**Article 112**

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# Performance and Condition of Biofilters in the Pacific Northwest

What exactly is a biofilter? Some would say it is a grassed swale with class. More technically, it a swale that is explicitly designed to treat stormwater rather than just conveying it along. In the last few years, our knowledge about biofilters has increased as a result of research from the Pacific Northwest.

Local governments in the Puget Sound region of Washington have turned to biofilters as cost-effective methods to treat urban stormwater runoff. They are passive, technically simple, and flexible methods of treating runoff in developing areas. Biofiltration is a process where stormwater is treated by contact with vegetation and soil surfaces along a long and broad grass swale. A cooperative team of researchers from several cities and universities has investigated the performance of biofilters over the last few years. In addition, the researchers have gathered field data to define some of the most critical variables for the design of biofilters.

The biofilter design process relies on an adaptation of Manning's formula of open channel flow for the six month, 24-hour design storm, using an iterative process constrained by a specified maximum velocity and slope. Manning's formula for open channel flow expresses the relationship among all of the principal biofilter design variables, with the exception of biofilter length. It is frequently expressed as follows:

$$Q = (1.49/n) * A * R^{0.67} * s^{0.5}\text{, where}$$

Q = the volumetric flow rate, $ft^3/s$

$n$ = Manning's coefficient, accounting for boundary friction

A = cross-sectional area, $ft^2$

R = hydraulic radius, the ratio of cross-sectional area to wetted perimeter, ft

s = channel slope (ft vertical/ft horizontal)

Horner *et al*. (1988) have developed an iterative biofilter design procedure based on the capacity of the biofilter during the water quality design event and the stability (erosion potential) of the biofilter during more extreme events. Key design variables in Horner's procedure include the Manning's *n* value, swale shape, maximum flow velocity for the design storm, and residence time in the biofilter (Seattle Metro, 1992).

To determine the pollutant removal performance of a typical biofilter, the City of Mountlake Terrace (Washington) constructed a test 200-foot long biofilter. The geometry of the trapezoidal biofilter was as follows: 4% average slope, five-foot bottom width, and 3:1 (h:v) sideslopes. Average residence time for runoff within the biofilter was computed to be just under ten minutes. The biofilter was about two years old, and was mowed twice a year. The biofilter served a comparatively large 15.5 acre watershed, consisting of single family and multi-family residential homes, parks, and a major arterial road. Total imperviousness in the contributing watershed was approximately 47%.

During the second phase of the study, the upper 100 feet of the test biofilter was piped, thereby effectively reducing its length by half. This modification enabled the researchers to test the performance of biofilters designed for a shorter length and corresponding residence times (about five minutes).

Runoff inflow and outflow from the 200-foot configuration was monitored during six storm events in the summer and fall of 1991. An additional six flow-weighted composite samples were collected from the shorter 100-foot biofilter in the Fall and Winter of 1992. Removal rates were computed based on the change in pollutant concentration occurring between the inflow and outflow from the biofilter. Consequently, the sampling method did not measure the possible reduction in pollutant loads due to runoff infiltration within the biofilter itself. Infiltration, however, was very minor. The swale was on a glacial till not far below the surface, and the upper soil layer was observed to saturate rapidly (<1 hour) after the onset of a storm.

The 200 foot long biofilter was found to be reasonably effective in removing many pollutants contained in urban stormwater (Table 1). In general, high rates of removal were reported for sediment, hydrocarbons, and particulate trace metals, but nutrient removal was very modest. Less than 30% of the total phosphorus entering the biofilter was removed, and the biofilter actually was a net exporter of nitrate. More encouraging removal rates were observed for biologically available phosphorus forms. Surprisingly, the biofilter tended to increase the level of fecal coliform bacteria as runoff passed through it. This increase was thought to be due to pet droppings and possible bacterial multiplication within the biofilter itself.