Amendment to the Cape May County and Lower Delaware Water Quality Management Plans

Eight Total Maximum Daily Loads for Total Coliform to Address Shellfish-Impaired Waters in Watershed Management Area 16 Atlantic Coastal Water Region

Proposed: February 21, 2006
Established:
Approved:
Adopted:

Prepared by:
New Jersey Department of Environmental Protection
and

TETRA TECH, INC.

With assistance provided by:
U.S. Environmental Protection Agency, Region 2

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EXECUTIVE SUMMARY

In accordance with Section 305(b) and 303(d) of the Federal Clean Water Act (CWA), the State of New Jersey, Department of Environmental Protection (NJDEP) developed the *2004 Integrated List of Waterbodies* addressing the overall water quality of the State's waters and, in Sublist 5, identifying impaired waterbodies for which Total Maximum Daily Loads (TMDLs) may be necessary. The *2004 Integrated List of Waterbodies* was adopted by the Department on October 4, 2004, (36 NJR 4543(a)) as an amendment to the Statewide Water Quality Management Plan, as part of the Department's continuing planning process pursuant to the Water Quality Planning Act at N.J.S.A. 58:11A-7 and the Statewide Water Quality Management Planning rules at N.J.A.C. 7:15-6.4(a). The *2004 Integrated List of Waterbodies* Sublist 5 identifies twenty waterbodies that are impaired with respect to total coliform in Watershed Management Area (WMA) 16. In that list, a waterbody was determined to be impaired if it does not fully support shellfish harvest in accordance with National Shellfish Sanitation Program (NSSP) criteria. Portions of some waterbodies that were initially listed as impaired on the *2004 Integrated List of Waterbodies* Sublist 5 were subsequently determined through this study to be ineligible for development of a TMDL. There was insufficient or no data to develop a TMDL for some waterbodies. Where data was insufficient to develop a TMDL, the waterbodies will remain on Sublist 5. Where there was no data, the waterbody will be placed on Sublist 3 in the 2006 Integrated List. In addition, based on a spatial analysis of monitoring station locations and best available data, some of these waterbodies were found to be closed according to administrative requirements and not because of water quality data. Closures of waters as the result of administrative precautions will be removed from Sublist 5 in the 2006 Integrated List of Waterbodies. TMDLs were developed for the shellfish impaired waterbodies that were impaired because of water quality, as listed in Table 1. Some of the waterbodies were divided into smaller sub-groups that reflect more consistent local water quality conditions, watershed characteristics, and local pollution sources.

Table 1. Waterbodies in WMA 16 identified on the *2004 Integrated List of Waterbodies* as impaired for shellfishing

Waterbody	2004 303(d) Listing	Action
Bidwell Ditch-Tidal	R39, 1890C-M	TMDL Assessment - Reduction
Big Elder Creek Estuary	3136	TMDL Assessment - No Reduction
Cape May Canal	1319B-D	TMDL Assessment – Reduction Grouped with Jarvis Sound
Cape May Island Creek - Tidal	*Not on Sublist 5* (3618, 3618A, 3618C, 3618D)	Unable to assess for TMDL
Coastal Tributaries to Jarvis Sound	*Not on Sublist 5*	TMDL Assessment - Reduction

Corson Sound	Crook Horn Creek-1,2; Corson Sound-6,9; Whale Creek-10,11; Ludlam Bay-7; Unnamed Creek-13	TMDL Assessment - No Reduction
Creesse Creek Estuary	3413A, 3500B, 3500C	TMDL Assessment - No Reduction
Dennis Creek Estuary	1888M-V	TMDL Assessment – No Reduction in WMA 17 Grouped with Delaware Bay
Fishing Creek Estuary	Fishing Creek Estuary	Unable to assess for TMDL
Great Sound	Gravens Thorofare-1; Long Reach-5; Holmes Cove-6	TMDL Assessment - Reduction
Hall Creek Estuary	Hall Creek Estuary	Unable to assess for TMDL
Jarvis Sound (formerly James Sound)	James Sound-1 thru 11	TMDL Assessment - Reduction
Jenkins Sound	Jenkins Sound-1 thru 10	TMDL Assessment - Reduction
Jones/ Stites/ Carino/ Taylor Creek Estuary	3603B	TMDL Assessment - Reduction
Richardson Sound	Old Turtle Thorofare-1; Unnamed Creek-2, 7; Old Turtle Thorofare-3; Taugh Creek-4; Slaughter Gut-6; Stingeree Creek-8; Grassy Sound-12	TMDL Assessment - No Reduction
Savages Run Estuary	1388K	TMDL Assessment – No Reduction in WMA 17 Grouped with Delaware Bay
Sluice Creek Estuary	Sluice Creek Estuary	Unable to assess for TMDL
Stiles Sound	Ingram Thorofare-2	TMDL Assessment - No Reduction
Townsend Sound	Clam Thorofare-1; Lower Ludlam Thorofare-2; Townsend Channel-4, 5	TMDL Assessment - No Reduction
West Creek Estuary	1887C, 1887D	TMDL Assessment – No Reduction in WMA 17 Grouped with Delaware Bay

Nonpoint and stormwater point sources are the primary sources of total coliform loads in these waterbodies. Source loads were estimated for land uses in each watershed and for local marinas that may be causing water quality impacts in these waterbodies. Traditional point sources, i.e., treatment facilities that have a sanitary waste component, were considered de minimus, due to the use of effective disinfection practices by these facilities. TMDLs were developed based on an analysis of the existing pathogen indicator data compared to National Shellfish Sanitation Program (NSSP) and NJDEP pathogen indicator criteria, and the loading capacity has been allocated among the point and nonpoint sources. This TMDL report includes implementation strategies that will bring the subject waterbodies into compliance with the NSSP criteria for unrestricted shellfish harvest.

This report proposes eight TMDLs for WMA 16 as amendments to the appropriate areawide water quality management plan in accordance with N.J.A.C. 7:15-3.4(g). This report was developed 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," (Sutfin, 2002) which describes the statutory and regulatory requirements for approvable TMDLs. Upon approval by EPA these TMDLs will be adopted by the Department as amendments to the Cape May County and Lower Delaware Water Quality Management Plans in accordance with N.J.A.C. 7:15-3.4 (g).

1.0 INTRODUCTION

In accordance with Section 303(d) of the Federal Clean Water Act (CWA) (33 U.S.C. 1315(B)), the State of New Jersey is required biennially to prepare and submit to the USEPA a report that identifies waters that do not meet or are not expected to meet water quality standards after implementation of technology-based effluent limitations or other required controls. This report is commonly referred to as the 303(d) List. In accordance with Section 305(b) of the CWA, the State of New Jersey is also required biennially to 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. The *Integrated List of Waterbodies* combines these two assessments and assigns waterbodies to one of five sublists. Sublists 1 through 4 include waterbodies that are generally unimpaired (Sublist 1 and 2), have limited assessment or data availability (Sublist 3), are impaired due to pollution rather than pollutants or have had a TMDL or other enforceable management measure approved by EPA (Sublist 4). Sublist 5 constitutes the traditional 303(d) list for waters impaired or threatened by one or more pollutants, for which a TMDL may be required. In WMA 16, the *2004 Integrated List of Waterbodies* currently identifies twenty waterbodies as impaired because they do not fully support shellfish use. In the course of developing TMDLs for the listed impairments, it was determined that portions of the waterbodies that were initially listed as impaired on the *2004 Integrated List of Waterbodies* Sublist 5 were subsequently determined to be ineligible for development of a TMDL. There was insufficient or no data to develop a TMDL for some waterbodies. Where data was insufficient to develop a TMDL, the waterbodies will remain on Sublist 5. Where there was no data, the waterbody will be placed on Sublist 3 in the 2006 Integrated List. In addition, based on a spatial analysis of monitoring station locations and best available data, some of the site identifications were found to be closed as the result of considering administrative requirements and not because of water quality data. Proximity to potential sources such as marinas, development served by septic systems and concentrated stormwater outfall locations warrants precautionary closures of shellfish waters on a seasonal or full time basis. Closures of waters for shellfishing as the result of administrative precautions will be removed from Sublist 5 in the 2006 Integrated List of Waterbodies. TMDLs were developed for the shellfish impaired waterbodies that were impaired because of water quality.

A 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 waterbody can assimilate and still conform to applicable water quality standards and support designated uses. The TMDL or loading capacity is allocated to known point and nonpoint sources in the form of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS).

Recent EPA guidance (Sutfin, 2002) describes the statutory and regulatory requirements for approvable TMDLs, as well as additional information generally needed for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations. These TMDLs address the following required 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.

This report establishes eight TMDLs for total coliform to address the impaired shellfish waters in WMA 16. With the exception of Bidwell Ditch-Tidal, all of the impaired waterbodies were assigned a High priority ranking in the *2004 Integrated List of Waterbodies* Sublist 5. Bidwell Ditch Tidal was assigned a Medium priority ranking in the *2004 Integrated List of Waterbodies* Sublist 5. These TMDLs include management approaches to reduce pathogen contributions from various sources in order to attain applicable surface water quality standards and fully support the designated shellfish use. These TMDLs cover more area than is actually listed as being impaired due to the fact that the implementation plans, as described in detail later in this document, cover entire watersheds, not just the impaired waterbodies. These waterbodies will be moved to Sublist 4 following approval of the TMDLs by USEPA. In addition to the shellfish impairments, Bidwell Ditch-Tidal was also listed as impaired for low dissolved oxygen on the 2004 *Integrated List*. This waterbody will remain on Sublist 5 for the remaining pollutant, which will be addressed in future TMDL efforts.

2.0 POLLUTANT OF CONCERN AND AREA OF INTEREST

The pollutant of concern for the proposed TMDLs is total coliform, which is measured as an indicator for the presence of pathogens. The National Shellfish Sanitation Program (NSSP) has established criteria for indicator organisms that are used to determine support of the shellfishing use. The NSSP sets forth other requirements for restricting shellfish harvest based on shoreline surveys. Where potential sources, such as wastewater or stormwater outfalls, septic systems or marinas, are present, precautionary restrictions are applied. These shellfish restrictions are referred to as administrative closures and are not appropriate for TMDL development. As discussed, where portions of listed impaired waterbodies were found to be administratively closed, they will be properly placed on Sublists 1 or 3 on the 2006 Integrated List. TMDLs were developed for the waterbodies listed in Table 2 and shown in Figure 1. As a aid to analysis, some waterbodies were divided into smaller sub-groups to reflect local water quality conditions, watershed characteristics, and local pollution sources. Sub-groups were delineated based on several criteria including the location of monitoring stations and data availability, the size and spatial extent of each waterbody, the location of possible pathogen sources, and other waterbody/watershed characteristics. A TMDL calculation was made for each waterbody sub-group or the entire waterbody if there were no sub-groups delineated. Waterbody sub-groups are listed in Table 2 and shown in Figure 1. The 2004 New Jersey 303(d) impairment listing for each waterbody (Sublist 5) is also provided in Table 2 for reference.

