STORMWATER CAPTURE:

OPPORTUNITIES TO INCREASE WATER SUPPLIES IN SOUTHERN CALIFORNIA

SOUTHERN CALIFORNIA WATER COMMITTEE

STORMWATER TASK FORCE | JANUARY 2012

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STORMWATER CAPTURE: OPPORTUNITIES TO INCREASE WATER SUPPLIES IN SOUTHERN CALIFORNIA

INTRODUCTION

Southern California's water future will be shaped largely through the management of stormwater. The availability of imported water supplies from the Colorado River and northern California has become uncertain due to regulatory issues, climate change, statewide shortages, and challenges resolving and implementing improvements in the Bay-Delta system.

Finding new sources of drinking water must include local supplies developed within the coastal plain of Southern California, including the increased use of stormwater. This is a departure from historical practices which relied primarily on augmenting supplies with imported water. Moving away from simply conveying stormflows off-site for flood control to increasing capture and infiltration has promise for increasing water supplies.

In recognition of these challenges, as well as the continuing need to protect and improve surface water quality, policy and planning frameworks are shifting toward more integrated management of these water resources. The regulation of stormwater on the local level through municipal separate storm sewer system (MS4) permits offers one of the most promising opportunities for realizing the goal of improving surface water quality while at the same time developing new water supplies through an increase in capture and infiltration of stormwater.

In January 2011, the Southern California Water Committee formed the Regional Stormwater Task Force. The purpose of the Task Force is to develop regional consensus-based strategies and recommendations for utilizing stormwater effectively as a new local water supply and to reduce water pollution from urban runoff within the region. The purpose of this white paper is to examine a number of relevant topics including:

- Existing statewide policies and goals and regional plans related to integrated stormwater management;
- Trends, structure, and requirements of MS4 permits as they pertain to both opportunities and constraints to maximizing stormwater capture for water supply purposes; and
- The advantages and disadvantages of two different, perhaps complementary strategies of storm water management: onsite low impact development and regional stormwater capture and infiltration.

The objective of this paper is to open the door to dialogue among the various stakeholders to discuss the merits and limitations of various stormwater management strategies in the context of water quality *and* water supply; to identify the needs as well as concerns associated with the planning and execution of strategies proposed in this paper; and to collaboratively find ways to work flexibly and creatively within the regulatory framework to achieve our common goals of attaining clean, safe waterbodies and sustainable, reliable water supply.

SUMMARY OF STATE WATER POLICIES AND PLANS

One of several unifying themes in recently adopted state water policies and plans is the emphasis on the utility of stormwater and the multiple benefits that potentially can be realized through innovative urban runoff management that is interlinked with other resource management strategies.

Existing state water policies and plans establish ambitious goals with specific deadlines to achieve significant, measurable increases in local water supply and use of stormwater above a specific baseline. They also share in common a basic understanding that the road to integrated water management will require collaboration, thinking outside of the box, "developing innovative incentives, streamlining permits, and applying little used regulatory authorities." [1] The following is a brief summary of relevant state water policies and plans.

California Water Plan

The state water plan is a strategic planning document describing the management of the state's water resources and integrating information and recommendations from a variety of agencies. The California Water Plan Update 2009 contains resource management strategies aimed at strengthening integrated regional water management, several of which encourage augmentation of local water supplies and urban water use efficiency as described below:

- "The primary benefits from urban runoff management are to reduce surface water pollution and improve flood protection. Additional benefits may be to increase water supply through groundwater recharge in areas with suitable soil and geological conditions, where pollution prevention programs are in place to minimize the impact on groundwater. Groundwater recharge and stormwater retention sites can also be designed to provide additional benefits to wildlife habitat, parks, and open space." [2]
- "Solutions to managing urban runoff are closely tied to many interrelated resource management strategies including land use planning, watershed planning, water use efficiency, recycled water, protecting recharge areas, and conjunctive management. How and why water is used in the urban environment needs to be considered comprehensively within a watershed." [3]

State Water Resources Control Board Final Strategic Plan 2008-2012

The State Water Resources Control Board's (State Water Board) Strategic Plan adopted in 2007 and subsequently updated in 2008 set ambitious goals for increasing sustainable local water supplies. The plan includes a goal to "increase sustainable local water supplies available for meeting existing and future beneficial uses by 1,725,000 acre-feet per year, in excess of 2002 levels, by 2015…" [4]. The State Water Board recognized that achieving these goals would demand an effort "to encourage, support, and require water conservation, water recycling, and stormwater and dry weather runoff reuse efforts." These efforts would need to include "developing innovative incentives, streamlining permits, and applying little used regulatory authorities."

[1] State Water Resources Control Board, *Strategic Plan 2008-2012*, p. 23

[2] California Department of Water Resources, *California Water Plan Update 2009*, p.19-9

[3] California Department of Water Resources, p. 19-12

[4] State Water Resources Control Board, *Strategic Plan 2008-2012*, p. 23

State Water Board Recycled Water Policy

The State Water Board's Recycled Water Policy adopted in 2009 encourages "local and regional water agencies to move toward clean, abundant, local water for California by emphasizing appropriate water recycling, water conservation, and maintenance of supply infrastructure and the use of stormwater (including dry-weather urban runoff)".[5]

Towards that end, one of the measurable goals adopted in the policy is for California to increase the use of stormwater from the 2007 baseline by at least 500,000 acre-feet per year by 2020 and by at least one million acre-feet per year by 2030. As for the State Water Board's part in this effort, the preamble of the policy notes that the "State Water Board expects to develop additional policies to encourage the use of stormwater, encourage water conservation, encourage the conjunctive use of surface and groundwater, and improve the use of local water supplies." [6]

The policy also recognizes the need for regulatory flexibility in this collaborative, statewide effort to achieve sustainable local water supply: "The State Water Board also encourages the Regional Water Boards to require less stringent monitoring and regulatory requirements for stormwater treatment and use projects than for projects involving untreated stormwater discharges." [7]

Delta Stewardship Council's Delta Plan (5th draft staff Delta Plan) August 2011

The Delta Plan lays out regulatory policies and recommendations that start the process of addressing the current and predicted ecological, flood control, water quality, and water supply reliability challenges associated with the Sacramento-San Joaquin Delta. As required by statute, the Delta Plan adopts a science-based adaptive management strategy to manage decision-making in the face of uncertainty.

The Delta Plan integrates the diverse efforts of state and local agencies while being responsive to the mandates of the Delta Reform Act, which requires linked actions to achieve a more reliable water supply while retaining regional flexibility and reducing overall reliance on the Delta. In this way, the 2012 Delta Plan promotes expedited statewide actions and investments while encouraging the actions of California's local agencies, which are vital to achieving water supply reliability and a protected and improved Delta ecosystem—all in a manner that respects the unique character of the Delta. Increased utilization of stormwater throughout California will reduce the need to export water from the Delta.

[5] State Water Resources Control Board, *Policy for Water Quality Control for Recycled Water*

[6] State Water Resources Control Board, 2009

[7] State Water Resources Control Board, 2009 , p. 14

BACKGROUND: SOUTHERN CALIFORNIA WATER COMMITTEE

The Southern California Water Committee (SCWC) is comprised of representatives of counties, flood control districts, cities, water and wastewater agencies, and private and non-profit sectors. Key technical support is provided by flood control district staff, city engineers, urban planners and redevelopment staff, water resource planners, real estate development professionals, hydrogeologists, and experts from consulting firms.

The goal of the SCWC Stormwater Task Force is to identify potential issues, constraints and opportunities related to the management of stormwater and to provide a forum for discussion and evaluation of challenges for individual watersheds within the coastal plain of southern California. Key focus areas are:

- Regional integrated water resources management strategies and plans;
- Stormwater management as related to water quality and protection of beneficial uses of receiving waters;
- Flood control, stormwater recharge, and groundwater conjunctive use;
- Synergies in developing new local supplies including groundwater, recycled water, and stormwater within the coastal plain of southern California;
- Relationship between MS4 permits and stormwater management and groundwater recharge; and
- Low impact design standards and development incentives.

REGIONAL CONTEXT: IMPORTANCE OF CONJUNCTIVE USE OF STORMWATER IN SOUTHERN CALIFORNIA

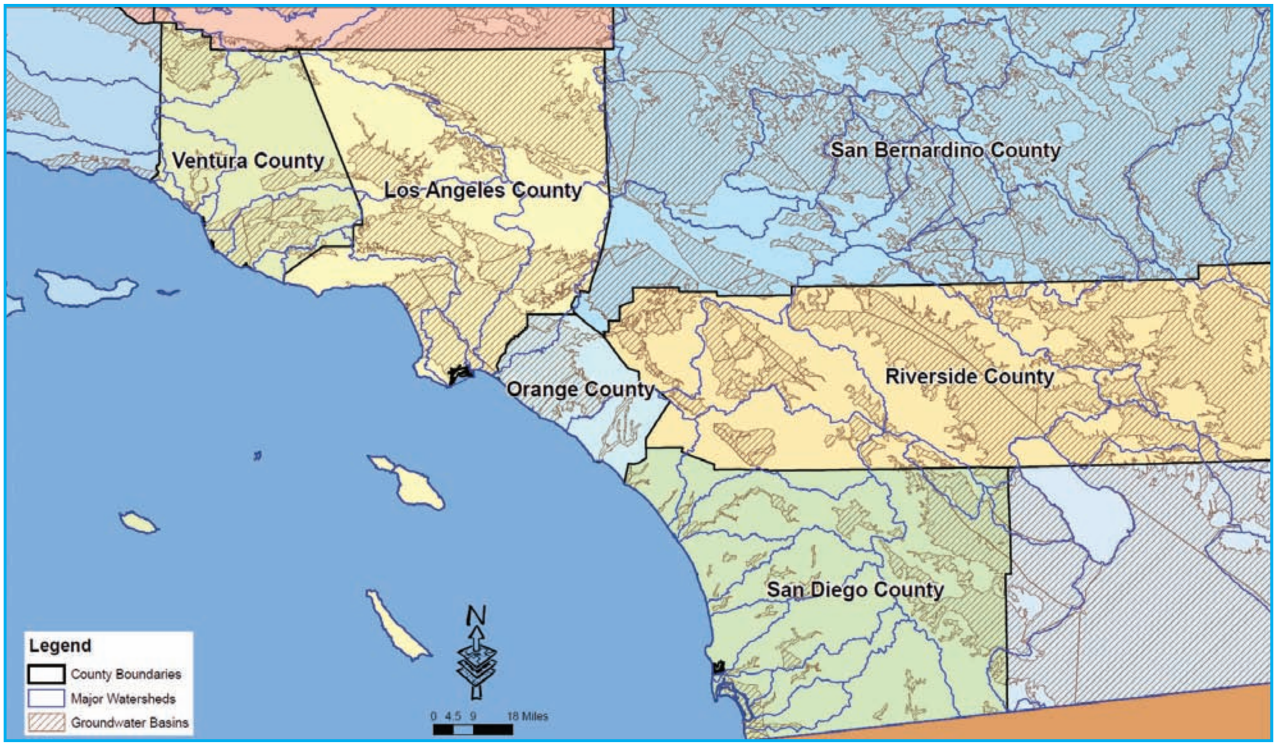
The Stormwater Task Force was formed in response to the findings of a stakeholder work group convened by The Metropolitan Water District of Southern California (MWD). The work group included MWD, its 26 member agencies, groundwater basin management agencies, county flood control districts, and many other stakeholders focused on enhancing stormwater capture to augment local water supplies and increasing the yield of groundwater basins by increasing stormwater recharge. The group's findings, published by MWD in the 2010 Update to the Integrated Water Resources Plan Issue Paper, included:

- Urban areas on the valley floors within the MWD service area generate an annual average of more than 1 million acre-feet of stormwater runoff, of which approximately 0.5 million acre-feet is actively recharged each year.
- About 3-4 million acre-feet of storage space is available in all of the southern California groundwater basins, shown in Figure 1, which could be utilized to capture and store the additional stormwater runoff. Increased stormwater capture would potentially expand the yields of the local groundwater basins as demonstrated in the Chino and Orange County basins.
- The captured runoff can be recharged into groundwater basins, captured and stored on-site primarily for irrigation, and/or stored in surface water reservoirs and used to meet municipal demands.
- Conjunctive use must be a key part of the state's overall water management strategy in terms of coping with a growing population.[8]

[8] According to the California Department of Water Resources, conjunctive use means "the deliberate combined use of groundwater and surface water". It also refers to actively managing the aquifer systems as an underground reservoir. During wet years, when more surface water is available, surface water (including stormwater) is stored underground by recharging the aquifers with surplus surface water.

Figure 1: Southern California Groundwater Basins

Los Angeles, Orange, Riverside, San Diego, San Bernadino, and Ventura Counties Watersheds and Groundwater Basins



URBAN STORMWATER REGULATIONS IN SOUTHERN CALIFORNIA

In California, the State Water Board and Regional Water Quality Control Boards (Regional Water Boards) are responsible for regulating and permitting stormwater discharges. These boards are taking a lead in developing a regulatory approach aimed at holistic and sustainable stormwater management, with permits regulating municipal stormwater discharges playing an increasingly important role.

MS4 permits issued to county and city stormwater management agencies in Southern California call for greater integration of sustainable land development practices at the local level. These include requirements for new developments and significant re-developments to retain stormwater on-site using low impact development (LID) [9] best management practices (BMPs), as well as provisions for regional and other alternative compliance approaches.

MS4 permits require that land development projects be designed to infiltrate, harvest and re-use, evapotranspire, or bio-treat a specified volume, the "design capture volume", of stormwater on-site using LID BMPs if feasible. Increasing on-site capture of stormwater is expected to yield improvements in surface water quality; if performed strategically this could also increase use of stormwater for groundwater recharge.

INTEGRATED URBAN STORMWATER MANAGEMENT: OPPORTUNITIES AND CHALLENGES

On-site capture and infiltration of urban stormwater may increase water supplies by capturing water that is not already used in regional recharge facilities as well as provide other water resource benefits including:

- Improvements in surface water quality of downstream receiving waters will result if urban runoff is reduced, since urban runoff is often high in bacteria, nutrients, and other pollutants which negatively affect beneficial uses of water bodies.
- Reduction in downstream channel hydromodification will result if excessive runoff is reduced. [10] Hydromodification causes expensive damage to channel slopes and reduces flood water storage capacity as well as destroying valuable natural habitat.
- Retaining water on-site may reduce the potential for downstream flooding and the expensive damages associated with flooding. It also may help reduce the burden on downstream flood control systems by reducing flows of excess water.
- On-site capture and infiltration of stormwater will increase water supplies in cases where on-site LID BMPs are designed for water supply augmentation and captured stormwater is recharged to groundwater basins that are utilized as drinking water supplies.
- Several studies have demonstrated that infiltration of stormwater through well-designed and properly maintained LID BMPs does not negatively impact groundwater quality. [11]

continued...

