LOWER SAN DIEGO RIVER WATER QUALITY

WY19 Water Quality Monitoring Report

(Appendices A through H)

Late-summer proliferation of submerged, free-floating Hornwort/coon's tail in mid Mission Valley, Upper FSDRIP channel viewing west from Qualcomm Way bridge toward Camino del Este.

Supporting Water Quality Monitoring Data for the Lower San Diego River

John C. Kennedy, PE

November 2019

LOWER SAN DIEGO RIVER
WY19 WATER QUALITY REPORT
(APPENDICES A-H)

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Appendix A - SDRPF RiverWatch WQM Team

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Appendix B - Glossary

Abbreviations:

AADF - Average Annual Daily Flow
ACC - Average Coliform Count (arithmetic mean of fecal coliform, e-Coli & total coliform in MPN/100mL)
ADWF – Average Daily (stream) Dry-Weather Flow
AFY - acre-feet 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 Depletion (level below minimum required
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)
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 $^oC = (^oF-32)*5/9$
^{o}F – degrees Fahrenheit $^oF = (^oC*9/5) + 32$

Formulas:

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 LSDR 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 ^{o}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 could also be applied to water quality and hydrologic data for other coastal 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

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Appendix D - LSDR Water Quality Monitoring Metrics 15-yr Summary

Table D.1 WQM Metrics 15-yr Summary (Annual & Seasonal Averages)

WY	05	06	07	08	09	10	11	12	13	14	15	16	17	18	**19**	*15-yr Norms*
Annual (October-September):																
ADF, cfs	58	13	9	17	19	32	25	13	9	5	9	14	42	6	**23.7**	*19.5*
Temp, °C	17.8	18.3	17.8	17.8	17.9	18.1	17.9	18.1	17.4	18.0	18.7	18.2	18.6	18.3	**17.90**	*18.04*
SpC, uS/cm	2.05	2.14	2.37	2.22	2.40	2.26	2.15	2.30	2.42	2.53	2.16	2.23	2.15	2.78	**2.162**	*2.289*
DO, mg/L	6.32	5.66	5.52	5.99	5.92	4.85	5.10	4.73	4.90	3.52	3.93	4.10	4.70	3.95	**4.55**	*4.92*
DO%Sat,	60	56	56	61	61	50	53	49	50	37	42	43	50	41	**47.1**	*50.4*
pH	7.57	7.34	7.47	7.88	7.61	7.83	7.86	7.68	7.75	7.64	7.76	7.73	7.78	7.95	**7.74**	*7.71*
WQI	40	35	34	36	35	32	36	31	30	20	25	25	31	22	**29**	*31*
Grade	C	D+	D	D+	D+	D	D+	D	D	E	D-	D-	D	E	**D**	*D*
Summer (June-September) Period:																
ADF, cfs	3.4	3.8	1.4	1.9	1.2	1.9	3.2	1.6	1.1	0.8	5.2	0.7	1.8	0.5	**2.4**	*2.1*
Temp, °C	21.7	23.6	21.8	23.0	23.0	22.0	21.8	23.0	21.7	22.8	22.9	21.9	23.3	23.0	**22.13**	*22.51*
SpC, uS/cm	2.52	2.37	2.69	2.93	3.10	2.88	2.75	2.96	2.95	2.94	2.16	3.05	2.73	3.16	**2.736**	*2.795*
DO, mg/L	4.02	4.20	3.81	4.56	4.20	3.45	3.28	3.20	2.91	2.26	3.06	2.60	3.13	2.53	**2.62**	*3.32*
DO%Sat, %	42	49	43	51	49	39	38	38	34	27	35	30	37	29	**29.9**	*38.1*
pH	7.51	7.47	7.41	7.91	7.50	7.84	7.92	7.94	7.71	7.94	7.81	7.80	7.74	8.00	**7.74**	*7.69*
WQIa	24	23	20	22	20	19	20	17	14	11	17	11	17	9	**14**	*18*
Grade	E+	E	E	E	E	E	E	E	E	F	E	F	E	F	**E**	*E*
Winter (December-March) Period:																
ADF, cfs	147	19	18	45	53	83	50	20	20	11	18	34	116	15	**63.3**	*47.5*
Temp, °C	13.7	12.9	13.9	12.5	13.4	14.2	13.8	12.4	12.4	13.4	15.3	14.1	14.4	13.8	**14.24**	*13.63*
SpC, uS/cm	1.38	2.00	2.02	1.53	1.49	1.32	1.32	1.65	1.99	2.22	1.86	1.69	1.22	2.16	**1.283**	*1.675*
DO, mg/L	9.16	6.40	6.59	6.96	7.31	5.76	7.01	6.30	7.26	4.68	4.56	5.56	7.24	5.46	**7.14**	*6.50*
DO%Sat	83	58	64	66	71	57	68	59	68	45	46	54	72	53	**70.4**	*62.3*
pH	7.57	7.33	7.69	8.06	7.72	7.68	7.84	7.41	7.76	7.53	7.79	7.57	7.77	7.89	**7.67**	*7.74*
WQIa	58	46	47	52	53	49	50	41	48	29	32	37	53	36	**52**	*45*
Grade	B	C	C	B-	B-	C+	B-	C	C+	D	D	D+	B-	D+	**B-**	*C*

(a) Values in red text are below 15-yr norms; values above norms in blue.

Table D.2 WQM Metrics Summary by River Section and Reach (WY19 & 15-yr Norms)

Section	Mission Valley		Mission Gorge	Santee Basin		**Watershed**
Sites	1-4	5-7	8-10	11,12,15	13,14	**all (1-15)**
Reach	LMV	UMV	MG	LSB	USB	**LSDR** [a]
Annual (October - September):						
ADF, cfs	35.6 *(28.3)*	33.5 *(26.3)*	22.0 *(18.2)* [b]	18.6 *(16.0)*	8.9 *(4.8)*	**23.7** ***(19.5)***
Temp, °C	19.75 (19.36)	17.66 (17.85)	17.23 (17.12)	17.37 (17.46)	18.88(18.13)	**18.27 (18.05)**
SpC, mS/cm	3.214 (2.587)	3.096 (2.563)	3.032 (2.305)	2.561 (2.273)	2.035(1.806)	**2.778 (2.298)**
DO, mg/L	4.04 (5.01)	3.73 (4.44)	6.39 (7.51)	5.21 (6.60)	2.03 (3.11)	**3.95 (4.94)**
DO %of Sat, %	43 (53)	38 (46)	65 (77)	54 (65)	22 (32)	**41 (51)**
WQIa	26 (34)	22 (30)	33 (46)	28 (36)	10 (17)	**22 (31)**
WY19 Grade	C	E (D)	D (C)	D (D+)	F (E)	**E (D)**
15-yr Norm	*D*	*D*	*C*		*E*	*D*
Summer (June - September) Period:						
ADF, cfs	3.5 *(3.2)*	0.8 (2.8)	0/3 (1.7) [c]	0.2 (1.7)	0.1 (0.3)	**0.5 (2.0)**
Temp, °C	24.74 (24.27)	22.23 (21.85)	22.11 (21.82)	20.79 (21.60)	24.04(22.85)	**23.01 (22.54)**
SpC, mS/cm	3.707 (3.252)	3.443 (3.188)	3.675 (2.891)	2.818 (2.636)	2.246(2.052)	**3.159 (2.799)**
DO, mg/L	2.45 (3.16)	1.81 (2.54)	3.90 (5.58)	4.30 (5.34)	1.79 (2.23)	**2.53 (3.37)**
DO % of Sat, %	30 (38)	21 (29)	43 (64)	49/57	21 (26)	**29 (39)**
WQI	12 (20)	8 (15)	8 (28)	16 (24)	6 (10)	**9 (18)**
Grade	F+ (E)	F (E)	F (D)	E (E+)	F (F)	**F (E)**
15-yr Norm	*E*		*D*		*F*	*E*
Winter (December - March) Period:						
ADF, cfs	96.2 *(70.5)*	23.2 (62.9)	17.2 (43.5)	15.3 (37.2)	7.4 (11.3)	**17.5 (46.5)**
Temp, °C	14.89 (14.44)	13.44 (13.69)	12.33 (12.65)	14.19 (13.38)	14.29(13.53)	**13.82 (13.58)**
SpC, mS/cm	2.432 (1.881)	2.453 (1.792)	2.125 (1.643)	2.043 (1.839)	1.728(1.464)	**2.163 (1.703)**
DO, mg/L	5.56 (6.76)	5.66 (6.38)	8.84 (9.11)	6.46 (7.89)	2.56 (4.04)	**5.46 (6.46)**
DO % of Sat, %	55 (67)	55 (62)	83 (87)	63 (72)	26 (38)	**53 (62)**
WQI	38 (49)	37 (47)	58 (62)	41 (49)	16 (28)	**36 (45)**
Grade	C- (C+)	D+(C)	B (B)	C (C+)	E (D)	**D+ (C)**
15-yr Norm	*B*	*C*	*B*		*D*	*C*

