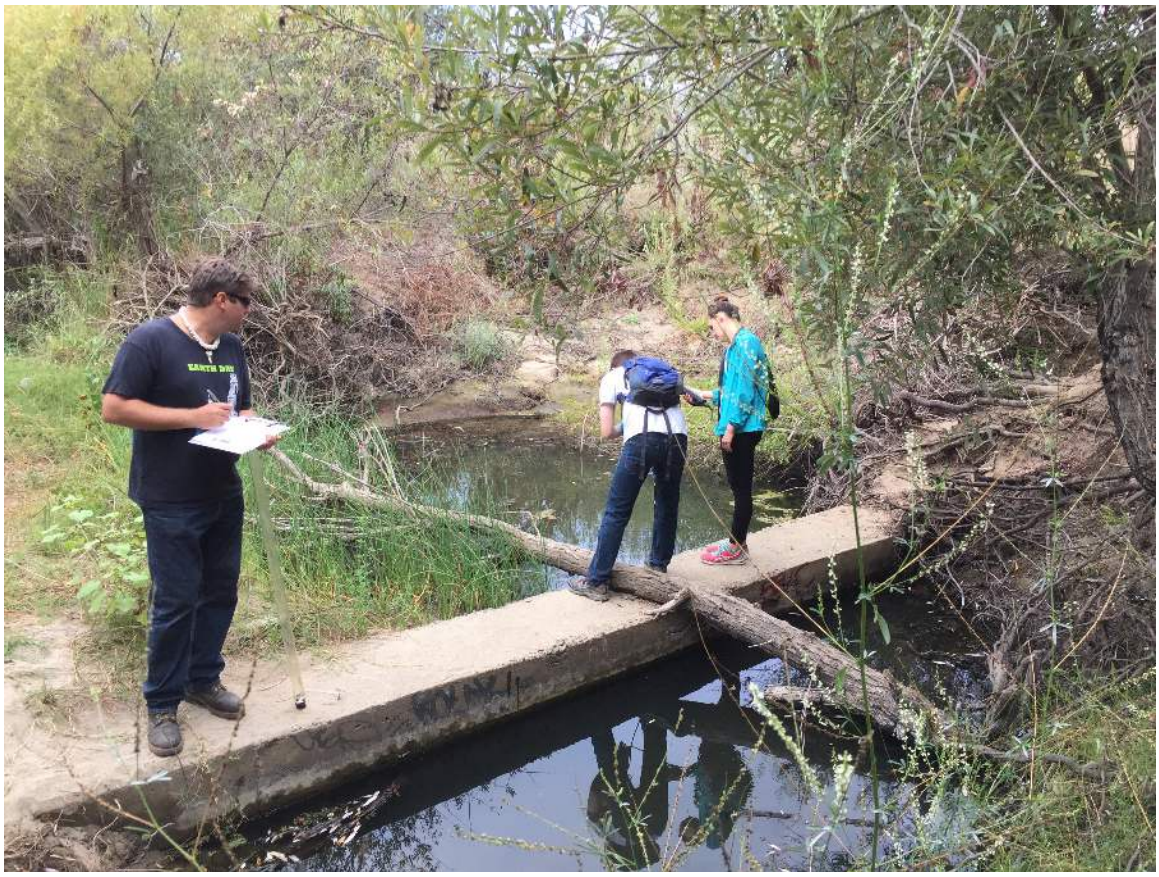
LOWER SAN DIEGO RIVER
WATER QUALITY 2005 - 2017

WY17 Annual Water Quality Monitoring Report



Water quality monitoring of groundwater seeps adjacent to YMCA/River Gardens (Site 3)

RiverWatch Water Quality Monitoring Results (October 2004 - September 2017)

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October 2017

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Lower San Diego River Water Quality 2005 - 2017

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[a] *Appendices D-I are contained in a separate document.*

Questions regarding the San Diego RiverWatch WQM database or interpretation of results expressed in this and similar SDR WQ data monitoring reports can be directed to the attention of John C. Kennedy, through contacting SDRPF at info@SanDiegoRiver.org or the WQM Coordinator, Shannon-Quigley Raymond, at 619-297-7380.

Section 1 - Introduction

This report provides a summary of monthly values, seasonal patterns and annual trends in water quality monitoring data gathered and evaluated by SDRPF's RiverWatch citizen volunteers. WQM data collected monthly over the past 13 years at 15 sites within the Lower San Diego River (LSDR) watershed have been aggregated, in conjunction with hydrologic stream flow data to develop a numeric water quality index (WQI). Basic monthly data regarding individual water quality parameters and river hydrology for each of the sites monitored are maintained in an extensive Excel database file available at the SDRPF offices; this report examines Water Year 2017 (WY17) data in comparison to previous year results and 13-yr averages (norms). The LSDR watershed and water quality monitoring site locations are shown on **Figure 1-1**.

Figure 1-1 LSDR Watershed and Water Quality Monitoring Sites

Color Code for LSDR reaches on Figure 1-1 above: Estuary (orange), Lower Mission Valley (purple), Upper Mission Valley (red), Mission Gorge (green), Lower Santee Basin (pink), Upper Santee Basin (dark blue), Lakeside to El Capitan Reservoir (light green) and principal tributaries (light blue)

The water quality sites on Figure 1-1 and monthly RiverWatch water quality data can be viewed in detail from the RiverWatch page on the SDRPF website available at <www.sandiegoriver/river_watch.html>. Clicking on the right hand side of the page allows access to the data portal. In addition to water quality monitoring data, the portal also contains: San Diego StreamTeam Bio-assessment data, 401 Project information and USGS real-time streamflow data regarding daily peak discharge and gauge height for the two San Diego River gauging stations (Fashion Valley & Mast Bridge near Santee).

The SDRPF RiverWatch water quality index (WQI) represents the monitoring team's response to the public's general questions and concerns regarding overall health of the Lower San Diego River. The index is a numeric (0-100) whereby increasing values signify improving water quality. The numerical index incorporates basic physical, chemical and bacteriological water quality data by integrating six parameters: water temperature (Temp), pH, specific conductivity (SpC), dissolved oxygen (DO and/or %DOSat), mean coliform count (MCC) and streamflow (Q); through determination of weighted factors for each parameter. The resulting values are aggregated to arrive at an overall score for each site, reach, section as well as the lower watershed (LSDR) as a whole. The index values, grade, color codes and general conventions employed are presented in **Table 1.1.**

Table 1.1 LSDR Water Quality Index

SDR WQI (0-100)	Grade	Color Code	Percentile Range	Water Quality Threshold	General
75 or >	A - Very Good	Dark Blue	25%	Well Above Acceptable WQ Criteria	Healthy (>50)
50 - 74	B - Good	Light Blue	25%	Exceeds Acceptable WQ Criteria	
38 - 49	C - Fair	Green	12.5%	Meets Many but not all WQ Criteria	Impaired/Ailing (25-49)
25 - 37	D - Marginal	Yellow	12.5%	Meets Limited Minimum WQ Criteria	
13 - 24	E - Poor	Brown	12.5%	Meets Few Minimum WQ Criteria	Unhealthy (< 25)
0 - 12	F - Very Poor	Pink/ Rose	12.5%	Well Below Minimum WQ Criteria	

Note: The WQI has been developed for fresh water quality metrics only; it is not applicable to or for estuarine or ocean waters.

In general, sites with WQI values of 50 or above exceed expectations for acceptable water quality and are indicative of 'Healthy' conditions. Scores between 25 and 49 describe 'Impaired or Ailing' quality levels where solid evidence exists regarding failure to meet acceptable minimum water quality criteria. Water quality with scores of less than 25 do not meet minimum expectations and are considered 'Unhealthy' or highly stressful to most aquatic life forms. For WQ parameters monitored by RiverWatch, the index expresses results relative to levels necessary to sustain designated beneficial water uses for the LSDR (Hydrologic Area 907.1) based on State of California Water Quality Standards. Where criteria are non-specific, results are expressed relative to Southern California coastal area freshwater norms. The index can not, without considerable loss of relevancy, be applied to estuaries and ocean waters.

Index values have been computed using two similar formulas; one involving four key parameters (Temp, SpC and DO) monitored by RiverWatch combined with streamflow (Q), the second with two additional parameters (pH and MCC) combined with averaged streamflow. The equations used for both formulas (WQI_4 and WQI_6) are presented in Appendix I. Differences between the two determinations have are found to be small. The initial determination (WQI_4) typically presents a broader range (from low to high value) than the second, as the 'normalizing' effects of pH and MCC (both of which present less spatial and temporal variances) are excluded. The broader range WQI_4 values are expressed in this report.

The index, developed specifically for the San Diego RiverWatch program, can also be applied to other Southern California coastal area watercourses where comparable water quality metrics (i.e., DO, SpC, Water Temp and streamflow) have been or are monitored on a regular and consistent basis. A special report comparing relative water qualities in three San Diego County watercourses; Los Penasquitos Creek below Poway, the Santa Margarita River below Temecula and near Fallbrook (SUMP), and the Lower San Diego River below Santee and in Mission Valley has been compiled by the SDRPF RiverWatch program.

Section 2 - Spatial Comparison of WY17 Water Quality Data and 13-yr Norms

Monthly water quality data collected and recorded at each site by RiverWatch WQM Team volunteers are used to determine annual averages, seasonal patterns and trends as presented in this report and appendices. Supplemental data collected by other monitoring organizations for streamflow (USGS) and coliform counts (SD CoastKeepers) are also included. The annual average water quality values for each of the 15 monitoring sites for WY17 as well as the 13-yr norms (average values calculated over past 13 years of monitoring) are presented in **Table 2.1**. WY17 values greater than the 13-yr norms are shown in blue, whereas values for this past water year below norms are displayed in red.

Table 2.1 Annual WQ Metrics for WY17 and 13-yr Norms by Site, Reach and Section

Site:	*LSDR Reach & Section*		Temp, oC	SpC, mS/cm	pH	DO, mg/L	DO %Sat	Flow, cfs	WQI Value [a], (Difference) & Grade	
1	LMV	West	**20.1**/*19.5*	**2.58**/2.63	**7.9**/7.7	**6.4**/*6.1*	**72**/67	**58**/*32*	**38**/*38* (0)	**C**/*C*
2			**19.7**/*19.0*	**2.52**/2.59	**7.7**/7.7	**4.6**/*4.6*	**43**/47		**28**/*31* (-3)	**D**/*D*
3			**19.9**/*19.2*	**2.43**/2.50	**7.8**/7.7	**4.6**/*4.6*	**50**/49		**31**/*32* (-1)	**D**/*D*
4			**20.4**/*19.7*	**2.33**/2.43	**7.8**/7.8	**5.6**/*6.2*	**62**/67		**37**/*41* (-4)	**D+**/*C*
5	UMV		**17.8**/*17.2*	**2.45**/2.55	**7.6**/7.6	**4.4**/*4.8*	**47**/49	**33**/*28*	**31**/*32* (-1)	**D**/*D*
6			**18.9**/*18.3*	**2.40**/2.56	**7.7**/7.6	**3.6**/*3.7*	**38**/38		**26**/*26* (0)	**D**/*D-*
7			**18.8**/*18.0*	**2.22**/2.46	**7.6**/7.5	**5.7**/*5.0*	**61**/52		**40**/*34* (+6)	**C**/*D*
8	MG	Mid	**17.7**/*17.1*	**2.22**/2.26	**7.6**/7.6	**6.1**/*7.5*	**63**/77	**28**/*20*	**40**/*49* (-9)	**C**/*C+*
9 [b]			**14.6**/*15.9*	**4.68**/4.95	**8.1**/7.8	**9.9**/*9.1*	**99**/93		**37**/*36* (+1)	**D**/*D+*
10			**17.9**/*17.7*	**2.03**/2.22	**8.0**/7.9	**6.9**/*7.2*	**73**/75	**26**/*18*	**43**/*45* (-2)	**C**/*C*
11	LSB	East	**17.0**/*16.7*	**2.12**/2.22	**7.7**/7.7	**5.4**/*6.1*	**56**/61		**35**/*38* (-3)	**D**/*C-*
12 [b]			**18.3**/*17.7*	**1.22**/1.67	**8.0**/7.9	**8.0**/*7.1*	**83**/72		**44**/*35* (+9)	**C**/*D+*
15 [b]			**19.2**/*18.1*	**2.50**/2.72	**8.0**/8.1	**7.8**/*7.9*	**84**/75	**14**/*10*	**48**/*41* (+7)	**C**/*C*
13	USB		**18.3**/*18.5*	**1.79**/1.91	**7.7**/7.7	**2.7**/*3.2*	**29**/*33*	**8**/*6*	**18**/*18* (0)	**E**/*E*
14			**18.9**/*17.2*	**1.23**/1.50	**8.0**/7.8	**2.5**/*3.3*	**33**/*32*		**20**/*18* (+2)	**E**/*E*
(1-15)	**LSDR Avg.**		**18.6**/*18.0*	**2.14**/2.27	**7.8**/7.7	**5.1**/*5.4*	54/*56*	**39**/*24*	**33**/*34* (-1)	**D**/*D*

a) Average annual water quality index value, change (+/-) and resultant WQ letter grade for WY17 (bold) and the 13-yr norms (italics); values below the norms for each metric are expressed in red; values above norms are shown in blue.
b) Lower San Diego River water quality monitoring sites located on tributary (T) streams.

