AWSA - TIER I APPLICATION

submitted July 14, 2011

by

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Stream Dynamics, Inc.

Executive Summary

This is a three part proposal. This proposal may be broken into three separate proposals and submitted as such during the Tier II evaluation, but for now let it stand. The parts are 1) Water Harvesting, 2) Watershed Restoration, and 3) Road Drainage. These three techniques are intimately related because they share a guiding philosophy which is about paying close attention to the sources of runoff and their proximity to demands. It is also about creating regenerative resources. A regenerative resource is one that improves itself over time with very little human inputs of time, money, or energy.

Although Stream Dynamics, Inc. is the applicant, the purpose of this proposal is merely to put forth what we feel is the best solution to the AWSA, one that will provide the greatest water resources and the greatest benefits to the residents of the four county area. These ideas can be implemented by any qualified individuals, firms, or agencies.

1. State whether the proposal is for the "New Mexico Unit," a "water utilization alternative," or both.

This three part proposal is for a water utilization alternative.

2. Describe how the proposal will meet a "water supply demand" in the Southwest New Mexico Water Planning Region, comprised of Catron, Grant, Hidalgo and Luna Counties.

Water Supply Demand Summary

This three part proposal will meet a water supply demand through water harvesting, watershed restoration, and road drainage. A combination of these three techniques will create the most equitably distributed and largest overall benefit for the people of our four county region from our water resources and the funds that have been appropriated to properly utilize them.

The next largest demand for water in this region after agriculture and mining is water for commercial and residential use. Currently, the supply is mostly met through groundwater pumped from municipal and private wells. Harvesting rainwater and greywater on a large scale would dramatically increase the effective supply of water available while decreasing the depletion of precious groundwater resources. Watershed restoration increases the ability of soils to absorb and retain moisture and release it slowly over time, decreasing accelerated runoff and erosion, keeping the supply closer to the demand rather than sending it downstream. The same concept can be used to properly drain roads so that erosion is minimized and water is retained longer on the landscape.

Each of the three parts is addressed separately below:

2 A Water Supply Demand through Water Harvesting

Water Harvesting Defined

Imagine if you poured a five gallon bucket of water out in the middle of a dirt parking lot on a hot spring day. It would spread out 10 feet wide and wet the earth ½ inch deep. By the next day, all the water would be lost to evaporation. The whole game changes if you dump the same five gallon bucket of water into a ten gallon hole. Most of the water would then soak deeply into the subsoil where it would be available for tree roots to utilize during the entire dry season. This is the basis of water harvesting.

People need food, and food production requires water. Water harvesting employs a suite of techniques that direct concentrated runoff from anthropogenic surfaces (such as the roof of your house), towards shallow permeable basins where it will soak into the ground. Water harvesting also includes roof catchment cisterns (where allowed), and greywater recycling (which is legal in New Mexico). Note that a cistern is not required to do water harvesting: a simple water harvesting earth basin stores water in the soil where it can be used to deeply irrigate vegetable gardens, and the roots of trees – fruit trees, shade trees, windbreaks, etc. Below are a few basic calculations to demonstrate that this can create a significant supply, located adjacent to important points of demand, such as your house.

Water Harvesting Supply

The four county area has a population of 65,493 (2000 census). Divide this by approximately 3.5 people per house, multiply by 1700 square feet roof area per house, multiply by 1.2 feet of rain annually, and finally divide by 43,560 cubic feet per acre foot to arrive at over 800 acre feet of water that falls on the roofs of our homes in the four county area. A calculation of the roof area of all commercial and municipal buildings would significantly add to this.

The average house in the four county area has approximately 1700 square feet of roof; this times 1.2 feet of rain annually, times 90% runoff coefficient, times 7.48 gallons per cubic foot equals: over 13,000 gallons of water that goes down the downspouts of an average house annually. For many homes, this water goes past the landscaping (which must therefore be watered with the hose), down the driveway, down the street, and then into the nearest arroyo, contributing to traffic safety hazards, and erosion, as well as flooding problems for downstream landowners.

