LOWER SAN DIEGO RIVER
WATER QUALITY 2011

WY11 Water Quality Monitoring Report

RiverWatch Water Quality Monitoring Results (October 2010 - September 2011)

John C. Kennedy, PE

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Lower San Diego River Water Quality - 2011

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Section 1
Introduction

This report provides a summary of patterns and trends in water quality monitoring results gathered by SDRPF's RiverWatch citizen volunteers. WQM data collected monthly over the past 7 years at 15 sites within the Lower San Diego River (LSDR) watershed have been aggregated, in conjunction with hydrologic data on stream flows and coliform counts, to 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 excel database available at the SDRPF offices; this report examines Water Year 2011 (WY11) data in comparison to previous annual results. The WQI presented herein was developed specifically for SDRPF's RiverWatch Program although it can also be applied to other coastal watercourses as discussed in Section 5. The WQI is also presented on the RiverWatch web portal (Ecolayers) following data collection and analysis for each monitoring site. The LSDR watershed and water quality monitoring site locations are shown on **Fig 1.1** at the end of this section.

SDRPF's RiverWatch monitoring team's water quality index (WQI) represents an imperfect answer to general questions regarding water quality in the Lower San Diego River. The index constitutes a unit-less number ranging from 1 to 100; where higher values are indicative of better water quality. The numerical index expresses basic physical, chemical and bacteriological water quality data by integrating values on five key water quality parameters (Temp, pH, SpC, DO and MCC) combined with stream flow (ADF) through determination of 'Q-factors' (numerical ratings) for each. The resulting values have then been aggregated to arrive at a score ranging from 0-100 for each river monitoring site, reach, section and an overall (LSDR) average. The SDR WQI values, grade, color codes and general conventions employed are presented in **Table 1.1.**

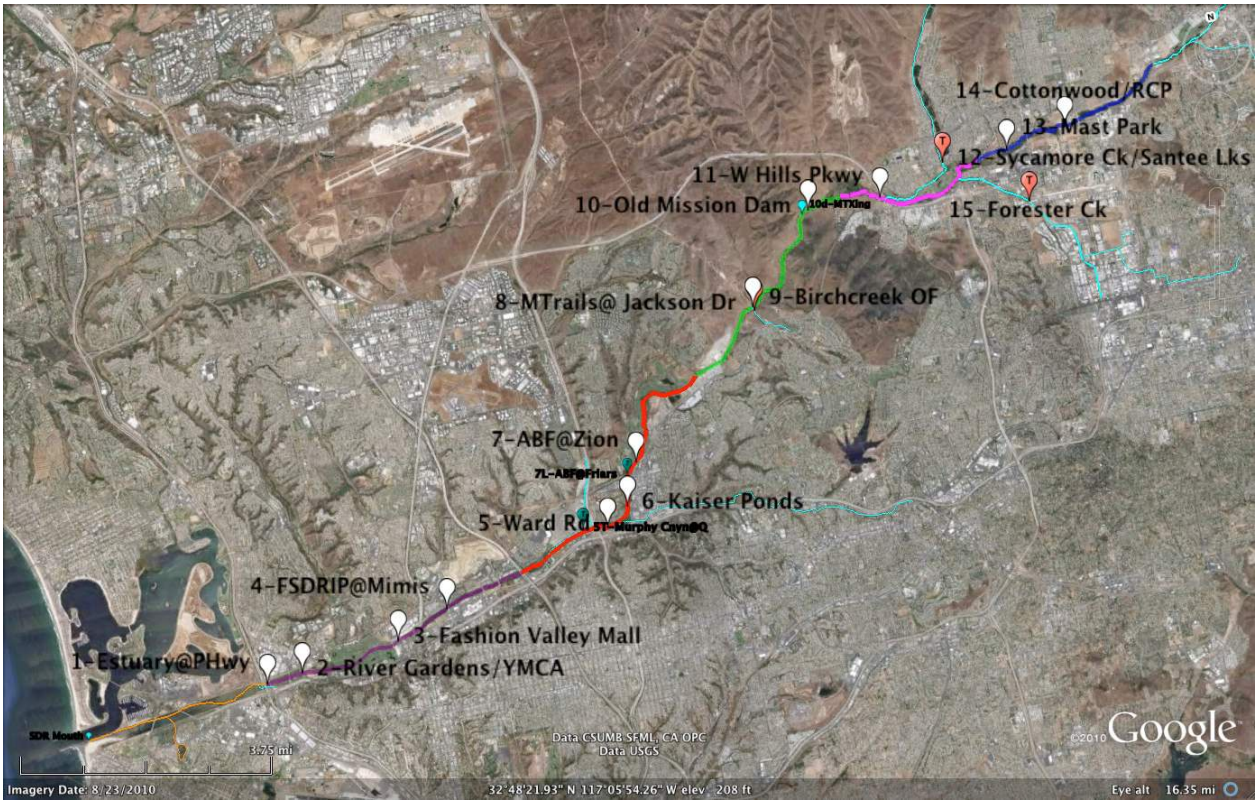
Table 1.1 LSDR Water Quality Index

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	Optimal (>50)
50 - 74	B - Good	Light Blue	25%	Exceeds Acceptable Criteria	
35 - 49	C - Fair	Green	15%	Meets Criteria	Intermediate (25-49)
25 - 34	D - Marginal	Yellow	10%	Meets Some Minimum Criteria	
10 - 24	E - Poor	Brown	15%	Meets Few Minimum Criteria	Sub-Standard(< 24)
0 - 9	F - Very Poor	Red	10%	Falls Well Below Minimum Criteria	

In general, sites scoring 50 or above exceed expectations for acceptable water quality and are indicative of 'Optimal' conditions. Scores between 25 and 50 indicate 'Intermediate' quality levels where some concerns exist regarding minimum acceptable criteria. Water quality at sites or sections with scores below 25 do not meet minimum criteria and are considered 'Sub-Standard'. or below minimum acceptable expectations. For WQ parameters monitored by RiverWatch, the index expresses results relative to generally acceptable levels required to maintain beneficial water uses based on State of California Water Quality Standards. Where criteria are non-specific, (i.e., stream flow) results are expressed relative to norms for southern California coastal watercourses.

The WQI has been computed by two different methods; one using 4 key WQ parameters (Temp, SC and DO) monitored by RiverWatch combined with stream flow (Q), the second using 2 additional WQ parameters (pH and MCC) that are also combined with stream flow (Q). The equations used for both WQIs (WQI_4 & WQI_6) are presented in Appendix E. Value differences between the two determinations are small, however, the first determination (WQI_4) typically presents a broader range (from low to high value) than the second (WQI_6) as the 'normalizing' effect of pH and MCC (both of which present less spatial and temporal variance) are not considered in computing WQI_4. When neither WQI_4 or WQI_6 is indicated, the values shown represent an average (WQI_a) of the two.

Figure 1-1 LSDR Watershed and Water Quality Monitoring Sites



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

Figure 1.1 can be viewed in greater detail through Google Earth by accessing file "Fig1.1WQMR.kmz" from the SDRPF website/River Monitoring page at: http://www.sandiegoriver.org/riverwatch.php>. The RiverWatch monthly water quality monitoring data at each site, as well as associated WQI values, are also provided on this webpage at: http://www.ecolayers.biz/sdrpf%2Driverwatch/> through clicking on access to 'Web-based Information Center'. In addition to water quality monitoring data, the portal also contains: River Blitz data, SDR Conservancy Project information, SD StreamTeam Bio-assessment data, 401 Project information and USGS realtime stream flow data on daily peak discharge and gauge height for San Diego River stations.

Section 2 - LSDR Spatial Water Quality Data WY11

Average annual water quality data for each of the LSDR monitoring sites (15) for WY 2011 are summarized in **Table 2.1**. Monthly water quality data collected and recorded at each site by RiverWatch are presented in Appendix C. Supplemental LSDR data collected by other monitoring organizations pertaining to streamflow (USGS) and coliform counts (SD CoastKeepers) are presented in Appendix D.

Table 2.1 LSDR Average Annual WQ Values by Individual Monitoring Site for WY11

Site:	*Reach & Section*		*oC*	*mS/cm*	*unit*	*mg/L*	*% Sat*	*cfs*	*#/100ml*	*Value & grade*	
1	LMV	West	18.7	3.861	7.80	6.60	70	33	549	44-47	C
2			18.7	2.390	7.74	5.00	53	33		36-42	
3			18.9	2.291	7.74	4.79	50	33		35-41	
4			19.0	2.214	7.78	5.78	61	32		42-46	
5	UMV		17.5	2.447	7.76	5.13	53	28	483	36-44	
6			18.3	2.413	7.76	4.49	47	27		34-42	
7			18.3	2.389	7.73	6.07	63	23		45-47	
8	MG	Mid	17.2	2.178	7.94	8.59	89	18	416	62-55	B
9T			14.7	4.912	8.14	9.80	102	2	232	64-50	B
10			18.0	2.113	8.12	7.15	75	13	324	52-48	C+
11	LSB	East	16.6	2.226	7.54	6.49	67	13	278	46-47	
12T			18.1	1.540	8.13	7.43	79	2	232	55-52	B-
15T			17.1	2.770	8.14	7.20	75	4	278	24-32	D
13	USB		18.0	1.796	7.81	1.68	17	7	232	48-45	C
14			17.9	1.568	8.03	3.28	34	3		13-26	E
(1-15)	**LSDR**		**17.9**	**2.253**	**7.85**	**5.55**	**58**	**23**	**416**	**40-43**	**C**

a) Streamflows are gauged by USGS at Fashion Valley (Sta. 11023000) and Mast Rd. near Santee (Sta. 11022480).

b) Mean coliform count (geometric mean of fecal coliform, E-coli and total coliform results) as monitored by SD CoastKeepers.

c) Range in calculated values based on four RiverWatch physical-chemical parameters (WQI_4) and expanded six parameter determination (WQI_6) including bacteriological and pH data. First value listed is WQI_4; the second WQI_6..

Average annual, seasonal and minimum-to-maximum range water quality values for WY11 are summarized in **Table 2.2** by river reach and section. The overall spatial water quality values presented in the two tables for the Lower San Diego River system are also expressed in **Charts 2.1** (Water Quality Data) and **2.2** (Water Quality Index and Streamflow).

