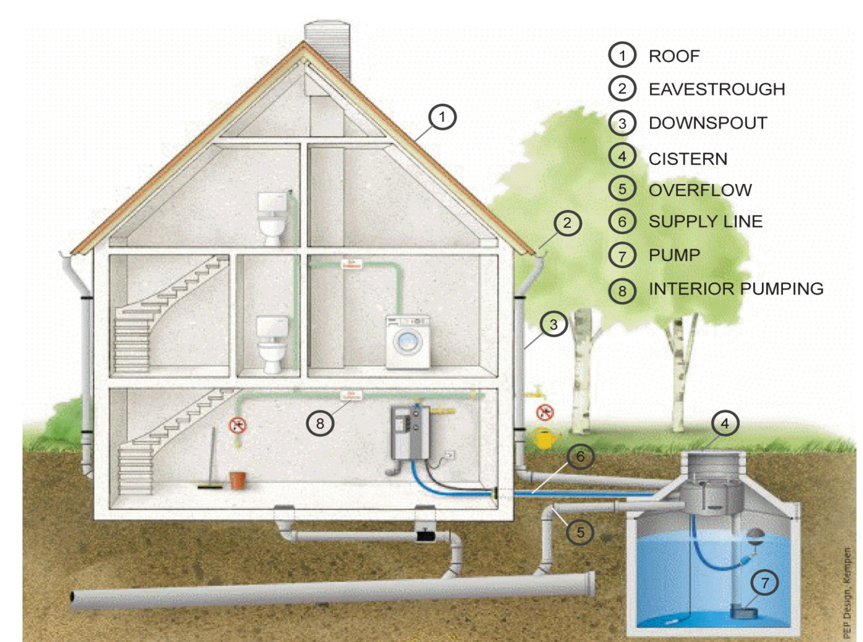
Sustainable Technologies
EVALUATION PROGRAM

Rainwater Harvesting

Rainwater Harvesting is the process of intercepting, conveying and storing rainfall for future use. The term "rainwater harvesting" (RWH) is used herein to refer to capturing rainfall onto rooftops (i.e. "roofwater") and stormwater runoff from the ground surface (i.e. "stormwater"), and then reusing for irrigation or other uses. The rain that falls upon a catchment surface, such as a roof, is collected and conveyed into a storage facility. Storage tanks, a common method for storage, range in size from rain barrels for residential land uses (typically 190 to 400 litres in size), to large cisterns for industrial, commercial and institutional land uses. A typical pre-fabricated cistern can range from 750 to 40,000 litres in size. Ponds are another type of storage facility for larger quantities.

The source area and quality of that runoff, as well as the end use, will affect how easily harvested water can be used. In the case of roof runoff, with minimal pretreatment (e.g., gravity settling or first-flush diversion), the captured rainwater may be appropriate for outdoor, non-potable water uses such as irrigation and pressure washing, or in the building to flush toilets or urinals. Continued research is being done on the quality of harvested runoff, such as rooftops, for non-potable uses, and local regulations may affect the level of treatment needed. It is estimated that these applications alone can reduce household municipal water consumption by up to 55%. The capture and use of rainwater can, in turn, significantly reduce stormwater runoff volume and pollutant load. By providing a reliable and renewable source of water to end users, rainwater harvesting systems can also help reduce demand on municipal treated water supplies. This helps to delay expansion of treatment and distribution systems, conserve energy used for pumping and treating water and lower consumer water bills.

	Ability to meet stormwater criteria		
	Water balance	Water quality	Stream erosion control
Rainwater Harvesting	Yes - magnitude depends on water usage	Yes - size for the water quality storage requirement	Partial - can be used in series with other practices



Source: PEP Design, Kempen

DESIGN

CATCHMENT AREA

The catchment area is simply the surface from which rainfall is collected. Generally, roofs are the catchment area, although rainwater from low traffic parking lots and walkways, may be suitable for some non-potable uses (e.g., outdoor washing). The quality of the harvested water will vary according to the type of catchment area and material from which it is constructed. Water harvested from parking lots, walkways and certain types of roofs, such as asphalt shingle, tar and gravel, and wood shingle roofs, should only be used for irrigation or toilet flushing due to potential for contamination with toxic compounds. The CSA/ICC standard specifies additional treatment requirements for all surfaces when rainwater is harvested for anything except fire suppression, ice rinks, restricted access spray irrigation or sub-surface irrigation. Some surfaces, such as tar shingles or green roofs, may produce runoff that has a faint tint or colour, which would not be suitable for re-use in toilets.

PRE-TREATMENT

Pre-treatment is needed to remove debris, dust, leaves and other debris that accumulates on roofs and prevents clogging within the rainwater harvesting system. For dual use cisterns that supply water for irrigation and toilet flushing only, filtration or first-flush diversion pretreatment is recommended.