Water harvesting turns this nuisance runoff directly into a water supply - potentially for every home in the four county area! This water could grow a vegetable garden or fruit trees instead of creating a public liability for the municipal and county streets departments. The annual water needs of a mulched vegetable garden planted in a sunken bed (ideal for water harvesting roof runoff) is 64 gallons per square foot of vegetable garden per year (This figure is for Tucson, Arizona). This equates to over 200 square feet of vegetable garden for the average home that will be watered for free, without depleting our precious groundwater resources, and without using electricity to pump it. Alternatively, the rainwater could be used to grow shade trees in strategic locations around the house to provide shade in the summer, which would reduce summer temperatures around the building, reducing the need to run the evaporative cooler, thus reducing the demand on our municipal and local water systems, and also reducing the need for electricity, which uses even more water in its generation.

Commercial and municipal establishments could use the water from their roofs and parking areas to irrigate shade trees and windbreaks, while eliminating their contribution to nuisance storm water runoff.

Water Harvesting Project Examples
Water Harvesting includes cistern installation, curb cuts and/or earth basins. Greywater Recycling could be for an entire house minus blackwater appliances: (toilet, kitchen sink, dishwasher), or merely a "Laundry to Landscape" installation.

Cisterns
Water Supply and Demand illustrated: In the photo below, the hose is used to water the garden (demand) using the rainwater collected from the roof and stored in the cistern (supply). This supply of water is located adjacent to the point of demand, and requires no electricity to access, making it more reliable than any other water supply during emergencies such as fire or electricity outage (which often happen at the same time).

Curb Cuts
Curb cuts, where appropriate, allow water from the street gutter to flow into a small basin on the back side of the curb within the public right of way. The rim of the basin is designed to be at a higher elevation than the curb itself, so that it will not overflow except back to the street. The basin is lined with rock, and mulched. This works well for existing as well as newly planted trees.

A tidy example of a bore hole curb cut with tree basin is seen in the photo below. This is on the small side, perhaps 100 gallon capacity. Depending on the runoff duration and intensity and the soil percolation rate, this feature could harvest much more water during a storm. A larger curb cut and basin system could harvest 600 gallons per storm or even more.

Urban stormwater runoff (supply) is used to irrigate a tree (demand). The tree provides shade, food, windbreak, visual screening, and beauty. All these benefits are free with rain that falls from the sky.

Bore hole curb cut, Tucson, Arizona:

Curb cut with diversion gutter: A supply of water from Swan Street in Silver City meets the demands of grass and wildflowers along the public right of way. In the photo below, the basin is hidden by lush vegetation.

Water Harvesting Basins

A variety of these can be constructed to receive roof runoff (as well as street runoff), and cause the water to soak deeply into the ground where tree roots can utilize the moisture during the entire dry season. Gardens can benefit from the huge increase in soil moisture during monsoon. This will also keep the runoff from going into the street, where during large rainstorms, it often causes a safety hazard.

In the example below, water was previously going down the driveway, down the street, and out of town in the Big Ditch. Simple earthworks have turned this into a water resource for the property. The supply is coming from roof runoff, and the demand is the vegetable garden that will be planted here in the spring. Cost and detention volume for this practice is similar to curb cuts.

Earth basin, Cheyenne Street, Silver City.

In the picture below, a concrete basin fills with roof runoff from the downspout. This creates a supply of water for the demands of wildlife habitat in the desert just outside a friend's window in Rodeo, NM.