Table 2. Waterbodies listed for total coliform impairment in WMA 16

Waterbody	2004 303(d) Listing Site IDs	TMDL Site ID	Subgroup	Percent Reduction
Bidwell Ditch-Tidal	R39, 1890C-M	R39, 1890C, 1890D, 1890E, 1890F, 1890G, 1890H, 1890I, 1890J, 1890K, 1890L, 1890M	-	74%
Big Elder Creek Estuary	3136	3136, 3136A, 3136B	-	0%
Coastal Tributaries to Jarvis Sound	*not on sublist 5*	3604B, 3609, 3609A, 3610	-	46%
Corson Sound	Crook Horn Creek-1,2; Corson Sound-6,9; Whale Creek-10,11; Ludlam Bay-7; Unnamed Creek-13	Corson Sound-1, 2, 6, 9	A	0%
		Corson Sound-7	B	0%
		Corson Sound-10A, 11	C	0%
Creesse Creek Estuary	3413A, 3500B, 3500C	3410B, 3413A, 3500B, 3500C	-	0%
Great Sound	Gravens Thorofare-1; Long Reach-5; Holmes Cove-6	Great Sound-1, 5	A	68%
		Great Sound-6	B	0%
Jarvis Sound	James Sound-1 thru 11	Jarvis Sound- 1,2,3,4,5,6	A	45%
		Jarvis Sound- 7,8,9,10,11; **Cape May Canal; Atlantic Ocean-6, Cape May Channel-7** of WMA 12	B	71%
Jenkins Sound	Jenkins Sound-1 thru 10	Jenkins Sound-1 thru 10	-	28%
Jones/ Stites/ Carino/ Taylor Creek Estuary	3603B	3603B, 3603, 3605	-	36%
Richardson Sound	Old Turtle Thorofare-1; Unnamed Creek-2, 7; Old Turtle Thorofare-3; Taugh Creek-4; Slaughter Gut-6; Stingeree Creek-8; Grassy Sound-12	Richardson Sound-1,2,3,4	A	0%
		Richardson Sound-8, 13	B	0%
		Richardson Sound-12, 14	C	0%
Stiles Sound	Ingram Thorofare-2	Stiles Sound-2	-	0%
Townsend Sound	Clam Thorofare-1; Lower Ludlam Thorofare-2; Townsend Channel-4, 5	Townsend Sound-1, 2	A	0%
		Townsend Sound-4, 5	B	0%

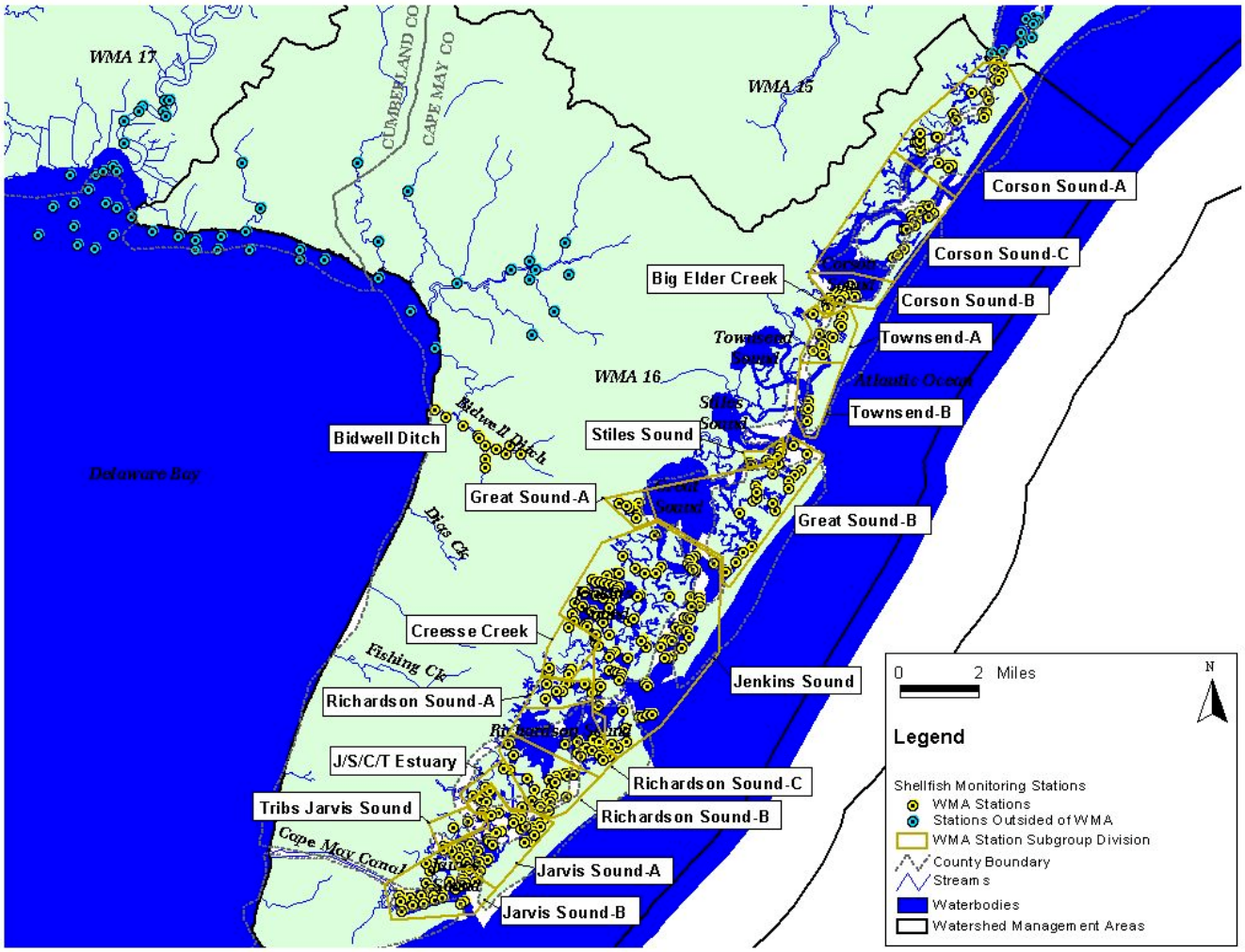

Figure 1. Shellfish impaired waterbodies in WMA 16

2.1 Applicable Water Quality Standards

New Jersey Surface Water Quality Standards (SWQS) include pathogen indicator criteria for the assessment of the recreational use (primary and secondary contact recreation) for all waterbodies (Table 3). New Jersey SWQS also specify that shellfish waters shall meet the guidelines of the National Shellfish Sanitation Program (NSSP). The NSSP guidelines include stringent criteria, expressed in terms of indicator organisms, to protect against the harvest of shellfish in waters where the sanitary quality could have health risks for consumers. Total coliform data are used to assess the shellfish designated use for the waterbodies in all waters according to the New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report. In non-ocean waters, data were collected by the Department using Systematic Random Sampling (SRS) protocol. Ocean waters were collected using the Adverse Pollution Condition (APC) protocol. The analytical methods used were 3-tube dilution analysis for total coliform and 5-tube analysis for fecal coliform. These TMDLs were developed to meet the NSSP 90th percentile (330 cfu/100ml) and geometric mean (70 cfu/100ml) criteria for total coliform (in colony forming units, or cfu) because this is the basis for determining impairment in the subject waters.

Table 3. Water quality criteria expressed as cfu/00ml

Bacterial Indicator	NJ Surface Water Quality Standards (SWQS) *		National Shellfish Sanitation Program (NSSP)
	Within 1500 ft. of shoreline	1500 ft. to 3 mi. from shoreline	
Total Coliform	N/A	N/A	• Geometric Mean (Geomean) shall not exceed 70 • No more than 10% of samples shall exceed 330 for APC monitoring • Estimated 90th percentile shall not exceed 330 for SRS monitoring
Fecal Coliform	• Geomean shall not exceed 50	• Geomean shall not exceed 200 • No more than 10% in any 30-day period to exceed 400	• Median or geomean shall not exceed 14 • No more than 10% shall exceed 49 for APC monitoring • Estimated 90th percentile shall not exceed 49 for SRS monitoring
Enterococcus	• Geomean shall not exceed 35 • Single sample shall not exceed 104/100ml	N/A	N/A

Source: NJDEP SWQS, 2005 and USFDA NSSP Guide for the Control of Molluscan Fish, 2003.
Notes:

- Samples shall be obtained at sufficient frequencies and at locations during periods which will permit valid interpretation of laboratory analyses. A minimum of five samples as equally spaced over a 30-day period, as feasible, should be collected; however, the number of samples, frequencies and locations will be determined by NJDEP or other appropriate agency in any particular case.
- NSSP standards shown are based on a 3-tube decimal dilution test. Additional standards for 5- and 12-tube decimal dilution tests apply.
- For NSSP sampling, sample collection requirements vary based on attributes of the waters where samples are collected (e.g., whether the area is affected by point sources, etc.).
- Standards shown are those that apply to waters approved for shellfish growing. Additional requirements and exceptions may apply and can be found in NJDEP's SWQS and NSSP's guidelines documents.
- APC = Adverse Pollution Conditions. APC sampling occurs in areas with known point sources, including around some marinas.

SRS = Systematic Random Sampling. SRS sampling methods are used in the majority of shellfish waters and is based on a random statistical sampling approach.

Each year, the Department updates the classification of New Jersey's coastal waters for shellfish harvesting based on analysis of extensive sampling (over 15,000 samples per year) and pollution source surveys. The classifications indicate sanitary coastal water quality. New Jersey has had a long history of improving the sanitary quality of its coastal waters.

In accordance with the NSSP, the Department must also perform a sanitary survey and produce a Local Area Report (LAR) to collect and evaluate information concerning actual and potential pollution sources that may adversely affect the water quality in each growing area. Based on the sanitary survey information, the Department assigns the growing area to one of five classifications. These classifications are summarized below.

Classification	Description
Approved	No restrictions on licensed harvesters
Seasonal (November - April)	Water open for harvest seasonally from Nov - April
Seasonal (January - April)	Water open for harvest seasonally from January - April
Special Restricted	Harvest only by Special Permit. Shellfish harvested must be further purified by relay to Approved waters or processing in a depuration plant prior to being sold.
Prohibited	No harvest under any conditions.

The impaired waterbodies addressed in this document are classified as Saline Estuary 1 (SE1), except for small portions in the upper reaches of tidal streams that are classified as Fresh Water 2 (FW2).

In all SE1 waters the designated uses are:

1. Shellfish harvesting in accordance with N.J.A.C. 7:12;
2. Maintenance, migration and propagation of the natural and established biota;
3. Primary and secondary contact recreation; and
4. Any other reasonable uses.

In all FW2 waters, the designated uses are (from NJAC 7:9B-1.12):

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.

2.2 Description of Land Use in the Watershed Management Area

Watershed management area 16 includes watersheds draining the Cape May portion of New Jersey, south and east of the Tuckahoe River watershed. The region represents a low lying, gently rolling plain in which the highest point is 54 feet above sea level; much of the land surface is wet soils and wetlands and contains minimal surface water flow. Large swamps (Great Cedar, Timber and Beaver Swamps) occupy the north-central part of the county. Most, if not all, streams are tidal in their lower reaches and terminate by flowing into fresh water swamps that, in turn, discharge into saltwater marshes near the shore. Table 4 shows the land use distribution among the waterbody subgroup watersheds. Land use data for each watershed were derived from the 1995/1997 land use/land cover dataset developed for New Jersey.

Table 4. Land use area distribution in WMA 16 subgroup watersheds

Waterbody	Subgroup	Agriculture		Barren Land		Forest		Urban		Water		Wetlands		Total Area
		km²	%	km²	%	km²	%	km²	%	km²	%	km²	%	km²
Bidwell Ditch-Tidal	-	1.44	4.4%	0.34	1.0%	7.68	23.7%	2.82	8.7%	0.88	2.7%	19.26	59.4%	32.40
Big Elder Creek Estuary	-	0.05	1.6%	0.00	0.0%	0.31	10.9%	0.58	20.1%	0.08	2.7%	1.87	64.7%	2.89
Coastal Tributaries to Jarvis Sound	-	0.13	3.6%	0.00	0.1%	0.27	7.3%	0.70	19.3%	0.40	11.1%	2.13	58.5%	3.64
Corson Sound	A	0.06	0.3%	0.10	0.5%	1.63	8.3%	4.48	22.9%	1.83	9.3%	11.49	58.6%	19.59
Corson Sound	B	0.13	2.1%	0.00	0.0%	0.54	9.0%	1.01	16.8%	1.22	20.2%	3.12	51.9%	6.01
Corson Sound	C	0.81	2.8%	0.24	0.8%	2.91	10.0%	4.09	14.0%	7.49	25.7%	13.64	46.7%	29.18
Creesse Creek Estuary	-	0.26	3.1%	0.14	1.7%	1.72	20.9%	1.50	18.2%	0.48	5.9%	4.14	50.3%	8.24
Great Sound	A	0.00	0.0%	0.09	2.1%	0.85	18.5%	1.59	34.8%	0.43	9.3%	1.62	35.3%	4.58
Great Sound	B	0.00	0.0%	0.02	0.3%	0.02	0.3%	1.29	18.5%	1.85	26.5%	3.80	54.4%	6.98
Jarvis Sound	A	1.48	5.4%	0.01	0.0%	1.53	5.5%	6.37	23.1%	6.00	21.8%	12.15	44.1%	27.53
Jarvis Sound	B	3.17	5.5%	0.71	1.2%	4.11	7.2%	15.95	27.8%	10.21	17.8%	23.14	40.4%	57.30
Jenkins Sound	-	1.14	1.7%	0.73	1.1%	5.84	8.7%	11.02	16.3%	18.53	27.5%	30.16	44.7%	67.42
Jones/Stites/Carino/ Taylor Creek Estuary	J/S/C/T Estuary	1.34	12.2%	0.00	0.0%	0.98	8.8%	2.70	24.5%	0.85	7.7%	5.17	46.8%	11.04
Richardson Sound	A	0.20	2.0%	0.14	1.5%	1.41	14.6%	1.75	18.1%	0.88	9.2%	5.28	54.6%	9.67
Richardson Sound	B	0.34	2.3%	0.02	0.1%	1.18	7.8%	4.43	29.4%	4.25	28.2%	4.84	32.1%	15.07
Richardson Sound	C	0.20	1.2%	0.14	0.9%	1.45	8.9%	2.71	16.6%	4.52	27.7%	7.32	44.8%	16.34
Stiles Sound	-	0.07	0.4%	0.16	1.0%	0.79	4.8%	1.44	8.8%	5.96	36.2%	8.03	48.8%	16.45
Townsend Sound	A	1.59	8.5%	0.01	0.1%	3.11	16.5%	3.85	20.5%	2.24	11.9%	7.99	42.5%	18.80
Townsend Sound	B	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.37	94.2%	0.00	0.4%	0.02	5.5%	0.39

3.0 SOURCE ASSESSMENT

A source assessment was conducted to identify and characterize potential pathogen sources that may be impacting water quality and shellfish growing areas in the listed waters. Point and nonpoint sources of total coliform were considered in TMDL development. Source assessment also included the determination of the relative contribution of the primary bacteria sources to facilitate proper management responses through TMDL implementation. A variety of information was used to characterize possible pathogen sources including shoreline surveys conducted by the Department, land use information gathered for each watershed, point source information, literature sources, and other available data.