Seven of the 15 sites; four in Mission Valley (#2-5), two in Mission Gorge (#8&10) and one in the Lower Santee Basin (#11) portions of the lower watershed, present WY17 average annual WQI values slightly below the 13-yr norms. The greatest negative change (-9 points) is associated with Mission Trails Crossing at Jackson Dr. (Site #8) whereas the greatest positive change (+11 points) is upstream at W Sycamore

Cnyn. Ck./Santee Lakes (#12). Average annual water temperatures in WY17 are greater than the 13-yr norms at all but two sites (#9&13) and overall up 0.6 degrees (18.6 C) from the LSDR 13-yr annual average of 18.0 C. WY17 Specific Conductivity values are running below the 13-yr norms at all sites and in all reaches over the lower river watershed. Overall SpC (average all sites) is only 6% (0.3 mg/L) below the 13-yr average annual norm of 2.27 mS/cm. DO values in WY17 are slightly lower than norms at nine of the sites and higher at six others; overall DO values are about 6% below the 13-yr LSDR average annual norm of 5.4 mg/L. DO values for WY17 are, however, up from last several years by approximately 0.5 mg/L (10%) and the poorest year (WY14) by over 1.0 mg/L (20%). WY14 witnessed the lowest DO values (2.89 mg/L or 31% Sat.) monitored over the past 13 years of record. The highest average annual DO levels on the river were monitored in WY05 at 6.80 mg/L (72% Sat.).

Average annual, seasonal and monthly min.-max. range water quality metrics for WY17 and the 13-yr norms are also presented by river reach and section in **Table 2.2.** Three reaches of the river present slightly higher water quality values for WY17 than their associated 13-yr norms. Two reaches (MG & LMV) show slightly lower WQI values than their norms. Average annual water temperatures and stream flow for all reaches and sections of the river were higher in WY17 than the norms. Dissolved oxygen and SpC values remained below the 13-yr norms for each river reach and section during WY17 although both metrics improved compared to the past three years. Most noticeable improvements in water quality metrics throughout the lower river watershed occurred during the wet-weather months.

Table 2.2 Water Quality Metrics for WY17 and 13-yr Norms by Season, Reach and Section

Parameter, units		Temp, oC	SpC, mS/cm	pH	DO, mg/L	DO %Sat	Flow, cfs	WQI Value, [a](Diff) & Grade	
Max. Month		24.4/*25.3*	3.06/*3.46*	8.2/*8.3*	9.5/*10.2*	103/*100*	185/*289*	78/*78* (0)	A/*A-*
Winter (D,J,F,M)		14.4/*13.5*	1.29/*1.67*	7.8/*7.7*	7.5/*6.9*	75/*66*	111/*56*	54/*48* (+6)	B/C+
Average Annual		**18.6/*18.0***	**2.14/2.27**	**7.8/7.7**	**5.1/*5.4***	**54/*56***	**40/*24***	**28/*34* (-6)**	**D/*D***
Summer (J,J,A,S)		23.1/*22.5*	2.70/*2.77*	7.7/*7.7*	2.8/*4.0*	32/*46*	1.6/*2.2*	18/*20* (-2)	E/E
Min. Month		11.1/*9.2*	0.97/*0.97*	7.5/*7.1*	2.8/*1.9*	29/*22*	0.8/*0.4*	12/*8* (+4)	F+/F
LSDR Reach & Section Averages:									
USB	East	18.5/*18.1*	1.70/*1.79*	7.8/*7.7*	1.6/*3.2*	17/*33*	7.5/*5.2*	**18**/*18* (0)	**E**/*E*
LSB		18.2/*17.5*	2.10/*2.25*	7.8/7.8	6.6/*6.7*	71/*74*	30/*18*	40/38 (+2)	C/*C*
MG	Mid	17.5/*17.1*	2.08/*2.24*	7.9/*7.7*	7.2/*7.6*	73/*79*	35/*21*	42/47 (-5)	C/*C*
UMV	West	18.5/*17.9*	2.36/*2.52*	7.6/7.6	3.1/*4.5*	32/*46*	60/*28*	32/31 (+1)	D/*D*
LMV		20.0/*19.3*	2.47/*2.54*	7.8/*7.7*	4.8/*5.1*	52/*54*	66/*30*	34/35 (-1)	D/*D*

a) Average annual water quality index value, difference (+/-) from 13-year norms and resultant WQI letter grade. Values/grades below 13-year norms (in italics) are expressed in red; values above in blue.

Spatial water quality values expressed in Tables 2.1 and 2.2 for the fifteen Lower San Diego River system monitoring sites are presented in **Chart 2.1** (Water Quality Data Profile) and **Chart 2.2** (Water Quality Index and LSDR Streamflow) on the following page. The overall water quality index for WY17 of 33 (D Marginal) is only one point below the 13-yr average annual norm of 34 (D Marginal). This year's average annual index value is 11 points above the lowest annual WQI of 22 (E Poor) experienced in WY14. The lower river's highest overall average annual index of 41 (Fair) occurred in WY05.

Average annual water quality values for water temperature, pH, dissolved oxygen and specific conductivity at each monitoring site, river reach and section in order of their location upstream for WY17 (Oct.'16-Sept.'17) and the 13-yr norms are shown in **Chart 2.1**. This year's average annual results are shown as heavy solid lines in black with values shown; blue lines are last year's (WY16) results and the red lines are 13-yr annual norms for each site. Average annual water temperatures for WY17 are greater than the 13-yr norms at most sites (excluding 9T) as well as last year's averages. Average downstream site water temperatures are typically higher than monitored at upstream sites. There is little variance in average pH values between each site or from one year to the next. DO levels for WY17 are generally above those from last year (WY16) and comparable to the 13-yr norms. Average annual DO values at three sites (#s 6,13&14) remain below threshold levels of 4 mg/L. DO values represent the greatest variation between sites. Lowest values are typically recorded in the Upper Santee Basin (Site #13&14) and Upper Mission Valley below Kaiser Ponds (site #5&6). Highest DO values are observed in the Mission Gorge section (middle reach sites 8,9&10) and Forester Ck (15T). With exception of two tributary sites (#9T&15T), average annual SpC values generally increase from upstream to downstream with minimal change from year-to-year.

The WQI, an aggregate or composite index of water quality monitoring metrics for WY17, the 13-yr norms and the overall best (WY05) and worst (WY14) year results are presented in **Chart 2.2**. As shown by the solid black line and bars, the two sites furthest upstream, #13 (Mast Park) and #14 (RCP/ Cottonwood), continue to experience Poor (E grade) water quality. On an average annual basis, highest WQI values for WY17 continue to be associated with Forester Creek (#15T), Santee Lakes (12T) and the Mission Gorge (8&10) sites. The overall WQI profile for WY17 (black line) is in general slightly below the 13-yr norm (heavy blue line) but well above the WY14 lows. Greatest departures (variance) from the 13-yr WQI norms for WY17 are found in the Upper Mission Valley portion of the river. Water quality conditions throughout Mission Valley (both Upper and Lower reaches) in WY17 are 'on par' with last year's (WY16) monitoring results. Forester Ck (#15) monitoring results represent the greatest overall improvement in water quality above the 13-yr norm. River water quality profiles are expected to remain relatively stable during WY18 if the watershed remains within the current hydrologic cycle of normal rainfall and runoff. Another second year of above normal streamflow resulting from above normal precipitation levels would be expected to have a beneficial effect on overall river water quality. Another below normal rainfall and runoff year would predictably have the opposite effect.

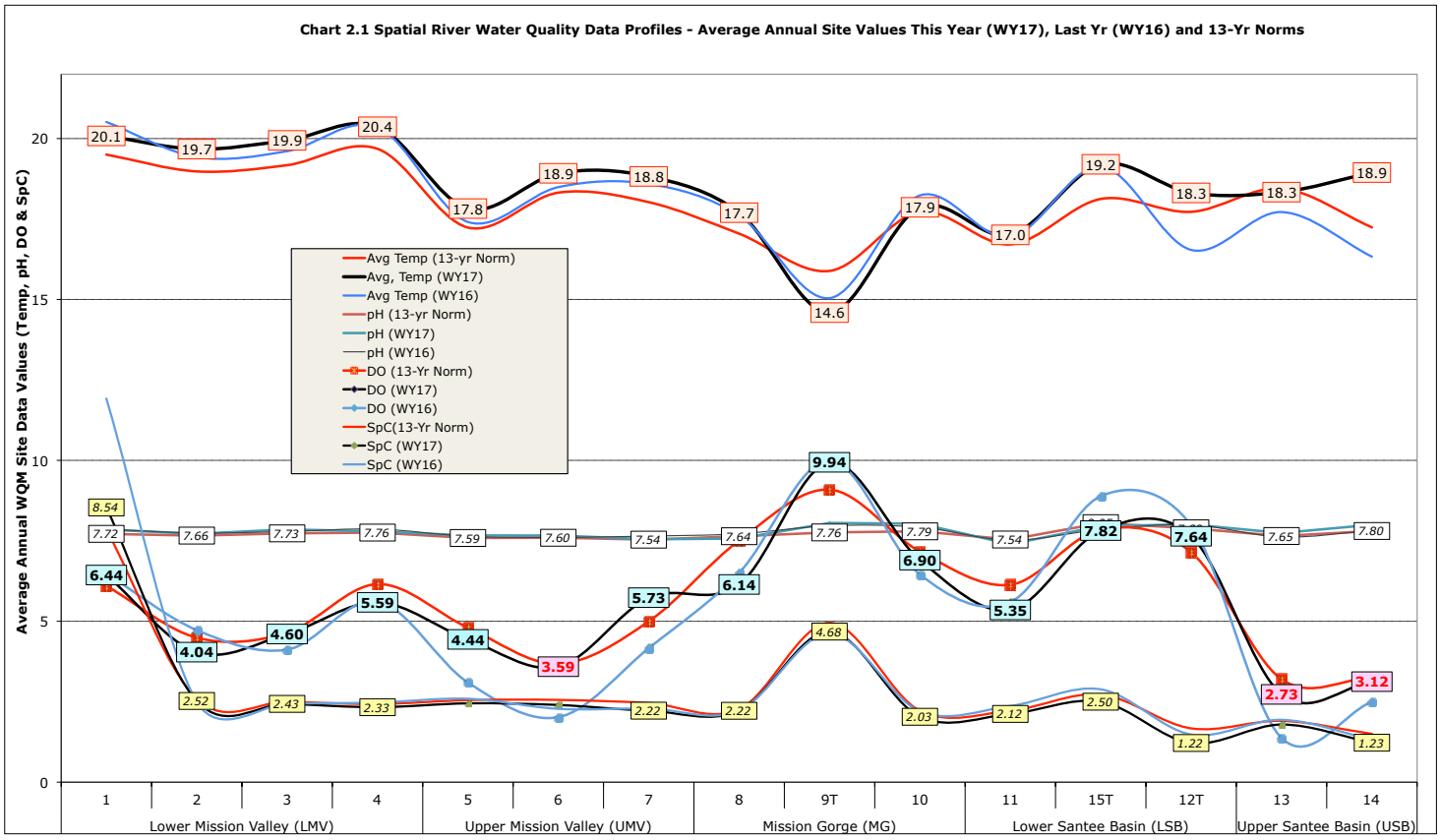


Chart 2.1 Spatial River Water Quality Data Profiles - Average Annual Site Values This Year (WY17), Last Yr (WY16) and 13-Yr Norms
Average Annual WQM Site Data Values (Temp, pH, DO & SpC)
Avg Temp (13-yr Norm)
Avg, Temp (WY17)
Avg Temp (WY16)
pH (13-yr Norm)
pH (WY17)
pH (WY16)
DO (13-Yr Norm)
DO (WY17)
DO (WY16)
SpC(13-Yr Norm)
SpC (WY17)
SpC (WY16)
Lower Mission Valley (LMV)
Upper Mission Valley (UMV)
Mission Gorge (MG)
Lower Santee Basin (LSB)
Upper Santee Basin (USB)

