Before It All Goes Down the Drain:

Case Studies of Rain Harvesting Use & Dry Weather Runoff Reuse in Santa Monica, CA

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Abstract. In a time of severe water shortages in many parts of the country, the City of Santa Monica has emerged as a leader in watershed management with numerous public and private projects that demonstrate the benefits of harvesting rain and dry weather runoff. This paper will examine local residential, multi-family, governmental and institutional sites that are using rain-harvesting techniques such as cisterns, rain barrels, and infiltration pits. Then we will examine how harvested water is distributed through the landscape with drip irrigation systems. Next we will look at how dry weather runoff is collected from streets, treated and used in overhead irrigation. We will reflect upon past successes and failures, look toward to the future of water, and explore how we can harness this precious resource now… before it all goes down the drain… carrying with it not only contaminants that pollute the ocean, but the opportunity to use a local valuable resource.

Keywords. Rain Harvest, Cistern, Rain Barrel, Dry Weather Runoff, Infiltration, Stormwater

Since 1991 the City of Santa Monica, CA has been creating and enforcing requirements for the design, construction, and long-term management of new and redevelopments in order to reduce urban runoff water and the pollution it contains. Urban runoff includes wet and dry weather flows on one's property or public right-of-way. The runoff occurs when water, originating from rainfall, washing activities or over-irrigation, runs into the surrounding aquatic environment. Pollutants such as heavy metals, nutrients, bacteria, organic compounds and trash, in automotive fluids, restaurant equipment, pesticides, lawn care products, debris, construction materials, pet wastes, and paint-related products are washed into our storm drain system and into the Santa Monica Bay on a daily basis, rain or shine. Urban runoff flows

untreated from buildings, yards, sidewalks, roads, and parking areas into the greater watershed of our region – and all pipes, gutters and storm drains of our city end up in the Santa Monica Bay. Urban runoff is now the single greatest source of pollution to the beaches and near shore waters of the Bay.

One important way to address this problem is by managing the design, construction and long-term operations and maintenance of developments in such a way as to minimize urban runoff from the site. We do this by treating rainwater, stormwater and dry weather runoff as resources rather than a waste product needing to be quickly ushered offsite.

The design, construction and the long-term operations and maintenance of a development come together with the submittal and implementation of the Urban Runoff Mitigation Plan or Drainage Plan, an integral component of any permitted building project. A plan is required for any project that meets the definition of "new/re-development" as outlined in our City's Urban Runoff Pollution Control Ordinance. The Drainage Plan you submit acts as your road map to ensure that the projected urban runoff from your proposed project (property/parcel) is reduced through installation of permanent structural (e.g. post-construction) Best Management Practices (BMPs). BMPs promote the natural movement of water within an ecosystem or watershed, keeping precipitation onsite as much as possible, providing for permeability such that soil can absorb water falling onto the site, or it can be stored in cisterns for direct non-potable applications. The ordinance requires that new/re-developed parcels reduce the projected rainfall on all impermeable surfaces of the parcel up to a 0.75" storm event. Each development project is considered a micro-watershed within the greater watershed or drainage basin of the City. BMPs promote the concept of retaining as much rainfall on each site in order to minimize runoff.

Permanent BMPs harvest precipitation for non-potable uses – passive, indirect infiltration and direct indoor and outdoor authorized uses, such as irrigation and flushing. Residential units in Santa Monica are incorporating Low Impact Development (LID) strategies with BMPs to harvest rain either for treatment via infiltration (soil ecology does a wonderful job in neutralizing low-level or background concentrations of pollutants) or for use in landscape irrigation and indoor flushing after appropriate treatment. An inexpensive approach is to harvest precipitation in a rigid or collapsible container, like a rain barrel or series of interconnected barrels. Each barrel generally holds 50-75 gallons. A step up from a rain barrel is a small cistern that holds 200 gallons. Larger storage systems called cisterns come in different

sizes and shapes. Cistern capacity is generally over 500 gallons. Some cisterns have thousands of gallons of storage space.

One example is a residential family home with two cistern tanks in the front and rear of the house connected to a sub-surface drip irrigation system. Each cistern is capable of holding up to 500 gallons of rainwater. Harvested water can be used for sub-surface irrigation. Homes with rain gutters directed to landscaped areas, or homes with no gutters at all, are required to mitigate volume onsite. The landscape is the solution and must have the proper storage volume above or below the surface to mitigate the required runoff volume.

