

Turning Drains Into Sponges and Scarcity Into Abundance

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INTRODUCTION

As communities grow and develop, formerly vegetated and porous earthen watersheds are paved over and made impervious. Over 25% of the land area in my hometown of Tucson, Arizona is now paved, roofed, or otherwise turned to hardscape.¹ In more densely populated communities, such as Los Angeles, California, over 60% of the land surface is paved.² This urban phenomena dehydrates landscapes, increases downstream flooding, increases the heat island effect, degrades water quality, and creates sterile living environments (unless you like kayaking in urban runoff).

A recent report prepared by American Rivers states that rapid expansion of paved-over and developed lands in communities across the U.S. is worsening the effects of drought. For example, development in Atlanta, Georgia, and surrounding counties contributes to a yearly loss of rainwater infiltration ranging from 57 to 133 billion gallons. If managed on site, this rainwater—which could support the annual household needs of 1.5 to 3.6 million people—would filter through the soil to recharge aquifers and increase underground flows to replenish rivers, streams, and lakes.³

In association with creating hardscapes, the remaining exposed earth is often denuded and increasingly compacted. Tucson's over consumption of groundwater (exceeding the rate of net natural recharge), along with the paving and dehydration of its watershed, has contributed to the severe degradation of the once perennially-flowing Santa Cruz River. Water tables have dropped over 300 feet (90 meters) since the early 1900s, and many springs and wells have dried up. While 12 inches (304 mm) of rain falls on Tucson in an average year, we are lucky if a fraction of this rainfall infiltrates into the soils of the city's urbanized watershed and our household landscapes. In these desiccated landscapes, automatic irrigation systems frequently turn on just hours after a downpour or even while the rain is pouring from the sky. And an adventurous few even kayak down streets and stormdrains that are surging with urban runoff rapidly draining out of the watershed.

CHOOSING WATER ABUNDANCE OVER WATER SCARCITY

It does not have to be this way. We have a choice. We can choose to either dehydrate or rehydrate our watersheds. We can choose between water scarcity and water abundance.

Hardscapes that drain water away can be turned into sponges that hold water in place. Unnecessary hardscape can be reduced, and runoff from the remaining hardscape can be harvested in soil to passively irrigate native vegetation. This vegetation can in turn cast a canopy of shade over pavement. This process can begin to rehydrate landscapes, decrease

downstream flood peaks, reduce stormwater pollution and counteract the heat island effect. For example, since the 1940s unshaded streets, driveways, patios, buildings, and parking lots have contributed to a 6°F rise in summer temperatures in Tucson and more than 10°F rise in Phoenix. Yet, neighborhoods with shade canopies over more than 50% of the streets, sidewalks, and driveways have experienced a 10°F *decrease* in summer temperatures. These trees, once established, can be irrigated solely by harvested rainfall and runoff from the streets and driveways if they are low-water-use indigenous trees planted within water-harvesting earthworks. Such rehydration and reforestation of landscapes also creates dynamic, sustainable living environments that produce native food, create wildlife habitat, improve stormwater quality, and control erosion.

“Draining” landscapes—consisting of vegetation placed at the top of earthen mounds—can be replaced with creative undulating landscapes consisting of water harvesting depressions and plants placed within or adjacent to water collection areas. Besides harvesting water, these landscapes harvest organic leaf drop and reduce soil erosion. Water-draining landscapes can create mosquito problems when runoff pools at the bottom of the system and stands for the three days necessary for mosquitoes to develop from eggs to adults. In contrast, water-harvesting landscapes create a mosquito solution by distributing water evenly over multiple small basins in the landscape. Water-harvesting earthworks should be designed to infiltrate standing water within 12 hours, though water often infiltrates much quicker in well-designed water harvesting landscapes. The more organic mulch and vegetation contained in the depressions, the faster the rate of water infiltration.

SUSTAINABLE HIERARCHY OF WATER USE

With the construction of harvesting landscapes, we can move away from the unsustainable practice of using costly potable water (or reclaimed water that has been treated off site and pumped back to the site) to irrigate landscapes. Instead we can move towards a sustainable hierarchy in household and community water management in which:

- Rainwater and localized runoff are the *primary* water sources for our landscapes and gardens.
- Greywater is the *secondary* water source for landscapes, with greywater consisting of on-site household "wastewater" drained from sinks, clothes washers, showers, bathtubs, reverse-osmosis water filters, evaporative cooler bleed off, and condensate from air conditioners. Greywater does not include the drainwater from toilets, which is considered blackwater.
- Municipal/well water that must be pumped to a site is strictly a *supplemental* source used for landscape watering *only* in times of great need such as drought.

Outdoor irrigation conducted on standard, non-harvesting landscapes consumes about

30% of the potable water used at single-family residences in the U.S.⁶ In hot, dry climates the potable water consumed for irrigation can be much higher. In Albuquerque, NM irrigation constitutes 40% of potable water demand.⁷ In San Diego, CA, Denver, CO, and Phoenix, AZ, outdoor water use is well over half the water consumed at single-family residences.⁸ In contrast, outdoor irrigation in water-harvesting landscapes typically constitutes 5% or less of the potable water consumed at a single-family residence.

