GREEN STORMWATER INFRASTRUCTURE (GSI) FACT SHEET

GSI OVERVIEW

Green Stormwater Infrastructure

WHAT IS IT?

Green Stormwater Infrastructure (GSI) is a suite of “systems and practices that restore and maintain natural hydrologic processes in order to reduce the volume and water quality impacts of stormwater runoff.” Riparian buffers, green roofs, bioswales, cisterns, permeable pavements and constructed wetlands are all examples of GSI.

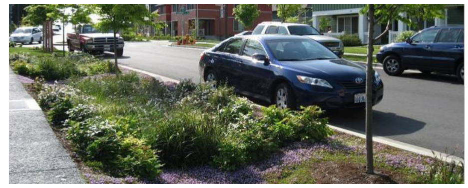
MOVING FROM GRAY TO GREEN

GRAY

Traditionally, stormwater runoff has been collected and conveyed in closed systems to off-site locations where it is then discharged, without treatment on surface waters. The series of pipes, catch basins, and storm drains that result is known as ‘gray infrastructure.’ Because ‘gray infrastructure’ does little to improve water quality and reduce water quantity, stormwater discharges from these systems often contribute to unhealthy stream flow regimes marked by chronic flash flooding, altered stream morphologies, elevated nutrient and contaminant levels, excessive sedimentation, loss of species diversity, and higher water temperatures.

GREEN

Green stormwater infrastructure is a complimentary and sometimes alternative system to ‘gray infrastructure’ that utilizes infiltration, evapotranspiration, storage and reuse. GSI is decentralized by design and either prevents runoff from occurring or treats it as close to the source as possible. GSI provides multiple benefits and functions such as reduced and delayed stormwater flows, enhanced groundwater recharge, stormwater pollutant reductions, reduced sewer overflows, urban heat island mitigation, improved air quality, additional wildlife habitat and recreational space, improved human health, and increased land values. GSI can be used at many spatial scales, from an individual site to an entire watershed.



HOW DOES GSI RELATE TO LOW IMPACT DEVELOPMENT?

For many years, the terms green stormwater infrastructure (GSI) and low impact development (LID) were used interchangeably. When these concepts were first introduced, the field of practice was fairly narrow and this worked well. However, as the field broadened and developed, the interchangeable nature of the terms became confusing. In Vermont, we make a clear distinction between the two terms. LID refers to an approach to land planning and site design that tries to prevent and minimize environmental degradation. GSI, on the other hand, refers to and relies on the physical elements (natural or man-made) of the landscape when addressing or minimizing impacts from stormwater runoff. In other words, LID is a series of planning principles and GSI is a set of physical best management practices.

Factsheet prepared by the Vermont Green Infrastructure Initiative, a program of the Watershed Management Division of the VT Department of Environmental Conservation (http://watershedmanagement.vt.gov/).

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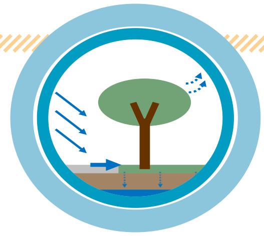
GSI OVERVIEW



PUTTING THE CONCEPT TO WORK

The use of infiltration, evapotranspiration, storage, and reuse provide the basis for a wide range of best management practices (BMPs) useful at both rural and urban sites. As with most practices, specific site details will dictate which GSI BMPs will be most appropriate. Soils, topography, depth to water table, and site constraints all play a part. Below are just a few examples of practices that have been implemented in Vermont. A more complete listing of BMPs with descriptions can be viewed at: http://www.watershedmanagement.vt.gov/stormwater/htm/sw_green_infrastructure.htm.