[9] State Water Board defines LID as "a stormwater management strategy aimed at maintaining or restoring the natural hydrologic functions of a site or project to achieve natural resource protection objectives and fulfill environmental regulatory requirements; LID employs a variety of natural and built features that reduce the rate of runoff, filter pollutants out of runoff, and facilitate the infiltration of water into the ground and/or on-site storage of water for reuse." (Proposition 84 Storm Water Grant Program Guidelines, 2009).

[10] However, flow-through biofiltration allowances in some MS4 permits may reduce the potential hydromodification benefit.

[11] One such study, the Water Augmentation Study, is a long-term project led by the Council for Watershed Health. One aspect of the study focused on the relationship between stormwater infiltration and impacts to water quality. Water quality data was collected from untreated stormwater infiltrating through LID BMPs in six locations. Results of the study showed that infiltration of stormwater did not negatively impact groundwater quality.

- On-site LID integrated with other "green" landscape design practices can be aesthetically pleasing and result in water conservation, reduced greenhouse gas emission, require less fertilizers, pesticides and other harmful chemicals, and encourage recycling and reuse of wastewater and green waste.
- On-site LID presents an opportunity to educate the public about sustainable building practices.

Complementary options to on-site LID BMPs include regional recharge basins and regional stormwater storage and use programs. Some major benefits from use of regional solutions as equally viable compliance approaches are:

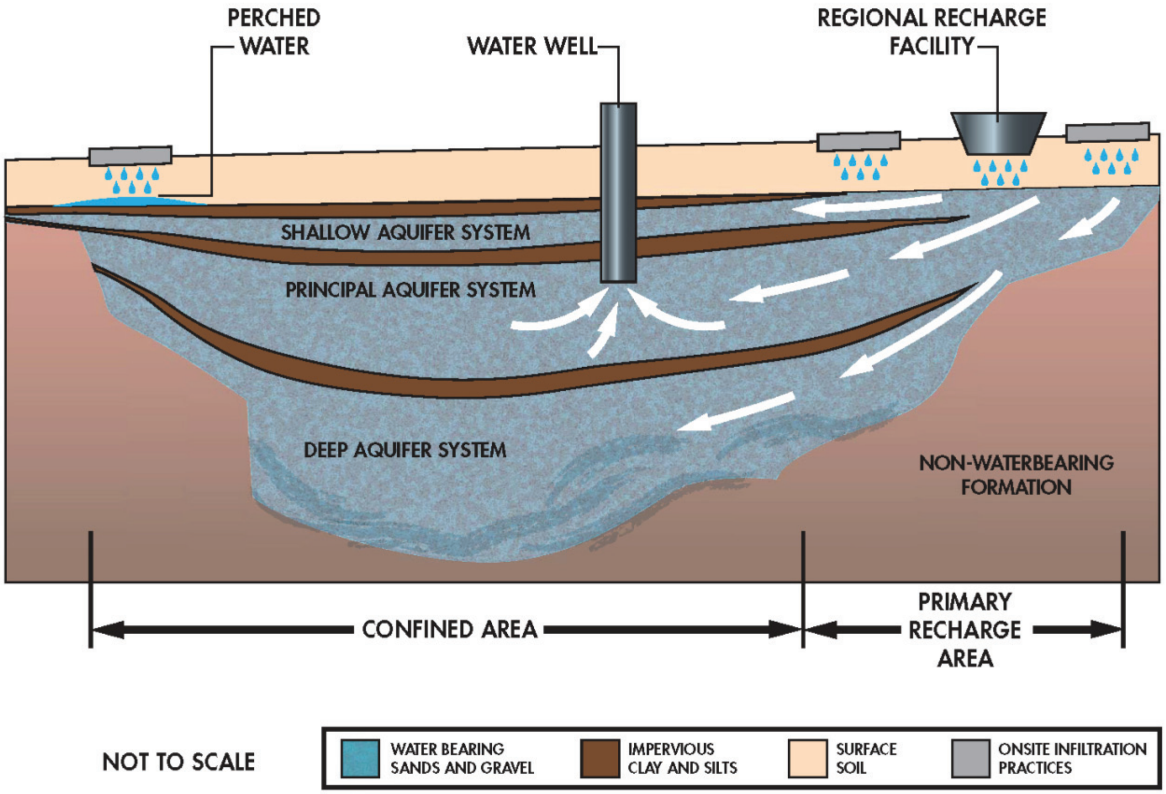
- Regional sites can be designed, operated, and maintained by water supply agencies and other public agencies with expertise in groundwater management and water supply protection. Facility oversight by professional managers will result in long-term and effective maintenance of infiltration rates, the documentation of pollutant-load reduction, protection against groundwater contamination, and adequate long-term operational funding.
- In-depth studies that will be needed for building regional facilities, such as modeling, soil studies, and evaluation of groundwater contamination plumes, will assure that sites chosen will maximize infiltration and protection of groundwater resources.
- Regional facilities will be located in areas that maximize water supply benefits. As shown in Figure 2, all on-site infiltration will not result in recharge of groundwater basins. Infiltration over a confined aquifer or in an area with an underlying aquitard (e.g. clay layer) may result in water that is perched and that does not reach the deeper aquifers that provide water supply.
- Facilities may be designed to accept stormwater flows from the proposed new land development as well as existing developments, which could result in greater pollutant load removal.

Regional and on-site BMPs represent two approaches for managing stormwater at new developments and re-developments and involve different design and cost/benefit assessments. It is important to note that the selection of BMPs, either regional or on-site, should be based on finding the optimal combination considering performance, site availability, and site constraints, while evaluating the benefits and costs to maximize overall benefits to the watershed.

Appendix 1 contains case studies of both on-site LID and regional solutions that illustrate the benefits of each type of approach. Cost data are included where available; additional data are expected to be forthcoming, especially for long-term implementation of full scale LID.

An evaluation of the relative costs of on-site infiltration and regional solutions should be an important consideration in regulatory decision making and policy development. In some areas, development and use of regional solutions as a stormwater management option may be the most effective approach. This may be the case particularly for groundwater basins like the Central Basin and the Orange County Basin, provided that the infiltration occurs in the portion of the basin where percolated water reaches the aquifers that provide water supply.

Figure 2: Schematic Cross Section of Storm Water Infiltration Effects on Groundwater Supplies



Many studies are available in the literature investigating costs associated with stormwater management. Utilizing those studies, the Center for Watershed Protection (2007) derived a comprehensive list of unit costs for a variety of stormwater management options; details of data sources and supporting studies are included in the report. Table 1 below provides cost comparisons between typical regional and on-site type BMP retrofit practices that have been widely used in the watersheds, while Table 2 presents a similar cost comparison for new construction. The cost for land acquisition that would be part of the project specific conditions was not included. It appears that, in many cases, regional solutions for stormwater management are still relatively more cost-effective even when groundwater recharge is not an immediate opportunity.

Table 1: Retrofit Construction Costs $ per cubic foot of runoff treated

	RETROFIT TYPE	MEDIAN
REGIONAL	Pond Retrofits	$3.00
	New Storage Retrofits	$5.00
	Large Bioretention Retrofits	$10.50
	Cisterns	$15.00
	Infiltration Retrofits	$15.00
ON-SITE	Rain Gardens	$4.00
	Water Quality Swale Retrofit	$12.50
	French Drain/Dry Well	$12.00
	Rain Barrels	$25.00
	Stormwater Planter	$27.00
	Small Bioretention Retrofits	$30.00
	Underground Sand Filter	$65.00
	Stormwater Tree Pits	$70.00
	Permeable Pavers	$120.00
	Extensive Green Rooftops	$225.00
	Intensive Green Rooftops	$360.00

Table 2: New Stormwater BMP Construction Costs $ per impervious acre treated

	NEW BMP TYPE	MEDIAN
REGIONAL	Constructed Wetlands	$2,900
	Extended detention	$3,800
	Wet Ponds	$8,350
ON-SITE	Water Quality Swales	$18,150
	Bioretention	$25,400
	Residential Rooftop	$27,200
	Filtering Practices	$58,100
	Non-Residential Roof	$90,750

Adopted from Center for Watershed Protection (2007)

THE ROLE OF MUNICIPAL STORMWATER PERMITS IN ACHIEVING INTEGRATED STORMWATER MANAGEMENT

Regulatory requirements contained in MS4 permits in the Southern California region present both opportunities and challenges to achieving integrated stormwater management, as presented below.

Some MS4 permits prescribe a hierarchy of on-site controls that must be applied to each land development project.

Prescribing a hierarchy in permits may limit the achievement of integrated management of water resources. Some regional permits require that every land development project incorporate BMPs in a prescribed order; developers will be required to satisfy these permit conditions even when designs utilizing a different suite of BMPs based on site-specific conditions would capture and treat more stormwater and result in greater water quality improvements. This could result in cases, for example, where regional solutions may not be utilized even though their use would result in equal or greater water quality improvements and/or groundwater recharge benefits.

Limitations on use of regional facilities may result in reduced groundwater recharge opportunities.

Not all development will occur in areas where on-site capture and infiltration results in augmentation of groundwater basins used as drinking water supplies, as discussed previously and illustrated in Figure 2. In these cases, flexible permit conditions are essential to encourage site-specific designs to maximize water supply benefits. However, some existing MS4 permit conditions may discourage regional infiltration even in cases where it would provide equal or greater water quality benefits and makes the most sense for regional water supply.

Requiring and/or encouraging the construction of individual, privately owned infiltration facilities shifts the primary responsibility for operation and maintenance from professional water managers to private property owners.

Placement of infiltration BMPs on-site will make individual property owners responsible for long-term operation and maintenance. This raises concerns as to the ability of property owners to effectively manage on-site BMPs in a manner that protects groundwater quality and maintains their performance over the long term. Sediment build-up in BMPs may result in clogging and the need for frequent cleaning. Additionally, water managers are concerned that infiltration BMPs that are not properly sited, monitored, and maintained may become conduits for the transport of pollutants especially due to accidental spills and illegal dumping of hazardous chemicals into groundwater. Of greatest concern in this regard, perhaps, is use of dry wells for infiltration of stormwater. [12]

[12] Santa Clara Valley Water District reports at least 8 serious contamination sites were caused or aggravated by the presence of dry wells introducing contamination into the groundwater. (Santa Clara Valley Water District Groundwater Management Plan 2001, page 50)

Requirements for implementation timetables for regional BMPs pose a challenge for the development and use of regional solutions.

Some stormwater permits require that regional BMPs be functional prior to issuance of occupancy permits. Requiring functional BMPs prior to releasing final permits for developments creates timing and financing impediments for developers, including the time and costs associated with arranging for land acquisition, design, construction, operation and maintenance of regional BMPs. If a developer wants to move forward with a regional BMP ahead of public or private funding partners, the developer may be responsible for the purchase of offsite properties, preparing and arranging for environmental documents and other time-intensive and costly aspects of facilitating the completion of a regional BMP.

SUMMARY

Communities will have a very significant role in future stormwater management through land use decisions such as zoning, watershed plans, general or specific plans, and LID/smart growth incentives/regulations.[13]

The key to maximizing the beneficial use of stormwater lies in fully recognizing that surface water quality improvement and groundwater resource protection/enhancement are co-equal goals. In the case of managing stormwater on-site, these goals must be realized through creative site design, flexible local implementation of MS4 permit conditions, engagement and cooperation of a diverse group of stakeholders, and the development, encouragement, and use of a variety of innovative compliance approaches.

In cases where on-site LID BMPs are the most cost-effective control method, they will naturally be incorporated into the development plans. Opening the door to regional solutions will give local agencies the flexibility to identify and implement solutions that are at least equally cost-effective and environmentally beneficial and protective. This would include flexibility to allow regional facilities to accept stormflows from developments within the area tributary to those facilities as an alternative to on-site controls where appropriate.

As regulations increasingly emphasize stormwater infiltration it will be important to provide a role for groundwater management agencies to review the stormwater management plans for development projects at an early stage. This early review would provide for the identification of site-specific constraints to infiltration such as areas of high groundwater and contamination plumes.

RECOMMENDATIONS

The SCWC Task Force will continue to work with all stakeholders to identify opportunities to expand stormwater capture throughout the coastal plain of southern California.

Key next steps for 2012 include:

- Holding workshops and discussions with U.S. EPA, the State Water Resources Control Board and Regional Water Quality Control boards on strategies to increase stormwater recharge and on-site retention as a water supply strategy for the region.
- Submitting this white paper to the California Department of Water Resources for the Bulletin 160 Water Plan update.
- Continuing to review legislation related to stormwater management bills.
- Collaborating with the U.S. Army Corps of Engineers to enhance stormwater capture on federal facilities within the region.

