SWIMMING IN SEWAGE

The Growing Problem of Sewage Pollution and How the Bush Administration Is Putting Our Health and Environment at Risk

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ABOUT NRDC

The Natural Resources Defense Council is a nonprofit environmental organization with more than 1 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have been working to protect the world's natural resources and improve the quality of the human environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, and San Francisco. Visit us on the World Wide Web at www.nrdc.org.

ABOUT EIP

The Environmental Integrity Project is a nonpartisan, nonprofit organization established in March of 2002 to advocate for more effective enforcement of environmental laws. The organization was founded by Eric Schaeffer, former director of the U.S. Environmental Protection Agency's Office of Regulatory Enforcement, with support from the Rockefeller Family Fund and other foundations. Visit us on the World Wide Web at www.environmentalintegrity.org.

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EXECUTIVE SUMMARY

Today, the United States is the richest and most powerful nation in the world. Across the globe, government leaders and concerned citizens look to this country as a model of technological advancement and effective infrastructure management.

Let's hope they're not looking too closely at our sewage collection system. These pipes, some as much as 200 years old, carry enough raw sewage to fill the Great Lakes about every four months.[1] Laid end to end, the pipes that carry raw sewage from America's homes, businesses, institutions, and industries would stretch to the moon and back—twice.[2] But in too many communities across the land, pipes are broken or leaking, systems are overloaded, and treatment is sometimes bypassed. The result is that in this most technologically advanced nation on the face of the planet, raw sewage backs up into people's homes with disturbing frequency, and is routinely permitted to flow into bodies of water that are sources of drinking water.

Theoretically (and by law), all this raw sewage, with its cargo of infectious bacteria, viruses, parasites, and a growing legion of potentially toxic chemicals, gets treated in wastewater treatment plants. But in reality, this aging, often neglected, and sometimes insufficient network of pipes releases untreated or only partly treated sewage directly into the environment.[3] The average age of collection system components is about 33 years, but some pipes still in use are almost 200 years old.[4,5]

Ironically, the nation at the forefront of the information age has about as clear a view of the quantity of raw sewage that leaks, spills, and backs up each year as we do of the sewage pipes buried beneath our feet. In the face of woefully inadequate data on the frequency and volume of sewage overflows, the Environmental Protection Agency's best guess is that every year, for every county in the United States, enough untreated sewage overflows to fill both the Empire State Building and Madison Square Garden.[6] These raw sewage overflows, occurring primarily during wet weather, spill into our recreational and drinking water, into groundwater, and directly onto private property, often in the form of basement backups.

Health experts in government, academia, and the private sector voice concern over lack of information and potential health impacts, particularly for the most vulnerable in our society (young children, the elderly, the immuno-suppressed, etc.) who are more susceptible when exposed to the mix of infectious organisms and toxic chemicals in untreated sewage. The problem is compounded by the rise of antibiotic-resistant "superbugs," emerging infectious organisms (such as SARS) that can be transmitted through sewage, and increases in the release of myriad toxic industrial chemicals into sewage collection systems. While there's disagreement over whether the numbers of people made sick every year from waterborne diseases in the United States are in the hundred thousands or millions, there is wide agreement that not enough information is being collected to protect public health.

This problem is bound to worsen as: (1) population growth puts added pressure on sewage collection and treatment systems already operating at or above design capacity; (2) urban sprawl creates more land area impervious to stormwater, further aggravating insufficiencies and weaknesses in the collection system during wet weather; (3) climate change increases the frequency and severity of storms in some areas; and (4) proposed changes to existing laws expose more people to untreated sewage.

Recommendations

Lack of engineering solutions is not the primary obstacle to fixing the problem of sewer overflows. Rather, what is needed is political will, enforcement of existing laws, adequate information, and billions of dollars to improve the integrity and capacity of the wastewater system infrastructure. While the costs of correcting this problem are high, ignoring it will be even more costly. Sewage overflows already cost billions every year in cleanup, emergency repair, lost tourism revenue, lost productivity, and medical treatment.

Increase federal funding for wastewater infrastructure and enforcement: Federal funding for wastewater infrastructure received the largest cut of any environmental program in President Bush's budget proposal for fiscal year 2005. The president is cutting funding while needs are spiraling out of control. The federal government should greatly increase its contribution to water infrastructure needs through a clean water trust fund. Just as a trust fund exists for highway and airport expenditures, the government should establish a trust fund for clean water. Until a trust fund is in place, funding should be increased substantially for the Clean Water State Revolving Fund—a program with an impressive track record of low-interest loans to localities for clean water projects—and for grants to assist communities in controlling combined sewer overflows.[7]

Enforce current sewage treatment plant requirements instead of allowing wet weather discharges of inadequately treated sewage: Sanitary sewer overflows are illegal, yet the EPA estimates that the number of these overflows is growing.[8] Instead of weakening environmental standards through its recently proposed policy changes, which would allow sewage to bypass certain treatment processes, the Bush administration should enforce the Clean Water Act to protect public health and the environment. Only when sewer operators know that the administration will enforce the law will they have an incentive to invest in solutions.

Fully fund and implement the federal BEACH Act of 2000: Beach closures and advisories due to high bacterial levels are at record high numbers across the United States. The Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH) requires that by April 2004, states with coastal recreational waters adopt the EPA's recommended water quality standards for bacteria and requires the EPA to update its pathogen standards by October 2005.[9] The EPA should establish water quality criteria for pathogenic viruses *Cryptosporidium,* and *Giardia,* as their presence is not well correlated with bacteria-based health standards in drinking and recreational waters and they are a leading cause of waterborne illness in the United States.

The BEACH Act also authorizes $30 million per year for state grants for monitoring and public notification, yet the EPA has provided only $10 million in annual grants since 2001 due to inadequate congressional funding. The BEACH Act should be fully funded and grants should be used for identification of beachwater contamination sources, as well as for monitoring and public notification.

Promulgate provisions of the sanitary sewer overflow (SSO) rule: In January 2001, the Bush administration announced it would set aside for further review a proposed regulation designed to keep bacteria-laden raw sewage discharges out of America's streets, waterways, and basements and make public reporting and notification of sewer overflows mandatory. The rule was based on consensus recommendations of a federal advisory committee that studied the matter for five years. The EPA still has not completed its review of the SSO rule. The agency should issue rules consistent with the recommendations of the federal advisory committee.

Require monitoring and public notification: While the EPA has the legal authority to move forward with regulations to require monitoring and reporting of raw sewage overflows, it has not done so. Therefore, NRDC and EIP urge passage of legislation introduced in Congress by Rep. Timothy Bishop (D-NY), the Raw Sewage Overflow Community Right-to-Know Act (H.R. 2215), which would force the EPA to require sewer operators to set up a program to monitor for sanitary sewer overflows and notify the public and public health authorities of raw sewage discharges.

Create a national "Sewage Release Inventory": The EPA's Toxics Release Inventory is a public database of toxic chemical releases by certain industries. A similar database of sewage releases could spur significant, voluntary reductions in raw sewage releases by making public the quantity, frequency, and impact of sewage overflows from particular sewer authorities.

Sewage authorities, local governments, and states with the highest number and volume of overflows nationally or regionally would likely be spurred to action to get out of the public spotlight. Conversely, others might be inspired by the opportunity for public recognition of good performance.

Adopt water quality standards for nutrients: Nutrients input from human sewage are implicated as a major source of harmful algae blooms in waters at our nation's bay and estuarine beaches. The EPA should require states to adopt water quality standards for nutrients, set water quality–based effluent limits for sewage treatment plants on the basis of narrative and numeric standards, and require biological nutrient removal to limit nutrient discharges into impaired waters.

Fill the data gaps: The American Society of Microbiologists concluded in 1999 that a database of information on exposure to waterborne pathogens, which would include the frequency of sewer overflows, pathogens present in the sewage, and disease outcomes of exposed individuals, is necessary to assess risk, but no such database exists. The EPA and

Centers for Disease Control should work together to fill that gap with comprehensive data from across the country, new analysis and epidemiological studies, a publicly available, searchable database, and a public education campaign. Lack of adequate information on waterborne disease is putting people at risk.

CHAPTER 1

CONTEXT

What goes up must come down. But what goes down the sewer should not come up into our basements, streets, or streams. Few Americans give much thought to the fate of the infectious wastes we flush down the toilet or the toxic wastes we pour down the drain. Most assume that raw sewage from homes, offices, and industries is kept at a safe distance from people and the environment. Few realize that treated waste is released back into our waterways, making millions of Americans sick

The nation's million-mile network of sewage collection pipes[10] is designed to safely carry roughly 50 trillion gallons of raw sewage daily[11] to about 20,000 treatment plants.[12] In 2001, however, the Environmental Protection Agency estimated there were 40,000 sanitary sewer overflows (SSO) and 400,000 backups of untreated sewage into basements.[13]

Small wonder. Sewage pipes, many between 50 and 100 years old,[14] can develop cracks or joint openings from the weight and vibration of roads, soil, and structures above them, and from the corrosive actions of water, bacteria and chemicals from inside and out. Opportunistic plant roots widen these openings, allowing raw sewage to escape into groundwater. Rainwater entering the pipes through cracks and openings, or from illegal connections, can overwhelm the capacity of the system, forcing raw sewage to purge through manholes into streets and streams, back up into basements, or otherwise bypass treatment plants. Even during dry weather, clogged, malfunctioning, or overloaded systems can discharge raw sewage.

Older municipalities, predominantly in the Northeast and the Great Lakes area, have sewage collection systems that were designed to carry both sewage and stormwater runoff. When the combined volume of sewage and stormwater overwhelm the capacity of these systems, combined sewer overflows (CSO), which contain a mix of untreated sewage and stormwater, automatically bypass treatment plants. The EPA estimates that 1.3 trillion gallons of raw sewage are dumped by CSOs each year,[15] putting communities with CSOs at risk from high concentrations of microbial pollutants.[16]

When waterways are used by multiple communities, as is the case for most of the interior portions of the United States, sewage overflows can put downstream users at risk. The Missouri River, for instance, is the source of drinking water for some of the major cities of the Midwest. Yet the distance between wastewater discharges and water supply intakes is often very short. In Michigan, for example, the distance between wastewater discharge points and water supply intakes is often less than 5 miles. The case is similar for the Ohio and Missouri rivers.[17] Thus, it is essential that the sewage collection and treatment systems operate properly to avoid exposing people to human pathogens. As

Teddy Roosevelt said in 1910, "[C]ivilized people should be able to dispose of sewage in a better way than by putting it in the drinking water."[18]

Exposure to inadequately treated sewage causes illness across the nation. The EPA estimates as many as 1.8 million to 3.5 million people get sick each year just from swimming in waters contaminated by SSOs.[19] Burgeoning populations increase both the volume of sewage sent into sewer systems and the number of people potentially exposed when SSOs and CSOs occur. A trend toward increased resistance to antibiotics and emerging infectious diseases among the larger population add greater urgency to the need for improved management of the nation's sewage collection and treatment systems and enforcement of existing laws.

SSOs are largely avoidable: the EPA estimates that about 90 percent can be fixed just through better operations and maintenance.[20] But the Association of Metropolitan Sewerage Agencies (AMSA), the sewer operators' trade association, downplays the public health significance of accidental or routine discharges of untreated sewage, and proposes study instead of action.[21] In fact, in a February 2003 letter to the EPA, the association's executive director suggested that public health would be better protected by spending money on a "national hand washing program" than by controlling raw sewage overflows.[22]

According to the EPA, without substantially increasing investment and treatment efficiency, by 2025 U.S. waters will again suffer from sewage-related pollutant loadings that are as high as they were in 1968—the highest in our nation's history.

While the sewerage agencies wash their hands of responsibility, the nation's wastewater infrastructure continues to receive an overall grade of D from the American Society of Civil Engineers (ASCE) based on condition, performance, capacity, and funding; ASCE reports a continuing downward trend.[23] According to the EPA, without substantially increasing investment and treatment efficiency, by 2025 U.S. waters will again suffer from sewage-related pollutant loadings that are as high as they were in 1968—the highest in our nation's history.[24]

The Association of Metropolitan Sewerage Agencies' resistance to action is more than matched by the Bush administration's. The administration is actively seeking to reduce federal government funds and oversight of sewage collection and treatment systems, scale back enforcement of existing laws, and limit public notification when SSOs and CSOs occur. For example, the Bush administration supports the following:

- Authorizing the intentional and routine discharge of largely untreated sewage during rain events. The EPA proposes to allow sewer operators to bypass microbial treatment of sewage, a move that would put more viruses, parasites, and other pathogens into the environment where they will make people sick.
- Shelving the EPA's SSO rule of January 2001, which, among other things, would have encouraged better operation and maintenance of sewage collection and treatment systems; required, for the first time, permits for smaller "satellite" systems; and required that health officials and the public be notified when SSOs occur.
- Reducing the Clean Water State Revolving Fund, which provides low-interest loans to states and localities for clean water projects. According to the EPA, the revolving fund "is considered a tremendous success story,"[25] but the Bush administration's budget for fiscal year 2005 proposed cutting it by $492 million, the largest cut of any environmental program.

HOLLYWOOD'S BLOCKBUSTER BACKUPS

Good operation and maintenance practices could prevent sewage spills and backups that are a chronic problem in the aging sewer pipes under Los Angeles.[a]

- **In-Need-of-Soap Opera:** Over the past three years, Los Angeles had more than 2,000 sewage spills—an annual average of about 10 per 100 miles of pipe. About 17 percent, or 341, of those spills were in buildings or on private property, but caused by problems in the city's sewer pipes.
- **Box Office Flop:** The California State Water Resources Control Board estimates public losses for the City of Los Angeles at about $2.4 million due to beach closures that reduced attendance and prohibited swimming following sewage spills in February and March 1998.[b]
- **The Vile Vile West:** In the southwest region as a whole, the rate of basement backups doubled between 1999 and 2000 from an average of 3.6 per 100 miles of sewer pipe to an average of 7.1 per 100 miles. These rates are likely an underestimate due to inadequate reporting. The Orange County Sanitation Districts, for example, do not track "[p]rivate property spills, whether caused by owners' trouble or the problems in the public system."[a]
- **Vintage Footage:** By 2010, about 75 percent of the nearly 6,000-mile Los Angeles sewer system will be more than 50 years old. Ten years after that, about 93 percent of the system will be more than 50 years old, and 49 percent will be more than 70 years old. "Similar to the wave of aging baby-boomers [Los Angeles] is facing a huge wave of sewer pipes that will soon be at retirement age."[a]
- **Our Hero:** "[G]ood management and maintenance practices can prevent spills even in old pipes. Pipe rehabilitation and replacement can be used to renew systems and thus prevent sewage spills…. [T]he fact that dozens of collection systems examined in this report have very low spill rates is evidence that it is possible to operate a collection system to have few sewage spills."[a]

[a] Greenberg, K.D., *Expert Report in United States v. City of Los Angeles,* U.S. EPA, Region IX, San Francisco, October 15, 2003.
[b] Griffin, A., Memorandum entitled: "Losses resulting from City of Los Angeles Sewage Spills," California State Water Resources Control Board, October 27, 1998.

- Ratcheting down EPA enforcement efforts. The Bush administration's budget proposals for 2004 would have eliminated 270 EPA enforcement positions, or about 13 percent of the workforce engaged in inspections and support of enforcement actions at the start of the administration.[26] So far, Congress has rejected these proposals, and should resist any further attempts by the administration to cripple the enforcement program. Reduced enforcement means increased pollution. The EPA estimates that 660 million pounds of pollutants were prevented from reaching our waters as a result of enforcement activities in fiscal year 2001, while only 261 million pounds of pollutants were blocked in fiscal year 2002.[27] As a result of its CSO and SSO enforcement actions in recent years, the EPA prevented more than 19 billion gallons of sewage from entering our nation's waters untreated in 2003.[28,29]

According to evidence compiled in a 1999 study by the American Society for Microbiology, the government should be doing more to protect public health. The group found that exposure to microbial pollution through surface water and groundwater "may become more important in the future—unless some key contributing factors are addressed immediately: improper treatment and disposal of wastewaters, aging water treatment and distribution systems, mismanagement of animal wastes, and the current lack of an integrated regulatory approach."[30]

The costs of prevention are likely to be less than the full costs of reaction to sewer overflows. When the full costs associated with SSOs and CSOs are accounted for, it is generally more expensive to repair a breach in a sewer system and clean up after a spill than it is to avoid the spill in the first place. Some of these additional costs include health care, lost revenue at recreational or commercial fishing sites closed due to sewage contamination, reduced property values, and lost worker productivity.

This report lays out some of what we know about the public health, environmental, and economic impacts of sewage discharges and outlines the major steps needed to reduce them.

CHAPTER 2

HEALTH AND ENVIRONMENTAL IMPACT

In 2002, Centers for Disease Control and Prevention (CDC) concluded that the incidence of waterborne infections from recreational water use has steadily increased over the last several decades.[31] The increase is attributed both to better reporting of these infections and to an actual increase in the number of people becoming ill. Scientists at the Johns Hopkins School of Public Health report that the majority of waterborne illnesses in the United States are associated with heavy rain storms.[32] Without proactive measures by government and sewage authorities, this trend is likely to continue because:

- Population and development pressures are generating increasing volumes of sewage and stormwater;
- Climate change is predicted to increase extreme wet weather events in parts of the United States;
- Sewer systems continue to deteriorate due to inadequate upkeep;
- "Super bugs" with resistance to antibiotics are on the rise;
- The incidence of emerging infections (e.g., SARS and pathogenic forms of *E. coli*) are increasing;
- The number of people in the United States most vulnerable to waterborne illness is increasing (e.g., the elderly); and
- Discharges of toxic industrial chemicals to wastewater treatment plants are on an upward trend.

In the face of these facts, effective and thorough sewage treatment is more urgent than ever. This section describes pollutants that may be in untreated or inadequately treated sewage and their associated health impacts.

WHAT'S IN RAW SEWAGE AND HOW IT CAN AFFECT YOUR HEALTH

Ever since the summer of 1854, when Dr. John Snow first linked sewage-contaminated water at the Broad Street pump with London's worst cholera epidemic, we've known that discharges of untreated sewage can cause disease and even death. One hundred fifty years later, sewage routinely discharged from homes, hospitals, and industrial facilities may convey any combination of pathogens, industrial chemicals, pharmaceuticals, solids, and debris through the collection system. Current laws, however, do not require as much monitoring of sewage for this broad range of pollutants as they should in order to provide

OLD NEWS

One hundred years ago, U.S. scientists and political leaders clearly recognized the public health danger of allowing raw sewage to be released into the nation's waterways:

- In 1894, "scientists at the Massachusetts State Board of Health's Lawrence Experimental Station had noticed a strong relationship between the severity of [typhoid] and the source of a city's water supply. Consequently, they explored the link and confirmed that [the disease] was transmitted by ingesting water that had been polluted with human waste containing the typhoid bacillus."[a]
- In 1909, New York Governor Charles Evans Hughes declared that the state could "no longer afford to permit the sewage of our cities and our industrial wastes to be poured into our watercourses."[b]
- In 1910, former president Theodore Roosevelt called for state and federal water pollution legislation observing that "civilized people should be able to dispose of sewage in a better way than by putting it into drinking water."[b]

[a] Andreen, W.L., "Evolution of Water Pollution Control in the United States--State, Local, and Federal Efforts, 1789-1972: Part 1," *Stanford Environmental Law Journal*, January 2003, p. 9.
[b] *Ibid,* p. 11.

the data needed to ensure effective sewage treatment regimes and better assessment of the risk of exposure to raw sewage overflows.

