PERMEATING CHALLENGES

The rivers and streams entering the parks of the National Capital Region provide an impressive combination of natural, scenic, cultural, historical, and recreational value. Along the Potomac River, paddlers, fishermen, bird watchers, and many others take advantage of the many recreational opportunities offered by the parks. With the continued development and population growth throughout the Washington, D.C. metropolitan area, the integrity and health of our rivers and streams are seriously compromised. Some of the impacts of this accelerated development on streams are readily noticed, others are hidden.

National Park areas sit within a landscape matrix made up not only of forest, grassland, agricultural lands, but also of roadways, buildings, and residential and commercial development. Areas surrounding the Parks range from relatively little development to highly developed cityscapes. The gradual conversion of lands surrounding the National Parks into roadways, buildings, and parking lots has increasingly adverse impacts on water resources, according to the Water Resources Program at the Center for Urban Ecology. What is the culprit? Impervious surfaces--because they prevent the infiltration of water into the soil. Unfortunately, it may take years or even decades for the cumulative, detrimental effects of impervious surfaces to become apparent.

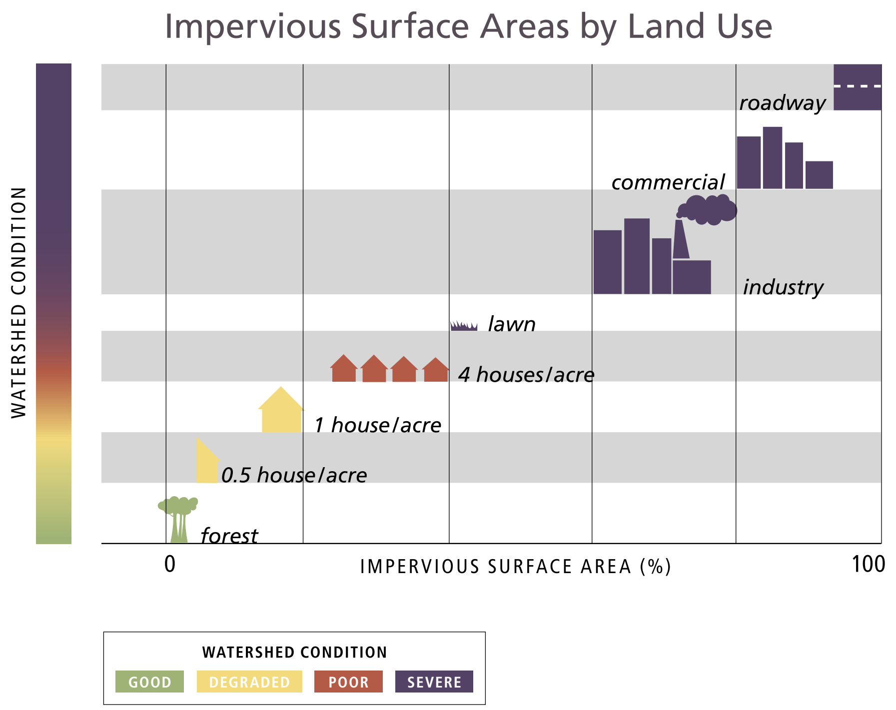
The challenge for the National Park Service is to protect resources threatened by development and to mitigate and restore resources already impacted. This is particularly difficult when threats and impacts to the resources within the parks originate outside the park boundaries. For example, three of our parks are long, skinny ribbons with large perimeter areas. One of these, the Chesapeake and Ohio Canal National Historical Park, is 184 miles (296 km) long and includes over 109 streams that are potentially affected by pollution from the surrounding developed lands in Maryland and the District of Columbia. Seven other parks are either entirely inside cities or abutting development from one or more directions. Rock Creek Park is an island of green forest within a sea of impervious surfaces (Figure 1).

Figure 1 (above)
Rock Creek Park (dark green center), located in the Washington, D.C. metro area, is a forested island surrounded by a sea of impervious surfaces created by residential and commercial development.

