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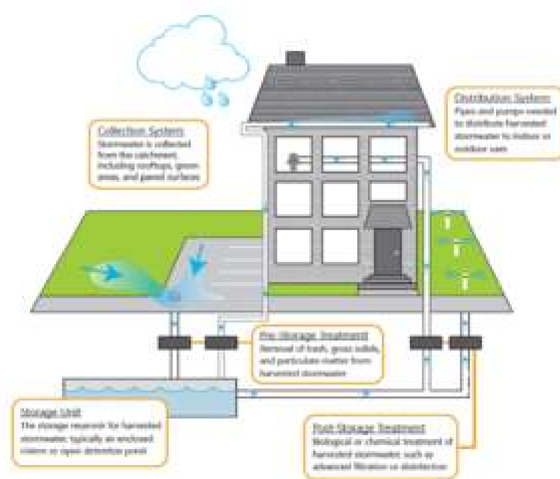
Green Infrastructure benefits of harvest and use/re-use practices

This page provides general information

Harvest and reuse is the practice of collecting and/or storing stormwater on site to be used in water applications as needed. Harvest and reuse systems use collected water from various sources, treats them, and then reuses this water on site for different purposes such as irrigation or water features. This practice mitigates the users cost for water, reduces the site's stormwater runoff, and prevents pollution runoff.

Sites containing these systems are not regulated by the EPA but may be regulated by the state through the Safe Drinking Water Act or the Clean Water Act. Water harvest and reuse systems are regulated in Minnesota by Minnesota Rules Section 4714, chapter 17 (https://www.revisor.mn.gov/rules/4714/).



Example Stormwater Harvesting and Use System Schematic

Rainwater harvesting is categorized into two types of harvest:

- Surface runoff harvesting
- Rooftop harvesting

Both categories of rainwater harvesting follow the same principles for stormwater reuse. When the rainwater falls onto the site the water is collected through a series of conveyance systems into a storage system, the water is then treated and stored, and the user applies it to their site through a distribution system for the designed purpose. Some designed purposes include;

- irrigation systems;
- potable water resources (with treatment);

- urinal flushing;
- water features;
- vehicle, building, and street cleaning; and
- fire suppression systems

Harvest and reuse systems are excellent stormwater treatment practices due to the pollutant removal mechanisms they can be paired with such as vegetative filtering, settling, evaporation, infiltration, transpiration, biological and microbiological uptake, and soil adsorption. Additionally, the pollutants stay on site instead of being flushed downstream. These systems are particularly effective when used for irrigation on C and D soils where traditional infiltration practices are less effective.

Contents

Green infrastructure and multiple benefits

Green infrastructure (GI) encompasses a wide array of practices, including stormwater management. **Green stormwater infrastructure** (GSI) encompasses a variety of practices primarily designed for managing stormwater runoff but that provide additional benefits such as habitat or aesthetic value.

There is no universal definition of GI or GSI (link here fore more information (https://stormwater.pca.state.mn.us/index.php?title=Green_infrastructure_and_green_stormwater_infrastructure_terminology)). Consequently, the terms are often interchanged, leading to confusion and misinterpretation. GSI practices are designed to function as stormwater practices first (e.g. flood control, treatment of runoff, volume control), but they can provide additional benefits. Though designed for stormwater function, GSI practices, where appropriate, should be designed to deliver multiple benefits (often termed "multiple stacked benefits". For more information on green infrastructure, ecosystem services, and sustainability, link to Multiple benefits of green infrastructure and role of green infrastructure in sustainability and ecosystem services.

Green Infrastructure benefits of harvest and reuse systems

- **Water quality** (https://stormwater.pca.state.mn.us/index.php?title=Water_quality_benefits_of_Green_Stormwater_Infrastructure):
  - Installation of harvest and reuse systems prevents or reduces a sites’ total pollution runoff amount
  - Reduces downstream water treatment levels when water is stored on site
  - Wastewater treatment requirements may be reduced due to the incorporation of reuse systems that use on site water for functions such as urinal flushing, water features, and sprinkler systems
- **Water quantity and hydrology** (https://stormwater.pca.state.mn.us/index.php?title=Water_quantity_and_hydrology_benefits_of_Green_Stormwater_Infrastructure):
  - Reduction in total water volume movement on the site through water retention techniques and retardation of peak flow from rainfall events at the site
  - Harvest and reuse systems designed with storage containers are better able to withstand drought conditions than sites without them (Herndon, 2016 (https://efc.web.unc.edu/2016/04/25/water-reuse-drivers/))

