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An Introduction to Stormwater Indicators

Municipal officials are increasingly asked to protectthreatened water resources in the face of urban growth pressures. While municipalities, industries, and governments have all developed technologies to treat human sewage and industrial wastes (i.e., point source discharges), and have developed scientifically accepted methods to monitor the success of these treatment strategies, the ability to successfully treat urban stormwater and measure the effectiveness of these treatments is still several levels below the "point source control" field.

The reasons appear to be relatively simple to explain, yet hard to quantify. Sewage treatment plant outfalls and industrial site discharges generally come from one location or source and therefore the chemical makeup of the outfall is reasonably easy to identify. Numerical limits for pollutant concentrations are relatively easy to establish (at least for dry weather conditions) and, in theory, are reasonably easy to enforce. On the other hand, pollutants in stormwater runoff are likely to come from many very small source areas that are often hard to pinpoint. Furthermore, stormwater runoff varies widely as a function of rainfall intensity and duration. Therefore, pollutant concentrations are likely to differ spatially along a given waterbody due to varying dilutions as mixing occurs from other drainage areas. Finally, stormwater runoff events are often very short-lived, particularly in urban streams. These episodes are often highly variable with large inputs of runoff and pollutants occurring and dissipating in a few hours.

Until recently, most stormwater monitoring was conducted at pipe outfalls along the urban drainage system. The data gleaned from these investigations have helped us to characterize the concentrations of untreated urban runoff. For example, the National Urban Runoff Program (NURP) studies, conducted by EPA and others in the early 1980s, helped establish a database that has proved useful in computing stormwater loadings of pollutants from various land uses. More recently, NPDES monitoring data from municipal and industrial stormwater permits have helped confirm the earlier NURP data, as well as confirm particular pollutant source increases or decreases over time (e.g., reductions in lead due to discontinuation of leaded gasoline in automobiles). An example of typical stormwater runoff concentrations is shown in Table 1.

Stormwater pollutant concentration data have been used frequently to assess compliance with water data quality standards and criteria. Examples of specific criteria include limits on maximum concentrations for either human ingestion or aquatic life exposure. These criteria were developed by EPA (1983) in an attempt to define the effects of short term and intermittent exposures typically associated with urban runoff. Problems with relying on water quality criteria include:

- An exceedance of a numerical limit in a receiving waters may occur for only a short period of time during or immediately after a storm
- An exceedance at an outfall does not necessarily mean that water quality criteria have been exceeded in a stream because of dilution
- There is a considerable scientific uncertainty about exact species effects and lethality for a given pollutant concentration
- Human ingestion limits may not appropriately reflect the aquatic life uses of the receiving waters

Consequently, it has been difficult for municipal officials and regulators to relate stormwater pollutant concentration data to evaluate the effectiveness of stormwater management practices. Furthermore, pollutant concentrations are generally similar from location to location. In fact, with the exception of a few isolated urban "hotspots," there is surprisingly little difference among recent stormwater chemistry monitoring studies.

More recently, biological monitoring methods have been used to help evaluate the cumulative effects of stormwater runoff on receiving waters. In at least one aspect, biological monitoring is perhaps a more reliable indicator than chemical monitoring, since biological communities can accumulate the effects associated with continual exposure to both stormwater and low flow events. Dr. Robert Karr, one of the preeminent scientists in the field of bioassessment, found that the health of fish communities in mid-western U.S. streams was directly related to the degree of human influence on watersheds (Karr, 1986).

While the use of biological monitoring methods is not new, it is only within the last few years that they have been applied to directly assess the impacts of urban stormwater runoff.