Urban Runoff Harvesting - A Local Water Resource for Onsite Landscape Irrigation

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Abstract

This urban runoff harvesting pilot project would demonstrate how to harvest local water from an underground storm drain running under (or adjacent to) a community park, and use this non-potable water for irrigating a community park, replacing municipal potable water. By tapping into an existing storm drain line, the project would be designed to divert stormwater and dry weather flows from the storm drain into an adjacent storage tank. From the tank, urban runoff would be treated and delivered to the park's existing irrigation system.

Second, the stormwater harvesting and irrigation use pilot project would demonstrate water efficiency and savings over spray irrigation by installing a sub-surface irrigation system under a small test turf patch.

This green infrastructure project harvests a local water resource, augments local water supplies, supplants potable water for non-potable purposes, reduces polluted urban runoff discharge to the receiving water body, and helps protect the reliability of a municipality's water supply.

Background

City of Santa Monica Approach to Watershed Management

Since the mid-1990s, the City of Santa Monica has shifted its watershed management program away from treat and release solutions for stormwater and toward sustainable, onsite harvesting and use of this local water resource in lieu of potable water. Such a strategy is called Low Impact Development (LID) and Green Infrastructure (GI). The former strategy focuses on a variety of earthworks and proprietary solutions, both passive and active, including stormwater storage and onsite direct use. The latter strategy focuses only on earthworks systems, as per the U.S. EPA, directing precipitation from impermeable surfaces into permeable surfaces or high efficiency bio-filtration (and release) systems. These are indirect, passive systems that put water into the ground for groundwater recharge, if an aquifer is accessible and easily rechargeable in a short time frame, into surface waters, or into plants via root uptake.

Active systems include storage tanks from smaller, simple and inexpensive gravity-flow rain barrels, to large cisterns with stored water pumped under pressure. Passive systems include infiltration pits and trenches (sub-surface); surface depressions; rain gardens; permeable paving products; and green streets.

The city's watershed management approach integrates land use with the flow of local water, whether it is precipitation or surface runoff. One management objective is at the micro-watershed level, e.g. the individual parcel, in which water use on property occurs.

Precipitation Harvesting

A sustainable watershed management approach views precipitation as a valuable resource with multiple benefits. Whether rain is harvested from common elevated surfaces, e.g. roofs, from ground-level, e.g. parking lots, alleys, and transportation grids, or from below grade, e.g. channels and storm drain lines, this water resource is locally accessible with proper treatment for most end uses. (Many different definitions exist for rainwater and stormwater. For the purpose of this article, stormwater is used as the general term; rainwater is often used for rain that lands on a roof and is harvested.) Precipitation, when harvested close to where it lands or flows, has numerous benefits.

Primary Benefits

These benefits are non-potable and potable water supply augmentation and receiving water quality improvement:

- Onsite rain harvesting retains the maximum rainfall amount possible on an annual and sustainable basis. This strategy produces the least amount of stormwater runoff entering the public right-of-way, e.g. the municipal storm sewer system;
- Onsite rain harvesting delivers effectively a water supply to an end use at an acceptable water quality and minimal energy cost; and
- Onsite rain harvesting is the least polluted water resource and cheapest to treat compared to stormwater flowing in the public right-of-way. By keeping rainwater onsite, less pollution enters surface water bodies, where water quality violations can occur.

Secondary Benefits

Keeping precipitation onsite through various harvesting strategies, whether in storage tanks (active) or through permeable surfaces (passive), eliminates stormwater runoff and has these additional benefits:

- Reduces peak flows, flooding and erosion;
- Reduces combined sanitary sewer overflows;
- Reduces the urban heat island by converting impermeable, heat-absorbing and dry surfaces (driveways, parking lots) to permeable, heat-reflecting, moister surfaces;
- Promotes a water self-sufficiency goal;
- Increases property value due to sustainable water earthworks and storage systems;
- Reduces potable water demand; and
- Keeps more water in watersheds for wildlife and human enjoyment, and reduces environmental consequences when overexploited. For many areas, potable water is removed from local watersheds and pumped to distant water users.

The structural device, installed during construction or as a retrofit, that harvests rain for indirect and direct landscape purposes is called a Best Management Practice or BMP.

Harvesting BMPs – Types and Selection

Landscape Applications

Direct/Active Systems

Low volume irrigation is most practical when using rainwater for landscape irrigation, especially with climate-appropriate plants (not with non-native, high water demand plants). Once established, such plants survive on locally available precipitation. It can often be applied by gravity alone or used in combination with pumping (e.g. under additional pressure) systems. Spray irrigation is also an option; however, spray uses more water and could exhaust quickly one's rainwater supply. Spray for a small area would be effective, especially in climates with year-round rain.

A direct system involves a number of components to harvest rain from roofs and at-grade surfaces: impermeable harvesting surface; conveyance system from surface to storage tank; pre-treatment device; storage tank; final treatment; and conveyance to end use. Final treatment can include various filters to remove small particles, remove impurities, and disinfection, depending upon the water quality required for a particular end use, usually non-potable. It is important to note that final water quality must be of a high level to meet irrigation system warranties. If the quality is low and causes damage to irrigation components, warranties may be voided.