Table 2.2 LSDR Average Annual Water Quality Values by Reach and Section for WY11

Parameter		Temp	SC	pH	DO	DO%	Flow	MCC[a)]	WQI[b)]	
LSDR:		*oC*	*mS/cm*	*unit*	*mg/L*	*%Sat*	*cfs*	*#/100ml*	*Value & Grade*	
Maximum Mo.		22.4	3.480	8.24	9.35	89	141	1120	67-60	B
Winter (D,J,F,M)		13.8	1.653	7.92	7.37	72	51	466	53-53	B-
Annual Average		**17.9**	**2.253**	**7.85**	**5.55**	**58**	**23**	**416**	**40-43**	**C**
Summer (J,J,A,S)		21.9	2.989	7.83	3.82	44	3.0	262	24-31	D
Minimum Mo.		12.6	1.109	7.53	2.68	30	1.5	121	17-25	E
Section Averages:										
East	SB	17.5	2.253	7.86	4.56	47	13	282	33-38	C
Mid	MG	17.0	2.145	8.03	7.87	82	18	416	57-52	B
West	MV	18.5	2.553	7.76	5.39	57	23	549	39-45	C
Reach Averages:										
USB	East	18.0	1.720	7.89	2.21	23	13	232	17-28	D-
LSB		17.1	2.295	7.84	6.90	72	18	324	49-47	C+
MG	Mid	16.6	2.145	8.03	7.87	82	23	416	57-52	B
UMV	West	18.0	2.416	7.75	5.23	55	28	483	38-46	C
LMV		18.8	2.689	7.76	5.54	59	33	549	39-44	

a) Mean coliform count (geometric mean of fecal coliform, E-coli and total coliform results)
b) Range in calculated values based on four RiverWatch physical-chemical parameters (WQI_4) and expanded six-parameter determination (WQI_6) including bacteriological and pH data. WQI_4 first (left) value; WQI_6 the second (right hand) in range.

Chart 2.1 shows average annual water quality values at each monitoring site in order of their location upstream for the 2011 water year (1 Oct. 2010 - Sept. 31, 2011). The left-side arithmetic scale covers Temp,SC and pH; the right-side, log scale is for streamflow, DO%Sat and MCC. Overall (LSDR) average values are shown to the far right.

The WQI, an aggregate or composite of the average annual water quality monitoring results for WY11 is shown together with stream flow in **Chart 2.2**. Sites 14 (RCP/Cottonwood) and 15T (Forester Ck) commonly witness poorer overall water quality (D-Marginal) than do the down stream monitoring sites that average in the C-Fair to B-Good range. On the average annual basis, highest quality (B -Good) is evidenced in the mid-section (Mission Gorge) of the river, whereas the East (Santee Basin) and West (Mission Valley) sections both lie in the C-Fair range. Seasonal variance in water quality data and the resultant WQI throughout the Lower San Diego River system is presented in the next section.

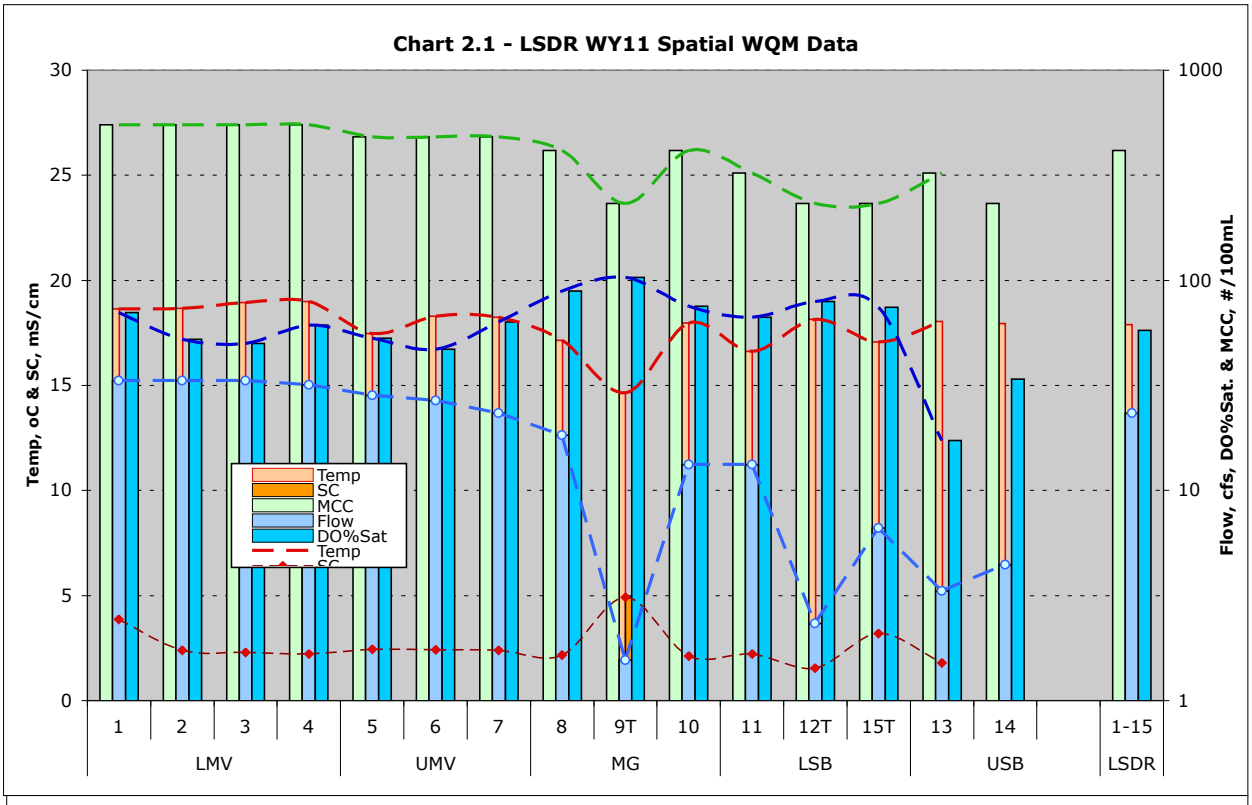


Chart 2.1 - LSDR WY11 Spatial WQM Data
Temp, oC & SC, mS/cm
Flow, cfs, DO%Sat. & MCC, #/100mL
Temp
SC
MCC
Flow
DO%Sat
Temp
SC
1 2 3 4 5 6 7 8 9T 10 11 12T 15T 13 14 1-15
LMV UMV MG LSB USB LSDR

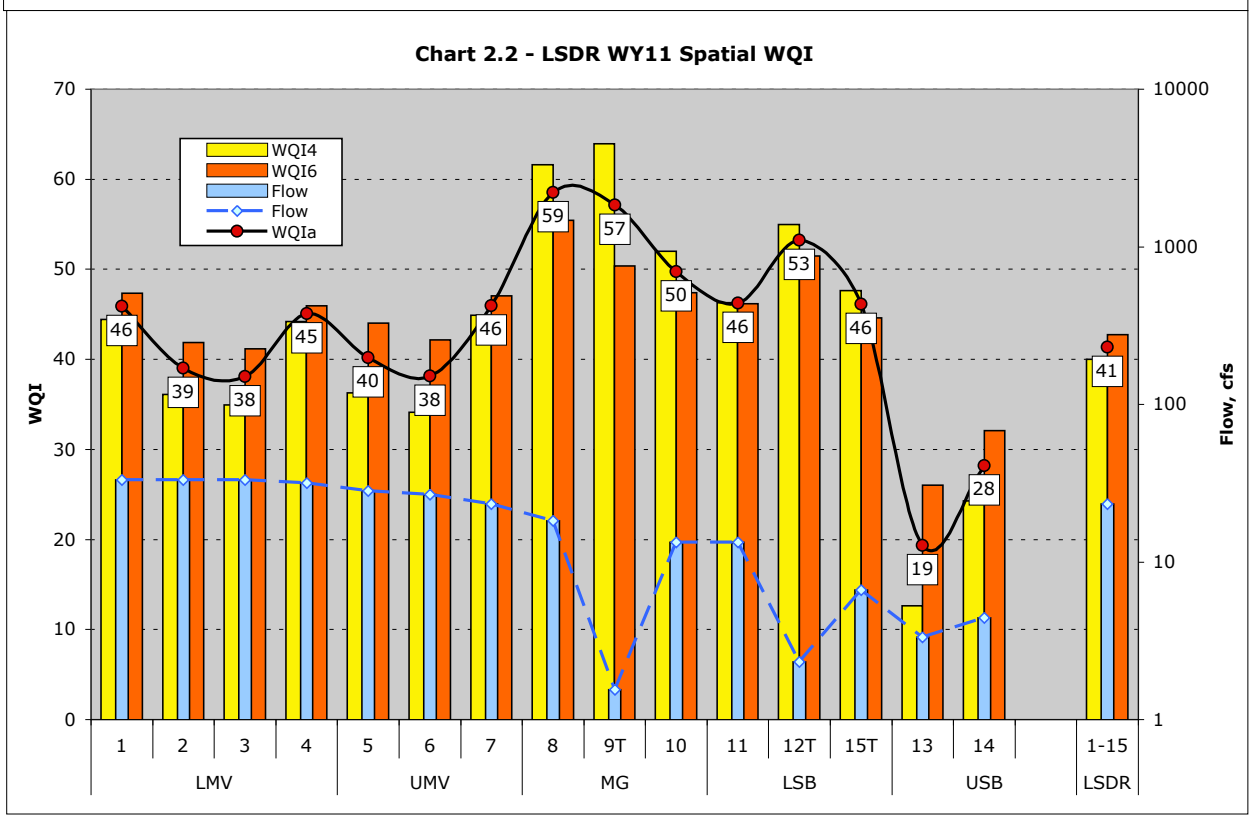


Chart 2.2 - LSDR WY11 Spatial WQI
WQI
Flow, cfs
WQI4
WQI6
Flow
Flow
WQIa
46 39 38 45 40 38 46 59 57 50 46 53 46 19 28 41
1 2 3 4 5 6 7 8 9T 10 11 12T 15T 13 14 1-15
LMV UMV MG LSB USB LSDR

Section 3 - LSDR Temporal Water Quality Data WY11

Monthly and seasonal water quality water quality monitoring averages for the Lower San Diego River are presented in **Table 3.1** for WY11. Monthly and seasonal variances in the monitoring results for WY11 are also expressed in Charts 3.1 (Water Quality Monitoring Data) and 3.2 (LSDR Water Quality Index). Comparison to other year monitoring results is expressed in Section 4.

