Chapter 5

Environmental Impacts of CSOs and SSOs

This chapter describes the extent to which CSOs and SSOs cause or contribute to environmental impacts. The chapter first discusses EPA's framework for evaluating environmental impacts from CSOs and SSOs, using water quality standards. The chapter then summarizes environmental impacts from CSOs and SSOs as reported in national assessments and presents the results of new analyses completed by EPA. Next, site-specific examples are presented to illustrate the types of impacts that CSOs and SSOs have at the local watershed level. Lastly, the factors that affect the extent of environmental impacts caused by CSO and SSO discharges are described.

In conducting data collection and research for this report, EPA found that CSOs and SSOs cause or contribute to environmental impacts that affect water quality and the attainment of designated uses. Pollutant concentrations in CSOs and SSOs alone may be sufficient to cause a violation of water quality standards. Impacts from CSOs and SSOs are often compounded by impacts from other sources of pollution such as storm water runoff, decentralized wastewater treatment systems, and agricultural practices. This can make it difficult to identify and assign specific cause-and-effect relationships between CSO or SSO events and observed water quality impacts and impairments.

For the purpose of this report, environmental impacts do not include human health impacts. The extent of human health impacts due to CSOs and SSOs is discussed in Chapter 6.

5.1 What is EPA's Framework for Evaluating Environmental Impacts?

EPA's water quality standards program provides a framework for states and authorized tribes to assess and enhance the quality of the nation's waters. Water quality standards define goals by designating uses for the water (e.g., swimming, boating, fishing) and setting pollutant

In this chapter:

limits (criteria) necessary to protect the uses.

Attainment of water quality standards is determined through a process of evaluation and assessment, as follows:

- States adopt water quality goals or standards that, once approved by EPA, serve as the foundation of the water quality-based control program mandated by the Clean Water Act.
- States, EPA, and other federal agencies (e.g., U.S. Geological Survey) conduct water quality monitoring studies to measure water quality and assess changes over time.
- States compare measured water quality to goals or standards in a statewide assessment required under section 305(b) of the Clean Water Act and report conditions as good, threatened, or impaired.
- Waters designated as impaired are included on a state's 303(d) list. A total maximum daily load (TMDL) is required for each pollutant causing impairment. The TMDL establishes an allowable pollutant load that, when achieved, will result in the attainment of the water quality standard.

The discussion of environmental impacts in this chapter is focused on circumstances in which a designated use is not being attained due entirely or in part to CSO and SSO discharges. The pollutants found in CSOs and SSOs can potentially impact five designated uses:

- Aquatic life support, meaning the water provides suitable habitat for the protection and propagation of desirable fish, shellfish, and other aquatic organisms.
- Drinking water supply, meaning the water can supply safe drinking water with conventional treatment.
- Fish consumption, meaning the water supports fish free from contamination that could pose a significant human health risk.
- Shellfish harvesting, meaning the water supports a population of shellfish free from toxics and pathogens that could pose a significant health risk to consumers.
- Recreation, meaning water-based activities (e.g., swimming, boating) can be performed without risk of adverse human health effects.

As discussed in Section 4.1 of this report, the principal pollutants present in CSOs and SSOs are: microbial pathogens, oxygen depleting substances, TSS, toxics, nutrients, and floatables. Table 5.1 summarizes designated uses likely to be impaired by each of these pollutants.

Pollutants of Concern in CSOs and SSOs Likely to Cause or Contribute to Impairment	Aquatic life support	Drinking water supply	Fish consumption	Shellfish harvesting	Recreation
Oxygen-demanding substances	●				
Sediment (TSS)	●				
Pathogens		●	●	●	●
Toxics	●		●	●	
Nutrients	●	●			
Floatables					●

Table 5.1

Pollutants of Concern in CSOs and SSOs Likely to Cause or Contribute to Impairment

The pathogens present in CSO and SSO discharges have the potential to impact several designated uses, including, drinking water supply, fish consumption, shellfish harvesting, and recreation.

5.2 What Overall Water Quality Impacts Have Been Attributed to CSO and SSO Discharges in National Assessments?

States are required to periodically assess the health of their waters and the extent to which water quality standards are being met. EPA compiles these reports into the NWQI, which offers a comprehensive review of water quality conditions nationwide. This section summarizes findings from the NWQI and describes two original analyses undertaken by EPA to identify potential water quality impacts from CSO and SSO discharges at the national level.

5.2.1 NWQI 2000 Report

Since 1975, EPA has prepared a series of biennial NWQI reports as required under Section 305(b) of the Clean Water Act. The *NWQI 2000 Report*, the most recently published report, is a compilation of assessment reports on the quality of state waters (EPA 2002c). The NWQI Report categorizes assessed waters as follows:

Good – fully supporting all uses or fully supporting all uses but threatened for one or more uses; or

Impaired – partially or not supporting one or more uses.

The national summary of the quality of assessed waters, by type, is presented in Figure 5.1. This summary shows that 19 percent of the nation's total river and stream miles; 43 percent of lake, reservoir, and pond acres; 36 percent of estuarine and bay square miles; 6 percent of ocean shoreline miles; and 92 percent of Great Lakes shoreline miles were assessed.

EPA's *NWQI 2000 Report* also identified the types of pollutants or stressors most often found to impair the assessed waters as well as the leading sources of these pollutants. These results are presented in Table 5.2 and Table 5.3, respectively. Overall, EPA found that the three pollutants most often associated with impaired waters were solids, pathogens, and nutrients. All three are present in CSO and SSO discharges. Therefore, at a minimum, CSOs and SSOs contribute

Figure 5.1

NWQI 2000 Report: Summary of Assessed Waters by Waterbody Type (EPA 2002c)

Waterbody assessments are normally based on five broad types of monitoring data: biological integrity, chemical, physical, habitat, and toxicity. Monitoring data are then integrated for an overall assessment.

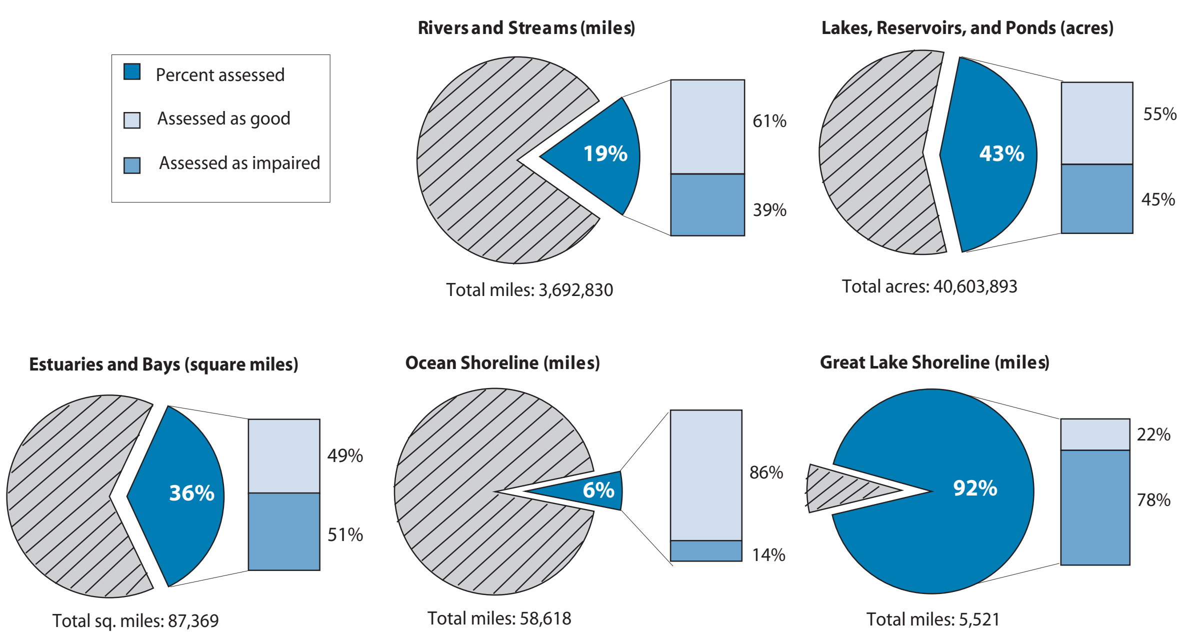


Table 5.2

Pollutants and Stressors Most Often Associated with Impairment (EPA 2002c)

Overall, EPA found that the three pollutants most often associated with impaired waters were solids (i.e., suspended solids, siltation, and total dissolved solids), pathogens, and nutrients. This table ranks the top five pollutants (or stressors) for each waterbody.