COLLECTION AND CONVEYANCE SYSTEM

The collection and conveyance system consists of the eavestroughs, downspouts and pipes that channel runoff into the storage tank. Eavestroughs and downspouts should be designed with screens to prevent large debris from entering the storage tank. For dual use cisterns (used year-round for both outdoor and indoor uses), the conveyance pipe leading to the cistern should be buried at a depth no less than the local maximum frost penetration depth and have a minimum 1% slope. If this is not possible, conveyance pipes should either be located in a heated indoor environment (e.g., garage, basement) or be insulated or equipped with heat tracing to prevent freezing. All connections between downspouts, conveyance pipes and the storage tank must prevent entry of small animals or insects into the storage tank.

STORAGE TANKS

The storage tank is the most important and typically the most expensive component of a rainwater harvesting system. The required size of storage tank is dictated by several variables: rainfall and snowfall frequencies and totals, the intended use of the harvested water, the catchment surface area, aesthetics, and budget. In the Greater Toronto Area, an initial target for sizing the storage tank could be the predicted rainwater usage over a 10 to 12 day period.

STORAGE TANKS, CONT.

Pre-formed above-ground tanks are usually constructed from polyethylene or galvanized steel. They are available with storage capacity up to around 50,000 L. Preformed below-ground tanks may be constructed from reinforced fiberglass or concrete. Fiberglass tanks are available up to around 150,000 L. Concrete vaults can be constructed in almost any size. Wooden tanks are less common but are also available and permitted in the regulations. As a standing body of freshwater, rainwater harvesting cisterns present ideal habitat for mosquitoes. Mosquitoes should be prevented from entering by using a mesh screen on all openings. Larvicides may be added when the water is only to be used for irrigation purposes. To prevent algal growth, the cistern must be opaque or otherwise protect the water from light.

END USE DEMAND

The end use of the harvested water is another key design parameter that will drive the rate at which the collected water is used. The water must be used to free up storage for capture of future precipitation events, thus affecting the stormwater treatment performance of the system. In harvesting systems, an alignment of the catchment area (source of water), storage tanks and end use(s) impact the system performance. In irrigation situations, the amount of green space available for irrigation can be a driving parameter in the design and effectiveness. Internal uses of the water similarly should be evaluated to ensure an alignment of the source, storage and uses.

TREATMENT

The important water quality parameters for harvested rainwater differ from other types of LID. This is due to the potential for direct human contact, rather than environmental discharge. The CSA and ICC standard CSA B805-18/ICC 805-2018 specifies different water quality treatment requirements according to the source (i.e., roof versus pavement runoff) and the intended use. Tier 1 end uses only require filtering out coarse suspended sediment and debris. If toilet flushing or other higher tier end uses are desired, disinfection of some type is required and consideration may be given to colour and odour of the water. Technologies for achieving higher standards of water quality include:

- Ultraviolet (UV) disinfection requires additional filtration to remove particles so that the light can penetrate the water and destroy the viruses and bacteria,
- Chlorine disinfection also requires additional filtration to remove larger particles,
- Micro- or ultra- filtration uses such fine membranes that the vast majority of harmful viruses, bacteria etc. are excluded from the water directly.

DESIGN, CONT.

DISTRIBUTION SYSTEM

Most distribution systems are gravity fed or operated using pumps to convey harvested rainwater from the storage tank to its final destination. Typical outdoor systems use gravity to feed hoses via a tap and spigot. For underground cisterns, a water pump is needed. Indoor systems usually require a pump, pressure tank, back-up water supply line and backflow preventer. The typical pump and pressure tank arrangement consists of a multistage centrifugal pump, which draws water out of the storage tank into the pressure tank, where it is stored for distribution.

The Ontario Building Code requires that rainwater harvesting systems are designed, constructed and installed to conform to good engineering practice. References are made to ASHRAE, ASPE and CSA guides for plumbing detailing. These guides focus on ensuring that the rainwater does not contaminate or become mistaken for the municipal drinking water supply. Similarly, rainwater must be prevented from becoming contaminated from the sewer. In both cases, an air gap or a back-flow preventer is required.

OVERFLOW SYSTEM

An overflow system must be included in the design. Overflow pipes should have a capacity equal to or greater than the inflow pipe(s). The overflow system may consist of a conveyance pipe from the top of the cistern to a pervious area down gradient of the storage tank, where suitable grading exists. The overflow conveyance pipe should be screened to prevent small animals and insects from entering. Where site grading does not permit overflow discharge to a pervious area, the conveyance pipe may either be indirectly connected to a storm sewer (i.e. discharge to an impervious area connected to a storm sewer inlet) or directly connected to a storm sewer with incorporation of a backflow preventer.

PLANNING CONSIDERATIONS

Available Space | Storage tanks can be placed underground, indoors, on roofs or adjacent to buildings depending on intended uses of the rainwater.

Site Topography | Influences the placement of the storage tank and design of the distribution and overflow systems.

