

WC Stream Reach Summary

Study Reach: WC, Willow Creek Reservoir downstream to Colorado River.

Reach Description: Approximate channel length: 3.75 miles, approximate channel slope 0.5%.

This tributary reach to the Colorado River begins at the outlet of Willow Creek Reservoir. Land use along this reach is generally agricultural, although the river is typically lined with open wetland meadows and grasses with a narrow corridor of willows along the banks. Camping is permitted near the reservoir.



Willow Creek downstream of reservoir



Willow Creek midway between Willow Creek Reservoir and the Colorado River confluence

Flow Recommendations:

Environmental Flow Methodology: A study site was not established within this reach and CWCB instream flows have not been set. Environmental flow ranges were developed from PHABSIM analysis by Miller Ecological Consultants, Inc. provided through the Northern Colorado Water Conservation District (Miller, 2007). See Appendix A for methodology.

Water Users:

- Irrigators, municipalities and industry flow-related issues: none reported
- Recreation: None reported

Summary of Flows:Environmental, recommended target flow ranges (See Appendix A for methodology).

- 7 to 10 cfs, summer
- 7 to 10 cfs, winter
- Flushing flow, at least 50 cfs for a 3-day duration with a frequency of 1 in 2 years during the mid-May to mid-June

Other Flows (operational requirement of Willow Ck Reservoir)

- 7 cfs or reservoir inflow, October 1 through April 30

Water Users

- Irrigators, municipalities and industry: The local diversions in this reach could potentially divert up to approximately 60 cfs. Most of the diversions are made in the summer for irrigation and will likely have some return flows
- There are an estimated three (3) surface water diversions by local water users in excess of 1 cfs in this reach
- Recreation: none reported

Stream Assessments: In August 2008 Tetra Tech conducted two stream assessments in WC. These included Stream Reach Inventory /Channel Stability Evaluation (SRI/CSE), and the EPA Habitat Quality Assessment (HQA). The SRI/CSE evaluation scored in the ‘fair to almost poor’ category’ and the EPA HQA evaluation scored in the ‘marginal’ category. Relevant issues revealed in the stream assessments include a relatively high degree of bank and bed instability, especially in the upper reaches, with most habitat quality attributes rated ‘marginal’. The high variability of releases out of Willow Creek reservoir likely contribute to the observed habitat and channel conditions. Results of the assessments are summarized in the following table. Details and methodology are presented in Appendix A.

Reach WC Stream Assessments					
Stream Reach Inventory/Channel Stability Evaluation			EPA Habitat Quality Assessment		
Attribute			Attribute	Score	
Upper Banks			Channel		
1	Landform Slope	4	1	Aquatic Habitat Barriers/ Diversion	8
2	Mass wasting hazard	6	2	Aquatic Structure as Cover	6
3	Debris Jam Potential	6	3	Velocity/ Depth Regimes	11
4	Vegetation Cover	9	4	Channel Flow Status	6
		Upper Bank Score:	5	Channel Alteration	13
			6	Frequency of Riffles	6
Lower Banks			7	Channel Sinuosity	8
5	Channel Capacity	3	Channel Score		58
6	Bank Rock Content	4	Banks		
7	Flow obstructors & Deflectors	7	8	Bank Stability	6
8	Cutting	12	9	Riparian Vegetation Cover and Disturbance	8
9	Deposition	12	10	Riparian Vegetation zone width	12
		Lower Bank Score:	Bank Score		26
			Total Score		84
Channel Bottom			Notes		
10	Rock Angularity	3			
11	Brightness	3			
12	Consolidation/Particle Packing	6			
13	Bottom size distribution	12			
14	Bed Scour and Deposition	22			
15	Clinging Aquatic Veg	3			
		Channel Bottom Score:			
		Total Score:			

Spawning Observations: No trout spawning survey was conducted on Willow Creek.

Hydrologic Records: Two streamflow gaging stations provide records applicable to reach WC. Below the reservoir, USGS Gage Station 09031000 operated continually from 1954 to 1982, was then discontinued, and since 1986 has been operated by the State of Colorado. Above the reservoir, USGS Gage Station 09020500 was operated year around from 1954 to 1960. Since 1988, the Northern Colorado Water Conservation District has operated a seasonal gage at this location. The daily stream flow exceedence plots and the IHA analysis for the station below the reservoir indicate the recommended environmental target flow ranges are commonly present in Willow Creek throughout much of the water year. The flushing flow recommended is well supported by both the historic and the recent hydrologic record. Likewise, the limited record for the reservoir inflow is also supportive of the recommended environmental flows.

Water Temperature: WC is a Tier I stream reach as designated by CDPHE with a chronic temperature standard of 17°C MWAT and an acute temperature standard of 21.2°C DM. Temperature data reviewed in reach WC indicate stream temperatures for Willow Creek in this area are generally well below the MWAT and DM standards.

Water Quality: Water quality data indicate exceedences of phosphorus. Out of the 145 samples reviewed for phosphorus, 16 (11%) samples equaled or exceeded 0.1 mg/l.

