# CALIFORNIA STATE UNIVERSITY, LONG BEACH

Capturing Urban Residential Storm water: What we can save in semi-arid climate

Submitted to:
The Metropolitan Water District of Southern California
700 North Alameda Street
Los Angeles, CA 90012

Attention:
Ms. Benita Lynn Horn, 10th Floor- Room 322

Project Strand: Local
Total Amount Requested from MWD: $10,000

Submitted by:
California State University, Long Beach
1250 Bellflower Blvd.
Long Beach, CA 90840

Rebeka Sultana, Ph.D., Faculty Project Manager, Principal Investigator
Nathaniel Summerville, Student Project Manager

December 21st, 2015

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Califorina State University, Long Beach

**Project Summary:**

Southern California meets its water demand from the Colorado River, the State Water Project, and local groundwater basin. Interestingly, amount of imported water is almost same as the amount of storm water runoff that drains to the Pacific Coast. This "lost" resource, if captured can reduce cost and energy of water importation. The proposed study seeks to develop a storm water management model for the city of Cerritos, located in Los Angeles County by using urban storm water management model PCSWMM. The city conserves water by uses recycled water for irrigation of public parks and educating its residents. With the modeling effort, the project's objective is to determine how much water the city can further save by capturing storm water runoff through low impact developments (LIDs). It is expected that with a single LID, the city can save up to 210 million gallons of water per year by capturing annual average rainfall of 12 inches/year. The city can also reduce cost of water and wastewater treatment. The project will give the opportunity to the student to learn key storm water management issues and LID guidelines. The results will be used to develop teaching material and outreach activities.

**CONTACT INFORMATION**

**1.**

| | |
|---|---|
| College | California State University, Long Beach |
| Department | Civil Engineering and Construction Engineering Management<br>California State University, Long Beach<br>1250 Bellflower Blvd., Long Beach, CA 90840 |
| Make Checks Payable to: | CSULB Foundatoin |

2.

| Application Strand | Select One |
|---|---|
| **LOCAL** "Capturing urban residential stromwater: what we can save in semi-arid climate" | X |
| **GLOBAL** Project Name | |

3.

| | |
|---|---|
| Faculty Project Manager (PI) | Rebeka Sultana, Ph.D. |
| Title | Assistant Professor |
| Department | Civil Engineering and Construction Engineering Management |
| Campus Address | 1250 Bellflower Blvd, Long Beach, CA 90840 |
| Telephone / Email Address | 562-985-5135 Rebeka.Sultana@csulb.edu |

4.

| | |
|---|---|
| Student Project Manager | Nathaniel Summerville |
| Undergraduate or Graduate | Graduate Student |
| Department | Civil Engineering and Construction Engineering Management |
| Cell Phone / Email Address | 619-647-8618 nathansummerville@outlook.com |

5.

| | |
|---|---|
| Contracts Manager/Officer | Sandra Shereman |
| Title | Senior Director Sponsored Programs |
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**Institutional Background**

California State University Long Beach (CSULB) is the third largest campus of 23 campuses of the California State University (CSU) system and one of the largest universities in the state. CSULB is recognized as a university with outstanding education at an affordable cost and one of the largest and most culturally diverse universities in the world which makes the university an attractive option for incoming students. For Fall 2015, CSULB received 96,468 student application and finally admitting almost 37,500 students. Of the 36,822 students enrolled in the 2014-2015 academic year, ethnicity of student body distributed as follows: 36% Hispanics, 22% Asian American, 21% Caucasian, 4% African Americans, and 1% Native Americans admitting nearly 40% of the student from underrepresented groups. Because of the large number of Hispanic student body, CSULB has been designated as a Hispanic-Serving Institution by the U. S. Department of Education in 2007 and has been ranked as one of the top 10 universities in the nation to award degrees to Hispanics.

