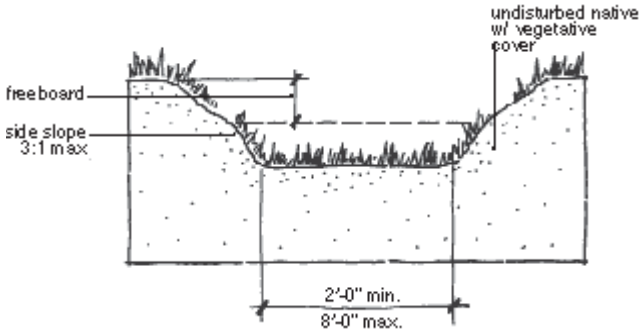
Bioswales

Bioswale is the term generally given to any vegetated swale, ditch, or depression that conveys storm water. The fully vegetated bioswale and the open channel bioswale (roadside example at the right) are the two basic types of vegetated swales based upon the degree of vegetation. Some subtypes of bioswale are based upon their general cross-sectional shape, i.e. "U", "V", and "trapezoid". Generally, the "U" and "V" shaped swales are just ditches that have become naturally vegetated and they are usually open channeled. The Trapezoidal fully vegetated bioswale is the most effective bioswale at removing pollutants. Open channels do not add much more than infiltration to the process of removing pollutants. When bioswales are designed, they are designed to address a certain storm event such as the two year or ten year 24-hour storm event. Statistically, around 90 percent of the storm events will be less than this design amount. Open channels typically are open to the extent that this 90 percent flow is in the open channel which results in very little bioremediation of the storm water most of the time. Fully vegetated, trapezoidal cross-section bioswales will result in much better remediation of the pollutants in the storm water runoff than open channels or the other cross-sections.

Trapezoidal Cross Section Example



Bioswales provide good treatment of stormwater runoff without the extensive maintenance required for some other stormwater BMPs. Pollutant removal rates increase when bioswales are well maintained, and as the residence time of water in a swale increases.

The effectiveness of bioswales is also dependent upon the retention time of the storm water in the bioswale. The longer the retention time, generally, the higher the removal effi-

ciency. The type of vegetation and the life cycle that the vegetation is in will also effect the pollutant removal rate. Consultation with a biologist is greatly beneficial when considering what vegetation to plant in the bioswale. Dormant vegetation will only reduce the storm water runoff velocity and not provide the benefits of vegetation uptake of the pollutants. Some reduction in the bacterial uptake and conversion of pollutants to more stable less toxic configurations will still take place but probably at much reduced rates.

Stormwater runoff contributes pollutants to streams, rivers and lakes. Pesticides, herbicides, and fertilizers come from residential lawns, commercial landscaping, and recreational facilities like golf courses. There can be residuals that leach from land that was once farmland. Heavy metals come from vehicles, buildings, roofs, and industrial sites. Oil and grease drip regularly from cars onto streets, parking lots, and are occasionally dumped into storm drains by residents performing maintenance on vehicles and equipment. Pathogens and bacteria in runoff can come from pet waste, broken or leaking sanitary sewers, wildlife, or sanitary sewer overflows.

Bioswales can remove and immobilize or break down a large portion of pollutants found in stormwater runoff. Bioswales have achieved high levels of removal of suspended solids (TSS), turbidity, and oil and grease. They can also remove a moderate percentage of metals and nutrients in runoff. This lower level of removal compared to sediment or oil and grease is due partly to the large percentage of metals and nutrients that appear in dissolved form in runoff. The term “dissolved form” includes microscopic particulate that generally is referred to as turbidity.

Bioswales can achieve good removal of metals or nutrients that are attached to suspended soil particles through settling of the solids by natural flocculation and vegetation uptake. Infiltrated storm water uses the soil and, in some cases depending upon the pollutant, the microbiology in the soil to filter dissolved pollutants from runoff. Since most bioswales infiltrate only a portion of their flow, removal rates for pollutants in dissolved form are lower than those for sediment or oil and grease unless retention time for the pollutants in the bioswale is sufficient for natural flocculation, infiltration, biological conversion/consumption, and/or vegetative uptake to occur.

Nutrients, including nitrogen and phosphorus, appear in urban runoff in dissolved form as well as attached to sediment particles, and can be removed by settling, flocculation, vegetation uptake, and infiltration. They are then broken down or converted to other forms by the biota, and are stored in the soil or taken up by plants. Nutrient remobilization can occur in the winter when plants become dormant or if the soil is transported. However, periodic mowing of swales and removal of the mowed vegetation can reduce remobilization.