3.1 Shoreline Surveys

WMA 16 includes six shoreline survey areas: Corsons Sound to Ludlam Bay (SE-4), Ludlam Bay to Townsend Inlet (SE-5), Great Sound, Grassy Sound, and Hereford Inlet (SE-6), Sunset Lake to Cape May Harbor (SE-7), Atlantic Ocean South (AOSO), and Delaware Bay (Cape

Shore) (DB-2). Local Area Reports (LARs) were completed for each shoreline survey area by the Department to characterize shellfish growing areas, surrounding land uses, and potential pollution sources in the watershed. These reports satisfy the requirements of the NSSP program by providing information on local shellfish growing areas. This information is also used by the Department in the assessment process and for determining impairment status. The data contained in these reports was used to help identify and characterize potential pathogen sources that may be impacting the shellfish harvest areas located within each TMDL waterbody sub-group. Note that recent data collected by NJDEP regarding shellfish classifications (2004 GIS coverage) and pollution sources may not be reflected in these reports. Updated information on the point and nonpoint sources identified and the respective loading estimates are provided in the following source assessment sections.

The 2004 shellfish classification GIS coverage was used to cross-reference with TMDL waterbody sub-groups. A summary of the information presented in the most recent LAR for each shoreline survey area is presented below.

- SE-4: Corsons Sound to Ludlam Bay
  A reappraisal report for SE-4 was published in May 2005 and represents the data collection period: 1996-2000. Shellfish Growing Area SE-4 is located northwest of Sea Isle City and southwest of Ocean City, in Cape May County. This area includes the shellfish growing waters from the south of Peck Bay in the north, to the north of Ludlam Bay in the south. Ludlam Bay is not included in this shellfish growing area. These estuarine and back bay waters are bordered on the east by Sea Isle City, Strathmere, and the south part of Ocean City, and to the west by Upper Township. Corsons Inlet and Strathmere Bay are also located in this shellfish growing area. The approximate size of this shellfish growing area is 1,504 acres, and the shellfish classification for this growing area is Approved, Seasonally Approved, Special Restricted, and Prohibited for shellfish harvesting. The ports of Cape May County provide at least half of the State of New Jersey's seafood value. An extensively urbanized area to the east and north and tidal wetlands to the south and west border much of this area. The urban areas to the east are resort areas (Sea Isle City, Strathmere, and Ocean City) with significant boating and marine activities during the summer months. There are currently 8 marinas in this area. Since some of these communities are still on septic systems, there is a potential for pollutant inputs from this source into these shellfish growing waters. Potential septic system impacts were listed for the area near the coast of Strathmore due to the presence of homes on septic systems. This growing area has a wide diversity of biological resources. There are many storm water outfalls located to the northeast and east of this shellfish growing area. Most of these storm water outfalls border Crook Horn Creek, the numerous creeks located to the west of Ocean City, Beach Creek (which is southwest of Ocean City), Strathmere Bay (which is west of Strathmere), Whale Creek (which is northwest of Sea Isle City), and Ludlam Bay (which is west of Sea Isle City). There are also storm water outfalls located to the west of this area in Upper Township near the Garden State Parkway.

- SE-5: Ludlam Bay to Townsend Inlet

A reappraisal report for SE-5 was published in June 2003 and represents the data collection period: 1997-2001. Shellfish Growing Area SE-5 is located northwest of Avalon and south of Strathmere, in Cape May County. This area includes the shellfish waters from Ludlam Bay in the north, to the north of Great Sound in the south. Great Sound is not included in this shellfish growing area. These estuarine and back bay waters are bordered on the east by Sea Isle City and Avalon, and to the west by Dennis Township and Middle Township. Townsends Inlet, Townsend Sound, and Stites Sound are also located in this shellfish growing area. Shellfish classifications listed in this survey include Approved, Seasonally Approved, Special Restricted, and Prohibited shellfish growing areas. Much of this growing area is bordered by an extensively urbanized area to the east, and tidal wetlands to the west. The urban areas to the east are resort areas (Sea Isle City and Avalon) with significant boating and marine activities during the summer. There are currently 22 marinas in this area. Several communities are still on septic systems. There is one permitted municipal point source discharge near this shellfish growing area, the Cape May County Utilities Authority – Seven Mile/ Middle Region Wastewater Treatment Facility Discharge Pipe. The discharge pipe conducts wastewater into the ocean outfall off the beach near 27th Street in Avalon. There are many storm water outfalls located to the south and east of this shellfish growing area. These storm water outfalls mainly border Ludlam Bay, Ludlam Thorofare, and Townsend Channel (which are west of Sea Isle City), and Ingram Thorofare, Gravens Thorofare, Cornell Harbor, Pennsylvania Harbor, Princeton Harbor, and Long Reach (which are west of Avalon). There are also storm water outfalls located to the west of this area in Upper Township, Dennis Township, and Middle Township near the Garden State Parkway.

- SE-6: Great Sound, Grassy Sound, and Hereford Inlet
  A reappraisal report for SE-6 was published in May 2005 and represents the data collection period: 1997-2000. Shellfish Growing Area SE-6 is located north of the city of Cape May and south of Sea Isle City, in Cape May County. It is bordered on the east by Avalon, Stone Harbor, North Wildwood, West Wildwood, and Wildwood. Middle Township is located to the west of this area. The principal bodies of water in this area are Great Sound, Jenkins Sound, Grassy Sound, Richardson Sound, and Hereford Inlet. The approximate size of this shellfish growing area is 7,081 acres. Shellfish classifications listed in this survey include Approved, Seasonally Approved, Special Restricted, and Prohibited shellfish growing areas. Much of this area is a resort area bordered by an extensively urbanized area to the east, and tidal wetlands to the west and north. The urban areas to the east are shoreline beach resort areas, with significant boating and recreational activities during the summer. There are currently 31 marinas in this area. There are many storm water outfalls located along the borders of this shellfish growing area along Wildwood Canal, Hoffman Canal, and Beach Creek (west of Wildwood, West Wildwood, and North Wildwood), the south side of Hereford Inlet, the east side of Great Channel, Muddy Hole Creek, Stone Harbor Creek (west of Stone Harbor), Long Reach, Princeton Harbor, and Pennsylvania Harbor (west of Avalon). There are also some storm water outfalls located to the west of this area in Middle Township near the Garden State Parkway and Route 9.

- SE-7: Sunset Lake to Cape May Harbor
  A reappraisal report for SE-7 was published in June 2005 and represents the data collection period: 1996-2000. Shellfish Growing Area SE-7 is located north of the city of Cape May and south west of Wildwood, in Cape May. These estuarine and back bay waters are bordered on the east by Wildwood Crest and Lower Township, and to the west by Lower Township. The principal bodies of water in this area are Taylor Sound, Sunset Lake, Jarvis Sound, Cape May Harbor, Cape May Canal and Cape May Inlet. Shellfish classifications listed in this survey include Seasonally Approved, Special Restricted, and Prohibited shellfish growing areas (2004). Much of this area is a resort area bordered by an extensively urbanized area to the east, and tidal wetlands to the west. The urban areas to the east are resort areas (Wildwood, Wildwood Crest, and Cape May City) with significant boating and water activities during the summer. There are currently 46 marinas in this area. Several communities are still on septic systems. There are many storm water outfalls located to the north and east of this shellfish growing area. These storm water outfalls mainly border Post Creek Basin (which is south of West Wildwood and west of Wildwood), Grassy Sound Channel (which is west of Wildwood and Wildwood Crest), Sunset Lake (which is west of Wildwood Crest), and Jarvis Sound (which is west of Wildwood Gables in Wildwood Crest). There are also some storm water outfalls located to the west of this area in Lower Township near the Garden State Parkway and Route 9, and north of the Cape May Canal. However, this shellfish growing area is not directly impacted by the outflow from these storm water outfalls.

- DB-2: Delaware Bay (Cape Shore)
  A reappraisal report for DB-2 was published in November 2003 and represents the data collection period: 1999-2002. The Delaware Bay Cape Shore (DB-2) area includes the shellfish waters from East Point down to Cape May Point. The Delaware Bay area was once known as the oyster capital of world. During the 1950's, a disease called MSX (multinucleated sphere unknown) attacked the oyster industry. The impact from this disease dramatically decreased the demand for oyster from the Delaware Bay. To this day, the oyster industries have not yet fully recovered to previous levels of production and harvesting. The primary waterbodies in this area include Maurice River, Bidwell Creek, Dennis Creek, Dias Creek, Fishing Creek, Cox Hall Creek, and the Cape May Canal. The DB-2 area was sampled under the Adverse Pollution Control strategy. Shellfish classifications listed in this survey include Approved (ocean waters), Seasonally Approved, Special Restricted, and Prohibited shellfish growing areas (2004). The data indicated bacteria counts were only higher during the summer months, which is most likely due to boating activities and increased populations resulting from the summer tourism industry. Regions within the Delaware Bay Cape Shore area consist primarily of wetland, forest, and agriculture. Within Cumberland and Cape May County, a very small percentage of land is in urban development. The DB-2 area includes the following municipalities: Maurice River Township, Dennis Township, Middle Township, Lower Township, and Cape May Point. Within the five municipalities listed above, Lower Township is the most populated community in the DB-2 area. There are two wastewater treatment facilities located in this portion of Cape May County: the Cape May County Utilities Authority - Cape May Regional Wastewater Treatment Facility and the Lower

Township Municipal Utilities Authority - Wastewater Treatment Facility. Both of these facilities use a common discharge pipe, which discharges the effluent to the Atlantic Ocean. The discharge pipe is approximately 5500 feet off the shore of Jefferson Avenue in Wildwood Crest, New Jersey. Since the discharge is directed to the Atlantic Ocean, there is no direct impact onto the Delaware Bay. There are numerous storm water outfalls located throughout this area. The main concern is the storm water outfalls that are situated along the shoreline. When heavy rainfall occurs, bacteria from domestic animal waste and other wastes from the streets enter these outfalls and are conveyed into the Delaware Bay. There are 2 marinas located in the area.

3.2 Assessment of Point Sources

For TMDL development purposes, point sources include domestic and industrial wastewater treatment plants that discharge to surface waters, as well as surface water discharges of stormwater subject to regulation under the National Pollutant Discharge Elimination System (NPDES). This includes facilities with individual or general industrial stormwater permits, Tier A municipalities, and federal, interstate agency, state, and county facilities regulated under the New Jersey Pollutant Discharge Elimination System (NJPDES) municipal stormwater permitting program. Tier A municipalities are generally located within the more densely populated regions of the state or along the coast. These municipalities meet the population size requirements of EPA's Municipal Separate Storm Sewer System (MS4) program for regulating urban stormwater discharges. Stormwater point sources, like nonpoint sources, derive their pollutant loads from runoff from land surfaces and load reduction is accomplished through the use of best management practices (BMPs). The distinction is that stormwater point sources are regulated under the Clean Water Act (under the MS4 program). Stormwater point sources are or will be addressed through the management practices required through the discharge permits.

