S A N   D I E G O   R I V E R   P A R K   F O U N D A T I O N

LOWER SAN DIEGO RIVER
WATER QUALITY 2005 - 2018

WY18 Annual Water Quality Monitoring Report

Water Primrose (various mat development stages) viewing upstream at YMCA/River Gardens (WQM Site 3)

Water Quality Monitoring Results (October 2004 - September 2018)

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October 2018

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Lower San Diego River Water Quality 2005 - 2018

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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 14 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 2018 (WY18) data in comparison to previous year results and 14-yr averages (norms). The LSDR watershed and water quality monitoring site locations are shown on **Figure 1-1**.

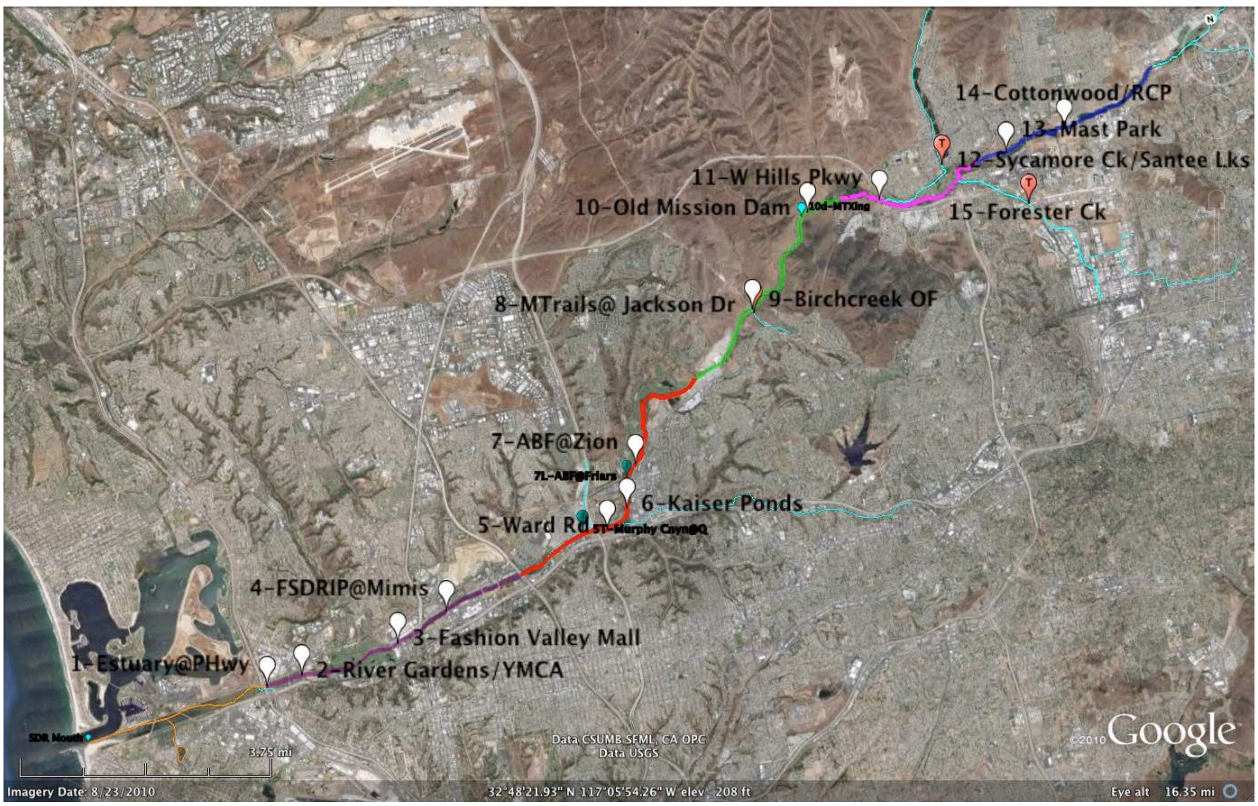


Figure 1-1 LSDR Watershed and Water Quality Monitoring Sites

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 Rd 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 entire 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 some acceptable 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's 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 those 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 credability, be applied to estuaries and ocean waters.

Index values have been computed using two 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 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 for the LSDR) are excluded. The broader range WQI_4 values are expressed in this report.

The index, although specifically developed for the San Diego River, can also be applied to other Southern California coastal area watercourses where comparable water quality metrics (i.e., DO, SpC, Water Temp and streamflow) 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 WY18 Water Quality Data and 14-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 in the computations. The annual average water quality values for each of the 15 monitoring sites for WY18 as well as the 14-yr norms (average values calculated over past 14 years of monitoring) are presented in **Table 2.1**. WY18 values greater than the 14-yr norms are shown in blue, whereas values for this past water year below norms are displayed in red.

Table 2.1 Average Annual WQ Metrics for WY18 and 14-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 Values [a], (Difference) & Grade	
1	LMV	West	20.6/*19.6*	3.9/3.4	8.0/7.7	5.6/*6.1*	63/66	**9**/*28*	29/**37** (-8)	**D**/*D+*
2			18.8/*19.0*	3.8/3.3	7.8/7.7	2.9/*4.4*	30/46		**19**/*30* (-11)	**E**/*D*
3			19.4/*19.2*	3.2/2.6	8.0/7.8	3.9/*4.6*	42/48		**23**/*31* (-8)	**E**/*D*
4			20.1/*19.7*	3.0/2.5	8.0/7.8	5.4/*6.1*	59/65		**31**/*40* (-9)	**D**/*C*
5	UMV		16.7/*17.2*	3.3/2.6	7.9/7.6	4.2/*4.8*	42/49	**9**/*26*	**25**/*32* (-7)	**D-**/*D*
6			18.2/*18.3*	3.2/2.6	7.8/7.6	2.1/*3.6*	21/36		14/***24*** (-10)	E-/*E+*
7			18.0/*18.0*	2.8/2.5	7.8/7.6	5.0/*5.0*	51/51		**29**/*33* (-4)	**D**/*D*
8	MG	Mid	17.8/*17.1*	3.2/2.3	7.8/7.7	5.0/*7.3*	50/74	**7**/*18*	30/*47* (-17)	**D**/C+
9 [b]			14.9/*15.8*	4.9/4.9	8.3/7.8	9.7/*9.1*	95/93		**29**/*35* (-6)	**D**/*D*
10			17.8/*17.7*	2.9/2.3	8.2/7.8	6.2/*7.1*	65/74	**6**/*16*	**37**/*44* (-7)	**D+**/*C*
11	LSB	East	16.6/*16.7*	2.6/2.2	7.7/7.6	5.8/*6.1*	59/60		**32**/*37* (-5)	**D**/*D+*
12 [b]			17.5/*17.8*	1.7/1.7	8.4/7.9	6.2/*7.0*	65/71		**32**/*35* (-3)	**D**/*D*
15 [b]			17.9/*18.1*	2.7/2.7	8.1/8.1	4.1/*7.6*	43/72	**4**/*10*	**21**/39 (-18)	**E**/*C*
13	USB		18.5/*18.5*	2.2/1.9	7.9/7.7	1.5/*3.1*	16/32	**3**/*5*	**7**/*17* (-10)	**F**/*E*
14			19.4/*17.4*	1.6/1.5	8.0/7.8	3.3/*3.3*	35/32		**17**/*18* (-1)	**E**/*E*
(1-15)	**LSDR Avg.**		**18.7/*18.0***	**2.8/*2.3***	**8.0/*7.7***	**4.3/*5.3***	**44/*54***	**7/*19***	**25/*35* (-10)**	**D-/*D***
c	**LSDR (Qwt)**		**18.7/18.1**	**2.8/*2.3***	**8.0/*7.7***	**4.0/4.9**	**41/51**	**8/20**	**22/*31* (-9)**	**E/D**

a) Average annual water quality index values, change (+/-) and resultant WQ letter grade for WY18 (bold) and the 14-yr norms (italics); values below norms for each metric are expressed in red; values above norms in blue.
b) Lower San Diego River water quality monitoring sites located on tributary (T) streams.
c) Average flow-weighted LSDR WQ Index values based on USGS streamflow data presented in Appendic H.

All 15 monitoring sites present WY18 average annual WQI values below the 14-yr norms. The greatest decline (-17 points) is associated with Mission Trails Crossing at Jackson Dr. (Site #8) whereas the least change (-1 point) is Site #14 situated furthest upstream east of Magnolia Bridge. Average annual water temperatures in WY18 are greater than the 14-yr norms at about half the sites while up 0.7 degree overall from the LSDR 14-yr annual average of 18.0 C. Specific Conductivity values in WY18 are well above the 14-yr norms at all sites within the lower watershed. Overall SpC (average all sites) is 12% above the 14-yr average annual norm of 2.3 mS/cm. DO values are lower than norms at all but two sites where they are the same and one small tributary site (#9) where elevated levels were monitored. Overall this year's DO values are roughly 20% below the 14-yr LSDR average annual norm of 4.9 mg/L. DO values for WY18 are also down from last year by approximately 0.8 mg/L although above the poorest year (WY14) by 0.4 mg/L. The highest average annual DO levels on the river were monitored in WY05 at 6.60 mg/L (64% Sat.).

Average annual, seasonal and monthly min.-max. range water quality metrics for WY18 and the 14-yr norms are also presented by river reach and section in **Table 2.2.** All five reaches of the river present lower water quality values for the past year than the associated 14-yr norms. Average annual water temperatures and specific conductivities for all reaches and sections of the river were higher in WY18 than the norms. Dissolved oxygen levels and streamflows remained below the 14-yr norms for every river reach and section during WY18. The most significant declines in water quality metrics monitored throughout the lower river watershed occurred during the dry-weather months.

Table 2.2 Water Quality Metrics for WY18 and 14-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		24.8/*25.4*	4.0/*4.0*	8.2/*8.3*	6.0/*10.2*	60/*102*	42/*230*	**42**/*78* (36)	C/*A-*
Winter (D,J,F,M)		14.6/*13.6*	2.2/*1.7*	8.0/*7.8*	4.6/*6.1*	45/*55*	18/*47*	**38**/*47* (-9)	C-/*C+*
Avg. Annual		18.7/*18.0*	2.8/*2.3*	8.0/*7.7*	4.3/*5.3*	44/*54*	7/*19*	**24**/*33* (-9)	**E+**/*D*
Avg. (Flow Wtd)		**18.7**/18.1	**2.8**/2.3	**8.0**/7.7	**4.0**/4.9	**41**/51	**6**/22	**22**/*31* **(-9)**	**E+/D**
Summer (J,J,A,S)		23.1/*22.5*	3.2/*2.8*	7.9/*7.7*	2.8/*4.0*	32/*46*	0.5/*2.0*	**10**/*19* (-9)	**F**/E
Min. Month		11.1/*9.3*	1.4/*1.0*	7.5/*7.1*	2.2/*1.9*	29/*16*	0.8/*0.1*	**7**/*8* (-1)	**F**/F
LSDR Reach & Section Averages:									
USB	East	18.9/*17.2*	2.0/*1.8*	8.0/*7.7*	1.6/*3.2*	17/*33*	3/*5*	10/*17* (-7)	**F**/*E*
LSB		17.4/*17.5*	2.6/*2.3*	8.1/*7.8*	6.6/*6.7*	71/*74*	6/*16*	28/*36* (-8)	**D**/*D+*
MG	Mid	19.6/*17.3*	3.0/*2.3*	8.1/*7.8*	7.2/*7.6*	73/*79*	7/*18*	33/*46*(-13)	**D**/*C*
UMV	West	17.8/*17.9*	3.1/*2.6*	7.8/*7.6*	3.1/*4.5*	32/*46*	9/*26*	22/*30* (-8)	**E**/*D*
LMV		19.8/*19.4*	3.2/*2.6*	7.9/*7.7*	4.8/*5.1*	52/*54*	9/*28*	26/*34*(-8)	**D-**/*D*

a) Average annual water quality index value, difference (+/-) from 14-year norms and resultant WQI letter grade. Values/grades below 14-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 WY18 of 22 (E Poor) is nine points below the 14-yr average annual norm of 31 (D Marginal). This year's average annual index value is only two points above the lowest annual WQI of 20 (E Poor) experienced in WY14. The river's highest overall average annual index of 40 (Fair) occurred in WY05. Only two water year's (WY18 and WY05) have shown overall average index values in the Poor E (WQI 13-24) range.