Water Supply Issues (UPCO): No water supply issues are reported for this reach.

Results and Remarks:

1. The recommended flow ranges for brook trout (see discussion below) are commonly present, and often exceeded, within the reach. Rapid flow changes are identified as a potential issue in the stream assessments, causing bank and bed instability that in turn affects the overall channel and aquatic habitat quality.
2. No significant concerns were identified from the temperature data.
3. Phosphorus appears to be slightly high, but no cause is obvious.
4. CDOW electrofishing records from 1993 to 1998 indicate brook and brown trout are the predominant game fish, with limited numbers of rainbow trout also being captured. Available habitat for both brook and brown trout was analyzed using PHABSIM. However, the recommended environmental target flows were based upon brook trout because the preferred flow ranges for brown trout commonly exceeded both reservoir inflows and outflows by substantial amounts.

Restoration Opportunities: The upper reaches of Willow Creek appear to be adjusting to flow changes brought on by Willow Creek Reservoir operations. It is unknown at this time what the extent of the adjustment will be and how long it will take. However, at some point, restoration of the channel could be considered, for aesthetic purposes and to enhance the trout fishery. However, at this time no specific recommendations are made.

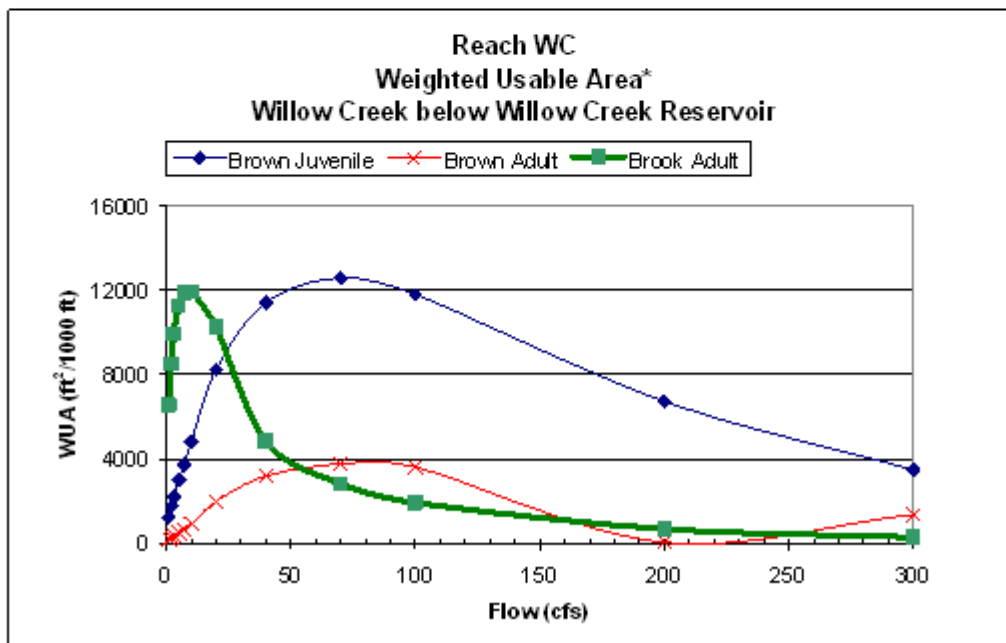
Monitoring: Monitor channel morphology. Continue to monitor streamflows and surface water temperatures.

Support Data

Weighted Useable Area Plots and Tables

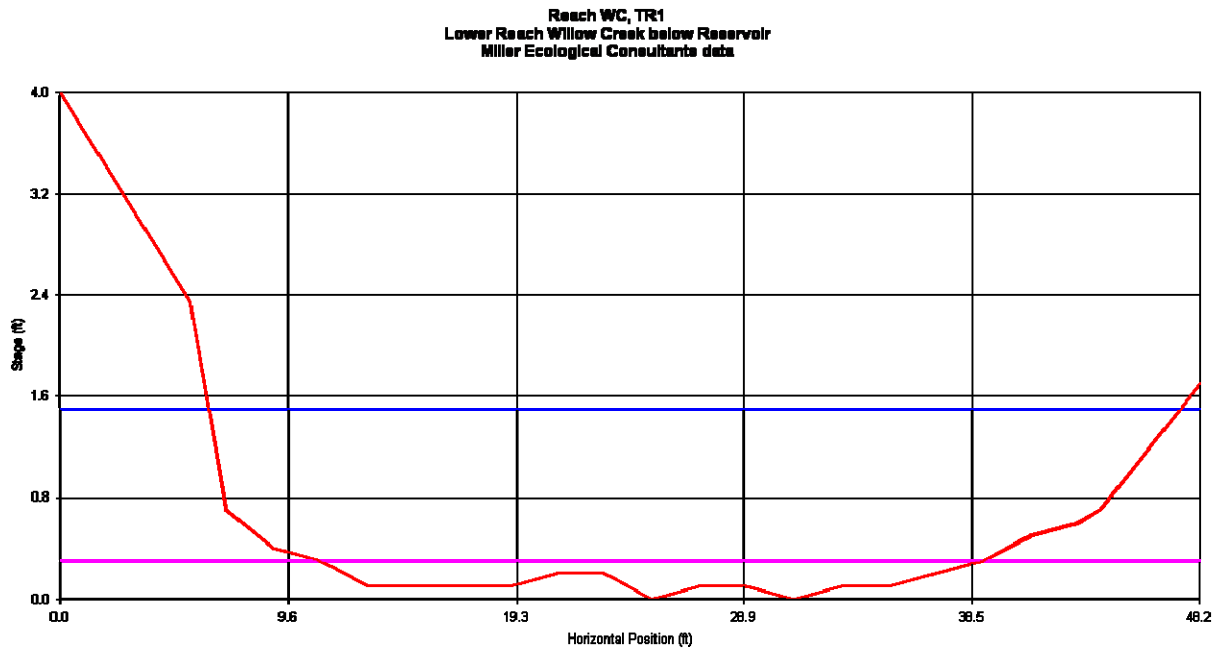
Habitat-flow relations for the target species and life stages for Reach WC, from Miller Ecological Consultants data.

