Rain Barrel Downspout Disconnect Best Management Practice Effectiveness Monitoring and Operations Program

Final Report

Prepared for:

City of San Diego
Storm Water Department
Pollution Prevention Division
9370 Chesapeake Drive, Suite 100, MS 1900
San Diego, California 92123

June 11, 2010

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EXECUTIVE SUMMARY

This report presents the results of the Phase II Rain Barrel Downspout Disconnect (RBDD) Best Management Practices (BMPs) Effectiveness Monitoring and Operations Program. The study and implementation area included the six watershed management areas (WMAs) within the jurisdiction of the City of San Diego (City). The assessment included RBDD systems installed in Summer 2009 and Winter 2009 at the San Ysidro Library, Southcrest Recreation Center, Rose Canyon Yard Service Building, Scripps Institution of Oceanography (SIO), Mission Trails Regional Park Nature and Visitor Center, Mira Mesa Library, Rancho Bernardo Recreation Center, and South Bay Wastewater Treatment Plant. This report provides the basis to assess the effectiveness of RBDD systems to attenuate and treat roof runoff during storms, and to determine the cost effectiveness of implementing RBDD systems as a qualifying watershed water quality activity under the San Diego Regional Water Quality Control Board (Regional Board) Municipal Storm Water Permit. Under the City's *Strategic Plan for Watershed Activity Implementation* (Strategic Plan), this project was identified as a Tier II source control BMP. The effectiveness monitoring and operational assessments had the following objectives:

- Determine the average volume of runoff captured and treated during the wet weather season in extreme southwestern California by the RBDD systems located at each site.
- Determine the average pollutant load removal by the RBDD systems located at each site.
- Determine the approximate operational and maintenance costs and requirements associated with each RBDD system.

The study evaluated three system configurations, including 1) gravity-flow system discharging to existing landscaped areas which eliminates roof runoff to the storm water conveyance system, 2) gravity-flow system discharging to a raised precast concrete planter (planter-barrel system) which captures and treats a portion of roof runoff, and 3) capture/storage system that captures roof runoff and stores runoff for later use. Table ES-1 provides a relative ranking of the efficiency, effectiveness, and operational considerations of the three configurations.

Rain Barrel Downspout Disconnect System Implementation

Water quality monitoring data from this report indicate that buildings with copper or galvanized building materials (e.g., roofs, downspouts, gutters, and air conditioning units) are potentially significant point sources of metals. RBDD systems are best used for flow reduction/attenuation from large buildings with known building material pollutant sources and in combination with other BMPs (i.e. in-series with low impact development (LID) projects such as porous pavement or bioswales). Higher load reductions are possible for buildings with high metals source building materials and an existing narrow strip of vegetation (or an opportunity for porous pavement) that may be used for continuous infiltration thus eliminating discharges to the storm water conveyance system.

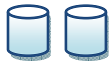
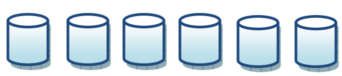
Rain Barrel Downspout Disconnect Systems Load Reductions & Total Maximum Daily Loads

Individual RBDD systems can attenuate and infiltrate up to six times the original volume of the barrel based on design storm criteria (Table ES-1). Although constituent load reductions are low at most locations that do not include copper-based and zinc-based roofing materials, the systems offer value added flow reduction or elimination. At 0.2 gallon of water infiltrated per dollar spent for gravity-flow systems, RBDD systems may have a cost-advantage as a flow reduction BMP.

Flow reduction is a key BMP strategy for addressing pollutant load reductions. With the 2010 adoption of the *Revised Total Maximum Daily Loads for Indicator Bacteria, Project I – Twenty Beaches and Creeks in the San Diego Region (including Tecolote Creek)* and its concentration-based objectives, the City may benefit most from efforts to implement BMPs that eliminate discharges within RBDD systems' capability and not simply reducing discharges and sources.

A single-barrel gravity flow system costs approximately $500 to design and implement and may be used for nearly any building/landscaping configuration. Having a wide-spread public appeal, RBDD systems may also be a viable flow-reduction BMP when implemented on a larger scale by the public. It may also be appropriate to modify building code(s) and/or specifications to prohibit use of copper/galvanized roofs, rain gutters, and downspouts unless alternative disconnect or treatment is provided. This type of policy change would reduce future contributions and effect measurable reductions during redevelopment.

Table ES-1. Evaluation of Rain Barrel Downspout Disconnection System Configurations

GOOD	**PLANTER – BARREL** *Cost: $$$* FLOW  *Planter-barrel systems detain/filter runoff through an engineered soil media. They are used to retrofit impervious areas and will discharge to MS4, unless in-series to LID BMPs.* LOAD  *Load reduction improvement is anticipated once vegetation becomes established.* O&M  *Plants may be vandalized and require regular watering. Consider enhanced iron/zeolite soils with decorative rock instead of plants to reduce O&M costs while improving treatment.*	
BETTER	**AUTOMATED / CAPTURE** *Cost: $$* FLOW  *Automated or manual capture systems hold 100% roof runoff up to the capacity of the barrel/cistern.* LOAD  *100% load reduction for runoff is captured in barrel.* O&M  *Automated systems have the most moving parts and greatest motivation for theft. Manual timers powered by 12-volt DC photovoltaics are recommended rather than 120-volt AC ground fault circuit interrupt (GFCI) systems. Algae and adverse odors were present in translucent tan barrels.*	
BEST	**GRAVITY-FLOW** *Cost: $* FLOW  *Gravity-flow systems act like miniature detention basins. Roof runoff is attenuated and a volume, up to six times the capacity of the original barrel, is infiltrated to existing landscaping eliminating discharges to the storm water conveyance system.* LOAD  *100% load reduction for runoff is attenuated and infiltrated.* O&M  *Allows for the easiest, fastest, and cheapest repairs. This configuration was vandalized the least. Use opaque barrels to eliminate potential algae growth.*	

1.0 INTRODUCTION

The Rain Barrel Downspout Disconnect (RBDD) Program was selected by the City of San Diego (City) as a potential cost-effective best management practice (BMP) for the reduction of wet weather runoff and associated pollutants. Phase I of this program was initiated in 2007 and was identified as a Tier II source control BMP that could be implemented in watersheds identified in the *Strategic Plan for Watershed Activity Implementation* (Strategic Plan) (Weston, 2007) as having Priority Water Quality Problems (PWQPs).

Phase I of the program involved an extensive desktop analysis in which 1,600 City-owned properties were examined to determine which of these buildings met the selection criteria for placement of RBDD systems. The selection criteria included appropriate downspout systems and building designs for rain barrel installation, availability of existing landscaping for inclusion in the treatment system and water reuse, and location within watersheds with PWQPs. In addition, several sites were chosen because the RBDD systems could be integrated with planned structural BMPs. Phase I of the program evaluated different types and configurations of RBDD systems, finalized the RBDD system design, conducted stakeholder engagement meetings, and developed public relations material.

The Phase II 2009 RBDD BMP Effectiveness and Maintenance Program continues the program from 2007–2008 by providing monitoring and maintenance of the RBDD systems. Monitoring and maintenance includes evaluating performance as pollutant reduction BMPs and assessing the operation and maintenance (O&M) activities of the different system types and installations.

Several of the RBDD systems are located in the vicinity of other Tier II Low Impact Development (LID) projects and/or Tier III restoration and treatment BMPs. Using the assessment process outlined in the Strategic Plan, the program will quantify the pollutant load and flow reductions achieved by the individual RBDD systems, how the performance of the systems in combination with other LID approaches can achieve the pollutant reduction and flow management goals for the watershed, and determine how these reductions will influence the future design of more structurally intensive BMP projects.

1.1 Regulatory Framework

The regulatory drivers outlined below were considered during site selection for installation of RBDD systems.

San Diego Regional Water Quality Control Board Municipal Storm Water Permit for the City of San Diego

According to the jurisdictional requirements presented in the San Diego County Municipal Storm Water Permit (Permit) (Final Order R9-2007-0001, 2007), Copermittees are required to implement no less than two water quality activities and two education activities each year in each watershed that result in a "significant pollutant load reduction, source abatement, or other quantifiable benefits to discharge or receiving water quality in relation to the watershed's high-priority water quality issues." To address this permit requirement, RBDD BMPs were installed in all six watersheds under the jurisdiction of the City.

San Diego Regional Water Quality Control Board Total Maximum Daily Load Program

The Regional Board adopted an amendment to the Water Quality Control Plan for the San Diego Basin (Basin Plan) on August 14, 2002 (Resolution Number (No.) R9-2002-01213), to incorporate a total maximum daily load (TMDL) for Diazinon in the Chollas Creek Subwatershed. This TMDL was developed to address acute and chronic toxicity to aquatic life in Chollas Creek due to the organophosphate insecticide Diazinon.

The Regional Board adopted another amendment to the Basin Plan for the San Diego Basin on June 13, 2007 (Resolution No. R9-2007-0043), to incorporate TMDLs for dissolved copper, lead, and zinc in the lowest 1.2 miles of Chollas Creek, which is located in the Pueblo San Diego Watershed. This TMDL addresses impairment to water quality due to levels of metals that exceed numeric targets as set forth in the California Toxics Rule (CTR). This dissolved metals TMDL requires the City to address multiple pollutants in addition to CTR metals, including bacteria (TMDL pending), Diazinon, and trash. The RBDD BMPs will be monitored to determine reduction of PWQP.

All watershed areas, except for the Tijuana River, will also be subject to the *Revised Total Maximum Daily Loads for Indicator Bacteria, Project I – Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek),* which has been adopted by the Regional Board and is awaiting adoption by the State Water Resources Control Board (State Board) and Office of Administrative Law.

Ocean Plan Area of Special Biological Significance Exception Process for La Jolla Shores

The draft Area of Special Biological Significance (ASBS) Exception Process indicated defined pollutant load reductions are likely to be required to meet the criteria of the Ocean Plan or “natural water quality” conditions. Watershed activities will therefore need to better define the source of pollutants of concern, their impact on the marine ecology, and result in targeted reductions that address these potential impacts. This project will determine if roof runoff is a source of constituents of concern (COCs).

1.2 Program Objectives

The RBDD Program is a Tier II BMP as identified in the Strategic Plan. The program not only assists the City in meeting Permit requirements, but also integrates into current and future TMDL programs that address watersheds impaired by bacteria, heavy metals, pesticides, nutrients, and sediments. This BMP is designed to attenuate the volume of storm water runoff originating from rooftop drainage areas and treat the captured storm water using vegetative planters or existing landscaping prior to release to the watershed. Several of the locations may completely eliminate runoff from rooftops under various storm conditions.

The key management questions that are answered as part of this Phase II 2009 RBDD BMP Effectiveness and Maintenance Program are as follows:

- What is the average volume of runoff captured and treated during the wet weather season in Extreme Southwestern California[1] by the RBDD systems located at the San Ysidro Library, South Bay Treatment Plant, Southcrest Recreation Center, Rose Canyon Maintenance Yard, Mira Mesa Library, Scripps Institution of Oceanography (SIO), Mission Trails Regional Park Nature and Visitor Center, and Rancho Bernardo Recreation Center?
- What is the average pollutant load removal by the RBDD systems located at the installation sites?
- What are the approximate operational and maintenance costs and issues associated with a RBDD system?

In addition to the key management questions and objectives, this report provides recommendations for program expansion, and system upgrades are presented based on the results of the assessment monitoring and operational evaluation.

1.3 Program Team

Individuals involved in the implementation and completion of the RBDD Program are summarized in Table 1-1.

Table 1-1. Contact Information for Project Team

Name	Organizational Affiliation	Title	Contact Information (Telephone number, fax number, email address)
Clement Brown	City of San Diego	Project Manager	858-541-4336 (tel) cmbrown@sandiego.gov
David Pohl, Ph.D.	Weston Solutions, Inc	Client Manager / Technical Advisor	760-795-6918 (tel) 760-931-1580 (fax) david.h.pohl@westonsolutions.com
Sara Huber, EIT	Weston Solutions, Inc.	Assistant Engineer	760-795-6937 (tel) 760-931-1580 (fax) sara.huber@westonsolutions.com
Garret Williams	Weston Solutions, Inc.	Project Manager	760-795-6993 (tel) 760-908-5754 (cell) 760-931-1580 (fax) garret.williams@westonsolutions.com
Andrea Crumpacker	Weston Solutions, Inc.	Data Manager	760-795-6987 (tel) 760-931-1580 (fax) andrea.crumpacker@westonsolutions.com
Sheri Dister	Weston Solutions, Inc.	GIS Manager	760-795-6996 (tel) 760-931-1580 (fax) sheri.dister@westonsolutions.com
Eugene Chae (CRG) Jennifer Beyer (EMA)	CRG Laboratories or EMA Laboratories	Chemical/ Microbiological Laboratory	310-533-5190 x134 (CRG) 858-560-7717 (EMA)

[1] Language based on regional designation by the National Weather Service.

2.0 PROGRAM SITES

Selection of the seven sites for installation of the RBDD systems was completed during Phase I of the program. During the Phase II system installations, the South Bay Wastewater Treatment Plant was added as an eighth site based on the preliminary recommendations of the *Fiscal Year 2009 Conceptual Designs for Watershed Capital Projects Report* (Weston, 2010).

Table 2-1 provides the site name, address, City facility number, and watershed management area (WMA) associated with each site. Figure 2-1 shows the location of each site within the respective watershed. Locations of RBDD systems at each site are presented in sitemaps in Appendix A.

The following subsections (i.e., Subsection 2.1–Subsection 2.8) describe each of the implementation locations; include photographs of typical installations (Figure 2-2 through Figure 2-9); and provide information regarding the regulatory drivers, State Board Section (§)303(d) listings, and TMDL status. All watershed areas, except for the Tijuana River, are subject to *Project 1 Beaches and Creeks Bacterial TMDL*, which has been adopted by the Regional Board and is awaiting adoption by the State Board and Office of Administrative Law.

Table 2-1. Rain Barrel Downspout Disconnect Site Locations and Addresses

	Site Name	ID	Address	Site Contact(s) Phone No.	Facility Number	Watershed Management Area	No. of Disconnects
1.	San Ysidro Library [1]	SY	101 W San Ysidro Blvd	Lynn Russo 619-424-0475	484	Tijuana River	2
2.	Southcrest Recreation Center	SC	4149 Newton St	Kim Mathis 619-527-3414 Hector Rios 619-527-3413	299	San Diego Bay	5
3.	Rose Canyon Yard Service Buildings	RCyn	3775 Morena Blvd	Facilities Manager	333/913/ 914	Mission Bay	4
4.	Scripps Institution of Oceanography	UCSD	Discovery Way at Scripps Pier	Kimberly O'Connell 858-534-6018	Machine Shop	Mission Bay / La Jolla ASBS	1
5.	Mission Trails Regional Park Nature and Visitor Center	MT	Father Junipero Serra Trail	Jay Wilson 619-405-0177 Tracy Walker 619-668-3276	10051	San Diego River	2
6.	Mira Mesa Library	MM	8405 New Salem St	Facilities Librarian(s)	10136	Los Peñasquitos	2
7.	Rancho Bernardo Recreation Center	RB	18448 West Bernardo Dr	Helen Phillips 858-538-8129 Steve Palle 619-221-8903	10052	San Dieguito	4
8.	South Bay Wastewater Treatment Plant	SB	2411 Dairy Mart Road	Linda Ruiz-Lopez 619-428-7313	11048	Tijuana River	4

[1]The impact to the historical San Ysidro Library building was also discussed with Jodie Brown from the City Planning and Community Investment Department (P: 619-533-6300).