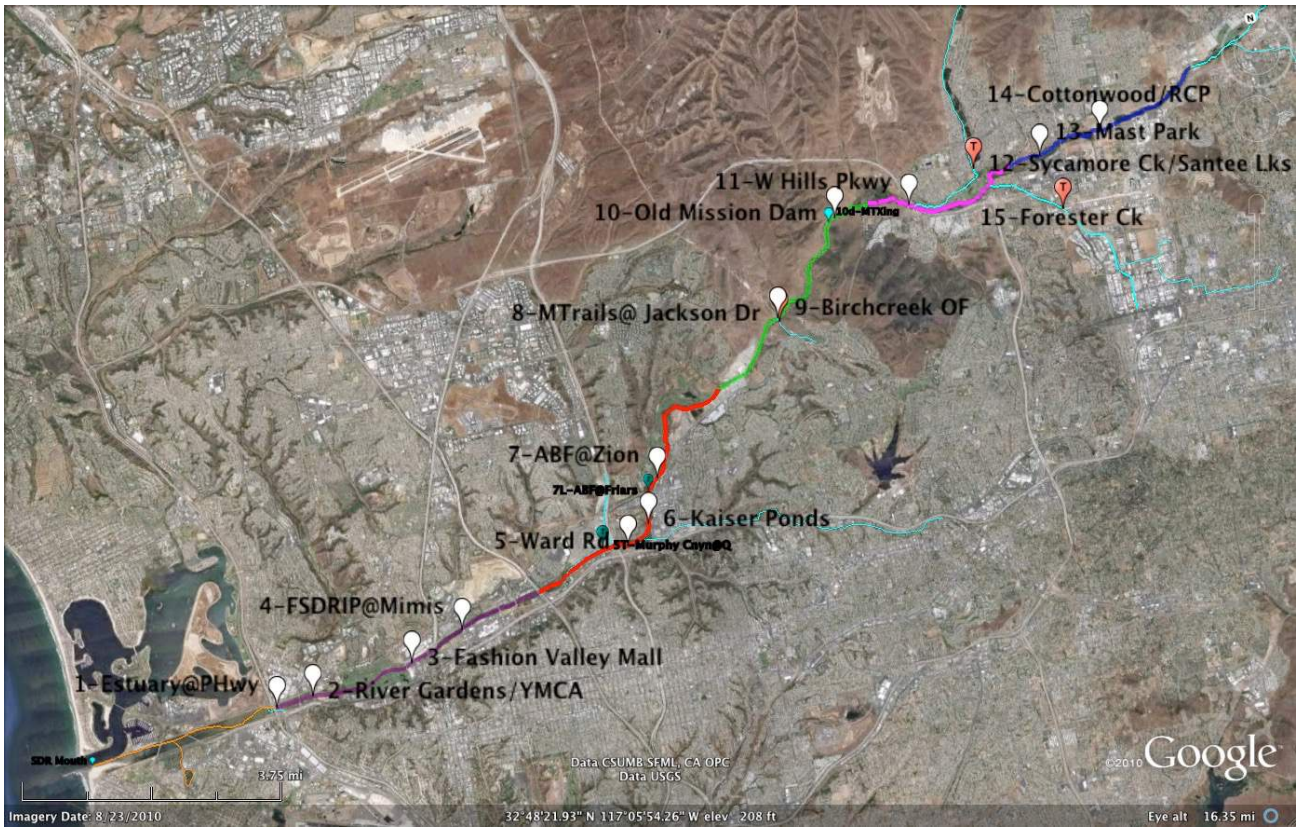
WY19 WQ metrics below (less than) 15-yr norms are shown in red text; values above norms are shown in blue.
(a) Weighted average of all five reaches within the Lower River watershed.
(b) Stream flow based on river channel gains/losses averaged between Santee Basin and Mission Valley.

Appendix E - San Diego RiverWatch WQ Monitoring Program

Appendix E provides an overview of SDRPF's RiverWatch water quality monitoring (WQM) program that, over the last 14 years, has been engaged in collecting and assessing data pertaining to the Lower San Diego River (LSDR) watershed on a continuous monthly basis.

Monitoring Period & Coverage: Monthly monitoring over past 14 years (Oct. 2004 – Sept. 2018) covering the Lower San Diego River and its tributaries extending downstream from Lakeside (river mile 19.8 elev. 340 ft amsl) to the Estuary (river mile 2.96, elev. 5.8 ft amsl) under the I-5/ Pacific Hwy. overpasses. The LSDR watershed and monitoring sites are shown on **Figure E.1.**

Figure E.1 - Lower San Diego River Catchment and WQM Sites



Color Code for LSDR reaches on figure above: Estuary (orange), LMV (purple), UMV (red), MG (dark green), LSB (violet), USB (dark blue), Lakeside (light green), tributaries (light blue). Figure details can be downloaded through Google Earth from SDRPF website/River Monitoring page: file <Fig1.1WQMR.kmz>

Monitoring Sites: 15 total - 12 on main course (Mission Valley Section - sites 1-7, Mission Gorge Section - sites 8-10, Santee Basin Section - sites 11-15) plus three tributary stream sites are listed in **Table E.1.**

Table E.1 LSDR Sections, Reaches and Monitoring Sites

Section/Reach/Tributary	Site #s	Comments
Estuary Entrance	1E/1W	Tidal influence at transition from river to estuary
Lower Mission Valley (LMV)	2E/W, 3 & 4	4 miles of lower river extending to I-805
Upper Mission Valley (UMV)	5,6 & 7	4-mile stretch from I-805 to Princes View Dr
Mission Valley (West Sites)	1-7	8-mile western portion through Mission Valley
Mid-Section : Mission Gorge (MG)	8,9T & 10	5-mile mid-section, Princess View Dr to Kumeyaay Lk
Lower Santee Basin (LSB)	11,12T&15T	2-mile stretch from Kumeyaay Lk to Carlton Hills Blvd
Upper Santee Basin (USB)	13 & 14	3-mile stretch from Carlton Hills Blvd to Riverford Rd
Santee Basin (SB)	11-15T	5-mile eastern section from Kumeyaay Lk to Lakeside
Eastern Sections (East Sites)	8 -15T	10-mile eastern/upper 3 reaches (2 sections)
Tributaries:		
Murphy Canyon/Qualcom [a)]	5a	Enters LSDR southwest of SDSSU Stadium
Jackson Dr/Birchcreek Drain [b)]	9T	Enters LSDR at Sycott Wash (d/s of Site 8)
Santee Lakes/E. Sycamore Cnyn Ck	12T	Enters LSDR at Carlton Oaks GC (u/s of 15T)
Forester Creek [c)]	15T	Enters LSDR d/s of Carlton Oaks GC at Site 11
Lower SDR Watershed (LSDR)	1-15T	Weighted average of all 5 reaches or all 3 sections

(a) Monthly monitoring discontinued in WY07; nearby Ward Rd Bridge site renumbered as 5.
(b) Monthly monitoring initiated in 2008; site also termed Jackson Dr. Outfall (OF).
(c) Monthly monitoring initiated in 2007 with adjusted site location in 2009 and again in 2017 back to original location in vicinity of SR 52.

WQ Parameters: Seven measured and recorded parameters (Temp, pH, SpC, DO, DO%Sat, NO_3 & PO_4) plus subjective field observations re: environs and characteristics are listed in **Table E.2.** As nutrient testing for NO_3 and PO_4 is carried out at five selected sites; two in West (2 & 6) and three in East (11,14 & 15T), respectively, results are not used in performing statistical analyses regarding reaches/sections of the river. Number of datum for each of the five physical-chemical parameters monitored monthly at each site over the 13-yr period (Oct. 04 - Sept. 17) are in the range of 100 to 120. Two other water quality parameters monitored by others at several sites, streamflow from USGS (Poway Office) and coliform counts from SDCoastKeeper, are also recorded for purposes of computing the water quality index.

Protocol: *East Side* – (Santee Basin & Mission Gorge Sections). The 8 sites within upper three reaches (MG, LSB & USB) typically monitored 3rd Fri. or Sat. of month. *West Side* - (Mission Valley Section). Seven sites within the lower two reaches (LMV & UMV) monitored monthly, typically 3rd Sun. of month.

Table E.2 - LSDR Water Quality Monitoring Parameters

WQ Parameter	unit	Comments
Measured monthly at all sites:		
1. Temperature (Temp)	°C	Basic characteristic and WQ driver (see Table G.1)
2. pH	-	Degree of acidity (<7.0) or alkalinity (>7.0) (see Table G.3)
3. Specific Conductivity (SpC)	mS/cm	Measure of ionic content or dissolved solids (see Table G.2)
4. Dissolved Oxygen (DO)	mg/L	Good indicator of relative water quality (see Table G.4)
5. Percent of DO Saturation (DO%Sat)	%	Good indicator of general water quality (see Table G.5)
Sampled/tested monthly at selected sites: (typically 5 - 3 East & 2 West)		
6. Nitrate (NO_3-N)	mg/L	Important nutrient for biological activity
7. Phosphate (PO_4-P)	mg/L	Key nutrient for biological activity
8. Turbidity	NTU	Discontinued due to probe replacement
9. Barometric Pressure	mBars	Suspended readings as external data readily available
Environmental Observations recorded at all sites:		
Atypical or notable conditions (scum, discoloration, odors, etc.), trash/debris, homeless encampments, biological activity (aquatic, avian, terrestrial), expansion of invasive species, erosion, scouring, other noteworthy comments re: watercourse, shoreline and adjacent environs. Special note as to invasive aquatic plant growth on water surface.		
General WQ Conditions observed at all sites: (numerical coding added in 2010)		
Weather Condition, Presence of Algae, Clarity, Color, Odor, Flow, Foam, Litter, Odor, Oil and Grease (O&G), e		
Parameters measured by others at selected sites		
10. Streamflow	cfs	USGS gauging stations at Fashion Valley and Mast Rd. near Santee (see Table H.1)
11. Coliform counts: (Escheria-coli, Enterococcus, Total Coliform bacteria)	MPN/ 100mL	SD CoastKeeper data taken at Fashion Valley Rd and Old Mission Historic Dam monitoring sites (see Table H.2)

Team Leaders (1-2) and citizen volunteers (3-8) meet at an appointed location, organize field equipment/transportation, drive to sites, measure physical-chemical water quality using the YSI Sonde meter, note special conditions/observations, collect samples for subsequent testing, then return to office, perform nutrient (NO_3 & PO_4) tests, store samples for subsequent laboratory analyses and clean/check-in/store field equipment.

Data Management: Water quality data are typically managed in a three-step process.

1. *Raw* (source) data - each site, several of which have two monitoring locations (e.g. upstream/downstream of dam, riffle or crossing), date/time, measured WQ parameters, and non-quantifiable supporting observations and comments.