WC				
Discharge (cfs)	Total Area (ft ²)	Brown Juvenile	Brown Adult	Brook Adult
Weighted Usable Area (ft ² /1000 ft stream length)				
1	16521	1232	164	6550
2	17842	1734	247	8486
3	19269	2181	331	9909
5	20943	2988	493	11264
7	22416	3734	658	11866
10	23574	4781	911	11910
20	31403	8225	1967	10238
40	32786	11397	3167	4824
70	34001	12590	3754	2805
100	34630	11800	3605	1914
200	36602	6718	24.9	670
300	37658	3470	1358	278



* Data from Miller Ecological consultants

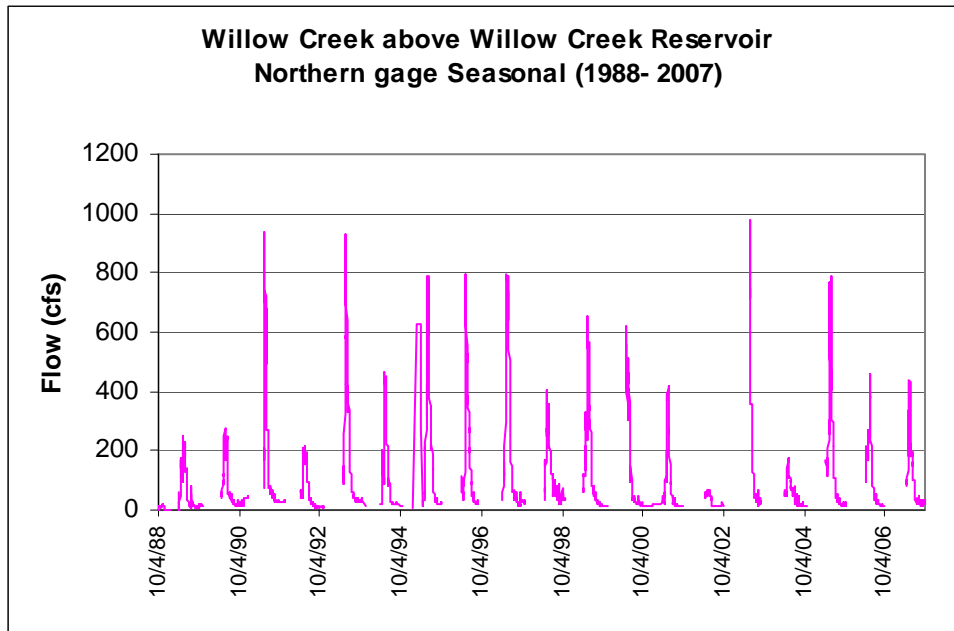
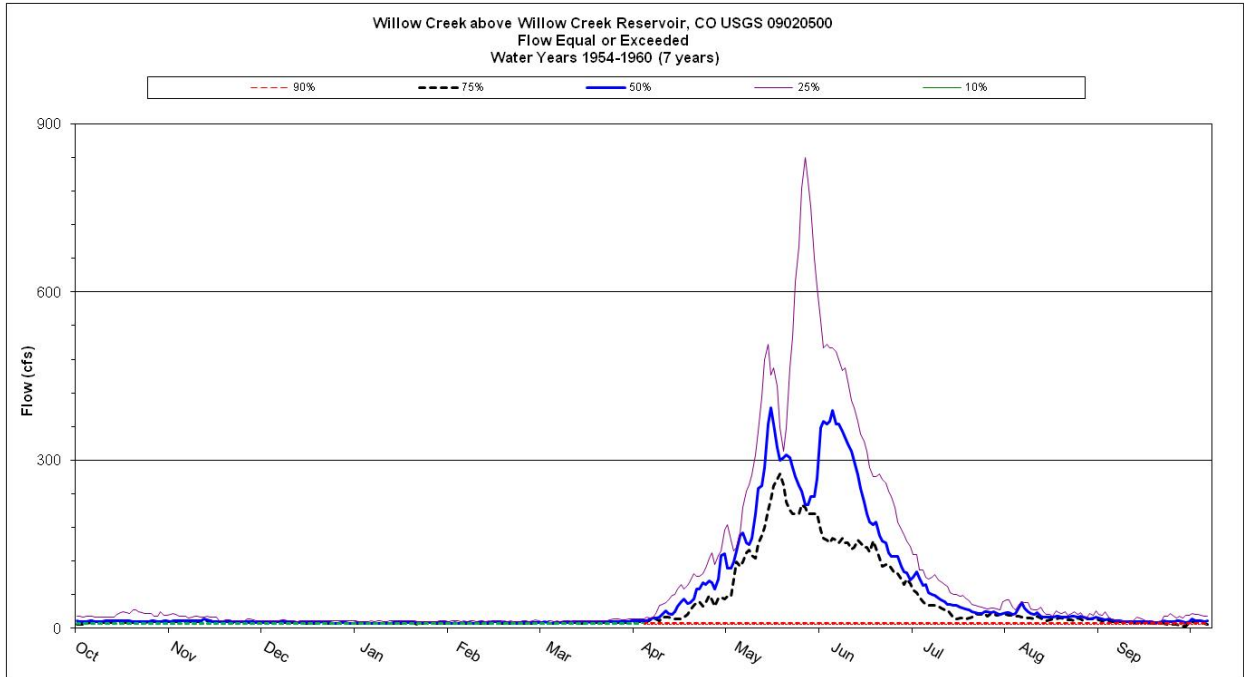
Transect and Bedload Threshold