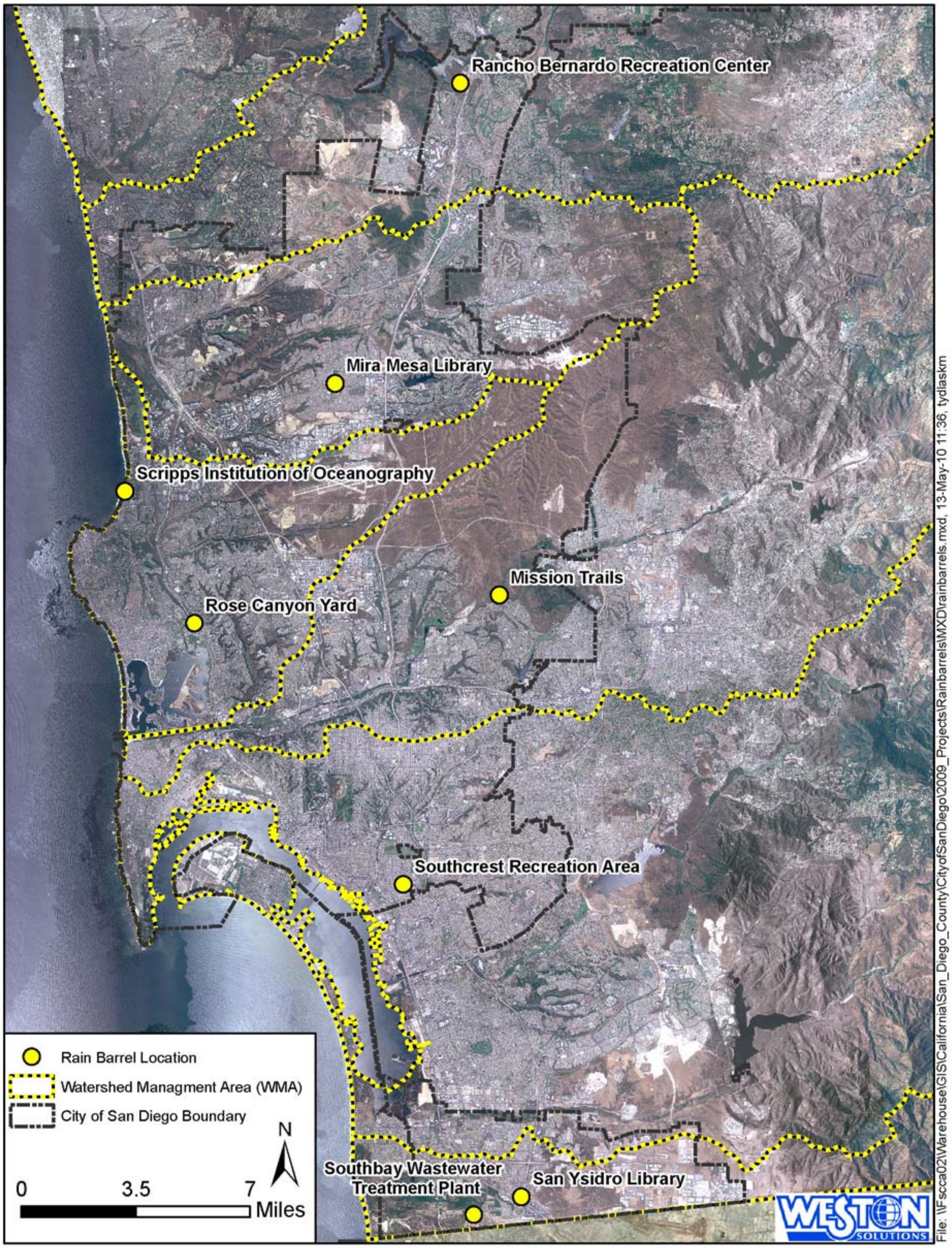


Figure 2-1. City of San Diego Rain Barrel Downspout Disconnect Sites

2.1 San Ysidro Library

San Ysidro Library is located in the Tijuana River WMA and in the Tijuana Valley Hydrologic Unit (HU) (911.10). Within this watershed, contaminants identified on the State Board §303(d) list include bacteria, eutrophic conditions, low dissolved oxygen, pesticides, solids, synthetic organics, trace elements, and trash. The two RBDD systems (barrel configuration) at the San Ysidro Library are designed to address the PWQP of bacteria and dissolved metals. Captured storm water is used to irrigate existing lawn and shrubbery.

San Ysidro Library is a historical building. At no point could an installed RBDD systems come in contact with the building. Design, implementation, and maintenance of these systems was in coordination with the City Planning and Community Investment Department and site managers from the Library.

	**RBDD System:** **SY-1 Gravity-Flow Barrel Discharging to Existing Landscaping**
	**RBDD System:** **SY-2 Gravity-Flow Barrel Discharging to Existing Landscaping**

Figure 2-2. San Ysidro Library Downspout Disconnect Installation Photograph(s)

2.2 Southcrest Recreation Center

Southcrest Recreation Center is located in the San Diego Bay WMA and in the Chollas Creek HU (908.22). Within this watershed, contaminants identified on the State Board §303(d) list include bacteria, pesticides, copper, lead, and zinc. There are currently two TMDLs (i.e., dissolved metals and Diazinon) adopted for the watershed. The installation at this location falls within a watershed subject to *Project 1 Beaches and Creeks Bacterial TMDL*. The entire roof at the Southcrest Recreation Center has been disconnected from direct discharge to the storm water conveyance system. The five RBDD systems (i.e., two in-series barrel configurations and three planter-barrel configurations) around the Recreation Center are designed to address the PWQP of bacteria and dissolved metals. The five RBDD systems were incorporated into the multi-system LID designed to infiltrate the TMDL 1.5-inch design storm at Southcrest Park. Three of the five planter-barrel systems were installed adjacent to a future porous pavement area.

Design, implementation, and maintenance of these systems was in coordination with site managers and community programmers at the Recreation Center.

	**RBDD Systems:** **SC-1 and SC-2 Multiple Gravity-Flow Barrels in Series Discharging to Existing Landscaping**
	**RBDD Systems:** **SC-3, SC-4, and SC-5 Gravity-Flow Planter-Barrel**

<u>NOTE:</u> Based on recommendations from the Facility Manager and facilities maintenance staff, all easily moved and/or damaged components of the RBDD systems installed at the Southcrest Recreation Center were enclosed with security caging.

Figure 2-3. Southcrest Recreation Center Downspout Disconnect Installation Photograph(s)

2.3 Rose Canyon Yard Service Building

The Rose Canyon Yard Service Building are located in the Mission Bay and La Jolla WMA and in the Tecolote Creek Hydrologic Area (HA) (906.5). Within this watershed, contaminants identified on the State Board §303(d) list include bacteria, cadmium, copper, lead, zinc, toxicity, phosphorus, and turbidity. The installation at this location falls within a watershed subject to *Project 1 Beaches and Creeks Bacterial TMDL*. The four RBDD systems (planter-barrel configuration) at the Rose Canyon Yard Service Building are designed to address the PWQP of bacteria, dissolved metals, and phosphorus.

Three of four systems required coordinating with the facility manager and facility staff in order to identify appropriate power sources and circuit breakers. Additional coordination with City Facilities Maintenance Staff was necessary in order to evaluate electrical repairs necessary for RCyn-1.

	**RBDD Systems:** **RCyn-1, RCyn-2, RCyn-3 Automated Planter-Barrel with Pump (110-v electrical service)**
	**RBDD System:** **RCyn-4 Gravity-Flow Planter-Barrel**

Figure 2-4. Rose Canyon Yard Service Buildings Downspout Disconnect Installation Photograph(s)

2.4 Scripps Institution of Oceanography

In coordination with Environmental Management Division staff at the University of California, San Diego, the City was authorized to place a planter-barrel RBDD system at the machine shop located off Naga Way within the SIO. The site is located near the Pacific coastline; its roof construction is corrugated metal.

SIO is located in the Mission Bay & La Jolla WMA and in the Scripps HA (906.30). The ASBS Exception Process identifies pollutants of concern that will require reduction to meet the requirements for storm water discharge into the two La Jolla ASBS. The RBDD system at SIO is designed to address the PWQP of bacteria and suspended solids. The installation at this location falls within a watershed subject to *Project 1 Beaches and Creeks Bacterial TMDL*. It is anticipated that this RBDD system will also capture condensation roof runoff.

RBDD System:
UCSD-1 Gravity-Flow Planter-Barrel

Figure 2-5. Scripps Institution of Oceanography Metalshop Building Downspout Disconnect Installation Photograph(s)

2.5 Mission Trails Regional Park Nature and Visitor Center

Mission Trails Regional Park is located in the San Diego River WMA and in the Lower San Diego River HA (907.10). Within this watershed, contaminants identified on the State Board §303(d) list include fecal coliforms, low dissolved oxygen, pH, total dissolved solids (TDS), and phosphorus. The installation at this location falls within a watershed subject to *Project 1 Beaches and Creeks Bacterial TMDL*. The two RBDD systems (i.e., barrel configuration, below grade) at the Mission Trails Regional Park Nature and Visitor Center are designed to address the PWQP of bacteria and phosphorus.

The Mission Trails Regional Park was closed outside of normal business hours. Access for baseline water quality monitoring in 2008-2009 was not possible. Through coordination with the Park Ranger and Visitor Center staff, monitoring was conducted outside of normal business hours during the 2009-2010 Monitoring Season. Additional reconnaissance of the facility allowed the City to determine the true roof drain configurations to MT-1 and MT-2.

	**RBDD System:** **MT-1 Automated Barrels Discharging to Existing Landscaping (12-volt solar electrical service with manual turn timer)** **Rain Chain and Solar Powered Pump (see photo)**  (photo source Homedepot.com)
	**RBDD System:** **MT-2 Automated Barrel Discharging to Existing Landscaping (12-volt solar electrical service with manual turn timer)**

Figure 2-6. Mission Trails Regional Park Nature and Visitors Center Downspout Disconnect Installation Photograph(s)

2.6 Mira Mesa Library

Mira Mesa Library is located in the Los Peñasquitos WMA and in the Miramar Reservoir HA (906.10). The installation at this location falls within a watershed subject to *Project 1 Beaches and Creeks Bacterial TMDL*. The Regional Board is currently developing a TMDL for the Los Peñasquitos Lagoon based on the State Board §303(d) listing of the lagoon for impairments due to sediment/siltation. The two RBDD systems (i.e., one in-series barrel configuration and one planter-barrel configuration) at the Mira Mesa Library are part of an integrated LID bioretention planter system designed to capture, retain, and treat storm water prior to the water entering the storm drain system.

Design, implementation, and maintenance of these systems was in coordination with the site manager for the Library.

	**RBDD System:** **MM-1 Gravity-Flow Planter-Barrel**
	**RBDD System:** **MM-2 Multiple Gravity-Flow Barrels in Series Discharging to Existing Landscaping**

Figure 2-7. Mira Mesa Library Downspout Disconnect Installation Photograph(s)

2.7 Rancho Bernardo Recreation Center

Rancho Bernardo Recreation Center is located in the San Dieguito River WMA and in the Hodges HA (905.20). Within this watershed, contaminants identified on the State Board §303(d) list include color, nitrogen, phosphorus, turbidity, manganese, and pH. The installation at this location falls within a watershed subject to *Project 1 Beaches and Creeks Bacterial TMDL*. The four RBDD systems (barrel configuration) at the Rancho Bernardo Recreation Center are designed to address the PWQP of nitrogen and phosphorus.

Design, implementation, and maintenance of these systems was in coordination with the site manager and staff for the Recreation Center.

	**RBDD System:** **RB-1 Gravity-Flow Barrel Discharging to Existing Landscaping**
	**RBDD System:** **RB-2, RB-3, and RB-4 Gravity-Flow Barrel Discharging to Existing Landscaping**

Figure 2-8. Rancho Bernardo Recreation Center Downspout Disconnect Installation Photograph(s)

2.8 South Bay Wastewater Treatment Plant

The South Bay Wastewater Treatment Plant is located in the Tijuana River WMA and in the Tijuana Valley HA (911.1). Within this watershed, contaminants identified on the State Board §303(d) list include eutrophic conditions, indicator bacteria, low dissolved oxygen, pesticides, solids, synthetic organics, trace elements, and trash. The four RBDD systems (planter-barrel configuration) at the South Bay Wastewater Treatment Plant are designed to address the PWQP of bacteria, metals, and nutrients.

South Bay Wastewater Treatment Plant was identified as a potential site for the RBDD program in the *Fiscal Year 2009 Conceptual Designs for Watershed Capital Projects Report* (Weston, 2010). Access to the secured facility for design, implementation, and maintenance of these systems was in coordination with the site manager for the South Bay Wastewater Treatment Plant.

	**RBDD Systems:** **SB-1, SB-2, SB-3, and SB-4 Gravity-Flow Planter-Barrel**

Figure 2-9. South Bay Wastewater Treatment Plant Downspout Disconnect Installation Photograph(s)

3.0 SYSTEM COMPONENTS

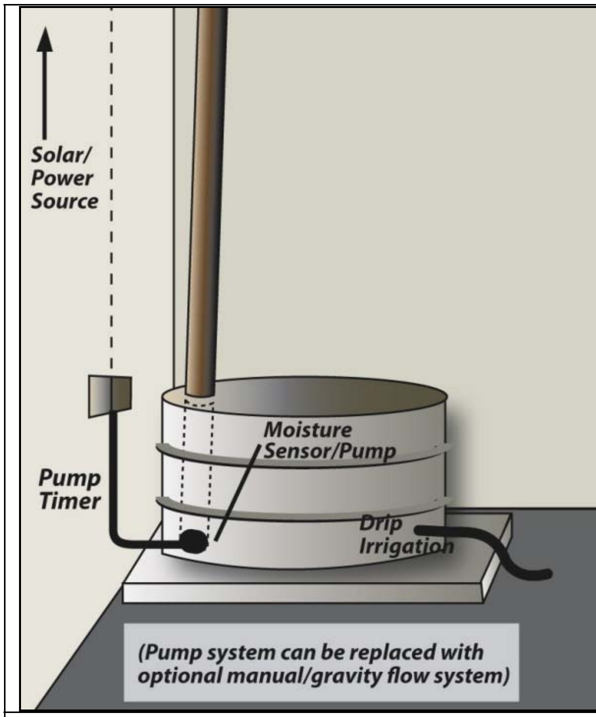


Figure 3-1. General Configuration for a Rain Barrel Downspout Disconnect System

Barrel systems and planter-barrel systems were the two configurations of RBDD systems designed for this program. A conceptual design sketch of the barrel configuration is presented on Figure 3-1; a conceptual design sketch of the planter-barrel configuration is presented on Figure 3-2. The two configurations mainly differ in terms of the irrigation component of the design. Barrel systems discharge captured runoff into an adjacent, existing landscaped area. Planter-barrel systems were installed where no landscaping was in place (e.g., an impervious asphalt surface or low infiltration soils). The design for the planter-barrel configuration incorporated an above-ground planter filled with native plants and a special soil mixture designed to promote infiltration and to provide a level of treatment. Figure 3-2 also highlights an opportunity to increase flow and pollutant load reductions through an expanded treatment train. While not currently in place, the RBDD systems at Mira Mesa Library and Southcrest Recreation Center are placed in-series with a bioswale and porous pavement, respectively (Weston, 2010).

The irrigation component of both the barrel system and the planter-barrel system could be designed to be automated (i.e., pump-driven irrigation) or gravity flow. This report evaluates RBDD systems in terms of the configuration types and the automated versus gravity-flow irrigation component. Components of a RBDD system include the following:

- (Existing) Gutter(s) and Downspout(s).
- Base – Installed at grade on a flat concrete base, on a raised wooden platform elevated to a level which allows gravity discharge to a precast concrete planter, or below grade.
- Rain Barrel – Single or multiple barrels connected in series to expand capacity.
- Irrigation System and Plumbing – Gravity drip irrigation or automated pump connected to a drip irrigation system.
- Infiltration Area – Existing landscaped area or precast concrete planter filled with soil mixture and drought tolerant plants.

These general system components are summarized in Table 3-1. Site specific configurations and components are presented in Appendix A.