2. *Compiled* (vetted/proofed) data - provided on Ecolayers w/date, site location, parameter value and additional observations of interest.

Table E-3 - WQM Site Locations

Site #	Site Name	u/s mi.	Elev. ft.	Location	GIS Coordinates Lat.	Long.
LMV - Lower Reach W Mission Valley: I-5 Bridge to I-805 Bridge (Sites 1-4)						
1	Estuary W/E	2.96	6	between PCH & I-5 on encased sewer main	32.76131	-117.20373
2	River Gardens E/W	3.50	11	W of YMCA, d/s of Trolly at foot bridge	32.7623	-117.1944
3	Fashion Valley Mall W	5.08	22	below Town & Country Pedestrian Bridge	32.76517	-117.16869
4	FSDRIP	5.98	36	N of Mimi's on Mission Center Rd. Bridge	32.76986	-117.15482
UMV - Upper Reach E Mission Valley: I-805 Bridge to N end of Admiral Baker Field (Sites 5-7)						
5	Ward Rd Bridge	8.89	50	S. of Trolly overpass at Del Rio S intersection	32.78024	-117.11029
6	Kaiser Ponds	9.46	56	E. of Mission SD de Acala at SD Mission Rd.	32.78406	-117.10419
7	Admiral Baker Field	9.98	58	L - Lower (below Friars Rd bridge)	32.79038	-117.10314
	ABF - Zion Rd	10.2	62	Z - Terminus of Zion Ave at Riverdale St.	32.79304	-117.09984
West (MV) - Mission Valley Section: Estuary to Admiral Baker Field (Sites 1-7) [LMV+UMV]						
MG - Mission Gorge Reach: Quarry Area to Old Mission Dam (Sites 8-10)						
8	Mission Trails @ Jackson Dr	13.82	159	SDCWA downstream of Scycott Crossing	32.82124	-117.06205
9T	Jackson/Birchcreek Outfall	13.86	198	San Marcos area drainage by Jackson Dr. Trail	32.82268	-117.06224
10	Old Mission Dam W/E	15.65	265	Downstream side of Old Mission Dam	32.83977	-117.04332
Mid-Section (MG) -Mission Gorge Section: Quarry Area to Old Mission Dam (Sites 8-10)						
LSB - Lower Reach Santee Basin: W Hills Pkwy to Carlton Hills Bridge (Sites 11,12 &15)						
11	West Hills Pkwy	17.03	300	at/below West Hills Pkwy Bridge	32.83936	-117.02436
12T	Carlton Oaks Dr/Santee	18.23	320	W Sycamore Ck/Santee Lakes @ Carlton Oaks Dr.	32.84431	-117.00635
15T	Forester Creek at Rt 52	18.86	334	Forester Ck (primary tributary) at Rapture/Atlas View Dr. (enters SDR just u/s Site 11)	32.83221	-116.98658
USB - Upper Reach Santee Basin: Carlton Hills Bridge to Riverford Rd (Sites 13-14)						
13	Mast Park	18.50	330	Pedestrian Bridge behind (N of) Walmart, end of River Rock Ct.	32.84696	-116.97335
14	Cottonwood Ave/RCP	19.84	340	N. of Chubb Ln. at N. Magnolia Ave.	32.84434	-116.98947
East (SB) - Santee Basin Section: West Hills Parkway to Lakeside (Sites 11-15 above) [LSB+USB]						
LSDR - Lower San Diego River Watershed: SD Estuary to Lakeside (Sites 1-15 above) [LMV+UMV+MG+LSB+USB]						

3. *Processed* (formatted/aggregated) data - with statistical computations associated with LSDR sites, reaches, sections and tributaries for each WQ parameter of interest including those monitored by others.

Statistical Computations: Various basic statistical values have been calculated from the data.

Mean – average of a series (sum of values divided by number of values)
Median – middle value of an ordered series (50% larger - 50% smaller)
Minimum – lowest or smallest value measured
Maximum – highest or greatest value measured
Range – Difference between maximum and minimum values
1st Quartile (Q1) – 25% of values smaller - 75% larger
2nd Quartile (Q2) – 50% of values larger - 50% smaller (same as median value)
3rd Quartile (Q3) – 75% of values smaller - 25% larger
Variance – sum of the squares of deviation from the mean or average value
Standard Deviation (SD) – square root of the variance
Skew – third moment about the mean divided by the standard deviation (SD)
Coefficient of Variance (CoV)– Variance divided by the mean
Trend line - Moving/running average values taken over a 12-month period.

Appendix F - LSDR Hydrology and Water Quality

Stream flow or river discharge, is the volume of water moving past a designated location over a fixed period of time. It constitutes one of the primary drivers of changes in water quality. Often expressed as cubic feet per second (cfs) or million gallons per day (mgd), flow is the amount of water moving off a watershed into a watercourse, as affected by weather (increasing during rainstorms and decreasing during dry spells) and continually changing during each season. River flow rapidly decreases during summer months when rainfall is minimal, evaporation rates high and riparian vegetation extracts water from the ground. August and September, the last two months of summer (and a water year), are typically, but not always, the months of lowest flow. A function of both volume and velocity, stream flow has a major impact on living organisms, riparian habitat, benthic conditions and overall water quality. Velocity of flow, typically increasing as volume increases, determines the kinds of organisms that live in the aquatic system and also affects the amount of silt and sediment transported. Fast moving water typically contains much higher DO concentration levels than sluggish flow, as it is better aerated.

LSDR average daily flow (ADF) values as recorded at the two USGS gauging stations in the lower watershed are expressed in **Table F.1** for both the 15-yr monitoring period (Oct 2004 - Sept 2019) and over the past 55 years (1965-2019) of record**.** The ADF values are in close accord for both stations. River discharge over the last 15 years is about 21 percent below the 55-year norm in Mission Valley and 27% below the Santee norm. WY19 discharges are 1.3% less than than the 55-yr norm at the Fashion Valley Site and 15% below the norm at Santee. Stream flow on average for WY19 for LSDR is 12% less than the long-range norm and 23% below the current 15-year norm.

Correlations between total annual rainfall and ADF over the past 55 years of hydrologic record and during the 15 year period of RiverWatch monitoring for the two lower SDR gauging stations are presented in **Tables F.2 and F.3**, respectively. In terms of total annual rainfall (TARF), WY05 was a "Very Wet" (TARF > 20") hydrologic year, whereas WY07 and WY18 were "Very Dry" years (TARF <5"). WY11, WY15, WY17 and WY19 were all "Above Normal" rainfall years (12-15") while WY09 and WY10 (8-12") were considered "Normal". The 15-yr ADF in the East and West sections are 11 and 30 cfs, respectively; values that are 15-20 percent below long-range ADFs at the two stations. WY19 total rainfall (12.83 inches/326 mm) is 29% above the long-range average while average daily flow for the year was 4% less than the long-range (55-yr) norm of 28.4 cfs/18 mgd.

Monthly discharge data (min, max and average daily flow) for the two USGS gauging stations extending from Oct. 2004 through Octt. 2019 are plotted in **Chart F.1.** Average daily flow (ADF) for the Lower San Diego River varies from less than 0.2 cfs (0.1 mgd) during the summer (dry) months to nearly 220 cfs (142 mgd) during several winter (wet) periods in the East (Santee Basin) and up to 390 cfs (252 mgd) in the West (Mission Valley) section. Running average ADF values, trending downward in WY12-WY14 increased in WY15, fell in WY16 and WY18, then increased in WY17 and WY19 as expressed on **Charts F.1** and **F.3**.

Table F.1 - Lower SDR Average Daily Flow (WY19 and 15-yr Norms)

Season	West - Mission Valley		East - Santee Basin		LSDR [a]	
	WY19	15-yr	WY19	15-yr	WY19	15-yr
Fall (Oct-Nov)	2.0	7.8	1.1	4.0	1.3	5.1
Winter (Dec-Mar)	96.0	70.5	48.4	37.9	63.3	47.5
Spring (April-May)	12.4	17.9	9.9	11.4	9.8	12.8
Summer (June-Sept)	3.5	3.2	2.1	1.7	2.4	2.1
Annual ADF [b], cfs	35.6	28.3	18.7	16.0	23.7	19.5
15-yr ADF (05-19), mgd	23.0	18.3	12.1	10.3	15.3	12.4
55-yr ADF (1965-2019), mgd	-	23.3	-	14.2	-	17.4
Total Discharge, KAFY [c]	25.8	20.5	13.5	11.6	17.2	14.1

(a) Lower San Diego River average daily flow represents a mean hydrologic condition based on averaging the two USGS gauging station flow values.
(b) ADF values are expressed in cubic feet per second (cfs) and million gallons per day (mgd); 1 cfs = 0.646 mgd.
(c) Total annual discharge volume expressed in thousand acre-feet (1 AF = 325,900 gallons); WY19 and 15-Yr averages.

Table F.2 - Rainfall and Long-Term Average Daily Flow (1914-2019)

Type	# of Years	Percent of Total Years		Total Annual Rainfall [a]			Average Daily Stream Flow, mgd		
				inches	mm	Avg., mm	East [b]	West [c]	LSDR
Very Wet	3	3%	31%	>20	>500	580	68	113	92
Wet	10	10%		15-20	380-499	430	48	81	66
Above Norm [d]	19	18%		12-15	300-379	340	26	44	35
Normal	40	38%	38%	8-12	200-299	250	10	18	15
Dry	26	25%	31%	5-8	125-199	160	7	12	10
Very Dry	7	7%		<5	<125	100	5	9	7
Sum/An. Avg	105	100%		9.94		250	14.2	23.3	17.4

a) Total annual rainfall from 1 October through September 31.
b) Santee Basin USGS Stream Gauge Station #11022480 at/below Mast Road Bridge in Santee.
c) Mission Valley USGS Stream Gauge Station #11023000 at Fashion Valley Mall; incomplete data prior to 1968.
d) Above normal annual rainfall (12-15 in/yr) resulting in LSDR average daily flows in the 25-50 mgd range.