Like nutrients, metals appear in both dissolved form and attached to sediment particles. Metals removal rates by swales can be maximized by:

* maximizing the amount of water captured by a swale through infiltration;

* increasing the pH of a bioswale's flow--basic flows drop out more metals;

* increasing the cation exchange capacity and pH of the bioswale's soil (soils with more organic matter remove a greater amount of metals); and

* maximizing the density of a bioswale's vegetative cover without unduly restricting the flow.

Metals reduction concentrations ranging from twenty to sixty percent in the storm water runoff have been documented in studies of bioswales. The higher reduction values were common for well-designed and maintained swales, and the lower reduction values were seen for swales with patches of bare soil or short retention times.

Since much of the metals removal ability of bioswales has been related to infiltration, an important concern is whether the heavy metals will accumulate to toxic levels in the bioswale underlain soil and whether they will migrate into and contaminate the groundwater. In removing heavy metals either through vegetation uptake or through soil filtration, a bioswale concentrates them. Maintenance of the bioswale vegetation by mowing or removing dead vegetation will remove some of the accumulated metals. Soil particles will attract and bind much of the remaining concentrations of the metals. Studies of bioswales in sandy, loamy, and clayey soils, found that in many cases metals accumulated only in the top several inches of soil. In clayey and loamy soils showed metals accumulating only in the top two inches of soil.

Some people consider the filtration of the storm water through the soil as being one of the largest benefits to using bioswales. Experience dealing with septic systems indicates that there can be a limit to the amount of filtration that can be obtained by the soil in filtering out and retaining some pollutants. The degree of the soils ability to continually remove some pollutants depends to some extent on whether or not the pollutant is biologically degradable.

Metals have not been found to accumulate to toxic levels in grassy swales. One study in 1986, of a bioswale adjacent to a four-lane high-way carrying 29,000 vehicles per twelve hours fifteen years after its construction, showed metals levels in the grassy bioswale were far below the required standards for metals in municipal wastewater sludges recommended for agriculture usage, with the exception of lead, which was at the standard. The lead probably came from the use of leaded gasoline in that time frame. With the elimination of leaded gasoline since that time, concentrations of lead in swales constructed in the last few years would probably not be as high as that measured in the particular study.

Biologic action accounts for the high removal of oil and grease from swales. A minimum seventy-five percent reduction of oil and grease was found in one study in a bioswale with a residence time of approximately 9 minutes. A check of the length of the same bioswale equivalent to a residence time of four and a half minutes resulted in a minimum oil and grease removal of forty-nine percent. It has been found that, to a certain extent

and with a small lag time, as the concentration of oil and grease increase the removal efficiency increases. The lag is probably due to the time required for the establishment of a additional new growth of bacteria and the increased efficiency was probably due to the increased bacteria present.

In the few studies that have been done on pathogen removal by swales, grassy swales have not been found to significantly reduce concentrations of escherichia coli (e. coli) bacteria. This could be due to the fact that swales attract more wildlife which add to the e. coli in the swale. There is no conclusive information as to whether swales will or will not remove pathogens.

Besides removing pollutants from storm water runoff, bioswales provide storm water detention and thus can reduce the increased peak flow rate that is the result of increased impervious surfaces from site development. Many municipalities in Oregon are now requiring water quality or detention ponds or devices to mediate the expected increased peak flow rates from development and thus reduce or eliminate increased stream flows which typically cause stream bank erosion. Bioswales can be an alternative to those detention facilities.

Vegetation

Swale vegetation must meet certain criteria for the vegetation planted along a swale to maintain channel stability and improve the bioswale's ability to filter pollutants from stormwater. The vegetation must:

* provide a dense cover and a root or rhizome structure that holds the soil in place in order to resist erosion;

* during water quality level flows (event design), it must stand upright in order to provide maximum residence time and pollutant removal;

* tolerate a bioswale's soil conditions (pH, compaction, composition); and

* tolerate periodic flooding and drought. It must not be dormant during the period of the year that the pollutants are to be treated.

In some cases, the bioswale vegetation must also meet aesthetic and functional criteria by selecting the appropriate plant for the use, water cycle, aesthetic goals, and local government codes. Many municipalities require setbacks from intersections, require low height vegetation for visibility at intersections, along parking lots, streets, and pedestrian walkways, or for police surveillance. Bioswales and their plant materials can present unique and different visual characteristics from conventional drainage or landscape design. Turf grass lawns, woody perennials, drought-tolerant, riparian or exotic plants, and cobbles can all be used, depending on the desired aesthetic effect.