CR4 Stream Reach Summary

Study Reach: CR4, Colorado River - Windy Gap (confluence of CR3 and F10 immediately upstream of Windy Gap) downstream to the confluence of Williams Fork at Parshall, Colorado.

Reach Description: Approximate channel length: 14.25 miles, approximate channel slope 0.5%.

Windy Gap Reservoir is located west of the town of Granby on the upstream end of CR4. This facility consists of a diversion dam on the Colorado River, a 445-acre-foot reservoir, a pumping plant, and a six-mile pipeline to Lake Granby. The Windy Gap Project can deliver an average of 48,000-acre feet of water annually at a volumetric rate of 600 cfs primarily between April and July. During the spring runoff, Fraser River water is pumped from Windy Gap Reservoir to Lake Granby, where it is stored for delivery through the Colorado-Big Thompson facilities to water users on the Front Range.

Below Windy Gap, this reach of the Colorado River is designated a Gold Medal Fishery by CDOW. The river passes under U.S. Highway 40 twice in CR4 and flows through the town of Hot Sulphur Springs. From Windy Gap to Hot Sulphur Springs the Colorado River is relatively flat in slope, with a wide and unconfined channel planform. From Hot Sulphur Springs downstream through Byers Canyon, the river valley is confined with steep canyon walls and steeper channel slopes. Above and below Hot Sulphur Springs the valley is dominated by agricultural land uses with a relatively narrow cottonwood canopy along the river. Downstream of Byers Canyon is Lone Buck, a CDOW property and popular fishing and camping area. The railroad and highway generally both parallel the river channel through this reach.

Colorado River downstream of County Road 57 Bridge at Chimney Rock Ranch between Hot Sulphur and Windy Gap

Colorado River on Sheriff's Ranch between Hot Sulphur and Windy Gap

Fisherman at Lone Buck DOW site downstream of Byers Canyon

Flow Recommendations:

***Environmental Flow Methodology*:** In 1985, CDOW conducted a PHABSIM study at Lone Buck State Wildlife Area (pers. comm., Barry Nehring, CDOW, 2007) while in 2006 Miller Ecological Consultants, Inc. also established a study site at Lone Buck. The 2006 PHABSIM analysis was provided through the Northern Colorado Water Conservation District (Miller, 2007). In summer of 2008, Tetra Tech established a third PHABSIM site in CR4 downstream of County Road 57 on the Chimney Rock Ranch. See Appendix A for methodology. The environmental flow ranges recommended herein are derived using data from all three studies. See Appendix A for methodology and Appendix E for PHABSIM survey information. CWCB instream flows have also been set for CR4 and a flushing flow was established through an agreement between the State of Colorado and Northern.

Water Users:

- Irrigators, municipalities and industry flow-related issues:
  - Hot Sulphur Springs' municipal water and wastewater facilities are along this reach. Water temperatures at low flow have been and will continue to be problematic. Otherwise, facilities are generally able to function.
  - At low flows, agricultural diversions can become difficult, requiring frequent regrading of the riverbed to create temporary dikes to channel sufficient flows.
- Recreation: This section of the river gets sporadic floatboating use when sufficient flows exist. At low water levels, many dangerous obstacles exist. At higher flows, many of the hydraulic controls wash out and benefit boating. Byers Canyon is a short stretch occasionally used for kayaking.
- Angling is popular in a reach located immediately above Hot Sulphur Springs. Anglers report that flows can become shallow and warm in mid to late summer so most fishing occurs during early morning. The Lone Buck Area is also very popular with anglers.

Summary of Flows:

<u>Environmental, recommended target flow ranges.</u>

- 200 to 400 cfs, April through September
- 125 to 250 cfs, October through March
- Flushing flow, at least 600 cfs for a 3-day duration with a frequency of 1 in 2 years during the late May to late June period.

<u>CWCB Flows</u>

- 90 cfs year round (1/1 – 12/31)
- Flushing flow, 450 cfs for 50 hours 1 in 3 years.

<u>Water Users:</u>

- Irrigators, municipalities and industry: The local diversions in this reach could potentially divert up to approximately 75 cfs. Most of the diversions are made in the summer for irrigation and likely have some return flows. Hot Sulphur Springs can divert up to 3.3 cfs year round.
- Recreational flows: Results from private and commercial users are presented below along with minimum, or tolerable flow ranges from American Whitewater for floatboating.
  - Kayaking: 300-1600 cfs (Byers Canyon)
  - American Whitewater:
    - Byers Canyon: minimum 700-2500 cfs, optimum 1700 cfs
  - Angling: 60-300 cfs

Stream Assessments: In August 2008 Tetra Tech conducted three stream assessments in three locations along CR 4 (upper, middle and lower). These included Stream Reach Inventory /Channel Stability Evaluation (SRI/CSE) and an EPA Habitat Quality Assessment (HQA). The upper site was located downstream of County Road 57 on the Chimney Rock Ranch at the PHABSIM site established in 2008; the middle site was located downstream of Hot Sulphur Springs in Byers Canyon; and the lower site was located upstream of County Road 3 at Parshall, Colorado. A Riffle Stability Index (RSI) evaluation was also conducted at the upper site.

The SRI/CSE assessments scored in the upper 'fair' category at the upper and lower sites, while the Byer's Canyon site was rated as 'good'. The EPA HQA evaluations all scored in the middle range of the 'suboptimal' category. The RSI indicated riffle substrates were highly unstable with up to 93% of the particles mobilized during recent high flow events Relevant issues revealed in the stream assessments include a lack of aquatic structure and cover in many areas, an embedded substrate in many locations having low to moderate water velocities, and the presence of a fish passage barriers at the upper end of the reach, Windy Gap dam. Riparian vegetation cover and width was poor at the Byer's Canyon site. Results of the assessments are summarized in the following tables and plot. Details and methodology are presented in Appendix A.

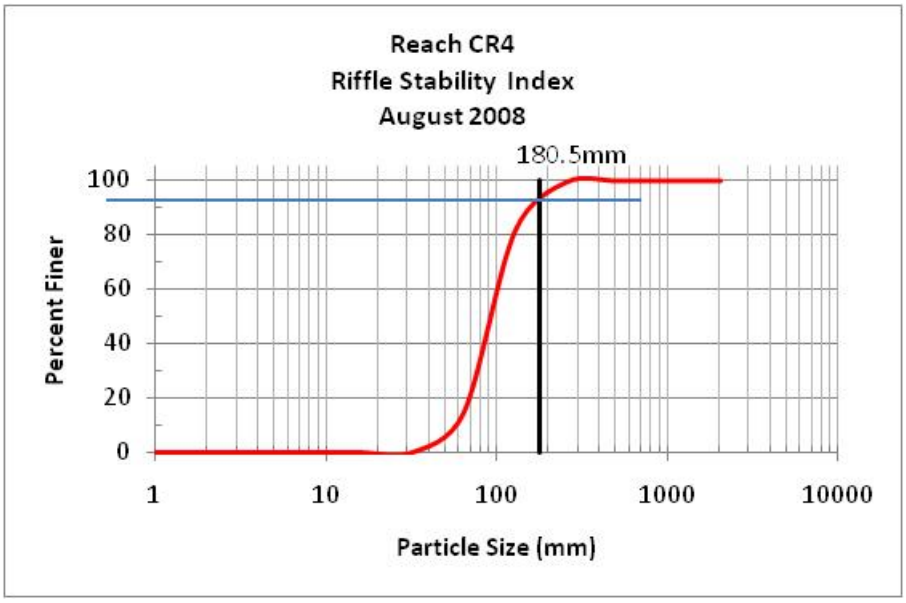
Reach CR4-U
Stream Assessments

Stream Reach Inventory/Channel Stability Evaluation		
Attribute		
Upper Banks		
1	Landform Slope	2
2	Mass wasting hazard	6
3	Debris Jam Potential	4
4	Vegetation Cover	8
	Upper Bank Score:	**20**
Lower Banks		
5	Channel Capacity	4
6	Bank Rock Content	6
7	Flow obstructors & Deflectors	4
8	Cutting	8
9	Deposition	4
	Lower Bank Score:	**26**
Channel Bottom		
10	Rock Angularity	3
11	Brightness	2
12	Consolidation/Particle Packing	5
13	Bottom size distribution	8
14	Bed Scour and Deposition	12
15	Clinging Aquatic Veg	3
	Channel Bottom Score:	**33**
	Total Score:	**79**

EPA Habitat Quality Assessment		
Attribute		**Score**
Channel		
1	Aquatic Habitat Barriers/ Diversion	8
2	Aquatic Structure as Cover	8
3	Velocity/ Depth Regimes	16
4	Channel Flow Status	16
5	Channel Alteration	15
6	Frequency of Riffles	16
7	Channel Sinuosity	8
	Channel Score	**87**
Banks		
8	Bank Stability	16
9	Riparian Vegetation Cover and Disturbance	14
10	Riparian Vegetation zone width	12
	Bank Score	42
	Total Score	**129**
Notes		

Reach CR4-M Stream Assessments					
Stream Reach Inventory/Channel Stability Evaluation			**EPA Habitat Quality Assessment**		
Attribute			**Attribute**		**Score**
Upper Banks			**Channel**		
1	Landform Slope	6	1	Aquatic Habitat Barriers/ Diversion	18
2	Mass wasting hazard	9	2	Aquatic Structure as Cover	14
3	Debris Jam Potential	2	3	Velocity/ Depth Regimes	18
4	Vegetation Cover	12	4	Channel Flow Status	15
	Upper Bank Score:	**29**	5	Channel Alteration	16
Lower Banks			6	Frequency of Riffles	16
5	Channel Capacity	1	7	Channel Sinuosity	8
6	Bank Rock Content	2		**Channel Score**	**105**
7	Flow obstructors & Deflectors	2	**Banks**		
8	Cutting	4	8	Bank Stability	18
9	Deposition	4	9	Riparian Vegetation Cover and Disturbance	2
	Lower Bank Score:	**13**	10	Riparian Vegetation zone width	2
Channel Bottom				**Bank Score**	22
10	Rock Angularity	3		**Total Score**	**127**
11	Brightness	2	**Notes**		
12	Consolidation/Particle Packing	4			
13	Bottom size distribution	6			
14	Bed Scour and Deposition	9			
15	Clinging Aquatic Veg	3			
	Channel Bottom Score:	**27**			
	Total Score:	**69**			

Reach CR4-L 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	15
2	Mass wasting hazard	12	2	Aquatic Structure as Cover	12
3	Debris Jam Potential	3	3	Velocity/ Depth Regimes	16
4	Vegetation Cover	6	4	Channel Flow Status	15
	Upper Bank Score:	**25**	5	Channel Alteration	15
Lower Banks			6	Frequency of Riffles	17
5	Channel Capacity	4	7	Channel Sinuosity	10
6	Bank Rock Content	7		**Channel Score**	**100**
7	Flow obstructors & Deflectors	4	**Banks**		
8	Cutting	8	8	Bank Stability	14
9	Deposition	8	9	Riparian Vegetation Cover and Disturbance	12
	Lower Bank Score:	**31**	10	Riparian Vegetation zone width	12
Channel Bottom				**Bank Score**	38
10	Rock Angularity	3		**Total Score**	**138**
11	Brightness	2	**Notes**		
12	Consolidation/Particle Packing	4			
13	Bottom size distribution	8			
14	Bed Scour and Deposition	12			
15	Clinging Aquatic Veg	3			
	Channel Bottom Score:	**32**			
	Total Score:	**88**			



Spawning Observations: A trout spawning survey was conducted on 29 October 2008 in the vicinity of the Chimney Rock Ranch PHABSIM site. Numerous adult brown trout were observed exhibiting spawning behavior and field measurements were taken at six completed redds.

Hydrologic Records: Two USGS Gage Stations have been operated within CR4, Station 09034250 (CR at Windy Gap) from 1981 to present and Station 09034500 (CR at Hot Sulphur Springs) operated year round from 1904 to 1994, then seasonally from 1997-2007. These records indicate the recommended environmental flow ranges are commonly present within the reach during the April to July period, but less available under current river operations for the remainder of the year. Based upon the IHA analysis, the recommended flushing flow was commonly present in the river prior to 1985 during the May through June period when median monthly flows were 1145 and 1795 cfs, respectively. Since 1986, the recommended flushing flow falls between the median 1-day and 3-day maximum flows at the Hot Sulphur Springs gage (1986 - 1994) and is less than the median 1-, 3-, and 7-day maximums at the Windy Gap gage (1986 - 2007).

Water Temperature: CR4 is a Tier II stream reach as designated by CDPHE with a chronic temperature standard of 18.2^{o}C MWAT and an acute temperature standard of 23.8^{o}C DM. Temperature data reviewed in reach CR4 indicate stream temperatures for the Colorado River in this area generally exceed the MWAT standard during the summer months, typically late July to early August. The DM standard has been occasionally exceeded also in the summer months. This reach has been identified by the State of Colorado for having temperature impairment, with a high priority, as defined by the Clean Water Act, Section 303(d).

Water Quality: Based on visual observations in July 2007 and August 2008, algae were abundant in reaches upstream of Hot Sulphur Springs. In Byers Canyon, however, algae were less abundant, most likely due to the faster-moving waters along the steeper channel. Available data indicate that the pH of the Colorado River near Windy Gap has occasionally exceeded the criteria of 9 standard units since 2000. All other available data indicate that water quality in this reach meet established criteria.

Water Supply Issues (UPCO): UPCO reports that current flows in this reach are generally adequate and under future conditions water supply will have occasional shortages. Model results also indicate that under both existing and future conditions flows are and will be below the CWCB ISF for substantial periods of time.

Summary of Results and Additional Remarks:

1. Recommended environmental target flows are commonly present within the reach during the April to July period, but less available under current river operations for the remainder of the year.
2. The stream assessments indicate limited aquatic structure and cover, an embedded substrate in lower velocity areas, the presence of a fish passage barrier (Windy Gap), and poor riparian vegetation in localized areas.
3. Onsite observations indicate isolated stream bed manipulation to facilitate irrigation diversions.
4. Temperatures exceedences are common and CR4 is currently on the proposed 303(d) list with a high priority.
5. Flows for recreation are generally adequate except late summer low flows combined with high temperatures are believed to be impacting the fisheries. There is little float boating in CR4 due to limited access and low flows.
6. The CDOW conducted a study in January 2010 temporally and spatially comparing aquatic macro invertebrate abundance and fish population surveys for the Colorado River in Middle Park. The results indicate the overall abundance and distribution of the stonefly *Pteronarcys californica (Pc)* and the mottled sculpin *Cottus bairdi* have been dramatically reduced

downstream of Wind Gap Dam since the dam was constructed in the early 1980s. Stomach contents of trout caught in 1980 through 1984 in the Colorado River indicate that Pc nymphs were the single most important food item in the trout diet. However, based on 2009 data the Pc nymphs now appear to be almost extricated between Windy Gap and Hot Sulphur Springs. In the same reach mottled sculpin populations represent 0% to 5% of the fish population below Windy Gap versus 23.1% to 80% above. The specific cause of these declines has not yet been identified and further investigation appears warranted. (CDOWb).