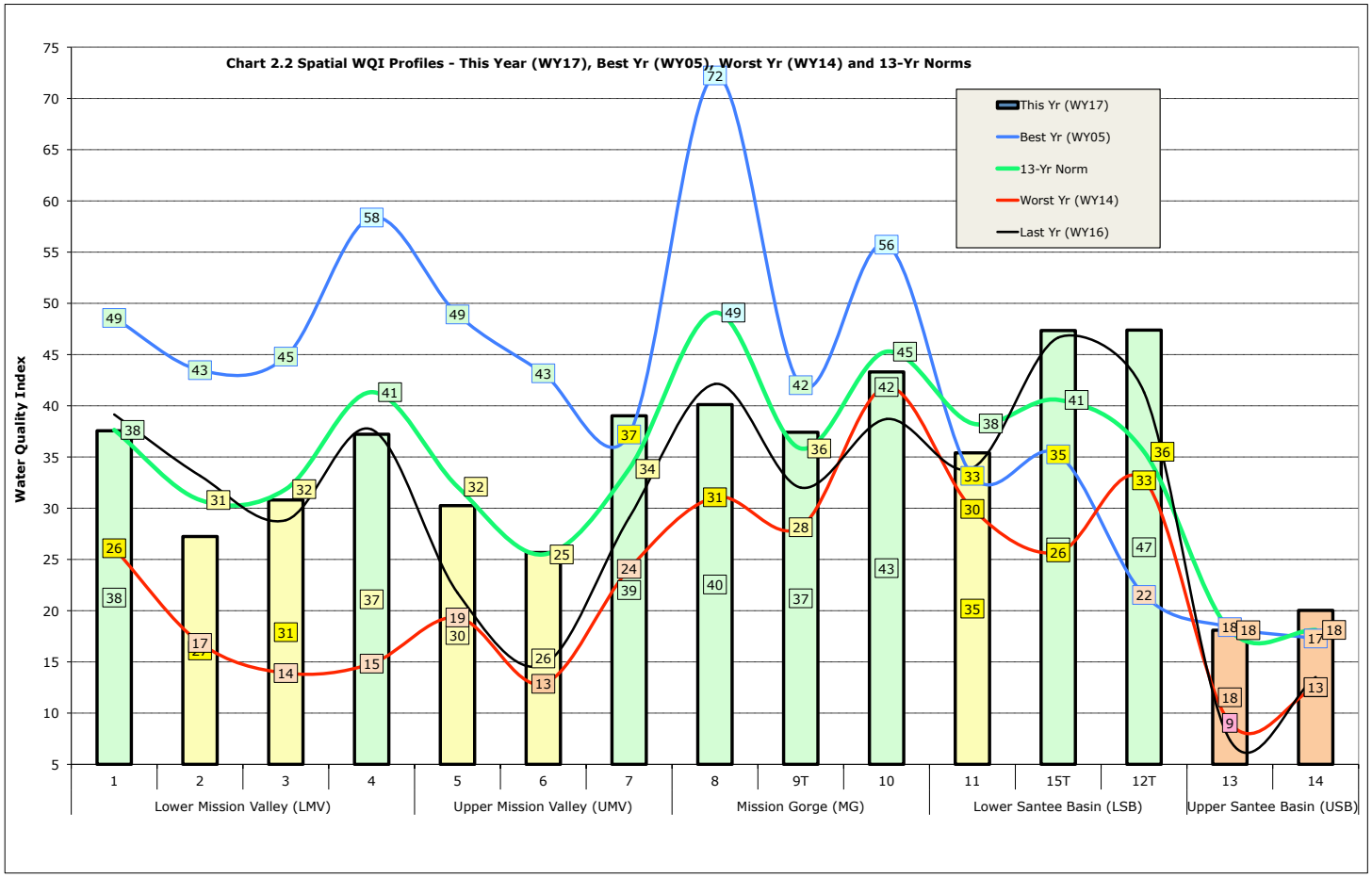


Chart 2.2 Spatial WQI Profiles - This Year (WY17), Best Yr (WY05), Worst Yr (WY14) and 13-Yr Norms
Water Quality Index
This Yr (WY17)
Best Yr (WY05)
13-Yr Norm
Worst Yr (WY14)
Last Yr (WY16)
Lower Mission Valley (LMV)
Upper Mission Valley (UMV)
Mission Gorge (MG)
Lower Santee Basin (LSB)
Upper Santee Basin (USB)

Section 3 - Temporal Comparison of WY17 Data and 13-yr Norms

Monthly, seasonal and annual water quality monitoring data and WQI results for the Lower San Diego River are presented in **Table 3.1** for this year (WY17) in comparison to 13-yr norms shown italicized. Values above the 13-yr norms are in blue; values below in red. In general, temporal water quality in WY17 exceeded last year's (WY16) results most noticeably during the winter and spring months but fell short by slight margins of 13-yr norms during fall and summer seasons. Overall water quality showed the greatest improvements during the Winter and Spring months of Jan., March and May. The least improvement occurred last Fall during the first two months (Oct. and Nov.) of the water year.

Table 3.1 LSDR WQM Metrics for WY17 and 13-yr Norms by Month and Season

		Temp	SpC	pH	DO	DO%	Flow	WQI [a]	
Month	*Season:*	*oC*	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Value & Grade*	
Oct	Fall	**17.6**/*18.8*	**3.06**/*2.77*	**7.7**/*7.6*	**2.75**/*4.10*	**29**/*43.1*	**1.3**/*14*	**13**/*22*	E-/*E*
Nov		**15.0**/*14.9*	3.05/*2.51*	**7.6**/*7.8*	**3.62**/*5.56*	**36**/54.4	**6.7**/*13*	**16**/*32*	**E**/***D***
Dec	Winter	**12.7**/*11.9*	1.46/*1.69*	**7.7**/7.7	5.04/6.74	**48**/61.8	**48**/*56*	**31**/*43*	**D**/*C*
Jan		**11.1**/*11.5*	0.97/*1.74*	**7.5**/7.7	**8.59**/8.13	**79**/73.9	**169**/*66*	58/*51*	**B**/*B-*
Feb		**14.9**/*13.8*	**1.22**/*1.69*	**7.7**/7.8	**6.99**/7.13	**70**/68.2	**185**/*68*	**48**/*47*	**C**/*C*
Mar		**18.6**/*16.8*	1.49/*1.67*	8.2/7.7	**9.53**/6.79	**103**/69.4	**42**/*34*	**78**/*50*	**A-**/B-
Apr	Spring	**19.9**/*18.0*	2.02/*1.94*	**8.0**/7.7	**4.67**/5.92	52/62.5	**7.6**/*16*	**33**/*43*	**D**/*C*
May		**20.1**/*20.2*	1.63/*2.22*	8.0/7.6	**5.93**/5.26	**66**/58.0	**17**/*8.7*	**44**/*36*	**B**/*C*
June	Summer	**23.2**/*22.1*	2.40/*2.58*	**7.9**/*7.7*	**4.42**/*4.51*	**52**/*51.6*	**2.8**/*2.8*	**29**/*27*	**D**/*D*
July		**24.4**/*23.1*	**2.73**/*2.71*	7.8/*7.6*	**3.22**/*3.59*	**39**/*41.6*	**1.2**/*2.8*	**15**/*18*	**E**/*E*
Aug		**22.7**/*23.2*	**2.77**/*2.91*	**7.7**/*7.7*	**2.99**/*3.61*	**35**/*41.9*	**1.1**/*1.2*	**14**/*17*	**E**/*E*
Sept		22.5/*21.5*	**2.84**/*2.90*	**7.7**/*7.7*	**3.22**/*3.70*	**37**/*41.5*	**1.3**/*1.8*	**12**/*19*	**F+**/*E*
Fall (O&N)		**17.8**/*16.8*	**3.05**/*2.64*	**7.7**/*7.7*	**2.81**/*3.98*	32/*45.8*	**1.8**/*13*	**15**/*25*	**E**/*D-*
Winter (D,J,F,M)		**14.4**/*13.5*	**1.29**/*1.70*	**7.8**/*7.7*	7.54/*6.91*	**75**/*66.1*	**111**/*56*	**54**/*46*	**B**/*C*
Spring (A&M)		**19.0**/*19.1*	**1.83**/*2.08*	**7.9**/*7.7*	**5.30**/*5.59*	**59**/*60.2*	12/*12*	**38**/*37*	**B-**/*C*
Summer (J,J,A,S)		**23.1**/*22.5*	**2.70**/*2.78*	**7.7**/*7.7*	**3.47**/*3.85*	**36**/45.8	1.6/*2.2*	**18**/*18*	**E**/*E*
Annual (O-S)		**18.6**/*18.0*	2.14/*2.27*	**7.7**/*7.7*	**5.08**/*5.42*	**54**/*55.7*	**40**/*24*	**31**/*32*	**D**/*D*

a) Values based on RiverWatch physical-chemical metrics (WQI_4) combined with USGS stream flow for eastern (West Hills Pkwy) and western sections (Fashion Valley). WY17 values/grades below the 13-yr norms (expressed in italics within parentheses) are shown in red, those equal to or above in blue.

Monthly and seasonal variances in water quality monitoring data metrics for the past two water years and the 13-yr norms are also expressed in **Chart 3.1.** (WQM Data) on the next page. Dissolved Oxygen values are highest during the winter/spring months (Dec-May) whereas Specific Conductivity and water temperatures are greatest during the dry summer months (June-Sept) and early Fall. Coliform counts and pH values show very little seasonal fluctuation, although small variances from norms in monthly values are evident. The broad range in DO and temperature values monitored at all sites throughout the year provide the best indications of the temporal variance in water quality. Seasonal variances between this year's data (WY17), shown as bars with solid lines, last year's results (dashed lines) and the 13-yr norms (heavy solid lines with monthly markers) are comparable. In general, temporal variance in WY17 water quality data more closely matches patterns in 13-yr norms than did last year's data. This year's temporal water quality patterns were more indicative of normal monthly occurrences than monitored during the previous year (WY16).

Chart 3.2 provides an overall perspective of temporal variance in WQI values and streamflow throughout WY17 compared to monthly averages over the previous water year (WY16) and the 13-year monthly norms. As listed in the right-hand columns of **Table 3-1** and shown in **Chart 3.2**, the WQI values for WY17 (color-shaded bars) remain lower than the 13-yr norms (heavy black line) in all but four months of the year (Jan., Feb., April & June). The relationship between flow (both wet weather and dry) and water quality continues to effect results. Depletion in DO levels combined with well-below normal dry-weather flows constitute the primary drivers in low index values during the Fall and Summer months. The well above normal wet weather flows during Jan. and Feb combined with seasonal norms for Dec. and May resulted in overall improvement over WY16 results. In general, water quality for the Lower San Diego River watershed was highest (C-, Good) when flows were greatest during the Winter months and lowest in late Summer when flows are least. The overall annual average WQI for the LSDR in WY17 of 31 (D, Marginal) is only one point below the 13-yr norm of 32. The slightly below average results during a year of above normal rainfall and streamflow occurring throughout most reaches and in all sections is thought to be closely associated with un-flushed decayed biomass from non-native invasive aquatic plants. DO deficits remained high at multiple sites throughout the dry weather period. Trends over the past 13 years in the water quality metrics monitored and resultant WQI by river reach and section are presented in Sections 4 and 5, respectively, of this report.

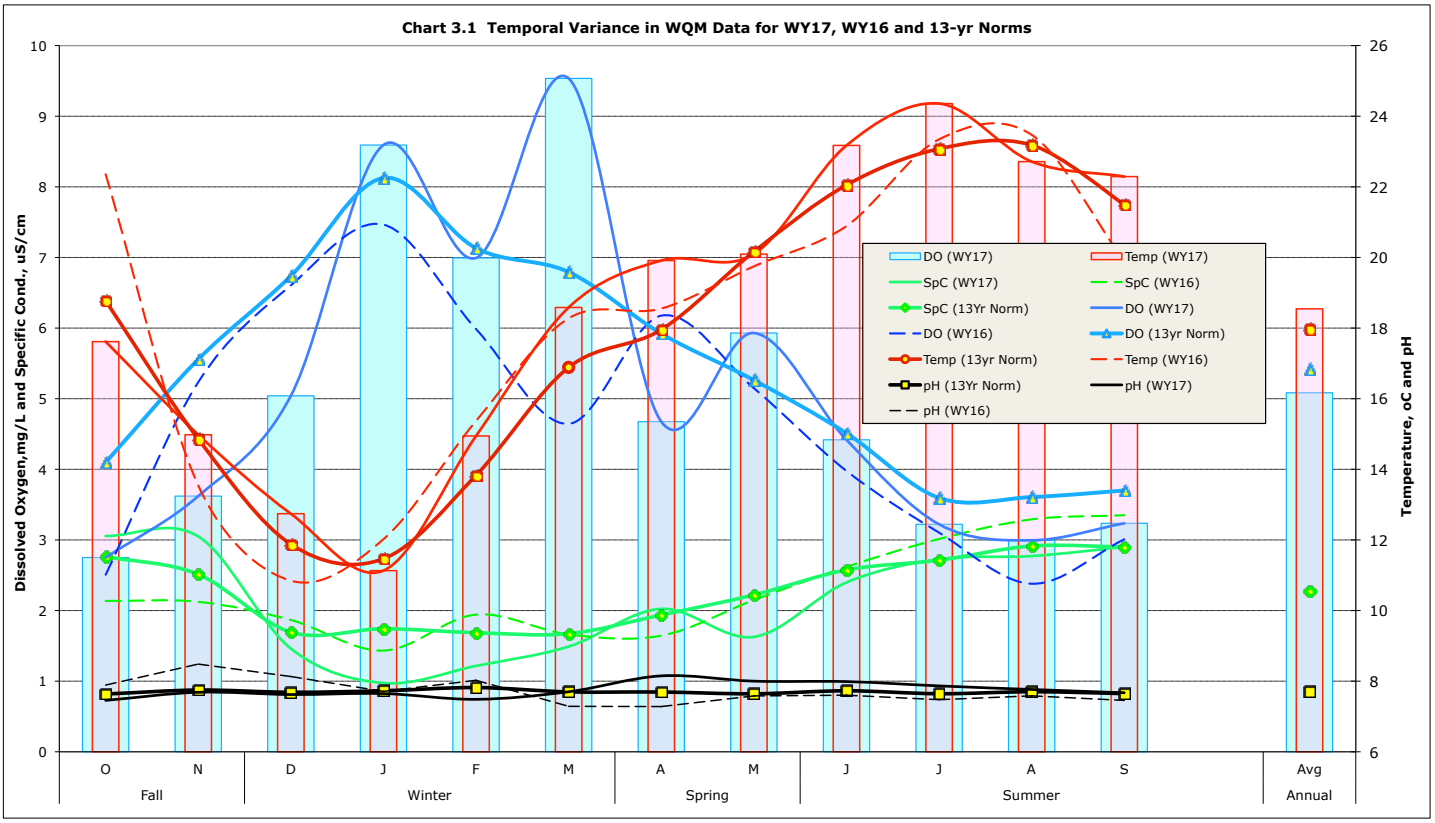


Chart 3.1 Temporal Variance in WQM Data for WY17, WY16 and 13-yr Norms
Dissolved Oxygen,mg/L and Specific Cond., uS/cm
Temperature, oC and pH
DO (WY17)
Temp (WY17)
SpC (WY17)
SpC (WY16)
SpC (13Yr Norm)
DO (WY17)
DO (WY16)
DO (13yr Norm)
Temp (13yr Norm)
Temp (WY16)
pH (13Yr Norm)
pH (WY17)
pH (WY16)
O N D J F M A M J J A S Avg
Fall
Winter
Spring
Summer
Annual

