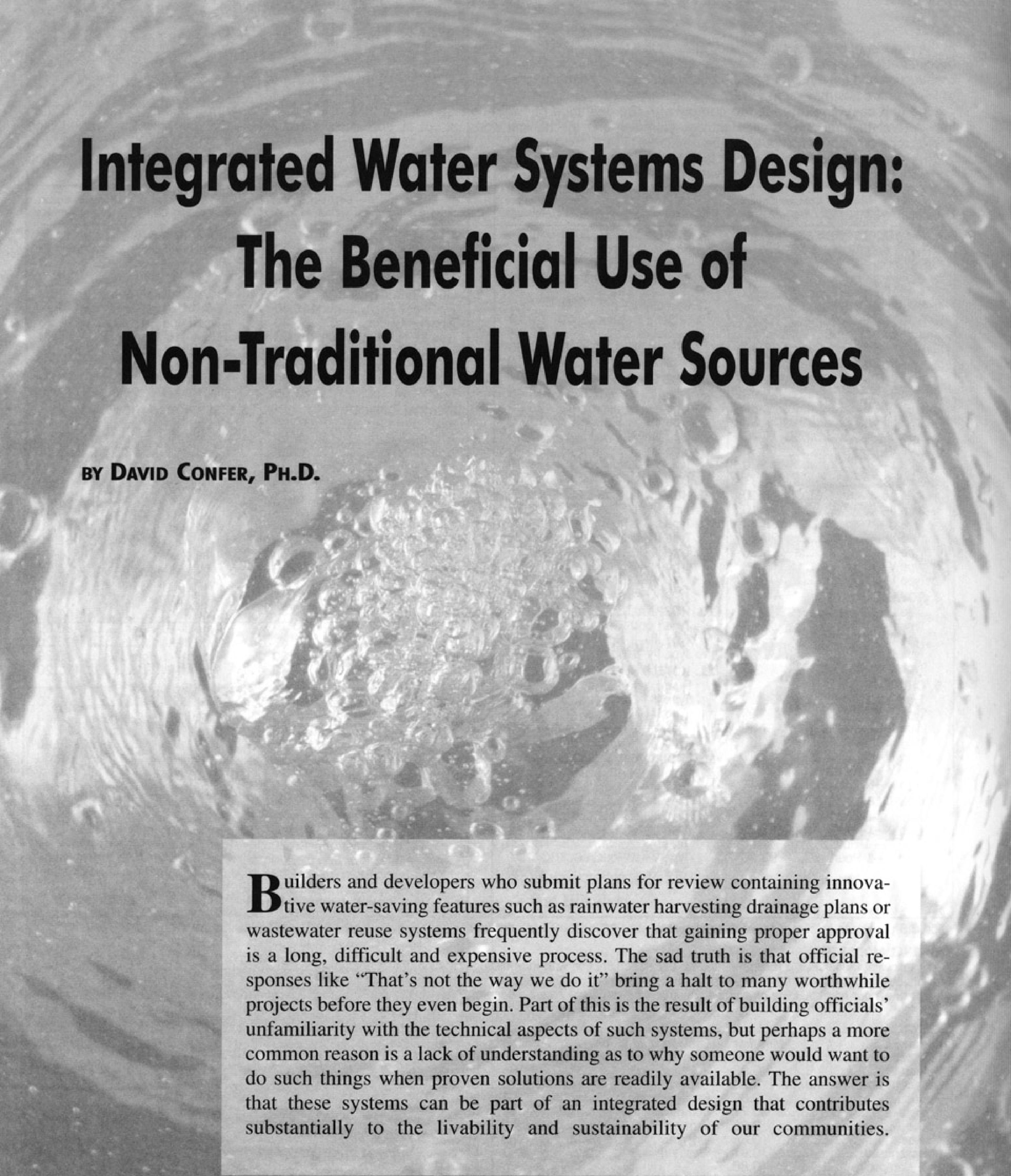


Integrated Water Systems Design: The Beneficial Use of Non-Traditional Water Sources

BY DAVID CONFER, PH.D.

