



Memorandum

To: Rick Whetsel, SAWPA

From: CDM

Date: September 14, 2011

Subject: Source Evaluation Task 2.3 – Dry Weather Flows from MS4 Outfalls (2011 Dry Season)

Study Purpose

In Spring 2011, the TMDL Task Force and CDM initiated dry weather flow (DWF) monitoring to enhance the existing DWF dataset for the Middle Santa Ana River (MSAR) watershed. The purpose of this study is to gain additional information to support updates to existing bacterial indicator source contribution analyses (see Technical Memorandum for Task 2.4, Calculate Mass Balance for Dry Weather Conditions). The new data will support characterization of DWF from MS4 outfalls not previously assessed and allow for analysis of the nature of DWF variability.

Flows exist in many MSAR waterbodies during dry weather conditions. Sources of flow include:

- Tertiary treated effluent from Publicly-Owned Treatment Works (POTWs)
- Turnouts of imported water by the Metropolitan Water District (MWD) purchased for groundwater recharge by water agencies in the Santa Ana River watershed
- Groundwater inputs from areas of rising groundwater
- Temporary de minimus discharges, such as well blow-offs
- Water transfers between water agencies for conjunctive use programs
- Authorized non-stormwater discharges as defined by Waste Discharge Requirements issued by the Santa Ana Regional Water Quality Control Board (RWQCB)
- Non-permitted discharges including Phase 2 Municipal Separate Storm Sewer System (MS4) discharges.

Within the MSAR watershed, many MS4 drainage areas do not typically cause or contribute to flow at downstream watershed-wide compliance monitoring sites established under the MSAR Bacteria Total Maximum Daily Load (TMDL). DWF from these drainage areas is hydrologically disconnected from downstream waterbodies, by either (1) purposefully recharging groundwater in constructed regional retention facilities, or (2) through losses in earthen channel bottoms, where the recharge capacity of underlying soils exceeds dry weather runoff generated in upstream drainage areas.

Identification of Flow Monitoring Sites

CDM worked with San Bernardino County Flood Control District (SBCFCD) and Riverside County Flood Control & Water Conservation District (RCFC&WCD) staff to select at least ten locations in the MSAR watershed to collect flow measurements for ten consecutive weeks under dry weather conditions from April to June 2011. CDM coordinated with SBCFCD and RCFC&WCD staff to finalize site selection after proposing a potential list of MS4 outfalls for field review.

Site selection considered factors such as where flow data are lacking, other data collection efforts ongoing or in the past, potential for the site to receive water transfers, and need for additional data for better understanding of hydrologic connectivity during dry weather conditions. Additional selection factors included outfall/channel physical constraints and any limiting factors that could hinder field staff from measuring or estimating flows.

Riverside County MS4 Outfall/Channel Locations

Riverside County MS4 outfalls/channels considered for new or additional flow monitoring included those tributary to the Santa Ana River and Cucamonga Creek channel. CDM presented a list of potential MS4 outfalls or channels for flow monitoring. CDM and RCFC&WCD staff then conducted a field visit at each site on March 17, 2011, to gather additional information concerning presence of flow and connectivity to downstream waterbodies. Table 1 summarizes the observations recorded from the field visit.

Field staff also observed flow connectivity was often limited from MS4 outfalls tributary to the Santa Ana River (SAR), particularly where outfalls are located a significant distance from the SAR mainstem due to the changing course of the SAR.

Based on field observation, CDM and RCFC&WCD staff narrowed the list of flow monitoring sites to seven locations. Table 2 lists the seven sites selected for DWF monitoring (see also Figure 1).