Pollutant/Stressor	Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries and Bays	Ocean Shoreline	Great Lakes Shoreline
Habitat alterations	3				
Metals		2	1		
Nutrients	5	1			2
Oil and grease				5	
Oxygen-depleting substances	4	5	3	2	5
Pathogens (bacteria)	1		4	1	3
Pesticides			2		
Priority toxic organic chemicals			5		1
Siltation (sedimentation)	2	3			4
Suspended solids				4	
Total dissolved solids		4			
Turbidity				3	

Table 5.3

Leading Sources of Pollutants and Stressors Causing Water Quality Impairment (EPA 2002b)

Overall, EPA found that pollution from urban and agricultural land, transported by precipitation and runoff, is a leading source of impairment. This table ranks the top five pollutant sources causing water quality impairments.

Pollutant Source	Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries and Bays	Ocean Shoreline	Great Lakes Shoreline
Agriculture	1	1	5		3
Atmospheric deposition		5	4		4
Contaminated sediment					1
Forestry	5				
Habitat modifications	3				5
Hydrologic modifications	2	2			
Industrial discharges			3		
Land disposal				3	
Municipal point sources			1	5	
Nonpoint sources		4		2	
Septic tanks				4	
Urban runoff/storm sewers	4	3	2	1	2

to the loading of these pollutants where they occur.

The *NWQI 2000 Report* did not cite CSOs or SSOs as a leading source of impairment in any of the five waterbody types listed in Table 5.3 (EPA 2002c). CSOs were identified as a source of impairment for 1,466 square miles (5 percent) of assessed estuaries and 56 miles (1 percent) of Great Lakes shoreline.

The *NWQI 2000 Report* is based on a compilation of individual state assessments, and reporting of the source of impairment varies widely from state to state. The lack of uniformity in assessment and reporting makes it difficult to fully assess the magnitude of CSO and SSO impacts. Inconsistencies in state reporting of CSOs and SSOs as pollutant sources are described below.

Unknown sources and failure to classify: Some states cite unknown pollutant sources or do not attribute impairment to a specific source.

Inconsistent source listing*:* CSOs are tracked as a specific pollutant source in many, but not all, states where they occur. Twenty of the 32 CSO states identified "combined sewer overflow" as a source of impairment, in the NWQI at least once. Where SSOs are identified by states, they are tracked in an inconsistent manner. States use categories such as "collection system failure (SSO)," "wet weather discharges," and "spills" for tracking SSOs.

Cumulative impacts from multiple pollutant sources: Impacts from CSOs and SSOs are often compounded by impacts from other sources of pollution, particularly during wet weather. As such, CSOs and SSOs may be grouped into municipal or urban source categories.

EPA is working with the states to develop a framework to promote consistent listing of sources of impairment (EPA 2002d).

5.2.2 Analysis of CSO Outfalls Discharging to Assessed or Impaired Waters

As described in Section 4.5, a key EPA initiative undertaken as part of this report was to update, verify, and digitally georeference the inventory of CSO outfall locations documented as part of EPA's 2001 *Report to Congress-Implementation and Enforcement of the CSO Control Policy*. Through this effort, EPA established latitude and longitude coordinates for over 90 percent of CSO outfalls. EPA then linked CSO outfall locations to other national-level data and assessments. For example, permitted CSO outfall locations were linked to 305(b)-assessed waters and 303(d)-impaired waters. These analyses are presented in the following subsections. A similar analysis linking permitted CSO outfall locations with classified shellfish growing areas is presented in Section 5.3.2. An analysis of CSO outfall proximity to drinking water intakes is presented in Chapter 6. More information on each of these analyses is provided in Appendix F.

As discussed in Chapter 4, SSOs do not necessarily occur at fixed locations. Therefore, a parallel effort to georeference SSO locations and evaluate their location with respect to other national-level data and assessments was not possible.

Analysis of CSO Outfalls Discharging to EPA's 305(b) Assessed Waters

EPA was able to compare CSO outfall locations with assessed waters in the *NWQI 2000 Report* through the 305(b) assessment database for 19 CSO states with electronic 305(b) data. The purpose of this analysis was to determine the number of CSO outfalls discharging to waters classified as good or impaired. EPA limited the analysis to assessed water segments located within one mile downstream of a CSO outfall. The results of this analysis are summarized in Table 5.4. EPA found that of the 59,335 assessed water segments in CSO states with electronic 305(b) data only a small number (733 segments) were in close proximity to CSO outfalls. Of these, 75 percent (552 segments) were impaired. The proximity of a permitted CSO outfall to an impaired segment does not in and of itself demonstrate that the CSO is the cause of the impairment. CSOs generally are located in urban areas where waterbodies also receive relatively high volumes of storm water runoff and other pollutant loads. Nevertheless, the high percentage of impairment associated with CSO outfalls suggests some correlation between impairment and CSOs.

Analysis of CSO Outfalls Discharging to EPA's 303(d) Waters

EPA also compared CSO outfall locations to water segments identified in EPA's Section 303(d) list of impaired waters in states with NHD-index data. For the purpose of this analysis, EPA assumed the causes of reported Section 303(d) impairment most likely attributed to or associated with CSOs were:

- Pathogens
- Organic enrichment, leading to low dissolved oxygen
- Sediment and siltation

Again, EPA limited the analysis to water segments located within one mile downstream of a CSO outfall. The results of this analysis are summarized in Table 5.5. EPA found that although less than one-tenth of one percent (1,560 of more than 1,495,000) of all waterbody segments in CSO states are within one mile of a CSO outfall, between five and 10 percent of the waters assessed as impaired are within that one mile. EPA believes the strong correlation between CSO location and impaired waters is due in part to the

Table 5.4

Occurrence of 305(b) Assessed Waters Within One Mile Downstream of a CSO Outfall

EPA was able to complete this analysis only for states with electronic 305(b) data; that is, for 19 of the 32 states with active CSO permits.

Assessed Waters	Total Assessed	Assessed as Good	Assessed as Impaired	Percent Impaired
Assessed 305(b) segments in CSO states with electronic 305(b) data	59,335	44,457	14,878	25%
Assessed segments within one mile downstream of a CSO outfall	733	181	552	75%

Table 5.5

Occurrence of 303(d) Listed Waters Within One Mile Downstream of a CSO Outfall

Waters within one mile of a CSO outfall are much more likely to be assessed as impaired than a typical water in a CSO state.

Listed Waters	Reason or Cause of Listing		
	Pathogens	Enrichment Leading to Low Dissolved Oxygen	Sediment and Siltation
Total number of listed waters in CSO states	3,446	1,892	3,136
Number of listed waters within one mile of a CSO outfall	191	163	149

following factors: CSOs generally are located in urban areas where waterbodies also receive relatively high volumes of storm water runoff and other pollutant loads; and waters within urban areas are much are more likely to be assessed as part of the 305(b) process.

As described in the 305(b) analysis, the existence of a permitted CSO outfall in close proximity to an impaired water does not in and of itself demonstrate that the CSO is the cause of the impairment. It does suggest, however, that CSOs should be considered as a potential source of pollution with respect to TMDL development. EPA has collected anecdotal data demonstrating that CSOs are being considered in TMDL development and that substantial load reductions have been assigned to CSOs in some communities as a result of the TMDL process.

5.2.3 Modeled Assessment of SSO Impacts on Receiving Water Quality

The unpredictable nature of most SSO events makes it difficult to monitor and collect the data needed to measure the occurrence and severity of environmental impacts. As described in Section 4.7 of this report, however, EPA was able to compile a substantial amount of information on the frequency, volume, and cause of SSO events. From these data, EPA found 72 percent of these SSO events reach a surface water.

Using the national SSO data, EPA developed a simple model for estimating the likely impact of SSO events on different size receiving waterbodies, based on reasonable assumptions about SSO event duration and concentrations of fecal coliform bacteria in SSO discharges. For the purpose of this report, modeled impacts associated with SSO events are evaluated in terms of violations of the single sample maximum water quality criterion for fecal coliform. That is, a predicted concentration of greater than 400 counts of fecal coliform per 100 mL of surface water would be considered to be a water quality standards violation.

The model was run under three different scenarios: one that assumed the entire volume of each modeled SSO discharge reached a surface water (100% delivery), a second that assumed half the volume of each modeled SSO discharge reached a surface water (50% delivery), and a third that assumed ten percent of the volume of each modeled SSO discharge reached a surface water (10% delivery).