Builders and developers who submit plans for review containing innovative water-saving features such as rainwater harvesting drainage plans or wastewater reuse systems frequently discover that gaining proper approval is a long, difficult and expensive process. The sad truth is that official responses like "That's not the way we do it" bring a halt to many worthwhile projects before they even begin. Part of this is the result of building officials' unfamiliarity with the technical aspects of such systems, but perhaps a more common reason is a lack of understanding as to why someone would want to do such things when proven solutions are readily available. The answer is that these systems can be part of an integrated design that contributes substantially to the livability and sustainability of our communities.

Building safety departments are charged with protecting the health and safety of the people who live, work in or visit a community's buildings and the areas that surround them. Like structural safety, building officials approach water safety with great care and thoroughness. For example, today's drainage procedures for roadways and residential and commercial developments are quite effective at disposing of stormwater and protecting structures. Many lives and countless millions of dollars have been saved thanks to improvements to earlier construction practices that did not properly assess or mitigate stormwater problems. Similarly, the municipal wastewater collection and centralized treatment facilities that have become the standard for managing wastewater over the past 100 years have greatly improved public health and aided in virtually eliminating water-borne diseases. The aquatic environment has also benefitted as secondary (biological) and tertiary (advanced) wastewater treatment have greatly decreased the negative impacts that discharged wastewater has on receiving waters. Modern stormwater and wastewater management methods come, however, with unintended consequences.

Inhabitants of arid regions have long known that water is often the limiting resource for development, yet the fact that stormwater and wastewater can be important resources and not just waste products is largely overlooked in the U.S. With periodic droughts stressing water supplies even in typically wet regions like the Pacific Northwest and the Northeast, people are becoming increasingly aware that we live in a water-short world. With households, industry, agriculture and wildlife competing for finite, limited supplies, providing sufficient water for new development remains one of the greatest challenges facing the majority of communities.

An Integrated Approach

In our culture, areas of study are typically divided into small pieces and we produce experts who know everything about their particular piece . . . except, usually, how it relates to the other small pieces that the other experts are studying. As an example, a typical development project might need to be reviewed by transportation, flood control, water service, wastewater management, landscape and environmental quality departments. Each of these departments has a direct effect on how a project manages its water resources, but because each has its own specific area of interest there are often conflicting concerns. In contrast, a plan-review system based on an integrated approach to water issues can address genuine health and safety concerns and transcend the parochial interests of individual departments to better serve the public interest. Such an approach requires that water issues be addressed from a broader perspective while paying special attention to the connections among individual elements.

Indoor Water Use

One part of an integrated approach to water systems design is to encourage conservation. This is accomplished in many regions through the adoption of plumbing codes requiring low-flow showers, faucets and toilets in new construction and remodeling projects. Programs that offer rebates or other incentives for the replacement of high water-use fixtures and appliances have also proven effective.

Public education is a critical component of any approach because water-saving fixtures need user input to serve their purpose. Even with a low-flow showerhead a 20-minute shower uses 50 gallons of water, and the installation of a whirlpool bathtub can easily counteract the savings from more water-efficient fixtures and appliances.

Landscape Water Use

Not all water needs to be potable; quality can be matched to specific uses. This is particularly applicable to landscape water, which can account for a significant portion of overall use (in Tucson, Arizona, for example—a rapidly growing metropolitan area of more than 800,000 residents—30 to 50 percent of the potable water supply is used outdoors).

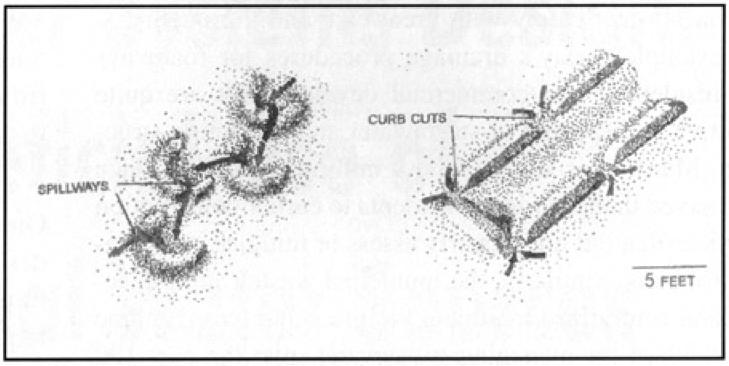
While municipal-scale systems designed to treat wastewater and deliver it for landscape use can help alleviate stress on potable water systems, the infrastructure costs are very high and it can take decades to retrofit existing areas and extend service to new developments. As such, these systems are typically only feasible for serving large, water-intensive turf areas like athletic fields or golf courses.