[13] For more detailed information on the role of local government in stormwater management see: Ahwahnee Water Principles by the Local Government Commission in 2005 , Green Building Guide, and LA Bureau of Sanitation LID Handbook, and NRC Water Science and Technology Board report to EPA on Urban Stormwater Management in the US, 2008

REFERENCES

1. California Department of Water Resources, 2009, *California Water Plan Update 2009*, Bulletin 160-09.
2. California State Water Resources Control Board, September 2, 2008, *Final Strategic Plan Update 2008-2012*.
3. California State Water Resources Control Board, February 3, 2009, *Policy for Water Quality Control for Recycled Water, State Water Resources Control Board Resolution No. 2009-0011*.
4. Center for Watershed Protection, 2007, Urban *Subwatershed Restoration Manual No. 3: Stormwater retrofit practices V.1*.
5. Council for Watershed Health, *Water Augmentation Study*, www.watershedhealth.org
6. Delta Stewardship Council, August 2, 2011, *Fifth Staff Draft Delta Plan*
7. Local Government Commission, 2005, *Ahwahnee Water Principles*
8. Los Angeles Bureau of Sanitation *LID Handbook*.
9. NRC Water Science and Technology, 2008, Report to EPA on *Urban Stormwater Management in the United States*.
10. Santa Clara Valley Water District, July 2001, *Groundwater Management Plan*

APPENDIX 1

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San Bernardino Valley Municipal Water District
San Diego County Flood Control District
Santa Ana Watershed Project Authority
Three Valleys Municipal Water District
TreePeople
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Ventura County Public Works Agency
Water Replenishment District of Southern California
Western Municipal Water District

APPENDIX 1

CASE STUDIES

CASE STUDY A: MULTI-OBJECTIVE STORMWATER MANAGEMENT IN SUN VALLEY WATERSHED

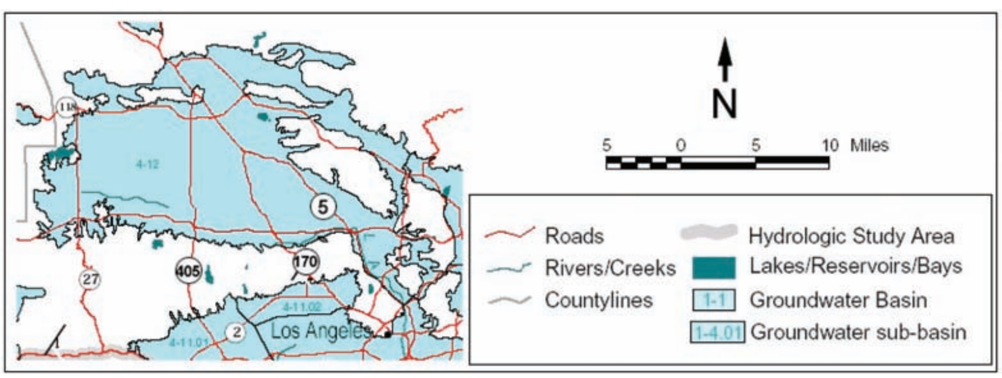
BACKGROUND

The Sun Valley Watershed is located in the San Fernando Valley in the City of Los Angeles about 14 miles northwest of Downtown Los Angeles. It is a subbasin of the Los Angeles River Watershed. The Sun Valley area is not served by a major flood control system and is highly developed. The watershed is densely urbanized with approximately 60 percent of the area dedicated to industrial and commercial use. The area is mostly impervious with limited open space. In 1998 the Sun Valley Stakeholders group was formed to develop a plan to resolve the flooding and water quality issues in the watershed while conserving open space and improving the quality of life for Sun Valley residents. This effort resulted in the Sun Valley Watershed Management Plan (Management Plan) that was adopted by the Los Angeles County Flood Control District in March 2004. The plan identified several Best Management Practice projects that focus on flood protection, water conservation, water quality, habitat restoration, and recreational opportunities. It has been recognized that stormwater conservation practices can be an important aspect of solving the flooding problem by retaining or detaining stormwater for beneficial use. Among other objectives, this case study will highlight the projects to achieve water conservation using stormwater recharge projects.

Groundwater Basin as Water Supply Resources

The study area is located within the San Fernando Groundwater Basin (SFGB). The SFGB covers 112,000 acres. It is designated as Basin 4-12 by the California Department of Water Resources as shown in Figure A-1. It is an unconfined aquifer composed of alluvial deposits. The total groundwater storage capacity of the SFGB is estimated to be approximately 3,200,000 acre-feet (ULARA Watermaster, 2002). Groundwater from the SFGB is an important source of drinking water for the Los Angeles region, including the cities of Los Angeles, Glendale, and Burbank. SFGB is an adjudicated groundwater basin. Urban development has decreased the amount of water that naturally infiltrates to the SFGB. To partially offset this decrease, the County, in cooperation with LADWP, attempts to optimize the use of the spreading basins or other facilities to maximize the stormwater recharge of the SFGB.

Figure A-1: San Fernando Groundwater Basin



Source: *Modified from DWR, 2003*

STUDY DESCRIPTION

Much of the runoff from the Sun Valley Watershed is currently lost to the Los Angeles River as a result of the large amount of urbanization in the watershed. Capturing this runoff can increase local water supplies by groundwater recharge. Specific objectives include:

- Maximizing opportunities for infiltration BMPs where feasible (e.g. recharge basins, dry wells)
- Replacing existing uses of potable water with captured stormwater

Project Selection Process

A process was developed to evaluate and select the most cost-effective solutions that meet the recharge objective from the range of potential projects available. The projects identified were considered based on infiltration, water conservation, stormwater reuse, and urban storm protection. The individual focus of each project would cause significant variation in overall project costs and schedule.

RESULTS AND DISCUSSION

Table A-1 shows the list of ultimately selected projects that are mainly intended to capture and infiltrate stormwater runoff. The selection of individual BMP type and sizes was based on consideration of target stormwater quantity control, site opportunities and constraints, and benefit and cost. Note that BMPs listed in Table A-1 consist of projects that capture from the offsite as well as onsite runoff, often referred to as regional and onsite projects, respectively.

Table A-1: List of Optimally Selected Stormwater Management Projects Including Storage Capacity and Costs

Description	Storage Volume (acre-feet)	Capital Cost	Annual O&M Cost	Total Cost (Capital + O&M[1])	Total Cost Per Unit Storage Volume ($/acre-feet)
Regional Projects					
Vulcan Gravel Processing Plant	65	$952,000	$10,000	$1,452,000	$22,338
LADWP Steam Plant	234	$4,539,000	$71,000	$8,089,000	$34,568
Sun Valley Middle School	35	$3,033,000	$6,000	$3,333,000	$95,229
Sun Valley Park	49	$5,200,000	$16,000	$6,000,000	$122,449
Strathern Pit	736	$17,450,000	$239,000	$29,400,000	$39,946
Powerline Easement	455	$18,100,000	$54,000	$20,800,000	$45,714
Onsite Projects					
Parking Lot Infiltration	129	$33,100,000	$35,000	$34,850,000	$270,155
Onsite Infiltration, Reuse, Street Storage	137	$61,988,000	$112,000	$67,588,000	$493,343

[1] Over 50 year life

The ultimate combination of projects of various sizes and types were based on site availability and constraints, and benefit and costs. No predetermined preference was used toward either regional or onsite projects. A brief summary of a few representative projects is provided below.

Sun Valley Park Project (Figure A-2)

The proposed project facilities would be designed to capture and infiltrate flows generated from up to a 50-year frequency design storm (approximately 33 cubic feet per second). The facilities collect and convey stormwater flows from the local drainage Subarea (approximately 25 acres of residential property and 20 acres of park) to infiltration basins located in Sun Valley Park. The project is expected to remedy existing stormwater flooding issues in the vicinity of the park, provide for the beneficial use of stormwater via infiltration to the regional groundwater system, and ensure protection and/or improvement of regional groundwater resources. The project also includes habitat enhancements, additional recreational opportunities, and educational benefits. The proposed project facilities would be designed to capture and infiltrate flows generated from up to a 50-year frequency design storm (approximately 33 cubic feet per second). The facilities collect and convey stormwater flows from the local drainage Subarea (approximately 25 acres of residential property and 20 acres of park) to infiltration basins located in Sun Valley Park.

Figure A-2: Sun Valley Park Project

Strathern Pit Multi use Project (Figure A-3)

This project would consist of converting the existing landfill area to an area dedicated to stormwater detention, treatment, and infiltration. The pit currently has a maximum depth of about 80 feet and a storage volume of about 2,000 acre-feet. This pit/ landfill facility has the potential to be converted to a multi-purpose park that includes a retention basin and a constructed wetland.

Figure A-3: Strathern Pit Multi use Project

A park blooms on land that once was a landfill, in this artist's rendering.

Parking Lot Infiltration Project (Figure A-4)

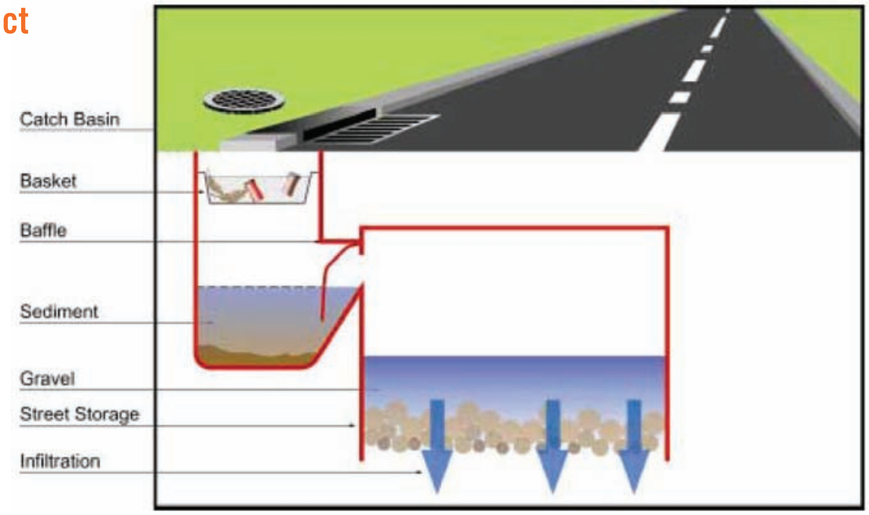
The project would be implemented in commercial areas and would involve installing subsurface infiltration devices beneath the parking lots to infiltrate runoff from the parking lots and buildings as well as adjacent upstream tributary areas. The project would involve installing subsurface infiltration devices beneath the parking lots to infiltrate runoff from the parking lots and buildings as well as adjacent upstream tributary areas.

Figure A-4: Parking Lot Infiltration Project

Street Storage Project (Figure A-5)

Street storage is to augment the volume of runoff captured in this densely urbanized area where space for components is limited. Street storage consists of large, underground storage tanks and infiltration galleries. Each unit of street storage is 6 feet deep with a variable length and width. A project of this type using infiltration trenches has recently been implemented along Elmer Ave ("Elmer Ave Project").

Figure A-5: Street Storage Project



Onsite Projects (Figure A-6)

Onsite projects are implemented where open space is limited. Since they are mostly to be implemented in the privately owned areas, the participation rates of landowners and storage capacities of the BMPs may vary. Type of onsite projects may vary depending on the land uses of the project site. Typically residential areas would implement rain barrels, bioretention, and porous pavement, while commercial and industrial areas would implement porous pavement in parking lots, and bioretention to retain runoff from parking lots and building rooftops.

Figure A-6: Onsite Projects

Benefits Achieved Using Proposed Stormwater Management Practices

Qualitative Benefits

Selected projects are primarily intended to capture and infiltrate stormwater. In addition to stormwater recharge benefits, other benefits achieved by the projects include flood mitigation via peak flow reduction, stormwater quality improvement via removal of polluted water, stormwater storage and reuse, aesthetic enhancement, creation of open space, and habitat improvement and other environmental benefits.

Quantitative or Measurable Benefits

Table A-1 includes the stormwater storage capacity of each project in acre-feet. Note the stormwater recharge potential of each project was expressed as storage capacity. For actual recharge volume can be estimated per each storm event or a series of events for a given year. For the purpose of relative comparison of different BMPs, storage capacity is a good indicator of expected recharge volume. Most of the projects provide in the range of hundred to several hundred acre-feet of storage capacity. Among the projects listed, Sun Valley Park project is the only one that has been built while others are still in planning phase. According to the actual data, Sun Valley Park project has been recharging average 30 acre-feet of stormwater annually. Other types of benefits can be quantified but are not available yet.

Benefit and Cost Considerations

In addition to the stormwater storage capacity, Table A-1 includes capital and O&M costs of each project. It is obvious from the total costs per unit storage volume that projects recharging offsite stormwater runoff in a larger scale (so called regional projects) are much more economical in achieving stormwater conservation. It is somewhat intuitive that projects that handle larger drainage areas would need less unit capital costs compared to the smaller scale onsite projects; therefore more economical.

However, it may not always be true that "regional projects" are more economical or better in performance. Often times, regional projects would involve high costs of land acquisition, more complex upfront infrastructure investment, and various environmental and permitting issues. On the other hand, "onsite projects" can be relatively simple to install, and do not need a large space and may be appropriate in the heavily urbanized areas.

SUMMARY AND CONCLUSION

Using the multi-objective approaches adopted in the Sun Valley watershed plan, a cost effective set of stormwater management projects has been identified. For the purpose of this case study, only the projects for stormwater recharge are specifically presented. The ultimately selected projects are a good combination of regional and onsite type projects based on their performance, site availability and constraints, and benefit/costs. It is important to note that the selection was not biased with a particular preference of either regional or onsite projects. Rather it was done simply to determine the optimal combination among them that will achieve the objective of the Sun Valley watershed management.

REFERENCES

1. California Department of Water Resources (DWR), 2003. Groundwater Basin Quadrangles – Draft 1 Version. Available: http://www.waterplan.water.ca.gov/groundwater/pdf/losangeles.pdfAccessed: March 13, 2003
2. Los Angeles County Flood Control District, *Sun Valley Watershed Management Plan*, March 2004
3. Upper Los Angeles River Area Watermaster (ULARA Watermaster). 2002. *Watermaster Service in the Upper Los Angeles River Area, Los Angeles County: 2000-2001 Water Year, October 1, 2000 – September 30, 2001.* May 2002.

CASE STUDY B: BALLONA FRESHWATER WETLANDS SYSTEM[1]

BACKGROUND

Photo of Ballona Freshwater Marsh

The 51.1 acre Ballona Freshwater Wetlands System, located in West Los Angeles between Marina del Rey and Playa del Rey was constructed by the developer Playa Capital for the new Playa Vista Community. It is maintained by the non-profit Ballona Wetlands Conservancy with the underlying land of the freshwater marsh portion owned by the State Lands Commission. The urbanized watershed that drains into the Freshwater Weltands System consists of over a thousand acres, including 440 acres of the Playa Vista project and over 600 acres of off-site areas.

The Wetlands System was created with multiple goals: (1) re-establish freshwater habitat that had been lost with the channelization of Ballona and Centinela Creeks, (2) improve the quality of stormwater and urban runoff into Ballona Creek and Santa Monica Bay, and (3) provide stormwater management and flood control.