Pathogens

A small drop of fecal matter can contain millions of microorganisms of many types, some of which are pathogenic.[33] Microbial pathogens in raw or inadequately treated sewage can cause illnesses ranging from temporary stomach cramps to life-threatening conditions such as inflammation of the heart. While, in a healthy population, most of the illnesses resulting from exposure to inadequately treated sewage are relatively minor (respiratory illness; ear, nose or throat irritation; gastroenteritis), they can become serious in more vulnerable populations, including pregnant women, young children, the elderly, and people with suppressed immune systems (such as people with HIV, transplant recipients, and cancer patients).[34] This group accounts for 20 to 25 percent of the U.S. population and is rapidly growing in number.[35]

Infants and children show a higher incidence of waterborne illnesses than the general population.[36] The elderly, too, are at greater risk—people older than 74 have the highest mortality from waterborne or food-borne diarrheal illnesses.[37,38] Adding insult to injury, some medications required to treat waterborne illnesses (such as metronidazole, which is used to treat amoebic dysentery) may be carcinogenic or have other toxic side effects.[39]

Table 1 identifies most common waterborne pathogens and the diseases they cause. Giardiasis (a protozoan infection) is the most commonly reported intestinal disease in North America. [40,41,42] Combined sewer overflows (CSOs) are a very significant source of *Giardia*.[43] Most waterborne and seafood-borne diseases throughout the world are caused

Figure 1 Sewage Contamination at Ogden Dunes Beach on Lake Michigan. Aerial photo of Burns Waterway, Porter County, Indiana, Earth Day, April 22, 2000, one day after a major rain storm and a 20 million to 30 million gallon combined sewer overflow reported by the City of Valparaiso. Photo: Lake Erie Land Company, Coffee Creek Watershed Conservancy Project, and Tom Anderson, Save the Dunes Council.[44]

by viruses.[45] While most of the waterborne pathogens enter the sewage system through human wastes, others may enter through animal wastes such as cat feces, which many urban pet owners flush down the toilet. Cat feces may contain the infectious protozoan *Giardia lambia* [46] or the SARS (Severe Acute Respiratory Syndrome) virus.[47]

Conversely, inadequately treated human sewage can contaminate edible filter-feeding shellfish, such as clams, mussels, scallops, and oysters that eat plankton—microscopic plants and animals—by filtering them from water, which can reinfect humans with concentrations of viruses that are 100 to 900 times greater than in the surrounding water. High concentrations of infectious viruses can cause disease in unsuspecting consumers. Nationally, at least 100 outbreaks of hepatitis and viral gastroenteritis have been associated with sewage-contaminated shellfish.[48] Between 1973 and 1994, 65 cases of cholera were reported, primarily associated with consumption of raw oysters or undercooked crabs or shrimp from the Gulf of Mexico.[49] Studies by the National Academy of Sciences and CDC suggest that most seafood-associated illnesses are related to seafood contaminated with untreated or inadequately treated sewage.[50,51,52,53] The *Vibrio* bacterium, a sewage-related pathogen, is a growing problem in Florida, where almost 90 percent of fatal cases of *V. vulnificus* septicemia are due to consumption of raw Gulf Coast oysters.[54]

Other routes of exposure to pathogens in raw or inadequately treated sewage from overflows include, but are not limited to, direct contact with sewage that has backed up into homes, schools, institutions, and playgrounds; from exposure to contaminated drinking water or groundwater; or from diving, swimming, kayaking, canoeing or other activities in recreational waters.[55,56] Recreational exposure usually occurs through ingestion, but also can occur through the eyes, ears, nose, anus, skin, or genitourinary tract.[57] For example, 21 police scuba divers became ill after training in sewage-contaminated waters in New York City in 1982.[58] In a 1998 study, one-third of reported gastroenteritis cases and two-thirds of ear infections were associated with swimming in sewage-contaminated marine waters.[59] The amount of human illness after exposure to marine water appears to be increasing, and there is evidence that the rate of infection is proportional to both the amount of time swimmers are exposed and the levels of pollution in the waters where they swim.[60]

According to public health experts, the EPA's proposed policy of allowing sewage to be discharged without full treatment during rain events would exacerbate these health risks.[61] Analysis by a leading microbiologist indicates that approximately 1000 times more people would become sick from swimming in waters into which this inadequately treated sewage—euphemistically called "blended" sewage by the EPA—has been discharged.[62] The increased risk of illness from exposure to blended sewage comes from several factors: little or no treatment for *Cryptospiridium, Giardia,* or viruses, and ineffective treatment for bacteria.[63] Chlorination, the most widely used form of disinfection for sewage, does not work well when the wastewater to which it is being applied is cloudy, as blended sewage inevitably is.[64] In addition, the high concentrations of suspended solids in the partially treated wastewater could impede the switch from chlorine to less toxic and hazardous disinfection methods such as ultraviolet light—UV disinfection is less effective when wastewater contains large amounts of solids.[65]

In 2002, CSOs, sanitary sewer overflows (SSOs), and discharges of inadequately treated sewage from treatment plants were responsible for 25 percent of closing and advisory days at U.S. beaches where information on known sources of beachwater contamination were provided.[66]

Table 1
Waterborne Pathogens, Associated Illnesses, and the Wastes They're Found In

Pathogenic Agent	Acute Effects/Chronic or Ultimate Effects[67]	Wastes[68]
Bacteria:		
Campylobacter jejuni	Gastroenteritis/death from Guillain-Barré syndrome	Human/animal feces
E. coli (pathogenic or enterovirulent strains)	Gastroenteritis/*E. coli* O157:H7, adults: death from thrombocytopenia; children: death from kidney failure	Domestic sewage
Leptospira	Leptospirosis	Animal urine
Salmonella typhi	Typhoid fever/reactive arthritis from certain strains	Domestic sewage
Other salmonella species	Various enteric fevers (often called paratyphoid), gastroenteritis, septicemia (generalized infections in which organisms multiply in the bloodstream)	Domestic sewage, animal wastes, food, compost
Shigella dysenteriae and other species	Bacillary dysentery	Human feces, domestic sewage
Vibrio cholera	Cholera/death	Domestic sewage, shellfish, saltwater
Yersinia spp.	Acute gastroenteritis (including diarrhea, abdominal pain)/reactive arthritis	Water, milk, mammal-ian alimentary canal
Viruses:		
Adenovirus	Respiratory and gastrointestinal infections	Domestic sewage
Astrovirus	Gastroenteritis	Domestic sewage
Calicivirus	Gastroenteritis	Domestic sewage
Coxsackievirus (some strains)	Various, including severe respiratory diseases, fevers, rashes, paralysis, aseptic meningitis, myocarditis	Domestic sewage
Echovirus	Various, similar to Coxsackievirus (evidence is not definitive except in experimental animals)	Domestic sewage
Hepatitis A	Infectious hepatitis (liver malfunction); also may affect kidneys and spleen	Domestic sewage
Norwalk and Norwalk-like viruses	Gastroenteritis	Domestic sewage
Poliovirus	Poliomyelitis	Domestic sewage

Pathogenic Agent	**Acute Effects/Chronic or Ultimate Effects**[67]	**Wastes**[68]
Reovirus	Respiratory infections, gastroenteritis	Domestic sewage
Rotavirus	Gastroenteritis	Domestic sewage
Protozoa:		
Balantidium coli	Dysentery, intestinal ulcers	Human/animal feces (especially swine)
Cryptosporidium parvum	Gastroenteritis/death in immuno-compromised host	Human/animal feces
Cyclospora cayetanensis	Gastroenteritis	Human feces
Dientamoeba fragilis	Mild diarrhea	Human feces
Entamoeba histolytica	Amoebic dysentery, infections of other organs	Human/animal feces, domestic sewage
Giardia lambia	Giardiasis, diarrhea, abdominal cramps/failure to thrive, severe hypothyroidism, lactose intolerance, chronic joint pain	Human feces
Isospora belli and *Isospora hominus*	Intestinal parasites, gastrointestinal infection	
Toxoplasma gondii	Newborn syndrome, hearing and visual loss, mental retardation, diarrhea/dementia and/or seizures	Cat feces
Helminths (worms):		
Digenetic trematodes (flukes)		
Schistosoma haematobium	Schistsomiasis	Human feces
Schistosoma japanicum	Schistsomiasis	Human feces
Schistosoma mansoni	Schistsomiasis	Human feces
Echinostoma spp.	Diarrhea	Animal feces
Faxciola hepatica	Liver necrosis and cirrhosis	Animal feces
Paragonimus westermani	Paragonimiasis	Animal feces and crustaceans
Clonorchis sinensis	Bile duct erosion	Human feces, raw fish
Heterophyes heterophyes	Diarrhea and myocarditis	Human feces, raw fish
Cestodes (tapeworms)		
Diphyllobothrium latum	Diarrhea and anemia	Human feces, raw fish
Taeniarhynchus saginatus	Dizziness, nausea, pain, and inappetence	Human feces, raw beef
Taenia solium	Dizziness, nausea, pain, inappetence, cysticercosis	Human feces, raw pork
Echinococcus granulosus	Hydatidosis	Dog, other animal feces
Hymenolepis nana	Dizziness, nausea, pain, and inappetence	Human feces
Nematodes (roundworms)		
Trichuris trichiura	Asymptomatic to chronic hemorrhage	Human feces
Strongyloides stercoralis	Strongyloidiasis	Human feces
Necator americanus	Iron-deficiency anemia and protein deficiency	Human feces
Ancylostoma duodenale	Iron-deficiency anemia and protein deficiency	Human feces
Ascaris lumbricoides	Ascariasis	Human, pig, and other animal feces

Emerging and Reemerging Infections

New and amazing developments in technology seem to pop up by the minute in our 21st-century world, from chopsticks impregnated with antibacterials[69] to goats engineered to produce spider silk proteins in their milk.[70] Nature herself is a 24-hour, 7-day-a-week technology wizard, prodigiously engineering new "products" ranging from purple frogs[71] to lethal viruses such as HIV and SARS.

Where new meets old, the consequences can be deadly. For example, a poorly maintained sewage collection system is implicated as a factor leading to the initial spread of SARS at the Amoy Gardens residential complex in Hong Kong. Local health officials concluded that people infected with SARS "excrete coronavirus in their stools, where it could survive for longer periods than on ordinary surfaces.…It is probable that the index patient… infected… the rest of the residents in that block through the sewage system [and by other means]."[72]

Escherichia coli O157:H7, another emerging infectious organism, is mainly a food-borne pathogen, but has been transmitted through sewage-contaminated drinking water. An estimated 73,000 cases of infection and 61 deaths occur in the United States each year. Infection often leads to bloody diarrhea, and occasionally to kidney failure.[73]

Over the past 25 years, *Cryptosporidium* has emerged as one of the most common causes of drinking and recreational waterborne diseases in humans in the United States. In the spring of 1993 in Milwaukee, municipal drinking water that was within bacterial standards was contaminated with *Cryptosporidium*. An estimated 400,000 people became ill and the disease contributed to the deaths of some AIDS patients (see the Milwaukee, Wisconsin case study in Chapter 4).[74] The *Cryptosporidium parvum* parasite is found in every region of the country and throughout the world.[75] *C. parvum* "spores," called oocysts, can persist outside the body for substantially longer periods of time than other pathogens. Worse still, the oocysts are resistant to traditional types of drinking water treatment, including chlorination and ozonation (only filtration can remove oocysts), and can cause illness in humans even when present at extremely low numbers. *Cryptosporidium* was detected in more than half of raw sewage samples tested in two studies conducted in 1997.[76]

Of increasing concern recently is nature's response to the widespread use of antibiotics: the emergence of so-called superbugs that are increasingly resistant to once-powerful medications.

Of increasing concern recently is nature's response to the widespread use of antibiotics: the emergence of so-called superbugs that are increasingly resistant to once powerful medications. Whereas drug resistance used to be most common in hospital settings, there is evidence that this problem is on the rise in the general population as well.[77,78,79] The public health literature is replete with observations and warnings:

- "Widespread and permissive use of antibiotics in agriculture and for human therapeutic use where antibiotics are ineffective have resulted in an explosion of drug resistance among environmental bacterial species."[80]
- "Antimicrobial resistance in human pathogens has become a major public health issue."[81]
- "The development and spread of resistant bacteria worldwide… create the potential for the U.S. public health burden to increase."[82]
- "The rate of resistance has become so high that there are no longer effective agents to treat some pathogens."[83]
- "The incidence of antibiotic-resistant infections acquired by individuals with no risk factors [i.e. healthy individuals with normal immune systems] is increasing rapidly."[84]
- "Microbes have the extraordinary capacity for generating genetic variations and growing to immense population sizes at incredible rates; for microbes, minutes are tantamount to years."[85]

Hospitals that care for the sick, the aged, and the immuno-compromised are likely to have greater concentrations and varieties of drug-resistant pathogens, as well as the drugs themselves, in their sewage effluents.[86] In the age of frequent intercontinental jet travel, it is not improbable that exotic foreign diseases could find their way into the United States—indeed, that appears to have been the case with SARS from China and HIV from Africa. Hospitals in the United States caring for patients who have contracted particularly virulent diseases from overseas may be discharging exotic-disease pathogens into sanitary sewers. For example, CDC reports that in Africa, transmission of viral hemorrhagic fever caused by the Ebola and other viruses has been associated with exposure to body fluids, including urine and feces.[87] While CDC expects viral hemorrhagic fever infection through exposure to fully treated sewage to be extremely low, the agency recommends chemical pretreatment before discharge to the sanitary sewer system. However, there are no specific "Effluent Guidelines" for hospital wastewater discharges to publicly owned treatment works.[88] At the same time, CDC's "Issues in Health Care Settings: Infectious Waste" webpage suggests: "[s]anitary sewers may also be used to dispose of other potentially infectious [hospital] wastes that can be ground and flushed into the sewer."[89] Overflows containing inadequately treated or raw hospital sewage could pose a particularly dangerous public health threat.

For moderate-to-large metropolitan areas with diverse and mobile populations, the mix of people changes constantly and with them comes a wide range of diseases and infectious agents that are discharged into the municipal wastewater collection system as human waste. It is estimated that at any given time, the average number of people who are ill in a community ranges from 1 to 25 percent.[90] A 1999 study reported virus contamination from fecal sources in 20 percent of the groundwaters tested nationwide. More than 100 million Americans rely on groundwater for drinking.[91]

According to the World Health Organization, "[t]here will be more emerging infectious diseases."[92] Health experts warn that "[w]e live in a world in which new human pathogens emerge and old infectious diseases once thought conquered can resurface with a vengeance."[93]

"We live in a world in which new human pathogens emerge and old infectious diseases once thought conquered can resurface with a vengeance."

Industrial Chemicals

Accompanying the pathogens from human and animal wastes are the myriad chemical wastes discharged into sewage collection systems from industrial, commercial, institutional, and household activities. For simplicity in this report, we will refer to these wastes as "industrial chemicals."

Industrial chemicals include a wide range of substances, from heavy metals such as mercury, lead, and cadmium; to agents that have been manufactured and used since the dawn of the industrial age, such as sodium hydroxide and sulfuric acid; to more recently engineered compounds such as the toxic plastic additive di(2-ethylhexyl)phthalate (DEHP).

Municipalities generally require industrial facilities to "pretreat" their wastes prior to discharge into the sewage collection system. The level of pretreatment assumes further treatment will occur at the municipal waste treatment plant.[94] Sewage overflows, therefore, may contain inadequately treated industrial chemical wastes.

In 1999 and 2000, the U.S. Geological Survey (USGS) tested 139 streams in 30 states—most in close proximity to urban areas or livestock production—for 95 industrial chemicals, many of emerging environmental or public health concern. These chemicals are potentially associated with human, industrial, and agricultural wastewaters and include antibiotics, other prescription drugs, nonprescription drugs, steroids, reproductive hormones, personal care products, products of oil use and combustion, and other extensively used chemicals—they are expected to enter the environment through wastewater pathways because many are not removed by the most commonly used secondary wastewater treatment techniques.[95] In 75 percent of the streams, more than one industrial chemical was found. [96]

Quantities of Industrial Chemicals Discharged to Sewers

The EPA's Toxics Release Inventory (TRI) requires industrial facilities of a certain size and in certain sectors to report annual discharges of about 650 chemicals and chemical categories (e.g., arsenic and "arsenic compounds") sent to publicly owned treatment works. These 650 substances represent only a portion of the more than 75,000 chemicals registered in the United States for commercial use.

In 2001, the most recent year for which data are available, 339 million pounds of 247 TRI chemicals were discharged into sewage collection systems en route to publicly owned treatment works. This quantity does not include the amount discharged from facilities outside the TRI reporting universe and does not include the amount routinely poured down drains or flushed down toilets in the normal course of product use and disposal at institutions, businesses, and homes.

Figure 2 shows an overall increasing trend in the quantity of TRI chemicals sent to publicly owned treatment works between 1995 and 2001 (this comparison is based on a consistent set of industries and chemicals over the seven-year period.)

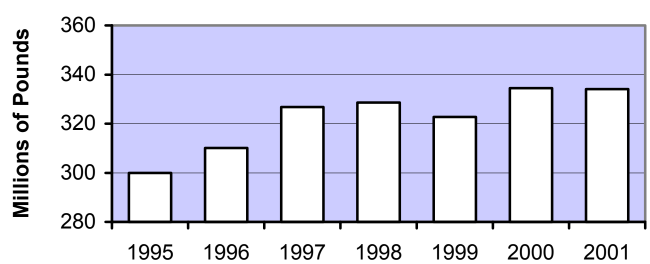

Figure 2 TRI Chemicals Sent to Publicly Owned Treatment Works

Health Effects of Industrial Chemicals

Our nation's quest to understand the potential health threats posed by industrial chemicals lags far behind our zest to use them commercially. For example:

- Relatively little is known about the health effects of most industrial chemicals registered for commercial use, including those produced in large volumes and those found in increasing quantities in blood, breast milk, and other body fluids;[97]
- Even less is known about the potential health effects of simultaneous exposure to multiple industrial chemicals (which is how most non-occupational exposures occur)—

research has shown that some chemical combinations can have additive or synergistic toxic effects;[98] and

- Virtually nothing is known about the effects of simultaneous exposure to industrial chemicals and infectious organisms.

But important health effects are being uncovered, such as the tendency of some industrial chemicals to interfere with hormones—messengers that normally regulate a wide variety of functions in the human body: "The impact of endocrine disruptors on immune system function and disease resistance is poorly understood…. [T]here are hints, nonetheless, that this may be one of the most important and far reaching routes by which endocrine disrupting chemicals undermine human health. Several studies and reviews… indicate that contaminants can erode disease resistance in ways that make people mortally vulnerable to infectious diseases they might otherwise have been able to resist."[99] More than a third of the chemicals that USGS investigated in streams are known or suspected endocrine disruptors, all of which were detected in at least one stream sample.[100] Recent research shows that daily human exposure to DEHP—used most commonly as plasticizers in the food and construction industry and the most abundant phthalate ester in the environment—is significant in the United States and is associated with changes in hormone levels.[101]

While some may suggest that the concentrations of industrial chemicals in sewage overflows are too small to be of public health concern, "[r]ecent studies using artificial skin have shown that toxic and other sewage-derived chemicals in water may enter the body through a process known as dermal absorption. Chronic exposure to chemicals through this mechanism could affect the immune system. Submerged swimmers can also be exposed to sewage-derived chemicals that can enter through the mouth, eyes, ears, and nose."[102,103] Compared to adults, young children have a greater surface-area-to-body mass ratio, and pound for pound, take in more air, food, and liquids. Along with other characteristics, this can lead to relatively greater internal doses and body burden.[104,105] Though definitive cause-and-effect relationships between low-level chemical exposure and children's health are difficult to find, "[w]e must steer a middle course between bland indifference and blind panic. We cannot afford to pretend that chemicals pose no risks to children and that discussion of such risks is purely speculative."[106]

In addition to antibiotics mentioned earlier, a broader group of pharmaceutically active compounds have been found in sewage, surface, and ground- and drinking-water samples and are recognized as an issue of public health concern.[107] The EPA is also conducting research on the presence of illicit drugs in sewage and their potential impact on the environment.[108]

For this report, NRDC looked at five of the suspected health effects that are associated with one or more of the 247 TRI chemicals discharged to publicly owned treatment works in 2001.[109] These include:

- Endocrine toxicity;
- Gastrointestinal/liver toxicity;
- Immunotoxicity;
- Respiratory toxicity; and
- Skin or sense organ toxicity.

Seventy-one percent of the 247 TRI chemicals were associated with two or more of these suspected health impacts, accounting for 45 percent (155 million pounds) of the total discharged to publicly owned treatment works in 2001. Just over 1 million pounds of suspected endocrine disruptors were discharged in 2001.[110]

More than 55,000 pounds of persistent, bioaccumulative toxins (PBTs) were sent to publicly owned treatment works in 2001—an 18.9 percent increase over the previous year.[111] While this amount may seem relatively low, it's important to recognize that these substances persist and accumulate in fatty tissues where they can reach toxic levels, particularly in humans and other creatures at the top of the food chain. Lead accounts for the bulk of PBTs sent to publicly owned treatment works, followed by polyaromatic compounds and mercury.[112] Recent research suggests that bioaccumulation in fish can lead to wider than expected environmental distribution of toxic industrial chemicals. For example, PCB-laden salmon act as biological pumps by carrying their toxic loads upstream into pristine freshwater lakes hundreds of miles inland, where they spawn, die, and increase toxic sediment concentrations as much as seven fold, potentially affecting their own offspring and predators such as bears, eagles and humans.[113]

More than 55,000 pounds of persistent, bioaccumulative, toxins were sent to publicly owned treatment works in 2001—an 18.9 percent increase over the previous year.

Environmental Pollutants

Along with pathogens and industrial chemicals, sewage contains pollutants that can directly or indirectly affect public health by altering the environment into which they are released. In addition, the wide range of pollutants in sewage can have an effect on the health of aquatic organisms.

Biological Oxygen Demand

Like humans, fish and other forms of aquatic life need oxygen to survive. Raw sewage discharges take it away, causing fish kills, habitat loss, decreased tourism, and loss of recreational opportunities.

The science behind the oxygen loss is straightforward. Sewage is food for certain microorganisms. In fact, modern sewage treatment plants rely on such organisms to do much of the heavy lifting of treatment. After "primary treatment" of sewage, which removes the solids, the plants subject sewage to "secondary treatment," and that is where the microorganisms enter the picture. They come running to the dinner table when sewage is served, and their population explodes to meet the incoming flow of "food"—the decomposable organic carbon-based components of human waste. Just as humans need to inhale oxygen while consuming burgers or broccoli, microorganisms need oxygen as they go about decomposing our waste. So plant operators make sure there's plenty of dissolved oxygen to meet the demand of these living, breathing battalions so that the final effluent is largely free of its "food" content and, therefore, its "oxygen demand."