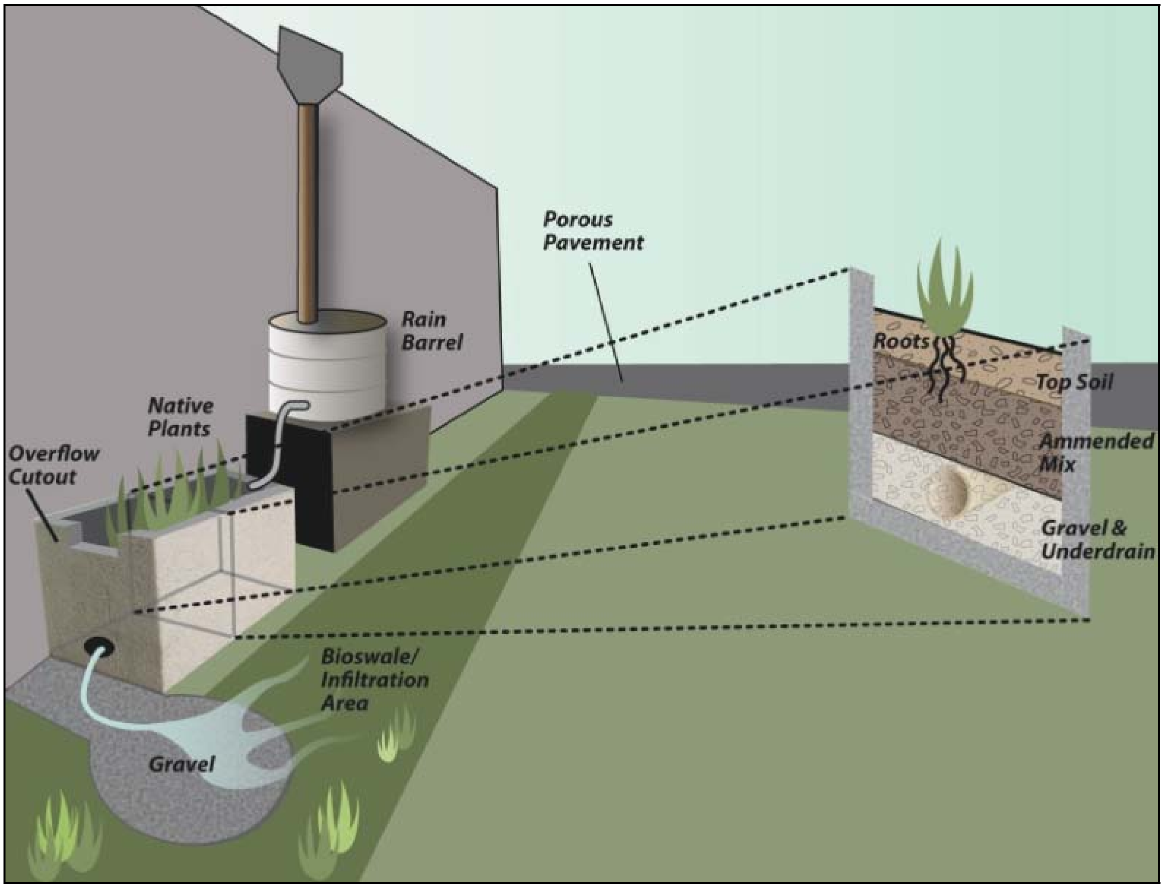


Figure 3-2. General Configuration for a Planter-Barrel Downspout Disconnect System In-Series with a Low Impact Development Project

Table 3-1. Components of a Typical Rain Barrel Downspout Disconnection System

System Component	Type(S)	System Configuration	Purpose	Potential Materials	No. Systems With Type of Component in Program
Gutter & Downspout	Existing	Barrel, Planter-Barrel	Gutters collect roof runoff and direct flow into a downspout, which is typically designed to discharge to parking areas or the storm drain system. A RBDD system disconnects the downspout and redirects flow into the rain barrel component.	Gutters: copper, galvanized metal, aluminum Downspouts: copper, galvanized metal, aluminum, polyvinyl chloride (PVC), ABS	ALL SYSTEMS.
Base	At Grade Formed Concrete	Barrel	A base provides a level surface for the system to rest upon. The RBDD system must be level to optimize water reuse and slightly above grade to allow gravity-flow conditions.	Concrete (existing)	Wood: 2 Concrete: 3 Dirt, below grade: 2 (MT) Existing condition: 4 (RB)
	At Grade Formed Concrete and Raised/Elevated Platform	Planter-Barrel	Planters were approximately 2-ft tall. For the barrel to discharge into the planter, the barrel must be elevated above the lip of the planter system to allow gravity flow. Elevation was typically achieved using a constructed wood base. A level concrete base was placed underneath an elevating wood base where the ground surface was not level.	Wood, formed concrete	Wood: 12 [(a)] Concrete/wood: 1 (MM-1)
	Below Grade	Barrel	A 54-gallon octagonal Rain Barrel was installed approximately 12 inches below grade. This was necessary in order to connect to the rood drains in the lower wall of the Regional Park Nature and Visitor Center. A hole was dug around the system and backfilled to secure in place. An automated (solar panel powered pump) irrigation system was necessary to push water from the bottom of the barrel.	Irrigation System: PVC pipe and fittings, Solenoid actuated valve Plumbing: Pump Electrical: Timer, switch, wiring, solar panel	Barrel Octagonal: 2
Rain Barrel	Singular, or Connected In Series	Barrel, Planter-Barrel	Rain barrels are receptacles used to capture and store roof runoff until the water is beneficially applied as irrigation. Barrels are typically fitted with an outlet at the bottom, overflow at the top, and a vector control screen. Additional roof runoff may be captured and stored in systems where multiple barrels are installed in series.	Barrels come in a variety of volumes, configurations, materials, and colors. Systems used in this program were molded plastic. 75-gallon Rainbox (Aquabarrel, black) 55-gallon Rain Barrel (Desert Plastics, Cubo, tan) 54-gallon octagonal Rain Barrel (tan)	Barrel Rainbox: 7 (3 systems in series) Cubo: 2 Octagonal: 2 Planter-Barrel Rainbox: 13
Irrigation System	Gravity-Flow	Barrel, Planter-Barrel	The RBDD system's infiltration area is irrigated through a drip irrigation system pressurized by gravity flow (pressure gradient created by water stored within the barrel).	Irrigation System: PVC pipe and fittings	17
	Automated	Barrel, Planter-Barrel	The RBDD system's infiltration area is irrigated through a drip irrigation system pressurized by a 1/8th horsepower pump and timer system.	Irrigation System: PVC pipe and fittings, Solenoid actuated valve Plumbing: Pump Electrical: Timer, switch, wiring, solar panel	7
Infiltration Area	Existing Landscaping and Vegetation	Barrel	Existing vegetation was assumed to capture and infiltrate 100% of flow discharged from a RBDD system.	Type of vegetation and surface area covered varied from site to site.	11
	Planter System	Planter-Barrel	Planters capture discharge from the rain barrel and are designed to provide a degree of attenuation and treatment before discharging water to an adjacent impervious surface. It was assumed that a portion of the water would be used by plants.	Rectangular Planter: Concrete (U.S. Concrete Precast Group, 24 inches x 72 inches x 22 inches) Square Planter: Concrete (U.S. Concrete Precast Group, 36 inches x 36 inches x 30 inches) Plants: Native (5 per planter) Soil: Top soil, treatment mix, gravel/sand Underdrain: PVC	Rectangular Planter: 11 Square Planter: 2

a) At the Rose Canyon Yard Service Buildings wood runners were used to provide a level surface for two of the planters (RCyn-1 and RCyn-2).

4.0 DOWNSPOUT DISCONNECT DESIGN EVALUATION

4.1 Rain Barrel Materials

Initial review of potential design materials for barrels and planters included determining availability, price, durability, and features (e.g., drainage ports, vector screens, overflows, and customization). Ultimately, three barrels were identified that provided the best value and were customizable, which allowed designs to accommodate site constraints. Due to the weight and transportation costs, a local precast concrete product supplier was selected to provide the planters used for the planter barrel systems. The local precast concrete product supplier was also willing to modify the planter drains to project specifications optimizing retention and treatment.

The materials chosen in the final design affect the system footprint (i.e., area, shape, and height) and storage capacity. Site constraints and site objectives were taken into account in the final design of any RBDD system. To assess different designs, the following three types of barrels were evaluated as part of the RBDD Program:

- 75-gallon Aquabarrel Rainbox (original black, painted white, painted tan).
- 55-gallon Desert Plastics Cubo rain barrel.
- 54-gallon octagonal rain barrel.

The footprint of a single rainbox or rain barrel was comparable (approximately 3 ft). The footprint of a single octagonal barrel was larger (4.8 ft), but this system is only 18-inches tall and therefore better suited to the roof drains in the lower walls of the Mission Trails Regional Park Nature and Visitor Center. All three systems could be placed into series, but the rectangular shape of the rainbox optimizes the footprint by allowing closer placement to walls and other systems. The rectangular rainbox was also the system of choice for the planter-barrel configuration when designing and building the 2-ft high wooded base.

Overall, the 75-gallon Aquabarrel Rainbox rain barrel component of the system outperformed the other two systems in terms of barrel capacity and preventing algal growth, but was ranked as the lowest in terms of accessibility for maintenance (Cubo barrel ranked highest). Further analysis of the different system configurations and rain barrel components has been further analyzed in Site Inspection and Maintenance, Section 5.0.

4.2 Automated versus Gravity-Flow Systems

The intent of this project was to evaluate various RBDD systems and determine system-specific structural and siting limitations. Systems were designed in three basic configurations (automated, gravity-flow, and planter-barrel) and implemented at locations with varying roof drainage areas and building materials. Automated systems were designed to capture and store roof runoff during a storm event, delaying use of the stored water until after the storm passed. Gravity-flow systems were designed to act like a detention basin, and continuously captured and discharged roof runoff to an infiltration area over the storm event. Planter-barrel systems were designed for both automated and gravity-flow operations and were designed as an alternative for areas with little to zero existing landscaping. Piloting these three configurations allowed the City to evaluate RBDD systems that could be installed at other City facilities, integrated with other BMPs / storm water programs for commercial/industrial use, and / or recommended to the public for at-home use.

Overall, gravity-flow irrigation systems outperformed automated systems in terms of flow reduction, load reduction, and O&M. The design of automated systems inherently captured less roof runoff and therefore treated a smaller pollutant load. Site inspections and maintenance activities indicated that automated systems were more likely to break down and required more complex O&M. Further analysis of the RBDD system configurations has been provided in Subsection 4.3, Section 5.0, and Section 7.0, below.

4.3 System Sizing and Flow Capture / Attenuation

Based on the City's design storm criteria, a volume-based design approach was used to evaluate the flow capacity of all the RBDD systems (Weston, 2009b). The design storm volume was location and system specific. Design storm volumes were calculated as the product of the roof area tributary to each downspout disconnected by a RBDD system and 0.6 inches of rainfall over a 24-hour storm event (cubic feet per day). The flow capacity of each system was determined using the calculator provided in Appendix B. Key variables included the roof area, number and type of barrels, "planter" infiltration area, and a factor of safety. Automated irrigation systems assumed zero infiltration area during a storm event and therefore the flow capacity was limited to the original barrel volume. Gravity-flow systems identified the flow capacity at the intersection of the roof runoff and cumulative infiltration (soil conservation service (SCS) distributed method). Assumptions and calculations are presented in Appendix B.

As part of the design process, the impact of re-sizing system components was evaluated and shown on Figure 4-1 and Figure 4-2. As hypothesized during design, gravity-flow systems attenuate more flow than automated systems capture and store. The flow captured / attenuated may be increased by increasing the storage capacity (larger barrels, or multiple barrels in series) or by increasing the infiltration area. Based on this analysis, larger storage volumes increase the overall flow capacity more than larger infiltration areas. For example, if two 75-gal rainboxes were installed below a 425 sq-ft section of roof, and discharged to a single 2-ft x 6-ft planter area, approximately 178 gallons of runoff would be attenuated (0.67 inch storm). For the same 425 sq-ft roof area, doubling the planter box area and using one 75-gallon rainbox would only attenuate 90 gallons of runoff (0.34 inch storm). Increasing the storage volume doubles the flow reduction effectiveness of the system. Furthermore, increasing the storage volume is the only way to increase the flow capacity of an automated RBDD system. Supporting calculations for these analyses are provided in Appendix B.

Using this information, the 18 RBDD systems were sized and designed to test system-specific limitations (typical sizing equations are presented on Table 4-1). The maximum volume and 24-hour storm event that can be captured / attenuated, and treated by each RBDD system is presented in Table 4-2. At some locations, gravity-flow systems attenuate flows 6.5 times the original capacity of the rain barrel! Twelve gravity-flow systems treat a volume of roof runoff in excess of the 0.6-inch design storm. Three systems treat the City's first flush criteria of 0.2 inches over a 24-hour storm. The roof area draining to SC-4, SC-5, and RCyn-4 was too large for the gravity-flow planter-barrel systems (insufficient filtration area in the planter). These systems were under-designed due to space constraints. In the future, overflow from the two systems at Southcrest Park Recreation Center will be infiltrated by a section of porous pavement per the Southcrest Park Infiltration for Chollas Creek Watershed Protection conceptual design (Weston, 2008).