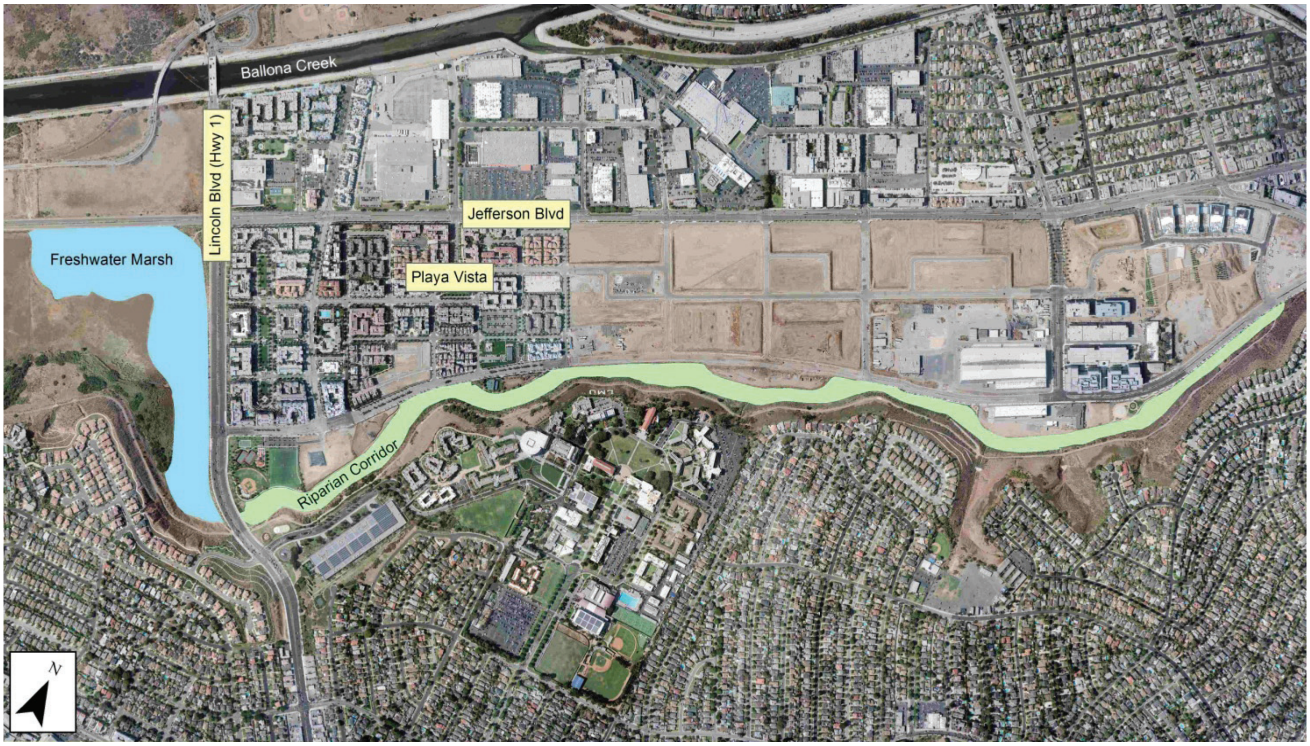
Conceived when all of the property was still under one private land owner, restoration plans for the freshwater wetland were designed with the adjacent Ballona Wetlands in mind. Since December 2003, the Ballona Wetlands have been owned by the State of California, which is currently planning restoration of the salt marsh and surrounding habitat.

PROJECT DESCRIPTION

Figure B-1 shows the location of the riparian corridor and freshwater marsh below the Westchester Bluffs near the interchange of Lincoln Blvd. and the Ballona Creek in West Los Angeles. The system captures and treats stormwater and urban runoff from both the new Playa Vista community and adjacent communities before releasing cleansed water in Ballona Creek.

[1] From Urban Coast 2/1 November 2010. *"Constructed Wetlands Help Achieve Water Quality and Conservation Goals at Ballona."* Edith Reed

Figure B-1: Freshwater Wetlands System



Phased construction of the wetland system began in 2001 and was completed in 2008 at a cost of $30 million. (This cost included drainage infrastructure to the freshwater marsh system.)

Figure B-2 shows a closer view of the freshwater marsh component of the system. The stormwater management approach used is a freshwater treatment system with impacted stormwater entering the marsh system at three principle locations, settling out, and ultimately releasing to the Ballona Creek through a tunnel structure at the western end of the marsh system.

Figure B-2: Ballona Freshwater Marsh

RESULTS AND DISCUSSION

There is a substantial body of research and numerous case studies regarding the design and effectiveness of treatment wetlands (e.g. Kadlec and Knight, 1996; Moshiri, 1993). The basic concept of a treatment wetland is to use sediment settling areas and natural wetland processes (such as uptake of nutrients by plants) to improve water quality. This concept is based on the premise that wetlands have a higher rate of biological activity than most ecosystems and can transform many common pollutants into harmless byproducts or even into essential nutrients (Kadlec and Knight 1996, 3). However, to achieve these functions without overloading the system with pollutants, the design of the treatment wetland must include (among other considerations) sufficient retention capacity, freshwater inflows, and upstream best management practices (BMPs) such as catch basins to prevent trash in storm runoff from reaching the wetland.

Additional design considerations for the Ballona Freshwater Wetland System included its location within the Ballona watershed and provision for a wildlife habitat.

Performance of the Ballona Freshwater Wetland System as a treatment wetland was evaluated by comparing average modeled versus average measured outflow concentrations (Geosyntec 2010) (Table B-1). Average measured concentrations have been lower than predicted for total copper, total lead, total zinc, and nitrate. Other constituents such as total suspended solids and total phosphorus have been more variable, but compared to the range of outflow values reported in the International Best Management Practice Database, the system appears to be performing better than similarly designed treatment systems for dissolved phosphorus, nitrate, total copper, total lead, and total zinc (Geosyntec 2010). Despite extensive use of the wetland by wildlife, measured outflow densities of fecal indicator bacteria, such as total coliforms, have not exceeded 5,000 MPN/100 ml, and are more typically below 1600 MPN/100 ml. These values are in the lower end of the range of total coliform densities of 1,000 to 1,000,000 MPN/ 100 ml reported for tidal channels of the Ballona Wetlands and Ballona Creek (Dorsey 2006).

SUMMARY AND CONCLUSIONS

Overall, monitoring results indicate that the Ballona Freshwater Wetland System is performing better than predicted for biological and water quality parameters, thus serving as a model for other systems that may be contemplated for urban watersheds. However, in addition to the high construction costs, it should be noted that this system is not completely self-sustaining and is costly to maintain because of its position in a highly urbanized watershed.

Accordingly, it is critical that other contemplated systems account for ongoing, dedicated maintenance funding. With more than 160 environmental parameters monitored over the past six years, only a few results can be summarized here. Details are in the latest annual monitoring report for the Ballona Freshwater Wetland System (Read and Strecker, 2010). While the wetland system has met or exceeded conventional biological performance criteria such as habitat acreage, tree height, and dominance of native vegetation, there has been no greater surprise than the rapid return of bird species thought to have been extirpated at Ballona as breeding populations (Cooper 2006, 2008). One example is the least bittern *(Ixobrychus Exilis)* a Species of Special Concern which was first observed nesting in the freshwater marsh in 2005, only two years after construction was completed. A more recent example is the Virginia rail *(Rallus limicola)*, first observed nesting in the riparian corridor in 2009 and believed to be the first breeding record at the Ballona Wetlands since 1902 (Cooper 2009).

Photo of Freshwater Marsh

REFERENCES

1. Camp Dresser and McKee (CDM) (1992). "Surface Water Quality, Technical Appendix to the Playa Vista First Phase Draft", EIR. State Clearinghouse No. 90010510.
2. Cooper, Daniel S., 2006. "Annotated checklist of extirpated, reestablished and newly-colonized avian taxa of the Ballona Valley, Los Angeles, California. Bulletin of the Southern California Academy of Sciences 105: 91-112.
3. Cooper, Daniel S., 2008. "The use of historical data in the restoration of the avifauna of the Ballona Wetlands, Los Angeles County, California." Natural Areas Journal 28: 83-90.
4. Cooper, Daniel S., 2009. "Breeding bird survey, Playa Vista Riparian Corridor and Ballona Freshwater Marsh – South." Report prepared for E Read and Associates, Inc., October 5, 2009.
5. Dorsey, John H., 2006. "Densities of fecal indicator bacteria in tidal waters of the Ballona Wetlands, Los Angeles County, California." Bulletin of the Southern California Academy of Sciences 105(2): 59-75.
6. Geosyntec, 2010. "Post-Development Assessment of Freshwater Marsh Wet-Weather Performance." Technical memorandum prepared for J. Marc Huffman, Ballona Wetlands Conservancy.
7. Kadlec, Robert H. and Robert L. Knight, 1996. Treatment Wetlands. CRC Press, Inc.
8. Moshiri, Gerald.A., 1993 (editor). Constructed Wetlands for Water Quality Improvement. CRC Press, Inc.
9. Read, Edith and Eric Strecker, 2009. "Ballona Freshwater Wetlands Annual Report of Monitoring, Operation, and Maintenance October 1, 2008 – September 30, 2009." Prepared for J. Marc Huffman, Ballona Wetlands Conservancy.

Table B-1: Predicted vs. Measured Wet-Weather Constituent Concentrations for the Ballona Freshwater Wetland System

Modeled Constituent	Units	Modeled Average Concentration[a]	Average (Range) of Wet-Weather Grab Samples, 2004-2009[b]	95% Confidence Interval of the Average Retention Pond Effluent Concentrations from International BMP Database (Oct. 2007)	Interquartile Range (25th - 75th percentiles) of Retention Pond Effluent Concentrations from International BMP Database (Oct. 2007)
Total Suspended Solids (TSS)	mg/L	10.2	20.5 (6-63)	22.1-29.2	4.3-28.3
Total Phosphorus (TP)	mg/L	0.06	0.23 (0.01-0.63)	0.28-0.56	0.06-0.28
Dissolved Phosphorus (DP)	mg/L	0.03	0.06 (0.002-0.24)[c]	0.08-0.12	0.04-0.12
Total Nitrogen (TN)	mg/L	0.56	1.39 (0.8-2.1)[d]	1.23-1.55[e]	0.77-1.57[e]
Nitrate (NO3)	mg/L	0.23	0.15 (0.1-0.37)	0.37-0.70	0.11-0.63
Total Copper (TCu)	ug/L	8.17	5.65 (1.8-11)	8.9-12.2	3.1-9.0
Total Lead (TPb)	ug/L	23.86	1.2 (0.2-2.5)	11.4-16.0	1.0-15.8
Total Zinc (TZn)	ug/L	41.51	20.97 (3.5-50)	28.3-37.6	7.2-37.2

a. *Computed from modeled annual load and modeled annual runoff volume leaving the Freshwater Marsh as reported in Playa Vista Phase I Environmental Impact Report (EIR) (CDM, 1992)*

b. *Detection limits were substituted for all non-detects prior to computing summary statistics.*

c. *DP is not monitored, therefore orthophosphate (PO4-P), which is the most bioavailable form of phosphorus and typically the largest component*

d. *TN is not monitored, so the calculated sum of total Kjeldahl nitrogen (TKN), nitrate, and nitrite is compared to the modeled TN value.*

e. *TKN reported from the BMP Database as TN was not summarized.*
International BMP Database – www.bmpdatabase.org

CASE STUDY C: MULTI-OBJECTIVE STORMWATER MANAGEMENT PROJECTS IN CHINO CREEK WATERSHED

This paper presents two related case studies of successful stormwater management: (1) the Chino Creek Wetlands Park; and (2) the Inland Empire Utilities Agency (IEUA) Headquarters. The IEUA Headquarters (HQ) project is considered an example of on-site stormwater management and could be classified as an example of Low-Impact Development (LID); whereas the Chino Creek Wetlands Park (the Park) is primarily a regional project since it was designed to handle flows from off-site. Both are successful and completed stormwater management efforts that were part of the overall plan for development of IEUA's new regional facilities complex. The HQ occupies 14 acres and the Park, which was developed a few years later, occupies an adjoining 23 acres. Both projects have objectives of flood mitigation, capture and infiltration of stormwater runoff, water quality improvement, and habitat creation.

BACKGROUND

Starting in the late 1990's, the Inland Empire Utilities Agency (IEUA) bought land for a new regional facilities complex in the southeastern area of the City of Chino, about 35 miles southeast of downtown Los Angeles. In the early 2000's, construction of IEUA's largest and most technologically-advanced wastewater treatment facility began at the site, as did innovative projects in manure treatment, energy generation, and the first Agency-owned, LEED-certified HQ.

The site is located near the lower end of the Chino Creek watershed, north of the Prado Dam flood control basin and wetlands. As a tributary to the Santa Ana River, it is a source of water supply for Orange County. The Chino Creek watershed is approximately 10,957 acres and is comprised of the following land uses: 1,691 acres residential, 3,949 acres open space/agricultural, and 5,317 acres industrial/commercial. The smaller tributary area whose flow is routed to both the Park and the HQ is 700 acres and is comprised primarily of commercial and industrial land uses.

Chino Creek starts at San Antonio Dam in the north and it ends at the Santa Ana River within the Prado Basin wetlands area. Approximately two-thirds of the channel has been engineered, concrete-lined, and maintained by the San Bernardino County Flood Control District. However, downstream of Central Avenue, the channel is unlined as it flows through relatively undeveloped portions of the cities of Chino and Chino Hills and onto federal property managed by the Army Corps of Engineers. Along the unlined section of the channel, future plans include potential concrete lining and eventually a major storm sewer system, but currently much of the tributary area is used for open space, agriculture, passive recreation, and prison property. In 2001, the unlined portion of Chino Creek was starting to show signs of stress due to increased development and there were areas of extreme erosion where storm drains from new developments discharged into the creek. Water quality concerns had been identified in that section and Chino Creek was on the Clean Water Act Section 303(d) list of impaired water bodies due to pathogen indicator levels.

Prior to IEUA's land purchase, the site was occupied by an operating dairy farm. Due to the environmental problems associated with dairy farm operations, the site was considered to be degraded. Flooding on the adjacent El Prado Road was a frequent event. Site runoff was surface flow via a natural stream, which ultimately discharged into Chino Creek.