Table 3.1 LSDR WY11 WQM Values by Month and Season

		Temp	SC	pH	DO	DO%	Flow	MCC [a]	WQI [b]	
Month	*Season:*	*oC*	*mS/cm*		*mg/L*	*% Sat*	*cfs*	*#/100ml*	*Value & Grade*	
Oct	Fall	19.8	2.902	7.53	2.68	30	2	810	17-25	E
Nov		15.5	2.047	7.63	5.86	53	33	940	45-47	C
Dec	Winter	13.4	2.114	7.81	6.67	65	16	1120	47-46	
Jan		12.6	1.748	7.90	9.35	89	22	340	67-60	B-
Feb		13.3	1.109	7.90	6.89	66	141	190	48-55	
Mar		16.1	1.641	8.07	6.59	67	25	210	52-52	
Apr	Spring	17.8	1.714	8.24	7.22	77	16	150	58-57	
May		18.0	1.800	7.86	6.07	66	15	190	49-52	
June	Summer	21.7	2.336	8.24	4.79	55	5	430	35-40	C
July		22.4	3.047	7.80	3.95	46	2	320	25-31	D-
Aug		22.3	3.480	7.78	3.60	42	1	120	21-28	E+
Sept		21.1	3.093	7.60	2.95	34	1	180	18-27	E
Season Averages										
Fall (O&N)		17.6	2.478	7.58	4.27	45	17	870	31-35	C-
Winter (D,J,F,M)		13.8	1.653	7.92	7.37	72	51	470	53-53	B-
Spring (A&M)		18.3	1.757	8.05	6.65	71	16	170	54-55	
Summer (J,J,A,S)		21.9	2.989	7.83	3.28	44	3	260	24-31	D
Annual Avg (O-S)		**17.9**	**2.253**	**7.85**	**5.55**	**58**	**23**	**420**	**40-43**	**C**

a) Mean coliform count (geometric mean of fecal coliform, E-coli and total coliform results)
b) Range in calculated values based on 4 RiverWatch physical-chemical parameters (WQI_4) and an expanded 6-parameter determination (WQI_6) including bacteriological and pH data.

Seasonal patterns in the WY11 water quality monitoring data for the overall LSDR system are shown in **Chart 3.1**. Dissolved Oxygen and stream flow values are highest during the wetter winter months (Dec-March) whereas conductivity and water temperatures are highest during the driest summer months (June-Sept). Mean coliform count (MCC) and pH values exhibit much less of a seasonal pattern than other parameters, although some variance in monthly values are evident. **Chart 3.2** provides an overall perspective of seasonal variance in LSDR water quality as evidenced by the WQI, comprising a composite or aggregate of the water quality parameters monitored. WQI_4 (yellow bar) is an index based on four physical-chemical WQ parameters (Temp, SC, DO and streamflow). WQI_6 (orange bar) is an index based on six parameters; those of WQI_4 plus MCC (a bacteriological indicator) and pH. As the latter two parameters tend to be more constant in value throughout the year (less seasonal variance), the resultant WQI tends to be more normalized from month-to-month (i.e., not as high in summer and not as low in winter). The WQIa, simply an average of the two WQI's (WQI_4 and WQI_6) that are shown as bars on the graph in Chart 3.2, is presented as a line together with associated monthly values.

In general, water quality for the Lower San Diego River system is highest (B Good) in winter months with greatest streamflow and lowest (D Marginal and/or E Poor ranges) during summer (minimum-flow) months. The overall annual average WQIa for the LSDR in WY11 is 41 (C Fair). Spatial variances in the WQI were shown and discussed in the previous section. Both spatial and temporal variances in the WQI and their associated patterns for WY11, in comparison to previous water years as well as anticipated for next year (WY12), are presented in the following section of the report. Comparison with other San Diego area watercourses and catchments is made in the final section (Section 5) of this document.

Questions regarding the San Diego River WQM database or interpretation of results expressed in this report can be directed to the attention of the author, John C. Kennedy, through contacting SDRPF at info@SanDiegoRiver.org, or the RiverWatch Coordinator at 619-297-7380.

Chart 3.1 - LSDR WY11 Temporal WQM Data

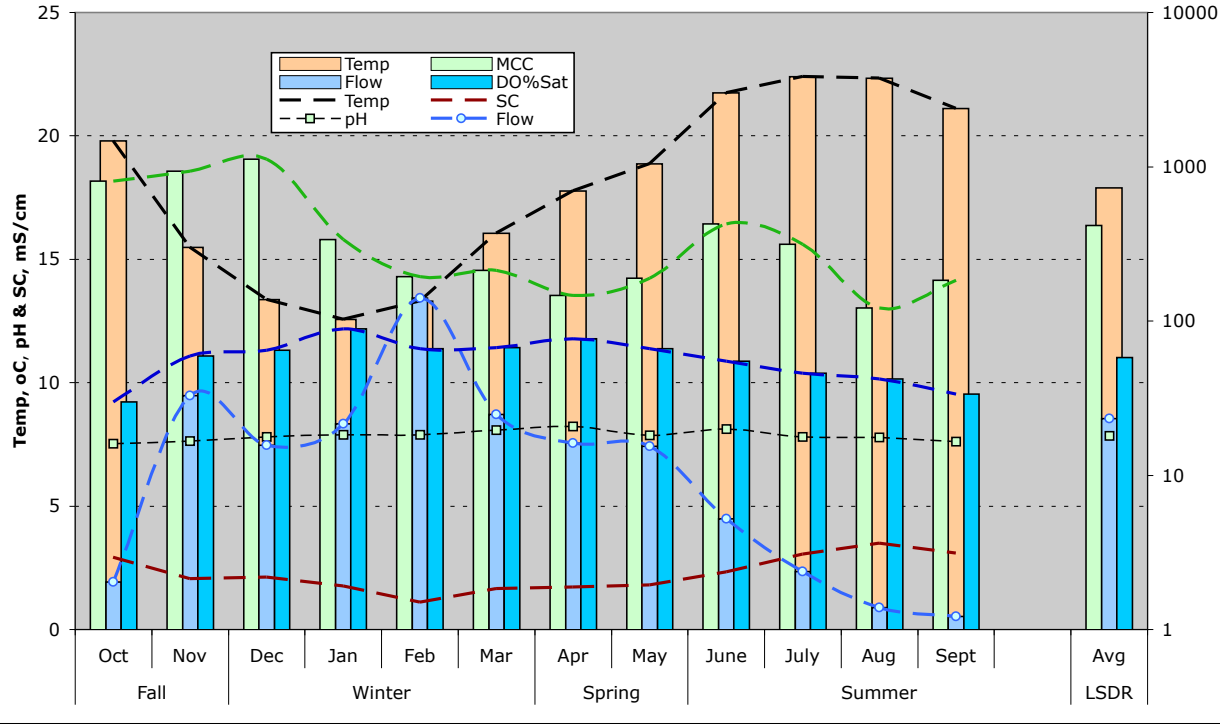
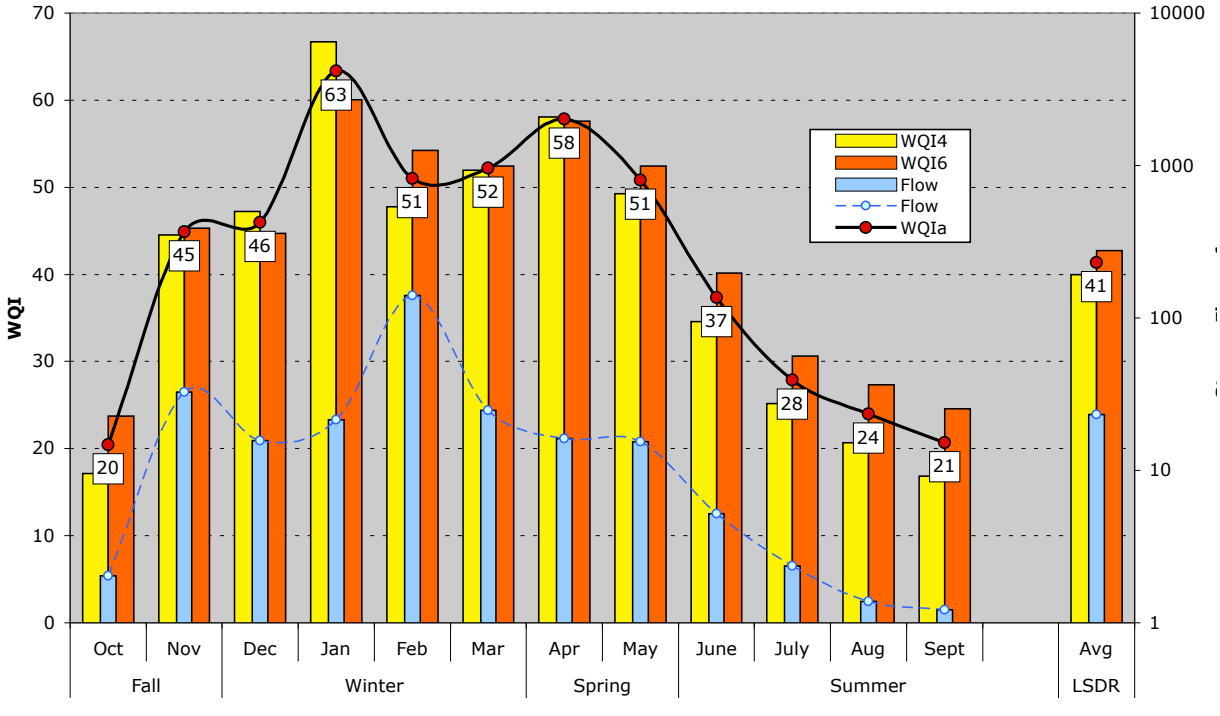


Chart 3.2 - LSDR WY11 Temporal WQI



Section 4 - WY11 WQI Compared to Prior Years

Annual and seasonal LSDR WQI values are presented in **Table 4.1** by river reach, section, overall (LSDR) average for each water year over the past 7 years (WY05-WY11) of RiverWatch monitoring. The WQI represents an average of two water quality indexes, WQI_4 (4 physical-chemical parameters) and WQI_6 (that also includes a bacteriological parameter and pH), whose values in nearly all instances are in close agreement.