Wastewater treatment facilities and Tier A municipalities that directly discharge to the shellfish waters in WMA 16 or tributaries that eventually flow into these waters are identified in Appendices B and C. Per Department NJPDES Regulation, N.J.A.C. 7:14A-12.5(a), "All wastewater that could contain pathogenic organisms such as fecal coliform and/or enterococci organisms shall be subject to continuous year round disinfection prior to discharge into surface waters." Therefore, loads from wastewater treatment facilities were considered de minimus, consistent with previous pathogen TMDLs developed by the Department. The NJPDES permit limits for these point sources will not be changed as a result of these TMDLs. Stormwater loads from Tier A MS4 systems are point sources that can be significant. These loads were estimated using the watershed loading methods described in the nonpoint source section.

3.3 Assessment of Nonpoint Sources

Nonpoint sources that may affect shellfish waters include stormwater discharges that are not subject to regulation under the Clean Water Act, including direct stormwater runoff from land surfaces, as well as malfunctioning sewage conveyance systems, failing or

inappropriately located septic systems, and direct contributions from wildlife, livestock and pets. Tier B municipalities are generally located in more rural, non-coastal regions of the state. There are no Tier B municipalities located in the affected drainage areas.

Alternative methods were considered to determine the best approach for estimating land-based loads contributed by each watershed, including the Watershed Treatment Model (WTM) a study of nonpoint source loadings generated in a study of the Toms River watershed, and simpler bacteria load estimation equations. The WTM model was selected because it encompasses local rainfall data and stream length information to better tailor load estimates. In addition, it has been successfully applied in previous coastal TMDL studies (Oyster Bay-New York, U.S. Virgin Islands TMDLs). The goal of applying WTM is to characterize all the point and nonpoint sources, as available data allows, in the existing system and to determine their relative contributions to the waterbody of interest. The loading values thus derived, along with the loads contributed by marinas as discussed below, serve as the reference point from which reductions are made to meet TMDL targets.

The WTM model is a series of spreadsheets that quantifies the loading of pathogen indicators based on land use distribution, stream network length in the watershed, and annual rainfall. The model is designed as a planning level tool for watersheds that do not have sufficient data for complex modeling applications. Although the WTM model has several tiers of data specificity, loading estimates can be calculated with simple land use data, as they were for these shellfish TMDLs. Land use loads are calculated on an annual basis by using a series of coefficients for runoff volume and pathogen loading derived from scientific literature. General land use categories are assigned either a coefficient that is then multiplied by an annual runoff volume to calculate an annual load (e.g., urban land uses), or an annual unit area load that is applied as a function of land use (e.g., rural land uses). These coefficients, presented in Table 5, were chosen based upon the best available research and are summarized in WTM's user manual (Caraco, 2001).

Table 5. Default WTM land use categories and loading variables

WTM Land Use	Corresponding New Jersey Land Uses	Average % Impervious Cover	Fecal Coliform Conc. (MPN/100 ml) or Annual Load (billion/acre)
Low Density Residential	Low Density Residential, Rural Residential, Recreational Land, Athletic Fields	19	20,000
Medium Density Residential	Medium Density Residential, Mixed Residential, Mixed Urban or Built-Up, Other Urban or Built-Up, Military Reservations, No Longer Military	35	20,000
High Density Residential	High Density Residential	56	20,000
Commercial	Commercial Services	71	20,000
Roadway	Transportation/Communication/Utilities	39	20,000
Industrial	Industrial, Industrial/Commercial	78	20,000
Forest	Forest	0	Load: 12 billion/acre
Rural	Agriculture	0	Load: 39 billion/acre
Barren (replaced "Vacant Lots"	Barren	2	Load: 12 billion/acre (estimated)

WTM Land Use	Corresponding New Jersey Land Uses	Average % Impervious Cover	Fecal Coliform Conc. (MPN/100 ml) or Annual Load (billion/acre)
category in WTM)			

The default fecal coliform loading rates in the WTM model were converted to total coliform values based on a regression equation developed to examine the relationship between fecal coliform and total coliform concentrations using shellfish monitoring data collected from 1991 through 2004. Fecal coliform is a component of total coliform, therefore, the loading values were increased based on this equation.

The potential to accurately convert observed fecal coliform values to equivalent total coliform values is supported by a November 1996 study by Espy, Huston, and Associates, Inc. This study investigated public health issues related to recreational and commercial fisheries use of Corpus Christi Bay, Texas produced for the Corpus Christi Bay National Estuary Program (Jensen et al., 1996). A significant correlation (R^2=85.7%) was found between total and fecal coliform concentrations reported for water samples collected in shared sampling quadrants when plotted on a logarithmic scale. The regression equation derived from the Texas data, converted into an exponential expression ($TC=1.69*FC^{1.013}$) is very similar to the equation derived from water quality data analyzed as part of these TMDLs ($TC=1.22*FC^{1.061}$).

The watershed for each TMDL waterbody sub-group was delineated using the Hydrologic Unit Coverage (HUC-14 digit) developed by NJDEP, digital elevation model (DEM) data, and the National Hydrography Dataset (NHD) stream coverage for New Jersey. Land use data for each watershed was obtained from the 1995/1997 land use coverage developed for New Jersey's WMAs. Land use categories were consolidated into broader groups for use in estimating land-based loads using the WTM model and for presenting the loading results. The percent impervious information for each land use category was derived from the percent impervious information in the Department's GIS land use coverage, averaged across similar land uses. The bacterial loads for urban areas in each watershed were calculated based on the default fecal coliform concentration literature value for urban land uses, the average percent impervious cover, and the annual runoff volume calculated by the WM model. Agricultural, forest, and barren land use loads were calculated based on the specific loading rate for each category. Wetland areas and waterways were not included in loading calculations based on WTM model assumptions.

In addition to land-based sources, pathogens can also be associated with direct discharges from boats at marinas. This potential source can be a primary cause of high bacteria concentrations in and around marinas. The bacteria load from inappropriate and illicit wastewater discharges in marinas and mooring locations was estimated based on the Department's marina GIS coverage. This dataset includes information on the number of boat slips and boat sizes typical of each marina. The marina formula presented in the Department's shoreline surveys (LARs) was used to calculate the bacteria load for each marina. Marina loads were calculated for the summer months (May – September). In

addition, marina loads were multiplied by a factor of 0.25 to recognize a lower contribution during other months (October through April) based on best professional judgment. The marina formula was updated to calculate total coliform loads based on the total coliform-fecal coliform regression equation developed for this TMDL study, as described in the WTM model discussion above. Marinas associated with each waterbody (or sub-group) and the calculated total coliform/fecal coliform loads are presented in Appendix D.

The equation used to estimate coliform loads from marina buffers is:

$$FC/day = 2x10^9(FC/person/day)x2(person/boat)x[(.25slips \geq 24') + (0.065 \times slips < 24')]$$

Explanation of terms in equation:

Fecal coliform per person per day:	2×10^9
Number of people per boat:	2
For slips able to accommodate boats > 24 feet (combination of factors yields multiplier of 0.25):	
Number of slips occupied:	50%
Number of boats occupied:	50%
For boats < 24':	6.5% discharge waste

Direct contributions from illicit discharges, livestock, pets, and wildlife (e.g. seagulls, geese, and other waterfowl in particular) were not estimated based on the lack of site-specific information needed to represent these sources. Note that waterfowl direct deposition in some shellfish areas was mentioned as a likely source according to several published shoreline survey reports for New Jersey. Population estimates, bacteria production rates, and other information would be needed to estimate the relative impact of these sources. Determining the relative importance of this source will be a component of the implementation plan, in order to determine the importance of focusing management strategies to address these sources. Therefore, loads from failing systems, discharges from malfunctioning sewer conveyances, and bacteria loads contributed by livestock, pets, and wildlife in each watershed were assumed to be included in the land use loading coefficients.

Pathogen indicator source data used in TMDL development are shown in Figures 2 and 3. Land uses, NJPDES-permitted wastewater treatment facilities, marinas, stormwater outfalls, and water quality stations are shown in these maps.

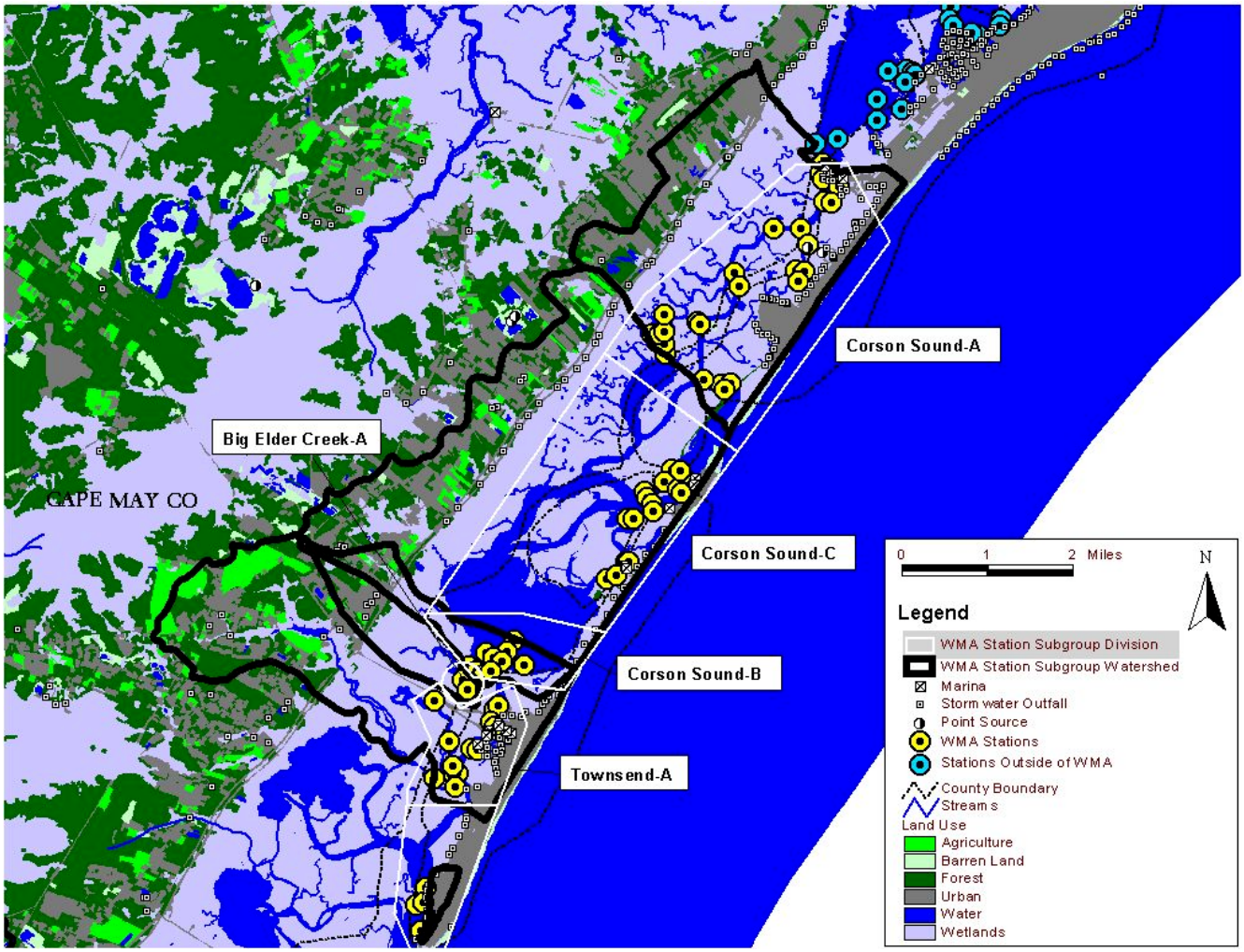

Figure 2. Primary bacteria source data used in TMDL development for northeastern portions of WMA 16