When raw sewage is discharged to the environment before such treatment is completed, or in some cases even begun, it delivers the same meal to hungry microorganisms in surface or groundwaters. Just as they do in treatment plants, the microorganisms' numbers swell in response to the available food source. But without the extra doses of oxygen delivered by treatment plant operators, the supply of dissolved oxygen cannot keep up with demand. When enough sewage is discharged, dissolved oxygen is depleted faster than it can be replenished by photosynthesis, wave action, or other natural means. The microorganisms instead deplete the oxygen of the receiving waters, doing grave harm to other living things in the water.

According to the EPA, primary treatment typically removes only about 35 percent of oxygen-demanding pollutants. Primary and secondary treatment together remove 84–89 percent of oxygen-demanding pollutants.[114] Too little dissolved oxygen means that fish and other aquatic organisms can't breath. Hypoxic conditions arise, causing fish kills, noxious odors, and habitat loss, and leading to decreased tourism and recreational water use.

According to the EPA's most recent national water quality assessment, low dissolved oxygen is the third most frequent pollution problem in impaired estuaries. The EPA reports that the largest known pollution sources in impaired estuaries are municipal sewage treatment plant discharges, which contribute to 37 percent of the reported water quality problems in the impaired estuaries.[115] Dissolved oxygen levels in Lake Erie, whose revitalization has often been trumpeted as one of the great success stories of the 1972 Clean Water Act,[116] remains "a persistent problem," according to the EPA.[117]

In 2000, the EPA reported oxygen depletion to be a leading cause of estuary impairment in Long Island Sound,[118] which generates at least $5 billion a year in immediate revenue through boating, tourism, commercial and sport fishing, swimming, and beach-going, and generates untold billions more in enhancement of property values, aesthetic value, and climate control.[119]

Nutrients

For thousands of years, we've known that animal wastes enrich soil with important nutrients for plant growth; human waste is no different. These wastes are high in nitrogen and phosphorous, the so-called "limiting" nutrients because their absence limits the extent of plant growth, while their abundance accelerates it. Hence, the widespread use of natural or synthetic fertilizers on crop fields and lawns. But too much of a good thing is no good.

Nutrients have the same effect on aquatic plants as they have on terrestrial plants. Overfertilization of lakes and estuaries triggers massive blooms of green algae that can kill submerged aquatic vegetation by blocking their access to sunlight. As succeeding generations of algal blooms die off, they settle to the bottom where they become food for microorganisms, which deplete dissolved oxygen as they live, breath, and multiply. Unbridled input of nutrients can result in water bodies that are overgrown with algae and rooted plants, and have persistent oxygen-deprived "dead zones" that may infringe on vital fishery habitats.[120]

In 1999, the National Oceanic and Atmospheric Administration (NOAA) studied 139 estuaries and found that one-third (44) had significant nutrient pollution problems. In the North Atlantic, CSOs were ranked second out of 10 major pollution sources, after wastewater treatment plants. Nationally, wastewater treatment plants ranked second, after agricultural runoff. The report did not track the impact of SSOs. In its report, NOAA predicted that conditions will worsen in 86 estuaries by 2020 as population and development increase in coastal areas.[121]

The population of counties along the Gulf Coast, for example, increased 52 percent between 1970 and 1990. With this growth, the already poor condition of Gulf Coast estuaries from the standpoint of excessive algal growth will certainly deteriorate further without advanced wastewater treatment.[122] When they are healthy, Gulf Coast estuaries provide feeding, spawning, and breeding habitats to hundreds of species of birds, recreational and commercial fish and shellfish, and threatened and endangered species such as manatees, sea turtles, and Gulf sturgeon.[123]

Nutrient enrichment also sets the stage for blooms of toxic algae frequently associated with nerve poisons such as saxitoxin, brevetoxin, and maito-toxin, which are damaging to seabirds, marine mammals and even humans when ingested via contaminated seafood or inhaled through contaminated sea spray. More than 60,000 human infections occur each year in the United States alone, caused by toxins that exist at the limit of detection. These toxic algal blooms are increasing nationally and worldwide—both in frequency and duration.[124]

Exposure to the toxin produced by one such organism, *Pfiesteria,* during episodes of "red tides" are thought to cause memory impairment in humans.[125] Red tides, such as the particularly severe 1997 *Pfiesteria* bloom in the Chesapeake Bay region, have occurred in marine waters from Delaware to the Gulf Coast. The Mote Marine Laboratory in Sarasota, Florida, reported "moderate to high bloom with massive fish kills and respiratory irritation from St. Pete to Charlotte Harbor" from August 2001 into mid-2002. Bay waters on the Texas Gulf Coast experienced "one of the longest seasonal red tide blooms" from January through April 2002.[126]

Fecal contamination from sewage in the Florida Keys is thought to be a major source of disease in coral.

Sewage treatment plants are designed to remove a portion of the nutrients from raw sewage by transfer into solid sludge or air stripping, thereby reducing the nutrient load released to water bodies. Conventional primary and secondary treatment processes remove up to 63 percent of total nitrogen and 65 percent of total phosphorous from sewage.[127] Overflows of raw or inadequately treated sewage, therefore, inject higher concentrations of nutrients into water bodies than sewage that has received basic microbial treatment. The addition of a biological nutrient removal process increases those removal rates to up to 88 percent for nitrogen and 99 percent for phosphorous.[128] Advanced nutrient removal technologies can reverse the trend toward increasing estuary pollution as its installation in Tampa Bay has shown.[129]

Pathogens

While the environmental effects of chemical substances in sewage are well documented, pathogens themselves are now implicated as a cause of environmental impacts as well. Fecal contamination from sewage in the Florida Keys is thought to be a major source of disease in coral—the first time a bacterium from the human digestive system has been found to harm a marine invertebrate (see the Florida Keys case study in Chapter 4). Elkhorn coral (*Acropora palmata*) was once the most common form of coral in the Caribbean. Over the past decade, more than 90 percent has died. In 1999, the species was proposed for inclusion on the U.S. Endangered Species Act.[130] Concentrations of human

LAKE ERIE: CONDITION IMPROVED, BUT STILL CRITICAL

As a result of massive sewage pollution, Lake Erie was pronounced "dead" in the late 1960s and became a symbol of the urgent need to stop sewage discharges into our nation's waters. While pollution levels in Lake Erie have been reduced significantly, the lake—an important source of drinking water for communities including Buffalo, NY—is still threatened by sewage pollution, as tributaries that feed into it continue to receive thousands of gallons of untreated sewage and stormwater every time there is heavy rainfall.[a]

- The Buffalo and Niagara Rivers in Erie County, New York, are among the most polluted sites in the entire Great Lakes Basin. These rivers are impaired from both sanitary sewer overflows and combined sewer overflows.[b]
- In 2002, five beaches monitored by the Erie County Health Department were closed for 19 days—twice as many days as in 2001—because of concerns related to contaminants in sewage discharge after heavy rains and/or tests indicating potentially harmful levels of *E. coli*, fecal coliform, total coliform or enterococcus.[c]
- Residents in the greater Buffalo area report that sewage backups into their homes, which have been going on for decades, continue at the rate of several times each year.[d]

[a] Citizens Environmental Research Institute.
[b] Citizens Environmental Research Institute, "Sewage Overflows: A Discharge Map and Information on Erie County's Foremost Urban Water Quality Problem," December 1999.
[c] Mary Pasciak, "A Splash of Safety: Water Quality Officials Have Closed Local Beaches Almost Twice as Many Days This Year as Last," *Buffalo News*, August 23, 2002.
[d] Barbara O'Brien, "Board Hears Residents' Gripes About Flooded Basements," *Buffalo News*, March 13, 2001.

fecal bacterial indicators were found at two-thirds of coral surfaces tested in the Florida Keys, and viral indicators were found at 93 percent tested.[131] Each year 4 million visitors augment the 90,000 inhabitants of the Florida Keys; its reefs are the biggest diving destination in the world.[132]

Some pathogens present in raw or inadequately treated sewage will settle into bottom sediments of lakes, rivers, or streams, where they remain viable for days, months or years. Contrary to what many people assume, pathogens do not all die quickly once they enter the environment. One study, for example, found that when tracking a *Salmonella* species discharged in wastewater effluent, sedimentation effectively removed much of the bacteria from the overlying water column where it accumulated in the bottom deposits of a river. But the viable *Salmonella* species were still being recovered in the sediment over the 12-month study period.[133] Thus, when water column testing indicated a reduced number of *Salmonella* present, this result missed the high concentrations present in the sedimentary materials of the river bottom. Storm events and increases in river turbulence and flow rates resuspend the bacteria and effectively move them further downstream over time.

The risk posed by pathogens settling into bottom sediments is clearly summarized by a recent EPA discussion document, *Developing Strategy for Waterborne Microbial Disease*. In the section on "Pathogens in Sediments" is the following:

"Programs are in place to regulate discharges of chemical and biological wastes, and guidelines exist for evaluation of contamination potential from discharges. However, we do not have similar programs or guidelines to regulate or evaluate microbiological impacts of pathogens in sediments. Pathogens released from sediments pose a potential water quality risk that must be assessed. Fecal pathogens (and indicators) that normally die out within a few days in ambient water environments are known to survive for much longer periods when embedded in fecal material. Sediments also serve as a sink for pathogens (and indicators) from the water column, especially when they are attached to feces, soils, and clay particles that enhance the settling out process. A few studies have shown that particulate associated pathogens may survive for months or even years in bottom sediments under certain circumstances."[134]

THE PREVALENCE OF DISEASES LINKED TO SEWER OVERFLOWS

Inadequate data on the occurrence and impact of sewer overflows makes it difficult to definitively estimate the incidence of diseases caused by exposure to sewage-contaminated waters. Accurate estimates are further complicated by the difficulty in tracking secondary transmissions—infections passed on to others from people or pets directly exposed to untreated sewage. CDC Surveillance Summaries, for example, do not track secondary transmissions. The wide range of estimates of disease occurrence linked to sewage include these data from separate studies:

Lack of information and underreporting of waterborne illnesses is a serious obstacle to estimating their prevalence.

- 7.1 million cases of mild to moderate infectious waterborne illness cases per year and 560,000 serious cases per year;[135]
- 1.8 million to 3.5 million cases per year from swimming in waters contaminated by sanitary sewer overflows;[136]
- 900,000 cases of illness and as many as 900 deaths as a result of waterborne microbial infections;[137,138] and
- 500,000 cases of illness per year attributed to microbial contamination of drinking water.[139]

Lack of information and underreporting of waterborne illnesses is a serious obstacle to estimating their prevalence.[140] All agencies that track waterborne illnesses agree that the number of reported cases is a small subset of the actual number of illnesses caused by sewage exposure or waterborne pathogens.[141] For example, the much-publicized 1993 Milwaukee *Cryptosporidium* outbreak, the largest documented in U.S. history, went unnoticed for more than two weeks until an increase in the sale of antidiarrheal medicines was observed and reported to the local public health agency.[142] The American Society of Microbiologists concluded in 1999 that a database of information on exposure to waterborne pathogens, which would include the frequency of sewer overflows, pathogens present in the sewage, and disease outcomes of exposed individuals, is necessary to assess risk, but that no such database exists.[143]

According to the latest National Survey on Recreation and the Environment, more than 89 million Americans above the age of 16, and an undetermined number of younger and potentially more vulnerable children, went swimming in natural waters, an increase of 17 percent (13.3 million people) in six years. Additional millions were involved in other water-related recreational activities, such as kayaking, canoeing, and surfing, at even greater rates of growth (see Table 2). Despite these large numbers, few epidemiological studies have been done of swimmers, surfers, kayakers, divers, and others with regular exposure to waterborne pathogens carried by sewage.

Table 2
Recreational Activity Trends in the United States (in millions of people)[144]

Activity	1994–1995	2000–2001	Growth	
			People	Percent
Visit beach or waterside	121.5	129.4	7.9	6%
Swimming in natural waters	76.3	89.6	13.3	17%
Canoeing	13.8	20.6	6.9	50%
Kayaking	2.6	7.3	4.7	183%
Snorkeling or scuba diving	14.2	15.5	1.3	9%
Surfing	2.6	3.5	0.9	35%
Jet skiing	9.3	20.3	11.1	119%

Although a definitive national estimate is hard to pin down, local stories abound of sewer overflows that have made people sick and, in extreme cases, have caused death. In the small town of Cabool, Missouri, in 1990, a pathogenic strain of *E. coli* linked to a sewage overflow killed 4 people, hospitalized 32 and caused diarrhea and other problems for 243 more.[145] In 1988, sewage overflows in Ocoee, Florida, periodically flooded a mobile home park during heavy rains and caused occasional outbreaks of disease, including 39 cases of hepatitis A.[146] In 1997, an avid young surfer died of a heart condition apparently caused by infection with the fecal Coxsackie B4 virus after surfing in sewage-contaminated water off the Malibu coast in California (see the Malibu, California, case study in Chapter 4). In July of 1998, as a result of a power outage from a thunderstorm, about 167,000 gallons of raw sewage flowed into Brushy Creek, Texas, where it contaminated drinking water wells. As a result, about 6,000 people were exposed to contaminated drinking water and 1,440 of those became ill with gastroenteritis.[147]

The mere presence of pathogens and toxic chemicals in untreated or inadequately treated sewage does not necessarily lead to the onset of disease. A variety of factors come into play, including the volume of sewage, the pathogenic load (concentration of pathogens and/or chemicals), the type of exposure (inhalation, ingestion, dermal, etc.), the duration of exposure, and the ability of an exposed person to resist the disease (immunity).

Vulnerable populations may be susceptible to the effects of sewer overflows even if they avoid water recreational activities.[148] For example, sanitary sewer overflows can back up into basements, contaminate surface and groundwaters used as drinking sources, and often occur in areas that may be frequented by pedestrian traffic.[149] Disease outbreaks may occur in vulnerable populations after exposure to smaller concentrations of pathogens over shorter time periods than would cause outbreaks among healthy adults.

Disease-causing doses of viral and other pathogens in sewage may be lower even for healthy individuals than the bacterial doses that are used to determine water safety. For example, in an outbreak of infectious hepatitis that occurred in a military community, viruses were detected in water samples that did not detect bacteria.[150]

While bacteria die off comparatively quickly in the environment, viruses may remain active for days or weeks, and helminth eggs and protozoan cysts may remain active for many months.[151] Pathogens often survive long enough in the environment to be a potential health threat.[152]

Future Forecast

The Bush administration has recently begun to acknowledge the serious consequences of climate change.[153,154] Precipitation increased 5 to 10 percent over land areas of the Northern Hemisphere during the 20th century,[155] and global warming is predicted to further increase the intensity of rainfall events for parts of the United States.[156] What might be the impact of climate change on sewer overflows and the related health effects?

Milwaukee's experience may help us forecast. To avoid sewer overflows, Milwaukee's Metropolitan Sewer District constructed an underground sewage storage tunnel, basing the tunnel's capacity on the largest storm previously recorded in the area, which occurred in June 1940. Since 1994, the tunnel's first year of operation, five storms have exceeded the size of the 1940 storm, and at least 63 overflows have occurred, releasing more than 13 billion gallons of untreated sewage into the local environment (see the Milwaukee, Wisconsin, case study in Chapter 4).[157]

Scientists at the Johns Hopkins School of Public Health report a significant association between outbreaks of waterborne illness and rainfall, particularly during extreme weather events, which can contaminate both surface and groundwaters.[158,159]

Without measures taken to improve the operation and integrity of the nation's sewage collection systems and treatment plants, an increase in extreme wet weather events in the United States can be expected to lead to increased frequency and intensity of sewage overflows and sewage treatment bypasses. The EPA's Office of Research and Development is currently assessing the potential impacts of climate change on the frequency and size of CSOs in the Great Lakes region, and the cost implications for mitigating these impacts.[160]

CHAPTER 3

ECONOMIC IMPACT

Besides causing illness and even death, sewer overflows wreak economic damage as well. Clean water is worth hundreds of billions of dollars to the U.S. economy, including such sectors as recreation and tourism, commercial fishing, beverages, and agriculture, as well as the chemical and electronics industries, which need clean water for processing. The value of clean water to the economic and social well-being of the nation is not a recent revelation. A group of attendees at the 1909 Conference of State and Provincial Boards of Health concluded: "[t]he fact that many of our streams and lakes have been ruined for boating, bathing, and fishing, by reason of their pollution, cannot be else than a material loss to the people at large and a serious diminution in the value of the resources of the country."[161]

Nearly 100 years later, we are still in the dark regarding the real cost of sewage-contaminated waters because there is no coordinated and comprehensive national database covering the occurrence and impact of sewer overflows. For example, the Environmental Protection Agency reports that "[a]lthough SSO events that impact drinking water supplies are not uncommon, the role of SSOs in contaminating drinking water supplies and spreading illnesses may often go unidentified, unrecognized, or unreported. The toll associated with waterborne disease outbreaks—in lost work days, medical costs, and even lives—can be large."[162]

In fact, even required data often go unreported. According to the EPA, "national information on the status of collection systems and the extent of SSO problems remains limited and many municipalities are unaware of the overall extent of SSO problems in their own systems…. Forty percent of the municipalities participating in the sewerage agencies' survey reported that they did not have information on the annual number of SSOs in their systems…. Only 30 percent of the States responding to the Association of State and Interstate Water Pollution Control Administrators survey estimate that all or nearly all of their municipal permittees comply with SSO reporting requirements, with a corresponding figure of 22 percent of States for their private sector permittees."[163]

In 2002, the Congressional Budget Office echoed the uncertainty of estimating the future costs of operation and maintenance: "there is limited information available at the national level about existing [drinking and wastewater] infrastructure…. That lack of adequate system-specific data compounds the uncertainty inherent in projecting costs two decades into the future."[164] Just as the lack of accurate health-effects data should not be construed as an indication of minimal health impacts, the lack of accurate information on economic effects should not be construed as an indication of minimal economic impacts.

This section provides an overview of the estimated economic impacts of sewage-contaminated waters described in EPA, CDC, university, state government, public interest, and trade association reports. Table 3 lists the major cost elements associated with responding to, or preventing, sewer overflows.

Table 3
Costs Associated with Sewer Overflows

Response	Prevention
• Cleanup	• Sewage system upgrades
• Emergency repair	• Preventive operation/maintenance
• Medical care	• Data collection/management/reporting
• Reduced tourism/commerce/property values	
• Lost productivity	
• Increased drinking water costs	
• Natural resource damages (i.e., dead fish)	
• Fines/legal fees	
• Reporting requirements	

The EPA estimates $50.6 billion is needed to control CSOs,[165] and $28 billion to $88 billion in capital spending is needed for reducing wet weather SSOs.[166] Yet no national framework for SSO control that addresses cost information exists.

Annual costs of responding to SSOs (including basement backups) range from $1.1 billion to $6.1 billion in 1999 dollars.[167] These response costs are likely a gross underestimate due to the paucity of comprehensive information on the occurrence and consequences of sewer overflows. The EPA estimated in 2000 that monetized costs of its proposed SSO rule were on the same order of magnitude as the anticipated benefits.[168] But the agency was not able to monetize any of the following: enhanced commercial fishing, enhanced recreational shellfishing, improved water quality, reduced health risks, reduced property damage, improved aesthetic quality such as clean water and beaches, or avoided illnesses from contaminated drinking water.[169] While many of these are difficult to qualify, they are central to the value of reducing sewer overflows from the public's perspective. The EPA estimated that better monitoring and management practices required by the proposed rule would, on average, cost only $1.92 per household per year. Even in the smallest communities (under 10,000), the average cost would be $4.87 per year.[170]

COSTS ASSOCIATED WITH SEWER OVERFLOWS

At the local and regional levels, costs of responding to the impacts of sewer overflows is often in the tens of millions of dollars. In 1993, the *Cryptosporidium* outbreak in Milwaukee, for example, cost that community well over $55 million. The 1997 *Pfiesteria* bloom in the Chesapeake Bay region caused $43 million in eco nomic losses.[171]

Cleanup and Emergency Repair

Cleanup costs for basement backups caused by both CSOs and SSOs range from $305 million to $654 million per year in 1999 dollars.[172] As already mentioned, the broader universe of sewage leaks, spills, and bypasses leads to billions of dollars in emergency response, repair, and cleanup costs annually. If funds are not increased for routine, preventive maintenance programs, response costs are likely to mount as the nation's sewage collection system ages. According to the EPA, the vast majority of the sewage collection pipe network in the United States was installed after the Second World War, and pipes installed at the beginning of this wave of installation are now reaching the end of their useful life—a point at which deterioration occurs more rapidly. In 2000, the EPA reported that 23 percent of the nation's sewer pipes were in poor or very poor condition, or the timeframe of their useful life had already expired. By 2020, that number is projected to nearly double to 44 percent of the sewer collection system.[173] For example, cleanup of basements flooded with sewage from just one recent storm in Hamilton County, Ohio, will cost the sewer district $275,000. Backups from spring rains are expected to cost the sewer district a lot more.[174] If sewer operators across the country were required to pay these costs rather than passing them on to homeowners, they would have a strong incentive to prevent overflows.

In 2000, the EPA reported that 23 percent of the nation's sewer pipes were in poor or very poor condition, or the timeframe of their useful life had already expired.