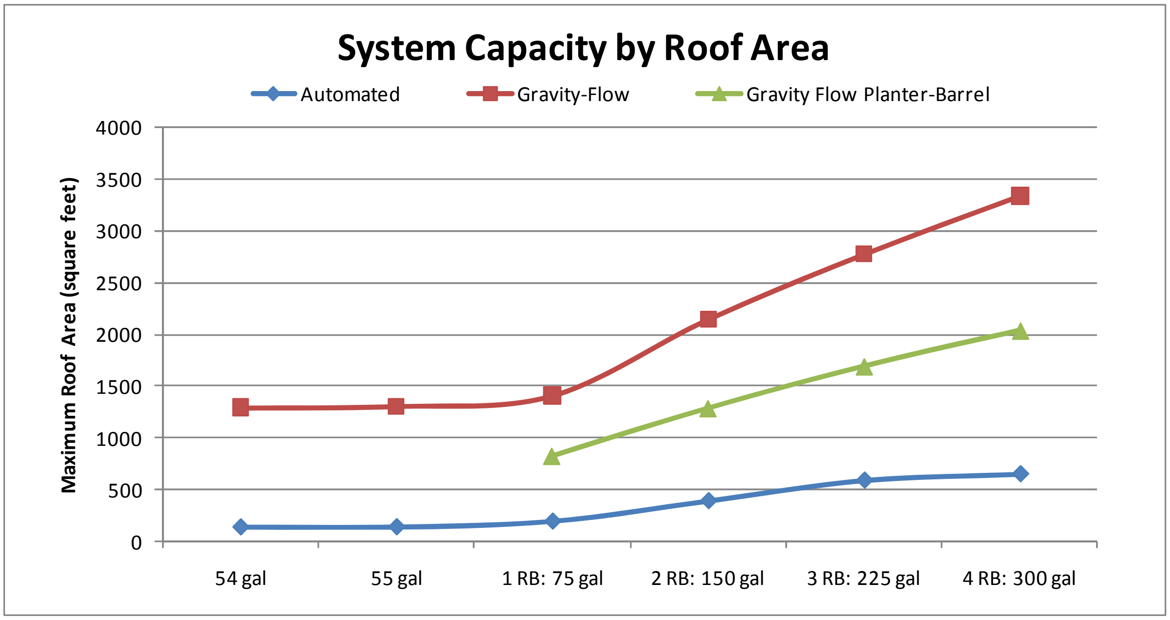


Figure 4-1. Roof Area and Flow Captured for the 0.6 inch, 24 hour Design Storm

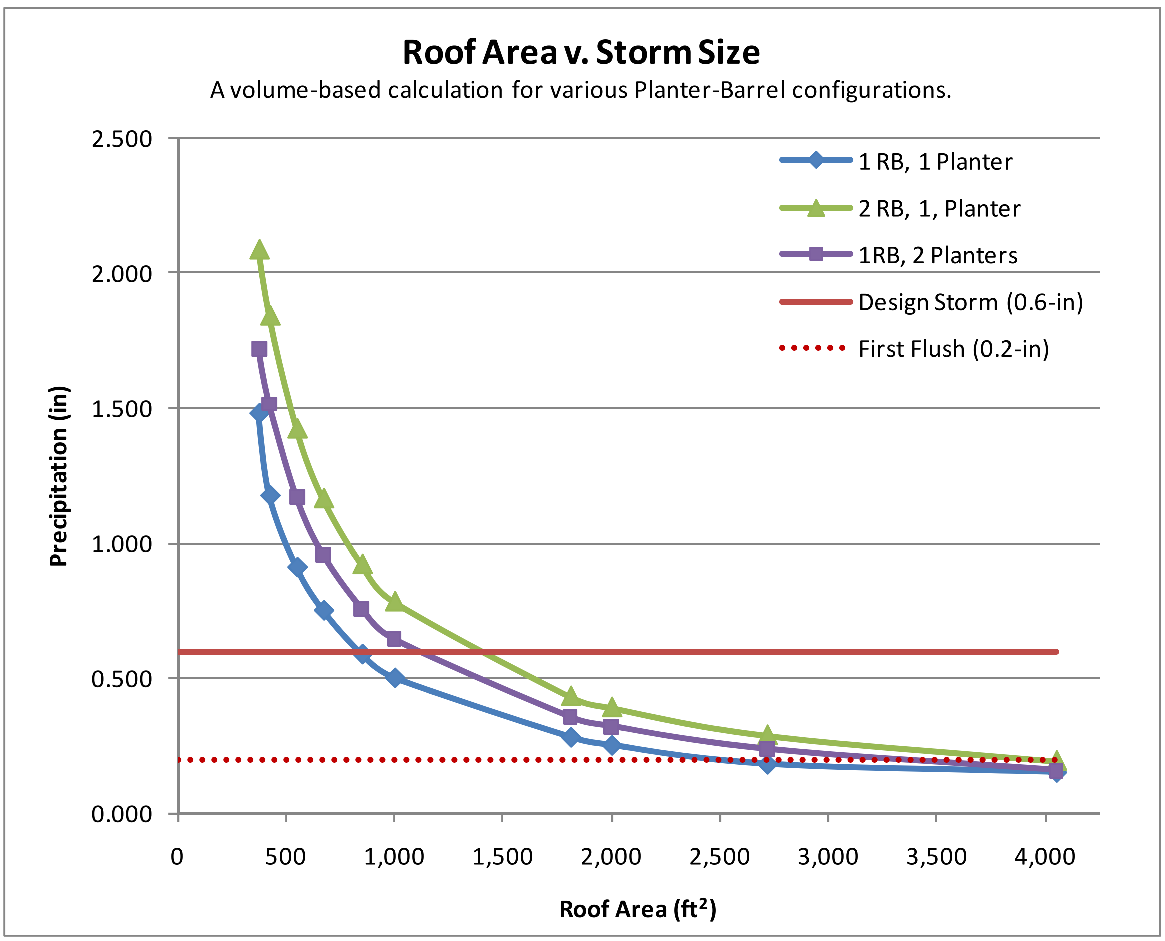


Figure 4-2. Maximum Rainfall Intensity (over 24-hours) Captured from a Given Roof Area for Different Planter-Barrel Configurations

Table 4-1. Maximum Roof Area for which a Given Number of 75-gallon Rainboxes Could Capture / Attenuate / Treat the 0.6-inch Design Storm Event

RBDD Configuration	Equation of the Line
Gravity-Flow	Roof Area (sq-ft) = 1406 * (No. 75-gal rainboxes) $^{0.62}$
Planter-Barrel	Roof Area (sq-ft) = 828 * (No. 75-gal rainboxes) $^{0.65}$
Automated / Capture	Roof Area (sq-ft) = 206 * (No. 75-gal rainboxes) $^{0.90}$

Table 4-2. Maximum Storm Depth and Treatment Volume Versus Barrel Capacity and Roof Area for each System

Site Location	System ID	Barrel Capacity (gal)	Type of System	Roof Area (ft^2)	Max Storm Volume Treated (cft)	Max Storm Volume Treated (gal)	Max Storm Captured from Roof Area (inches over 24 hrs)	Max Storm as a Portion of the 0.6 inch Design Storm	Max Storm as a Portion of the 0.2 inch First Flush Event	Notes
San Ysidro Library	SY-1	55	Gravity-flow	100	44.9	336	5.35	891.7%	2675.0%	Flows to existing landscaping.
San Ysidro Library	SY-2	75	Gravity-flow	550	54	404	1.17	195.0%	585.0%	Flows to existing landscaping.
Southcrest Recreation Center	SC-1	150	Gravity-flow	1,811	108.1	809	0.71	118.3%	355.0%	Flows to existing landscaping.
Southcrest Recreation Center	SC-2	150	Gravity-flow	1,811	108.1	809	0.71	118.3%	355.0%	Flows to existing landscaping.
Southcrest Recreation Center	SC-3	75	Gravity-flow, Planter-barrel	1,811	42	314	0.71	118.3%	355.0%	Flows to precast planter (P247222REC-MOD). Overflow discharges to pavement.
Southcrest Recreation Center	SC-4	75	Gravity-flow, Planter-barrel	2,717	42	314	0.18	30.0%	90.0%	Flows to precast planter (P247222REC-MOD). Overflow discharges to pavement.
Southcrest Recreation Center	SC-5	75	Gravity-flow, Planter-barrel	2,717	42	314	0.18	30.0%	90.0%	Flows to precast planter (P247222REC-MOD). Overflow discharges to pavement.
Rose Canyon Yard Service Buildings	Rcyn-1 *	68	Automated, Planter-barrel	4,050	9	67	0.03	5.0%	15.0%	Automated planter-barrel. Flow capped unless discharged to precast planter (P247222REC-MOD). Overflow discharges to pavement.
Rose Canyon Yard Service Buildings	Rcyn-2	75	Automated, Planter-barrel	4,050	10	75	0.03	5.0%	15.0%	Automated planter-barrel. Flow capped unless discharged to precast planter (P247222REC-MOD). Overflow discharges to pavement.
Rose Canyon Yard Service Buildings	Rcyn-3	75	Automated, Planter-barrel	3,600	10	75	0.03	5.0%	15.0%	Automated planter-barrel. Flow capped unless discharged to precast planter (P247222REC-MOD). Overflow discharges to pavement.
Rose Canyon Yard Service Buildings	Rcyn-4	75	Gravity-flow, Planter-barrel	4,050	42	314	0.15	25.0%	75.0%	Flows to precast planter (P247222REC-MOD). Overflow discharges to pavement.
Scripps Institution of Oceanography	UCSD-1	75	Gravity-flow, Planter-barrel	672	42	314	0.75	125.0%	375.0%	Flows to precast planter (P247222REC-MOD). Overflow discharges to pavement.
Mission Trails Regional Park Nature and Visitor Center	MT-1	54	Automated	625	7.2	54	0.14	23.3%	70.0%	Automated system. Flow capped, but overflow discharges to existing landscaping.
Mission Trails Regional Park Nature and Visitor Center	MT-2	54	Automated	625	7.2	54	0.14	23.3%	70.0%	Automated system. Flow capped, but overflow discharges to existing landscaping.
Mira Mesa Library	MM-1	75	Gravity-flow, Planter-barrel	375	46.6	349	1.48	246.7%	740.0%	Flows to precast planter (P247222REC-MOD).
Mira Mesa Library	MM-2	150	Gravity-flow	406	108.1	809	3.17	528.3%	1585.0%	Flows to existing landscaping.
Rancho Bernardo Recreation Center	RB-1	55	Manual	525	7.4	55	0.17	28.3%	85.0%	Manual operation however, overflow discharges to existing landscaping. The Facility manager wanted his staff to be able to water the plants out front of the building manually. Flows to existing landscaping
Rancho Bernardo Recreation Center	RB-2	75	Gravity-flow	1,250	60.8	455	0.58	96.7%	290.0%	Flows to existing landscaping.

Table 4-2. Maximum Storm Depth and Treatment Volume Versus Barrel Capacity and Roof Area for each System

Site Location	System ID	Barrel Capacity (gal)	Type of System	Roof Area (ft^2)	Max Storm Volume Treated (cft)	Max Storm Volume Treated (gal)	Max Storm Captured from Roof Area (inches over 24 hrs)	Max Storm as a Portion of the 0.6 inch Design Storm	Max Storm as a Portion of the 0.2 inch First Flush Event	Notes
Rancho Bernardo Recreation Center	RB-3	75	Gravity-flow	1,250	60.8	455	0.58	96.7%	290.0%	Flows to existing landscaping.
Rancho Bernardo Recreation Center	RB-4	75	Gravity-flow	1,250	60.8	455	0.58	96.7%	290.0%	Flows to existing landscaping.
South Bay Wastewater Treatment Plant	SB-1	75	Gravity-flow, Planter-barrel	725	42	314	0.69	115.0%	345.0%	Flows to precast planter (P247222REC-MOD). Overflow discharges to pavement.
South Bay Wastewater Treatment Plant	SB-2	75	Gravity-flow, Planter-barrel	725	42	314	0.69	115.0%	345.0%	Flows to precast planter (30-in x 30-in). Overflow discharges to pavement.
South Bay Wastewater Treatment Plant	SB-3	75	Gravity-flow, Planter-barrel	725	42	314	0.69	115.0%	345.0%	Flows to precast planter (30-in x 30-in). Overflow discharges to pavement.
South Bay Wastewater Treatment Plant	SB-4	75	Gravity-flow, Planter-barrel	725	42	314	0.69	115.0%	345.0%	Flows to precast planter (P247222REC-MOD). Overflow discharges to pavement.

* RCyn-1 was assessed for the optimal 75-gallon size. However, the barrel was vandalized/broken during start up and achieved a performance approximately 10% lower than designed.

5.0 SITE INSPECTION AND MAINTENANCE

All RBDD systems at each installation site were inspected on November 30, 2009, as part of the system startup process. The operational status of all systems was evaluated during three subsequent inspections in December 2009, January 2010, and March 2010. In the event that operational status was compromised, the condition of the RBDD was recorded on the RBDD Program Inspection Form (Appendix C) and photographed. During an inspection, the cause of the damage was determined to be due to normal wear and tear or vandalism. Routine maintenance was completed on compromised RBDD systems. Inspection results and maintenance activities are summarized in this report. Data and photographs are presented in Appendix E.

5.1 Rain Barrel Downspout Disconnect System Startup

On November 30, 2009, Weston Solutions, Inc. (Weston®) staff members visited each installation site and inspected all RBDD systems for operational status prior to system startup. This system startup evaluation ensured that the RBDD systems operated as intended, including on/off functionality of the pumps (if applicable) and proper flow of irrigation systems associated with the systems.

During the startup evaluation, all systems were determined to be operational and ready for use. Figure 5-1 provides an example of a complete planter-barrel installation.

Figure 5-1. Complete Planter-Barrel System Ready for Operation

5.2 Mechanical Inspection Program

The operational status of all systems was evaluated during three system inspections; one evaluation was completed approximately every five to eight weeks, in December 2009, January 2010, and March 2010. During each inspection, RBDD systems were evaluated for structural integrity and potential repairs. Field notes were recorded on the RBDD Program Inspection Form (for blank inspection form see Appendix C). This form distinguished incidental/minor repairs (i.e., piping/fittings replacement, planter material addition, irrigation tubing repairs, repairs to downspout connection to barrels, etc.) from major repairs. Incidental and/or minor repairs were considered part of the routine maintenance of RBDD systems. A system requiring major repairs was flagged as "not operational" on the Inspection Form. For systems like RCyn-1, the infrastructure may be functional (with a reduced capacity) but damaged such that it requires replacement. Major repairs included electrical work and the replacement of missing/vandalized rain barrels, plants, or planters. Major repairs were typically postponed until the operations evaluation and maintenance program was transferred from the contractor (i.e., Weston) to the

City on March 30, 2010. All maintenance activities were documented with pre-maintenance and post-maintenance photographs (Appendix E).

Inspection field measurements for pH and conductivity were made using an Oakton CON10 pH/conductivity meter according to the manufacturer specifications to determine potable water signature or to indicate potential contamination. Calibration of the instrument was conducted prior to each field inspection.

5.3 Inspection Number 1 – December 2009

The first round of mechanical inspections after the RBDD system startup was completed on December 22, 2009. As summarized in Table 5-1, nine systems at four sites were identified as needing repair work due to vandalism. The location most vandalized was Southcrest Recreation Center where three of the five systems needed repair. During the December inspections and repairs, educational signage was installed at designated systems at each site and was expected to reduce vandalism of the system. The remaining 13 systems were determined to be in good operational condition and not in need of any major repair or replacement. The remaining system inspection results and photo-documentation are presented in Appendix E.

Two automated systems at the Rose Canyon Yard Service Buildings site (RCyn-1 and RCyn-3) were inoperable due to electrical service problems. The pumps were plugged into 110v outlets that were either non-operational or intermittently operational, thus the pumping systems were not operating according to the timer and watering schedule. Working with the facility staff, Weston determined that the circuit breaker in Panel No. 1, Switch No. 17 was the culprit. The circuit breaker was reset, and the facility electrician was going to evaluate the loads on the circuit to determine how to best ensure continuous electrical service.

During the December inspection, the barrel system near the patio entrance at Mission Trails Regional Park Nature and Visitor Center (MT-1) showed no evidence of receiving flow. After speaking with the site contact and photo-documenting flow conditions during the storm event on January 18, 2010, it was determined that the roof drain configuration does not regularly discharge to the RBDD system. The roof drainage system is configured in a paired configuration with a main downspout and an overflow. The main downspout conveys flow during all storms and the overflow drain is functional if the main drain is plugged and non operation or if the capacity of the main drain has been exceeded due to intense rainfall. The main roof drains discharge to an untraceable underground conveyance system according to as built drawings. The facility maintenance staff has determined that reconfiguring the roof drains will create a flow condition where the barrels are receiving runoff and have received a work order to reconfigure the drains. Irrigation tubing at Mission Trails (system MT-2) had been vandalized. New tubing had to be connected to the pump. In order to maintain the existing electrical connections to the pump, maintenance activities had to be conducted inside the barrel, in algae-filled water.[2] Once tubing was re-connected, the solar panel powered pump and timer system operated as designed.

[2] MT-2 was installed below grade. This configuration did not make it possible to empty the barrel by means of gravity flow like the 75-gallon rainboxes at Rose Canyon. Baling water was time consuming and impractical.

The gravity-flow barrel system at San Ysidro Library was fully operational, and during the inspection, it was determined that complaints from facility staff regarding an unpleasant odor were due to excessive algal growth inside of the 55-gallon Cubo barrel. The grass immediately adjacent to SY-2 and the library building is longer than the main section of grass. The placement and siting of RBDD systems may have unforeseen impacts to other maintenance activities, such as landscape maintenance.

Table 5-1. Systems Requiring Repair Identified during Inspection Number 1 (December 2009)

Site Name	System ID	Operational Status/Condition	Water in Barrel (% full)	Vandalism	Repairs Completed
Mission Trails Regional Park Nature and Visitor Center	MT-1	No: Does not receive flow. Needs redesign or relocation.	0%	No vandalism. No graffiti.	Service request provided to Maintenance Division
Mission Trails Regional Park Nature and Visitor Center	MT-2	No: Parts missing. Needs repair.	100%	Vandalism observed. No graffiti.	–
Rose Canyon Yard Service Buildings	RCyn-1	No: Parts missing. Barrel broken. Needs repair (electrical).	0%	Vandalism observed. No graffiti.	See Inspection Memorandum No. 2 (Appendix F). System replaced 03/10/2010.
Rose Canyon Yard Service Buildings	RCyn-2	Yes: Needs repair.	50%	No vandalism. No graffiti.	Installed 2-inch overflow pipe.
Rose Canyon Yard Service Buildings	RCyn-3	No: Needs repair (electrical).	0%	Vandalism observed. No graffiti.	See Inspection Memorandum No. 2 (Appendix F).
Southcrest Recreation Center	SC-2	No: Parts missing. Needs repair.	0%	Vandalism observed. No graffiti.	Reattached irrigation hose to system.
Southcrest Recreation Center	SC-4	No: Parts missing. Needs repair.	25%	Vandalism observed. Graffiti on caging (planter).	Attached new irrigation hose to system. Watered Plants. Installed sign.
Southcrest Recreation Center	SC-5	No: Parts missing. Needs repair.	25%	Vandalism observed. No graffiti.	Attached new irrigation hose to system. Planted/watered five plants.
San Ysidro Library	SY-1	Yes: Standing water. Needs repair.	25%	No vandalism. No graffiti.	See Inspection No. 2

5.4 Inspection Number 2 – January 2010

The second round of mechanical inspections was completed on January 29, 2010 and February 2, 2010. As summarized in Table 5-2, eight systems at four sites were identified as needing repair work. Unlike the first round of inspections, no maintenance activities were related to vandalism, which could have been attributed to a series of storms that likely limited outdoor activity and/or reduced pedestrian traffic due to school holidays. Detailed system inspection results and photo-documentation are presented in Appendix E.