Greywater Supply
The available supply of greywater is located very close to the point of demand for many houses. Typical household water use, in gallons per week (gpw), for two adults and two kids, is calculated in the table below. (from Create an Oasis with Greywater, by Art Ludwig):

Washer	5 loads/week x 32 gal/load	= 160 gpw
Shower	1 shower/day/person x 8 min x 2 gpm x 4 people x 7 days	= 448 gpw
Bathroom Sink	2 gal/day/person x 4 people x 7 days	= 56 gpw
Tub	2 baths/wk x 30 gal	= 60 gpw
	Greywater Total	= 724 gpw
	Times 52 weeks/year	x 52
		37,648 gal/year

According to New Mexico law, kitchen sink water and toilet water are considered blackwater which must still go to the sewage treatment plant

Toilet	3 flushes/day/person x 1.6 gal/flush x 4 people x 7 days	= 126 gpw
Kitchen Sink	3 gal/day/person x 4 people x 7 days	= 84 gpw
	Black Water Total	= 210 gpw
	Times 52 weeks/year	x 52
		10,920 gal/year

In this example, 78% of indoor use water is recycled for the landscaping, and previous outdoor water use is drastically cut. This extends the supply for the whole community.

This is 37,000 gallons per house per year that does not have to be treated by the sewage treatment plant, resulting in a cost savings for municipalities, mostly labor and electricity. Since the greywater recycled does double duty by irrigating the landscaping and garden, this also represents 37,000 gallons of water saved at the well. This will save electricity and protect the groundwater resource from depletion. Note that water is used for electrical energy generation, so by saving electricity, we are also saving more water!

Laundry to Landscape
The photo below shows installation of new plumbing to route greywater from the washing machine to the landscaping.

The newly created supply of greywater goes to a mulched basin next to a fruit tree in the yard (demand) instead of the sewer system. This simple and legal plumbing project turns wastewater into a water supply at the point of demand. Ten thousand households in the four county area could have this very simple system installed using funds from AWSA. This would permanently reduce the need for developing additional water infrastructure.

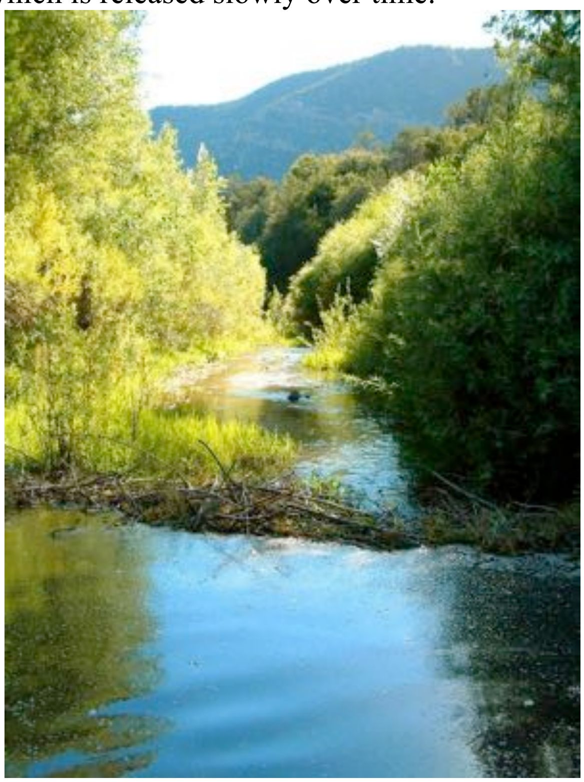
Greywater Law
Greywater recycling has been fully legal in New Mexico since 2003. Details of this can be found at http://www.oasisdesign.net/greywater/law/#newmexico. This is a well considered law, which requires the installation of a convenient Y valve that can direct laundry water to the sewer when required, such as when washing greasy coveralls from an auto repair, or washing diapers.

