Stormwater Best Management Practice

Infiltration Basin

Minimum Measure: Post Construction Stormwater Management in New Development and Redevelopment
Subcategory: Infiltration

Description

An infiltration basin is a shallow impoundment that infiltrates stormwater into the soil. This control is effective at increasing groundwater recharge (thus increasing baseflow to nearby streams) and can also help remove pollutants from stormwater. Infiltration basins have specific underlying soil requirements, which can preclude them from being feasible on all sites. Pretreatment design and regular inspection and maintenance procedures are crucial to ensure they do not fail.

Applicability

While most regions of the country use infiltration basins, soil infiltration rate, groundwater contamination concerns, spatial constraints and shallow groundwater tables can limit their application.

Regional Applicability

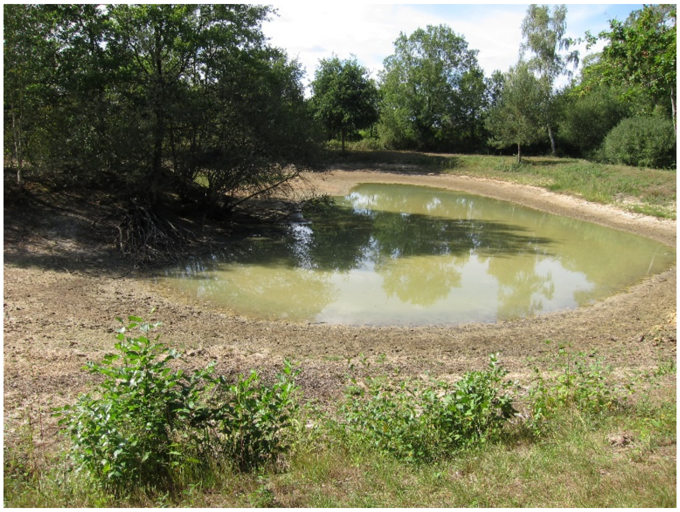
Infiltration basins apply in most places, with some design modifications in cold and arid climates. They are often inappropriate in karst (i.e., limestone) regions due to concerns of sinkhole formation and groundwater contamination.

Urban Areas

Infiltration basins are generally not appropriate for dense urban areas largely due to space requirements, the potential of infiltrated water to interfere with existing infrastructure and the relatively poor infiltration capacity of most urban soils.

Stormwater Hot Spots

Infiltration basins should not receive discharges from stormwater hot spots, unless another control has already treated the stormwater. Direct infiltration of discharges from stormwater hot spots can lead to groundwater contamination.



Infiltration pond in a natural area. The infiltration portion consists of sand with a high infiltration rate.

Cold Water (Trout) Streams

Infiltration basins are an excellent option for cold water streams because they encourage infiltration of stormwater and maintain dry weather flow. Because stormwater travels underground to the stream, it has little opportunity to increase in temperature.

Common Terms

Stormwater hot spots are areas where land use or activities generate highly contaminated stormwater discharges, with concentrations of pollutants in excess of those typically found in stormwater. Examples include gas stations, vehicle repair areas and waste storage areas.

Siting Considerations

Designers need to carefully locate infiltration basins and ensure that the soils on-site are appropriate for infiltration and that the potential for groundwater contamination and long-term maintenance problems are minimal.

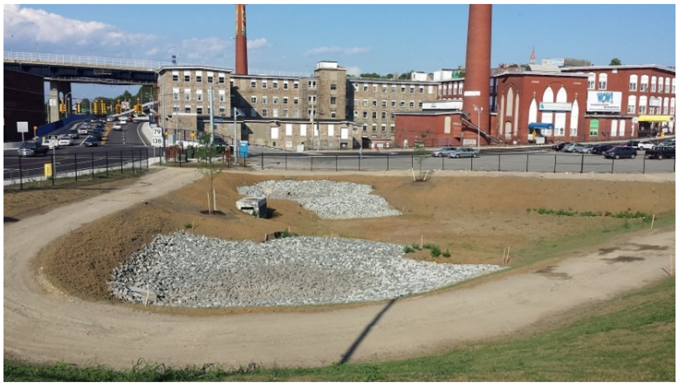
Drainage Area

Municipalities and site developers have historically used infiltration basins as large-scale facilities, serving for both quantity and quality control. In some regions of the country, they are feasible, particularly if the soils are sandy. In most areas, infiltration basins experience high rates of failure when treating too large a drainage area. In general, they best apply to relatively small drainage areas. Less than 5 acres is ideal, but less than 10 can be acceptable under the right conditions (MDE, 2009).