Soil | Underground cisterns should be placed on or in native, rather than fill soil, unless geotechnical analysis has been completed on the fill soil and confirms that the fill soil can support the load of the tank when full.

Head | Rain barrels or above ground cisterns with gravity distribution systems should be sited up-gradient of landscaping areas to which rainwater is to be applied.

Pollution Hot Spot Runoff | RWH can be an effective best management practice for roof runoff from sites where land uses or activities at ground level have the potential to generate highly contaminated runoff.

Winter Operation | RWH systems can be used throughout the winter if tanks are located below the local frost penetration depth or indoors,and the use is still active in the winter, such as indoor uses.

Proximity to Underground Utilities | Presence of underground utilities may constrain the location of underground storage tanks.

Plumbing Code | Code allows the use of harvested rainwater for toilet and urinal flushing, but systems require installation of backflow prevention devices.

Standing Water | If improperly managed, tanks can create habitat suitable for mosquito breeding, so screens should be placed on inlets and outlets to prevent entry.

Child Safety | Above and below ground cisterns with openings large enough for children to enter must have lockable covers.

Setbacks from Buildings | Tanks should be watertight to avoid ponding or saturation of soils within 4 m of building foundations.

Vehicle Loading | Underground tanks should be sited in areas without vehicular traffic, or structurally designed to hold maximum vehicle loads.

GENERAL SPECIFICATIONS

Component	Specification
Eavestroughs and Downspouts	• Materials commonly used for eaves¬troughs and downspouts include polyvinylchloride (PVC) pipe, vinyl, aluminum and galvanized steel. Lead should not be used as solder as rainwater can dissolve the lead and contaminate the water supply.
Pre-Treatment	At least one of the following must be included in the system: • leaf and mosquito screens (1 mm mesh size); • first-flush diverter; • in-ground filter; • in-tank filter. • Large tanks (10 m3 or larger) should have a settling compartment for removal of sediments.
Storage Tanks	• Materials used to construct storage tanks should be structurally sound. • Tanks should be installed in locations where native soils or building structures can support the load associated with the volume of stored water. • Storage tanks should be water tight and sealed using a water safe, non-toxic substance. • Tanks should be opaque to prevent the growth of algae . • Previously used containers to be converted to rainwater storage tanks should be fit for potable water or food-grade products. • Cisterns above- or below ground must have a lockable opening of at least 450 mm diameter.
Safety Plan	• The CSA/ICC standard (CSA B805-18/ICC 805-2018), released in 2018, specifies that a water safety plan be developed for Rainwater Harvesting projects, and requires stringent treatment for most uses that pose moderate to high risk of human exposure to water droplets, such as outdoor spray irrigation or pressure washing.

Note: This table does not address indoor systems or pumps.

Drawdown Between Storms | A suggested target for sizing the storage tank to ensure drawdown between storms is the predicted rainwater demand over a 10 to 12 day period. Use of water budget models or calculators are encouraged and assist in ensuring the storage is being used effectively and can be the basis for regulatory approvals or credits.

End Use Demand | The demand side of the system can be a big driver in performance to ensure storage is available for capture through time, and should be considered in the analysis, especially if the use is irrigation and the project location is very urban with limited green space.

OPERATION AND MAINTENANCE

Access and Maintenance: For underground cisterns, a standard size manhole opening should be provided for maintenance purposes. This access point should be secured with a lock to prevent unwanted access.

Mosquito Control: If screening is not sufficient to deter mosquitoes, vegetable oil can be used to smother larvae. Alternatively, mosquito dunks or pellets containing larvicide can be used.

Winter Operation: Rainwater harvesting systems have a number of components that can be affected by freezing winter temperatures. For above-ground systems, winter-time operation may not be possible. Prior to the onset of freezing temperatures, above-ground systems should be disconnected and drained. For below-ground and indoor systems, downspouts and overflow components should be checked for ice blockages during snowmelt events.

Maintenance requirements for rainwater harvesting systems vary according to use. Systems that are used to provide supplemental irrigation water have relatively low maintenance requirements, while systems designed for indoor uses have much higher maintenance requirements. All rainwater harvesting system components should undergo regular inspections every six months during the spring and fall seasons to keep leaf screens, eavestroughs and downspouts free of leaves and other debris; check screens and patch holes or gaps; clean and maintain first flush diverters and filters, especially those on drip irrigation systems; inspect and clean storage tank lids, paying special attention to vents and screens on inflow and outflow spigots; and replace damaged system components as needed.

For more information:

Visit the online Low Impact Development Stormwater Management Planning and Design Guide for more information including links to all sources cited: wiki.sustainabletechnologies.ca.

LID Stormwater Inspection and Maintenance Guide (TRCA, 2016): sustainabletechnologies.ca.

LID Construction Guide (CVC, 2012): sustainabletechnologies.ca.

The water component of the Sustainable Technologies Evaluation Program is a collaboration of:

Toronto and Region Conservation Authority,
Credit Valley Conservation, and
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