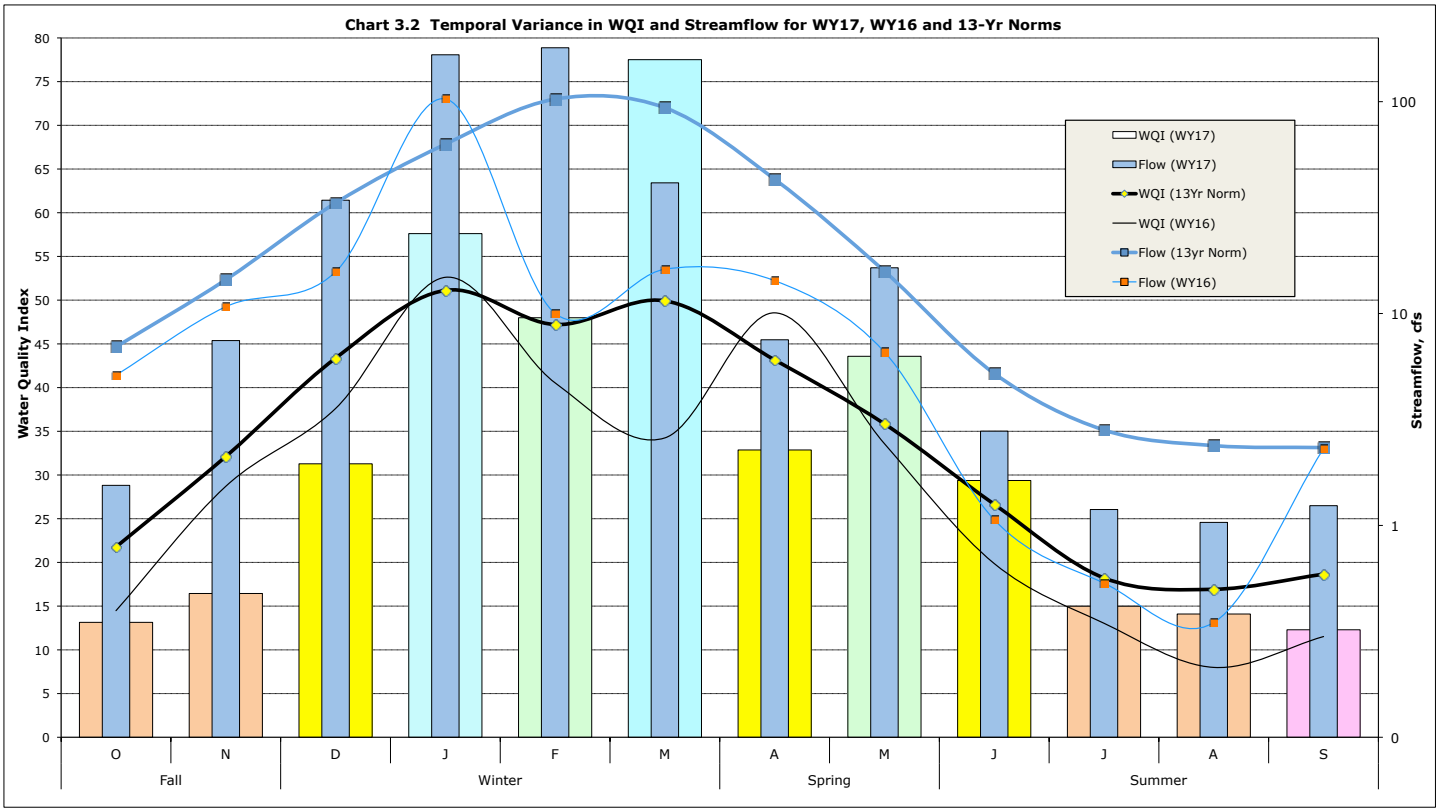


Chart 3.2 Temporal Variance in WQI and Streamflow for WY17, WY16 and 13-Yr Norms
Water Quality Index
Streamflow, cfs
WQI (WY17)
Flow (WY17)
WQI (13Yr Norm)
WQI (WY16)
Flow (13yr Norm)
Flow (WY16)
O N D J F M A M J J A S
Fall
Winter
Spring
Summer

Section 4 - Trends in Individual Water Quality Metrics (WY05 through WY17)

Trends in SDRPF monitored water quality metrics, based on data collected by RiverWatch from September 2005 through September 2017, are presented in this chapter. The metrics include water temperature, specific conductivity, pH, dissolved oxygen, streamflow and the water quality index. Twelve month running average values represent a rational indication of trends over the past 12 years of monitoring for each metric.

Table 4.1 presents 12-month running average values for each of the water quality metrics monitored over the past 13 years. Running averages above 13-yr norms are listed in blue; values below norms are in red. The 13-yr norms are expressed in italics within parentheses.

Table 4.1 - Running 12-mo. Average WQM Metrics (WY05-WY17)

	Temp	SpC	pH	DO	DO%	Flow	WQI [a]	
	oC	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Value & Grade*	
WY05	17.68	2.064	7.63	6.62	62.4	55.7	41	C Fair
WY06	18.32	2.141	7.44	6.00	59.0	11.7	37	D+ Marginal
WY07	17.70	2.342	7.53	5.95	60.3	8.0	36	D+ Marginal
WY08	17.67	2.223	7.89	6.26	64.9	15.8	38	C- Fair
WY09	17.73	2.393	7.66	6.25	65.4	17.8	37	D+ Marginal
WY10	18.08	2.287	7.84	5.22	55.1	29.7	35	D Marginal
WY11	17.77	2.160	7.83	5.53	57.6	23.4	38	C- Fair
WY12	18.03	2.339	7.64	5.16	53.7	12.1	33	D Marginal
WY13	17.32	2.441	7.77	5.30	53.9	7.6	32	D Marginal
WY14	17.86	2.505	7.67	3.87	39.9	4.4	22	E Poor
WY15	18.69	2.189	7.77	4.53	48.5	9.0	29	D Marginal
WY16	18.19	2.269	7.71	4.69	49.1	13.3	29	D Marginal
WY17	**18.55**	**2.142**	**7.77**	**5.08**	**53.9**	**40.6**	**33**	**D Marginal**
Norms	*17.97*	*2.269*	*7.70*	*5.42*	*55.7*	*19.2*	*33.8*	*(D Marginal)*

Values based on SD RiverWatch physical-chemical metrics (WQI_4) combined with USGS stream flow for eastern (West Hills Pkwy) and western (Fashion Valley) gauging stations. Values/grades below 13-yr norms shown in red; above in blue.

Running average, maximum and minimum monthly monitoring site **water temperature** values for the LSDR watershed are presented on **Chart 4.1**. Running average water temperatures that remained fairly steady between WY05 and mid-WY14, increased by approximately one full degree celsius over the past 36 months. The typical running average variance in water temperature over the past decade is in the range of 3% above to 3% below norms, however, over the past three years the temperature variance rose from 4.6% below (Oct. 2013) to 5.2% above (Oct. 2015) the 13-yr norm of 18°C. Maximum monthly water temperatures have also trended higher than monthly minimums over the past several years. Higher running average water temperatures observed over the past few years are a result of higher 24-hr average, daytime and nighttime lows in both air and ground temperatures experienced in San Diego as well as throughout the Southern California region. There were only two months in WY17 (Dec. & Jan.) when average water temperatures fell below 13°C while there were five months (May-Sept.) of this year when water temperatures were above 20°C. Elevated water temperatures result in greater rates of decay and lowered saturation levels of dissolved oxygen.

Trends in monthly monitored **Specific Conductivity** (SpC) values for the LSDR watershed are presented in **Chart 4.2**. Minimum and maximum running averages for all sites monitored have varied little over the 13-yr period, however the overall LSDR running average rose from a low 2.0 mS/cm range (*10% below average*) during the first several years (WY05-WY06) to 2.6-2.7 mS/cm (*10% above)* in WY12, WY13 and WY14. Greater rainfall during the summer months and resultant elevated (well above normal) dry-weather streamflows in WY15 as well as this year caused SpC values to decline considerably below the 13-yr norm of 2.27 mS/cm. The current LSDR running average SpC of 2.13 mS/cm for WY17, is 5.6% below the 13-yr norm. Running average values are expected to continue trending downward with less anticipated monthly rainfall and average dry-weather streamflow forecasted in WY18. Should drought conditions return in 2018, average conductivities can be expected to remain below long-range norms.

Trends in monthly **pH** values are presented in **Chart 4.3**. The overall or general trend in values monitored for the LSDR has been relatively stable during the past decade (WY08-WY17). It is possible that the lowest monthly minimum readings (between 6.3 and 6.8) recorded prior then were a result of a faulty probe. Minimum monthly readings since a replacement probe was acquired in 2009 have seldom been below 7.0. Maximum monthly site readings in the 8.0-8.5 range, have on the other hand remained fairly steady. Excluding the initial three year's, there has been minimal variance (<2%) in the overall running average pH from the 13-yr norm of 7.70.

Running average **dissolved oxygen (DO)** values and monthly minima-maxima are presented in **Chart 4.4.** A steady general decline in average and min./max. values for the lower watershed sites from Jan. 2009 through Feb. 2015 is evident. LSDR average, minimum and maximum monthly values since then have slowly but steadily increased although still below the 13-yr norms. The current running average DO value of 5.06 mg/L (Sept 2017) remains 5.3% below the LSDR norm. Depressed dissolved oxygen levels monitored throughout large segments of the lower river are the result of low flows, especially during the dry-weather months, combined with above average water temperatures and decay of oxygen demanding organic materials (biomass). With the lack of significant flushing action during recent (over past 6 years) relatively mild storm flow events, a large amount of decaying biomass* has accrued within the river channel. Running average DO values are expected to further improve subsequent one or more major storm flow events resulting in significant channel scour, displacement of organic-rich sediments and sizable reduction of invasive aquatic plants.