Observations of MT-1 at Mission Trails Regional Park Nature and Visitor Center indicate that this site does not receive flow during storm events as previously described under Subsection 5.3 Inspection No. 1 – December 2009. Technical Memorandum No.1 was submitted to the City to document MT-1 and MT-2 connection to the high-flow roof drains (Appendix F). Facility staff discussed a future butterfly garden that will be constructed in the drainage area of MT-2 where beneficial reuse of the captured water will be integrated into the butterfly garden design and be part of the interpretative signage.

The two non-operational planter-barrel systems at the Rose Canyon Yard were still experiencing electrical problems. Technical Memorandum No. 2 was submitted to the City to document the electrical wiring problems at RCyn-1 and RCyn-3 and recommend evaluation by a City Electrician (Appendix F).

The “Do Not Drink” stickers had fallen off all four of the rainboxes at the South Bay Wastewater Treatment Plant. A minor maintenance activity involved reapplying new stickers.

The Cubo, gravity-flow barrel system at San Ysidro Library (SY-1) was fully operational during both the first and second inspections. Between the two inspections, the City had received complaints regarding an unpleasant odor from the system. Based on the observations from Inspection No. 1, algae were determined to be the likely cause of the odor. While the tan colored barrel and polka-dot vector control lid are aesthetically pleasing and match the Adobe façade of the San Ysidro Library, these features expose stored water to light, thus promoting algal growth and the aforementioned musty, stagnant odor. During Inspection No. 2, routine maintenance activities included building a base for educational signage and re-designing the system to minimize the volume of water stored in the system. The system redesign involved installing a new bulk head fitting at the base of the barrel and connecting the irrigation lines to the new discharge pipe which will minimize standing water in the barrel.

The grass along the SY-2 was longer than observed during Inspection No. 1. When discharging water captured in the bottom 1/3 of the system, the longer grass around the edge of the rainbox, security pole, and building prevented proper drainage. Half of the water pooled on the concrete walkway around the system; no water was observed discharging to the MS4.

Table 5-2. Systems Requiring Repair Identified during Inspection Number 2 (January 2010)

Site Name	System ID	Operational Status/Condition	Water in Barrel (% full)	Vandalism	Repairs Completed
Mission Trails Regional Park Nature and Visitor Center	MT-1	SAME AS INSPECTION 1 – No: Does not receive flow. Needs redesign or relocation.	0%	No vandalism. No graffiti.	Reviewed roof drainage. See Inspection Memorandum No. 1 (Appendix F).
Mission Trails Regional Park Nature and Visitor Center	MT-2	SAME AS INSPECTION 1 – No: Parts missing. Needs repair.	100%	Vandalized. No graffiti.	Replaced irrigation piping. Replaced missing sticker.
Rose Canyon Yard Service Buildings	RCyn-3	SAME AS INSPECTION 1 – No: Needs repair (electrical).	25%	No vandalism. No graffiti.	Removed trash. Could not reinstall vector control.
South Bay Wastewater Treatment Plant	SB-1	Yes: Good condition.	25%	No vandalism. No graffiti.	Replaced missing sticker.
South Bay Wastewater Treatment Plant	SB-2	Yes: Good condition.	25%	No vandalism. No graffiti.	Replaced missing sticker.
South Bay Wastewater Treatment Plant	SB-3	Yes: Good condition.	25%	No vandalism. No graffiti.	Replaced missing sticker.
South Bay Wastewater Treatment Plant	SB-4	Yes: Good condition.	25%	No vandalism. No graffiti.	Replaced missing sticker.
San Ysidro Library	SY-1	SAME AS INSPECTION 1 – Yes: Standing water. Needs repair.	25%	No vandalism. No graffiti.	Lowered irrigation discharge point. Cleaned in side of barrel. Installed sign.

5.5 Inspection Number 3 – March 2010

The third and final round of mechanical inspections was completed on March 4, 2010. As summarized in Table 5-3, route maintenance (e.g., trash removal, weeding, and plant care) was completed for five systems at four locations. The only major maintenance effort was for RCyn-1, where the broken rainbox was emptied, remove, and replaced. This effort took two staff approximately six field hours to complete. Additional effort was needed to properly remove and reinstall the electrical systems (bulkhead fittings, pump, float, plugs, overflow). Detailed system inspection results and photo-documentation are presented in Appendix E. A step-by-step photo guide documenting how to remove and replace a broken rainbox has also been provided in Appendix E.

Table 5-3. Systems Requiring Repair Identified during Inspection Number 3 (March 2010)

Site Name	System ID	Operational Status/Condition	Water in Barrel (% full)	Vandalism	Repairs Completed
Mission Trails Regional Park Nature and Visitor Center	MT-2	Yes: Good condition	25%	No vandalism. No graffiti.	Removed sediment and leaves from top of system
Rose Canyon Yard Service Buildings	RCyn-1	SAME AS INSPECTION 1 – No: Needs repair (electrical)	100%	No new vandalism. No graffiti.	Removed broken rainbox and replaced system. Pulled weeds.
Southcrest Recreation Center	SC-3	Yes: Good condition	25%	Plants vandalized. No graffiti.	Replanted Boganvilla.
Southcrest Recreation Center	SC-5	Yes: Good condition	25%	Trash. No graffiti.	Removed trash.
Mira Mesa Library	MM-1	Yes: Good condition	25%	Trash observed. No graffiti.	Removed trash.
San Ysidro Library	SY-1	Yes: Good condition	0%	Vandalism observed. Light graffiti (on side of barrel).	–

5.6 Inspection Program Summary

During the 2009–2010 Operation and Maintenance Inspection Program, three systems were determined to be permanently inoperable (RCyn-1, RCyn3, and MT-1) due to electrical or roof drain problems (Appendix F). The remaining systems were evaluated for performance and maintenance needs, as summarized in Table 5-4 and the sections below.

Table 5-4. System Inspection Summary Results

Category	Inspection No. 1 (December 2009)	Inspection No. 2 (January 2010)	Inspection No. 3 (March 2010)
Operational	Yes: 17 No: 7	Yes: 19 No: 5	Yes: 22 No: 3
Vandalized	8	–	4
Graffiti	2	1	1
Significant Water Odor	1	1	–
Water Color	None: 17 Yellow: 5 Gray: 2	None: 13 Yellow: 10 Black: 1	None: 18 Yellow: 5 Black: 1

Vegetation

Plants were typically healthy. Newly placed plants were removed at several locations (i.e. Southcrest Recreation Center) and may need frequent replacement until roots are established.

The placement and siting of RBDD systems may impact to landscape maintenance (SY-2). See comments in the Recommended Additional Work column of Appendix E for more information.

Algae and Vectors

Due to the exclusion covers on all rain barrels, there were no observed instances of mosquito larva in the barrels and no complaints from facility staff. Algae were not observed in the 75-gallon rainboxes. Algae were a notable problem in both of the 55-gallon, tan, Cubo rain barrels, and in both of the 54-gallon, tan octagonal rain barrels. Since the Cubo and octagonal barrels are translucent (i.e., allow sunlight penetration), this condition could be expected to be exacerbated by longer, warm summer days. During Inspection No. 3, algae were also observed on the concrete and along the wood runners underneath the planters at South Bay Wastewater Treatment Plant, Rose Canyon Service Yard, and at the machine shop at SIO.

Vandalism/Graffiti

Vandalism and graffiti were a prevalent problem at the Southcrest Recreation Center and included graffiti, plant theft, vandalism of plants / drip irrigation systems, and damage to the chain link caging. After educational signage was installed, the degree of vandalism appeared to be reduced though may also be attributed to the end to holidays and children being in school and participating in scheduled activities.

Vandalism was repaired at the Mission Trails Regional Park Nature and Visitor Center (MT-2). Additional instances of vandalism were not recorded at this site once the initial repairs were completed (in addition to the maintenance repair work, the Center undergrounded the irrigation tubing, making it inaccessible at the ground surface).

Based on conversations with the Facility Manager at Rose Canyon Service Yard, the hole in the rainbox at RCyn-1 was due to weekend vandalism. Vandals have been reported to commonly enter the facility after hours on weekends.

Trash

The South Bay Wastewater Treatment Plant and the Mission Trails Regional Park Nature and Visitor Center were the only two sites with no incidents of recorded trash in or around the RBDD systems. Trash was a minor problem at the remaining six facilities.

During the site inspection and system maintenance process, it was determined that without educational signage in place, the public perceives the 55-gallon Cubo rain barrel as a trash receptacle despite the screened cover on the top of the barrel. Based on conversations with staff from San Ysidro Library, the Cubo RBDD system near the main entrance was often used to dispose of gum, food items, and trash. The same type of system was installed at Rancho Bernardo Recreation Center but was located further away from the main entrance of the facility. The system was less frequented but was also used as a tray for disposing of gum, seeds, and other small food items (no liquids). The rainboxes and octagonal rain barrels were occasionally vandalized but typically not perceived as a trash receptacle.

Trash was found most frequently in the free-standing planter box of planter-barrel systems. At Southcrest Recreation Center, trash was also found in the caging around the systems.

Routine Maintenance

Under circumstances where systems were determined to be operational and of good condition or only in need of routine maintenance (e.g., stickers, cleaning, polyvinyl chloride (PVC) fitting replacement, and gardening), all 24 systems could be inspected and conditions documented within a standard eight-hour work day on the inspection form (Appendix C). Inspections averaged between 10 and 15 minutes for each system. If parts were readily available on hand, additional maintenance efforts required less than an hour to complete. Maintenance involving pumps or security caging took longer due to the added complexities related to system access. Parts required to complete routine maintenance of a system typically cost approximately $15. If a bulk head connection had to be replaced, the fitting cost approximately $12 a piece.

Access inside RBDD systems for routine maintenance activities was easiest for the 55-gallon Cubo rain barrel. The lid can be easily removed by unscrewing the wing nuts holding the vector-control lid in place. Access into the 54-gallon octagonal barrel was difficult due to the small opening in the top of the barrel and the need for a non-standard No. 2 square tipped screwdriver. But, unlike the taller barrel/rainbox, the bottom and sides of the octagonal system were easily accessible due to the low, 18-inch height. Completing routing repairs and accessing the inside of the Aquabarrel rainbox was most difficult. The height of the system and small opening in the top made it possible to reach only approximately 2/3 down into the system.

6.0 WET WEATHER MONITORING PROGRAM

Wet weather monitoring, sampling, and analysis of runoff water was conducted during Spring 2009, prior to installation of RBDDs (baseline monitoring), and during the 2009–2010 Wet Weather Monitoring Season, post-system installation. Wet weather sampling locations and monitoring activities by site are summarized in Table 6-1.

Table 6-1. Wet Weather Monitoring for the Rain Barrel Downspout Disconnect Program

Site Location	Spring 2009 (Baseline Monitoring)		2009–2010 Wet Weather Season	
	Sampling Date	System ID/Locations	Sampling Date	System ID/Locations
San Ysidro Library	02/07/2009	SY-1	11/28/2009 01/18/2010	All systems
Southcrest Recreation Center	02/07/2009	SC-1, SC-2	11/28/2009 01/18/2010	All systems
Rose Canyon Yard Service Buildings	Not monitored	Not accessible after hours	Not monitored	Not accessible after hours
Kellogg Park (1)	02/13/2009	Comfort station	Site abandoned	
Scripps Institution of Oceanography (1)	–	–	11/28/2009 01/18/2010	All systems
Mission Trails Regional Park Nature and Visitor Center	Not monitored	Not accessible after hours	11/28/2009 01/18/2010	MT-2
Mira Mesa Library	02/05/2009	MM-1	11/28/2009 01/18/2010	All systems
Rancho Bernardo Recreation Center	02/13/2009	RB-1	11/28/2009 01/18/2010	All systems
South Bay Wastewater Treatment Plant (2)	–	–	01/18/2010 01/26/2010	All systems

1) The SIO site replaced Kellogg Park site.
2) New site from the 2009 Conceptual Designs Report.
– = Not Applicable.

6.1 Baseline Monitoring

Wet weather monitoring, sampling, and analysis of runoff water was conducted during Spring 2009, prior to installation of RBDDs at five RBDD sites. The Rose Canyon Yard Service Buildings and Mission Trails Regional Park Nature and Visitor Center were not accessible after normal hours of operation and therefore were not included in the baseline wet weather monitoring effort. During preliminary system design, a barrel system was planned for the comfort station at Kellogg Park, but due to technical difficulties, the Kellogg Park site was abandoned. Instead, a planter-barrel system was installed at the metal shop at the SIO.

Grab samples were taken from downspouts associated with each of the monitored RBDD sites, and field duplicates and field blanks were collected for quality control.

The samples were taken during the front end of the storm event approximately 30 minutes to two hours after rainfall began, depending upon intensity and confirmation of barrel effluent starting.

Each field sample was uniquely identified with sample labels in indelible ink. All sample containers were identified with the sample identifier, the sample collection date and time, any special notations, the sampler’s initials, and the preservation method. Samples were collected and kept on ice under chain of custody (Appendix G) and were delivered to the appropriate laboratory within the required holding time. Samples for bacteria were specifically kept away from light and stored in a cooler until delivery to the analyzing laboratory.

Completed chain-of-custody forms were placed in a plastic envelope and were kept inside the container containing all samples. Once delivered to the analytical laboratory, the chain-of-custody form was signed by the sample recipient. The condition of the samples were noted and recorded by the receiver. Chain-of-custody records were to be included in the final reports prepared by the analytical laboratories and are considered an integral part of the report (Appendix G).

6.2 Post-Installation Wet Weather Monitoring (2009–2010)

Based on the current or proposed TMDLs affecting each of the watersheds where systems were installed, wet weather samples were analyzed for the COCs listed in Table 6-2. All samples were analyzed for total and dissolved metals. Samples from Southcrest Recreation Center were analyzed for the largest suite of COCs (e.g., organophosphate pesticides and synthetic pyrethroids), and this site served as the location where field duplicates were collected for quality control. These additional analyses were used to evaluate potential pesticide reduction consistent with the integrated TMDL approach for this watershed.

The wet weather sampling procedures, chain-of-custody procedures, and analyses were the same as implemented for the baseline monitoring procedures implemented in Spring 2009.

Table 6-2. Wet Weather Sample Analyte List and Constituents of Concern for each of the Watershed Management Areas

Analyte	San Ysidro Library	SouthBay Treatment Plant	Southcrest Recreation Center	SIO	Mira Mesa Library	Rancho Bernardo Recreation Center	Mission Trails Regional Park
	Tijuana	Tijuana	San Diego Bay	Mission Bay	Los Peñasquitos	San Dieguito	San Diego River
Total and Dissolved Metals	X	X	X	X	X	X	X
Total Hardness as $CaCO_3$ in Water Determination	X	X	X	X	X	X	X
Organophosphorus Pesticides			X				
Synthetic Pyrethroid Pesticides			X				
Nitrate in Water Determination			X			X	
Nitrite in Water Determination			X			X	
Total Phosphorus			X			X	X
Ammonia			X			X	
TKN in Water Determination			X			X	
Total Suspended Solids in Water Determination			X	X	X	X	
Turbidity							X
Indicator bacteria (total and fecal coliform and enterococcus)	X	X	X	X		X	X

6.3 Laboratory Water Chemistry

Upon completion of field monitoring activities, samples were sent to CRG Marine Laboratories, Inc. for analysis. Samples for bacterial assessment were analyzed at the Weston Microbiology Laboratory. Both laboratories are certified by the State of California to perform the analyses required. Analytical methods are presented in Table 6-3.