7. This reach of the Colorado River has been highly affected by whirling disease and elevated water temperatures, both of which may be exacerbated by the warm, nutrient rich environment of Windy Gap located immediately upstream. Studies of TAM production and introduction of whirling disease resistant rainbow trout are two efforts concurrently ongoing to increase the rainbow trout populations.
8. Nutrient loading at Windy Gap may warrant further study, in particular nutrient loading from water fowl that forage in the vicinity of the reservoir and defecate in the water.
9. A high quality fishery, designated as "Gold Medal" by CDOW, exists for brown and rainbow trout within CR4. Recent trout population surveys at the Paul Gilbert Area below Byer's Canyon indicate brown trout biomass of 103 lbs/ac with 30 trout >14" (Ewert 2009). Rainbow trout numbers remain low in comparison to brown trout.
10. The winter target flow recommendation was based upon available trout spawning and incubation habitat at the upstream most PHABSIM study site (Chimney Rock Ranch) because of the aggregation of actively spawning brown trout found in this area and the closer agreement of the resultant flow recommendations with recent and historic water availability.
11. CDOW indicates that much of this reach and in particular just upstream of Pioneer Park appears excessively wide and very shallow, often preventing fish movement under low flow conditions. CDOW would like to see restoration in this area. (Pers. Comm., Jon Ewert, CDOW, 2008).
12. Review of future flow conditions as depicted by Denver Water's PACSM model indicate that the late summer flows, flushing flows and winter base flows, without flow enhancements or restoration, will be typically lower than recommended target flow ranges in this reach.

Restoration Opportunities: There are numerous restoration opportunities in CR4. Recommendations presented here are aimed at reducing the impacts from elevated temperatures, high pH, frequent low flows in late summer, infrequent flushing flow, lack of aquatic structure and cover, and fish barriers to upstream passage. Specific restoration opportunities include the following:

- ✓ Apply enhancement flows to increase low flows, typically in August and September and/or to increase flushing flows during spring runoff. Alternate application of enhancement and flushing flows as needed.

- ✓ Assess the pro's and con's of realigning the river channel around Windy Gap to eliminate the 'petri-dish' effect of the reservoir on river quality by creating an off-line forebay for the Windy Gap pumps. Fish passage would also be enhanced by such an action.

- ✓ Increase aquatic structure and cover with 'cover and pool' structures and construct channel bar enhancements to narrow the low flow channel. See Appendix F for details.

- ✓ Inspect headgates at irrigation diversions and replace as needed where stream bed manipulation is currently required to maintain adequate headwater.

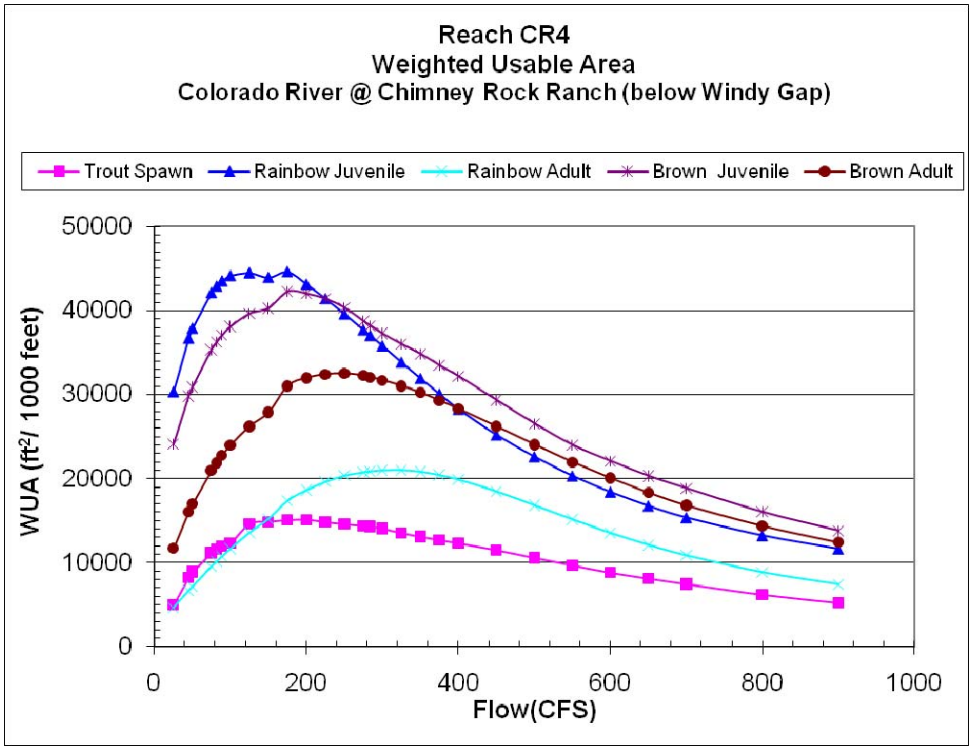
Monitoring: Establish and implement a monitoring program. Parameters should include water quality; air temperature; intergravel fine sediments; fish population and diversity; cross sectional surveys and stream assessments; and benthic macro invertebrates. Continue to monitor surface water temperatures and flows. Continue to monitor for whirling disease. Replace the seasonal streamflow gage at Hot Sulphur Springs with a year round gage.

Support Data

Weighted Useable Area Plots and Tables

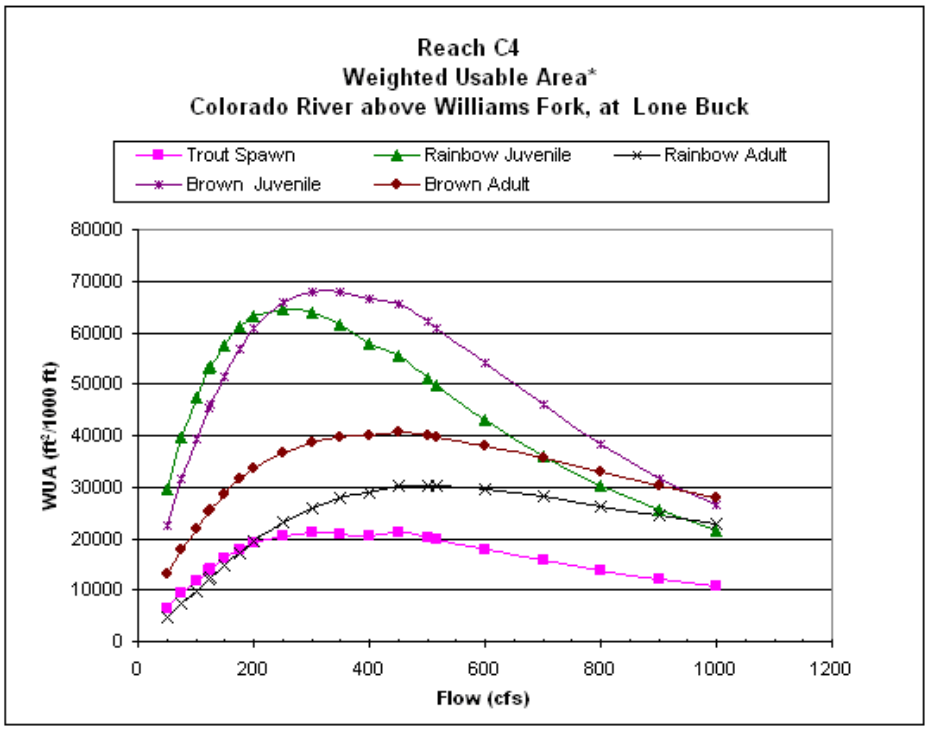
Habitat-flow relations for the target species and life stages for Reach CR4, Tetra Tech site.

Reach CR4						
Discharge	Total Area	Trout Spawn	Rainbow Juvenile	Rainbow Adult	Brown Juvenile	Brown Adult
(cfs)	(ft^2)	Weighted Usable Area (ft^2/1000 ft stream length)				
25.00	81840.6	4981.3	30368.1	4643.9	24107.4	11705.8
45.00	88289.0	8223.8	36721.0	6674.7	29803.7	16056.7
50.00	89193.4	8879.5	37910.6	7163.6	30931.4	16987.1
75.00	92949.7	11172.5	42157.0	9543.7	35364.1	20952.1
82.00	93451.6	11608.5	42934.7	10161.9	36269.2	21906.6
89.00	93924.6	11980.6	43541.8	10756.5	37088.6	22795.6
100.00	94618.3	12314.0	44177.5	11663.9	38110.6	24013.4
125.00	96182.8	14629.6	44507.5	13578.6	39635.2	26235.0
150.00	98051.1	14870.8	43964.3	15238.7	40305.7	27888.9
175.00	99435.3	15061.7	44644.6	17378.3	42264.0	31035.2
200.00	100235.1	15119.5	43155.7	18645.9	42019.1	31991.1
225.00	100771.1	14820.1	41437.1	19627.6	41410.3	32407.7
250.00	101157.6	14580.0	39609.5	20359.5	40345.7	32518.0
275.00	101517.4	14385.4	37719.8	20763.5	38731.2	32263.4
284.00	101641.2	14293.5	37047.1	20870.7	38212.5	32077.6
300.00	101854.6	14046.4	35816.4	20992.9	37269.6	31710.7
325.00	102134.5	13533.1	33858.2	21016.4	35999.4	31041.1
350.00	102356.3	13085.1	31933.8	20825.9	34853.1	30228.9
375.00	102933.2	12691.8	30079.0	20424.9	33461.5	29279.4
400.00	103165.9	12306.0	28276.3	19886.0	32189.3	28291.1
450.00	103576.5	11505.8	25217.4	18473.8	29336.7	26207.9
500.00	103933.1	10585.9	22626.7	16818.1	26540.8	24064.7
550.00	104263.7	9686.5	20343.4	15127.5	23990.5	21979.0
600.00	104572.2	8821.3	18425.7	13520.3	22089.1	20087.3
650.00	104853.8	8131.0	16770.5	12104.4	20316.6	18355.7
700.00	105085.4	7473.6	15378.0	10853.4	18830.8	16839.2
800.00	105512.8	6213.5	13248.8	8843.4	16022.9	14393.7
900.00	105900.9	5238.2	11660.2	7413.7	13792.6	12438.5



Habitat-flow relations for the target species and life stages for Reach C4, developed from CDOW

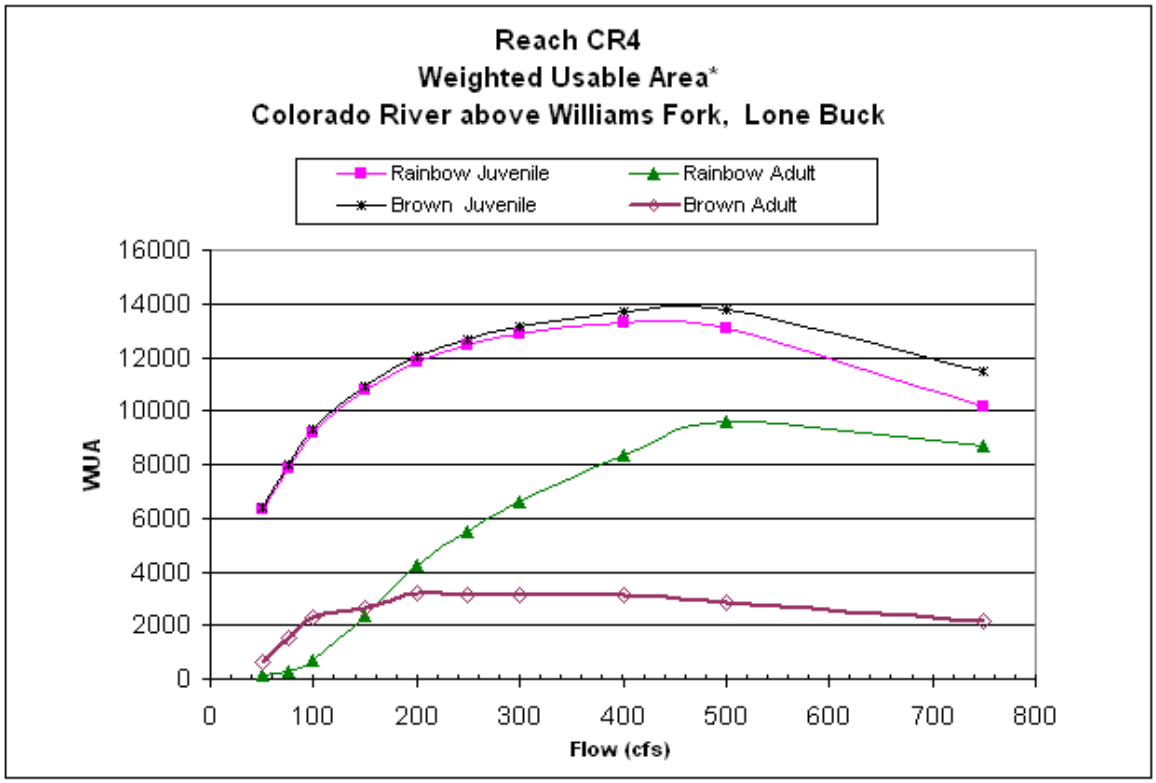
CR4						
Discharge	Total Area	Trout Spawn	Rainbow Juvenile	Rainbow Adult	Brown Juvenile	Brown Adult
(cfs)	(ft^2)	Weighted Usable Area (ft^2/1000 ft stream length)				
50.0	90050.1	6530.3	29716.6	4809.9	22629.3	13146.2
75.0	99610.1	9340.0	39608.6	7325.5	31534.7	17766.9
100.0	102757.5	11767.1	47448.3	9905.5	39226.6	21907.3
123.0	105511.7	13911.5	52957.8	12199.5	45405.8	25129.6
125.0	105675.0	14081.1	53354.6	12396.6	45897.8	25392.1
150.0	107532.8	16109.3	57628.0	14732.9	51580.3	28440.7
175.0	109011.8	17963.7	61227.4	17286.4	56878.3	31500.8
200.0	110480.9	19279.4	63240.5	19432.5	60701.3	33602.8
250.0	112063.2	20620.9	64701.3	23169.9	65821.5	36752.5
300.0	113130.5	21079.4	63952.7	26011.9	68042.5	38671.9
350.0	113969.2	20980.9	61371.3	27934.1	67953.0	39623.5
400.0	114776.3	20397.6	57937.5	29048.5	66513.3	39874.1
450.0	115497.0	21010.8	55350.5	30227.8	65613.7	40584.5
500.0	116290.4	20035.1	51222.7	30399.4	62312.7	39994.9
517.0	116521.4	19709.6	49804.3	30350.8	60853.7	39716.8
600.0	117436.3	17978.4	43179.4	29650.9	54165.7	38078.9
700.0	118513.1	15889.6	36023.2	28183.6	45900.9	35535.8
800.0	119598.8	13883.3	30193.3	26382.2	38299.8	32906.6
900.0	121855.8	12253.5	25404.8	24571.2	31743.1	30341.3
1000.0	122766.5	10893.3	21630.7	22764.9	26571.7	27938.9



