City of Tucson Water Harvesting Guidance Manual – A Multifunctional Tool for Sustainable Water Use, Water Conservation and Stormwater Management

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INTRODUCTION

ftp://sahra.arizona.edu/upload/symposium/proceedings/PhillipsA_pro.doc

Rainfall is clean, free, and distributed throughout the City of Tucson twice a year during predictable rainy seasons. This water is an important resource that has been treated traditionally as a liability to be shed from the landscape as soon as possible at great expense. Water harvesting is the process of intercepting stormwater runoff from a surface (e.g. roof, parking area, land surface) and putting it to beneficial use. Intercepted stormwater can be collected, slowed down, and retained or routed through the site landscape using earthen collection locations and tanks. The City of Tucson Land Use Code requires that rainwater be harvested and put to beneficial use to support vegetation at new commercial developments, subdivisions, public buildings and public rights-of-way. The City's Water Harvesting Guidance Manual was prepared to assist designers, engineers and others to effectively design and implement water harvesting at a range of sites. The City of Tucson Water Harvesting Guidance Manual provides the basic water harvesting information needed for the design of sites subject to City requirements. These requirements do not apply to residences, but the information in the manual is also useful for homeowners who want to incorporate water harvesting at their sites.

The Manual provides information about integrated design principles and basic water harvesting techniques, and includes example designs for large-scale projects. In addition, appendices address Tucson Code requirements; considerations in engineering, landscaping, and mosquito control; engineering calculations; the locations of on-the-ground examples; and water harvesting resources. In the arid climate of Tucson, Arizona, use of harvested rainwater can reduce dependence on dwindling groundwater reserves and expensive Central Arizona Project (CAP) water. Water harvesting at these sites fulfills multiple functions including reducing stormwater runoff; improving stormwater quality, reducing municipal water demand and supporting on-site vegetation. Water harvesting-supported vegetation in turn abates air pollution and noise pollution, reduces the heat island effect, creates habitat and improves site aesthetics.

TYPES OF WATER HARVESTING STRUCTURES

Harvesting water is easiest and least expensive when it is collected and stored directly in soil. Water harvesting earthworks are depressions of different sizes and shapes that collect precipitation that falls directly on them and intercept water that flows into them from upgradient locations. Typical water harvesting earthworks include microbasins collecting water from very localized areas, swales intercepting overland flow, gabions that slow and infiltrate water in small drainages, and French drains that collect water in the pore space of gravel-filled trenches. Earthworks increase water availability in soil during rainfall seasons, and retain soil moisture for a period after rainfall occurs. Above or below-ground tanks can be used to collect water from clean hard surfaces, most commonly rooftops. Use of tanks for water storage can dramatically increase the time period when harvested rainwater is available, but at a trade off of the cost to install storage tanks. Above-ground tanks maintain head pressure that allows some water to be delivered using gravity flow.

BENEFITS OF WATER HARVESTING

Stormwater Quality Improvements. In addition to meeting requirements of Tucson’s Land Use Code, water harvesting assists with stormwater quality management. Federal regulations established under the Clean Water Act require large municipalities to implement measures to reduce pollutants in stormwater to the “maximum extent practicable.” As a result, Tucson was required to obtain a Municipal Stormwater Quality permit from the Environmental Protection Agency. To effectively implement the federal permit, Tucson must implement a Stormwater Ordinance that reflects federal requirements that developments include permanent structural controls to reduce pollutants discharged from a site. On-site retention of the Stormwater Quality Storm (SQS) rainfall depth within the required landscape water harvesting areas qualifies as an excellent tool to control stormwater quality. Currently, the SQS rainfall depth for Tucson varies with impervious cover (IMP) as follows: 0.30” of rainfall depth for <25% IMP, 0.40” for >25% to 70% IMP, and 0.6” for >70% IMP. Harvesting stormwater and vegetating stormwater collection areas can help improve stormwater quality by reducing particulates and pollutants in stormwater.

Reductions in Stormwater Volumes

Rainfall over Tucson averages around 47 billion gallons per year. This stormwater volume is managed by a complex system of natural and altered drainages, on-site detention/retention basins, regional detention facilities, and manmade conduits for stormwater including stormdrains, and in some cases depressed street profiles. Water harvesting benefits the City and its resident by hydrating the watershed, reducing the volume of stormwater flowing in streets or onto adjacent properties, and providing cost savings on large-scale structural stormwater controls. At individual sites, the City can allow reduction in the size of the retention/detention basin based on the volume of stormwater retained in water harvesting structures elsewhere at the site. Conversely, a retention/detention basin can be used to perform multiple functions at a site including using the stormwater harvested there to support plants that also provide required landscape buffering and visual screening. This approach saves land and money for site developers.