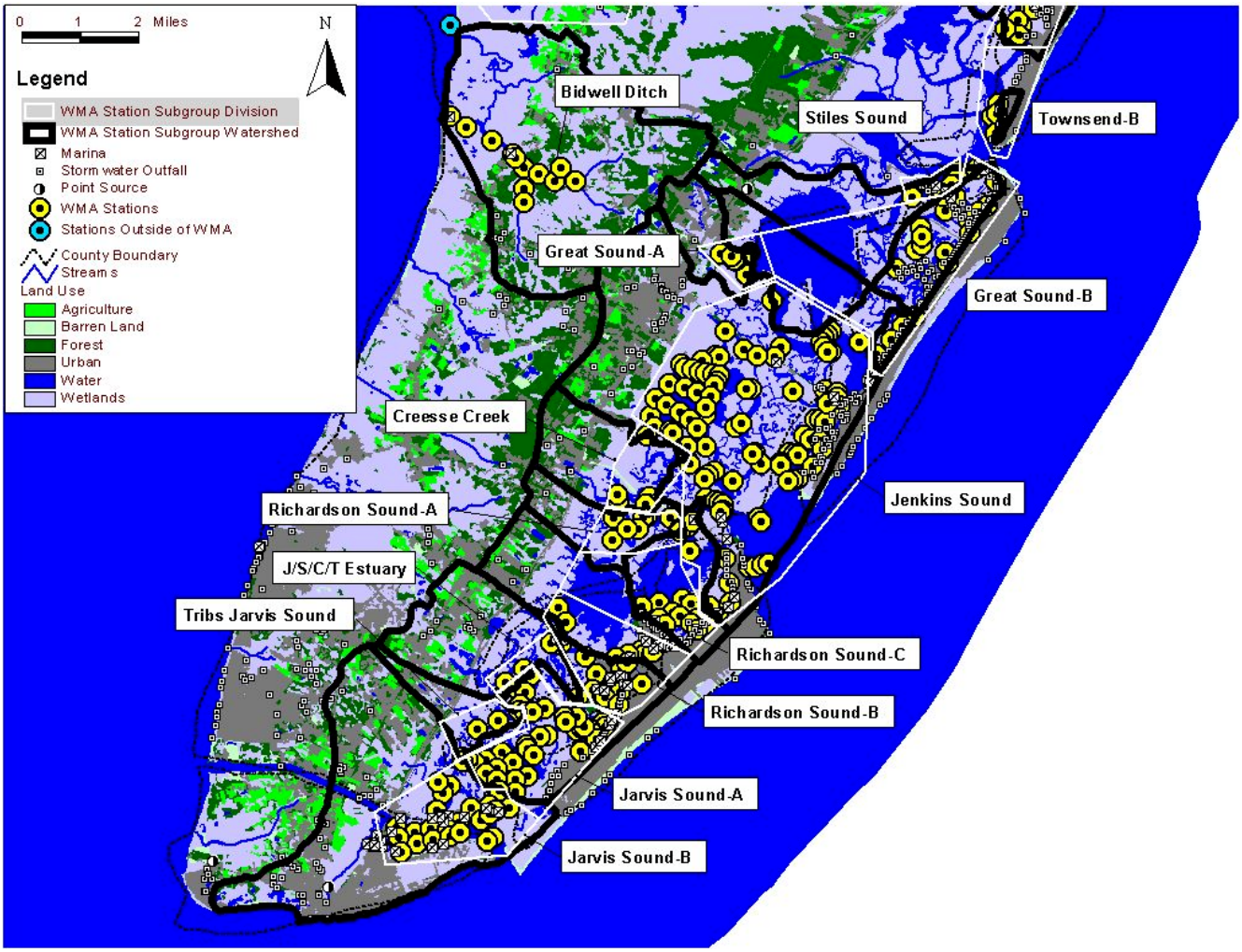

Figure 3. Primary bacteria source data used in TMDL development for southeastern portions of WMA 16

4.0 WATER QUALITY ANALYSIS

Relating pathogen sources to concentrations of bacterial indicators in the impaired waters 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 bacteria loads and concentrations can vary many orders of magnitude over short distances and over time at a single location, dynamic water quality models can be very difficult to calibrate. Options available to control nonpoint sources of bacteria typically include measures such as sewage infrastructure improvements, goose management strategies, pet waste ordinances, agricultural conservation management plans, and septic system replacement and maintenance. The effectiveness of these control measures is not easily measured relative to observed ambient concentrations. Given these considerations, detailed water quality modeling was not selected for determining the load reductions needed to attain standards and support the designated shellfish use.

Shellfish monitoring data collected by the Department, in accordance with NSSP guidelines, were used as the basis for TMDL development for the listed shellfish waters. Total coliform data were used to assess the shellfish designated use for the listed waterbodies in WMA 16 according to the New Jersey 2004 *Integrated Water Quality Monitoring and Assessment Report;* therefore, total coliform data were used in TMDL development. As described in Section 3.0, each waterbody was divided into smaller sub-groups (as necessary) in order to better represent local water quality conditions, watershed characteristics, and local pollution sources and, thereby inform implementation efforts. The data collected for each waterbody sub-group (or the entire waterbody if not sub-divided) were compared to the NSSP criteria for total coliform. In order to account for the spatial distribution in pathogen sources, critical conditions, and other TMDL considerations, the "worst case" station within each waterbody (or sub-group) was identified and used in TMDL development. Monitoring data collected at stations located within marina buffer areas were not included in the analysis because these areas will remain restricted for shellfish harvest as a precautionary measure. Seasonal trends and other factors were evaluated to determine the critical condition period for TMDL development, as described in the next section. Critical condition analyses indicated that bacteria concentrations were typically higher during summer months, therefore, summer data (collected during May-September) were exclusively used in the analysis.

"Worst case" stations were identified based on the calculated 90th percentile (arithmetic), median, data period (emphasis on recent data), and sample size (priority given to stations with sample sizes >20). The "worst case" station identified for each waterbody (or sub-group) is shown in Table 6, along with summary data statistics. The data collected at each "worst case" station was then used to develop TMDLs for each respective waterbody (or sub-group), based on total coliform or fecal coliform, depending on the basis for the impairment determination. The percent reduction required was based on the difference between the calculated 90th percentile (using the FDA method specified in NSSP guidelines) and the NSSP 90th percentile criteria or the calculated geometric mean and the NSSP geometric mean criteria, whichever was greater. Source loads were then reduced for each waterbody (or sub-group) to meet the overall percent reduction required.

As a result of this analysis, several waterbodies (or sub-groups) were found to meet the NSSP criteria. These waterbodies reflect application of the shoreline survey information in making water classifications. Critical to the shoreline survey is the identification of <u>potential</u> pollution sources that may intermittently impact water quality and not be detected by water samples collected 5-12 times a year. According to the NSSP *Guide for the Control of Molluscan Shellfish*, if in the judgment of the state authority, pollution sources present an actual <u>or</u> potential public health hazard, those waters cannot be classified as "Approved". Shellfish harvest restrictions that are imposed because of the shoreline surveys will remain restricted, regardless of water quality. Therefore, development of a TMDL for these areas is not generally appropriate. These areas will be reassigned on the 2006 Integrated List. In areas subject to administrative closure where water quality conforms to criteria, the areas will be placed on Sublist 1; where there is insufficient data to determine conformance with the criteria, the areas will be placed on Sublist 3; where the water quality does not conform to the

criteria, but the areas would not be open even if water quality improved, the areas will be placed on Sublist 4.

Table 6. Worst case stations in WMA 16

Waterbody	Subgroup	Worst Case Station	Parameter	Count*	Start Date	End Date	90th Percentile* (arithmetic)	Geometric Mean*	Median*
Bidwell Ditch-Tidal	-	3890E	Total Coliform	2	10/16/84	5/27/87	418	141	252
Big Elder Creek Estuary	-	3136	Total Coliform	71	10/7/87	9/1/04	240	10	4
Coastal Tributaries to Jarvis Sound	-	3604B	Total Coliform	62	5/29/84	9/15/98	460	58	43
Corson Sound	A	3008B	Total Coliform	83	5/20/85	12/16/04	416	17	9
Corson Sound	B	3134A	Total Coliform	89	5/20/85	10/8/03	240	16	9
Corson Sound	C	3124	Total Coliform	67	1/3/84	6/24/04	93	8	4
Creesse Creek Estuary	-	3410	Total Coliform	31	10/27/88	8/12/04	150	18	9
Great Sound	A	3307C	Total Coliform	59	1/31/84	6/17/04	1360	84	75
Great Sound	B	3303B	Total Coliform	95	5/30/84	3/18/04	73	9	4
Jarvis Sound	A	3603A	Total Coliform	94	6/6/84	9/15/03	1100	60	59
Jarvis Sound	B	3612C	Total Coliform	95	5/29/84	4/23/04	1100	69	75
Jenkins Sound	-	3309D	Total Coliform	87	5/30/84	11/15/04	460	35	43
Jones/Stites/Carino/Taylor Creek Estuary	J/S/C/T Estuary	3603	Total Coliform	94	6/6/84	9/15/03	460	56	84
Richardson Sound	A	3500F	Total Coliform	54	5/31/88	4/26/04	196	20	23
Richardson Sound	B	3504F	Total Coliform	58	5/31/88	4/26/04	110	12	9
Richardson Sound	C	3511	Total Coliform	55	5/31/88	9/2/04	93	12	9
Stiles Sound	-	3301	Total Coliform	90	5/31/84	7/21/04	39	6	4
Townsend Sound	A	3138	Total Coliform	64	5/22/89	4/13/04	240	22	18
Townsend Sound	B	3211A	Total Coliform	90	5/31/84	10/28/04	43	8	4

* - Concentration expressed in cfu/100 ml
Green highlighted, worst case stations meet SWQS.

4.1 Seasonal Variation/Critical Conditions

The technical approach used to develop these TMDLs includes conservative assumptions that take into account seasonal variability and critical conditions. Tidal waterbodies are difficult to assess given the dynamic flow regime, flushing characteristics, spatial and temporal variability in pathogen sources and contributions, watershed characteristics, and other factors. Seasonal trends were evaluated to determine the critical condition period for TMDL development. The results of this analysis indicated that bacteria concentrations were typically higher during summer months. The influx of summer vacationers and the resulting increase in septic and potential leaking sewer volumes, increased marina and boat use, and other factors contribute to this seasonal trend. Rainfall and flow impacts were also evaluated, but correlation results did not show a clear relationship between bacteria concentrations and these factors. As a result, TMDLs were developed based on summer data collected at the "worst case" station identified for each waterbody (or sub-group). Figure 5 shows the seasonal trend in shellfish monitoring data for "worst case" stations located in WMA 16.

This conservative approach takes into account seasonal variation and critical conditions because only the data collected during summer months were used to identify "worst case" stations and for determining the TMDL percent reduction required and load allocations. These assumptions are consistent with previous freshwater TMDLs developed in New Jersey and recent shellfish TMDLs developed in New York.

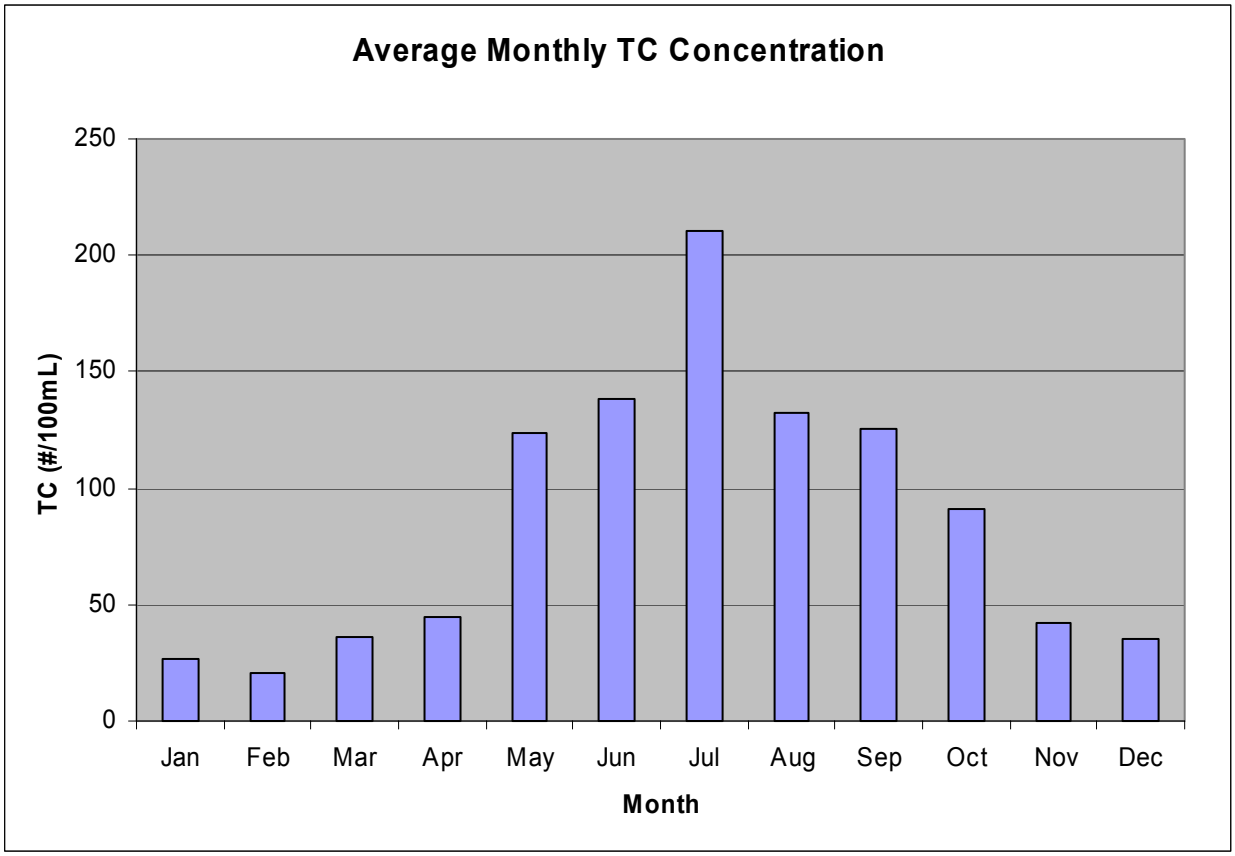

Figure 4. Seasonal trend in TC data for all worst case stations in WMA 16

4.2 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, both an implicit and explicit Margin of Safety (MOS) was incorporated. An implicit MOS was incorporated by using conservative assumptions, including the use of "worst case" stations to determine the percent reduction required, using data collected during the summer critical condition period to develop TMDLs, treating total coliform as a conservative substance (source loads were estimated without including die-off rates, soil incorporation, etc.), using conservative methods to estimate land-based loads, and other factors. In addition, a 5% explicit MOS was calculated for each TMDL-eligible waterbody.