Figure 2 (right)
Impervious surface areas associated with different land uses. The colors represent the predicted levels of water quality condition for a watershed comprised entirely of each land use category (compiled from Anacostia 1991, CWP 1998, NVPDC 1980).

When it comes to impervious surface, it does not take much coverage to affect water resources. Generally, impaired water quality is detectable when the impervious surface area rises above 5% of the total area within the watershed. When impervious surface area rises above 30%, the water resources are permanently degraded (Brabec et al. 2002, Goetz et al. 2003). Forests are very beneficial to a watershed, but a residential development with only one house per two acres (0.8 ha) contains enough impervious surface to produce a detectable decrease in stream water quality (Figure 2). Roadways and parking lots have the most detrimental effects and are the largest contributors to impervious surfaces associated with development. However, the roofs on buildings are also a major contributor to the total impervious surface of an area.

We use watersheds as frames of reference when describing the effects of impervious surface area on water resources such as the water quality of a stream. Impervious surface area values are calculated for an entire watershed. For example, if there is a watershed with one-half of the area in medium-density residential land use equaling 40% impervious surface area and the other half is a forest with 1% impervious surface area, then the average impervious surface area for that watershed is 20.5%. The 20.5% indicates that the water resources are degraded, but the adverse effects may still be reversible.



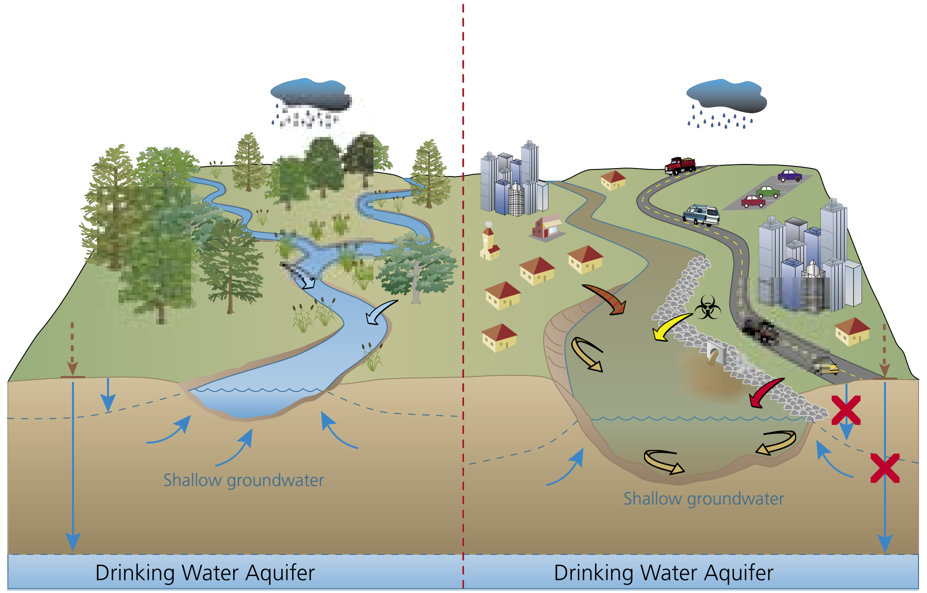
> “Impervious surfaces interfere with the percolation of water into the soil layer. In a natural system, rain water soaks into the soil and replenishes both shallow and deep groundwater reservoirs.”

Where does the water go if it is not percolating downward due to the impervious surfaces? First, the rain water gets concentrated into roof downspouts, roadside gutters, and storm water drain pipes and is quickly transported into city distribution systems such as the storm sewers. From there, the water is dumped into unprotected gullies or directly into streams and rivers, resulting in severe erosion (Figure 3). In a natural setting, streams develop over decades and commonly take a meandering form. This process is a balance between the force of the running water versus the resistance of the soils and rocks in the valley. Urbanization disrupts this balance by changing the amount and speed of the water that flows through the watershed. Increased flows force the stream to change its path and down-cut the stream channel, erode the bank, or straighten and widen the stream. Ultimately, this affects the habitat quality both in and out of the stream for fish and other organisms. Eroded urban streams can lose all their fish and turn into breeding grounds for aquatic worms, nuisance flies, and mosquitoes.