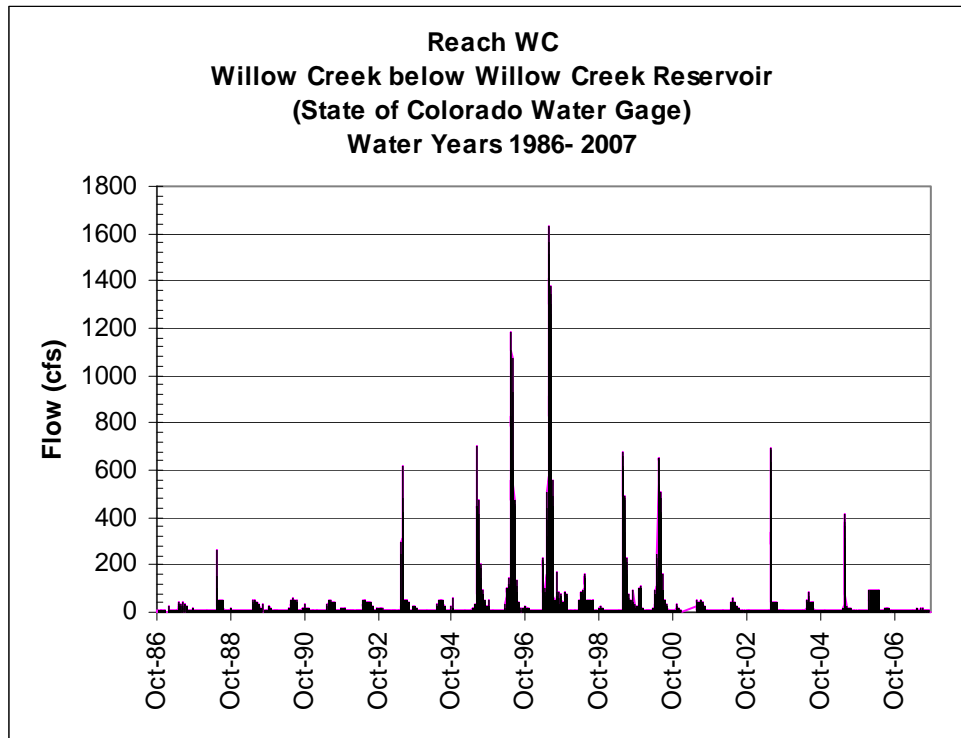
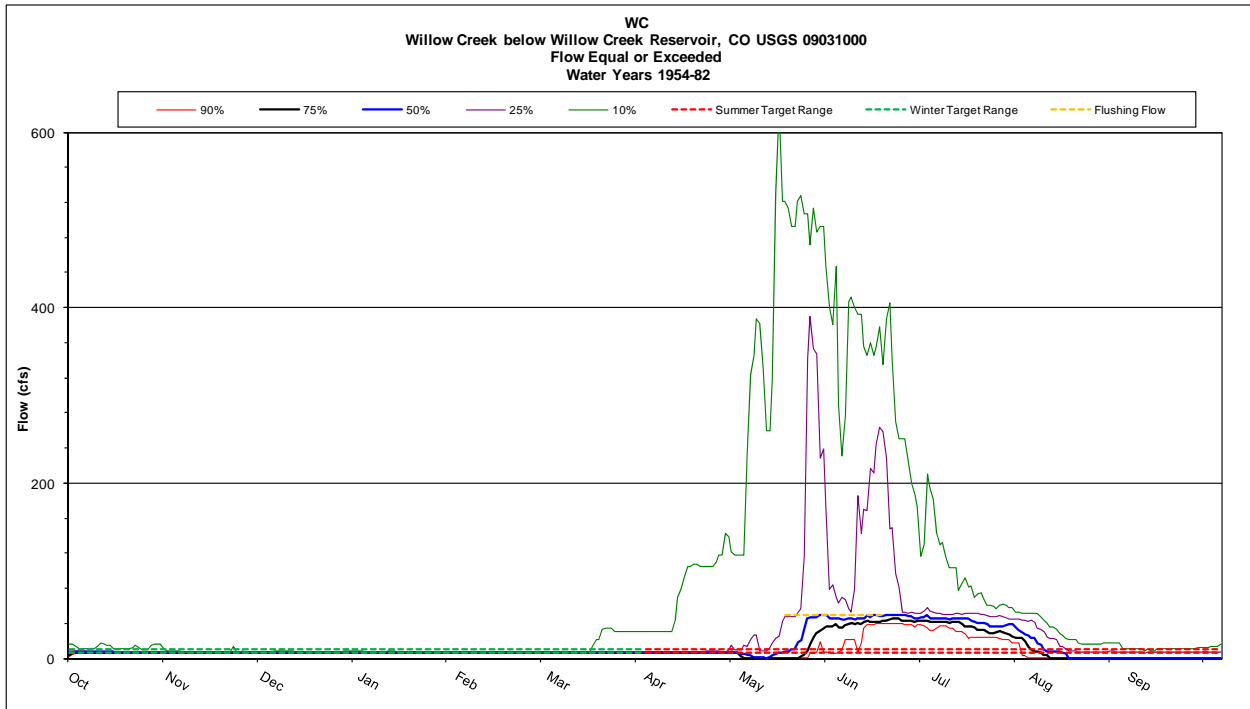


