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Protecting Our Water and Environmental Resources

Land Use

Impacts of Development on Waterways

Leslie Dorworth
Aquatic Ecology Specialist,
Illinois-Indiana Sea Grant
College Program

Robert McCormick
Coordinator,
Planning with POWER

Planning with POWER
765-494-3627
www.planningwithpower.org

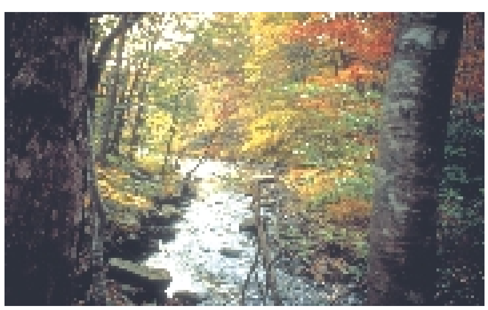
Key Finding

Traditional land development can drastically alter waterways. Increased storm water runoff associated with development often begins a chain of events that includes flooding, erosion, stream channel alteration, and ecological damage. Combined with an increase in man-made pollutants, these changes in waterway form and function result in degraded systems no longer capable of providing good drainage, healthy habitat, or natural pollutant processing.

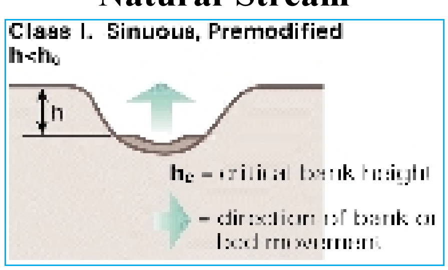
Local officials interested in protecting local waters must go beyond standard flood and erosion control practices and address the issues of polluted runoff through a multilevel strategy of planning, site design, and storm water treatment.

Disruption of the Water Cycle

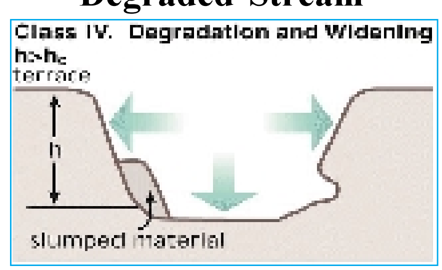
When development occurs, the resultant alterations to the land can lead to dramatic changes to the *hydrolog*y, or the way water is transported and stored. Impervious man-made surfaces (asphalt, concrete, rooftops) and compacted earth associated with development create a barrier to the percolation of rainfall into the soil, increasing surface runoff and decreasing ground water infiltration (Figure 1).



Natural Stream



Degraded Stream



Class I and Class IV figures. Channel Evolution Model. Source: Simon, 1989; US Army Corps of Engineers, 1990. In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98. © John Wiley & Sons Limited. Reproduced with permission

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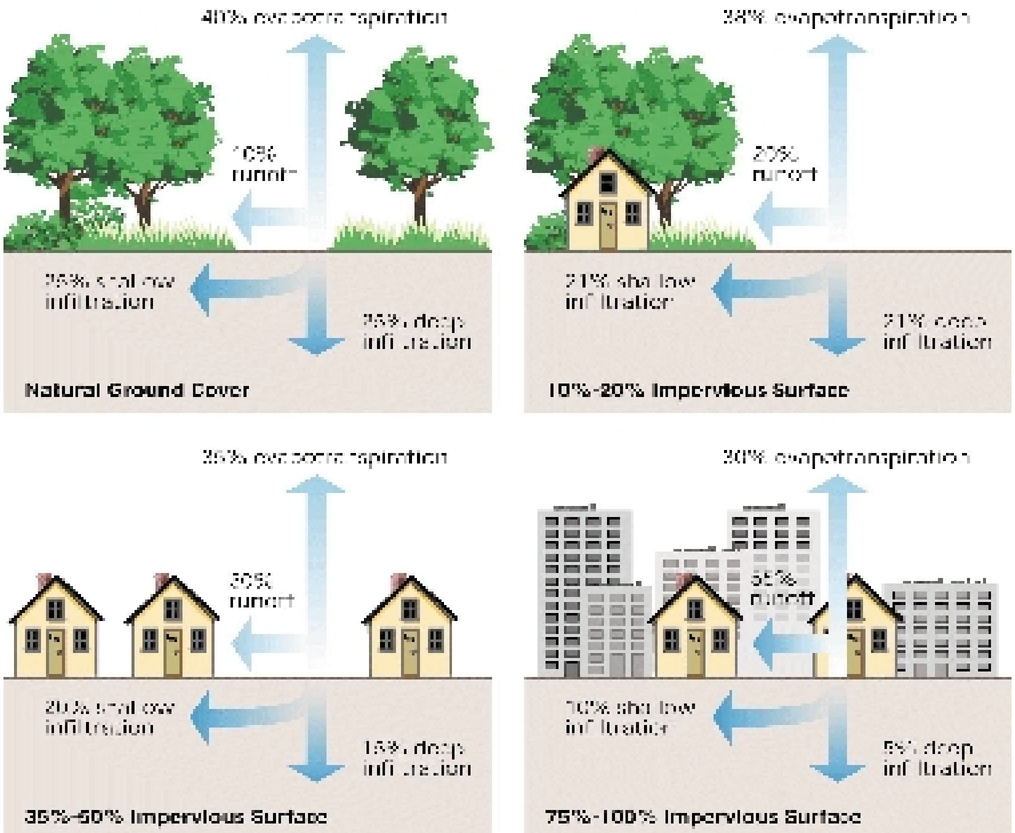

