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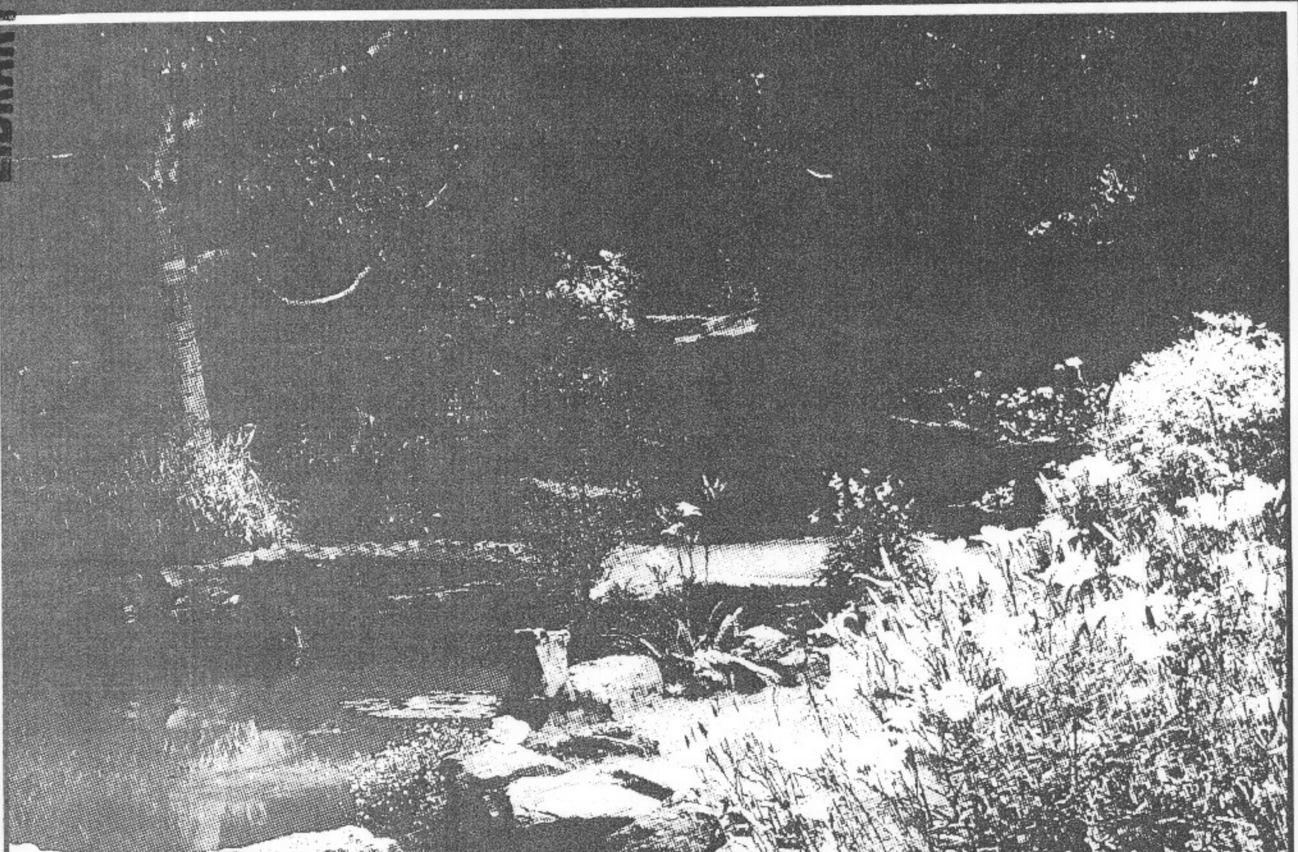
CONTROLLING URBAN RUNOFF:

A PRACTICAL MANUAL FOR PLANNING AND DESIGNING URBAN BMPs



THIRTY 1957 1987 YEARS

Department of Environmental Programs

METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS improve the level of their urban housekeeping, and, consequently, improve the quality of urban runoff.

