
THE CONSEQUENCES OF URBAN STORMWATER POLLUTION

National Resources Defense Council

The degradation caused by urban stormwater pollution is serious, and affects a significant proportion of the nation's population. Changes in land use that increase impervious cover lead to flooding, erosion, habitat degradation, and water quality impairment. Everyday activities such as driving, maintaining vehicles and lawns, disposing of waste, and even walking pets often cover impervious surfaces with a coating of various harmful materials. Construction sites, power plants, failed septic systems, illegal discharges, and improper sewer connections also contribute substantial amounts of contaminants to runoff. When these contaminants enter lakes, streams, and estuaries they result in stormwater pollution. This pollution, in turn, impacts important natural resources as well as other, equally important activities such as commercial and recreational fishing, swimming, and boating. While urban stormwater runoff is not alone in causing these impacts (industrial and agricultural runoff are equal or greater contributors to water quality impairment on a national scale), the environmental, aesthetic, and public health impacts outlined in this chapter will not be eliminated until urban stormwater pollution is controlled.

An Announcement from the Experts: "No One Safe From Flooding," FEMA Says

WASHINGTON April 1, 1997 -- Destructive floods can -- and do -- occur in -- every state in the nation, according to recent statistics issued by the Federal Emergency Management Agency (FEMA).

While some communities are less likely to experience flooding than others, nowadays very few, if any, are entirely safe from this threat, which is by far the most common type of natural disaster in the United States. "About 90% of our natural disasters involve flooding in one way or another," FEMA Director James Lee Witt said, "and the impression many people have that floods seem to happen more frequently now than they used to is quite accurate."

"As more and more land is cleared for development and paved over, there is less and less available to soak up excess water," Witt said. "The runoff has to go somewhere, and places that never flooded before are now at risk."

The records of the Federal Insurance Administration indicate that approximately \$1.1 billion in claims under the National Flood Insurance Program were paid in each of fiscal years 1995 and 1996. Those same records indicate that the Federal Insurance Administration paid flood insurance claims in every state of the union during that two-year period.

Source: "No One Safe from Flooding, FEMA Says" FEMA News Desk, April 1997, <http://www.fema.gov/home/NWZ97/97095.htm>

Flooding and Property Damage

The most dramatic consequence of increases in the volume and rate of stormwater runoff is flooding and property damage. As discussed in the preceding chapter, undeveloped areas such as forests and wetlands serve as sponges for excess rainwater, so when these areas are eradicated, filled in, or replaced with impervious cover such as asphalt, the volume of water entering streams and rivers

increases. One study estimated that because of the increase in impervious cover in a watershed a flood event that should be expected once in 100 years could occur once every 5 years when the impervious cover reaches 25 percent, and could become an annual event when impervious cover reaches 65 percent.¹

Conventional urban stormwater management, with its emphasis on engineered flood control measures such as dams, dikes and levees, and detention facilities, has in many areas helped to mitigate some of the worst flood damage. But it has been vastly outstripped by the pace of flood-producing urbanization. Furthermore, by quickly channeling stormwater away from certain areas via paved channels, stormwater pipes, and stream bank stabilization techniques (e.g., riprap, cutbacks, plantings, and bulkheads) rather than providing for retention or infiltration, conventional stormwater management can simply transfer hydrologic impacts downstream.² At times, downstream areas experience greater habitat loss, increased channel widening and erosion, and worse flooding due to the reduced storage and facilitated runoff upstream.

Streambank and Streambed Erosion

The increased volume and rate of urban stormwater runoff erodes streambanks and streambeds, dislodging and suspending sediment that might otherwise have remained in place. Erosion can be gradual, or can occur rapidly through a sudden collapse of a streambank.³ Changes in hydrology also affect the shape and dimension of river channels, thereby altering aquatic habitat and channel stability.⁴

Siltation and Sedimentation

Rapidly flushing stormwater can increase erosion from all land, not just streambanks and streambeds. Stormwater then transports the eroded sediment downstream into the receiving waters. Eventually, when sediment-laden water is stilled, that sediment settles to the bottom of the stream, river, lake, or estuary. When sediments settle out, they may cover or destroy important habitat such as spawning beds or submerged aquatic vegetation. Pollutants such as phosphorus attach to sediment particles and become suspended or dissolved in receiving waters. The magnitude of the sedimentation problem is staggering: one study estimates that each year erosion from construction sites puts 80 million tons of sediment into receiving waters.⁵

Siltation and sedimentation has economic impacts as well. These excess deposits of sediment clog harbors and other water transport routes and reduce the storage capacity of reservoirs, obliging governments to spend billions of dollars each year to dredge and maintain those channels and facilities.⁶ The U.S. Army Corps of Engineers dredges 83 million cubic yards of sediment linked to pollution sources each year at an annual cost of \$180 million.⁷ In many cases, these dredged sediments are laden with nutrients, heavy metals, and toxic chemicals -- making disposal expensive. Siltation can also affect commercial and recreational fishing by degrading necessary habitat and can impede recreational boating by creating obstructions.