Example: Change in Flow in Washington, D.C. Area Waterbodies as a Result of Wet Weather

Flow in a particular waterbody can increase dramatically with a wet weather event. For example, after an extended period without rain, 2.6 inches of rain fell in the Washington, DC area over two days in late February, 2004. This, in turn, caused flow in local waterbodies to increase by varying amounts–e.g., to 63 times the median flow in the Anacostia River. The flows given reflect the peak daily flow observed due to this rainfall event.

Waterbody	Median Flow (cfs)	February Storm Peak (cfs)	Peak Factor
Potomac River	8,490	79,300	9
Monocacy River	624	9,130	15
Goose Creek	250	4,480	18
Seneca Creek	91	1,630	18
Anacostia River	47	2,950	63

Flow varies widely in receiving waters both from year to year and seasonally. Flow can also increase substantially in a particular receiving water during local wet weather events. The potential impact of a specific SSO discharge depends on a number of factors including flow and background pollutant concentrations in the receiving water at the time the discharge occurs, and the volume and strength of the discharge that reaches the receiving water.

The results of EPA's simple model of SSO-related water quality impacts are presented in Table 5.6 for a range of flow conditions, wastewater strength, and delivery ratios. In general, SSOs consisting of concentrated wastewater are predicted to violate water quality standards the majority of the time, particularly under low flow conditions. In contrast, SSOs consisting of more dilute wastewater are much less likely to cause water quality standards violations, particularly under high flow conditions.

Table 5.6

Estimated Percentage of Time SSOs Would Cause Water Quality Standard Violations

EPA developed a frequency distribution characterizing typical volumes of SSO events based on available data in order to estimate the likely impact of SSO events on water quality.

Flow Rate (cfs)	Dilute Wastewater (FC = 500,000 #/ml)			Medium Strength Wastewater (FC = 10,000,000 #/100 ml)			Concentrated Wastewater (FC = 1,000,000,000 #/ml)		
	10% Delivery	50% Delivery	100% Delivery	10% Delivery	50% Delivery	100% Delivery	10% Delivery	50% Delivery	100% Delivery
50	12%	27%	36%	45%	68%	77%	95%	99%	100%
100	9%	20%	27%	36%	58%	68%	92%	98%	99%
250	5%	12%	18%	25%	45%	55%	84%	95%	97%
500	3%	9%	12%	18%	36%	45%	77%	92%	95%
1000	2%	6%	9%	13%	27%	36%	68%	86%	92%
5000	1%	2%	3%	5%	13%	18%	45%	68%	77%
10000	0%	1%	2%	3%	9%	13%	36%	58%	68%

A detailed description of the methodology used to develop these estimates is presented in Appendix H. No comparable analysis of SSO discharges to lake or estuarine waters was undertaken.

5.3 What Impacts on Specific Designated Uses Have Been Attributed to CSO and SSO Discharges in National Assessments?

EPA, other federal agencies, and non-governmental organizations periodically conduct national assessments of environmental impacts that are framed in terms of the loss of a specific designated use. Examples include beach closures in waters designated for recreation and shellfish harvesting restrictions in waters designated for shellfishing. This section summarizes findings from a number of national assessments, with emphasis placed on environmental impacts identified as being caused, or contributed to, by CSOs or SSOs.

EPA was unable to identify national assessments that specifically consider the impacts of CSOs and SSOs on aquatic life, although EPA found several state and local watershed assessments which do so. These assessments are discussed in Section 5.5 of this report. Also, for purposes of this report, impairment of drinking water supply as a designated use is considered to be a human health rather than an environmental impact. Consequently, drinking water supply is discussed in Chapter 6 of this report.

5.3.1 Recreation

Recreation is an important designated use for most waters of the United States. The results of national assessments of recreational waters and the causes of impairment are described in the following subsections.

EPA BEACH Program

EPA's Beaches Environmental Assessment and Coastal Health Program (BEACH Program) conducts an annual survey of the nation's swimming beaches, the National Health Protection Survey of Beaches. Nearly 2,500 agencies representing beaches in coastal locations, the Great Lakes, and inland waterways participate in the survey. With respect to designated use impairment during the 2002 swimming season, 25 percent of the beaches inventoried (709 of 2,823) had at least one advisory or closing (EPA 2003a). Elevated bacteria levels accounted for 75 percent of recreational use impairments, manifested as beach advisories and closings. As shown in Figure 5.2, a wide variety of pollutant sources were reported as causing beach advisories and closings. Nearly half of the advisories and closings, however, were reported as having an unknown cause. CSOs were reported to be responsible for 1 percent of reported advisories and closings, and 2 percent of advisories and closings that had a known cause. SSOs (including sewer line blockages and breaks) were reported to be responsible for 6 percent of reported advisories and closings, and 12 percent of advisories and closings that had a known cause.

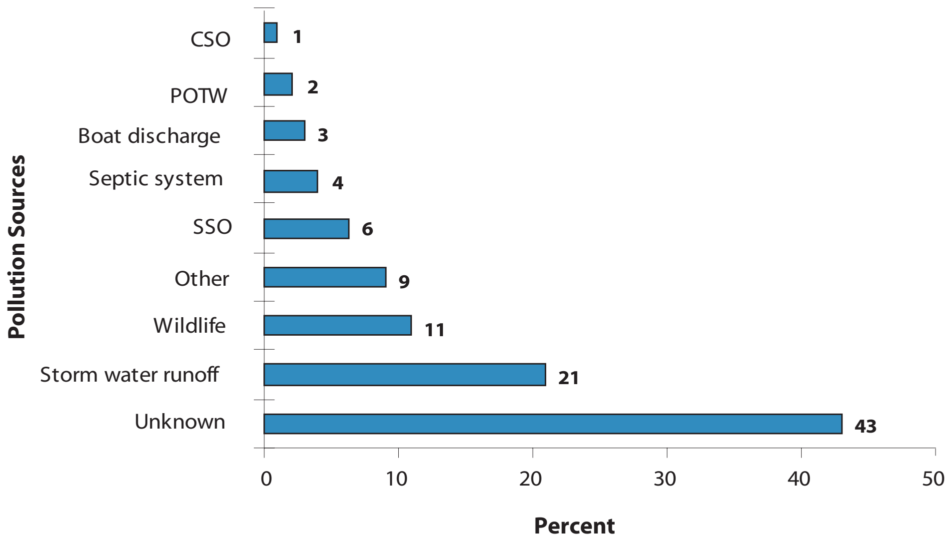


Figure 5.2

Sources of Pollution that Resulted in Beach Advisories and Closings (EPA 2003a)

EPA's BEACH Program conducts an annual survey of the nation's swimming beaches. During the 2002 swimming season, CSOs and SSOs were responsible for 1 and 6 percent, respectively, of reported advisories and closings.

Floatables

Floatables are visible buoyant or semi-buoyant solids that originate from a variety of sources, including CSOs and SSOs. CSOs can be a source of floatables when debris in raw sewage and storm water is released into the receiving waterbody. The type of floatables typically found in CSOs include sewage-related items (e.g., condoms and tampons), street litter, medical items (e.g., syringes), and other material from storm drains, ditches, or runoff (EPA 2002c).

Floatables on beaches and waterways, also known as marine debris, create aesthetic impacts and safety issues that detract from the recreational value of beaches and other public shorelines. As defined by the EPA, marine debris includes all objects found in the marine environment that do not naturally occur there. The marine environment includes the ocean, salt marshes, estuaries, and beaches.

The National Marine Debris Monitoring Program (NMDMP), coordinated by the Ocean Conservancy (formerly the Center for Marine Conservation) and funded by EPA, maintains a national marine debris database. The NMDMP has conducted monthly beach cleanups since 1996. Volunteers track information on specific marine debris items that are added to the national database. The most frequently collected marine debris items from 1996 to 2002 are presented in Table 5.7 (Ocean Conservancy 2003).

Medical and personal hygiene items are an important component of marine debris. Given the nature and use of these items and their disposal in toilets, CSOs and SSOs are considered a possible source. The Ocean Conservancy's 2003 International Coastal Cleanup, a large one-day event, found a substantial amount of medical and personal hygiene items on U.S. beaches (Ocean Conservancy 2004). More than 7,500 condoms and 10,000 tampons and tampon applicators were collected from 9,200 miles of U.S. shoreline during this event. While this

Table 5.7

NMDMP Marine Debris Survey Results from 1996 - 2002 (Ocean Conservancy 2003)

Funded by EPA is Office of Water, the NMDMP uses standardized data collection methods to determine the status of and trends in marine debris pollution. The data are compiled in a national database.