INFILTRATION

TO LEARN MORE ABOUT INFILTRATION BMPS, SEE: GSI CONCEPT #1: INFILTRATION FACT SHEET

INFILTRATION TRENCH

BIO-RETENTION

POROUS PAVEMENT

EVAPOTRANSPIRATION

TO LEARN MORE ABOUT EVAPOTRANSPIRATION BMPS, SEE: GSI CONCEPT #2: EVAPOTRANSPIRATION FACT SHEET

GREEN ROOF

CONSTRUCTED WETLAND

STORMWATER TREE PIT

STORAGE AND REUSE

TO LEARN MORE ABOUT STORAGE AND REUSE BMPS, SEE: GSI CONCEPT #3: STORAGE AND REUSE FACT SHEET

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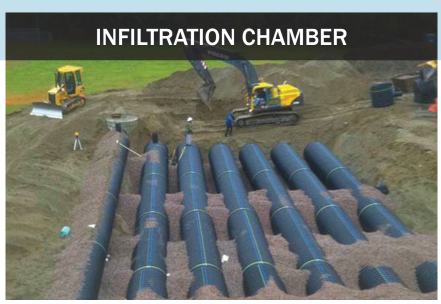

INFILTRATION CHAMBER

RAINWATER REUSE

Better Buildings for Oregon [Julie Waters]

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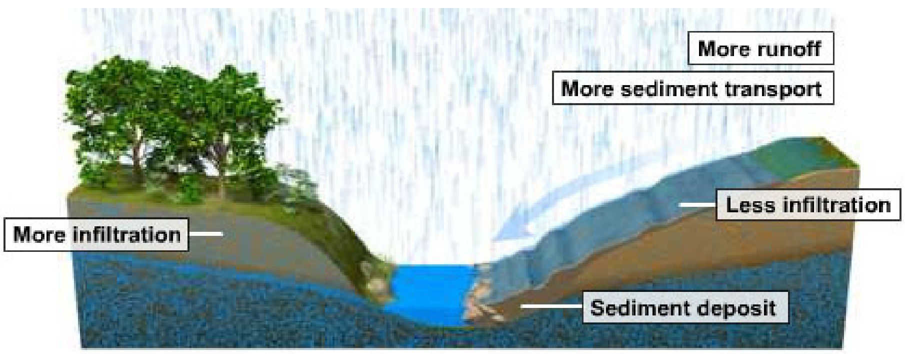
GREEN STORMWATER INFRASTRUCTURE (GSI) FACT SHEET

GSI CONCEPT #1

Infiltration

WHAT IS IT?

Infiltration is a natural process by which water moves into and through soil and other porous materials. Movement through the media is dominated by gravitational and capillary forces. Gravitational forces pull water down vertically through the soil. Capillary forces pull water horizontally and laterally within the soil profile.



Source: www.meted.ucar.edu

HOW CAN IT ASSIST IN THE MANAGEMENT OF STORMWATER?

The continued urbanization of our landscape has adverse hydrologic impacts including increased flooding, diminished water quality, and decreased baseflow. Stormwater infiltration removes sediments and pollutants, decreases peak flows, and recharges groundwater. Infiltration also delays the transport of stormwater to nearby waterways, helping to alleviate and reduce flash flooding during intense storm events. Infiltration is best used on well drained soils with low water tables. In these locations, stormwater infiltration can be the most cost effective way to manage runoff.

WHAT FACTORS AFFECT IT?

Infiltration is highly dependent on soil structure and soil saturation. Soils with a high percentage of sand generally pass water fairly easily while clayey soils restrict water movement. This has a lot to do with how much physical space (pore space) is available between the individual soil particles When soils become saturated (their pore spaces are completely filled with water) as a result of heavy rain-fall, seasonal snow melt, or high/perched water tables, infiltration will slow or not occur at all. Similar results occur when soils are compacted.


Source: USDA

DETERMINING A SOIL'S INFILTRATION RATE

Knowing a soil's infiltration rate can help you figure out whether or not an infiltration based practice will be successful. Here are some simple steps to perform a basic infiltration test.

- Dig a hole in the ground that is roughly one foot deep. Be careful not to disturb the soil layers or to compact the sides while digging.
- Fill the hole with water to moisten the soil and allow it to drain completely.
- Fill the hole with water a second time after the original water drains out, and place a ruler or stick in the hole. Note the water level and time, and after 15 minutes check the water level again. Multiply this by four to get the number of inches of infiltration in an hour. Rates between 0.5 and 8 in/hour are generally appropriate for stormwater infiltration.