Table 4.1 - Average Annual and Seasonal WQI by LSDR Reach and Section

Annual Avg.	LMV Reach	UMV Reach	MV Section	MG Section	LSB Reach	USB Reach	SB Section	Overall Average LSDR	
WY05	50	45	48	63	35	25	30	44	C (highest)
WY06	40	36	38	57	41	31	36	41	C
WY07	37	30	34	52	45	36	41	40	C
WY08	38	32	35	47	44	42	44	41	C
WY09	37	31	34	48	45	40	43	40	C-
WY10	37	34	36	49	42	25	33	37	C- (lowest)
WY11	**42**	**41**	**41**	**54**	**47**	**22**	**35**	**41**	**C**
7Yr Avg	*40*	*36*	*38*	*53*	*43*	*32*	*38*	*41*	*C Fair*
Winter Avg	LMV	UMV	MV	MG	LSB	USB	SB	LSDR	
WY05	68	67	68	78	43	36	40	59	B (highest)
WY06	53	51	52	61	44	37	41	49	C + (lowest)
WY07	48	43	46	63	56	49	54	52	B-
WY08	55	47	52	54	51	54	54	53	B-
WY09	57	48	53	61	56	53	56	55	B-
WY10	54	53	54	62	51	33	43	51	B-
WY11	**59**	**59**	**59**	**62**	**52**	**32**	**43**	**53**	**B-**
7Yr Avg	*56*	*53*	*55*	*63*	*51*	*42*	*47*	*53*	*B- Good*
Summer Avg	LMV	UMV	MV	MG	LSB	USB	SB	LSDR	
WY05	33	28	31	50	29	15	21	31	D
WY06	25	17	22	49	39	29	34	32	D+ (highest)
WY07	23	17	21	38	32	22	27	26	D-
WY08	23	21	22	37	34	31	32	29	D
WY09	21	16	19	37	33	25	29	26	D- (lowest)
WY10	23	21	22	38	36	19	27	27	D
WY11	**25**	**20**	**23**	**41**	**38**	**13**	**25**	**27**	**D**
7Yr Avg	*25*	*20*	*23*	*41*	*35*	*22*	*28*	*28*	*D Marginal*

WQI Code: A-Very Good (drk blue), B-Good (lt blue), C-Fair (green), D-Marginal (yellow), E-Poor (brown), F-Very Poor (red)

All WQI values listed in the table are the average (WQI_a) of WQI_4 and WQI_6.

WY11 values shown in red are 2 or more points below the 7-Yr Averages (expressed in italics) for the same reach.

Temporal WQI results are presented in **Charts 4.1-4.4** (monthly values over past 7 years by section, site and reach) and spatially (by site number in ascending order upstream) in **Chart 4.5**. The average river distance between adjacent monitoring sites is roughly 1 mile although there is a considerable difference (from <0.3 mi. to >1.8 miles) from one to the next.

The recurrent annual cyclic pattern of water quality data expressed on a monthly (Charts 4.1-4.3) and 7-Yr average (Charts 4.4 & 4.5) basis within the LSDR watershed is evident in all 5 charts. WQI values determined at all river monitoring sites, reaches and sections are highest in the winter (wettest period) and lowest in the summer (driest) months. Irrespective of time of year or season, WQI values are also highest in the Mid-Section or Mission Gorge reach (Sites 8-10), and lowest in the Upper Santee Basin (Sites 13 &14) and Mission Valley (Sites 5-7) reaches. The lower reaches of both the East (Sites 11, 12 & 15t) and West (Sites 1-4) sections show somewhat higher WQI's (improved water quality) than found in the upper reaches of each section. Over the 7-year period the East section shows somewhat better water quality than the West section in the spring and summer but slightly poorer quality during the fall and winter, as evidenced in Chart 4.4. WY11 WQIs for all but two reaches and all 3 sections as well as the overall (LSDR) values are slightly above the 7-Yr averages. WY10 presented the lowest values over the past 7 water years; the highest annual average values were in WY05 (the wettest the past 7 years).

LSDR WQI extending from Oct 2004 through Oct 2011, typically fluctuates between the low 20's (E Poor) during the dry season and the high 50's (B Good) during the winter (wet) season. Greater river discharge (stream flow) results in improved water quality (higher DO levels combined with lower specific conductivity and temperatures). Index values decline as river temperatures and conductivity increase while flow and dissolved oxygen levels drop to summer month lows. With increased discharges, lower temperatures and elevated DO levels, river water quality noticeably improves during the fall and into the winter months. Overall (LSDR) 7-yr average WQI values range from low '(D) Marginal' in summer to '(B-) Good' in winter, or '(C) Fair' expressed on a average annual basis. WY11 WQI values for all reaches and sections of the river are within one point of the 7-yr averages. As shown in Chart 4.5, WY11 water quality at each monitoring site is also very close to 7-yr annual and seasonal (winter and summer) averages for that same site.

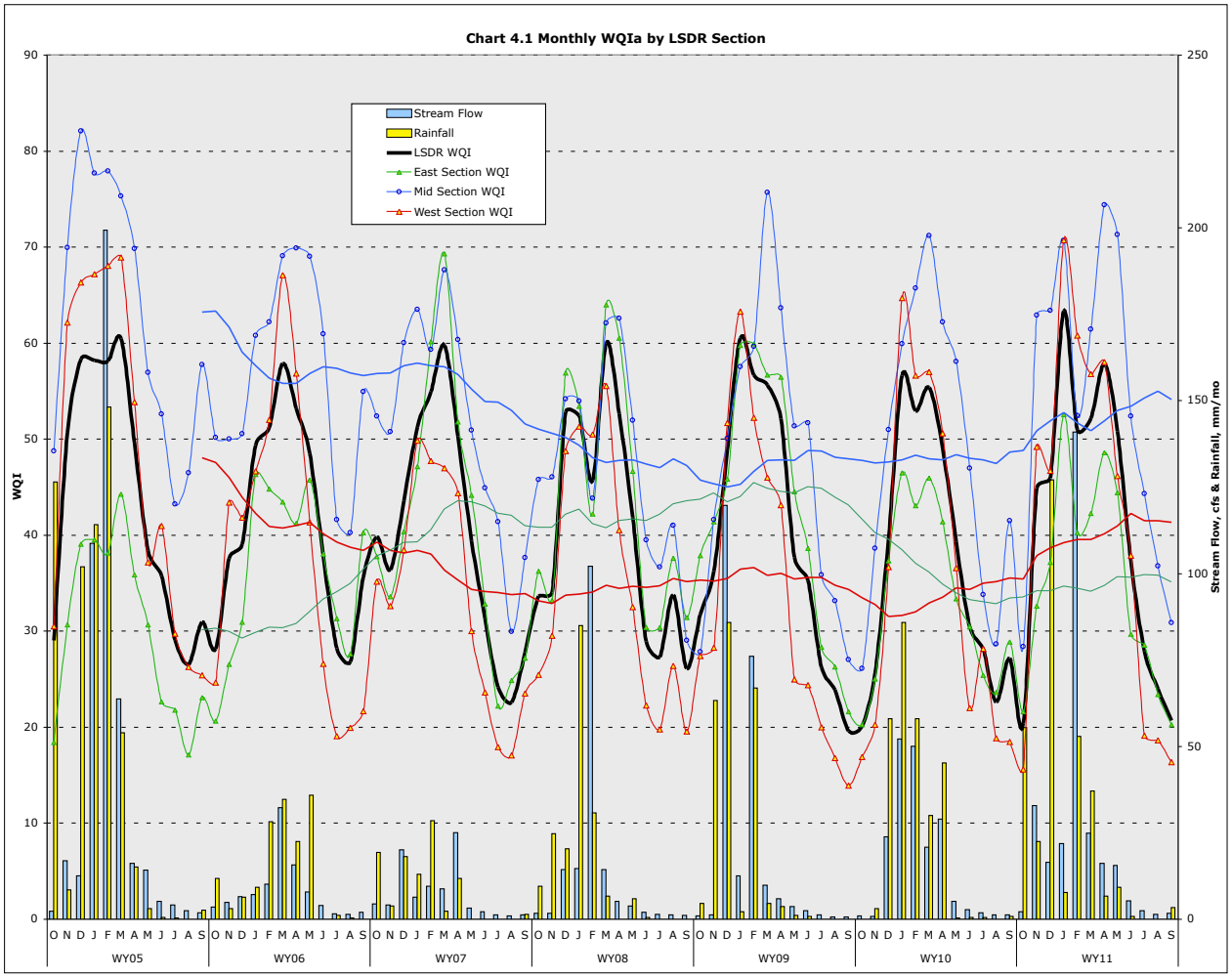
WQI trend lines for the SDR reaches, sections and the aggregated average value (LSDR) shown in charts 4.1-4.3 are presented in **Table 4.2.** The previous water year (WY10) presented the lowest overall LSDR WQI of 39 (C Fair); with summer values running 40% below 7-yr seasonal averages and the annual WQI about 20% below the annual average. Current (Sept WY11) values are very close/near to the 7yr averages both spatially and temporally. The range (high to low), year of occurrence, 7-Yr average and end of WY11 trend line values are also expressed in Table 4.2. In general WY11 WQI values have improved over WY10 values in all but the Upper Santee Basin reach (Sites 13 & 14) where the current index value of 24 represents a new 7-year low.

Next year (WY12) is expected to present an above average rainfall and stream flow (runoff) year. Both winter and average annual LSDR water quality values are expected to continue improving slightly above WY11 results. Next summer's water quality results could, however, continue to remain poor, should dry-weather stream flow be noticeably below seasonal norms. Upper reaches in both the Santee Basin and Mission Valley might be expected to present somewhat poorer water quality values than found in the lower reaches and the mid-section (Mission Gorge) of the watershed until proposed local mitigation measures (river improvements now underway) are successfully completed within these two reaches. Overall, the upward trend in water quality index values that has occurred this past year is expected to prevail unless WY12 ends up being a well below normal rainfall year with associated stream flow adversely impacted.

