identified and the process by which they will become identified or need to be identified or verified varies by segment based on data availability, watershed size and complexity, and pollutant sources. Implementation strategies to achieve SWQS are addressed in this report.

Each TMDL shall be proposed and adopted by the Department as an amendment to the appropriate area wide water quality management plan(s) in accordance with N.J.A.C. 7:15-3.4(g).

This TMDL Report is consistent with the United States Environmental Protection Agency's (USEPA's) May 20, 2002 guidance document entitled: "Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992," (Suftin, 2002) which describes the statutory and regulatory requirements for approvable TMDLs.

2.0 Introduction

Sublist 5 (also known as List 5 or, traditionally, the 303(d) List) of the State of New Jersey's proposed *2002 Integrated List of Waterbodies* identified several waterbodies in the Raritan Water Region as being impaired by pathogens, as evidenced by the presence of high fecal coliform concentrations. This report establishes forty-eight TMDLs, which address fecal coliform loads to the identified waterbodies. These TMDLs serve as management approaches or restoration plans aimed toward reducing loadings of fecal coliform from various sources in order to attain applicable surface water quality standards for the pathogen indication. Several of these waterbodies are listed in Sublist 5 for impairment caused by other pollutants. These TMDLs address only fecal coliform impairments. Separate TMDL evaluations will be developed to address the other pollutants of concern. The waterbodies will remain on Sublist 5 with respect to these pollutants until such time as TMDL evaluations for all pollutants have been completed and approved by USEPA. With respect to the fecal coliform impairment, the waterbodies will be moved to Sublist 4 following approval of the TMDLs by USEPA.

3.0 Background

In accordance with Section 305(b) of the Federal Clean Water Act (CWA) (33 U.S.C. 1315(B)), the State of New Jersey is required to biennially prepare and submit to the USEPA a report addressing the overall water quality of the State's waters. This report is commonly referred

to as the 305(b) Report or the Water Quality Inventory Report. In November 2001, USEPA issued guidance that encouraged states to integrate the 305(b) Report and the 303(d) List into one report. This integrated report assigns waterbodies to one of five categories. In general, Sublists 1 through 4 include waterbodies that are unimpaired, have limited assessment or data availability or have a range of designated use impairments, whereas Sublist 5 constitutes the traditional 303(d) List for waters impaired or threatened by one or more pollutants. The Department chose to develop an Integrated Report for New Jersey. New Jersey's proposed *2002 Integrated List of Waterbodies* is based upon these five categories and identifies water quality limited surface waters in accordance with N.J.A.C. 7:15-6 and Section 303(d) of the CWA. Water quality limited waterbodies require total maximum daily load (TMDL) evaluations.

A Total Maximum Daily Load (TMDL) represents the assimilative or carrying capacity of a waterbody, taking into consideration point and nonpoint sources of pollutants of concern, natural background and surface water withdrawals. A TMDL quantifies the amount of a pollutant a water body can assimilate without violating a state's water quality standards and allocates that load capacity to known point and nonpoint sources in the form of wasteload allocations (WLAs), load allocations (LAs), and a margin of safety. A TMDL is developed as a mechanism for identifying all the contributors to surface water quality impacts and setting goals for load reductions for pollutants of concern as necessary to meet the SWQS.

Recent EPA guidance (Suftin, 2002) describes the statutory and regulatory requirements for approvable TMDLs, as well as additional information generally needed for USEPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations. The Department believes that the TMDLs in this report address the following items in the May 20, 2002 guideline document:

1. Identification of waterbody(ies), pollutant of concern, pollutant sources and priority ranking.
2. Description of applicable water quality standards and numeric water quality target(s).
3. Loading capacity – linking water quality and pollutant sources.
4. Load allocations.
5. Wasteload allocations.
6. Margin of safety.
7. Seasonal variation.
8. Reasonable assurances.
9. Monitoring plan to track TMDL effectiveness.
10. Implementation (USEPA is not required to and does not approve TMDL implementation plans).
11. Public Participation.

4.0 Pollutant of Concern and Area of Interest

The pollutant of concern for these TMDLs is pathogens, the presence of which is indicated by elevated concentrations of fecal coliform bacteria. Fecal coliform concentrations were found

to exceed New Jersey's Surface Water Quality Standards (SWQS), published at N.J.A.C. 7-9B et seq., for the segments in the Raritan Water Region identified in Table 2. As reported in the proposed 2002 Integrated List of Waterbodies, also identified in Table 2 are the river miles and management response associated with each listed segment. All of these waterbodies have a high priority ranking, as described in the *2002 Integrated List of Waterbodies*.

Table 2 Abridged Sublist 5 of the 2002 Integrated List of Waterbodies, listed for fecal coliform impairment in the Raritan Water Region.

TMDL No.	WMA	Station Name/Waterbody	Site ID	River Miles	Management Response
1	7	WB Elizabeth River near Union	1393350	4.2	establish TMDL
2	7	Elizabeth River at Ursino Lake at Elizabeth	1393450	5.7	establish TMDL
3	7	WB Rahway River at Northfield Ave. at West Orange	1393960	4.4	establish TMDL
4	7	Rahway River near Springfield	1394500	26.3	establish TMDL
5	7	Rahway River at Rahway	1395000	8.6	establish TMDL
6	7	Robinson Branch at Scotch Plains	1395200	3.3	establish TMDL
7	7	Robinson Branch at St Georges Ave. at Rahway	1396003	20.7	establish TMDL
8	8	Stony Brook at Fairview Avenue at Naughright	1396219	3.4	establish TMDL
9	8	South Branch Raritan River at Middle Valley	1396280	15.2	establish TMDL
10	8	South Branch Raritan River Arch St at High Bridge	1396535	4.3	establish TMDL
11	8	Spruce Run at Newport	1396550	8.6	establish TMDL
12	8	Spruce Run near Glen Gardner	1396588	3.6	establish TMDL
13	8	Mulhockaway Creek at Van Syckel	1396660	16.5	establish TMDL
14	8	South Branch Raritan River at Stanton Station	1397000	8.3	establish TMDL
15	8	South Branch Raritan River at Three Bridges	1397400	7.4	establish TMDL
16	8	Neshanic River at Reaville	1398000	37.0	establish TMDL
17	8	South Branch Raritan River at South Branch	1398102	7.1	establish TMDL
18	8	North Branch Raritan River near Chester	1398260	8.5	establish TMDL
19	8	North Branch Raritan River at Burnt Mills	1399120	5.8	establish TMDL
20	8	Lamington River near Ironia	1399200	2.7	establish TMDL
21	8	Lamington River near Pottersville	1399500	12.8	establish TMDL
22	8	Rockaway Creek at Whitehouse	1399700	3.6	establish TMDL
23	8	Lamington River at Burnt Mills	1399780	10.0	establish TMDL
24	8	Chambers Brook at North Branch Depot	1399900	8.5	establish TMDL
25	8	North Branch Raritan River near Raritan	1400000	7.9	establish TMDL
26	9	Peters Brook at Rt 28 at Somerville	1400395	12.2	establish TMDL

TMDL No.	WMA	Station Name/Waterbody	Site ID	River Miles	Management Response
27	9	Raritan River at Manville	1400500	10.8	establish TMDL
28	9	Raritan River at Queens Bridge	1403300	12.0	establish TMDL
29	9	Bound Brook at Route 28 at Middlesex	1403385	17.8	establish TMDL
30	9	Green Brook at North Plainfield	1403470	17.8	establish TMDL
31	9	Bound Brook at Middlesex	1403900	2.8	establish TMDL
32	9	Matchaponix Brook at Englishtown	1405195	4.9	establish TMDL
33	9	Manalapan Brook at Federal Rd near Manalapan	1405340	14.6	establish TMDL
34	9	Manalapan Brook near Spotswood	1405400[a]	5.9	establish TMDL
35	9	McGolliard Brook at Main St In Englishtown	22	1.1	establish TMDL
36	9	Lake Topanemus at Pond Rd In Freehold	61	5.7	establish TMDL
37	9	Wemrock Brook at Rt #9 (Before Pipes) In Freeh	68	2.9	establish TMDL
38	9	Weemaconk Creek at Main St In Manalapan	9	6.7	establish TMDL
39	10	Millstone River near Manalapan	1400540	11.3	establish TMDL
40	10	Millstone River at Grovers Mill	1400650	27.3	establish TMDL
41	10	Cranbury Book near Prospect Plains	1400690	13.9	establish TMDL
42	10	Stony Brook at Princeton	1401000	8.3	establish TMDL
43	10	Duck Pond Run at Clarksville	1401200	2.8	establish TMDL
44	10	Heathcote Brook at Kingston	1401400	13.7	establish TMDL
	10	Millstone River at Kingston	1401440	3.8	water quality monitoring needed to identify if an impairment exists; move to Sublist 3.
45	10	Bedens Brook Nr Rocky Hill	1401600	2.4	establish TMDL
46	10	Pike Run near Rocky Hill	1401700	2.8	establish TMDL
47	10	Millstone River at Blackwells Mills	1402000	10.5	establish TMDL
48	10	Millstone River at Weston	1402540	1.5	establish TMDL

[a] This station was incorrectly labeled "01405440" in the *2002 Integrated List of Waterbodies.*

These forty-eight TMDLs will address 454 river miles or approximately 99% of the total river miles listed as impaired relative to fecal coliform (458 total fecal coliform impaired river miles) in the Raritan watershed region. Based on the detailed county hydrography stream coverage, 1151 stream miles, or 53% of the stream segments in the Raritan region (2168 total miles) are directly affected by the 48 TMDLs due to the fact that the implementation plans cover entire watersheds; not just impaired waterbody segments.

Table 2 identifies one segment for which a TMDL will not be developed at this time based on investigations following the *2002 Integrated List of Waterbodies* proposal. The Millstone River at Kingston, station #01401440, is identified as needing further monitoring to confirm impairment and will be moved to Sublist 3 of the 2002 Integrated List of Waterbodies. A further discussion can be found in Appendix A.

4.1. Description of the Raritan Water Region and Sublist 5 Waterbodies

4.1.1. Watershed Management Area 7

Watershed Management Area 7 includes large portions of Essex, Union, and Middlesex counties. The mainstem of the Rahway River is 24 miles long, flowing from Union into the Arthur Kill near Linden and is tidal from the Pennsylvania Railroad Bridge at Rahway down to the mouth. Major tributaries include the East Branch Rahway River, Woodbridge River and Robinsons Branch and major impoundments are the Middlesex Reservoir, Orange Reservoir, Lower and Upper Echo Lakes and Diamond Mill Pond. The Elizabeth River is 11 miles long and much of it channelized for flood control purposes. Land uses in the Rahway and Elizabeth Watersheds are principally residential, commercial and industrial. There are 50 NJPDES permitted discharges and 12 biological monitoring stations in these watersheds.

Sublist 5 Waterbodies in WMA 7

Seven river segments of the forty-eight impaired segments addressed in this report, the West Branch Elizabeth River (#01393350), Elizabeth River (#01393450), West Branch Rahway River (#01393960), Rahway River (#01394500, #01395000), Robinson Branch (#01395200, #01396003) are located in WMA 7. Several of these stream segments are geographically located in close proximity, thus, when these segments were found to contain similar levels of bacteria contamination (geometric means value), water quality data from these segments were grouped when calculating the TMDL. The spatial extent of each segment is identified in Figure 1 and described in Table 3. River miles, watershed sizes and land use/land cover by percent area associated with each segment are listed in Table 4.

Figure 1 **Spatial extent of Sublist 5 segments for which TMDLs are being developed in WMA 7**

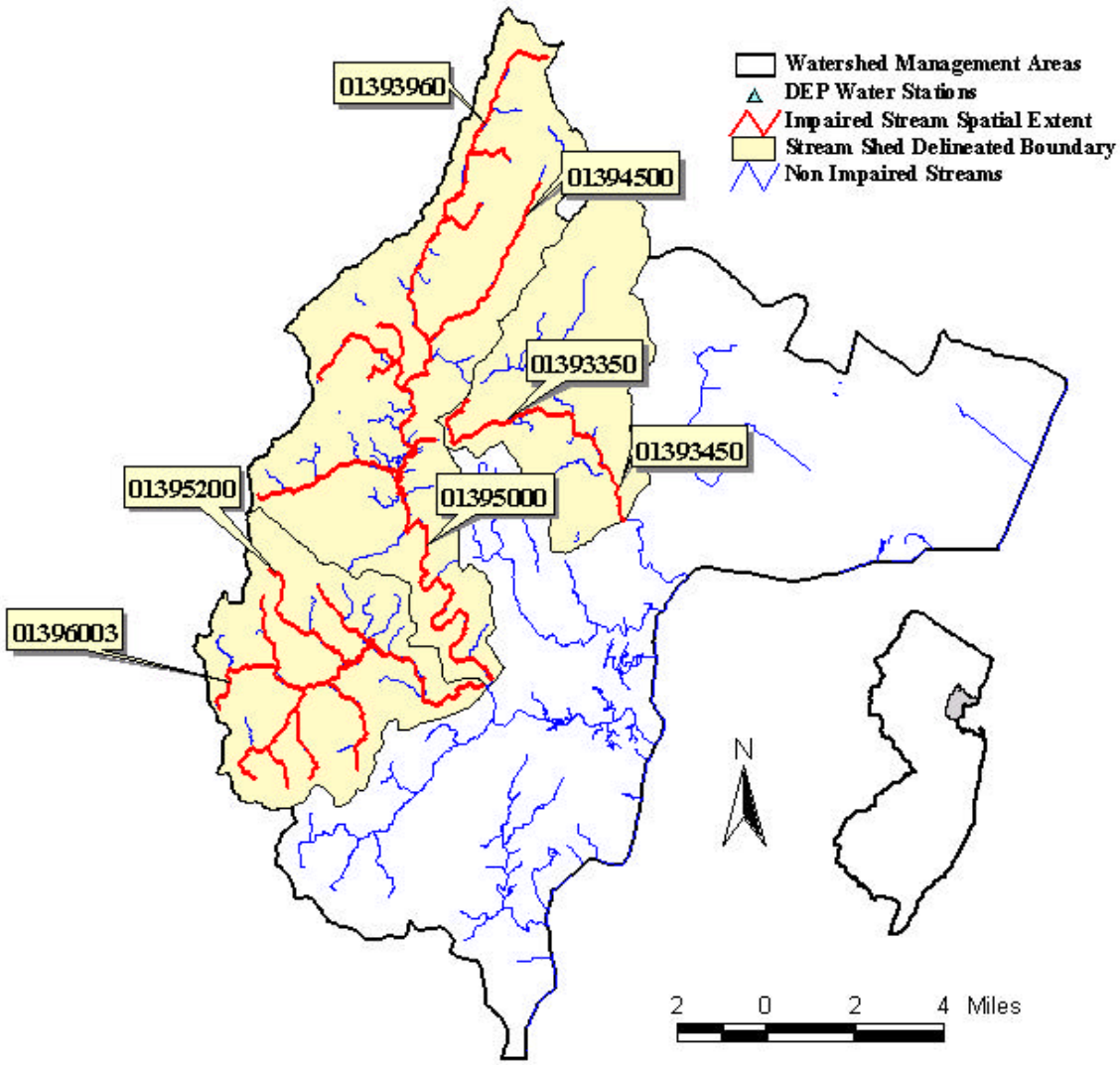


Table 3 **Description of the spatial extent for each Sublist 5 segment, listed for fecal coliform, in WMA 7.**

Segment ID	Watershed area associated with impaired stream segments
1393350, 1393450	Elizabeth River watershed upstream of the head of tide; located near Elizabeth. Includes Irvington Brook, Lightening Brook, Maplewood Brook, and the West Branch Elizabeth River tributaries.
1393960, 1394500, 1395000	Rahway River watershed upstream of the Rahway River/Robinsons Branch confluence. Includes the following tributaries: Nomagegan Brook, Turtle

	Brook, Van Winkle Brook, and the West Branch Rahwah River
1395200, 1396003	Robinsons Branch watershed upstream of the Rahway River/Robinsons Branch confluence. Tributaries in this watershed include Ash Brook, Pumpkin Patch Brook, and Winding Brook.

Table 4 River miles, Watershed size, and Anderson Landuse classification for seven Sublist 5 segments, listed for fecal coliform, in WMA 7.

	Segment ID		
	1393350, 1393450	**1393960, 1394500, 1395000**	**1395200, 1396003**
Sublist 5 impaired river miles (miles)	9.9	39.3	24.1
Total river miles within watershed and included in the implementation plan (miles)	20.9	61	33.4
Watershed size (acres)	13247	27006	14152
Landuse\Landcover			
Agriculture	0.1%	0.2%	0.3%
Barren Land	0.1%	0.6%	0.3%
Forest	4.0%	16.2%	8.2%
Urban	93.6%	79.2%	79.1%
Water	0.3%	1.1%	0.9%
Wetlands	2.1%	2.8%	11.1%

4.1.2. Watershed Management Area 8

Watershed Management Area 8 includes the North and South Branches of the Raritan River and their tributaries. Large portions of Somerset, Hunterdon, and Morris counties are included in this land area.

The North Branch of the Raritan River is 23 miles long and flows from northwestern Morris County through Somerset County to the confluence with the South Branch between the towns of Branchburg and Raritan. Major tributaries include the Peapack Brook, Rockaway Creek, and Lamington River and the only major impoundment is the Ravine Lake. Land use in the North Branch Raritan River Watershed is primarily rural, woodland, and agricultural with scattered areas of commercial and residential but there is intense development along the major road corridors. There are over 20 NJPDES permitted discharges and 51 biological monitoring stations in this watershed.

The South Branch of the Raritan River is 51 miles long and flows from western Morris County through central Hunterdon County and into western Somerset County before joining the North Branch. Major tributaries include the Neshanic River, Spruce Run Creek,

Mulhockaway Creek, and Cakepoulin Creek and major impoundments are the Spruce Run and Round Valley Reservoirs. Land use in the South Branch Raritan River Watershed is mostly agricultural, but suburban-industrial development is increasing at a rapid rate. There are approximately 23 NJPDES permitted discharges and 51 biological monitoring stations in this watershed.

Sublist 5 Waterbodies inWMA 8

Eighteen of the forty-eight TMDLs in the Raritan region are located in WMA 8. Included are several segments of the Chambers Brook (#01399900), Lamington River (#01399780, #01399200, #01399500), Mulhockaway Creek (#01396660), North Branch Raritan River (#01399120, #01398260, 01400000), Neshanic River (#01398000), Rockaway Creek (#01399700), South Branch Raritan River (#01396535, #01396280, #01398102, #01397000, #01397400), Spruce Run (#01396550, 01396588), and Stony Brook (#01396219). The spatial extent of each segment is identified in Figure 2 and described in Table 5. River miles, watershed sizes and land use/land cover by percent area associated with each segment are listed in Table 6.

Figure 2 **Spatial extent of Sublist 5 segments for which TMDLs are being developed in WMA 8**

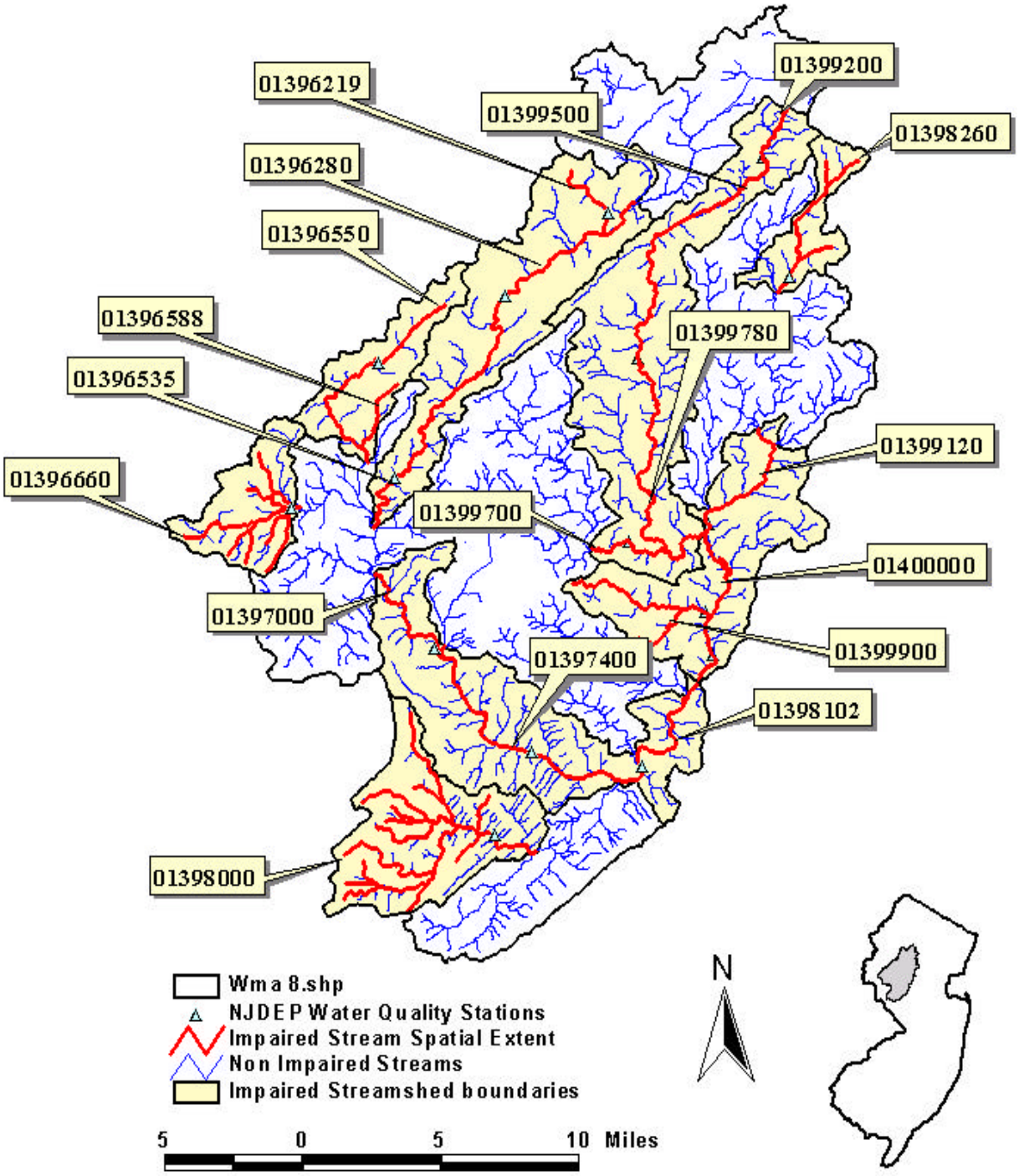


Table 5 Description of the spatial extent for each Sublist 5 segment, listed for fecal coliform, in WMA 8.