5.0 TMDL CALCULATIONS

TMDLs were developed based on the percent reduction calculated by comparing the data collected at each "worst case" station to the NSSP criteria for total coliform. The overall percent reduction (including a minimum explicit 5% MOS) was calculated and load reductions for point and nonpoint sources were estimated. The percent reduction specified for each waterbody (or sub-group) was applied equally to pathogen sources in each watershed for which source reductions measures can reasonably be applied. The loads contributed by forest lands and barren lands were not reduced in the TMDL allocation because these loads represent natural background levels (e.g. wildlife contributions) and/or sources that cannot be reasonably reduced. As a result, existing loads from these sources are equal to the future loads. Therefore, the load reduction from land uses and marinas for which reduction measures can reasonably be applied must be increased proportionally, as presented in Table 9.

The TMDL was allocated among point and nonpoint sources. Wastewater treatment plants typically have a negligible discharge due to required disinfection practices designed to reduce and/or eliminate the bacteria concentration in wastewater. These point source loads were, therefore, considered de minimus discharges and were assigned a WLA of zero. Stormwater from Tier A municipalities, as represented by urban land uses, was assigned a WLA. Nonpoint sources, as represented by non-urban land uses and marinas, were assigned LAs.

5.1 Wasteload Allocations and Load Allocations

WLAs were established for point source discharges within each watershed and for NJPDES-regulated municipal stormwater discharges subject to regulation under the CWA. LAs were established for all stormwater sources that are not subject to regulation under the CWA, and for all other nonpoint sources. Stormwater point sources that received a WLA were distinguished from stormwater sources receiving a LA on the basis of land use type and municipal tier designation (Tier A/Tier B).

This distribution of loading capacity between WLAs and LAs is consistent with recent EPA guidance that clarifies existing regulatory requirements for establishing WLAs for stormwater discharges (Wayland, November 2002). Stormwater discharges are captured within the runoff sources quantified according to land use, as described previously. Distinguishing between regulated and unregulated stormwater is necessary in order to express WLAs and LAs numerically; however, "EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability within the system" (Wayland, November 2002, p.1). Therefore, allocations are established according to source categories as shown in Table 7. This demarcation between WLAs and LAs based on land use source categories is not perfect, but it represents the best estimate defined as narrowly as data allow. The Department acknowledges that there may be stormwater sources in the residential, commercial, industrial and mixed urban runoff source categories that are not NJPDES-regulated. Nothing in these TMDLs shall be construed to require the Department to regulate a stormwater source under NJPDES that would not already be regulated as such, nor shall anything in these TMDLs be construed to prevent the NJDEP from regulating a stormwater source under NJPDES.

Table 7. Assignment of WLAs and LAs for stormwater point sources and nonpoint sources

Land Use Source Category	Municipal Tier	TMDL Allocation Type
High density residential	A	WLA
Medium density residential (incl. mixed residential, mixed urban, other urban, military reservations, and no longer military)	A	WLA
Low density residential (incl. rural residential, recreational land, and athletic fields)	A	WLA
Commercial	A	WLA
Industrial	A	WLA
Roadways	A	WLA
High density residential	B	LA
Medium density residential (incl. mixed residential, mixed urban, other urban, military reservations, and no longer military)	B	LA
Low density residential (incl. rural residential, recreational land, and athletic fields)	B	LA
Commercial	B	LA
Industrial	B	LA
Roadways	B	LA
Agricultural	N/A	LA
Forest	N/A	LA
Barren land	N/A	LA

Note: Wetland areas were not included in load estimates based on model assumptions.

A summary of the WLAs, LAs and MOS is provided for each subject waterbody (or sub-group) in Table 8 and source loads and allocations are presented in Table 9. The loads contributed by forest lands and barren lands were not reduced in the TMDL allocation table, as described above. The load reduction for controllable sources (i.e. urban lands, agricultural lands, and marinas) was increased proportionally to meet the overall percent reduction required for each waterbody (or subgroup).

Table 8. TMDL calculations for shellfishing impaired waters in WMA 16

Waterbody	Subgroup	WLA		LA		MOS		TMDL	Overall Percent Reduction
		Load (cfu/yr)	Percent of TMDL	Load (cfu/yr)	Percent of TMDL	Load (cfu/yr)	Percent of TMDL		
Bidwell Ditch-Tidal	-	5.25E+13	40%	7.27E+13	55%	6.59E+12	5%	1.32E+14	74%
Coastal Tributaries to Jarvis Sound	-	3.80E+13	87%	3.91E+12	9%	2.17E+12	5%	4.35E+13	46%
Great Sound	A	6.25E+13	86%	6.23E+12	9%	3.62E+12	5%	7.23E+13	68%
Jarvis Sound	A	5.89E+14	60%	3.48E+14	35%	4.93E+13	5%	9.87E+14	45%
Jarvis Sound	B	7.28E+14	52%	5.94E+14	43%	6.96E+13	5%	1.39E+15	71%
Jenkins Sound	A	1.32E+15	72%	4.22E+14	23%	9.16E+13	5%	1.83E+15	28%
Jones/Stites/Carino/ Taylor Creek Estuary	-	2.42E+14	86%	2.49E+13	9%	1.41E+13	5%	2.81E+14	36%

Table 9. WMA 16 land-based load allocations

Waterbody	Subgroup	Overall % Reduction	Agriculture (LA)			Barren Land (LA)			Forest (LA)			Urban Total (WLA)			Marinas (LA)			MOS	TMDL
			Existing Load (cfu/yr)	Percent Reduction	Allocated Load (cfu/yr)	Existing Load (cfu/yr)	Percent Reduction	Allocated Load (cfu/yr)	Existing Load (cfu/yr)	Percent Reduction	Allocated Load (cfu/yr)	Existing Load (cfu/yr)	Percent Reduction	Allocated Load (cfu/yr)	Existing Load (cfu/yr)	Percent Reduction	Allocated Load (cfu/yr)		
Bidwell Ditch-Tidal	-	74%	3.09E+13	83%	5.23E+12	2.23E+12	0%	2.23E+12	5.08E+13	0%	5.08E+13	3.11E+14	83%	5.25E+13	8.56E+13	83%	1.45E+13	6.59E+12	1.32E+14
Coastal Tributaries to Jarvis Sound	-	46%	2.85E+12	47%	1.50E+12	2.78E+10	0%	2.78E+10	1.77E+12	0%	1.77E+12	7.20E+13	47%	3.80E+13	0.00E+00	N/A	0.00E+00	2.17E+12	4.35E+13
Great Sound	A	68%	1.68E+10	70%	5.01E+09	6.21E+11	0%	6.21E+11	5.61E+12	0%	5.61E+12	2.09E+14	70%	6.25E+13	0.00E+00	N/A	0.00E+00	3.62E+12	7.23E+13
Jarvis Sound	A	45%	3.18E+13	45%	1.74E+13	6.64E+10	0%	6.64E+10	1.01E+13	0%	1.01E+13	1.07E+15	45%	5.89E+14	5.85E+14	45%	3.21E+14	4.93E+13	9.87E+14
Jarvis Sound	B	71%	6.82E+13	72%	1.94E+13	4.71E+12	0%	4.71E+12	2.72E+13	0%	2.72E+13	2.56E+15	72%	7.28E+14	1.91E+15	72%	5.43E+14	6.96E+13	1.39E+15
Jenkins Sound	A	28%	2.45E+13	29%	1.75E+13	4.83E+12	0%	4.83E+12	3.86E+13	0%	3.86E+13	1.85E+15	29%	1.32E+15	5.06E+14	29%	3.61E+14	9.16E+13	1.83E+15
Jones/Stites/ Carino/Taylor Creek Estuary	-	36%	2.89E+13	36%	1.85E+13	9.34E+09	0%	9.34E+09	6.45E+12	0%	6.45E+12	3.79E+14	36%	2.42E+14	0.00E+00	N/A	0.00E+00	1.41E+13	2.81E+14

5.2 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 for the subject waters. Wastewater treatment facilities will continue to be required to achieve disinfection. Nonpoint source reduction strategies applied to land uses will be equally effective with respect to existing and future use of the land.

6.0 FOLLOW - UP MONITORING

The Department maintains a large network of monitoring stations throughout the state's coastal region. The Department's Bureau of Marine Water Monitoring collects water quality data to determine compliance with the National Shellfish Sanitation Program, for the evaluation of the ecological health of coastal waters, and to monitor, identify and track pollution sources impacting the State's coastal waters. Shellfish monitoring data collected the Bureau and information on pollution sources within each watershed and waterbody were used to identify the shellfish-impaired waters that are the subject of these TMDLs. Pathogen indicator data will continue to be collected by the Bureau on a routine basis to assess changes in water quality over time and to determine compliance with the NSSP criteria for shellfish growing areas.

7.0 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, citing criteria, operating methods, or other alternatives" (USEPA, 1993).

Development of effective management measures depends on accurate source assessment. Coliform bacteria are contributed to the environment from a number of categories of sources including human, domestic or captive animals, agricultural practices, and wildlife. Coliform bacteria 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 coliform bacteria. 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 waterbodies through "municipal separate storm sewer systems" (MS4s) are regulated under the Department's Municipal Stormwater Regulation Program. Under these rules and associated general permits, many municipalities (and various county, State, and other agencies) 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 MS4s, 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. These measures are to be phased in over a timeframe specified in the Department's Municipal Stormwater permitting program. The Department will use its Water Quality Management Planning program to expedite implementation of these measures where amendments to areawide Water Quality Management Plans are proposed. The Department has provided State funds as well as a portion of its Clean Water Act 319(h) pass through grant funds to assist municipalities in meeting these requirements.

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 affected 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; 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 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.

Geese are migratory birds that are protected by the Migratory Bird Treaty Act of 1918 and other Federal and State Laws. Resident Canada geese do not migrate, but are nevertheless protected by this and other legislation. The United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS)-Wildlife Services program reports that the 1999 estimated population of non-migratory geese in New Jersey was 83,000. Geese may produce up to 1½ pounds of fecal matter a day and when the congregate in large numbers they can represent a locally significant source of coliform bacteria. This may warrant taking steps to reduce populations in these areas.

Because geese are free to move about and commonly graze and rest on large grassy areas associated with schools, parks, golf courses, corporate lawns and cemeteries, measures to reduce populations, where necessary, are best developed and conducted at the community level through a community-based goose damage management program. USDA's Wildlife Services program recommends that a community prepare a written Canada Goose Damage Management Plan that may include the following actions:

- Initiate a fact-finding and communication plan
- Enact and enforce a "no feeding" ordinance
- Conduct goose damage control activities such as habitat modification
- Review and update land use policies
- Reduce or eliminate goose reproduction (permit required)

- Hunt geese to reinforce nonlethal actions (permit required)

Procedures such as handling nests and eggs, capturing and relocating birds, and the hunting of birds require a depredation permit from either the USDA APHIS Wildlife Services or U.S. Fish and Wildlife Services. Procedures requiring permits should be a last resort after a community has exhausted the other listed measures. The Department's draft guide *Management of Canada Geese in Suburban Areas, March 2001,* which may be found at www.state.nj.us/dep/watershedmgt under publications, provides extensive guidance on how to modify habitat to serve as a deterrent to geese as well as other prevention techniques such as education through signage and ordinances.