Table 1. Potential Flow Monitoring Locations, Riverside County

MS4 Outfall/Channel	Flow Observation (March 17, 2011)
Tributary to Santa Ana River	
Wilson Street Storm Drain	No connectivity to SAR; flow was observed from outfall pipe but limited to area surrounding outlet structure; lots of standing water around structure
University Wash -Lake Evans Outlet	No connectivity to SAR; slight flow exiting lake; appears to be a lake shutoff valve in a box
Outfall located just north of Mission Avenue and SAR	No connectivity – flow from the outfall proceeds along left bank of riverbed (~100 ft downstream of Mission Avenue Bridge overcrossing), but then ponds and infiltrates; SAR mainstem is located ~500' to the west along the right bank
Box Springs Channel ¹	Observed flow connectivity to SAR mainstem; part of channel half covered with sand bar; flow depth is 5"-6"
Magnolia Avenue Storm Drain ("Magnolia Center Outlet")	No flow connectivity to SAR mainstem due to over ½ mile of floodplain between the outfall and SAR mainstem; may reach SAR if SAR mainstem changes course over time
Phoenix Avenue Storm Drain	No flow connectivity to SAR mainstem; over ½ mile of floodplain between the outfall and SAR mainstem; may reach SAR if SAR mainstem changes course over time
Anza Channel (Drain) ¹	Observed flow connectivity to SAR mainstem
Sunnyslope Channel ¹	Observed flow connectivity; flow observed from end of lined portion of Sunnyslope Channel to convergence with SAR mainstem
Norco North Sub Drainage D1	Observed no flow at outlet structure; completely dry; distance to mainstem is several hundred feet to the west
Tributary to Cucamonga Creek	
Eastvale MDP Line A	Directly connected outfall to Cucamonga Creek; observed slight sheet flow into Cucamonga Creek
Eastvale MDP Line B	Directly connected outfall to Cucamonga Creek; slight amount of sheet flow
Schleishman Road Storm Drain	Directly connected outfall to Cucamonga Creek; slight amount of sheet flow
Chandler Street Channel	No flow observed, completely dry channel; observation from Hellman Avenue overcrossing
County Line Channel	Observed flow downstream to Cucamonga Creek

¹ Previous 2007-08 USEP Monitoring Program site

Table 2. Selected Flow Monitoring Locations, Riverside County

Flow Site	Site Description
Tributary to Santa Ana River	
US-BXSP	Box Springs Channel at Tequesquite Avenue
US-SNCH	Sunnyslope Channel near confluence with SAR
US-ANZA	Anza Drain upstream of confluence of Riverside effluent channel
Tributary to Cucamonga Creek	
US-CLCH	County Line Channel near confluence with Cucamonga Creek
US-EVLA	Eastvale MPD Line A – Outfall discharges to Cucamonga Creek on east side of channel at near 65 th Street.
US-EVLB	Eastvale MPD Line B - Outfall discharges to Cucamonga Creek on east side of channel at just downstream of Schleishman Ave overcrossing.
US-SRSD	Schleishman Road Storm Drain - outfall discharges to Cucamonga Creek on west side of channel at Schleishman Road

San Bernardino County MS₄ Outfalls/Channel Locations

CDM coordinated with SBCFCD staff to identify at least five MS₄ outfall/channels to collect dry weather flows. CDM presented for SBCFCD review a recommended list of locations to conduct additional flow measurements. Table 3 summarizes SBCFCD staff observations at outfalls/channels visited on March 30 and April 6, 2011. SBCFCD staff also made visual estimates of flow by conducting windshield surveys of other outfalls in the area.

Table 3. Potential Flow Monitoring Locations, San Bernardino County

MS ₄ Outfall/Channel	Field Observations
Tributary to San Antonio Channel	
Chino-Central Storm Drain	Small discharge; drain outlet is at same elevation of channel invert leading to backflow and ponding into drain outlet; accurate flow measurement not possible
Boys Republic South Channel	Observed constant flow; invert allows for easier flow measurement
Yorba-Chino Storm Drain	Drain outlet is at same elevation of channel invert leading to backflow and ponding in drain outlet; accurate flow measurement not possible
San Antonio Channel at Riverside Drive	Slight flow observed
Tributary to Cucamonga Creek	
Cucamonga Creek at Chino Avenue	Observed runoff mixes with Inland Empire Utilities Agency recycled water
Airport Drive Storm Drain	Storm drain has four separate discharge outlets to the channel; flows to channel observed had shallow depth
Tributary to SAR	
San Sevaire Channel at Philadelphia Street	DWF with very shallow depth; flows split into different separate ribbons; challenge to collect flow measurement