Curtailed Recreation, Tourism, Commerce, and Property Values

The U.S. economy relies on clean water. The EPA estimates that coastal waters alone support 28.3 million jobs and generate $54 billion in goods and services each year. Americans spend about $44 billion on a total of 910 million trips to coastal areas each year.

Manufacturers use about 9 trillion gallons of fresh water every year for products, such as soft drinks, valued at almost $58 billion. Anglers spent $38 billion on their sport in 1996—fishing expenditures increased by 37 percent between 1991 and 1996.[175]

Polluted water puts these revenues at risk. Sewage overflows may discharge directly into water bodies where they can interfere with these commercial and recreational activities, or into basements, streets, playgrounds, and other areas where they can disrupt traffic and routine activities, effect property values, and require prompt repair and thorough cleanup.

Nutrients from sewage can cause "red tides"—blooms of the toxic algae *Pfiesteria* have occurred in marine waters from Delaware to the Gulf Coast. The 1997 *Pfiesteria* bloom in the Chesapeake Bay region caused $43 million in economic losses. Losses to the U.S. seafood and tourism industries from *Pfiesteria* are estimated at $1 billion.[176]

The California State Water Resources Control Board estimates public losses for the City of Los Angeles at about $2.4 million due to beach closures that reduced attendance and prohibited swimming following sewage spills in February and March 1998.[177]

In 2001, the public interest group Improving Kids' Environment (IKE), found that proximity to river water contaminated by CSOs had a dramatically negative impact on property values in Indianapolis, Indiana. The group's study compared a relatively clean segment of Fall's Creek, upstream of CSO outfalls, to a highly contaminated downstream segment. The downstream segment receives large and frequent sewer overflows compounded by low river volume and flow due to water utility withdrawals and a dam. By integrating address mapping information with property transaction and census data, IKE

THE U.S. ECONOMY DEPENDS ON CLEAN WATER[a]

- A third of all Americans visit coastal areas each year, making a total of 910 million trips while spending about $44 billion.
- Coastal waters support 28.3 million jobs and generate $54 billion in goods and services each year.[b]
- The travel, tourism and recreation industries supported more than 6.8 million jobs and generated annual sales in 1996 of more than $450 billion.
- The EPA estimates medical wastes and sewage on beaches cost New York and New Jersey $4 billion in losses from recreation and tourism in 1988.[c]
- The $45 billion commercial fishing and shellfishing industries need clean wetlands and coastal waters to stay in business. Every year, 250,000 people in the Great Lakes, Gulf of Mexico and coastal areas harvest more than 10 billion pounds of fish and shellfish.[b]
- In 1995, the Fish and Wildlife Service reported that the fishing industry in the U.S. Great Lakes generated about $2.2 billion in sales to local businesses.[c]
- Thirty-five million American anglers, aged 16 or older, spent $38 billion in pursuit of their sport in 1996. Fishing expenditures increased by 37 percent between 1991 and 1996. If sportfishing were incorporated as a single business, it would rank 24th on the Fortune 500 list of top sales producers, surpassing such giants as General Motors, Exxon, Mobil, and AT&T.[b]
- Manufacturers use about 9 trillion gallons of fresh water every year. The soft drink manufacturing industry alone uses more than 12 billion gallons of water annually to produce products valued at almost $58 billion.
- A *Money Magazine* survey found that clean water and clean air are two of the most important factors Americans consider in choosing a place to live. (*Money Magazine*, April 2000).
- In 1996 nearly 14 million people spent about $20 billion hunting game and migratory waterfowl. They made 223 million trips and spent $5.2 billion on trip-related expenses and $11 billion on equipment.[b]
- More than 62 million people watch and photograph wildlife every year, spending more than $29 billion.[b]
- A 1993 National Association of Home Builders study found that proximity to a body of water increases property values by an average of 28 percent. When surface water quality is poor, any positive influence is lost, or even reversed.[c]
- A 1996 study in Maine found that one meter of improved visibility in selected lakes resulted in property value increases of $11 to $200/ft of lake frontage.[c]
- In 1995, the Lake Champlain Management Conference found that improved water quality could raise property values as much as 10 percent. With an estimated $430 million in lakefront property, improved water quality would increase property values as much as $43 million.[c]

[a] U.S. EPA, *Liquid Assets 2000: America's Water Resources at a Turning Point* (2000). *Liquid Assets 2000*, http://www.epa.gov/water/liquidassets/goodnews.html.
[b] Water and Infrastructure Network, *Clean & Safe Water for the 21st Century: A Renewed National Commitment to Water and Wastewater Infrastructure*, April 2000.
[c] *Liquid Assets 1996* cited by Rubin, K.I., *A National Clean Water Trust Fund: Principles for Efficient and Effective Design*, PA Consulting Group, Prepared for AMSA, August 5, 2003.

found that along the stretches contaminated by CSOs, the 1998 median sales price for residential property along the shore dropped by 13 to 38 percent, compared to prices more than a half mile from shore. During the same time period, a significant source of combined sewer overflows to the White River, another urban waterway in Indianapolis, was eliminated. Property values of the nearby residences increased 40 percent, nearly twice the rate at Fall's Creek (an average of 23 percent). On the basis of these findings, IKE urges the State of Indiana and/or the City of Indianapolis to conduct a rigorous and comprehensive analysis by financial experts to determine the overall economic benefits that these communities may expect from reducing or eliminating CSOs.[178] For more detailed information, see the Indianapolis case study in Chapter 4.

Businesses in Allegheny County, Pennsylvania, that depend on tourist dollars during the local river recreation season may be feeling more than the effects of a national recession—river users face an increasing number of days in which they must be wary of sewage-contaminated river water. "CSO Alert Days" in 2003 were the highest since the alert program began, affecting 79 percent of the river recreation season (see Figure 3).[179]

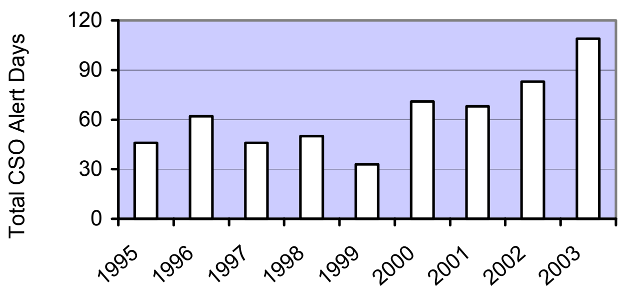

Figure 3 Total Number of CSO Alert Days in Allegheny County, PA

Nationally, estimates of the annual cost of beach closures and recreational fishing advisories due to SSOs range from $37 million to $170 million, and commercial fishing losses range from $2 million to $17 million in 1999 dollars.[180]

Medical Costs and Lost Productivity

Even a mild case of diarrhea costs an estimated $280 in lost work productivity and over-the-counter medicines, according to the *Journal of the American Water Works Association*. More severe episodes can cost $8,000 per person for medical diagnosis and treatment. Many waterborne pathogens can cause chronic diseases with costly long-term effects, such as degenerative heart disease and stomach cancer. [181]

Medical costs associated with swimming in SSO-contaminated waters (both fresh and marine) range from $591 million to $4.1 billion per year. Medical costs associated with eating shellfish harvested from SSO-contaminated waters range from $2.5 million to $22 million per year in 1999 dollars.[182]

Estimates from the 1993 Milwaukee *Cryptosporidium* outbreak indicate that about 725,000 lost work/school days were recorded during the six-week outbreak. It is estimated that the total cost of the outbreak was $96.2 million: $31.6 million in medical costs and $64.6 million in productivity losses.[183] The average cost of each case of disease ranged from $116 for mild cases to $7,808 for severe cases.[184] The EPA estimates that there are 200,000 to 643,000 cases of waterborne *Cryptosporidiosis* annually.[185] *E. coli* O157:H7 is estimated to cause 7,000 to 20,000 cases and 150 to 300 deaths each year, at a cost of $230 to $600 million in medical and productivity costs.[186] Further, there are

PITTSBURGH'S "THREE RIVERS" ARE JOINED BY A FOURTH IN WET WEATHER

Pittsburgh is famous for its location at the confluence of the Allegheny, Monongahela and Ohio rivers. But during wet weather, CSOs form a river of their own, according to Professor Jared L. Cohon, Carnegie Mellon University president recruited by the Allegheny Conference on Community Development to spearhead efforts to rectify southwestern PA's water condition:[a]

- "After a rainstorm, [the Allegheny, Monongahela and Ohio rivers] are dangerous for human contact."
- "We have the problem worse than anyone else—Pittsburgh leads the nation with the most combined sewage overflow."
- "We have to limit new development and its ability to tap into the existing sewage system."
- "We're looking at something like $10 billion to fix this."
- "By working together, there are a lot of savings to be had."

[a] Dickerson, L.A. "Perspectives: CMU's Cohon sounds $10 billion alarm on sewage treatment needs," *Pittsburgh Post Gazette*, 10/27/02 (as presented on 12/23/2003 at http://www.post-gazette.com/businessnews/20021027dickerson4.asp).

approximately 4,600 *Giardia*-related hospitalizations annually at an average cost of $3,100 per case for a total of $14 million.[187]

Transmission of drug resistance could cost the nation's health-care system upwards of $30 billion.[188] While there are a variety of ways in which drug-resistant pathogens enter the environment, sewage overflows may be an important source, particularly in areas where hospitals or other health-care facilities discharge sewage into the municipal collection system.

Long-Term Perspective

Preventing sewer overflows makes economic sense, especially in light of growing population and development pressures, anticipated increases in extreme wet weather events, emergence of resistant "superbugs" and new infectious diseases, and rising discharges of toxic industrial chemicals (see previous chapter). A case in point is the EPA's 1985 estimate of the costs and benefits of controlling CSOs in the Boston Harbor area. Restoration of recreational uses (particularly swimming) and commercial shell-fishing, as well as reduced health impacts from swimming in sewage-contaminated water and eating contaminated shellfish, were the major sources of economic benefit. In four areas around Boston Harbor (Dorchester Bay, Neponset River, Constitution Beach, and Quincy), the EPA estimated that the annual economic benefits would range from $5.4 to $11.1 million, compared to annualized CSO abatement costs ranging from $0.2 to $6.1 million.[189]

CHAPTER 4

CASE STUDIES

Sewage overflows affect the lives of real people, in real places, sometimes with devastating and tragic results. While systematic, quantitative studies on the occurrence, causes, and health, environmental, and economic impacts of sewage overflows are too few and far between, information from those who experience these events firsthand is all too common. This chapter provides a handful of case studies describing the uphill struggle facing communities that have experienced sewage overflows.

HAMILTON COUNTY, OHIO

Although the ebb and flow of tides are not associated with the U.S. Midwest, the municipal sewer system in Hamilton County, Ohio, might be an exception. But it is not ocean water coming and going—it is thick, odiferous, and infectious raw sewage from toilets flowing into the county's residential basements, playgrounds, streets, and nearby waterways.

Figure 4 Basement Backup, Cincinnati, OH

The Setting

Bordered on the south by the Ohio River and on the west by the Indiana state line, Hamilton is Ohio's third largest county, with a population of 845,303, including Cincinnati's 331,285 residents.

Thirty percent of the county's 3,000 miles of sewer lines are combined with storm sewers; most of these predate the 1950s, particularly those in the county's oldest neighborhoods. In Cincinnati, about 90 percent of the sewer lines carry both sewage and stormwater, for example.[190] Currently, the county has 256 permitted combined sewer overflows (CSOs), 99 numbered sanitary sewer overflows (SSOs) (like the one shown in Figure 5), and approximately 45 unnumbered points where SSOs occur—ranging from manholes to illicit connections to the stormwater system.[191] Such SSO discharges have been illegal for more than three decades—since the Clean Water Act was passed in 1972.[192]

The Problem

The fundamental problem with Hamilton County's sewer system is that it is overloaded. New connections have been added in areas with insufficient capacity, even while the system is badly in need of upgrades to control wet-weather infiltration that overloads the system. As a result, for a generation, millions of gallons of raw sewage and toxic industrial chemicals have been directly discharged into local waters and private homes from illegal SSOs.

Repeated Sewage Backups and Overflows

The 99 numbered SSOs occur about 900 times per year, while thousands of SSOs erupt from an estimated 45 or more unnumbered and unreported locations.[193] In one 11-month period (January to November 2001), Hamilton County saw 796 illegal sanitary sewer overflows of raw sewage from 99 sites. Over the last five years, county residents have filed 12,000 complaints of sewer backups, and many more such overflow events undoubtedly

Figure 5 SSO 603 from which raw sewage spilled seven times in 2000 and nine times in 2001 into the E.B. Mill Creek, which flows through residential yards in Hamilton County, OH.[194]

go unreported because residents are afraid of driving down property values, among other reasons. [195] The Metropolitan Sewer District of Greater Cincinnati (MSD) estimates that the county has three backups for every one homeowner complaint, and the problem of sewage in the basement may affect as many as one in four households in Hamilton County, OH.[196]

The largest of the numbered SSOs in Hamilton County is SSO 700. The sewer here runs 94 percent full even in dry weather and overflows with any size rainfall, discharging raw sewage directly into Mill Creek. SSO 700 overflows as many as 44 days per year, emitting as much as 75 million gallons of raw sewage each year. In 2001, SSO 700 discharged several times in June, July, and August—the dry weather months. Downstream, inner-city children play by the banks and even swim in Mill Creek.

Economic Impacts

In September and October 2003, the *Cincinnati Enquirer* ran a series of articles on sewage overflows in Hamilton County, after conducting interviews with a number of local residents, portions of which follow:

- A homeowner in the Cheviot community who reported a foot of flooding in his basement three times in 2003 due to a nearby combined sewer line said, "This is a health hazard to me, my wife and our two young children." Cheviot's Safety Service Director said, "That's what [sewer fees] are supposed to go to. It's like Cheviot residents have to pay twice."
- "Annette and Rick Roland estimate they have spent close to $20,000 trying to flood-proof the basement of their Delhi Township home, to no avail. 'We've lost everything four times,' she said. The Roland's house was one of 57 on Rapid Run Road that flooded when a combined sewer overflowed during a rainstorm early May 10."
- "'The city's not liable for that kind of incident because it's an act of God.' That's the response Wyoming homeowner Barbara Ross got in 2001 when she submitted a claim of about $275 for carpet ruined by flooding. 'I don't think they have a right to do this to us,' said Ross, 71, a retired professor of nursing. Ross estimates she has called MSD 150 times since 1989 seeking a solution to recurring flooding in her basement. She said she installed the carpet because MSD had told her the problem was fixed."

Largely as a result of a lawsuit filed by the Ohio Chapter of the Sierra Club, the Metropolitan Sewer District is creating a program aimed at preventing future basement backups, with MSD estimating its costs ranging from $37 million to $250 million. The Sierra Club argues that these numbers are not reliable, asserting that the sewer district's estimates are "replete with double counting and exaggerations that drive up the estimated costs of remediation beyond what is actually necessary and beyond which MSD has any realistic belief that it will either build or fund."[197]

Health impacts

Hamilton County residents are routinely exposed to pathogens in raw sewage, as well as to used condoms, tampon applicators, toilet paper, and floating human excrement. This presents a serious health risk to the residents of the county.[198]

In 1997, nine pediatricians affiliated with Cincinnati Children's Hospital urged the County Commissioners to formulate a plan for addressing the "deplorable situation" of "raw sewage overflows." Cholera and other harmful organisms are still present in many streams.[199]

In addition to infectious agents, untreated sewage can also contain toxic industrial chemicals. In 2001, 8.6 million pounds of 33 industrial chemicals were discharged into the sewer collection system in Hamilton County by the subset of industries required to report such discharges to the EPA's Toxics Release Inventory (TRI). Among these were 2,786 pounds of suspected endocrine disruptors (chemicals that can potentially damage the developing fetus even at small concentrations), and at least 2.6 million pounds of chemicals suspected of being skin, sense organ, gastrointestinal, liver, and/or respiratory toxicants. Not included in that accounting are discharges from facilities outside the TRI reporting universe, or products routinely poured down drains or flushed down toilets in the normal course of product use and disposal at institutions, businesses, and homes in Hamilton County.

Environmental Impact

Millions of gallons of raw sewage containing high levels of fecal coliform bacteria and toxic industrial wastes have been, and continue to be, directly discharged into Hamilton County waterways, including the Mill Creek and the Little Miami National Scenic River.[200] These discharges have caused or contributed to serious water pollution.[201]

The Sierra Club analyzed permit data from the Ohio EPA and found numerous permit violations for all six of MSD's wastewater treatment plants in 2001 and 2002 (see Table 4).

People swim in the Ohio River, Mill Creek, the Little Miami and other area waters that receive sewage overflows. The Ohio River Sanitary Commission warns against physical contact with the Ohio River for three days after a rainfall, because of raw sewage overflowing from SSOs and CSOs.

Table 4
Hamilton County Publicly Owned Treatment Works Violations, 2001 and 2002 Combined*

MSD Wastewater Treatment Plant	Number of Violations
Little Miami	2,273
Mill Creek	134
Muddy Creek	1,046
Polk Run	44
Sycamore	297
Taylor Creek	637

* Data source: Ohio EPA, which claims its own data are not entirely accurate. Despite repeated requests, the agency has not provided better data to the Sierra Club.[202]

Bush Administration Policies Could Discourage MSD's Planned Actions

The solutions to Hamilton County's sewage overflow problems do not require the invention of new technology; they involve a number of well-established techniques for maintaining, repairing and rehabilitating sewer systems to control overflows. Similarly, while funding issues pose a serious challenge, they are not the major stumbling block either; rate analyses suggest that system improvements are affordable over a 20-year period.[203]

The primary barrier to preventing overflows appears to be the lack of political will to rebuild the local sewer infrastructure so that it will comply with federal and state environmental laws. For example, in 1992, the Director of the Ohio EPA issued Director's Findings of Facts and Orders (DFFOs) against Hamilton County over the very same sanitary sewer overflows that bedevil the county to this day. The DFFOs required the county, within nine months, to prepare a plan for elimination of "all unpermitted discharges of sewage, industrial waste, and other wastes to the waters of the state from identified overflow points in MSD's separate sanitary sewerage system." The county failed to comply. Eleven years later, prompted by a Sierra Club lawsuit, Federal District Court Judge Arthur Spiegel ordered MSD, the Ohio EPA and the U.S. EPA to put together an agreed-to consent decree that would include remedies for victims of sewer overflows, a subject that the sewer district had refused to address for decades on the grounds that overflows were "acts of God."[204]

In January 2004, MSD's second consent decree included a new program to provide assistance to approximately 1,000 homeowners in the county with cleanup, payment for damages and a permanent fix to problems—but not for another 20 years. The Bush administration's inaction on the January 2001 SSO rule, the EPA's recent efforts to allow inadequately treated sewage to be released from treatment plants during wet weather, and cuts to federal water infrastructure funding continue to give communities across the country excuses to put off fixing their sewer systems. For Hamilton County residents, however, citizen action and litigation may finally bring an end to the stalling. Residents believe it is long overdue. In the words of one, "For over 20 years we have put up with sewage in our basements, backyards, and creek. At our own expense, we have made thousands of dollars of modifications to our properties to fight the increasing influx of sewage."[205]

THE ANACOSTIA RIVER, WASHINGTON, D.C.

The Anacostia River has long been known as the "forgotten river" among residents and river enthusiasts of Washington, D.C. It flows eight miles from Bladensburg, Maryland, to its confluence with the better-known Potomac River in the nation's capital. Once the Anacostia sustained abundant populations of fish, birds and other wildlife, but it came to be considered one of the Top Ten most polluted urban rivers in the country[206]—impoverished and underused, flowing through some of Washington's poorest communities. Recently, that has changed, the result of a new initiative to clean up the river and revitalize the Anacostia Waterfront.[207]

The Problem

Two-thirds of the Anacostia River lies on relatively flat ground, so it flows slowly—so slowly, in fact, that its movement is due less to gravity's pull on the water than to tides washing in and out of the Chesapeake Bay.[208] But tides are in no rush, and flushing the river can take from less than three weeks[209] to more than a month.[210] Several hundred years ago, when rainwater filtered through the lush forests and rich wetlands of the

Figure 6 A Dirty River Runs Through It: The Anacostia meets the Potomac in George W. Bush's backyard. The dramatic difference in color is due to the high level of sediments from combined sewer overflows and stormwater runoff.

Anacostia watershed before reaching the river, these conditions may have been advantageous to spawning fish and delicate aquatic seedlings. But now that 80 percent of the lower Anacostia's watershed is "developed,"[211] pollutant-laden water reaches the slow-moving river after washing over pavement and lawns, exiting from wastewater treatment plants, or spilling directly from sewer pipes. Rather than an environment conducive to healthy fish and laughing children, the river is a repository for microorganisms and macrotrash.