Another example is a multi-family building cistern project built in 2008. It demonstrates the city's highest sustainable end use urban runoff strategy: direct use. By directly using runoff, one can reduce the demand for more valuable potable water, most of which is imported into Southern California from distant watersheds. Runoff from the roof is collected and piped through three downspout BMPs before entering the 5,000 gallon plastic box cistern wrapped with an impermeable layer, which is located beneath the landscape. A typical sub-surface infiltration pit for residential and commercial properties is a plastic crate or concrete vault structure to store precipitation. In this example, the sub-surface chamber was modified to retain the water rather than infiltrate it. The landscape includes climate-appropriate and native plants. Stored water is pumped to the landscape's sub-surface drip irrigation system. The multiple family units have saved 800,000 gallons of potable water since the installation. However, the project has not been without its share of problems. Tree roots have been discovered in the vault housing the pump, and the electrical conduit corroded causing the pump to fail. Routine inspection and maintenance of the system, or any system, is required to make sure it operates properly.

Rebuilt from the ground up, the Santa Monica Main Library opened in 2006. Runoff from roofs, decks and surface parking areas is collected and piped through 17 downspout filter BMPs before entering the 200,000 gallon concrete cistern BMP, which is located beneath the underground parking structure. Downspout filters are capable of removing some pollutants. Stored water is pumped to the library's sub-surface irrigation system. The landscape includes climate-appropriate and native plants. The surface parking lot has two BMPs to collect and filter water before it reaches the cistern: slotted drains and a StormFilter® catch basin. The catch basin contains a media-filled cartridge to filter soluble pollutants, as well as remove trash. All site runoff is directed to these four BMPs.

Airport Park is an example of a project that incorporates LID strategies with BMPs to harvest most stormwater for treatment via infiltration. This project is also an example of creating new park land in highly urbanized and built-out areas where impermeable hardscape previously existed, providing additional open spaces for recreational and water quality improvement activities. Opened on April 29, 2007, Airport Park has many BMPs throughout the park. The BMPs include Bay Boxes (i.e., Santa Monica's term for a filtering or infiltration device that protects water quality of the Santa Monica Bay) along much of the park perimeter as well as in other locations near impermeable surfaces, such as an adjacent tie-down airplane parking lot. The north and south parking lots use porous asphalt as the BMP, allowing runoff to infiltrate. The parking lots allow runoff to pass through the permeable hard surface and into the subgrade for infiltration, where soil ecology filters runoff and improves stormwater quality. The park also includes a synthetic turf soccer field, which eliminates the need for irrigation and saves water at a time of increasing drought concern, and drier and warmer weather predictions. The soccer field and the adjacent dog park can also absorb, infiltrate and treat urban runoff.

Another example is a city beach parking lot that was converted to a permeable turf surface for recreational activities to harvest and infiltrate parking lot runoff and also allow beach parking- a dual function parking lot. In the City's first Green Street, parking lanes are paved with pervious concrete. Pervious concrete, like porous asphalt or pavers on sand, allows parking and road runoff to infiltrate. Other ways to reduce parking lot pollution include curbless green strips and permeable pavement to capture and percolate runoff where possible. At Virginia Avenue Park, parking stalls with pavers allow parking lot runoff to infiltrate into the ground. Bio-filters for treatment and percolation are used throughout various sites in the City, too.

The City employs other strategies to mitigate urban runoff. Numerous alleys have pervious concrete in the center to allow runoff to infiltrate into the ground layer. Trench drains are routinely installed to collect and direct runoff from a roof, driveway or parking lot to an infiltration pit. Downspouts are modified to redirect roof runoff to landscaped areas (rain gardens) instead of directly connected to impermeable surfaces and the public right-of-way. Any construction project adding downspouts, gutters and sub-surface pipes directing stormwater to the curb face should have a French drain system of perforated pipe and gravel (some exceptions for public safety).