Based on SBCFCD staff knowledge of typical DWF conditions and field observation, seven MS₄ flow locations were selected for DWF measurements (Table 4 and Figure 1). Sites were

prioritized based on ability to measure an accurate flow reading. Many outfalls have physical constraints such that flow from the channel backflows into the outfall pipe which makes flow measurements challenging, requiring entry into confined spaces in the outfall pipes.

Table 4. Selected Flow Locations, San Bernardino County

Flow Location	Site Description
Tributary to Cucamonga Creek	
US-CUC57	Outfall located upstream of Union Pacific Railroad
US-CUC25	Outfall located 110-ft downstream of Riverside Avenue
Tributary to San Antonio Channel	
US-CHSD	Chino Storm Drain at San Antonio Channel
US-SAC21	Outfall located 1/4 mile downstream of Grand Avenue
US-BRSC	Boys Republic South Channel
US-SAC13	Outfall located below Pipeline Avenue / State Route 71
Tributary to Santa Ana River	
US-SSCH-PHIL	San Sevaine Channel at Philadelphia Street, near county line

2011 Dry Season Flow Monitoring

Flow monitoring for the 14 selected MS4 outfalls/channels commenced on April 19 and concluded on June 24, 2011 (Figure 1). In addition to these flow sites, Figure 1 also includes US-CHINOCRK and US-BXSP monitoring locations. US-CHINOCRK was monitored for bacterial indicators and flow as part of a Task 2.2 - Preliminary Characterization of Bacteria Loading in Pomona and Claremont. US-BXSP was also monitored as part of Task 2.1 – Box Springs Channel Follow-up Study.

Table 5 lists the combined flow locations in the MSAR watershed located in both San Bernardino and Riverside County jurisdictions. SBCFCD staff recorded flows at seven MS4 outfalls/channels within SBCFCD jurisdiction, while CDM conducted monitoring at seven locations within RCFC&WCD jurisdiction. Flow measurements were collected weekly for ten weeks at varying times and days using methods established in the MSAR Water Quality Monitoring Plan, May 2011.

Table 5. Flow Locations within MSAR Watershed

Flow Location	Site Description
Tributary to Santa Ana River	
US-BXSP ¹	Box Springs Channel at Tequesquite Avenue
US-SNCH	Sunnyslope Channel near confluence with SAR
US-ANZA	Anza Drain upstream of confluence of Riverside effluent channel
US-SSCH-PHIL	San Sevaime Channel at Philadelphia Street
Tributary to Cucamonga Creek	
US-CUC57	Outfall located upstream of Union Pacific Railroad
US-CUC25	Outfall located 110-ft downstream of Riverside Avenue
US-CLCH	County Line Channel above confluence with Cucamonga Creek
US-EVLA	Eastvale MPD Line A – Outfall discharges to Cucamonga Creek on east side of Cucamonga Creek channel south of 65 th Street
US-EVLB	Eastvale MPD Line B - Outfall located on east side of Cucamonga Creek channel just downstream of Schleishman Avenue overcrossing
US-SRSD	Schleishman Road Storm Drain - outfall located on west side Cucamonga Creek channel at Schleishman Road
Tributary to Chino Creek	
US-CHINOCRK ²	Chino Creek upstream of confluence with San Antonio Channel
Tributary to San Antonio Channel	
US-CHSD	Chino Storm Drain at San Antonio Channel
US-SAC21	Outfall located 1/4 mile downstream of Grand Avenue
US-BRSC	Boys Republic South Channel
US-SAC13	Outfall located below Pipeline Avenue / State Route 71

¹ US-BXSP: Initial five weeks of flow measurements collected by RCFC&WCD; latter 5 weeks of flow collected by CDM

² US-CHINOCRK: Flow measurements collected as part of Preliminary Characterization of Bacteria Loading from MS4 in Pomona (reported in Task 2.2 Technical Memorandum).