Reach WC, Miller Ecological Consultants data
Lower Reach Willow Creek below Willow Creek Reservoir
TR
Resistance Method: Jarrett's Equation

STAGE (ft)	ARE (sq)	PERI (ft)	WIDTH (ft)	R (ft)	DHYD (ft)	SLOP (ft/ft)	n	VAV (ft/s)	Q (cfs)	SHEA (psf)
0.	4.4	24.03	23.9	0.1	0.1	0.00	0.04	0.4	1.9	0.0
0.	6.9	27.04	26.9	0.2	0.2	0.00	0.04	0.5	4.	0.0
0.	9.7	28.72	28.6	0.3	0.3	0.00	0.04	0.7	7.	0.0
0.	12.7	31.39	31.3	0.4	0.4	0.00	0.04	0.8	10.	0.0
0.	15.9	32.98	32.9	0.4	0.4	0.00	0.04	0.9	15.	0.0
0.	19.2	33.60	33.4	0.5	0.5	0.00	0.04	1.1	21.	0.0
0.	22.6	34.17	33.9	0.6	0.6	0.00	0.03	1.2	29.	0.0
1.	26.0	34.74	34.4	0.7	0.7	0.00	0.03	1.4	37.	0.0
1.	29.5	35.31	35.0	0.8	0.8	0.00	0.03	1.5	46.	0.1
1.	33.0	35.88	35.5	0.9	0.9	0.00	0.03	1.6	55.	0.1
1.	36.6	36.45	36.0	1.0	1.0	0.00	0.03	1.8	66.	0.1
1.	40.2	37.02	36.5	1.0	1.1	0.00	0.03	1.9	78.	0.1
1.	43.9	37.59	37.0	1.1	1.1	0.00	0.03	2.0	90.	0.1

Hydrographs and Exceedence Plots and Tables





Return Period T (year)	Probability P (percent)	Flood Discharge Q (ft³/sec)
1.05	95.2	26
1.11	90.1	39
1.25	80	64
2	50	171
5	20	468
10	10	805
25	4	1451

Flood frequency analysis for USGS 09021000 Willow Creek below Willow Creek Reservoir, CO, for 30 years of record (Water years 1953-82; regulated).