The university has been also ranked 4$^{th}$ or 5$^{th}$ (depending upon the year) by *U.S News & World Report* as the best public regional university in the western United States. In 2014, *Time* magazine ranked CSULB the 10$^{th}$ best value in the nation among all universities and colleges using new criteria defined from the White House that include accessibility and affordability with academic excellence. Princeton Review also ranks CSULB as a top 75 "Best value" university from the list of 150. The University is committed to being an outstanding teaching-intensive, research-driven university that emphasizes student engagement, scholarly and creative achievement, civic participation, and global perspectives which is reflected in the CSULB's Mission statement: "*California State University Long Beach is a diverse, student centered, globally-engaged public university committed to providing highly-valued undergraduate and graduate educational opportunities through superior teaching, research, creative activity and service for the people of California and the world*".

Among seven colleges in CSULB, the College of Engineering (COE) is the third largest college by the number of students' enrollment in Fall 2015. As COE continues to grow and evolve, the college will remain dedicated to its mission: "to develop innovators who design and implement practical solutions to meet the ever-changing societal challenges of today and tomorrow". The COE has established different programs and activities to engage students in hands-on activities that make the graduating student competitive to local engineering firms and agencies. For the best value for engineering careers, Payscale.com ranks the college as 7$^{th}$ in the nation. American Society of Engineering Education (ASEE) also recognizes the college in several other categories.

Among five departments, the Department of Civil Engineering and Construction Engineering Management (CECEM) is the second largest department in the College of Engineering. The program offers ABET accredited B.S. and M.S. degree in five specialty areas including

structural, geotechnical, transportation, environmental and water resources engineering. The department has 18 full-time faculties with excellent records of research and professional experience. The faculties strive to achieve the program mission: "to educate and prepare students to succeed in the civil engineering profession by providing them with essential technical tools and skills which will enable them to perform current and future civil engineering tasks and to promote the need for lifelong learning". They train the students with in class examples and involve both undergraduates and graduate students in their research projects to get hands-on experience. In 2005 and 2011, Dr. Antonella Sciortino and her team of students from the CECEM department received student grants from the Metropolitan Water District World Water Forum to conduct research on water conservation in a local community. The faculties also encourage the students for continued professional growth.

## PROJECT DESCRIPTION

### Introduction and Background

Urbanization changes the landscape by increasing impervious land. Infiltration is reduced resulting in increasing quantities of runoff [1]. For long, this storm water runoff has been regarded as nuisance [2], so conventional storm water drainage systems have been developed to drain away the runoff from the developments as quickly as possible following a rainfall.

This runoff can also be understood as a lost resource in arid and semi-arid environments especially where water supply is limited and runoff is discharged to coastal waters. In semi-arid California, increasing demand for freshwater is met by importation of water supplies by three aqueduct systems (Los Angeles Aqueduct, East Branch California Aqueduct, and Colorado River Aqueduct). Interestingly, the volume of imported water in Southern California is almost equal to the net loss of storm water runoff to coastal waters. For example, in year 2000, the amount of precipitation in this region was 7,500 x 1000 acre-feet. This rainfall provided 72% of supply of total water demand. Rest of the demand was met by imported water (2,991x 1000 acre-feet) and ground water supply (1,245 x 1000 acre-feet). The amount of strom water runoff to the ocean was close to the amount of imported water (Table 1).

Further, it takes 10,200 kilowatthours (kWh) to import every million gallons (MG) of water to Southern California. Strom water runoff also washes off the pollutants from nonpoint sources and impairs the quality of receiving water bodies. In semi-arid Califronia, the pollutant build up is higher during the dry weather period than areas with more frequent rainfall. So, the strom water runoff needs treatment to meet National Pollutant Disposal Elimination System (NPDES) permit which require additional energy for treatment and disposal. The total energy requirement for water importation and strom water treatment is 40 times greater than the national average and 20% of total residential energy usage of the region [2] (Table 2).

With continued population increase in the area, the demand is likely to grow and deficit in natural water resources will potentially increase in future. So, by ***capturing storm water runoff***, demand for imported water and energy needed for water importation as well as strom water treatment can be reduced.