2011 Dry Weather Flow Monitoring Results

Table 6 shows the range of DWF measurements from all MS4 outfall/channel locations monitored during the 2011 dry weather period. Within the Chino and Cucamonga Creek watersheds, these measurements provide information for MS4 outfalls that were not characterized in the original Urban Source Evaluation Plan (USEP) Monitoring Program (2007-2008), increasing the monitored urbanized drainage area by 16,800 acres. Figure 2 shows that there are still unmonitored areas for assessment in upcoming years, but that the 2011 dry season provided data for about 40 percent of the MS4 drainage area that was not evaluated in the original USEP Monitoring Program.

Table 6 also estimates the urban runoff generation rate (gal/acre/day) by comparing the median of DWF measurements with the upstream MS4 drainage area. Urban runoff generation rates vary widely between the 2011 dry season monitoring sites. As expected, relatively high rates (> 100 gal/ac/day) were measured at outfalls where SBCFCD and RCFC&WCD staff have observed

groundwater inputs occur via springs in unlined channels or weep holes in concrete lined channels; such as drainage from Boys Republic South Channel, Chino Creek, Sunnyslope Channel, Box Springs Channel, and Anza Drain. Conversely, several sites with MS4 drainage areas in the Cities of Chino and Ontario had very low rates of urban runoff generation.

Table 6. Flow Results for 2011 Dry Weather Flow Monitoring

Location	Dry Weather Flow (cfs)			Drainage Area (acre)	Urban Runoff Rate (gal/ac/day)
	Min	Max	Median		
Chino Creek at Central Avenue (WW-C7)					
US-CCCH	2.30	15.31	6.55	1,766	2,396
US-SACH	0.17	1.25	0.71	5,031	91
US-CHSD	0.00	0.07	0.015	3,224	3
US-CHINOCRK	1.12	2.94	1.49	6,036	159
US-BRSC	0.08	1.08	0.33	1,161	181
US-SAC21	0.06	0.39	0.09	312	178
US-SAC13	0.00	0.06	0.01	1,148	5
Cucamonga Creek at Chino Corona Road (WW-M5)					
US-CHRIS	0.25	1.72	0.79	3,091	165
US-CLCH	0.00	2.00	0.06	373	95
US-CUC	1.30	4.63	2.77	602	2,974
US-CUC57	0.01	0.06	0.02	1,051	13
US-CUC25	0.001	0.01	0.005	98	33
US-CLCH	0.00	0.13	0.00	2,474	0
US-EVLA	0.01	0.19	0.05	499	69
US-EVLB	0.00	0.01	0.00	335	0
US-SRSD	0.003	0.09	0.05	463	73
Santa Ana River at MWD Crossing (WW-S1)					
US-BXSP	0.50	3.66	1.50	5,632	172
US-SNCH	1.15	3.18	1.96	4,646	273
Santa Ana River at Pedley Ave (WW-S4)					
US-ANZA	2.12	6.08	2.81	9,268	196
US-DAY	0.00	4.91	0.52	2,759	122
US-SSCH	0.00	11.84	1.30	2,489	338
US-SSCH-PHIL	0.00	1.75	0.01	788	8

Discussion

Based on monitoring data from the watershed-wide compliance monitoring program and USEP Monitoring Program, the San Bernardino County and Riverside County MS4 Programs have each developed a long term dry weather Comprehensive Bacteria Reduction Plan (CBRP)

designed to achieve compliance with urban wasteload allocations under dry weather conditions. Understanding dry weather hydrology is critical in implementing the CBRP, Attachment B.2 – Dry Weather Hydrology (CBRP, June 28, 2011), evaluates DWFs within the MSAR watershed on a watershed-wide compliance site basis (please refer to the CBRP for more background discussion). The following section updates findings based on the additional flow monitoring data obtained during the 2011 dry season for each Watershed-wide compliance monitoring site.