IHA Results

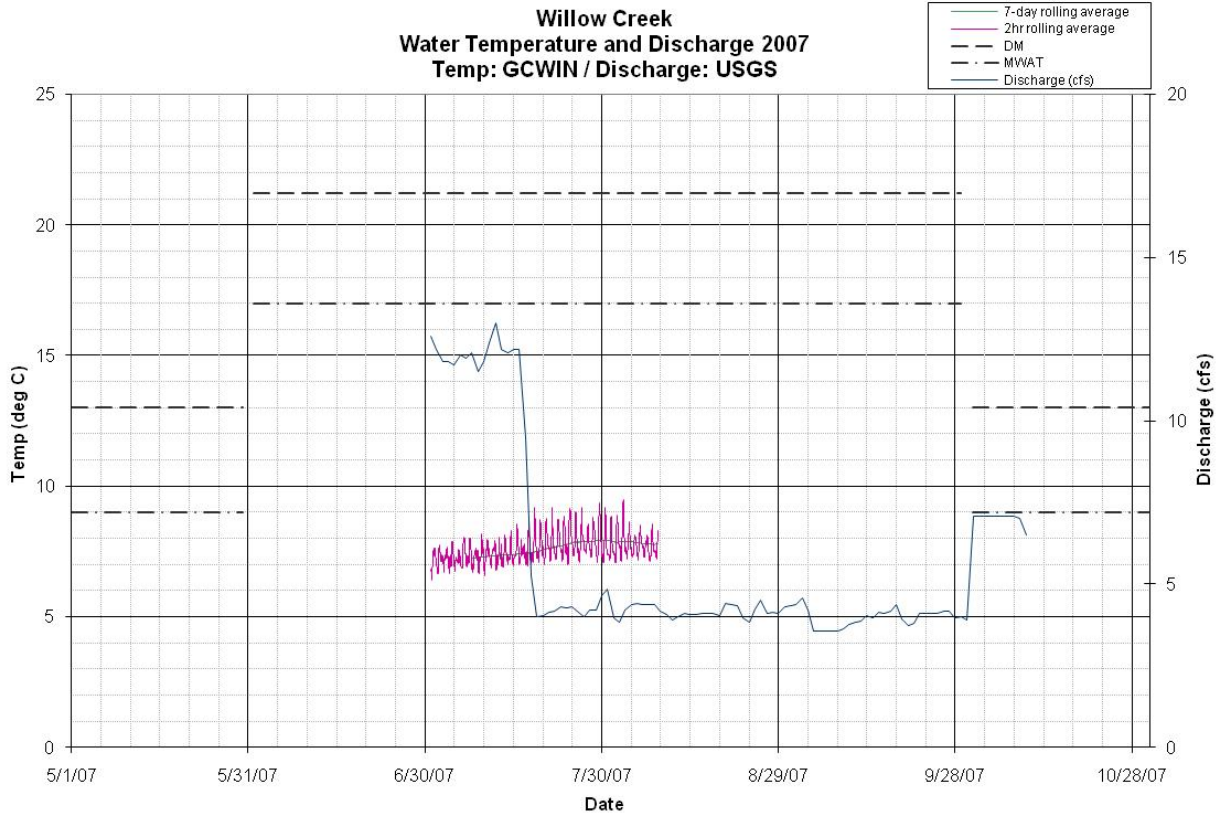
Reach WC Non-Parametric IHA Scorecard Willow Creek below WC Reservoir

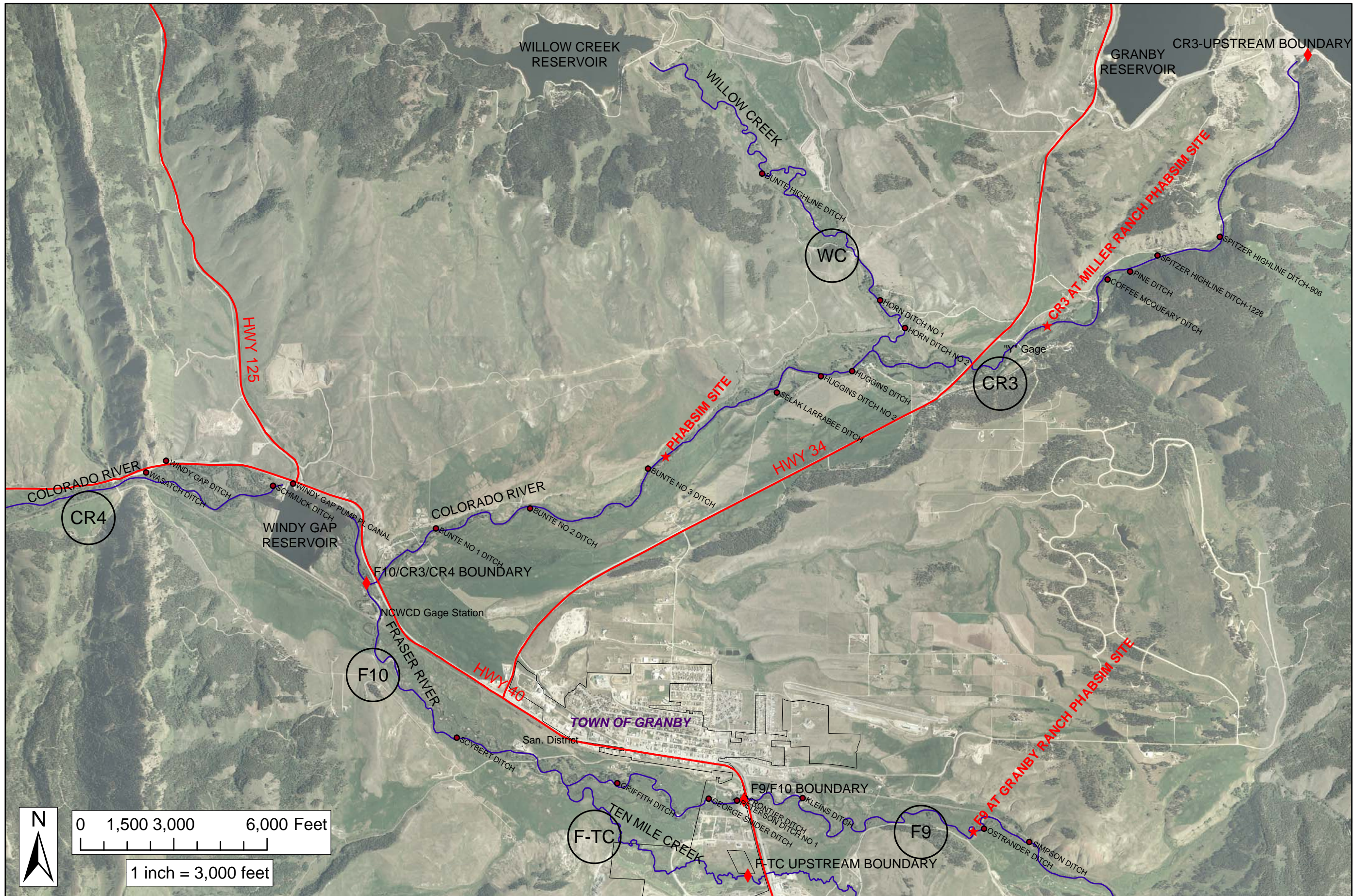
Period of Analysis: 1954-2007 (51 years)