Segment ID	Watershed area associated with impaired stream segments
1396219, 1396280, 1396535	Raritan River watershed upstream of the Raritan River/Spruce Run confluence. Excludes upstream portions of the Rocky Brook based on distance from impaired stream segment. Tributaries in this watershed included: Stony Brook, Electric Brook, and Little Brook.
1396550, 1396588	Spruce Run Watershed upstream of the Spruce Run/Willoughby Brook confluence. Included also is Rocky Run watershed.
1396660	Mulhockaway Creek upper watershed to approximately 1500 ft downstream of USGS station #01396660
1398000	Neshanic River watershed upstream of Neshanic River/Back Brook confluence. Tributary included in this area is Wallnut Brook
1397000, 1397400, 1398102	Raritan River watershed beginning at the Raritan River/Grandin Stream confluence and extending to 3000 ft downstream of the Raritan River/Holland Brook confluence. Included the following tributaries: Pleasant Run, Bushkill Creek, Minneakoning Creek, Assicong Creek, Lower Prescott Brook, Allerton Creek, and Cramers Creek.
1398260	North Branch Raritan River upstream of Raritan River/McVickers Brook confluence. Included are the lower portions of Burnett Brook, and India Brook watersheds
1399200, 1399500, 1399700, 1399780	Laminton River watershed upstream of the Lamington River/North Branch Raritan River confluence. Included are the following tributaries: Muddy Run, Rockaway Creek below the Rockaway Creek/South Branch Rockaway Creek confluence, Cold Brook, Herzog Brook, Rinehart Brook, Trout Brook, and Tanners Brook.
1399120, 1399900, 1400000	North Branch Raritan River watershed from the North Branch Raritan River/Peapack Brook confluence to the North Branch Raritan River/Raritan River confluence. Excludes Laminton River watershed. Included are Chambers Brook, River Brook, and Moggy Brook watersheds.

Table 6 River miles, Watershed size, and Anderson Landuse classification for eighteen Sublist 5 segments, listed for fecal coliform, in WMA 8.

	Segment ID							
	1396219 1396280 1396535	**1396550 1396588**	**1396660**	**1398000**	**1397000 1397400 1398102**	**1398260**	**1399200 1399500 1399700 1399780**	**1399120 1399900 1400000**
Sublist 5 impaired river miles (miles)	22.9	12.3	16.5	37.0	22.8	8.5	29.1	22.2
Total river miles within watershed and included in the implementation	59	12.3	30.9	62.7	98.8	17.4	111.8	65.2

plan (miles)	Segment ID							
	1396219 1396280 1396535	**1396550 1396588**	**1396660**	**1398000**	**1397000 1397400 1398102**	**1398260**	**1399200 1399500 1399700 1399780**	**1399120 1399900 1400000**
Watershed size (acres)	27308	9973	58	19909	122	6106	37534	22432
Landuse\ Landcover								
Agriculture	16.9%	19.6%	19.5%	43.4%	33.8%	5.7%	25.1%	19.0%
Barren Land	0.5%	0.7%	0.8%	0.3%	0.7%	0.3%	0.5%	1.3%
Forest	43.9%	52.6%	46.3%	20.3%	21.1%	44.9%	42.6%	28.5%
Urban	25.7%	17.5%	22.0%	25.3%	32.3%	38.2%	20.2%	41.1%
Water	0.9%	0.5%	0.3%	0.2%	1.3%	0.4%	0.8%	0.9%
Wetlands	12.2%	9.2%	11.1%	10.5%	10.8%	10.5%	11.0%	9.2%

4.1.3. Watershed Management Area 9

Watershed Management Area 9 includes the mainstem of the Raritan River, the South River, and Lawrence Brook. Middlesex, Somerset, and Monmouth Counties make up most of the political geography of this WMA.

The Mainstem of the Raritan River spans from the confluence of the North and South Branches to the Raritan Bay. For the most part, this drainage area is densely populated. There are two low dams in this river, Fieldsville Dam and Calco Dam. Among the many small recreational lakes and ponds in this area are Watchung Lake, Surprise Lake, Spring Lake and Green Brook Pond (all manmade). Land use in the Mainstem Raritan River Watershed is primarily urban/suburban, with industrial and commercial centers throughout. There are about 73 NJPDES permitted dischargers and about 29 biological monitoring stations in this watershed.

The South River begins at Duhernal Lake in Spotswood and flows to the Raritan River at Sayreville. It is formed by the confluence of Manalapan and Matchaponix Brooks. Other tributaries include Deep River and Tennants Brook and major impoundments are Duhernal Lake and Lake Manalapan. The South River Watershed is made up of three subwatersheds, the Manalapan and Matchaponix Brooks and South River. Land use in the upper part of this area, the Manalapan and Matchaponix Brook Subwatersheds, is predominantly agriculture and forests. New industrial and residential development are becoming incorporated into these areas and there is existing, older development in the South River subwatershed. There are about 5 NJPDES permitted discharges in the South River Watershed and 11 biological monitoring stations in the South River and Lawrence Brook Watersheds combined.

Sublist 5 Waterbodies in WMA 9

Thirteen of the forty-eight TMDLs in this report are located in WMA 9. Included are segments in Bound Brook (#01403385, #01403900), Green Brook (#01403470), Lake Topanemus (#61), Manalapan Brook (#01405340, #01405400), Matchaponix Brook (#01405195), McGolliard Brook (#22), Peters Brook (#01400395), Raritan River (#01400500, #01403300), Weemaconk Creek (#9), and Wemrock Brook (#68). The spatial extent of each segment is identified in Figure 3 and described in Table 7. River miles, watershed sizes and land use/land cover by percent area associated with each segment are listed in Table 8.

Figure 3 **Spatial extent of Sublist 5 segments for which TMDLs are being developed in WMA 9**

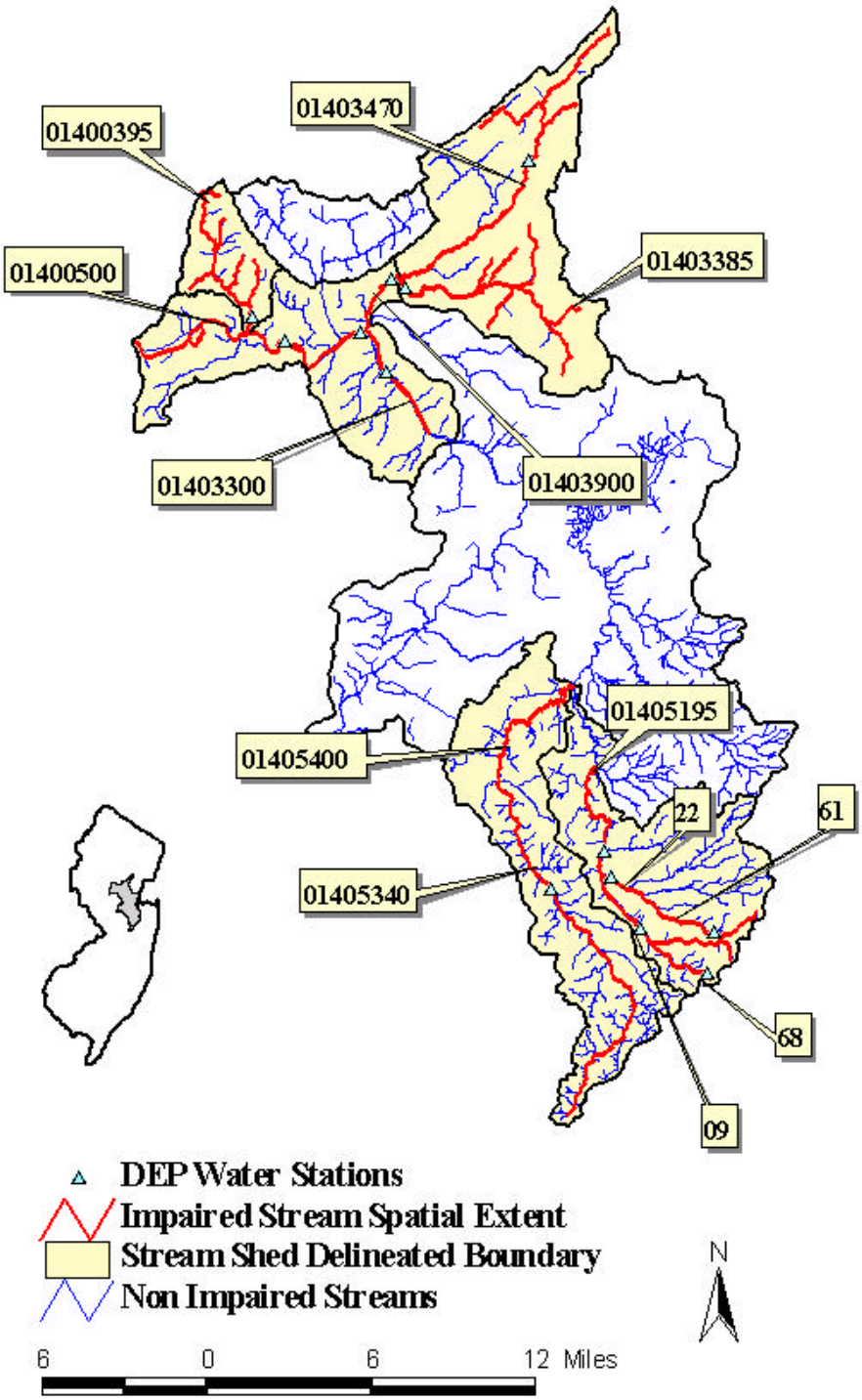


Table 7 Description of the spatial extent for each Sublist 5 segment, listed for fecal coliform, in WMA 9.

Segment ID	Watershed area associated with impaired stream segments
1400395	Peters Brook Watershed upstream of the confluence of Peters Brook with the Raritan River. Additional tributaries in the watershed include Macs Brook and Ross Brook.
1403385, 1403470	Green Brook and Bound Brook watersheds upstream of the confluence of Green Brook and Brown Brook. Tributaries include Blue Brook, Cedar Brook, Bonygut Brook, Bound Brook, Crab Brook, East Branch Green Brook, Green Brook, Stony Brook, and West Branch Stony Brook.
1400500, 1403300, 1403900	Raritan River watershed, from the confluence on the Raritan and Millstone Rivers, including the northwest branch of the Raritan River, the Raritan River to the confluence of Mile Run with the Raritan River, and Green Brook downstream of the confluence of Green Brook and Bound Brook. Additional tributaries in this watershed include: Cuckels Brook, Dukes Brook, and Randolph Brook.
1405195, 9, 22, 61, 68	Matchaponix Brook watershed upstream of confluence of Manalapan Brook with Matchaponix Brook at Duhernat Lake. Tributaries include McGellairds Brook, Milford Brook, Pine Brook, South Branch Tepehemus Brook, Tepehemus Brook, Weamaconk Brook, and Wemrock Brook
1405340, 1405400	Impaired grouped segments include upstream portions of Manalapan Brook from the headwaters of Manalapan Brook extending to the confluence of Manalapan Brook with Matchaponix Brook at Duhernat Lake. Tributaries included in the watershed include Cedar Brook, Gander Brook, South River, Wigwam Brook, and Stillhouse Brook.

Table 8 River miles, Watershed size, and Anderson Landuse classification for thirteen Sublist 5 segments, listed for fecal coliform, in WMA 9.

	Segment ID				
	1400395	**1403385, 1403470**	**1400500, 1403300, 1403900**	**1405195, 9, 22, 61, 68**	**1405340, 1405400**
Sublist 5 impaired river miles (miles)	12.2	35.6	25.8	21.4	20.4
Total river miles within watershed and included in the implementation plan (miles)	16.6	54.4	75.1	90.7	105.2
Watershed size (acres)	6358	30796	25864	24416	28110
Landuse\Landcover					
Agriculture	0.1%	0.4%	10.5%	11.0%	17.8%
Barren Land	0.5%	1.0%	1.4%	2.0%	2.1%
Forest	17.8%	15.2%	13.2%	16.7%	25.7%
Urban	72.5%	70.8%	54.4%	46.5%	27.9%

	Segment ID				
	1400395	**1403385, 1403470**	**1400500, 1403300, 1403900**	**1405195, 9, 22, 61, 68**	**1405340, 1405400**
Water	0.3%	0.5%	3.0%	0.5%	1.1%
Wetlands	8.9%	12.2%	17.6%	23.3%	25.3%

4.1.4. Watershed Management Area 10

Watershed Management Area 10 includes the Millstone River and it's tributaries. The Millstone River itself is a tributary to the Raritan River. This watershed lies in parts of Hunterdon, Somerset, Middlesex, Mercer, and Monmouth Counties.

The Millstone River is 38 miles long and flows from Millstone Township in Monmouth County to the Raritan River near Manville and Bound Brook. Major tributaries include Stony Brook, Cranbury Brook, Bear Brook, Ten Mile River, Six Mile River, and Bedens Brook and the largest impoundment is Carnegie Lake. Land use in the Millstone Watershed is primarily suburban development with scattered agricultural areas although there is extensive, recent development present in the upper portion. There are over 40 NJPDES permitted discharges and 81 biological monitoring sites in WMA 10.

Sublist 5 Waterbodies WMA 10

Ten of the forty-eight TMDLs in this report are located in WMA 10. Included are segments in Bedens Brook (#01401600), Cranbury Book (#01400690), Duck Pond Run (#01401200), Heathcote Brook (#01401400), Millstone River (#01402000, #01400650, #01402540, #01400540), Pike Run (#01401700), Stony Brook (#01401000) The spatial extent of each segment is identified in Figure 4 and described in Table 9. River miles, watershed sizes and land use/land cover by percent area associated with each segment are listed in Table 10.

Figure 4 Spatial extent of Sublist 5 segments for which TMDLs are being developed in WMA 10

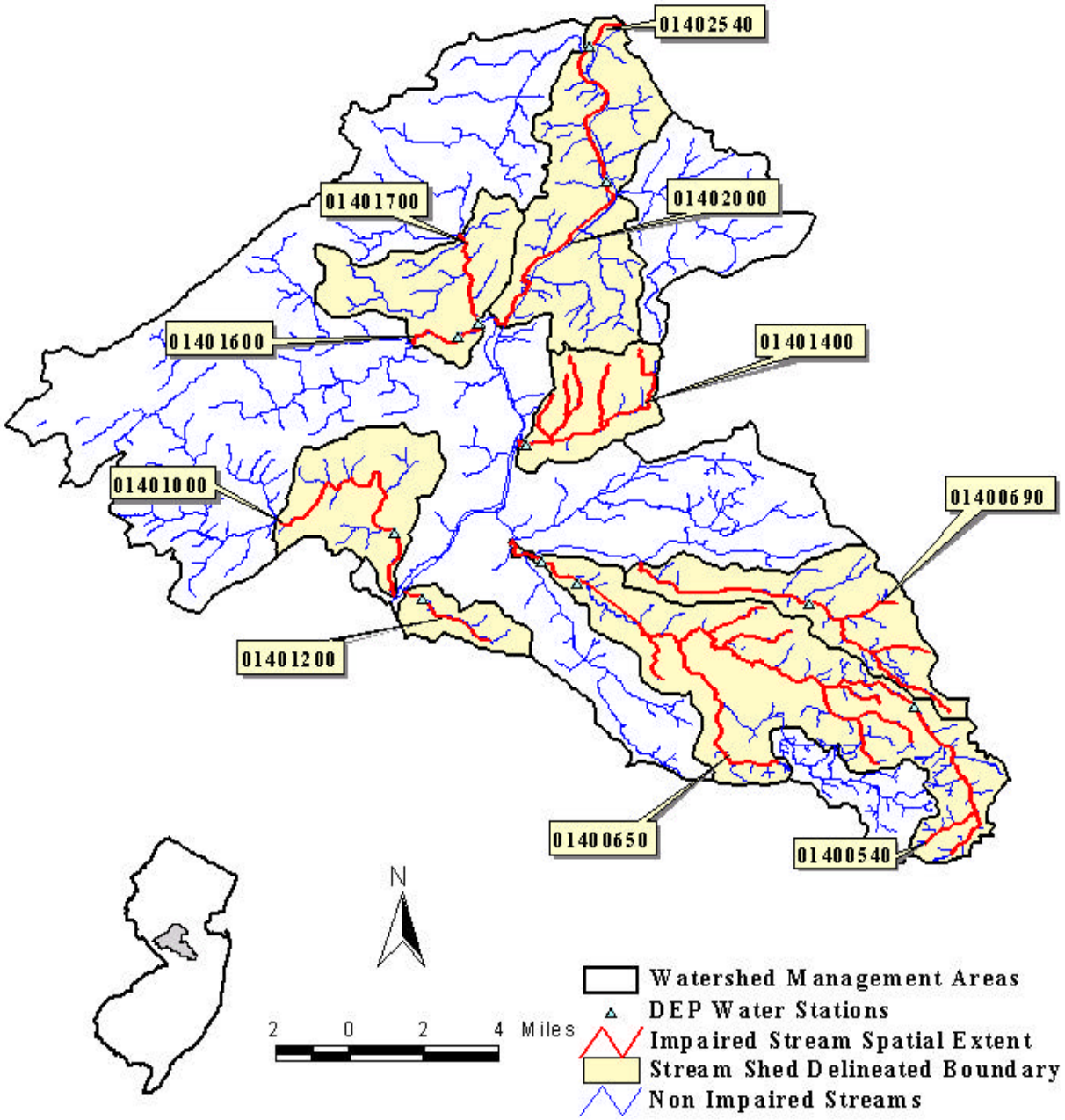


Table 9 Description of the spatial extent for each Sublist 5 segment, listed for fecal coliform, in WMA 10.

Segment ID	Watershed area associated with impaired stream segments
1400540, 1400650	Millstone river watershed upstream of the Millstone River/Devils Brook confluence. Excludes upstream portions of the Rocky Brook based on distance from impaired stream segment.
1400690	Cranbury Brook watershed upstream of its confluence with Cedar Brook.
1401000	Watershed area begins at the confluence of Honey Branch with Stoney River and continues to the confluence of the Stoney River with the Delaware and Raritan Canal near Port Mercer.
1401200	Duck Pond Run watershed upstream of its confluence with the Delaware and Raritan Canal
1401400	Heathcote and Carters Brooks watershed to the confluence of Heathcote Brook with Carnegie Lake.
1401600, 1401700	Impaired watersheds include portions of Benden Brook and Pike Run. The impaired watershed associated with the Benden Brook begins at the confluence of Rock Brook and Benden Brook and extends downstream to the confluence of Benden Brook and Pike Run. The impaired watershed associated with Pike Run begins at confluence of Pike Run and Cruser Brook and extends downstream to the confluence of Pike Run and Rock Brook.
1402000, 1402540	Portions of the Millstone River watershed. Impaired watershed associated with these segments begins at the confluence of Benden Brook and Millstone River and continues north to its confluence with the Raritan River. Excludes subwatersheds associated with Royce Brook and Six Mile Run

Table 10 River miles, Watershed size, and Anderson Landuse classification for ten Sublist 5 segments, listed for fecal coliform, in WMA 10.

	Segment ID						
	1400540, 1400650	**1400690**	**1401000**	**1401200**	**1401400**	**1401600, 1401700**	**1402000, 1402540**
Sublist 5 impaired river miles (miles)	38.6	13.9	8.3	2.8	13.7	5.2	12.1
Total river miles within watershed and included in the implementation plan (miles)	78.0	27.6	19.5	9.11	17.1	26.7	58
Watershed size (acres)	23502	9390	8169	2677	5857	8334	16325

	Segment ID						
	1400540, 1400650	**1400690**	**1401000**	**1401200**	**1401400**	**1401600, 1401700**	**1402000, 1402540**
Landuse\ Landcover							
Agriculture	33.7%	34.7%	11.5%	17.6%	13.9%	26.4%	27.7%
Barren Land	1.3%	1.8%	1.0%	0.5%	0.6%	2.8%	1.0%
Forest	13.0%	7.0%	35.4%	9.5%	24.9%	19.5%	19.3%
Urban	22.0%	26.3%	38.7%	40.9%	29.8%	38.5%	31.5%
Water	0.7%	1.2%	1.2%	0.4%	0.3%	0.5%	2.3%
Wetlands	29.3%	29.0%	12.2%	31.2%	30.7%	12.4%	18.3%

4.2. Data Sources

The Department's Geographic Information System (GIS) was used extensively to describe Raritan watershed characteristics. In concert with USEPA's November 2001 listing guidance, the Department is using Reach File 3 (RF3) in the 2002 Integrated Report to represent rivers and streams. The following is general information regarding the data used to describe the watershed management area:

- Land use/Land cover information was taken from the 1995/1997 Land Use/Land cover Updated for New Jersey DEP, published 12/01/2000 by Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA), delineated by watershed management area.
- 2002 Assessed Rivers coverage, NJDEP, Watershed Assessment Group, unpublished coverage.
- County Boundaries: Published 11/01/1998 by the NJDEP, Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA), "NJDEP County Boundaries for the State of New Jersey." Online at: http://www.state.nj.us/dep/gis/digidownload/zips/statewide/stco.zip
- Detailed stream coverage (RF3) by County: Published 11/01/1998 by the NJDEP, Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA). "Hydrography of XXX County, New Jersey (1:24000)." Online at: http://www.state.nj.us/dep/gis/digidownload/zips/strm/
- NJDEP 14 Digit Hydrologic Unit Code delineations (DEPHUC14), published 4/5/2000 by Department of Environmental Protection (NJDEP), New Jersey Geological Survey (NJGS) Online at:
  http://www.state.nj.us/dep/gis/digidownload/zips/statewide/dephuc14.zip
- NJPDES Surface Water Discharges in New Jersey, (1:12,000), published 02/02/2002 by Division of Water Quality (DWQ), Bureau of Point Source Permitting - Region 1 (PSP-R1).
- Dams statewide coverage. Published 5/16/2000 by Dam Safety Section. Titled "NJDEP Dams for the State of New Jersey." New Jersey Department of Environmental Protection(NJDEP).
  Online at: http://www.state.nj.us/dep/gis/digidownload/zips/statewide/dams.zip

5.0 Applicable Water Quality Standards

5.1. New Jersey Surface Water Quality Standards for Fecal Coliform

As stated in N.J.A.C. 7:9B-1.14(c) of the New Jersey SWQS, the following are the criteria for freshwater fecal coliform:

> "Fecal coliform levels shall not exceed a geometric average of 200 CFU/100 ml nor should more than 10 percent of the total samples taken during any 30-day period exceed 400 CFU/100 ml in FW2 waters".