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 WY18 (Oct.'17-Sept.'18) and the 14-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 (WY17) results and the red lines are 14-yr annual averages or norms for each site. Average annual water temperatures for WY18 remain greater than the 14-yr norms at most sites (excluding 9T), although slightly lower than last year's averages. Average downstream 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 WY18 are generally below those from last year (WY17) as well as the 14-yr norms. Average annual DO values at five sites (2,3,6,13&14) were below threshold levels of 4 mg/L; whereas last year only three sites (6,13&14) showed averages below a threshold of 4 mg/L. Monitored 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 6) whereas the highest values are observed in the Mission Gorge section (middle reach sites 8,9&10). Excluding the tributary sites, average annual conductivity (SpC) values generally increase from upstream to downstream sites with slight change from year-to-year. SpC averages for WY18 present some of the highest values recorded; overall they are up 22 percent from 14-yr norms and 30% above last year's results.

The WQI, an aggregate or composite index of water quality monitoring metrics for WY18, the 14-yr norms, the overall best (WY05) and worst (WY14) year results are presented in **Chart 2.2**. As shown by the solid black line (this year's results) in comparison to the colored bars (14-yr norms), the two sites furthest upstream, #13 (Mast Park) and #14 (Magnolia Ave), continue to experience Poor (E grade) water quality as does the Kaiser Ponds site (#6). On an average annual basis, highest WQI values continue to be associated with the three Mission Gorge (8, 9&10) sites. The overall WQI profile for WY18 (black line) is in general well below the 14-yr norms (colored bars) and last year's (WY17) results (dashed black line). This year's values at several sites (8,10,15T &13) are also below previous WY14 lows. Greatest departures (variance) from the 14-yr WQI norms for WY18 are found in the Mission Gorge and Santee Basin portions of the lower river watershed. Water quality conditions throughout Mission Valley (both Upper and Lower reaches) in WY18 are slightly improved from last year's (WY17) monitoring results. Forester Ck (#15T) monitoring results represent the greatest overall decline in water quality over a year ago, while the Mission Gorge sites represent the greatest declines from individual site norms. Another well below normal rainfall and runoff year in WY19 would predictably result in a continued decine in overall water quality within the lower San Diego River system. As has been evidenced in the past, above normal wet weather flow conditions tend to flush the lower river system resulting in improved overall water quality.

Chart 2.1 Spatial River Water Quality Data Profiles - Average Annual Site Values This Year (WY18), Last Yr (WY17) and 14-Yr Norms

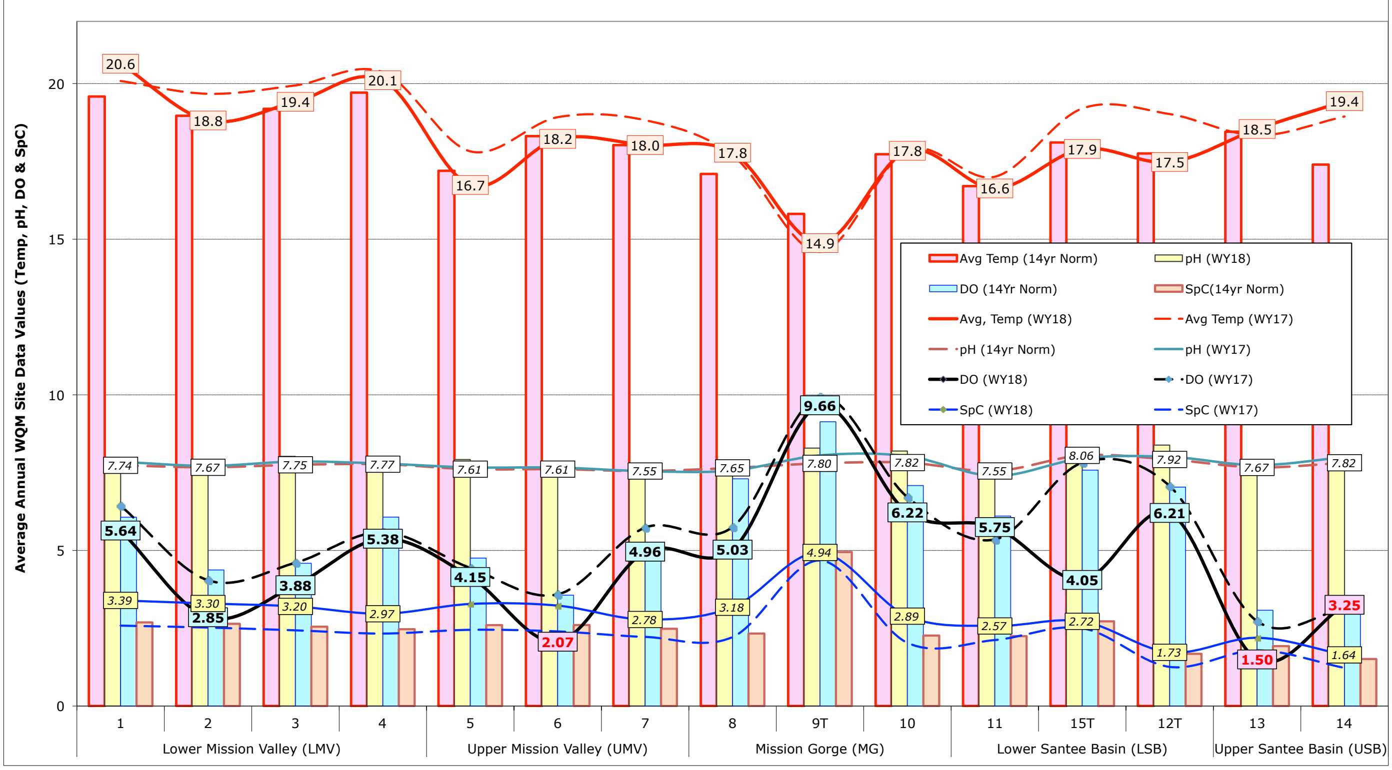
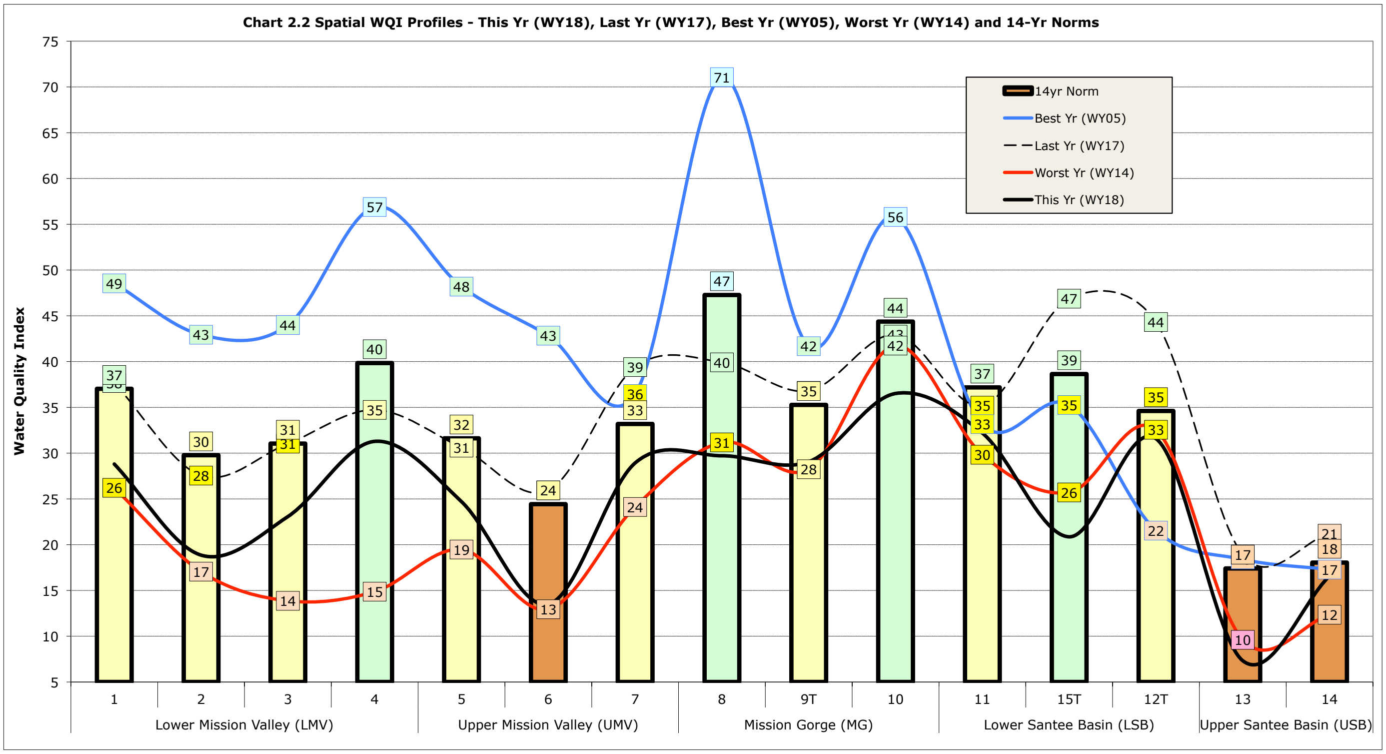


Chart 2.2 Spatial WQI Profiles - This Yr (WY18), Last Yr (WY17), Best Yr (WY05), Worst Yr (WY14) and 14-Yr Norms



Section 3 - Temporal Comparison of WY18 Data and 14-yr Norms

Monthly, seasonal and annual water quality monitoring metric data and WQI results for the Lower San Diego River are presented in **Table 3.1** for this year (WY18) in comparison to 14-yr norms shown italicized. WY18 values above the 14-yr norms are in blue; values below in red. With few exceptions temporal water quality WY18 values exceeded last year's (WY17) results for water temperatures, Specific Conductivity and pH, while DO, flow and WQI values were without exception lower this year than last. Overall water quality declined by an entire grade (10 points) throughout the year, irrespective of the season.