Marine Debris (excluding ocean-based)	Total Items
Straws	83,714
Plastic beverage bottles	60,426
Other plastic bottles	36,598
Balloons	34,355
Plastic food bottles	18,383
Plastic bottles	11,946
Condoms	1,675
Syringes	1,379
Plastic bags with seam <1 meter	422
Cotton swabs	171
Metal beverage cans	109
Plastic bags with seam > 1 meter	88
Tampon applicators	61
Motor oil containers	19
Six-pack rings	17

information is inconclusive on its own, it does suggest that CSOs and SSOs may contribute to the occurrence of medical and personal hygiene waste found on beaches and other shorelines.

5.3.2 Shellfish Harvesting

Commercial and recreational shellfishing in populated coastal areas has declined steadily since the early 1900s, when outbreaks of typhoid were linked to untreated wastewater. Environmental impacts that restrict shellfish harvesting as a designated use are discussed in the following section. Human health impacts related to the consumption of contaminated fish and shellfish are discussed in Chapter 6.

NOAA National Shellfish Register

NOAA published assessments of classified shellfish growing waters in the contiguous states every five years between 1966 and 1995. The last report, *1995 National Shellfish Register of Classified Growing Waters*, provided an assessment of 4,230 different classified shellfish growing areas in 21 coastal states (NOAA 1997). Areas open for harvesting are rated as “approved” or “conditionally approved;” areas where harvesting is limited are rated as “restricted” or “conditionally restricted;” and areas where harvesting is not allowed are rated as “prohibited.”

Findings from the 1995 report with respect to shellfish harvesting are as follows:

- 76 percent of all classified waters were approved or conditionally approved for harvest (14.8 million acres);

- 11 percent of all classified waters were restricted or conditionally restricted (3.9 million acres); and
- 13 percent of all classified waters were prohibited (2.8 million acres).

NOAA reported that the primary basis for harvest restrictions was the concentration of fecal coliform bacteria associated with untreated wastewater and wastes from livestock and wildlife. CSOs are one of many sources of fecal coliform that impact shellfish harvesting. A summary of all pollution sources identified in the 1990 and 1995 National Shellfish Registers as causing or contributing to restrictions and prohibitions is presented in Table 5.8.

A cooperative effort between the Interstate Shellfish Sanitation Conference and NOAA has resulted in the development of a state Shellfish Information Management System. The system will summarize basic information about shellfish programs

CSO controls implemented in Oswego, NY, have helped provide suitable habitat for desirable fish.

Photo: P. MacNeill

Table 5.8

Pollution Sources Reported for Harvest Limitations on Classified Shellfish Growing Waters in the 1990 and 1995 National Shellfish Registers (NOAA 1997)

Compared to the 1990 Register, the 1995 Register shows significant decreases in the acreage that is harvest-limited due to contributions from industry and wastewater treatment plants; the acreage impacted by CSOs remained relatively constant during the five-year period.

Pollution Source	1990[a]	1995[a]
Urban Runoff Precipitation-related discharges (e.g., septic leachate, animal wastes) from impervious surfaces, lawns, and other urban land uses	38%	40%
Upstream Sources Contaminants from unspecified sources upstream of shellfish growing waters	46%	39%
Wildlife Precipitation-related runoff of animal wastes from high wildlife concentration areas (e.g., waterfowl)	25%	38%
Decentralized Wastewater Treatment Systems Discharge of partially treated sewage from malfunctioning on-site septic systems	37%	32%
Wastewater Treatment Plants Routine and accidental sewage discharge from public and private wastewater treatment plants with varying levels of treatment	37%	24%
Agricultural Runoff Precipitation- and irrigation-related runoff of animal wastes and pesticides from crop and pasture lands	11%	17%
Marinas Periodic discharge of untreated or partially treated sewage from berthed vessels	–	17%
Boating Periodic discharge of untreated or partially treated sewage from vessels underway or anchored offshore	18%	13%
Industry Routine and accidental discharges from production/manufacturing processes and on-site sewage treatment	17%	9%
CSOs Discharge of untreated sewage/storm water when sewage system capacity is exceeded by heavy rainfall	7%	7%
Total harvest-limited area, in acres	**6.4 million**	**6.7 million**

[a] Harvest-limited areas are impacted by multiple pollution sources. Annual values do not total 100 percent.

in each state, replacing NOAA's national shellfish register. This system, which will provide spatial data through a web-based interface, is expected to be operational in 2004.

Analysis of CSO Outfalls Discharging Near Classified Shellfish Growing Areas

EPA associated the location of individual CSO outfalls with classified shellfish growing areas as reported by NOAA in 1995, the last year for which national data were available. EPA limited the analysis to classified shellfish growing areas within five miles of a CSO outfall. The number of classified areas was tabulated by shellfish harvest classification. As shown in Table 5.9, harvesting was prohibited or restricted in most of the classified shellfish growing areas that are proximate to CSO outfalls. As discussed earlier under similar 305(b) and 303(d) analyses, the presence of a CSO outfall alone does not necessarily mean that the CSO is causing or contributing to the prohibition or restriction. Many classified shellfish growing areas where shellfish harvesting is currently prohibited or restricted are in urban areas in the Northeast where CSOs are one of several factors that might account for impairment. Nevertheless, the association between prohibited and restricted conditions and the presence of CSO outfalls is strong.

5.4 What Overall Water Quality Impacts Have Been Attributed to CSO and SSO Discharges in State and Local Assessments?

State and local governments track environmental impacts and gather data for programmatic reasons that are not necessarily included in national assessments. Examples of environmental impacts included in this section were gathered from state and local reports and from watershed studies in which broad assessments of water quality were undertaken. These examples are not meant to be comprehensive. They are presented to illustrate environmental impacts attributed to CSO and SSO

Table 5.9

Harvest Limitations on Classified Shellfish Growing Areas Within Five Miles of a CSO Outfall

Fifty-eight active CSO permits in nine states cover outfalls located within five miles of a classified shellfish growing area. Shellfish harvesting is prohibited or restricted in the majority of the 659 shellfish growing areas in proximity to CSO outfalls national database.

Shellfish Harvest Classification	Number of Classified Shellfish Growing Areas within 5 Miles of a CSO outfall
Prohibited	411
Restricted	80
Approved	154
Unclassified	14
Total	**659**

discharges, and, in some instances, the site-specific circumstances under which they occurred.

5.4.1 Water Quality Assessment in New Hampshire

In its 2000 *Water Quality Report*, New Hampshire reported that bacteria is the third leading cause of water quality impairment in the state, causing or contributing to 13 percent of the total miles of impaired rivers and streams in the state (NHDES 2000). Elevated levels of bacteria impaired recreational uses as well as shellfish harvesting uses in New Hampshire. The overall sources of water quality impairment to rivers and streams in New Hampshire are presented in Figure 5.3. As shown, unknown sources cause 79 percent of the 642 miles of impairment reported. A total of 24.1 miles were impaired due to CSOs; this represents 3 percent of all impaired waters in the state and 19 percent of impaired waters with a known source of impairment.

5.4.2 Water Quality Assessment of the Mahoning River Near Youngstown, Ohio

Working in cooperation with the City of Youngstown, Ohio, USGS conducted a comprehensive assessment of water quality and habitat in the Mahoning River and its tributaries (USGS 2002). The City of Youngstown has 80 CSOs that discharge to local receiving waters. Water quality monitoring was conducted during 1999 and 2000. CSO discharges were found to contribute to bacterial and nutrient loads observed in the Mahoning River, but they were not the only factor adversely affecting water quality and habitat. USGS found that:

> *"Improvement of water quality in the lower reaches of the Mahoning River and Mill Creek (a tributary) to the point that each waterbody meets its designated-use criteria will likely require an integrated approach that includes not only abatement of sewer overflow loadings but also identification and remediation of other loadings in Youngstown and improvement of water quality entering Youngtown."*

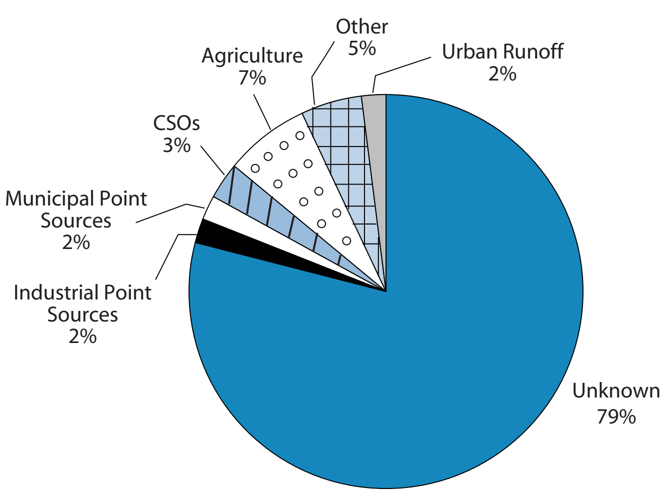


Figure 5.3

Sources of Water Quality Impairment in New Hampshire (NHDES 2000)

In 2000, New Hampshire reported a total of 24.1 miles of rivers and streams impaired by CSOs; this represents 3 percent of all impaired waters in the state and 19 percent of impaired waters with a known source of impairment.