PROJECT DESCRIPTION

In the fall of 2001, a stormwater design charette was held to consider both traditional and innovative structural alternatives and BMPs to handle the stormwater coming to the HQ site. The charrette was modeled after the 2000 LA County Public Works Department's Watershed Department's Alhambra HQ's Parking Lot Charrette. It was attended by City of Chino engineers, consultants, a retired LA County Deputy Director, Treepeople, and IEUA staff. Consideration was given to stormwater infiltration, detention, treatment, water conservation, recycled water, habitat restoration, native and California adaptive landscape palettes, and flood protection. The importance of controlling project costs and schedule were always stressed, which ultimately led to the HQ being a design/build project and being completed within 18 months from the charrette. In addition, tools and methods of tracking costs and cost-effectiveness for the projects were developed. Efficacy was a management approach that started in the planning phase and carried through construction.

On-site Project – IEUA Headquarters

The IEUA HQ, a LEED Platinum facility, was designed to meet all LEED requirements for both site and water, including stormwater, and became a demonstration of on-site BMPs. This site is an aesthetically pleasing site, with outdoor opportunities for staff, including picnicking. It has provided opportunities for extensive public outreach, including numerous tours and demonstration visits. It has also provided many educational opportunities, since this was considered an integral component to the design.

Based on the City of Chino's Stormwater Master Plan, as a condition of approval to build the HQ, IEUA would have been required to construct a 10 ft x 10 ft box culvert to transport stormwater flows from the HQ site all the way to Chino Creek. The City would have required the box culvert to be sized to also handle the runoff from several hundred acres lying north of the IEUA property. This is labeled as the "conventional" approach in the cost section later in this paper.

At the 2001 HQ stormwater design charette, several less conventional solutions emerged which were later implemented, including elimination of the box culvert to Chino Creek and retention of the design storm on-site.

The goals of the HQ site comprised four main activities which were both internally driven as well as requirements for LEED Platinum certification:

- Maximize open space, native plants, and habitat
- Reduce stormwater
- Treat stormwater
- Use of recycled water

All four of these elements involved specific requirements and calculations for LEED certification, but played a role in accomplishing and succeeding in the individual objectives.

Maximizing open space involved conserving existing natural areas, restoring damaged areas (dairy farm activities), providing habitat and promoting biodiversity within the vicinity. The Agency reduced the development of its footprint (site area, building footprint, future building expansion, parking lot, water feature and pavement) to exceed the local zoning open space requirement for the site by 25%.

Reducing stormwater flow involved eliminating runoff and contamination and increasing on-site infiltration by limiting the disruption of natural water flows. The site was graded in such a way as to create an on-site retention basin with a capacity of 75.9 acre-feet. This was in addition to the infiltration capacity of the site itself and the parking lot. Reuse of stormwater was not done at the site, as it was seen as not cost-effective and potentially O&M intensive.

It was estimated that the site could retain a 25-year storm event with a controlled release of 80 cfs. The roof drainage system receives and conveys storm water to the storm drain system by following a flow pattern that maximizes infiltration and minimizes runoff. All storm drain pipes discharge into the channel and pond between the buildings. Many of these pipes are perforated to increase infiltration prior to the channel and pond.

The treatment of stormwater was accomplished by focusing on both suspended solids and phosphorus by limiting disruption of natural water flows by eliminating stormwater runoff, increasing on-site infiltration and using vegetation and the natural biota in soil to treat stormwater contaminants.

Infiltration and retention basins were used to estimate the removal of pollutants (Total Suspended Solids [TSS] and Total Phosphorus [TP]) from on-site storm runoff produced from an 85th percentile 24-hour storm event ("first flush" storm runoff). Bio-filters and bio-swales are included as pre-treatment for the infiltration/retention basins. The large wet pond is also used as a BMP facility. The majority of the parking areas have permeable surfaces which provide additional stormwater treatment, thus improving water quality.

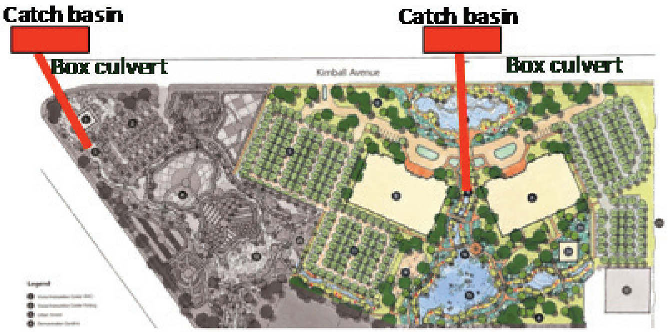
Recycled water from the adjacent Regional Wastewater Treatment Plant No. 5 (RP-5) was considered to be a critical component for reducing water consumption and demonstrating water conservation practices. Recycled water is an important product of the Agency. Demonstrating the use of this water on grass lawns and native and California adaptive plants is still seen today as important in overcoming barriers to its use.

Regional Project – Chino Creek Wetlands Park

In concept, this project was modeled after the Sepulveda Basin in Los Angeles, where a public park is a part of the flood control system. The purpose of this project was two-fold. The first objective was to detain, infiltrate and treat stormwater from the upper, off-site watershed and tributary areas; and the second was to be a demonstration site for different types of constructed wetlands so that developers in the area would understand the most cost-effective wetland type for their projects. At the time, there were no published results of various wetland treatment types for stormwater; one project had only been done as a small pilot, and cost information was not clear. Developers were very interested in understanding if there was a wetland type that had a small footprint, reasonable capital and O&M cost, and was reliable over time so that regulations were met consistently. Having different types of wetlands operating in parallel would provide comparable treatment data.

The Park was designed to capture and infiltrate flows generated from up to a 25-year frequency design storm as well as to attenuate flows from the 100-year storm event (395 cubic feet per second (cfs)) from the upper tributary area of 700 acres.

Stormwater enters the Park from two reinforced concrete boxes on the north and northwest of the site. Flow from the upper tributary area was estimated to be 100 cfs at the north location and 295 cfs at the northwest location at full build-out. Currently, a 3 ft x 10 ft box culvert transports this flow under Kimball Avenue in the north location into an unlined channel and then a detention pond before entering the Park for treatment.



The detention basin is set up to divide the flow into three types of wetlands:

- Subsurface Flow
- Surface Emergent Marsh/Pond Habitat
- Cottonwood/ Native Willow Riparian Channel

The Park design also included small surface flow channels and swales, called bioswales, in order to provide further water quality improvement and create habitat and native flora and fauna.

Both the subsurface flow and surface type of wetlands were expected to provide water quality improvement as well as retaining storm flows on-site. The subsurface wetlands were designed based on a pilot project that was completed at a local dairy previous to the design of the park.

Surface Wetlands Shortly After Construction

Subsurface Flow Wetlands at Chino Creek Park

The Cottonwood/Native Willow Riparian Channel was designed to mimic natural wetlands typically found in southern California and in this region.

Riparian Channel Wetlands Shortly After Construction

The wetland basins were all designed so that grab sampling could occur as well as electrical outlets for automatic sampling if desired. Key Operations and Maintenance (O&M) personnel were involved in the design to promote ease of maintenances. While the site looks very organic, the entire site is set up for easy re-routing of flow from one basin and/or wetland to another, so that cleaning out of basins, such as vegetation removal, can be done.

The upland areas of the Park have trails, habitat and open space. These areas were designed for detention and sheet flow of stormwater. The bioswale is in this area on the western side. Open areas were planted with native vegetation and mulched with compost. After traversing through the wetlands and the habitat, flow is discharged under El Prado Road and then surface flows on the western side of El Prado Road in an existing flow pattern into Chino Creek.

Chino Creek Park Native Plant Upland Habitat

STORMWATER MANAGEMENT PRACTICE BENEFITS AND COSTS

Table C-1 presents cost data and storage volumes for both the HQ and the Park. Because projects are usually constructed where there is more than one storm event per year, it was considered appropriate to assume the cost per unit storage volume on an annual basis and not a one-time event basis.

Table C-1: Summary Cost Data - Chino Creek Watershed Projects

Description	Storage Volume (acre-feet)	Capital Cost	Annual O&M Cost	Total Cost (Capital + O&M[1])	Total Cost Per Unit Storage Volume ($/acre-feet)[2]
Regional Project					
Chino Creek Park Wetland treatment, infiltration, recycled water, detention	91	$3,000,000	$20,000	$3,020,000	$33,187
Onsite Project					
HQ - Parking Lot and on-site Infiltration, recycled water habitat, detention, treatment	25	$1,827,150	$35,000	$1,862,150	$74,486

1. *Total costs are off-set for annual $18,000 savings due to parking lot design -included in total O&M costs.*
2. *The storage volume is an annual number and assumes five storm events per year with the capacity in the ponds available. Also, the values may be low as storage volume relates to the actual ponds and basins constructed and not on-site swales, infiltration in the vegetated ground, storage under the porous concrete, etc., particularly for the HQ.*

IEUA Headquarters

Table C-1 indicates that the total cost per unit storage volume was less than half for the regional project (the Park) than for the on-site project (the HQ). However, the environmental benefits of the HQ design cannot be overemphasized. Furthermore, the cost of the HQ was considerably less than it would have been if it had been designed according to the conventional approach originally requested by local government agencies (see Table C-2). The conventional approach, in this case, would have been to build an underground box culvert large enough to convey the runoff from the HQ site, as well as 700 acres of upstream tributary area, all the way to a discharge point into Chino Creek.

Table C-2: HQ Actual Construction Costs Compared to Estimated Costs of Conventional Stormwater Conveyance Approach

Item No. Description	Unit Cost	Quantity	Headquarters	Conventional
Off-site Stormwater Management		1 L.S.	$621,879	$2,000,000 [1]
Hardscape Pavers (Vehicular)	$6.65	11,890 S.F.	$79,069	N/A
Precast Concrete Pavers (Pedestrian)	$5.50	11,077 S.F.	$60,924	N/A
Asphalt 2	$2.30	89,329 S.F.	$205,457	$434,774
Pervious Concrete	$7.50	12,000 S.F.	$90,000	N/A
Decomposed Granite (Vehicular & Pedestrian)	$3.00	29,760 S.F.	$89,280	N/A
Natural Gray Concrete (Vehicular)	$7.50	34,976 S.F.	$262,320	
Natural Gray Concrete (Pedestrian)	$7.50	22,400 S.F.	N/A	$168,000
Base 3 14" Class II (Vehicular Pavers)	$14.00	1,321 S.Y.	$18,496	N/A
4" Class II (Pedestrian Pavers)	$6.00	1,321 S.Y.	$7,385	N/A
6" & 4" Class II (Vehicular Asphalt)	$8.00	9,925 S.Y.	$79,404	$168,028
10" _" Rock (Pervious Concrete)	$15.00	1,333 S.Y.	$20,000	N/A
4" Class II (Decomposed Granite)	$6.00	3,307 S.Y.	$19,840	N/A
4" Class II (Vehicular Concrete)	$6.00	34,976 S.Y.	$209,856	N/A
4" Class II (Pedestrian Concrete)	$6.00	22,400 S.Y.	N/A	$134,400
Storm Drain		1 L.S.	$42,289	$87,070
Boulders	$73.26	286 Each	$20,953	N/A
Curb & Gutter	$13.00	19,400 L.F.	N/A	$252,200
TOTAL COST:			**$1,827,150**	**$3,244,472**
HEADQUARTERS SAVINGS: (Net Incremental Savings)				**$1,417,322**

Note 1: This was the cost IEUA estimated they would have had to pay for the 10 ft x 10 ft box culvert originally requested by local government agencies.

Cost Savings

Knowing that the biggest issue for stormwater BMP projects had been the uncertainty and debate over the actual costs of construction, careful data collection from the contractor was enforced.

Cost savings realized with the IEUA HQ design approach included the following:

- Estimated capital cost savings of over $1.4 million compared to the conventional approach, which would have required construction of a major box culvert to convey local runoff to a creek discharge point
- O&M savings of $18,000/ year due to ability to wash vehicles on the porous parking lot
- Reduction in HVAC costs due to reduction in heat island effect (reflectivity and shading)

Environmental Values

The area surrounding the IEUA HQ is recognized as being part of a critical transitional zone that buffers the aquatic and wildlife resources of the Prado Basin from the urbanized environment. Because the HQ site was previously a dairy farm, the habitat value had deteriorated. Along Chino Creek, even though there were some areas that were considered to be flourishing riparian and floodplain habitat, other areas were overwhelmed with exotic species and deteriorated habitat. Recognizing the special environmental values of the area, the Agency reduced the size of its footprints (site area, building footprint, future building expansion, parking lot, water feature and pavement) and set a goal to optimize open space locations surrounding the HQ. Maximizing open space involved conserving existing natural areas, restoring damaged areas (dairy farm activities), providing habitat and promoting biodiversity within the vicinity.

Chino Creek Wetlands Park

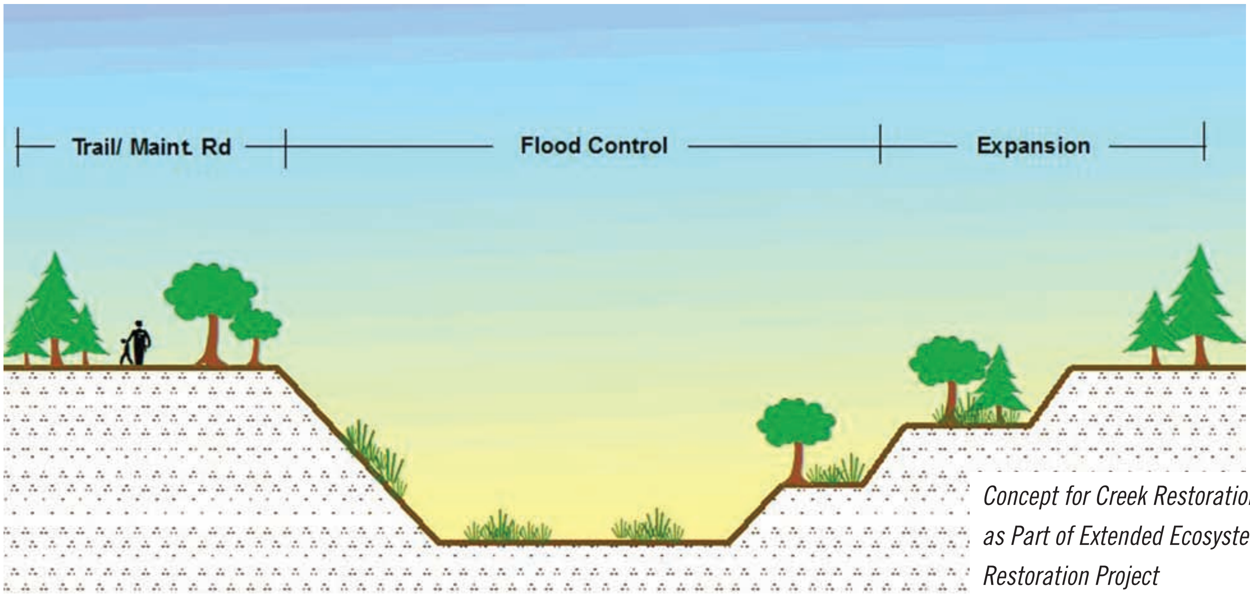
Chino Creek Wetlands Park was intended to provide flood mitigation via peak flow reduction, demonstrate which wetland type was the most cost-effective for developers, capture and infiltrate stormwater, provide habitat for endangered species, and provide an educational and recreational area for the community. It is assumed that there are some stormwater recharge benefits as well as stormwater quality improvement via removal of polluted water.