Table 3.1 LSDR WQM Metrics for WY18 and 14-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	19.6/*18.8*	3.19/*2.80*	7.7/*7.6*	**2.93**/*3.73*	**32**/*39*	**1.2**/*2.1*	**15**/*20*	**E-**/*E*
Nov		16.9/*15.0*	4.00/*2.63*	7.8/*7.8*	**3.84**/*4.94*	**39**/48	**1.4**/*8.6*	**20**/*29*	**E**/*D*
Dec	Winter	12.0/*11.9*	3.07/*1.80*	8.1/*7.7*	**5.41**/*6.20*	**49**/*57*	**1.6**/*24*	**27**/*40*	**D**/*C*
Jan		14.7/*11.7*	1.80/*1.75*	7.8/*7.7*	**5.39**/*7.61*	**52**/*69*	**42**/*57*	**38**/*48*	**C**/C+
Feb		15.6/*14.0*	2.39/*1.74*	8.1/*7.8*	**5.73**/*6.75*	**57**/*65*	**6.6**/*54*	**39**/*45*	**C**/*C*
Mar		16.5/*16.9*	1.36/*1.65*	8.1/*7.7*	**5.29**/*6.35*	**53**/*64*	**20**/**51**	**40**/*47*	**C**/*C*
Apr	Spring	18.0/*18.0*	2.16/*1.95*	8.3/*7.7*	**4.51**/*5.46*	**47**/58	**4.1**/*16*	**29**/*40*	**D**/*C*
May		19.1/*20.1*	2.76/*2.26*	8.1/*7.6*	**4.12**/*4.75*	**45**/52	**1.6**/*10*	**22**/*32*	**E**/*D*
June	Summer	22.1/*22.1*	2.99/*2.61*	7.7/*7.7*	**2.87**/*4.01*	**32**/*46*	**1.0**/*3.6*	**12**/*23*	**F+**/*D*
July		23.8/*23.1*	3.11/*2.74*	7.4/*7.6*	**2.45**/*3.18*	**29**/*37*	**0.5**/*2.0*	**9**/*16*	**F**/*E*
Aug		24.5/*23.3*	3.29/*2.94*	7.8/*7.7*	**2.57**/*3.13*	**31**/*36*	**0.2**/*1.2*	**7**/*15*	**F**/*E*
Sept		21.0/*21.5*	3.32/*2.94*	**8.7**/*7.7*	**2.23**/*3.17*	**25**/*36*	**0.1**/*1.3*	**8**/*16*	**F**/*E*
Fall (O&N)		18.3/*16.9*	3.60/*2.71*	7.7/*7.7*	**3.39**/*4.34*	**36**/*44*	**1.6**/*5.4*	**18**/*24*	**E**/*E+*
Winter (D,J,F,M)		14.7/*13.6*	2.16/*1.73*	8.1/*7.8*	**5.46**/*6.73*	**53**/*64*	**18**/*47*	**36**/*45*	**D+**/*C*
Spring (A&M)		18.5/*19.0*	2.46/*2.11*	8.2/*7.7*	**4.32**/*5.10*	**46**/*55*	**2.9**/*13*	**26**/*36*	D-/*D+*
Summer (J,J,A,S)		22.9/*22.5*	3.18/*2.81*	8.0/*7.7*	**2.53**/*3.37*	**29**/39	**0.9**/*2.0*	**9**/*17*	**F**/*E*
Annual (O-S)		**18.7**/*18.0*	**2.79**/*2.31*	**8.1**/*7.8*	**3.95**/*4.90*	**41**/*51*	**6.7**/*19.3*	**22**/*31*	**E**/*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). WY18 values/grades below the 14-yr norms (in italics) are shown in red; those equal to or above in blue.

Monthly and seasonal variances in water quality monitoring metrics for the past two water years and the 14-yr norms are 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) into early Fall. Coliform counts and pH values show much less seasonal fluctuation, although lesser variances from norms in monthly values are evident. The broad range in DO, SpC 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 (WY18), shown as solid lines, last year's results (dashed lines) and the 14-yr norms (bars) are comparable. In general, temporal variance in WY18 water quality data closely match patterns in 14-yr norms as well as last year's data. This year's temporal water quality metrics are considered indicative of both normalized monthly occurrences as well as those monitored during the previous year (WY17). The greatest distinction between last year's metrics and this year's can be observed as occuring during the wet-weather (winter) season. Streamflows, as shown on the next chart, has a major impact on variance in stemporal WQ metrics.

Chart 3.2 provides an overall graphic showing temporal variance in WQI values and streamflow throughout WY18 compared to monthly averages over the previous water year (WY17) as well as the 14-year monthly norms. As shown in **Chart 3.2**, the WQI values for WY18 (heavy red line) that are also listed in Table 3.1 (far left coulumn) are considerably lower than the 14-yr norms (colored bars) for all months of the year. 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 both Fall (O,N) and Summer (J,J,A,S) months. The normal and somewhat above wet weather flows from Dec. through May resulted in slight improvements over WY17 results. In general, water quality for the Lower San Diego River watershed was highest (C, Marginal) when flows were greatest during the four Winter months (D,J,F,M) and poorest (E Poor) in Summer when streamflow is lowest and water temperatures the highest. The overall annual average WQI for the LSDR in WY18 of 22 (E, Poor) is only two points above the lowest index recorded for WY14. Last year's slightly below average results during a wateryear of above normal rainfall and streamflow occurring throughout most reaches and in all sections of the river was considered to be closely associated with unflushed decayed biomass from non-native invasive aquatic plants. Although DO deficits were not quite as high this year as last they remained at multiple sites throughout the extended dry weather period.

Chart 3.1 Temporal Variance in WQM Data for WY18, WY17 and 14-yr Norms

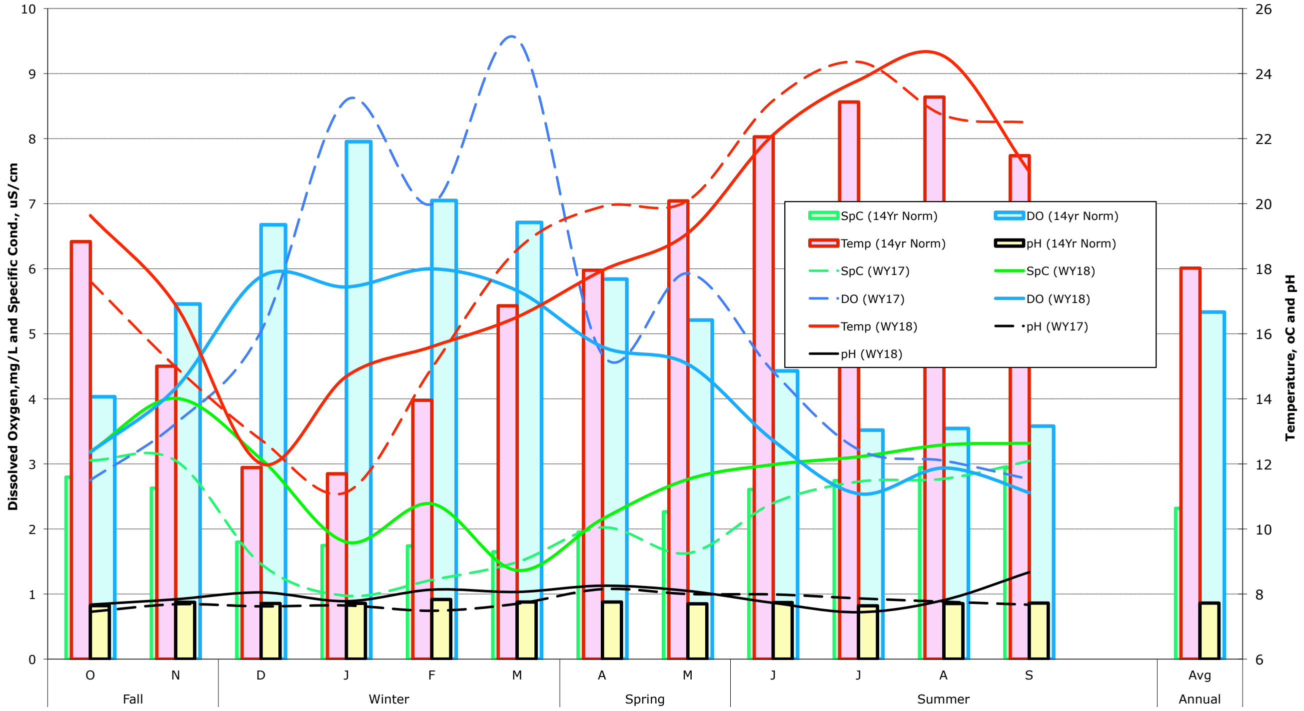
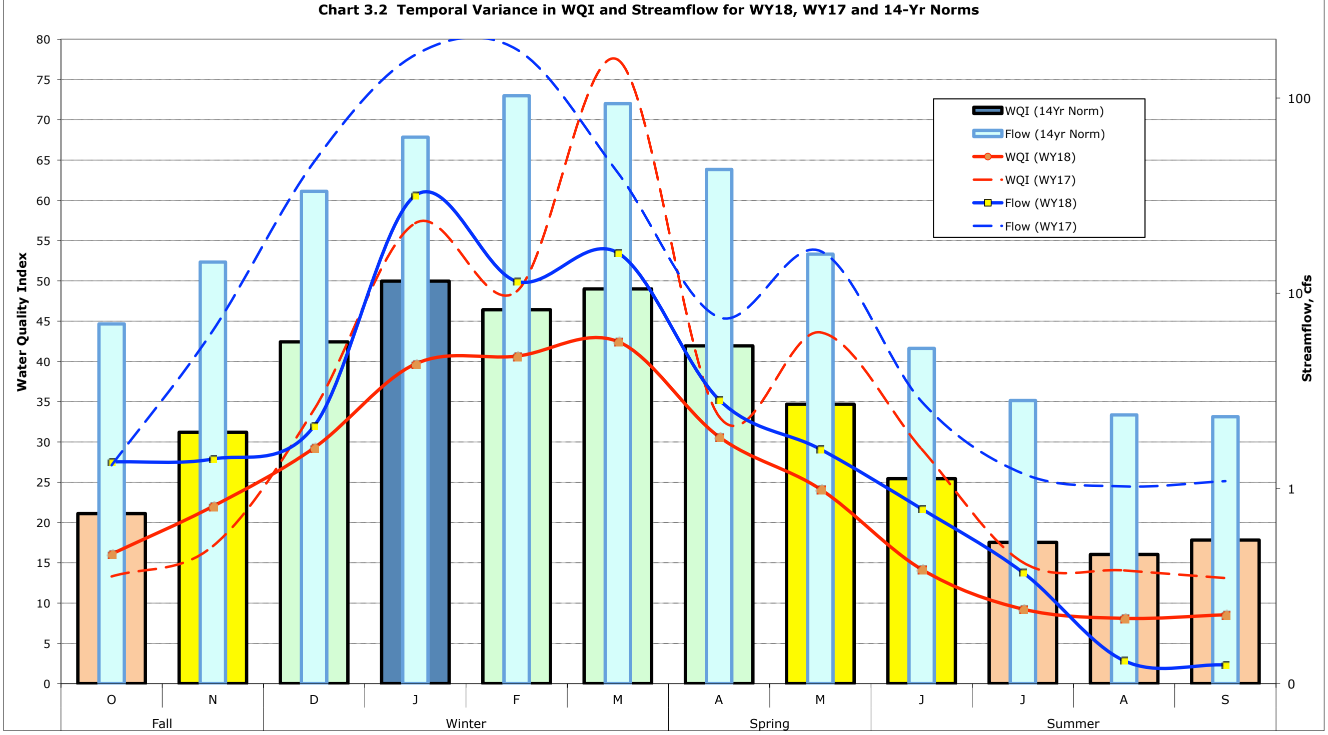


Chart 3.2 Temporal Variance in WQI and Streamflow for WY18, WY17 and 14-Yr Norms



Section 4 - Variance in Water Quality Metrics (WY05 through WY18)

Trends in SDRPF monitored water quality metrics, based on data collected by RiverWatch from September 2005 through September 2018, 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 together with overall straight-line averages represent a rational indication of trends considered over the past 14 years of monitoring for each metric.