Table 6-3. List of Constituents and Methods for Analysis for 2009–2010 Wet Weather Sampling

Water Matrix	Method	MDL	RL	Units	Volume/Container	Holding Time
Total and Dissolved Trace Metals in Water Analysis						
Aluminum (Al)	EPA 200.8(m)	5.0	10.0	µg/L	250-mL HDPE plastic	48 hours
Antimony (Sb)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Arsenic (As)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Barium (Ba)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Beryllium (Be)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Cadmium (Cd)	EPA 200.8(m)	0.2	0.4	µg/L	250-mL HDPE plastic	48 hours
Chromium (Cr)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Cobalt (Co)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Copper (Cu)	EPA 200.8(m)	0.4	0.8	µg/L	250-mL HDPE plastic	48 hours
Iron (Fe)	EPA 200.8(m)	5.0	10.0	µg/L	250-mL HDPE plastic	48 hours
Lead (Pb)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Manganese (Mn)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Molybdenum (Mo)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Nickel (Ni)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Selenium (Se)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Silver (Ag)	EPA 200.8(m)	0.5	1	µg/L	250-mL HDPE plastic	48 hours
Strontium (Sr)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Thallium (Tl)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Tin (Sn)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Titanium (Ti)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Vanadium (V)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Zinc (Zn)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Vanadium (V)	EPA 200.8(m)	0.2	0.5	µg/L	250-mL HDPE plastic	48 hours
Zinc (Zn)	EPA 200.8(m)	0.1	0.5	µg/L	250-mL HDPE plastic	48 hours
Synthetic Pyrethroid Pesticides in Sample Extract Analysis by NCI-GCMS – **Southcrest Recreation Center Only**						
Allethrin	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days
Bifenthrin	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days
Cyfluthrin	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days
Cypermethrin	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days
Danitol	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days
Deltamethrin	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days
L-Cyhalothrin	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days
Permethrin	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days
Prallethrin	NCI-GCMS	0.5	2.0	ng/L	2-L amber glass	40 days

Table 6-3. List of Constituents and Methods for Analysis for 2009–2010 Wet Weather Sampling

Water Matrix	Method	MDL	RL	Units	Volume/Container	Holding Time
Organophosphate Pesticides in Water Analysis – **Southcrest Recreation Center Only**						
Azinphos-methyl (Guthion)	NCI-GCMS	10	10	ng/L	2-L amber glass	40 days
Bolstar (Sulprofos)	NCI-GCMS	2	4	ng/L	2-L amber glass	40 days
Chlorpyrifos	NCI-GCMS	1	2	ng/L	2-L amber glass	40 days
Demeton	NCI-GCMS	1	2	ng/L	2-L amber glass	40 days
Diazinon	NCI-GCMS	2	4	ng/L	2-L amber glass	40 days
Dichlorvos	NCI-GCMS	3	6	ng/L	2-L amber glass	40 days
Dimethoate	NCI-GCMS	3	6	ng/L	2-L amber glass	40 days
Disulfoton	NCI-GCMS	1	2	ng/L	2-L amber glass	40 days
Ethoprop (Ethoprofos)	NCI-GCMS	10	100	ng/L	2-L amber glass	40 days
Ethyl Parathion	NCI-GCMS	1	2	ng/L	2-L amber glass	40 days
Fenchlorphos (Ronnel)	NCI-GCMS	2	4	ng/L	2-L amber glass	40 days
Fenitrothion	NCI-GCMS	3	6	ng/L	2-L amber glass	40 days
Fensulfothion	NCI-GCMS	1	2	ng/L	2-L amber glass	40 days
Fenthion	NCI-GCMS	50	100	ng/L	2-L amber glass	40 days
Malathion	NCI-GCMS	10	20	ng/L	2-L amber glass	40 days
Merphos	NCI-GCMS	1	2	ng/L	2-L amber glass	40 days
Methamidophos (Monitor)	NCI-GCMS	8	16	ng/L	2-L amber glass	40 days
Methidathion	NCI-GCMS	6	12	ng/L	2-L amber glass	40 days
Methyl Parathion	NCI-GCMS	50	100	ng/L	2-L amber glass	40 days
Mevinphos (Phosdrin)	NCI-GCMS	2	4	ng/L	2-L amber glass	40 days
Phorate	NCI-GCMS	3	6	ng/L	2-L amber glass	40 days
Phosmet	NCI-GCMS	1	2	ng/L	2-L amber glass	40 days
Tetrachlorvinphos (Stirofos)	NCI-GCMS	10	100	ng/L	2-L amber glass	40 days
Tokuthion	NCI-GCMS	2	4	ng/L	2-L amber glass	40 days
General Chemistry in Water Analysis						
Ammonia in water determination	SM 4500-NH3 F	0.01	0.05	mg/L	1-L amber glass (H_2SO_4)	28 days
Nitrate in water determination	EPA 300.1	0.01	0.05	mg/L	250-mL HDPE plastic	48 hours
Nitrite in water determination	EPA 300.1	0.01	0.05	mg/L	250-mL HDPE plastic	48 hours
Total hardness as $CaCO_3$ in water determination	SM 2340-B	1	5	mg/L	250-mL HDPE plastic	6 months
Total kjeldahl nitrogen in water determination (subcontract)	EPA 351.3	0.455	0.50	mg/L	500-mL amber glass	28 days
Total phosphorus in water determination	SM 4500-P C	0.016	0.05	mg/L	250-mL HDPE plastic	28 days
Turbidity in water Determination	EPA 180.1	1	2	NTU	1-L HDPE plastic	48 hours
Total suspended solids (TSS) in water determination	SM 2540-D	0.5	0.5	mg/L	1-L HDPE plastic	7 days
Microbiology Indicator Bacteria in Water Analysis						
Total coliforms	SM 9221 B and E	20	20	MPN/100 mL	120-mL HDPE plastic	6 hours
Fecal coliforms	SM 9221 B and E	20	20	MPN/100 mL	120-mL HDPE plastic	6 hours
Enterococci	SM 9223	10	10	MPN/100 mL	120-mL HDPE plastic	6 hours

MPN = most probable number, MDL = method detection limit, RL = reporting limit

6.4 Quality Assurance / Quality Control

Quality assurance (QA) and quality control (QC) for sampling processes included proper collection of the samples to minimize the possibility of contamination. All samples were collected in clean, contaminant-free sample bottles. Field staff wore powder-free nitrile gloves during sample collection. Sampling personnel were trained according to the field sampling standard operating procedures. Additionally, the field staff was made aware of the significance of the project's detection limits and the requirement to avoid contamination of samples at all times.

A set of QA/QC samples (i.e., field blank and field duplicate) were assessed. The field blank and field duplicate samples were analyzed for all parameters monitored at the Southcrest Recreation Center, including nutrients, bacteria, pesticides, metals, and other general chemistry (Table 6-2).

6.5 Data Analysis

All field and laboratory data collected were subjected to Weston's QA/QC control protocols to ensure accuracy and validity. Data were then entered into Weston's Data Management System, and data tables were generated from this data system. Analytical data were used in conjunction with volume of runoff capture and roof drainage areas to determine the quantity of pollutants captured by each RBDD system during the wet weather monitoring events. Also, these data were used to estimate the yearly reduction in watershed pollutants that can be achieved using the RBDD system.

7.0 DOWNSPOUT DISCONNECT MONITORING RESULTS

7.1 Actual Roof Runoff and Captured / Attenuated Volumes

The intent of this project was to evaluate various RBDD system configurations and determine their cost-effectiveness as a non-structural BMP for City application. Systems were designed in three basic configurations and implemented at locations with varying roof drainage areas and building materials. Based on site constraints and project assessment objectives, some systems were designed to capture, attenuate, and treat more than the design 0.6-inch, 24-hour storm, while others would need additional barrels to increase capacity to meet the design storm criteria.

Total storm rainfall and total roof runoff captured for the three monitored storms are summarized in Table 7-1. Results for Storm 1 and Storm 2 represent actual performance, while results for the Baseline storm event represent what would have occurred if RBDD systems had been in place. Highlighted boxes indicate storm events where the roof runoff volume exceeded the capacity of the connected RBDD system (see Subsection 4.3). The automated irrigation system at Mission Trails Park (MT-1) and the manual gravity-flow irrigation system at Rancho Bernardo Recreation Center (RB-1) exceeded capacity for both Storm 1 and Storm 2. Planter-barrel systems filtered flow through the amended soil layer until they reach flow capacity; there was no evidence that flow overtopped the planter. Storm flows to single and double barrel gravity-flow systems were 100% attenuated. There were no observed instances of runoff and/or overflow to an inlet from RBDD systems which discharged to existing vegetation (planter-barrel systems were designed to treat flow before discharge to impervious surfaces). The flow assessment results indicate that gravity-flow systems have a greater potential as a flow reduction BMP than planter-barrel and automated irrigation systems.

Table 7-1. Storm Runoff Volumes for Each Monitoring Event, for Each System

Site Location	System ID	Roof Area (ft^2)	Baseline Storm Rainfall (in)	Baseline Storm Volume (cft)	Storm 1 Rainfall (in)	Storm 1 Volume (cft)	Storm 2 Rainfall (in)	Storm 2 Volume (cft)
San Ysidro Library	SY-1	100	0.57	4.75	0.41	3.42	0.57	4.75
San Ysidro Library	SY-2	550	0.57	26.13	0.41	18.79	0.57	26.13
Southcrest Recreation Center	SC-1	1,811	1.39	209.80	0.13	19.62	0.9	135.84
Southcrest Recreation Center	SC-2	1,811	1.39	209.80	0.13	19.62	0.9	135.84
Southcrest Recreation Center	SC-3	1,811	1.39	42.00	0.13	19.62	0.9	42.00
Southcrest Recreation Center	SC-4	2,717	1.39	42.00	0.13	29.43	0.9	42.00
Southcrest Recreation Center	SC-5	2,717	1.39	42.00	0.13	29.43	0.9	42.00
Scripps Institution of Oceanography	UCSD-1	672	0.13	7.28	0.46	25.77	1.25	42.00
Mission Trails Regional Park Nature and Visitor Center	MT-2 *	625	–	–	0.41	7.20	1.7	7.20
Mission Trails Regional Park Nature and Visitor Center	MM-1	375	0.22	6.88	0.65	20.31	0.65	20.31
Mira Mesa Library	MM-2	406	0.22	7.45	0.65	22.01	0.65	22.01

Table 7-1. Storm Runoff Volumes for Each Monitoring Event, for Each System

Site Location	System ID	Roof Area (ft^2)	Baseline Storm Rainfall (in)	Baseline Storm Volume (cft)	Storm 1 Rainfall (in)	Storm 1 Volume (cft)	Storm 2 Rainfall (in)	Storm 2 Volume (cft)
Rancho Bernardo Recreation Center	RB-1	525	0.13	5.69	0.66	7.40	1.24	7.40
Rancho Bernardo Recreation Center	RB-2	1,250	0.13	13.50	0.66	68.75	1.24	129.17
Rancho Bernardo Recreation Center	RB-3	1,250	0.13	13.50	0.66	68.75	1.24	129.17
Rancho Bernardo Recreation Center	RB-4	1,250	0.13	13.50	0.66	68.75	1.24	129.17
South Bay Wastewater Treatment Plant	SB-1 *	725	–	–	0.57	34.7	0.07	4.3
South Bay Wastewater Treatment Plant	SB-2 *	725	–	–	0.57	34.7	0.07	4.3
South Bay Wastewater Treatment Plant	SB-3 *	725	–	–	0.57	34.7	0.07	4.3
South Bay Wastewater Treatment Plant	SB-4 *	725	–	–	0.57	34.7	0.07	4.3

No equipment in place during the baseline monitoring activity. If the RBDD system were in place, the monitored storm event would have exceeded the system's capacity (signified by the underlined volume).

The monitored storm event exceeded the capacity of the RBDD system (signified by the underlined volume).

* Mission Trails and South Bay Wastewater Treatment Plant were added to the monitoring program after baseline monitoring had been completed.

7.2 Sources of Metals and Building Material Composition

Results from the *City of San Diego Aerial Deposition Study, Phase II, Source Evaluation of TMDL Metals in the Chollas Creek Watershed* indicate that storm water runoff from metal roofs and building materials may contribute to copper and zinc loading (Weston, 2009a). The concentrations of total metals measured in roof runoff from the seven sites have been summarized in Table 7-2. The raw concentration data from these wet weather monitoring events are presented in Appendix G.

Table 7-2. Metals Concentrations in Roof Runoff and Potential Building Material Sources (downspout/barrel inlet concentrations)

Site [1]	Building Materials on Site	Storm	Total-Cu (µg/L)	Total-Pb (µg/L)	Total-Zn (µg/L)	Total-Al (µg/L)	Total-Fe (µg/L)
Mira Mesa Library	Galvanized downspouts, copper roofing	**Average**	**4,627**	**25.2**	**156.7**	**1,551**	**1,194**
		Baseline	741.1	6.2	49.5	23.0	19.0
		1	12,450	64.2	383.3	4,350	3,281
		2	692.1	5.3	37.4	281.0	282.0
Mission Trails Regional Park Nature and Visitor Center [2]	Asphalt shingle (*existing copper roofs not monitored*)	**Average**	**57.9**	**3.9**	**159.3**	**405.0**	**523.5**
		1	65.3	1.9	183.1	265.0	436.0
		2	50.5	5.9	135.5	545.0	611.0

Table 7-2. Metals Concentrations in Roof Runoff and Potential Building Material Sources (downspout/barrel inlet concentrations)

Site [1]	Building Materials on Site	Storm	Total-Cu (µg/L)	Total-Pb (µg/L)	Total-Zn (µg/L)	Total-Al (µg/L)	Total-Fe (µg/L)
Rancho Bernardo Recreation Center	Galvanized downspouts	**Average**	**25.0**	**8.8**	**1,436**	**936.0**	**1,010**
		Baseline	3.6	1.2	110.6	489.0	512.0
		1	50.2	23.4	2,672	2,092	2,282
		2	21.3	1.8	1,526	227.0	238.0
South Bay Wastewater Treatment Plant	Galvanized downspouts	**Average**	**5.1**	**3.2**	**945.0**	**114.5**	**139.5**
		1	6.9	3.5	348.0	150.0	178.0
		2	3.2	2.9	1,542.0	79.0	101.0
Southcrest Recreation Center	ABS plastic and galvanized downspouts (very old)	**Average**	**206.6**	**14.3**	**802.1**	**513.3**	**737.3**
		Baseline	16.9	0.9	157.4	50.0	47.0
		1	593.7	38.2	2,179	1,348	2,007
		2	9.1	3.7	69.9	142.0	158.0
Scripps Institution of Oceanography	Metal corrugated roof	**Average**	**11.2**	**0.6**	**5,693**	**119.7**	**99.7**
		Baseline	12.6	0.1	786.4	28.0	25.0
		1	20.1	1.6	15,839	313.0	266.0
		2	0.9	0.1	456.1	18.0	8.0
San Ysidro Library	Galvanized (very old)	**Average**	**25.9**	**7.9**	**291.4**	**276.7**	**308.0**
		Baseline	29.0	4.5	132.2	153.0	174.0
		1	35.4	15.7	601.9	548.0	625.0
		2	13.4	3.6	140.2	129.0	125.0

1) Access to the Rose Canyon Yard Service Buildings was restricted; therefore, no water quality data are available for this site.
2) Although the Mission Trails Regional Park and Nature and Visitors Center contained copper roof and flashing, the roof catchment area monitored under this program was composed entirely of asphalt, rolled roofing.