Along with the two other major waterways in the District of Columbia (the Potomac River and Rock Creek), the Anacostia is designated for use by swimmers, but water quality does not measure up to the designation, and a permanent advisory against swimming is in place due to safety concerns.[212] The district has long been in violation of fecal coliform standards designed to protect the public from becoming ill from recreational exposure to sewage-contaminated water. Similarly, since 1994, the district's rivers and tributaries have been under a fish consumption advisory issued by the D.C. Department of Health because of toxic chemical contaminants, including PCBs and polycyclic aromatic hydrocarbons.[213] By one measure, more than 50 percent of brown bullhead catfish (*Ameiurus nebulosus*) caught in the Anacostia had liver tumors, and nearly 37 percent had skin tumors.[214] Dissolved oxygen levels in the river fall below life-supporting levels 75 percent of the time, causing multiple fish kills per year.[215] In addition, the Anacostia is a "Region of Special Concern"—one of three toxic hotspots in the Chesapeake Bay—based on chemical contaminant concentrations in sediments.[216]

Figure 7 Tip of the Trashberg: Street litter washes into the Anacostia via stormwater and overflows.

The principal causes of these problems: CSOs and stormwater runoff, with recent information suggesting that SSOs are also a contributing factor.

Combined Sewer Overflows

Approximately one-third of the capital city—including the White House, U.S. Capitol, Supreme Court, U.S. Naval Observatory, many federal office buildings, and embassies—is served by a combined sewer system built by the federal government in the 1890s. Although 29 percent of Washington's 58 CSO discharge points are along the Anacostia, the river receives 66 percent (2.1 billion gallons) of the average annual volume of the city's CSOs with its cargo of raw sewage, trash, oil, grease, and other pollution. CSOs occur on average about 75 times per year in the Anacostia River, and according to the District of Columbia Water and Sewer Authority (DCWASA), as little as one-tenth to one-half inch of rain can cause CSOs.[217]

The CSO policy of April 1994 requires sewage authorities in communities with combined stormwater and sewage systems to develop a Long Term Control Plan to reduce discharges from CSOs.[218] Part of the water and sewer authority's $1.3 billion Long Term Control Plan includes the design and construction of an Anacostia River Tunnel, planned to store raw sewage during rain events long enough to be treated. NRDC and other local groups support full funding and prompt implementation of the plan, along with the use of stormwater controls to reduce the volume of the combined sewer system.[219]

Sanitary Sewer Overflows

While the CSOs have been the focal point of local efforts to clean up sewage in the Anacostia River, DNA testing shows that 14 percent of sewage in the Anacostia is of

Figure 8 Raw sewage leaking from a broken pipe (left) into the Sligo Creek, which flows into the Anacostia (right). When a staff member of the Anacostia Watershed Society noticed raw sewage flowing in the creek, he notified Washington sanitation officials who claimed its source was a stormwater pipe under the jurisdiction of another agency. Continuing upstream, he found and photographed the real source of the sewage leak: a broken WSSC sewer pipe.[220] Photo source: Anacostia Watershed Society.

human origin. It comes from sources in suburban Maryland, upstream of D.C.'s CSO outfalls.[221] Montgomery and Prince George's counties in suburban Maryland are served by an antiquated sewer system under the jurisdiction of the Washington Suburban Sanitary Commission, whose aging pipes leak human waste into tributaries of the Anacostia River.

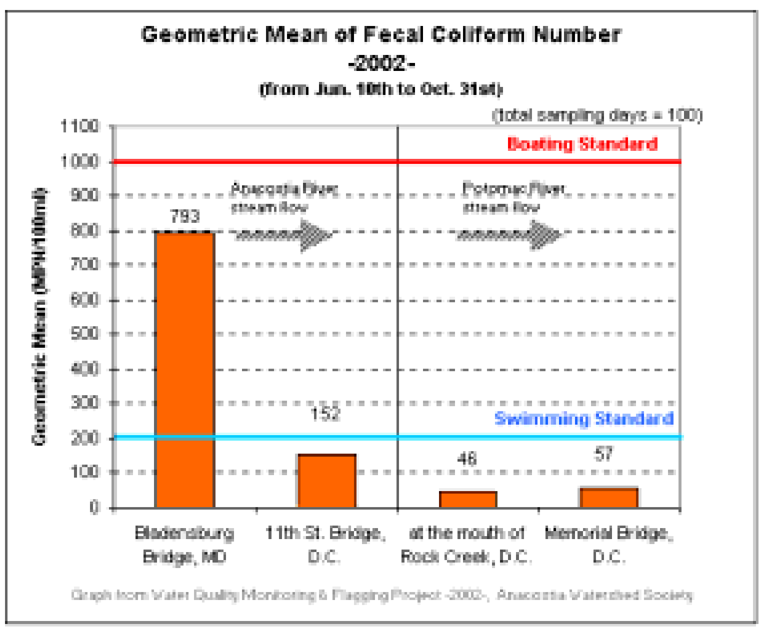

Figure 9 Fecal Coliform Levels in the Anacostia. The Bladensburg Bridge is upstream of CSO outfalls; the 11th St. Bridge is downstream.

Data collected by DCWASA and the Anacostia Watershed Society's annual Water Quality Monitoring & Flagging Project demonstrate that fecal coliform concentrations are higher upstream in suburban Maryland, above the CSO outfalls, than downstream in the District of Columbia (see Figure 9).[222, 223] That finding indicates that the sewage system in suburban Maryland is a large contributor to the pollution in the river, and it contradicts the presumption that stormwater pollution alone represented the greatest and most significant pollution source in the upper Anacostia. Sewage flows into the river from various point and nonpoint sources are literally flooding the Anacostia with human and animal waste. Therefore, upgrading the CSO system downriver in the district will only alleviate a small portion of the fecal contamination problem in the Anacostia. The problem of sewage drainage from suburban Maryland must be addressed as well; indeed, it is essential to the long-term goal of a clean and healthy Anacostia River.

INDIANAPOLIS, INDIANA

Indianapolis, Indiana, covers the bulk of Marion County in the central part of the state, population 860,454. The city is situated in the upper part of the White River watershed—a system of rivers draining more than 11,000 square miles of central and southern Indiana. Major tributaries flowing into the river in Indianapolis include Fall Creek, Pogues Run, Pleasant Run, Bean Creek, Buck Creek, Eagle Creek, and Crooked Creek. While many Indianapolis parks, trails and greenways are located along these streams, city law prohibits swimming because of poor water quality—a problem largely caused by sewer overflows.[224] The law notwithstanding, children still play in many of these neighborhood streams.

Aquatic life is also unprotected by the city's no-swimming ordinance, and succumbs to pollution caused by sewage overflows. Modeling by the City of Indianapolis indicates that a typical summer rain can create a "dead zone" near downtown Indianapolis where dissolved oxygen levels are at nearly zero for several hours.[225] Improving Kids' Environment (IKE), a local Indianapolis environmental public interest organization, provides the following overflow data for the Indianapolis metropolitan area:[226]

- SSOs and treatment plant bypasses totaled 201 in 2002, with the number of events and the gallons reported exceeding previous years;
- CSOs occur 65 days a year, with a total of 7 billion gallons released to the White River each year; and
- More than 1 billion gallons of untreated sewage are discharged over 31 days a year because treatment plants cannot handle the flow during typical wet weather.[227]

New Connections to the Sewer System Exacerbate Overflows in Indiana

Despite these problems, the Indiana Department of Environmental Management (IDEM) continues to issue permits to allow new housing developments and commercial operations to hook up to already overflowing community sewer systems. The department does not consider the impact of the new flow on CSOs when it rains. In Indianapolis, and in many of Indiana's other 106 communities plagued by CSOs, systems overflow in even a light rain. Raw sewage overflows occur in Marion County with as little as 0.3 inches of rain.[228,229]

THE INDY 500

Raw sewage from nearly 500 SSO and bypass events raced into local waterways in Indianapolis and Marion County in 2001 and 2002.[a]

- Reported overflows increased by 44 events (20 percent) in 2002.
- More than 15 million gallons of raw sewage were reportedly discharged each year. Because overflows are under reported, the actual figure is undoubtedly higher.
- More than a third of the reports of overflows each year contained no information on gallons of sewage discharged.
- From 65 to 86 percent of overflow reports with no discharge information were caused by rain, when high volumes of sewage releases could be expected.

Table 5
Indianapolis and Marion County Sewage Overflows in 2001 and 2002

			2001	2002
(A)	Number of reported sewage overflows		223	267
(B)	Gallons of sewage discharged		18,448,230	15,673,672
(C)	Reported overflows with no data on gallons of sewage discharged	Number	97	103
		Percent of (A)	43%	39%
(D)	Reported overflows with no data on gallons discharged where cause was rain related	Number	83	67
		Percent of (C)	86%	65%

[a] Indiana Department of Environmental Management data submitted to U.S. EPA and provided to NRDC.

New hookups to already overflowing systems inevitably result in more sewage overflowing into local streams. In essence, IDEM's permitting standard allows more sewage into the sewer, regardless of the certain damage to water quality and the potential impact on public health.

Even as it issues these new permits, IDEM mandates that communities with CSOs develop long-term control plans to reduce overflows, plans that are likely to cost taxpayers billions of dollars to implement. Plans submitted by Indianapolis suggest that the massive investment in controls may only be enough to offset new flows that have resulted from urban sprawl since the 1950s.

In 1999, IDEM authorized 114 new sewage connections to treatment plants in Indianapolis, for a total new authorized flow in 1999 of 3.5 million gallons a day. IKE initially described that as 100 million more gallons of new annual overflows approved in one year alone, but these increases were offset by reductions in industrial discharges to the sewage system triggered by a combination of an economic slowdown, increased water-supply rates and sewer-use fees, process changes as companies tried to reduce costs, and added storage capacity.

Chronic CSOs Depress Property Values

Fall Creek downstream from Keystone Avenue and White River downstream from 30th Street suffer the most severe effects of sewage overflows. CSO outfalls along Fall Creek are especially bad. The city's own estimates reveal that the sewer system along the creek performs much more poorly than in other areas. In normal years, it captures less of the wet weather flow (between 33 percent and 40 percent goes into the stream) and has a larger overflow volume (1.4 billion gallons) than the other systems. And for 85 days a year, neighbors must endure the stench of sewage and industrial waste flowing through the stream in this densely populated residential area.[230]

So in 2001, IKE set out to determine whether these chronic CSOs were affecting property values along Fall Creek. IKE's study compared property values along a five-mile stretch of river. The upstream half of the stretch is above CSO outfalls and is relatively clean, while the downstream half is badly contaminated from the high volume and frequency of overflows, and has low river volume and flow resulting both from water utility withdrawals and the presence of a dam. IKE integrated address-mapping information with property transaction and census data for 1990 and 1998. In the lower, contaminated stretch of the river, mean sales prices for homes dropped with proximity to the waterfront on both the north and south shorelines. In the less-contaminated stretch, property values were higher near the north shore and lower near the south shore. In 1998, mean residential property values closer to the CSO-contaminated stretch of Fall Creek dropped by 13 to 39 percent, compared to property farther from the river. IKE concluded that property values decrease with proximity to CSO-contaminated rivers, and predicted that property values would quickly increase once CSOs are eliminated. IKE called for more study, saying, "[T]he State of Indiana and/or the City of Indianapolis should arrange to have a comprehensive analysis performed in a more rigorous fashion by financial analysts to determine the overall economic benefits that the CSO communities may expect from reducing or eliminating CSOs."[231]

Property values decrease with proximity to CSO-contaminated rivers.

Industrial Chemicals Discharged into Sewers Are on the Rise

Children playing in local streams, and others exposed to sewage overflows, not only risk contracting potentially infectious waterborne diseases, but they are also exposed to an increasing amount of industrial toxic chemicals (see Figure 10). More than 1.1 million pounds of 48 industrial chemicals were discharged into the sewer collection system in Marion County in 2001, the most recent year for which EPA data are available.[232]

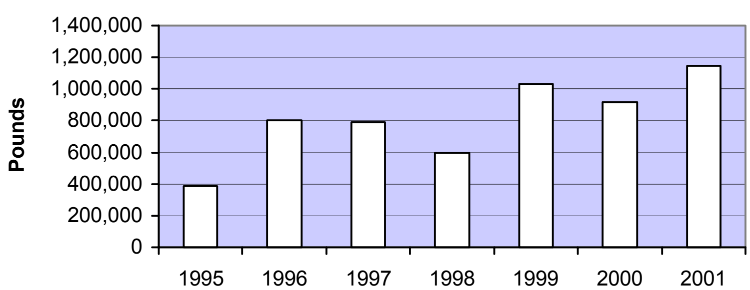

Figure 10 Toxics Release Inventory Chemicals Sent to Publicly Owned Treatment Works in Marion County, Indiana (general increasing trend in pounds, using only the set of TRI chemicals reportable in all years).

Industries discharging toxic chemical wastes directly into the sewer collection system are required to "pretreat" their wastes. But discharge-permit requirements also anticipate that a certain level of treatment will be conducted at the municipal wastewater treatment plant, prior to release into the environment. So when sewers overflow, certain of these industrial toxic wastes can be released into the environment before that additional treatment, and may pose additional health risks to exposed individuals.

Table 6 lists the quantities discharged according to suspected health effects associated with these substances. Some chemicals may cause more than one health effect. In 2001, more than 265,000 pounds of 24 individual substances associated with three or more suspected health effects were discharged into the Marion County sewers.[233]

Table 6
TRI Chemicals with Suspected Health Effects Discharged to Publicly Owned Treatment Works in Marion County, IN in 2001 (in Pounds)

Suspected Health Effect	Pounds Discharged to POTWs*
Respiratory toxicity	305,116
Gastrointestinal or liver toxicity	284,364
Skin or sense organ toxicity	269,218
Immunotoxicity	8,468
Endocrine disruption	1,451

* Exceeds annual total discharge because a chemical can have more than one health impact.

Public Notification Should Include SSOs

Before November 2003, Indianapolis was the only city in Indiana that provided any notification to the community when a CSO discharged sewage into the stream. Following the city's lead, other communities in the state are now required to notify the public.

Despite strong efforts by the environmental community, however, IDEM and the Water Pollution Control Board have not committed to adopting rules that would require public notification when SSOs occur, even though these events probably pose a greater threat to public health than CSOs because of the higher concentration of pollutants. A study by the Indiana Clean Water Coalition examined facilities discharging more than 10 million gallons of raw sewage through bypasses and SSOs during the five-and-a-half-year period from January 1, 1997, to May 2, 2002. Three facilities in Marion County discharged a total of 160 million pounds over this period, for an annual average of more than 29 million pounds (see Table 7).

Table 7
Marion County Facilities with More Than 10 Million Gallons of Bypasses and SSOs From January 1, 1997, to May 2, 2002 (does not include wet weather CSOs)[234]

Facility Name	Type	Total Gallons
Indianapolis-Belmont Municipal Sewage Treatment Plant	Municipal	133,720,300
Cumberland Municipal Sewage Treatment Plant	Municipal	15,278,812
Allison Engine Company, Inc.	Industrial	11,000,000

According to IKE, IDEM initially suggested waiting for the EPA to publish its own rule as part of the capacity, maintenance, operation and management program for sanitary sewer systems. The Bush administration has put those rules on hold, but the environmental community in Indiana continues to ask for public notification of SSOs when they occur.[235]

FLORIDA KEYS

Coral reefs are not only stunningly beautiful, they are among the oldest, most biologically diverse and economically important ecosystems in the world. Millions of aquatic organisms, from tiny crustaceans to giant fish, rely on reefs for their survival.[236] Thousands of coastal communities around the world depend on coral reefs for their food, jobs, tourism dollars, and protection from destructive ocean waves.[237] Globally, coral reefs provide an estimated $375 billion each year from food, tourism, and coastal protection.[238]

Coral reefs are considered to be the medicine cabinets of the 21st century, seen as potential sources of new disease-fighting medicines drawn from the spectacular array of self-defense and predatory chemicals produced by many of these organisms.[239] That promise of medical advances is accompanied by economic benefit: The pharmaceutical value of coral reefs in Jamaica's Montego Bay reef system alone is calculated to be between $54 million and $85 million.[240]

But coral reefs are in trouble. Over the past 10 years, the frequency of coral diseases has increased significantly, with the subsequent death of many reef-building corals around the world. Water pollution, including human sewage, and rising sea surface temperatures are thought to be major causes, because they provide suitable conditions for the proliferation and colonization of disease-causing microbes.[241]

Over the past 10 years, the frequency of coral diseases has increased significantly.

Once diseased corals die, their exposed limestone skeletons attracts foreign organisms, a process that often leads to the "health of the entire [coral reef] colony taking a downward spiral from which it seldom recovers."[242] At the current rate, coral reefs could shortly disappear. If that happens, they will not soon return. Growth rates range from 0.3 to 10 centimeters (0.1 to 4 inches) per year, and so it can take up to 10,000 years for a coral reef to form. Depending on their size, barrier reefs and atolls can take from 100,000 to 30 million years to fully form.[243]

The Setting

The Florida Keys are home to the third-largest shallow-water coral reef in the world, extending 220 miles west from just south of Miami to the Dry Tortugas. The Keys include the only emergent reefs off the continental United States.[244,245] The Keys comprise 88 percent of coral reefs in Florida, excluding the reefs of the Middle Grounds situated 100 miles off the coast in the Gulf of Mexico, reefs whose isolation and distance from populated shorelines likely provide protection from pollutants and heavy recreational fishing activity.[246] The remaining 12 percent are in southeastern Florida, extending north from Miami to Palm Beach County, and in the eastern Gulf of Mexico. Millions of people visit the coral reefs of the Florida Keys every year, and the reefs have an estimated asset value of $7.6 billion.[247]

Almost all the reefs off the Florida coast are at risk from a number of threats, including runoff of fertilizers and pollutants from farms and coastal development.[248] Coral reefs of the region are in decline, as demonstrated by decreases in coral coverage, species fluctuations, and disease.[249] The Coral Reef/Hardbottom Monitoring Project of the Water Quality Protection Program documented a 36.6 percent decline in coral cover at monitoring stations during the period between 1996 and 2000.

Human Sewage Contributes to Diseased Coral in the Florida Keys

Much of the pressure on Florida Keys coral reefs is a byproduct of heavy tourism; some 3 million visitors travel to the region each year. But tourists are not the sole source of environmental pressure. Monroe County, home of the Keys, has 78,556 permanent residents, and nearby Miami-Dade County has 2.3 million.[250] Those numbers are increasing, too. Populations in both counties grew between 1990 and 2000—by 16.3 percent in Miami-Dade and 2 percent in Monroe.[251] Monroe's slower growth rate during the last decade obscures a much more precipitous long-term population gain—160 percent since 1960.

Of course, growing populations generate larger volumes of wastewater and spur increased stormwater runoff from expanded development. Declining water quality from "highly inadequate" wastewater and stormwater management in the region already

LOSING NEMO

A 1998 World Resources Institute study finds that nearly 60 percent of the earth's coral reefs are threatened by human activity—ranging from coastal development and overfishing to inland and marine pollution—leaving much of the world's marine biodiversity at risk:[a]

- "Close to half of Hawaii's reefs are threatened."[a]
- "Virtually all of Puerto Rico's reefs are at risk—reef fisheries have plummeted during the last two decades, dropping 69 percent between 1979 and 1990."[b]
- "Jobos Bay National Estuarine Research Reserve in Puerto Rico is in poor condition due to sewage disposal and coastal erosion—coral cover averages less than 5 percent."[c]
- "Dredging, sand extraction, pier construction, and sewage effluent have all impacted U.S. Virgin Island reefs, especially those off St. Thomas and St. Croix. On some reefs, living elkhorn coral cover has fallen from 85 percent to 5 percent."[b]
- "Nearly two-thirds of Caribbean reefs are in jeopardy. Most of the reefs on the Antilles chain, including the islands of Jamaica, Barbados, Dominica and other vacation favorites, are at high risk. Reefs off Jamaica, for example, have been ravaged as a result of overfishing and pollution. Many resemble graveyards, algae-covered and depleted of fish."[a]
- "More than 80 percent of coral reefs of Southeast Asia, the most species-rich on earth, are the most threatened of any region, are at risk primarily from coastal development and fishing-related pressures."[a]

[a] Bryant, D., L. Burke, J. McManus, M. Spalding, *Reefs at Risk: A map-based indicator of potential threats to the world's coral reefs,* World Resources Institute, 1998, ISBN: 1-56973-257-4 (http://pubs.wri.org/pubs_description.cfm?PubID=2901).
[b] Rogers, Z. et al., *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2002,* National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science, Silver Spring, MD.
[c] U.S. EPA, *National Coastal Condition Report,* Office of Water, Office of Research and Development, Washington, D.C., September 2001, www.epa.gov/owow/oceans/NCCR/index.