Even in dry climates, rain can constitute an abundant water source. Studies have found that over 70% of the average residential water use of 165 gallons per person per day (gpcd) (625 liters) in Tucson's urban core could be met by direct rainfall.⁹ In addition, recycling greywater can provide up to 40 gpcd (152 liters) of greywater for landscape irrigation.¹⁰ The easiest place to begin harvesting rainwater and greywater is in the landscape where the quality of these water sources is appropriate for the intended use.

WATER HARVESTING PRINCIPLES

The Eight Universal Principles of Successful Water Harvesting listed below provide guidance on how to implement both the sustainable hierarchy of water use and the stewardship path to abundance within our community's landscapes.

1. Begin with long and thoughtful observation.

Observe where water flows, where it collects, where it drains to, and where it drains from. Careful observation informs you of site resources and challenges. Observe what is working and build on that. Observe what is not working and change it.

2. Start at the top (highpoint) of your watershed and work your way down.

It is easier to harvest water high in the watershed where the volume and velocity of flow is relatively small, compared to harvesting and managing water at the bottom of the watershed where flow is concentrated and fast-moving. Harvesting water at the top of the watershed also allows the use of gravity to distribute harvested water downslope.

3. Start small and simple.

Small, simple systems of appropriate scale are easier to create and maintain than complex, extensive systems. As an added benefit, large numbers of small earthwork structures distributed throughout a watershed will be far more effective at hydrating the land than a small number of large-scale earthwork structures placed in just a few areas of the watershed.

4. Slow, spread, and infiltrate the flow of water.

Zig-zag the flowpath of water to calm the flow, reduce destructive erosion, and increase the time and distance water flows. This will increase infiltration into the soil from *source* (high point) to *sink* (low point). This practice achieves *waterspread* throughout the watershed.

5. Always plan an overflow route, and manage that overflow as a resource.

You cannot turn off the rain once your water harvesting earthworks and cisterns fill up, so always be prepared for overflow. Design cistern overflow so it fills a vegetated earthwork nearby, then overflows to the next earthwork, and the next, passively irrigating sheltering vegetation. Route water in a zig-zag pattern that follows the fourth principle: slow, spread, and sink.

6. Maximize living and organic groundcover.

Plant vegetative groundcover and spread organic mulch over the surface of the soil to create a living sponge that combines with harvested water to grow more resources. As roots expand and soil life increases, the soil's ability to infiltrate and hold water steadily increases as well.

7. Maximize beneficial relationships and efficiency by "stacking functions."

Design your water harvesting strategies so they do more than hold water. Cisterns and earthworks provide high quality irrigation water and serve as on-site stormwater control strategies. In turn, rain-irrigated vegetation and above-ground cisterns can passively shade and cool the east and west sides of buildings in summer. Plants supported with harvesting rainwater clean the air, produce food, create wildlife habitat and add beauty to our lives.

8. Continually reassess your system: the "feedback loop."

The value of long and thoughtful observation extends throughout the life of your system. How is the land responding to your work? How are your strategies performing? What still needs to be addressed? Make any needed changes using the principles to guide you.

WATER HARVESTING IN INTEGRATED SITE DESIGN

Solar Arc

Design sites to work with the seasonally changing sun angles to increase the site's functionality and comfort. Harvested water should support perennial vegetation planted west, north and east of a home in the northern hemisphere, or west, south, and east of a home in the southern hemisphere. This creates a vegetative "solar arc" that helps to passively heat the home in winter by retaining winter sun access, and helps cool it in summer when vegetation blocks the rising and setting sun. Studies have found the shade cast by such plantings can reduce summer temperatures around buildings by as much as 20°F, while maintaining access to winter sun can help passively meet 50% or more of the building's heating needs.^{11,12}

Hardscape design

Raise pathways, accessways, and gathering areas and direct water running off these surfaces to adjacent sunken, mulched, and vegetated basins. The mulch and vegetation help bioremediate contaminants in the runoff while the runoff boosts vegetation growth. Vegetation then matures to passively shade, shelter, and cool the hardscape of the accessways and gathering areas.

Food production

Use rainwater and greywater to grow food. The average meal in America travels 1,500 to 2,500 miles (2,413 to 4,022 km) from farm to plate.¹³ but much of this could be produced right outside the kitchen door. One hundred fruit trees scattered throughout a neighborhood of 1,000 people are as productive as 100 trees in a 1-acre (0.4-ha) irrigated orchard.¹⁴ One-thousand such neighborhoods yield as much as 1,000 acres (404 ha) of orchard. Neighborhood orchards serve multiple functions when integrated with homes and whole neighborhoods, providing food, passive cooling, beauty, living playgrounds, windbreaks, erosion control, and creating stronger local economies. In addition, watering these trees and other food plants with harvested rainwater and on-site greywater drastically reduces the strain that distant groundwater-irrigated orchards put on community resources. It also saves the fossil fuel otherwise needed to harvest, package, transport, and sell the distant orchard's produce to us.