If over 10% of a watershed is covered by impervious surfaces, stream quality may be moderately impacted.

Watersheds with over 25% impervious surfaces have severely impacted streams.

Figure 1. Relationships between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation. In *Stream Corridor Restoration: Principles, Processes, and Practices* (10/98) By the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S)

This disruption of the natural water cycle leads to a number of changes, including:

- Increased volume and velocity of runoff
- Increased frequency and severity of flooding
- Peak (storm) flows many times greater than in natural basins
- Loss of natural runoff storage capacity in vegetation, wetlands, and soil
- Reduced groundwater recharge
- Decreased *base flow* (the ground water contribution to stream flow). This can result in streams becoming intermittent or dry, and also affects water temperature.

Impacts on Stream Form and Function

Impacts associated with development typically go well beyond flooding. The greater volume and intensity of runoff leads to increased erosion from construction sites, downstream areas and stream banks. Because a stream's shape evolves over time in response to the water and sediment loads that it receives, development-generated runoff and sediment cause significant changes in stream form.

To facilitate increased flow, streams in urbanized areas tend to become deeper and straighter than wooded streams, and as they become clogged with eroded sediment, the ecologically important "pool and riffle" pattern of the streambed is usually destroyed (Figure 2).

These readily apparent physical changes result in less easily discerned damage to the ecological function of the stream. Bank erosion and severe flooding destroy valuable streamside, or *riparian*, habitat. Loss of tree cover leads to

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greater water temperature fluctuations, making the water warmer in the summer and colder in the winter. Most importantly, there is substantial loss of aquatic habitat as the varied natural streambed of pebbles, rock ledges, and deep pools is covered by a uniform blanket of eroded sand and silt.

All this, of course, assumes that the streams are left to adjust on their own. However, as urbanization increases, physical alterations like stream diversion, channelization, damming and piping become common. As these disturbances increase, so do the ecological impacts—the endpoint being a biologically sterile stream completely encased in underground concrete pipes. In addition, related habitats like ponds and wetlands may be damaged or eliminated by grading and filling activities.

Then There's Water Quality…

With development comes more intensive land use and a related increase in the generation of pollutants. Increased runoff serves to transport these pollutants directly into waterways, creating *nonpoint source pollution,* or *polluted runoff.* Polluted runoff is now widely recognized by environmental

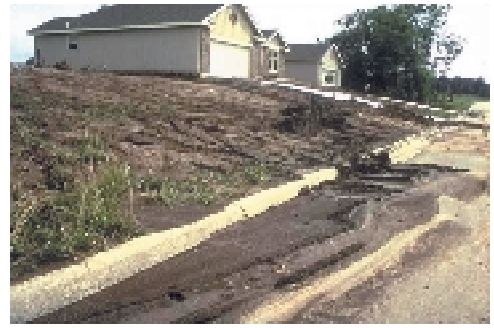

Photo courtesy of Shawnee County Conservation District, Kansas

scientists and regulators as the single largest threat to water quality in the United States. The major pollutants of concern are pathogens (disease-causing microorganisms such as bacteria), nutrients (e.g., phosphorus and nitrogen), toxic contaminants, and debris. Sediment is also a major nonpoint source pollutant, both for its effect on aquatic ecology and because of the fact that many of the other pollutants tend to adhere to eroded soil particles.