THE KNEE BONE'S CONNECTED TO THE THIGH BONE

The natural world is a vast, interconnected network, and coral is no exception. As go coral reefs, so go seagrasses:

- "Vast underwater meadows of seagrass skirt the coasts of Australia, Alaska, southern Europe, India, east Africa, the islands of the Caribbean and other places around the globe. They provide habitat for fish and shellfish and nursery areas to the larger ocean, and perform important physical functions of filtering coastal waters, dissipating wave energy and anchoring sediments. Seagrasses often occur in proximity to, and are ecologically linked with, coral reefs, mangroves, salt marshes, bivalve reefs and other marine habitats."[a]
- "Seagrasses are also considered one of the most important shallow-marine ecosystems for humans, since they play an important role in fishery production."[b]
- "[S]eagrasses often protect coral reefs by filtering sediment and nutrients from the water."[a]
- "Like coral reefs, the seagrasses are threatened by sewage effluent and coastal developments."[c]
- "The true economic value [of seagrasses] is difficult to measure, but [UNEP's *World Atlas of Seagrasses*] suggests it is immense."[a]
- "The new $1 billion sewage processing system in Boston Harbor has encouraged seagrasses to return for the first time in 200 years."[c]

[a] United Nations Environment Program, *World Atlas of Seagrasses*, E.P. Green, F.T. Short (eds), World Conservation Monitoring Centre, University of California Press, November, 2003, www.unep-wcmc.org/marine/seagrassatlas/introduction.htm.
[b] Ibid, inside cover jacket.
[c] American Chemical Society, "Seagrasses under threat," *Environmental Science and Technology Online News,* November 21, 2003, http://pubs.acs.org/subscribe/journals/esthag-w/2003/nov/science/mb_seagrass.html.

contributes to the degradation of coral reefs.[252] Approximately 900 prefabricated wastewater treatment systems called "package plants" discharge sewage underground, and more than 25,000 septic tanks continuously leach sewage in or near coastal waters.[253] Nutrient levels in septic tank effluents are likely unsafe for coral reefs.[254]

Some attempts have been made to improve the situation. A Key West wastewater treatment plant has been upgraded to incorporate "nutrient-stripping advanced wastewater treatment" technology, and to replace a 7-million-gallon-per-day ocean outfall pipe with a deep-well injection system for treated effluent. Plant officials are also considering effluent reuse options.[255] But underground injection remains a serious problem for Florida corals, according to documents prepared on behalf of a coalition of local groups that included the Eastern Surfing Association, Palm Beach County District, Floridians for Environmental Accountability and Reform, Inc., the Surfrider Foundation's Palm Beach County and South Florida (Miami-Dade) Chapters, and Wetlands Alert, Inc.[256] The groups maintain that sewage effluent and other fluid contaminants injected into Florida's aquifer system, via hundreds of shallow and deep wells throughout the Florida Keys and south Florida, contribute to the eutrophication of nearshore waters and the death and decline of the coral reefs. The groups conclude that if harmful pathogens associated with human sewage injected into Florida's aquifer system are not destroyed before injection, they will not be destroyed while in the aquifer either. In fact, some may proliferate after injection. Approximately 404 billion gallons of injected effluent from the South Dade Wastewater Treatment Plant exceeded the fecal coliform standards over a six-and-a-half-year period.[257]

Scientists at the Harbor Branch Oceanographic Institution (HBOI) agree with the groups' conclusions: "Every day in South Florida about one billion gallons of nutrient-rich sewage that has undergone only limited treatment is pumped offshore or into underground aquifers that can allow seepage into the ocean."[258] HBOI found that the nitrogen signature of seaweed and algae overgrowing the corals matched that of nitrogen found in sewage rather than that of the natural surroundings:[259] "[T]he coral reef, the ocean's most biologically diverse and sensitive ecosystem, is telling us we're making some bad decisions."[260] HBOI scientists are working with at least one developer to design a zero-discharge development where sewage and stormwater runoff will have virtually no negative impact on the quality of the estuary and coastal ocean. The plan will use a mix of new wastewater treatment technology and aquaculture.

While nutrient pollution from wastewater and stormwater combine with other factors—including rising sea temperatures, hurricanes, oil spills, destructive fishing practices, careless tourists, and reckless boaters—to cause the overall decline of coral reefs, recent research suggests that human sewage carries a yet-unforeseen threat: bacteria that directly infect living coral. A 2002 study published in the *Proceedings of the National Academy of Sciences* reports that "[p]opulations of the shallow-water Caribbean elkhorn coral, *Acropora palmate,* are being decimated by white pox disease, with losses of living cover in the Florida Keys typically in excess of 70 percent. The rate of tissue loss is rapid, averaging 2.5 cm^2 per day…. We identify a common fecal enterobacterium, *Serratia marcescens,* as the causal agent of white pox. This is the first time, to our knowledge, that a bacterial species associated with the human gut has been shown to be a marine invertebrate pathogen."[261]

Also in 2002, researchers in the Florida Keys found higher concentrations of bacteria and enteroviruses associated with human feces at the living surface of corals (the "coral surface microlayer") than in the water above the coral reefs. This development has both environmental and public health implications: (1) higher and longer-lived concentrations of infectious organisms at the surface of living corals could exacerbate potential outbreaks of such coral disease as white pox, and (2) swimmers, snorkelers, and scuba divers may be at higher risk of infection when in the vicinity of coral reefs.[262]

Coral is vulnerable at the surface microlayer because that is where the living tissue, or polyp, resides. Hard coral reefs grow as each soft polyp builds a new limestone perch from which it extends its tentacles to feed or into which it retracts when in danger. Their bright colors come from entrapped algae that provide the polyp with oxygen, sugars and starches from photosynthesis. The algae, in turn, benefit from a secure location and the nutrients in the polyp's waste. In addition to exposing polyps to infectious microorganisms, human sewage endangers coral reefs in at least two other ways: by clouding water with suspended solids, and by providing nutrients that spur algae blooms. Both forms of pollution ultimately block sunlight from reaching the coral.

Chemical contamination may also pose risks to coral reefs, though little research has been conducted on the subject. A 1995 study in Hawaii showed that polycyclic aromatic hydrocarbons, common constituents of municipal wastes and urban runoff, become toxic and can kill coral larvae when exposed to ultraviolet radiation from sunshine.[263]

Human Sewage Contaminates Florida's Drinking Water

Underground injection of treated sewage threatens not just coral health but human health as well. Wastewater migrating from injection wells has contaminated underground sources of drinking water in south Florida. Rules proposed by the EPA would allow continued, and possibly increased, injection of treated sewage into municipal wells, even if those wells have already caused, or may cause, migration of pathogens and industrial chemicals into drinking water.[264] The Legal Environmental Assistance Foundation, a Florida-based public interest organization, is concerned that the EPA proposal threatens underground sources, because even advanced water treatment technologies may not effectively remove the myriad chemicals entering the sewage system from small industries and households, or remove viruses that otherwise pass through conventional disinfection processes.[265] The EPA should drop its rulemaking and protect the drinking water of the citizens of Florida.

MALIBU, CALIFORNIA

Erik Villanueva was an avid California surfer, whose passion brought him face to face with the most menacing of waves. He always triumphed over the waves, but in the end, it wasn't a massive wall of water that took this young man's life but a tiny virus hiding in its mist—a virus borne of human sewage that damaged his heart beyond repair.

On a stormy afternoon in May 1992, then-20-year-old Erik went surfing at Surfrider Beach in Malibu. Although the water was blackened with waste, dirt, and silt, no warning signs had been posted.[266] Soon after, he became sick and nauseated, and his symptoms

THE DEADLY SIDE OF SEWAGE

While most illnesses resulting from exposure to inadequately treated sewage appear to be relatively minor (respiratory illness; ear, nose or throat irritation; gastroenteritis), in some cases, such as Erik Villanueva's, it can turn deadly:

- CDC reports as many as 900 deaths resulting from waterborne microbial infections (see endnotes 137 and 138);
- Milwaukee's municipal water became contaminated with *Cryptosporidium* in 1993, causing 54 deaths (see endnote 142);
- In the small town of Cabool, Missouri, in 1990, a pathogenic strain of *E. coli* linked to a sewage overflow killed four people (see endnote 145);
- *Escherichia coli* O157:H7 is mainly a food-borne pathogen, but has been transmitted through sewage-contaminated drinking water. An estimated 61 deaths occur in the United States each year (see endnote 73);
- During 1999-2000, 23 states reported 59 disease outbreaks associated with recreational water use, resulting in four deaths (see endnote 31).

Figure 11. Contaminating the California Coast. Divers film a sewer outfall off the Santa Barbara coast, where the local sanitary district dumps partially treated sewage a mile from a popular beach. Photo: Jim Knowlton, healtheocean.org, April 2002.

grew progressively worse. Less than a month after he had gone surfing in the polluted waters, doctors found that his blood had been infected with the Coxsackie B4 virus, a viral infection associated with domestic sewage. Although doctors cannot say with certainty that he contracted the virus while surfing, Erik believed, and his surviving family still believes, that exposure to the sewage-laden beachwater caused his illness.

Surfrider Beach—No Stranger to Sewage Contamination

The Los Angeles County Department of Health Services, Recreational Health Program, monitors Surfrider Beach daily for three bacterial indicators of fecal contamination (total coliform, fecal coliform, and enterococcus). When tests show bacterial levels exceeding state standards for any one of these indicators, a warning sign is posted at the beach until levels drop back within safe limits.

Table 8 illustrates the ongoing problem of fecal contamination at Surfrider Beach—an average of 20 contamination events per year, each lasting an average of 4.2 consecutive days, for an average of 88 days of swimming advisories per year. Year-to-year fluctuations are partially a reflection of rainfall levels. While anecdotal reports of illnesses associated with swimming at Malibu beaches are numerous, no systematic record is maintained. The Malibu Chapter of the Surfrider Foundation has begun to document the incidence of beachwater-related illnesses through its Ocean Illness Survey, online at www.surfrider.org/oceanillness.htm.

While Los Angeles should be applauded for monitoring Surfrider Beach on a daily basis, it needs to do more to identify and control sources of fecal contamination. For 59 percent of beachwater monitoring samples showing elevated levels of fecal contamination at Surfrider Beach in 2002, the source of the contamination was reported as "unknown."[267] As a first step, California's Clean Beaches Initiative funding priority list includes the City of Malibu's proposed $7 million study of beachwater pollution sources.[268]

Table 8
Swimming Advisories at Surfrider Beach[269]

Year	Number of Advisory Events	Total Days Posted	Average Number of Consecutive Days Posted
2002	14	49	3.5
2001	26	103	4.0
2000	30	160	5.3
1999	10	39	3.9
Average	**20**	**88**	**4.2**

California Beaches—No Stranger to Viral Contamination

Viral contamination is a well-documented problem in the area. A study by the Department of Environmental Analysis and Design of the University of California, Irvine, found human adenoviruses (a group of viruses that can infect the membranes of the respiratory tract, the eyes, the intestines, and urinary tract) in four of twelve samples taken on beaches and at the mouths of major rivers and creeks from Malibu to the border of Mexico, between February and March 1999.[270]

The Santa Monica Bay Restoration Project's 1996 large-scale epidemiological study investigated possible adverse health effects associated with swimming in ocean waters contaminated by urban runoff.[271] Researchers collected water samples at three stormdrain sites on Santa Monica Bay, including Malibu Creek at Surfrider Beach, and analyzed them for enteric viruses (viruses associated with the human intestinal tract). The study found viruses at all three stormdrain sites, and a higher incidence of illness associated with swimming near flowing stormdrain outlets in Santa Monica Bay, than with swimming more than 400 yards away. In addition, illnesses were reported more often on days when the samples were positive for enteric viruses.

But Surfrider Beach does not have the benefit of regular testing for viruses, which can persist in the ocean even when bacteria tests, used by California health agencies to determine beachwater safety, indicate that beaches are safe. Fewer than 100 miles to the north of Surfrider beach, Heal the Ocean, a nonprofit public action group in Santa Barbara County, has been collaborating with Dr. Jed Fuhrman at the University of Southern California to test 10 beaches for the presence of hepatitis A and enteroviruses (including Coxsackievirus, echovirus and poliovirus), and eight potential sources of those viruses. The ten beaches are Arroyo Burro Beach, Butterfly Beach, Carpinteria State Beach, East Beach at Mission Creek, Goleta Beach, Goleta Beach East, Goleta Beach West, Hope Ranch Beach, Leadbetter Beach, and Summerland Beach. The eight potential viral sources are Arroyo Burro, Arroyo Burro Creek, Carpinteria State, El Estero Sewage Treatment Plant, Goleta Sanitary District, Goleta Slough, Las Palmas Creek (Hope Ranch), and Leadbetter.

Except during the fall of 2000, 50 to 80 percent of Santa Barbara beaches routinely test positive for hepatitis A and/or enteroviruses, and 33 to 100 percent of potential sources of contamination test positive for these viruses (see Table 9). In California, sewage contamination in beachwater is often blamed on stormwater runoff into creeks that empty into the ocean. But in the dry summer months when creeks are not running, a high percentage of the USC-tested samples still showed the presence of viruses, raising the possibility that leaky sewer pipes or septic fields are leaching into groundwater aquifers and contaminating beachwater.

Table 9
Santa Barbara Sites Testing Positive for Hepatitis A and/or Enteroviruses[272]

Season and Year	Type of Site	Total Sites Tested	Sites Testing Positive for:			
			Hepatitis A	Entero-viruses	Hep A and/or Entero	
					Number	Percent of Total
Summer 2001	beach	7	4	2	5	71%
	source	*4*	*0*	*2*	*2*	*50%*
Fall 2000	beach	4	0	0	0	0%
	source	*2*	*1*	*1*	*1*	*50%*
Summer 2000	beach	5	3	0	3	60%
	source	*3*	*1*	*0*	*1*	*33%*
Winter 1999	beach	6	0	3	3	50%
	source	*3*	*0*	*2*	*2*	*67%*
Fall 1999	beach	5	2	3	4	80%
	source	*3*	*2*	*2*	*3*	*100%*

MICHIGAN

Sewage contamination manifests itself in a variety of ways in Michigan, from sewage backups in homes to beachwaters unfit for recreation. The serious sewage problems in the state led lawmakers to place a $1 billion Clean Water Bond issue before voters on November 5, 2002, and Michiganders overwhelmingly approved the measure. The funding provided by the bond is targeted primarily at the repair and replacement of Michigan's antiquated sewer system infrastructure.[273]

Sewage-Contaminated Beaches

During the 2002 swimming season (the most recent season for which EPA data are available), beaches in Michigan's Great Lakes counties were closed, or a swimming advisory was in effect, for a total of 209 days. Sewage from CSOs, SSOs, bypasses of publicly owned treatment works, or broken sewer pipes was reported as the source of contamination for 74 closing/advisory days—61 percent of the year's total, excluding closing/advisory days where the source of contamination was reported as "unknown" (see Table 10). Sewage contamination from septic systems accounted for an additional 30 days. Other sources of beachwater contamination, including stormwater runoff, boat discharges, and wildlife, account for just 14 percent (again excluding "unknowns").

Clearly, parts of Michigan's sewage collection and treatment system, particularly in Macomb, Muskegon, and Grand Traverse counties, need improvement if beachgoers are to be protected from exposure to inadequately treated sewage (see Table 11).

Table 10
Contamination Sources of Closings/Advisories at Michigan Beaches, 2002[274]

Reported Source of Contamination	Total Closing and Advisory Days	Percent of Closing and Advisory Days	
		Total	With a Reported Contamination Source
Sewage overflows*	74	35%	61%
Septic systems	30	14%	25%
Stormwater, other**	17	8%	14%
"Unknown"	88	42%	
Total days	**209**		

* Includes CSOs, SSOs, bypasses of publicly owned treatment works, and broken sewer pipes; but excludes septic systems.
** Includes boat discharges, wildlife, etc.

Table 11
Michigan Counties Reporting Sewage Contamination at Local Beaches, 2002[275]

Great Lakes Shoreline County	Water Body	Closing and Advisory Days Due to Sewage Contamination
Macomb	Lake Saint Clair	50
Muskegon	Mona Lake	20
Grand Traverse	Grand Traverse Bay	4

Michigan CSOs and SSOs in 2001

A database tracking the occurrence and volume of CSOs and SSOs would be a valuable tool for identifying problem areas and tracking progress, but few states and localities maintain such databases. In fact, Michigan was one of only 18 states that provided data on CSOs and SSOs to the EPA for 2001.

According to that information, at least 52 counties reported 333 SSOs that spilled more than 281 million gallons; 52 additional SSOs occurred in 18 counties, but no data on gallons spilled were provided for 2001. More than 31 billion gallons were discharged from 463 CSOs in 16 counties. An additional 22 CSOs were reported in 7 counties, but no information on gallons discharged was provided (see Table 12).

Table 12
Michigan Sewage Overflows in 2001[276]

Type	Number of Overflow Events	Counties	Gallons Discharged
SSOs	333	52*	281,635,335
	52	18	No data
CSOs	463	16	31,071,608,847
	22	7	No data

* One SSO was reported for an entity named "Commerce Two" but no information was provided on the county in which this entity is located.

Genesee, Wayne (which includes Detroit), Gogebic, Oakland, and Muskegon were the top five ranking counties by reported gallons of SSOs in 2001 (see Table 13). Genesee, Oakland, Wayne, Mason, and Macomb counties ranked highest for the number of SSOs in 2001. Oakland, Genesee, and Ingham counties reported the highest number of SSOs without data on gallons of sewage spilled.

Similarly, Wayne, Macomb, Ingham (which includes Lansing), Saginaw, and Bay were the top five ranking counties by reported gallons of CSOs in 2001, with Wayne alone accounting for 88 percent of the total (see Table 14). Wayne, Ingham, Berrien, Manistee, and Kent counties ranked highest for the number of CSOs in 2001. Wayne and Ingham counties reported the highest number of CSOs without data on gallons of sewage discharged. In 2001, two beaches in Wayne County (Pier Park and Crescent Sail Yacht Club) were closed for 16 and 10 consecutive weeks, respectively—essentially the entire swim season—partly because of bacterial contamination from CSOs and SSOs.[277] Again in 2002, in addition to the 209 days of beach closings and advisories noted earlier, the same two Wayne County beaches were each closed for more than 11 consecutive weeks, again because of bacterial contamination from overflows.[278]

Annual tracking and public reporting of these data could spur the top-ranking counties to prevent CSOs and SSOs, if only to avoid the negative attention.

Table 13
Rank of Michigan Counties by Reported Gallons of SSOs in 2001[279]

County	SSO Gallons Spilled	Number of SSO Events	
		With Data on Gallons Spilled	Without Data on Gallons Spilled
Genesee	81,452,670	34	5
Wayne	62,946,285	30	4
Gogebic	47,982,800	9	0
Oakland	37,482,614	25	12
Muskegon	27,200,200	9	0
Macomb	5,078,450	27	4
Eaton	2,997,005	5	1
Mason	2,474,271	31	1
Washtenaw	1,692,475	15	3
Berrien	1,522,600	14	0
Kent	1,513,060	7	1
Ingham	1,333,150	4	5
Lenawee	1,237,920	5	0
Clinton	1,116,200	7	0
Sanilac	1,037,450	3	0
Saginaw	996,973	8	1
Tuscola	902,600	2	0
Shiawassee	554,700	8	2
Lapeer	500,600	2	4
Ottawa	333,800	5	0
Montcalm	209,000	1	0
Allegan	172,740	5	0
Oceana	120,000	1	0
St. Clair	120,000	1	2
Ionia	112,000	3	1
Livingston	108,500	7	0
Cheboygan	108,000	1	0
Kalamazoo	102,700	3	1
Mecosta	65,000	1	0
Huron	50,850	3	0
Ogemaw	18,000	1	0
Manistee	14,000	3	0
Newaygo	13,000	2	0
Cass	12,100	2	0
Jackson	8,320	3	0
Branch	8,000	2	0
Midland	6,000	2	0
Grand Traverse	5,100	2	0

County	SSO Gallons Spilled	Number of SSO Events	
		With Data on Gallons Spilled	Without Data on Gallons Spilled
Hillsdale	5,000	1	0
Barry	4,108	17	0
Calhoun	3,150	3	1
Charlevoix	3,000	2	0
Ontonagon	3,000	1	0
Van Buren	2,450	3	2
Keweenaw	1,500	1	0
Marquette	1,100	3	2
Antrim	1,000	1	0
Baraga	1,000	2	0
(County name missing*)	500	1	0
Menominee	200	2	0
Bay	150	1	0
Isabella	40	1	0
Iron	4	1	0
TOTAL	**281,635,335**	**333**	**52**

* Entity listed as "Commerce Two."