*data provided by Bary Nehring at CDOW, WUA plots based on updated curves and vary slightly from 1985 analysis

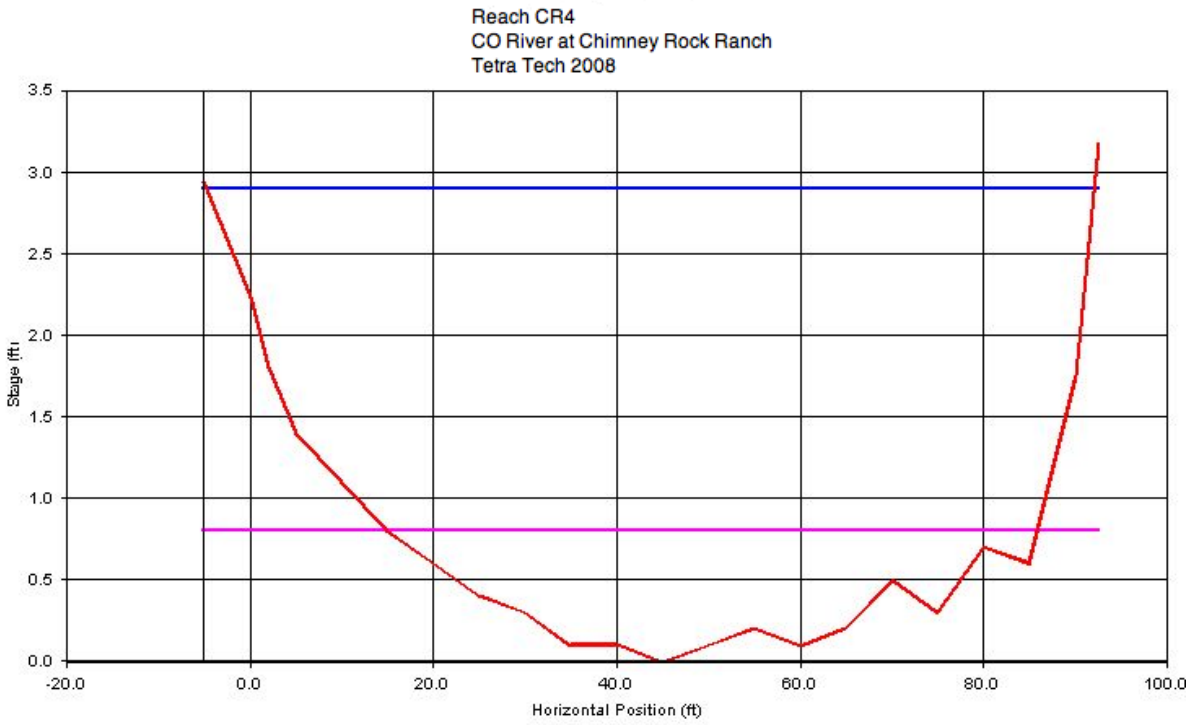
Habitat-flow relations for the target species and life stages for Reach C4, from Miller Ecological Consultants River 2D data.

CR4						
Discharge	Total Area	Trout Spawn	Rainbow Juvenile	Rainbow Adult	Brown Juvenile	Brown Adult
(cfs)	(ft^2)	Weighted Usable Area				
50			6301	125	6414	594
75			7881	292	8012	1557
100			9186	722	9325	2322
150			10758	2375	10903	2610
200			11857	4267	12044	3203
250			12478	5521	12673	3127
300			12888	6616	13159	3111
400			13278	8347	13685	3104
500			13065	9569	13749	2855
750			10166	8714	11470	2189



*WUS provided by Miller Ecological Consultants

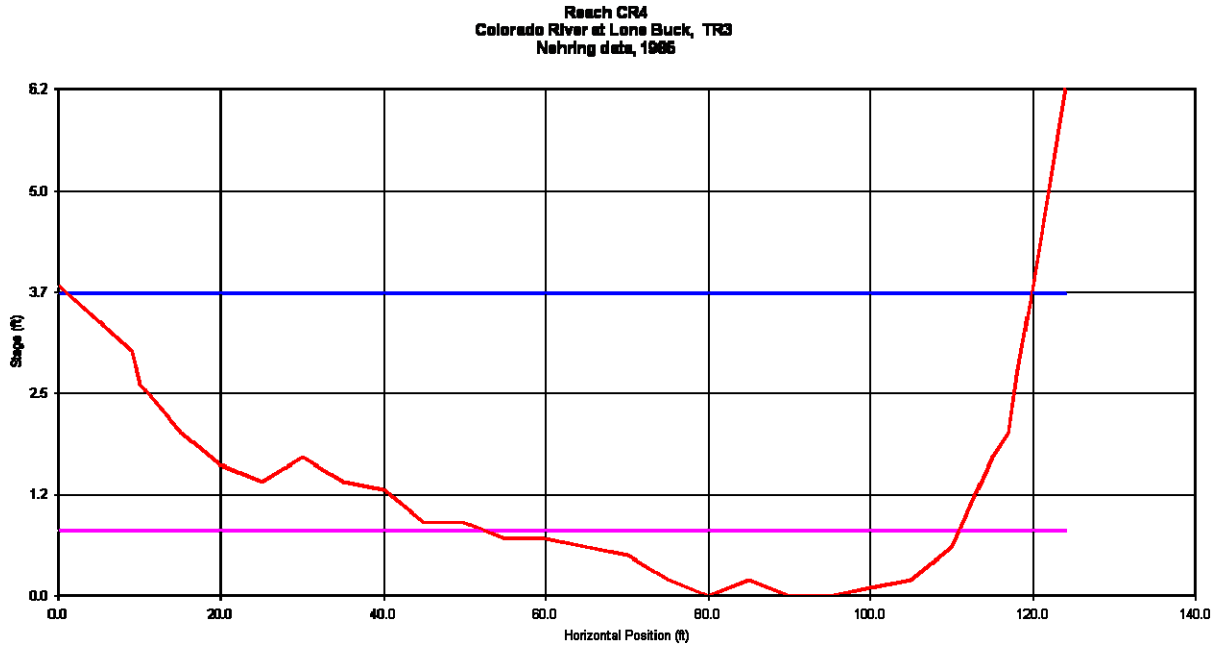
Transect and Bedload Threshold Plots and Tables



Reach CR4, TR5
TT2008 site

Resistance Method: Jarrett's Equation

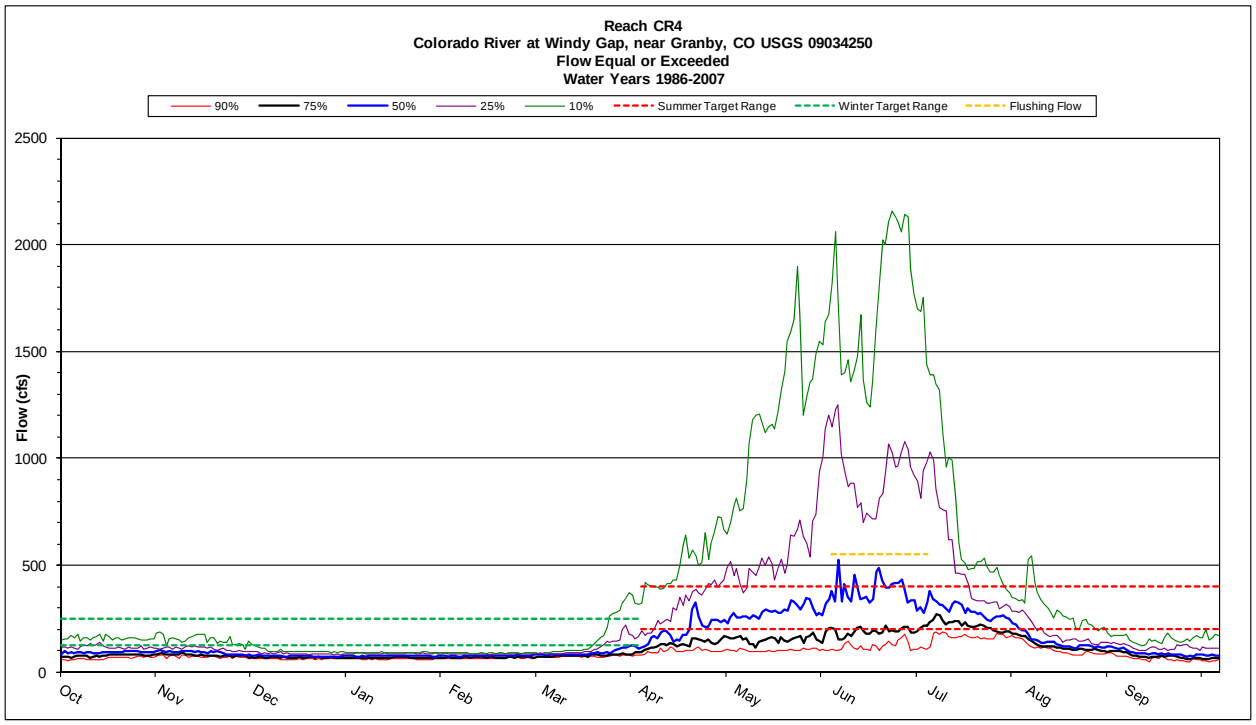
STAGE (ft)	AREA (sq ft)	PERIM (ft)	WIDTH (ft)	R (ft)	DHYD (ft)	SLOPE (ft/ft)	n	VAVG (ft/s)	Q (cfs)	SHEAR (psf)
0.80	34.59	70.94	70.87	0.49	0.49	0.003	0.048	1.05	36.15	0.09
0.90	41.78	73.05	72.97	0.57	0.57	0.003	0.047	1.20	50.04	0.11
1.00	49.18	75.16	75.06	0.65	0.66	0.003	0.047	1.34	66.11	0.13
1.10	56.79	77.28	77.16	0.73	0.74	0.003	0.047	1.49	84.36	0.15
1.20	64.61	79.39	79.26	0.81	0.82	0.003	0.046	1.62	104.82	0.17
1.30	72.64	81.51	81.36	0.89	0.89	0.004	0.046	1.76	127.51	0.19
1.40	80.88	83.62	83.46	0.97	0.97	0.004	0.046	1.88	152.45	0.22
1.50	89.29	84.81	84.64	1.05	1.05	0.004	0.046	2.03	181.13	0.24
1.60	97.81	86.00	85.81	1.14	1.14	0.004	0.046	2.17	212.20	0.27
1.70	106.45	87.20	86.98	1.22	1.22	0.004	0.046	2.31	245.67	0.29
1.80	115.21	88.28	88.05	1.30	1.31	0.004	0.046	2.45	281.82	0.32
1.90	124.04	88.98	88.71	1.39	1.40	0.004	0.046	2.59	321.45	0.35
2.00	132.95	89.66	89.36	1.48	1.49	0.004	0.046	2.74	363.63	0.38
2.10	141.91	90.35	90.00	1.57	1.58	0.004	0.046	2.88	408.30	0.42
2.20	150.95	91.03	90.65	1.66	1.67	0.004	0.045	3.02	455.47	0.45
2.30	160.05	91.88	91.46	1.74	1.75	0.004	0.046	3.15	504.43	0.48
2.40	169.24	92.81	92.36	1.82	1.83	0.005	0.046	3.28	555.47	0.51
2.50	178.52	93.74	93.26	1.90	1.91	0.005	0.046	3.41	608.95	0.55
2.60	187.89	94.67	94.15	1.98	2.00	0.005	0.046	3.54	664.88	0.58
2.70	197.35	95.60	95.05	2.06	2.08	0.005	0.046	3.66	723.28	0.62
2.80	206.90	96.53	95.95	2.14	2.16	0.005	0.046	3.79	784.14	0.66
2.90	216.54	97.46	96.85	2.22	2.24	0.005	0.046	3.91	847.48	0.69