As an example of how a large municipality in our region is dealing with its water resource issues, the City of Tucson has a recently adopted water harvesting ordinance that requires greywater stub outs on all new construction, as well as water harvesting basins to infiltrate any new runoff caused by new construction. The text of the ordinance is in the appendix of this application. It was obtained from *www.tucsonaz.gov/water/docs/rainwaterord.pdf*

2 B Water Supply Demand through Watershed Restoration

Watershed restoration greatly benefits the water supply through flow modulation. Healthy watersheds have a much less flashy flood hydrograph, with a more gradual slope during the rising limb, a lower flood peak, and a greatly extended declining limb. This reduces the magnitude of destructive floods that blow out bridges and diversion structures, erode streambanks, and deposit coarse grained sediment on roadways, stream terraces, and other growing surfaces. It also affords downstream water users a much longer interval in which to use the water flowing past their diversions, thus improving the consistency of the water supply.

The photo below illustrates how miles of healthy stream banks improve the quality of the water. Shaded, tree lined stream banks reduce the water temperature, while stable banks narrow the channel, promoting overbank flooding at a lower stage. This increases percolation, storing water higher in the watershed, which is released slowly over time.



The rock lined pool grade control structure in the photo below was built to heal a gully in a high mountain meadow. This raised the water table and substantially increased the amount of water that is stored in the local alluvium.

2 C   Water Supply Demand through Road Drainage

Improperly drained roads contribute directly to flash flooding, sending New Mexico rainwater from the Gila and San Francisco basins to Arizona in a sudden erosive rush, while exacerbating the deterioration of our beleaguered watercourses. This situation does not benefit our neighbors in Arizona, because it causes flooding and sediment problems for them. There are innumerable gullies caused by culverts set too low, that could be cost effectively repaired with drop inlets, rock rundowns, and other best management practices that would result in greatly increased alluvial storage in the upper watershed. Many roads in the national forest have roadside ditches that go for 1,300 feet before being cross drained. This is longer than the average length of a first order tributary in New Mexico, and adds a huge dendritic network of thousands of miles of ditches to our natural watercourses. This has the effect of draining the water from our landscape, precluding it from being put to beneficial use!

Cross draining all the dirt roads in a small watershed at more frequent intervals to appropriate places in the landscape with rolling dips and other best management practices has been demonstrated to significantly reduce the flood flashiness of the watershed. A cumulative effect is achieved when all the sub-watersheds contributing to a stream are similarly treated. This directly benefits the water supply for downstream users by modulating the flood hydrograph and reducing flood peaks. Proper drainage of roads can incorporate water harvesting earth basins on the margins of road rights of way.

There are at least 4500 miles of roads in the Gila National Forest. A mile of road 8 feet wide takes up an acre of land. If the average road width is 16 feet, there are therefore at least 9000 acres of roads in the national forest; this times 1.5 feet of precipitation per year, times a 55% runoff coefficient **equals approximately 7,400 acre feet of water that runs off our National Forest roads. Much of this goes quickly into our watercourses, causing damage to both streams and roadways!** At present, our road infrastructure is wasting a huge amount of water.

In addition to the accelerated runoff caused by the surface of these roads, most roads cross ephemeral watercourses. Many of these crossings are causing resource damage to the watercourses and accelerating stormwater runoff.

The Grant County Road Department maintains 583 miles of dirt road (average width 20 ft) and 106 miles of paved (average width 22 ft). A quick calculation reveals that approximately 2600 acre feet of rain falls on these county maintained roads. The total miles of all city and county maintained roads as well as all state and federal roads in the four county area is in the thousands. There are many more miles of privately maintained roads and driveways. It is easy to see that at present, in the four county area, we are probably wasting 20,000 acre feet of water that falls on existing infrastructure, causing flood damage to some of that infrastructure, while degrading our stream channel network. Doesn't it make sense to address these basic repairs to our road drainage system before we attempt expensive and heroic engineering feats at the downstream end of our degraded, flood prone rivers?