Table 4.2 LSDR WQI Trend Lines

	Chart	High & WY	Low & WY	7-Yr Avg.	End WY11[a]
East Section	4.1	46 (C) WY09	30 (D) WY05	38 (C)	35 (C-) Fair
Mid Section	4.1	63 (B) WY05	46 (C) WY09	55 (B-)	54 (B-) Good
West Section	4.1	48 (C+) WY05	32 (D+) WY10	40 (C)	42 (C) Fair
LSDR Avg.	4.2 & 4.3	**46 (C) WY05**	**39 (C) WY10**	**43 (C)**	**44 (C) Fair**
Maximum sites	4.2 & 4.3	73 (B+) WY05	56 (B) WY08	65 (B)	63 (B) Good
Best 2 sites [b]	4.2	63 (B) WY05	45 (C) WY09	54 (B-)	54 (B-) Good
Worst 2 sites [c]	4.2	35 (C-) WY05	24 (E+) WY10	30 (D)	34 (D) Marginal
Minimum sites	4.2 & 4.3	28 (D) WY09	18 (E) WY10	23 (E+)	19 (E) Poor
Mission Gorge	4.1 & 4.3	63 (B) WY05	46 (C) WY09	55 (B-)	54 (B-) Good
Upper Santee Basin	4.3	45 (C) WY09	25 (D-) WY05	38 (C)	24 (E+) Poor

a) End of WY11 (Sept) trend line values that are 2 or more points below 7-yr averages are shown in red.
b) Highest overall WQI_a values are associated with Sites 8 & 10 in the Mission Gorge reach (Mid-Section).
c) Lowest overall WQI_a values are associated with sites 14 (USB reach) and 7 (UMV reach).



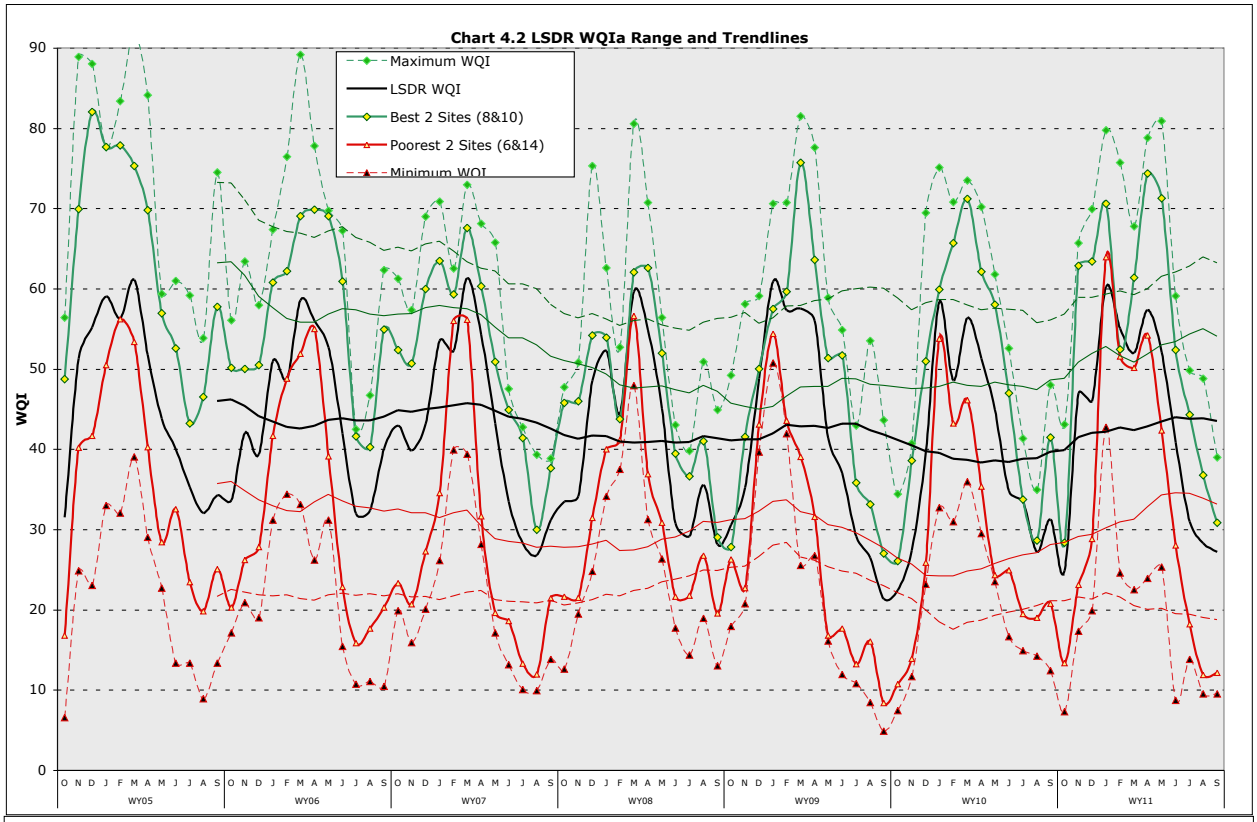


Chart 4.2 LSDR WQIa Range and Trendlines
Maximum WQI
LSDR WQI
Best 2 Sites (8&10)
Poorest 2 Sites (6&14)
Minimum WQI
WQI
0
10
20
30
40
50
60
70
80
90
O N D J F M A M J J A S
WY05
WY06
WY07
WY08
WY09
WY10
WY11

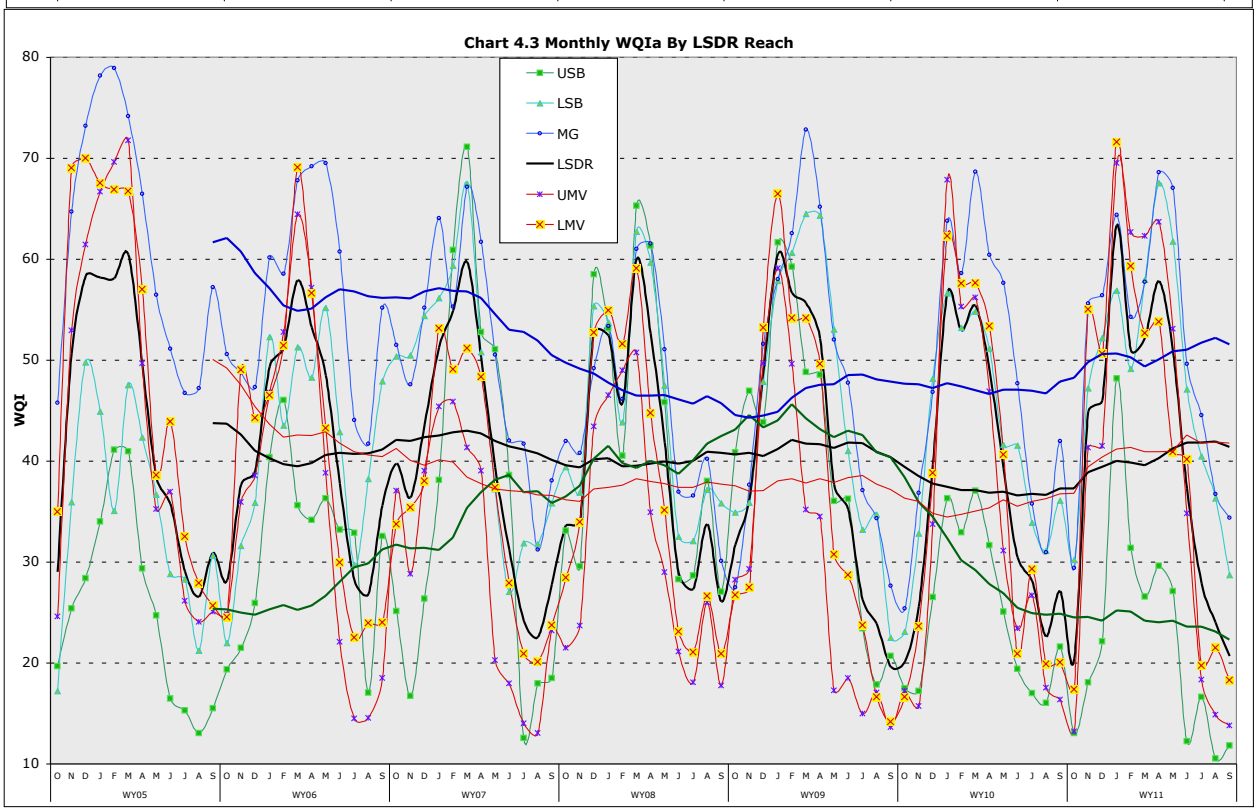


Chart 4.3 Monthly WQIa By LSDR Reach
USB
LSB
MG
LSDR
UMV
LMV
WQI
10
20
30
40
50
60
70
80
O N D J F M A M J J A S
WY05
WY06
WY07
WY08
WY09
WY10
WY11