Benefit	Effectiveness	Notes
Water quality	◕	Can be used in a variety of settings, including low permeability soils.
Water quantity/supply	◕	Benefit depends on the amount of water that can be stored. Use of ponds or multiple dispersed systems can provide significant volume reduction.
Energy savings	◑	Savings associated with reductions in potable water usage.
Climate resiliency	◔	Depending on design, may provide energy and water savings.
Air quality	◔	
Habitat improvement	◔	Benefits are associated with how the system is used (e.g. in vegetated applications).
Community livability	◑	Provides water-related benefits; can be used for indoor applications.
Health benefits	◔	
Economic savings	◑	Cost savings associated with water use and decreased use of potable water.
Macroscale benefits	◔	Individual practices are typically microscale, but multiple practices, when incorporated into a landscape design, can provide macroscale benefits.
Level of benefit: ○ - none; ◔ - small; ◑ - moderate; ◕ - large; ● - very high		

- Energy:
  - Harvest and reuse systems provide indirect energy savings through reduced water treatment and distribution required by outside sources
  - Harvest and reuse systems used to irrigate vegetation provide shade, trees and plants, reduce air conditioning and heating costs (Using Trees and Vegetation to Reduce Heat Islands - US EPA (https://www.epa.gov/heatislands/using-trees-and-vegetation-reduce-heat-islands))
- **Air quality** (https://stormwater.pca.state.mn.us/index.php?title=Air_quality_benefits_of_Green_Stormwater_Infrastructure):
  - Air quality impact is minimal, most benefits are indirect through vegetation grown by the harvest and reuse system
- **Climate resiliency** (https://stormwater.pca.state.mn.us/index.php?title=Climate_benefits_of_Green_Stormwater_Infrastructure):
  - Site water containment in harvest and reuse systems offers some reduction in flooding during rainfall events
  - Plant vegetation grown with reuse irrigation systems provide carbon sequestration
  - Reduction in pollutant runoff and wastewater treatment lowers total energy consumption and lowers the amount of chemicals needed to produce useable water for the site; this reduction in energy also lowers greenhouse gas requirements
  - Reduction of the heat island effect when reuse systems are used to support a healthy on-site vegetation that provides shade (Using Trees and Vegetation to Reduce Heat Islands - US EPA (https://www.epa.gov/heatislands/using-trees-and-vegetation-reduce-heat-islands))
  - Lower greenhouse gas emissions when harvested and recycled water is used for cooling purposes (Losoya et al., 2022)
- **Habitat improvement** (https://stormwater.pca.state.mn.us/index.php?title=Wildlife_habitat_and_biodiversity_benefits_of_Green_Stormwater_Infrastructure):
  - Habitat benefits are typically associated with vegetation incorporated into the site design.
  - Benefits associated with reduced runoff, such as reduced erosion, can provide increased soil stability promotes vegetation growth
- **Community livability** (https://stormwater.pca.state.mn.us/index.php?title=Social_benefits_of_Green_Stormwater_Infrastructure):
  - Harvest and reuse systems help to protect recreation sites for people by ensuring safe and healthy access to water sources and promotes on-site watering availability

    - Water harvest and reuse are adaptable to meet needs such as community gardening, water fountain structures, promoting healthy green spaces, and may be used for recreation purposes if water quality requirements are met
    - Water harvesting and reuse that promotes healthy landscaping can promote mental health improvements for those who frequent them (What are the physical and mental benefits of gardening? - MSU Extension)
    - Larger reuse systems utilizing irrigation and trees or other shade proving vegetation reduce temperature levels (Reducing Urban Heat Islands: Compendium of Strategies: Trees and Vegetation (https://www.epa.gov/heatislands/heat-island-compendium) - US EPA)
- **Health benefits** (https://stormwater.pca.state.mn.us/index.php?title=Social_benefits_of_Green_Stormwater_Infrastructure):
    - Reduction of downstream buildup of nutrients, pathogens, metals, TSS, and phosphorus among others as an indirect, off site benefit to humans and wildlife
    - Mental health improvements for the people who visit and live in areas that use reuse systems when reuse systems are used in conjunction with landscaping practices (What are the physical and mental benefits of gardening? (https://www.webmd.com/mental-health/how-gardening-affects-mental-health#:~:text=Provides%20exercise.,to%20still%20get%20these%20benefits.) - Michigan State University Extension)
- **Economic benefits and savings** (https://stormwater.pca.state.mn.us/index.php?title=Economic_benefits_of_Green_Stormwater_Infrastructure):
    - Harvest and reuse systems can be expensive to install but they can reduce the total operating water cost for a building, site, or water features once they are implemented
    - Well maintained harvest and reuse systems combined with vegetation can improve property aesthetics that increase property value
    - Harvest and reuse systems provide a safeguard against drought conditions through stored water that can be used to keep landscaping alive and well over several days or weeks if necessary
    - Potential for more affordable housing conditions when implemented as part of a renting strategy (Losoya et al., 2022)
- Macroscale benefits: Individual systems are typical small scale and provide benefits at the site level, but implementation of distributed systems at the watershed scale can provide macroscale benefits.