Impervious surfaces interfere with the percolation of water into the soil layer. In a natural system, rain water soaks into the soil and replenishes both shallow and deep groundwater reservoirs. Streams often are partially fed by groundwater; therefore, decreases in the volume of groundwater can dramatically change stream water flows. Many streams become dry during part of the year as a direct result of the lowering of the groundwater levels. In addition, the lack of percolation also increases the frequency and severity of flooding—the water needs to go somewhere. Flooding is a particular problem for the parks in the National Capital Region because of the proximity of many historical and cultural resources along waterways.

Urban sprawl generates large quantities of seemingly innocuous chemicals (e.g., salt, nitrogen, and phosphorus), as well as known hazardous materials (e.g., oils, metal contaminants, and bacteria). When impervious surfaces displace the natural landscapes that filter and retain contaminants, these chemicals and materials are easily transported directly into streams and rivers. In urban systems, direct input of excess nutrients can stimulate algae and aquatic plant growth to

Figure 3
Storm water flowing into an unprotected gully causes massive erosion.



Natural System

Forests, grasslands, wetlands, and meandering streams represent the natural state of the environment. Rainfall permeates natural surfaces and recharges the shallow groundwater layer and the deeper drinking water aquifer. Groundwater supplies a baseflow for streams by percolating through stream banks and stream bottoms. Forests and wetlands provide a natural buffer for absorption of pollutants and interception and storage of rainfall. Overland flow is slowed by vegetation.

Urbanized System

City and suburban development increase impervious surfaces. Impervious surfaces provide pathways for direct transport of pollutants and sewage into streams and rivers. Impervious surfaces also prevent rainfall from penetrating into the groundwater and drinking water aquifer. Lowered groundwater levels provide less input for stream flow. Increased water flow from development causes stream erosion from both the banks and the stream bottom, causing the stream to widen and deepen.

> “To interpret the potential threat of impervious surface area to watersheds, we need to demonstrate the relationship between impervious surface area and water quality in a stream.”

harmful levels. Each year in the Chesapeake Bay, plant and algae decay create areas of such low oxygen that beneficial aquatic organisms die.

In 2004, Dr. Jeff Runde in the National Park Service Water Resources Program collaborated with the Woods Hole Research Center, Woods Hole, Massachusetts and the Mid-Atlantic Regional Earth Science Applications Center, University of Maryland, College Park to obtain satellite maps for the years 1986, 1990, 1996, and 2000 that showed impervious surfaces for parts of Maryland, Virginia, West Virginia, and the District of Columbia. These maps allowed Dr. Runde to calculate the percent impervious surface area for watersheds in the National Capital Region parks. Figure 4 shows the highest impervious surface area value for each park measured in any single watershed during the year 2000.

Knowing the magnitude and growth (trend) of impervious surface area is the first step in understanding their effect on water resources. To interpret the potential threat of impervious surface area to watersheds, we need to demonstrate the relationship between impervious surface area and water quality in a stream. This relationship is called a potential threat assessment, and it has been divided into four categories. If a watershed has less than 5% impervious surface area it has “good” water quality, 10% impervious surface area is rated as having “impaired” water quality, between 11% and 30% impervious surface area is rated as “poor” water quality, and over 30% impervious surface area, the water quality is ranked as “severely degraded” (Brabec et al. 2002, Goetz et al. 2003). The satellite imagery from 2000 shows that the parks range from less than 10% potentially threatened watersheds in Catoctin Mountain Park to 100% threatened in Rock Creek Park (Figure 5).

Based on satellite imagery from 1986, Dr. Runde estimated that 68% of the National Capital Region’s waterways had a potential threat assessment of “good” back then. By 2000, the imagery showed a decrease, and only 53% of the waterways rated “good.” Of most concern was a 75% increase from 1986 to 2000 in the proportion of the waterways rated as “severely degraded.”