5.4.3 Water Quality in Indianapolis, Indiana

The City of Indianapolis, Indiana, is working to identify and implement CSO controls. The city identified specific water quality problems in waterbodies receiving CSO discharges (City of Indianapolis 2000). The city's assessment of pollutant sources contributing to water quality problems is presented in Table 5.10. As shown, CSO discharges and wet weather bypasses at POTWs are ranked high relative to other sources of pollution.

5.4.4 Water Quality Risk Assessment of CSO Discharges in King County, Washington

King County, Washington, conducted a CSO water quality risk assessment for the Duwamish River and Elliot Bay, an estuary in Seattle (KCDNR 1999). The water quality assessment consisted of three main parts. First, more than 2,000 environmental samples were collected and analyzed to determine pollutant concentrations in the water, sediment, and tissues of aquatic organisms. Six CSO locations within the estuary were included in this sampling. The samples were analyzed for 35 chemical, physical, and biological attributes. Next, a computer model was developed to describe water flow and contaminant transport within the estuary. The model was used to estimate current pollution levels in estuarine water and sediment as well as to predict pollution levels after CSO control. Finally, a risk assessment was conducted to determine the impacts of the various pollutants on aquatic life, wildlife, and people that use the estuary. Key study findings with respect to risk reduction resulting from CSO control are as follows:

- No predicted reduction in risks for water-dwelling organisms;
- Some predicted reduction in risks to sediment-dwelling organisms near the CSO discharges;
- A possible increase in the variety of benthic organisms near CSOs as the result of a decrease in organic matter;
- A possible reduction in impacts of localized scouring and sedimentation, which may be

Table 5.10

Relative Contributions of Pollutant Sources to Water Quality Problems in Indianapolis, Indiana (City of Indianapolis 2000)

Indianapolis ranked the contribution of CSO discharges and wet weather bypasses at POTWs high relative to other sources of pollution in local receiving waters. Blank spaces represent negligible or no contribution in comparison to other sources.

Pollutant Source	Dissolved Oxygen Violations	Bacteria Violations	Aesthetic Problems
CSO Discharges	High	High	High
Upstream Sources		Low	
Storm Water		Low	High
Wet Weather Bypass at POTW	High	High	
Electric Utility Thermal Discharge	Low		
Sediment Oxygen Demand	Low		
Dams	Low		
Water Supply Withdrawals	Low		
Septic Tanks		Low	

small compared to the overall scouring impacts of the river and sediment from other sources; and

- No predicted reduction in risks to wildlife as other sources contribute the majority of the risk-related chemicals.

A stakeholder committee composed of local citizens, business owners, environmental organizations, and tribal governments drew the following conclusions from the study results:

- Existing sediment quality and associated risks to people, wildlife, and aquatic life in the estuary are unacceptable;
- Levels of human pathogens and fecal coliform in the estuary are unacceptable;
- Controlling CSOs according to the King County comprehensive sewer plan will improve some aspects of environmental quality; and
- Even if CSOs are completely eliminated, overall environmental quality of the estuary will continue to be unacceptable.

5.5 What Impacts on Specific Designated Uses Have Been Attributed to CSO and SSO Discharges in State and Local Assessments?

Examples of environmental impacts included in this section were gathered from state and local reports and watershed studies; the examples are presented according to the designated use impacted by CSO and SSO discharges. They are not meant to be comprehensive. They are presented to illustrate representative environmental impacts attributed to CSO and SSO discharges, and, in some instances, the site-specific circumstances under which they occurred. CSO or SSO discharges are clearly the cause of documented environmental impacts in some cases, and are a contributing factor in others. Several examples summarize studies in which impacts from CSOs and SSOs were sought, but were not found.

5.5.1 Aquatic Life Support

The designated use for aquatic life support is achieved when the water provides suitable habitat for the protection and propagation of desirable fish, shellfish, and other aquatic organisms. Oxygen-demanding substances are the principal pollutants found in CSOs and SSOs that can cause or contribute to impaired aquatic life support. CSO and SSO discharges can also contribute sediment, pathogens, nutrients, and toxics to receiving waters, but there is little evidence that levels of these pollutants in CSOs and SSOs are major causes of aquatic life impairment. Select examples of impacts or relevant studies are presented below.

Fish Kills in North Carolina

Reports of impaired aquatic life (i.e., fish kills) have been investigated and documented in North Carolina since 1997 (NCDENR 2003). A summary of fish kills attributed to sewage spills from 1997 to 2002 is presented in Table 5.11. As shown, SSOs are a relatively small cause of the documented fish kills. Other causes of

Table 5.11

Fish Kills Reported in North Carolina: 1997 - 2002 (NCDENR 2003)

Between 1997 and 2002, NCDENR attributed the deaths of nearly 10,000 fish to SSOs (sewer spills).

Year	Total Number of Fish Kills	Number of Fish Kills Attributed to Sewer Spills	Total Number of Fish Killed	Number of Fish Killed in Events Attributed to Sewer Spills
1997	57	8	91,998	8,384
1998	58	3	593,545	336
1999	54	1	1,298,472	200
2000	58	2	716,141	400
2001	77	2	1,369,140	490
2002	45	0	269,635	0

fish kills include chemical spills, heavy rainfall, eutrophication, low dissolved oxygen due to unspecified causes, natural phenomena (e.g., temperature and salinity effects), and unknown causes.

Individual fish kill events linked to sewage spills in North Carolina are presented in Table 5.12. Descriptive comments provided by field crews investigating the fish kills are listed in an abbreviated manner. The oxygen-depleting substances in the spilled sewage appear to reduce oxygen levels to a point at which there is insufficient oxygen to support aquatic life, particularly when spills occur in relatively small streams. No North Carolina communities are served by CSSs.

Assessment of SSO Impacts on Fish and Aquatic Life at Camp Pendleton, California

In September 2000, an SSO occurred at the Marine Corps Base Camp Pendleton near Oceanside, California. The California State Water Resources Control Board investigated the spill, monitored water quality, and assessed the impact of the spill on fish and aquatic life (Vasquez 2003). The SSO occurred at a deteriorated access port in a sewer force main operated by the Marine Corps. An estimated 2.73 million gallons of sewage was spilled over an eight-day period. Data showed that dissolved oxygen levels in the impacted area dropped below 1 mg/L, well below the numeric criteria of 5 mg/L and levels needed to support most aquatic life, and remained low for several days. The assessment of impacted wildlife documented 320 dead fish, 67 dead shrimp, 169 dead clams, 1 dead snail, and 1 dead bird.

Assessment of PCBs in the Buffalo River, New York

Polychlorinated biphenyls (PCBs) are a contaminant of concern for the Buffalo River in New York and the Great Lakes in general. PCB levels in the river often exceed state water quality criteria, and PCBs found in fish tissue exceed levels allowed by the Food and Drug Administration. In 1994, a study was conducted to identify sources of PCBs to the Buffalo River (Loganthan et al. 1997). Monitoring was conducted in the 700-acre Babcock Creek sewershed, one of 27 sewersheds served by combined

Table 5.12

Fish Kills Caused by Sewage Spills in North Carolina: 1997 - 2001 (NCDENR 2003)

Oxygen-depleting substances in SSOs (sewer spills) can reduce in-stream dissolved oxygen to levels that are insufficient to support aquatic life.