Table 4.1 presents 12-month running average values for each of the key water quality metrics monitored over the last 14 years. Running averages above 14-yr norms are listed in blue; values below norms are in red. The 14-yr norms are expressed in italics. The percent change over the entire l4-year period, presented in bottom row of the table, expresses the straight-line average annual gradient (i.e., trendlines).

Table 4.1 - Running 12-mo. Average WQM Metrics (WY05-WY18)

	Temp	SpC	pH	DO	DO%	Flow	WQI (a)	
	oC	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*Values & Grade*	
WY05	17.68	2.064	7.63	6.61	62	55.7	41/40	C Fair
WY06	18.32	2.141	7.44	6.00	59	12.5	36/35	D+ Marginal
WY07	17.70	2.342	7.53	5.95	60	8.6	36/34	D+ Marginal
WY08	17.67	2.223	7.89	6.26	63	16.6	37/36	C- Fair
WY09	17.73	2.393	7.66	6.25	64	19.2	36/35	D+ Marginal
WY10	18.08	2.287	7.84	5.21	54	32.4	34/32	D Marginal
WY11	17.77	2.160	7.83	5.53	57	24.5	38/36	C- Fair
WY12	18.03	2.339	7.64	5.16	53	12.7	33/31	D Marginal
WY13	17.32	2.441	7.77	5.30	54	8.5	32/30	D Marginal
WY14	17.86	2.505	7.67	3.87	40	4.9	22/20	E Poor
WY15	18.69	2.189	7.77	4.53	48	9.4	29/25	D Marginal
WY16	18.19	2.269	7.71	4.69	49	14.1	28/25	D Marginal
WY17	18.56	2.154	7.77	5.05	53	41.7	33/31	D Marginal
WY18	**18.65**	**2.788**	**7.96**	**4.28**	**44**	**6.7**	**24/22**	**E Poor**
14yr Avg	*18.02*	*2.307*	*7.72*	*5.33*	*54*	*19.3*	*33/31*	*(D Marginal)*
Change, %	*+0.4*	*+2.5*	*+0.3*	*-2.5*	*-2.1*	*-6.3*	*-41/-45*	(-0.64 pts/yr)

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 14-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 remained fairly steady between WY05 and mid-WY11, declined by approximately one-half a degree celsius by WY14 have increased by approximately one full degree over the past four years. The typical variance in running average water temperature over the past decade is in the range of 3% above to 3% below norms, however, from Oct. 2013 to Oct. 2015 (24 months) variance in water temperature rose from 4.6% below to 5.2% above the 14-yr norm of 18^{o}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 entire Southern California region. There were only two months in WY17 (Dec. & Jan.) when average water temperatures fell below 13^{o}C while this year (WY18) there was just one (Dec.). Elevated water temperatures commonly result in greater rates of decay and lowered saturation levels of dissolved oxygen. As can be seen by both the three 12-mo running average colored lines (red-max, black-average, and blue-minimum) and the dashed lines (straight-lines) that trends in water temperature over the past 14 years increase. The average annual increase is on the order of 0.4 percent; an overall rise in average river temperature of approximately 0.7 ^{o}C per annum. Average water temperatures for the LSDR in WY18 reached 18.68 ^{o}C the highest value since RiverWatch monitoring was initiated in 2004. The coolest water temperature year since monitoring began was WY13 when the average annual value was computed at 17.42 ^{o}C.

Trends in monthly monitored **Specific Conductivity** (SpC) values for the LSDR are presented in **Chart 4.2**. Minimum and maximum running averages for all sites monitored have varied little over the 14-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 2.8 mS/cm (21*% above)* in WY18. Considerably less rainfall during the past year and resultant depressed (well below normal) dry-weather streamflows have caused SpC values to continue rising well above the 14-yr norm of 2.3 mS/cm. The current LSDR running average SpC of 2.78 mS/cm is 21% above the 14-yr norm. Running average values are expected to decline somewhat with greater anticipated monthly rainfall and average dry-weather streamflow forecasted for WY19. The overall rising trend in SpC for all sections of the lower river, however, is expected to continue. The current average annual overall LSDR rise in conductivity is 2.5% or 0.05 mS/cm per annum. The change in maxima at all sites has remained fairly steady of the last 14 years of monitoring, however, site minima values have increased due to less average daily flow and higher average daily temperatures.

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 consistant over the last 14 years (WY05-WY18). The initial five years of below average pH may have in part been due to a faulty probe as monthly minima and maxima values since WY10 have consistently been higher. Excluding the initial year's, there has been but a small variance (<3%) in the overall running average pH from the 14-yr norm of 7.70. The overall trend in pH for the lower river is, however, positive (similar to Temperature and Conductivity). Values have increased by an average of 0.3% per annum since RiverWatch monitoring was started, primarily as site minima values have risen. It is concluded that the river may be becoming slightly more alkiline (basic) as average flows have declined and water temperatures have increased. The most common cause of higher pH water is less available carbon dioxide caused by elevated rates of aerobic resperation that accompany warmer waters.

Running average **dissolved oxygen (DO)** values and monthly minima-maxima are presented in **Chart 4.4.** A general if unsteady decline in average and min./max. values for the lower watershed sites from Jan. 2009 through Feb. 2015 can be observed. LSDR average, minimum and maximum monthly values betweenearly 2015 and late last year (Dec. 2017) slowly increased although remaining below the 14-yr norms. The current running average DO value of 3.95 mg/L (Sept 2018) is 20% below the LSDR norm.

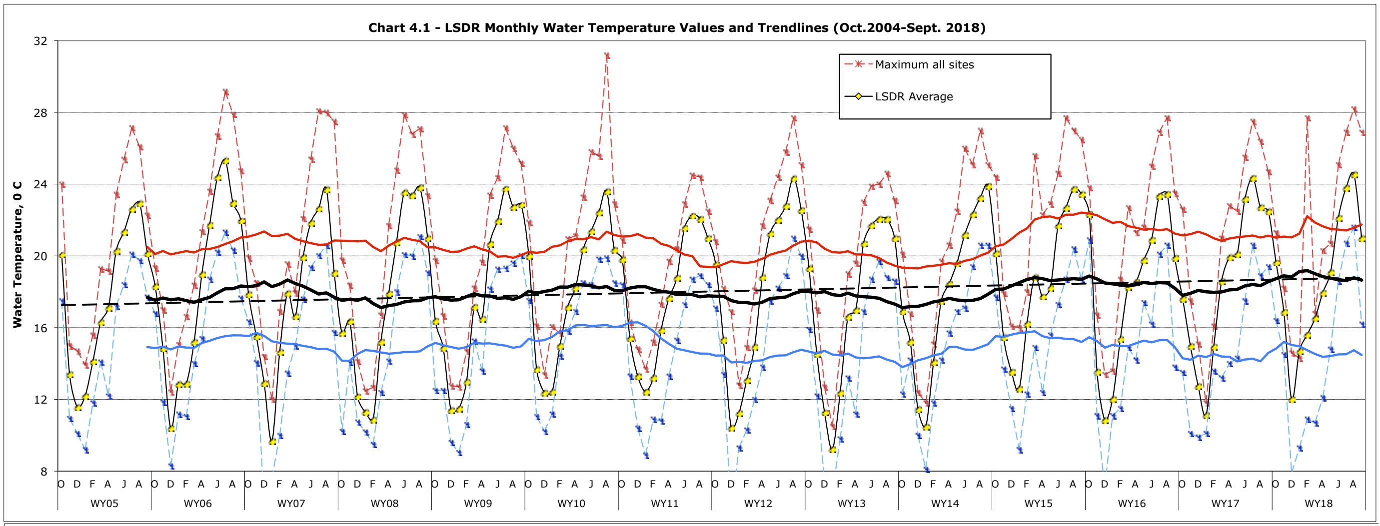


Chart 4.1 - LSDR Monthly Water Temperature Values and Trendlines (Oct.2004-Sept. 2018)
Maximum all sites
LSDR Average
Water Temperature, 0 C
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18

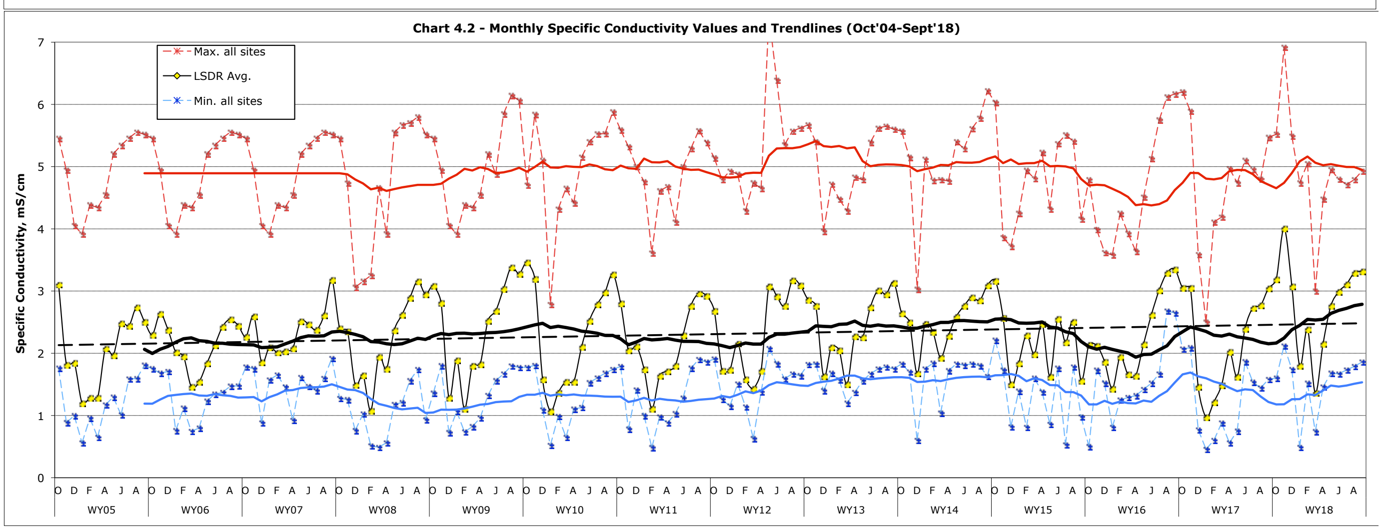


Chart 4.2 - Monthly Specific Conductivity Values and Trendlines (Oct'04-Sept'18)
Max. all sites
LSDR Avg.
Min. all sites
Specific Conductivity, mS/cm
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18