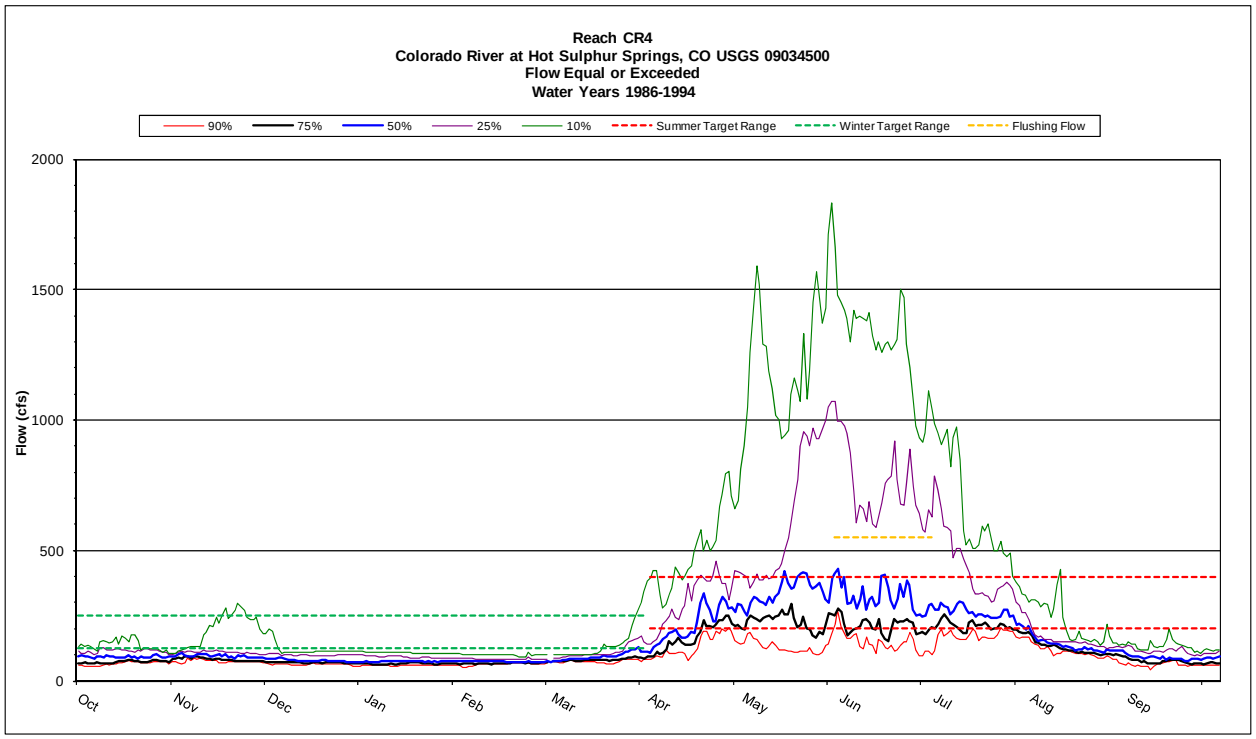


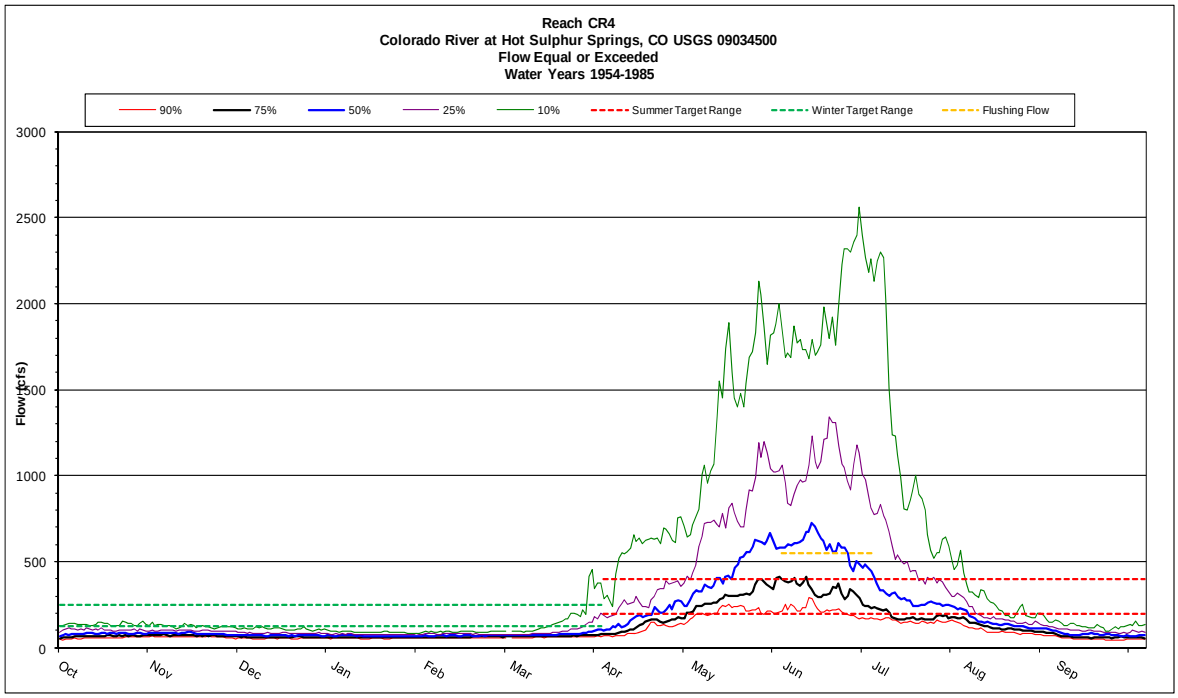
Reach CR4, TR3
Colorado River at Lone Buck
Nehring data, 1985

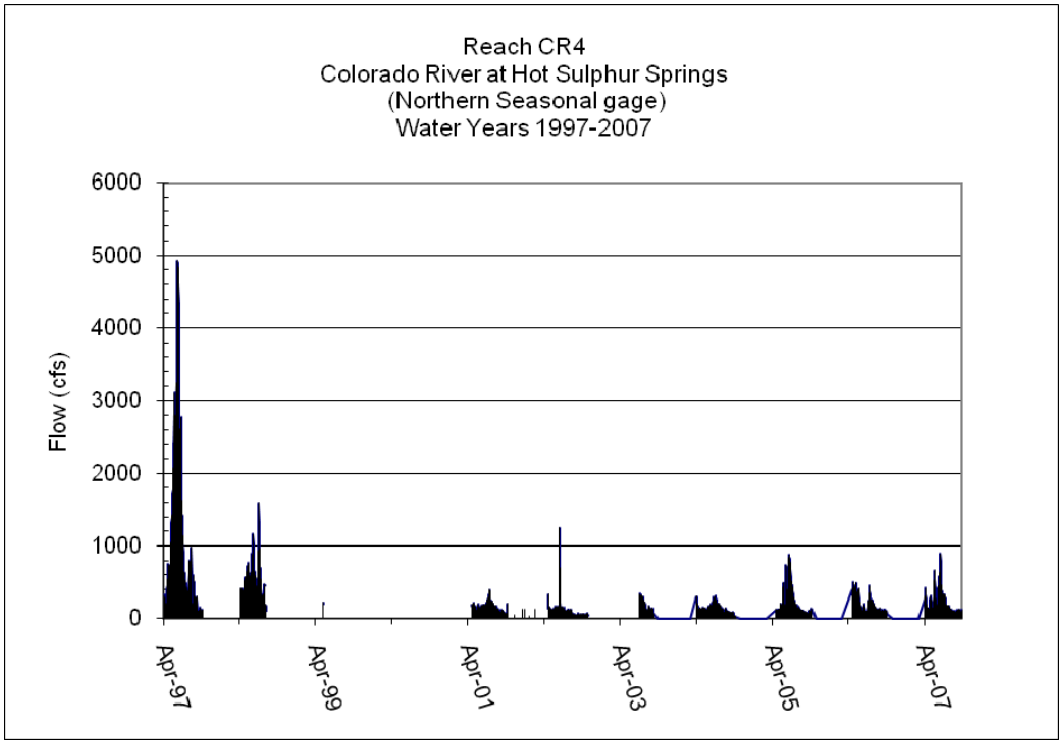
STAGE (ft)	AREA (sq ft)	PERIM (ft)	WIDTH (ft)	R (ft)	DHYD (ft)	SLOPE (ft/ft)	n	VAVG (ft/s)	Q (cfs)	SHEAR (psf)
0.8	28.47	58.47	58.41	0.49	0.49	0.002	0.041	0.99	28.3	0.06
0.9	34.45	61.44	61.36	0.56	0.56	0.002	0.040	1.12	38.5	0.07
1.0	41.17	68.16	68.07	0.60	0.60	0.002	0.040	1.19	49.0	0.08
1.1	48.07	69.88	69.77	0.69	0.69	0.002	0.039	1.32	63.7	0.09
1.2	55.13	71.60	71.47	0.77	0.77	0.002	0.038	1.45	80.2	0.10
1.3	62.36	73.32	73.18	0.85	0.85	0.002	0.038	1.58	98.5	0.11
1.4	69.95	78.78	78.63	0.89	0.89	0.002	0.037	1.64	114.6	0.11
1.5	78.13	85.09	84.92	0.92	0.92	0.002	0.037	1.68	131.6	0.11
1.6	86.94	91.40	91.21	0.95	0.95	0.002	0.037	1.73	150.7	0.12
1.7	96.31	96.45	96.25	1.00	1.00	0.002	0.037	1.81	173.9	0.12
1.8	106.03	98.38	98.16	1.08	1.08	0.002	0.036	1.92	203.9	0.13
1.9	115.94	100.31	100.08	1.16	1.16	0.002	0.036	2.04	236.3	0.14
2.0	126.04	102.24	102.00	1.23	1.24	0.002	0.036	2.15	271.0	0.15
2.1	136.29	103.25	102.97	1.32	1.32	0.002	0.035	2.28	310.2	0.16
2.2	146.64	104.27	103.95	1.41	1.41	0.002	0.035	2.40	351.7	0.18
2.3	157.08	105.28	104.92	1.49	1.50	0.002	0.034	2.52	395.7	0.19
2.4	167.62	106.29	105.90	1.58	1.58	0.002	0.034	2.64	442.2	0.20
2.5	178.26	107.31	106.88	1.66	1.67	0.002	0.034	2.75	491.0	0.21
2.6	189.00	108.32	107.85	1.74	1.75	0.002	0.034	2.87	542.2	0.22
2.7	199.80	108.76	108.25	1.84	1.85	0.002	0.033	2.99	598.2	0.23
2.8	210.65	109.24	108.68	1.93	1.94	0.002	0.033	3.12	656.6	0.24
2.9	221.54	109.72	109.11	2.02	2.03	0.002	0.033	3.24	717.5	0.25
3.0	232.47	110.19	109.54	2.11	2.12	0.002	0.033	3.36	780.8	0.26
3.1	243.49	111.53	110.85	2.18	2.20	0.002	0.032	3.46	841.3	0.27
3.2	254.64	112.87	112.15	2.26	2.27	0.002	0.032	3.55	904.2	0.28
3.3	265.92	114.20	113.46	2.33	2.34	0.002	0.032	3.65	969.3	0.29
3.4	277.33	115.54	114.77	2.40	2.42	0.002	0.032	3.74	1036.7	0.30
3.5	288.87	116.88	116.08	2.47	2.49	0.002	0.032	3.83	1106.4	0.31
3.6	300.55	118.22	117.38	2.54	2.56	0.002	0.032	3.92	1178.4	0.32
3.7	312.35	119.55	118.69	2.61	2.63	0.002	0.032	4.01	1252.8	0.33

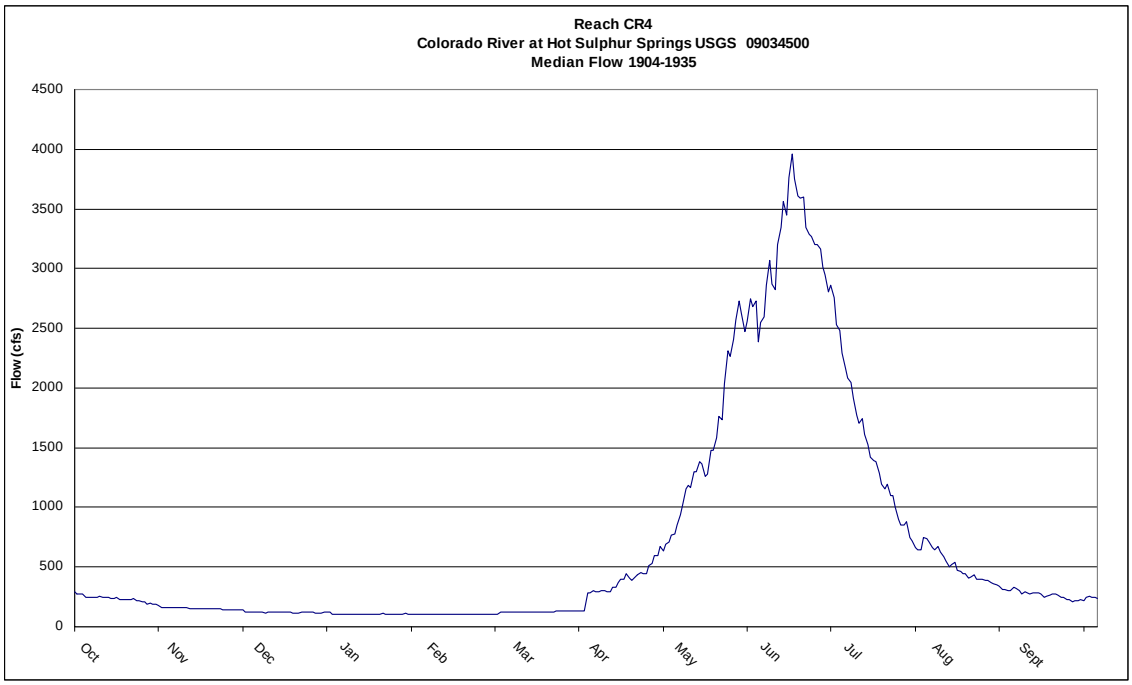
Hydrographs and Exceedence Plots and Tables