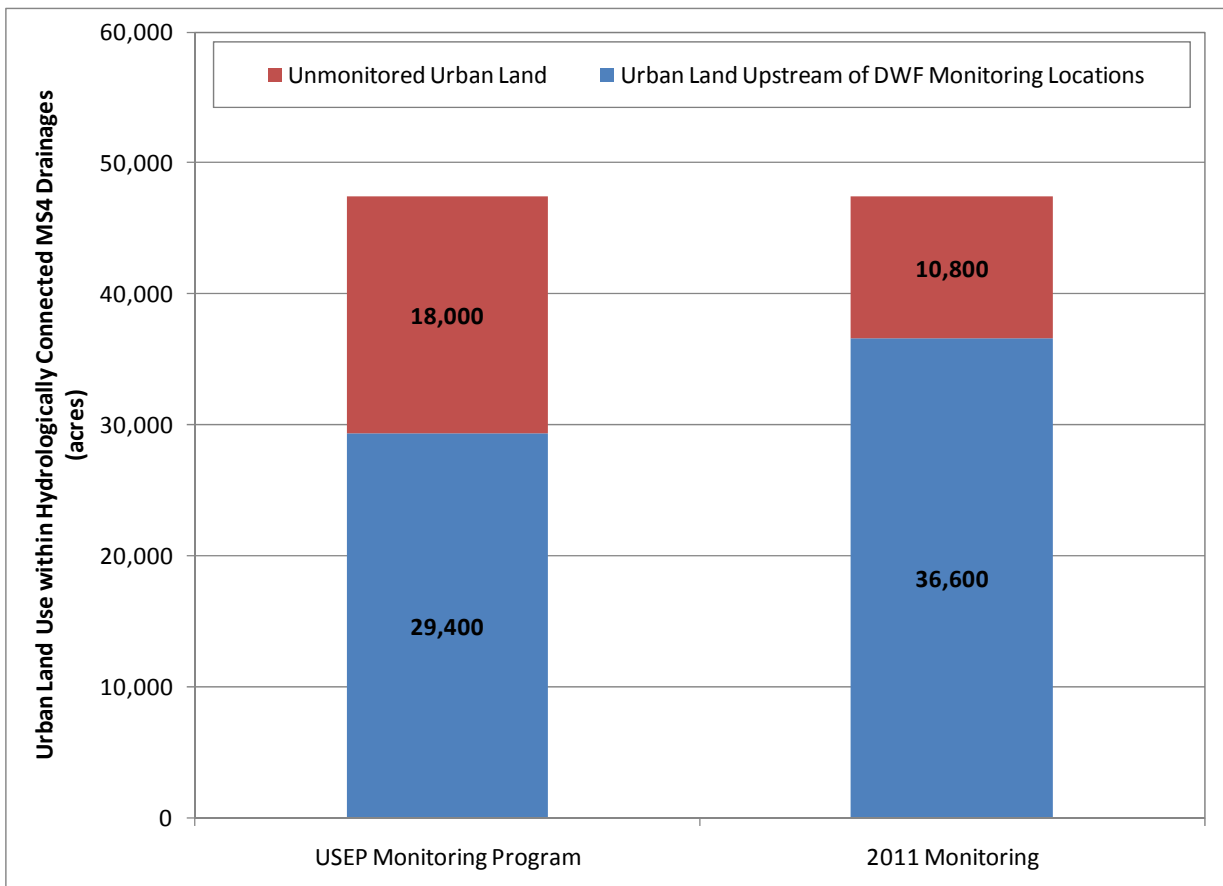


Figure 2. Coverage of DWF Assessment for all Urban Landuse within Hydrologically Connected MS4 Drainage Area within the MSAR Watershed (post 2007 USEP Monitoring Program; post 2011