Single-family residence

Those of us living in the Lancaster household in Tucson, Arizona, have turned a sterile lot into an oasis providing 15 to 25% of its food needs on site by irrigating over 95% of the landscape and garden using harvested rainwater and greywater. While a 1,200-gallon (4,548-liter) cistern harvests roof runoff to supplement the irrigation of the vegetable garden, the bulk of the site's water is harvested within passive earthworks.

One example of the site's simple greywater-harvesting systems is the clothes washing machine. There are four drain pipes installed beside it—each labeled with the name of a different tree. Each pipe directs greywater directly to a different rainwater-harvesting, mulched basin within which, or beside which, is planted a fruit tree. Each time someone uses the washing machine, they move the washer's drain hose in a clockwise direction to the next greywater drain pipe. This conveniently spreads the greywater resource around the yard to the different trees where it is needed. Higher-water-use exotic fruit trees are *only* planted where harvested greywater is available to supplement harvested rainwater.

The rainwater harvesting earthworks and plantings extend beyond the property into the public right-of-way and the community at large. Along the street, existing street curbs are cut to allow street runoff to enter mulched basins and passively irrigate street-side plantings of native trees, shrubs, and ground cover. Only one curb cut is made per basin so the cut can serve as both the inflow and overflow for street water. This pattern creates a very stable, self-maintaining system of “eddies” or “backwater” locations along the flowpath of street runoff. Water “settles” into the basins rather than flowing through them so there is no erosion. Mulch floats up with the incoming water, then sinks back down as the water quickly infiltrates into the soil. Using this strategy, native-plant landscapes thrive on harvested street water alone once plants are well established. These systems reduce street flooding, decrease the need for more flood-control infrastructure, reduce urban heat island conditions, beautify neighborhoods, create wildlife habitat, and naturally filter pollutants from soil and air. These curb cuts and plantings have reduced runoff from this street by over 90%. See www.DesertHarvesters.org for ways we are promoting the “planting of rain” along with the planting and use of food-producing native trees along neighborhood streets.

At the Lancaster household, we harvest over 100,000 gallons (379,000 liters) a year of rainwater and greywater in the soils of the 1/8th of an acre (0.05 ha) property and 20-foot (6 m) wide surrounding right-of-way, while using less than 20,000 gallons (75,800 liters) per year of municipal water inside the house. We give more water back to our watershed than we take from it.

Multifamily residence

The 28-unit Milagro co-housing site in Tucson, AZ has no conventional detention or retention basins at the low end of the site. Instead dozens of small infiltration basins are arranged throughout the site's landscape and watershed. These small basins are the foundation of the landscape, harvesting direct rainfall and rooftop runoff. In addition, the basins hold household wastewater that is distributed subsurface to the basins via pipes after being treated at the on-site constructed wetlands. The salt-free rainwater helps leech the salts that have been introduced to the root zone of plants by treated wastewater. Once plants are established, no additional potable water is used for irrigation. There is no runoff from the development's parking lot because it is paved with Gravelpave2 porous pavement.

At this cluster development only 5 acres (2 ha) of the 43-acre (17-ha) site is developed. The remaining 38 acres (15 ha) have been set aside as natural open space to preserve the native desert ecosystem. Here intact plants, leaf drop and undisturbed native soil create a natural sponge in the watershed. Site plans can be seen at www.milagrocohousing.org.

Neighborhood streets

Installation of water-harvesting, vegetation-growing traffic circles and other traffic-calming strategies can reduce impervious asphalt and calm traffic in residential neighborhoods. If it is located at the high point of a crowned road, a traffic circle should have a solid curb surrounding the sunken planting area to prevent direct rainfall from flowing out of the planting area. If a traffic circle is located in the low point of a sunken road, the curb around the traffic circle can be cut with periodic openings or constructed flush with surrounding asphalt to allow street runoff to flow into the circle's planting area. The same approach applies to road medians and pullouts.

CONCLUSIONS

Throughout urban, suburban, and rural watersheds we can strive to create multi-functional sponges that passively enhance and hydrate landscapes and improve our communities and lives. Using the water-harvesting principles, we can begin to harvest water at the top of watersheds, and continue down to the bottom. Every home, business, school ground, park, farm, and ranch is part of the larger community watershed. We can harvest water throughout, creating organic sponges in the landscape and planting primarily low-water-use native vegetation. These plants naturally survive in native soils under local rainfall conditions. They thrive when planted within or beside water-

harvesting structures that increase soil moisture in dry seasons and drought periods.

For streets that act as ephemeral waterways, build on this role by planting native vegetation found along natural ephemeral waterways along these urban waterways. Water-harvesting earthworks placed within public rights-of-way can create self-sustaining, flood-controlling, “greeninfrastructure” that doubles as neighborhood-enhancing, pedestrian and bicyclist-friendly, cool-island green belts.

Take the stewardship path to abundance, and begin by planting the rain.

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- Portland, Oregon Sustainable Stormwater Program featuring Natural Drainage Systems and more. www.portlandonline.com/bes/index.cfm?c=34598
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- The Keeling Neighborhood Greenway, Tucson, Arizona. www.drachmaninstitute.org (portfolio section)

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