Water conservation

With declining groundwater tables, the need to import Colorado River water, prolonged drought, and increasing competition for limited water resources in the western US, Tucson faces a challenging and uncertain water future. Outdoor water use constitutes nearly half of residential water demand in Tucson. Commercial and public facilities typically have extensive landscapes supported by potable or reclaimed water. Retaining instead of shedding rainfall, and converting landscape plants to native and drought-tolerant species, are critical steps for reducing demand for utility-provided water. Tucson Water, the City’s water utility, has included rainwater harvesting as an important component of its long-term water conservation strategy. Supporting landscapes using harvested rainwater--instead of groundwater, CAP water, and reclaimed water--provides direct benefits to the community by reducing utility water demand and some associated costs. Those individuals and organizations who practice water harvesting receive the direct benefit of lower water bills for their sites. It is important to note that water harvesting is not a groundwater recharge strategy. Rain collected in small, localized water harvesting basins will not infiltrate hundred’s of feet to Tucson’s regional water table. However, when rainwater harvesting results in decreased demand for groundwater supplies, the aquifer is directly benefited by this strategy.

Supporting Vegetation

Vegetation is a key factor in the quality of life for people living in the desert where harsh sun and hot winds desiccate the landscape. Rainwater is typically low in salt content and relatively high in nitrogen--

factors that benefit plant growth. Proper placement of plants within the built environment can help ameliorate the harsh conditions of the desert. Trees placed on the west side, north side and east side of buildings reduce heat load in the summer and benefit from water running off rooftops. Trees placed on the west side and southwest side of buildings and outdoor spaces provide a shield from the hot desiccating winds of May and June. Tree-shaded parking areas greatly improve human comfort. Trees and understory plants act as visual barriers to surrounding sites.

To maximize the benefits of water harvesting, its important to use native and drought-tolerant plants that adjust well to seasonal rainfall patterns, and that look good during the dry season with only minimal supplemental irrigation. The appropriate placement of vegetation relative to water harvesting basins depends in part on the plant species and basin size. Placing plants inside the basin is advantageous because the roots perforate the soil, increasing water infiltration into the basin. Vegetation planted inside basins can be located on slightly raised mounds that are created in the bottom of basins. This strategy elevates the base of the plant above the bottom of the basin, reducing exposure of the stem to standing water and mulch. Plants that are less tolerant of standing water can be planted outside the perimeter of a basin where their roots can still grow toward the high soil-moisture zone underneath the basin. The bottom of large water harvesting basins can be contoured to create plateaus and mounds surrounded by depressions. These plateaus and mounds are ideal planting locations.

CITY OF TUCSON CODES REQUIREMENTS FOR WATER HARVESTING

The City of Tucson Land Use Code requires that rainwater be harvested and put to beneficial use to support vegetation at new commercial developments, subdivisions, public buildings and public rights-of-way. The City of Tucson Land Use Code (LUC) states that landscaping is intended to accomplish energy, water and other natural resource conservation (LUC Section 3.7.1.1.A) and to reduce soil erosion by slowing stormwater runoff and assisting groundwater recharge (LUC sections 3.7.1.1.A.4 and .5). Per LUC Section 3.7.4.3.B, “Grading, hydrology, and landscaping structural plans are to be integrated to make maximum use of site storm water runoff for supplemental onsite irrigation purposes. The landscape plan shall indicate use of all runoff, from individual catch basins around single trees to basins accepting flow from an entire vehicular use area or roof area.” In LUC Section 3.7.4.5.B, it states that “Storm water and runoff harvesting to supplement drip irrigation are required elements of the irrigation system for both new plantings and preserved vegetation.”

CITY OF TUCSON WATER HARVESTING GUIDANCE MANUAL

The City of Tucson Water Harvesting Guidance Manual was prepared to assist designers, engineers, landscape architects, and others to effectively design and implement water harvesting at a range of sites. The Manual provides information about integrated design principles and basic water harvesting techniques that can guide design and implementation at large sites required to practice water harvesting by the City, and at residential sites, which are not currently required by City Code to undertake water harvesting.

As discussed in the Manual, water harvesting at large sites should be integrated into drainage design, buildings design, traffic flow and landscaping. Design specifications should clearly delineate where water harvesting will occur, what earthen or tank structures will look like, where overflow will occur, and how harvested rainwater will be utilized. Specifications should include planting instructions, mulching instructions and maintenance needs. By integrating water harvesting from the beginning of the design process, the locations of water harvesting structures and associated plantings can be designed to perform multiple functions including reducing site energy use, improving site function, and increasing site comfort. It is key to make sure plans are implemented as designed. Because water harvesting-based grading and planting constitutes a change in typical site construction techniques, site inspections should be conducted during construction to verify that plans are being correctly implemented.