Table F.3 - Annual Rainfall and Average Daily Flow (WY05-WY19)

(Type of Year)	Annual Rainfall		Variance [a]	ADF, cfs (mgd)			Variance [d]
	mm	inches		East [b]	West [c]	LSDR	
WY05 (Very Wet)	574	22.60	127%	50.9 (33)	100 (65)	71.5 (46)	152%
WY06 (Dry)	152	6.00	-40%	10.7 (7)	17.5 (11)	13.6 (9)	-52%
WY07 (Very Dry)	98	3.85	-61%	7.2 (5)	12.8 (8)	9.5 (6)	-67%
WY08 (Dry)	183	7.20	-28%	13.3 (9)	25.0 (16)	18.2 (12)	-36%
WY09 (below normal)	232	9.15	-8%	15.0 (10)	27.2 (18)	20.1 (13)	-29%
WY10 (above normal)	282	11.10	12%	25.1 (16)	42.5 (27)	32.4 (21)	14%
WY11 (above normal)	323	12.70	28%	43.3 (28)	61.9 (40)	46.9 (30)	65%
WY12 (Dry)	201	7.91	-20%	10.1 (8)	19.0 (12)	14.9 (10)	-48%
WY13 (Very Dry)	166	6.56	-34%	8.2 (5)	10.9 (7)	9.1 (6)	-68%
WY14 (Very Dry)	129	5.06	-49%	4.3 (3)	6.1 (4)	5.1 (3)	-82%
WY15 (above normal)	302	11.91	20%	7.1 (5)	15.2 (10)	10.5 (7)	-63%
WY16 (Dry)	208	8.20	-18%	12.2 (8)	24.4 (16)	15.6 (10)	-45%
WY17 (above normal)	323	12.73	28%	27.7 (18)	57.3 (37)	40.0 (26)	41%
WY18 (Very Dry)	83	3.34	-67%	5.0 (4)	7.2 (5)	5.9 (4)	-79%
WY19 (above normal)	324	12.83	29%	20.5 (13)	36.9 (24)	27.3	-4%
15-yr Norm (05-19)	232	9.41	-8%	10.8 (6)	30.2 (20)	22.7 (14)	-20%
55-yr AADF	252	9.92	0%	21.8/(14)	36.7 (24)	28.4 (18)	0%

a) Percent difference from 55-yr average annual rainfall (252 mm/yr or 9.92 in/yr); black-above, red-below average.
b) Santee Basin USGS Stream Gauge Station 00067556 at Mast Rd., Santee.
c) USGS Stream Gauge Station 00459999 at Fashion Valley Mall; incomplete data prior to 1965.
d) Percent difference from average annual daily flow (AADF).

Monthly and seasonal average annual flow (lines) and rainfall (bars/columns) over the monitoring period for both stations are shown in **Chart F.2.** The seasonal flow patterns express range, variance and positive correlation in monthly ADF and rainfall over the past 14 years. Winter season flows within the lower watershed is several hundred times greater than summer, dry-season flow.

Average annual, winter and summer flow and rainfall for the last 15 years are expressed graphically in **Chart F.3.** Highest flows during the monitoring period at both gauging stations were recorded in WY05 (very wet year); the lowest in WY14 (very dry year). Water years '06, '07, '08, '12, '13, and '14 were all below normal, witnessing both below average rainfall and stream discharge. Water years '10, '11, '15, and '17 were slightly above normal in terms of total annual rainfall (verticle bars) and average daily streamflow (lines). WY19 witnessed above normal rainfall but below normal stream flow.

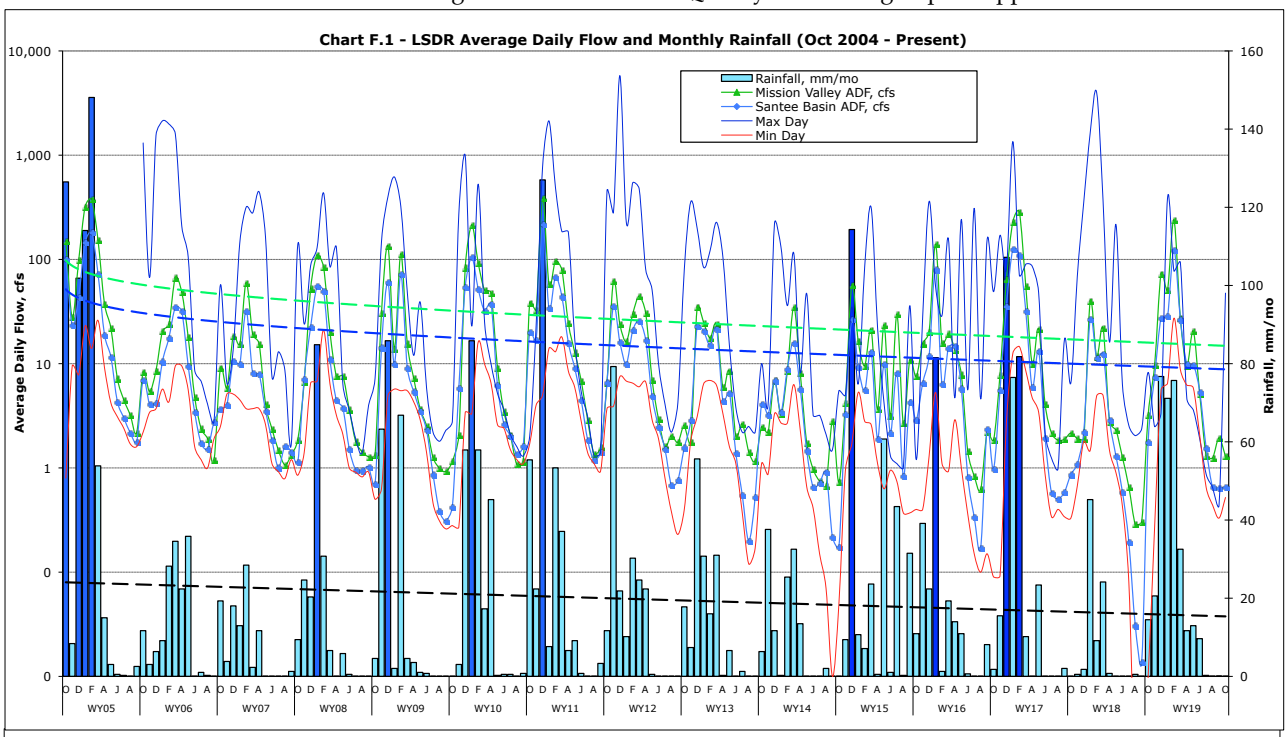


Chart F.1 - LSDR Average Daily Flow and Monthly Rainfall (Oct 2004 - Present)
Rainfall, mm/mo
Mission Valley ADF, cfs
Santee Basin ADF, cfs
Max Day
Min Day
Average Daily Flow, cfs
Rainfall, mm/mo
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18
WY19

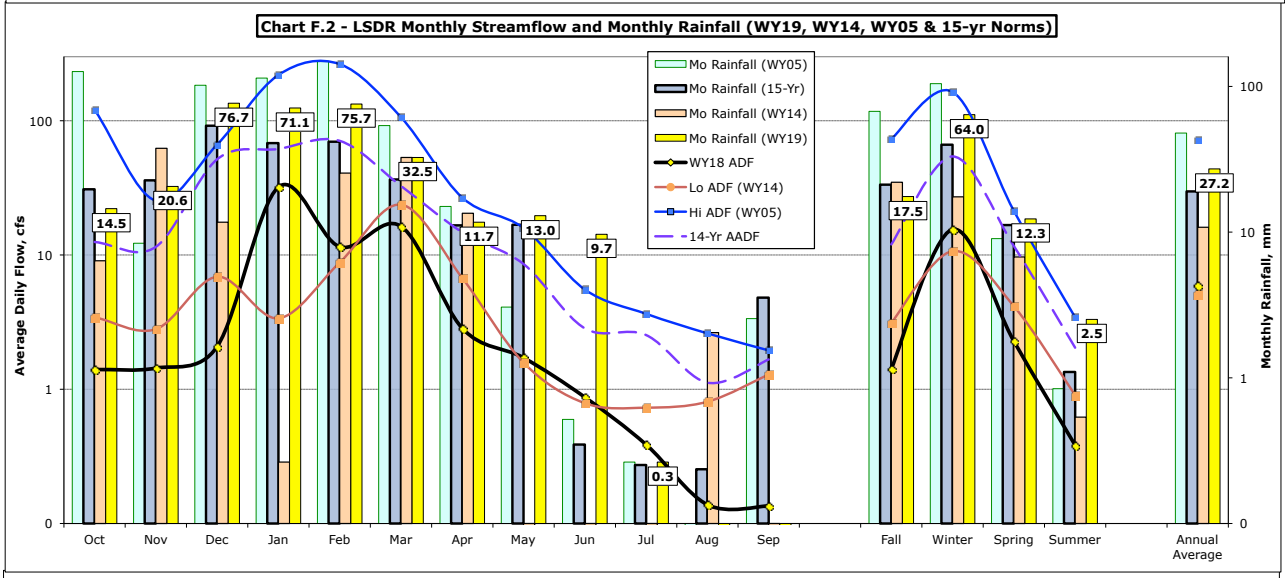


Chart F.2 - LSDR Monthly Streamflow and Monthly Rainfall (WY19, WY14, WY05 & 15-yr Norms)
Mo Rainfall (WY05)
Mo Rainfall (15-Yr)
Mo Rainfall (WY14)
Mo Rainfall (WY19)
WY18 ADF
Lo ADF (WY14)
Hi ADF (WY05)
14-Yr AADF
Average Daily Flow, cfs
Monthly Rainfall, mm
14.5
20.6
76.7
71.1
75.7
32.5
11.7
13.0
9.7
0.3
17.5
64.0
12.3
2.5
27.2
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Fall
Winter
Spring
Summer
Annual Average