Design considerations

Maximizing specific green infrastructure (GI) benefits of constructed areas requires design considerations prior to installation. While site limitations cannot always be overcome, the following recommendations are given to maximize the GI benefit of water harvesting and reuse.

Caution: The following discussion focuses on design considerations. All benefits delivered by the practice require appropriate construction, operation, and maintenance of the practice. O&M considerations should be included during the design phase of a project. For information on O&M for GSI practices, see Operation and maintenance of green stormwater infrastructure best management practices

- Water quality
    - The designer should consider the project site pollutant sources during design and determine if additional stormwater treatment measures are required for use, what level of pretreatment is needed, and whether first flush diverters are appropriate. For more information on pollutant sources and pretreatment needs see Water quality considerations for stormwater and rainwater harvest and use/reuse. Also see information on Pretreatment.
    - The designer should consider first flush diverters in the collection system design to bypass high pollution loads during snowmelt or pollutant laden events when necessary to meet the requirements of the water use. However, first flush diverters should be utilized with caution ([1] (https://www.bluebarrelsystems.com/blog/first-flush-diverter/); [2] (https://rainharvesting.com.au/field-notes/articles/rain-ha

  - rvesting/the-benefits-of-using-first-flush-diverters/#:~:text=First%20flush%20diverters%20are%20a,first%20initial%20millimetres%20of%20rain.)).
  - Designer should place the appropriate settlement and solid removal procedures in the treatment train to prevent their entry into the reuse containment system
  - Design the site container to maximize capture and storage of runoff and prevent short-circuiting during rainfall events. See Determining the appropriate storage size for a stormwater and rainwater harvest and use/reuse system and Estimating the water balance for a stormwater and rainwater harvest and use/reuse site.
- Water quantity and hydrology:
  - Consider using harvesting on low permeability soils (**hydrologic soil group (https://stormwater.pca.state.mn.us/index.php?title=Design_infiltration_rates)** C and D soils), where captured water can be distributed through irrigation and/or used indoors.
  - Size the system to meet the intended uses of the harvest system. This includes ensuring appropriate water supply in response to demand. See Determining the appropriate storage size for a stormwater and rainwater harvest and use/reuse system and Design criteria for stormwater and rainwater harvest and use/reuse.
  - Construct the distribution system to reach all areas of the site that require water when economically feasible
  - Determine the sites' water needs for vegetation and plant systems over a given time period and design the water storage container to meet these needs. Typically, harvest systems are designed and built with a specific use and vegetation scheme in mind, but if feasible, consider adopting vegetation to an intended harvest system (i.e. if the objective is driven by performance goals for the harvest system, vegetation considerations should be built into the design considerations).
  - Utilize tandem systems which combine multiple storage units, such as multiple rain barrels in sequence (Kwiatkowski, 2012 (https://www.ecolandscaping.org/04/managing-water-in-the-landscape/rain-gardens/rainwater-harvesting-a-simple-approach-to-conservation/))
  - Determine the feasibility of distributed systems, which employs a combination of residential (parcel) harvesting, neighborhood harvesting, and regional harvesting, matching the system to the appropriate storage capacity (Nguyen et al., 2022 (https://iwaponline.com/bgs/article/4/1/58/89139/Multi-scale-stormwater-harvesting-to-enhance-urban)).
- Climate resiliency:
  - Incorporate vegetation into the water reuse system to help remove pollutants and reduce the sites' carbon footprint
  - Establish water reuse systems that will meet the vegetation needs for the site and provide adequate water for growth and maintenance
  - Construct the water reuse system in the area best for interception of pollutants
- Habitat improvement:
  - When using water reuse systems that will have direct interactions with people, ensure the appropriate treatment techniques are used to meet the necessary water standards
  - Rainwater harvest systems can be designed to benefit wildlife. Though many of these designs are for livestock applications, some can be modified for use on individual parcels in urban and semi-urban areas (Texas Cooperative Extension, 2014 (https://texnat.tamu.edu/files/2018/08/Water-rainwater-harvesting-for-wildlife-2006.pdf). Designer should be aware of the wildlife of the area and ensure any treatment measures, especially ones that use chemicals, do not pose a threat to the wildlife and their ecosystem.
  - Water reuse systems can establish vegetation that can attract pollinators (https://stormwater.pca.state.mn.us/index.php?title=Pollinator_friendly_Best_Management_Practices_for_stormwater_management) and promote plant propagation
  - Develop conveyance systems in such a way to minimize changes in temperature that can be detrimental to cold water fish habitats. Give particular consideration to runoff from roofs. be aware that water from constructed ponds and wetlands may have elevated temperatures.
- Community livability:
  - Include recreational infrastructure and interpretative signs