Chino Creek at Central Avenue (WW-C7)

New flow sites at US-CHINOCRK, US-BRSC, and US-SAC21 have urban runoff generation rates ranging from 159 to 178 gal/acre/day (Table 6). DWF from the drainage areas upstream of these sites is higher than was assumed (100 gal/ac/day) in the CBRP. The US-CHINOCRK site captures DWF from most of the City of Pomona’s drainage area within the MSAR watershed. DWF measured at this site ranged from 1.1 to 3.0 cfs, with a median of 1.5 cfs, which equates to approximately 15 percent of the DWF from the MS4 to Chino Creek.

Mill-Cucamonga Creek at Chino Corona Road (WW-M5)

The results from 2011 DWF monitoring sites upstream of this watershed-wide compliance site show that these outfalls (US-CUC57, US-CUC25, US-CLCH, US-EVLA, US-EVLB, and US-SRSD) contribute very small volumes (<0.05 cfs) of DWF to Cucamonga Creek. DWF at US-CLCH in 2007 was 0.06 cfs (median), which was similar to median DWFs in 2011 from other MS4 outfalls to Cucamonga Creek. DWF from US-CHRIS in 2007 was 0.79 (median) and is therefore a more significant source of urban DWF to Cucamonga Creek than other monitored outfalls.

In 2011, DWF measurements were taken at US-CUC57, which discharges to the segment of Cucamonga Creek downstream of the Turner Basins and upstream of the US-CUC site. DWF measurements showed very low DWF (median of 0.02 cfs). In addition, SBCFCD windshield surveys evaluated all 36" diameter and larger outfalls in this segment of Cucamonga Creek. These surveys identified only minimal additional DWF, which could not explain the DWF in Cucamonga Creek above RP1. Therefore, DWF in Cucamonga Creek above RP1 is most likely from MS4 discharges that bypass or flow through the Turner Basins. IEUA is currently developing a project to improve operations at the Turner Basins, which will improve the capacity to capture urban DWF from Upper Deer and Cucamonga Creeks.

Santa Ana River at MWD Crossing (WW-S1)

Sources of urban runoff to the Santa Ana River at MWD Crossing during the dry season are limited to two key tributaries; Sunnyslope Channel and Box Springs Channel. In 2011, DWF at US-SNCH was 1.96 cfs (median) compared to 2.9 cfs in 2007. For US-BXSP, median DWF was 1.50 cfs compared to 3.33 cfs in 2007.

CDM and RCFC&WCD conducted field observations of other potential MS4 discharges to the Santa Ana River upstream of the MWD Crossing site on March 17, 2011. With one exception, no measurable DWF was observed to connect to the Santa Ana River from other MS4 drainages in this watershed including High Grove Channel, Agua Mansa Storm Drain, Phoenix Storm Drain, and a few other minor outfalls along the north side of the river. For Magnolia Storm Drain, significant DWF was observed at the outfall; however the distance from the MS4 outfall to the mainstem of the SAR is approximately one-half mile, over which recharge into the river bottom sediment occurs. Observations at Magnolia Storm Drain and other MS4 outfalls should continue to assess DWF connectivity or confirm that the lack of DWF is consistent.