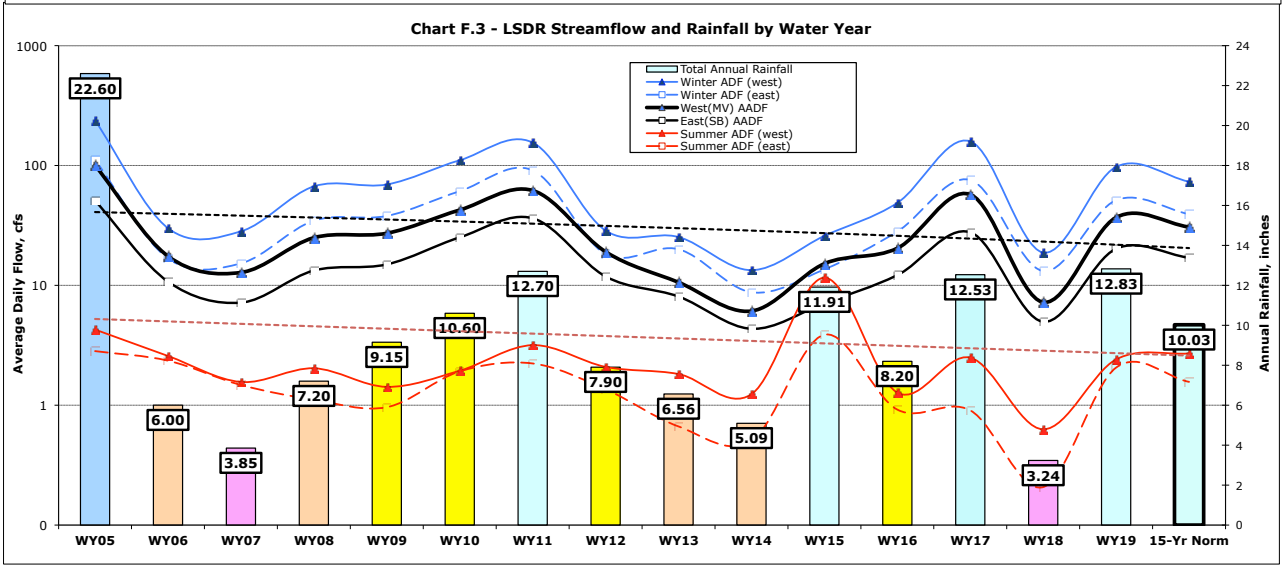


Chart F.3 - LSDR Streamflow and Rainfall by Water Year
Total Annual Rainfall
Winter ADF (west)
Winter ADF (east)
West(MV) AADF
East(SB) AADF
Summer ADF (west)
Summer ADF (east)
Average Daily Flow, cfs
Annual Rainfall, inches
22.60
6.00
3.85
7.20
9.15
10.60
12.70
7.90
6.56
5.09
11.91
8.20
12.53
3.24
12.83
10.03
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18
WY19
15-Yr Norm

Appendix G - WY19 LSDR Monthly WQM Site Data

Appendix G consists of ten tables listing WY19 RiverWatch water quality monitoring data by month and site. Tables G.1(W) and G.1(E) present water temperature recordings. Tables G.2 (W&E) Specific Conductance, Tables G.3 - pH, G.4 - Dissolved Oxygen Concentration and G.5- DO Percent of Saturation. Nutrient recordings at selected sites are not expressed in this report but are available for WY19 and previous years through the SDRPF RiverWatch coordinator.

Table G.1(W) West Section Water Temperature (WY19 Readings)

Site #	1	2	3	4	5	6	7
Reach	Lower Mission Valley				Upper Mission Valley		
Oct	19.5	18.6	18.6	19.1	15.3	16.6	16.3
Nov	18.9	16.1	15.2	15.6	12.4	12.8	12.2
Dec	15.9	14.5	14.5	14.3	13.7	13.8	13.9
Jan	15.3	14.8	15.0	14.4	13.4	14.1	14.1
Feb	14.3	14.1	13.9	13.7	13.8	13.9	13.7
Mar	16.2	16.1	16.1	15.8	14.4	15.0	14.8
Apr	21.3	20.6	21.3	21.0	19.8	20.6	20.2
May	20.6	20.8	20.7	20.9	20.0	20.6	20.2
Jun	22.2	21.8	22.2	22.2	20.6	22.0	21.1
Jul	25.9	24.2	24.5	25.6	20.6	23.4	23.6
Aug	25.2	23.8	24.2	25.3	20.2	22.8	23.9
Sept	25.2	23.0	23.3	23.8	18.6	21.1	22.3
WY19	**20.04**	**19.03**	**19.13**	**19.31**	**16.90**	**18.06**	**18.03**
15-yr	*19.62*	*19.0*	*19.2*	*19.7*	*17.2*	*18.3*	*18.0*

a) All values expressed in °C; WY19 averages greater than 15-yr norms (in parenthese) are shown in red; below in blue.
b) Water year results are based on unweighted averaging of monthly data (Oct- Sept); temps >22oC in tan cells, values < 15oC within blue.

Table G.1(E) Mid and East Section Water Temperature (WY19 Readings)

Site	8	9T	10	11	12T	13	14	15T
Reach	Mission Gorge			Lower Santee Basin		Upper Santee Basin		LSB [c]
Oct	17.4	12.4	15.2	15.3	-	17.0	17.3	15.3
Nov	15.3	9.7	10.7	12.9	15.60	13.5	13.0	11.2
Dec	11.3	12.8	12.3	13.4	14.6	13.0	14.0	12.5
Jan	13.7	13.6	14.0	14.6	15.4	18.2	13.6	15.1
Feb	13.6	13.7	13.5	13.4	15.4	14.0	14.5	15.0
Mar	13.2	10.9	13.8	13.2	15.5	14.6	15.3	13.6
Apr	18.8	15.8	18.1	17.2	21.10	17.7	20.8	20.0
May	18.2	15.3	18.2	17.8	20.00	19.2	20.5	19.3
Jun	21.2	18.8	21.0	19.7	22.70	21.7	23.9	21.2
Jul	22.7	19.7	23.1	20.5	-	23.2	25.8	22.2
Aug	22.6	19.4	22.7	20.5	-	22.6	-	22.0
Sep	19.6	16.1	20.2	18.9	-	20.9	22.70	19.9
WY19[b]	**17.30**	**14.85**	**16.90**	**16.45**	**17.54**	**17.97**	**18.31**	**17.28**
Norm	*17.11*	*15.75*	*17.68*	*16.69*	*17.74*	*18.42*	*17.46*	*18.05*

a) All values expressed in oC; WY18 values greater than 14-yr norms are shown in red; below in blue.
b) Water year WY19 and 15-yr values are based on unweighted averaging monthly data (Oct-Sept); temps >22oC in tan cells, <15oC blue cells.
c) Forester Creek discharges within the Lower Santee Basin section beyond Carlton Hills Golfcourse just upstream of Site 11.

Table G.2(W) West Section Specific Conductance (WY19 Readings)

Site #	1	2	3	4	5	6	7
Reach	Lower Mission Valley				Upper Mission Valley		
Oct	4.85	3.66	3.16	2.80	3.35	4.13	3.01
Nov	16.40	3.83	3.17	2.86	4.19	4.18	2.96
Dec	4.19	1.86	1.77	1.86	1.98	1.69	1.93
Jan	1.06	0.86	0.92	1.01	1.13	1.04	1.13
Feb	1.09	0.64	0.65	0.66	0.61	0.60	0.61
Mar	1.54	1.53	1.50	1.57	1.59	1.46	1.45
Apr	2.94	2.45	2.35	2.31	1.77	2.12	2.12
May	2.65	2.47	2.38	2.42	2.35	2.34	2.12
Jun	3.93	2.61	2.51	2.46	2.49	2.15	2.34
Jul	10.15	3.19	3.12	2.96	3.20	2.70	3.09
Aug	11.03	3.60	3.51	3.20	3.53	3.16	3.20
Sep	9.74	3.86	3.64	3.21	3.54	3.57	3.08
Avg [b]	**5.797**	**2.547**	**2.390**	**2.277**	**2.477**	**2.429**	**2.253**
Norm	*8.422*	*2.635*	*2.540*	*2.455*	*2.593*	*2.592*	*2.469*

a) All values expressed in milli-Siemens/cm; values >4.0 are in tan cells, values < 2.0 uS/cm are in blue cells.
b) WY19 annual average values greater than 15-yr norms are in red; blue values below.

Table G.2(E) Mid and East Section Specific Conductance (WY19 Readings)

Site	8	9T	10	11	12T	13	14	15T
Reach	Mission Gorge			Lower Santee Basin		Upper Santee Basin		LSB [c]
Oct	2.35	4.72	1.91	3.03	-	2.57	1.84	2.73
Nov	3.20	4.99	3.27	2.87	2.124	2.55	1.78	3.02
Dec	2.23	4.38	2.22	2.16	1.84	1.73	1.53	2.76
Jan	1.54	2.84	1.60	1.21	1.50	1.96	1.13	0.69
Feb	0.50	1.10	0.42	0.57	0.23	0.50	0.43	1.26
Mar	1.25	3.00	1.26	1.48	0.76	1.11	0.97	2.48
Apr	1.90	4.25	1.96	1.84	0.920	1.57	1.31	2.51
May	1.83	2.75	1.87	1.44	1.010	1.66	1.46	1.07
Jun	2.26	4.53	2.32	2.49	1.300	1.87	1.58	2.82
Jul	2.58	4.81	2.66	2.82	-	2.09	1.64	2.92
Aug	2.93	5.04	2.95	2.88	-	2.32	-	2.93
Sep	3.80	5.19	2.99	3.37	-	2.39	1.300	2.88
Avg [b]	**2.197**	**3.966**	**2.120**	**2.180**	**1.211**	**1.860**	**1.361**	**2.339**
Norm	*2.321*	*4.820*	*2.257*	*2.241*	*1.653*	*1.922*	*1.504*	*2.697*

a) All values expressed in milli-Siemens/cm; WY19 values greater than 15-yr norms are in red, below in blue.
b) WY19 and 15-yr values based on averaging of monthly data (Oct-Sept); cells in blue <2.0, cells in tan >4 uS/cm
c) Forester Creek discharges within the Lower Santee Basin enter SDR beyond the west end of Carlton Hills Golf Course.