The Low impact development (LID) approach is an alternative to conventional strom water management tools that are purely structural and mitigation based. The LID approach, started in 1990 in Maryland, allows storm water runoff to infiltrate, store at or close to its source and are primarily used to reduce concentration of pollutants' in receiving water bodies. LIDs can also be used to "harvest" rain for use. Depending on the source or application, captured storm water can be used without any treatment or may be blended to augment local supplies [3]. The primary objective of this project is to assess

(1) How much water can be saved in an urban residential area of Southern California using LIDs?
(2) What other benefits, such as pollutant removal, energy conservation can also be achieved?

The proposal seeks to *apply an urban storm water management model to simulate the capture efficiency of various low impact developments* in an urban city. To assess overall benefit of capturing storm water runoff at a scale of a city, modeling of the water distribution system with low impact developments is much less costly than building the prototypes [4]. In addition, through model simulation, wide range of system design can be evaluated in a relatively short time to obtain optimum result. The project goal is improve ***local water conservation and pollutant removal from storm water runoff.***

Table 1. Water Balance in Southern California for 2000 [2]

| **Supply** | Amount (x1000 acre-feet) | **Demand** | Amount (x1000 acre-feet) |
|---|---|---|---|
| Precipitation | 7,500 | Evapotranspiration | 7,441 |
| Imported water | 2,991 | Consumptive use | 1,819 |
| Ground water extraction | 1,245 | Stromwater runoff to the ocean | 2,498 |
| **Total Supply** | **11,752** | **Total Demand** | **11,758** |

Table 2. Southern California Energy Demand for water supply [2]

| | Energy required (kWh/MG) |
|---|---|
| Supply and Conveyance | 8,900 |
| Treatment and Disposal | 1,300 |
| **Total** | **10,200** |
| **National average** | **250** |

## METHOD

### Storm Water Management Model:

Strom water management model selected for this study is PCSWMM developed by ChiWater [5]. PCSWMM can be used to represent surface hydrology, flow routing, water quality constituents through sewer system, and is also capable water quality modeling [6]. In PCSWMM, various low impact development tools can be designed and performance can be evaluated by changing design parameters. This dynamic water quality and quantity model is selected because of its powerful GIS interface and its full support of Environmental Protection Agency's (EPA) Storm water Management Model (SWMM5) hydrology and hydraulic engines. The model has been applied throughout the world [6-11]. The software is freely available through ChiWater's educational grant program.

The data required for the model is GIS map of the city, land use and land cover data, demographic information, design rainfall and continuous rainfall data. These are freely available from various national data portal. Additional data required is the storm sewer distribution which will be requested from the local water agency, Central basin Metropolitan Water District.

### Project Study Site

The site selected for this study is Cerritos, a suburban city in Los Angeles County. The 8.86 square miles city is located at the crossroads of three major freeways and serves as a residential and commercial area. The city has 28 parks and recreational facilities and an award winning library for its residents. Beautifully maintained neighborhoods and abundant recreational facilities earned the city many awards and honors including "Playful City USA", "Tree City USA" [12].

The city receives it water from the State Water Project, the Colorado River, and local groundwater basin. The city also uses reclaimed water generated from wastewater from industries, businesses, and homes and uses for irrigation of its 200 acres of parks and parkways and since 1978, the city has been saving approximately 815 million gallons of potable water per year [13]. During this 2014-2015 extreme drought year, the city reduced water consumption by 18.9% compared to 2013-2014 by educating its residents and businesses about water conservation. But, the city failed to achieve its 28% state mandated goal [14], primarily because of the water used for irrigation of the residential lots. The city plans to continue educating their consumer to save water to reach the goal in future. Therefore, this city is a perfect site to study if collection of storm water and use of it will help achieving water conservation target.

### LID Modeling

First, the model will be built with existing land use and storm water distribution system. Next, various Low impact developments will be added to the model. LIDs, such as rain barrels, green

roofs, bioretention, infiltration trench, vegetated swales, vegetated filter strips, permeable pavements are used to reduce pollutant concentration from the storm water runoff by capturing the rainfall at its source. The choice of LID for a site depends on site conditions – size, topography, soil type, drainage area, groundwater level, land use type, and climate [15]. For modeling LIDs in the city of Cerritos, the site conditions will be discussed with the respective water agency and considered prior to LID selection. Once LIDs are selected, effect of various design parameters will be assessed, such as number and capacity of rain barrels, width of vegetative strips, size of bioretention, depth of permeable pavement. Location of LIDs will be based on the guideline "Managing rainfall where it originates, do no convey" which is part of the sustainable site planning process [2].