The overall **water quality index** (WQI) for LSDR as well as minimum and maximum running average values for monitoring sites within the watershed are presented in **Chart 4.5.** The WQI provides an overall indication of the relative condition of the river based on the individual water quality parameters monitored by RiverWatch and streamflow (river discharge) measured by the USGS at two gauging stations. Similar to trends in DO (Chart 4.4), running average WQI values which were in general decline

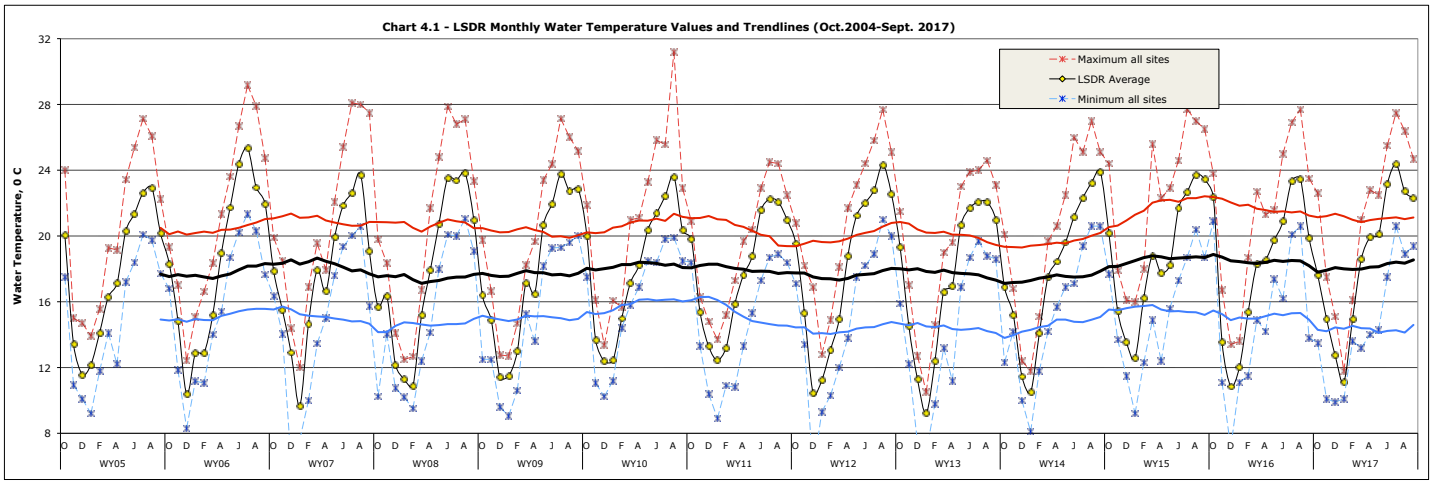


Chart 4.1 - LSDR Monthly Water Temperature Values and Trendlines (Oct.2004-Sept. 2017)
Water Temperature, 0 C
Maximum all sites
LSDR Average
Minimum all sites
32
28
24
20
16
12
8
O D F A J A
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17

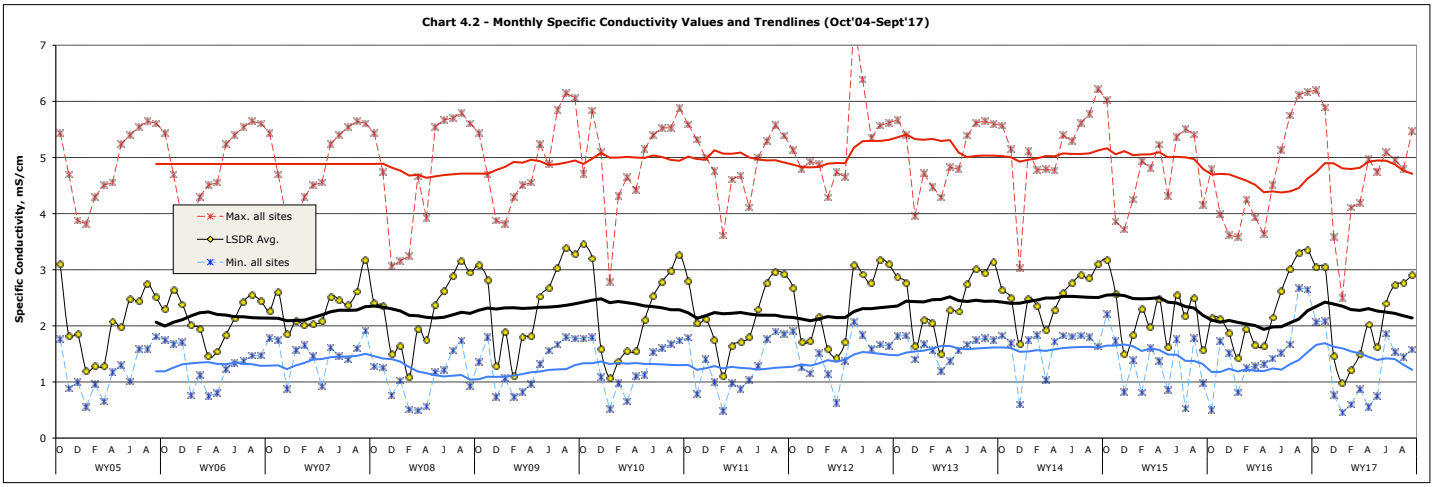


Chart 4.2 - Monthly Specific Conductivity Values and Trendlines (Oct'04-Sept'17)
Specific Conductivity, mS/cm
Max. all sites
LSDR Avg.
Min. all sites
7
6
5
4
3
2
1
0
O D F A J A
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17

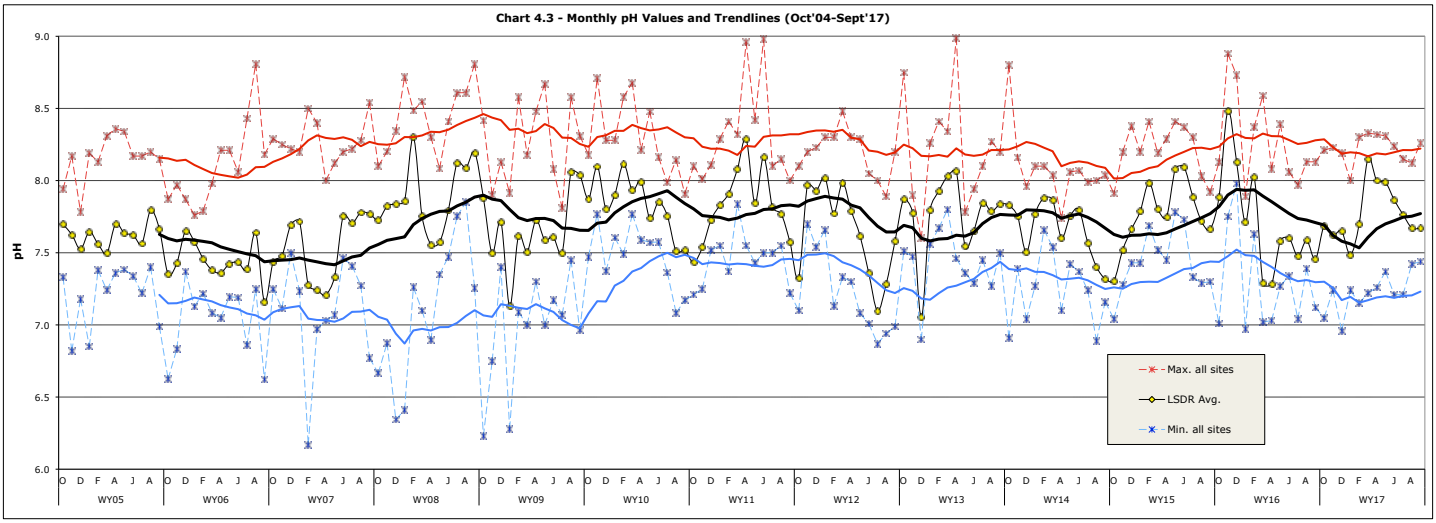


Chart 4.3 - Monthly pH Values and Trendlines (Oct'04-Sept'17)
pH
Max. all sites
LSDR Avg.
Min. all sites
9.0
8.5
8.0
7.5
7.0
6.5
6.0
O D F A J A
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17

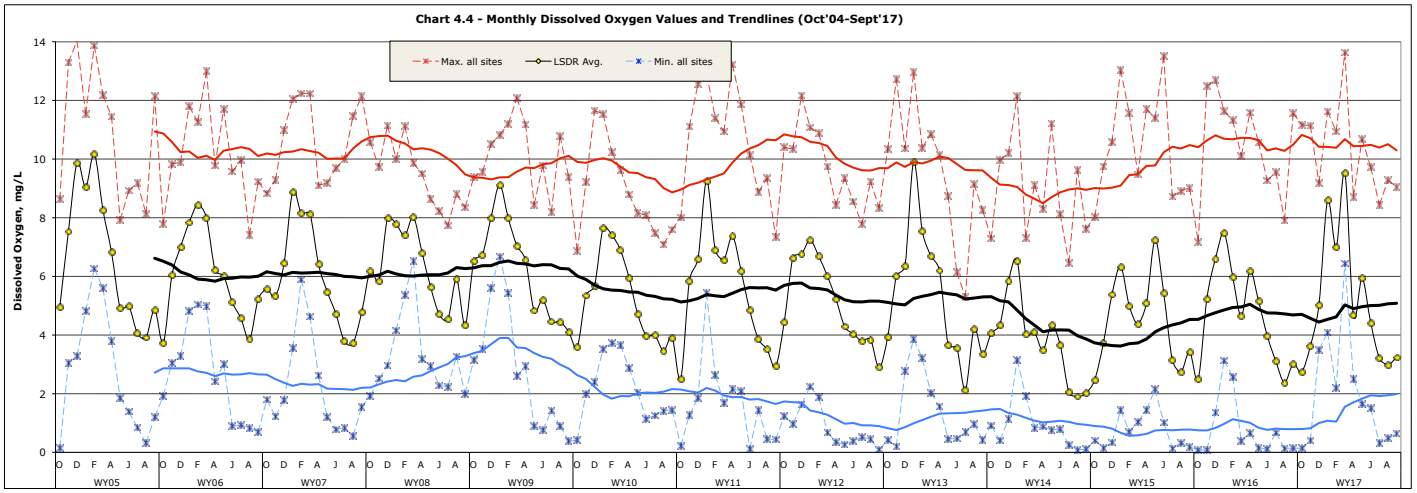


Chart 4.4 - Monthly Dissolved Oxygen Values and Trendlines (Oct'04-Sept'17)
Max. all sites
LSDR Avg.
Min. all sites
Dissolved Oxygen, mg/L
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17

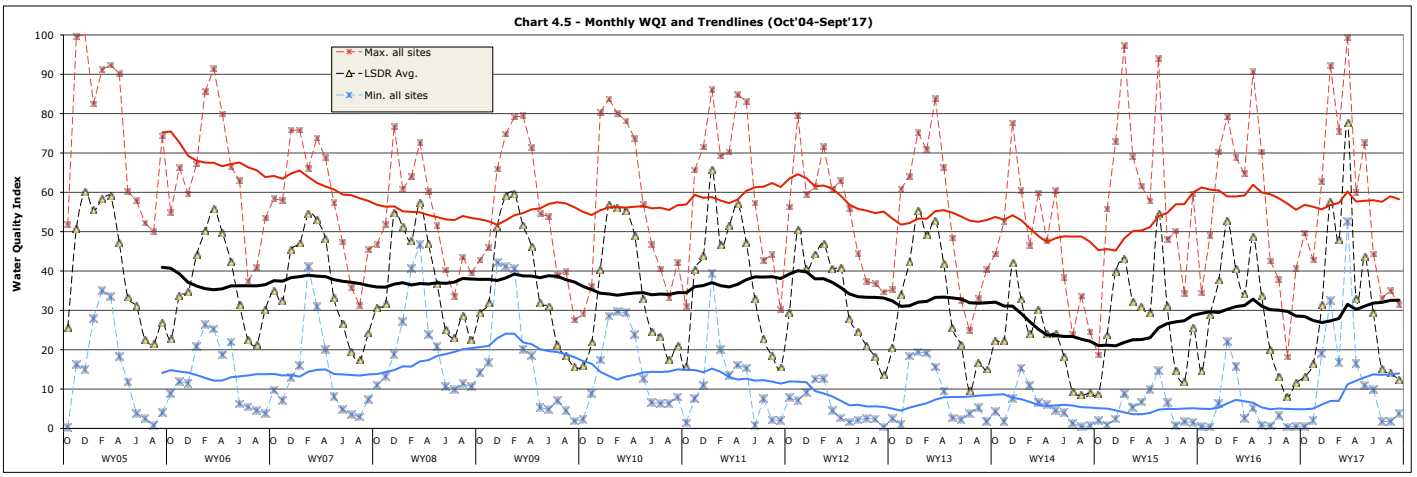


Chart 4.5 - Monthly WQI and Trendlines (Oct'04-Sept'17)
Max. all sites
LSDR Avg.
Min. all sites
Water Quality Index
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17

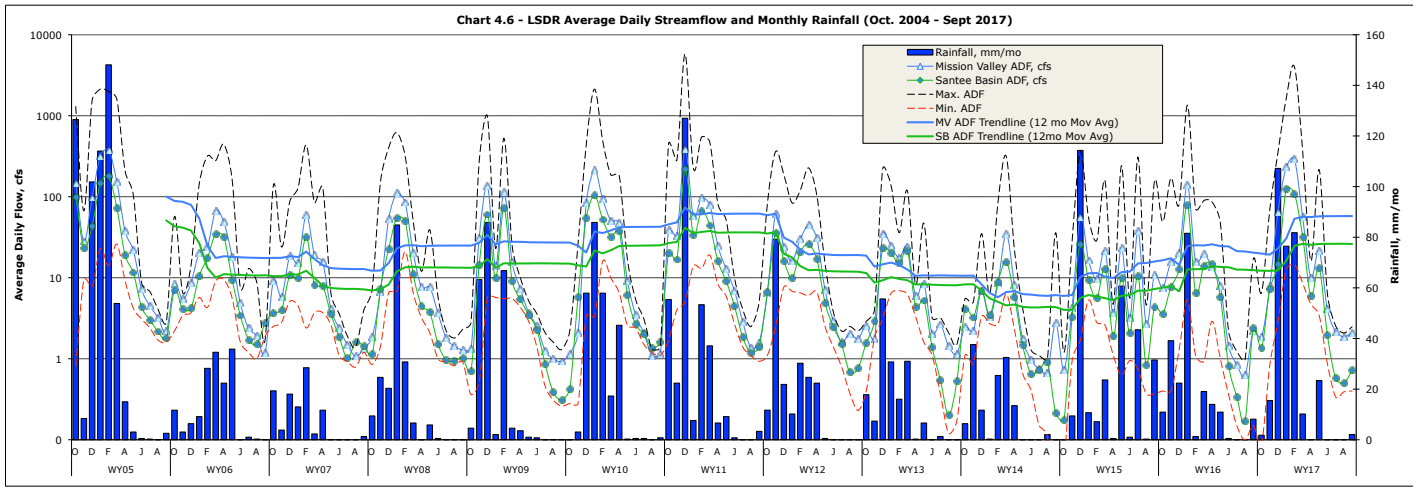


Chart 4.6 - LSDR Average Daily Streamflow and Monthly Rainfall (Oct. 2004 - Sept 2017)
Rainfall, mm/mo
Mission Valley ADF, cfs
Santee Basin ADF, cfs
Max. ADF
Min. ADF
MV ADF Trendline (12 mo Mov Avg)
SB ADF Trendline (12mo Mov Avg)
Average Daily Flow, cfs
Rainfall, mm/mo
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17

from late WY09 to early WY15 have been slowly but fairly steadily increasing. LSDR running averages reached their lowest value of 21 (grade E, Poor) in Oct.-Dec. of 2014, at 38% below the 13-yr norm of 33.3 (grade D, Marginal). The current WQI (Sept 2017) of 33.0 (grade D, Marginal) is only 3% below the 13-yr average. An above average rainfall year in WY18 would be expected to result return to running average index values in mid 30's as previously experienced in WY09 and WY11. A normal or below average rainfall year will likely result in a further decline in the index.