All of the waterbodies covered under these TMDLs have a FW1 or FW2 classification (NJAC 7:9B-1.12). The designated use, i.e. surface water uses, both existing and potential, that have been established by the Department for waters of the State, for all of the waterbodies in the Raritan Water Region is as stated below:

In all FW1 waters, the designated uses are:
1. Set aside for posterity to represent the natural aquatic environment and its associated biota;
2. Primary and secondary contact recreation;
3. Maintenance, migration and propagation of the natural and established aquatic biota; and
4. Any other reasonable uses.

In all FW2 waters, the designated uses are:
1. Maintenance, migration and propagation of the natural and established aquatic biota;
2. Primary and secondary contact recreation;
3. Industrial and agricultural water supply;
4. Public potable water supply after conventional filtration treatment (a series of processes including filtration, flocculation, coagulation and sedimentation, resulting in substantial particulate removal but no consistent removal of chemical constituents) and disinfection; and
5. Any other reasonable uses.

5.2. Pathogen Indicators in New Jersey's Surface Water Quality Standards (SWQS)

A subset of total coliform, fecal coliform originates from the intestines of warm-blooded animals. Therefore, because they do not include organisms found naturally in soils, fecal coliform is preferred over total coliform as a pathogen indicator. In 1986, USEPA published a document entitled *"Implementation Guidance for Ambient Water Quality Criteria for Bacteria – 1986"* that contained their recommendations for water quality criteria for bacteria to protect bathers from gastrointestinal illness in recreational waters. The water quality criteria established levels of indicator bacteria *Escherichia coli* (*E. coli*) for fresh recreational water and enterococci for fresh and marine recreational waters in lieu of fecal coliforms. Historically,

New Jersey has listed water bodies for exceedances of the fecal coliform criteria. Therefore, the Department is obligated to develop TMDLs for Sublist 5 water bodies based upon fecal coliform, until New Jersey makes the transition to *E. coli* and enterococci in its SWQS and sufficient data have been collected to assess impairment in accordance with the revised indicators.

6.0 Source Assessment

In order to evaluate and characterize fecal coliform loadings in the waterbodies of interest in these TMDLs, and thus propose proper management responses, source assessments are warranted. Source assessments include identifying the types of sources and their relative contributions to fecal coliform loadings, in both time and space variables.

6.1. Assessment of Point Sources other than Stormwater

Point sources of fecal coliform, namely sewage treatment discharges, for these TMDLs are listed in Appendix B. Sewage treatment plants, whether municipal or industrial, are required to disinfect effluent prior to discharge and to meet surface water quality criteria for fecal coliform in their effluent. In addition, New Jersey's Surface Water Quality Standards at N.J.A.C. 7:9B-1.5(c)4 reads "No mixing zones shall be permitted for indicators of bacterial quality including, but not limited to, fecal coliforms and enterococci". This mixing zone policy is applicable to both municipal and industrial sewage treatment plants.

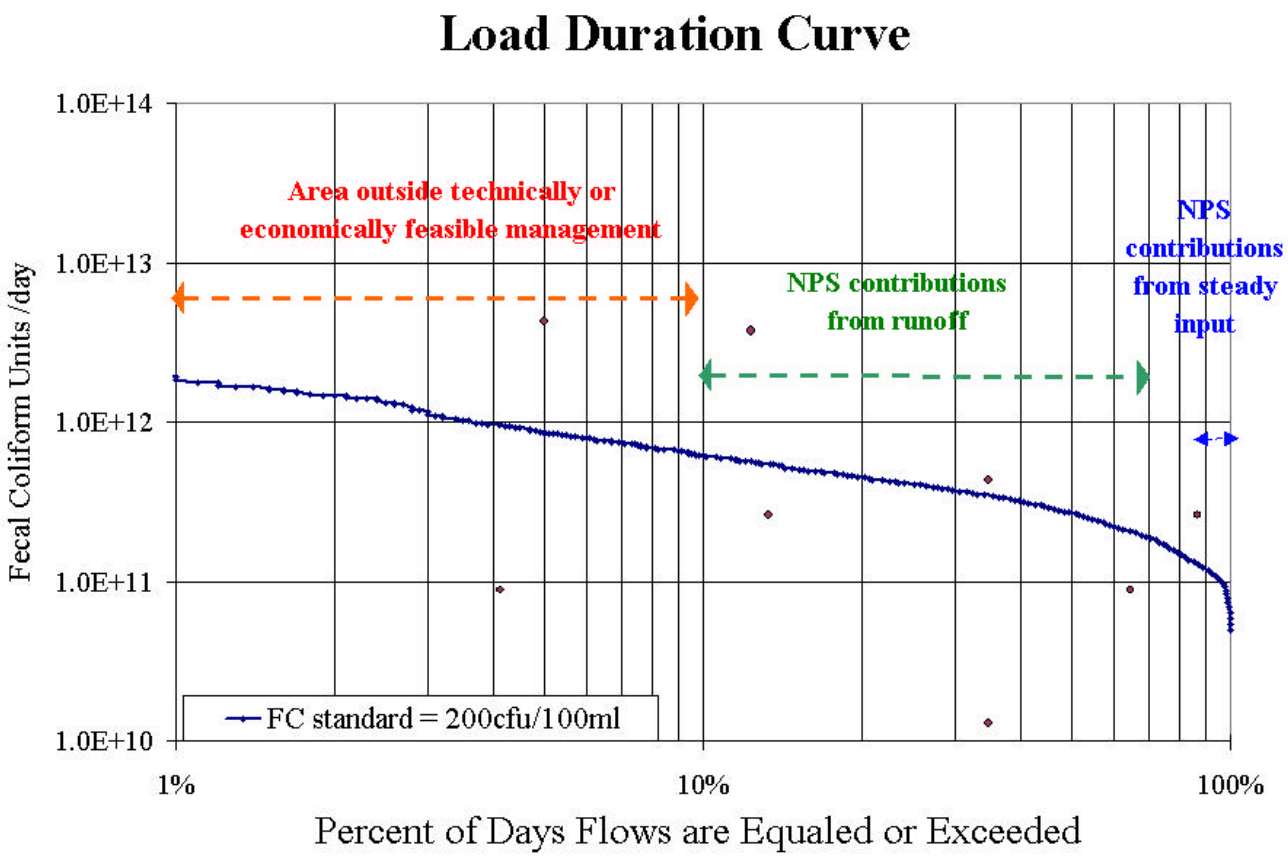
Since sewage treatment plants routinely achieve essentially complete disinfection (less than 20 CFU/100ml), the requirement to disinfect results in fecal coliform concentrations well below the criteria and permit limit. The percent of the total point source contribution is an insignificant fraction of the total load. Consequently, these fecal coliform TMDLs will not impose any change in current practices for POTWs and industrial treatment plants and will not result in changes to existing effluent limits.

6.2. Assessment of Nonpoint and Stormwater Point Sources

Nonpoint and stormwater point sources include storm-driven loads such as runoff from various land uses that transport fecal coliform from sources such as geese, farms, and domestic pets to the receiving water. Domestic pet waste, geese waste, as well as loading from storm water detention basins will be addressed by the Phase II MS4 program. Nonpoint sources also include steady-inputs from "illicit" sources such as failing sewage conveyance systems, sanitary sewer overflows (SSOs), and failing or inappropriately located septic systems. When "illicit" sources are identified, either through the Phase II MS4 requirements or trackdown studies conducted by the Department, appropriate enforcement measures will be taken to eliminate them.

When streamflow gage information is available, a load duration curve (LDC) is useful in identifying and differentiating between storm-driven and steady-input sources. As an example, Figure 5 represents a LDC using the 200 CFU / 100 ml criterion.

Figure 5 Example Load Duration Curve (LDC)



The load duration curve method is based on comparison of the frequency of a given flow event with its associated water quality load. A LDC can be developed using the following steps:

1. Plot the Flow Duration Curve, Flow vs. % of days flow exceeded.
2. Translate the flow-duration curve into a LDC by multiplying the water quality standard, the flow and a conversion factor; the result of this multiplication is the maximum allowable load associated with each flow.
3. Graph the LDC, maximum allowable load vs. percent of time flow is equaled or exceeded.
4. Water quality samples are converted to loads (sample water quality data multiplied by daily flow on the date of sample).
5. Plot the measured loads on the LDC.

Values that plot below the LDC represent samples below the concentration threshold whereas values that plot above represent samples that exceed the concentration threshold.

Loads that plot above the curve and in the region between 85 and 100 percent of days in which flow is exceeded indicate a steady-input source contribution. Loads that plot in the region between 10 and 70 percent suggest the presence of storm-driven source contributions. A combination of both storm-driven and steady-input sources occurs in the transition zone between 70 and 85 percent. Loads that plot above 99 percent or below 10 percent represent values occurring during either extreme low or high flows conditions and are thus considered to be outside the region of technically and economically feasible management. In this report, LDCs are used only for TMDL implementation and not in calculating TMDLs.

LDCs for listed segments in the Raritan region are located in Appendix D. In each case, thirty (30) years of USGS gage flow data (water years 1970-2000), from the listed station, were used in generating the curve. When a recent 30-year period was not available at the listed station, an adjacent station was selected based on station correlation information in US Geological Survey Open File Report 81-1110 (USGS, 1982). When an adjacent station was used in the manner, flows were adjusted to the station of interest based on a ratio of watershed size. LDCs were not developed for stations in which a satisfactory correlation could not be found.

7.0 Water Quality Analysis

Relating pathogen sources to in-stream concentrations is distinguished from quantifying that relationship for other pollutants given the inherent variability in population size and dependence not only on physical factors such as temperature and soil characteristics, but also on less predictable factors such as re-growth media. Since fecal coliform loads and concentrations can vary many orders of magnitude over short distances and over time at a single location, dynamic model calibrations can be very difficult to calibrate. Options available to control non-point sources of fecal coliform typically include measures such as goose management strategies, pet waste ordinances, agricultural conservation management plans, and septic system replacement and maintenance. Given these considerations, detailed water quality modeling may not provide adequate insight or guidance toward the development of implementation plans for fecal coliform reductions.

As described in EPA guidance, a TMDL identifies the loading capacity of a waterbody for a particular pollutant. EPA regulations define loading capacity as the greatest amount of loading that a waterbody can receive without violating water quality standards (40 C.F.R. 130.2). The loadings are required to be expressed as either mass-per-time, toxicity, or other appropriate measures (40 C.F.R. 130.2(i)). For these TMDLs, the load capacity is expressed as a concentration set to meet the state water quality standard. For bacteria, it is appropriate and justifiable to express the components of a TMDL as percent reduction based on concentration. The rationale for this approach is that:

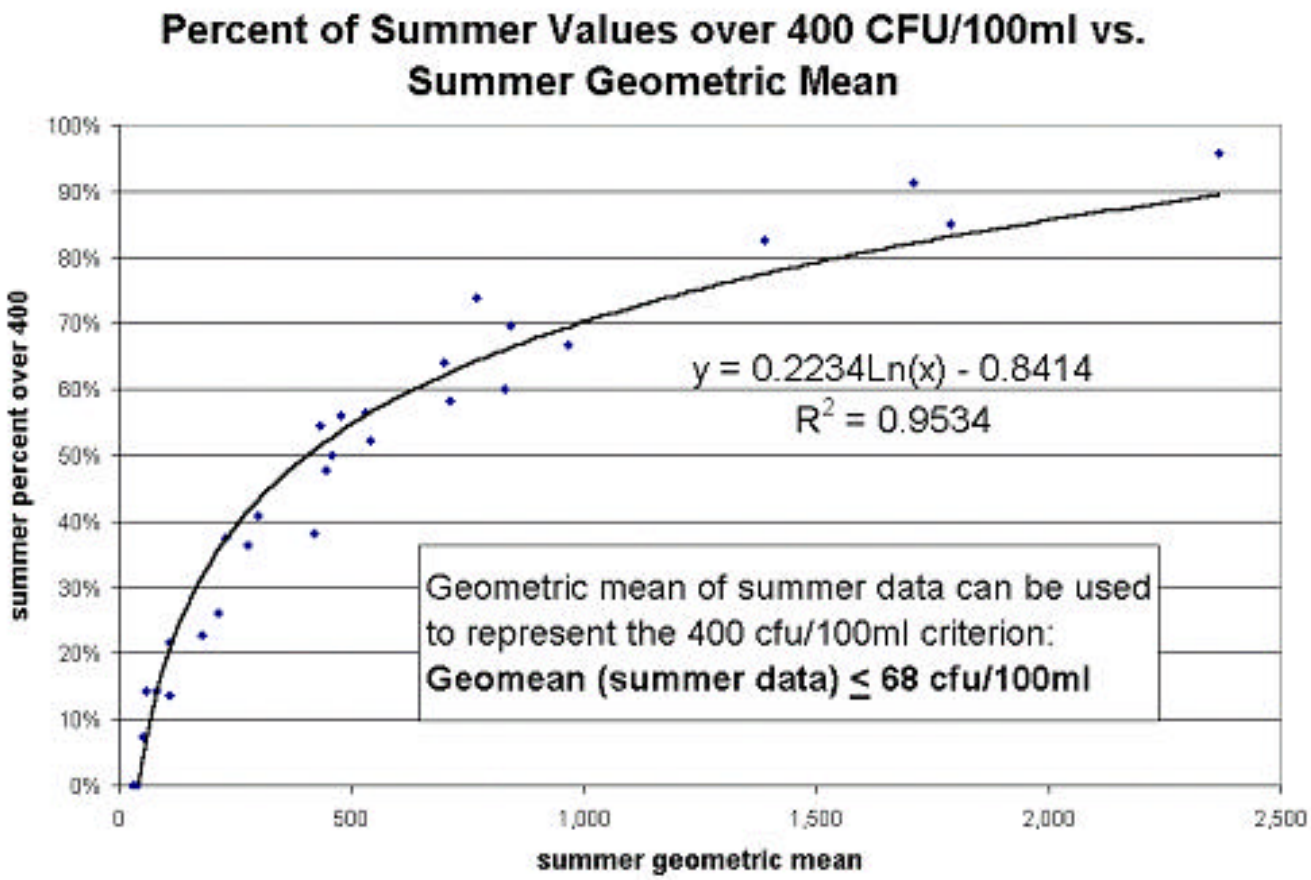
- expressing a bacteria TMDL in terms of concentration provides a direct link between existing water quality and the numeric target;
- using concentration in a bacteria TMDL is more relevant and consistent with the water quality standards, which apply for a range of flow and environmental conditions; and

- follow-up monitoring will compare concentrations to water quality standards.

Given the two criteria of 200 CFU / 100 ml and 400 CFU / 100 ml in FW2 waters, computations were necessary for both criteria and resulted in two percent reduction values. The higher percent reduction value was applied in the TMDL so that both the 200 CFU / 100 ml and 400 CFU / 100 ml criteria were satisfied.

To satisfy the 200 CFU / 100ml criteria, the geometric mean of all available data between water years 1994-2002 was compared to an adjusted target concentration. The adjusted target accounts for an explicit margin of safety and is equal to 200 minus the margin of safety. A calculation incorporating all available data is generally conservative since most samples are taken during the summer when fecal coliform is generally higher. A geometric mean of summer data was used to develop a percent reduction to satisfy the 400 CFU / 100 ml criteria. A summer geometric mean can be used to represent the 400 criteria by regressing the percent over 400 CFU / 100 ml against the geometric mean (Figure 6). Thus, each datapoint on Figure 6 represents all the data from one individual monitoring station. Sites with 20 or more summer data points were used to develop this regression, in order to make use of more significant values for percent exceedance. A statewide regression was used rather than regional regressions because the regression shape was not region-specific and the strength of the correlation was highest when all statewide data were included. The resulting regression has an r-squared value of 0.9534. Solving for X when Y is equal to 10% yields a geometric mean threshold of 68 CFU / 100ml. This means that, using summer data, a geometric mean of 68 can be used to represent the 400 CFU / 100ml criterion. Since the geometric mean is a more reliable statistic than percentile when limited data are available, 68 CFU / 100ml was used to represent the 400 CFU / 100ml criterion for all sites. The inclusion of all data from summer months (May through September) to compare with the 30-day criterion is justified because summer represents the critical period when primary and secondary contact with water bodies is most prevalent. A more detailed justification for using summer data can be found in Section 7.1,"Seasonal Variation and Critical Conditions."

Figure 6 **Percent of summer values over 400 CFU/100ml as a function of summer geometric mean values**



$y = 0.2234\mathrm{Ln}(x) - 0.8414$ Equation 1
$R^2 = 0.9534$

Geometric mean, and summer geometric mean, and percent reductions were determined at each location for both criteria using Equations 2 through 4. To satisfy the 200 CFU / 100ml criteria, equations 2 and 3 were applied. Equations 2 and 4 were used in satisfying the 400 CFU / 100ml criteria.

$$Geometric\ Mean\ \ for\ 200 CFU\ criteria = \sqrt[n]{y_1 y_2 y_3 y_4 .... y_n}$$ Equation 2

where:
y = sample measurement
n = total number of samples

$$200\ CFU\ criteria\ \ Percent\ \mathrm{Re}duction = \frac{(Geometric\ \ mean - (200 - e))}{Geometric\ \ mean} \times 100\ \%$$ Equation 3

$$400\ CFU\ criteria\ Percent \mathrm{Re}duction = \frac{(Summer Geometric\ mean - (68 - e))}{Summer Geometric\ mean} \times 100\ \%$$ Equation 4

where:

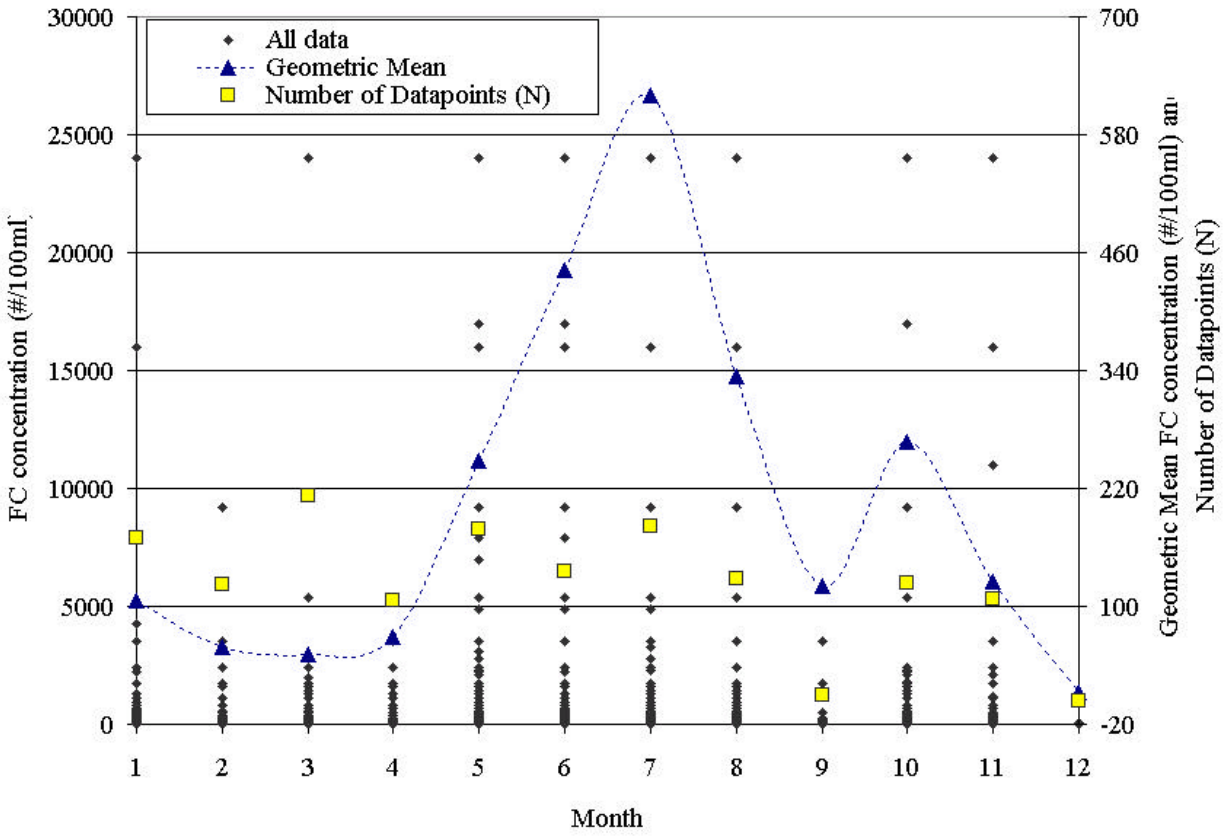
e = (margin of safety)

This percent reduction can be applied to nonpoint and stormwater point sources as a whole or be apportioned to categories of nonpoint and stormwater point sources within the study area. The extent to which nonpoint and stormwater point sources have been identified or need to be identified varies by study area based on data availability, watershed size and complexity, and pollutant sources.

7.1. Seasonal Variation/Critical Conditions

These TMDLs will attain applicable surface water quality standards year round. The approach outlined in this paper is conservative given that in most cases fecal coliform data were collected during the summer months, a time when in-stream concentrations are typically the highest. This relationship is evidenced when calculating, on a monthly basis, the geometric mean of fecal coliform data collected statewide. Statewide fecal coliform geometric means during water years 1994-1997 were compared on a month basis and are shown in Figure 7. The 1994-1997 period was chosen for this analysis so that the significance of the number of individual datapoints for any given month was minimized. During the 1994-1997 period year-round sampling for fecal coliform was conducted by sampling four times throughout the year. Following 1997, the fecal coliform sampling protocol was changed to five samples during a 30-day period in the summer months. As evident in Figure 7, higher monthly geometric means are observed between May and September with the highest values occurring during mid-summer. This relationship is also evident when using the entire 1994-2002 dataset or datasets from individual water years. Given this relationship, summer is considered the critical period for violating fecal coliform SWQS and, as such, sampling during this period is considered adequate for meeting year round protections and designated uses.

Figure 7 Statewide monthly fecal coliform geometric means during water years 1994-1997 using USGS/NJDEP data.