The Anacostia River receives trash and contaminants from urban streams in the Washington, D.C. metro area, some of which flow through National Parks.

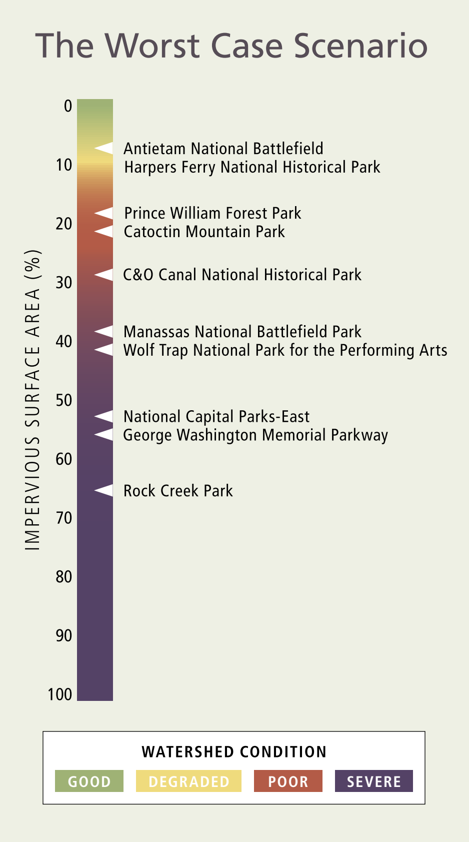


Figure 4
Year 2000 data from satellite maps. Shown here are the highest value of impervious surface area for each park.

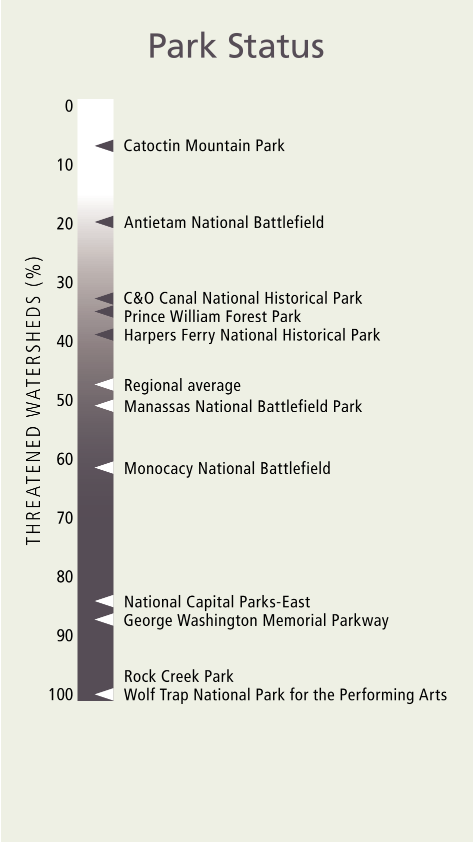


Figure 5
Percent of threatened watersheds for each park based on the percent of impervious surface area, year 2000 data.

> “The goal of the NPS Water Resources Program is to continue assessing the effects of development located both inside and outside of park boundaries to better understand potential threats to water resources. We are giving special attention to assessing the potential threat of increased impervious surface around the parks.”

It is important to note that the percent of impervious surface area in a watershed is used to predict the potential condition of the water quality in streams; the data used come from across the country (Brabec et al. 2002, Goetz et al. 2003). In 2006, the NPS Water Resources Program began water quality testing, which will help verify or ground-truth the relationship between impervious surface area and water quality for the individual watersheds within the parks.

Figure 6 shows a potential threat assessment case study for Manassas National Battlefield Park, comparing the years 1986 and 2000. Over the 14 years, development pressures outside the Park degraded the condition of five of the Park's 17 watersheds. One primary contributor was the Virginia highway system. The park is bisected by two heavily traveled highways (Virginia Routes 29 and 234) and is bordered on the south by a commuter freeway, Highway 66. The most threatened watershed is in the southeastern corner of the Park; it has doubled in impervious surface area from 20% to 40% during this period. The threat assessment predicts that water quality in this particular watershed will remain permanently degraded.