According to the monitoring data (Figure 7-1), buildings with roof area and runoff conveyance systems composed of copper or galvanized metal were observed to result in higher measurable copper and zinc concentrations. The copper roof at Mira Mesa Library had total copper concentrations up to 12,450 µg/L and typical concentrations of approximately 700 µg/L. Concentrations at Mira Mesa Library were over 20 times larger than facilities without known sources of over (e.g. 26 µg/L at San Ysido Library). Galvanized downspouts had an average zinc concentration of 1,440 µg/L at the Rancho Bernardo Recreation Center, and hits as high as 15,800 µg/L at the SIO metalshop. The asphalt shingles which make up the roof for the Southcrest Recreation Center translated levels of total copper, zinc, aluminum, and iron greater than 200 µg/L. The data indicates that building materials are not a source of lead, as shown by total lead results consistently less than 20 µg/L, and no higher than 65 µg/L

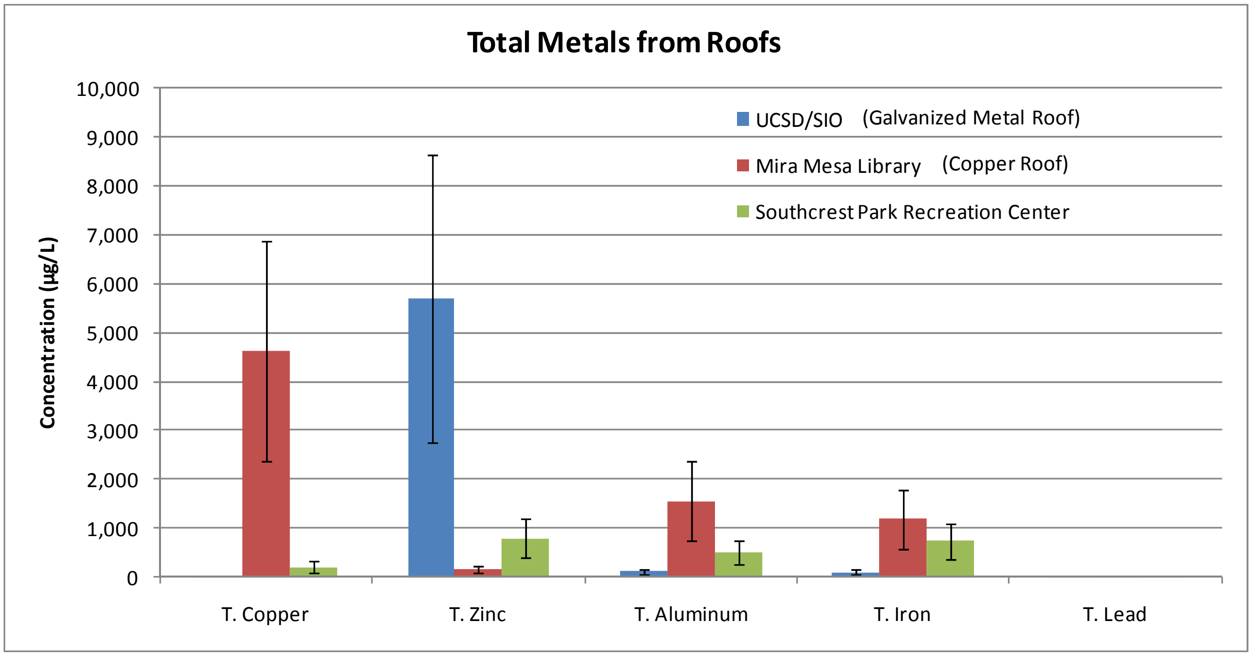


Figure 7-1. Average (Total) Metals Concentrations ± Standard Error from Roofs and Downspouts of Known Building Materials

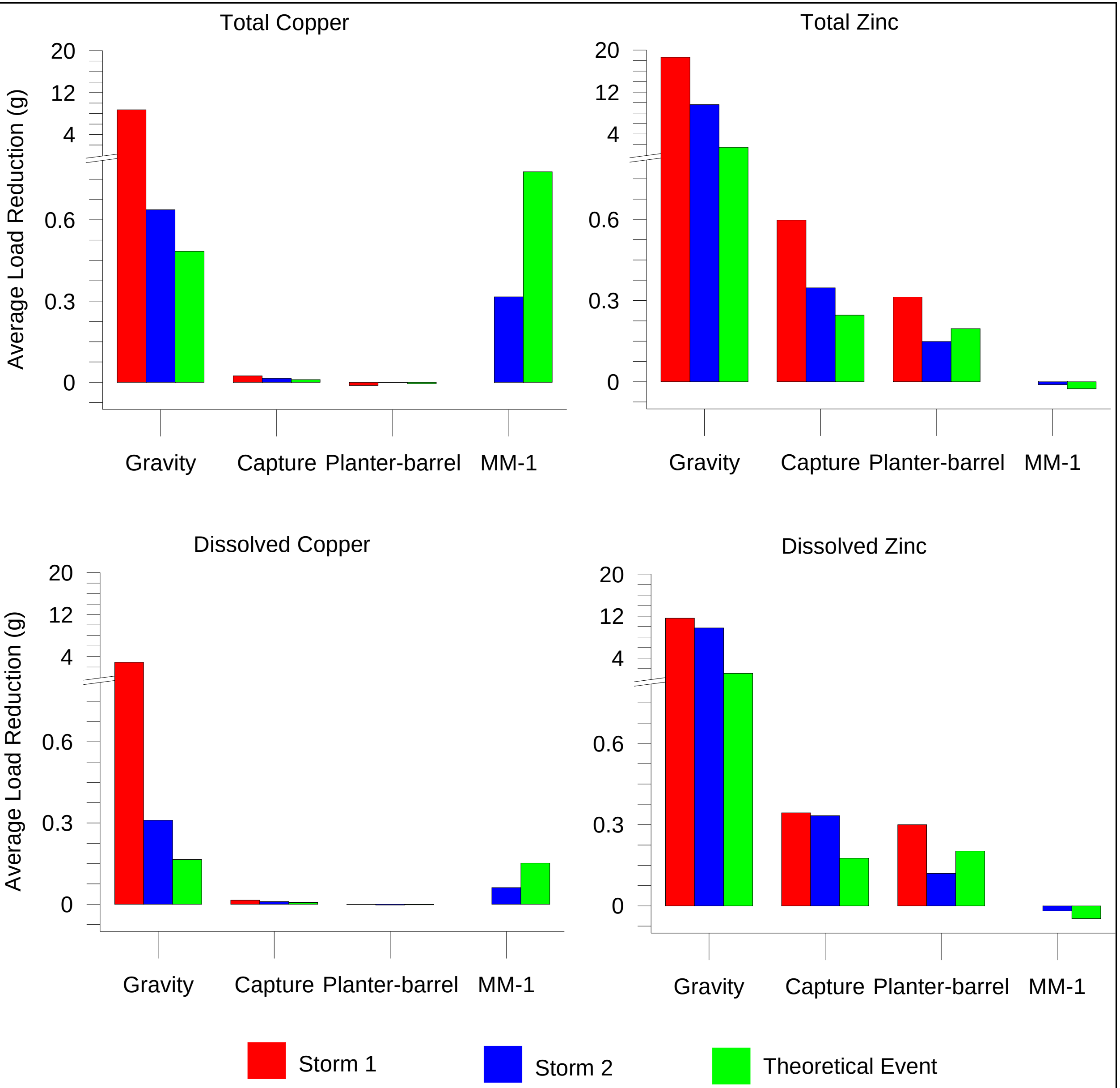
7.3 Rain Barrel / Downspout Disconnect System Load Reductions

Due to current and pending TMDLs, an average load reduction for the three RBDD system configurations was calculated for metals, TSS, and bacteria. Load reductions from RBDD systems were determined by multiplying the influent pollutant concentration by the site-specific storm flow (Storm 1 or Storm 2 only). An average load reduction for each system configuration (gravity-flow, planter-barrel, and automated) was based on system-specific load reductions. Given the variability of the data and small number of sample repetitions, percent load reductions were not calculated. The average load reductions for each RBDD configuration are presented on Table 7-3. Since the rainfall and roof area for each system was variable, the average total and dissolved copper and zinc load reductions for storm 1 and storm 2 were compared to a "theoretical" event (Figure 7-2). The "theoretical" event was modeled for runoff from a 1,000 sq-ft roof during a 0.6-inch, 24-hour storm. Assumptions and load reduction calculations for these tables and figures are presented in Appendix H.

Table 7-3. Average Load Reduction (grams) Achieve by Each System Configurations Base on Data from 2009-2010 (Storm 1 and Storm 2)

Analyte	UNIT	Average Load Reduction for System Configuration		
		Capture/Store	Gravity Flow to Existing Vegetation	Planter-Barrel System
				Mira Mesa Library
				Scripps Institution of Oceanography
		Rancho Bernardo Recreation Center	San Ysidro Library	Southcrest Recreation Center
Sites Inclusive of Load Reductions		Mission Trails Regional Park Nature and Visitor Center	Rancho Bernardo Recreation Center	South Bay Wastewater Treatment Plant
Total copper	Grams	0.01	0.59	-4.39E-03 (MM1: +3.16E-01)
Total lead	Grams	1.72E-03	0.02	+5.44E-04 (MM1: +7.02E-04)
Total zinc	Grams	0.24	1.77	+2.04E-01 (MM1: -1.04E-02)
Dissolved copper	Grams	0.01	0.20	-1.92E-03 (MM1: +6.19E-02)
Dissolved lead	Grams	1.05E-04	2.93E-03	-8.74E-05 (MM1: -3.28E-04)
Dissolved zinc	Grams	0.17	1.33	+2.01E-01 (MM1: -1.91E-02)
TSS	Grams	28.54	229.93	-1.17+02 (MM1: -1.14E+02)
Total coliforms	MPN	1.73E+07	1.26E+08	-1.84E+07 (MM1: N/A)
Enterococci	MPN	1.06E+07	7.73E+08	-9.35E+07 (MM1: N/A)
Fecal coliforms / *E. coli*	MPN	5.84E+04	5.34E+05	-2.62+06 (MM1: N/A)

N/A = Not applicable.



* The theoretical load reduction is a modeled event representing the averaged load for Storm1 and Storm 2 normalized to a 0.6-inch (design) storm and 1,000-sqft roof area.
** Mira Mesa Library (MM-1) is a planter-barrel system installed below a copper roof. Metals concentrations and load reductions were significantly different from planter-barrels at other loctions.

Figure 7-2. Average Load Reductions (grams) for Three Different System Configurations and Mira Mesa Library (planter-barrel system with known source of copper)

During the first post-installation storm event monitoring, staff observed discharge from the planter effluent pipe, which was designed to discharge treated roof runoff. During the first storm, it was assumed that the systems captured and treated 100% of the flow. Load reductions specific to the planter-barrel configuration were monitored during the second storm by comparing constituent concentrations influent to the RBDD system and effluent from the planter. A load reduction was determined for each constituent by multiplying the difference between the influent concentration and effluent concentration by the modeled flow. The average load reduction for planter-barrel systems was determined for all sites during the second storm event and for the four systems at the South Bay Wastewater Treatment Plant during the first storm monitored at that site. Since Mira Mesa Library had known sources of copper (i.e., roof, gutters, and downspouts), the copper concentration and associated copper load reduction was extremely high relative to other locations and skewed the average load reduction when Mira Mesa Library reductions were included in the average. As such, the table presents the average load reduction for all sites excluding Mira Mesa Library and then presents the load reduction at Mira Mesa Library in parenthesis (i.e., MM: +3.16E-01). Positive numbers indicate load reduction, whereas negative numbers indicate higher loads leaving the barrel planter system.

Gravity-flow systems provided the greatest load reduction for metals (i.e., dissolved and total), TSS, and bacteria. Capture/store systems provided smaller load reductions for total zinc, TSS, and bacteria along with negligible load reductions for copper and lead. While the planter-barrel systems reduced metals loads at locations with known sources of copper and zinc, the planter-barrel systems provided negligible treatment at locations without known sources of copper and zinc. Although no qualitative results are available, the longer soil-water contact time through the 36”x36”x30” planters installed at SB-2 and SB-3 likely provide additional treatment compared to the 72”x36”24” planters at SB-1, SB-3, and other planter-barrel locations. The levels of copper and zinc in runoff from facilities with no known source of copper and zinc were very low (near laboratory detection limits), and it is possible that small amounts of copper and zinc were present in the topsoil, compost, sand, and gravel soil treatment mixture or leaching from the newly formed concrete planter.

The 2009–2010 monitoring season was the first year the planter-barrel systems have been in operation, and the vegetation had not been fully established. Even though care was taken to wrap the underdrain with geotextile fabric, fine silts and sediments may have also been present in the underdrain system that had not been flushed out prior to the storm. The increase in TSS concentration would be expected to decrease with operation and establishment of vegetation and associated root systems. Indicator bacteria results may be associated with regrowth in the underdrain and environmental bacteria present in the soils. The source of the increased bacteria requires further study. The system should be flushed at least annually to remove fines and possible biofilms.

8.0 EFFECTIVENESS ASSESSMENT SCORECARD

As part of the overall BMP implementation process, the City is documenting the information and results obtained during the site selection process, water quality investigations, conceptual design development, construction, and finally, the effectiveness assessment phases. These data are then used to guide the process forward with the goal of implementing cost-effective BMPs that meet the target reduction goals. The Effectiveness Assessment Scorecard highlights efficiency and effectiveness evaluation criteria to be considered and incorporates baseline assessment results, as applicable. These scorecards can form the basis of guiding future site selection, BMP type, conceptual design, and modifications to the Strategic Plan. The scorecard for the RBDD Program is presented below.

<table>
<tr><th colspan="2">Project Title:</th><th colspan="2">Rain Barrel Downspout Disconnection (RBDD) Program</th></tr>
<tr><td colspan="2">Watershed:</td><td colspan="2">City of San Diego</td></tr>
<tr><th colspan="3">Efficiency Assessment</th><th>Compliance Assessment</th></tr>
<tr><td colspan="3">Overview: The fundamental management question the City of San Diego is working to answer in its efficiency assessment program is: “What is the most efficient combination of storm water programs and activities that will maximize pollutant load reductions most cost effectively?”