7.2. Margin of Safety

A Margin of Safety (MOS) is provided to account for "lack of knowledge concerning the relationship between effluent limitations and water quality" (40 CFR 130.7(c)). For these TMDLs calculations, both an implicit and explicit Margin of Safety (MOS) are incorporated. Implicitly, a MOS is inherent in the estimates of current pollutant loadings, the targeted water quality goals (New Jersey's SWQS) and the allocations of loading. This was accomplished by taking conservative assumptions throughout the TMDL evaluation and development. Examples of some of the conservative assumptions include treating fecal coliform as a conservative substance, applying the fecal coliform criteria to stormwater point sources, and applying the fecal coliform criteria to the stream during all weather conditions. Fecal coliforms decay in the environment (i.e. outside the fecal tract) relatively rapidly, yet this analysis assumes a linear relationship between fecal load and instream concentration. Furthermore, it is generally recognized that fecal contamination from stormwater poses much less risk of illness than fecal contamination from sewage or septic system effluent (Cabelli, 1989). Finally, much of the fecal coliform is flushed into the system during rainfall events and passes through the system in a short time. Primary and secondary recreation generally occur during dry periods.

An explicit MOS is provided by incorporating a confidence level multiplier associated with log-normal distributions in the calculation of the load reduction for both the 200 and 400 standards. Using this method, the 200 and 400 targets are reduced based on the number of data points and the variability within each data set. For these TMDLs, a confidence level of 90% was used in calculating the MOS. As a result, and as identified in Appendix C, the target value will be different for each stream segment or grouped segments. The explicit margin of safety is calculated using the following steps:

1- FC data (x) will transformed to Log form data (y),
2- the mean of the Log- transformed data (y) is determined, $\bar{y}$
3- Determine the standard deviation of the Log-transformed data, S_y using the following equation:

$$S_y = \sqrt{\frac{\sum_i (y_i - \bar{y})^2}{N-1}}$$

4- Determine the Geometric mean of the FC data (GM)
5- Determine the standard deviation of the mean (standard error of the mean), $s_{\bar{y}}$, using the following equation:

$$s_{\bar{y}} = \frac{s_y}{\sqrt{N}}$$

6- For the 200 standard ($x_{standard}$), $y_{standard}$ = Log(200)= 2.301, thus for a confidence level of 90%, the target value will be the lower confidence limit (n= -1.64), $y_{target} = y_{std} - n \cdot s_{\bar{y}}$, for example, the 200 criteria: $y_{target} = 2.301 - n * s_{\bar{y}}$
7- The target value for x, $x_{target} = 10^{y\ target}$
8- The margin of safety (e) therefore will be $e = x_{standard} - x_{target}$
9- Finally, the load reduction = $\frac{GM - x_{target}}{GM} \cdot 100\%$, for example the 200 criteria will be defined as: $\frac{(GM - (200 - e))}{GM} \cdot 100\%$

   The 400 criteria would be defined as: $\frac{(GM - (68 - e))}{GM} \cdot 100\%$

8.0 TMDL Calculations

Because these TMDLs are calculated based on ambient water quality data, the allocations are provided in terms of percent reductions. In the same way, the loading capacity of each stream is expressed as a function of the current load:

$LC = (1 - PR) \times L_o$, where

LC = loading capacity for a particular stream;
PR = percent reduction as specified in Tables 7-10;

L_o = current load.

8.1. Wasteload Allocations and Load Allocations

For the reasons discussed previously, these TMDLs do not include WLAs for traditional point sources (POTWs, industrial, etc.). WLAs are hereby established for all NJPDES-regulated point sources (including NJPDES-regulated stormwater), while LAs are established for all stormwater sources that are not subject to NJPDES regulation, and for all nonpoint sources. Both WLAs and LAs are expressed as percentage reductions for particular stream segments.

Table 11 identifies the required percent reduction necessary for each stream segment or group of segments to meet the fecal coliform SWQS. The reductions reported in these tables include a margin of safety factor and represent the higher percent reduction (more stringent) required of the two criteria. Reductions that are required under each criteria are located in Appendix C. In all cases, the 400 CFU/100ml criteria was the more stringent of the two criteria, thus values reported in Table 11 were equal to the percent required to meet the 400 CFU/100ml criteria.

Table 11 TMDLs for fecal coliform-impaired stream segments in the Raritan Water Region as identified in Sublist 5 of the 2002 Integrated List of Waterbodies. The reductions reported in this table represent the higher, or more stringent, percent reduction required of the two fecal colifom criteria.

TMDL Number	WMA	303(d) Category 5 Segments	Water Quality Stations	Station Names	Load Allocation (LA) and Margin of Safety (MOS)					Wasteload Allocation (WLA)
					Summer N	Summer geometric mean CFU/100ml	MOS as a percent of the target concentration	Percent reduction without MOS	Percent reduction with MOS	
1 2	7	01393350, 01393450	01393350, 01393450	WB Elizabeth River near Union, Elizabeth River at Ursino Lake at Elizabeth	13	2340	42%	97%	98%	98%
3 4 5	7	01393960, 01394500, 01395000	01393960, 01394500, 01395000	WB Rahway River at Northfield Ave. at West Orange, Rahway River near Springfield, Rahway River at Rahway	63	1680	23%	96%	97%	97%
6 7	7	01395200, 01396003	01395200, 01396003	Robinson Branch at Scotch Plains, Robinson Branch at St Georges Ave at Rahway	10	626	60%	89%	96%	96%
8 9 10	8	01396219, 01396280, 01396535	01396219, 01396280, 01396535	Stony Brook at Fairview Avenue at Naughright, South Branch Raritan River at Middle Valley, South Branch Raritan River Arch	21	809	34%	92%	94%	94%

				St at High Bridge						
11 12	8	01396550, 01396588	01396550, 01396588	Spruce Run at Newport, Spruce Run near Glen Gardner	28	99	32%	31%	53%	53%
13	8	01396660	01396660	Mulhockaway Creek at Van Syckel	29	464	36%	85%	91%	91%
14	8	01398000	01398000	Neshanic River at Reaville	28	313	40%	78%	87%	87%
15 16 17	8	01397000, 01397400, 01398102	01397000, 01397400, 01398070, 01398102	South Branch Raritan River at Stanton Station, South Branch Raritan River at Three Bridges, South Branch Raritan River at Elm St. at Neshanic Station, South Branch Raritan River at South Branch	43	261	25%	74%	80%	80%
18	8	01398260	01398260	North Branch Raritan River near Chester	8	138	37%	51%	69%	69%
19 20 21 22	8	01399200, 01399500, 01399700, 01399780	01399200, 01399500, 01399700, 01399780	Lamington River near Ironia, Lamington River near Pottersville, Rockaway Creek at Whitehouse, Lamington River at Burnt Mills	48	531	25%	87%	90%	90%
23 24 25	8	01399120, 01399900, 01400000	01399120, 01399900, 01400000	North Branch Raritan River at Burnt Mills, Chambers Brook at North Branch Depot, North Branch Raritan River near Raritan	34	487	28%	86%	90%	90%
26	9	01400395	01400395	Peters Brook at Rt 28 at Somerville	5	1952	47%	97%	98%	98%
27 28	9	01403385, 01403470	01403385, 01403470	Bound Brook at Route 28 at Middlesex, Green Brook at North Plainfield	25	1503	43%	95%	97%	97%
29 30 31	9	01400500, 01403300, 01403900	01400500, 01403300, 01403900	Raritan River at Manville, Raritan River at Queens Bridge, Bound Brook at Middlesex	16	549	36%	88%	92%	92%
32 33 34 35 36	9	01405195, 9, 22, 61, 68	01405302, 01405195, 9, 22, 61, 68, 69	Matchaponix Brook at Mundy Ave at Spotswood, Matchaponix Brook at Englishtown, Weemaconk Creek at Main St In Manalapan, McGolliard Brook at Main St In Englishtown, Lake Topanemus at Pond Rd In Freehold, Wemrock Brook at Rt #9 In Freehold, Wemrock Brook at Rt #9	54	188	20%	64%	71%	71%
37 38	9	01405340, 01405400	01405340, 01405400	Manalapan Brook at Federal Rd near Manalapan, Manalapan Brook near Spotswood	28	403	37%	83%	89%	89%
39 40	10	01400540, 01400650	01400540, 01400650, 5	Millstone River near Manalapan, Millstone River at Grovers Mill, Millstone River at Route 33 In Millstone	36	453	27%	85%	89%	89%
41	10	01400690	01400690	Cranbury Book near Prospect Plains	5	269	50%	75%	87%	87%
42	10	01401000	01401000	Stony Brook at Princeton	8	840	52%	92%	96%	96%

43	10	01401200	01401200	Duck Pond Run at Clarksville	5	2019	75%	97%	99%	99%
44	10	01401400	01401400	Heathcote Brook at Kingston	19	746	36%	91%	94%	94%
45 46	10	01401600, 01401700	01401600, 01401700	Bedens Brook near Rocky Hill, Pike Run near Rocky Hill	15	1499	44%	95%	97%	97%
47 48	10	01402000, 01402540	01402000, 01402540	Millstone River at Blackwells Mills, Millstone River at Weston	30	527	35%	87%	92%	92%

[1] MOS as a percent of target is equal to: $\frac{e}{200\ CFU/100ml}$ or $\frac{e}{68\ CFU/100ml}$ where "e" is defined as the MOS in Section 7.2

8.2. Reserve Capacity

Reserve capacity is an optional means of reserving a portion of the loading capacity to allow for future growth. Reserve capacities are not included at this time. The loading capacity of each stream is expressed as a function of the current load (Section 8.0), and both WLAs and LAs are expressed as percentage reductions for particular stream segments (Section 8.1). Therefore, the percent reductions from current levels must be attained in consideration of any new sources that may accompany future development. Strategies for source reduction will apply equally well to new development as to existing development.

9.0 Follow - up Monitoring

In association with the Water Resources Division of the U.S. Geological Survey, the NJDEP have cooperatively operated the Ambient Stream Monitoring Network (ASMN) in New Jersey since the 1970s. The ASMN currently includes approximately 115 stations that are routinely monitored on a quarterly basis. Bacteria monitoring, as part of the ASMN network, are conducted five times during a consecutive 30-day summer period each year. The data from this network has been used to assess the quality of freshwater streams and percent load reductions. Although other units also perform monitoring functions, the ASMN will remain a principal source of fecal coliform monitoring.

10.0 Implementation

Management measures are "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint and stormwater sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint and stormwater source pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives" (USEPA, 1993).

Development of effective management measures depends on accurate source assessment. Fecal coliform is contributed to the environment from a number of categories of sources including human, domestic or captive animals, agricultural practices, and wildlife. Fecal

coliform from these sources can reach waterbodies directly, through overland runoff, or through sewage or stormwater conveyance facilities. Each potential source will respond to one or more management strategies designed to eliminate or reduce that source of fecal coliform. Each management strategy has one or more entities that can take lead responsibility to effect the strategy. Various funding sources are available to assist in accomplishing the management strategies. The Department will address the sources of impairment through systematic source trackdown, matching strategies with sources, selecting responsible entities and aligning available resources to effect implementation.

For example, the stormwater discharged to the impaired segments through "small municipal separate storm sewer systems" (small MS4s) will be regulated under the Department's proposed Phase II NJPDES stormwater rules for the Municipal Stormwater Regulation Program. Under those proposed rules and associated draft general permits, many municipalities (and various county, State, and other agencies) in the Raritan Region will be required to implement various control measures that should substantially reduce bacteria loadings, including measures to eliminate "illicit connections" of domestic sewage and other waste to the small MS4, adopt and enforce a pet waste ordinance, prohibit feeding of unconfined wildlife on public property, clean catch basins, perform good housekeeping at maintenance yards, and provide related public education and employee training. Sewage conveyance facilities are potential sources of fecal coliform in that equipment failure or operational problems may result in the release of untreated sewage. These sources, once identified, can be eliminated through appropriate corrective measures that can be effected through the Department's enforcement authority. Inadequate on-site sewage disposal can also be a source of fecal coliform. Systems that were improperly designed, located or maintained may result in surfacing of effluent and illicit remedies such as connections to storm sewers or streams add human waste directly to waterbodies. Once these problems have been identified through local health departments, sanitary surveys or other means, alternatives to address the problems can be evaluated and the best solution implemented. The Department has committed a portion of its CWA 319(h) pass through grant funds to assist municipalities in meeting Phase II requirements. In addition, The New Jersey Environmental Infrastructure Financing Program, which includes New Jersey's State Revolving Fund, provides low interest loans to assist in correction of water quality problems related to stormwater and wastewater management.

Agricultural activities are another example of potential sources of fecal coliform. Possible contributors are direct contributions from livestock permitted to traverse streams and stream corridors, manure management from feeding operations, or use of manure as a soil fertilizer/amendment. Implementation of conservation management plans and best management practices are the best means of controlling agricultural sources of fecal coliform. Several programs are available to assist farmers in the development and implementation of conservation management plans and best management practices. The Natural Resource Conservation Service is the primary source of assistance for landowners in the development of resource management pertaining to soil conservation, water quality improvement, wildlife habitat enhancement, and irrigation water management. The USDA Farm Services Agency

performs most of the funding assistance. All agricultural technical assistance is coordinated through the locally led Soil Conservation Districts. The funding programs include:

- **The Environmental Quality Incentive Program (EQIP)** is designed to provide technical, financial, and educational assistance to farmers/producers for conservation practices that address natural resource concerns, such as water quality. Practices under this program include integrated crop management, grazing land management, well sealing, erosion control systems, agri-chemical handling facilities, vegetative filter strips/riparian buffers, animal waste management facilities and irrigation systems.

- **The Conservation Reserve Program (CRP)** is designed to provide technical and financial assistance to farmers/producers to address the agricultural impacts on water quality and to maintain and improve wildlife habitat. CRP practices include the establishment of filter strips, riparian buffers and permanent wildlife habitats. This program provides the basis for the Conservation Reserve Enhancement Program (CREP). The New Jersey Departments of Environmental Protection and Agriculture, in partnership with the Farm Service Agency and Natural Resources Conservation Service, has recently submitted a proposal to the USDA to offer financial incentives for agricultural landowners to voluntarily implement conservation practices on agricultural lands through CREP. NJ CREP will be part of the USDA's Conservation Reserve Program (CRP). The enrollment of farmland into CREP in New Jersey is expected to improve stream health through the installation of water quality conservation practices on New Jersey farmland.

- **The Soil & Water Conservation Cost-Sharing Program** is available to participants in a Farmland Preservation Program pursuant to the Agriculture Retention and Development Act. A Farmland Preservation Program (FPP) means any voluntary FPP or municipally approved FPP, the duration of which is at least 8 years, which has as its principal purpose as long term preservation of significant masses of reasonably contiguous agricultural land within agricultural development areas. The maintenance and support of increased agricultural production must be the first priority use of the land. Eligible practices include erosion control, animal waste control facilities, and water management practices. Cost sharing is provided for up to 50% of the cost to establish eligible practices.

- **The State Conservation Cost Share Program (SCCSP)** is administered by the State Soil Conservation Committee and is integrated with the federal Environmental Quality Incentives Program (EQIP). It provides technical and financial assistance to producers for prevention and control of nonpoint sources of pollution. Cost sharing is provided for up to 75%, and in some cases 90% of the cost of installing approved conservation practices. Applications are approved based upon their environmental benefits and water quality enhancements.

10.1. Source Trackdown

Through the watershed management process and New Jersey Watershed Ambassador Program, river assessments and visual surveys of the impaired segment watersheds were conducted to identify potential sources of fecal coliform. Watershed partners, who are intimately familiar with local land use practices, were able to share information relative to potential fecal coliform sources. The New Jersey Watershed Ambassadors Program is a community-oriented AmeriCorps environmental program designed to raise awareness about watershed issues in New Jersey. Through this program, AmeriCorps members are placed in watershed management areas across the state to serve their local communities. Watershed Ambassadors monitor the rivers of New Jersey through River Assessment Teams (RATs) and Biological Assessment Teams (BATs) volunteer monitoring programs. Supplemental training was provided through the fall/winter of 2002 to prepare the members to perform river assessments on the impaired segments. Each member was provided with detailed maps of the impaired segments within their watershed management area. The Department worked with and through watershed partners and AmeriCorps members to conduct RATs surveys in fall of 2002. The Department reviewed monitoring data, RATs surveys, other information supplied by watershed partners, load duration curves, and aerial photography of the impaired segments to formulate segment specific strategies. Segment specific monitoring strategies in combination with generic strategies appropriate to the sources in each segment will lead to reductions in fecal coliform loads in order to attain SWQS.

10.2. Short Term Management Strategies

Short-term management measures include projects recently completed, underway and planned which will result in reductions in fecal coliform load. Pertinent projects in the Raritan region are as follows:

WMA 7

- **Warinaco Park Lake and Lagoon Restoration Project**
  Union County was awarded $99,000 to complete a restoration of a pond and Stream Bank stabilization in Warinaco Park

- **Robinson's Branch stream stabilization and rehabilitation**
  The Rahwah River Association was awarded $110,000 to complete this project. The project involves Phase 2 of the Robinsons Branch rehabilitation. The establishment of a riparian buffer and bank stabilization for this Stream appears to be primarily focused on erosion control and biostabization.

- **Flood Plain Restoration at Union and Allen Streets, City of Rahway, Union County, NJ**
  The City of Rahway received $147,5000 to restore flood plain habitat and improve water quality of the Rahway River Watershed. The City of Rahway has already purchased 11 flood prone properties and razed the houses that occupied these properties. With funding assistance from the New Jersey Wetland Mitigation Council, the City has completed the final design for the project and has applied for permits. The restoration

site will encompass approximately 4-½ acres in the Rahway River flood plain. Historic maps of the area and geologic sampling indicate that this site was once a riparian wetland until it was filled and developed as residential homes. This project will restore this riparian wetland to provide wildlife habitat and help filter pollutants from stormwater runoff. The site will provide for stormwater retention to help minimize flooding in the area and provide for public access for recreation and public education on wetlands and watershed management.

- **Rahway River Watershed NP Pollution Implementation Project Milton Lake & Robinson's Branch, Rahway River Watershed**
  The NY/NJ Bay Keeper was awarded $112, 000 to complete this project. The project is in an urban area and offers an opportunity to demonstrate stream restoration to city residents. It is in a highly visible location and would help promote good watershed management. The project also intends to utilize volunteers from the city's schools and will help promote environmental education.

WMA 8

- **Restoring Our Rivers**
  Restoration of a 1000 foot long reach of 10 foot high vertical stream bank adjacent to the South Branch just below its confluence with the Neshanic River. The project utilized a combination of hard engineering stabilization techniques and softer soil bioengineering techniques on agricultural land in Hillsborough Township, Somerset County. This project provided a reduction on sediment loads to streams, improvement of fisheries and aquatic resources, improvement of riparian resources habitat and the creation of a filter adjacent to the river.

- **Stormwater Management Plan for the Mulhockaway Creek Watershed**
  This project will produce a stormwater management plan to reduce nonpoint source pollution impacts on the Spruce Run Reservoir located in Union Township, Hunterdon County. This project is critical to the protection of a major regional water supply resource and will produce a significant regional benefit.

- **Peapack Brook Water Quality Assessment**
  The Peapack Brook is a trout production stream that flows through Chester Boro, Chester Township and the Boro of Peapack-Gladstone and Bedminster Township. This project will assess causes of the current quality of the Peapack Brook subwatershed, develop management strategies to protect and restore areas of the subwatershed, implement BMP's to address nonpoint source pollution and increase public knowledge of NPS pollution and participation in watershed conservation activities.

- **South Branch Raritan River Remediation Project**
  The project assessed pollution from stormwater runoff and septic systems and developed an education program. The project also retrofitted stormwater drains and implemented BMP's to reduce the impact on the waterway.

- **Action Plan Presentations to Communities to Address NPS Pollution**
  The project implemented a NPS pollution educational outreach program that encouraged municipal officials and residents to protect their water resources and reduce the amount of NPS pollution entering the surface and ground water supplies of the South Branch Raritan River.

WMA 9

- **Restoration of Victor Crowell Park**
  Restoration of the Middlesex Borough Park along with the lake which will be dredged. The project installed BMP's on several stormwater discharge points, utilized swales and structural solutions and created a dense landscape buffer along the banks. The project stabilized the eroding lake shore and reduced the input of sediment to the lake, reduced nutrient loadings and NPS pollutants, aided in the control of geese and mosquitoes, and provided quality open space for the community.

- **Stream Bank Stabilization and Riparian Buffer Restoration of Cedar Brook**
  This project located in the City of Plainfield, Union County offers the potential to remove prior "hard" stream bank stabilization and replace it with bioengineering mechanisms in order to restore the stream habitat. The project is in an urban area in a highly visible location and offers an opportunity to demonstrate stream restoration to city residents.

WMA 10

- **Riparian Wetland Restoration Powder Mill Pond**
  This project is located within Colonial Park in Franklin Township, Somerset County. The project will construct a riparian buffer to improve water quality within the pond which is a headwaters tributary of the Millstone River. In addition, a long term monitoring program and educational program will be implemented.

- **Clean Water Action Watershed Restoration Program**
  This project performed a characterization and assessment of two subwatersheds within the Millstone Watershed named the Bedens Brook and Rocky Brook. The project also developed action plans and implementations of nonpoint source pollution reduction programs, such as watershed restoration and reforestation projects and execution of a River Friendly Program designed to educate targeted audiences such as golf courses.

- **Nonpoint Source Pollution Control and Management for the Stony Brook-Millstone Watershed**
  This project is a continuation of an existing watershed plan. The main focus will be the restoration of Amwell Lake and Stony Brook headwaters including restoring stream banks, stabilizing eroding shorelines and replanting.

