



Infiltrating Stormwater

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The Pennsylvania Stormwater Manual encourages the infiltration of stormwater runoff. In fact the Manual states that, wherever possible, stormwater runoff from storms smaller than or equivalent to the 2-year return period runoff event, should be infiltrated. This new and somewhat unusual expectation raises many questions by engineers, contractors, developers, and even regulators about just how stormwater can or should be infiltrated.

Infiltration is the process by which water ponded or flowing over the land surface moves into the soil. The expectation is that once this stormwater has infiltrated into the soil, the water will continue to move vertically down through the soil profile, be treated by the soil, and eventually join with the local groundwater, thus enhancing the quantity of groundwater available for local use. This picture of recharging the local groundwater with stormwater, instead of discharging

the stormwater into a channel or stream and sending it down to another community or the ocean, is a very positive and encouraging concept. Much more difficult is how you actually infiltrate stormwater into the soil profile and how we make sure the infiltrated water percolates vertically to the groundwater?

The purpose of this fact sheet is to provide guidance that should be useful for encouraging infiltration of stormwater.

The Infiltration Process

From a soil physics perspective, infiltration is a time dependent process (Fig. 1). The rate at which water enters the soil, especially dry soil, starts very fast and then declines and eventually approaches a constant rate of entry. This constant rate of infiltration is also referred to as the saturated hydraulic conductivity,

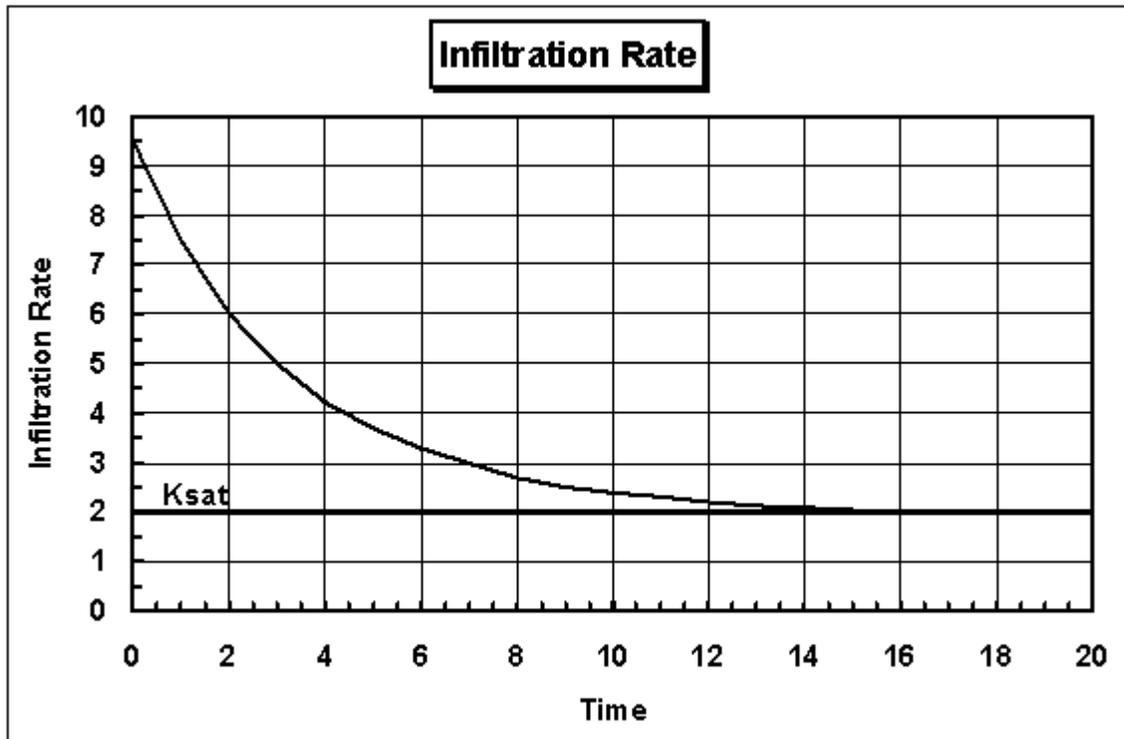


Figure 1. How infiltration rate changes with time and its relationship to K_{sat} .

K_{sat} , and sometimes called the soil's permeability. In almost all cases, when laypeople refer to an infiltration rate they mean the long-term constant rate, permeability, or K_{sat} . When attempting to infiltrate stormwater it is reasonable to assume that the soil will infiltrate the stormwater at a rate equal to the long-term constant rate, permeability or K_{sat} .

Measuring or Determining Infiltration Rate

The most reliable source of long-term constant rate infiltration rate data is the USDA-NRCS Soil Survey data published for each county in Pennsylvania. Here permeability data is given in limited ranges (Table 1) for each soil layer or horizon within the surface 6 feet. Some designers shy away from using these data because they are in ranges and not specific. There is also a long held opinion by those who have been indoctrinated to Pennsylvania on-lot sewage procedures, that the permeability's in the published Soil Surveys are not reliable or site specific. The soil science profession has come a long way towards establishing fundamental soil parameters based on the soil texture and structure used in soil mapping. Therefore, the permeability data given in the Soil Surveys are considered reliable and in almost every case better than permeability data measured in the field. This is also true because the Soil Survey data represents an average permeability that applies over a large area, not just isolated points where sampling occurred. These large-area averages effectively account for the natural variability in the soil's permeability, which makes them better estimates of how a specific soil will transmit water than "point" measurements. To be conservative, most practitioners will design their stormwater infiltration system based on the low-side of the range given.