Older neighborhoods tend to become more impervious over time, as each new deck, patio, driveway, infill development and road improvement is constructed. Also, as both intended landscaping and "weed" trees grow older and become more widespread, their leaves and pollen (which would normally be slowly converted to humus on the forest floor) are more likely to fall on impervious surfaces and be washed into the channel. During the growing season, nutrients leach from tree leaves and stems during storms, and are quickly conveyed to the stream if the trees' drip line extends over an impervious area.

IMPACTS OF URBAN POLLUTANTS ON RECEIVING WATERS

The net effect of urbanization is to increase pollutant export by at least an order of magnitude over pre-development levels. The impact of the higher export is felt not only on adjacent streams, but also on downstream receiving waters such as lakes, rivers and estuaries. The nature of the impacts associated with specific urban pollutants are reviewed below. Also, the development situations that are likely to result in the most severe receiving water impacts are identified. Planners and designers should become familiar with these situations so that they can determine the pollutants of greatest concern and then choose the most appropriate BMP for the site.

Sediment

High concentrations of suspended sediment in streams cause many adverse consequences including increased turbidity, reduced light penetration, reduced prey capture for sight feeding predators, clogging of gills/filters of fish and aquatic invertebrates, reduced spawning and juvenile fish survival, and reduced angling success. Additional impacts result after sediment is deposited in slower moving receiving waters, such as smothering of the benthic community, changes in the composition of the bottom substrate, more rapid filling of small impoundments which create the need for costly dredging, and reduction in aesthetic values. Sediment is also an efficient carrier of toxicants and trace metals. Once deposited, pollutants in these enriched sediments can be remobilized under suitable environmental conditions posing a risk to benthic life (Gavin and Moore, 1982).

The greatest sediment loads are exported during the construction phase of any development site. On stabilized develpoment sites, the greatest sediment loads are exported from larger, intensively developed watersheds, that are not served by BMPs that effectively control streambank erosion.

Nutrients

Excess levels of phosphorus and nitrogen in urban runoff can lead to undesirable algal blooms in downstream receiving waters (also known as eutrophication). Generally, phosphorus is the controlling nutrient in freshwater systems. Bioassays (OWML, 1983) have indicated that the typical nutrient concentrations in urban runoff are more than sufficient to stimulate excessive algal growth. A major reason is that a majority of the nutrients in urban runoff are present in soluble forms that are readily taken up by algae.

The greatest risk of eutrophication is in urban lakes and impoundments that have long retention times (2 weeks or greater). Under optimal environmental growing conditions, these lake systems can experience chronic and severe eutrophic symptoms such as surface algal scums, water discoloration, strong odors, depressed oxygen levels (as the bloom decomposes), release of toxins, and reduced palatability to aquatic consumers. High nutrient levels also promote the growth of dense mats of green algae that attach to rocks and cobbles in shallow, unshaded headwater streams. Finally, nutrient loads from urban runoff, in combination with other sources, can contribute to eutrophication in both fresh and tidal waters. Regional examples in the Washington, D.C. area include the Occoquan and Little Seneca reservoirs, the upper Potomac and Patuxent estuaries, and the Chesapeake Bay.

As a general rule of thumb, nutrient export is greatest from development sites with the most impervious area. Exceptions include land uses that receive unusually high fertilizer inputs, such as golf courses, cemeteries, and other intensively landscaped areas.

Bacteria

Bacterial levels in undiluted urban runoff exceed public health standards for water contact recreation almost without exception. Bacteria standards violations are also a routine occurrence during storms in most of the urban streams monitored in the Washington region (MWCOG, 1984). Because bacteria multiply faster during warm weather, it is not uncommon to find a twenty-fold difference in bacterial levels between summer and winter. (US EPA, 1983). Even though bacterial levels are very high, there is some debate whether the kinds of bacteria found in urban runoff really present a severe health hazard (BRPC, 1986b). The test itself is only a count of coliform bacteria, which are an indirect and often imprecise indicator that more potent pathogens and viruses might be present (US EPA, 1983).