10.3. Long–Term Management Strategies

Long term strategies include source trackdown as well as selection and implementation of specific management measures that will address the identified sources. Source categories and responses are summarized below:

Source Category	Responses	Potential Responsible Entity	Funding options
Human Sources			
Inadequate (per design, operation, maintenance, location, density) on-site disposal systems	Confirm inadequate condition; evaluate and select cost effective alternative, such as rehabilitation or replacement of systems, or connection to centralized treatment system	Municipality, MUA, RSA	CWA 604(b) for confirmation of inadequate condition; Environmental Infrastructure Financing Program for construction of selected option
Inadequate or improperly maintained stormwater facilities; illicit connections	Measures required under Phase II Stormwater permitting program plus Alternative measures as determined needed through TMDL process	Municipalty, State and County regulated entities, stormwater utilities	CWA 319(h)
Malfunctioning sewage conveyance facilities	Identify through source trackdown	Owner of malfunctioning facility--compliance issue	User fees
Domestic/captive animal sources			
Pets	Pet waste ordinances	Municipalities for ordinance adoption and compliance	
Horses, livestock, zoos	Confirm through source trackdown: SCD / NRCS develop conservation management plans	Property owner	EQIP / SCCSP, CRP, CREP (when approved),
Agricultural practices	Confirm through source trackdown; SCD / NRCS develop conservation management plans	Property owner	EQIP / SCCSP, CRP, CREP (when approved)
Wildlife			

Source Category	Responses	Potential Responsible Entity	Funding options
Nuisance concentrations, eg resident Canada geese	Feeding ordinances; Goose Management BMPs	Municipalities for ordinance; Community Plans for BMPs	CBT, CWA 319(h)
Indigenous wildlife	Confirm through trackdown; consider revising designated uses	State	NA

10.4. Segment Specific Recommendations

10.4.1. Watershed Management Area 7

West Branch Elizabeth River near Union (Site ID #01393350)

Two golf courses are within the watershed of the impaired segment. Geese were observed at both golf courses. Three stormwater outfalls are located at the headwaters of the segment. The streamshed drains a large urbanized area to the north. The majority of immediate area contains urbanized land use that has many detention basins, pets, and geese. Strategies: organize local community based goose management programs; Phase II stormwater program.

Elizabeth River At Ursino Lake at Elizabeth (Site ID #01393450)

This station is located at the beginning of the channelization of the Elizabeth River and is at the site of a dam. Canada geese were observed at the park and lawns where the station is located. The majority of immediate area contains urbanized land use that has many detention basins, stormwater outfalls, pets, and geese. Strategies: organize local community based goose management programs; Phase II stormwater program.

West Branch Rahway River at Northfield Ave. (Site ID #01393960)

The site is located at the head of Orange Reservoir and South Mountain Reservation. The South Mountain Reservation and two area golf courses are potential source for fecal coliform because of the wildlife, includinge geese. Strategies: organize local community based goose management programs; Phase II stormwater program.

Rahway River near Springfield (Site ID #01394500)

Potential sources for fecal coliform for include golf courses and parks at which geese were observed. The majority of immediate area contains urbanized land use that has many detention basins, pets, and geese. Strategies: organize local community based goose management programs; Phase II stormwater program.

Rahway River at Rahway (Site ID #01395000)

The headwaters of this segment contain golf courses, large parks and reservations that contribute to the fecal coliform impairment. The majority of immediate area contains urbanized land use that has many detention basins, pets, and geese. Strategies: organize local community based goose management programs; Phase II stormwater program.

Robinson Branch At Scotch Plains (Site ID #01395200)

The site is located about 200 yards down stream of a golf course where geese are a contributing factor. Most of the runoff drains directly to the stream with no filtration. This site is also located in the Ash Brook Reservation were wildlife, including deer, are probably a contributing factor to the impairment of this stream for fecal coliform. Strategies: organize local community based goose management programs; Phase II stormwater program.

Robinson Branch at St. Georges Ave. at Rahway (Site ID #01396003)

The headwaters of this station are located in the Ash Brook Reservation where there are large numbers of geese and wildlife. Also within the headwaters of this segment there are several golf courses that are home to geese and have little or no treatment of runoff, which drains directly to the headwaters of the Robinson Branch. There are three stormwater outfalls located in the headwaters of the impaired segment; the majority of the immediate area contains urbanized land use, with many detention basins, pets, and geese. Strategies: organize local community based goose management programs; Phase II stormwater program.

10.4.2. Watershed Management Area 8

SB Raritan River at Stanton Station (#1397000), SB Raritan River at Three Bridges (#1397400), and SB Raritan River at South Branch (#1398102)

Land uses include agriculture and residential. Possible sources of fecal coliform include geese, deer and other wildlife, and agricultural operations, including livestock, poultry and equine areas. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Chambers Brook at North Branch Depot (#1399900)

Land uses in this area include mostly agriculture and residential. There is a golf course in this watershed. Possible sources of fecal coliform contamination include equine, cattle, geese, deer, and suburban development. Monitoring: coliphage to determine presence of any human sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPS; Phase II stormwater program.

NB Raritan River at Burnt Mills (#1399120)

Land uses in this area include agriculture, including hobby farms (equine), residential, commercial, and an industrial park. Riparian buffer is lacking or disturbed and frequented by geese and deer. Load duration curve is consistent with a mix of steady state and storm driven sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; Phase II stormwater program.

North Branch Raritan River near Raritan (#1400000)

Land use suggests sources include suburban stormwater at Far Hills, Bridgewater and Bedminster Village. Geese, equine, and bovine sources present on tributaries, especially Middle Brook. Crop farming and loss of riparian buffer occurs along with bovine activity near mouth of Chambers Brook-Bridgewater/Bedminster border; sheep are managed at the mouth of Lamington River. Geese are present at North Branch Park. Load duration curve is consistent with a mix of steady state and storm driven sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Rockaway Creek at Whitehouse (#1399700)

Land uses in the area include forest, agriculture, field & pasture, residential, some industry and golf courses. Riparian buffers are poor. Horse, cattle and crop farming occurs downstream of New Bromley Road to mouth. Dairy farming is also found within this area. Cushetunk Lake has a noticeable goose population. Load duration curve is consistent with a mix of steady state and storm driven sources, with a tendency toward storm driven sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Lamington (Black) River near Pottersville (#1399500)

Land uses in the area include forest, field & pasture, commercial, and residential. Potential sources of fecal coliform include geese, wildlife, agriculture and domestic pets. Load duration curve is consistent with a mix of steady state and storm driven sources, with a tendency toward storm driven sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Lamington River near Ironia (#1399200)

Land use suggests sources including suburban development and geese. Load duration curve is consistent with a mix of steady state and storm driven sources, with a tendency toward storm driven sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Lamington River at Burnt Mills (#1399780)

Land uses in this area include residential, forest and agriculture. Geese populations are a potential source with large populations found throughout the area on golf courses and parks. In addition, heavy residential areas are a source of pet waste. There are also potential fecal coliform sources from agriculture. These include horses, manure spreading, and cattle. There are heavy deer populations throughout this area. Load duration curve is consistent with a mix of steady state and storm driven sources, with a tendency toward storm driven sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

NB Raritan River near Chester (#1398260)

Assessing sources from the headwaters downstream: stormwater from suburban development is a source in the Morris Turnpike area; Combes Hollow/Randolph/Mendham Township border has geese and heavy deer populations. North of Mendham Boro has suburban development. Downstream of Route 24 to #1399120 has sheep; pigs; small livestock operations. The Pleasant Valley area has cattle and horses. There are many small impoundments in the watershed. Monitoring: a fecal coliform survey is recommended to focus on the sources of impairment. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Mulhockaway Creek at Van Syckel (#1396660)

Land use is primarily forest and agriculture. Sources are deer and large geese populations in ponds. Load duration curve is consistent with steady state sources. Monitoring: a fecal coliform survey is recommended to focus on the sources of impairment. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Spruce Run near Glen Gardner (#1396588) and at Newport (#1396550)

Land use is agricultural and residential. Sources also include deer and geese in the parks, which have ponds. Load duration curve is consistent with a mix of sources, with a tendency toward storm driven sources. Monitoring: a fecal survey to focus on the sources of impairment and coliphage to determine if human sources are present. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs

SB Raritan River Arch Street at High Bridge (#1396535)

This area is predominantly residential; Califon Borough is served by septic systems. Potential sources of fecal coliform include failing septic systems and domestic pet waste. There are also horses in this area. Monitoring: Coliphage sampling is

recommended to determine if there are human sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Stony Brook at Fairview Avenue at Naughtbright (#1396219)

Land uses in this area are primarily forest, agriculture and residential. Riparian buffers are lacking in some areas. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs.

SB Raritan River at Middle Valley (#1396280)

This area is predominantly residential with some agriculture. Domestic pet waste and horses are potential sources of fecal coliform. Load duration curve is consistent with a mix of steady state and storm driven sources. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; Phase II stormwater program.

Neshanic River at Reaville (#1398000)

Land uses in this area are predominantly agriculture with some residential. Potential sources of fecal coliform include domestic pet waste, horses, geese, cattle, and sheep. There are large deer populations in this area. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

10.4.3. Watershed Management Area 9

Raritan River at Manville (#1400500)

The area consists of mainly agricultural and residential areas. Some possible sources of fecal contamination include suburban stormwater, agriculture and wildlife, including deer and geese. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Wemrock Brook at Route #9 (Before Pipes) in Freehold (Segment #68)

Primary land uses in this area are residential and commercial, including Freehold Borough. Possible sources of fecal contamination are suburban stormwater, geese and other wildlife. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Weemaconk Creek at Main Street in Manalapan (Segment #9)

This is primarily a residential area; suburban stormwater is the prime source. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize

local community based goose management programs; Phase II stormwater program.

LakeTopanemus at Pond Road in Freehold (Segment #61)

Topanemus Brook from Taylors Mills Road to Dam on Pond Road: Land uses in the watershed include primarily agriculture and residential. Possible sources in this area include livestock and geese and other wildlife. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Mc Golliard Brook at Main Street in Englishtown (Segment #22)

Pine Brook/McGallard Brook Tributary beginning at Wilson Ave ending at Sobecko Road. Possible sources of fecal coliform are geese and wildlife. Wilson Ave. to Taylors Mills Road: Primary land use is residential. Possible sources of fecal coliform are geese, wildlife and suburban runoff. Strategies: organize local community based goose management programs; Phase II stormwater program.

Manalapan Brook at Federal Road near Manalapan (#1405340) and at Spotswood (#1405400)

The primary land use in this area is residential with some agricultural and forested areas. A prime source of contamination is suburban stormwater. Other sources are wildlife, especially geese. Strategies: organize local community based goose management programs; Phase II stormwater program.

Bound Brook at Middlesex (#1403900)

This area consists of commercial, warehouse, and industrial land uses. There is also an urban residential area, and some forested areas. Primary sources of contamination include suburban stormwater and geese populations. Strategies: organize local community based goose management programs; Phase II stormwater program.

Green Brook at North Plainfield (#1403470)

The primary land uses in this area are sewered residential, commercial and forest. Possible sources of fecal contamination include suburban stormwater, horses from stables in the area, and geese and ducks by lakes. Strategies: organize local community based goose management programs; prioritize for EQIP/SCCSP funds to install agricultural BMPs Phase II stormwater program.

Bound Brook at Route 28 at Middlesex (#1403385)

This area consists of commercial and residential land. Possible contamination sources include suburban stormwater, and wildlife (including geese) around lakes

and swamps. Strategies: organize local community based goose management programs; Phase II stormwater program.

Raritan River at Fieldsville Dam (#1403300)

Primary land uses in the area are commercial and warehouse. There are also sewered residential and septic residential areas. Possible sources of fecal contamination include suburban stormwater and geese. Strategies: organize local community based goose management programs; Phase II stormwater program.

Peters Brook at Route 28 at Somerville (#01400395)

Land uses are commercial, industrial, and residential. The area is mostly sewered. The prime source of contamination is suburban stormwater. Strategies: Phase II stormwater program.

Matchaponix Brook at Englishtown (#01405195)

This are is primarily forest and residential and suburban stormwater is the principle source of contamination. Strategies: Phase II stormwater program.

10.4.4. Watershed Management Area 10

Bedens Brook near Rocky Hill (#1401600)

Land uses include forest, fields, agriculture, and residential. Potential sources of contamination include livestock, suburban stormwater, kennels, very old residential sections on septic systems as well as golf courses due to geese, and riding facilities. Strategies: organize local community based goose management programs; prioritize for EQIP/SCCSP funds to install agricultural BMPs Phase II stormwater program.

Millstone River at Weston (#1402540)

This area of the watershed is very flat and has shale soils. There are large deer and geese populations located throughout the area, particularly where there are large tracts of green lawns (sod farms, parks, golf courses). Griggs Street Area: Land uses in the area include forest, fields, and residential. Possible sources in this area include domestic pets, geese, and wildlife. Wilhousky Street Area: Land uses in the area include forest, fields, agriculture, and residential. Possible sources of fecal coliform include geese, wildlife, and domestic pets. Monitoring: confirm impairment. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Pike Run near Rocky Hill (#1401700)

This area is largely residential, both sewered and on individual septic systems. There are a large number of condo and townhouse complexes that are a source of

domestic pet waste and geese. Possible sources of fecal coliform include geese, domestic pets, old septic systems, and some livestock. Harlingen Road Bridge area: land uses include forest, agriculture, wetlands, and residential. This section contains a township dog park. The Township does have a Dog Litter Ordinance (ORD #99-965). Strategies: organize local community based goose management programs; Phase II stormwater program.

Heathcote Brook at Kingston (#1401400)

This area has many corporate commercial establishments with geese populations. Possible fecal coliform sources within this area include horse, sheep, crop farms, geese, wildlife (mostly deer), and domestic pets. Cook Natural Area, by Ridge Road Bridge: land uses in this area are forest and agriculture. Stouts Lane: land uses in the area are forest and agriculture. Ridge Road: predominant land uses in the area include forest and residential. Beginning at Route 1 just before Raymond Road and ending at Promenade Boulevard: predominant land uses in the area include forest and agriculture. Commercial land uses are also found throughout this area. There is one residential community with a dog-walking path, however no pet waste was evident along this path. However, domestic pet waste could be a potential source in other residential areas. Promenade Boulevard: Land uses in this area are forest and agricultural uses. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Duck Pond Run at Clarksville (#1401200)

This area is predominately residential, agricultural and forested. Possible sources of fecal coliform include domestic pets, livestock, horses, manure handling. Strategies: Phase II stormwater program.

Stony Brook at Princeton (#1401000)

Bridge on Mercer Road to Bridge on Rosedale Road (Route 604): Forest and residential are the predominant land uses in the area. There was also a golf course observed on the left bank. Geese, wildlife and domestic pets are potential sources of fecal coliform contamination. Bridge on Quaker Road to Bridge on Mercer Road (Princeton Pike): Predominant land uses along this segment include agriculture and urban. Riparian areas are a mixture of wetlands and forest and successional areas with sparse trees and herbaceous vegetation. Potential sources of fecal coliform include geese and other wildlife, horses, and domestic pets. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Cranbury Brook near Prospect Plains (#1400690)

Federal Road, just east of intersection with England Road ending at Perrineville Road, approximately 1800 feet south of Federal Road: Wildlife and domestic animals are a potential source of fecal coliform in this area. Main Street to 200 feet downstream of Bridge: Predominant land uses in the watershed include agriculture and urban. Possible sources of fecal coliform contamination include geese, wildlife, and domestic pets. Applegarth Road Bridge to approximately 100 feet upstream of Applegarth Road Bridge: Predominant land uses in this watershed are forest and agriculture. Possible sources of contamination are geese, wildlife and domestic pets. Approximately 100 feet upstream of County Route 615 Bridge to approximately 100 feet downstream of County Route 615 Bridge: Land uses in the area include: forest, agriculture and residential. Potential sources include agricultural runoff, wildlife and geese frequenting the agricultural fields. There is a farm along Federal Road with chickens, goats, ducks and guinea fowl. George Davison Road Bridge to dam upstream: Forest and agriculture are the predominant land use in the area. There are large open fields suitable for geese and a few farms that may be applying manure. Perrineville Road to North Bergen Mills Road: There is a large horse farm in this area on North Bergen Mills Road near Federal Road. The land uses in this area are residential, agricultural and forested. Other sources of fecal coliform are domestic pets and geese. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Millstone River at Grovers Mill (#1400650)

Area of Bentley Road: Predominant land uses in the area include forest, agriculture, and residential. Possible sources of fecal coliform include geese, wildlife and domestic pets. Area around Cranbury Road: Land uses in the area include agriculture and forest. Possible sources of fecal coliform include domestic pets, geese, deer, and other wildlife. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Millstone River near Manalapan (#1400540)

Baird Road Area: Land uses in the area include forest and agriculture. Possible sources in this area include horses, wildlife and geese. Bergen Mills Road: Land uses in this area include forest and residential. Possible sources of fecal coliform include geese, wildlife, and domestic pets. Strategies: prioritize for EQIP/SCCSP funds to install agricultural BMPs; organize local community based goose management programs; Phase II stormwater program.

Millstone River at Blackwells Mills (#1402000)

Between Blackwells Mills Road and Route 632 Causeway: This stretch contains fields and pastures along the right bank of the stream. There was also a horse trail that ran along the stream. The predominant land uses in this watershed are agriculture and urban. Geese, wildlife, and domestic pets can be found throughout the watershed. Possible sources of fecal coliform within this segment include geese, poultry, wildlife, domestic pets, and horses. Monitoring: a fecal coliform survey is recommended to focus on the significant sources of contamination. Strategies: organize local community based goose management programs; prioritize for EQIP / SCCSP funds to install agricultural BMPs Phase II stormwater program.

10.5. Pathogen Indicators and Bacterial Source Tracking

Advances in microbiology and molecular biology have produced several methodologies that discriminate among sources of fecal coliform and thus more accurately identify pathogen sources. The numbers of pathogenic microbes present in polluted waters are few and not readily isolated nor enumerated. Therefore, analyses related to the control of these pathogens must rely upon indicator microorganisms. The commonly used pathogen indicator organisms are the coliform groups of bacteria, which are characterized as gram-negative, rod-shaped bacteria. Coliform bacteria are suitable indicator organism because they are generally not found in unpolluted water, are easily identified and quantified, and are generally more numerous and more resistant than pathogenic bacteria (Thomann and Mueller, 1987).

Tests for fecal organisms are conducted at an elevated temperature (44.5°C), where the growth of bacteria of non-fecal origin is suppressed. While correlation between indicator organisms and diseases can vary greatly, as seen in several studies performed by the EPA and others, two indicator organisms *Esherichia coli* (*E. coli*) and enterococci species showed stronger correlation with incidence of disease than fecal coliform (USEPA, 2001). Recent advances have allowed for more accurate identification of pathogen sources. A few of these methods, including, molecular, biochemical, and chemical are briefly described in the following paragraph.

Molecular (genotype) methods are based on the unique genetic makeup of different strains, or subspecies, of fecal bacteria (Bowman et al, 2000). An example of this method includes “DNA fingerprinting” (i.e., a ribotype analysis which involves analyzing genomic DNA from fecal *E. coli* to distinguish human and non-human specific strains of *E. coli*.). Biochemical (phenotype) methods include those based on the effect of an organism’s genes actively producing a biochemical substance (Graves et al., 2002; Goya et al 1987). An example of this method is multiple antibiotic resistance (MAR) testing of fecal *E. coli.* In MAR testing, *E. coli* are isolated from fecal samples and exposed to 10-15 different antibiotics. In theory, *E. coli* originating from wild animals should show resistance to a smaller number of antibiotics than *E. coli* originating from humans or pets. Given this general trend, MAR patterns or '"signatures" can be defined for each class of *E. coli* species. Chemical methods are based on finding chemical compounds associated with human wastewater, and useful in determining

if the sources are human or non-human. Such methods measure the presence of optical brighteners, which are contained in all laundry detergents, and soap surfactants in the water column. Unlike the optical brightener method, the measurement of surfactants may allow for some quantification of the source.

BST methods have already been successfully employed at the NJDEP in the past decade. Since 1988, the Department's Bureau of Marine Water Monitoring has worked cooperatively with the University of North Carolina in developing and determining the application of RNA coliphage as a pathogen indicator. This research was funded through USEPA and Hudson River Foundation grants. These studies showed that the RNA coliphages are useful as an indicator of fecal contamination, particularly in chlorinated effluents and that they can be serotyped to distinguish human and animal fecal contamination. Through these studies, the Department has developed an extensive database of the presence of coliphages in defined contaminated areas (point human, non-point human, point animal, and non-point animal). More recently, MAR and DNA fingerprinting analyses of *E. coli* are underway in the Manasquan estuary to identify potential pathogen sources (Palladino and Tiedemann, 2002). These studies along with additional sampling within the watershed will be used to implement the necessary percent load reduction.

10.6. Reasonable Assurance

With the implementation of follow-up monitoring, source identification and source reduction as described for each segment, the Department has reasonable assurance that New Jersey's Surface Water Quality Standards will be attained for fecal coliform. The Department proposes to undertake the identified monitoring responses beginning in 2003-2004. As a generalized strategy, the Department proposes the following with regard to categorical sources: 1) As septic system sources are identified through the monitoring responses, municipalities will be encouraged to enter the Environmental Infrastructure Financing Program, which includes New Jersey's State Revolving Fund, to evaluate, select and implement the best overall solution to such problems; 2) To address storm water point sources, the Phase II stormwater permitting program will require control measures to be phased in from the effective date of authorization to 60 months from that date; 3) The locations of impaired segments with significant agricultural land uses will be provided to the State Technical Committee for consideration in the FFY 2004 round of EQIP/SCCSP project selection; 4) Through continuing engagement of watershed partners, measures to identify and address other sources will be pursued, including encouragement and support of community based goose management programs, where appropriate. The Department has dedicated a portion of its Corporate Business Tax and FY 2002 Clean Water Act Section 319(h) funds to carry out the segment specific source trackdown recommendations. A portion of FY 2003 319(h) funds will be dedicated to assisting municipalities in implementing the requirements of the Phase II municipal stormwater permitting program.

The fecal coliform reductions proposed in these TMDLs assume that existing NJPDES permitted municipal facilities will continue to meet New Jersey's Surface Water Quality

Standard requirements for disinfection. Any future facility will be required to meet water quality standards for disinfection.

The Department's ambient monitoring network will be the means to determine if the strategies identified have been effective. Where trackdown monitoring has been recommended, the results of this monitoring as well as ambient monitoring will be evaluated to determine if additional strategies for source reduction are needed.

11.0 Public Participation

The Water Quality Management Planning Rules NJAC 7:15-7.2 require the Department to initiate a public process prior to the development of each TMDL and to allow public input to the Department on policy issues affecting the development of the TMDL. Further, the Department shall propose each TMDL as an amendment to the appropriate areawide water quality management plan in accordance with procedures at N.J.A.C. 7:15-3.4(g). As part of the public participation process for the development and implementation of the TMDLs for fecal coliform in the Raritan Water Region, the Department worked collaboratively with a series of stakeholder groups as part of the Department's ongoing watershed management efforts.

The Department's watershed management process includes a comprehensive stakeholder process that includes of members from major stakeholder groups, (agricultural, business and industry, academia, county and municipal officials, commerce and industry, purveyors and dischargers, and environmental groups). As part of this watershed management planning process, Public Advisory Committees (PACs) and Technical Advisory Committees (TACs) were created in all 20 WMAs. The PACs serve in an advisory capacity to the Department, examining and commenting on a myriad of issues in the watersheds. The TACs are focused on scientific, ecological, and engineering issues relevant to the issues of the watershed, including water quality impairments and management responses to address them.