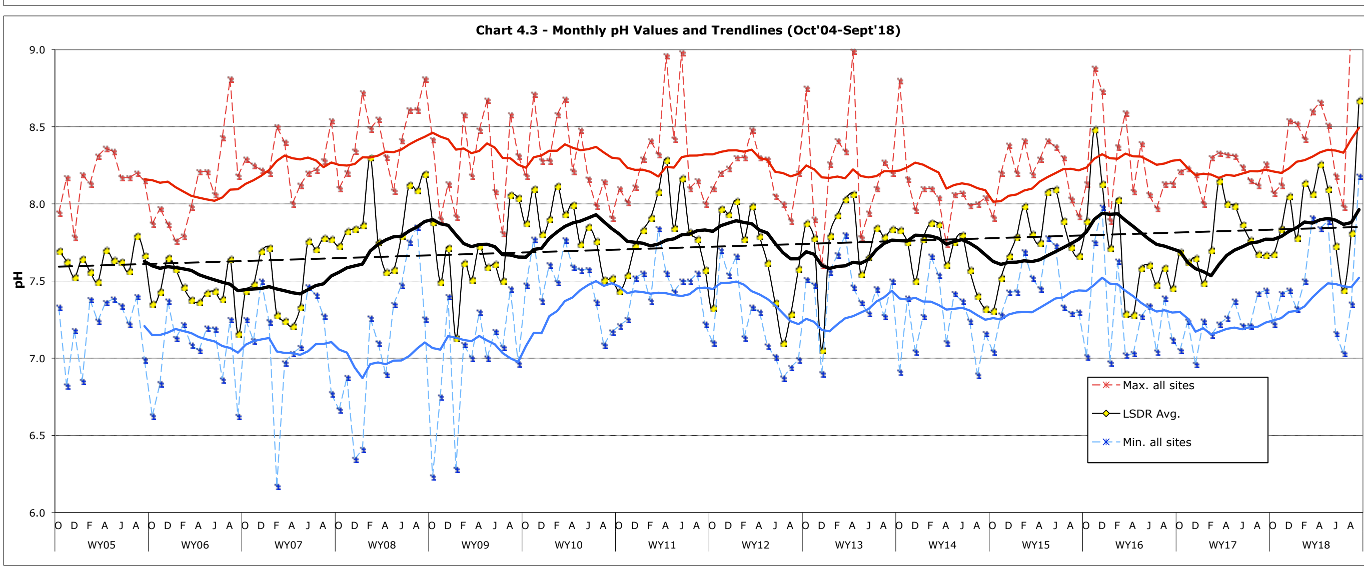


Chart 4.3 - Monthly pH Values and Trendlines (Oct'04-Sept'18)
pH
Max. all sites
LSDR Avg.
Min. all sites
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18

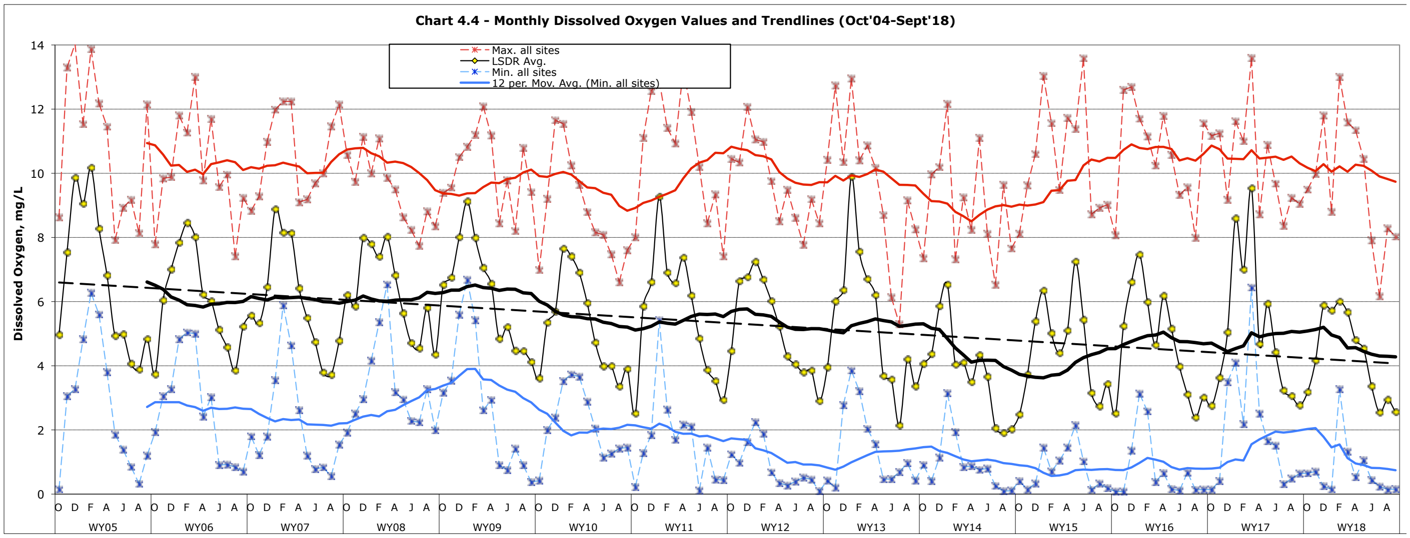


Chart 4.4 - Monthly Dissolved Oxygen Values and Trendlines (Oct'04-Sept'18)
Max. all sites
LSDR Avg.
Min. all sites
12 per. Mov. Avg. (Min. all sites)
Dissolved Oxygen, mg/L
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18

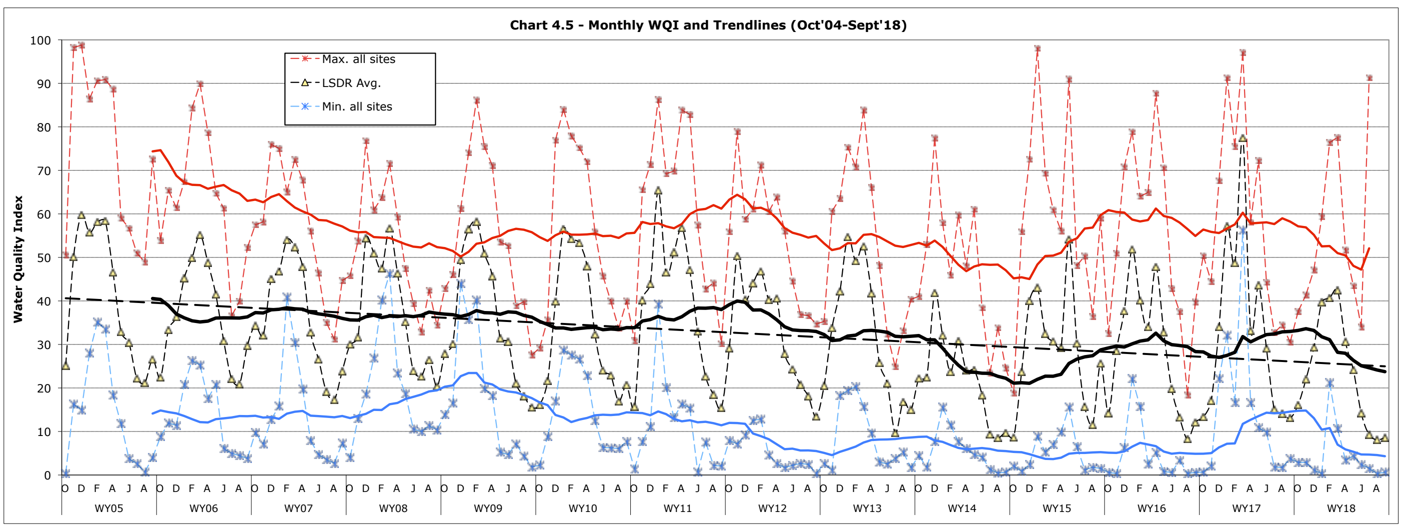


Chart 4.5 - Monthly WQI and Trendlines (Oct'04-Sept'18)
Max. all sites
LSDR Avg.
Min. all sites
Water Quality Index
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18

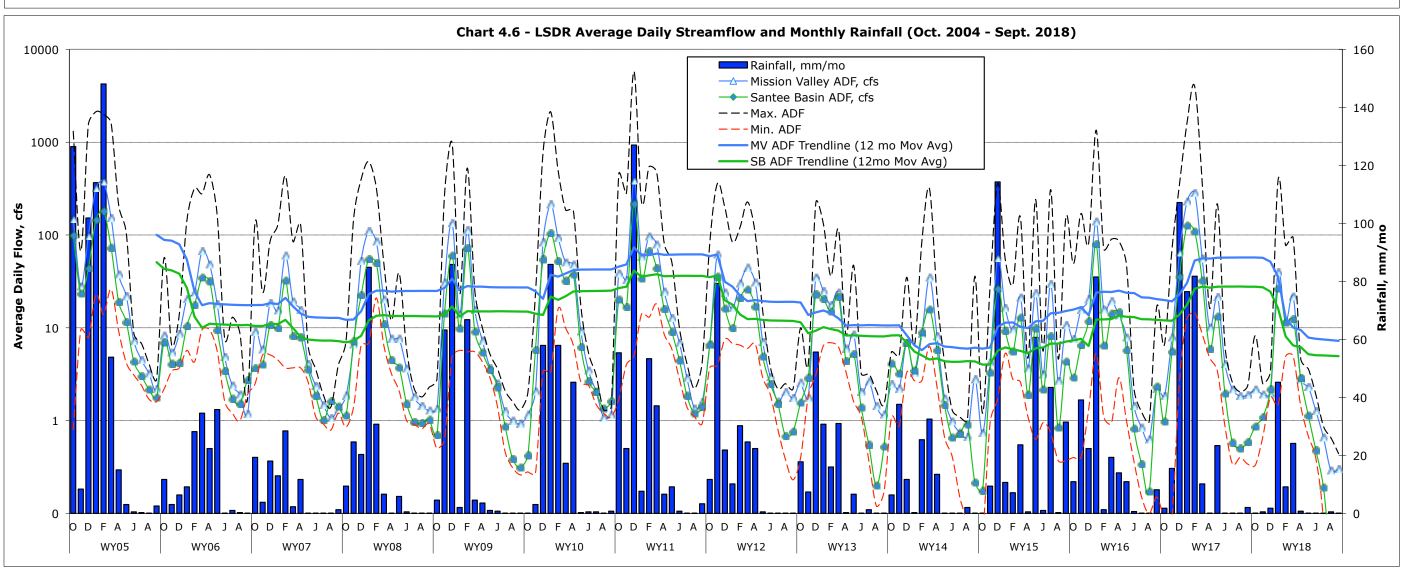


Chart 4.6 - LSDR Average Daily Streamflow and Monthly Rainfall (Oct. 2004 - Sept. 2018)
Rainfall, mm/mo
Mission Valley ADF, cfs
Santee Basin ADF, cfs
Max. ADF
Min. ADF
MV ADF Trendline (12 mo Mov Avg)
SB ADF Trendline (12mo Mov Avg)
Average Daily Flow, cfs
Rainfall, mm/mo
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18

Depressed dissolved oxygen levels monitored throughout large segments of the lower river are the result of low streamflow, 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 the past seven 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 improve subsequent to one or more major storm flow events resulting in significant channel scour, displacement of organic-rich sediments and significant reduction of invasive aquatic plants. The trend in overall LSDR DO values has, over the past 14 years, declined in excess of 2 mg/L (from roughly 6.5 mg/L to 4.3 mg/L). This represents an average annual decline in DO of 2.5% or 0.16 mg/L per year since RiverWatch monitoring began. As can be seen on Chart 4.4 the rate of annual decline in minimum values (-3 %) is noticably greater than the rate of decline in maxima (-0.5%). Extended periods of low flow result in lower DO levels.