Date Investigated	Waterbody	Number of Fish Killed	Comments
7/1/97	Tributary to Cokey Swamp	300	Spill of at least 23,000 gallons of sewage
7/14/97	Elerbee Creek	120	Sewer spill at storm drain due to sump overflow
7/29/97	Tributary to Elerbee Creek	100	30,000 gallon spill at pump station
8/13/97	Swift and Mahlers Creeks	1,000	500,000–1,000,000 gallon sewer line spill
8/14/97	Tributary to Northeast Creek	200	20,000 gallon sewer line spill
8/19/97	Coon Creek	3,500	1,200,000 gallon spill at pump station
9/23/97	Little Buffalo Creek	25	50,000 gallon sewage spill
10/7/97	Lovills Creek	3,099	Sewage leakage at junction in sewage lines
11/9/97	East Beaverdam Creek	40	500,000 spill at broken manhole
1/5/98	Cooper's Pond	85	Sewage spill
3/16/98	Unnamed Lake	175	114,000 gallons spilled
7/6/98	Reedy Fork Creek	76	3,000 gallons spilled at pump station
6/29/99	Muddy Creek	200	Sewer overflow reported in area
4/13/00	South Fork Catawba River	200	3,000 gallons spilled
6/9/00	Town Branch	200	5,200 gallons spilled due to blockage
5/3/01	Subdivision Pond	400	Sewage overflow
10/23/01	Tributary to Hare Snipe Creek	90	40,000 gallon sewage spill

sewers in the City of Buffalo. The study detected the presence of PCBs in CSO discharges from the Babcock Creek CSO outfall and confirmed that the city's CSS was a source of PCBs to the river. Monitoring at other study locations as well as watershed modeling indicated that the PCB loadings from unknown, non-CSO sources were more than 10 times greater than the loading from all of the CSOs in the lower Buffalo River (Atkinson et al. 1994).

Whole Effluent Toxicity of CSO Discharges in Toledo, Ohio

Whole effluent toxicity testing uses *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnow) to measure if a discharge is toxic. The City of Toledo, Ohio, conducted whole effluent toxicity testing on samples collected at four separate CSO outfalls during wet weather conditions (Jones & Henry Engineers 1997). In comparison with laboratory control groups, acute (short-term) toxicity was observed in samples from two CSO outfalls, and chronic (long-term) toxicity was observed in samples from the other two CSO outfalls. Some chronic toxicity effects were also observed in river samples taken above and below the CSO discharges. Parallel modeling analysis of CSO discharges by the City of Toledo identified copper, lead, silver, and zinc as pollutants of concern.

As a result of the testing, Toledo recently developed a draft *Industrial Wastewater Release Minimization Plan* with policies and procedures for minimizing the discharge of industrial wastewater during CSO events (City of Toledo 2003). The plan includes a variety of measures to reduce the volume and concentration of industrial wastewater discharged to the CSS during wet weather events. Eight industrial facilities identified as having the potential to contribute toxics to CSO discharges have implemented or scheduled changes to their operations to reduce flow, load, or both. The city plans to contact the remaining industrial facilities participating in its Industrial Pretreatment Program to encourage operational modifications to reduce the volume and concentration of wastewater discharged to the CSS during wet weather events.

Analysis of Toxics in CSOs in Washington, D.C.

The District of Columbia Water and Sewer Authority monitored its CSO outfalls for nine months during 1999 and 2000 (DCWASA 2002). The purpose of the monitoring was to characterize the chemical composition of CSO discharges in order to assess the potential for receiving water impacts. Monitoring was carried out for 127 priority pollutants including:

- Total recoverable metals and cyanide
- Dissolved metals
- Pesticides and PCBs
- Volatiles and semivolatiles

The CSO monitoring data reported by the Water and Sewer Authority indicated that all results for priority pollutants were below the laboratory method reporting limits, except for cyanide, chloroform, and several metals. The cyanide and chloroform concentrations were found to be well below the applicable water quality criteria. Further evaluation of detected metals showed that all but dissolved copper and dissolved zinc were at acceptable levels. Additional analysis using the EPA-approved CORMIX and Biotic Ligand models indicated that the effective instream concentrations of dissolved copper and dissolved zinc were also at acceptable levels. Although Washington, D.C. is not a heavily industrialized city, 25 permitted significant industrial users and approximately 3,000 smaller commercial dischargers (e.g., medical facilities, printing and photocopying facilities) discharge to its sewer system.

Fish Diversity in Chicago-area Waterways

Prior to the implementation of wastewater treatment facility upgrades in the 1970s and CSO controls in the 1980s, aquatic life suffered in urban Chicago-area streams. The ability of Chicago-area waterways to support a rich and diverse aquatic community was severely limited by inadequate levels of wastewater treatment, discharges of chlorinated effluent at treatment facilities, and CSO discharges. In particular, CSO discharges contributed large amounts of oxygen-demanding organic substances that depressed oxygen levels in the waterways, and the presence of chlorine in treatment plant effluent contributed to conditions that were toxic to aquatic life. Improved wastewater treatment, including facilities to dechlorinate treated wastewater, and CSO control over the past 30 years have improved the richness and diversity of aquatic life. As shown in Figure 5.4, the total number of fish species found and supported in the principal waterways in Chicago has expanded during this period (MWRD 1998).

5.5.2 Recreation

Primary contact and secondary contact recreation uses are protected when a waterbody supports swimming and other water-based activities, such as boating, without risk of adverse human health effects from contact with the water. The principal pollutants found in CSOs and SSOs that affect recreational uses at beaches are microbial pathogens and, to a lesser extent, floatables. Select local examples of impacts to recreational uses and relevant studies are presented below. Additional information about potential human health impacts from recreational exposure to water contaminated by CSO or SSO discharges is presented in Chapter 6.

Beach Closures in California

SSOs were identified by the California State Water Resources Control Board as one of several sources of beach pollution in its *California Beach Closure Report 2000* (CSWRCB 2001). Beach closures result from exceedences of bacterial standards. A closure provides the public with notice that the water is unsafe for contact recreation (i.e., swimming poses an unacceptable risk of illness).

The majority of beach closures during 2000 were attributed to unspecified creek and river sources. As shown in

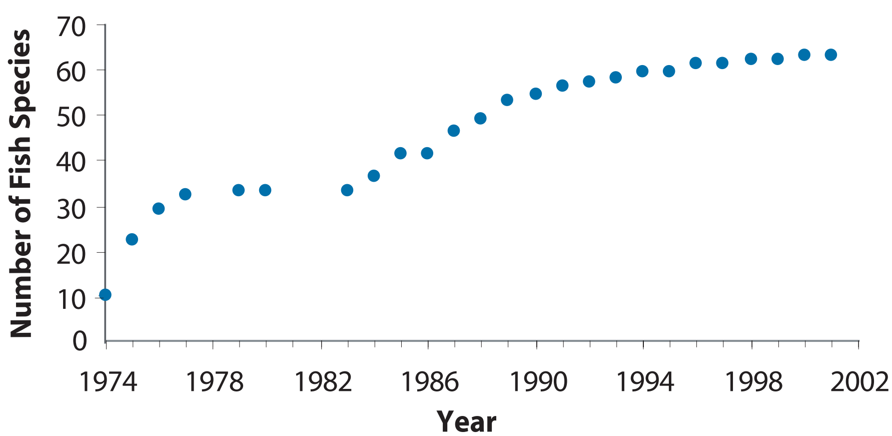


Figure 5.4

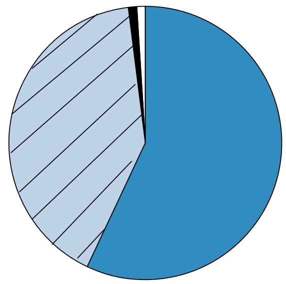
Fish Species Found in the Chicago and Calumet River System, 1974 - 2001 (MWRD 1998; Dennisen 2003)

The total number of fish species found in the Chicago and Calumet River system increased six-fold between 1974 and 2001.

Figure 5.5

Sources of Contamination Resulting in California Beach Closures in 2000 (CSWRCB 2001)

In California, problems with sewer lines such as line breaks; blockages due to grease, roots, or debris; and pump station failures have been identified as the cause of a to a significant number of beach closures.



Sources of Contamination Resulting in Beach Closures	Percent
Unspecified river sources	58%
SSOs	42%
CSOs	<1%
Unknown	<1%
Total	**100%**

Figure 5.5, SSOs accounted for 42 percent and CSOs accounted for less than one percent of all beach closures in California during 2000. California has only two communities with CSSs: San Francisco and Sacramento.

A summary of beach closures due to SSOs in California in 2000 is presented in Figure 5.6. The total number of days that at least one beach was closed is presented in the map by county. The accompanying bar graph shows closures by county in beach-mile days, a measure of beach availability for recreation that integrates miles of beach closed with days of impairment.

Beach Closures in Connecticut

The Connecticut Council on Environmental Quality reported on beach closures in the state in its 2001 Annual Report (CTCEQ 2002). Connecticut's goal is to eliminate beach closures caused by discharges of untreated or poorly treated wastewater, which Connecticut identified as the most common cause of elevated bacteria levels. Currently, several towns close beaches following a heavy rainfall as a precaution, presuming that CSO, SSO, and storm water discharges will occur and contaminate water. The average number of days that beaches are closed depends largely on the frequency and amount of rainfall during the beach season. The long-term trend in beach closures reported by the Council is presented in Figure 5.7.