Trend-lines for total monthly rainfall and running average streamflows in the Santee Basin (SB) and Mission Valley (MV) sections are presented in **Chart 4.6.** The trend in average daily streamflow throughout the LSDR fell by an order of magnitude (from 100 cfs to 10 cfs) from WY05 to WY06, then slowly rose to 80 cfs in WY11. Lowest running average streamflow of 7-8 cfs for Mission Valley and 3 cfs for the Santee Basin, was monitored in WY14. Due to the distribution and magnitude of rainfall in both WY15 and WY16, running average streamflows were back up to 15-20 cfs (Mission Valley) and 8-12 cfs (Santee Basin), still below the 13-yr norms. This year, however, WY17 average daily flows were 70% above the Santee Basin norm (16 cfs) and 108% above the Mission Valley norm of 27 cfs. More importantly, from a water quality standpoint, average dry-weather flow in WY17 increased by over 200% above the 13-yr dry-season norms in both the eastern section (Santee Basin) and western portion (Mission Valley) of the watershed.

The trends and relative variances in water quality metrics as shown in **Charts 4.1-4.6** are clearly interrelated. Declining rainfall results in less streamflow which results in declining dissolved oxygen levels and increased specific conductivities. As all of the parameters are incorporated within computation of the water quality index, trends over the past 13 years are similar. The lower river system experienced its best water quality during the wettest year (WY05) followed by a general decline during the well-below average rainfall and river discharge period from WY12 through WY14. The river experienced its poorest water quality during the driest, lowest streamflow year (WY14) monitored over the last 13 years. An uptrend toward normalized values has been evident over the past several years (WY15-WY17). WQI trend-lines by individual river reach and specific segment as well as for the overall system are presented in Section 5.

Section 5 - Trends in LSDR Water Quality Index (WY05 through WY17)

Annual and seasonal LSDR WQI values are presented in **Table 5.1** by river reach, section, and overall (LSDR) average for each water year (WY05-WY17) of monitoring. Values and grades above 13-yr norms are listed in blue; below the 13-yr norms (expressed in black italics) are shown in red. The WY17 values, expressed in bold font, are higher than last year's results for all but the LMV section. Overall the LSDR average annual WQI improved four points (to 33) from last year's 29 value remaining in the Marginal (D) water quality range.

Table 5.1 - Average Annual and Seasonal WQI by Reach and Section (WY05-WY17)

Annual Avg.	LMV Reach	UMV Reach	MV Section	MG Section	LSB Reach	USB Reach	SB Section	LSDR Overall Avg.	
WY05	49	43	46	64	31	18	24	41	C (highest)
WY06	40	33	37	54	34	22	28	37	D+
WY07	37	28	33	50	40	27	34	36	D+
WY08	39	31	36	45	40	34	37	38	C-
WY09	38	29	34	45	42	32	37	37	D+
WY10	36	33	35	48	38	18	28	35	D
WY11	40	38	39	54	44	15	29	38	C-
WY12	35	35	35	48	39	9	24	33	D
WY13	37	32	35	44	35	11	23	32	D
WY14	18	19	18	36	28	10	19	22	E-(lowest)
WY15	24	22	23	44	43	10	27	29	D
WY16	35	22	29	40	37	9	23	29	D
WY17	**34**	**32**	**33**	**41**	**40**	**18**	**29**	**33**	**D**
13-yr Norm	*35.4*	*30.5*	*33.3*	*47.3*	*37.7*	*18.0*	*27.8*	*33.8*	*D Marginal*
Winter	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	64	65	64	85	44	33	39	58	B (highest)
WY06	54	47	51	60	40	29	35	46	C
WY07	50	42	46	62	55	41	48	50	B-
WY08	57	48	53	55	52	52	52	53	B
WY09	57	47	53	62	61	50	55	55	B
WY10	55	54	55	67	55	29	42	52	B-
WY11	57	57	57	66	54	27	40	52	B-
WY12	48	49	49	59	45	14	29	43	C
WY13	58	54	56	67	49	21	35	50	B-
WY14	25	26	26	55	40	15	27	32	D (lowest)
WY15	33	28	31	58	52	11	32	36	D+
WY16	44	38	42	58	52	14	33	41	C
WY17	**53**	**59**	**55**	**67**	**61**	**33**	**47**	**55**	**B**

13-yr Norm	*50.4*	*47.3*	*49.1*	*63.0*	*50.8*	*28.4*	*39.6*	*48.0*	*C+ Fair*
Summer	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	31	25	29	45	20	5	13	25	D-
WY06	23	14	19	45	31	19	25	26	D- (highest)
WY07	23	15	20	35	24	13	18	22	E
WY08	24	20	23	32	29	18	24	25	D-
WY09	21	14	18	31	25	16	20	22	E
WY10	21	18	20	33	26	9	18	22	E
WY11	23	17	20	37	30	5	17	22	E
WY12	22	18	21	25	27	4	16	19	E
WY13	18	13	16	18	23	5	14	16	E
WY14	10	11	10	12	16	8	12	11	F (lowest)
WY15	15	11	13	31	37	9	23	21	E
WY16	**17**	**6**	**13**	**18**	**20**	**5**	**12**	**13**	**E-**
WY17	**20**	**16**	**18**	**20**	**23**	**11**	**17**	**18**	**E**
13-yr Norm	*20.8*	*15.3*	*18.4*	*29.3*	*25.4*	*9.8*	*17.6*	*20.1*	*E Poor*

Table 5.1 WQI Letter/Color Code: A (>75) Very Good (dark blue), B (50-74) Good (light blue), C (38-49) Fair (green), D (25-37) Marginal (yellow), E (13-24) Poor (brown), and F (0-12) Very Poor (red). WQI values in red are below 13-yr norms (expressed in italics) for the same reach or section of the river; values above 13-yr norms are in blue.

The range in running average WQI values determined over the past 13 years of monitoring are summarized in **Table 5.2**. WY17 values remain below the 13-yr norms for several reaches of the watershed (MG and LMV). The running averages, as well as variances in monthly index values, for each reach of the lower river system are presented in a series of charts (5.1 through 5.6) on pages 19 and 20.

Table 5.2 Summary of LSDR WQI Running Average (Trending) Values

	Chart	High / WY	Low / WY	13-yr Norm	WY16	WY17[a]
East Section (SB):	5.6	68 (B) WY09	6 (F) WY16	*28 (D)*	23 (E)	**29 (D Marginal)**
Upper Santee Basin	5.5	66 (B) WY09	1 (F) WY16	*18 (E)*	9 (F)	**18 (E Poor)**
Lower Santee Basin	5.4	73 (B+) WY09	9 (E) WY15	*38 (C-)*	37 (D+)	**39 (D+ Marginal)**
Mid-Section (MG)	5.3	95 (A+) WY05	4 (F) WY14	*47 (C+)*	40 (C)	**41 (C Fair)**
West Section (MV):	5.6	82 (A) WY05	5 (F) WY16	*33 (D)*	29 (D)	**33 (D Marginal)**
Upper Mission Vly	5.2	84 (A) WY05	4 (F) WY16	*31 (D)*	22 (E)	**32 (D Marginal)**
Lower Mission Vly	5.1	81 (A-) WY05	4 (F) WY13	*35 (D+)*	35(D)	**33 (D Marginal)**
LSDR Overall Avg.	*5.6*	*78 (A) WY05*	*8 (F) WY14*	*34 (D)*	*29 (D)*	***33 (D Marginal)***
Best Site (#8)	5.3	92 (A+) WY05	2 (F-) WY14	*49 (C+)*	42 (C)	**40 (C Fair)**
Greatest Range (#4)	5.1	100 (A+) WY10	1 (F-) WY05	*41 (C)*	38 (C-)	**37 (D+ Marginal)**
Poorest Site (#13)	5.5	77 (A-) WY09	1 (F-) WY16	*18 (E)*	7 (F)	**18 (E Poor)**

a) WY17 and WY16 running averages (September) shown in red are below 13-yr norms; above in blue.
b) Highest overall WQI values are associated with Site #8 (Jackson Dr/Suycott Xing) located in the Mission Gorge (mid) Section.
c) Lowest overall WQI values are associated with Site #13 (Mast Park) in the Upper Santee Basin reach.
d) The greatest range in WQI values (0 to 100) is associated with Site #4 (FSDRIP at Mission Center Rd.)

Over the past decade, as shown on **Chart 5.1**, average monthly WQI values associated with the **Lower Mission Valley Reach** (Sites 1-4) of the lower river system have varied from a high of 81 (A, Very Good) in March of this year to a low of 4 (F, Very Poor) in September 2014. The general trend in running average WQI for the reach, as well as for four individual monitoring sites, declined from the low 40's (C, Fair) during WY's '05 and '06 to the mid-teens (E, Poor) by early WY15. The running average WQI (*black line*) has improved to the mid-30's during the second half (April-Sept) of WY16 and most of this year. Site 3 (Fashion Valley Mall, *blue line*) has consistently exhibited the lowest running average WQI, while Site 4 (FSDRIP at Mission Valley Rd., *red line*) has consistently witnessed the highest values for the reach. The most significant decline in the WQI for the reach over the 13-year monitoring period occurred in WY14. There has been a steady, general improvement from the WY14 lows during the second half of WY15 and throughout WY16 and WY17. Further recovery from an overall Marginal (D) to Fair (C) grade, as experienced between WY07 and WY13, is not anticipated without improved water quality management actions for dissolved oxygen enhancement such as mechanical re-aeration during extended periods of very low (< 2 cfs) stream flow.

As shown in **Chart 5.2** , the range in monthly WQI values for the **Upper Mission Valley Reach** (Sites 5-7) of the river are similar to those in Lower Mission Valley, although not as variable. Site 6 (Kaiser Ponds at Mission Valley Rd, *green line*) has continuously presented lowest running average WQI values since WY07, while Site 7 (Admiral Baker Field at Zion, *blue line*), situated just upstream of the ponds, has presented the highest values on an extended basis since WY09. The highest monthly WQI reading for the Upper Mission Valley reach of 84 (A, Very Good) was monitored in March of this year, whereas the lowest reading of 3 (F, Very Poor) was experienced in October 2016. The overall trend in running average WQI values (*black line*) over the past three years (since WY14) has been marginally positive, especially during the second half of WY16. The overall trend since WY06, however, has been one of general decline as growth of invasive aquatic plants has proliferated during extended periods of very low flow (drought cycle).

Running average WQI for the **Mission Gorge Reach** (Sites 8-10) of the river, as shown in **Chart 5.3**, has also declined, especially during WYs12-14. Highest monthly WQI values of 89 (A, Very Good) monitored in Nov. 2004, and Feb. 2005, contrast with a low of 4 (F, Very Poor) in Aug. 2014. In general running average WQI for this reach is the best of the five reaches with average WQI of 48 (C+, Fair). The trend in Mission Gorge WQI values (*black line*) are, however, comparable to those in the Mission Valley reaches. General decline in index values from WY06 through WY09, followed by a slight upturn in WY10 and WY11, and a more significant decline in subsequent water years to a low of 32 (D, Marginal) in early WY15. WY17 witnessed an overall nine-point recovery in the running average WQI reaching 41 (D+, Marginal) in September. Running averages from both WY16 and WY17 represent a return to 15% values below the long-range norm of 47 (C, Fair) for this section of the river. Further increase in the Mission Gorge index is anticipated in WY18, unless rainfall is well below normal.