Rainwater Harvesting and Wastewater Reuse

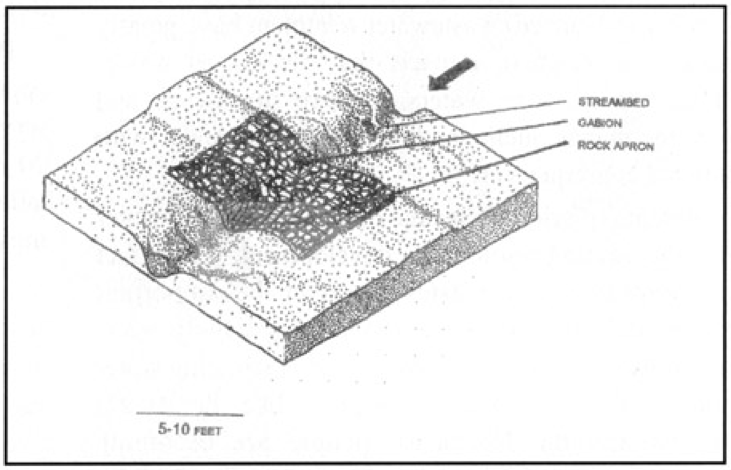
Rainwater harvesting and wastewater (usually greywater) reuse are, in contrast, appropriate for individual homes and neighborhood-scale developments at a reasonable cost and can provide significant and lasting benefits. Of the two, rainwater harvesting has the greatest potential bene-

Rainwater Harvesting Techniques

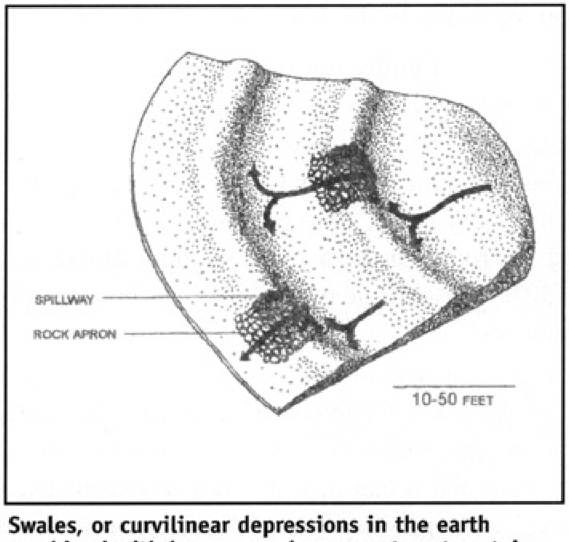
Storing water directly in soil for plant use is a low-cost, low-maintenance and highly effective method of rainwater harvesting, especially when used for watering plants that are native to a region and therefore adapted to regional rainfall patterns. The basic idea is to create a landform that intercepts runoff, slows it down and allows it to be absorbed into the soil in locations where plants are desired. Water-retaining structures need to be provided with overflow structures designed to safely direct stormwater downhill (preferably to another water-retention structure) during high-rainfall events.



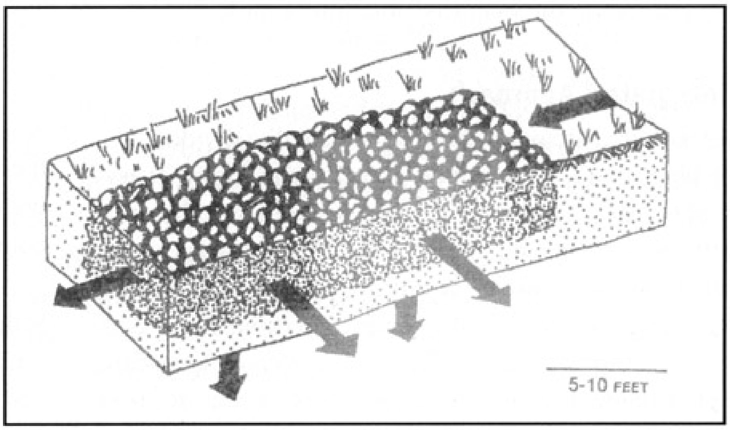
Microbasins are small basins used to retain low volumes of runoff. When used in parking lots, they can water trees that shade the pavement and cars.