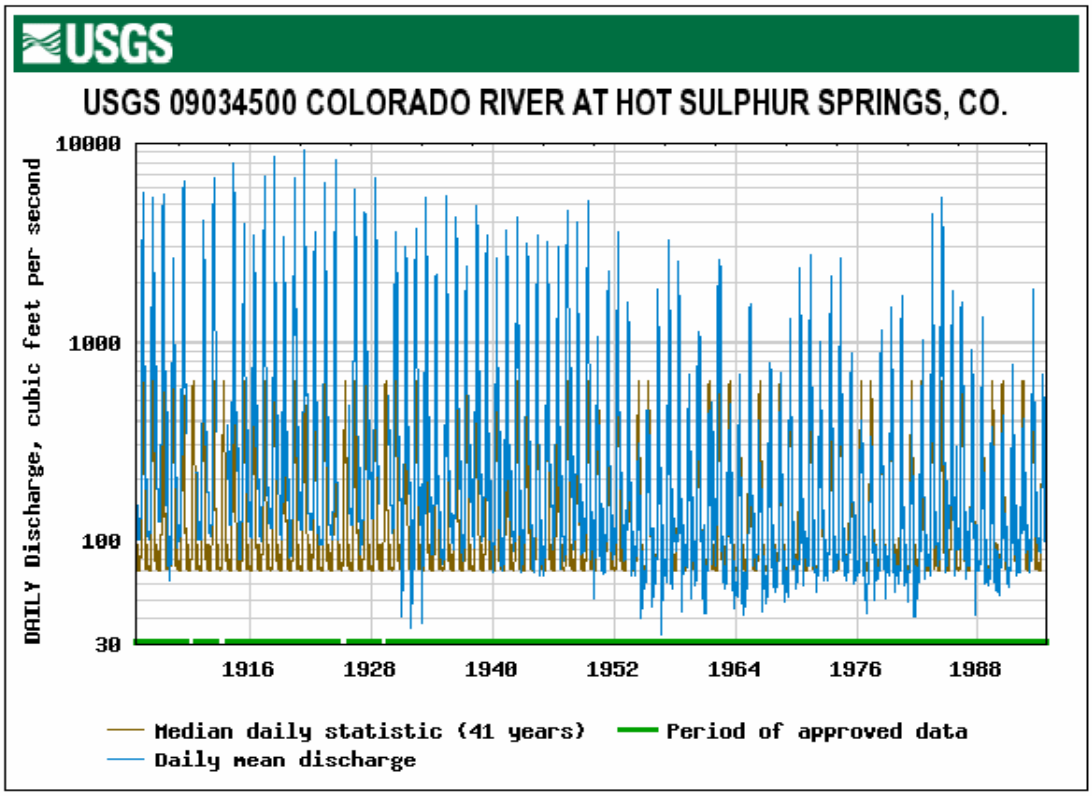





Reach CR4
Colorado River at Hot Sulphur Springs, CO USGS 09034500
Flow Equal or Exceeded
Water Years 1954-1985
90%
75%
50%
25%
10%
Summer Target Range
Winter Target Range
Flushing Flow
Flow (cfs)
3000
2500
2000
1500
1000
500
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep


Reach CR4
Colorado River at Hot Sulphur Springs
(Northern Seasonal gage)
Water Years 1997-2007
Flow (cfs)
6000
5000
4000
3000
2000
1000
0
Apr-97
Apr-99
Apr-01
Apr-03
Apr-05
Apr-07


Reach CR4
Colorado River at Hot Sulphur Springs USGS 09034500
Median Flow 1904-1935
Flow (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept


USGS
USGS 09034500 COLORADO RIVER AT HOT SULPHUR SPRINGS, CO.
DAILY Discharge, cubic feet per second
10000
1000
100
30
1916
1928
1940
1952
1964
1976
1988
Median daily statistic (41 years)
Period of approved data
Daily mean discharge

Return Period T (year)	Probability P (percent)	Flood Discharge Q (ft^3/sec)
1.05	95.2	303
1.11	90.1	407
1.25	80	582
2	50	1147
5	20	2245
10	10	3178
25	4	4595

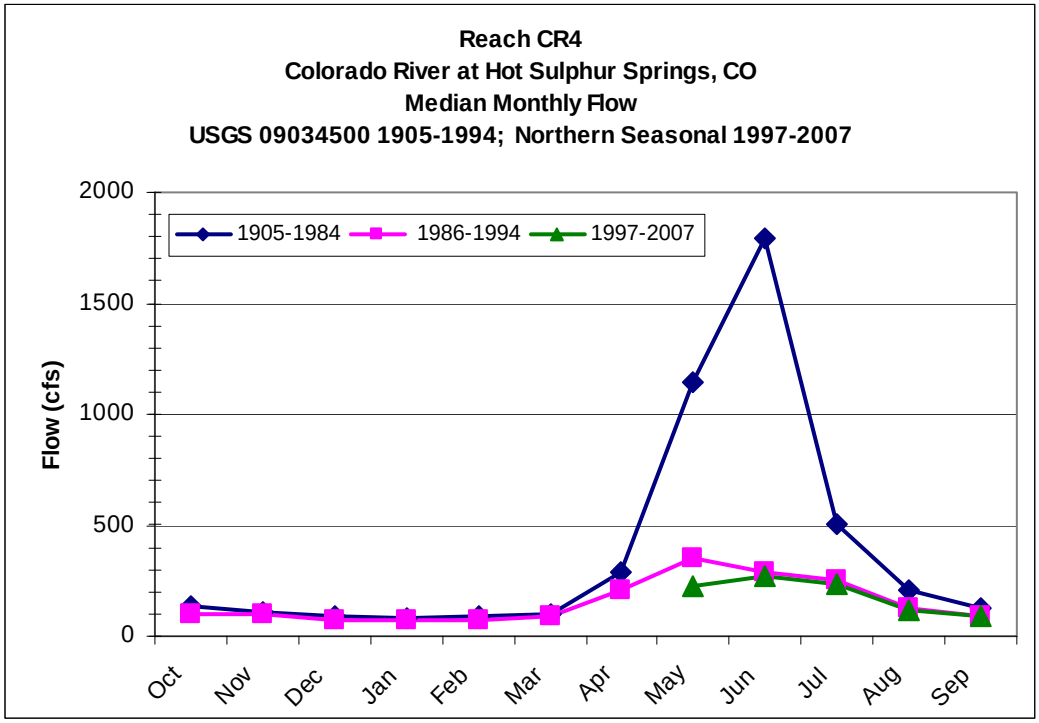
Flood frequency analysis for USGS 09034250 Colorado River at Windy Gap, near Granby, CO, for 22 years of record (Water years 1985-2006).

Return Period T (year)	Probability P (percent)	Flood Discharge Q (ft^3/sec)
1.05	95.2	3086
1.11	90.1	3570
1.25	80	4232
2	50	5742
5	20	7599
10	10	8712
25	4	10009

Flood frequency analysis for USGS 090345000 Colorado River at Hot Sulphur Springs, CO for 31 years of record (Water years 1905-35).

Return Period T (year)	Probability P (percent)	Flood Discharge Q (ft^3/sec)
1.05	95.2	424
1.11	90.1	613
1.25	80	931
2	50	1921
5	20	3595
10	10	4807
25	4	6383

Flood frequency analysis for USGS 090345000 Colorado River at Hot Sulphur Springs, CO for 49 years of record (Water years 1936-85).



IHA Results

Reach CR4
Non-Parametric IHA Scorecard
USGS 09034250 Colorado River at Windy Gap

Period of Analysis: 1986-2007 (22 years)

Mean annual flow (cfs)	214.8
Mean flow/area (dimensionless)	214.8
Annual C. V.	1.55
Flow predictability (%)	0.69
Constancy/predictability	0.68
% of floods in 60d period	0.45
Flood-free season (days)	105

	Medians	**Coeff. of Disp.**
Parameter Group #1		
October (cfs)	99.5	0.3417
November (cfs)	93	0.2728
December (cfs)	75.5	0.202
January (cfs)	75.5	0.2219
February (cfs)	76.25	0.1918
March (cfs)	84.5	0.2781
April (cfs)	187.8	0.7716
May (cfs)	283.5	1.422
June (cfs)	390.5	2.012
July (cfs)	254	0.4075
August (cfs)	123.5	0.3522
September (cfs)	82.5	0.5288
Parameter Group #2		
1-day minimum (cfs)	51.5	0.2913
3-day minimum (cfs)	56.17	0.2463
7-day minimum (cfs)	62.29	0.203
30-day minimum (cfs)	69.53	0.1846
90-day minimum (cfs)	73.61	0.162
1-day maximum (cfs)	954	1.437
3-day maximum (cfs)	894.2	1.514
7-day maximum (cfs)	834.5	1.303
30-day maximum (cfs)	502.4	1.475
90-day maximum (cfs)	342.9	1.433
Number of zero days (count)	0	0
Base flow index (7day minimun in cfs/median in cfs)	0.3808	0.6124
Parameter Group #3		
Date of minimum (Julian day)	278	0.2261
Date of maximum (Julian day)	165	0.07514
Parameter Group #4		
Low pulse count (#)	10	1.2
Low pulse duration (days)	2.75	0.7727
High pulse count (#)	5.5	0.5455
High pulse duration (days)	3.25	3.231
The low pulse threshold is (cfs)	79	
The high pulse threshold is (cfs)	195	
Parameter Group #5		
Rise rate (cfs difference between consecutive days)	8	0.6094
Fall rate (cfs difference between consecutive days)	-7.5	-0.5667
Number of reversals	133	0.3947

Reach CR4
IHA Percentile Data
USGS 09034250 Colorado River at Windy Gap

Period of Analysis: 1986-2007 (22 years)

	Period of Analysis					
	10%	**25%**	**50%**	**75%**	**90%**	**(75-25)/50**
Parameter Group #1						
October (cfs)	63.8	78.75	99.5	112.8	151.6	0.3417
November (cfs)	74.8	79.25	93	104.6	156.8	0.2728
December (cfs)	63.9	70	75.5	85.25	94.7	0.202
January (cfs)	62.3	69.25	75.5	86	91.4	0.2219
February (cfs)	66	70.38	76.25	85	87.85	0.1918
March (cfs)	74.3	77.75	84.5	101.3	114.8	0.2781
April (cfs)	115.6	150.3	187.8	295.1	425.9	0.7716
May (cfs)	121.5	170	283.5	573.3	1307	1.422
June (cfs)	182.5	192.6	390.5	978.1	1592	2.012
July (cfs)	178.1	224	254	327.5	491.6	0.4075
August (cfs)	105.9	111.5	123.5	155	234.4	0.3522
September (cfs)	63.35	71	82.5	114.6	136.1	0.5288
Parameter Group #2						
1-day minimum (cfs)	38.3	45.25	51.5	60.25	62	0.2913
3-day minimum (cfs)	44.57	49.67	56.17	63.5	69.07	0.2463
7-day minimum (cfs)	50.93	54.61	62.29	67.25	73.79	0.203
30-day minimum (cfs)	59.77	63.89	69.53	76.73	83.07	0.1846
90-day minimum (cfs)	63.98	71.2	73.61	83.13	90.19	0.162
1-day maximum (cfs)	356	444.3	954	1815	3327	1.437
3-day maximum (cfs)	327.2	433.3	894.2	1788	3009	1.514
7-day maximum (cfs)	305	382.6	834.5	1470	2688	1.303
30-day maximum (cfs)	251.1	315.7	502.4	1057	1736	1.475
90-day maximum (cfs)	193.8	231.7	342.9	723.2	1297	1.433
Number of zero days (count)	0	0	0	0	0	0
Base flow index (7day minimun in cfs/median in cfs)	0.163	0.2034	0.3808	0.4365	0.4837	0.6124
Parameter Group #3						
Date of minimum (Julian day)	252	264	278	346.8	363	0.2261
Date of maximum (Julian day)	130.5	151.5	165	179	190.3	0.07514
Parameter Group #4						
Low pulse count (#)	2.3	4	10	16	22.1	1.2
Low pulse duration (days)	1	1.875	2.75	4	13.7	0.7727
High pulse count (#)	2.6	4	5.5	7	8.7	0.5455
High pulse duration (days)	1.3	2	3.25	12.5	21.4	3.231
Parameter Group #5						
Rise rate (cfs difference between consecutive days)	5.3	6.5	8	11.38	13.7	0.6094
Fall rate (cfs difference between consecutive days)	-14.4	-10.25	-7.5	-6	-5	-0.5667
Number of reversals	82.9	108	133	160.5	166.8	0.3947
EFC Monthly Low Flows						
October Low Flow (cfs)	72.2	80.5	95	108.6	151.8	0.2961
November Low Flow (cfs)	76.45	80.5	91	100	115.1	0.2143
December Low Flow (cfs)	69.65	71.75	76	86.75	94.7	0.1974
January Low Flow (cfs)	69.1	71.5	76	88	91.8	0.2171
February Low Flow (cfs)	68.3	72.5	76.5	85	87.85	0.1634
March Low Flow (cfs)	74.15	77.88	84.5	90.5	101.4	0.1494
April Low Flow (cfs)	95	97.5	120.5	138	163	0.3361
May Low Flow (cfs)	95	98	125.8	155	185.5	0.4533
June Low Flow (cfs)	87.7	102.5	114.5	147.3	180.4	0.3908
July Low Flow (cfs)	133.7	157.3	177	183.8	191.5	0.1497
August Low Flow (cfs)	100.8	110.8	121.3	136.1	170.5	0.2093
September Low Flow (cfs)	74	76.13	81.25	103	113.4	0.3308
EFC Parameters						
Extreme low peak (cfs)	55.8	60.38	63	64	65.4	0.05754
Extreme low duration (days)	1	1	2	3	6.4	1
Extreme low timing (Julian date)	263.3	267.3	337	359.3	22.2	0.2514
Extreme low freq. (#/year)	1	2.75	4	9	15.9	1.563
High flow peak (cfs)	163.2	167.8	203.3	233	297.2	0.321
High flow duration (days)	3	3	5	8.625	13.65	1.125
High flow timing (Julian date)	104.4	129.9	152.3	245.3	298.8	0.3152
High flow frequency (#/year)	3.3	5.75	7.5	9.25	11	0.4667
High flow rise rate (cfs differnenc between consecutive days)	19.8	25	36.5	40.17	48.35	0.4155
High flow fall rate (cfs difference between consecutive days)	-23.3	-18.55	-16.18	-13.13	-6.27	-0.3353
Small Flood peak (cfs)	1010	1385	1710	2050	2480	0.3889
Small Flood duration (days)	23	51	108	123	129	0.6667
Small Flood timing (Julian date)	126	145.5	153	174	184	0.07787
Small Flood freq. (#/year)	0	0	0	1	1	0
Small Flood riserate (cfs difference between consecutive days)	13.53	28.82	35.64	73.41	122.1	1.251
Small Flood fallrate (cfs difference between consecutive days)	-237.9	-60.95	-34.3	-25.45	-15.03	-1.035
Large flood peak (cfs)	3690	3690	3975	4260	4260	0.1434
Large flood duration (days)	124	124	131.5	139	139	0.1141
Large flood timing (Julian date)	161	161	168	175	175	0.03825
Large flood freq. (#/year)	0	0	0	0	0.7	0
Large flood riserate (cfs difference between consecutive days)	35.67	35.67	55.27	74.87	74.87	0.7092
Large flood fallrate (cfs difference between consecutive days)	-83.45	-83.45	-70.87	-58.29	-58.29	-0.3551

Reach CR4
Non-Parametric IHA Scorecard
USGS 09034500 Colorado River at Hot Sulphur Springs 1905-84 vs 1986-1994