The Total Picture: Degradation of an Aquatic System

The hydrologic, physical, and ecological changes caused by development can have a dramatic impact on the natural function of our waterways. When increased pollution is added, the combination can be devastating. In fact,

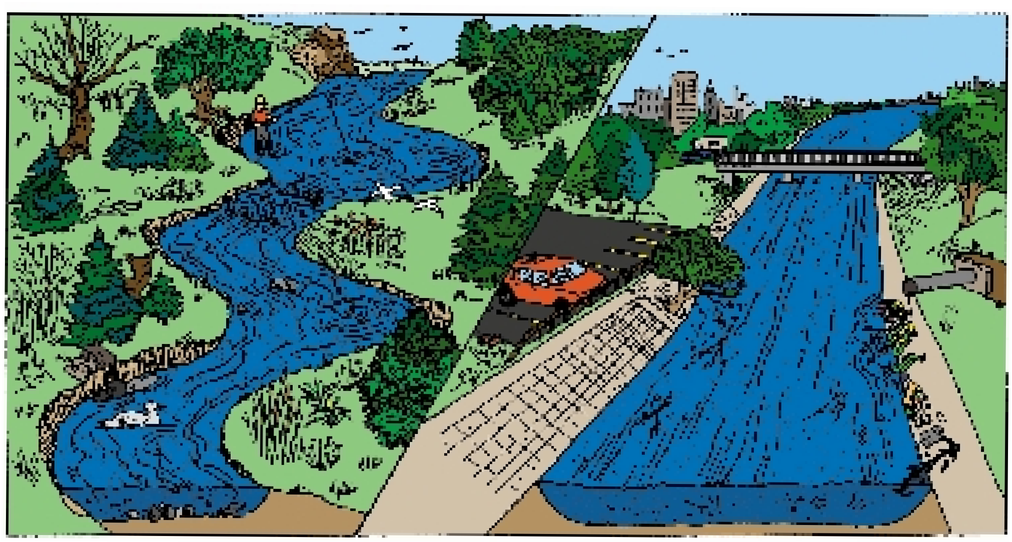

Figure 2. Changes in stream form associated with urbanization

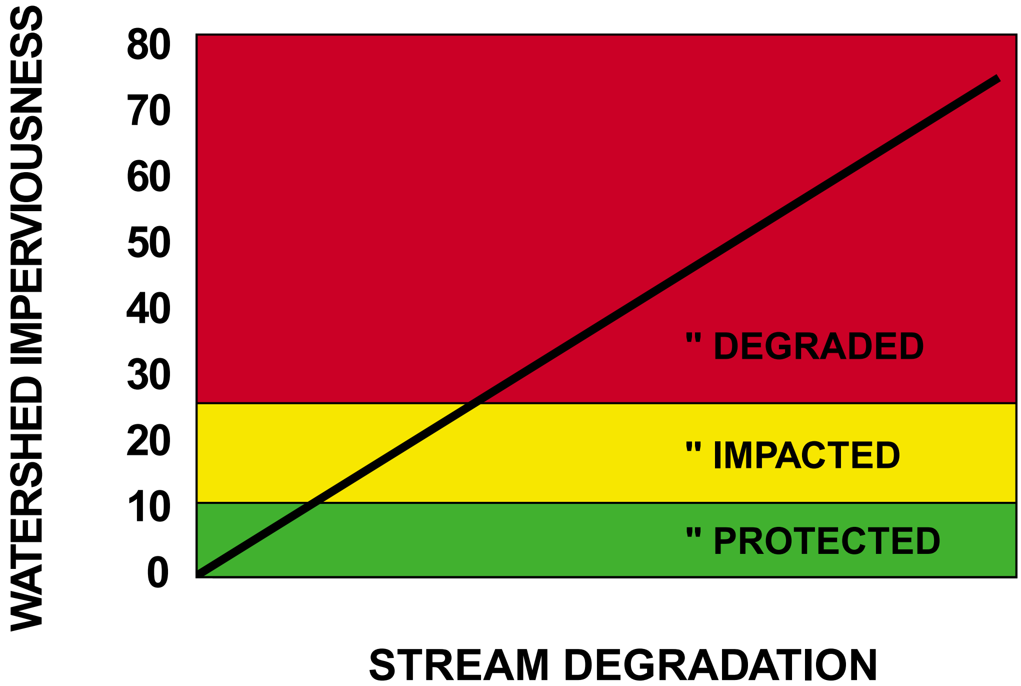

Figure 3. Stylized relationship between watershed imperviousness and receiving stream impact (adapted from Schueler, 1992).

many studies are finding a direct relationship between the intensity of development in an area—as indicated by the amount of impervious surface—and the degree of degradation of its streams (Figure 3).

These studies suggest that aquatic biological systems begin to degrade at impervious levels of 10%, or at even lower levels for particularly sensitive streams. As the percentage of imperviousness climbs above these levels, degradation tends to increase accordingly.