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 from late WY09 to early WY15 slowly increased through the end of 2017. LSDR running averages reached their lowest value of 20 (grade E, Poor) in 2014, at 34% below the 14-yr norm of 31 (grade D, Marginal). This year's running average WQI of 22 (grade E, Poor) is 28% below the 14-yr norm. WY18 presents the second lowest index. A well above average rainfall year in WY19 might be expected to result in a return to running average index values in the low-30's as was previously experienced in WY09 and WY11. However, a normal or below average rainfall year could actually result in a further decline in the index. Much depends on river hydraulics during the wet weather period. A major flushing flow would have a significant impact on the downward trend in the index. Over the past 14 years the index has fallen over nine points total for an average of 0.64 points per annum. Both minima and maxima values have declined at comperable rates.

Trendlines 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 streamflows of 7-8 cfs for Mission Valley and 3 cfs for the Santee Basin, occured in WY14. Due to the distribution and magnitude of rainfall in both WY15 and WY16, running average streamflows rose back to 15-20 cfs (Mission Valley) and 8-12 cfs (Santee Basin), still below 14-yr norms. Last year (WY17) average daily flows were 70% above the Santee Basin norm of 16 cfs and 108% above the Mission Valley norm of 27 cfs. WY18 streamflows fell sharply as the watershed recieved near record low rainfall. Dry weather flows in June through September have been some of the lowest recorded in the past 4-5 decades.

The trends and relative variances in water quality metrics 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 in computation of the water quality index, trends over the past 14 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 WY10 through WY13. The river experienced its poorest water quality during the driest, lowest average annual streamflow year (WY14) monitored over the last 14 years. An uptrend toward normalized values was evident over the past several years (WY15-WY17), but has again declined in WY18. WQI trendlines 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 WY18)

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-WY18) of monitoring. Values and grades above 14-yr norms are listed in blue; values below the 14-yr norms (expressed in black italics) are shown in red. The WY18 values, expressed in bold font, are lower than last year's results for all reaches and sections of the lower river. Overall the LSDR average annual WQI declined nine points from last year's value droping from the Marginal (D) water quality range to Poor (E+).

Table 5.1 - Average Annual and Seasonal WQI by Reach and Section (WY05-WY18)

Annual Avg.	LMV Reach	UMV Reach	MV Section	MG Section	LSB Reach	USB Reach	SB Section	LSDR Overall Avg.	
WY05	48	42	46	63	31	18	24	41/40	C (highest)
WY06	39	33	37	54	34	22	28	36/35	D+
WY07	36	28	33	49	40	27	34	36/34	D+
WY08	38	30	35	45	38	34	36	37/36	C-
WY09	38	29	34	45	38	32	35	36/35	D+
WY10	36	32	34	47	37	18	27	34/32	D
WY11	39	38	39	54	44	15	29	38/36	C-
WY12	35	35	35	47	39	9	24	33/31	D
WY13	37	32	35	44	35	11	23	32/30	D
WY14	18	19	18	36	28	11	19	22/20	E (lowest)
WY15	24	22	23	44	43	11	27	29/25	D
WY16	35	22	29	40	37	9	23	28/25	D
WY17	**34**	**32**	**33**	**41**	**39**	**19**	**29**	**33/31**	**D**
WY18	**26**	**22**	**24**	**33**	**28**	**10**	**19**	**24/22**	**E+**
14-yr Norm	*34*	*30*	*32*	*46*	*36*	*17*	*27*	*33/31*	*D Marginal*
Winter	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	63	65	64	84	44	33	39	58/58	B (highest)
WY06	54	50	52	60	40	29	35	47/46	C
WY07	49	42	46	61	55	40	48	50/47	B-/C+
WY08	56	47	52	54	52	52	52	52/52	B
WY09	57	48	53	61	54	49	52	54/53	B
WY10	54	53	54	66	54	28	41	51/49	B-/C+
WY11	57	56	56	66	54	27	40	52/50	B-
WY12	48	49	49	58	44	14	29	43/41	C
WY13	58	53	56	67	49	21	35	50/48	B-/C+
WY14	26	26	26	55	39	15	27	32/29	D (lowest)
WY15	33	29	31	58	53	11	32	37/32	D+/D
WY16	44	38	41	57	52	14	33	41/37	C/D+

WY17	53	58	55	66	60	35	48	54/53	B
WY18	**38**	**37**	**38**	**58**	**41**	**16**	**29**	**38/36**	**C/D+**
14-yr Norm	*49*	*47*	*48*	*62*	*49*	*28*	*38*	*47/45*	*C+ Fair*
Summer	LMV	UMV	MV	MG	LSB	USB	SB	LSDR Overall	
WY05	31	24	28	45	20	5	13	25/24	D-/E+
WY06	23	14	19	44	30	18	24	26/23	D-/E+
WY07	23	14	19	34	24	14	19	22/20	E
WY08	23	20	22	31	25	18	21	23/22	E
WY09	21	14	18	31	25	16	20	21/20	E
WY10	21	17	20	33	26	9	17	21/19	E
WY11	23	17	20	37	30	5	17	22/20	E
WY12	22	18	20	25	27	4	15	19/17	E
WY13	18	14	16	18	23	5	14	16/14	E
WY14	10	11	10	12	16	9	12	11/11	F+
WY15	15	11	13	32	37	9	23	21/17	E
WY16	**18**	**7**	**13**	**18**	**19**	**5**	**12**	**13/11**	**E-/F+**
WY17	20	16	18	20	22	11	17	18/17	E
WY18	**12**	**8**	**10**	**8**	**16**	**6**	**11**	**10/9**	**F (lowest)**
14-yr Norm	*20*	*15*	*18*	*28*	*24*	*10*	*17*	*19/18*	*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 14-yr norms (expressed in black italics) for the same reach or section of the river; values above 14-yr norms are in blue. Overall LSDR WQI values are site averages/and flow-weighted averages.

The running averages, as well as variances in monthly index values, for each reach of the lower river system are presented in the series of charts (5.1 through 5.6) on pages 19 and 20.

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*) improved to the mid-30's during the second half (April-Sept) of WY16 and much of last 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 14-year monitoring period occurred in WY14. There was a steady, general improvement from WY14 lows during the second half of WY15 and throughout WY16 into WY17. A general decline has occurred throughout the past 16 months. The running average index has dropped 33% from 42 to 38 over 14 years at an average rate of 1 point per annum. Future recovery from an overall Marginal (D) to Fair (C) grade, as experienced between WY07 and WY13, is not anticipated without enhanced water quality management actions such as DO improvement through re-aeration or channel dredging 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 slightly less 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 of 84 (A, Very Good) for the Upper Mission Valley reach was monitored in March of last year, whereas the lowest reading of 3 (F, Very Poor) was recorded in October 2016. The overall trend in running average WQI values (*black line*) from WY14 through Dec 2017 was in general positive. The index for each site and for the entire reach has trended downward since then. The overall trend since WY06 has been negative (in decline) as growth of invasive aquatic plants and increase in biomass has proliferated throughout much of this reach during extended periods of very low flow. The rate of decline in running average index in this reach over 14 years is 42% falling from 38 in WY06 to the present value of 22. Significant recovery in this reach is problemmatic due to extensive ponding and insufficient flushing of accrued biomass.

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 WY's 12-14. Highest monthly WQI values of 89 (A, Very Good) were computed in Nov. 2004 and Feb. 2005, contrasted with a low of 4 (F, Very Poor) in Aug. 2014 and again in August of this year. In general running average WQI for this reach is the best of the five reaches with average WQI of 47 (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 33 (D, Marginal) in early WY15. WY17 witnessed an overall nine-point recovery in the running average WQI by September. The index for this reach has fallen during the second half of WY18 to a record low of 32. The overal index has fallen 24 points (43%) over 14 years in this section of the river. An increase in the Mission Gorge index is anticipated in WY19, unless rainfall is again well below normal, as this section recovers more rapidly with enhanced flow from runoff.

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 10-15 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. The previous low was surpassed by one point in both August and September of this year. Completion of the Forester Creek enhancement project (indicated by the *blue line*) extending from Prospect Ave. to the Mission Gorge Rd. has had a significant effect on overall river quality (*black line*) in the Lower Santee Basin portion of the river system. With well below normal rainfall experienced in WY18, the Lower Santee Basin running average index has fallen to previous lows. The overall rate of decline in the index from 38 to 35 from WY05 through WY18 is approximately 3%. This reach of the river has shown the least change in water quality metric values over the 14 years of monitoring, due in large part to Forester Creek improvements.

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 presents the lowest water quality values of all sections of the lower river watershed. Monthly values have seldom exceeded 20 (E, Poor) since the summer of 2011 and are typically less than 12 (F+, Very Poor) throughout all but wet-weather 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, however WY18 witnessed the opposite with a steady decline back toward previous lows. The greatest variability has been associated with site #13, Mast Park (*green line).* The index has fallen 70% (from 27 to 8) over 14 years presenting the greatest decline in running average WQI of all reaches.

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

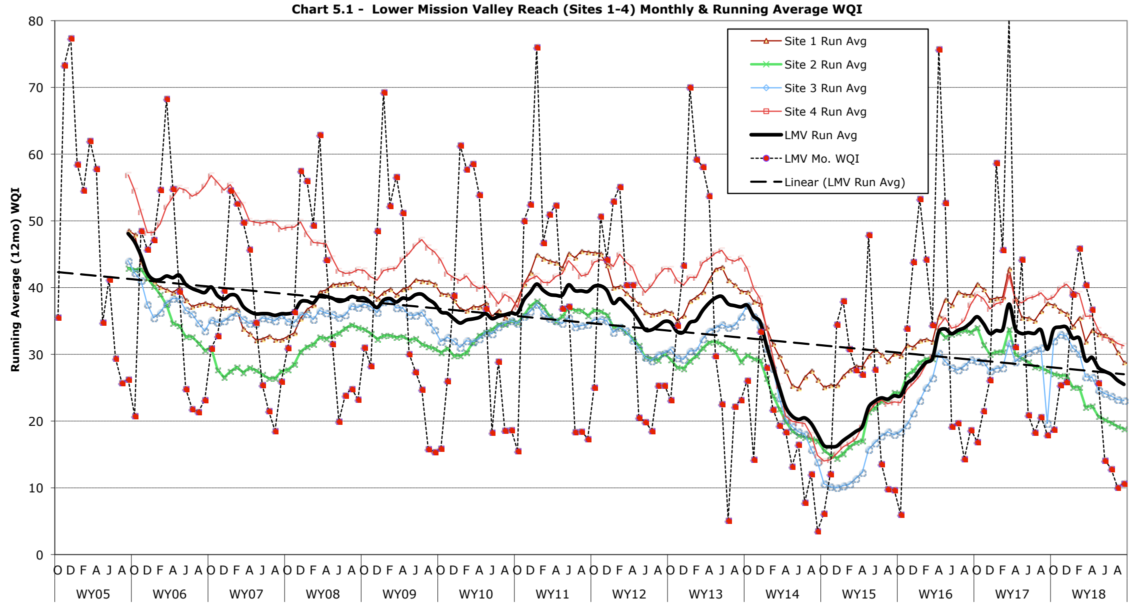


Chart 5.2 - Upper Mission Valley Reach (Sites 5-7) Monthly and Running Average WQI