In Santa Monica, the storm drain system is separate from the sanitary sewage system. Storm drains are intended to take stormwater straight to the ocean to avoid area flooding and without treatment. Santa Monica is unique in that a high percentage (94%) of the dry-weather runoff is treated. The Santa Monica Urban Runoff Recycling Facility (SMURRF) cleans dry weather urban runoff from the City's largest flows, the Pico-Kenter and Pier Storm Drains, which drain 4,200 and 900 acres respectfully. The Pico-Kenter drainage also includes parts of the City of Los Angeles and the Santa Monica Mountains.

Dry weather runoff is created from excess irrigation, spills, construction sites, pool draining, car washing, washing down paved areas and residual wet weather runoff. The SMURRF treats and reuses most of the runoff during dry weather, up to 500,000 gallons of dry weather runoff daily. The recycled water is used for irrigation and dual plumbed office buildings. The primary objective of the SMURRF is to eliminate pollution entering Santa Monica Bay caused by dry weather urban runoff (storm drain low flows). Secondary project goals include: providing cost-effective treatment; producing high quality water for reuse in landscape irrigation and indoor flushing; raising public awareness of Santa Monica Bay pollution and the role of each individual in the watershed through appropriate educational exhibits; and constructing an aesthetically pleasing and functional facility with an appropriate emphasis on art and educational elements that attracts people while providing new access to the beach.

The treatment train is first "coarse" screened in a Continuous Deflective Separation (CDS) unit. Coarse screening removes large floating debris and trash (such a bottles, twigs, etc.) that typically flow down gutters into streets. "Coarse" screened flows are then pumped about a mile to the recycling facility. The first process unit is the Rotating Drum Screen. The Rotating Drum Screen removes fine floating particles (that escaped the coarse screening) greater than 0.04 inches in size. From the screen the water flows to the cyclone-type Grit Chamber. This unit removes grit and sand. Screening and de-gritting systems remove inorganic settleable material that may damage the downstream treatment processes and reduce the treatment efficiency. From the Grit unit the preliminary treated water is stored in the raw water storage tank. The raw water storage tank dampens the fluctuations in the influent flows, thereby allowing downstream filtration and disinfection processes to operate at a steady rate, and more efficiently. From the raw water storage tank the water is pumped to the Dissolved Air Flotation (DAF) unit. In this unit, compressed air is injected into the water at the unit inlet. As the water reaches the open tank surface, it reaches atmospheric pressure whereby fine air bubbles are released in the water. The air bubbles rise to the top and carry with it the oil and

grease with the help of a flocculating agent. The oil and grease blanket formed at the DAF unit open surface is then skimmed off the top. From the DAF unit the water flows to the Microfiltration treatment unit. Here, the vacuum applied on perforated membranes forces the water through the membrane thereby "filtering" out the turbidity. The membranes have to be regularly back-flushed to clean pollutant "buildup." From the Microfiltration unit the water flows to the Disinfection process, which uses Ultraviolet (UV) radiation to disinfect the water. As the water passes by the UV lamps in series, UV light kills or neutralizes bacteria and viruses. The UV bulbs have to be periodically cleaned of the scale "buildup," or they will lose efficiency. Finally, treated water is stored in the "clean water tank," from where it is pumped into the distribution system for reuse. The daily reuse of runoff is about four percent of Santa Monica's daily water use. Once purified, the water is safe for all landscape irrigation and dual-plumbing systems as prescribed by the California Department of Health Services and meets California's Title 22 requirements.

Landscape irrigation customers include the Olympic Boulevard center median, some parks, and the City's Woodlawn Cemetery. Recycled SMURFF water can be used in sites with overhead irrigation but only at night. Dual-plumbed customers include the City's Public Safety Facility and commercial complexes, e.g. the Water Garden and the RAND Corporation. The SMURRF cost approximately $I2 million including the recycled water distribution system. The SMURRF is a multi-agency partnership built upon the regional benefits of the facility. Funding sources included the City of Santa Monica, the City of Los Angeles, the State Revolving Loan Fund, and two local and federal grants.

In summary, the City of Santa Monica has emerged as a leader in watershed management by recognizing and seizing the opportunities created by harvesting rain and dry weather runoff. While future potable water sources and treatment will continue to present challenges to urban infrastructures, cities can begin now to explore new ways to harness this precious resource before it all goes down the drain. This sustainable strategy will result in a cleaner beach, ocean and environment and a more reliable water supply for our communities and future generations to come.