	Pre-impact period: 1905-1984 (76 years)	Post-impact period: 1986-1994 (9 years)
Mean annual flow	478.9	191.4
Mean flow/area	478.9	191.4
Annual C. V.	1.78	1.17
Flow predictability	0.54	0.58
Constancy/predictability	0.58	0.68
% of floods in 60d period	0.61	0.61
Flood-free season	134	246

	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Parameter Group #1								
October (cfs)	134.5	97	1.072	0.4485	0.2788	0.5819	0.3493	0.1311
November (cfs)	112	96.5	0.5882	0.2746	0.1384	0.5331	0.3514	0.1031
December (cfs)	93.5	76	0.4786	0.4145	0.1872	0.134	0.2462	0.7457
January (cfs)	85	74	0.4176	0.3311	0.1294	0.2073	0.3954	0.5125
February (cfs)	86.5	74	0.3786	0.1959	0.1445	0.4825	0.2102	0.1261
March (cfs)	100	90	0.4975	0.2333	0.1	0.531	0.3844	0.1341
April (cfs)	284.3	204.5	1.029	0.4584	0.2806	0.5543	0.3263	0.1361
May (cfs)	1145	353	1.026	0.8839	0.6917	0.1387	0.05506	0.7427
June (cfs)	1795	285	1.246	1.444	0.8412	0.1587	0.07908	0.7397
July (cfs)	503.5	254	1.755	0.5138	0.4955	0.7072	0.2442	0.08809
August (cfs)	207.5	124	1.257	0.2339	0.4024	0.8139	0.2983	0.04104
September (cfs)	123.8	93.5	1.191	0.3182	0.2444	0.7328	0.4685	0.05606
Parameter Group #2								
1-day minimum (cfs)	67.5	60	0.6185	0.175	0.1111	0.7171	0.4154	0.03403
3-day minimum (cfs)	69.83	60.67	0.5907	0.2198	0.1313	0.6279	0.4264	0.03604
7-day minimum (cfs)	71.43	61.71	0.561	0.2014	0.136	0.641	0.3353	0.03704
30-day minimum (cfs)	79.92	71.9	0.4687	0.1929	0.1003	0.5885	0.5295	0.04304
90-day minimum (cfs)	84.59	75.77	0.426	0.2919	0.1044	0.3147	0.3564	0.2783
1-day maximum (cfs)	3185	770	1.086	1.355	0.7582	0.2484	0.02503	0.5415
3-day maximum (cfs)	3018	722.3	1.059	1.258	0.7607	0.1888	0.01902	0.6316
7-day maximum (cfs)	2811	646.7	1.1	1.254	0.77	0.1397	0.01502	0.7117
30-day maximum (cfs)	2202	438.7	1.128	1.103	0.8007	0.02202	0.02703	0.96
90-day maximum (cfs)	1389	352	1.178	0.9388	0.7465	0.2031	0.03704	0.6286
Number of zero days (count)	0	0	0	0				
Base flow index (7day minimun in cfs/median in cfs)	0.1719	0.3951	0.7447	0.3742	1.299	0.4975	0.00	0.1572
Parameter Group #3								
Date of minimum (Julian day)	19	253	0.2384	0.3634	0.7213	0.5244	0.006006	0.2042
Date of maximum (Julian day)	160	153	0.04918	0.06557	0.03825	0.3333	0.2222	0.4164
Parameter Group #4								
Low pulse count (#)	3	6	2	0.9167	1	0.5417	0.02503	0.2863
Low pulse duration (days)	4	3	3.188	3.083	0.25	0.03268	0.6587	0.974
High pulse count (#)	3	3	0.6667	1.5	0	1.25	0.4585	0.05906
High pulse duration (days)	8	4	6.016	0.5	0.5	0.9169	0.3684	0.09009
The low pulse threshold is (cfs)	92							
The high pulse threshold is (cfs	385							
Parameter Group #5								
Rise rate (cfs difference between consecutive days)	11	7	1.841	0.9286	0.3636	0.4956	0.3323	0.5365
Fall rate (cfs difference between consecutive days)	-12	-8	-1.604	-0.5	0.3333	0.6883	0.3383	0.2382
Number of reversals	103.5	105	0.3841	0.3	0.01449	0.2189	0.8318	0.6186

Reach CR4
IHA Non-Parametric RVA Scorecard
USGS 09034500 Colorado River at Hot Sulphur Springs 1905-84 vs 1986-2007

	Pre-impact period: 1905-1984			Post-impact period: 1986-1994				RVA Boundaries			Hydrologic Alteration
	Medians	Coeff. of Dispersion	Minimum	Maximum	Medians	Coeff. of Dispersion	Minimum	Maximum	Low	High	iddle Category)
Hydrologic Parameters											
	134.5	1.072	52	355	97	0.4485	71	125	99.82	183.8	-0.02564
Parameter Group #1	112	0.5882	58	245	96.5	0.2746	74.5	210	97.41	144.8	-0.02564
October (cfs)	93.5	0.4786	49	220	76	0.4145	65	115	77.23	106.8	-0.02564
November (cfs)	85	0.4176	47	150	74	0.3311	59	105	73	100	0.1259
December (cfs)	86.5	0.3786	53	150	74	0.1959	66	100	78.41	100	-0.1264
January (cfs)	100	0.4975	55	408	90	0.2333	74	103	86.41	120	0.8765
February (cfs)	284.3	1.029	73	1480	204.5	0.4584	169.5	417.5	220.8	401.9	-0.02564
March (cfs)	1145	1.026	193	3460	353	0.8839	147	1190	608.1	1492	-0.6752
April (cfs)	1795	1.246	171	6090	285	1.444	186.5	1290	906.3	2580	-0.3745
May (cfs)	503.5	1.755	140	2170	254	0.5138	189	534	327.1	942	-0.3504
June (cfs)	207.5	1.257	77	745	124	0.2339	106	157	154.6	311.8	-0.6752
July (cfs)	123.8	1.191	39	490	93.5	0.3182	61	121	96	205.7	-0.06173
August (cfs)											
September (cfs)											
	67.5	0.6185	33	130	60	0.175	42	69	55.41	82.77	0.9487
Parameter Group #2	69.83	0.5907	35	130	60.67	0.2198	52.33	69	57.47	84.59	0.9487
1-day minimum (cfs)	71.43	0.561	37	130	61.71	0.2014	56.71	73.86	60.69	86.6	0.9487
3-day minimum (cfs)	79.92	0.4687	44.2	130.7	71.9	0.1929	59	95.47	67.66	95.2	0.6239
7-day minimum (cfs)	84.59	0.426	50.3	146.9	75.77	0.2919	64.32	103.2	77.25	100.5	-0.02564
30-day minimum (cfs)	3185	1.086	310	9280	770	1.355	377	1830	2158	4075	-1
90-day minimum (cfs)	3018	1.059	270	8637	722.3	1.258	364.7	1733	2090	3943	-1
1-day maximum (cfs)	2811	1.1	246.3	8230	646.7	1.254	344.7	1554	1890	3698	-1
3-day maximum (cfs)	2202	1.128	219.6	5970	438.7	1.103	282.6	1383	1368	2799	-0.6752
7-day maximum (cfs)	1389	1.178	190.5	3176	352	0.9388	221.7	1061	923.4	1822	-0.6752
30-day maximum (cfs)	0	0	0	0	0	0	0	0	0	0	0
90-day maximum (cfs)	0.1719	0.7447	0.05966	0.4812	0.3951	0.3742	0.1943	0.4952	0.1381	0.214	-0.6752
Number of zero days (count)											
Base flow index (7day minimun in cfs/median in cfs)											
	19	0.2384	1	365	253	0.3634	32	363	48.46	278	0.8765
Parameter Group #3	160	0.04918	131	273	153	0.06557	126	192	152.4	166	-0.3745
Date of minimum (Julian day)											
Date of maximum (Julian day)											
	3	2	0	17	6	0.9167	2	10	1.41	5	0.08961
Parameter Group #4	4	3.188	1	196	3	3.083	1.5	26	3	8.69	0.1515
Low pulse count (#)	3	0.6667	0	7	3	1.5	0	6	2	3.59	-0.2963
Low pulse duration (days)	8	6.016	1	142	4	0.5	1.5	5.5	5	38.38	-0.3745
High pulse count (#)			92								
High pulse duration (days)			385								
The low pulse threshold is (cfs)											
The high pulse threshold is (cfs)											
	11	1.841	4	150	7	0.9286	5	16	8.205	20	-0.06173
Parameter Group #5	-12	-1.604	-100	-4	-8	-0.5	-17	-4	-19.18	-8	0.5638
Rise rate (cfs/day)	103.5	0.3841	25	147	105	0.3	81	144	90.41	114.2	-0.02564
Fall rate (cfs/day)											
Number of reversals (count)											

Assessment of Hydrologic Alteration

	Middle RVA Category			High RVA Category			Low RVA Category		
	Expected	Observed	Alter.	Expected	Observed	Alter.	Expected	Observed	Alter.
Parameter Group #1									
October (cfs)	3.079	3	-0.02564	2.961	0	-1	2.961	6	1.027
November (cfs)	3.079	3	-0.02564	2.961	1	-0.6622	2.961	5	0.6889
December (cfs)	3.079	3	-0.02564	2.961	1	-0.6622	2.961	5	0.6889
January (cfs)	3.553	4	0.1259	2.605	1	-0.6162	2.842	4	0.4074
February (cfs)	3.434	3	-0.1264	2.605	0	-1	2.961	6	1.027
March (cfs)	3.197	6	0.8765	2.842	0	-1	2.961	3	0.01333
April (cfs)	3.079	3	-0.02564	2.961	1	-0.6622	2.961	5	0.6889
May (cfs)	3.079	1	-0.6752	2.961	0	-1	2.961	8	1.702
June (cfs)	3.197	2	-0.3745	2.842	0	-1	2.961	7	1.364
July (cfs)	3.079	2	-0.3504	2.961	0	-1	2.961	7	1.364
August (cfs)	3.079	1	-0.6752	2.961	0	-1	2.961	8	1.702
September (cfs)	3.197	3	-0.06173	2.961	0	-1	2.842	6	1.111
Parameter Group #2									
1-day minimum (cfs)	3.079	6	0.9487	2.961	0	-1	2.961	3	0.01333
3-day minimum (cfs)	3.079	6	0.9487	2.961	0	-1	2.961	3	0.01333
7-day minimum (cfs)	3.079	6	0.9487	2.961	0	-1	2.961	3	0.01333
30-day minimum (cfs)	3.079	5	0.6239	2.961	1	-0.6622	2.961	3	0.01333
90-day minimum (cfs)	3.079	3	-0.02564	2.961	1	-0.6622	2.961	5	0.6889
1-day maximum (cfs)	3.079	0	-1	2.961	0	-1	2.961	9	2.04
3-day maximum (cfs)	3.079	0	-1	2.961	0	-1	2.961	9	2.04
7-day maximum (cfs)	3.079	0	-1	2.961	0	-1	2.961	9	2.04
30-day maximum (cfs)	3.079	1	-0.6752	2.961	0	-1	2.961	8	1.702
90-day maximum (cfs)	3.079	1	-0.6752	2.961	0	-1	2.961	8	1.702
Number of zero days (count)	9	9	0	0	0		0	0	
Base flow index (7day minimun in cfs/median in cfs)	3.079	1	-0.6752	2.961	8	1.702	2.961	0	-1
Parameter Group #3									
Date of minimum (Julian day)	3.197	6	0.8765	2.842	2	-0.2963	2.961	1	-0.6622
Date of maximum (Julian day)	3.197	2	-0.3745	2.842	3	0.05556	2.961	4	0.3511
Parameter Group #4									
Low pulse count (#)	3.671	4	0.08961	2.368	5	1.111	2.961	0	-1
Low pulse duration (days)	2.605	3	0.1515	2.132	2	-0.06173	1.895	4	1.111
High pulse count (#)	4.263	3	-0.2963	2.961	4	0.3511	1.776	2	0.1259
High pulse duration (days)	3.197	2	-0.3745	2.842	0	-1	2.724	6	1.203
Parameter Group #5									
Rise rate (cfs/day)	3.197	3	-0.06173	2.842	0	-1	2.961	6	1.027
Fall rate (cfs/day)	3.197	5	0.5638	2.842	4	0.4074	2.961	0	-1
Number of reversals (count)	3.079	3	-0.02564	2.961	2	-0.3244	2.961	4	0.3511

Reach CR4
IHA Percentile Data
USGS 09034500 Colorado River at Hot Sulphur Springs 1905-84 vs 1986-1994