Chart 4.4 LSDR 7-Yr Temporal WQIa Averages

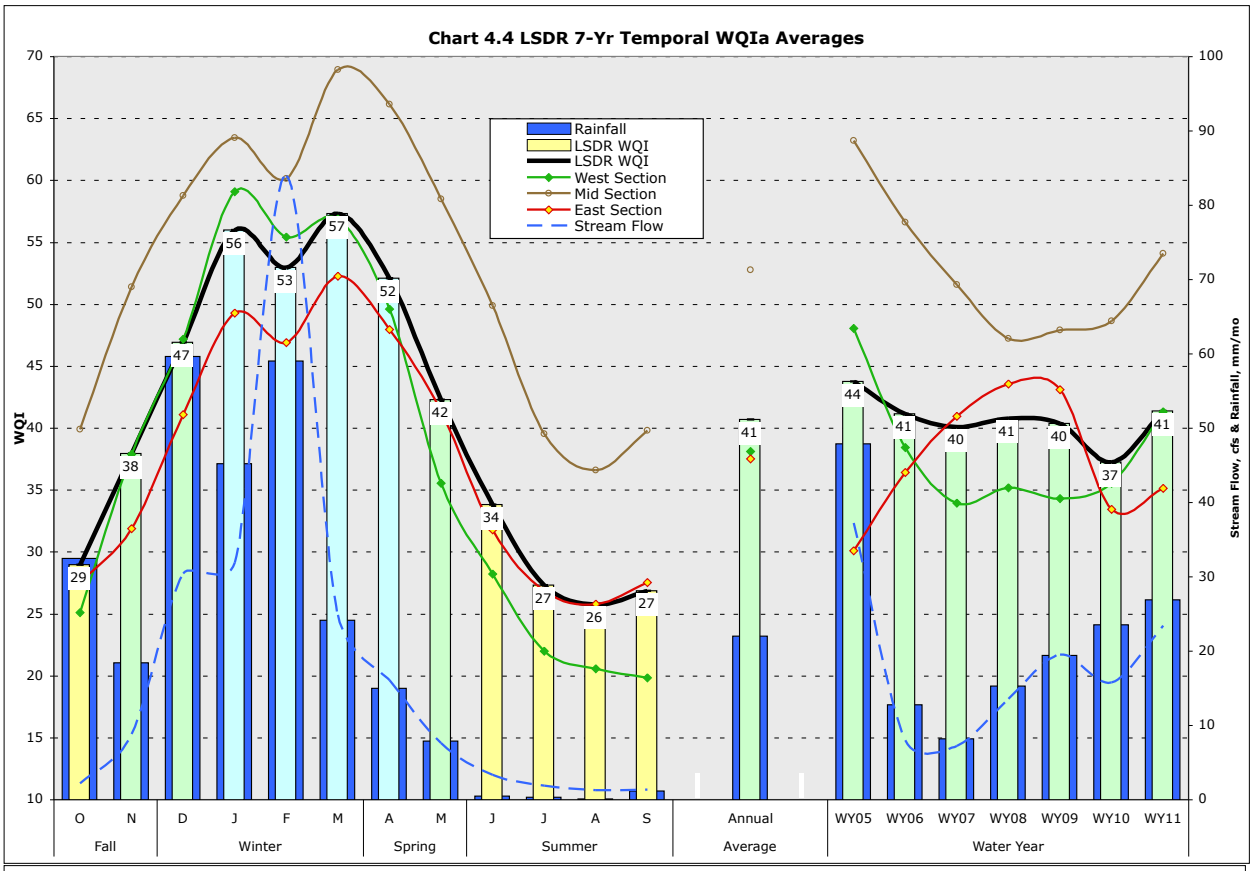
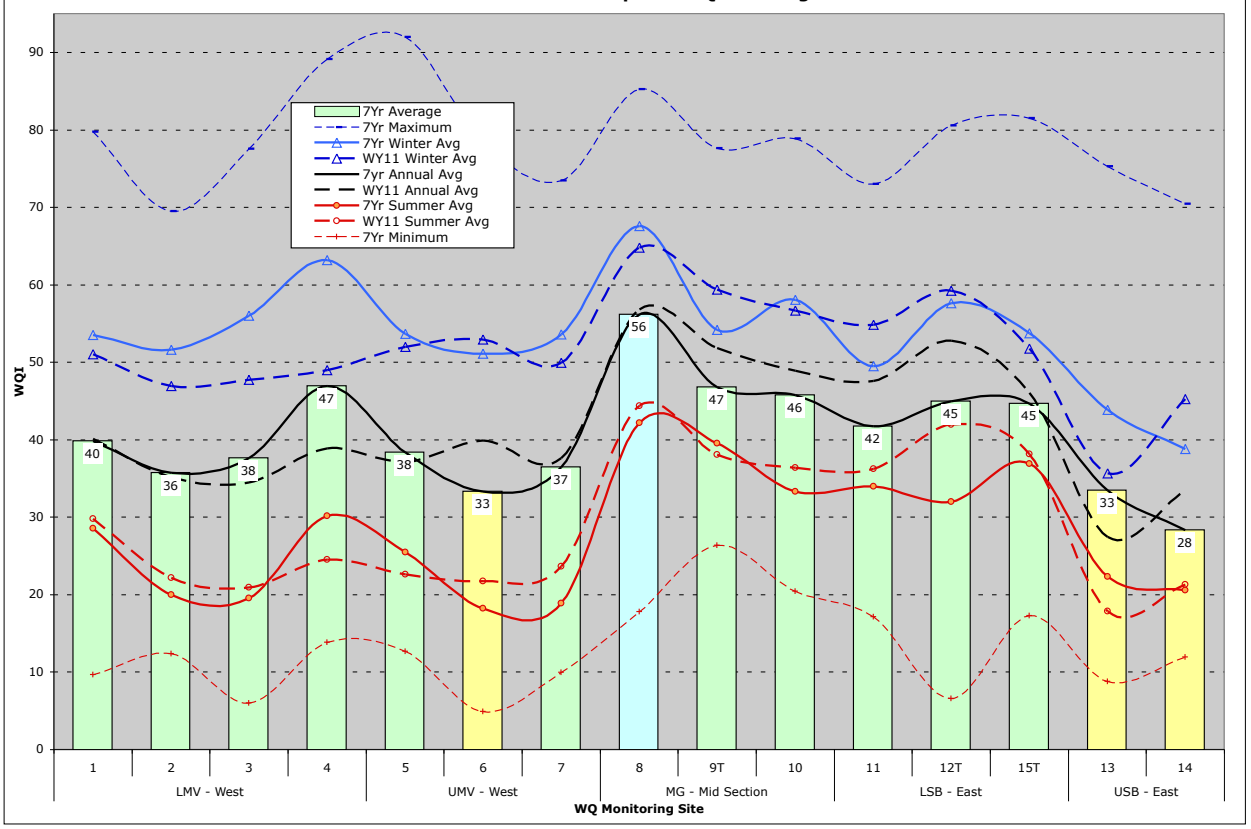


Chart 4.5 LSDR 7-Yr Spatial WQIa Averages



Section 5 - LSDR and Other San Diego Watercourses WQIs

WQI values presented in previous sections of this report were specifically developed for use in analyzing and expressing RiverWatch water quality monitoring data for the Lower San Diego River. The methodology may also be applied, where similar data are monitored, to other watercourses in the region. **Table 5.1** lists sections of San Diego area watercourses where sufficient water quality and hydrologic data necessary to determine the index have been identified. The table presents average WQI over the past 3-year period (Oct 2008-Sept 2011) and the WY11 (Oct 2010-Sept 2011) value. Also listed is the range (max.-to-min.) and the percentage of time during the period that values exceed 50 in the Optimal (Good or Very Good) range, are below 25 in the Sub-Standard (Poor or Very Poor) range, or when no measurable stream flow was recorded.

Table 5.1 San Diego Area Watercourse WQIs

River/Stream	Average WQI		Range[c]	Percent of Year		
(HSU)	3-Yr[a]	WY11[b]	(Max-Min)	WQI>50[d]	WQI<25[e]	No Flow[f]
Santa Margarita R. (902.1)	**61**	**60**	**(75-43)**	**86%**	**0%**	**0%**
East (near Temecula)	*74*	*72*	*(95-60)*	*100%*	*0%*	*0%*
Mid (at FPUDPS)	*64*	*63*	*(82-46)*	*97%*	*0%*	*0%*
West (below Ysidora)	*46*	*44*	*(68-19)*	*47%*	*19%*	*0%*
San Luis Rey R. (903)[g]	**41**	**43**	**(69-10)**	**50%**	**33%**	**22%**
East (near Pala/I-15)	*35*	*38*	*(67-8)*	*31%*	*33%*	*22%*
West (near I-5/Oceanside)	*44*	*44*	*(97-7)*	*50%*	*36%*	*22%*
Carlsbad Streams (904)[h]	26	23	(53-6)	6%	53%	20%
San Dieguito R. (905)	**45**	**47**	**(100-16)**	**42%**	**11%**	**24%**
East (u/s of Lk Hodges/I-15)[i]	*52*	*51*	*(107-15)*	*44%*	*6%*	*22%*
West (near I-5)	*39*	*44*	*(96-12)*	*33%*	*39%*	*25%*
Los Penasquitos Ck. (906.1)	**41**	**48**	**(59-28)**	**42%**	**0%**	**0%**
East (near Poway/I-15)	*51*	*52*	*(75-28)*	*56%*	*0%*	*0%*
West (near I-5)	*41*	*45*	*(61-26)*	*22%*	*0%*	*0%*
Lower San Diego R. (907.1)	**40**	**41**	**(63-20)**	**33%**	**19%**	**0%**
East (Santee Basin)	*37*	*35*	*(60-20)*	*14%*	*17%*	*0%*
Mid (Mission Gorge)	*50*	*54*	*(76-26)*	*58%*	*0%*	*0%*
West (Mission Valley)	*37*	*41*	*(71-14)*	*31%*	*36%*	*0%*
South Bay (909.2-910.1)[k]	24	24	(45-6)	0%	65%	20%
Lower Tijuana R. (911.11)[l]	12	12	(33-3)	0%	92%	33%

a) Average WQI value over past 3 years (Oct 1, 2008 - Sept. 31, 2011).
b) Average WQI value for WY11 (Oct 1, 2010 - Sept. 31, 2011); values in red are less than the 3-Yr average.
c) Maximum to minimum monthly values experienced over past 3 years.
d) Percent of time monthly WQI values above 50 in 'Optimal' (Good or Very Good) quality range.
e) Percent of time monthly WQI values below 25 in 'Sub-Standard' (Poor or Very Poor) quality range.
f) Percent of time no monthly average discharge gauged within watercourse.
g) Lower, western reach in proximity of Camp Pendleton.
h) Composite of 6 coastal streams (Loma Alta, Buena Vista, Aqua Hedonia, Encinas, San Marcos, & Escondido)
i) Composite of 3 streams (San Pasqual, Santa Maria, & Santa Ysibel)
j) Sum of 3 tributary streams (Santa Ysabel, Santa Maria and San Guejito) downstream of their confluence.
k) Average of 2 watercourses (Sweetwater and Otay) monitored just upstream/east of entry to South San Diego Bay.
l) Lower Tijuana River in vicinity of Nestor and I-5.

Over the past three years, sections of four San Diego area watercourses show WQI values above 50 (Good) on a consistent basis; the East and Middle sections of the Santa Margarita R., the eastern (inland) sections of San Dieguito and Los Penasquitos creeks and the Mid (Mission Gorge) section of the Lower San Diego River. Many other sections of the watercourses listed commonly present WQI values in the Intermediate (25-49) quality range. Poor-to-Very Poor quality conditions are typical of a number of lesser watercourses of the region which experience intermittent and or hyporheic flow during the dry-weather period as well as the lower Tijuana River.

Review of the WQI averages where sufficient monitoring data were available results in a relative water quality ranking of San Diego area watercourses as shown in **Table 5.2.** In only two cases (Santa Margarita R. and Escondido Ck. in the Carlsbad unit) were this year's WQI values found to lower than last year's (WY10) and the 3-yr averages. WY11 WQI values for other San Diego area watercourses were found to be above last year's averages indicating slightly improved water quality conditions.