The end result is a system changed for the worse. Properly working water systems provide drainage, aquatic habitat, and a degree of pollutant removal through natural processing. Let's look at those functions in an urbanized watershed where no remedial action has been taken:

Drainage: Increased runoff leads to downstream flooding. Drainage systems that pipe water off-site often improve that particular locale at the expense of moving flooding (and erosion) problems downstream. Overall, system-wide water drainage and storage capacity is impaired.

Habitat: Outright destruction, physical alteration, pollution, and wide fluctuations in water conditions (levels, clarity, temperature) all combine to degrade habitat and reduce the diversity and abundance of aquatic and riparian organisms. In addition, waterway obstructions like bridge abutments, pipes and dams create barriers to fish movement.

Pollutant removal: Greater pollutant loads in the urban environment serve to decrease the effectiveness of natural processing. Damage to bank, stream, and wetland vegetation further reduces the ability to naturally process pollutants. Finally, the greater volume and irregular, "flashy" pulses of water caused by storm water runoff impair natural processing by decreasing the time that water is in the system.

Planning with POWER
is funded by:

Purdue Cooperative Extension Service

Illinois-Indiana Sea Grant College Program

Indiana Department of Environmental Management (Sec. 319 Grant)

NOAA Coastal Services Center

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What You Can Do

Flood and erosion control have long been part of many land use regulatory processes. Traditional flood control measures are usually addressed with engineered systems designed to pipe drainage off-site as quickly and efficiently as possible. However, flooding and erosion are only two of the more easily recognized components of the overall impact of development on waterways.

Photo source unknown

Standard drainage "solutions" address neither the root cause of these symptoms—increased runoff due to the way we develop land—nor the resultant environmental effects. To begin to truly address the impacts of development, county officials need to look at waterways as an interconnected system and recognize the fundamental changes that development brings to the water cycle, stream form and function, aquatic ecology, and water quality.

Incorporating this understanding into local land use decisions can help to guide appropriate development. There are a number of options that can be employed to reduce the impacts of development on water quantity and quality. Preventing such impacts in the first place is the most effective (and *cost* effective) approach and should always be emphasized.

To this end, county officials should consider a three-tiered strategy of 1) natural resource-based planning, 2) appropriate site design and use of best management practices, and 3) remediation and maintenance of existing structures.

1. Natural resource-based planning can be used to *minimize* runoff, pollutants, and impacts on natural resources by locating development in non-sensitive areas and by providing protection for critical natural resources.

2. Improved site design and use of best management practices can *reduce* the amount of runoff and pollutants resulting from development. Reducing the amount of impervious pavement in new developments and routing water to natural areas and filter strips where water can slowly percolate into the soil are examples of effective ways to reduce the impact of new development. Technological advances are continually being developed that can be used by communities to protect their natural resources while accommodating growth.

3. Remediation measures can be employed to *mitigate* the impact of development when proper siting and design of development are not sufficient to control runoff and pollutants resulting from development. Practices such as retention basins, constructed wetlands, and percolation areas are examples of practices that can mitigate the impacts of development on water resources in your community.

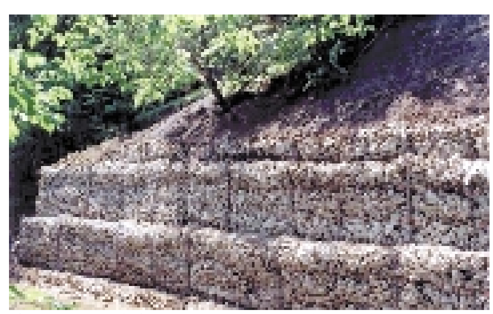

Photo courtesy of Shawnee County Conservation District, Kansas

Additional Information

To learn more about how to apply this three tiered strategy in your community or how you and your community can reduce the impacts of development on waterways, contact:

Robert McCormick
765-494-3627
Fax: 765-496-6026

E-mail: rmccormick@fnr.purdue.edu

Purdue University
1200 Forest Products Building
West Lafayette, IN 47907-1200

www.planningwithpower.org

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This paper has been modified from a publication originally written by Chester Arnold of the Connecticut Sea Grant College Program and Jim Gibbons of the Cooperative Extension Service for the University of Connecticut. Revisions and adaptations were made with permission of the Connecticut NEMO Program.

New 3/01

Illinois-Indiana Sea Grant College Program is 1 of 30 National Sea Grant College Programs. Created by Congress in 1966, Sea Grant combines university, government, business and industry expertise to address coastal and Great Lakes needs. Funding is provided by the National Oceanic Atmospheric Administration, U.S. Department of Commerce, Purdue University, West Lafayette, Indiana, and the University of Illinois at Urbana-Champaign.