Cost Savings

The capital cost of the Park and the cost per unit storage volume (annual storage volume) were shown above in Table C-1. As a regional project, the Park was very cost-effective on the basis of cost per unit volume of stormwater captured. Although it is not a perfect apples and apples comparison, the data that was collected does seem to indicate that the cost per unit volume of water stored was much lower for the Park system than for the on-site system (the HQ). Another cost savings was the avoided cost associated with the treatment of stormwater flowing into Chino Creek.

Regional Benefits

The Chino Creek Park Wetlands was planned to function as a component of a larger Ecosystem Restoration Project involving Chino Creek and other tributaries that impact the Prado Dam flood control basin. The velocity of the tributaries entering the Prado Basin as well as the increased flow due to urbanization are contributing factors to erosion and sedimentation problems that need to be addressed in relation to Prado Dam. The Chino Creek Park Wetlands project helps to address water and sediment transport issues by redirecting flows and adding detention basins upstream of the Dam. In addition, the project protects the endangered birds that are located in vegetation in the wetlands north of the dam by establishing habitat further up in the watershed.



Concept for Creek Restoration as Part of Extended Ecosystem Restoration Project

Reduction of Flooding

One of the major goals for this project was to reduce flooding and erosion in a creek which crosses built-up residential, commercial, and industrial property. Stormwater runoff has significantly increased in this area over the last two decades. The 2.5--mile unlined reach of Chino Creek has areas of severe erosion and unstable slopes and other areas where illegal dumping of construction debris line the banks. Without implementation of projects such as the Chino Creek Wetlands Park, the escalating problems associated with outdated flood control strategies, flooding and erosion will continue to impact Chino Creek and the Prado Dam. The ultimate conceptual plan for ecosystem restoration along Chino Creek involves rehabilitation of over 25 acres, including stabilizing slopes, removing outdated berms to allow meandering, earthwork moving for modifying drainage paths, and creation of detention basins for flow detention.

Environmental Values

In addition to decreasing flooding and erosion, this project has enhanced environmental values by contributing to the improvement of water quality in Chino Creek, re-establishing riparian habitat, and restoring a riverine corridor. Conservation of plant and wildlife resources within this region is an important goal of the region.

Chino Creek currently receives poor quality nuisance runoff from upstream properties. In 1998, the California Department of Parks and Recreation specifically identified the protection and enhancement of riparian habitat in this area as a critical element in the long-term protection of the riparian-dependent species in the Prado Basin. In addition, the following environmental benefits are associated with the Park:

- Unique habitat, designed for many native animals, including endangered birds such as the least Bell's Vireo and the Burrowing Owl.
- Extensive public outreach – numerous tours and demonstration visits are held, particularly for schools, using the Park's amphitheater, which was designed for students.
- Educational opportunities – since this was an integral component to the design, science teachers participated in the facility layout.

Chino Creek Wetlands Park and Student Visitors

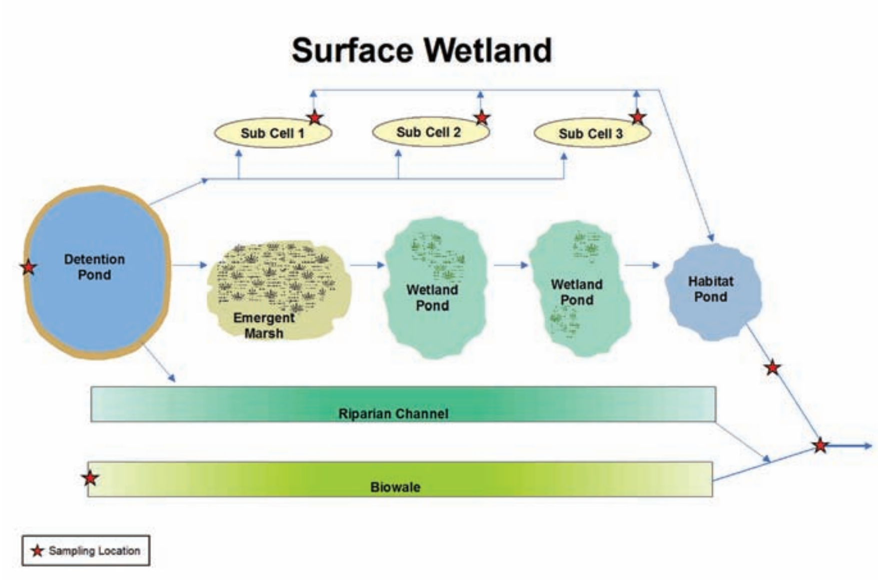
Creative arrangements were sought to minimize operation and maintenance costs for the Park. Being a multi-purpose site, an agreement was formed with Santa Ana Watershed Authority (SAWA), a non-profit organization, to maintain much of the Park vegetation, reducing O&M costs to IEUA.

WATER QUALITY RESULTS AND DISCUSSION

Chino Creek Wetlands Park

The overall goals for the Park included not only detaining and treating stormwater, but also determining the most cost-effective means of stormwater runoff treatment for both public and private developments using natural systems and designs. Monitoring of the wetlands was done during the 2007/2008 rainy season. IEUA collected and analyzed samples on nine different occasions during the reporting period of October 1, 2007, through March 31, 2008. Because the majority of the 700 acres of tributary area north of the Park was still in an undeveloped state, there was not much runoff flowing into the Park when it rained, and what did flow in tended to infiltrate or accumulate on-site. Therefore, except during one very large storm event, on February 24, 2008, a majority of the water entering and leaving the Park was recycled water. So, those sample results are more representative of recycled water treatment than stormwater treatment performance.

The Park system is designed to utilize recycled water from IEUA's Regional Water Recycling Plant No. 5, so that the wetlands vegetation has a water source year-round. The recycled water entering the park meets Title 22 recycled water requirements; therefore, large removal rates of pollutants were not anticipated, particularly bacteria and metals. Still, the Park wetlands showed an overall good performance in treating water, with measurable removal rates of metals, nitrogen, turbidity and total organic carbon. On the following page is an illustration of the wetlands in parallel and in series at Chino Creek Park.



As illustrated, there was one influent sampling station before the first detention pond and one at the start of the bioswale. Flow was directed from the first detention pond into the subsurface and surface wetlands. The level in the pond never became high enough for there to be overflow from the detention pond into Riparian Channel. There was an effluent sampling station at the end of each of the three subsurface wetland cells, making it possible to determine the removal rates due to each treatment cell. There was a final effluent sampling station, which was a combination of the effluent from the surface ponds and the subsurface wetlands. There was another effluent station for the bioswale, but there was never any significant discharge from the bioswale, so the station was used to sample mainly local runoff from the site and the riparian channel. The bioswale does not receive recycled water except for irrigation.

During the February 24, 2008 storm event, the subsurface wetlands removed 97.7% to 99.9% of all bacterial indicators—total and fecal coliform, E. coli, and enterococcus. The results were similar for the combined subsurface and surface wetland effluent, except E. coli removal was only 77%. These results could have been influenced by inputs of non-pathogenic bacteria from sources such as waterfowl in the ponds. The local on-site runoff sampling results were highly variable, with levels of total coliform and enterococcus similar to the levels in runoff coming from off-site. Fecal coliform and E. coli results, however, were lower in the on-site runoff than in the off-site runoff. During the long periods with no flow, there may have been an accumulation of constituents on the soil surface that the first storm flows picked up in the local runoff.

The monitoring results for wetland treatment highlighted that the subsurface system was very effective at treating stormwater runoff and removal of many heavy metals and bacteria. Maintenance was low as was the footprint area required for construction. However, the cost of construction per square foot was still higher than the surface emergent marsh/habitat wetlands or the cottonwood/willow woodland areas.

IEUA Headquarters

Influent sampling was performed at several locations on the HQ site where there were swales and drains; and effluent sampling was done at the detention pond. Sampling for water quality was completed for the 2004/2005 season with the following results:

- TSS was reduced by 89% (exceeding 80 % required by LEED)
- Total coliform was reduced by 95%
- Fecal coliform was reduced by 84%
- 80% of the 30 constituents that were tested resulted in removals ranging from 74% up to 95%.

It was estimated that the following quantities of pollutants would be prevented from flowing into Chino Creek over 20 years:

- Over 6 pounds of bacteria, 1,600 pounds of oil & grease, and 2,400 pounds of nitrogen
- A total of two million pounds of organic and inorganic constituents.

The IEUA HQ was a combination of many stormwater BMPs. Several of the highlights of the BMPs implemented at the HQ are summarized below.

HQ BMP — One of Several Swales and Drains Capturing Stormwater

Approximately 60% of the parking areas have permeable surfaces, which not only decreases impacts on infrastructure, minimizing costs, but also reduces stormwater flows and treatment and improves overall water quality.

While the site is considered unique due to the combination of stormwater BMP elements, the actual BMPs themselves are not unique. For example, swales have been designed and constructed on the east coast for decades as well as over a decade in Santa Monica and Arizona. Perforated pipes are used to infiltrate both grey water and wastewater and are standard for septic systems. Vegetated lined channels with high storm flow velocities have been done in Arizona for over a decade as have roof drains and curbless or gutterless street designs.

The capture and infiltration results at the HQ site were much better than anticipated during design. It is believed that it was the combination of all of the BMPs that contributed to the increased infiltration, capture and greater than expected capability of the site to function under a larger than designed storm event. A 100-year storm event in early 2004 resulted in the site infiltrating or detaining all stormwater flow. The infiltration rate of the soil used for infiltration calculations was conservative and based on the one soil boring for the approximately 100-acre site, which indicated that it would not percolate. This assumption did not take into account that after construction, the compaction rate would not be the same as undisturbed soil.

SUMMARY AND CONCLUSIONS

Using the multi-objective approaches embraced in 2001 at the HQ stormwater charrette, IEUA designed and developed two projects that assist in the discussions and management decision-making efforts regarding the true costs and benefits associated with regional and on-site stormwater projects. It took considerable leadership to move forward with implementing many of the stormwater BMPs and approaches that at the time were not considered conventional, particularly for southern California. By addressing options and bringing in experts early, working with public officials and public works departments, and then keeping track of actual costs during construction, the process was successful and information was made available for others to utilize.

Being able to provide cost-effective solutions not only to those spending public tax dollars, but also to those spending private dollars is considered the right way of spending public funds. Although comparing the costs of the regional system (the Park) with the on-site LID approach (the HQ) may not be a perfect apples and apples comparison, the data that was collected does seem to indicate that the cost per unit volume of water stored was much higher for the on-site system than for the regional system. However, the cost of the HQ project was estimated to be considerably less than it would have been if it had been designed as a conventional project, where all the stormwater would have been conveyed as quickly as possible to a creek discharge point. Moreover, the surprise that not only did the HQ project work as designed during a 100-year storm event, but better, handling the entire flow by infiltrating and detaining, was rewarding to many and validating for those on the fence of BMP viability.

The performance and collective benefits of the IEUA HQ stormwater system were greater than expected. This is a demonstration that both the larger regional projects and the smaller-scale, on-site projects have cost advantages. Collectively, these projects will be integral in answering the comprehensive water issues and saving money at all levels.

It cannot be emphasized enough how critical and valuable the tracking of the construction costs have become over the years in validating stormwater management approaches. For future projects, the verification of cost results and building of standardized databases will be valuable for advancing the solution of regional water issues in southern California.

CASE STUDY D: LOW IMPACT DEVELOPMENT (LID) AND WATER CONSERVATION DEMONSTRATION AND TESTING FACILITY AT RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT HEADQUARTERS

BACKGROUND

This $2,500,000 retrofit project incorporates state-of-the-art water conservation and low impact development (LID) technologies at the District's headquarters in Riverside, California. The project started construction in August of 2011 and is expected to be completed by January 2012.

The testing and demonstration project will evaluate constructability, maintainability and performance of LID integrated management practices in managing and conserving runoff in Riverside. The Low Impact Development and Water Conservation Demonstration and Testing Facility is part of a three pronged plan to promote effective conservation and treatment of runoff from new development in Riverside County through standardized design guidance, deployment of effective maintenance mechanisms and proactive effectiveness assessment of the LID Integrated Management Practices (IMPs). The data collected as part of this project will be used to improve the design and deployment of these LID IMPs in the future.

This project is part of a statewide effort supported by the Santa Ana Watershed Project Authority, Stormwater Monitoring Coalition of Southern California, California Stormwater Quality Association and State Water Resources Control Board to promote the use of LID and water conservation technologies. The Santa Ana Watershed Project Authority also facilitated a $475,000 Proposition 13 grant from the State Water Resources Control Board for this project on the District's behalf. Monitoring results will also be incorporated in the American Society of Civil Engineers International Stormwater Best Management Practices Database.

Additional information is available at www.rcflood.org/lid.aspx.

PROJECT FEATURES

The project is located at the District's 15 acre campus located in downtown Riverside, California.

The major LID IMPs of the project include (See Figure D-1):

- Conversion of approximately 8,400 square feet of existing impervious asphalt to porous asphalt and porous concrete.
- Construction of two planter boxes that will treat runoff from the roof of the District's office.
- Construction of a bioretention IMP.
- Replacement of 600 feet of curb, gutter and storm drain with a vegetated infiltration swale.
- Replacement of approximately 41,500 square feet of asphalt with pervious pavers.
- Construction of 10 monitoring stations for water quality monitoring and water conservation measurement.
- Conversion of approximately 5 acres of landscaping to California friendly landscaping, including conversion to purple pipe to facilitate future reclaimed water delivery.