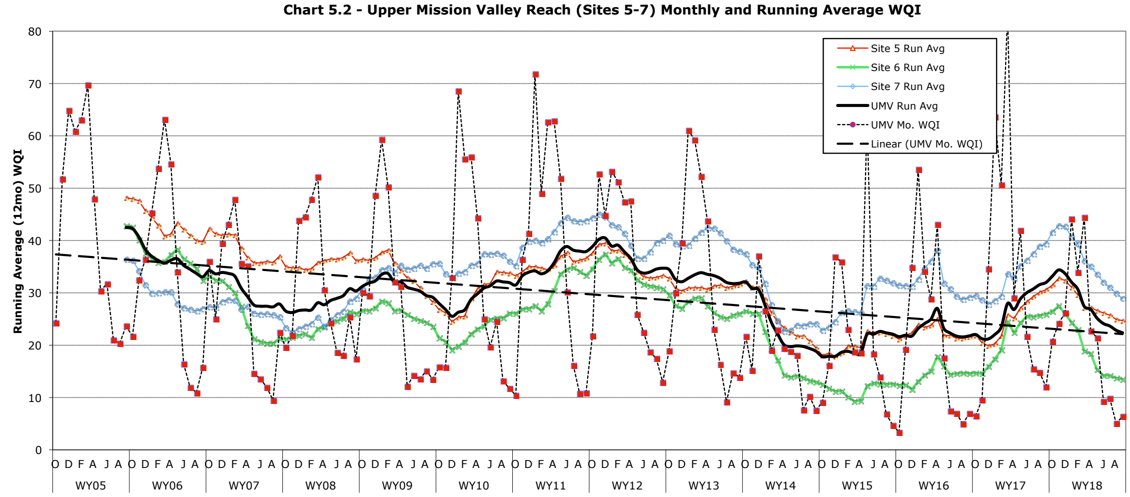
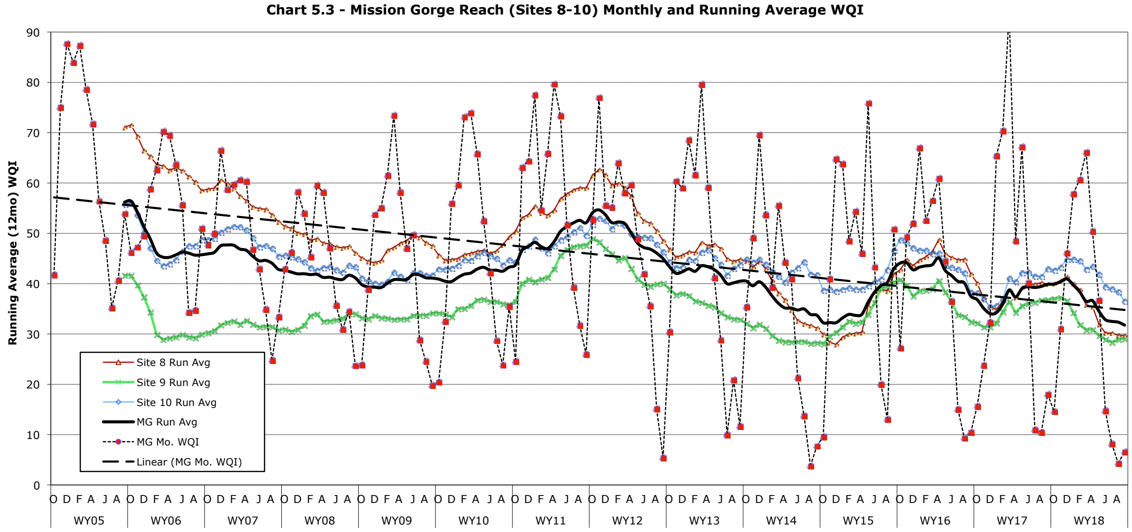


Chart 5.3 - Mission Gorge Reach (Sites 8-10) Monthly and Running Average WQI



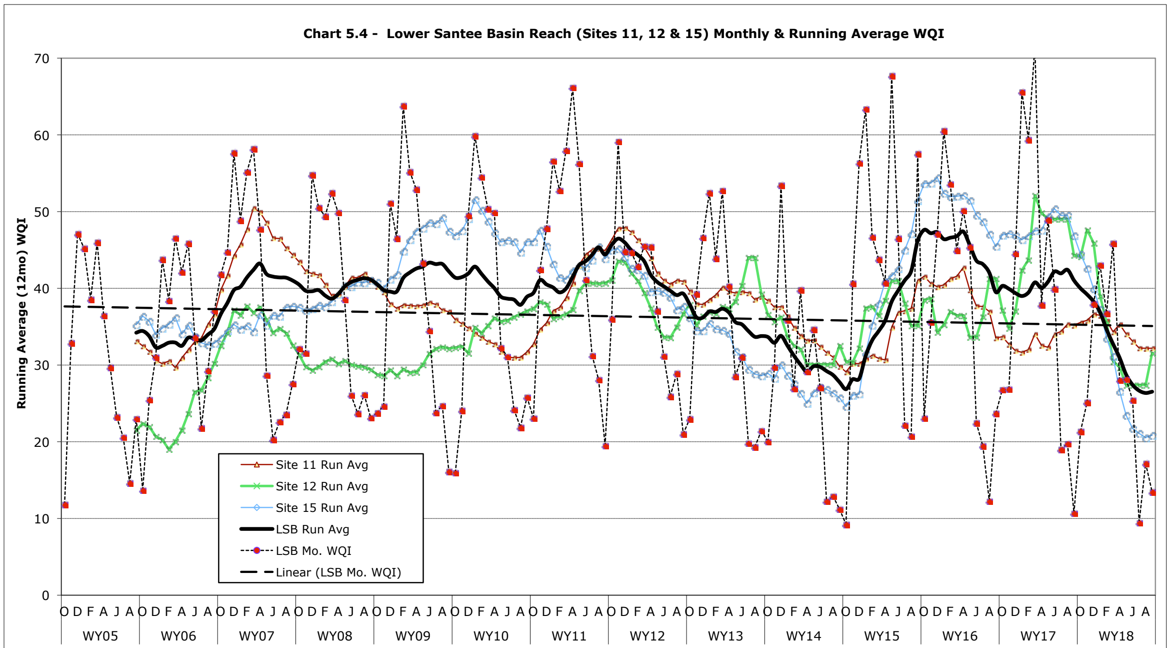


Chart 5.4 - Lower Santee Basin Reach (Sites 11, 12 & 15) Monthly & Running Average WQI
Running Average (12mo) WQI
Site 11 Run Avg
Site 12 Run Avg
Site 15 Run Avg
LSB Run Avg
LSB Mo. WQI
Linear (LSB Mo. WQI)
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16 WY17 WY18

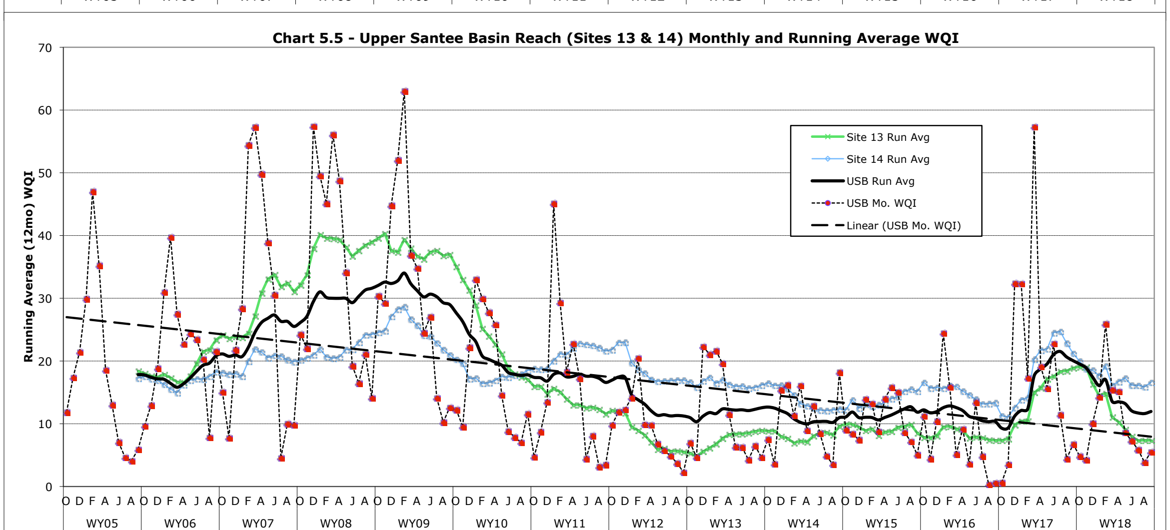


Chart 5.5 - Upper Santee Basin Reach (Sites 13 & 14) Monthly and Running Average WQI
Running Average (12mo) WQI
Site 13 Run Avg
Site 14 Run Avg
USB Run Avg
USB Mo. WQI
Linear (USB Mo. WQI)
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16 WY17 WY18

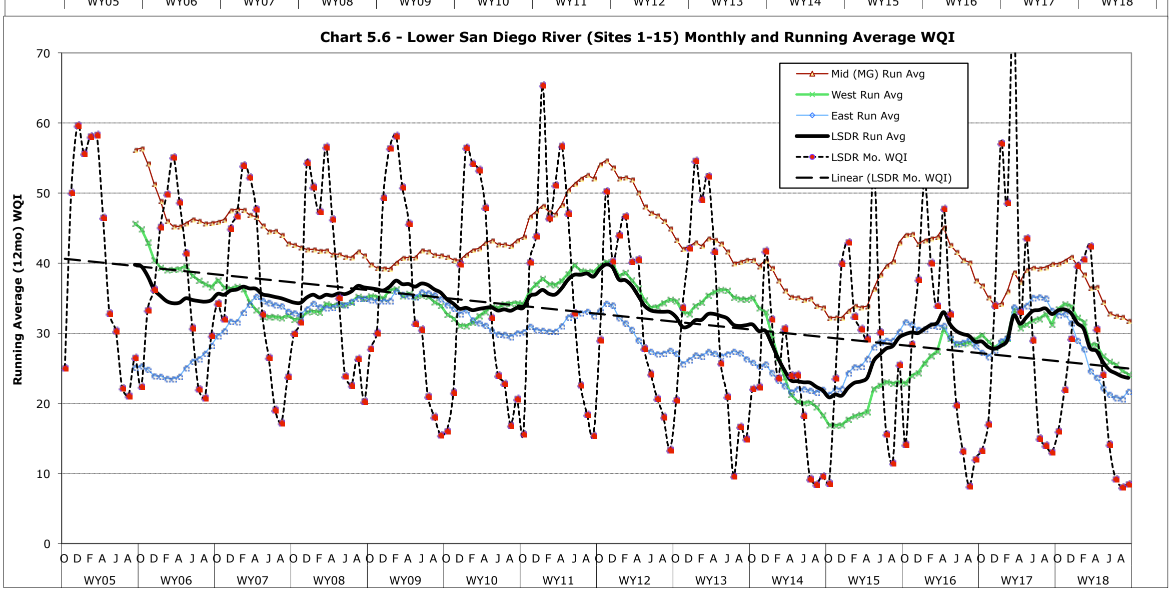


Chart 5.6 - Lower San Diego River (Sites 1-15) Monthly and Running Average WQI
Running Average (12mo) WQI
Mid (MG) Run Avg
West Run Avg
East Run Avg
LSDR Run Avg
LSDR Mo. WQI
Linear (LSDR Mo. WQI)
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16 WY17 WY18

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 (flow-weighted average of all 15 monitoring sites) are presented in **Chart 5.6.** WQI running average values recovered from WY14 lows for all three sections of the river during WY15 through WY17. They again declined throughout WY18 in all sections of the lower river. The Mission Gorge section (Chart 5.3) declined the least, while the upstream section (Santee Basin) fell the most. There were significant declines in index values in all three sections of the river and thus overall during WY18. The current LSDR running average WQI of 22 (E, Poor) is two points above the previous low of 20 computed in early WY15. The overall trend in running average WQI for the LSDR that remained relatively 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 low 30's in WY16 and WY17. The LSDR flow weighted running average index is now back in the lower 20's. The overall rate of decline has fallen 18 points from 40 to 22 over the past 14 years; presenting a 45% decline or nearly 1.3 point drop per annum.