The **Lower Santee Basin Reach** (Sites 11,15T&12T) monthly WQI values and running averages are shown in **Chart 5.4**. The range from winter month highs in the 50-70 range (B, Good) to summer lows in the 13-24 range (E, Poor) are common. Water quality improved in this reach from WY06 through WY11, then declined in subsequent water years, reaching a running average low of 27 (D-, Marginal) in Oct. 2015, before recovering to the mid-40s (C, Fair) throughout WY16 and low 40's in WY17. Completion of the Forester Creek enhancement project (indicated by the *blue line*) extending from Prospect Ave. to the Mission Gorge Rd. has had a very positive effect on overall river quality (*black line*) in the Lower Santee Basin portion of the river system. Unless well below normal rainfall is experienced in WY18, the Lower Santee Basin running average index is expected to remain in the low to mid-40s.

Chart 5.1 - Lower Mission Valley Reach (Sites 1-4) Monthly & Running Average WQI

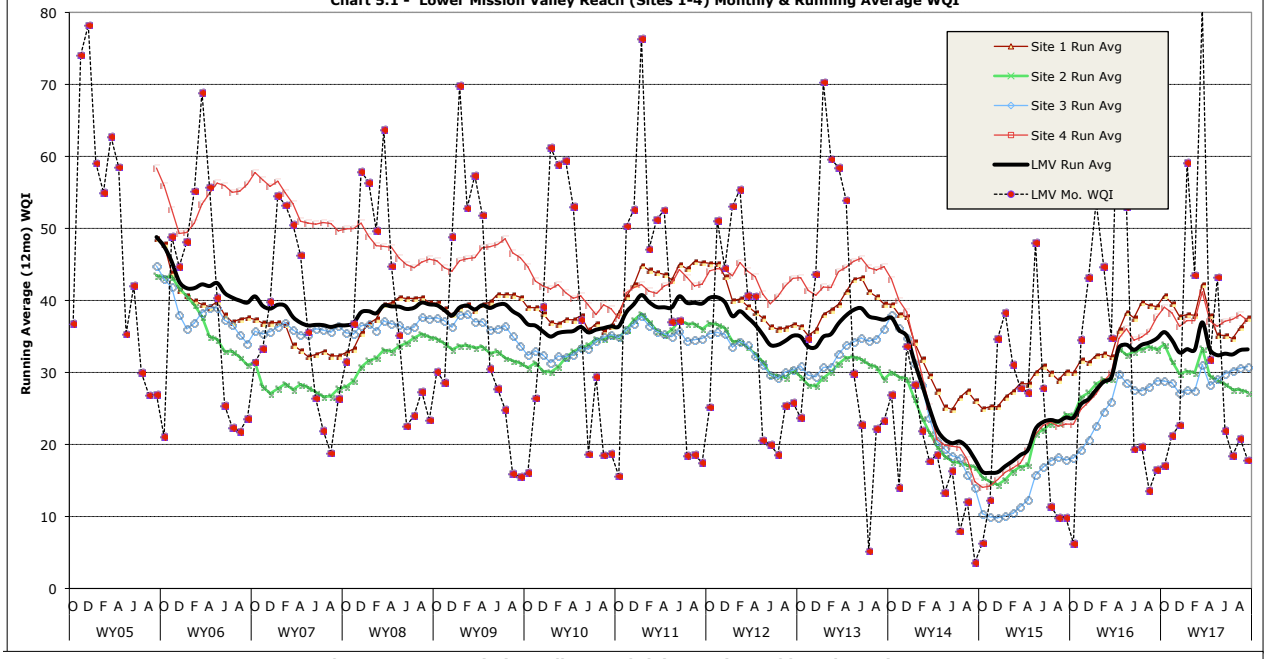


Chart 5.2 - Upper Mission Valley Reach (Sites 5-7) Monthly and Running Average WQI

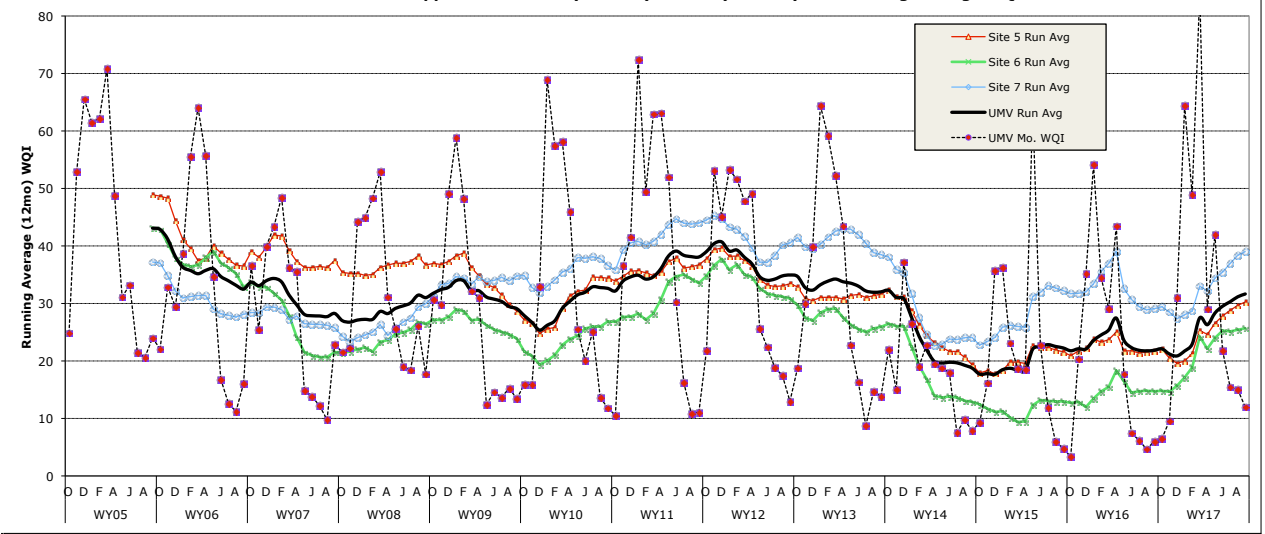
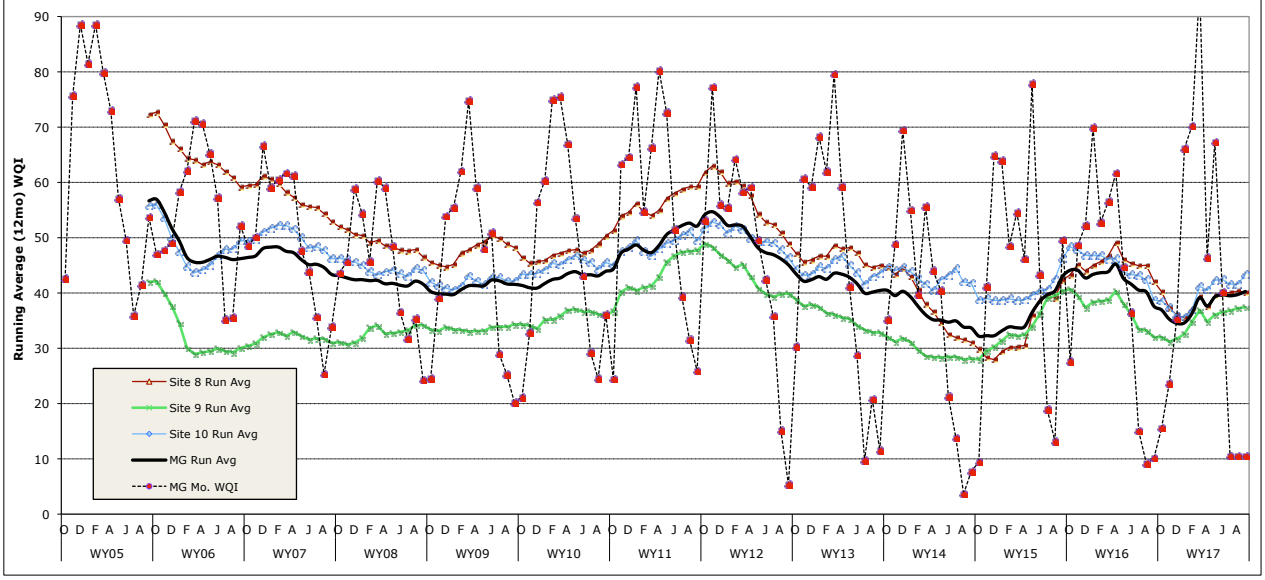


Chart 5.3 - Mission Gorge Reach (Sites 8-10) Monthly and Running Average WQI



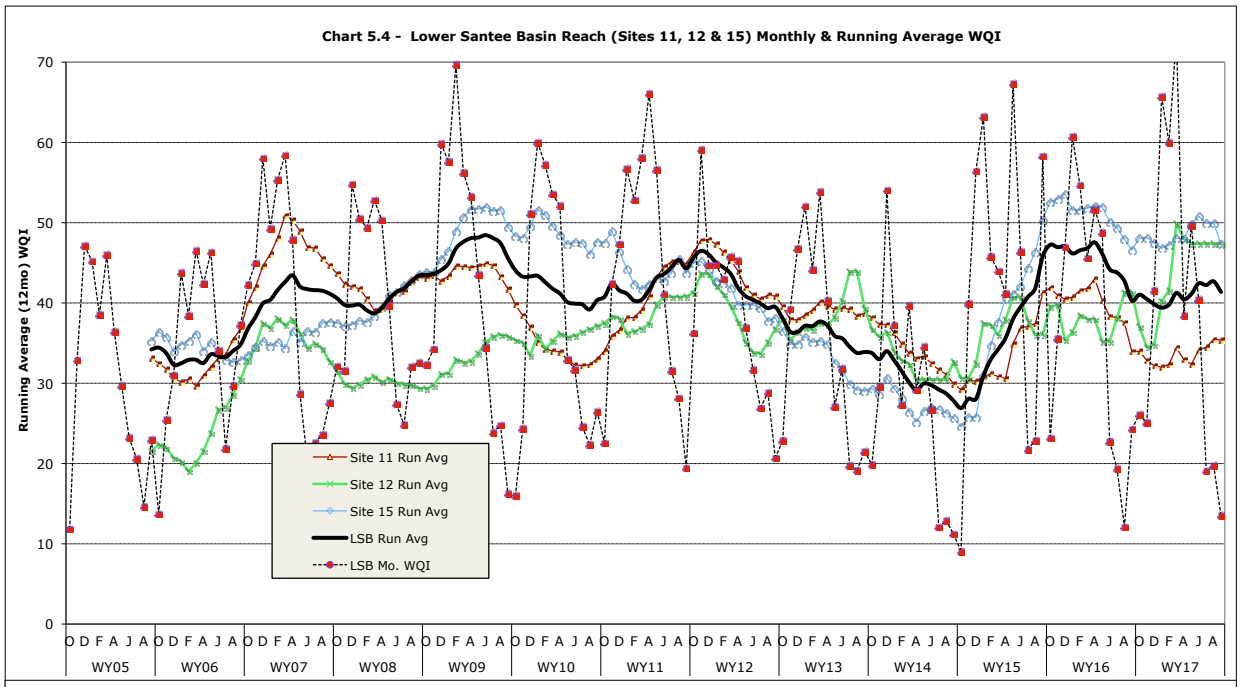


Chart 5.4 - Lower Santee Basin Reach (Sites 11, 12 & 15) Monthly & Running Average WQI
Running Average (12mo) WQI
Site 11 Run Avg
Site 12 Run Avg
Site 15 Run Avg
LSB Run Avg
LSB Mo. WQI
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16 WY17

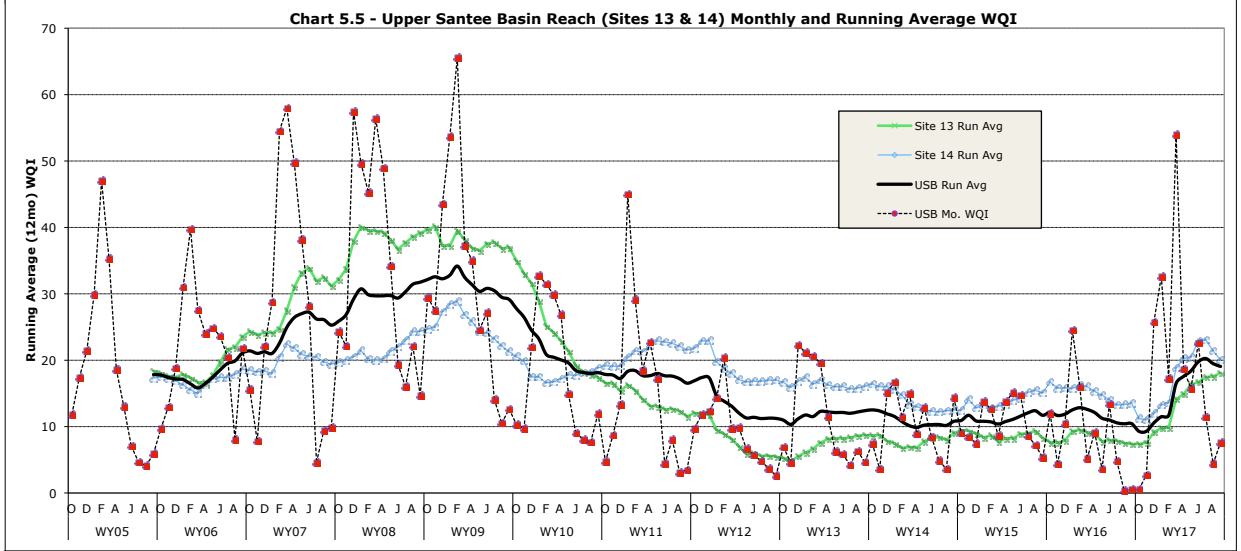


Chart 5.5 - Upper Santee Basin Reach (Sites 13 & 14) Monthly and Running Average WQI
Running Average (12mo) WQI
Site 13 Run Avg
Site 14 Run Avg
USB Run Avg
USB Mo. WQI
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16 WY17