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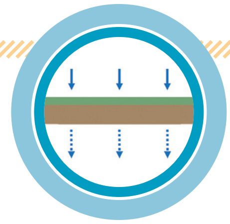


GREEN STORMWATER INFRASTRUCTURE (GSI) FACT SHEET
GSI CONCEPT #1: INFILTRATION

PUTTING THE CONCEPT TO WORK

Many green stormwater infrastructure systems and practices utilize infiltration because it effectively filters pollutants, slows water movement, provides temporary water storage and recharges groundwater. While infiltration practices are fairly common (infiltration trenches, infiltration basins, flow through planters, dry wells, and pervious pavement), they are often inappropriately designed. The key to effective use of infiltration is an in-depth understanding of site-specific soil characteristics. At sites with high nutrient and pollutant loads (hot spots), infiltration practices are not recommended due to potential groundwater contamination. Below are a few examples of GSI best management practices that utilize infiltration. Additional BMPs can be viewed at our website: http://www.watershedmanagement.vt.gov/stormwater/htm/sw_green_infrastructure.htm

Infiltration Trench

BENEFITS

> Groundwater recharge
> Peak flow reduction
> Water quality

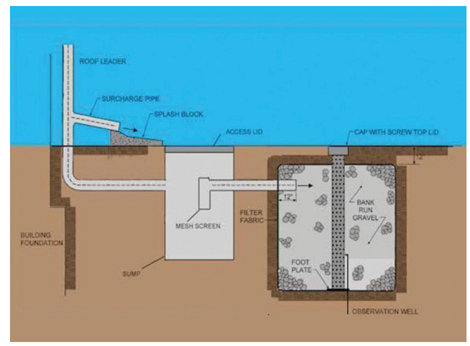
Infiltration trenches are shallow open channels lined with dense vegetation. The first flush from a storm event can be diverted to infiltration trenches. They are highly versatile and can be applied in small residential areas to extensive systems to address downtown, commercial, and industrial impervious surfaces such a parking lots, roads/sidewalks and rooftops.

Porous Pavement

BENEFITS

> Reduced impervious area
> Decrease in other structures
> Reduced sewer overflows

Porous pavement (a term that includes pervious concrete, porous asphalt, permeable paver blocks and reinforced turf) is an infiltration BMP that combines stormwater infiltration, storage, and structural pavement consisting of a permeable surface underlain by a storage or infiltration reservoir. Pervious pavement is well suited for parking lots and paths.



Source: PA Stormwater Best Management Practices Manual

Dry Well

BENEFITS

> Additional storage
> Low maintenance

A dry well is a subsurface storage facility that temporarily stores and infiltrates stormwater runoff from the roofs of residential and small structures. Roof leaders connect directly into the dry well, which may be either an excavated pit filled with uniformly graded stone, wrapped in geotextile or a prefabricated storage chamber or pipe segment.

REFERENCES

Stormwater Management Manual for Western Australia: Structural Controls, Government of Western Australia, Department of Water

Soil Quality Kit - Guides for Educators, United States Department of Agriculture, Natural Resources Conservation Service

The Water Cycle: Infiltration, U.S. Department of the Interior, U.S. Geologic Survey, http://ga.water.usgs.gov/edu/watercycleinfiltration.html

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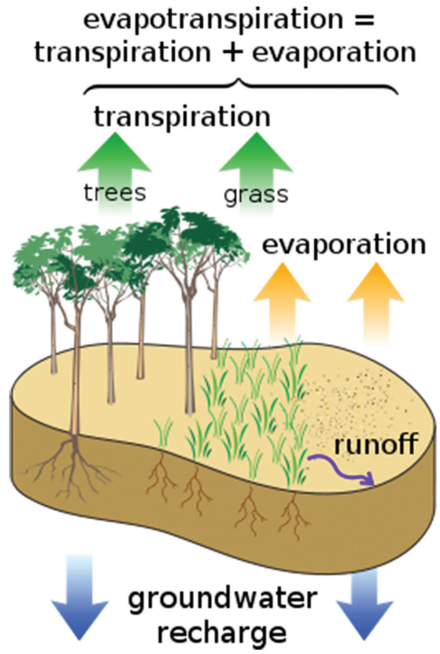
GREEN STORMWATER INFRASTRUCTURE (GSI) FACT SHEET
GSI CONCEPT #2

Evapotranspiration

WHAT IS IT?