In coastal areas, other waterfowl are naturally present in significant numbers and vary seasonally with migratory patterns. Other wildlife contributions may include deer populations, which have been identified as a potential fecal coliform source in the impaired watersheds. The forested and low-density residential areas that provide deer habitat can be found in close proximity to the impaired stream segments. Deer have been evaluated in fecal coliform TMDLs by other States (e.g. Alabama and South Carolina) and could be a fecal coliform source in New Jersey. Management measures to reduce coliform bacteria contributed by wildlife are not generally practicable.

Agricultural activities are another example of potential sources of coliform bacteria. 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 coliform bacteria. 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 Conservation Reserve Enhancement Program** The New Jersey Departments of Environmental Protection and Agriculture, in partnership with the Farm Service Agency and Natural Resources Conservation Service, have established a $100 million dollar CREP agreement. The program matches $23 million of State money with $77 million from the Comodity Credit Corporation within USDA. Through CREP, financial incentives are offered for agricultural landowners to voluntarily implement conservation practices on agricultural lands. NJ CREP will be part of the USDA's Conservation Reserve Program (CRP). There will be a ten-year enrollment period, with CREP leases ranging between 10-15 years. The State intends to augment this program thereby making these leases permanent easements. 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.

Uses of the marine environment as a recreational area and receiving water have the potential to contribute pathogen loads. As part of the Governor's Coast 2005 initiative, the Department has taken many steps toward stronger protection for water quality and habitat, including:

- The Department has worked to strengthen standards for ocean dischargers to avoid impacts to water quality. The Department requires implementation of measures that will prevent catastrophic sewage spills though the maintenance and upgrading of aging infrastructure.
- The Department targets $30 million in grants to accelerate projects that improve coastal water quality.
- The Department partners with other state agencies, non-profit groups, trade organizations, and marina owners to activate the "New Jersey Clean Marina" program.
- New Jersey will work with anglers, environmentalists, and the New Jersey congressional delegation to establish a "Clean Ocean Zone" to protect water quality in the NY/NJ Bight by eliminating and preventing pollution.

In March 2005, the New Jersey Clean Marina Program was established. It is a voluntary education program that provides information, guidance, and technical assistance to marina operators, local government, and recreational boaters regarding the most effective practices to protect water quality and coastal resources. Marina and boat operational and maintenance activities can contribute to nonpoint source pollution by discharging substances such as oil, grease, paint and cleaning chemicals, and fish waste. This Program gives marina managers the information they need to reduce these incidental effects of their activities. Facilities that meet the requirements of the Program are recognized as "Clean Marinas." By adopting pollution prevention measures, marina owners and managers can engage in environmentally responsible operations and management of their facility. The New Jersey Clean Marina Program is a partnership among state and federal government agencies, trade associations,

marine businesses and other interested parties. The Department website (www.njcleanmarina.org) contains more information and a complete list of participating agencies and organizations.

Another program designed for coastal water quality improvement is New Jersey's Clean Vessel Act (CVA) Committee. Passed by the Congress in 1992, the CVA helps reduce pollution from vessel sewage discharges. Federal grants are available to states on a competitive basis for the construction and/or renovation, operation and maintenance of pumpout and portable toilet dump stations. Currently, states submit grant proposals, by May 1st of each year, to one of seven Fish and Wildlife Service regional offices for review. The service's Division of Federal Aid then convenes a panel including representatives from the Service's Washington Office of the Division of Federal Aid, the National Oceanic and Atmospheric Administration (NOAA), the USEPA, and the U.S. Coast Guard. The panel reviews, ranks and makes funding recommendations to the Director of the Fish and Wildlife Service. The Director gives priority consideration to grant proposals which provide installation and/or operation of pumpout and dump stations under federally approved state plans.

All recreational vessels must have access to pumpouts funded under the Clean Vessel Act. NOAA will mark pumpout and dump station locations on its nautical charts. Halfway through the program, grants have been awarded to install 1,200 pumpout stations and 630 dump stations. A maximum fee of $5.00 may be charged for the use of pumpout facilities constructed or maintained with grant funds.

As part of this program, four CVA funded pumpout boats are in service in New Jersey. They are operated by the Borough of Seaside Park, by Monmouth County, and by Ocean County. Pumpout boats can pull up along side a recreational boat and pump out its sewage holding device with a suction hose. Once a pumpout boat is full of waste, it discharges the waste into a sewage treatment facility for proper disposal.

Management strategies are summarized below in Table 10.

Table 10. Implementation management strategies

Source Category	Responses	Potential Responsible Entity	Funding options
Human Sources			
Inadequate (per design, operation, maintenance, location, density) on-site disposal systems	Sanitary surveys, septic management programs/ordinances	Municipality	CWA 604(b) for confirmation of inadequate condition; Environmental Infrastructure Financing Program for construction of selected option

Source Category	Responses	Potential Responsible Entity	Funding options
Inadequate or improperly maintained stormwater facilities; illicit connections	Measures required under Municipal Stormwater permitting program including any additional measures determined in the future to be needed through TMDL process	Municipality, State and County regulated entities, stormwater utilities	CWA 319(h); Environmental Infrastructure Financing Program for construction of selected option
Malfunctioning sewage conveyance facilities	Identify through source trackdown and repair	Owner of malfunctioning facility--compliance issue	User fees
Marinas	Clean Marina Program; No Discharge Zones; Marina BMPs including: Marine pump-out facilities; Marina flushing design; Fish waste management including fish-cleaning restrictions, public education, and fish waste disposal; Proper sewage handling including: installing a sanitary pump-out system, providing on-shore restrooms, provide accommodations for emptying potable Marine Sanitation Devices (MSDs), safeguarding and maintaining septic systems, providing live aboard facilities, offering MSD inspections, encouraging compliance, and educating boaters.	Marina property owner; Municipalities for ordinance adoption and compliance	State sources and CWA319(h) assistance for BMPs
Domestic/captive animal sources			
Pets	Pet waste ordinances	Municipalities for ordinance adoption and compliance	State source and CWA 319(h) assistance to municipalities to implement municipal stormwater regulations
Horses, livestock, zoos	Confirm through source trackdown: SCD/NRCS develop conservation management plans	Property owner	EQIP, CRP, CREP

Source Category	Responses	Potential Responsible Entity	Funding options
Agricultural practices	Confirm through source trackdown; SCD/NRCS develop conservation management plans, exercise CAFO/AFO authority if applicable	Property owner	EQIP, CRP, CREP
Wildlife			
Locally excessive populations of resident Canada geese or other waterfowl	Feeding ordinances; Goose Management BMPs	Municipality for ordinance; local community groups for BMPs	State source; CWA 319(h)
Indigenous wildlife	Confirm through trackdown; riparian buffer restoration; consider revising designated uses	State	State source

7.1 Source Trackdown

Sewage Infrastructure Improvement Act (SIIA)

N.J.A.C. 7:22A was originally adopted by the Department on December 29, 1989 (see 22 N.J.R. 368(a)) to implement the Sewage Infrastructure Improvement Act (SIIA), N.J.S.A. 58:25-23 et seq. The SIIA has two main components: (1) to address discharges from combined sanitary and stormwater sewer systems (CSO) throughout the State (planning and design grants for CSOs) and (2) to map and investigate stormwater sewer systems in Atlantic, Cape May, Monmouth and Ocean counties (stormwater mapping grants). The SIIA, which became effective on August 3, 1988, was designed to address nonpoint and point sources of pollution from stormwater sewer systems and combined sewer overflow points. The New Jersey Legislature has declared that these sources of pollution contribute greatly to the biological and chemical degradation of coastal and surface waters of the state. The SIIA recognized that nonpoint sources of pollution create public health dangers and mandate beach and shellfish bed closings by contributing high levels of bacteria to surface waters through stormwater sewer systems. The SIIA also recognized that overflows of raw sewage from combined sewer systems are another major source of water pollution and established various requirements for municipalities and public entities to address these pollution problems.

The SIIA required all municipalities with stormwater sewer systems discharging into the salt waters of Monmouth, Ocean, Atlantic or Cape May counties to prepare and submit a map of their sanitary and stormwater sewer systems and to conduct periodic stormwater monitoring of outfalls discharging to saltwater. Grant funding was provided for mapping, sampling and identification of cross connections and interconnections between the stormwater and sanitary sewers. This work is essentially complete and will inform implementation efforts.

While there are no CSOs in the waterbodies addressed in this TMDL report, it should be noted that significant source reduction strategies have been and continue to be put in place to address this source of pathogens in other waterbodies, such as the New York/New Jersey Harbor, which will be addressed in future TMDL efforts.

Pathogen Indicators and Microbial 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 in bathers than fecal coliform (USEPA, 2001). Similar epidemiological studies for shellfish consumption have not been performed for *E. coli* or enterococci. 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 10-23 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.

MST methods have already been successfully employed at the Department in the past decade. Since 1988, the Department 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, the Department has established a MST methodology that utilizes both genotype (genotyping of F+RNA coliphages) and phenotype (MAR testing) tests. The results of these tests are collectively evaluated to best determine sources of fecal contamination. The Bureau's methodology includes evaluation of long-term microbial results as well as data (GIS Land use coverage, aerial photographs, visual assessments) of actual and potential sources, stormwater monitoring to delineate location of major sources and the use of MAR and F+ coliphage in conjunction with conventional microbial indicators. This methodology has been successfully applied in several areas including; Seaside Park, Long Swamp, Atlantic City, and Parvin State Park. This methodology may be utilized for select TMDL waterbodies.

7.2 Segment Specific Strategies

In addition to generic strategies described previously, a number of projects have been undertaken which are expected to aid in achieving the load reductions assigned to the impaired waterbodies. Ongoing activities to develop and implement watershed restoration plans are expected to result in additional specific projects to reduce pollutant loads.

Table 11. WMA 16 Outreach and Restoration Projects

WMA	FY	Funding Source	Recipient	Project Title	Grant Amount
16	1996	319	Rutgers Cooperative Ext	Home-A-Syst Education Program	$30,000.00
16	2001	319	ANJAC	To perform a reforestation project in the headwaters of East Creek in Dennis Twp and perform monitoring.	$57,480.00
16	2002	319	Cape May County	Cox Hall Creek feasibility study and restoration plan	$100,000.00
State	1998	319	Rutgers Department of Environmental Services	BMPs for the use of Non-traditional Organic Wastes in Agriculture	$79,000.00

8.0 REASONABLE ASSURANCE

With the implementation of follow-up monitoring, source identification and source reduction as described in general and for each segment, the Department has reasonable assurance that a significant increase in the shellfish designated use will be attained. The results of trackdown and follow up ambient monitoring will be evaluated to determine effectiveness of the identified measures and if additional measures are needed.

9.0 PUBLIC PARTICIPATION

The Water Quality Management Planning rules at N.J.A.C. 7:15-7.2 require the Department to initiate a public process prior to the development of each TMDL to provide an opportunity for 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).

For the set of TMDLs developed to address shellfish impairment in coastal waters, the Department conducted three outreach sessions: November 17, 2005 for WMAs 12 and 13 with the Barnegat Bay Advisory Committee at Ocean County College; December 15, 2005 for WMAs 14, 15, and 16 at the Galloway Township Library in Galloway, New Jersey; and January 3, 2006 for WMAs 16 and 17 at the Commercial Township Municipal Building in Port Norris. During the sessions, the Department presented the TMDL process, the locations of impaired shellfish waterbodies, and potential methods to achieve bacteria source reductions. GIS maps aided in soliciting information regarding potential sources within each watershed.

10.0 AMENDMENT PROCESS

Notice proposing these TMDLs was published February 21, 2006 in the New Jersey Register and in newspapers of general circulation in order to provide the public an opportunity to review the TMDL document and submit formal comments. In addition, a public hearing will be held on March 23, 2006 at the Ocean County Community College – Toms River Campus in the Technology Building Lecture Hall. There will be an informal presentation from 7:00 p.m. to 7:30 p.m., which will be followed by the public hearing from 7:30 p.m. to 9:00 p.m., or until the end of testimony, whichever is earlier. The public comment period will remain open for 15 days following the public hearing. Notice of the proposal and hearing was provided to affected municipalities in the watershed.