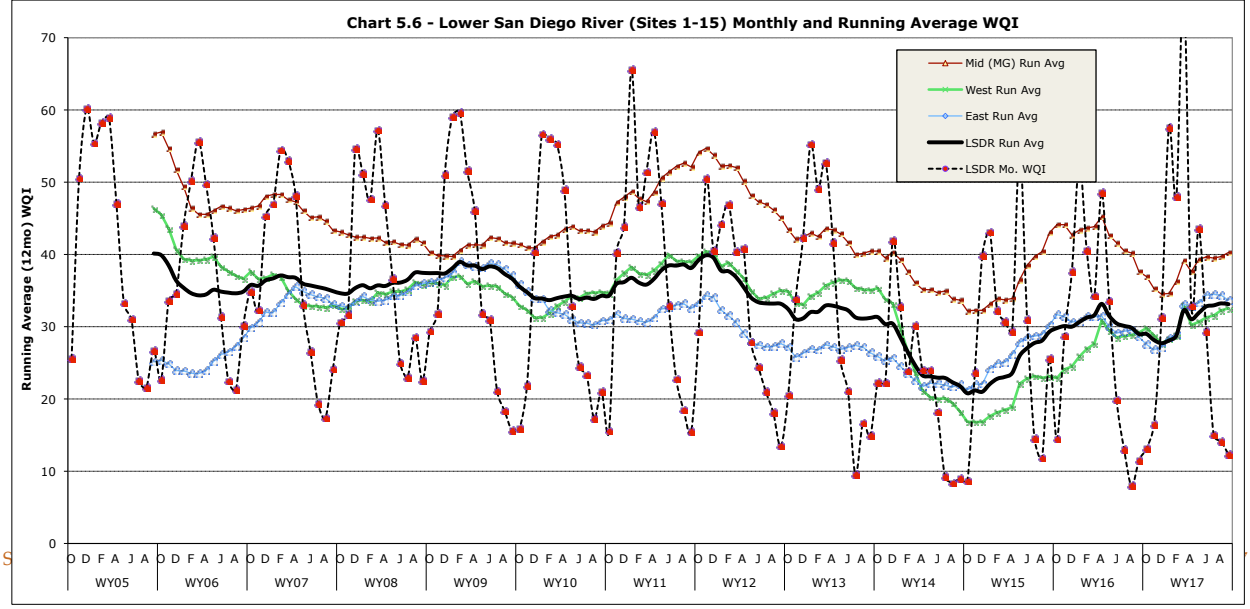


Chart 5.6 - Lower San Diego River (Sites 1-15) Monthly and Running Average WQI
Running Average (12mo) WQI
Mid (MG) Run Avg
West Run Avg
East Run Avg
LSDR Run Avg
LSDR Mo. WQI
O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16 WY17

Chart 5.5 presents monthly and running average WQI values for the **Upper Santee Basin Reach** (Sites 13 & 14) of the river system. This reach represents the lowest water quality values of all sections of the lower watershed. Monthly values have seldom exceeded 20 (E, Poor) since the summer of 2011 and are typically less than 12 (F+, Very Poor) throughout most months. The running average WQI for this reach has declined from highs above 30 (D, Marginal) in WY09 to continuously between 10 and 12 (F, Very Poor) during the five years (WY12-WY16). WY17 saw a noticeable increase (10 points) in the running average index from early in the year reaching 18 (E -Poor) in September. The greatest improvement has been at site #13, Mast Park (*green line).*

The monthly and running average variation in WQI values for the three main sections of the lower river (i.e., Santee Basin, Mission Gorge and Mission Valley) and the overall **Lower San Diego River** system (composite of all 15 monitoring sites) are presented in **Chart 5.6.** WQI running averages recovered from WY14 lows for all three sections of the river during WY15 and the first half of WY16. The Mission Gorge section (Chart 5.3) improved in water quality the most, while the downstream section (Mission Valley) responded more slowly. WY17 saw some improvement in all three sections of the river and thus overall. The current LSDR running average WQI of 33.1 (D, Marginal) is a full grade level above the low of 21 (E, Poor) computed as a low early in WY05 and now less than a point below the 13-yr norm. The highest running average WQI for the river of 41 (C, Fair) occurred during the last month (Sept.) of WY04 and first month (Oct.) of WY05. The lowest overall LSDR running average of 21 (E, Poor) was experienced during the first three months (Oct.-Dec.) of WY05. The overall trend in running average WQI for the LSDR that remained fairly steady in the range of 35 to 40 between WY06 and WY12, then declined to the low 20's in WY14 and early WY15, returning to the upper 20s in WY16 and into the low 30's in WY17.

The overall increase in running averages is a primarily a function of slightly elevated oxygen levels at multiple sites which are caused by improved streamflow gauged throughout the year. WQI values are expected to further improve should streamflow remain above normal and invasive aquatic growth abatement measures are effective or occur by natural flushing for specific reaches of the river. Higher minimum values during the summer months are quite likely to result in continued positive gradients for trend-lines (12-mo. running averages) over time. The current running average WQI for the Upper Santee Basin reach of 18 (E, Poor) is the same as the 13-yr norm, whereas the current running average for the best section (Mission Gorge) of 41 (C, Fair) is now only six points below the 13-yr WQI norm of 47 (C+, Fair).

Depressed dissolved oxygen levels (often less than 3 mg/L) in conjunction with minimal streamflow are the primary causes of low water quality index values. The low DO concentrations are believed to be the result of extensive and persistent eutrophication from bio-mass buildup of organic-rich detritus combined with restricted water movement. Until the spread of creeping water primrose (L*udwigia hextapetala)** can be effectively managed and the resultant effects of eutrophication controlled, water quality in multiple reaches of the lower river system is expected to remain below par compared to portions of the river where improved circulation, mixing and natural re-oxygenation occurs.

** Ludwigia hexapetala, L. peploides, L. grandiflora is a productive emergent aquatic perennial native to South and Central America, parts of the USA and likely Australia (USDA-ARS, 1997). It was introduced in France in 1830 and has become one of the most damaging invasive plants in that country (Dandelot et al., 2008). It has been more recently introduced to areas beyond its native range in the Unites States where it is often considered a noxious weed (INVADERS, 2009; Peconic Estuary Program, 2009).* ***L. hextapetala is adaptable and tolerates a wide variety of habitats where it can transform ecosystems both physically and chemically****. It sometimes grows in nearly impenetrable mats; can displace native flora and interfere with flood control and drainage systems, clog waterways and impact navigation and recreation. The plant also has allelopathic properties that can lead to dissolved oxygen crashes, the accumulation of sulphide and phosphate, 'dystrophic crises' and intoxicated ecosystems (Dandelot et al., 2005).*

Appendix A - Glossary

Abbreviations:

AADF - Average Annual Daily Flow
ACC - Average Coliform Count (arithmetic mean of fecal coliform, e-Coli & total coliform in MPN/100mL)
ADF – Average Daily (stream) Flow or discharge
AFY - acre-foot per year
Avg– Average
cfs - cubic feet per second (flow/discharge)
Ck – Creek
CY - Calendar Year (Jan 1 - Dec 31)
DO – Dissolved Oxygen
DOD- Dissolved Oxygen Deficit (level below minimum)
DO%Sat – Dissolved Oxygen expressed as percentage of DO level at saturation point
d/s – downstream // {u/s – upstream}
E – East // {W –West}
FSDRIP – First San Diego River Improvement Project
ft. – feet // {mi. - mile}
gal – gallon
Ln(x) - natural logarithm of (x) to base-e (2.718)
log(x) - common logarithm of (x) to base-10
L//U – lower//upper (as in river reaches)
LSDR – Lower San Diego River
max//min – maximum//minimum
MCC - Mean Coliform Count (geometric mean of fecal coliform, e-Coli & total coliform in MPN/100mL)
mg/L – milligrams per litre
mi. - mile
mS/cm – milliSeimens per centimetre (1 mS/cm = 1000 *u*S/cm)
MG – Mission Gorge (mid-section of LSDR)
MV – Mission Valley (West section of LSDR)
MPN - Most Probable Number (of coliform organisms)
SB – Santee Basin (East section of LSDR)
PDMWD – Padre Dam Municipal Water District
pH – measure of acidity or basicity (decimal logarithm of hydrogen ion activity)
ppm – parts per million
Q - stream flow or discharge
SB – Santee Basin
SpC – Specific Conductivity (also Conductivity or Conductance; sometimes abbreviated SC)
SD – Standard Deviation (also San Diego)
SDRPF – San Diego River Park Foundation
TDS – Total Dissolved Solids
Temp. – Temperature
TN/TP – Total Nitrogen/ Total Phosphorus (nutrients)
USGS – U.S. Geological Survey
*u*S/cm –microSeimens per centimetre (1 *u*S/cm = 0.001 mS/cm)
u/s - upstream // {d/s - downstream}
W - West // {E - East}
WQI – Water Quality Index (WQI_a)
WQI(4) - WQI using 4 parameters
WQI(6) - WQI using 6 parameters
WY – Water Year (Oct 1 – Sept 31)
% - percent
%Sat - percent of DO saturation value
^oC – degrees Celsius
^oF – degrees Fahrenheit

Formulas:

$^oC = (^oF-32) \times 5/9$
$^oF = (^oC*9/5) + 32$

Flow (cfs) = Velocity (ft/sec)*Cross-sectional area (sq ft)

Constituent Load (lbs/day) = Q (mgd)*Concentration (ppm)*8.34; or Q (cfs)*Concentration (mg/L)*5.39 where Q is streamflow/discharge.

Total Dissolved Solids (TDS in mg/L) = 670*Specific Conductivity, (where SpC is in mS/cm). An approximate relationship for Lower SDR watershed; other variables (e.g., temperature, pressure, specific ions) are considered negligible.

DO - DO%Sat relationship is defined by the following polynomial equation:
$DO(mg/L)=DO\%Sat*[0.004*T^2-0.343*T+14.2]/100$;
$DO\%Sat = DO(mg/L)*100/[0.004* T^2-0.343T+14.2]$,
where T = temperature is in ^oC.
Other variables, incl. barometric pressure, elevation and conductivity (SpC), have negligible impact on the DO-DO%Sat relationship within the LSDR watershed.

SDR Water Quality Index (WQI) is calculated using the following set of equations:

WQI_4 = DO%Sat*2.5*T factor*Q factor/log(SpC); where SpC is expressed in *u*S/cm;
the T factor = $0.0055T^3-0.163T^2+1.37T-2.5$, and the Q factor =
$0.56+0.173LnQ-0.002LnQ^2-0.0033LnQ^3$ (M Valley);
$0.72+0.15LnQ-0.0051LnQ^2-0.004LnQ^3$ (M Gorge);
$0.87+0.107LnQ-0.018LnQ^2-0.003LnQ^3$ (Santee);
$0.1+0.05LnQ-0.042LnQ^2-0.0011LnQ^3$ (Tributaries)

WQI_6 = Avg.[$DO\%f*wt_{(DO)}$, $SpCf*wt_{(SC)}$, $pHf*wt_{(pH)}$, $MCCf*wt_{(MCC)}$, $Qf*wt_{(Q)}$, $Tempf*wt_{(T)}$]^1.75
where $wt_{(DO)} = 3$, $wt_{(SC)} = 2$, $wt_{(pH)} = 1$, $wt_{(MCC)} = 1$, $wt_{(Q)} = 2$ and $wt_{(T)} = 1$

The SDR WQI is developed specifically for the SDRPF RiverWatch Monitoring Program, however, the equations have also be applied to water quality and hydrologic data for other coastal area watercourses where comparable metrics are monitored and recorded.

Water Equivalents:

1 cf = 7.48 gal = 62.4 lbs of water
1 AF = 43,560 cf = 325,900 gal
1 psi = 2.31 ft of water (head)
1 mg/L = 1 ppm (in water)
1 cfs = 450 gpm = 0.646 mgd =1.98 AF/day = 724 AFY
1 mgd = 694 gpm =1.547 cfs = 3.06 AF/day = 1,120 AFY
1,000 gpm = 1.436 mgd = 2.23 cfs = 4.42 AF/day = 1,614 AFY
1 inch (rainfall) = 25.4 mm

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Appendix C - SDRPF RiverWatch WQM Team

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Ang Nguyen
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Birgit Knorr
Bob Stafford**
Brent Redd
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Chandler Hood
Chris Peter
Clint Williams
Conrad Brennen**
Craig McCartney
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Krystal Tronboll
Laqueta Strawn
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Lindsey Dornes
Lindsey Teunis
Lindy Harshberger
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Marcus King
Mark Carpenter
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Tom Younghusband**
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