Evapotranspiration (ET) is a process by which water is transferred from the earth's surface into the atmosphere. ET is the sum of water surface evaporation, soil moisture evaporation, plant surface evaporation, and plant transpiration, a process in which trees and other plants absorb water through their roots and transfer it up to the atmosphere through leaf pores.

Evapotranspiration happens naturally and is an important and critical part of the water cycle because it represents a considerable loss of water from a watershed.



HOW CAN IT ASSIST IN THE MANAGEMENT OF STORMWATER?

The process of evapotranspiration can be used in a variety of ways to control stormwater runoff volumes and protect and restore natural hydrology. Surface vegetation and sprawling trees canopies provide a large surface area for evaporation and by planting trees and maintaining surface vegetation, rainwater can be intercepted before it hits the ground. Additionally, robust root systems pull water from underlying soils and transpire it into the atmosphere, decreasing soil saturation levels. Furthermore, by protecting, restoring, and mimicking natural wetlands, runoff is slowed and dispersed over the landscape, increasing surface water losses and providing opportunities for increased plant uptake.

WHAT FACTORS AFFECT IT?

Evapotranspiration is affected by a variety of environmental factors including air temperature, wind speed, relative humidity, soil moisture, and solar radiation. It can also be affected by plant characteristics such as plant type, size, age, and health. Geographic factors such as latitude, longitude, and elevation may also play a role as does season and time of year.

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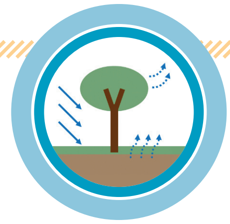
GREEN STORMWATER INFRASTRUCTURE (GSI) FACT SHEET

GSI CONCEPT #2: EVAPOTRANSPIRATION



PUTTING THE CONCEPT TO WORK

A variety of green stormwater infrastructure (GSI) systems and practices utilize evapotranspiration to manage stormwater. While the complexities of each differ, the basic goals are the same: increase surface area to promote evaporation and maintain healthy and robust vegetative cover to support transpiration. Below are a few examples of GSI best management practices that utilize evapotranspiration. Additional BMP's can be viewed at: http://www.watershedmanagement.vt.gov/stormwater/htm/sw_green_infrastructure.htm.

Green Roof

BENEFITS

> Reduced energy use
> Recreational enjoyment
> Roof longevity

A green roof is the roof of a building that is partially or completely covered with vegetation. Green roofs serve many purposes, one of which is stormwater management. They are capable of absorbing, storing, and evapotranspiring a great deal of water. In cold climates, architectural/engineering consultation is extremely important due to the additional weight of snow and ice.

Constructed Wetland

BENEFITS

> Wildlife and aquatic habitat
> Cost effectiveness
> Water quality

A constructed wetland is a shallow retention pond designed to permit the growth of wetland plants such as rushes, willows, and cattails. Constructed wetlands slow runoff and allow time for sedimentation, filtering, and biological uptake. Constructed wetlands are designed specifically to mimic natural wetland environments. They are heavily vegetated and thus have high evapotranspiration rates.

Stormwater Tree Pit

BENEFITS

> Decreased maintenance
> Shade to nearby buildings

Stormwater tree pit systems use engineered soils to infiltrate and filter stormwater. They are particularly useful in tight urban and downtown locations Some systems allow for increased soil volume to grow large mature trees resulting in increased ET and other benefits. Most of these systems are able to promote vigorous root growth beneath existing infrastructure such as roads and sidewalks with little to no conflict.