The overall decline in running averages is a function of lowered oxygen levels in combination with elevated water temperatures and higher specific conductivities monitored at nearly all sites. These values are impacted by low streamflows especially during extended months of no rainfall. WQI values can be expected to improve should streamflows return to above normal and effective aquatic growth abatement measures are sucessful or occur through natural flushing for specific reaches of the river. Higher minimum index values during the summer months can result in positive gradients for 12-mo. running averages within a single water year, especially the case in the Mission Gorge section. Overall negative trending in WQI values are, however, expected to persist in most if not all sections of the lower river in the foreseeable future.

Depressed dissolved oxygen levels (often less than 3 mg/L) in conjunction with minimal dry-weather flow resulting in warmer, higher-conductance (more dissolved solids) waters are the primary causes of the 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 (phytcombined with restricted water movement. Until the spread of creeping water primrose (L*udwigia hextapetala)** and other invasive aquatics can be effectively managed and the resultant effects of eutrophication controlled, water quality in multiple reaches of the lower river system are expected to remain well below levels in those reaches of the river where improved circulation, mixing and natural re-oxygenation occurs.

The overall trend in the running average water quality index values since RiverWatch monitoring was iniated in Sept. 2004 can be characterized as declining. The annual extent of maximim annual values during the wet weather period has seen a reduction while the extent of minimal values has increased in times of extended dry weather. Without greater dry-weather streamflow during the several critical months of summer, overall water quality in the lower river can be expected to continue to decline.

** Ludwigia hexapetala, L. peploides, L. grandiflora is a highly 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 = 1,000 *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
°C – degrees Celsius
°F – degrees Fahrenheit

Formulas:

$°C = (°F-32) \times 5/9$
$°F = (°C*9/5) + 32$

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/river 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 °C.
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 can also be applied to water quality and hydrologic data for other coastal area watercourses where comparable metrics are available.

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

Appendix B - References

1. *The Role of the San Diego River in Development of Mission Valley*, Nan Papageorge, The Journal of San Diego History (Vol. 17, No. 2), Spring 1971

2. *Evaluation of the Mission, Santee, and Tijuana Hydrologic Subareas for Reclaimed-Water Use, San Diego County, CA,* John Izbicki, USGS Water Resources Investigations Report 85-4032, 1985

3. *Water Quality Control Plan for the San Diego Basin,* San Diego RWQCB, 1994

4. *Waste Discharge and Water Recycling Requirements for the Production and Purveyance of Recycled Water,* Padre Dam Municipal Water District (PDMWD), San Diego County, San Diego RWQCB, 1997

5. *Groundwater Report*, San Diego County Water Authority (SDCWA), 1997

6. *Waste Discharge Requirements for PDMWD Padre Dam Water Recycling Facility, Discharge to Sycamore Creek and the San Diego River, San Diego County,* San Diego RWQCB Order No. 98-60 (NPDES No. CA010749), 1998

7. *Modification of Water Quality Order 99-08-DWQ State Water Resources Control Board (SWRCB) National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges Associated with Construction Activity,* San Diego RWQCB Resolution No. 2001-046, 2001

8. *General Waste Discharge Requirements for Groundwater Extraction Waste Discharges from Construction, Remediation, and Permanent Groundwater Extraction Projects to Surface Water within the San Diego Region except for San Diego Bay*. San Diego RWQCB, Order No 2001-96 (NPDES No. CAG919002), 2001

9. *Waste Discharge Requirements for Discharge of Urban Runoff from Municipal Separate Storm Sewer Systems (MS4) Draining the Watersheds of the County of San Diego, the Incorporated Cities of San Diego County, and the San Diego Unified Port District*, San Diego Regional Water Quality Control Board (RWQCB) Order No 2001-01 (NPDES No. CAS0108758), 2001

10. *San Diego River Watershed Urban Runoff Management Plan*, City of San Diego in conjunction with Cities of El Cajon, La Mesa, Santee, Poway and County of San Diego, 2001

note: all references (1-52) available online

11. *General Waste Discharge Requirements for Discharges of Hydrostatic Test Water and Potable Water to Surface Waters and Storm Drains or Other Conveyance Systems,* San Diego Region, San Diego RWQCB, 2002

12. *San Diego River Watershed Urban Runoff Management Plan*, City of San Diego Lead Agency, City of Santee, City of Poway, County of San Diego, Jan 2003

13. *Watershed Sanitary Survey*, City of San Diego Water Department, Jan 2001, rev. May 2003

14 . *Clean Water Action Plan and Status Report*, County San Diego Project Clean Water, June 2003

15. *San Diego River Watershed Water Quality Report,* Anchor Environmental & others, Oct 2003

16. *San Diego River Watershed Management Plan Final WMPlan*, Anchor Environmental and others, SDR Watershed Work Group, March 2005

17. *2005 Watershed Sanitary Survey - Volume 2 San Diego River System,* City of San Diego Water Department, Water Quality Laboratory, Aug 2005

18. *San Diego River Baseline Sediment Investigation Final Report, City of San Diego,* Weston Solutions, Oct. 2005

19. *Monitoring Workplan for the Assessment of Trash in San Diego County Watersheds*, (Weston Solutions Brown & Caldwell), County of San Diego, Aug 2007

20. *San Diego Integrated Regional Water Management Plan,* San Diego County Water Authority, City of San Diego and County of San Diego, Oct 2007

21. *Allopathic potential of two invasive alien Ludwig spp,* Dandelot et. al., Elsevier Aquatic Botany 88 (4):311-316, Dec 8, 2007

22. *Surface Water Ambient Monitoring Program (SWAMP) Report on the San Diego Hydrologic Unit, Final Technical Report 2007*, Southern California Coastal Water Research Project, San Diego RWQCB, Jan 2008

23. *San Diego River Watershed Urban Runoff Management Plan,* City of San Diego, Storm Water Pollution Prevention Division, TRC, March 2008

Appendix B - References (continued)

24. *There is No San Diego River*, Bill Manson, San Diego Weekly Reader, Oct 22, 2008

25. *The Ecological and Hydrological Significance of Ephemeral and Intermittent Streams in the Arid and Semi-arid American Southwest,* EPA/660/R-08/134, Nov. 2008

26. *Water, The Epic Struggle for Wealth, Power, and Civilization,* Steven Solomon, Harper, 2010

27. *San Diego River FY 2008-2009 WURMP Annual Report*, TRC, January 2010

28. *San Diego River Tributary Canyons Project* Final Feasibility Report, April 2010

29. *The invasive water primrose Ludwigia grandiflora in Germany: First record and ecological risk assessment,* Nehring & Kolthoff, Agency for Nature Conservation, Germany, Aquatic Invasions 2011 REABIC (Vol 6, i1: 83-89) Dec 16, 2010

30. *Guidelines for Citizen Monitors*, SWAMP Clean Water Team Citizen Monitoring Program Guidance Compendium, SWRCB website (10/5/11 update)

31. *2011 Long-Term Effectiveness Assessment, San Diego Stormwater Co-permittees Urban Runoff Management Programs,* Final Report, Walker Assoc. Weston Solutions, June 2011

32. *San Diego River Conservancy 2012 Work Plan*, Governing Board, March, 2012

33. *The Day the San Diego River Was Saved: The History of Floods and Floodplain Planning in Mission Valley,* Philip R. Pryde, Journal of San Diego History, (Vol. 57, No. 3) 2012

34. *San Diego River Watershed Bioassessment and Fish Tissue Analysis*, RWQCB, Feb. 2013

35. *San Diego River Park Master Plan*, City of San Diego, April 18, 2013

36. *Watershed Asset Management Plan, Final Report,* Storm Water Division, Transportation and Storm Water Department, City of San Diego, July 19, 2013

37. *San Diego River Watershed Comprehensive Load Reduction Plan - Phase II,* Tetra Tech Inc, Final July 24, 2013

38. *Aquatic Conservation: Marine and Freshwater Ecosystems, A success story: water primroses, aquatic pests,* Thouvenot, Haury & Thiebaut, (Vol 23, i5: 790-803) Oct. 2013

39. *San Diego River Restoration Involves Clearing Homeless, And Their Trash,* Susan Murphy, KPBS, Jan. 16, 2014

40. *San Diego River Watershed Monitoring and Assessment Program*, B. Bernstein (SWAMP-MR-RB9-2014-0001), RWQCB, Jan. 20, 2014

41. *Nonstructural Non-Modeled Activity Pollutant Load Reduction Research - Addendum Final,* HDR, City of San Diego, Nov. 5, 2014

42. *San Diego River Causal Assessment Case Study, Appendix C , Causal Assessment Evaluation and Guidance for CA*, SCCWRP Tech Rpt. 750, April 2015

43. *Lower San Diego River Dissolved Oxygen Levels,* J.C. Kennedy, San Diego River Coalition presentation, June 19, 2015

44. *Lower San Diego River Streamflow and Water Quality Metrics,* J.C. Kennedy, SDR Coalition presentation, Aug. 21, 2015

45. *San Diego River Watershed Management Area Water Quality Improvement Plan,* Walker Assoc. & AMEC, San Diego RWQCB, September 2015

46. *Analysis of Anionic Contribution to Total Dissolved Solids in the Lower San Diego River,* Janae Fried, SDSU Thesis (Geological Sciences), Fall 2015

47. *San Diego River Watershed Management Area Water Quality Improvement Plan,* L. Walker & Assoc., January 2016

48. *Application of regional flow-ecology relationships: ELOHA framework in the San Diego River watershed. E.D Stein SCCWRP Research Article,* DOI: Ecohydrology.e1869, April 2017

49. *Regional Assessment of Human Fecal Contamination in Southern California Coastal Drainages*, SCCWRP #0999, International Journal Env.Research & Public Health, Aug. 2017

50. *San Diego Region Bacteria TMDL Cost-Benefit Analysis, Final Report,* RWQCB, Oct. 2017

51. Increased Homeless Population Along San Diego River Hampers Water Quality, KPBS, Erik Anderson, Nov. 28, 2017

52. San Diego River Watershed Management Area Water Quality Improvement Plan (SDRWQIP), Project Clean Water, March 14, 2018

Appendix C - SDRPF RiverWatch WQM Team

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