Increased Water Temperature

Aquatic organisms have specific water temperature preferences and tolerance limits. Changes in water temperature can have a serious impact on aquatic ecosystems.⁸ Water that infiltrates the ground and flows beneath the surface is usually much cooler than surface runoff. Not only do impervious surfaces prevent infiltration, they often warm stormwater as it runs off. Unshaded rooftops, parking lots, and other impervious areas can be 10–12° F warmer than fields and forests and consequently can heat the stormwater passing over them, often to 90° F or more, even before it reaches a stream or lake.⁹ Research has found that the average stream temperature increases directly with the percentage of impervious cover in the watershed.¹⁰ One study documented a temperature difference of almost 20° F between a wooded section of a Maryland stream and an open section of the same stream 7/10ths of a mile

downstream.¹¹ Furthermore, trees shade water bodies keeping them cool, while development often replaces trees with impervious surfaces.

Harm to Aquatic Life

Urban runoff can harm aquatic life in many ways due to changes in water chemistry and habitat loss.¹² The metals and organics that stormwater carries are toxic to fish and other forms of aquatic life. For example, untreated urban runoff collected from an auto recycling facility near Los Angeles over several years repeatedly killed 20 percent or more of the minnows exposed to it.¹³ Urban stormwater is also often toxic to several species of aquatic insects, on which fish, frogs and other higher life forms feed.¹⁴ For example, organic chemicals may have effects on the immune systems and early development of aquatic life.¹⁵

Stormwater can also bring toxic levels of road salt to urban waters. In certain streams draining roadway areas, studies have measured concentrations of chloride at levels 25 or even 60 times the level harmful to trout.¹⁶ Even the trash that stormwater carries harms wildlife. The plastic loops that hold six-packs of beer or soda together can strangle gulls.

Sediment in stormwater has a number of harmful effects on aquatic life. Sediment still suspended in water increases infection and disease among fish by irritating their gills.¹⁷ A number of fish species, including endangered species such as the log perch or blue shiner, cannot tolerate sediment levels in the water above certain threshold levels, and thus disappear from water bodies under those conditions.¹⁸ Suspended sediment scours submerged plants attached to rocks, as well as blocks sunlight that aquatic plants use to produce growth through photosynthesis.¹⁹

When sediment settles, it can bury and smother bottom-dwelling insects and reduce the survival rate of fish eggs.²⁰ At the same time, sediment deposition fills in the spaces between the gravel in stream beds that fish use to spawn and raise their young and in which invertebrate food sources live.²¹ Furthermore, sediment may carry nutrients, bacteria, toxic metals and organic chemicals to the water.²²

The increase in surface runoff associated with land development also dramatically increases runoff of the nutrients phosphorus and nitrogen, causing receiving waters to suffer. Many nutrients, which cling to soil particles in natural settings, are dislodged by development and other activities making them free to run off with stormwater.²³ For example, in a comparison between two Maine watersheds, phosphorus export was 10 times greater in a developed watershed than a forested watershed.²⁴ In highly developed areas these increases are usually permanent.

The enrichment of waters with nutrients is termed eutrophication and is a concern for several reasons. Excess phosphorus causes elevated growth of algae and aquatic vegetation in lakes and streams. Excess nitrogen can have a similar effect in marine waters. The excessive plant growth interferes with the use of water bodies for recreation, fisheries, industry, agriculture, and drinking water supply. It can also lead to foul odors, noxious gas, and poor aesthetic quality of the receiving water.²⁵ In marine systems, nutrient enrichment can lead to red and brown tides that are a threat to marine organisms and human health. Perhaps most dramatically, eutrophication can cause fish kills.²⁶ When the vegetation dies and decomposes, it consumes oxygen dissolved in the water. Fish and other aquatic organisms cannot tolerate dissolved oxygen concentration below certain thresholds. As a result, eutrophic waters are typically devoid of most life.

Organic material discharged to a lake or stream also consumes oxygen when decomposing thereby reducing the dissolved oxygen content of the receiving water. As with nutrient enrichment, sudden additions of such material, perhaps in a storm or through illicit dumping, frequently causes fish kills.²⁷ Longer term impacts include changes in fish populations and reductions in shellfish.