Table G.3(W) West Section pH (WY19 Readings)

Site #	1	2	3	4	5	6	7
Reach	Lower Mission Valley				Upper Mission Valley		
Oct	9.05	8.57	8.75	8.89	8.74	8.74	8.29
Nov	7.58	7.40	7.58	7.66	7.43	7.45	7.23
Dec	7.43	7.45	7.65	7.55	7.98	7.59	7.60
Jan	8.07	7.51	7.66	7.75	7.61	7.56	7.47
Feb	7.71	7.78	7.80	7.65	7.65	7.69	7.50
Mar	7.94	7.82	7.93	7.84	7.62	7.63	7.52
Apr	7.86	7.73	7.87	7.77	7.66	7.56	7.29
May	8.07	7.94	8.04	7.95	7.79	7.69	7.65
Jun	8.20	8.08	8.20	8.14	8.04	7.98	7.57
Jul	7.99	7.64	7.83	7.83	7.55	7.49	7.59
Aug	8.04	7.62	7.83	7.87	7.43	7.39	7.35
Sep	7.98	7.59	7.83	7.90	7.48	7.49	7.39
Avg [b]	**7.99**	**7.76**	**7.91**	**7.90**	**7.75**	**7.69**	**7.54**
Norm	*7.75*	*7.68*	*7.76*	*7.78*	*7.62*	*7.62*	*7.55*

a) All values are unit-less; monthly values above 8 in tan cells, and above 8.5 in brown.
b) WY19 and 15-yr annual average values based on averaging monthly results (Oct-Sept); annual averages >15-yr norms are shown in blue; below norms in red.

Table G.3(E) Mid and East Section pH (WY19 Readings)

Site	8	9T	10	11	12T	13	14	15T
Reach	Mission Gorge			Lower Santee Basin		Upper Santee Basin		LSB [c]
Oct	8.01	9.03	8.74	-	-	8.26	9.00	8.84
Nov	6.71	8.16	7.24	7.47	7.43	7.04	7.49	7.55
Dec	7.97	8.31	7.50	7.46	7.78	7.37	7.66	7.65
Jan	7.87	8.13	7.90	7.54	7.94	7.50	7.60	7.67
Feb	7.44	7.94	7.48	7.26	7.20	7.35	7.44	7.89
Mar	8.06	8.57	7.71	7.57	8.25	7.43	8.00	8.29
Apr	7.94	7.99	7.51	7.14	8.04	7.40	7.92	7.98
May	8.13	8.50	7.62	7.39	8.53	7.85	7.01	8.31
Jun	8.08	8.47	7.70	7.20	8.52	8.08	8.43	8.42
Jul	7.50	8.41	7.72	7.65	-	7.41	7.97	7.80
Aug	7.06	8.17	7.47	7.60	-	7.35	-	7.70
Sep	7.40	8.18	7.98	7.60	-	7.32	7.72	7.75
Avg [b]	**7.68**	**8.32**	**7.71**	**7.44**	**7.96**	**7.53**	**7.84**	**7.99**
Norm	*7.66*	*7.83*	*7.82*	*7.55*	*7.93*	*7.66*	*7.82*	*8.05*

a) All values are unit-less; manthly values above 8 in tan cells, and above 8.5 in brown.
b) WY19 annual average and 15-yr norms are based on averaging of monthly data (Oct-Sept); averages > 15-yr norms are shown in blue; belwo norms in red.
c) Forester Creek discharges within the Lower Santee Basin section of the river downstream of Carlton Oaks Golf course; just upstream of Site 11.

Table G.4(W) West Section Dissolved Oxygen Concentration (WY19 Readings)

Site #	1	2	3	4	5	6	7
Reach	Lower Mission Valley				Upper Mission Valley		
Oct	10.95	0.81	2.30	9.44	5.46	0.59	2.68
Nov	6.08	4.26	4.11	6.88	4.62	2.83	3.97
Dec	6.28	7.24	8.17	8.85	6.42	7.82	7.47
Jan	5.21	5.60	5.30	6.57	7.03	5.45	6.86
Feb	8.95	8.57	9.80	8.67	8.46	8.67	10.16
Mar	9.23	9.49	10.43	11.19	7.97	8.32	9.89
Apr	4.75	3.83	3.31	4.83	4.61	4.87	3.53
May	3.51	3.45	3.03	4.00	3.38	3.31	4.00
Jun	4.97	3.17	2.06	4.69	3.18	0.65	2.76
Jul	7.53	2.95	2.72	4.30	2.06	0.16	3.45
Aug	7.52	2.11	3.11	3.67	1.61	0.07	3.94
Sep	6.80	1.82	2.31	4.58	1.37	0.10	2.77
Avg.	**6.82**	**4.44**	**4.72**	**6.47**	**4.68**	**3.57**	**5.12**
Norm	*6.12*	*4.38*	*4.60*	*6.10*	*4.77*	*3.56*	*5.00*

a) All values expressed in milligrams/liter and (Percent of Saturation); WY19 and 15-yr averages less than 5 mg/L (DO depletion threshold) shown in red, less than 2.5 mg/L (hypoxic level) cells highlighted in light yellow and <1.0 mg/L (exaerobic zone) in dark yellow.

Table G.4(E) Mid and East Section Dissolved Oxygen Concentration (WY19 Readings)

Site	8	9T	10	11	12T	13	14	15T
Reach	Mission Gorge			Lower Santee Basin		Upper Santee Basin		LSB [c]
Oct	8.44	10.29	3.83	3.61	-	0.11	1.45	4.21
Nov	4.02	12.09	9.45	5.79	6.67	0.63	2.88	6.75
Dec	8.38	11.12	10.34	6.65	7.12	1.29	2.71	6.02
Jan	10.70	10.49	7.08	7.21	8.04	2.21	5.58	7.22
Feb	10.57	9.87	11.16	8.08	8.70	2.77	6.75	9.69
Mar	12.79	14.74	8.74	8.46	12.09	2.22	11.48	9.38
Apr	5.50	7.21	5.26	4.24	6.06	1.28	4.47	3.69
May	6.17	7.00	5.00	3.63	5.48	1.31	3.03	3.03
Jun	6.05	9.56	6.52	5.12	7.60	0.59	2.87	4.47
Jul	4.38	9.05	5.38	4.80		0.23	2.69	3.36
Aug	1.77	8.32	3.19	4.23		0.08		3.45
Sep	3.30	6.63	1.82	3.36		0.13	1.54	3.02
Avg [b]	**6.84**	**9.70**	**6.48**	**5.43**	**7.72**	**1.07**	**4.13**	**5.36**
Norm	*7.27*	*9.18*	*7.05*	*5.88*	*7.08*	*2.94*	*3.31*	*7.43*

a) All values expressed in milligrams/liter; WY19 values less than 5 mg/L (DO depletion threshold) are expressed in red ,< 2.5 mg/L (hypoxic level) cells highlighted in light yellow and <1 mg/L (exaerobic zone) dark yellow.
b) WY19 and 15-yr values are based on averaging of monthly data (Oct-Sept).
c) Tributary discharges within the Lower Santee Basin reach enter below the west end of Carlton Oaks Golf Course.

Table G.5(W) West Section DO Percent of Saturation (WY19 Readings)

Site #	1	2	3	4	5	6	7
Reach	Lower Mission Valley				Upper Mission Valley		
Oct	121	9	25	103	55	6	28
Nov	66	43	41	70	48	27	37
Dec	62	72	81	87	63	76	72
Jan	53	56	53	66	69	54	67
Feb	88	84	96	85	82	85	99
Mar	95	97	107	115	79	84	99
Apr	54	43	38	55	51	57	39
May	40	39	34	45	38	38	45
Jun	57	36	25	55	36	7	32
Jul	91	35	33	53	23	2	42
Aug	98	25	37	43	18	1	47
Sep	77	21	27	55	15	1	32
Avg.	**75.1**	**46.8**	**49.9**	**69.4**	**48.0**	**36.5**	**53.3**
Norm	*66.9*	*45.8*	*48.4*	*65.6*	*48.7*	*36.5*	*51.5*

a) All values expressed as percent of saturation; WY19 values < 55% (DO depletion threshold) are expressed in red ,< 25% (hypoxic level) cells highlighted in light yellow and <10% (exaerobic zone) dark yellow.

Table G.5(E) Mid and East Section DO Percent of Saturation (WY19 Readings)

Site	8	9T	10	11	12T	13	14	15T
Reach	Mission Gorge			Lower Santee Basin		Upper Santee Basin		LSB [c]
Oct	90	98	38	37	-	1	15	43
Nov	43	107	86	56	68	7	28	62
Dec	78	105	98	65	61	13	27	57
Jan	104	102	70	72	81	24	55	73
Feb	102	96	109	78	88	30	67	97
Mar	123	135	85	81	122	22	117	91
Apr	60	75	56	45	70	15	51	41
May	66	71	54	39	61	14	34	33
Jun	69	104	74	57	87	7	34	51
Jul	52	100	63	54	-	3	32	39
Aug	21	96	38	48	-	1	-	40
Sep	37	68	20	37	-	1	3	33
Avg [b]	**70.3**	**96.5**	**66.0**	**55.6**	**79.8**	**11.5**	**42.0**	**55.2**
Norm	*74.0*	*93.2*	*73.3*	*59.2*	*71.6*	*30.3*	*33.0*	*70.9*

a) All values expressed as percent of saturation; WY19 values < 55% (DO depletion threshold) are expressed in red ,< 25% (hypoxic level) cells highlighted in light yellow and <10% (exaerobic zone) dark yellow.

b) WY19 and 15-yr values are based on averaging of monthly data (Oct-Sept).

c) Tributary discharges within the Lower Santee Basin reach enter below the west end of Carlton Oaks Golf Course.