Table 5.2 Relative WQ Ranking of San Diego Area Watercourses

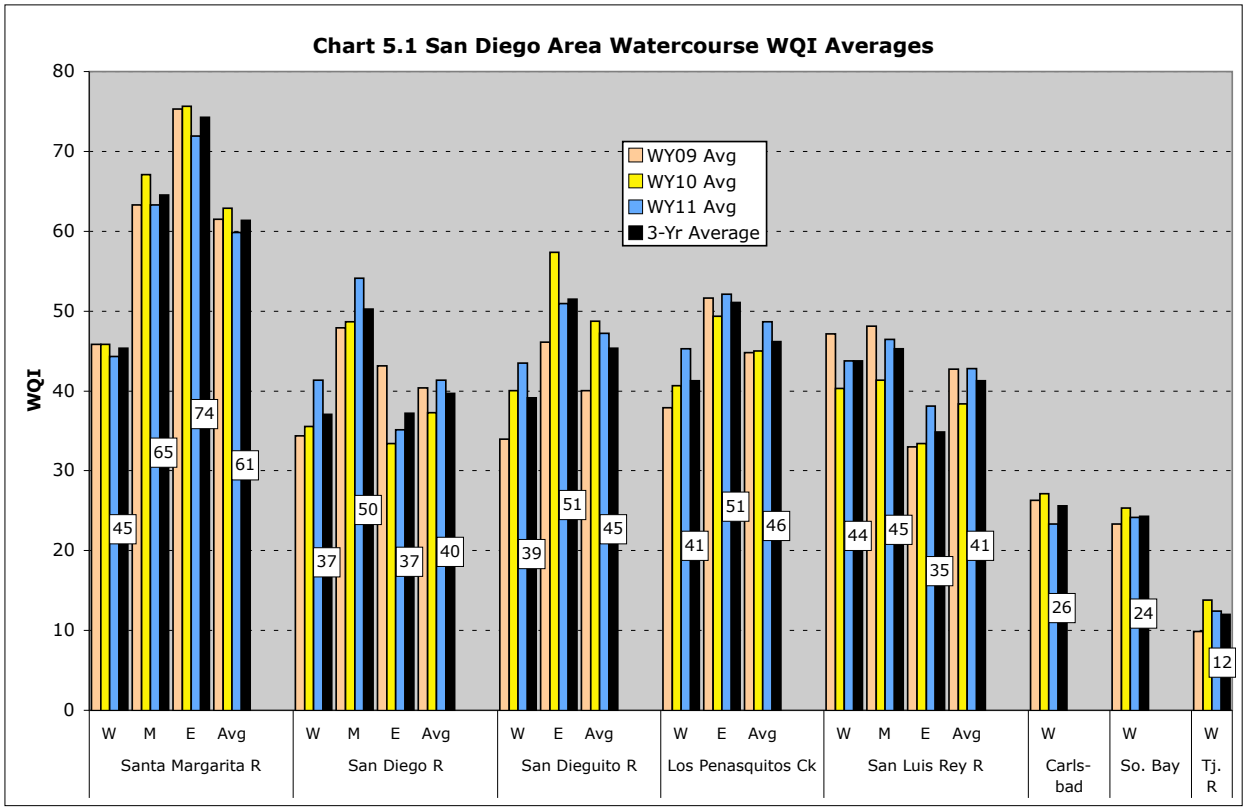
Rank	Watercourse / Catchment Area (HSA.HSU)	WQI Annual Averages			
		WY11	WY10	WY09	3-Yr Avg & Grade
1	Santa Margarita River (902.1 & 902.2)	60 [a]	63	61	61 B Good
2	Los Penasquitos Creek (906.1 & 906.2)	49	45	45	46 C Fair
3	Lower San Dieguito River (905.1)	47	49	40	45 C Fair
4	San Luis Rey River (903.1 & 903.2)	43	38	43	43 C- Fair
5	**Lower San Diego River (907.1)**	**41**	**37**	**40**	**40 C- Fair**
6	Carlsbad Group (904.1-904.6) [b]	23 [a]	27	26	26 D- Marginal
7	South SD Bay (909.1 & 910.2) [c]	24	25	23	24 E+ Poor
8	Lower Tijuana River (911.11)	12	14	10	12 E- Poor

a) WY11 values in red are less than (below) both last year's (WY10) and 3-yr average values.
b) Escondido Ck considered representative of other intermittent streams (Loma Alta, Buena Vista, Aqua Hedionda, Encinas and San Marcos) located within the Carlsbad hydrographic subarea.
c) Average of lower Sweetwater and Otay rivers; excludes Pueblo (908) & Coronado (910.1) subunits/watercourses.

The average WQI values associated with San Diego area watercourses listed in Tables 5.1 and 5.2 are also presented in **Chart 5.1.** The coastal sections of each watercourse are referred to as 'W' (west), the mid-sections as 'M', and the inland sections as 'E' (east). Averaging the WQI values for each river section results in an overall value referred to in the chart as 'Avg'. Water quality in all sections of the Santa Margarita over the past 3 years is consistently of higher standard than monitored elsewhere in the San Diego region. The Lower San Diego River WQI is, on average over the last three years, slightly below those calculated for the Los Penasquitos, Lower San Dieguito and San Luis Rey watercourses.

Charts 5.2 through 5.4 express the monthly WQI values for various sections of each of the San Diego area watercourses or catchments considered. **Chart 5.2** compares overall WQI values for each watercourse by month. **Charts 5.3 and 5.4** compare WQI values for the coastal (west) and inland (east) sections of the watercourses, respectively. Lower San Diego River results are expressed as bold black lines. In all instances maximum values are attained in winter months while minimum values are reached during low-

flow (summer) months. Seasonal variations in water quality, as evidenced by the WQI, is a dominant characteristic of San Diego area watercourses.