**Scenario Development**

Various climatic scenarios will be developed in order to evaluate performance of single as well as combination of LIDs. In Southern California, rainfall varies dramatically between communities. While average rainfall in Los Angeles County is 18 inch/year (https://www.ncdc.noaa.gov/cdo-web/), average rainfall in Cerritos is about 12 inch/year. Further, rainfall pattern also varies both annually and seasonally. Climatic scenarios will consider some of the seasonal variability and will include

(1) Event based rainfall scenario
(2) Rainfall with 2-year, 10-year, 25-year, and 100-year return period.
(3) Rainfall from climatic extreme years - drought years and El-Nino years.

**Cost Analysis**

Choice of optimal LID design will be based on cost of LID implementation as well as matrices on

(1) Storm water capture efficiency
(2) Storm water pollutant removal efficiency
(3) Savings of energy on recycled water or water importation.

The cost of LIDs will be calculated following guidelines from EPA and local water agencies.

## ANTICIPATED OUTCOMES

The anticipated outcomes of this modeling effort are both short term and long term. The immediate outcome of the project will be a development of storm water model for the city of Cerritos. The results will help in identifying LID potential in the city in terms of achieving city's objectives on water conservation and storm water pollutant removal. By reducing pollutant and conserving water, the community can save water bills as well as the city can save energy of using

reclaimed water, water importation. The city will also have the cost analysis of implementing and maintenance of the proposed storm water management system.

If the system is adopted by the city, in the long term, the city will stand as an example of a sustainable system for water conservation and storm water management. The "Tree city" will become even greener with t the city even greener by LID practice. Figure 1 is an example of transition of traditional development to a LID development, which aesthetically conserves water.

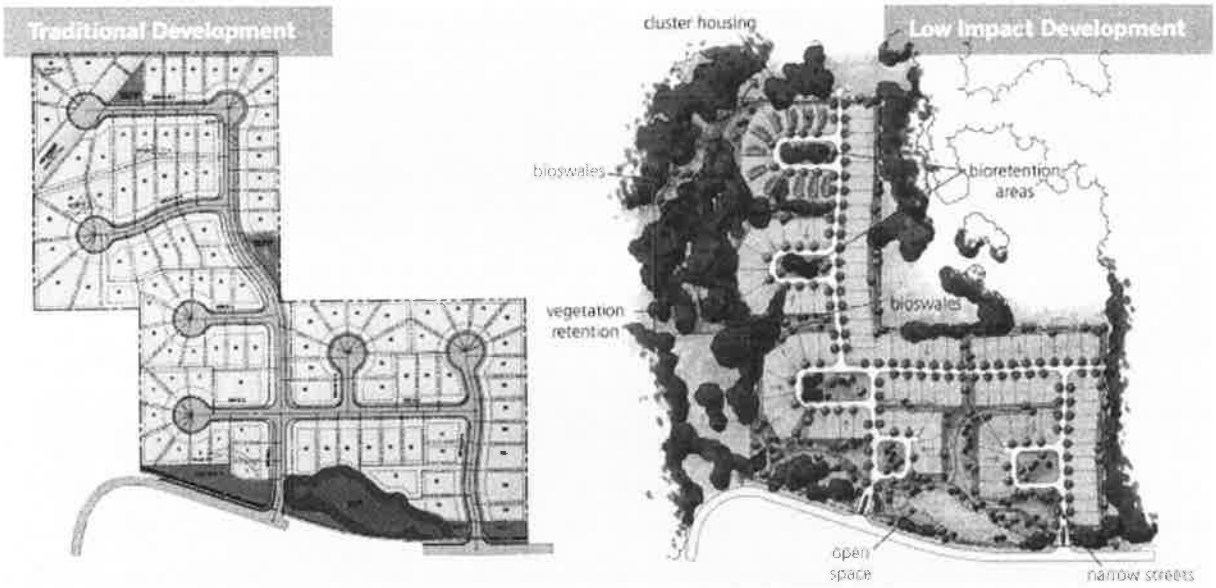


Figure 1. Example of transition of a traditional development to a low impact development [16]

The study will give the opportunity to the graduate student to work with a storm water management model. He will be able to build a detailed model of traditional urban storm water system as well as system with LIDs. He will learn limitations and problems of traditional system as well as LID systems. He will also learn the required guidelines for choosing and implementing LIDs in a semi-arid climate.