Slope

Infiltration pond in a natural area. Pond is filled with water and surrounded by vegetation

The bottom of an infiltration basin needs to be completely flat to allow infiltration throughout the entire basin bottom. Side slopes should be flat enough to prevent erosion of the sides of the basin.



Infiltration basin in an urban area. The basin has two gravel areas for infiltration. The remainder of the basin bottom and its slopes are planted with sod.
Credit: Massachusetts Department of Transportation

Soils

Soils are the most important factor when locating infiltration basins. Soils should be significantly permeable to ensure that the basin can infiltrate stormwater quickly enough. Soils that infiltrate too rapidly may not provide sufficient treatment, creating the potential for groundwater contamination. The infiltration rate should range between 0.5 and 3 inches per hour. In addition, the soils should have no greater than 20 percent clay content and less than 40 percent silt/clay content (MDE, 2009). Designers should confirm the infiltration rate and textural class of the soil in the field with approved testing methods; they should only use generic information such as soil surveys for preliminary siting considerations. Finally, infiltration basins may not be suitable in karst regions due to the potential for sinkhole formation or groundwater contamination.

Groundwater

Construction staff should maintain at least 4 feet of separation between the bottom of the infiltration basin's trench and the seasonal high groundwater table. For areas close to large waterbodies, this minimum distance may be as low as 2 feet. In either case, construction staff should follow local standards. Additional variables to consider may include the location of nearby drinking wells or sites with groundwater contamination.

Design Considerations

Specific designs may vary considerably, depending on local design requirements, site constraints or preferences of the designer or community. Designers should incorporate pretreatment, treatment, conveyance, maintenance reduction and landscaping into most infiltration basin designs.

Pretreatment

Pretreatment is important for all stormwater controls, but it is particularly important for infiltration basins. To ensure that pretreatment systems are effective, designers can consider a treatment train approach using multiple controls such as grassed swales, vegetated filter strips, rock swales, detention basins or plunge pools in series.

Treatment

Treatment design features enhance the effectiveness of a control. During the construction process, construction staff should stabilize the upland soils of an infiltration basin to ensure that it does not become clogged with sediment. Also, staff should size the treatment component itself so that the treatment volume can infiltrate into surrounding soils within 48 hours (ideally within 24 hours). Infiltration basins on less permeable soils can be significantly larger than those on more permeable soils.

Conveyance

It is important to convey stormwater through post-construction stormwater controls safely and in a way that minimizes erosion. Designers should ensure that channels leading to an infiltration basin minimize erosion and can use a flow spreader or riprap to minimize erosion from water entering the infiltration basin. If a main conveyance system delivers stormwater to the basin, an offline design is recommended.

Common Terms

Offline design refers to using a flow separator structure in order to divert only a portion of flow to a stormwater control.

Pretreatment plays an important role in stormwater treatment. Pretreatment structures, installed immediately upgradient to a stormwater control, reduce flow rates and remove sediment and debris before stormwater enters the stormwater control. This helps to improve the stormwater control's pollutant removal efficiency and reduces maintenance requirements.

Maintenance Reduction

In addition to specifying regular maintenance activities, designers should incorporate features into the design to reduce the maintenance burden of a stormwater control. In infiltration basins, designers should provide access to the basin for regular maintenance. Where possible, the basin should include a drainage mechanism, such as an underdrain, in case the bottom becomes clogged, water begins ponding for too long or sediment needs removal.

Landscaping

Landscaping can enhance the aesthetic value of post-construction stormwater controls and improve their function. In an infiltration basin, the most important purpose of vegetation is to reduce the basin's tendency to clog. Construction staff should properly stabilize upland drainage with a thick layer of vegetation, especially following construction. In addition, providing a thick turf at the basin bottom helps encourage infiltration and prevent the formation of rills.

Arid or Semiarid Climates

In arid regions, infiltration basins are often highly recommended because of the need to recharge groundwater. Designers should strongly emphasize pretreatment to ensure that an infiltration basin in an arid region does not clog due to relatively high sediment concentrations in these environments. In addition, construction staff may plant the basin bottom with drought-tolerant species and/or cover it with an alternative material such as coarse sand or gravel.

Cold Climates

In extremely cold climates (i.e., regions that experience permafrost), infiltration basins may be infeasible. They are feasible in most cold climates, but there are some challenges to their use. First, a basin may become inoperable during portions of the year when its surface becomes frozen. Designers may also need to increase the treatment capacity to accommodate the additional volume of stormwater associated with spring snowmelt.

Another option is to use a seasonally operated facility (Oberts, 1994). A seasonally operated infiltration/detention basin combines several techniques to improve performance in cold climates. Two of these features are underdrain systems and level control valves:

- At the beginning of the winter season, construction staff open the level control valve and drain the soil.
- As the snow begins to melt in the spring, construction staff close the underdrain and the level control valves. The snowmelt fills the basin until the soil reaches capacity. Then the facility acts as a detention facility, providing storage for particles to settle.