Appendix H - Water Quality Indexing

The Lower San Diego River (LSDR) Water Quality Index (WQI) has been developed for the purpose of providing a simple and concise expression of regularly monitored physical-chemical and bacteriological water quality data compiled by the SDRPF RiverWatch Team and others. The index is intended to aid in assessment of the LSDR watershed primarily for non-body contact recreational uses and environmental enhancement. As designed, the metric constitutes a means to compare averages, variances and trends in normalized values over time (temporally) and by relative location (spatially) within the watershed. The index allows one to interpret large amounts of aggregated data and relate overall water quality variations to changes, be they from natural causes or anthropogenic impairment. The WQI has been used to identify general water quality trends over the past 15 years of monitoring and potential problem areas within the LSDR watershed. Such patterns and locations are then screened and evaluated in greater detail through direct observation of pertinent site-specific data by public agencies and water quality professionals entrusted with protection and enhancement of the environment. Used in this manner, the index provides an additional metric for evaluating effectiveness of some of the San Diego River water quality improvement programs and may also assist responsible agencies and organizations in reformulating priorities or updating specific policies for improved watershed management.

Running average WQI values from WY05 through WY19 are expressed by river section and reach on charts H.1 and H.2, respectively. The overall temporal varience in WQI values and stream flow is expressed in Chart H.3. The spacial variance in index values for the lower river monitoring sites is shown on Chart H.4.

Chart H.1 provides the range (max-min) in monthly values, the running averages by river section as well as monthly streamflow over the 15-yr period of RiverWatch monitoring. The correlation in seasonal variances between streamflow and water quality are clearly shown. As are the general trends of lower quality at all sites in years of below average stream discharge. The overall decline in the index over 15 years is shown as a dashed line. Although the overall rate of decline in the index is on the order of 1.5 percent per year; WY19 witnessed a considerable recovery from last year's near-minimum lows. The current running average index of 29 is only five percent below the 15-year norm of 31.

Chart H.2 presents overall (LSDR) monthly WQI values over the 15-year period. Cyclic seasonal patterns expressed in monthly results and trends described by running averages in values are apparent for each reach of the river. The water quality fluctuations over time in individual reaches, sections and the overall LSDR flow-weaighted values expressed on both a running average and seasonal cycle basis can be observed. The Upper Santee Basin (USB) reach (sites 13&14) have shown the lowest index values since March of 2010, whereas Mission Gorge (mid-section of the lower river) consistently carries the highest index values. It can also be noted (in both charts) that the greatest rate of decline in lower river water quality over the three year period WY12 through occured during a period of well-below normal stream flow.

Chart H.3 presents a temporal summary of variances in the water quality index values profiled on a monthly, seasonal and average annual water year basis for the five river reaches and the overall flow-weighted LSDR averages. The variances in WQI can be visually compared to changes in streamflow (blue bars) on the same basis. The positive correlations are easy to see, i.e., increased average daily flow results in improved water quality metrics. Low flow throughout the summer period results in much poorer water quality. This year's above average dry-weather flow, extending from early April through the end of September, resulted in measurable improvements in index values for all five reaches of the lower river system from last year (WY18) results.

Chart H.4 provides a spatial profile of average annual WQI by river monitoring site, reach and section for this year (WY19), compared to the best (WY05), the worst (WY14) and 15-yr winter, summer and annual norms. The sites are in the order they occur ascending upstream. The current (WY19) average annual WQI values for each site, shown as a heavy black line, remain slightly below annual norms (colored bars) at five upstream site sites (8,10,11,13 and 15). The sites with poorest water quality both in WY19 and over the years include Kaiser Ponds (6), Mast Park (13) and Magnolia/RCP (14). For the seventh consecutive year, the Upper Santee Basin reach (sites 13 and 14) has experienced the poorest water quality in the Lower SDR watershed. The Mission Gorge reach (sites 8-10) continues to demonstrate best overall water quality. The 15-yr winter and summer WQI profiles are displayed in order to provide a basic appreciation of the broad range in index values occuring along the river from entrance to the estuary in lower Mission Valley to the upper portions of the Santee Basin.

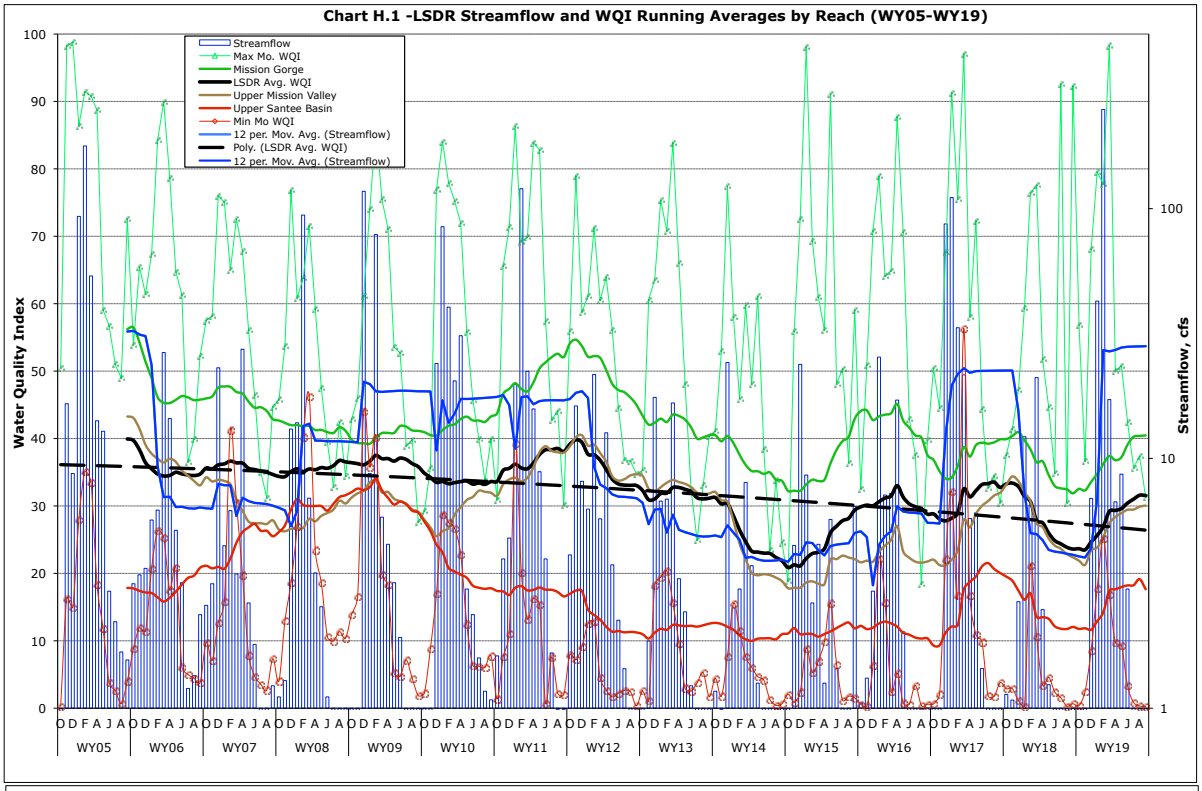


Chart H.1 -LSDR Streamflow and WQI Running Averages by Reach (WY05-WY19)
Streamflow
Max Mo. WQI
Mission Gorge
LSDR Avg. WQI
Upper Mission Valley
Upper Santee Basin
Min Mo WQI
12 per. Mov. Avg. (Streamflow)
Poly. (LSDR Avg. WQI)
12 per. Mov. Avg. (Streamflow)
Water Quality Index
Streamflow, cfs
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18
WY19