All comments received during the public notice period and at the public hearing will become part of the record for this TMDL and will be considered in the Department's decision to establish this TMDL through submittal to EPA Region 2. Once approved by EPA, this TMDL will be adopted as an amendment to the Cape May County and Lower Delaware Water Quality Management Plans in accordance with New Jersey's Water Quality Management Planning Rules at N.J.A.C. 7:15-3.4 (g).

APPENDIX A: REFERENCES

Bacteria Load Estimation methods used to estimate land-based bacteria load contributions: (1) Toms River studies – USGS (May 2005); (2) Loading Coefficient Analysis and Selection Tool (LCAST). Developed by NJDEP and Tetra Tech, December 2001.; (3) Watershed Treatment Model (WTM). Developed by the Center for Watershed Protection in July 2001; (4) Simple Method for calculating bacteria loads (Schueler, T. 1987).

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"NJDEP Streams of New Jersey (1:24000)", published 11/01/1998 by NJDEP, Office of Information Resources Management (OIRM), Bureau of Geographic Information and Analysis (BGIA). Online at: http://www.state.nj.us/dep/gis/strmshp.html

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APPENDIX B: NJPDES WASTEWATER TREATMENT FACILITIES

WMA 16 Wastewater Treatment Facilities

Waterbody	Subgroup	NJPDES ID	Facility Name	Pipe	Design Flow** (MGD)	FC Limit	Permit Category*	Receiving Waters
Corson Sound	A	NJ0035343	Cape May County MUA - Ocean City	001A	8.24	200 MoGeoAvg	A	Atlantic Ocean
		NJ0035343	Cape May County MUA - Ocean City	002A	8.24	200 MoGeoAvg	B	Crook Horn Creek to Peck Bay
Jarvis Sound	A	NJ0053007	Wildwood/Lower Region WTF	001B	14	200 MoGeoAvg	A	Atlantic Ocean via pipe
		NJ0053007	Wildwood/Lower Region WTF	003A	14	200 MoGeoAvg	A	Atlantic Ocean via pipe
	B	NJ0053007	Wildwood/Lower Region WTF	001B	14	200 MoGeoAvg	A	Atlantic Ocean via pipe
		NJ0053007	Wildwood/Lower Region WTF	003A	14	200 MoGeoAvg	A	Atlantic Ocean via pipe
Jones/Stites/ Carino/Taylor Creek Estuary	-	NJ0053007	Wildwood/Lower Region WTF	001B	14	200 MoGeoAvg	A	Atlantic Ocean via pipe
Richardson Sound	B	NJ0053007	Wildwood/Lower Region WTF	003A	14	200 MoGeoAvg	A	Atlantic Ocean via pipe
Stiles Sound	-	NJ0052990	Cape May Co MUA - Seven Mile Beach	001A	7.67	200 MoGeoAvg	A	Atlantic Ocean

*Permit Categories: A = Sanitary Surface Water Discharge; A8 = Discharge to Reg. Outfall Auth.; B = Industrial/Commercial Surface Water; RF = Stormwater; 05 = Stormwater Runoff

** Design Flow reflects the design capacity of the entire treatment facility, and does not indicate individual pipe/outfall capacity.

APPENDIX C: MUNICIPALITIES

WMA 16 Tier A Municipalities

Tier	Waterbody	Subgroup	Municipality	NJPDES Number
A	Bidwell Ditch-Tidal	-	MIDDLE TWP	NJG0149250
	Big Elder Creek Estuary	-	DENNIS TWP	NJG0150291
	Corson Sound	A	OCEAN CITY	NJG0151289
			UPPER TWP	NJG0153702
		B	DENNIS TWP	NJG0150291
			SEA ISLE CITY	NJG0150037
		C	DENNIS TWP	NJG0150291
			SEA ISLE CITY	NJG0150037
			UPPER TWP	NJG0153702
	Creesse Creek Estuary	-	MIDDLE TWP	NJG0149250
	Great Sound	A	MIDDLE TWP	NJG0149250
		B	AVALON BORO	NJG0152935
			MIDDLE TWP	NJG0149250
	Jarvis Sound	A	LOWER TWP	NJG0151092
			MIDDLE TWP	NJG0149250
			WILDWOOD CITY	NJG0150924
			WILDWOOD CREST BORO	NJG0150151
		B	CAPE MAY CITY	NJG0150185
			CAPE MAY POINT BORO	NJG0150401
			LOWER TWP	NJG0151092
			MIDDLE TWP	NJG0149250
			WEST CAPE MAY BORO	NJG0151866
			WILDWOOD CITY	NJG0150924
			WILDWOOD CREST BORO	NJG0150151
	Jenkins Sound	-	AVALON BORO	NJG0152935
			MIDDLE TWP	NJG0149250
			NORTH WILDWOOD CITY	NJG0154831
			STONE HARBOR BORO	NJG0149918
			WEST WILDWOOD BORO	NJG0154580
	Jones/Stites/Carino/Taylor Creek Estuary	-	LOWER TWP	NJG0151092
			MIDDLE TWP	NJG0149250
	Richardson Sound	A	MIDDLE TWP	NJG0149250
		B	LOWER TWP	NJG0151092
			MIDDLE TWP	NJG0149250
			NORTH WILDWOOD CITY	NJG0154831
			WEST WILDWOOD BORO	NJG0154580
			WILDWOOD CITY	NJG0150924
			WILDWOOD CREST BORO	NJG0150151
		C	MIDDLE TWP	NJG0149250
			NORTH WILDWOOD CITY	NJG0154831
			WEST WILDWOOD BORO	NJG0154580
	Stiles Sound	-	AVALON BORO	NJG0152935
			MIDDLE TWP	NJG0149250
	Townsend Sound	A	DENNIS TWP	NJG0150291
			SEA ISLE CITY	NJG0150037
		B	SEA ISLE CITY	NJG0150037
	Coastal Tributaries to Jarvis Sound	-	LOWER TWP	NJG0151092

APPENDIX D: MARINA LOADING ESTIMATES

WMA 16 Marina Loading Estimates

Waterbody	Subgroup	Marina Name	Load (cfu)
Bidwell Ditch-Tidal	-	Bayway Marina	6.14365E+13
	-	SMOKEY'S MARINA	2.42023E+13
Corson Sound	A	ALL SEASONS MARINA	2.46677E+14
		BLUE WATER MARINA	0
		MENTZERS MARINE	0
	C	CORSON'S INLET	2.32714E+13
		DEAUVILLE INN DOCK	1.11703E+13
		FRANK'S BOAT YARD	1.86171E+13
		Jersey Cape Boat Sal	9.30856E+12
		WHALE CREEK MARINA	0
Great Sound	B	AVALON ANCHORAGE	0
		Avalon Public Marina	1.39628E+13
		COMMODORE BAY CLUB	0
		Commodore Bay Club M	1.02394E+14
		MORAN'S DOCKSIDE	0
		South Jersey Ship	1.39628E+13
		Stone Harbor Municip	1.27937E+14
Jarvis Sound	A	CAPTAIN SINNS MARINE	2.79257E+12
		CONDOMINIUMS WITH SL	4.35641E+12
		GREATER WILDWOOD YAC	3.38832E+12
		GREATER WILDWOOD YAC	3.87236E+12
		LAKE VIEW DOCKS	9.6809E+11
		Lighthouse Point Con	0
		Lighthouse Point Eas	0
		LIGHTHOUSE POINTE MA	1.53591E+14
		MOCEAN	1.11703E+13
		PIER 47	2.34948E+13
		ROYAL FLUSH FLEET	2.79257E+12
		Schooner Island Mari	2.76464E+14
		SEA RAIDER CHARTER B	6.51599E+12
		Shawcrest Marina	9.21547E+13
		STARCREST MARINA	3.10906E+12
		SUNSET LAKE MARINA	0
	B	BREEZEE LEE YACHT BA	6.21812E+13
		CANYON CLUB RESORT M	2.3923E+14
		CAPE HARBOR YACHT CL	2.32714E+13
		Cape May Marina	1.9548E+14
		CAPE MAY MARINE	1.3637E+14
		CAPTAIN SINNS MARINE	2.79257E+12
		CEDAR CREEK MARINA	3.63965E+13
		CONDOMINIUMS WITH SL	4.35641E+12
		CORINTHIAN YACHT CL.	1.67554E+13
		GREATER WILDWOOD YAC	3.38832E+12
		GREATER WILDWOOD YAC	3.87236E+12
		HARBOR VIEW MARINA	1.98272E+13
		HARBOR VILL. & YACHT	2.42023E+13

Waterbody	Subgroup	Marina Name	Load (cfu)
		HINCH MARINA	1.02394E+14
		LAKE VIEW DOCKS	9.6809E+11
		Lighthouse Point Con	0
		Lighthouse Point Eas	0
		LIGHTHOUSE POINTE MA	1.53591E+14
		MCDUELL'S	1.98272E+13
		MILL CREEK MARINA	9.30856E+13
		MISS CHRIS FISHINF C	1.02394E+13
		MOCEAN	1.11703E+13
		PIER 47	2.34948E+13
		ROSEMAN'S BOAT YARD	8.28462E+12
		ROYAL FLUSH FLEET	2.79257E+12
		Schooner Island Mari	2.76464E+14
		SEA RAIDER CHARTER B	6.51599E+12
		Shawcrest Marina	9.21547E+13
		SOUTH JERSEY MARINA	5.65774E+13
		STARCREST MARINA	3.10906E+12
		SUNSET LAKE MARINA	0
		TONY'S MARINE RAILWA	0
		TWO MILE LANDING (CO	4.65428E+12
		TWO MILE LANDING MA	2.23405E+13
		U.S. COAST GUARD TRA	7.44685E+12
		UTSCH'S MARINA	2.32714E+14
		YACHT LODGE MARINA	1.11703E+13
Jenkins Sound	-	54th & Bay Park Mari	2.79257E+13
		B&E 26th Street Mari	6.98142E+13
		BAYFRONT BOAT BASIN	1.11703E+14
		Camp Marine Services	2.79257E+13
		DAD'S PLACE MARINA	7.98674E+12
		Dino's Marina	4.28194E+12
		Dolphin Cove	5.08247E+12
		Ed's Canal Boat Rent	7.44685E+12
		GRASSY SOUND MARINA	2.06836E+13
		HEREFORD INLET MARIN	9.49473E+13
		REUTER'S MARINA	0
		Smugglers Cove Boat	0
		STONE HARBOR MARINA	0
		STONE HARBOR MUNICIP	1.27937E+14
Richardson Sound	B	B & E MARINA	0
		BRIDGEPORT MARINA	0
		CONDOMINIUMS WITH SL	4.35641E+12
		Gallo's Marina	7.26068E+12
		HAYES WATERWAY MARIN	1.29389E+13
		Lighthouse Point Con	0
		Lighthouse Point Eas	0
		LIGHTHOUSE POINTE MA	1.53591E+14
		MOCEAN	1.11703E+13
		PIER 47	2.34948E+13
		ROYAL FLUSH FLEET	2.79257E+12
		Schooner Island Mari	2.76464E+14
		SEA RAIDER CHARTER B	6.51599E+12

Waterbody	Subgroup	Marina Name	Load (cfu)
		Shawcrest Marina	9.21547E+13
		SPRAY DOCK MARINA	2.90427E+12
		STARCREST MARINA	3.10906E+12
		SUMMER PLACE MARINA	0
		WEST BAY MARINA	8.71281E+12
	C	B&E 26th Street Mari	6.98142E+13
		Dino's Marina	4.28194E+12
		GRASSY SOUND MARINA	2.06836E+13
Stiles Sound	-	AVALON ANCHORAGE	0
		Avalon Anchorage	1.39628E+13
		Avalon Point Marina	9.77399E+13
		Avalon Public Marina	1.39628E+13
		COMMODORE BAY CLUB	0
		Commodore Bay Club M	1.02394E+14
		MORAN'S DOCKSIDE	0
		South Jersey Ship	1.39628E+13
		Stone Harbor Municip	1.27937E+14
Townsend Sound	A	Capt. Bob's commerci	3.72342E+12
		Capt. Robbins Fishin	3.72342E+13
		Larsens Boat Rental	5.21279E+13
		LARSEN'S MARINA	0
		Minmar Marine Basin	6.88833E+13
		Party Boat Dockage	3.72342E+12
		Sea Isle City Marina	6.32982E+13
		Sea Isle City Yacht	1.67554E+13
	B	Yacht Club of Townse	7.44685E+13