California Coastal Nonpoint Source Program
Water Quality Fact Sheet

Infiltration BMPs: factors controlling effectiveness

Note: This factsheet is a summary of information compiled by the Coastal Commission's water quality staff. It is not a finding by the Coastal Commission and this factsheet may be superseded by site-specific information.

Background

Infiltration BMPs should be considered for most projects because of the low cost and utility of using the natural characteristics of a site to improve water quality, preserve groundwater and maintain base flows in local stream channels. Examples of infiltration BMPs include preserving natural infiltration, constructing trenches and basins to enhance infiltration of site runoff, and providing subsurface galleries to infiltrate runoff where space is limited.

The ability of a site to infiltrate runoff is primarily dependent on the permeability of the substrate and the depth to the groundwater surface, but other factors are also important in deciding whether to use an infiltration BMP. These include type of development, amount of available space, geotechnical issues, pre-existing site contamination, and ability to properly maintain the BMP.

Type of Development

Industrial: Infiltration may not be appropriate for industrial land uses where concentrated pollutants from spills or even normal industrial practices be inadvertently released into soil. For sites where ongoing use of potential soil and groundwater contaminants create an elevated risk, it may be possible to isolate the high risk activities or "pre-treat" the runoff with other treatment control prior to infiltration.

Single Family Residences: Under most conditions, treatment control BMPs or other structural BMPs[1] are not required for development of individual single-family residences (SFRs), in part, because the costs can exceed the benefits given the low levels of polluted runoff from a typical SFR. For most SFRs, protection of coastal water quality can be achieved by site design and source control BMPs. On the other hand, even the relatively moderate levels of polluted runoff from a typical single-family residence may require more that site design and source control BMPs if they are directly adjacent (say within 200 feet) of environmentally sensitive habitat areas (ESHA) or surface waters. In this case even residential uses of pesticides and fertilizer, releases of landscaping materials (e.g., tanbark) or yard waste (e.g., grass cuttings), contributions to dry weather runoff from over watering or overspray, or animal waste may adversely impact important coastal resources.

Pre-Existing Subsurface Site Contamination

A second consideration in using infiltration techniques is whether or not there is preexisting subsurface contamination at a site. Contaminated soil or groundwater can result from past

[1] Structural BMPs require some construction as opposed to BMPs that only require changes in behavior. BMPs that keep pollutants out of runoff are called "source control" BMPs and they can be either structural or behavioral. BMPs that remove pollutants from runoff are called "treatment control" BMPs and they generally require some sort of construction and so most treatment control BMPs are also structural BMPs.

practices and activities that occurred at the site, such as aerially deposited lead along highways (from the days of leaded gasoline), residual materials from past industrial practices or even from concentrations of naturally occurring substances (e.g., selenium) that may concentrate in soils under certain conditions.

Infiltration BMPs also must be carefully sited to avoid adverse impacts to On-site Treatment Systems (OSTS or septic system) leach fields. OSTS work on the same principal as infiltration BMPs, using the soil and substrate to filter contaminants. BMPS that concentrate infiltration near OSTS leach fields can compromise both systems.

Available Space to Accommodate Infiltration

Infiltration BMPs can be as small as 2-3% of the property surface area (CASQA), but they can also be larger depending on the amount of impervious surfaces, infiltration rates and design storm. In Contra Costa County it is recommended that new development (presumably on appropriate soils) set aside 4% of property for infiltration type BMPs and that the setback from structures is 10 feet (or as recommended by a structural or geotechnical engineer). In either case, infiltration BMPs are likely to take up more surface are than simple inlet filter BMPs and so planning for their surface area and appropriate location during site design is important.

Infiltration BMPs need sufficient surface area and depth so that the volume of runoff of that needs to be treated (design volume) will not overflow from the infiltration area and so that changes to the groundwater conditions will not cause adverse impacts to structures (e.g., excessive moisture in crawlspace). The area needed for infiltration BMPs will depend on soil infiltration rates, depth of unsaturated soil above the groundwater surface and presence of materials that may slow infiltration (e.g., suspended solids in runoff, leaves).

Another spatial constraint on infiltration BMPs is the proximity of the location to coastal waters or wetlands. Infiltration may be a benefit near surface waters or wetlands if it helps to maintain the existing hydrology, but such situations will require close attention to potential sources of contamination to the runoff. Projects proposing infiltration BMPs within 200 feet of surface waters should be considered for additional site-specific evaluation. That evaluation may call for procedures that isolate the chemicals from the infiltration or may show that the soil has the capacity to adsorb the potential pollutants.

Geotechnical issues

Infiltration BMPs may not be appropriate on steep slopes, near coastal bluffs, where the saturation of soil lowers the slope factor of safety or where it reduces the strength of a structural foundation.

Slope of property: CASQA recommends that properties with a slope over 15% should not be considered. This could lead to problems with capture runoff moving at higher velocities, as well as the slope failure concerns below. In addition, construction of a flat basin on a steep slope would require cut and fill work exacerbating slope stability issues and possibly leading to infiltrated water exfiltrating (coming to the surface) prematurely.