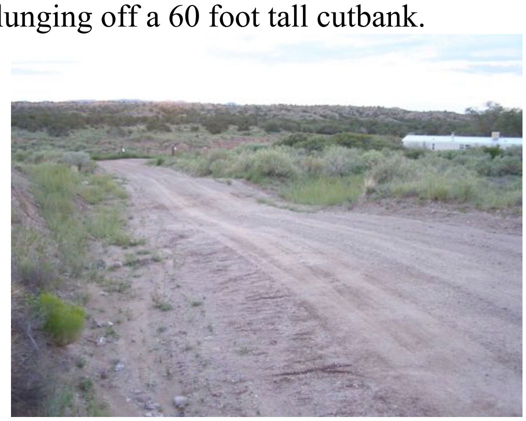
This photo shows a monsoonal thundershower in Bayard, NM on August 1, 2010. Proper water harvesting road drainage would protect public safety, while turning nuisance runoff to a beneficial resource - a water supply for gardens, trees, and green spaces that were previously watered with expensive city well water.

Water harvesting Road Drainage in action: This basin on Virginia street is rapidly infiltrating storm water diverted from a 75 acre urban sub-watershed during a monsoonal thundershower. The basin is infiltrating so rapidly that it takes a very long time to fill. It provides both surface and subsurface irrigation for the Silva Creek Botanical Gardens in Silver City.

This water harvesting basin is connected to a brand new rolling dip road drain in Rodeo, NM. In the photo below, it has redirected stormwater runoff from going erosively down the road. This water now has a chance to soak deeply into the ground in the desert instead. Note: this photo shows the results from the first runoff event after the feature was constructed. Recent tractor marks are still visible in the background. In the foreground is brush that was placed along the rim of the basin to prevent erosion and create mulch for rapid colonization of vegetation. Although some disturbance was done to create this water harvesting feature, I call this a "Zero footprint" technique. Material removed to excavate the basin is applied to the road bed, an area that is already devoid of vegetation. Vegetation is killed during excavation ot the basin, but this will be replaced within a few short years with the lushest vegetation around.

Water harvesting road drain, Magdalena, NM. In the photo below, notice a long, smooth hump that has been built across the road. This is easily negotiated by a semi, a pickup with a horse trailer, or a passenger car. It is only tall enough to redirect the water to a basin on the right. Note the response part way into the first monsoon season. This road drainage structure corrected a horrendous erosion problem where water was plunging off a 60 foot tall cutbank.

Jan 15, 2010



August 2, 2010

3. Describe how the proposal considers the Gila environment and describe how any negative impacts might be mitigated.

This proposal is specifically formulated to derive maximum water resource benefit for residents of the four county area without causing any harm whatsoever to the environment of the greater Gila area. Instead, the implementation of this proposal will have many positive impacts on the Gila environment. These are illustrated below.

3 A Gila Environment Benefits from Water Harvesting

Water Harvesting Benefits
"The best solution to the urban runoff problem is to detain this stormwater in small volumes as near to its source as possible, and then to release it slowly to natural stream channels or to the groundwater system," Dunne and Leopold, Water and Environmental Planning. Water harvesting from impervious roads and rooftops reduces storm water runoff and downstream erosion and sedimentation problems.

Water harvesting is preferable to groundwater pumping, which depletes aquifers and dries up and degrades streams, rivers and riparian habitats. By reducing the need for pumping, we are reducing electricity consumption, with its concommitant air pollution and groundwater depletion. Greywater harvesting reduces the amount of water that must be treated at the wastewater treatment plant, a huge electrical energy consumer. The air pollution from distant energy generation stations may already be affecting air quality in the Gila, so we must do our small part to minimize this, and to set a good example.

Precipitation is naturally distilled through evaporation prior to cloud formation and thus is one of our purest sources of water. Rain is considered *soft* due to the lack of carbonate or magnesium in solution, and is excellent for cooking, washing, and growing plants.
With modern water harvesting technology, rainwater stored in cisterns can easily be filtered to meet the highest water quality standards for drinking and cooking. We can save on water treatment systems, which consume electricity (and therefore use water and create air pollution).