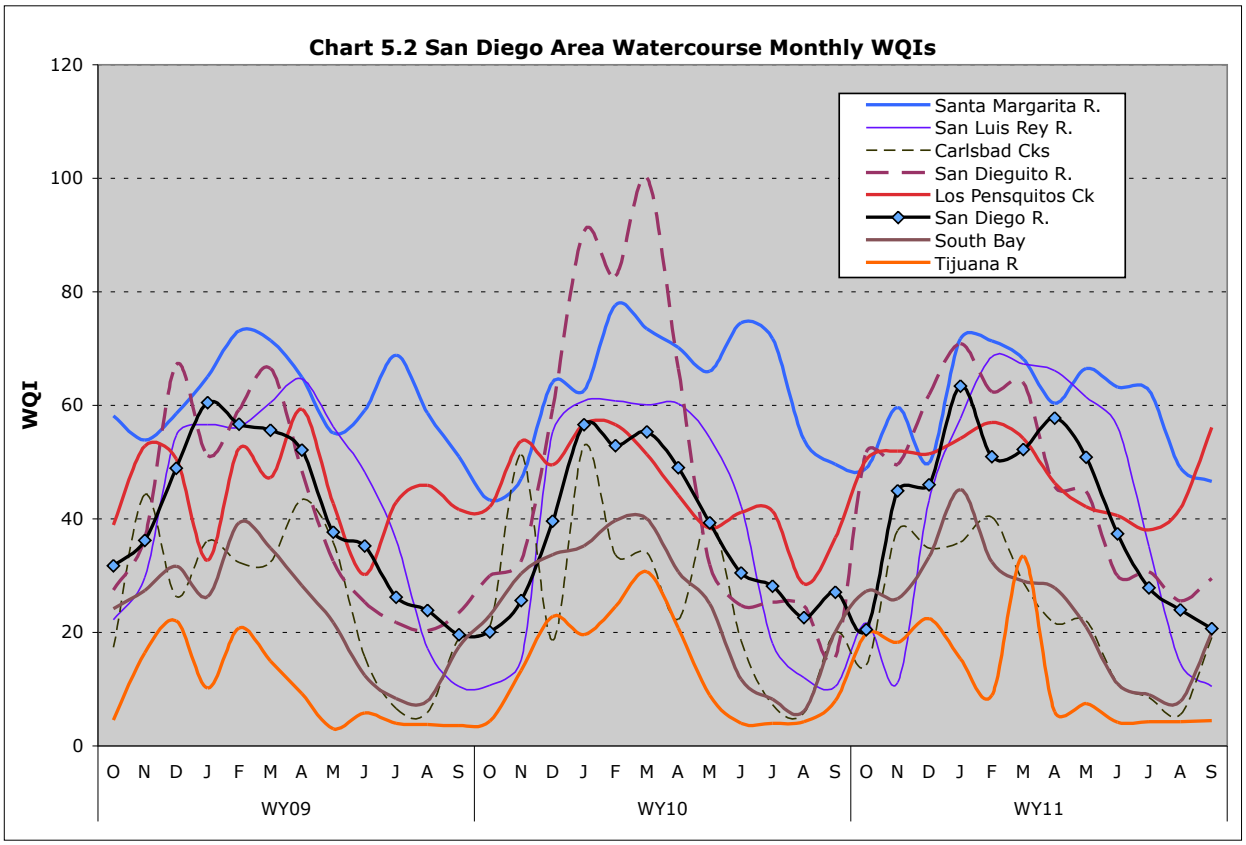


Chart 5.3 San Diego Area Coastal Watercourse Monthly WQIs

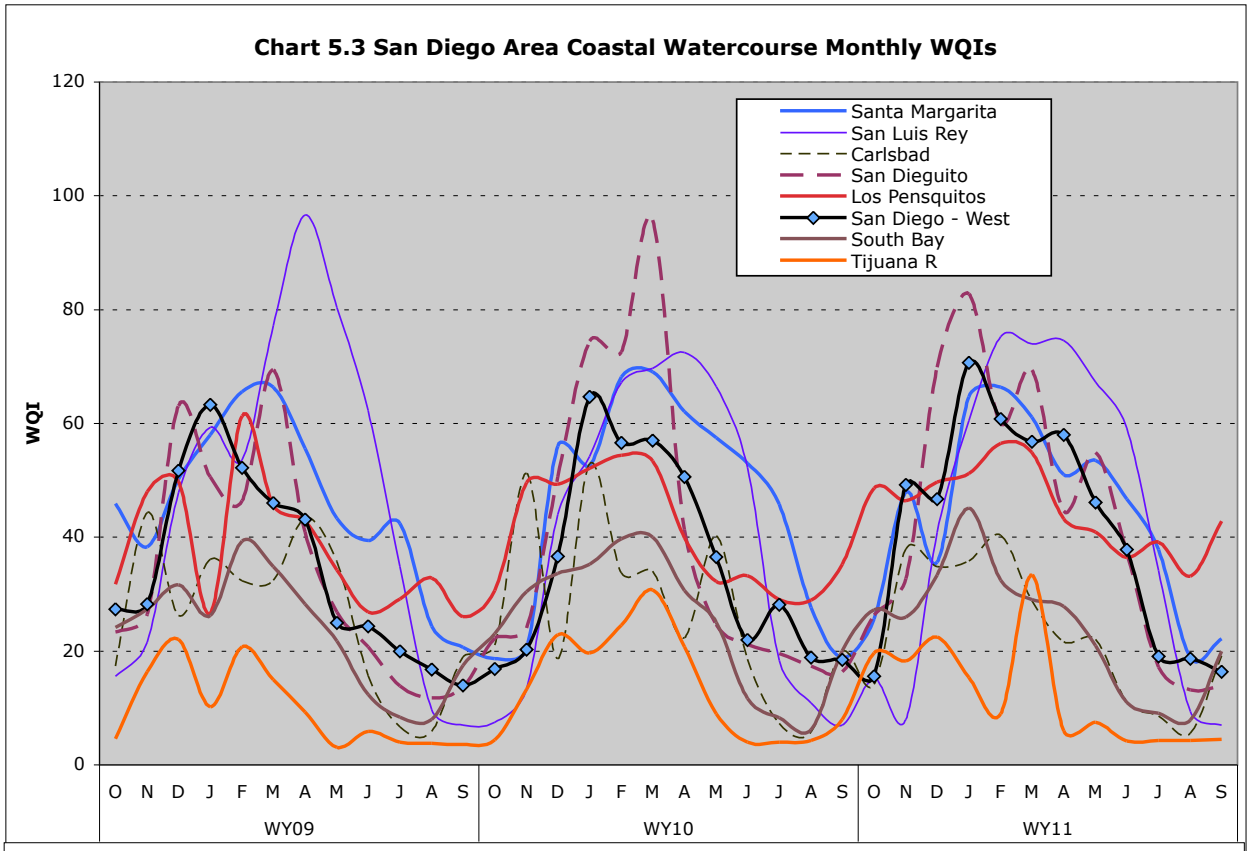
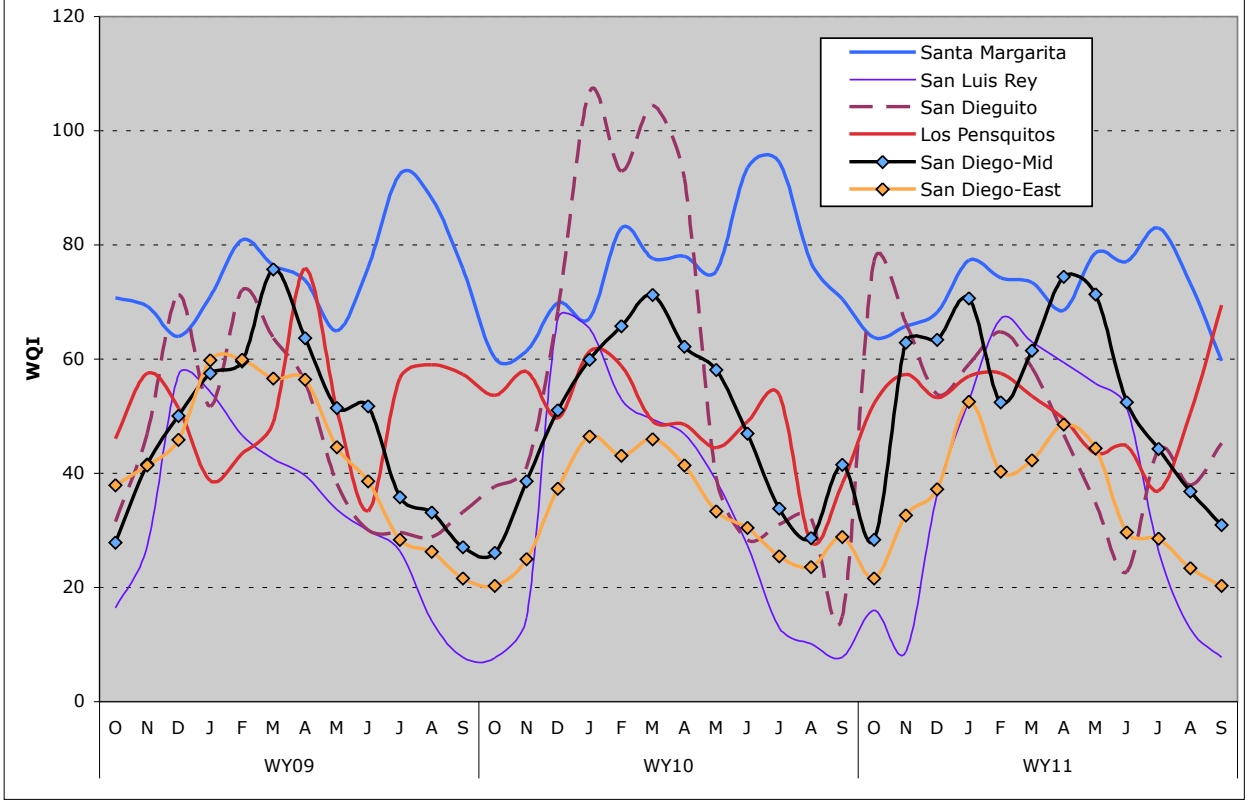


Chart 5.4 San Diego Area Inland Watercourse Monthly WQIs



Appendix G - 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
DO%Sat – Dissolved Oxygen expressed as percentage of DO level at saturation point
d/s – downstream // {u/s – upstream}
E – East // {W –West}
FSDRIP – First San Diego River Improvement Project
ft. – feet // {mi. - mile}
gal – gallon
Ln(x) - natural logarithm of (x) to base-e (2.718)
log(x) - common logarithm of (x) to base-10
L//U – lower//upper (as in river reaches)
LSDR – Lower San Diego River
max//min – maximum//minimum
MCC - Mean Coliform Count (geometric mean of fecal coliform, e-Coli & total coliform in MPN/100mL)
mg/L – milligrams per litre
mi. - mile
mS/cm – milliSeimens per centimetre (1 mS/cm = 1000 *u*S/cm)
MG – Mission Gorge (mid-section of LSDR)
MV – Mission Valley (west section of LSDR)
MPN - Most Probable Number (of coliform organisms)
SB – Santee Basin (east section of LSDR)
PDMWD – Padre Dam Municipal Water District
pH – measure of acidity or basicity (decimal logarithm of hydrogen ion activity)
ppm – parts per million
Q - stream flow or discharge
SB – Santee Basin
SC – Specific Conductivity (also Conductivity or Conductance); also commonly abbreviated SpC
SD – Standard Deviation (also San Diego)
SDRPF – San Diego River Park Foundation
SpC - Specific Conductivity; also abbreviated as SC
TDS – Total Dissolved Solids
T – Temperature (also abbreviated as Temp.)
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
°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 stream flow/discharge.

Total Dissolved Solids (TDS in mg/L) = 670*Specific Conductivity, (where SC 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 (SC), have negligible impact on the DO-DO%Sat relationship within the LSDR watershed.

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

WQI_4 = DO%Sat*2.5*T factor*Q factor/log(SC);
where SC 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.[$DO\%f*wt_{(DO)}$, $SCf*wt_{(SC)}$, $pHf*wt_{(pH)}$, $MCCf*wt_{(MCC)}$, $Qf*wt_{(Q)}$, $Tempf*wt_{(T)}$]^1.75
where $wt_{(DO)} = 3$, $wt_{(SC)} = 2$, $wt_{(pH)} = 1$, $wt_{(MCC)} = 1$, $wt_{(Q)} = 2$ and $wt_{(T)} = 1$
WQIa = Avg. [WQI_4 and WQI_6]

The SDR WQI has been developed specifically for the SDRPF RiverWatch Monitoring Program, however, the equations can also be applied to water quality and hydrologic data pertaining to other coastal area watercourses.

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
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
1000 gpm=1.436 mgd=2.23 cfs=4.42 AF/day=1,614 AFY
1 inch (rainfall) = 25.4 mm

Appendix H - References

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Appendix I - SDRPF's RiverWatch Team

Supervision/Coordination:

Shannon Quigley-Raymond ('08-11)
Kym Hunter ('06-07)
Rob Hutsel ('04-05)

Volunteers (4+ times):

Aidan Kennedy
Alan Ramirez
Amethyst Cruspero
Amy Cook
Ang Nguyen
Bill Martin
Birgit Knorr
Bob Stafford*
Brent Redd
Calvin Vine*
Cameron Bradley
Carl Abulencia
Celena Cui
Clint Williams
Conrad Brennen
Craig McCartney
Dani Tran
David Lapota
Demitrio Duran
Doug Taylor
Ebony Quilteret
Edward Garritty
Erin Babich
Fred Ward
Gabriel Martinez Mercado
Gary Strawn*
George Liddle
Gina Martin
Jack Greco
Jalil Ahmad
Jim Thornley
Joan Semler
John Kennedy*
Joyce Nower
Katharyn Morgan
Kathryn Stanaway
Kelly Brown
Kevin Bernaldez
Krissy Lovering
Krystal Tronboll
Laqueta Strawn
Linda King
Lois Dorn
Linda Tarke
Lindsey Teunis
Lucas Salazar
Maesa Hanhan
Mark Carpenter
Mark Hammer
Martin Offenhauer*
Mary Hansen
Melissa Garret
Melissa Maigler
Michael Mikulak
Mike Hanna*
Mike Hunter
Mitchell Manners
Mitzi Quizon
Natelie Rodriguez
Paul Hormick*
Raymond Ngo
Reggie Agarma
Russell Burnette
Sandra Pentney
Shelia-Ann Jacques
Tim Toole
Tina Davis
Silvana Procopio
Toni Nguyen
Tony de Garate
Trish Narwold
Veronika Shevchenko
Vidhya Nagarajan
Wendy Kwong
Yang Jiao
Yvette Navarro

** Team Leaders*