The marketplace is replete with companies that specialize in rainwater harvesting systems. The American Rainwater Catchment Systems Association, ARCSA, is the national organization focusing on these systems. Its website (www.arcsa.org) and membership contain helpful information. Generally, proprietary systems serve this market. They range from simple to complex, depending upon the water quality of the stormwater, which depends upon the harvesting surface. A roof is generally cleaner than a parking lot or road. (Roofs with accessible recreational areas are known to contain a variety of pollutants, as are commercial and industrial roofs, where repair work can leave building materials exposed to rain and runoff.)

Indirect/Passive Systems

Various types of earthworks (landscapes) are used to harvest and retain runoff from roofs, parking surfaces and roadways for passive infiltration. Examples include: bio-filters, (bio-)swales, rain gardens, and green strips and streets. While these terms differ, generally, these are vegetated or landscaped surfaces placed in the path of runoff or where harvesting surfaces direct the runoff. One can build mounds around fruit trees to retain runoff onsite to build a sub-surface water reservoir used during the dry season. Where soils have good infiltration rates and groundwater is relatively shallow, earthwork retention features, e.g. settling ponds, for large runoff volumes can recharge groundwater for future extraction.

The most common passive BMP is the infiltration pit, over 90% of all BMPs. Residential properties have the most open space for this type of BMP, as well as surface depressions and vegetative or bio-swales. As California and the western U.S. experience drought, infiltrating BMPs are giving way to storage and direct use BMPs to water one's landscape, and vegetable and fruit gardens, and for indoor uses where potable water is unnecessary. Generally, a property owner prefers to put the BMP out of sight since space is often a premium in the city. Surface BMPs can take up space desired for landscapes, and outdoor equipment and activities.

Besides the infiltration pit, surface depressions, rain gardens (though it only rains a dozen or two times over a few months), and swales work for limited mitigation volume.

The infiltration pit is a sub-surface, carved out chamber filled with a material that allows water to be stored, yet is structurally sound. In the past, rock was used; however, about 40% of storage volume is lost using rock. To compensate for this loss, one has to make the pit 2.5 times larger. Other products made from plastic and concrete provide 95+% void space yet are structurally strong, and do not require additional excavation, e.g. cost.

Components of a Typical Rain Harvesting System - direct use

Five steps for a rain harvesting system

As the rain harvesting industry continues to grow, it is important to understand that an effective rain harvesting system with minimal annual maintenance is essential as this industry continues to make positive strides and to ensure you have a properly functioning system over time. No matter the size of the system, five essential design steps will ensure an effective and sustainable harvesting system. A typical direct-use harvesting system has the following components:

- Collection system includes impermeable surfaces upon which rain lands, and conveyance conduit to move the rainwater to a storage tank;
- Pre-treatment (screening-separation) device;
- Storage tank (cistern);
- Polishing treatment system for end-uses, where necessary; and
- Distribution plumbing system to final end-uses, whether outdoor or indoor applications, and overflow.

<u>Step One: Collection Surface</u>

A collection system harvests rain that falls on impermeable surfaces and transports it to a storage tank. For a roof surface, generally, gutters and downspouts direct rain to a tank. For a surface parking area, generally, rain would sheet flow to a centralized location, such as a catch basin, trench drain or hard-paved swale, and then continue to a storage tank. For a large project involving harvesting from a stormwater surface channel or drain pipe, collection would involve diverting stormwater flow out of a channel or pipe, and into a storage tank.

<u>Step Two: Pre-treatment</u>

Before it enters a storage tank, rain that lands on a roof, parking lot, road or any other impermeable surface and flows, or stormwater that flows through a storm drain system, must be adequately pre-treated to remove debris, sediment, and free oil and grease. Pre-treatment devices can be self-cleaning, which requires minimal maintenance and provides highly oxygenated water. The correct pre-treatment device will significantly reduce the need to clean the storage tank. The type and size of this device depend upon the volume to be collected, which relates to the harvesting area or upstream drainage area, rainfall intensity, and expected pollutants on the harvesting surface, e.g. trash, sediments, or oil and grease. For a single- or multi-family property, generally these small devices are called first flush or debris excluder; they are appropriate for small volumes, e.g. small surface areas. For larger commercial, industrial, institutional and government projects, the device needs to be bigger to accommodate the higher volume and be effective. Generally, this category or type of pre-treatment is called screening-separation or a vortex (spinning motion) device.

<u>Step Three: Storage Tank</u>

The tank design should reduce any turbulence caused as the harvested water enters the tank, which causes re-suspension of bottom sediments. This re-suspension reduces water quality of any water pumped out to end uses.

Most rain storage tanks grow a bio-film that serves as an internal ecosystem, which often assists in treating the storage tank water. Disturbing (via turbulence) this bio-film by simply "dumping" the water into the tank from the top will not allow for this micro-ecosystem to flourish. Using the proper components and design will allow the water to gently enter the tank from the bottom and help distribute oxygen throughout the tank, which reduces anaerobic issues.