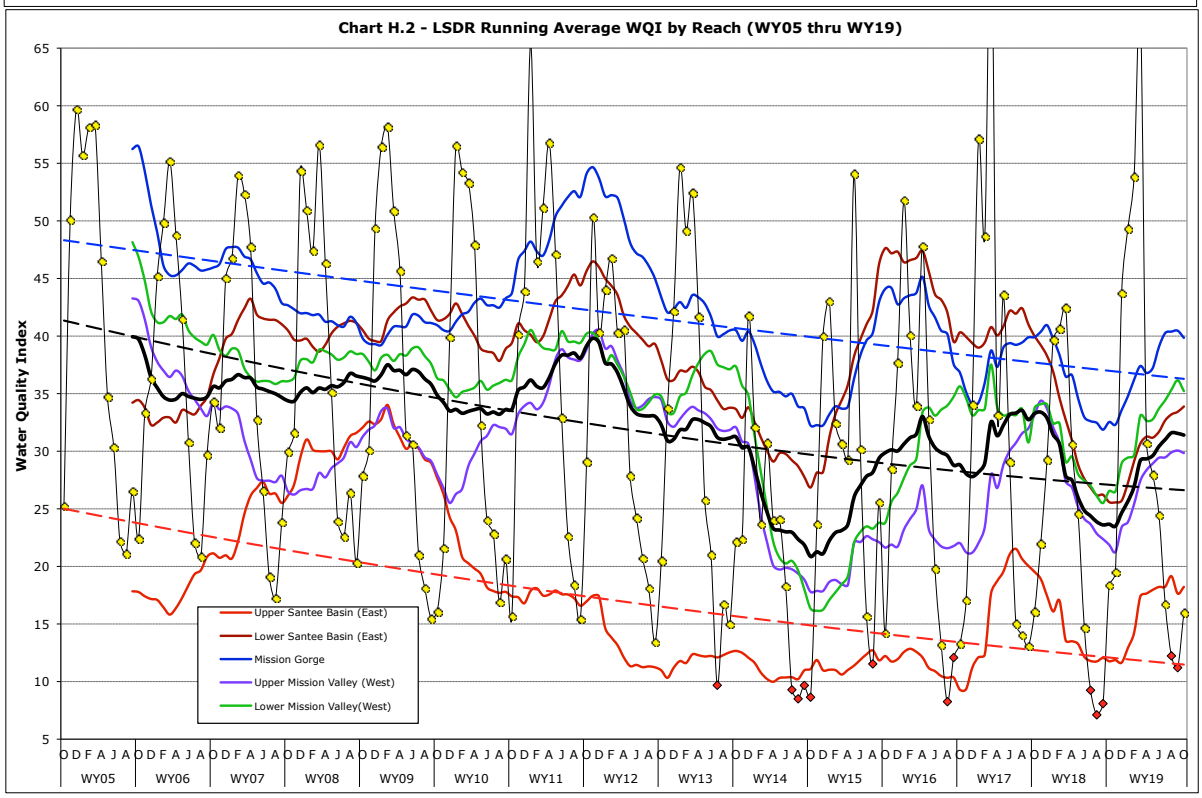


Chart H.2 - LSDR Running Average WQI by Reach (WY05 thru WY19)
Upper Santee Basin (East)
Lower Santee Basin (East)
Mission Gorge
Upper Mission Valley (West)
Lower Mission Valley(West)
Water Quality Index
WY05
WY06
WY07
WY08
WY09
WY10
WY11
WY12
WY13
WY14
WY15
WY16
WY17
WY18
WY19

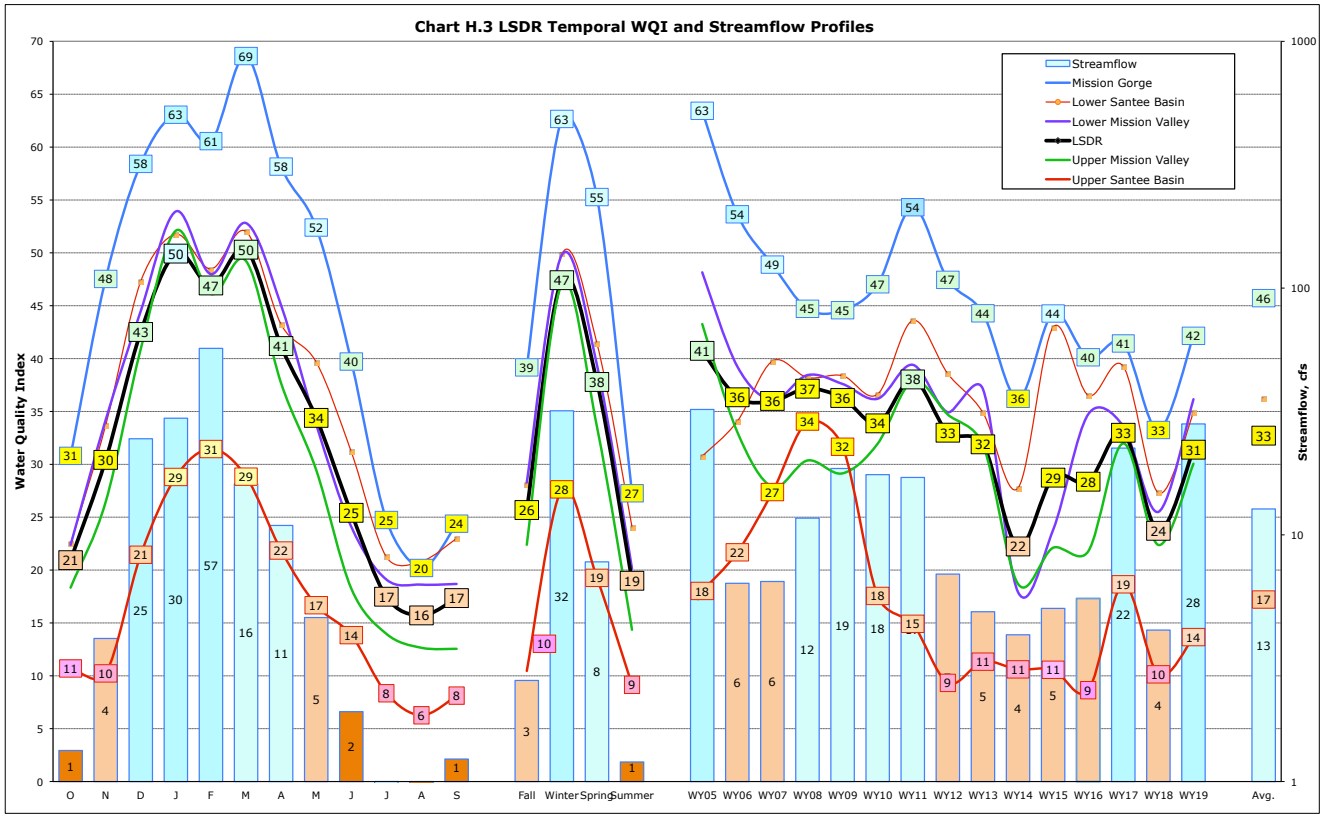


Chart H.3 LSDR Temporal WQI and Streamflow Profiles
Water Quality Index
Streamflow, cfs
Streamflow
Mission Gorge
Lower Santee Basin
Lower Mission Valley
LSDR
Upper Mission Valley
Upper Santee Basin
O N D J F M A M J J A S
Fall Winter Spring Summer
WY05 WY06 WY07 WY08 WY09 WY10 WY11 WY12 WY13 WY14 WY15 WY16 WY17 WY18 WY19
Avg.

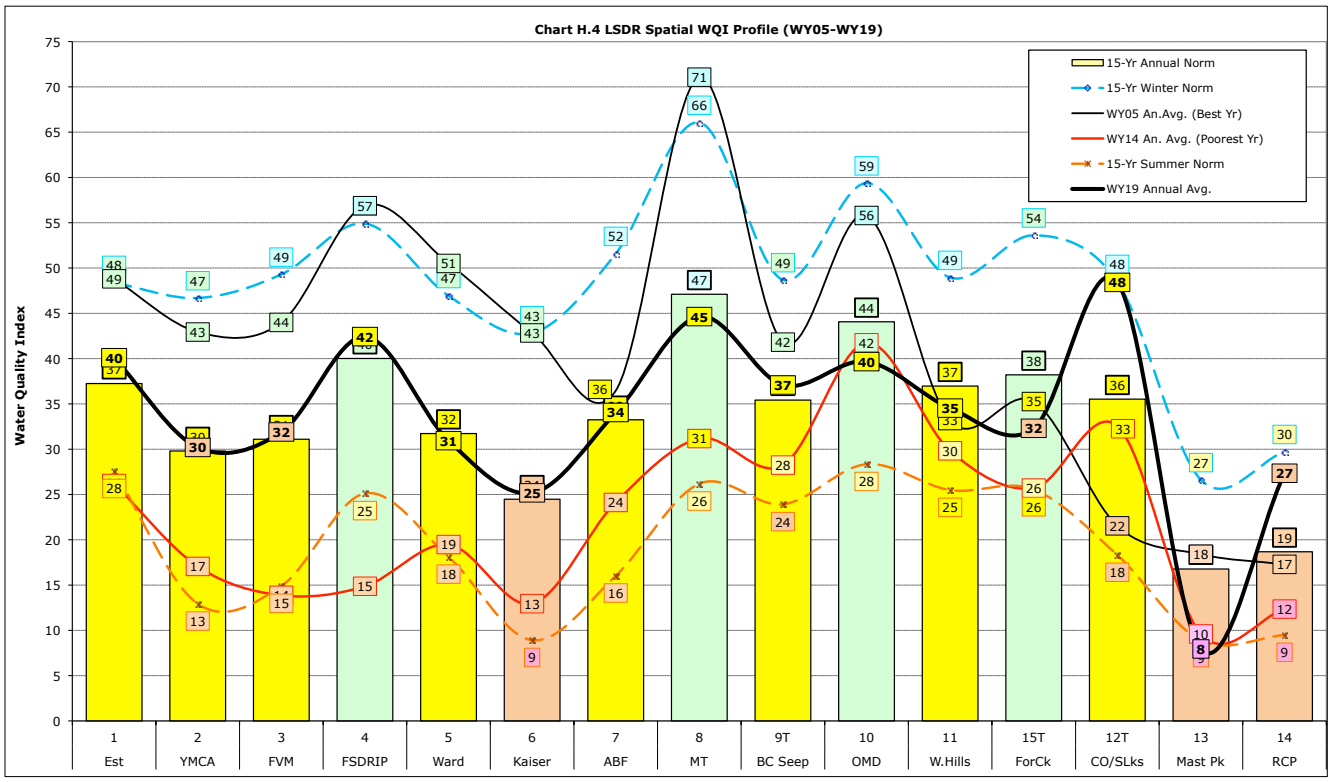


Chart H.4 LSDR Spatial WQI Profile (WY05-WY19)
Water Quality Index
15-Yr Annual Norm
15-Yr Winter Norm
WY05 An.Avg. (Best Yr)
WY14 An. Avg. (Poorest Yr)
15-Yr Summer Norm
WY19 Annual Avg.
1 Est
2 YMCA
3 FVM
4 FSDRIP
5 Ward
6 Kaiser
7 ABF
8 MT
9T BC Seep
10 OMD
11 W.Hills
15T ForCk
12T CO/SLks
13 Mast Pk
14 RCP