Therefore, to answer this question, the City is working to answer two program-wide management questions:
1. Has each individual program or activity optimized its efficiency (i.e., pollutant load reduction/cost)?
2. What is the optimal efficiency of each program or activity, so that the City can direct resources to the most efficient programs?
To answer these program-wide questions, the City identifies project-specific management questions to be evaluated as part of targeted watershed activities. The project-specific management questions are detailed below.</td><td>Overview: A description of the project’s effectiveness assessment as required by the Municipal Permit is provided below.</td></tr>
<tr><th colspan="4">Part I: Development of Project Specific Management Questions</th></tr>
<tr><td colspan="2">Project Specific Management Questions</td><td>• What is the average volume of runoff captured and treated during the wet weather season in Extreme Southwestern California by the RBDD systems located at each site?
• What is the average pollutant load removal by the RBDD systems located at monitored sites?
• What are the approximate operational and maintenance costs and issues associated with a RBDD system?</td><td>Not applicable.</td></tr>
<tr><th colspan="4">Part II: Development of Assessment Methodology (to be completed by Consultant)</th></tr>
<tr><td rowspan="4">Assessment Methodology</td><td>Targeted Measurable Outcome(s)</td><td>Level 3: Project implementation
Level 4: Measurable load reductions
Level 5: Changes in urban runoff and discharge quality (goal)</td><td>This is a watershed activity implemented and completed in each watershed.</td></tr>
<tr><td>Assessment Method(s)</td><td>▪ Baseline water quality monitoring.
▪ Post-implementation water quality monitoring and assessment.</td><td>Program completeness.</td></tr>
<tr><td rowspan="2">Data</td><td>Concentrations and loads for metals, TSS, and bacteria.</td><td>Report.</td></tr>
<tr><td>Photos and qualitative field observations of systems to understand O&M, operations, etc.</td><td>Report.</td></tr>
</table>

Project Title: Rain Barrel Downspout Disconnection (RBDD) Program
Watershed: Across City of San Diego
Part III: Project Scorecard

A: Technical Feasibility

	Pollutant Load Reductions				Average Pollutant Load Reduction (grams) (b)	Max Flow Captured/ Attenuated (gallons)	Overall Project Cost				Numeric Rating		Score for RBDD System
Site (a)	Total Copper (grams)	Total Zinc (grams)	TSS (grams)	Total Coliforms (MPN)			Education & Outreach (c)	Parts & Installation (d)	O&M (e)	Total Cost	Load (g / $)	Flow (gal / $)	
MM-1	0.316	-0.010	-113.9	0	-37.86	349		$4,600	$158	$4,758	-8.0E-03	0.07	3
MM-2	4.095	0.131	239.4	2.14E+07	81.22	809	$300	$3,520	$111	$3,931	2.1E-02	0.21	1
MT-2	0.012	0.032	10.6	1.63E+07	3.54	54	*$300	$3,880	$258	$4,438	8.0E-04	0.01	3
RB-1	0.007	0.440	37.5	1.834E+07	12.66	55	$300	$3,120	$167	$3,587	3.5E-03	0.02	2
RB-2	0.070	4.086	348.7	1.703E+08	117.61	455	-	$3,260	$111	$3,371	3.5E-02	0.13	1
RB-3	0.070	4.086	348.7	1.703E+08	117.61	455	*$300	$3,260	$113	$3,673	3.2E-02	0.12	1
RB-4	0.070	4.086	348.7	1.703E+08	117.61	455	-	$3,260	$111	$3,371	3.5E-02	0.13	1
SB-1	-0.006	0.250	-	-2.68E+06	0.12	314	-	$4,720	$113	$4,833	2.5E-05	0.07	3
SB-2	-0.006	0.250	-	-2.68E+06	0.12	314	-	$4,720	$113	$4,833	2.5E-05	0.07	3
SB-3	-0.006	0.250	-	-2.68E+06	0.12	314	$300	$4,720	$125	$5,145	2.4E-05	0.06	3
SB-4	-0.006	0.250	-	-2.68E+06	0.12	314	-	$4,720	$113	$4,833	2.5E-05	0.07	3
SC-1	0.182	0.740	47.1	2.12E+08	16.00	809	$300	$3,720	$111	$4,131	3.9E-03	0.20	1
SC-2	0.182	0.740	47.1	1.95E+08	16.00	809	-	$3,720	$236	$3,956	4.0E-03	0.20	1
SC-3	3.57E-04	0.061	-100.7	-4.88E+07	-33.56	314	-	$4,720	$150	$4,870	-6.9E-03	0.06	4
SC-4	3.57E-04	0.061	-100.7	-4.88E+07	-33.56	314	$300	$4,720	$244	$5,264	-6.4E-03	0.06	4
SC-5	3.57E-04	0.061	-100.7	-4.88E+07	-33.56	314	-	$4,720	$266	$4,986	-6.7E-03	0.06	4
SY-1	0.003	0.039	-	2.96E+06	0.02	336	$300	$3,190	$593	$4,083	5.0E-06	0.08	3
SY-2	0.014	0.212	-	1.22E+07	0.11	404	-	$3,330	$129	$3,459	3.3E-05	0.12	2
UCSD-1	-0.006	0.262	-164.5	-5.35E+07	-54.74	314	$300	$4,720	$125	$5,145	-1.1E-02	0.06	4
Technical Feasibility (baseline)?											Feasible.		
Technical Feasibility (expanded implementation)?											Feasible.		

* Signage not installed for this system at present.

Best Management Practice Scorecard Assumptions

(a) Water quality monitoring was not conducted at the Rose Canyon Yard Service Buildings. Samples were not collected from MT-1 at the Mission Trails Regional Park Nature and Visitor Center because rain did not fall to this system. Because site-specific load reductions could not be calculated, these systems were not included in the Scorecard. Based on O&M costs and the on-going problems associated with the electrical systems, it is likely that these systems would have a lower relative efficiency rating.

(b) Load reduction ratios were calculated for the actual (grams) load reduction for each system.

(c) Education and outreach signage includes approximately $3,500 for signage design and $2,200 for sign production and installation. Twenty signs were created. An average $300 per sign was applied to each site where educational signage was installed. Seven signs were installed. Two additional two signs may be installed at MT-2 and RB-3.

(d) Parts costs were based on the design cost estimates. Installation costs were based on an average cost per system of $3,000. Nearly every location had a site constraint that required additional labor and effort, coordination, and system design changes in excess of original estimate. After subsequent coordination with facility managers, changes to the designs were made. Some of the site constraints included underground utilities, access and egress issues, requested painting and color change, downspout reconfiguration, electrical services faults, and security / vandalism prevention.

(e) Standard annual O&M cost based on the average monthly O&M cost for City inspections, plus the average cost of parts and labor for routine maintenance activities conducts during Inspections No. 1–3.

   a. The average monthly O&M cost for City inspections (i.e., approximately $225/month) assumes $50 for use of a city vehicle (e.g., gas and use) and labor cost for one Class C Building Service Technician (1280) to visit all 24 sites (eight-hr day) plus two hours of oversight by one Class C Building Service Supervisor (1273), based on the City's salary rates from July 6, 2009.
   b. The cost of labor for routine maintenance conducted during Inspections No. 1–3 was determined by multiplying the time of labor by the hourly salary for one Class C Building Service Technician (1280) and one Class A Building Service Technician (1280) to complete the work. Most repairs will only require a single City technician to complete, but specialized repairs (e.g., bulk head fitting replacement in rain boxes and system replacements) require two people to complete the work and the purchase of non-standard equipment (e.g., fittings and plants).
   c. Vandalism that renders a system inoperable will need to be replaced at a greater cost than general maintenance. It is likely that concrete planters would never need replacement though additional allocations for complete replacement should be included in the O&M.

Project Title:	Rain Barrel Downspout Disconnection (RBDD) Program
Watershed:	City of San Diego

If project is technically feasible, complete Section B

B: Non-Quantifiable Factors *(do not change 1–4)*

1. Level of public support?	Public is supportive and interested. Once education materials are in place, this appears to be an activity which will be implemented under a citizens own initiative.
2. Opportunities for partnering leveraging?	Opportunity to partner with small businesses who develop RBDD systems
	Opportunity to partner with residents, Universities (UCSD–SIO) and local NGOs to promote RBDD systems.
	Opportunity to partner with other Departments within the City of San Diego to disconnect architectural copper and galvanized zinc building materials (Libraries, Parks & Recreation, etc).
3. Additional benefits derived from project implementation?	Water conservation and reuse opportunity. Opportunity to integrate RBDD systems into larger LEED buildings or Green Roof projects. Identification of sources of copper and zinc from building materials.
4. Overriding factors?	Possibly interfere with municipal operations, vandalism.

Overall Project Rating:				
	Ease of implementation	- 1 - Gravity Flow Systems	- 2 - Automated Systems	- 3 - Planter-Barrel Systems
		Gravity-flow systems, on an existing level surface adjacent to existing landscape, have the greatest potential for flow and load reduction (100% reduction of flows captured and attenuated), are the simplest to implement, and require little or no maintenance. Other systems may be implemented where site constraints do not allow for a gravity-flow system. Automated systems may be marketed to the public but are unlikely to be cost-effective on a city-wide level. The planter component of a planter-barrel system may be replaced with porous pavement or similar large filtration/infiltration LID.		
	Overall efficiency	Incorporate RBDD Systems into larger projects with multiple BMPs.		
		Load reductions relative to cost are low, but flow reductions relative to cost are higher. The best use of RBDD systems would be for flow reduction/attenuation from large buildings, in combination with other BMPs. Higher load reductions are possible for buildings with high metals source building materials and an existing narrow strip of vegetation (or an opportunity for porous pavement).		

Assuming the project is technically feasible and after analyzing the project's non-quantifiable factors, consultant to provide bulleted recommendations for optimizing the project.

C: Project Optimization Improvements and Recommendations *(consultant to provide anticipated cost savings, if any, resulting from full-scale implementation of the project)*

Electrical systems are difficult to operate and maintain at a City level. Preference should be for gravity-flow systems at buildings with metal roof, gutter, and downspout materials which are both easier to maintain and have fewer costs associated with parts and repairs. To further reduce maintenance and complaints, opaque barrels should be selected to minimize light exposure and associated algal growth.

9.0 PROJECT CONSIDERATIONS

The recommendations presented below are the result of a combined monitoring and operational assessment program. Results may vary at other locations and under varying storm conditions. In addition to observational and water quality data collected during storm event monitoring and operational assessments, many of the recommendations provided are based on input from facility maintenance staff, barrel manufacturer(s), further rooftop investigations, and identification of possible pollutant sources.

9.1 Continuing the Existing Municipal Program

If the City decides to maintain the existing RBDD systems, the following is suggested:

- Discontinue use of automated systems at the Rose Canyon Yard Service buildings. Electrical service circuit breakers routinely faulted causing failure of installed ground fault circuit interrupt (GFCI) outlets and/or resetting of programmable timers that operate the irrigation pumps. The following are RBDD system alternatives:
  - Converting Rcyn-1, Rcyn-2, and Rcyn-3 to gravity-flow systems. Conversion would involve building a base and raising the rain barrels to increase capacity and reduce O&M costs. If converted to a gravity-flow system, Rcyn-1 may need to be relocated for operations/safety, or
  - Converting Rcyn-1, Rcyn-2, and Rcyn-3 to solar-powered pumps. (Systems at Mission Trails operated as designed during all inspections.)
- Prevent algae growth by minimizing sun exposure to water (RB-1, SY-1, MT-1, MT-2) by painting tan-colored barrels a dark color or replacing with barrels made of an opaque material.
- Increase the attenuation and infiltration capacity of systems at facilities with copper/galvanized roofs to completely eliminate runoff, thus eliminating 100% of the pollutant loads for the design storm criteria. The following are RBDD system alternatives:
  - Convert RB-1 to a gravity-flow system from its current manual gravity flow configuration[3].
  - Evaluate the roof drainage design for MT-1 at Mission Trails Regional Park Nature and Visitor Center. Increase the flow capacity of MT-2 by installing the two barrels in series. Once a final design has been determined, install educational signage to continue to promote education/awareness and deter vandalism.
- System designs accounted for potential and incidental vandalism at Southcrest Recreation Center; however, nearly all systems were vandalized multiple times, and in some cases, the majority of the system had to be replaced. The cost for replacement and additional design or security needs to be considered in operating costs at this public facility.
- Evaluate RBDD system impacts on landscape maintenance. The grass immediately adjacent to SY-2 at San Ysidro Library is oversaturated from irrigation and may benefit from adding a French drain to enhance drainage and/or adjusting the irrigation schedule.

[3] Rancho Bernardo Recreation Center staff requested a manual operating gravity barrel so they could water their planters.

- Based on a literature review and analytical sampling, consider and evaluate additional soil mixture treatment media alternatives for planter systems and LID bioswales. This may provide options for improved treatment, identify sources of pollutants of concern in the treatment media, and eliminate plantings that have been a target for vandals.
- Include an annual flush of the planter barrel system components, including bagged topsoil, compost, sand, and gravel from local home improvement, as a routine O&M activity. Effort should be paired with analytical sampling of general soil treatment materials and/or washing rinsate.
- Review systems at least once per year (prior to start of the rainy season), but preferably on a quarterly basis. Maintenance activities may include the following:
  - Trash removal.
  - Replacing or reinstalling the vector control cover (San Ysidro Library, Rose Canyon Yard Service Buildings) and/or “Do No Drink” stickers.
  - Graffiti removal.
  - Replace irrigation system. All irrigation line and PVC parts should be standard sizes and available at local home repair stores.
  - Conduct routine plant maintenance for planter-barrel systems, including weeding, watering (summer time), replanting (vandalized), replacement (dead or missing plants).

9.2 Expanded Program and Public Participation

If the City decided to expand the current RBDD program to include other municipal facilities, residences, and/or businesses, the following is suggested:

System Configurations

- Use gravity-flow systems that discharge to existing landscape wherever feasible. This system configuration provided the best flow attenuation and the most reliable operation with little or no maintenance, in the absence of vandalism.
- Minimize use of automated systems. The flow captured is small compared to flow attenuated by gravity-flow systems. Automated systems also had a high occurrence of inoperability associated with unreliable electrical services.
- If an automated system is desired, use solar-powered pumps with a manual turn timer in place of GFCI outlets, with timer. The solar-power systems operated as designed during all inspections, whereas the GFCI systems were inoperable much of the program.

Barrels

- Use an opaque barrel (i.e. the black, opaque 75-gallon Aqua Barrel or similar) to limit penetration of sunlight, thus reducing algal growth and associated odor issues.
- Minimize use of the 55-gallon Cubo rain barrel. Despite educational signage, its trashcan-like shape and semi-open top attracted use for disposal of trash and fouling liquids (e.g., soda, milk, and coffee), which indicates facility visitors perceived the barrel to be a trash can. As well the translucent design allows light penetration which allows for algal growth.

- Increase flow capacity and the load reduction of systems by using larger barrels (i.e. 75,-gallon Aqua Barrels, cisterns, and tanks) or by connecting multiple barrels in series.

Other Materials

- Use nonproprietary fittings available at local retail hardware stores to simplify installation and allow for easy repairs.
- Maintain existing screens, and use interpretive signage to minimize inadvertent fouling by dumping of trash and liquids into the barrels.
- Integrate/evaluate opportunities to install a RBDD system with a Green Roof to reduce runoff and enhanced landscape infiltration.
- When designing planter-barrels, install systems that meet the needs of the specific building, but preference should be given to taller planters wherever feasible to prolong contact time with the engineered iron/zeolite treatment soil (i.e., use 36"x36"x30" square planters at SB-2 and SB-3 versus 72"x36"x24" rectangular planters).
- Rain chains should not consist of copper or galvanized metal.
- If security fencing is necessary to deter vandalism, it may be better to evaluate and consider using larger infiltration areas or integrated LID designs.
- To reduce O&M costs, consider alternatives including decorative rock at planter surfaces instead of plants to allow greater volume of iron-zeolite treatment soils and minimize plant vandalism and maintenance.

Siting Considerations

- Consider facility design, including composition of roof, rain gutter, and downspouts, which can be a source of COCs (e.g., zinc and copper), especially if composition includes metal, corrugated metal, galvanization, and copper sheeting. Removal of these sources or mitigation through coating may provide lower-cost pollution prevention of runoff in the interim.
- Focus implementation at facilities that use building materials consisting of copper/ galvanized roofing materials, rain gutters, and/or downspouts (Weston, 2009a).
- Ensure sufficient space for multiple barrels or a larger cistern/tank.
- Install systems where the RBDD is able to discharge to existing landscaping and primitive areas for enhanced filtration/infiltration and a 100% load reduction.
- Evaluate the potential impact of RBDD system location on routine landscape maintenance activities (e.g., grass cutting).
- Size and install systems for the appropriate roof area and recommended design storm (i.e., 0.6 inch over 24 hours preferred, and 0.2 inch over 24 hours for first flush).
- Install systems at sites with potential aerial deposition (e.g., near industrial areas, freeways, and major transportation corridors).
- Where facility conditions are constrained and a planter-barrel system is ideal, consider the following:
    - Planter should be filled with an enhanced treatment media (e.g., decorative gravel and compost/sand/iron-zeolite mixture).
    - Install multiple barrels, operating under gravity flow, to increase capacity beyond the design storm criteria and allow for slower infiltration.

  - Planter should be placed in series with a bioswale, porous pavement, or LID.
- Modify building code(s) or specifications to prohibit use of copper/galvanized roofs, rain gutters, and downspouts unless alternative disconnect or treatment is provided. This would reduce future contributions and affect reductions during redevelopment.

10.0 REFERENCES

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