Gabions are semipermiable rock barriers constructed in small (less than 25 cfs in a 100-year flood) drainages. They slow but do not stop the flow of water and help prevent erosion, trap sediment and organic matter, and allow water to infiltrate.



Swales, or curvilinear depressions in the earth combined with berms, can be on-contour to retain stormwater or off-contour to direct water downhill in a controlled manner.



French drains are rock-filled trenches that promote water infiltration deep into the soil. They work best for runoff that has a low sediment load.

(From the *City of Tucson Water Harvesting Guidance Manual*, edited and illustrated by Ann Audry Phillips.)

fit, since 50 to over 75 percent of the land in urban and suburban developments is hardscape: roofs, roads, parking lots, driveways and sidewalks. Even cities that have modest annual rainfall like Phoenix (9.5 inches) or Reno (12 inches) can collect the equivalent rainfall of Portland (36 inches) in landscaped areas if the water that falls on hardscape is directed to areas available for planting.

One of the greatest paradoxes in our water-short world is the sight of a landscape irrigated with potable water while an expensive stormwater drainage system designed to rapidly get rid of rainwater—the best quality water available for plants—lies inches away. Unfortunately, this is all too common. The typical engineering solution for stormwater management is to drain everything on a site to a detention basin at the lowest elevation on the property and design the detention basin to meter the outflow to reduce downgradient flooding potential. An alternative solution that recognizes the beneficial use of rainwater distributes site runoff into multiple smaller basins located throughout the site gradient that double as landscape areas. Each basin is provided with an overflow directed to the next lower basin, so the stormwater management function is fulfilled along with the additional benefit of making rainwater that soaks into the soil available to landscape plantings. This general pattern can be adapted for use in parking lots, residential and commercial sites, and roadways.

Greywater, domestic wastewater from bathtubs, showers, laundry and washbasins (not toilets or kitchen sinks), can also safely be used in landscapes so long as household occupants are careful of what goes down the drain. High-sodium detergents, for example, can harm soil structure, and common household chemicals like boron and chlorine are plant toxins. It is also advisable to rotate areas irrigated with greywater to allow the soil to dry between waterings and to direct rainwater to areas being watered with greywater in order to flush away salts present in detergents from plant root zones.

With a daily 40 gallon domestic production of greywater per capita, adding up to almost 60,000 gallons a year for a family of four, it is clear that greywater could serve as a significant source of landscape irrigation. It must be noted, however, that double-wastewater plumbing is required, making these systems much less expensive to install in new construction than to retrofit. While many local codes may severely restrict or even prohibit greywater use, regulatory agencies are becoming increasingly open to the idea. Nonetheless, from a public policy viewpoint the option should be reserved for those dedicated to providing the high and continuous user commitment necessary for safe reuse.

Milagro

Milagro is a 28-home cohousing development currently under construction in Tucson, Arizona. Recipient of the Arizona Planning Association's "Best Project of 2001" award, the development was designed using an integrated water-systems approach that compliments other progressive environmental and community design features.

The adobe homes are oriented for passive solar heating and the landscape is designed to allow solar access during winter months as well as to shade the walls and provide cooling evapotranspiration during the summer. Rain is harvested in 30 small (18-inch deep) landscaped detention basins located between concrete pathways in the community common area. The parking area, which is separate from the pedestrian-oriented residential area, and access drive have permeable confined gravel surfaces and are contoured to retain rainwater for infiltration.