The Department shared the TMDL process with the WMA 7, WMA 8, WMA 9, and WMA 10 PAC and TAC members through a series of presentations and discussions as described below. The Department has also engaged the public by meeting with Environmental Commissions and local Watershed Associations. In September 2002, the Department met with Environmental Commission Chairmen from 2 townships in Hunterdon County to discuss the TMDL process and impaired surface water bodies in their areas. On November 7, 2002, the Department met with approximately 8 Environmental Commisisions in Union County to discuss the TMDL process and the Phase II Stormwater Regulations.

The TMDL process and mapping was discussed with the WMA 7 steering committee at meetings held on October 11th 2002, February 7th 2003, March 7th 2003 and April 11th 2003. During the October 11th meeting a presentation was made about the TMDL processes, addressing the basic background of TMDLs, how the TMDLs are established and the process for adopting TMDLs. The TMDL Video "A Local Official's Guide to TMDLs" was presented which explained TMDLs in practical terms. The Department also provided the public with

the finalized Category 5 list, a fact sheet titled "TMDLs in the Metropolitan Watershed", and the Memorandum of Agreement between the Department and EPA Region 2. During the Feb. 7th meeting the protocol for listing waterbodies and the public comment process was discussed. At the March the 7th meeting the impaired segments were presented. There were several comments made by the steering committee on possible causes of the impairments. During the April 11th meeting the discussion revolved around public notification, the steering committees roles in TMDLs and any other possible sources for the impaired segments.

Expedited Fecal Coliform presentation was given at the WMA#10 Millstone Watershed Steering Committee on October 17th, 2002 and to the TAC on November 4, 2002. The TMDL Video "A Local Official's Guide to TMDLs" was shown, which explained TMDLs in practical terms. The Department also provided the public with the finalized Category 5 list, a fact sheet titled "TMDLs in the Millstone Watershed", and the Memorandum of Agreement between the Department and EPA Region 2.

On February 19, 2003, during the Raritan TAC Meeting (WMAs 8, 9 and 10), the committee was asked to review and comment on the sections of the TMDL that were specific to the Raritan Region, including the description of the Raritan Region, point sources in region, nonpoint sources of fecal coliform in the region, potential sources of fecal coliform contamination and the public participation section. This committee suggested that the NJDEP should meet with representatives of the region's watershed associations and Soil Conservation Districts to obtain information on sources of contamination. At the TAC's recommendation, a meeting was held on February 20, 2003 with representatives of the Raritan Basin's Watershed Associations and Soil Conservation Districts. At this meeting the representatives were asked to identify potential sources of fecal coliform. The information provided was then drafted and sent back out to attendees for comment.

Additional input was received through the NJ EcoComplex (NJEC). The Department contracted with NJEC in July 2001. The NJEC consists of a review panel of New Jersey University professors whose role is to provide comments on the Department's technical approaches for development of TMDLs and management strategies. The New Jersey Statewide Protocol for Developing Fecal TMDLs was presented to NJEC on August 7, 2002 and was subsequently reviewed and approved. The protocol was also presented at the SETAC Fall Workshop on September 13, 2002 and met with approval.

Amendment Process

In accordance with N.J.A.C. 7:15–7.2(g), these TMDLs are hereby proposed by the Department as an amendment to Lower Raritan Water Quality Management Plan (WQMP), Mercer and Monmouth Counties WQMP, Northeast WQMP, Upper Raritan WQMP and Sussex County WQMP.

Notice proposing these TMDLs was published April 21, 2003 in the New Jersey Register and in newspapers of general circulation in the affected area in order to provide the public an opportunity to review the TMDLs and submit comments. In addition, a public hearing will

be held on May 22, 2003. Notice of the proposal and the hearing has also been provided to applicable designated planning agencies and to affected municipalities.

References

Bowman, A.M., C. Hagedorn, and K. Hix. 2000. Determining sources of fecal pollution in the Blackwater River watershed. p. 44-54. *In* T. Younos and J. Poff (ed.), Abstracts, Virginia Water Research Symposium 2000, VWRRC Special Report SR-19-2000, Blacksburg.

Cabelli, V. 1989. Swimming-associated illness and recreational water quality criteria. Wat. Sci. Tech. 21:17.

Alexandria K. Graves, Charles Hagedorn, Alison Teetor, Michelle Mahal, Amy M. Booth, and Raymond B. Reneau, Jr. Antibiotic Resistance Profiles to Determine Sources of Fecal Contamination in a Rural Virginia Watershed. Journal of Environmental Quality. 2002 31: 1300-1308.

National Research Council. 2001. Assessing the TMDL Approach to water quality management. National Academy Press, Washington, D.C.

New Jersey Department of Environmental Protection. 1998. Identification and Setting of Priorities for Section 303(d) Water Quality Limited Waters in New Jersey, Office of Environmental Planning

New Mexico Environmental Department. 2002. TMDL for Fecal Coliform on three Cimarron River Tributaries in New Mexico.
Online at: http://www.nmenv.state.nm.us/swqb/CimarronTMDL.html

Palladino, M. A., and Tiedemann, J. (2001) Differential Identification of *E. coli* in the Manasquan River Estuary by Multiple Antibiotic Resistance Testing and DNA Fingerprinting Analysis. Monmouth University, NJ

Goyal, S.M. 1987. Methods in Phage Ecology. pp. 267-287. In: Phage Ecology, S.M. Goyal, C.P. Gerba and G. Bitton (Eds.) John Wiley and Sons, New York.

Saunders, William and Maidment, David. 1996. A GIS Assessment of Nonpoint Source Pollution in the San Antonio- Nueces Coastal Basin. Center for Research in Water Resources. Online Report 96-1:

Stiles, Thomas C. (2001). A Simple Method to Define Bacteria TMDLs in Kansas. Presented at the WEF/ASIWPCA TMDL Science Issues Conference, March 7, 2001.

Sutfin, C.H. May, 2002. Memo: EPA Review of 2002 Section 303(d) Lists and Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992. Office of Wetlands, Oceans and Watersheds, USEPA.

Thomann, R.V. and J.A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control, Harper & Row, Publishers, New York.

USEPA. 1986. Implementation Guidance for Ambient Water Quality Criteria for Bacteria. EPA-823-D-00-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA-840-B-92-002. Washington, DC.

USEPA. 1997. Compendium of tools for watershed assessment and TMDL development. EPA841-B-97-006. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2001. Protocol for Developing Pathogen TMDLs. EPA841-R-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

U.S. Geological Survey. 1982. Low - Flow Characteristics and Flow Duration of New Jersey Streams. Open-File Report 81-1110.

Appendix A: Explanation of stream segments in Sublist 5 of the *2002 Integrated List of Waterbodies* for which TMDLs will not be developed in this report.

River segments to be moved from Sublist 5 to Sublist 3 for fecal coliform.

- **Station #01401440, the Millstone River at Kingston**

Table 2 identifies one segment for which a TMDL will not be developed at this time based on investigations following the *2002 Integrated List of Waterbodies* proposal. The Millstone River at Kingston, station #01401440, was included on Sublist 5 based on its listing on previous 303(d) lists with no recent data to assess their current attainment status. Therefore, a TMDL will not be developed for this location until and unless recent data indicates a violation of the surface water quality standards.

Appendix B: Municipal POTWs Located in the TMDLs' Project Areas

WMA	Station #	NJPDES	Facility Name	Discharge Type[a]	Receiving waterbody
7	1393450	NJ0020648.005A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.041A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.003A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.006A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.007A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.008A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.008A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.011A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.012A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.036A	Elizabeth City	MMJ	Elizabeth River
7	1393450	NJ0020648.009A	Elizabeth City	MMJ	Elizabeth River
8	1399120	NJ0033995.001A	Environmental Disposal Corp	MMJ	Raritan River North Branch via unnamed trib
8	1399900	NJ0020362.001A	Branchburg Twp - Central School	MMI	Chambers Brook
8	1399120	NJ0028495.001A	Bedminster Twp	MMI	Raritan River North Branch
8	1399500	NJ0022675.001A	Roxbury Twp - Ajax Terrace	MMJ	Lamington River
8	1399500	NJ0026824.001A	Chester Shopping Center	MMI	Tiger Brook (Lamington R) via ditch
8	1399780	NJ0022781.001A	Valley Rd Sewer Co - Pottersville STP	MMI	Lamington River
8	1399780	NJ0021865.001A	Fiddler's Elbow CC - Reynwood Inc	MMI	Lamington River
8	1399780	NJ0020338.001A	Branchburg Twp - Fox Hollow STP	MMI	Lamington River
8	1398260	NJ0021334.001A	Mendham Boro	MMI	India Brook (Raritan River North Branch)
8	1397000	NJ0100528.001A	Glen Meadows/Twin Oaks	MMI	Raritan River S B via unnamed trib
8	1397400	NJ0022047.001A	Raritan Twp MUA	MMJ	Raritan River South Branch
8	1397400	NJ0028436.002A	Flemington Boro	MMJ	Bushkill Brook
8	1398102	NJ0020354.001A	Branchburg Twp - Neshanic Station	MMI	Raritan River South Branch
8	1397400	NJ0022047.SL3A	Raritan Twp MUA	MMJ	Sludge Application
8	1397400	NJ0022047.SL3B	Raritan Twp MUA	MMJ	Sludge Application
8	1397400	NJ0022047.SL3M	Raritan Twp MUA	MMJ	Sludge Application
8	1396660	NJ0024091.001A	Union Twp BOE	MMI	Mulhocaway Creek via unnamed trib
8	1396588	NJ0022144.001A	NJDHS - Hagadorn Center	MMI	Rocky Run via unnamed trib
8	1396280	NJ0023493.002A	Washington Twp SA - Schooley's Mt STP	MMI	Raritan River S B

8	1396280	NJ0109061.001A	Washington Twp - Long Valley Village	MMI	Raritan River South Branch
9	1405195	NJ0028479.001A	NJDC - Jamesburg	MMI	Matchaponix Brook
9	1405195	NJ0023728.001A	Western Monmouth UA	MMJ	Pine Brook
9	1403470	NJ0026727.001A	Colorado Cafe WTP	MMI	Green Brook
9	1400500	NJ0024864.001A	Somerset Raritan SA	MMJ	Cuckels Bk (Raritan R) via unnmd trib
9	1403300	NJ0024864.002A	Somerset Raritan SA	MMJ	Raritan River
10	1402000	NJ0050130.001A	Montgomery Twp - Riverside	MMI	Millstone River (Raritan R)
10	1402000	NJ0022764.001A	Valley Rd Sewer Co - River Rd Stp	MMI	Millstone River
10	1400650	NJ0023787.001A	East Windsor Twp MUA	MMJ	Millstone River (Raritan R)
10	1400650	NJ0029475.001A	Hightstown Advanced WTP	MMJ	Rocky Brook
10	1400650	NJ0067211.001A	East Windsor - 2	MMJ	Millstone River (Raritan R)
10	1401000	NJ0022110.001A	Educational Testing Service	MMI	Stony Brook
10	1401000	NJ0020770.001A	Princeton Sewer Oper Commission	MMI	Stony Brook
10	1401700	NJ0023124.001A	Montgomery Twp - High School	MMI	Back Brook (Millstone R)
10	1401700	NJ0026891.001A	Montgomery Twp - Burnt Hill STP 1	MMI	Back Brook
10	1401700	NJ0060038.001A	Montgomery Twp - Pike Brook	MMI	Pike Run
10	1401700	NJ0067733.001A	Montgomery Twp - Oxbridge	MMI	Pike Run

[a] "MMI" indicates a Municipal Minor discharge and "MMJ" indicates Municipal Major discharge.

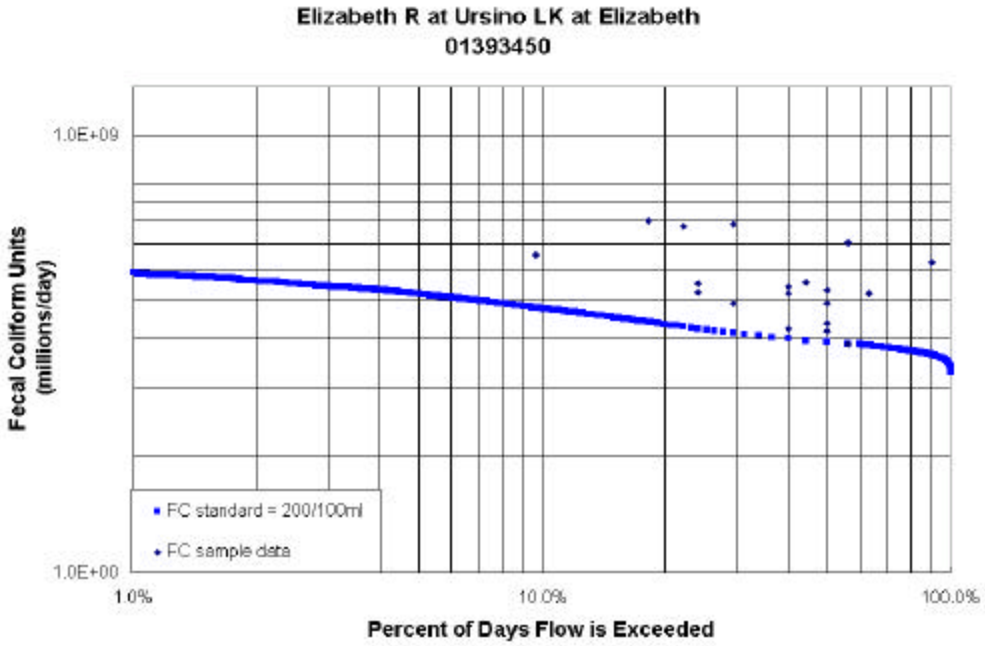
Appendix C: TMDL Calculations

WMA	303(d) Category 5 Segments	Water Quality Stations	Station Names	Load Allocation (LA) and Margin of Safety (MOS)										Wasteload Allocation (WLA)	Period of record used in analysis
				200 FC/100ml Standard					400 FC/100ml Standard						
				N (# of values)	Geometric mean CFU/100ml	MOS as a percent of the target concentration	Percent reduction without MOS	Percent reduction with MOS	Summer N	Summer geometric mean CFU/100ml	MOS as a percent of the target concentration	Percent reduction without MOS	Percent reduction with MOS		
7	01393350, 01393450	01393350, 01393450	WB Elizabeth River near Union, Elizabeth River at Ursino Lake at Elizabeth	24	2006	42%	90%	94%	13	2340	42%	97%	98%	98%	2/16/94 - 8/17/99
7	01393960, 01394500, 01395000	01393960, 01394500, 01395000	WB Rahway River at Northfield Ave. at West Orange, Rahway River near Springfield, Rahway River at Rahway	85	1568	23%	87%	90%	63	1680	23%	96%	97%	97%	2/14/94 - 8/2/01
7	01395200, 01396003	01395200, 01396003	Robinson Branch at Scotch Plains, Robinson Branch at St Georges Ave at Rahway	10	626	60%	68%	87%	10	626	60%	89%	96%	96%	6/2/98 - 8/30/00
8	01396219, 01396280, 01396535	01396219, 01396280, 01396535	Stony Brook at Fairview Avenue at Naughright, SB Raritan River at Middle Valley, SB Raritan River Arch St at	43	272	34%	26%	52%	21	809	34%	92%	94%	94%	1/25/94 - 8/26/99
8	01396550, 01396588	01396550, 01396588	Spruce Run at Newport, Spruce Run near Glen	39	110	32%	-82%	-24%	28	99	32%	31%	53%	53%	2/1/94 - 8/9/01
8	01396660	01396660	Mulhockaway Creek at Van Syckel	40	330	36%	39%	61%	29	464	36%	85%	91%	91%	2/1/94 - 8/9/01
8	01398000	01398000	Neshanic River at Reaville	39	288	40%	31%	58%	28	313	40%	78%	87%	87%	2/1/94 - 8/9/01

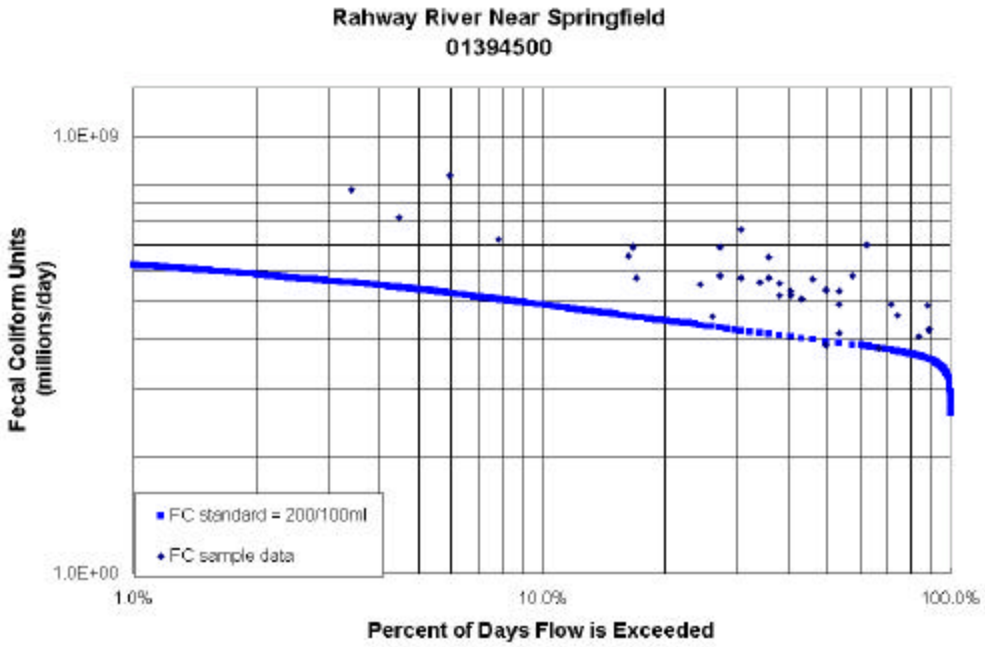
WMA	303(d) Category 5 Segments	Water Quality Stations	Station Names	Load Allocation (LA) and Margin of Safety (MOS)										Wasteload Allocation (WLA)	Period of record used in analysis
				200 FC/100ml Standard					400 FC/100ml Standard						
				N (# of values)	Geometric mean CFU/100ml	MOS as a percent of the target concentration	Percent reduction without MOS	Percent reduction with MOS	Summer N	Summer geometric mean CFU/100ml	MOS as a percent of the target concentration	Percent reduction without MOS	Percent reduction with MOS		
8	01397000, 01397400, 01398102	01397000, 01397400, 01398070, 01398102	SB Raritan River at Stanton Station, SB Raritan River at Three Bridges, SB Raritan River at Elm St. at Neshanic	64	259	25%	23%	42%	43	261	25%	74%	80%	80%	1/31/94 - 6/19/01
8	01398260	01398260	NB Raritan River near Chester	19	112	37%	-79%	-13%	8	138	37%	51%	69%	69%	1/24/94 - 7/30/97
8	01399200, 01399500, 01399700, 01399780	01399200, 01399500, 01399700, 01399780	Lamington River near Ironia, Lamington River near Pottersville, Rockaway Creek at Whitehouse, Lamington	81	243	25%	18%	38%	48	531	25%	87%	90%	90%	1/31/94 - 6/19/01
8	01399120, 01399900, 01400000	01399120, 01399900, 01400000	NB Raritan River at Burnt Mills, Chambers Brook at North Branch Depot, NB Raritan River near Raritan	45	331	28%	40%	57%	34	487	28%	86%	90%	90%	1/31/94 - 6/19/01
9	01400395	01400395	Peters Brook at Rt 28 at Somerville	5	1952	47%	90%	95%	5	1952	47%	97%	98%	98%	6/3/98 - 8/6/98
9	01403385, 01403470	01403385, 01403470	Bound Brook at Route 28 at Middlesex, Green Brook at North Plainfield	25	1503	43%	87%	92%	25	1503	43%	95%	97%	97%	6/4/98 - 8/29/01
9	01400500, 01403300, 01403900	01400500, 01403300, 01403900	Raritan River at Manville, Raritan River at Queens Bridge, Bound Brook at	36	234	36%	14%	45%	16	549	36%	88%	92%	92%	2/2/94 - 7/31/97

WMA	303(d) Category 5 Segments	Water Quality Stations	Station Names	Load Allocation (LA) and Margin of Safety (MOS)										Wasteload Allocation (WLA)	Period of record used in analysis
				200 FC/100ml Standard					400 FC/100ml Standard						
				N (# of values)	Geometric mean CFU/100ml	MOS as a percent of the target concentration	Percent reduction without MOS	Percent reduction with MOS	Summer N	Summer geometric mean CFU/100ml	MOS as a percent of the target concentration	Percent reduction without MOS	Percent reduction with MOS		
9	01405195, 9, 22, 61, 68	01405302, 01405195, 9, 22, 61, 68, 69	Matchaponix Bk at Mundy Ave, Matchaponix Bk at Englishtown, Weemaconk Ck at Main St, McGolliard Bk at Main St, Lake Topanemus at Pond Rd, Wemrock Bk at Rt #9, Wemrock Bk at Rt #9	171	57	20%	-252%	-181%	54	188	20%	64%	71%	71%	2/3/94 - 10/1/02
9	01405340, 01405400	01405340, 01405400	Manalapan Brook at Federal Rd near Manalapan, Manalapan Brook near Spotswood	39	192	37%	-4%	35%	28	403	37%	83%	89%	89%	2/3/94 - 8/29/01
10	01400540, 01400650	01400540, 01400650, 5	Millstone River near Manalapan, Millstone River at Grovers Mill, Millstone River at Route 33 In Millstone	77	110	27%	-83%	-32%	36	453	27%	85%	89%	89%	2/2/94 - 12/18/02
10	01400690	01400690	Cranbury Book near Prospect Plains	5	269	50%	26%	63%	5	269	50%	75%	87%	87%	7/1/99 - 7/29/99
10	01401000	01401000	Stony Brook at Princeton	19	255	52%	22%	62%	8	840	52%	92%	96%	96%	1/24/94 - 7/30/97
10	01401200	01401200	Duck Pond Run at Clarksville	5	2019	75%	90%	98%	5	2019	75%	97%	99%	99%	6/27/00 - 7/25/00
10	01401400	01401400	Heathcote Brook at Kingston	19	746	36%	73%	83%	19	746	36%	91%	94%	94%	6/3/98 - 8/29/01
10	01401600, 01401700	01401600, 01401700	Bedens Brook near Rocky Hill, Pike Run near Rocky Hill	26	569	44%	65%	80%	15	1499	44%	95%	97%	97%	1/24/94 - 7/21/99
10	01402000, 01402540	01402000, 01402540	Millstone River at Blackwells Mills, Millstone River at Weston	41	363	35%	45%	64%	30	527	35%	87%	92%	92%	2/2/94 - 6/19/01