Santa Ana River at Pedley Avenue (WW-S4)

In the 2011 dry season, DWF measurements were recorded for the Anza Drain tributary to the Santa Ana River at a location ~1,000 feet upstream of the US-ANZA site from the 2007 USEP Monitoring Program which resulted in a negligible increase in upstream drainage area. The new site facilitated access to a larger cross-sectional area with unobstructed flow, where more measurements were recorded in developing a velocity profile. The 2011 DWF measurements result in a reduced DWF estimate for Anza Drain (from 6.3 cfs in 2007 to 2.8 cfs in 2011). This revised flow is more comparable to measurements taken during a single day field survey in 2002

by RCFC&WCD¹, which suggested DWF flows to be less than 1.5 cfs. Other sources of urban DWF from MS₄s in this watershed include San Sevaine Channel and Day Creek. SBCFCD field observations for the 2011 dry season included 10 visits to San Sevaine Channel at the county line near Philadelphia Street (US-SSCH-PHIL). Most of San Sevaine Channel within San Bernardino County is upstream of the Jurupa and Declez Basins, where urban DWF is spread for groundwater recharge. At the US-SSCH-PHIL site, one flow reading was particularly high (1.75 cfs in early June 2011) compared to the average of less than 0.02 cfs for the remaining weeks. The field observations confirm that DWF is effectively captured in Jurupa Basin and that MS₄ outfalls between the Jurupa Basin and county line generate minimal DWF (<0.05 cfs). The remainder of flow in San Sevaine Channel that reaches the Santa Ana River comes from MS₄ outfalls in the City of Jurupa Valley or non-urban discharges.

Field observations of other potential MS₄ discharges to the Santa Ana River upstream of the Pedley Avenue site were conducted on March 17, 2011 by CDM and RCFC&WCD. During these field observations, no measurable DWF was observed from any other sites in this watershed. Observations at these outfalls should continue to confirm that the lack of DWF is consistent.

Summary of Findings

Additional DWF measurements taken at existing and new urban source evaluation sites showed that urban runoff generation was less than the assumed value of 100 gal/ac/day for unmonitored outfalls in the assessment of urban sources from the 2007 USEP Monitoring Program, except in the Chino Creek watershed. The data collected in the 2011 dry season was used to revise the bacterial indicator source contribution analysis, as described in the Technical Memorandum for Task 2.4, Calculate Mass Balance for Dry Weather Conditions.

Analysis of Variability of Dry Weather Flow

Additional DWF measurements were taken at Anza Drain, Box Springs Channel, and Sunnyslope Channel. These measurements increase the robustness of DWF estimates at these tributaries from the MS₄ to the Santa Ana River. In the case of Anza Drain, the measurements taken in the 2011 dry season were significantly lower than from the 2007 dry season. In 2011, a new field method was employed to measure flow. The new method involved moving the cross section for determining a velocity profile by ~200 ft to a location with more uniform flow and better access, which allowed for velocity readings at more intervals across the section. Therefore the dataset was reduced to the ten measurements from the 2011 dry season.

For Sunnyslope Channel, the data collected in the 2011 dry season increases the DWF dataset from 10 to 20 measurements. The coefficient of variation from the 2007-2008 USEP Monitoring Program and 2011 dry season measurements was relatively low; therefore, additional measurements at this site are not a high priority.

¹ RCFC&WCD staff, Clark and Clem, conducted flow field survey at Anza Drain in 2002.

Increasing the number of flow observations at dry outfalls in the MSAR provides additional statistical power to assessments of water balance at watershed-wide compliance sites during dry weather conditions. Power analysis is suited for naturally occurring variables, and therefore is not applied to approximate level of monitoring activities for variables that are controlled by human behavior. Urban DWF in the MSAR watershed is primarily controlled by human behavior. Sources range from actions by individuals that are relatively small but widespread such as illicit discharges and excess outdoor water use, to relatively high volume inputs at specific points by water and wastewater agencies such as tertiary treated effluent from POTWs, imported water turnouts, other water transfers, and temporary de-minimus discharges.

One important consideration in developing outfall monitoring programs is the diurnal pattern of outdoor water use. Accordingly, the CBRP Inspection Program includes assessment of DWF during different times of day as well as seasons to account for variability associated with diurnal outdoor water use patterns in the watershed. Data obtained from the CBRP Inspection Program will continue to be evaluated to understand specific sources of DWF in MS4 drainage areas in order to select appropriate controls for prioritized outfalls based on source contribution analysis.