	Pre-impact period: 1905-1984 (76 years)						Post-impact period: 1986-1994 (9 years)					
			Pre-Impact						Post-Impact			
	10%	25%	50%	75%	90%	(75-25)/50	10%	25%	50%	75%	90%	(75-25)/50
Parameter Group #1												
October (cfs)	67	85.75	134.5	230	294.3	1.072	71	72	97	115.5	125	0.4485
November (cfs)	70	90.25	112	156.1	176.5	0.5882	74.5	81.25	96.5	107.8	210	0.2746
December (cfs)	63.7	73	93.5	117.8	135.9	0.4786	65	68.5	76	100	115	0.4145
January (cfs)	60	70.25	85	105.8	121.5	0.4176	59	65.5	74	90	105	0.3311
February (cfs)	63.7	72	86.5	104.8	115	0.3786	66	68.5	74	83	100	0.1959
March (cfs)	70	79.25	100	129	160	0.4975	74	79	90	100	103	0.2333
April (cfs)	137.6	174.6	284.3	467	649.5	1.029	169.5	181	204.5	274.8	417.5	0.4584
May (cfs)	312.5	512.5	1145	1688	2275	1.026	147	241	353	553	1190	0.8839
June (cfs)	289.3	693.3	1795	2930	4331	1.246	186.5	243.3	285	654.8	1290	1.444
July (cfs)	175.1	276.5	503.5	1160	1590	1.755	189	213.5	254	344	534	0.5138
August (cfs)	106.8	131.5	207.5	392.3	541.8	1.257	106	117	124	146	157	0.2339
September (cfs)	62.35	80.5	123.8	227.9	318.8	1.191	61	73.25	93.5	103	121	0.3182
Parameter Group #2												
1-day minimum (cfs)	42	50.25	67.5	92	109.3	0.6185	42	54	60	64.5	69	0.175
3-day minimum (cfs)	44.13	53.75	69.83	95	110	0.5907	52.33	55.33	60.67	68.67	69	0.2198
7-day minimum (cfs)	45.51	57.39	71.43	97.46	110.3	0.561	56.71	59.43	61.71	71.86	73.86	0.2014
30-day minimum (cfs)	52.84	62.54	79.92	100	112.8	0.4687	59	63.37	71.9	77.23	95.47	0.1929
90-day minimum (cfs)	63.01	70.65	84.59	106.7	121.2	0.426	64.32	66.91	75.77	89.03	103.2	0.2919
1-day maximum (cfs)	500.2	1345	3185	4803	6660	1.086	377	416.5	770	1460	1830	1.355
3-day maximum (cfs)	453	1257	3018	4452	6160	1.059	364.7	405.5	722.3	1315	1733	1.258
7-day maximum (cfs)	421.7	1136	2811	4230	5834	1.1	344.7	365.3	646.7	1176	1554	1.254
30-day maximum (cfs)	368.9	884	2202	3366	4552	1.128	282.6	318.9	438.7	802.7	1383	1.103
90-day maximum (cfs)	307.1	566.7	1389	2203	2977	1.178	221.7	249.8	352	580.2	1061	0.9388
Number of zero days (count)	0	0	0	0	0	0	0	0	0	0	0	0
Base flow index (7day minimun in cfs/median in cfs)	0.1134	0.1285	0.1719	0.2564	0.3558	0.7447	0.1943	0.3009	0.3951	0.4487	0.4952	0.3742
Parameter Group #3												
Date of minimum (Julian day)	329.2	346.5	19	259.3	271.3	0.2384	32	151.5	253	284.5	363	0.3634
Date of maximum (Julian day)	143	150	160	168	177.3	0.04918	126	143.5	153	167.5	192	0.06557
Parameter Group #4												
Low pulse count (#)	0	0	3	6	11	2	2	3.5	6	9	10	0.9167
Low pulse duration (days)	1	2	4	14.75	67.1	3.188	1.5	2	3	11.25	26	3.083
High pulse count (#)	1	2	3	4	5	0.6667	0	1.5	3	6	6	1.5
High pulse duration (days)	2	3.5	8	51.63	98	6.016	1.5	2.875	4	4.875	5.5	0.5
Parameter Group #5												
Rise rate (cfs difference between consecutive days)	5	7	11	27.25	76.5	1.841	5	5.5	7	12	16	0.9286
Fall rate (cfs difference between consecutive days)	-47.2	-26.25	-12	-7	-5	-1.604	-17	-8.5	-8	-4.5	-4	-0.5
Number of reversals	59.4	80	103.5	119.8	134.6	0.3841	81	86	105	117.5	144	0.3
EFC Monthly Low Flows												
October Low Flow (cfs)	74	88	124	215	285	1.024	72	77.75	97	115.5	123.5	0.3892
November Low Flow (cfs)	72	90.5	112	150	176.5	0.5313	74.5	81.25	96.5	107.8	180	0.2746
December Low Flow (cfs)	70	75	96	122	137.4	0.4896	69	71	76	100	115	0.3816
January Low Flow (cfs)	70	73.5	90	107.5	125	0.3778	68	69.25	75.5	90	105	0.2748
February Low Flow (cfs)	70	77	90	105	115	0.3111	68	70	74	83	100	0.1757
March Low Flow (cfs)	72.1	80	100	122.8	137.9	0.4275	75	79	90	100	103	0.2333
April Low Flow (cfs)	116.2	136.5	180	245	311.1	0.6028	110	123.5	160	234	334	0.6906
May Low Flow (cfs)	198	254.5	305	339	368	0.277	128	163	268.3	315.5	371	0.5685
June Low Flow (cfs)	181.4	216.6	286.5	322.6	364.9	0.37	116	151	234.5	250	301	0.4222
July Low Flow (cfs)	162	182	264.5	306.4	358.4	0.4702	182	207.5	227.5	258	356.5	0.222
August Low Flow (cfs)	104.4	127	172.5	299.5	338.5	1	108	117	124	146	153.5	0.2339
September Low Flow (cfs)	75.2	83.5	125.5	226	292	1.135	72	75.75	93.5	103	118.5	0.2914
EFC Parameters												
Extreme low peak (cfs)	44	58.25	62	64.75	65.15	0.1048	53.5	60.63	62	63.75	65	0.0504
Extreme low duration (days)	1	2	3	8.75	33.1	2.25	1	1	3	6.5	7	1.833
Extreme low timing (Julian date)	256.8	268.6	326.8	12.25	44.2	0.2995	11	248.9	262.8	296.3	348	0.1294
Extreme low freq. (#/year)	0	0	0	4.75	8.6	0	0	1	2	4.5	7	1.75
High flow peak (cfs)	277	326.8	397.3	475.1	629	0.3735	254	312.3	423	435.5	587	0.2914
High flow duration (days)	3	4	5.5	8.5	20.5	0.8182	4	4.5	6.5	8.5	12	0.6154
High flow timing (Julian date)	106.5	130.3	169.5	222.1	279	0.251	93	134.5	154	162.3	198	0.07582
High flow frequency (#/year)	1	2	3	5	7	1	3	4.5	6	8.5	9	0.6667
High flow rise rate (cfs differnenc between consecutive days)	31.23	38.81	55.42	74.25	94.88	0.6395	33.56	39.88	46	59.5	82.67	0.4266
High flow fall rate (cfs difference between consecutive days)	-54.48	-42.89	-30.5	-22.38	-16.01	-0.6722	-45.54	-36.68	-26.63	-22.55	-15.2	-0.5308
Small Flood peak (cfs)	3418	3563	4280	5365	6360	0.4211						
Small Flood duration (days)	82.6	91.5	117	133.8	169.6	0.3611						
Small Flood timing (Julian date)	143	151.3	160	168	176.1	0.04577						
Small Flood freq. (#/year)	0	0	0	1	1	0	0	0	0	0	0	0
Small Flood riserate (cfs difference between consecutive days)	51.72	62.17	77.78	105.6	154.4	0.558						
Small Flood fallrate (cfs difference between consecutive days)	-98.25	-76.29	-68.7	-56.04	-43.41	-0.2947						
Large flood peak (cfs)	6700	6828	8155	8755	9280	0.2364						
Large flood duration (days)	105	115.5	137	146.5	154	0.2263						
Large flood timing (Julian date)	154	157.8	166	167.8	170	0.02732						
Large flood freq. (#/year)	0	0	0	0	0	0	0	0	0	0	0	0
Large flood riserate (cfs difference between consecutive days)	88.93	94.81	122.7	158.7	182.7	0.5204						
Large flood fallrate (cfs difference between consecutive days)	-176.2	-144.9	-104.5	-86.56	-72.99	-0.5581						

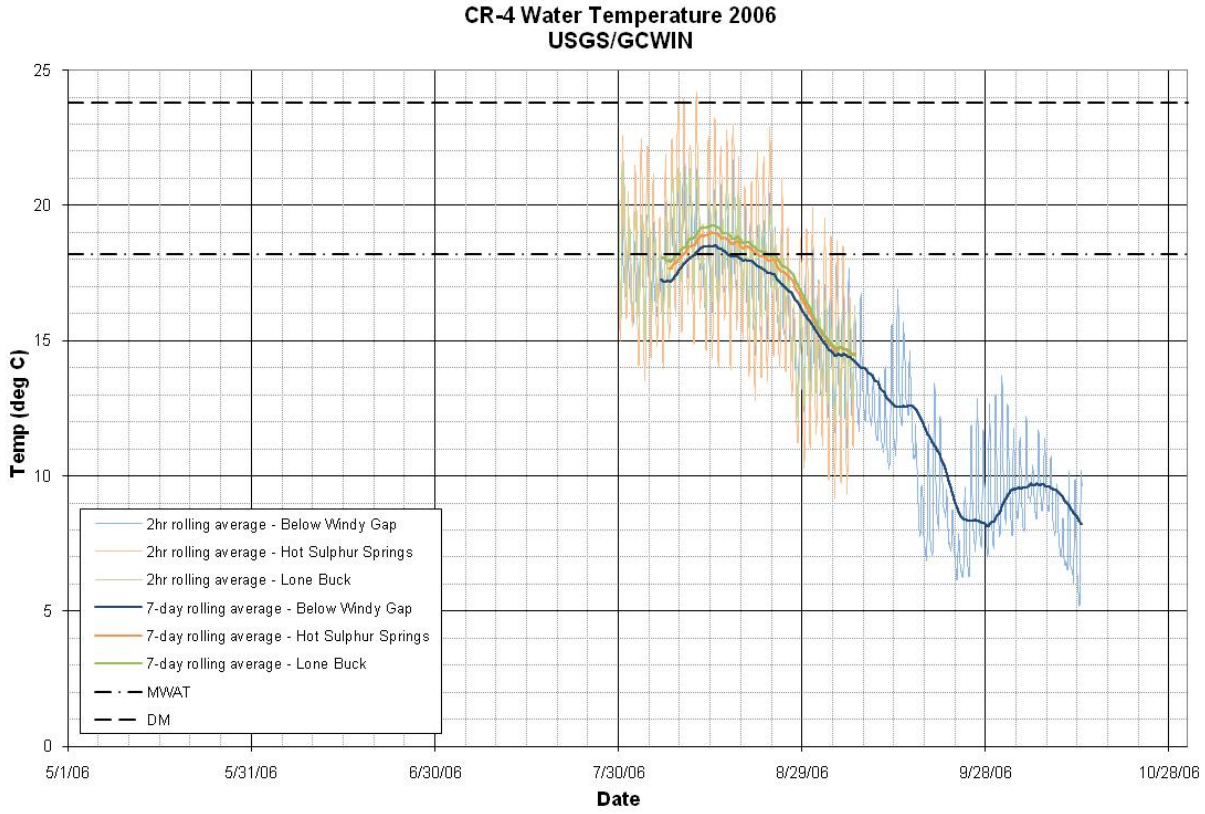
Reach CR 4			
Non-Parametric IHA Scorecard			
Colorado River at Hot Sulphur Springs (Seasonal Northern)			
Season from Julian date 122.to 274. (May 1 through Sept 30)			
Period of Analysis: 1997-2007 (10 years)			
Mean annual flow (cfs)	307.5		
Mean flow/area (dimensionless	307.5		
Annual C. V.	1.71		
Flow predictability (%)	0.57		
Constancy/predictability	0.71		
% of floods in 60d period	0.68		
Flood-free season (days)	43		
	Medians	**Coeff. of Disp.**	
Parameter Group #1			
October (cfs)			
November (cfs)			
December (cfs)			
January (cfs)			
February (cfs)			
March (cfs)			
April (cfs)			
May (cfs)	222.7	1.157	
June (cfs)	268.3	1.222	
July (cfs)	232.4	0.5047	
August (cfs)	113.1	0.5071	
September (cfs)	93.83	0.3475	
Parameter Group #2			
1-day minimum (cfs)	68.75	0.5829	
3-day minimum (cfs)	73.88	0.5452	
7-day minimum (cfs)	77.35	0.4427	
30-day minimum (cfs)	92.06	0.4481	
90-day minimum (cfs)	156	0.5899	
1-day maximum (cfs)	686.7	1.455	
3-day maximum (cfs)	603.9	1.153	
7-day maximum (cfs)	408.6	1.503	
30-day maximum (cfs)	323.5	1.129	
90-day maximum (cfs)	259.2	0.7907	
Number of zero days (count)	0	0	
Base flow index (7day minimun in cfs/median in cfs)	0.3622	0.5129	
Parameter Group #3			
Date of minimum (Julian day)	258	0.1817	
Date of maximum (Julian day)	171	0.09221	
Parameter Group #4			
Low pulse count (#)	3	1.5	
Low pulse duration (days)	9.5	0.9474	
High pulse count (#)	3	0.4167	
High pulse duration (days)	3	1.333	
The low pulse threshold is (cfs)	110.5		
The high pulse threshold is (cfs	277.8		
Parameter Group #5			
Rise rate (cfs difference between consecutive days)	5.55	1.869	
Fall rate (cfs difference between consecutive days)	-9.325	-1.714	
Number of reversals	54	0.5602	

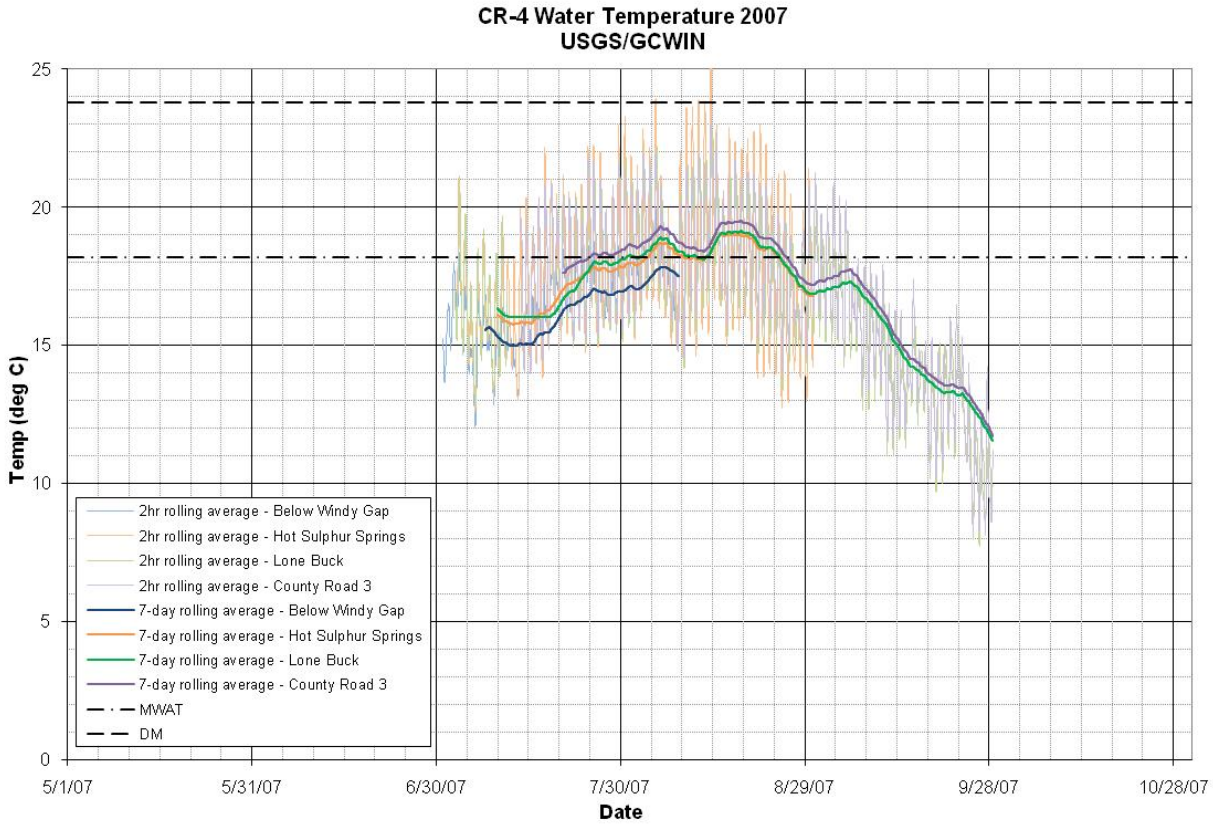
Reach CR4
IHA Percentile Data
Colorado River at Hot Sulphur Springs (Seasonal Northern)
Season from Julian date 122.to 274. (May 1 through Sept)