Finally, the results from this study will be used to develop lecture material and outreach activities to reach a larger audience of students and communities emphasizing management of the "lost" resource.

**Projected Project Benefits**

The modeling results from this project are expected to provide detail outcome of applying LID to manage storm water runoff. The city can benefit from this study with the awareness in the following areas:

(1) ***Makes more water available:*** The objective of modeling storm water runoff using various LIDs is to capture storm water runoff and use it for irrigation. With an average annual

rainfall of 12 in/year, rain barrel alone can save 209 million gallons of water per year from collecting rain water from 15,526 residential homes with an average 1,800 square foot of area. The residents can use the captured rain to irrigate their lawns. In a drought year, this number can reduce to half or less but still significant enough in achieving city's conservation goal.

(2) ***Savings on water treatment cost and energy:*** In order to maintain the 200 acres of public parks and recreational facilities, the city uses reclaimed water from the Sanitation Districts of Los Angeles County's Los Coyotes Water Reclamation Plant. The plant produces 37.5 million gallons of recycled water everyday [13]. By capturing storm water runoff and implementing LIDs, the demand on recycled water can be reduced. Thus, the city can save on cost and energy required to recycle water.

(3) ***Pollutant reduction in the receiving water:*** LIDs can significantly reduce the different pollutant concentration from the storm water runoff. As a result, the pollutant concentration in the storm water runoff will be reduced and causing less impairment to the receiving waterbodies.

(4) ***Sustainable environment for the communities:*** By conserving water, the entire community will benefit in reducing water bills. The community will benefit a sustainable environment and set up an example for the neighboring cities.

## FACULTY AND STUDENT EXPERTISE

The proposed project will be carried out by a team of a graduate student and a faculty member at CSULB. The Faculty Project Manager, Dr. Rebeka Sultana is an Assistant Professor in the Department of Civil Engineering and Construction Engineering Management. Her area of expertise is Water Resources with a focus on hydrologic modeling, land surface modeling, and application of Remote sensing data in hydrology. Dr. Sultana teaches courses in Fluid Mechanics, Engineering Hydraulics, Water Resources Engineering, Urban Surface Water Management, Advanced Hydrology, and GIS application in Water Resources. She is the author and co-author of several journal publications in her area of expertise. She has been working at CSULB since 2011 and since then she has advised several undergraduate and assisted the undergraduate students to receive CSU's Water Resources Policy Initiative (WRPI) and US Department of Agriculture (USDA) internship to conduct research under her supervision. She has also advised several graduate students to towards their Master degree. Dr. Sultana will be responsible for supervising the development of the storm water runoff model in PCSWMM and evaluating various scenarios for optimal result.

Nathaniel Summerville, the student project manager, is a graduate student in the department of Civil Engineering and Construction Engineering Management (CECEM). Nathaniel has received his California Polytechnic University Pomona with a GPA of 3.92 and was the Valedictorian of

the College of Engineering. As an undergrad, he was also a member of ASCE, CWEA, and captain of steel bridge team 2011 for ASCE Student Chapter Competition. He also received Julian McPhee Award for Student Excellence. After graduation, Nathaniel started working at CH2M, a full service environmental consulting firm. His work experience ranges from hydrologic modeling for large planning studies to detailed engineering and design for storm water treatment and conveyance systems. At CH2M, this year will be his second year in organizing local E-Week outreach. In his graduate studies, he wants to focus on water resources engineering with the passion for solving storm water quality, flood protection, and water scarcity issues. He is a California Professional Civil Engineer (Lic. 84246). Finally, he is already familiar with the storm water management model PCSWMM through a class project in his first semester in CECEM department (Fall 2015).