Beach Closures in Orange County, California

Orange County monitors and reports on bacteria levels along 112 miles of its ocean and bay coastline. Major findings documented in its *Annual Ocean and Bay Water Quality Report* (Orange County 2002) are:

- The total number of SSOs reported to the Orange County Health Care Agency has steadily increased over the past 15 years.
- The total number of ocean and bay beach closures due to SSOs has increased each year since 1999.
- The total number of beach mile-days lost as a result of sewage spills has remained constant since 1999.

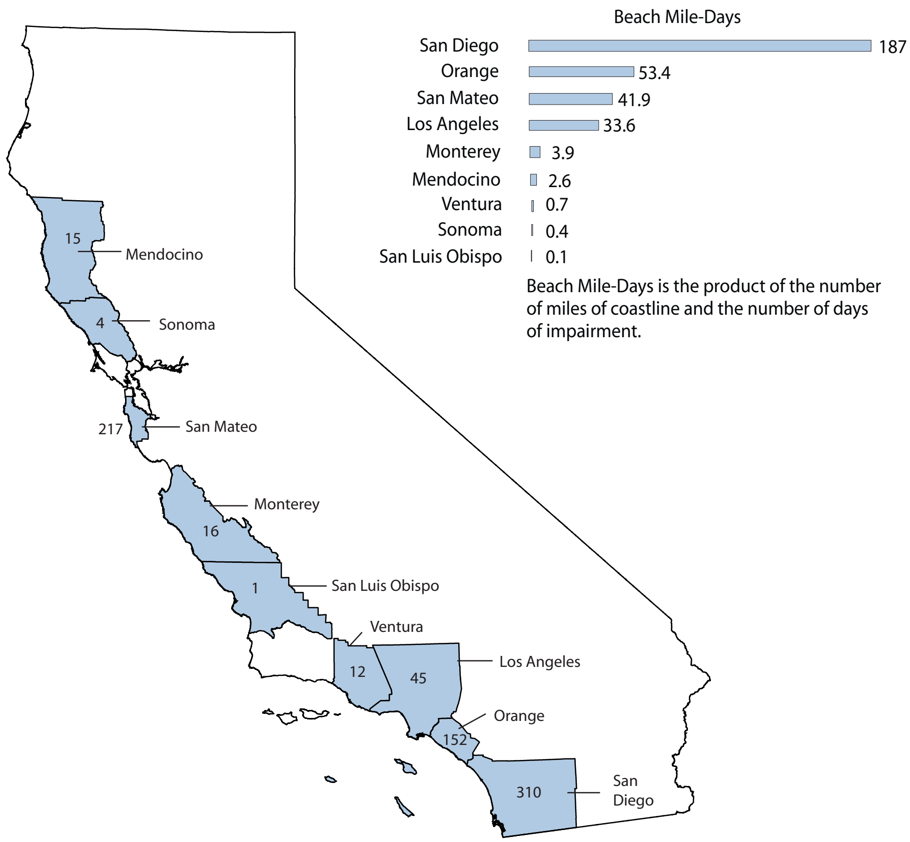


Figure 5.6

Beach Closures in California During 2000 Attributed to SSOs (CASWRCB 2001)

During 2000, nine coastal counties in California reported beach closures as a result of SSOs. Beach closure statistics are presented two ways. The number shown in each county indicates the total number of days that are least one beach in the county was closed in 2000. The number of lost beach mile-days in each county is presented in the adjacent bar chart.

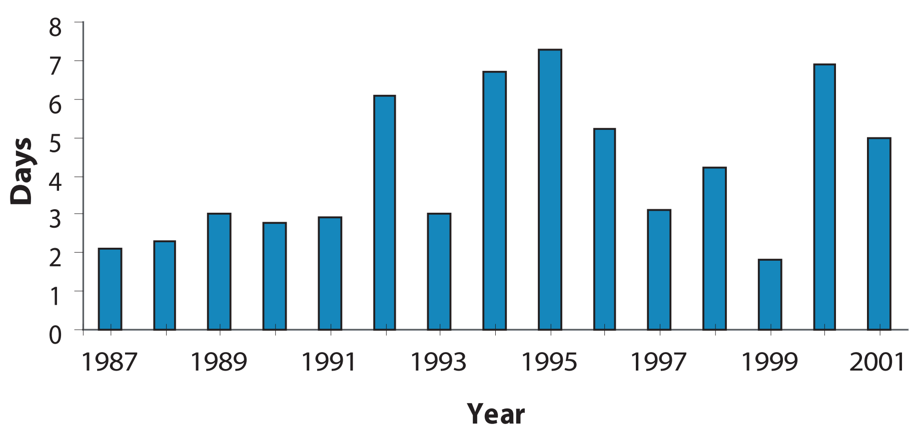


Figure 5.7

Average Number of Days per Year Coastal Municipalities in Connecticut Closed One or More Beaches (CTCEQ 2002)

Yearly variations in beach closures are a product of rainfall patterns and incidents such as sewer line ruptures. In 1999, a relatively dry summer led to less than two closings, on average. The sharp increase in beach closings in 2000 was the result of a rainy summer.

Table 5.13

Summary of Unauthorized Wastewater Discharges in Orange County, California, that Resulted in Beach Closures (Mazur 2003)

Blockages were identified as the cause of approximately three-quarters of all unauthorized wastewater discharges that resulted in beach closures in Orange County between 1999 and 2002.

Cause of Discharge	1999	2000	2001	2002
Line breaks	38	55	69	95
Blockages	210	288	308	409
Pump station failures	14	8	15	11
Treatment plant discharges	0	0	4	2
Miscellaneous	14	25	16	2
Total unauthorized discharges	**276**	**377**	**412**	**522**

A summary of the specific types of unauthorized wastewater discharges that resulted in beach closures is presented in Table 5.13. As shown, the total number of unauthorized discharges resulting in beach closures increased steadily between 1999 and 2002. However, during this same time period the total number of beach mile-days lost as a result of sewage spills has remained constant, suggesting that the impacts from individual spills have been reduced. The Orange County Health Care Agency attributes the reduced impacts to improvements in wastewater utility response procedures and increased regulatory oversight.

Lake Michigan Beach Closures

The Lake Michigan Federation tracks beach closures in Michigan, Indiana, Illinois, and Wisconsin based on data collected from local health departments, parks managers, and other municipal agencies. EPA and NRDC data were used to augment these sources prior to 2000. The Federation's tabulation of beach closures from 1998 to 2002 for all of Lake Michigan is presented in Figure 5.8. The Federation believes that CSOs are associated with a high percentage of the beach closures. Other sources of pathogens that cause or contribute to beach closures include wildlife, storm water runoff, direct human contamination, and re-suspension of bacteria in sediment (Brammeier 2003).

To examine whether CSOs were responsible for beach closures and advisories along Lake Michigan in Cook County, Illinois, the Metropolitan Water Reclamation District of Greater Chicago conducted independent research into river reversals to Lake Michigan (MWRD 2003). River reversals to Lake Michigan occur when, due to heavy rainfall, the gates that separate Lake Michigan and the Chicago River are opened. River water impacted by CSOs is discharged to the lake during river reversals. Swimming at nearby beaches is preemptively banned for two consecutive days by park officials when river reversals occur.

In its report, the District noted hat river reversals (and thus the discharge of CSO-impacted waters) to Lake Michigan were infrequent and did not explain most beach closings and advisories (MWRD 2003). Other sources of bacteria at Chicago beaches include sea gulls and bacteria in sand deposits (USGS 2001).

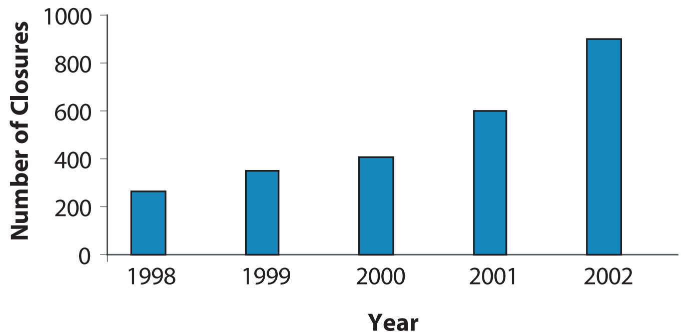


Figure 5.8

Lake Michigan Beach Closures, 1998 - 2002 (Brammeier 2003)

During the 2002 swimming season, authorities issued a total of 919 beach closures and advisories for Lake Michigan. Of the 34 Lake Michigan coastal counties, 65 percent were monitored for beach pollution, up from 50 percent in 2000.