Table 14
Rank of Michigan Counties by Reported Gallons of CSOs in 2001[280]

County	CSO Gallons Discharged	Number of CSO Events	
		With data on gallons discharged	Without data on gallons discharged
Wayne	27,312,290,627	173	7
Macomb	1,615,800,000	21	3
Ingham	740,796,016	50	5
Saginaw	656,570,000	12	0
Bay	244,450,000	12	0
Houghton	156,498,100	14	0
St. Clair	131,593,000	29	0
Oakland	66,880,000	10	3
Kent	62,939,000	30	0
Lenawee	32,617,600	9	0
Berrien	30,983,000	49	0
Gogebic	9,573,000	2	1
Dickinson	6,208,800	7	0
Manistee	2,955,054	40	0
Sanilac	1,452,000	4	1
Schoolcraft	2,650	1	0
Iron	no data	0	2
TOTAL	**31,071,608,847**	**463**	**22**

Basement Backups

After a "10-year" storm hit Michigan in 1998, the municipal sewer system in the greater Detroit area backed up into thousands of private basements. In two subsequent class-action suits, homeowners sued the cities of Allen Park and Farmington Hills to recover damages estimated at $2.2 million.[281] According to attorneys in those cases, 15,000 other families in nine downriver communities are also filing class-action suits.[282]

Basement backups in Michigan are not limited to unusually heavy storms. The assistant city attorney for Birmingham, in Oakland County, told reporters in 1999 that money was scarce for repair of the region's oldest pipes, but population growth is rapid. Residents filed 18 sewage-related suits against the city between 1996 and 1999.[283]

In 1999 and 2000, about 2,000 homeowners in Michigan sustained sewage-related damage to their homes.[284] An attorney in St. Clair Shores, Macomb County, told the *Detroit Free Press* that sewer problems have become so common in Michigan since 1993 that he has built his law practice around suing governments.[285]

MILWAUKEE, WISCONSIN

In the spring of 1993, Milwaukee made water-contamination history when its municipal drinking water became contaminated with *Cryptosporidium,* a parasite that passed through the filtration system of one of the city's two water-treatment plants. Indicator bacteria tests, used to determine drinking and recreational water safety, do not directly measure the levels of such parasites. An estimated 400,000 people became ill, and as many as 100 of them died.[286]

A FUNGUS AMONG US: TOXIC MOLD

Mold associated with prolonged moisture is an emerging health issue in the United States. Molds produce allergens, irritants and, in the case of toxic black mold (*Stachybotrys atra),* potentially toxic substances (mycotoxins). While the sources of toxic black molds are not necessarily a constituent of raw sewage, the molds are of increasing concern in indoor environments where chronic moisture problems occur.

- Sewage overflows, particularly repeated basement backups into homes, institutions and businesses, are known to provide an environment for the growth of molds and other fungi that can develop within 24–48 hours of exposure.[a]
- Toxic black molds proliferate on such cellulose-based materials as wood, paper and certain natural fibers, but have also been found on other common household and building materials, including pipe insulation, gypsum, fiberglass wallpaper and even aluminum foil. The American Society for Microbiology reports that "[s]tudies using cellulose-based agar techniques have reported a relatively high prevalence of *Stachybotrys,* with positive cultures in up to 30 percent of water-damaged homes."[b]
- As with other potential health impacts associated with sewage overflows, vulnerable populations, including infants, children, immune-compromised patients, pregnant women, individuals with existing respiratory conditions and the elderly are at higher risks for adverse health effects from mold.[a,c]
- The growth and proliferation of toxic black molds inside a home, business or institution can require immediate, disruptive and costly cleanup procedures to protect the health of humans and pets.

[a] Federal Emergency Management Agency (FEMA), *Dealing With Mold and Mildew in Your Flood Damaged Home,* Washington, D.C.
[b] Kuhn, D. M., M. A. Ghannoum, "Indoor Mold, Toxigenic Fungi, and Stachybotrys chartarum: Infectious Disease Perspective," *Clinical Microbiology Reviews,* vol. 16, no. 1, American Society for Microbiology, January 2003, p. 146.
[c] American College of Occupational and Environmental Medicine, *Adverse Human Health Effects Associated with Molds in the Indoor Environment,* October 27, 2002, pp. 1–2.

The Setting

The city of Milwaukee owns and operates its own sewer system. Together with the sewage from 27 other municipalities, the city's raw sewage travels through a 2,200-mile network of collection pipes to the Milwaukee Metropolitan Sewerage District (MMSD)—the largest wastewater discharger to the largest lake within U.S. borders.[287]

MMSD conveys this sewage, and in some cases stormwater, through its own 310-mile pipe system to two wastewater treatment plants or to the 19.4-mile-long Deep Tunnel, which can temporarily store up to 405 million gallons of untreated sewage during wet weather.[288,289] Milwaukee initiated the $716 million Deep Tunnel after the city was sued by Chicago for sewage discharges to Lake Michigan in the 1980s.[290,291] However, according to a 2002 Wisconsin Legislative Audit Bureau evaluation of MMSD, the Deep Tunnel has fallen short of original expectations: "Sanitary sewer overflows continue, and more than twice the predicted number of combined sewer overflows has occurred since the Deep Tunnel began operation."[292] Milwaukee's experience shows that even massive storage tunnels are not a substitute for regular operation and maintenance of sewage collection systems and effective prevention of stormwater inflow and infiltration.

Sewer Overflows

Within its own pipe system, MMSD maintains a total of 153 sewage overflow points (121 CSOs and 32 SSOs) from which untreated wastewater may be discharged to local waterways. MMSD designed and constructed the temporary storage Deep Tunnel in 1994 to avoid sewer overflows under the heaviest of storm conditions, using the largest previously recorded Milwaukee storm, which occurred in June 1940, as a benchmark.[293]

Since 1994, 43 SSOs have discharged more than 935 million gallons of full-strength, untreated sewage, and at least 24 CSOs have discharged more than 12 billion gallons of raw sewage and stormwater into the Milwaukee, Kinnickinnic and Menomonee rivers, and into Lake Michigan, a source of drinking water for more than 10 million people (see Table 15).[294] Between 2000 and 2002, the city of Milwaukee's sewage system released an additional 843,200 gallons during eight SSOs.[295]

In 2002, the Wisconsin Legislative Audit Bureau's evaluation of MMSD concluded that the larger than expected number and volume of sewage overflows since the construction of the Deep Tunnel are attributable to a number of factors, including stronger and more frequent storms and continued deterioration of the system's old pipes: "In planning the Deep Tunnel's capacity, engineers assumed inflow and infiltration would be reduced by 12.5 percent through projects undertaken as part of the Water Pollution Abatement Program. However, the most current information available suggests that inflow and infiltration have actually increased by 17.4 percent over 1980 levels. According to [MMSD], the increase in inflow and infiltration suggests progressive deterioration of the sewer systems over time, because higher rates of infiltration are expected in aging sewer systems."[296]

Table 15
Reported Sewer Overflows in Milwaukee[297,298]

Collection System Owner	Year	SSOs	SSO Gallons	CSOs	CSO Gallons
Milwaukee Metropolitan Sewerage District	1994	1	2,300,000	1	171,200,000
	1995	5	73,200,000	1	773,300,000
	1996	3	67,700,000	4	674,900,000
	1997	5	248,600,000	2	1,991,500,000
	1998	4	79,600,000	2	629,300,000
	1999	8	271,700,000	6	4,105,400,000
	2000	5	136,029,000	5	3,489,700,000
	2001	8	56,227,400	3	464,600,000
	2002	4	no data	no data	no data
	Total	**43**	**935,356,400**	**24**	**12,299,900,000**
Milwaukee, City	2000	3	752,000	no data	no data
	2001	2	51,000*	no data	no data
	2002	3	40,200	no data	no data
	Total	**8**	**843,200**	**no data**	**no data**

* Gallons are from one event only.

Sewage-Contaminated Beachwater

The vast majority of swimming advisories at beaches in the city of Milwaukee are due to sewage-related contamination (see Table 16). The Milwaukee Health Department monitors three beaches (Bradford Beach, McKinley Beach, and South Shore Beach) daily during the swimming season for *E. coli*. Beginning in the 2001 swim season, the city began using both of the EPA's recommended *E. coli* standards for freshwater beaches—a geometric mean of 126 and a single sample of 235—to determine water safety. In the past, the city used only the single sample standard.

Table 16
Swimming Advisories at Beaches in the City of Milwaukee, 2000–2002[299]

Year	Total Advisory Days	Advisory Days Related to Sewage Contamination	Percent of Advisory Days Related to Sewage Contamination
2000	58	36	62%
2001	38	38	100%
2002	89	80	90%

Beach advisories are just one symptom of Milwaukee's water quality problems. Recreational enthusiasts, including boaters, hikers, kayakers and canoers have reported diminished enjoyment of what should be the city's greatest asset.[300] For example, a local Milwaukee sailor gave this account of his experience in August 2002:

> *What I experienced happened when I went sailing the day after the rain event on a Wednesday morning. I was about to douse my spinnaker when I sailed into a raw sewage slick. At first I thought the white objects floating on the surface was thousands of small dead fish about ten inches in length. The surface of the water was coated with one about every foot or so. Intermingled with these fish-like objects were rafts of a greenish-brown muck that were about 3–6 feet in diameter and about 1–2 feet deep. As I got closer I saw that the fish-like objects were really condoms. Thousands and thousands of used condoms. Then it was clear to me the*

rafts of greenish-brown material was no doubt solid human waste. As I examined the rafts closer, cigarette butts and used tampons emerged as well. Tampons were evident due to the blob with a small string dangling into the water. These too were quite frequently seen floating in and amongst the conspicuous condoms. Occasionally there was visible feces that had managed to remain intact in the rafts. Seagulls were fairly numerous. I think they were eating the used condoms. On following days I saw many seagulls sitting in the water around the area and they did not appear to have the ability to fly. I think many seagulls may have died ingesting the used condoms. Though I do not have evidence of that. This entire slick continued for quite some ways. I sailed for approximately 15 minutes at 3.5–4 knots before traversing the width. I estimated it at around a half-mile wide—it was much longer than it was wide. I did not get sick but I was briefly nauseated at the disgusting sight.[301]

Recent EPA and MMSD Policies Could Lead to Another Disease Outbreak

When the Deep Tunnel was completed in 1994, it was intended to bring an end to SSOs. But as the Legislative Audit Bureau report concludes, "it has not achieved the anticipated results."[302] According to testimony by the Lake Michigan Federation, MMSD has recently changed its operating procedures in an attempt to avoid further SSOs. MMSD's initial protocol was to reserve 80 percent of the Deep Tunnel's 400-million-gallon capacity to accommodate CSOs. As SSOs persisted, MMSD and United Water, the district's private operations contractor, made the decision, with the approval of the Wisconsin Department of Natural Resources, to more than double the percentage of space allocated for sanitary sewage—from 20 percent to 50 percent.[303] In essence, MMSD decided to create a permanent placeholder for sanitary sewage regardless of whether flow from the sanitary sewer system ever materialized. This practice is acknowledged by the department in a fact sheet accompanying its National Pollutant Discharge Elimination System permit, which says, "it is possible should sufficient flow from the separated areas not materialize, that the Deep Tunnel would not fill to full capacity."[304] As a result of this policy change, the volume of individual CSOs has increased—six out of nine CSOs occurred when a significant portion of the Deep Tunnel was not full.[305]

MMSD has now applied this same policy to order bypasses of treatment processes within the treatment plant even when the Deep Tunnel is not filled to capacity. Under the district's permit, it can divert up to 60 million gallons of sewage per day around its secondary treatment unit even when the Deep Tunnel is not yet full.[306] The partially treated sewage is then recombined with fully treated sewage, disinfected, and discharged into local waterways, in a practice referred to as "blending" by the EPA. In June 2002, as a result of a sewage treatment bypass, 21 million gallons of only partially treated sewage were dumped into Lake Michigan, even though the Deep Tunnel was still two-thirds empty.[307]

Similarly, during a rainstorm on December 9 and 10, 2003, MMSD diverted nearly 40 million gallons of partially treated sewage from the Jones Island treatment plant—the third and largest such event in 2003. At the time, the 405-million-gallon Deep Tunnel was less than one-third full. MMSD officials said the bypass was necessary because winter plant maintenance had reduced the capacity of the secondary treatment units at the plant, making it necessary to reverse the flow from the plant back into the tunnels. In the nearly ten years of operation of the Deep Tunnel, MMSD has never attempted that maneuver at the Jones Island plant, although it has often done so at the South Shore plant in Oak Creek, most recently during the December rains. MMSD has since initiated a study to find out whether "throttling," or backing up flow from the plant to the Deep Tunnel, can be done safely.[308]

Sewage treatment bypasses put the community at risk of potential exposure to high levels of parasites and other pathogens. Sampling by the City of Milwaukee Health Department's Disease Control and Prevention Watershed Monitoring Project showed high levels of *Cryptosporidium,* the parasite responsible for the 1993 disease outbreak, and even higher levels of *Giardia*, in the diversion effluent from the Jones Island Wastewater Treatment Plant in May 2003, and high levels of *Giardia* in the diversion effluent in December 2003 (see shaded areas in Table 17).

Table 17
Results of Sampling for Waterborne Parasites in Milwaukee, 2003[309,310]

Date	**Results at sampling site**[(a)]		**Rainfall, Inches**[(b)]
	Crypto Oocysts/L	***Giardia*** Cysts/L	
03/19/03	<0.14	**0.25**	0.01
04/08/03	<1.0	**0.27**	0.26
04/15/03	**1.1**	<0.14	0.001
05/01/03	**1.1**	**500.27**	1.05
05/22/03	<0.14	<0.14	0.00
06/26/03	-	-	0.01
07/17/03	<0.15	<0.15	0
07/24/03	<0.14	<0.14	0
07/28/03	<0.14	**0.14**	0.001
09/03/03	<0.13	<0.13	0
10/07/03	**0.18**	**0.18**	0
11/24/03	<0.16	**0.16**	0.15
12/10/03	<0.62	**273.8**	1.46
1999 JI Influent[(c)]	**3.4-6.8**[(d)]	**505.4**[(e)]	

(a) Sample sites: Milwaukee at Erie and Polk, Pleasant, Canoe Launch, South Shore Beach, or JI-WWTP Diversion Effluent; (b) At Mitchell Field, within 24 hours prior to sampling. **Bolding** indicates high concentration of parasite, but does not necessarily indicate viable organisms. Shaded area indicates sampling results from the JI-WWTP In-Plant Diversion Effluent; (c) Most recent influent data; (d) Average of eight samples April–Oct. and Dec. 1999, four of which were below detection. The lower end of the range assumes nondetects are zero; the upper end assumes non-detects are equal to the detection limit value; (e) Average of eight samples April–Oct. and Dec. 1999.

Similarly, monitoring of diversion effluent for *E. coli* shows spikes that occurred during the December 10, 2003, blending event (see Table 18).[311] While the Jones Island plant has no numeric effluent limitation for *E. coli*, the EPA-recommended water quality criteria for a single sample of *E. coli* in freshwater used for recreation is 235/100 ml.[312] The levels of *E. coli* in these sample results are several times higher than a safe discharge level from a recreational water perspective. Application of a risk assessment model to these data shows an increased risk of about 1000 fold for Giardiasis.

Table 18
Results of Sampling During Sewage Treatment Bypass in Milwaukee, December 2003[313]

Sample Time	**Effluent Flow MGD**	***E. coli* #/100 mL**
00:10	223	-
02:45	214	440

04:00	206	-
06:00	180	-
07:25	222	300
10:10	233	1100
10:20	262	-
13:15	197	650
14.15	209	-
16.28	168	2900
17.45	169	-

The decision to divert sewage from full treatment is based on a judgment by United Water, using information it has received from MMSD's operations department. In August 2001, it was revealed that a faulty sluice gate had leaked thousands of gallons of untreated sewage into the river. Before that, it was learned that on several occasions, United's practice of switching to cheaper electric supplies during rain events had caused millions of gallons of sewage to be discharged. MMSD's explanation for the June 2002 diversion was that it had inaccurately assessed rainfall data; it said it expected another 1.6 inches of rain in the area, when in fact Milwaukee received only 0.78 inches

THE EPA'S PROPOSED SEWAGE TREATMENT BYPASS POLICY ("BLENDING") THREATENS KNOXVILLE'S ECONOMY AND WAY OF LIFE

Knoxville, Tennessee, is located on the Tennessee River in the foothills of the Great Smoky Mountains. Recent investments in downtown Knoxville focused on the waterfront exceed $4 billion. The region leads the state in population growth, housing starts and tourism. Three major boat-manufacturing companies are located on or near area lakes. Clean water is vital to Knoxville's economy, and so the practice of blending, which allows inadequately treated sewage to be released into waterways, is a threat to Knoxville's quality of life and economic development.

- Since 2001, close to 3 billion gallons (2,819,620,460) of partially treated sewage have been released into the Tennessee River at Knoxville. It would take a pipe 4 feet in diameter and 5,340 miles long (reaching about one and a half times across the United States) to carry the volume.
- This volume is equal to the entire flow of the Little River, which flows from the Great Smoky Mountains into the Tennessee River, at 237,880 gallons per minute for eight hours.
- Although the EPA claims that its proposed sewage treatment bypass policy is necessary to prevent treatment plant failure at times of heavy rain, Knoxville plants have discharged "blended" sewage even when there has been little or no rainfall.
- In the first 10 months of 2003, there were 86 releases of blended sewage into the river, flowing for 1,451 hours at 994,201 gallons per hour, totaling 1,443,652,000 gallons. In addition, 8,648,000 gallons of raw sewage entered Knoxville waters from SSOs.
- Downstream from these polluted releases people wade, swim and ski, and a public utility draws some 3.8 billion gallons of drinking water from the river each year.

Information provided by Nelson Ross, Executive Director, Tennessee Izaak Walton League (January 19, 2004).

in total.[314]

The EPA has proposed a national sewage "blending" policy that would authorize such sewage treatment bypasses even when a feasible alternative to the discharge of largely untreated sewage is available. Essentially, the proposal would attempt to legalize currently illegal practices by MMSD, instead of enforcing the law to protect the people of Milwaukee. In April 2003, the EPA declined to object to the state's natural resources department's approval of MMSD's operating permit, which allows in-plant diversions.[315]

According to the Legislative Audit Bureau report, through 2010, the district plans to spend $786.4 million on capital projects to increase capacity and reduce the amount of stormwater entering sanitary sewers. MMSD is also preparing its 2020 Facility Plan, which will review a broad array of alternatives for reducing future overflows, preventing flooding, protecting the environment, and improving water quality. The 2020 plan is expected to be complete in 2007.[316]

CHAPTER 5

RECOMMENDATIONS

Protecting all Americans from exposure to raw and inadequately treated sewage is not a matter of waiting for the next technology breakthrough. Keeping sewage in pipes and sending it through effective treatment regimens is dependent on the continual application of a series of well-known engineering practices. What is needed is the political will to adequately implement, enforce and fund existing laws and sewage infrastructure improvement programs and fill data gaps on the occurrence of sewage overflows, their health and economic impacts, and the condition of the U.S. sewage collection and treatment infrastructure.

INCREASE FEDERAL FUNDING FOR WASTEWATER INFRASTRUCTURE

Federal funding for wastewater infrastructure received the largest cut of any environmental program in President Bush's proposed budget for fiscal year 2004.[317] The Bush administration is cutting funding although needs are spiraling out of control.

The problems caused by discharges of untreated and inadequately treated sewage will only get worse if Americans continue to let our wastewater infrastructure deteriorate. The gap between expenditures at the federal, state, and local levels and sewer infrastructure needs is estimated at about $10 billion per year.[318] Those estimates can be expected to continue to rise as unaddressed maintenance, rehabilitation, and repair needs accumulate. The federal government should greatly increase its contribution to water infrastructure needs through a clean water trust fund, just as highways and airports have their own trust fund.[319]

The government also must start spending that money more wisely. No federal funds should be used to fund or build sewer systems for new developments. Those costs should be borne by the developers themselves. Instead, funds should be devoted exclusively to addressing existing wastewater infrastructure needs. Funds should also go only to those sewer systems that have a plan for meeting their compliance obligations. We need to stop throwing good money after bad. If a sewer system has thumbed its nose at federal and state clean water protections, we should ensure that they commit to comply before they receive taxpayer dollars.

Third, the government needs to fund the most cost-effective and environmentally beneficial approaches. There is a growing body of evidence that centralized treatment solutions cost more to develop and maintain in the long run than pollution-prevention approaches. Such approaches minimize the amount of sewage that needs to be treated,

PUBLIC SUPPORT FOR CLEAN WATER

Americans are worried about water pollution and strongly support action to clean it up.

- More than half of the American population worries about pollution of rivers, lakes and reservoirs a great deal (Gallup poll, conducted March 3–7, 2002).
- Water becoming more polluted is the top environmental concern of Americans (Greenberg Quinlan Rosner Research and the Tarrance Group, conducted April 13–19, 2002).
- 81 percent of voters indicated that clean water, clean air and open space are important in deciding how they vote in elections (Greenberg Quinlan Rosner Research and the Tarrance Group, conducted April 13–19, 2002).
- The National Association of Home Builders found that proximity to a water body raises the value of a home by up to 28 percent (NAHB, *Housing Economics,* 1993).
- Proximity to dirty water lowers the value of homes (T. Schueler, "The Economics of Watershed Protection," *Watershed Protection Techniques,* June 1997).
- 71 percent of Americans are extremely concerned about clean water (League of Conservation Voters, 2000).
- When deciding where to live, clean water ranked as the top priority above crime rate, health care and taxes (*Money Magazine*, April 2000).
- Polling data from 2003 indicates that clean and safe water supplies remain the top environmental concern of citizens of Florida, Michigan, and New Mexico. (Greenberg Quinlan Rosner, December 2003).

keep stormwater out of the sewage treatment system, and maximize the use of free storage and treatment systems provided by "Mother Nature" to filter pollution, restore the natural hydrology of stream systems, replenish groundwater, and often provide wildlife, air quality, and aesthetic benefits as well.[320] While establishment of a clean water trust fund is the best long-term source of sewage treatment funding, in the meantime Congress should increase funding for the Clean Water State Revolving Fund, which provides low-interest loans, and for increased grant funding to localities for clean water projects. According to the Environmental Protection Agency, the revolving fund program "is considered a tremendous success story,"[321] but President Bush's budget for fiscal year 2005 proposed cutting it by $492 million, the largest cut of any environmental program.[322]

Fully Fund and Implement the Federal BEACH Act of 2000

In 2002, for the third consecutive year, beaches across the United States were closed or under health advisories for more than 10,000 days, due primarily to excessive levels of fecal contamination. [323] Data for 2003 will likely show that the trend has continued. The high level of closings and advisories is an indication that new and more frequent monitoring continues to reveal serious water pollution at our nation's beaches.