Coastal Bluffs or Cliffs: Infiltration BMPs could cause new problems if they are above and close to coastal bluffs or cliffs. The focused area of infiltration could result in groundwater discharging through the bluff or cliff face leading to reduced cohesive strength and subsequent increased erosion. This type of impacts on coastal bluffs is already a problem caused by overwatering on some portions of the coast and infiltration BMPs should not be used if it is likely that they will make the problem worse.

Slope stability: Typically, an engineer will perform a slope stability analysis to determine whether or not a slope has an adequate factor of safety when development is planned. Since infiltration of runoff can change slope stability conditions, this should be considered in the analysis.

Structural foundations: Buildings and other structures distribute the weight of the structure on a foundation to reduce the pressure on the substrate or soil around it. The impact of infiltration needs to be considered where foundations or structures could be affected.

Soil and Substrate Characteristics

Clay soils absorb runoff slowly, but are effective in removing pollutants. Sandy soils absorb water quickly but are not as efficient at removing pollutants. Infiltrated runoff that mixes with unconfined groundwater moves slowly through the substrate, and further remove pollutants, but eventually flows to a surface water or may be extracted for use. The substrate hydraulic conductivity and pollutant removal effectiveness and groundwater characteristics are all factors in designing infiltration BMPs.

Hydraulic Conductivity: The variability of infiltration rate depends greatly on the site geology (stratigraphy, structure and other properties of the soil, sand, clay and rock). Sites with uniform subsurface conditions will have relatively uniform infiltration rates, whereas sites underlain by variable conditions (e.g., landslide debris, buried stream channels, fine-grained alluvial deposits, and sites that have had previous earthwork activities such as cuts and fills) will have much higher variability. A small difference in grain size can change hydraulic conductivity by orders of magnitude, and substrates with mixed grain sizes have a lower hydraulic conductivity than those with uniform grain size distribution. Thin layers of low permeability material may ultimately control the rate and the direction of infiltration.

Pollutant Removal Effectiveness: The removal of pollutants by infiltration is due to the natural properties of the substrate. These properties include physical filtering, sorption, chemical precipitation into the substrate, and for certain organics, biotransformation to less harmful constituents. The abundance and types of these pollutants that are present in runoff will impact the effectiveness of the substrate to remove the pollutants. Clays or silts with a substantial proportion of clay tend to have the highest pollutant removal capacity, but the lowest infiltration rates. In order for clay-rich substrates to be effective in pollutant removal, larger areas must be available for infiltration, which may cause conflicts with other site resources. CASQA recommends that a where substrate supports an infiltration rate over 2.4 in/hr pretreatment of the runoff should occur to protect groundwater.

Vector Control: The BMPs should be sized based both on the runoff from the design storm and the measured percolation rate. In order to control disease vectors (e.g., mosquitoes) the infiltration BMPs should be designed to drain completely within 72 hours of the last storm with a factor of safety to account for slowing of infiltration rates over time and between maintenance cycles.

Groundwater Characteristics

If infiltration BMPs are to be used to treat surface water or reduce runoff volume, there needs to be an adequate thickness of unsaturated substrate between the bottom of the BMP and the groundwater table, which is called the zone of separation. The thickness of the zone of separation needed to adequately treat the infiltrated water depends on the types of contamination and the type of soils beneath the BMP. In CASQA fact sheets for Infiltration Trenches and

Infiltration Basins it is recommended that vertical separation be at least 3 meters and horizontal separation of the BMPs from foundations, slopes and highway pavement of 6 meters (CASQA TC-10, TC-11).

Under infiltration BMPs the water table will rise due to the concentrated area of infiltration (forming a "groundwater mound"), decreasing the zone of separation. Those pollutants not removed in the unsaturated zone eventually find their way into the groundwater.

Proper Infiltration BMP Maintenance

Infiltration BMPs require ongoing and sometimes intensive maintenance in order to retain their effectiveness over the long-term. Clogging of substrate pore spaces and infiltration surface is probably the most obvious problem that can develop with an infiltration BMP. Permeability of the BMP substrate (which can be an existing soil or a specific medium developed for the BMP) can decrease over time by covering the substrate with new particles from runoff or by growth of organisms (e.g. bacteria or algae) that can clog pores. In addition, larger materials that cover the substrate (e.g., leaves or plastic bags) reduce permeability and slow infiltration. When infiltration BMPs take more than 72 hours to drain they need immediate maintenance, possibly including removal and replacement of the media in order to restore drainage rates and prevent the hatching of disease vectors such as mosquitoes.

Conclusion

Infiltration is an important BMP that can be used to both reduce runoff from a site and filter non-point source pollutants entrained in the runoff. Infiltration BMPs should be considered for most projects since they keep runoff and pollutants from smaller storms onsite, they help recharge groundwater and maintain stream base flows closer to natural conditions. Even where treatment control is not required, promoting infiltration on-site is a good way to protect coastal resources and minimize adverse impacts of new impervious surfaces.

References & Additional Resources

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