Looking into the Future

The goal of the National Park Service Water Resources Program is to continue assessing the effects of development located both inside and outside of park boundaries to better understand potential threats to water resources. We are giving special attention to assessing the potential threat of increased impervious surface around the parks. Monitoring the park waterways will quantify water quality and compare it to the predicted level of water quality from the satellite maps, which showed the amount of impervious surface within a park. This will allow the National Park Service to direct resource management efforts that will protect and improve stream quality.

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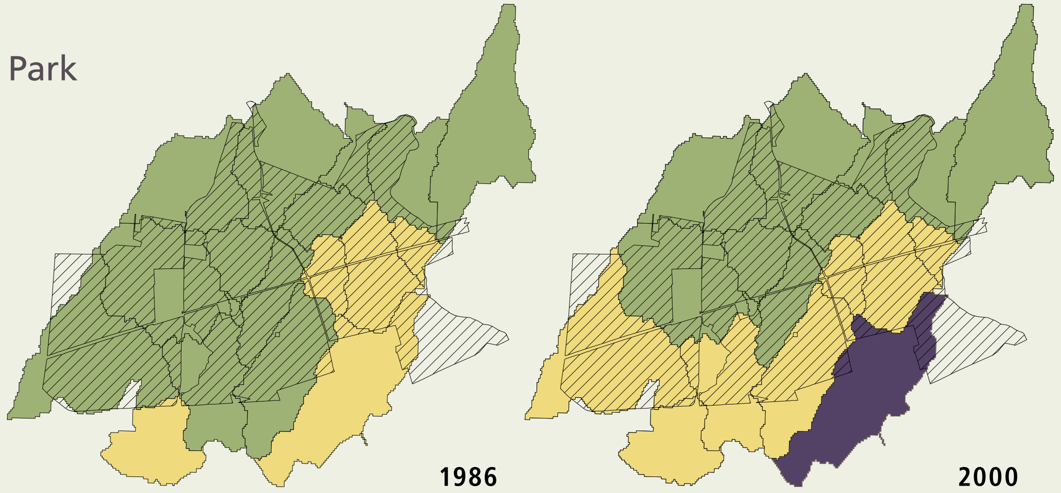
Staff from the National Capital Region Network Inventory and Monitoring program collect samples for water quality analysis.

Watershed Condition: Manassas National Battlefield Park

Figure 6
A comparison of threatened watersheds for Manassas National Battlefield Park during the years 1986 and 2000. The Park property is represented by the hatching. The most impacted watershed had 20% impervious surface area in 1986 (yellow) and more than 40% in 2000 (purple). Other watersheds moved from a good (green) to a degraded (yellow) condition.

WATERSHED CONDITION
GOOD | DEGRADED | POOR | SEVERE



CENTER FOR URBAN ECOLOGY

Water Resources Program The Water Resources Program at the Center for Urban Ecology provides technical assistance on water resource issues to protect the natural, cultural, and historical resources of the parks within the National Capital Region. Human-caused impacts such as urban development have seriously degraded aquatic ecosystems. Innovative approaches toward restoration and protection, such as long-term ecosystem monitoring, water quality assessment, and data analysis are used by scientists to address aquatic habitat health.

Protection of aquatic habitats is also accomplished through the management of the region's streams, wetlands, floodplains, riparian corridors, and groundwater systems. The Water Resources Program promotes best management practices and green infrastructure to reduce the amount of impervious surface area in the Region. They worked with Rock Creek Park to plan and place a green roof on the building that houses the Center for Urban Ecology. Green roofs have many benefits, including decreased storm water runoff. Following best management practices, the Water Resources Program assisted Rock Creek Park with creating bioengineered storm drains in the Park Maintenance Yard to reduce pollution and protect aquatic habitats in the Park. Effective water resource preservation, protection, and management are improved through research and partnerships between the Water Resources Program and other organizations concerned with the water resources of the Washington, D.C. metropolitan area.