Although nearly every urban and suburban land use exports enough bacteria to violate health standards, older and more intensively developed urban areas produce the greatest export. The problem is especially significant in urban areas that experience combined or sanitary sewer overflows that export bacteria derived from human wastes.

Oxygen Demand

Decomposition of organic matter by microorganisms depletes dissolved oxygen (DO) levels in slower moving receiving waters such as lakes and estuaries. The degree of potential DO depletion is measured by the biochemical oxygen demand (BOD) test that expresses the amount of easily oxidized organic matter present in water. Unfortunately, the BOD test is somewhat unreliable for measuring the oxygen demand of urban runoff since trace metals may inhibit bacterial growth and thus interfere with the test (OWML, 1982). The simpler chemical oxygen demand (COD) test, which measures all the oxidizable matter present in urban runoff, is not much better, since it includes some organic matter that does not ordinarily contribute to oxygen demand, and is only weakly correlated with BOD levels (OWML, 1982).

Despite the problems in measuring oxygen demand, it is clear that urban runoff can severely depress DO levels after large storms. BOD levels can exceed 10 to 20 mg/l during storm "pulses" which can lead to anoxic conditions (zero oxygen) in shallow, slow-moving or poorly-flushed receiving waters. The problem is particularly acute in some older urban areas, where pulses of storm runoff BOD mix with overflows from combined or sanitary sewers. Chronic examples in the Washington-Baltimore region include the lower Anacostia River in the District of Columbia and the mouth of Jones Falls in Baltimore.

The greatest export of BOD occurs from older, highly impervious residential areas with outdated combined storm sewers and large populations of pets. In contrast, only moderate BOD export has been reported from newer, low density suburban residential development.

Oil and Grease

Oil and grease contain a wide array of hydrocarbon compounds, some of which are known to be toxic to aquatic life at low concentrations (Stenstrom et al., 1984). The major source of hydrocarbons in urban runoff is through leakage of crankcase oil and other lubricating agents from the automobile (Tanacredi and Stainken, 1981). As might be expected, hydrocarbon levels are highest in the runoff from parking lots, roads, and service stations. Residential land uses generate less hydrocarbon export, although illegal disposal of waste oil into storm sewers can be a local problem.

While hydrocarbons have never been routinely monitored in Washington, D.C. area storm runoff, numerous studies in other regions of the country (Hoffmann et al., 1984; Stenstrom et al., 1984, and references cited therein) have reported average hydrocarbon levels during storms ranging from 2-10 mg/l. Hydrocarbons are lighter than water and are initially found in the form of a rainbow colored film on the water's surface. However, hydrocarbons have a strong affinity for sediment, and much of the hydrocarbon load eventually adsorbs to particles and settles out. If not trapped by BMPs hydrocarbons tend to rapidly accumulate in the bottom sediments of lakes and estuaries (Wakeham, 1977; Tanacredi and Stainken, 1981), where they may persist for long periods of time, and exert adverse impacts on benthic organisms (Whipple and Hunter, 1979).

The precise impacts of hydrocarbons on the aquatic environment are not well understood. Remarkably few toxicity tests have been performed to examine the effect of urban runoff hydrocarbon loads on aquatic communities under the typical exposure conditions found in urban streams. Bioassay data which does exist is largely confined to laboratory exposure tests for specific hydrocarbon compounds, which are difficult and expensive to routinely measure in the field. Clearly, community level toxicity testing for hydrocarbons should be a high research priority, both in the water column and sediment layer.

Trace Metals

Trace metals are primarily a concern because of their toxic effects on aquatic life, and their potential to contaminate drinking water supplies. As noted before, most of the metals found in urban runoff are derived from "leakage" of the urban landscape.

A wide variety of trace metals were found in urban runoff samples taken during the special trace metals sampling program conducted as part of the Washington, D.C. area and national Nationwide Urban Runoff Program (NURP) studies. Specifically, the following metals were measured in detectable concentrations: arsenic, beryllium, cadmium, chromium, copper, cyanide, mercury, nickel, lead, selenium, thallium, and zinc (JTC, 1982; DDN, 1982). With the significant exceptions of lead, cadmium, copper and zinc, most of