A storage tank must have a properly sized and directed overflow, either to the landscape or storm drain system. An overflow is as simple as allowing the water to exit the top of the tank once it becomes full; however, some designs call for using a skimming overflow that removes floating matter such as pollen from the tank more effectively. The overflow, as well as the influent port, should have protection to keep fauna, e.g. mosquitoes to rodents, from entering the tank.

Step Four: Final treatment (optional)

Before final end use, the stored water may need to go through a final treatment system to meet local water-quality standards for each end use. The highest quality stored water is extracted from just below the surface in the storage tank or just above the bottom. Generally, final treatment should include 1-50 micron filters (depending whether UV disinfection is included), activated carbon filter and disinfection (which may or may not be required for toilet-urinal flushing or spray irrigation). Finer filtering to meet irrigation system requirements may be necessary to avoid clogging valves and emitters, and potentially invalidating equipment warranties.

One's system may or may not have a day tank so that only water being used daily is treated. This strategy avoids treating all storage tank water whether it is used or not, and reduces treatment costs. Alternately, on-demand treatment is possible without a day tank.

Check with your local authority having jurisdiction on any required, specific water quality standards.

Step Five, Distribution

After leaving the storage tank, water is pumped to an end use. If one's system will not have enough rain for the annual demand, the system should have a back-up municipal water supply. The connection can be a 3-way valve (located between storage tank/final treatment and end use), or a direct feed into the day tank (or storage tank if no day tank) with an air gap. Many municipalities require a back-flow prevention device (RPZ) on the back-up supply to prevent reverse flow and possible contamination of the municipal supply. Your local authority having jurisdiction can provide specific backflow and cross-connection requirements.

City and Private Projects

Putting the direct application strategy together with the five installation steps, the city and private developers have implemented a number of projects.

Main Library

The city's main library has a 200,000 gallon cistern under the building and underground parking structure. Rain landing on the roof, decks and parking lot is pre-treated to remove debris, trash, and larger sediment and then directed to the cistern. In the cistern, fine sediment settles out. The stored and treated water is used for sub-surface drip irrigation.

Multi-family and Single-family Projects

The city completed in 2012 multi-family residential building that includes a 13,000 gallon cistern. Rain from the roof is pre-filtered, stored and used for sub-surface drip irrigation project. For these two city projects, since the rainwater is delivered sub-surface, no disinfection is required.

Private property owners have also installed cisterns (500-5,000 gallons) to collect roof and driveway runoff for storage and sub-surface irrigation use. Sub-surface irrigation with non-turf, climate-appropriate landscaping is an efficient way to use rain for landscape irrigation, to extend harvested rain for use during dry periods and avoid the use of municipal potable water.

Future Projects

The city has embarked on a stormwater harvesting strategy to tap into storm drain lines running adjacent to or under city parks. City parks and open spaces offer opportunities to replace potable water for irrigation with non-potable stormwater where a storm drain line is close by in which to tap for a water resource. The city is currently in the design phase for one park to harvest stormwater, and any dry weather runoff, from the storm drain running along a parallel residential street. A local water district grant is helping to financially support this budgeted project. Harvested and treated water will be used for athletic field irrigation.

Another park project is in design phase, though not budgeted, to tap into a storm drain line running under the park to do the same harvest, treat and deliver to turf irrigation. This project has a U.S. Environmental Protection Agency Green Infrastructure Design grant to develop a design plan for such a solution.

Conclusion

Summary

- The use of rain and stormwater for non-potable irrigation applications offers a significant opportunity in water management to maximize local water resources to supplement or displace potable, leaving more freshwater in our surface and underground supplies;
- Treatment systems are readily available and offer safe ways to utilize rainwater and stormwater, and protect health;
- Existing, safe and reliable plumbing design and standards exist;
- Permitting procedures exist;
- No technical, treatment or health and safety obstacles exist. There is only a lack of political will or the fear to try something ‘unconventional,’ though tested and proven to work.

Going Forward

Using these steps as guidelines will ensure your stormwater system is of the highest quality and will require minimal maintenance regardless of the size of the system. Because rain harvesting design and installation involve several disciplines, it is recommended that one consult qualified professionals in this water-harvesting field.

Treated rainwater and stormwater from a properly designed, installed and maintained harvesting system can be used for all traditional water uses. Rain harvesting should be part of any effective and sustainable local approach to water management. The key is to build on the existing positive record, and ensure rainwater and stormwater utilization become commonplace, e.g. part of new construction and major re-development, as well as retrofit construction, and available at a reasonable cost and least regulatory impact to anyone who is willing to invest in a system.

Appropriately treated rain and stormwater, which matches one’s end use from a properly designed, installed and maintained harvesting system, can be used for all traditional water uses, both non-potable and potable.

The city’s sustainable watershed management approach promotes practical solutions which integrate land type, local water availability, building construction, landscapes and climate. This approach encourages living within the means of locally available natural resources. It fosters landscape designs with appropriate irrigation systems to match local water supply with climate-appropriate species.