The Beaches Environmental Assessment and Coastal Health (BEACH) Act requires states with coastal recreational waters to adopt new or revised water quality standards for bacteria by April 2004. The state standards must be the same as, or as protective of public health as, the EPA's. The BEACH Act also directs the EPA to study issues associated with pathogens and public health and to publish new or revised criteria based on that study by October 2005, and at least once every five years thereafter. States must then adopt these new or revised criteria. Viruses and protozoa have relatively long survival times and low infective doses (the smallest dose that can cause infection), whereas bacteria require a high infective dose.[324] The long survival times and low infective dose of viruses and protozoa raise serious questions about reliance on bacterial standards as indicators of clean water. Bacterial indicators used by health agencies to warn the public of the presence of pathogens in recreational waters are also not good predictors of viral loads or protozoan parasites, such as *Cryptosporidium* and *Giardia*. The United States continues to have periodic outbreaks of hepatitis A from the consumption of shellfish from areas contaminated by sewage, even when bacterial standards are being met.[325] The EPA should conduct research to identify reliable indicators of pathogenic viruses and protozoa in drinking water sources, recreational waters, and shellfish beds.[326]

As a result of federal grants now available to states through the BEACH Act, virtually every coastal and Great Lakes state is in the process of either initiating or expanding monitoring and public notification programs. For example:

- In August 2002, the Florida Department of Health expanded beach-monitoring frequency from once every two weeks to once a week. Now that samples are taken once a week, Florida has begun using the EPA's recommended geometric mean standard for enterococcus to determine swimming advisories;
- Beginning in 2003, most Great Lake beaches are monitored once a week in Wisconsin and daily in Illinois;[327]
- Beginning in 2004, two coastal states that have lagged behind the rest will begin monitoring beaches. The Louisiana Department of Health and Hospitals and the State of Washington Department of Ecology plan to initiate a monitoring and public notification program during the 2004 beach season; and
- New Jersey plans to switch from fecal coliform to the EPA's recommended enterococcus standard beginning in the summer of 2004.

Alerting the beach-going public to potential risks from swimming in sewage-contaminated waters is a critical component of an effective public health protection program, but it's only half the battle.

Alerting the beach-going public to potential risks from swimming in sewage-contaminated waters is a critical component of an effective public health protection program, but it's only half the battle. The next logical step is to identify sources of sewage contamination to avoid beach water pollution in the first place. BEACH Act grant monies would be well spent identifying pollution sources, given that nearly two-thirds (62 percent) of beach closing and advisory days in 2002 were due to fecal contamination from unknown sources—an increase from previous years (see Figure 12).[328]

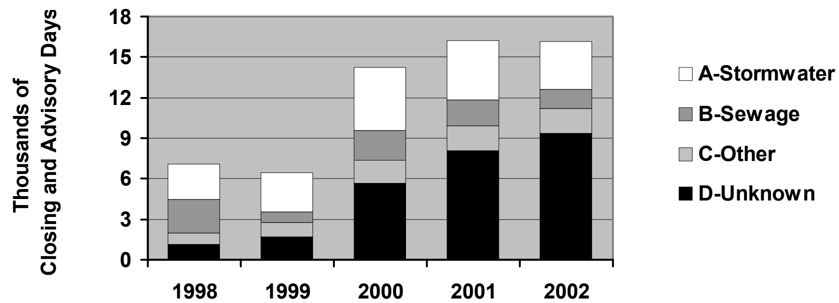

Figure 12 Reported Sources of Fecal Pollution Causing Beach Advisories/Closings, 1998–2002. Key: (A) polluted runoff, stormwater, or preemptive due to rain; (B) known sewage spills and overflows; (C) other reasons; (D) unknown.[329]

The BEACH Act authorizes $30 million a year for state grants for monitoring and public notification—the EPA has provided $10 million in annual grants since 2001. The law should be amended to allow these grants to be used for identification of beachwater contamination sources in addition to monitoring and public notification.

ENFORCE CURRENT SEWAGE TREATMENT PLANT REQUIREMENTS

Sanitary sewer overflows are illegal, yet the EPA estimates that the number of such overflows is growing. Enforcement of the Clean Water Act is critical to encouraging sewer operators to invest in solutions. Sewer operators, like everyone else, prioritize their expenditures. If there is no real threat of enforcement, they will not choose to invest in compliance with legal requirements, such as controlling raw sewage discharges. Sewer overflows will continue to mount, closing beaches, contaminating drinking water supplies, and endangering wildlife unless we step up both enforcement of the law and the resources available to communities.

The EPA's ability to enforce the law has been greatly compromised due to recently proposed policy changes that would allow sewage to "bypass" certain treatment processes at the plant. The EPA settled a number of successful CSO and SSO cases over the last several years—settlements that require cities to treat their sewage and make improvements to their sewage treatment plants and their collection and transportation systems. Adopting the proposed policy would hamper enforcement of standards by authorizing discharges of inadequately treated sewage that threaten public health and the environment during rain events. This policy would also act as a disincentive for cities to repair leaky collection systems. Cities bypass treatment processes when their treatment plants are overloaded by the volume of waste. This often happens during rain events because poorly maintained sewer pipes allow stormwater to mix with the sewage. Cities that maintain their sewer systems and their treatment plants do not have to bypass, except in emergencies. Cities should treat their waste, rather than merely diluting sewage with stormwater, and that means compliance with long-standing Clean Water Act treatment requirements. Instead of weakening treatment standards, the Bush administration should enforce the law to protect public health and the environment.

Drop the EPA Proposal to Allow Sewage to Skip Treatment Processes in Rain Events

The EPA should abandon its "blending" guidance that changes the Clean Water Act's current prohibition on discharges of inadequately treated sewage. The agency proposes to allow primary treated sewage to be blended with secondary sewage during wet weather events. Effective treatment for sewage is essential, and to accomplish it, the sewage must receive treatment that effectively removes pathogens and other pollutants before it is discharged. The EPA should abandon its proposed policy change of allowing dilution to substitute for effective treatment when it is raining. Except in emergency situations when no feasible alternative exists, sewage should be fully and effectively treated to reduce pollutant loadings and to reduce the risk of spreading waterborne disease throughout the population.[330]

Microbiologists at Michigan State University analyzed the risks associated with blending and found that over 99 percent of the quantity of pathogenic viruses and parasites comes from the untreated portion of the flow. They found the risks of swimming in waters receiving blended effluent are between 100 and 1000 times greater than if the wastewater had been completely treated, and said, "As a result of blending effluents during a wet weather event, waterborne disease outbreaks could have a higher plausible occurrence."[331]

Inadequately treated and diluted sewage contains high levels of nitrogen and suspended particulates, both of which interfere with chlorine disinfection. Not only could viable viruses and parasites more easily escape into the environment, but bacterial pathogens that might otherwise be effectively killed by chlorine could survive by shielding from particulates.[332,333] As a result, treatment facilities would have to dump much larger quantities of chlorine into the wastewater prior to disposal in a vain attempt to achieve adequate disinfection. Large injections of chlorine into the aquatic environment could produce higher levels of toxic disinfection byproducts, associated with increased risk of bladder, colon and rectal cancers.[334]

Treatment plants that come to rely on blending during rain events would be less likely to switch from toxic chlorine to safer disinfectants such as ultraviolet light (which leaves no chemical residue that is harmful to humans and aquatic life) because UV requires a clarified effluent. Chlorine disinfection byproducts are a matter of public health concern, but chlorine itself is a community security concern—many wastewater treatment plants store the gas onsite in large tankers. According to a new study by Environmental Defense, "[t]he practice [of chlorine gas storage] puts surrounding communities at risk from an accidental release or even an attack. Chlorine can burn the eyes, lungs and skin and is fatal in high concentrations. It is so powerful it was used as a chemical weapon by Germany in World War I."[335]

NRDC and EIP support continued use of biological treatment or a technology of equivalent effectiveness in removing pathogens from effluent. The United States cannot afford to risk the transmission of waterborne disease by allowing inadequately treated sewage to be discharged into rivers, lakes, streets, and even homes.

Promulgate Provisions of the SSO Rule

On Inauguration Day, the Bush administration announced that it was shelving (at least temporarily) a proposed regulation that would have controlled raw sewage discharges and required the public to be notified when sewer overflows occur. The rule was based on consensus recommendations of a federal advisory committee that met for 5 years. It was specifically agreed to by the sewer operators who are now seeking to exempt themselves from the sewage treatment requirements that they are violating.

The SSO rule would keep bacteria-laden raw sewage discharges out of America's streets, waterways and basements, and make public reporting and notification of sewer overflows mandatory. It would help protect the public from illnesses caused by exposure to raw sewage; improve capacity, operation and maintenance of sewer systems; and cost Americans only $1.92 per household per year. While the EPA continues to dither, Americans are still denied even rudimentary public notice of such contamination in the waters from which they drink and where they swim and fish.

Even if the EPA is no longer willing to require sewer systems to develop plans to correct the root causes of sewer overflows, as the proposed rule would have required, the agency should at least move forward immediately with the monitoring, reporting, and public notification provisions of the rule to minimize public exposure to sewage and its accompanying health dangers. Americans should not be unwittingly exposed to swimming, boating, or playing in sewage-infested waters.

While the EPA continues to dither, Americans are denied notice of contamination in the waters from which they drink and where they swim and fish.

Enforce Management, Operation and Maintenance Requirements

In its proposed rulemaking, the EPA reported that the number of SSOs can be substantially reduced through improved sewer system management, operation and maintenance. The agency cites a 1993 study conducted in Sacramento County where one section of a wastewater collection system was cleaned every one to two years, while the other was cleaned every three to six years: "The portion of the system on a more frequent one-to-two-year cleaning schedule experienced a noticeable reduction in the number of stoppages (from 384 in 1974 to 107 in 1984). By contrast, the portion of the system cleaned every three to six years experienced an increase in the number of stoppages over the same time."[336]

The EPA should enforce the capacity, maintenance, operation, and management requirements and the Long Term Control Plans for communities with CSOs incorporated into the Clean Water Act in 2000. For instance, Chicago has been given 15 years to enact its Long Term Control Plan, even though EPA policy says the plan should be developed within two years.[337]

Old and leaking sewer pipes may pose a serious threat to the nation's groundwaters. A limited review of information on exfiltration suggests that the range of raw sewage loss to the underground environment is generally between 10 to 25 percent of the total annual flow of sewage through sewer collection systems.[338]

Adopt Water Quality Standards for Nutrients and Require Sewage Treatment Plants to Meet Them.

Nutrients input from human sewage are implicated as a major source of oxygen depletion and harmful algal blooms in waters at our nation's bay and estuarine beaches. The EPA has asked states to develop plans to put nutrient standards in place by 2004.[339] Many states have not yet done so, and are also not using their existing narrative criteria to develop water quality–based standards for sewage treatment plants. The EPA should require states to adopt water quality standards for nutrients, set water quality–based effluent limits for sewage treatment plants according to narrative and numeric standards, and require biological nutrient removal in order to limit discharges into waterbodies impaired by nutrients. Congress should provide additional funding to assist states in adopting nutrient standards and assist sewage treatment plants in installing advanced wastewater treatment for nutrient removal.

COLLECT DATA AND INFORM THE PUBLIC

Collect National Public Data

A decade or more into the Information Age, we are presented with steadily improving hardware and software that provide a wide range of people with better access to vast amounts of data and the tools to use them. Accurate and timely information at our fingertips better enables government regulators and business and institutional leaders to increase efficiency, while empowering concerned citizens to make more informed choices in the home, the community, the marketplace, the workplace, and the voting booth.

But we're mired in the muck when it comes to adequate information on the condition of the nation's sewage collection infrastructure, the occurrence of raw and partially treated sewage overflows, and their subsequent health, environmental, and economic impacts. Inadequate information seems to be the one issue where there is broad agreement among government officials, scientists, economists, public interest organizations, and sewage authorities. For example:

We're mired in the muck when it comes to adequate information on the condition of the nation's sewage collection infrastructure, the occurrence of sewage overflows, and their impacts.

- The Congressional Budget Office concludes there is "limited information available at the national level about existing water infrastructure….[T]here is no accessible inventory of the age and condition of pipes, even for the relatively few large systems that serve most of the country's households."[340]
- The EPA reports that "national information on the status of collection systems and the extent of SSO problems remains limited and many municipalities are unaware of the overall extent of SSO problems in their own systems."[341]
- The EPA also says that "[a]lthough SSO events that impact drinking water supplies are not uncommon, the role of SSOs in contaminating drinking water supplies and spreading illnesses may often go unidentified, unrecognized, or unreported."[342]
- "Forty percent of the municipalities participating in the Association of Metropolitan Sewerage Agencies survey reported that they did not have information on the annual number of SSOs in their systems."
- "Only 30 percent of the states responding to the Association of State and Interstate Water Pollution Control Administrators survey estimate that all or nearly all of their municipal permittees comply with SSO reporting requirements, with a corresponding figure of 22 percent of states for their private sector permittees."[343]

THE POWER OF PUBLIC REPORTING

Creation of a "Sewage Release Inventory," based on the U.S. EPA's Toxics Release Inventory (TRI) model, could spur sewage authorities, municipalities, and states to make similar reductions in releases of raw or inadequately treated sewage to waterways, streets and basements.

- "From our company's point of view, [TRI] helped us to discover a problem that we weren't even aware of. We discovered we had leaking sewers and potential contamination of our water supplies." – Richard Harding, Eastman Gelatine; *North Shore Sunday* (Danvers, MA), August 12, 1990.
- "[TRI] makes us more accountable to the public, and public accountability has made us smarter businessmen." – John Johnstone, Chemical Manufacturers Association [American Chemistry Council]; *USA Today*, May 28, 1992.
- "Quite frankly we want to get off that list." – Joe Fallon, Slater Steels Corp (Fort Wayne, IN); *Indianapolis Star*, April 10, 1990.
- "The initial demand for environmental reporting came from the public. But in responding, we have discovered that the information is extremely useful to our own management. We have learned about our successes, our inadequacies and the gaps in our knowledge. It's a good example of the way in which external pressures ultimately prove the benefit both to the environment and to industry." – Ciba Geigy; *Corporate Environmental Report*, 1993.
- "This mandatory disclosure has done more than all other legislation put together in getting companies to voluntarily reduce emissions." – Millard Etling, Dow Chemical (Dalton, GA); *Atlanta Constitution*, August 22, 1991.
- "[TRI] really forced us to look at the numbers in a condensed way, and it dawned on us that these were some big numbers. Maybe it's just a big number, but people don't like that." – Randy Emery, Amoco; *Houston Chronicle*, July 24, 1989.

- The American Society of Microbiologists concludes that "[a]ny effective risk assessment [of microbial pollution in water] demands an adequate database of information on exposure and outcomes. This database does not exist."[344,345]
- Sixty-two percent (7,505) of beach closing and advisory days in 2002 were due to high levels of bacterial contamination from "unknown" sources. While monitoring programs are improving, beaches will continue to be closed and beachgoers will continue to get sick if the sources of pollution are not identified and controlled.[346]

The bottom line is that lack of adequate data is putting people at risk.

Require Monitoring and Public Notification

While the EPA has the legal authority to move forward with regulations to require monitoring and reporting of raw sewage overflows, it has not done so. Therefore, NRDC and EIP urge passage of legislation pending in Congress that would force the EPA to require sewer operators to set up a program to monitor sanitary sewer overflows and notify the public and public health authorities of raw sewage discharges.

The Raw Sewage Overflow Community Right-to-Know Act (HR 2215), introduced by Rep. Timothy Bishop (D-NY) and nine other House members, would amend the Federal Water Pollution Control Act. It would require sewage authorities to implement a means of detecting SSOs, notify the public and health authorities in a timely manner when SSOs are detected, and submit a written report to the state environmental agency documenting the volume, duration, and cause of the SSO and the steps taken to mitigate its impact and prevent or reduce similar occurrences. The bill would also require sewage authorities to submit this information in an annual report to the state environmental agency. Passage of this legislation would warn the public not to swim in sewage-infested waters and would vastly increase the available public information about the number of sewer overflows that occur in their community and why. This would enable citizens to push for stronger controls and more funding at the local level.

This bill takes important steps in closing the yawning gap of information on SSO occurrence and causes. However, given the type of data collection called for in the bill, an additional provision should be added to spur sewage authorities and state regulators to improve the integrity of the sewage collection system so that overflows do not occur. That provision would mandate public accessibility and data uniformity.

A Sewage Release Inventory may spur significant, voluntary reductions in raw sewage releases by publicly matching the name and location of each sewage authority with the quantity, frequency, and impact of its sewage overflows each year.

Create a National "Sewage Release Inventory"

Following the tragic chemical release at the Union Carbide facility in Bhopal, India, in 1984, where 2,000 local citizens were killed, the U.S. Congress took an innovative step to protect the American public from exposure to a lethal toxic chemical release here at home. Leveraging the recent advent of personal computers and the Internet, Congress mandated that the EPA create a publicly accessible database to name individual manufacturing facilities and report the quantities of each toxic industrial chemical they release to the nation's air, water, and land each year. Adding to the law's effectiveness is the requirement that each facility, regardless of location, reports in the same units of measure (pounds per year). The combination of public spotlighting, the naming of names, and comparable units of measure across facilities and states makes for a very powerful incentive to improve performance. The Toxics Release Inventory (TRI) was born in 1987(see www.epa.gov/tri).

Despite their initial opposition, industry CEOs publicly declared voluntary release reduction goals and timetables as soon as TRI data hit the headlines. Since then, the quantities of releases to the environment have fallen by nearly half, and industry leaders sing its praises (see box). With annual reporting and public accessibility as the only requirement, the law has had as dramatic an impact, if not more so, as laws that put quantitative limits on discharges or require installation of specific technologies.

A Sewage Release Inventory may have a similar impact on spurring significant, voluntary reductions in raw sewage releases by publicly matching the name and location of each sewage authority with the quantity, frequency, and impact of its sewage overflows each year. For example, sewage authorities, local governments, and states with the highest number and volume of overflows nationally or regionally would likely be spurred to action to get out of the public spotlight. Conversely, others may be inspired by the opportunity for public recognition of good performance.

Government officials and public interest groups could use the SRI data in a number of ways to track progress and its opposite. For example, a local sewage authority's performance may be tracked over time on the basis of number and volume of sewage releases per year. Sewage authorities across cities, counties, states, and regions could be compared to one another on the basis of such measures as the number or volume of overflows per mile of collection pipe or per capita served. Table 19 shows the categories of data and specific data elements that might be included in an annual Sewage Release Inventory.

Table 19
Data Elements of a Sewage Release Inventory

Sewage Authority ID	Overflow Facts	Overflow Impacts
• Name of sewage authority • Permit ID number • City and state • Public contact phone no. • Type of collection system (CSS or SSS) • Miles of collection pipe • Number of people (or households) served • Number of treatment plants • Number of permitted CSOs	• Start date and time • End date and time • Volume released (gallons) • Cause • Overflow location • Immediate receiving area (stream, street, stormdrain, beach, private yard, basement, etc.) • Ultimate receiving area (river, ocean, basement, etc.)	• Number of people potentially exposed • Types and incidence of waterborne illness • Estimated response costs (generally itemized as cleanup, sewer line repair, and private property replacement costs) • Estimated value of other economic losses (e.g., beach closings, fishing advisories, etc.)

Conduct Epidemiological Studies and Other Analyses and Educate the Public About Waterborne Disease

The American Society of Microbiologists concluded in 1999 that a database of information on exposure to waterborne pathogens, which would include the frequency of sewer overflows, pathogens present in the sewage, and disease outcomes of exposed individuals, is necessary to assess risk, but that no such database exists.[347] The EPA and Centers for Disease Control should work together to fill that gap with comprehensive data from across the country; new analysis and epidemiological studies; a publicly available, searchable database; and a public education campaign. Few epidemiological studies have been done of surfers, kayakers, divers, swimmers, and others with regular exposure to waterborne pathogens carried by sewage.

ENDNOTES

1 The EPA reports U.S. average daily sewage flow equals 50 trillion gal x 365 days = 18,250 trillion gal/year. Great Lakes occupy 5,652 miles^3 or 6,224 trillion gal (www.greatlakes-seaway.com/en/navigation/cruises_facts.html) = 0.34 years to fill Great Lakes with sewage.

2 The EPA estimates ~500,000 miles of municipal pipes and ~500,000 miles of private pipes connected to municipal systems: U.S. EPA, Notice of Proposed Rulemaking, National Pollutant Discharge Elimination System (NPDES) Permit Requirements for Municipal Sanitary Sewer Collection Systems, Municipal Satellite Collection Systems, and Sanitary Sewer Overflows (January 4, 2001) (*note*: there are no official page citations available since this proposal was not published), p.17; average distance from earth to moon is ~240,000 miles.

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