Mean annual flow	31.63	
Mean flow/area	31.63	
Annual C. V.	2.88	
Flow predictability	0.59	
Constancy/predictability	0.62	
% of floods in 60d period	0.54	
Flood-free season	1	
	Medians	Coeff. of Disp.
Parameter Group #1		
October (cfs)	7.39	0.406
November (cfs)	6.9	0.1768
December (cfs)	6.7	0.1701
January (cfs)	6.8	0.1471
February (cfs)	6.87	0.1456
March (cfs)	6.83	0.1318
April (cfs)	7	0.1979
May (cfs)	16.93	2.392
June (cfs)	47.4	1.008
July (cfs)	40.5	0.3778
August (cfs)	4.92	1.72
September (cfs)	5.47	1.475
Parameter Group #2		
1-day minimum (cfs)	0.494	7.53
3-day minimum (cfs)	2.1	2.305
7-day minimum (cfs)	2.917	1.726
30-day minimum (cfs)	3.674	1.428
90-day minimum (cfs)	6	0.1895
1-day maximum (cfs)	114	5.197
3-day maximum (cfs)	102	4.728
7-day maximum (cfs)	87.71	4.795
30-day maximum (cfs)	55.1	3.667
90-day maximum (cfs)	43.02	2.054
Number of zero days (count)	0	0
Base flow index (7day minimum in cfs/median in cfs)	0.09022	2.773
Parameter Group #3		
Date of minimum (Julian day)	239	0.3716
Date of maximum (Julian day)	148	0.05464
Parameter Group #4		
Low pulse count (#)	2	1
Low pulse duration (days)	27	1.338
High pulse count (#)	2	1.5
High pulse duration (days)	47.75	1.346
The low pulse threshold is (cfs)	6.14	
The high pulse threshold is (cfs)	21.3	
Parameter Group #5		
Rise rate (cfs difference between consecutive days)	0.6825	1.897
Fall rate (cfs difference between consecutive days)	-1	-2
Number of reversals	36	1.722