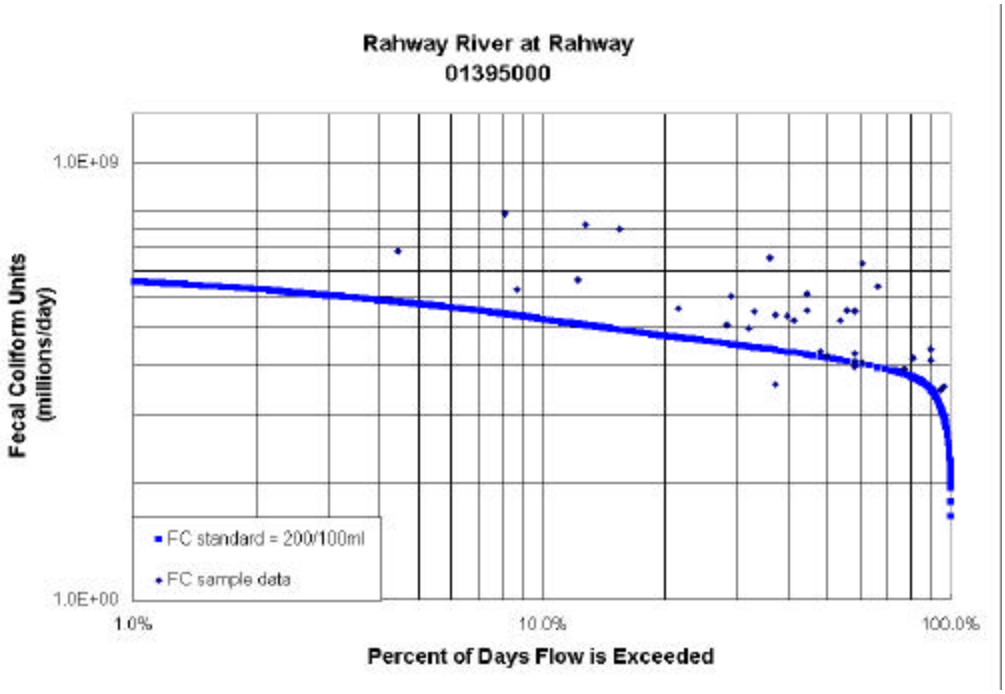
Appendix D: Load Duration Curves for selected listed waterbodies



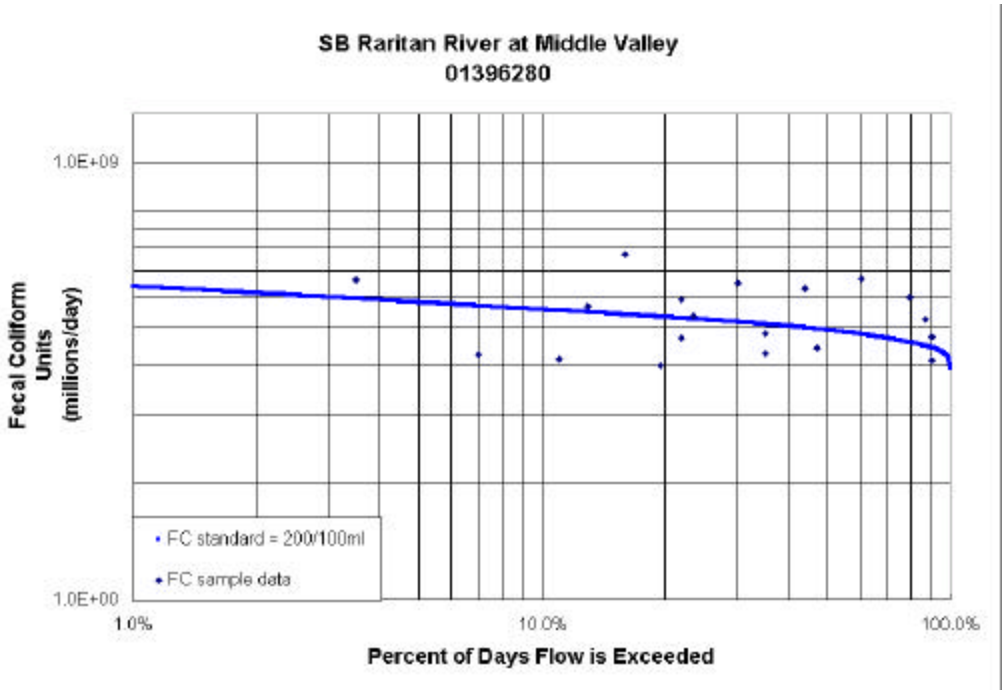
Load Duration Curve for Elizabeth River at Ursino Lake at Elizabeth. Fecal coliform data from USGS station # 01393450 during the period 2/16/94 through 7/29/97. Water years 1970-2001 from USGS station # 01393450 were used in generating the FC standard curve.



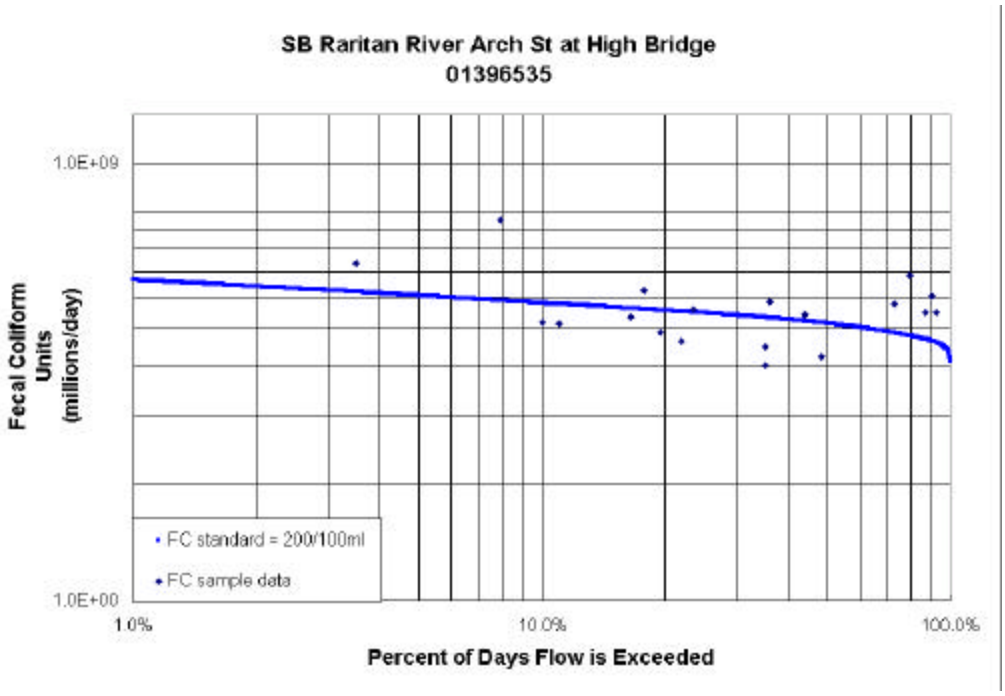
Load Duration Curve for Rahway River near Springfield. Fecal coliform data from USGS station # 01394500 during the period 2/14/94 through 7/10/01. Water years 1970-2001 from USGS station # 01394500 were used in generating the FC standard curve.



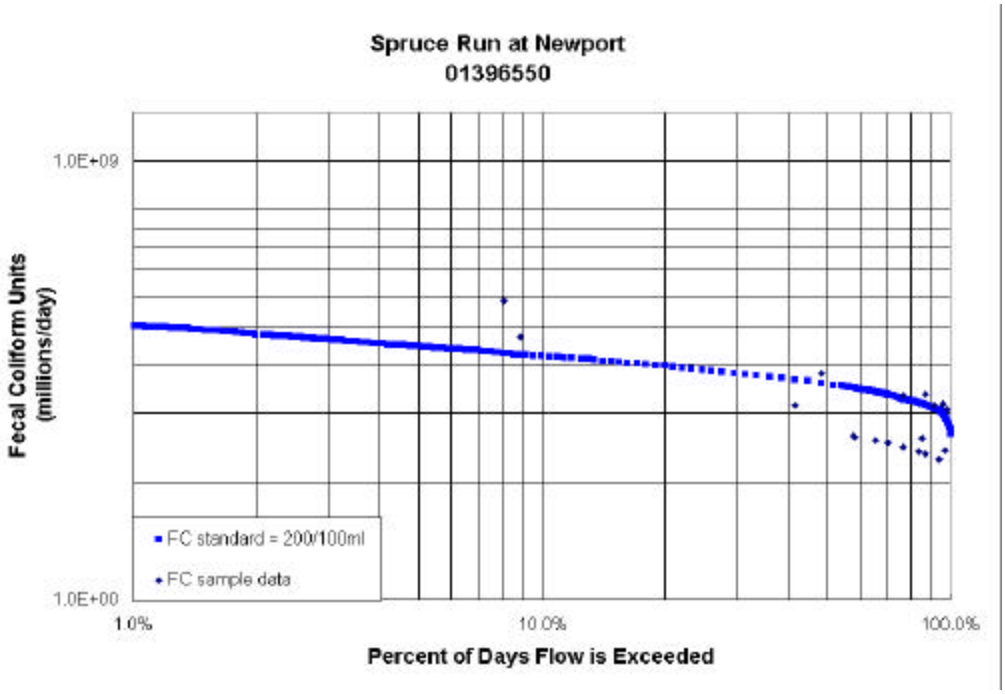
Load Duration Curve for Rahway River at Rahway. Fecal coliform data from USGS station # 01395000 during the period 2/15/94 through 7/6/01. Water years 1970-2001 from USGS station # 01395000 were used in generating the FC standard curve.



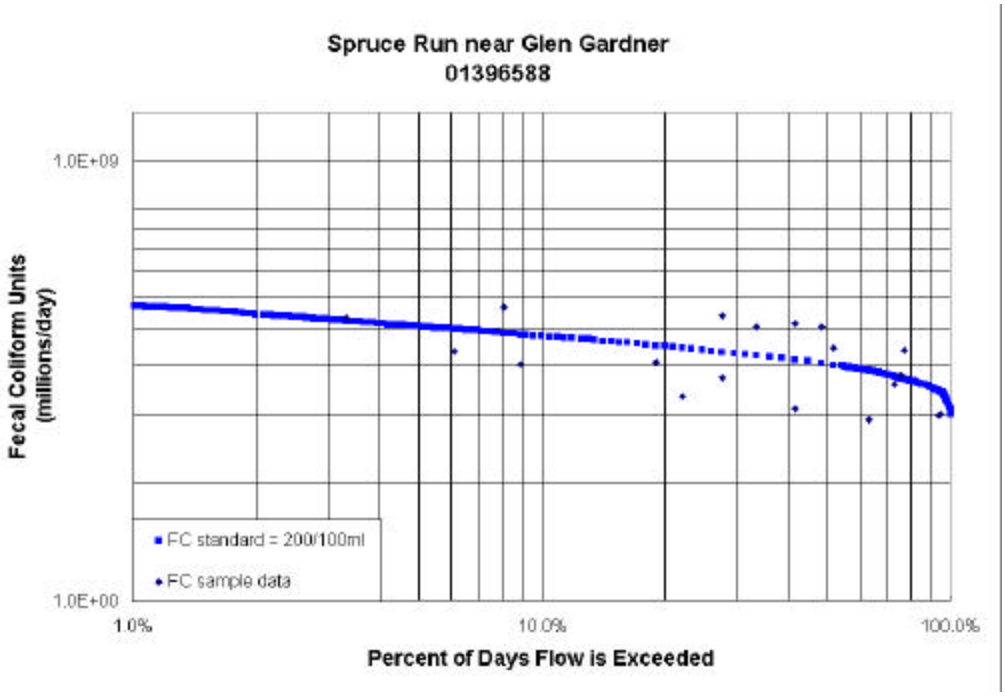
Load Duration Curve for South Branch Raritan River at Middle Valley. Fecal coliform data from USGS station # 01396280 during the period 1/15/94 through 7/15/97. Water years 1970-2001 from USGS station # 01396500 (South Branch Raritan River near High Bridge) were used in generating the FC standard curve.



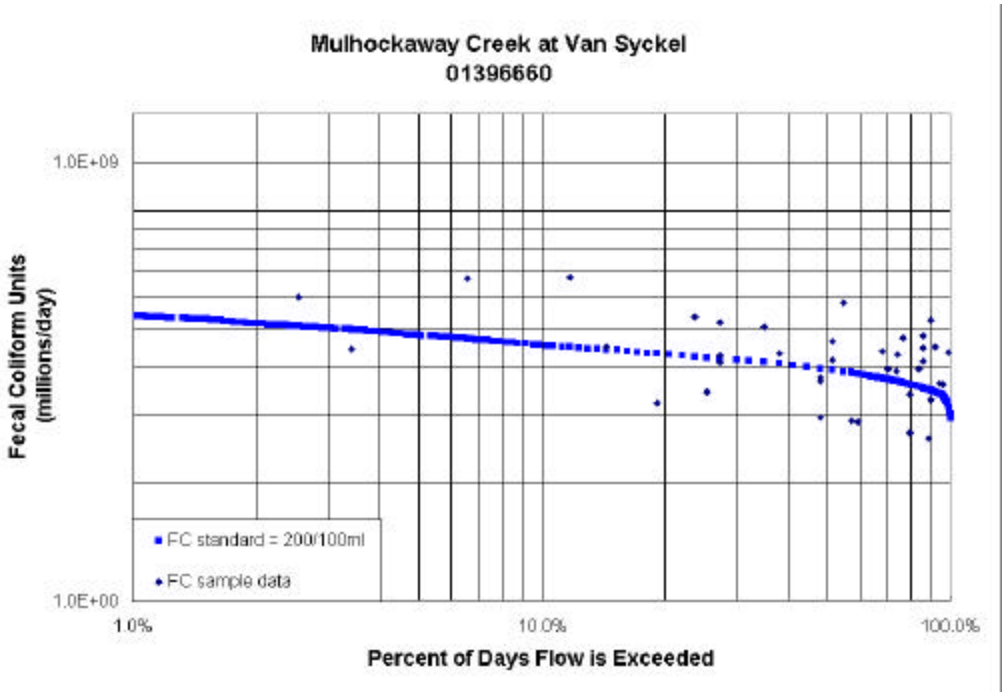
Load Duration Curve for South Branch Raritan River Arch St at High Bridge. Fecal coliform data from USGS station # 01396535 during the period 1/25/94 through 7/15/97. Water years 1970-2001 from USGS station # 01396500 (South Branch Raritan River near High Bridge) were used in generating the FC standard curve.



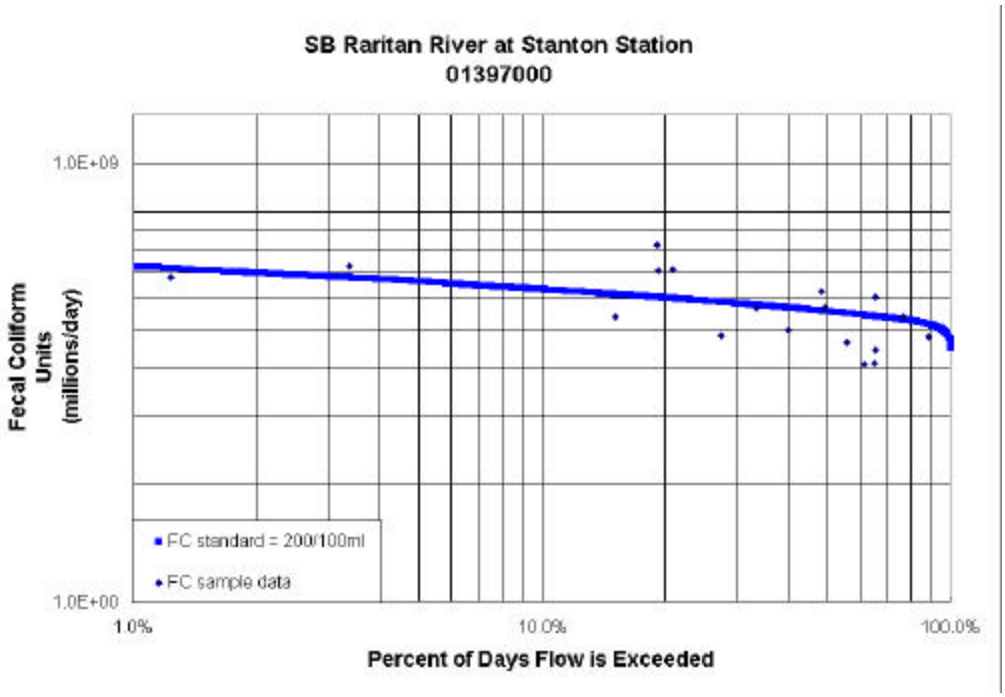
Load Duration Curve for Spruce Run at Newport. Fecal coliform data from USGS station # 01396550 during the period 6/8/98 through 8/9/01. Water years 1978-2001 from USGS station # 01396580 (Spruce Run at Glen Gardner) were used in generating the FC standard curve.



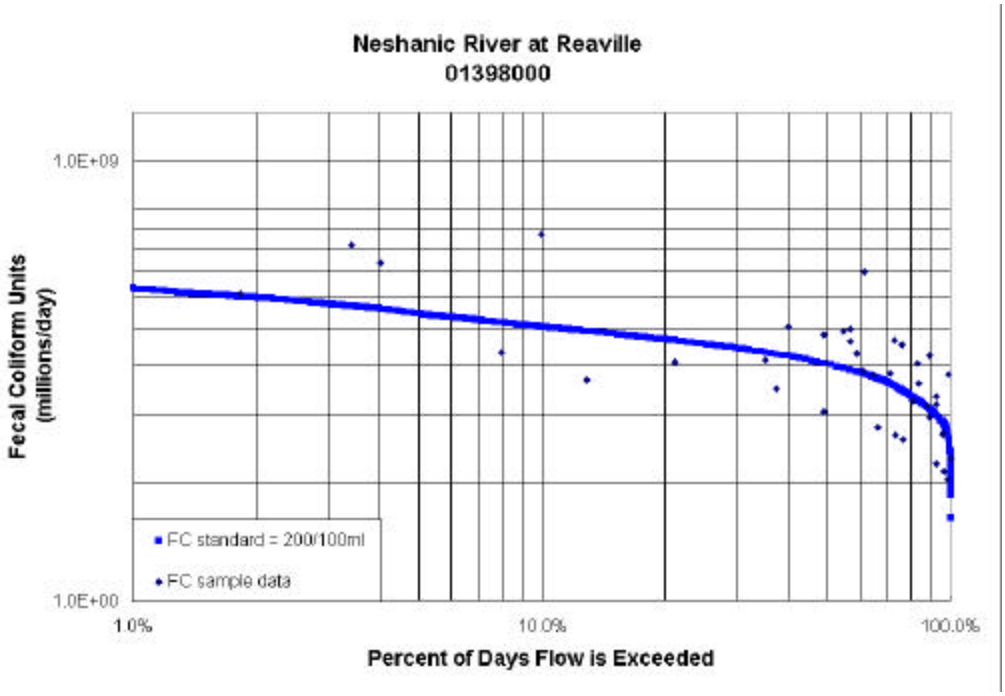
Load Duration Curve for Spruce Run near Glen Gardner. Fecal coliform data from USGS station # 01396588 during the period 2/1/94 through 7/17/97. Water years 1978-2001 from USGS station # 01396580 (Spruce Run at Glen Gardner) were used in generating the FC standard curve.



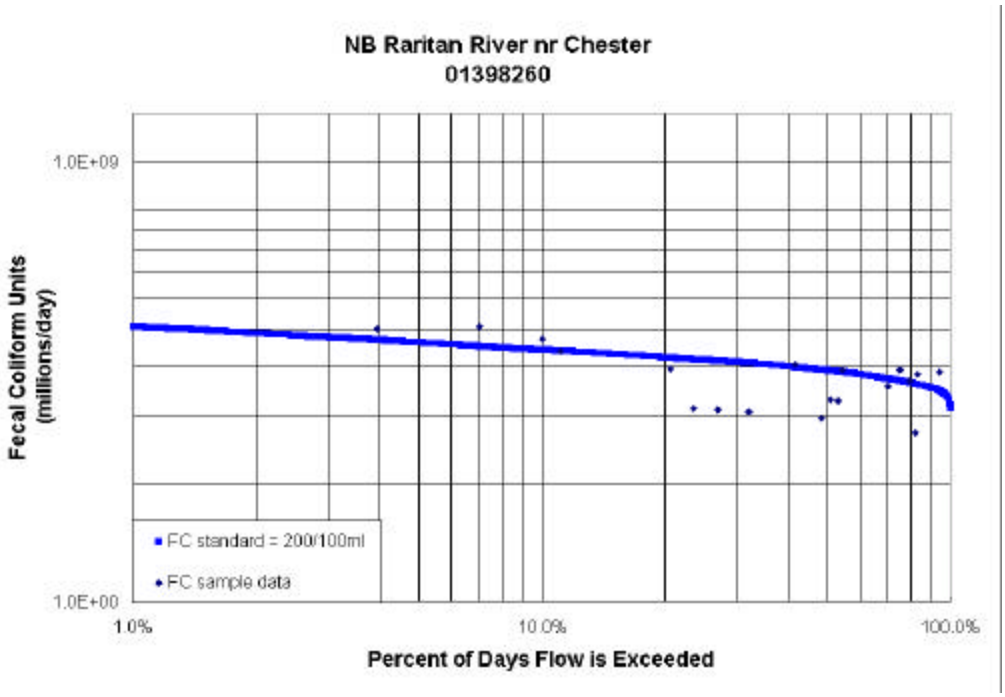
Load Duration Curve for Mulhockaway Creek at Van Syckel. Fecal coliform data from USGS station # 01396660 during the period 2/1/94 through 8/9/01. Water years 1977-2001 from USGS station # 01396660 were used in generating the FC standard curve.