WATER HARVESTING PRINCIPLES

Basic principles of water harvesting design are equally applicable to large- and small-scale systems. Principles of Water Harvesting Design include the following:

Start managing water at the top of the watershed
Harvest and utilize water in small increments beginning at the highest elevation ("top") of the site and continuing in small increments at multiple locations throughout the site. This approach spreads water to support vegetation throughout the site, and enables the use of gravity flow to move excess water from one water-harvesting site to the next. Water captured in multiple small increments is easier to manage then a large volume of stormwater collected at the lowest elevation ("bottom") of the site.

Create multiple small watersheds
Evaluate existing topography using a detailed site contour map and site visits. Divide the site into small watersheds based on existing topography, or based on grading and reshaping if necessary. Harvest water throughout these small watersheds.

Collect, slow and infiltrate the water
Slow and spread stormwater flow to reduce its erosive nature, allow sediment to drop out, and allow more water to infiltrate into soils. Expose stormwater to as much soil surface area as possible within the confines of the water harvesting structure to increase infiltration into the soil. The least expensive place to store water is in the soil. The International Building Code (IBC) recommends a minimum of 10 feet between building foundations and ponding water or infiltration areas [2000 IBC section 1803.3]. Consultation with a soil professional is recommended when planning water harvesting near a structure.

Prepare for overflow
Water harvesting structures need to allow excess stormwater to overflow safely to other locations where it will be used beneficially. Overflow devices (tank overflow pipes, spillways, etc.) should be sized to safely handle large rainfall events. Convey overflow discharge to safe locations to avoid contributing to erosion. Overflow devices should be checked and maintained regularly.

Mulch to reduce evaporation
Dryland environments typically have low rainfall rates and very high evaporation rates. As a result, water that infiltrates into the soil is quickly lost to evaporation. Covering soil with a thick layer of organic or inorganic material reduces evaporation of water from the soil. Mulch to an appropriate thickness (3" to 4" is usually sufficient) for the vegetation types present. Avoid placing mulch against tree trunks. Organic mulches include bark, leaves, straw, and other plant materials that decompose over time to create healthier, more porous soils. Inorganic mulches include rock, gravel and cobbles. Avoid placing decomposed granite around water harvesting structures because this material can shed clay particles that clog soil pores.

Put harvested water to beneficial use
Harvested rainwater is ideal for supporting landscape vegetation because rainwater is low in salts and high in nitrogen, which benefits plants. Appropriate plant placement can increase site efficiency and

comfort by shading windows from afternoon sun, shading large expanses of asphalt to reduce the heat island effect, and improving site comfort and aesthetics. Roof-top water harvested in tanks can supplement irrigation of plants beyond the rainy season, provide low-mineral water for car washing, and off set other uses that potable water is typically put to.

Adjust and maintain your systems as needed

Inspect water-harvesting systems periodically, especially after big rainstorms, and address basin or overflow sizing, erosion, or other performance issues as needed. Though all systems will require some observation and maintenance, systems should be designed to be as low-maintenance as possible.

MOSQUITO ABATEMENT IN WATER HARVESTING

Mosquitoes are an increasing problem in Tucson due to lush, heavily watered landscapes and the presence of shallow pockets of standing water (plant trays, bird baths, etc.). This is a concern because some mosquitoes harbor disease-causing organisms that can be passed to people through mosquito bites. To control mosquitoes in water harvesting systems, design and build systems to rapidly infiltrate water below the land surface and ensure that water does not pool at land surface for more than 12 hours. Precautions in water harvesting systems include avoiding compaction of the bottom of earthen basins since compaction reduces infiltration. It is also helpful to plant within basins so roots penetrate them and help increase infiltration. If water stands for more than 12 hours in a structure, loosen the bottom of the basin, add more mulch, lower the spillway, and/or construct smaller, more frequent water harvesting structures upslope. Periodically inspect your system to see if mosquitoes are breeding. If so, adjust the water harvesting areas accordingly and/or put *Bacillus thuringiensis israelensis* (BTI), a larvae-killing bacteria that inhibits completion of the mosquito life-cycle in the basins. Keep all bowl-shaped structures (plant trays, wheel barrows, tires, etc.) emptied of any standing water. Avoid standing water features such as fountains and birdbaths, or, if these features are desirable, use BTI in them on a regular basis.

CONCLUSIONS

Rainwater harvesting is an under-used strategy that can provide multiple including improved stormwater quality, decreased stormwater volume, municipal water conservation, and enhanced landscapes that improve function and comfort in urban environments. The City of Tucson requires that water harvesting be conducted at newly constructed large-scale sites through its Land Use Code, and provides guidance on how to conduct it through the City of Tucson Water Harvesting Guidance Manual. The Manual can be downloaded as a pdf from http://dot.tucsonaz.gov/stormwater/