The increase in water temperature compounds the oxygen-depletion problem. The warmer the water, the less dissolved oxygen it can carry. Research indicates that the thermal changes caused by urban runoff can increase visible algae blooms and have severe impacts on cold-water fish and other aquatic life.²⁸

Changes in hydrologic patterns also have a significant effect on aquatic life. Urbanization increases both the magnitude and frequency of extreme low and high flow events. It also leads to a decrease in infiltration resulting from decreased base flow, an increase in water temperature, and declines in upland, riparian, and instream habitat quality. Research indicates that larger flood events significantly reduce populations of young fish such as trout and salmon as well as invertebrate populations.²⁹

These impacts -- sedimentation, contaminant loadings, hydrologic instability, oxygen depletion and temperature increases -- not only threaten individual animals, but also reduce the diversity of life living in these waterbodies.³⁰ Studies have shown a sharp drop in the diversity of insect populations, which serve as food for higher life forms such as frogs and fish, as the amount of impervious cover in an urbanizing watershed passes 10 or 15 percent.³¹ Other research has shown that the variety of fish species drops as well, with the disappearance of sensitive fish such as trout and salmon.³² In short, stream biological health declines as watershed imperviousness increases.

Harm to Coastal Shellfisheries

Pathogens in stormwater also contaminate shellfish beds, and this contamination, along with pollution from other sources, causes closure of shellfish beds nationwide. Data collected from five coastal states indicate that urban runoff and storm sewers are the most pervasive source of shellfish harvesting restrictions, contaminating over 30 percent of the area reported as subject to such restrictions in those states.³³ A key contributing factor is the fact that levels of bacteria and viruses are usually much greater -- 100 to 1,000 times greater -- in the bottom sediment, where shellfish live, than in the water above.³⁴

Harm to Sport Fishing

The harm to fish leads quickly to harm to fisheries. Sport fishing is a big business in the United States, and many of the species that are most sensitive to degraded water conditions, such as brown trout and salmon, are the species anglers prize most. Quality fisheries can be an important economic asset to the surrounding communities.³⁵ The U.S. Fish & Wildlife Service estimates that over 35 million anglers spent over \$38 billion dollars in pursuit of their pastime in 1996, money that would not be spent if there were no fish to be caught.³⁶

Human Illness

Stormwater carries disease-causing bacteria, viruses, and protozoa. Swimming in polluted waters can make you sick.³⁷ A study in Santa Monica Bay found that swimming in the ocean near a flowing storm sewer drain during dry weather conditions significantly increased the swimmer's risk of contracting a broad range of health effects. Comparing swimming near flowing storm-drain outlets to swimming at a distance of 400 yards from the outlet, the study found a 66 percent increase in a group of symptoms indicative of respiratory disease and a 111 percent increase in a group of symptoms indicative of gastrointestinal illness within the next 9 to 14 days.³⁸ Increased sediment in receiving water is also related to human illness: sediment prolongs life of pathogens and makes it easier for them to reproduce.

Impacts to Drinking Water Supply

In urbanized areas, runoff pollution is a serious concern for water supply agencies. Over 90 percent of the people in the United States rely on public supplies of drinking water. Of that 90 percent, 19 percent are served by systems with reported health violations.³⁹ A nationwide survey of surface drinking water supply utilities found that with an increase in urbanization there arose an increased concern among managers over runoff pollutants, particularly nutrients, bacteria, and toxic organic chemicals.⁴⁰ The costs can be

astronomic. For example, runoff pollution from suburban and agricultural sources is one of the largest threats to New York City's currently unfiltered drinking water supply. If this pollution cannot be prevented, New York City may need to filter its water supply at a capital cost of perhaps \$5 billion or more.⁴¹

Aesthetic Losses

Even if stormwater does not cause illness in humans from direct exposure or through dining on contaminated shellfish, it can cause other annoyances or intrusions. The cigarette butts, polystyrene cups, and other trash that storm sewers dump in neighborhood waters are an obvious eyesore. Sediment loads reduce the clarity of water, which not only reduces its attractiveness but can also increase the likelihood of boating, swimming, and diving accidents.⁴² Excess nutrient loads can cause severe algal blooms, which coat the surface of water with an unpleasant scum, cloud the water, and add unpleasant odors and taste to water used for swimming or drinking.⁴³ The fish kills that urban stormwater pollution can cause are also community nuisances.

Harm to tourism and recreation. The combination of potential human illness and aesthetic losses can cause loss of revenues from tourism and recreational activities. Urban stormwater runoff was a documented contributing factor to approximately 25 percent of the approximately 1,651 beach closings reported in 1997, and was probably a factor in many more beach closings for which the contaminant sources were undocumented.⁴⁴ Coastal tourism is a major component of local economic activity across the nation, adding, for example, some \$54 billion dollars and more than 320,000 jobs to the economies of nine California counties alone.⁴⁵ Inland, along rivers and lakes, tourism and recreational activities dependent on clean water provide municipalities with tax revenues and employment opportunities. Each year, water-based recreation adds \$26 million to \$31 million and a minimum of 650 to 750 jobs to the economies of 13 New Hampshire towns along the Connecticut River, and over \$13 million and 290 jobs to the economy of the upper Delaware Valley between New York and Pennsylvania.⁴⁶