Table 1. USDA-NRCS Permeability Classes.

Description	Permeability (in/hr)
Very Slow	< 0.06
Slow	0.06 to 0.2
Moderately Slow	0.2 to 0.6
Moderate	0.6 to 2.0
Moderately Rapid	2.0 to 6.0
Rapid	6.0 to 20.0
Very Rapid	> 20.0

What infiltration rates are needed to make an effective stormwater infiltration system? This depends on what depth of water you desire to infiltrate and how long you are willing to wait for the water to infiltrate. For example, to infiltrate 6 inches of water into the bottom of a bioretention cell when the soil has a 0.2 in/hr permeability, will take $(6/0.2 =)$ 30 hours. Since rain events occur on average every 3 days in Pennsylvania, this seems very reasonable. Thus, in most cases soils with permeabilities > 0.2 in/hr can be effective as soils to infiltrate stormwater.

Soils exist in many layers and each soil layer will have its own infiltration rate. When you desire to infiltrate stormwater, it is important to consider exactly where you expect the stormwater to enter the soil. If you are designing a bioretention cell or porous pavement, the stormwater most likely will enter the soil several inches, and in some cases several feet, below the soil surface. It is important that, as a designer, you examine and know the permeability of all the soil layers. The permeability that should be used for your design is the permeability of the most limiting horizon. This is the layer through which the percolating water will move most slowly, and therefore will control the infiltration process.

Alternate Methods for Estimating a Soil's Permeability

There are a number of alternate methods that have been proposed and implemented to measure a soil's permeability. These include the Percolation Test, tension infiltrometers, and even driving a pipe into the soil and watching the water drain from it. The Perc Test, which has become the standard of the on-lot wastewater industry, is a three-dimension evaluation and the soil physics literature clearly shows that there is essentially no correlation between Perc Rate and K_{sat} . Applying a tension infiltrometer requires the services of a qualified soil scientist, and the results are limited by how many samples you are willing to pay for. Using many of these methods to evaluate infiltration capability at several depths can be very expensive.

Geology Issues

There is more to infiltration than the soil. What underlies the soil? From what geologic formation was the soil derived? In other words, when the

infiltrating water makes it through the soil profile will the rock under the soil let the water continue to move vertically downward to the groundwater? Two situations deserve your consideration. The first is when the soil is underlain by tight shale or other very slowly permeable rock. These layers of slowly permeable rock will divert the path of the vertically moving water and often cause it to reappear at the soil surface as a seep or spring. This defeats the purpose of infiltrating stormwater and is not a good infiltration system.

The second situation that must be considered is when the underlying rock is limestone or dolomite. These rock layers contain calcium carbonate, which may dissolve and form underground channels and eventually caverns and sinkholes. These karst topographies are not usually suitable for infiltrating stormwater. There are cases where successful infiltration systems have been developed on karst topographies, so it is important that a qualified geologist be consulted before making any final decisions.

Design Issues

Now you are ready to design your stormwater infiltration practice. Based on the watershed area and its land use, the volume of runoff can be estimated, most commonly using the Soil-Cover-Complex Method of hydrologic estimation. In Pennsylvania it is usually desirable to infiltrate all runoff up to and including the volume of runoff expected from a 2-year return period event. This volume establishes the required volume for the shallow temporary impoundment that will capture and store your stormwater runoff. Based on the permeability of the least permeable soil layer, the impoundment can be sized.

Geotextiles. Geotextiles have become an important inclusion in many earthmoving and building projects. If you are considering the infiltration of stormwater, the use of geotextiles should be avoided. If you wish to move water into and downward through the soil, **NEVER** place a layer of geotextile in the water's path. The fabric will clog and slow or stop the infiltration.

Construction Issues

Now that you have determined the soil's and the geology formation's ability to infiltrate stormwater, and you have designed your infiltration stormwater Low Impact Development (LID), it may be time for construction. Improper construction techniques, especially for stormwater infiltration LIDs, can negate the effectiveness of the LID. Why? Because the contractor compacts or puddles the soil at the infiltrating surface. The infiltrating surface, the location where the runoff water is expected to enter the soil, must be preserved in its natural state. Construction activities must be scheduled for times when the soil is relative dry; no recent rains, no standing water, no soils too wet for tillage. Even if the soil is quite dry, **NEVER** allow equipment onto the infiltrating surface. These infiltrating surfaces should be shaped and created by hand so the natural soil structure and permeability can be preserved.

Summary

Infiltrating stormwater is a great idea and one that is long overdue. Designing and constructing a functional stormwater LID practice that can reliably infiltrate the first flush, or even the 2-year storm requires careful planning, proper design, and construction supervision.

For additional assistance contact your County Extension Agent

For further information or to see our other available fact sheets, go to :
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