Other design features can help to minimize problems associated with winter conditions, particularly concerns that chlorides from deicing roads, parking lots and sidewalks may contaminate groundwater. If infiltration basins treat stormwater from roadsides or parking lots, construction staff may disconnect them during the winter to prevent chlorides from contaminating groundwater. If disconnection is infeasible or the basin provides snow storage, construction staff should plant the basin bottom with salt-tolerant vegetation.

Maintenance Considerations

Regular maintenance is critical to the successful operation of infiltration basins (see Table 1) and prevents sedimentation that could clog infiltration basins and lead to their failure (MDOT, 2018).

Table 1. Typical maintenance activities for infiltration basins

Activity	Schedule
▪ Replace pea gravel or topsoil (when clogged)	As needed
▪ Ensure inlets are clear of debris, including sediment and oil/grease ▪ Stabilize the surrounding area ▪ Mow grass and remove grass clippings of filter strip areas, if applicable ▪ Repair undercut and eroded areas at inflow/outflow structures	Monthly
▪ Inspect pretreatment devices and diversion structures for debris accumulation and structural integrity; take corrective action as needed	Semiannually
▪ Aerate the pretreatment basin bottom or de-thatch it, if applicable	Annually
▪ Scrape the pretreatment bottom to remove accumulated sediment and re-seed ground cover, if applicable	Every 5 years
▪ Perform total rehabilitation of the basin and restore design storage capacity Excavate the basin bottom to expose clean soil	Upon failure

Source: MPCA, 2016

Limitations

Infiltration basins are not appropriate for areas with compacted or poorly infiltrating soils, typically limiting their use in urban environments. They are also not suitable for areas with a high groundwater table or where groundwater contamination is a concern. Infiltration basins are not generally aesthetically pleasing, particularly if they clog. If an infiltration basin becomes clogged and takes more than 3 days to drain, the basin could become a source for mosquitoes. Finally, regular maintenance is key to the effectiveness of infiltration basins.

Effectiveness

Infiltration basins reduce stormwater discharge volume by enhancing groundwater recharge. In doing so, they address problems of low groundwater tables, flood control, channel erosion and pollutant removal to varying degrees.

Groundwater Recharge

Urbanization often changes the movement of water through the landscape by increasing stormwater and reducing groundwater recharge. Infiltration basins are effective at reversing these impacts, reducing stormwater by enhancing groundwater recharge.

Pollutant Removal

By reducing the volume of stormwater, infiltration basins also reduce the amount of pollutants that discharge directly to surface waters. In addition, by routing stormwater to underlying soils, infiltration basins use the soil as a filter, which can be an effective removal mechanism for pollutants like sediment, phosphorus and metals. Unfortunately, because the “outlet” of an infiltration basin is underlying soil, measuring effluent concentrations is impractical, and data are scarce on actual pollutant removal performance.

Instead, performance data for infiltration stormwater controls are generally related to the volume of stormwater that the basin captures and infiltrates, as well as the presumed level of filtration the soil provides for individual pollutants. For example, in pollutant loading guidance for infiltration basins, the New Hampshire Department of Environmental Services allows for an assumed removal efficiency of 90 percent for total suspended solids (TSS), 65 percent for total phosphorus, and 10 to 60 percent for total nitrogen for a 90 percent reduction in stormwater volume (NHDES, 2011). The TSS removal efficiency is due to TSS being composed of relatively large particles that the soil physically filters with high effectiveness. Total phosphorus removal is slightly lower and more due to soil adsorption processes, which can be effective but vary by soil type. Nitrogen is generally not well filtered or adsorbed to natural soil, causing a lower removal efficiency.

Cost Considerations[1]

Infiltration basins can be relatively cost-effective post-construction stormwater controls because their construction requires minimal infrastructure. Typical construction costs, including contingency and design costs, can range from $55,000 to $85,000 per acre of impervious surface treated (King & Hagan, 2011). As with many other stormwater controls, economies of scale may lower this unit cost when treating larger areas.

[1] Prices updated to 2019 dollars. Inflation rates obtained from the Bureau of Labor Statistics CPI Inflation Calculator website: https://data.bls.gov/cgi-bin/cpicalc.pl.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

References

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Oberts, G. (1994). Performance of stormwater ponds and wetlands in winter. *Watershed Protection Techniques, 1*(2), 64–68.

Disclaimer

This fact sheet is intended to be used for informational purposes only. These examples and references are not intended to be comprehensive and do not preclude the use of other technically sound practices. State or local requirements may apply.