The landscape detention basins and water-retaining roadways fulfill the project's drainage requirements without the necessity of conventional detention basins, thereby preserving more of the site's natural environment. Gabions in several small drainageways help retain site runoff and enhance the existing natural vegetation. Areas of the site that were disturbed for utility installation have been restored with water-retaining swales and microbasins and replanted with native seed mix. After initial establishment, these areas will not require water in excess of natural rainfall. The development will treat all wastewater on site using a subsurface flow wetlands. The treated effluent will be used to water the common area landscape and a small citrus orchard.

For more information on Milagro, visit *www.milagrocohousing.org/*. ◆

Other Concerns

Finally, an integrated water-systems design must consider the particular characteristics of the landscape and try to maximize its benefits accordingly. In most locations, this means using water to support sustainable landscapes that make extensive use of native species and are reflective of their bioregion. Native species, having evolved within their climate to be able to survive dry periods and be exuberant in wet seasons, also help support local birds, insects and other wildlife in a balanced system. Non-native species should only be planted when they serve a specific function beneficial for people, such as providing food. Designers and plan reviewers need to be mindful of the importance of designing water conservation into landscape practices and development standards because a project's landscape determines its water use for decades to come.

Urban and suburban landscapes should be designed to function as valuable community assets. For example, the "Cool Communities" program sponsored by the U.S. Department of Energy and U.S. Environmental Protection Agency promotes planting trees and encourages the use of reflective paving and roofing materials to mitigate urban heat-island effects. Studies at Village Homes, a residential development in Davis, California that harvests rainwater to help support a landscape which includes a dense tree canopy, show that ambient summer temperatures in this development are up to 10°F cooler than conventionally landscaped adjacent developments. Using cooling vegetation watered with rainfall is a win-win solution that can significantly reduce energy demand, particularly during expensive peak summer energy loads experienced by electricity generating systems, and tree selection at Village Home favors fruit-producing species, thereby providing an additional benefit to residents.

Changing Attitudes, Changing Patterns

Changing development patterns and the assumptions that accompany them is a challenging task. There is a great deal of inertia in both the development community and in the government agencies charged with regulating it, but there is cause for hope. One community stepping up to this challenge is the City of Tucson in Pima County, Arizona.

Prompted by committed grassroots activists in the environmental, alternative building and water resources communities, the Tucson City Council passed a resolution to promote rainwater harvesting for landscape watering. Although well intended, the local development community's lack of experience with water harvesting techniques produced only modest results, but benefits are expected to accelerate with the recent publication of the *City of Tucson Water Harvesting Guidance Manual*, which provides information to help both designers and plan reviewers understand water harvesting principles. In addition, the Pima County Department of Environmental Quality relaxed the regulations for permitting greywater reuse systems in 2001. The required involvement of a registered engineer, an expensive stipulation for systems that might save only $10 per month on summer water bills, was dropped in favor of user-friendly guidelines addressing pertinent health and safety concerns.

Important changes like these can take time, but Tucson's example proves that commitment and diligence pay off. I consider it a challenge to all segments of the development and regulatory communities to demonstrate their concern for the future by working to improve the livability and sustainability of our communities, and one of the most important ways of doing so is to support and promote the principles of integrated water-systems design. Building officials should seek to partner with progressive builders and developers to find ways to make these systems work in their communities. Come on in—the water's fine. ◆

Additional Resources

City of Tucson Water Harvesting Guidance Manual. 2002. Ann Audry Phillips, ed. Available from City of Tucson, Department of Transportation, Stormwater Section, P.O. Box 27210, Tucson AZ 85726. *www.ci.tucson.az.us/planning/*.

Create an Oasis with Greywater, Your Complete Guide to Choosing, Building and Using Greywater Systems, fourth edition. 2000. Art Ludwig. Published by Oasis Design. *http://oasisdesign.net*.

Domestic Greywater: a Review of Alternatives for its Use and Treatment. 1992. Martin Karpiscak, Glenn W. France and Kenneth E. Foster. Office of Arid Land Studies, University of Arizona College of Agriculture, Tucson AZ 86719.

Harvesting Rainwater for Landscape Use. 1998. Patricia Waterfall. Available from Arizona Department of Water Resources, Tucson Active Management Area, 400 West Congress, Suite 518, Tucson AZ 85701.

Permaculture: a Designer's Manual. 1988. Bill Mollison. Published by Tagari Press, Tyalgum, Australia.

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