**PROJECT TIMELINE**

The storm water runoff model requires data collection of the existing land use and storm water runoff system. With the given data, the model needs to be calibrated first before applying various LIDs and climate scenarios. If funded the following scheduled will be followed to achieve the project goal

| Timeline | Project benchmarks |
|---|---|
| Summer 2016 | Agreement executed, funds are disbursed to the college |
| Fall 2016-Winter 2017 | Data collection,<br>model development,<br>calibration,<br>Application of LID |
| Spring 2017 | Analysis and completion of the project and technical report |
| Spring 2017 | Dry run of the project presentation in upper division water resource class |
| Spring 2017 | Attend MWD expo featuring student projects, presentations |

**PROJECT MANAGEMENT TEAM**

The following is the list of members of the project management teams.

| | Timeline | Title/Organization | Address | Phone/Email |
|---|---|---|---|---|
| 1 | Rebeka Sultana, Ph.D | Faculty Project Manager | 1250 Bellflower Blvd, Long Beach, CA 90840 | 562-985-5135 Rebeka.Sultana@csulb.edu |
| 2 | Nathaniel Summerville, P.E. | Student Project Manager | 1822 E Palmyra Ave, Orange, CA 92866 | 619-647-8618 nathansummerville@outlook.com |

**BUDGET**

| Description | Amount | Notes |
|---|---|---|
| Grant Fund Requested | $10,000 | |
| Matching Funds | $2,500 | From College of Engineering, CSULB |
| **TOTAL** | **$12,500** | |

**BUDGET BREAKDOWN**

| Line Item | Amount | Description |
|---|---|---|
| Stipends | $4,892 | Student stipend + 10.68% benefit – Nathaniel Summerville |
| Salary | $4,048 | Faculty salary for Summer Effort + 8.85% benefits |
| Publication | $100 | Operating expenses |
| Office Supply | $50 | Operating Expenses |
| Overhead fees | $909 | Calculated a 10% as per RFP |
| **Total** | **$10,000** | |

## SIGNATURE BLOCK

| | NAME / TITLE | SIGNATURE | DATE |
|---|---|---|---|
| Faculty Project Manager | Rebeka Sultana, Ph.D./ Assistant Professor |  | 12.21.2015 |
| College Contracts Officer / Administrator | Sandra Shereman/ |  | 12.18.2015 |
| Student Project Manager | Nathaniel Summerville/ Graduate Student |  | 12.18.2015 |

| | | | |
|---|---|---|---|
| Member Agency/Local Water Representative | Mark Moss/ Educatino and Grant Manger, Central Basin MWD | | |

**References**


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# WORLD WATER FORUM LETTER OF SUPPORT FROM LOCAL WATER AGENCY

Horn,Benita L [bhorn@mwdh2o.com]
**Sent:** Thursday, December 17, 2015 4:16 PM
**To:** Rebeka Sultana; Mark Moss (markm@centralbasin.org)

*Note: Spell-check is inconsistent; pardon misspelled words.*

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Date: December 17, 2015

To: Dr. Rebeka Sultana, CSULB

Cc: Mark Moss, Outreach Manager, Central Basin MWD

From: Benita Lynn Horn, High School and College Outreach Programs

Re: WORLD WATER FORUM LETTER OF SUPPORT FROM LOCAL WATER AGENCY

I know that a lot of people are in the midst of final exams or holiday vacations ... so the letters of support can be submitted after the due date of December 21, 2015.

The rest of the application must be submitted on time.

Thank you!

Benita Lynn Horn, MBA
MWD External Affairs / Education ☎ (213) 217-6739 | 🖷 (FAX 213) 576-5109 |
✉ bhorn@mwdh2o.com; MWDh2o.com


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WWF College Grant Program

# Certificate of Participation

presented to

*Rebeka Sultana*

CSULB

Thank you for participating in the

# Southern California World Water Forum College Grant Program

on October 16, 2015.

worldwaterforum
Metropolitan Water District of Southern California College Grant Program

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water for people