Rainwater is a natural fertilizer and has the lowest salt content of all natural fresh water sources, so it is a superior water source for plants. By irrigating our gardens and fruit trees with rainwater we will be reducing the need for imported fertilizers, which can leach undesirable chemicals into the groundwater (and also have environmental transportation costs, such as smog).

Rainwater comes to each of us free of charge. It is the most democratic of all water sources, falling on rich and poor alike. This proposal will use the funding provided by the settlement act to provide water harvesting infrastructure for thousands of area residents. This improves the human environment, an important part of the equation.

3 B Gila Environment Benefits from Watershed Restoration

Watershed Restoration Benefits:
Properly done, watershed restoration is not only environmentally acceptable, it is urgently needed – just ask any resident with erosion problems! Statewide, the New Mexico Wilderness

Alliance, and the New Mexico Wildlife Federation support watershed restoration, as do many other groups. Private nonprofits as diverse as the Center for Biological Diversity, The Nature Conservancy and the Malpai Borderlands Group agree that watershed restoration is of paramount importance. The opinion of these nonprofit groups is shared with the New Mexico Environment Department and the U.S. Environmental Protection Agency.

The benefits from watershed restoration include: flood control, extended base flow for ephemeral streams, improved groundwater recharge, higher water quality, less turbidity and a lower sediment load, reduced flooding, lower summer water temperatures, better fishing and more productive wildlife habitat. In general, our watercourses will be more beautiful.

Perhaps the most important benefit realized from modern stream restoration is that it optimizes the economy and utility of the water in our natural stream networks by storing it in the alluvium during high runoff events where it is safe from tampering and evaporation, and then slowly releasing it, allowing it to be used over and over again as it is cleanly cycled to many downstream users, allowing gravity to move it where it needs to go, along ancient pathways, for free.

One of the most difficult challenges for those who understand natural stream processes is explaining them to those who do not. "People like to see the exposed water surface of a reservoir and think it is creating a supply of water, but in New Mexico, the evaporative loss from reservoirs is three times as much as the water put to beneficial use. Unfortunately, reservoirs in the desert southwest function more like evaporation ponds. Hydrologists have calculated that open reservoirs in hot arid regions exposed to wind and sun can have evaporative losses of six to ten feet per year" (from *Let the Water Do the Work: Induced Meandering, an Evolving Method for Restoring Incised Channels*, by Bill Zeedyk and Van Clothier, 2009, available from amazon.com)

3 C Gila Environment Benefits from Road Drainage

Road Drainage Benefits

Proper drainage of roads utilizes both a mulched basin and a vegetated buffer strip that causes road runoff to soak into the ground, thus preventing the road from being hydraulically connected to a watercourse. Any sediment coming off the road is trapped in the vegetation, transforming a major problem for water quality into a soil building resource.

Traditional road drainage systems trap water in roadside ditches for many hundreds of feet, then shunt it into the nearest gully, accelerating runoff and erosion in one place, while dessicating the lands that used to receive their fair share of this moisture. Water harvesting road drains are situated where they can redirect surface flows back to the original swales in the landscape, thus buttoning the watershed back together. A few runoff seasons after a water harvesting road drain is constructed, its basin is the most lush spot in the vicinity owing to the extra measure of water it receives. Other benefits include: lower road maintenance costs, safer roads during inclement weather, and all of the watershed restoration benefits listed above.

4. Describe how the proposal considers the historic uses of and future demands for water in the Southwest New Mexico Water Planning Region and the traditions, cultures and customs affecting those uses.

Historic Uses
Historically, the Gila River flowed from the mountains in New Mexico, all the way across Arizona and into the Colorado River, which flowed to the Gulf of Mexico. Water supply and demand were balanced naturally. Water manipulation through dams and large-scale irrigation diversion created a false impression of increased supply, resulting in an unsustainable demand over the long term, e.g., water hungry alfalfa grown with diverted river water. The balance has been tipped to the degree that the river now goes dry more frequently and rarely, if ever, completes its flow to the Gulf.