  - Ensure safety of water harvest and reuse systems and adjacent areas by making the storage container inaccessible to unauthorized individuals
  - Conduct surveys prior to and after development to identify features that enhance education, recreation, and other benefits of water reuse systems that are desirable to the served customer/community/stakeholder
  - Design grown vegetation and plantings with easy access (e.g. locate close to road, create public access)
  - Create attractive slopes using vegetation and proper erosion protection
- Health benefits:
  - Design storage containment systems for safety. Minimize the depth needed for pooled water if the containing area is exposed. Minimize access to infiltration or other treatment train areas by planting shrubs, fencing, or other area denial systems. Additionally, properly mark the area with signs. Minimizing depth of infiltration systems reduces hazards for children.
  - Infiltration systems naturally control mosquito habitats by going dray within a few days compared to typical stormwater ponds
- Economic benefits and savings:
  - Maximize sight-lines to the vegetation that the water reuse system services
  - Integrating water reuse into landscape design, including creating habitat, pathways, picnic areas, etc can increase property value

Recommended reading

- Scaling Green Stormwater Infrastructure Through Multiple Benefits in Austin, Texas: Distributed Rainwater Capture on Residential Properties in the Waller Creek Watershed (https://pacinst.org/wp-content/uploads/2020/06/Scaling-Green-Stormwater-Infrastructure-Through-Multiple-Benefits-in-Austin-Texas_Pacific-Institute_June-2020.pdf) - Sarah Diringer, Morgan Shimabuku, Heather Cooley, Madeline Gorchels, Jennifer Walker, and Sharlene Leurig; 2020.
- Water Reuse and Recycling (https://www.epa.gov/waterreuse) - US EPA
- Basic Information about Water Reuse (https://www.epa.gov/waterreuse/basic-information-about-water-reuse) - US EPA
- Stormwater Harvesting and Reuse Study (https://www.minnehahacreek.org/project/stormwater-harvesting-and-reuse-study) - Minnehaha Creek Watershed District
- Reducing and Reusing Basics (https://www.epa.gov/recycle/reducing-and-reusing-basics) - US EPA
- What are the Benefits and Advantages of Rainwater Harvesting? (https://www.watercache.com/faqs/rainwater-harvesting-benefits) - Innovative Water Solutions

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- Cathey, J.C., R.A. Persyn, D.O. Porter, M.C. Dozier, M. Mecke, and B. Kniffen. 2006. Harvesting Rainwater for Wildlife (https://texnat.tamu.edu/files/2018/08/Water-rainwater-harvesting-for-wildlife-2006.pdf). B-6182.
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- Losoya, J., Walker, J., Fuller, A., and Seefeldt, J. 2022. Ensuring One Water Works for All: Opportunities for Realizing Water Reuse in Affordable Housing (https://texaslivingwaters.org/wp-content/uploads/2022/04/Opportunities-for-Realizing-Water-Reuse-in-Affordable-Housing.pdf). Austin, TX: National Wildlife Federation.

- Nguyen, T.T., P.M. Bach, and M. Pahlow. 2022. Multi-scale stormwater harvesting to enhance urban resilience to climate change impacts and natural disasters (https://iwaponline.com/bgs/article/4/1/58/89139/Multi-scale-stormwater-harvesting-to-enhance-urban). Blue-green Systems, Volume 4, Issue 1.
- Savou, J. To First Flush, or not to First Flush (https://www.bluebarrelsystems.com/blog/first-flush-diverter/). BlueBarrel Rainwater Catchment Systems.