STUDY DESCRIPTION

Ten monitoring stations are incorporated into the project to facilitate IMP evaluation. Each tested IMP includes impermeable liners around the structural section of the IMP to facilitate estimation of the "worst case scenario" water quality and volume reduction benefits that may be achieved by the IMPs. It is expected that once the minimum benefits have been calculated, this information can be combined with in-situ soils data from future projects to estimate actual stormwater volume capture and pollutant load reduction benefits that may accrue from IMP deployment.

The monitoring stations will evaluate LID IMPs by:

- Measuring IMP water quality benefits by comparing effluent water quality with water quality measured at representative parking lot and roof control areas for various pollutants of concern; and
- Measuring IMP volume reductions and peak flow lag impact by comparing IMP runoff volume and flow rates with runoff volume and flow rates from representative parking lot and roof control sections.

The IMPs will additionally be evaluated by:

- Keeping records of constructability challenges and design issues encountered during construction of the IMPs; and
- Keeping records of IMP maintenance frequencies and issues over time.

Project Feature Selection Process

LID IMPs are being mandated for use by new developments and redevelopments through requirements contained in Municipal Separate Storm Sewer System Permits issued by the California Regional Water Quality Control Boards. The District therefore initiated efforts to develop design guidance ahead of the pending regulations. This guidance was published in 2011.

The LID IMPs selected as part of this project were taken from the District's 2011 Design Manual. The 2011 LID BMP Design Manual is based on research into existing IMP papers and guidance and consultation with national LID experts. However, many of the design elements contained in the LID Design Manual were ultimately based on theoretical assumptions from published papers or best professional judgment of our staff and the consulted experts. The District therefore determined that it was important to collect local data on the specific IMP designs contained in our LID Design Manual. Four different variations of porous pavement LID IMPs will be monitored for water quality and quantity impacts. Moreover, durability will be assessed for the different paving materials, including the impact of micro-fiber on the porous concrete's durability.

RESULTS AND DISCUSSION

Project construction is expected to be complete by January 1, 2012. Monitoring of the LID IMPs and other features of the project will be initiated shortly thereafter and is expected to continue for a minimum of five years.

Benefits Achieved Using Proposed Stormwater Management Practices

Qualitative Benefits

The project will implement a variety of LID IMPs that will be used to demonstrate the local application of these practices in contributing to basin water banking, storm water capture and management, including hydromodification, and water conservation. It is expected that the demonstration of these IMPs will assist in promoting their use throughout the watershed, thus amplifying the benefits of this project.

As a demonstration and training facility, the benefits described above will promote the increased usage of LID principles and IMPs throughout Southern California.

Quantitative or Measurable Benefits

Measurable benefits of the project will be determined through water quality and flow data collected starting in the Spring of 2012. The design volume capture capacity of the LID IMPs is approximately 0.5 AF.

The study will estimate the "worst case scenario" water quality and stormwater capture benefits of these IMPs by using impermeable liners to mimic the impact of impermeable in-situ soils. This data will help to estimate the minimum volume reduction, water quality treatment and hydromodification mitigation benefits of these IMPs. These benefits can then be adjusted upwards to reflect actual in-situ soils permeability for future applications.

The worst-case scenario volume capture data will also provide an accurate estimation of the stormwater volume incidentally captured by the IMPs, which can help facilitate future modeling of the impacts of these BMPs on groundwater recharge goals.

Benefit and Cost Consideration

As this project is still under construction, final IMP costs have not been calculated. However, future reports will include data on construction costs and operation and maintenance costs for each of the tested IMPs. The cost data, combined with water quality and volume capture data will allow cross-comparisons of the effectiveness of each of these BMPs, as well as comparisons of the IMP cost with other IMPs and regional stormwater management solutions being studied elsewhere.

The project will also evaluate IMP construction and operation and maintenance issues to inform future revisions of the IMPs conducted as part of updates to the District's 2011 LID Design Manual.

Finally, the project will serve as a demonstration facility to assist with training of municipal, regulatory and developer staff as well as members of the general public.

SUMMARY AND CONCLUSION

LID IMPs are being mandated for use by new developments and redevelopments through requirements contained in Municipal Separate Storm Sewer System Permits issued by the California Regional Water Quality Control Boards. However, detailed design guidance and actual effectiveness data for LID IMPs, particularly in semi-arid environments such as southern California, remains lacking.

This project is designed specifically to test and evaluate the volume capture, peak flow timing impacts and pollutant load reduction capabilities of several common LID IMPs as well as demonstrate other water conservation techniques including use of reclaimed water and California friendly landscaping. Data collected will include costs, construction and operation and maintenance data, pollutant reduction benefits and volume capture benefits and will facilitate future iterations of LID IMP designs. The project will also serve as a regional demonstration and training center for LID IMPs.

Figure D-1: Low Impact Development IMP Examples

(Completed IMPs as of 11/21/11)

CASE STUDY E: TREEPEOPLE CENTER FOR COMMUNITY FORESTRY

BACKGROUND

TreePeople is headquartered in 45-acre Coldwater Canyon Park, a City of Los Angeles park in the Santa Monica Mountains, located at the intersection of Mulholland Drive and Coldwater Canyon Avenue in Studio City. TreePeople sought to create a welcoming campus that would demonstrate low-impact development practices, provide an inspiring meeting space to address environmental challenges, and serve as a destination for schoolchildren participating in environmental education fieldtrips.

The 5-acre plateau upon which TreePeople Center for Community Forestry is located presents a unique set of conditions. The plateau and surrounding hillsides provide good opportunities for rainwater capture, but the site's location atop a hill, and the associated risks of mudslides and slope destabilization, make it a poor candidate for large-volume infiltration. As project manager, TreePeople elected to harvest the majority of rain that falls on the property – by capturing, filtering and storing it for use in irrigating the park's landscaped areas.

PROJECT DESCRIPTION

Constructed in two phases between 2003 and 2008, the complex is composed of several design elements:

Cistern

This underground rainwater storage tank has a capacity of 216,000 gallons, a 70 foot diameter and a depth of 15 feet. The cylindrical cistern stores water collected from the roofs of two nearby buildings as well as runoff captured from the parking lot. Rainwater is filtered prior to entering the cistern and is then stored until it is used to irrigate the planted landscape of native and other climate-appropriate species. Mulch and sub-surface drip irrigation help make the most efficient use of cistern water by minimizing evaporation. Construction costs for the cistern were $411,404.

The underground cistern, here seen under construction, holds up to 216,000 gallons of rainwater collected from surrounding surfaces.

Parking Grove

Recycled asphalt in the parking lot is coated with light-colored paint to reduce the heat-island effect and increase reflectivity. About one-third of the parking spaces are not paved and are instead filled with gravel, allowing rainwater to infiltrate naturally and vehicle toxins to be captured onsite and naturally filtered by gravel and soil. Trees are strategically planted to shade parked vehicles and reduce the emissions of volatile organic compounds that occur when parked vehicles heat up. Rainwater that flows across the impervious asphalt surface is directed toward a trench drain and then sent to a gravel swale outfitted with a perforated pipe, where, when volumes are sufficiently high, it is directed to the cistern for storage. Catch basins are fitted with debris collectors that trap leaves and other organic matter, and "FloGard" filters manufactured by KriStar that reduce hydrocarbon loads in runoff.

The Parking Grove is coated with light-colored paint to reduce heat retention. A third of the parking spaces are filled with gravel instead of being paved.

La Kretz Urban Watershed Garden

This outdoor space features various elements designed to help schoolchildren and park visitors understand current urban environmental challenges and visualize nature-inspired solutions. Two functioning single-family home models, approximately ten feet high, show differences in water use and management between a conventional urban home and its more sustainable counterpart. On the "urban urgencies" side, water is wasted: thirsty turf, sprinkler overspray, standard gutter downspouts directed toward impervious surfaces, and hoses used to spray sidewalks and driveways combine to waste water. On the "sustainable solutions" side, concrete is broken up to create areas for water to infiltrate, bioswale depressions with drought-tolerant landscaping collect and filter rainwater, trees shade the home, and a rain barrel (fashioned from a repurposed 60-gallon commercial food container) stores water collected from the roof and provides a source of irrigation water.

On the "sustainable solutions" side of the La Kretz Urban Watershed Garden, rainwater flows into a rain barrel for later irrigation use, or into a swale where it is absorbed into soil.

TreePeople Conference Center

This 3,870-square-foot meeting space, designed by architecture firm Marmol Radziner and Associates, received the highest possible rating – LEED Platinum – from the U.S. Green Building Council through its Leadership in Energy and Environmental Design green building rating system. The building's many sustainable features include dual-flush toilets that conserve water, and a roof sloped to direct rainwater to a spout that flows into a sand pit, where water is filtered and then released into a cistern.

S. Mark Taper Foundation Environmental Learning Center

This 750-square-foot building provides a space for workshops and other educational events. In place of a conventional downspout, the structure has a rain chain that directs water to the cistern. Twenty-four solar panels atop the building provide a portion of the energy required to operate TreePeople Conference Center.

The W.M. Keck Foundation Nursery

The nursery is used to cultivate and care for young trees in preparation for restoration projects in local mountain and parkland areas.

RESULTS AND DISCUSSION

The demonstration site at TreePeople Center for Community Forestry illustrates a variety of benefits achievable through low impact development practices and green design.

Since its first year of operation in 2008, the 216,000-gallon cistern has filled to capacity from winter rains. The cistern was sized to meet the site's irrigation needs, and the irrigation system was designed for high efficiency through use of bubblers, sub-surface drip lines and generous amounts of mulch applied throughout the landscape. In practice, stored water in the cistern has thus far provided sufficient irrigation water to preclude the use of potable municipal water each year.

Whereas prior to being retrofitted the site used to contribute runoff to the Los Angeles River Watershed, virtually no runoff leaves the site as a result of the practices demonstrated on site. The notable exception is overflow from the cistern, which, after being filtered, is conveyed to a natural creek located in a canyon just downstream of the cistern.

The use of predominantly California-native plants provides multiple benefits, including water conservation and wildlife habitat, while the use of high-albedo paint coating on asphalt surfaces keeps surface temperatures down during the hot summer months.

Since October 2011, Los Angeles County Department of Public Health, Cross Connections and Water Pollution Control Program, has collected and tested water samples from the cistern. While monitoring has just begun and results are limited, pollutant loads were generally found to be low or not detectable, with the exception of fecal and total coliform. It should be noted that the samples were collected early in the rainy season and that results first-flush runoff containing months of dry-weather atmospheric deposits, bird and wildlife droppings, and other pollutants. Samples taken later in the rainy season are expected to have lower pollutant loads. The most recent lab results are included at the end of this case study (Figure E-1).

SUMMARY AND CONCLUSIONS

TreePeople Center for Community Forestry demonstrates a variety of low-impact development practices, from simple, do-it-yourself options for area residents and their families to tackle as weekend projects (e.g., downspout redirects or rain gardens), to significantly more involved BMPs suitable for the institutional or municipal entities (e.g., large cisterns or high-albedo asphalt coating). The site receives upwards of 70,000 visitors a year, and since its completion has provided the multiple benefits of stormwater capture, runoff reduction, potable water demand reduction, wildlife habitat, heat-island mitigation, and public education. The site will continue to serve as testing ground for new techniques in urban stormwater and resource management in the future.

Figure E-1

COUNTY OF LOS ANGELES

Department of Agricultural Commissioner/ Weights and Measures

Environmental Toxicology Laboratory
11012 S. Garfield Ave.
South Gate, California 90280
http://acwm.lacounty.gov

Kurt E. Floren
Agricultural Commissioner
Director of Weights and Measures

Richard K. Iizuka
Chief Deputy

ANALYTICAL RESULTS

Workorder: E1102851 Alternate Water Systems-PH/CDC

Lab ID:	**E1102851003**	Date Received:	11/8/2011 14:11 Matrix: Water
Sample ID:	**3 (Tree People Cold Water)**	Date Collected:	11/8/2011 12:20
System Number:		Purpose:	
System Name:		Sample Type:	

Parameters	Results Units	Report Limit	MDL	DF	Analyzed	By	Qual	MCL
METALS, TOTAL								
Analysis Desc: EPA 200.8	Preparation Method: EPA 200.8							
	Analytical Method: EPA 200.8							
Copper	ND ug/L	50.0		1	11/17/2011 11:56	GS		
Lead	ND ug/L	5.00		1	11/17/2011 11:56	GS		
MICROBIOLOGY								
Analysis Desc: SM 9221B	Analytical Method: SM 9221B							
Total Coliform	30000 MPN/100mL	20.0		1	11/8/2011 14:30	TA		
Analysis Desc: SM 9221E	Analytical Method: SM 9221E							
Fecal Coliform	2400 MPN/100mL	20.0	20.0	1	11/8/2011 14:30	TA		
ORGANICS								
Analysis Desc: EPA 418.1	Preparation Method: EPA 418.1							
	Analytical Method: EPA 418.1							
Total Petroleum Hydrocarbons	ND mg/L	5.00	1.50	1	11/10/2011 12:30	OV		
Analysis Desc: EPA 624	Analytical Method: EPA 624							
1,1,1-Trichloroethane	ND ug/L	0.500		1	11/18/2011 23:18	THM		
1,1,2,2-Tetrachloroethane	ND ug/L	0.500		1	11/18/2011 23:18	THM		
1,1,2-Trichloroethane	ND ug/L	0.500		1	11/18/2011 23:18	THM		
1,1-Dichloroethane	ND ug/L	0.500		1	11/18/2011 23:18	THM		
1,1-Dichloroethylene	ND ug/L	0.500		1	11/18/2011 23:18	THM		
1,2-Dichloroethane	ND ug/L	0.500		1	11/18/2011 23:18	THM		
1,2-Dichloropropane	ND ug/L	0.500		1	11/18/2011 23:18	THM		
2-Chloroethyl vinyl ether	ND ug/L	2.50		1	11/18/2011 23:18	THM		
4-Bromofluorobenzene (SS)	2.00 ug/L	1.00		1	11/18/2011 23:18	THM		
Benzene	ND ug/L	0.500		1	11/18/2011 23:18	THM		
Bromodichloromethane	ND ug/L	0.500		1	11/18/2011 23:18	THM		
Bromoform	ND ug/L	0.500		1	11/18/2011 23:18	THM		
Bromomethane	ND ug/L	0.500		1	11/18/2011 23:18	THM		
Carbon Tetrachloride	ND ug/L	0.500		1	11/18/2011 23:18	THM		
Chlorobenzene	ND ug/L	0.500		1	11/18/2011 23:18	THM		