A thriving agricultural economy existed for a very short time frame in the historical sense, but the traditions, cultures and customs established during that 200-year timeframe have become sacred to some, to be preserved at all costs. Agriculture for profit in the Southwest is now struggling to survive, and is decreasingly cost-effective as the cost to run such operations increases and the production profit decreases. The demand for water has surpassed the supply, and contradictory uses vie for control.

Implementation of this proposal on any scale would move us toward a more natural balance of water supply and demand.

Future Demands
To meet future demands, we must do something intelligent to extend our limited supply. In the domestic greywater recycling example above, 78% of indoor water use, or 37,646 gallons a year, was recycled as greywater to the garden and landscaping trees, drastically cutting the need for outside irrigation. In the rainwater harvesting example 13,000 gallons of water from the roof of the average home can be put to beneficial use by the residents (i.e. meet a "water supply demand"). These two items add up to a water savings of approximately 50,000 gallons per year per average household. Multiply this by an estimated 18,700 households in the four county area and you get 935,000,000 gallons, or 2,800 acre feet of water savings. This is water that we don't have to pump out of the ground. It can be stored there to meet future demands. (This is not including water harvesting from roads using curb cuts, which can add thousands of gallons more to irrigate street trees within the public right of way. In concert, these practices add up to a significant decrease in the strain on existing water infrastructure and resources. If population growth is in our future, we will have a fine example of how this growth can be done with the least strain on our water resources.

Traditions, Cultures, and Customs

The Desert Southwest has a long tradition of water harvesting. Before the advent of modern irrigation technology, peoples of the American Southwest relied on water harvesting techniques for drinking water and to grow their food. Check dams were built for many hundreds of years across small ephemeral drainages to catch soil and water and to provide irrigation for crops. Terraces and linear borders were built along contour lines to catch soil, nutrients and water. Sunken beds were built to catch and infiltrate water and grow valuable crops. Plantings were often situated advantageously at the base of cliffs and rock outcrops where water would run off and become concentrated. Brush weirs were used to spread water across floodplains.
(from August 1994 article in Permaculture Drylands Journal by Joel Glansburg)

Many old homesteads in New Mexico had kitchen gardens that were irrigated in part by greywater. Rain barrels and cisterns were an important water source back in the day. The traditional self-sustaining hacienda was, out of necessity, a study in wise use of resources. It's exciting to see these important traditions being revived with the recent popularity in water harvesting. Growing your own garden and fruit trees with harvested rainwater in an urban or rural setting can again become the norm.

Appendices

1) Enclosure 1 Bioswale Treatment of Parking Lot Runoff
2) Enclosure 2 Urban Stormwater Management
3) Enclosure 3 Tucson Rainwater Ordinance

4) Other references

A) A Prototype Analysis for Determining the Stormwater Retention and Water Supply Benefits of Cisterns, by Evan Canfield and Lisa Shipek:
http://www.watershedmg.org/sites/default/files/publications/canfielde_paper.pdf

B) see attached "nrc_stormwaterreport.pdf" - a publication by National Research Council, 2008 focused on urban stormwater management. Suggest a coupling of flow proxies like impervious cover to better evaluate potential pollution loading issues

C) City of Tucson and Pima County Water Study and recommendations - focus on lot-scale water harvesting practices for most efficient use of rainwater and to benefit infrastructure:
http://www.tucsonpimawaterstudy.com/

D) Conference proceedings and good places to look for examples and related contacts for more info:
http://www.aridlid.org/

E) EPA resource links:
http://cfpub.epa.gov/npdes/docs.cfm?program_id=6&view=allprog&sort=name --> related presentation listed on page: http://www.epa.gov/npdes/pubs/ginm13.pdf

F) Fabulous article Silver City water harvesting projects in the July edition of Desert Exposure:
http://www.desertexposure.com/201107/201107_van_clothier_water.php