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The Water Cycle: Evapotranspiration, U.S. Department of the Interior, U.S. Geologic Survey, http://ga.water.usgs.gov/edu/watercycleevapotranspiration.html

Gulliver, J.S., A.J. Erickson, and P.T. Weiss (editors). 2010. "Stormwater Treatment: Assessment and Maintenance." University of Minnesota

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GSI CONCEPT #3

Storage and Reuse

WHAT IS IT?

Storage and reuse practices are designed to intercept and store runoff from impervious surfaces, such as rooftops, reducing the volume of stormwater runoff exiting a site. The stormwater is contained in a vault or other storage vessel and reused for irrigation, car washing, or other non-potable uses. A water budget, which calculates expected water captured and used, is typically developed for larger systems. The reuse of stormwater for potable needs and human consumption is not recommended.

Storage and reuse has minimal direct effect on water quality, however, indirectly it helps mitigate erosion and nutrient loading by reducing stormwater runoff volumes and the magnitude and timing of peak flows.

HOW CAN IT ASSIST IN THE MANAGEMENT OF STORMWATER?

There are two main issues associated with stormwater runoff: quality and quantity. Storage and reuse systems provide a means of addressing the latter. By capturing stormwater near its source, these systems reduce the amount of water entering nearby waterways, thus decreasing the risk of flooding, channel instability, and nutrient loading.

Storage and reuse systems are extremely useful in tight urban settings where other stormwater management techniques may be difficult to implement. Storage systems come in a variety of shapes, sizes, and configurations suitable for residential, commercial, and industrial settings.

Source: Hydro International

WHAT FACTORS AFFECT IT?

There are many things to consider when utilizing storage and/or reuse. First, it is important to measure the catchment area and calculate the expected water volume. Estimated or typical annual rainfall amounts vary by location. Annual or seasonal rainfall amounts can be obtained on the web. The storage system should be sized according to this number and include an appropriate overflow mechanism. Expected use of the stored water should also be considered. If water use is expected to be low, the system can still be used for volume reduction but may need special modifications to be as effective. Climate can also come into play. Storage systems often need to be protected from light and designed to handle freezing temperatures.

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GSI CONCEPT #3: STORAGE AND REUSE

PUTTING THE CONCEPT TO WORK

Storage and reuse systems are an effective means of managing stormwater quantity and can be used in a variety of settings from urban to rural. Above ground options are perfect for residential areas while below ground systems provide greater storage capacity without a loss of space. Remember, rain water does not become stormwater until it travels across some impervious surface and gets discharged. Below are a few examples of GSI best management practices that utilize storage and reuse. Additional BMPs can be viewed at our website: http://www.watershedmanagement.vt.gov/stormwater/htm/sw_green_infrastructure.htm.

Source: Better Buildings for Oregon [Julie Waters]

Rain Barrel/Cistern

BENEFITS

> Diversion of "first flush"
> Volume reduction

Rain barrels/cisterns are designed to intercept and store runoff from rooftops. The stored volume can then be used for a variety of things. Rain barrels are typically 55 gallons in size and are perfect for small residential sites. Cisterns can be 100 gallons or more and are appropriate when greater storage is needed. 1,000 square feet of impervious generates 623 gallons of water in a 1"storm.

Underground Storage

BENEFITS

> Effective use of space
> Groundwater recharge

Underground storage can be used to capture and store rainwater from surrounding impervious surfaces such as a building roof or parking lot. Often, riser pipes and curb cuts lead runoff to subsurface vaults and large diameter pipes. Stored water is often used for irrigation. Underground storage can be placed beneath a parking lot or recreation field.

Rainwater Reuse

BENEFITS

> Independent water supply
> Decreased water demand

Rainwater reuse systems often involve the storage and reuse of water collected from roof surfaces during rain events. These systems are somewhat similar to rain barrels and cisterns but done on a much larger scale and include pumps and sometimes complex filtering systems. Potential uses include water for flushing toilets and irrigation.

REFERENCES

Lake Superior Streams, Tools for Stormwater Management, Underground Storage, http://www.lakesuperiorstreams.org/stormwater/toolkit/underground.html

Pennsylvania Department of Environmental Protection, Stormwater Best Management Practices Manual, 2006.

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