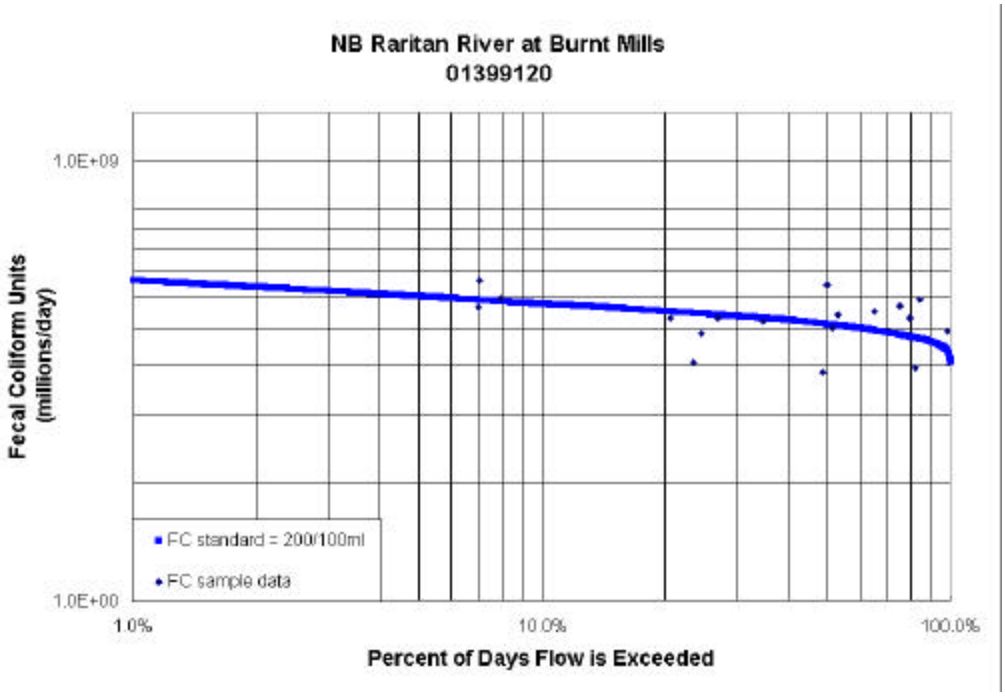
Load Duration Curve for South Branch Raritan River at Stanton Station. Fecal coliform data from USGS station # 01397000 during the period 1/31/94 through 7/16/97. Water years 1970-2001 from USGS station # 01397000 were used in generating the FC standard curve.



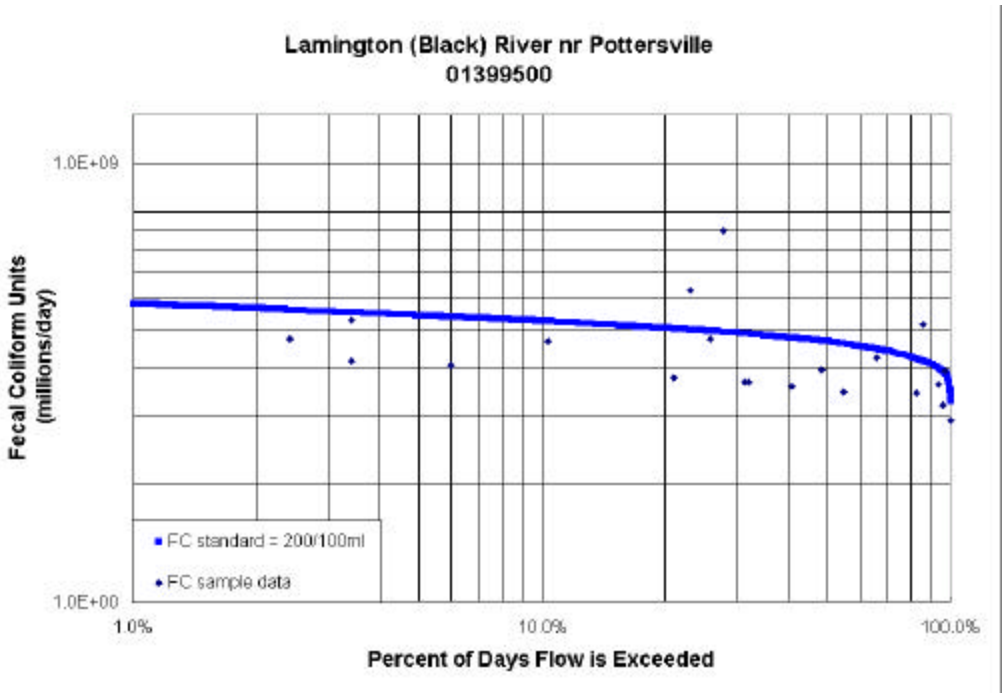
Load Duration Curve for Neshanic River at Reaville. Fecal coliform data from USGS station # 01398000 during the period 2/1/94 through 8/9/01. Water years 1970-2001 from USGS station # 01398000 were used in generating the FC standard curve.



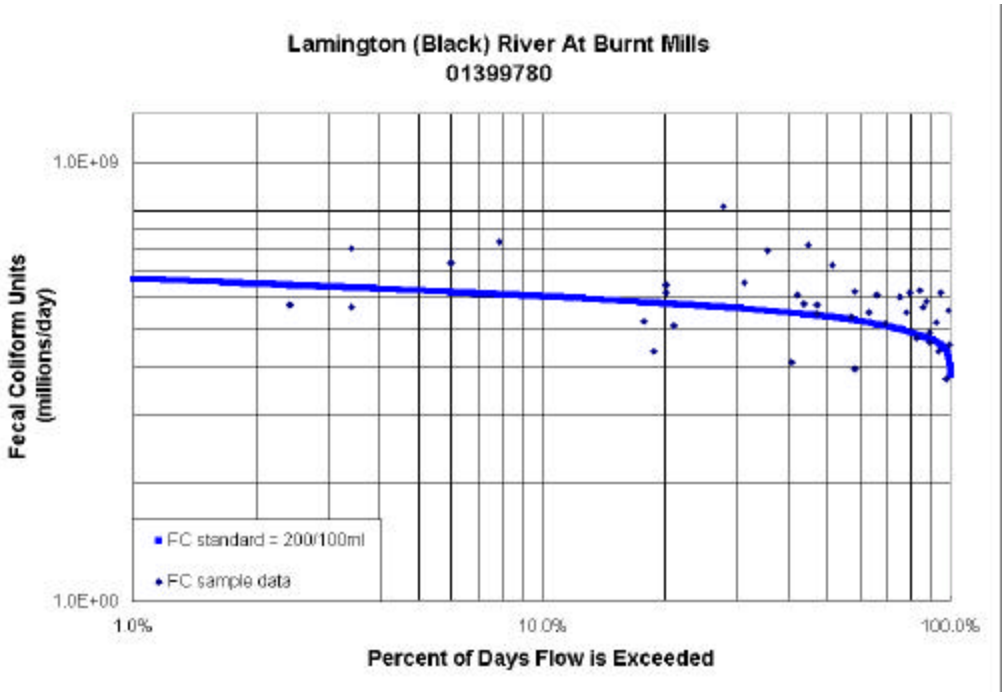
Load Duration Curve for North Branch Raritan River near Chester. Fecal coliform data from USGS station # 01398260 during the period 1/24/94 through 7/30/97. Water years 1970-2001 from USGS station # 01396500 (South Branch Raritan River near High Bridge) were used in generating the FC standard curve.



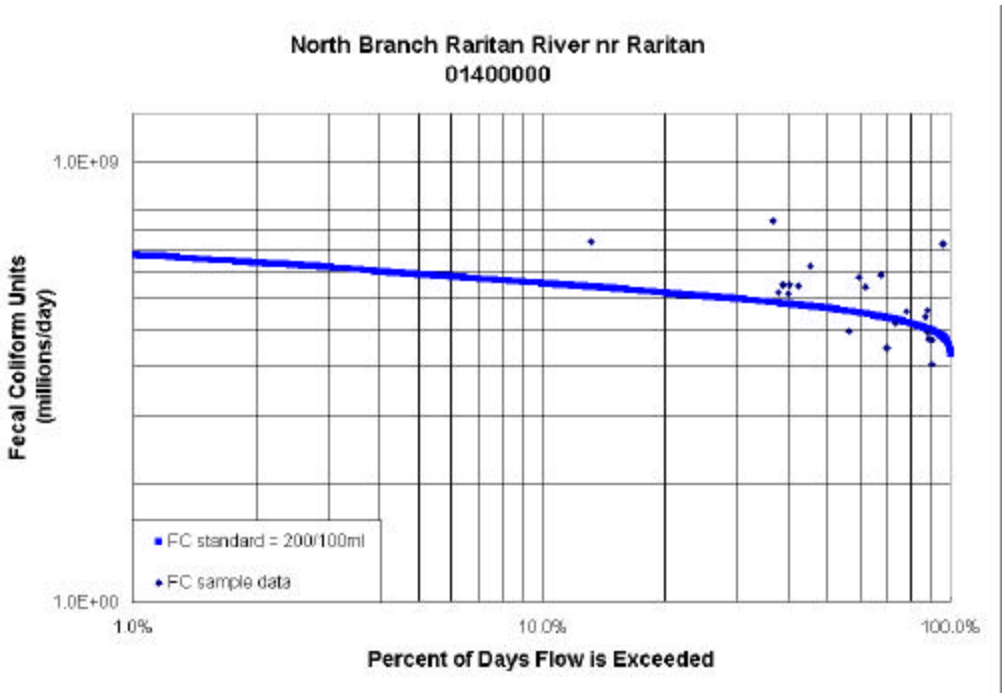
Load Duration Curve for North Branch Raritan River at Burnt Mills. Fecal coliform data from USGS station # 01399120 during the period 1/31/94 through 7/29/97. Water years 1970-2001 from USGS station # 01396500 (South Branch Raritan River near High Bridge) were used in generating the FC standard curve.



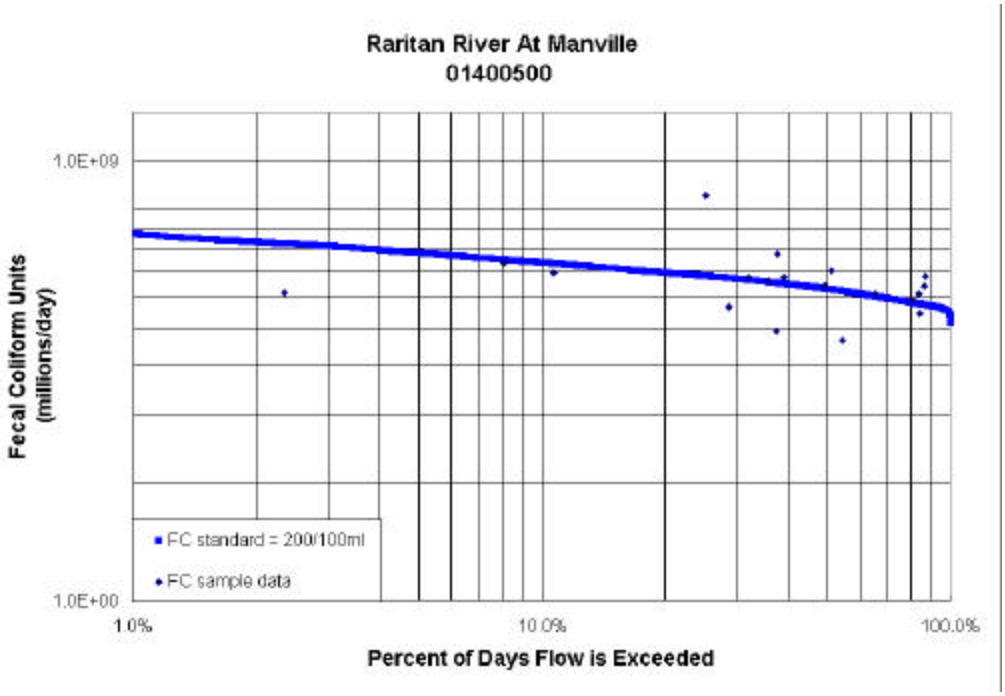
Load Duration Curve for Lamington (Black) River near Pottersville. Fecal coliform data from USGS station # 01399500 during the period 1/31/94 through 8/02/99. Water years 1970-2001 from USGS station # 01399500 were used in generating the FC standard curve.



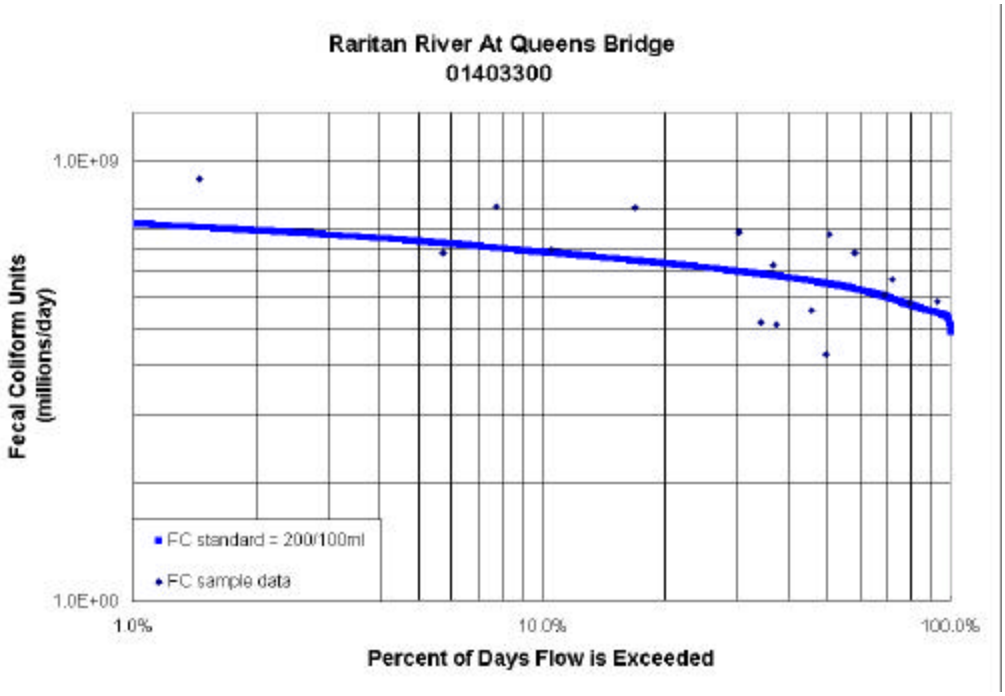
Load Duration Curve for Lamington (Black) River at Burnt Mills. Fecal coliform data from USGS station # 01399780 during the period 1/31/94 through 6/19/01. Water years 1970-2001 from USGS station # 01399500 (Lamington (Black) River near Pottersville) were used in generating the FC standard curve.



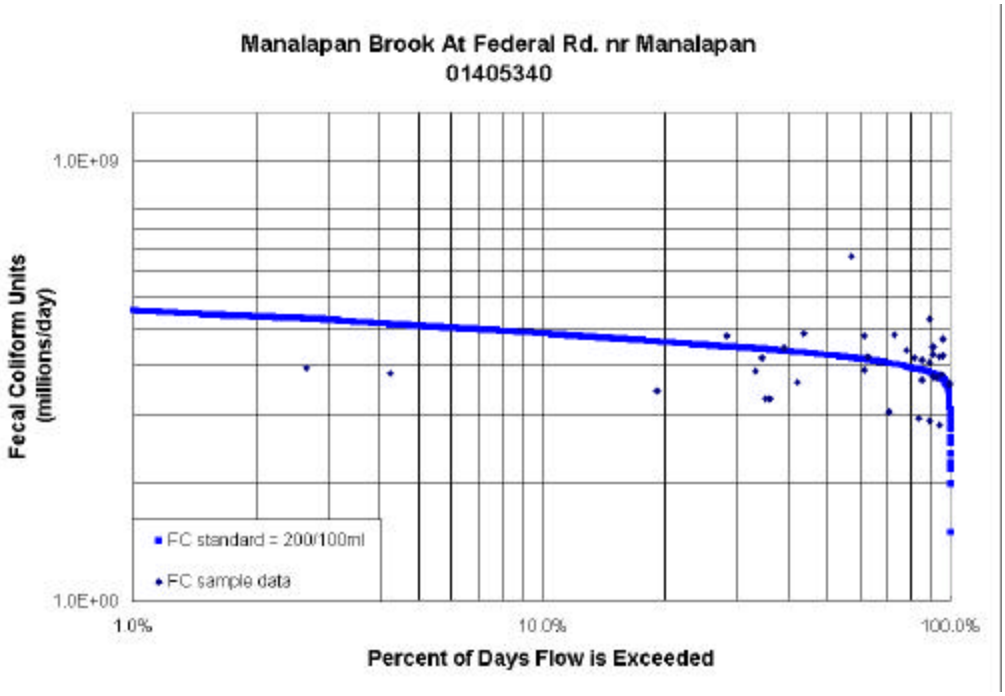
Load Duration Curve for North Branch Raritan River near Raritan. Fecal coliform data from USGS station # 01400000 during the period 6/4/98 through 6/19/01. Water years 1970-2001 from USGS station # 01400000 were used in generating the FC standard curve.



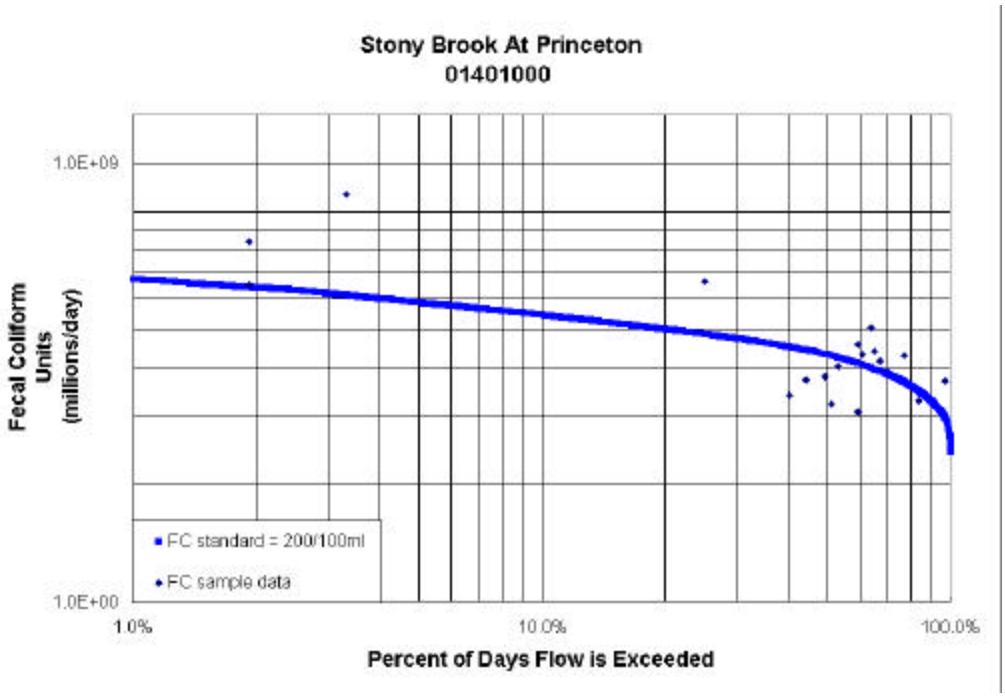
Load Duration Curve for Raritan River at Manville. Fecal coliform data from USGS station # 01400500 during the period 2/2/94 through 7/31/97. Water years 1970-2001 from USGS station # 01400500 were used in generating the FC standard curve.



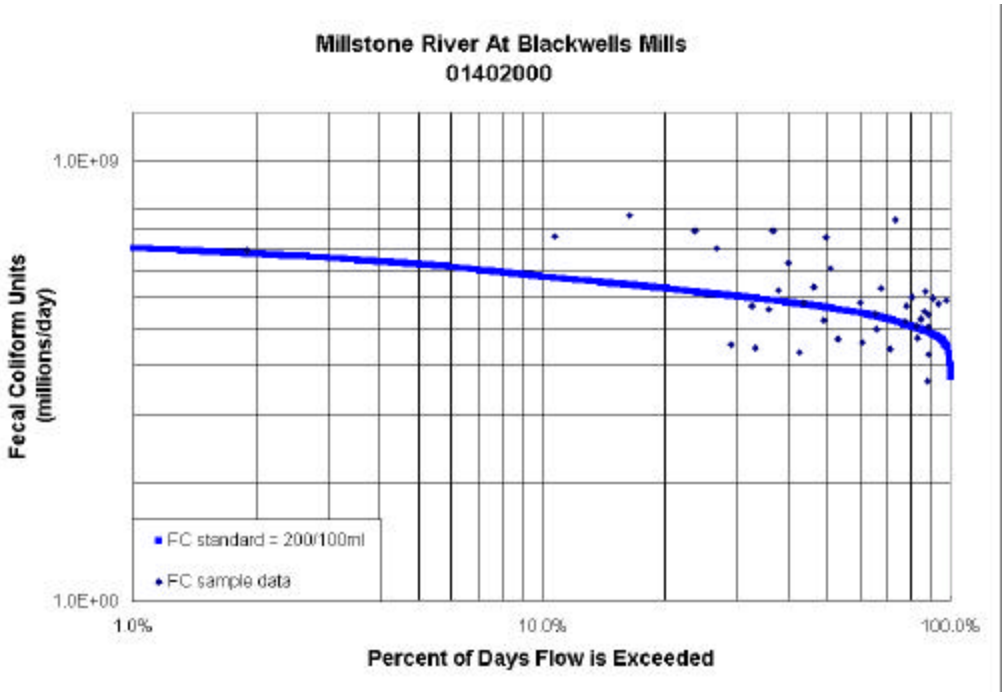
Load Duration Curve for Raritan River at Manville. Fecal coliform data from USGS station # 01403300 during the period 2/18/94 through 7/31/97. Water years 1970-2001 from USGS station # 01403060 (Raritan River Below Calco Dam at Bound Brook) were used in generating the FC standard curve.



Load Duration Curve for Manalapan Brook at Federal Rd. near Manalapan. Fecal coliform data from USGS station # 01405340 during the period 2/3/94 through 8/29/01. Water years 1970-2001 from USGS station # 01405400 (Manalapan Brook at Spotswood) were used in generating the FC standard curve.



Load Duration Curve for Stony Brook at Princeton. Fecal coliform data from USGS station # 01401000 during the period 1/24/94 through 7/30/97. Water years 1970-2001 from USGS station # 01401000 were used in generating the FC standard curve.



Load Duration Curve for Millstone River at Blackwells Mills. Fecal coliform data from USGS station # 01402000 during the period 2/2/94 through 6/19/01. Water years 1970-2001 from USGS station # 01402000 were used in generating the FC standard curve.