Report ID: 12092 - 302801

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Figure E-1

COUNTY OF LOS ANGELES

Department of
Agricultural Commissioner/
Weights and Measures

Environmental Toxicology Laboratory
11012 S. Garfield Ave.
South Gate, California 90280
http://acwm.lacounty.gov

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Richard K. Iizuka
Chief Deputy

ANALYTICAL RESULTS

Workorder: E1102851 Alternate Water Systems-PH/CDC

Lab ID:	**E1102851003**	Date Received:	11/8/2011 14:11 Matrix: Water
Sample ID:	**3 (Tree People Cold Water)**	Date Collected:	11/8/2011 12:20
System Number:		Purpose:	
System Name:		Sample Type:	

Parameters	Results	Units	Report Limit	MDL	DF	Analyzed	By	Qual	MCL
Chloroethane	ND	ug/L	1.00		1	11/18/2011 23:18	THM		
Chloroform	ND	ug/L	0.500		1	11/18/2011 23:18	THM		
Chloromethane	ND	ug/L	1.00		1	11/18/2011 23:18	THM		
Dibromochloromethane	ND	ug/L	0.500		1	11/18/2011 23:18	THM		
Dichlorodifluoromethane	ND	ug/L	0.500		1	11/18/2011 23:18	THM		
Ethylbenzene	ND	ug/L	1.00		1	11/18/2011 23:18	THM		
Methyl tert-butyl Ether (MTBE)	ND	ug/L	1.00		1	11/18/2011 23:18	THM		
Methylene Chloride	ND	ug/L	1.00		1	11/18/2011 23:18	THM		
Pentafluorobenzene (SS)	2.08	ug/L	1.00		1	11/18/2011 23:18	THM		
Tetrachloroethylene (PCE)	ND	ug/L	0.500		1	11/18/2011 23:18	THM		
Toluene	ND	ug/L	0.500		1	11/18/2011 23:18	THM		
Total Trihalomethanes	ND	ug/L	0.500		1	11/18/2011 23:18	THM		
Trichloroethene	ND	ug/L	1.00		1	11/18/2011 23:18	THM		
Trichlorofluoromethane	0.00	ug/L			1	11/18/2011 23:18	THM		
Vinyl Chloride	ND	ug/L	1.00		1	11/18/2011 23:18	THM		
cis-1,3-Dichloropropene	0.00	ug/L			1	11/18/2011 23:18	THM		
trans-1,2-Dichloroethylene	ND	ug/L	0.500		1	11/18/2011 23:18	THM		
trans-1,3-Dichloropropylene	ND	ug/L	0.500		1	11/18/2011 23:18	THM		
Analysis Desc: SM 4500-OG	Analytical Method: SM 4500-OG								
Dissolved Oxygen	2.94	mg/L	2.00	1.00	1	11/8/2011 14:11	THP		
WETCHEMISTRY									
Analysis Desc: EPA 300.1	Analytical Method: EPA 300.1								
Nitrate	ND	mg/L	2.00		1	11/10/2011 15:16	RZ		
Nitrate-N	ND	mg/L	0.450		1	11/10/2011 15:16	RZ		
Nitrite	ND	mg/L	0.100		1	11/10/2011 15:16	RZ		
Nitrite-N	ND	mg/L	0.0300		1	11/10/2011 15:16	RZ		
Analysis Desc: SM 2130B	Analytical Method: SM 2130B								
Turbidity	4.35	NTU	0.100		1	11/9/2011 14:45	KZ		
Analysis Desc: SM 2320B	Analytical Method: SM 2320B								
Alkalinity, Bicarbonate	42.9	mg/L	2.00		1	11/16/2011 10:00	JK		
Alkalinity, Carbonate	ND	mg/L	2.00		1	11/16/2011 10:00	JK		
Alkalinity, Hydroxide	ND	mg/L	2.00		1	11/16/2011 10:00	JK		

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3004.1.0.0

Figure E-1

COUNTY OF LOS ANGELES

Department of Agricultural Commissioner/ Weights and Measures

Environmental Toxicology Laboratory
11012 S. Garfield Ave.
South Gate, California 90280
http://acwm.lacounty.gov

Kurt E. Floren
Agricultural Commissioner
Director of Weights and Measures

Richard K. Iizuka
Chief Deputy

ANALYTICAL RESULTS

Workorder: E1102851 Alternate Water Systems-PH/CDC

Lab ID:	**E1102851003**	Date Received:	11/8/2011 14:11 Matrix: Water
Sample ID:	**3 (Tree People Cold Water)**	Date Collected:	11/8/2011 12:20
System Number:		Purpose:	
System Name:		Sample Type:	

Parameters	Results	Units	Report Limit	MDL	DF	Analyzed	By	Qual	MCL
Alkalinity, Total	42.9	mg/L	2.00		1	11/16/2011 10:00	JK		
Analysis Desc: SM 2340C	Analytical Method: SM 2340C								
Hardness (as CaCO3)	50.0	mg/L	5.00		1	11/16/2011 12:30	JK		
Analysis Desc: SM 2540C	Analytical Method: SM 2540C								
Total Dissolved Solids	90.0	mg/L	1.00		1	11/18/2011 12:43	LS		
Analysis Desc: SM 4500-Cl	Analytical Method: SM 4500-Cl								
Chlorine	ND	mg/L	0.100		1	11/8/2011 14:50	KZ		
Analysis Desc: SM 4500-H B	Analytical Method: SM 4500-H B								
pH	7.44	pH units	0.1		1	11/8/2011 15:35	KZ		8.5

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CASE STUDY F: ELMER AVENUE NEIGHBORHOOD RETROFIT PROJECT

BACKGROUND

Elmer Avenue Neighborhood Retrofit Project is a two-block community enhancement project located in the community of Sun Valley in the city of Los Angeles. The project was managed by the Council for Watershed Health and comprises work both in the public right-of-way (City of Los Angeles) and on private property (private property owners). The project is the demonstration phase of the LA Basin Water Augmentation study. The goal was to use a mixture of strategies to provide multiple benefits—reduce flooding and water pollution. The increase groundwater supplies, add green space, and enhance the community.

The 7700 block of Elmer Avenue was selected because of numerous problems connected to the lack of a storm drain system. Rather than install storm drains in Sun Valley, partners including the Los Angeles Flood Control District and City of Los Angeles chose to work with multiple partners to develop the Watershed Management Plan which is a blueprint for sustainable re-development and retrofitting to reduce flooding and enhance the community. Infiltration projects in this region of the city help to recharge the aquifer and reduce water-borne pollutants reaching the Los Angeles River.

Phase II of Elmer Avenue is under design currently. This two part project will more than double the capacity of the project to infiltrate stormwater (from 16 acre-feet/yr to 40 acre-feet/yr) through improvements in the upstream watershed and through an enhancement/infiltration retrofit of a one-block walkway (Paseo). These two enhancements will be completed in 2013.

Pre-project Condition

PROJECT DESCRIPTION

Project Details

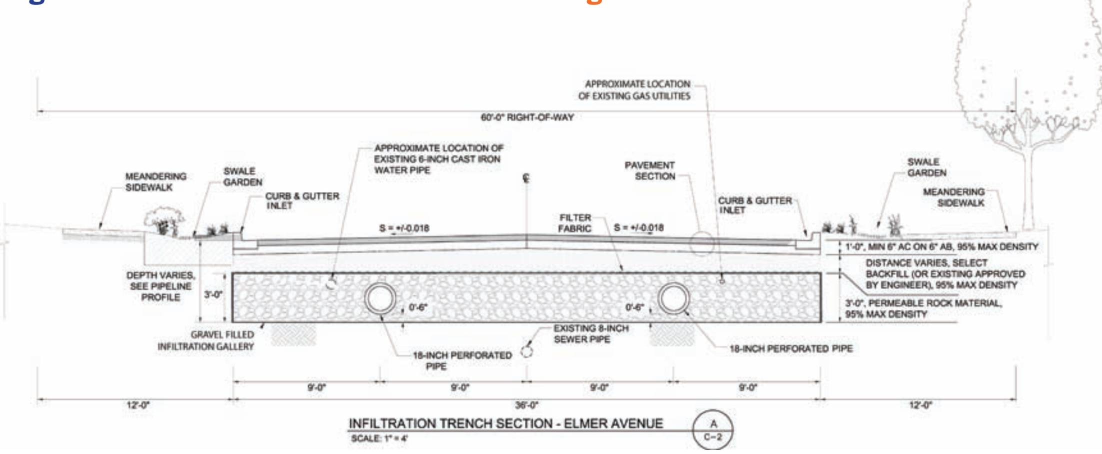
Project Goals

The purpose of the Sun Valley neighborhood project is to demonstrate an integrated, comprehensive approach to resource management by retrofitting a residential street with Best Management Practices (BMPs) to address runoff, pollution reduction, and flooding, while promoting water conservation and enhancing urban wildlife habitat. The goal of the study is to provide strategies to increase local water supply reliability and decrease the need to import water from the Bay-Delta and other regions. The Sun Valley project is intended to serve as a model for more sustainable approaches to water management in Southern California and other regions.

Stormwater Management Practices Utilized

In the public right-of-way, the city installed two catch basins and associated underground infiltration galleries for groundwater recharge. These capture water before it flows to the street. Installed on the street were sidewalks, curbs, and gutters and bioswales in front of each home. Additional street trees were also planted. Bioswales have upstream inlets and downstream outlets. Native soils and rocks/cobbles were used for the bioswales, which were planted using a California-friendly plant palette. On private properties, homeowners had installed drip irrigation, drought-tolerant and native plants, smart controllers, rock swales, rain barrels, and permeable pavers. Residents also received maintenance manuals and training in how to take care of their new bioswales and landscapes. Figure F-1 provides a schmatic illustrating these features.

Figure F-1: Schematic of Stormwater Management Features



Project Schedule

The Project started November 2008, suffered from an eight month halt from the bond funding freeze, restarted July 2009, and was completed in April 2010.

Project Costs

Capital costs were $2,065,045. Operation and maintenance costs are about $12,000 per year.

Project Infiltration Gallery

Stakeholder Process

Partners of the Council for Watershed Health

City of Los Angeles (Bureaus of Sanitation, Street Services, Street Lighting), U.S. Bureau of Reclamation, California Department of Water Resources, County of Los Angeles Department of Public Works, Metropolitan Water District, Water Replenishment District of Southern California, LA Department of Water & Power, TreePeople, UC Riverside, City of Santa Monica. For Phase II (Elmer Paseo), partners and funders include Santa Monica Mountains Conservancy, U.S. Bureau of Reclamation, California Strategic Growth Council, and LA DWP.

Community Outreach

The Council began community outreach in October 2006 and conducted six community meetings from then to the start of construction. Everyone on the street was in support of the project, having been consulted on the goals and design of the project. The Council retained outreach specialists to maintain good contact with the residents. All outreach and materials were in both Spanish and English.

RESULTS AND DISCUSSION

Benefits achieved using proposed stormwater management practices:

Qualitative Benefits

The Elmer Avenue Neighborhood Retrofit Project was designed to achieve stormwater recharge (16 acre-feet/year initial design), flood control (eliminate flooding), water quality improvement, increase habitat for "birds and butterflies," and create a walkable street.

Quantitative or Measurable Benefits

Research and monitoring are ongoing to quantify benefits achieved. As mentioned, the design for 16 acre-feet/year is going to be more than doubled to 40 acre-feet/year by the completion of all phases of the project.

The Council published the Water Augmentation Study: Research, Strategy, and Implementation Report in January 2010. Chapter six describes challenges and recommendations, broken down into six categories: institutional barriers, existing development rules, stormwater regulations, groundwater management, costs and funding, and education and awareness.

The report can be found at: http://watershedhealth.org/programsandprojects/was.aspx

SUMMARY AND CONCLUSION

The project is unique in the region because it addresses stormwater at its source through the seamless integration of private property and public right-of-way improvements. This integration is primarily the result of homeowners engaged as critical partners throughout the project. During final site selection, most indicated they were willing to have improvements installed along their street. Residents participated in the development of conceptual and final designs through six community meetings and numerous door-to-door interactions. The final plant palette of native and climate-appropriate vegetation includes the stated preferences of the neighborhood for evergreens, blooming color, variety, as well as reduced watering and maintenance needs. The outreach continued throughout construction where homeowners were provided refrigerator magnets with single points of contact no matter the concern.

Outreach continues today with residents helping to monitor the landscapes. Maintenance and training days are held quarterly on Saturdays for all residents covering the items in the Maintenance Manual. The manual provided to each house has a calendar of activities to be performed from the clean-out of inlets to the trimming of native plants, and includes contact numbers for additional resources.

Modeling conducted as a part of the Water Augmentation Study estimates that annually 16 percent of precipitation currently percolates to groundwater (about 194,000 acre-feet) in the Los Angeles Region, while 50 percent (approximately 601,000 acre-feet) becomes runoff that flows directly through the stormwater conveyance system to the ocean. Implementing a regional decentralized stormwater management where the first 3/4" of each rain storm is captured and directed for infiltration on all parcels could add up to 384,000 acre-feet bringing the estimated total to 578,000 acre-feet of recharge per year, on average, to the groundwater basins- enough water for 1.5 million people. This total does not factor the existing efforts to capture runoff into spreading basins, approximately another 202,000 acre-feet of water runoff from the upper natural watersheds outside the model area.

The Water Augmentation Study showed that it was safe and feasible to use stormwater to augment groundwater drinking supplies and that stormwater infiltration could contribute to local and regional water sustainability, reducing our reliance on imported water supplies. Now in its twelfth year, the Water Augmentation Study continues to demonstrate that low impact re-development is a part of the suite of solution to multiple local and regional issues all based around water. The project stands as an example of what is possible to bring Los Angeles to a sustainable water future.

REFERENCES

Council for Watershed Health. Water Augmentation Study: Research, Strategy, and Implementation Report. January 2010.