Reach WC						
IHA Percentile Data						
Willow Creek below WC Reservoir						
Period of Analysis: 1954-2007 (51 years)						
	Period of Analysis					
	10%	25%	50%	75%	90%	(75-25)/50
Parameter Group #1						
October (cfs)	6	7	7.39	10	15.88	0.406
November (cfs)	5.542	6.08	6.9	7.3	13.74	0.1768
December (cfs)	5.47	5.96	6.7	7.1	7.757	0.1701
January (cfs)	5.572	6.08	6.8	7.08	7.488	0.1471
February (cfs)	5.74	6.1	6.87	7.1	12.76	0.1456
March (cfs)	5.74	6.4	6.83	7.3	31.04	0.1318
April (cfs)	5.611	6.6	7	7.985	95.24	0.1979
May (cfs)	0.344	6.2	16.93	46.7	487.4	2.392
June (cfs)	32.6	44	47.4	91.8	264.8	1.008
July (cfs)	18.12	32	40.5	47.3	54	0.3778
August (cfs)	0.14	0.3	4.92	8.762	27.08	1.72
September (cfs)	0.14	0.33	5.47	8.4	15.72	1.475
Parameter Group #2						
1-day minimum (cfs)	0.032	0.1	0.494	3.82	5.098	7.53
3-day minimum (cfs)	0.08	0.1	2.1	4.94	5.66	2.305
7-day minimum (cfs)	0.08	0.14	2.917	5.174	5.663	1.726
30-day minimum (cfs)	0.1204	0.3167	3.674	5.561	6.147	1.428
90-day minimum (cfs)	5.371	5.623	6	6.76	7.931	0.1895
1-day maximum (cfs)	46.2	49.5	114	642	749	5.197
3-day maximum (cfs)	46	48.77	102	531	707.1	4.728
7-day maximum (cfs)	44.97	47.57	87.71	468.1	656.5	4.795
30-day maximum (cfs)	41.09	45.73	55.1	247.8	486.1	3.667
90-day maximum (cfs)	29.97	33.61	43.02	122	303.2	2.054
Number of zero days (count)	0	0	0	0	0	0
Base flow index (7day minimum in cfs/median in cfs)	0.002876	0.007759	0.09022	0.2579	0.4138	2.773
Parameter Group #3						
Date of minimum (Julian day)	122	133	239	269	303.2	0.3716
Date of maximum (Julian day)	133.4	139	148	159	168	0.05464
Parameter Group #4						
Low pulse count (#)	1	2	2	4	8	1
Low pulse duration (days)	3.9	12.13	27	48.25	81	1.338
High pulse count (#)	1	1	2	4	5	1.5
High pulse duration (days)	5	9.5	47.75	73.75	93	1.346
Parameter Group #5						
Rise rate (cfs difference between consecutive days)	0.14	0.205	0.6825	1.5	8.027	1.897
Fall rate (cfs difference between consecutive days)	-7.588	-2.21	-1	-0.21	-0.15	-2
Number of reversals	20	23	36	85	100.6	1.722
EFC Monthly Low Flows						
October Low Flow (cfs)	5.171	6	7	7.523	13.83	0.2175
November Low Flow (cfs)	5.491	6.06	6.6	7.02	7.403	0.1455
December Low Flow (cfs)	5.47	5.79	6.6	7	7.28	0.1833
January Low Flow (cfs)	5.534	6.043	6.77	7.06	7.229	0.1503
February Low Flow (cfs)	5.74	6.08	6.8	7	7.56	0.1353
March Low Flow (cfs)	5.74	6.08	6.7	7	7.344	0.1373
April Low Flow (cfs)	5.508	6.3	7	7.1	7.994	0.1143
May Low Flow (cfs)	1.66	3.6	5.42	7.19	8.56	0.6624
June Low Flow (cfs)	5.1	6.35	7.42	12.05	13.4	0.7682
July Low Flow (cfs)	4.402	5.74	8.8	17	20.98	1.28
August Low Flow (cfs)	3.003	4.873	7.4	10.48	17.65	0.7571
September Low Flow (cfs)	2.466	4.3	6.39	8.317	11.68	0.6287
EFC Parameters						
Extreme low peak (cfs)	0.014	0.1	0.1925	0.3263	0.4442	1.175
Extreme low duration (days)	1	6.5	20.5	36.75	51.7	1.476
Extreme low timing (Julian date)	122.7	146.9	178.3	228.3	259.2	0.2223
Extreme low freq. (#/year)	0	0	1	2	2.8	2
High flow peak (cfs)	8.25	17.63	29.25	39.88	47.75	0.7607
High flow duration (days)	5	7.125	16.5	48.75	75	2.523
High flow timing (Julian date)	42	138	195.5	277.5	316	0.3811
High flow frequency (#/year)	0	1	2	4	6	1.5
High flow rise rate (cfs difference between consecutive days)	0.7916	1.297	2.724	4.871	15.22	1.312
High flow fall rate (cfs difference between consecutive days)	-6.563	-3.943	-2.034	-0.7509	-0.4708	-1.57
Small Flood peak (cfs)	169.1	251.3	437.8	674.8	704.7	0.9674
Small Flood duration (days)	13.7	51.25	75.5	91.75	186.1	0.5364
Small Flood timing (Julian date)	132.3	136.9	148	155.6	160.4	0.05123
Small Flood freq. (#/year)	0	0	0	1	2	0
Small Flood riserate (cfs difference between consecutive days)	3.491	12.25	33.74	64.85	131.9	1.559
Small Flood fallrate (cfs difference between consecutive days)	-56.82	-24.79	-8.862	-5.954	-3.493	-2.125
Large flood peak (cfs)	755	787	912	1405	1630	0.6776
Large flood duration (days)	63	72.5	103	216.5	301	1.398
Large flood timing (Julian date)	138	141	149	154.5	159	0.03689
Large flood freq. (#/year)	0	0	0	0	0.8	0
Large flood riserate (cfs difference between consecutive days)	3.799	11.52	42.66	123.2	162.5	2.617
Large flood fallrate (cfs difference between consecutive days)	-24.54	-20.42	-14.62	-11.98	-10.2	-0.5769

Surface Water Temperature Plots





0 1,500 3,000 6,000 Feet

1 inch = 3,000 feet

GRAND COUNTY
STREAM MANAGEMENT PLAN
REACHES

Legend

- ◆ REACH BOUNDARY
- ★ PHABSIM SITES
- DIVERSIONS

REACH: WC
SHEET # :
1 OF 1