5.5.3 Shellfish Harvesting

The designated use of shellfish harvesting is achieved when a waterbody supports a population of shellfish free from toxics and pathogens that could pose a significant human health risk to consumers. Accordingly, the principal pollutants in CSO and SSO discharges found to impact this use are pathogens, and, to a lesser extent, toxics. An example of shellfishing restrictions imposed as a result of SSO discharges is presented below.

Shellfish Harvest Limitations as a Result of SSO to the Raritan River, New Jersey

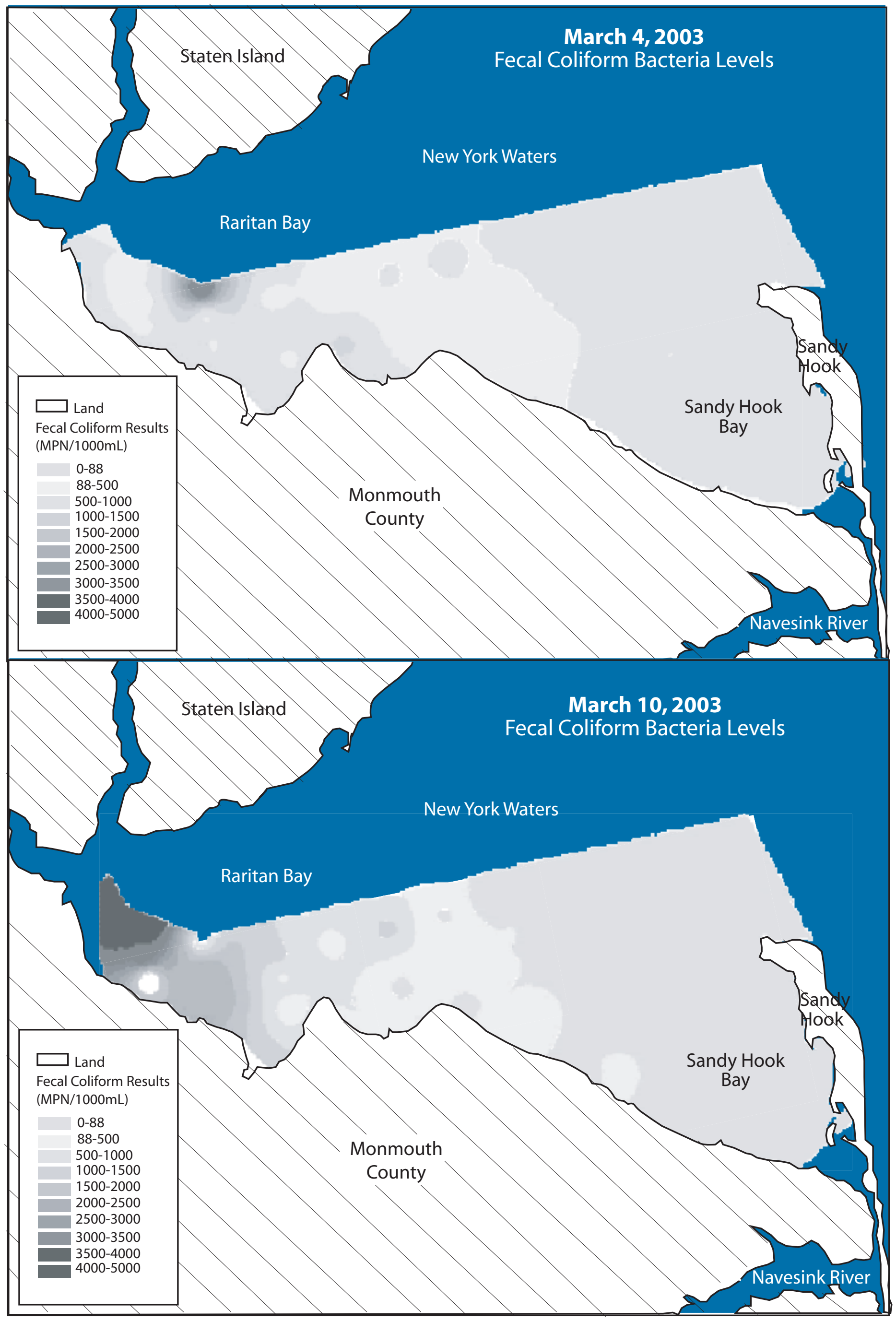
On March 2, 2003, a 102-inch diameter sewer in Middlesex County, New Jersey, ruptured and spilled untreated wastewater into residential areas and the Raritan River. Approximately 570 million gallons of wastewater were discharged over a nine-day period while the pipeline was being repaired. Daily monitoring tracked the movement of elevated bacteria levels in the river (NJDEP 2003). The spill caused high levels of fecal coliform in nearby, downstream waters including Raritan Bay, Sandy Hook Bay, and the Navesink River. EPA and the New Jersey Department of Environmental Protection (NJDEP) sampled affected waters daily and determined that fecal coliform counts were highest in the Raritan Bay (2,400–4,500 fecal coliform counts per 100 mL); counts were also high in Sandy Hook Bay (up to 1,100 fecal coliform counts per 100 mL). Once the spill was stopped, levels of fecal coliform dropped to below 88 counts per 100 mL throughout the river and bay system. By March 15, 2003 (two weeks after the spill began), the highest level reported was in the western end of Raritan Bay at an acceptable level of 43 counts per 100 mL. Fecal coliform was not detected at nearby ocean beaches. The movement of the bacteria plume and its dissipation and dilution over time are illustrated in Figure 5.9.

The spill forced NJDEP to close shellfish beds totaling approximately 30,000 acres in Raritan and Sandy Hook Bays, as well as in the Navesink and Shrewsbury Rivers. Of the total acres closed, more than 6,000 acres were reopened after four weeks, and an additional 20,000 acres were reopened after six weeks (NJDEP 2003).

Figure 5.9

Movement of Bacteria Plume from SSO Discharge in Raritan Bay, New Jersey (NJDEP 2003)

This large SSO event (570 million gallons over nine days, beginning on March 2, 2003) resulted in the closure of more than 30,000 acres of shellfish beds for four to six weeks, until shellfish tissue was clear of fecal coliform, viral, and metal contamination. Data are not shown for the Navesink River and portions of Sandy Hook Bay.



5.6 What Factors Affect the Extent of Environmental Impacts Caused by CSOs and SSOs?

Compiling and presenting information on the extent of environmental impacts caused by CSOs and SSOs is complicated by a number of factors. At the local level, site-specific water quality impacts vary depending on the volume and frequency of CSO or SSO discharges, the size and type of waterbody that receives the overflows, other sources of pollution, and the designated uses for the waterbody. Depending on the particular combination of these factors, impacts from CSOs and SSOs can be visible and intense or relatively minor. Further, because CSO and SSO discharges are intermittent and often occur during wet weather, resulting impacts can be transient and difficult to monitor. This section discusses key factors, including timescale and receiving water characteristics, that affect the extent of environmental impacts caused by CSOs and SSOs.

5.6.1 Timescale Considerations

Although CSO and SSO discharges are intermittent, the resultant impacts may not be temporary and can persist to varying degrees. Some impacts, such as aesthetic impairment due to the presence of floatable material, occur immediately when sewers overflow and are considered short-term impacts. In contrast, nutrients discharged with CSOs and SSOs can contribute to eutrophication on a time scale of weeks or months; such impacts are classified as long-term impacts. Similarly, chronic toxicity impacts associated with metals, pesticides, and synthetic organic compounds that contaminate both waterbodies and sediments can affect aquatic systems over decades.

5.6.2 Receiving Water Characteristics

The degree to which a CSO or SSO discharge produces an environmental impact in a particular waterbody depends on the rate and volume of the discharge, the degree of mixing and dilution, and the assimilative capacity of the waterbody (see Section 5.2.3). In general, the larger the waterbody and the smaller the discharge, the less likely it is that environmental impacts will occur. In contrast, small waters with little dilution and little assimilative capacity can be severely impacted by relatively small discharges.

Once pollutants are discharged into a waterbody, fate and transport processes determine the extent and severity of environmental impacts. Small-scale hydraulics, such as water movement near a discharge point, determine the initial dilution and mixing of the discharge. Large-scale water movement due to river flow and tidal action largely determine the transport of pollutants over time and distance. Processes identified as most important in assessing the impacts of CSOs and SSOs include:

- Dilution and transport of pathogens and toxics in the water column;
- Deposition of settleable solids;
- Resuspension or scour of settleable solids; and
- Chemical exchange or dilution between the water column and sediment pore water (Meyland et al. 1998).