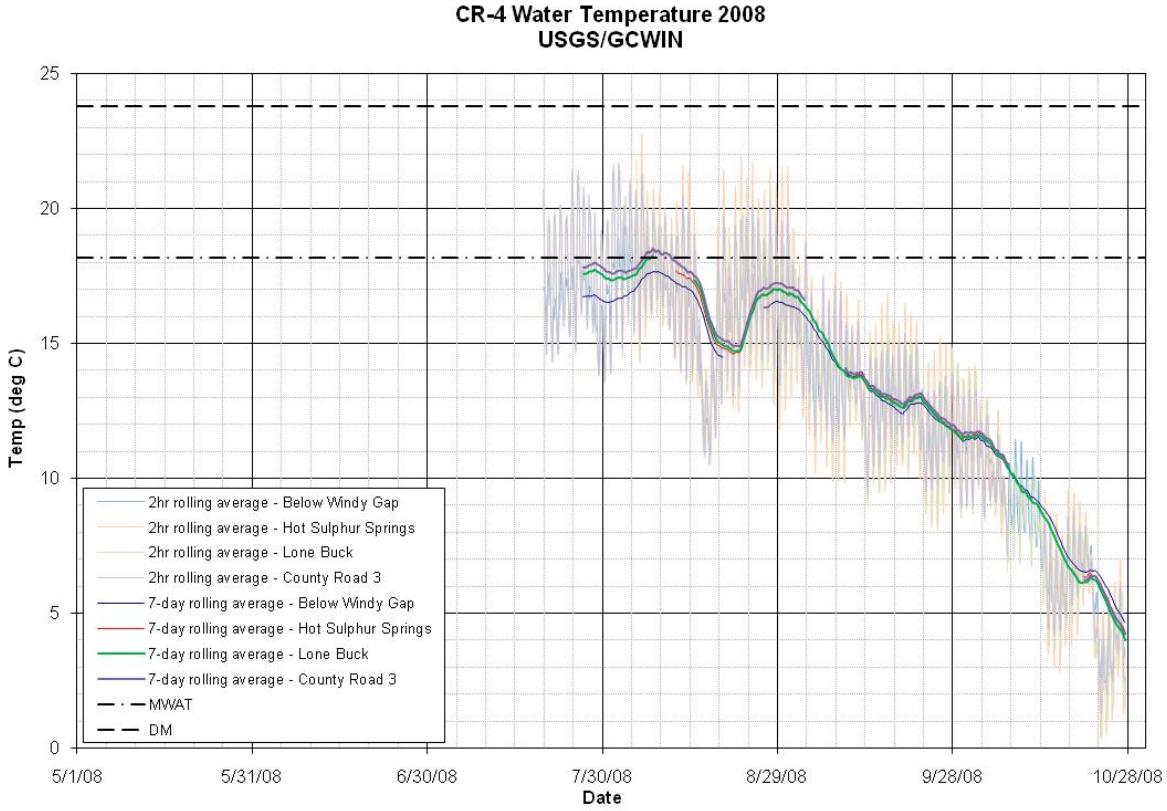
Period of Analysis: 1997-2007 (10 years)

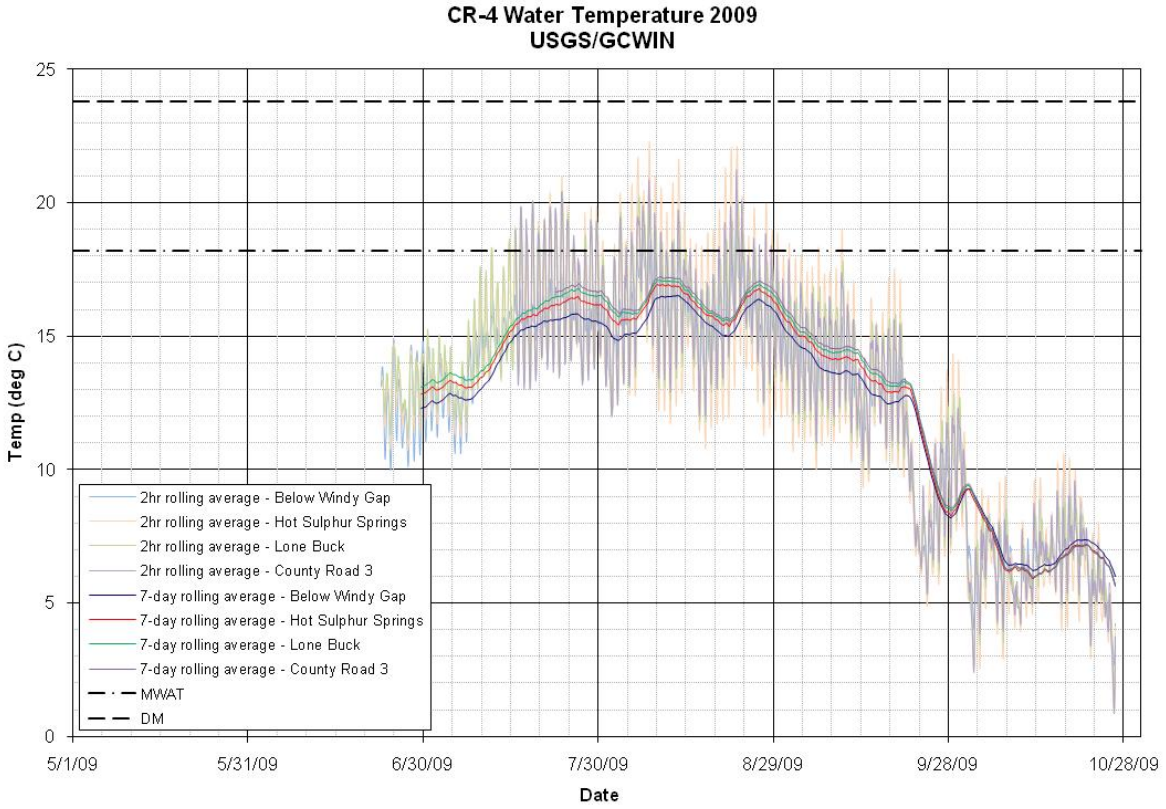
	Period of Analysis					
	10%	**25%**	**50%**	**75%**	**90%**	**(75-25)/50**
Parameter Group #1						
October (cfs)						
November (cfs)						
December (cfs)						
January (cfs)						
February (cfs)						
March (cfs)						
April (cfs)						
May (cfs)	124.6	137.5	222.7	395.2	1620	1.157
June (cfs)	99.74	167.8	268.3	495.7	2519	1.222
July (cfs)	115.8	182.9	232.4	300.1	423.1	0.5047
August (cfs)	63.15	98.18	113.1	155.5	430.3	0.5071
September (cfs)	50.28	78.21	93.83	110.8	209.2	0.3475
Parameter Group #2						
1-day minimum (cfs)	28.55	50.83	68.75	90.9	196.1	0.5829
3-day minimum (cfs)	39.51	55.74	73.88	96.02	196.5	0.5452
7-day minimum (cfs)	43.16	65.7	77.35	99.94	197.3	0.4427
30-day minimum (cfs)	49.38	76.41	92.06	117.7	208.5	0.4481
90-day minimum (cfs)	80.67	130.7	156	222.7	343.8	0.5899
1-day maximum (cfs)	227.7	332	686.7	1331	4593	1.455
3-day maximum (cfs)	223.6	320.7	603.9	1017	4540	1.153
7-day maximum (cfs)	222.7	312.7	408.6	926.9	4460	1.503
30-day maximum (cfs)	215.3	222	323.5	587.3	3022	1.129
90-day maximum (cfs)	151.7	188.4	259.2	393.4	1694	0.7907
Number of zero days (count)	0	0	0	0	0	0
Base flow index (7day minimun in cfs/median in cfs)	0.1003	0.2805	0.3622	0.4662	0.905	0.5129
Parameter Group #3						
Date of minimum (Julian day)	126.1	205	258	271.5	273.9	0.1817
Date of maximum (Julian day)	130	151	171	184.8	195.1	0.09221
Parameter Group #4						
Low pulse count (#)	0.1	1.75	3	6.25	7.9	1.5
Low pulse duration (days)	3	5.5	9.5	14.5	112	0.9474
High pulse count (#)	0.1	1.75	3	3	4.8	0.4167
High pulse duration (days)	1	1.5	3	5.5	10	1.333
Parameter Group #5						
Rise rate (cfs difference between consecutive days)	0.3789	0.9902	5.55	11.36	65.17	1.869
Fall rate (cfs difference between consecutive days)	-57.16	-20.89	-9.325	-4.9	-0.73	-1.714
Number of reversals	4.6	32.5	54	62.75	67.7	0.5602
EFC Monthly Low Flows						
October Low Flow (cfs)						
November Low Flow (cfs)						
December Low Flow (cfs)						
January Low Flow (cfs)						
February Low Flow (cfs)						
March Low Flow (cfs)						
April Low Flow (cfs)						
May Low Flow (cfs)	123.3	136	143.1	163.5	219.1	0.1922
June Low Flow (cfs)	94.7	141.7	170.2	181.3	219.1	0.2327
July Low Flow (cfs)	109.4	160	185.3	211.6	219.1	0.2783
August Low Flow (cfs)	97.07	101.3	112.6	139.1	212.6	0.3352
September Low Flow (cfs)	78	83.48	101.7	112.4	219.1	0.285
EFC Parameters						
Extreme low peak (cfs)	48.15	48.18	60.9	65.35	66.7	0.282
Extreme low duration (days)	1	1	3.5	31.25	48	8.643
Extreme low timing (Julian date)	268	268.3	271	283.3	294.5	0.04098
Extreme low freq. (#/year)	0	0	1	3	3.9	3
High flow peak (cfs)	215.5	278.1	311.3	339.4	352	0.1968
High flow duration (days)	4.5	5.125	7.75	12.63	20.5	0.9677
High flow timing (Julian date)	15	140.9	177.3	203.6	234	0.1714
High flow frequency (#/year)	0	1.5	3	4.5	6	1
High flow rise rate (cfs differnenc between consecutive days)	14.45	20.47	38.25	85.49	99.7	1.7
High flow fall rate (cfs difference between consecutive days)	-97.8	-56.88	-33.03	-21.61	-20.85	-1.068
Small Flood peak (cfs)	880	883.8	1070	1504	1591	0.5802
Small Flood duration (days)	5	9.75	34	186.5	234	5.199
Small Flood timing (Julian date)	167	167.8	171	181	184	0.0362
Small Flood freq. (#/year)	0	0	0	1	1	0
Small Flood riserate (cfs difference between consecutive days)	6.769	15.26	49.37	428.1	551.4	8.362
Small Flood fallrate (cfs difference between consecutive days)	-287.2	-229.4	-48.85	-28	-23.47	-4.123
Large flood peak (cfs)			4927			
Large flood duration (days)			121			
Large flood timing (Julian date)			158			
Large flood freq. (#/year)	0	0	0	0	0.9	0
Large flood riserate (cfs difference between consecutive days)			92.57			
Large flood fallrate (cfs difference between consecutive days)			-67.07			

Surface Water Temperature Plots






CR-4 Water Temperature 2008
USGS/GCWIN
Temp (deg C)
25
20
15
10
5
0
5/1/08
5/31/08
6/30/08
7/30/08
8/29/08
9/28/08
10/28/08
Date
2hr rolling average - Below Windy Gap
2hr rolling average - Hot Sulphur Springs
2hr rolling average - Lone Buck
2hr rolling average - County Road 3
7-day rolling average - Below Windy Gap
7-day rolling average - Hot Sulphur Springs
7-day rolling average - Lone Buck
7-day rolling average - County Road 3
MWAT
DM


CR-4 Water Temperature 2009
USGS/GCWIN
Temp (deg C)
25
20
15
10
5
0
5/1/09
5/31/09
6/30/09
7/30/09
8/29/09
9/28/09
10/28/09
Date
2hr rolling average - Below Windy Gap
2hr rolling average - Hot Sulphur Springs
2hr rolling average - Lone Buck
2hr rolling average - County Road 3
7-day rolling average - Below Windy Gap
7-day rolling average - Hot Sulphur Springs
7-day rolling average - Lone Buck
7-day rolling average - County Road 3
MWAT
DM

GRAND COUNTY STREAM MANAGEMENT PLAN REACHES

HWY 125

WINDY GAP DITCH

WASATCH DITCH

SCHMUCK DITCH

WINDY GAP PUMP PL CANAL

WINDY GAP RESERVOIR

BUNTE NO 1 DITCH

CR4 PHABSIM SITE

F10/CR3/CR4 BOUNDARY

NCWCD Gage Station

FRASER RIVER

HWY 40

ISLAND DITCH

SHERIFF DITCH (156)

COLORADO RIVER

CR4

UTE BILL NO 2 DITCH

HOT SULPHUR SPGS WTR SYS

WWTP

Pioneer Park

TOWN OF HOT SULPHUR SPRINGS

0 1,500 3,000 6,000 Feet

1 inch = 3,000 feet

N

Legend

- REACH BOUNDARY
- PHABSIM SITES
- DIVERSIONS

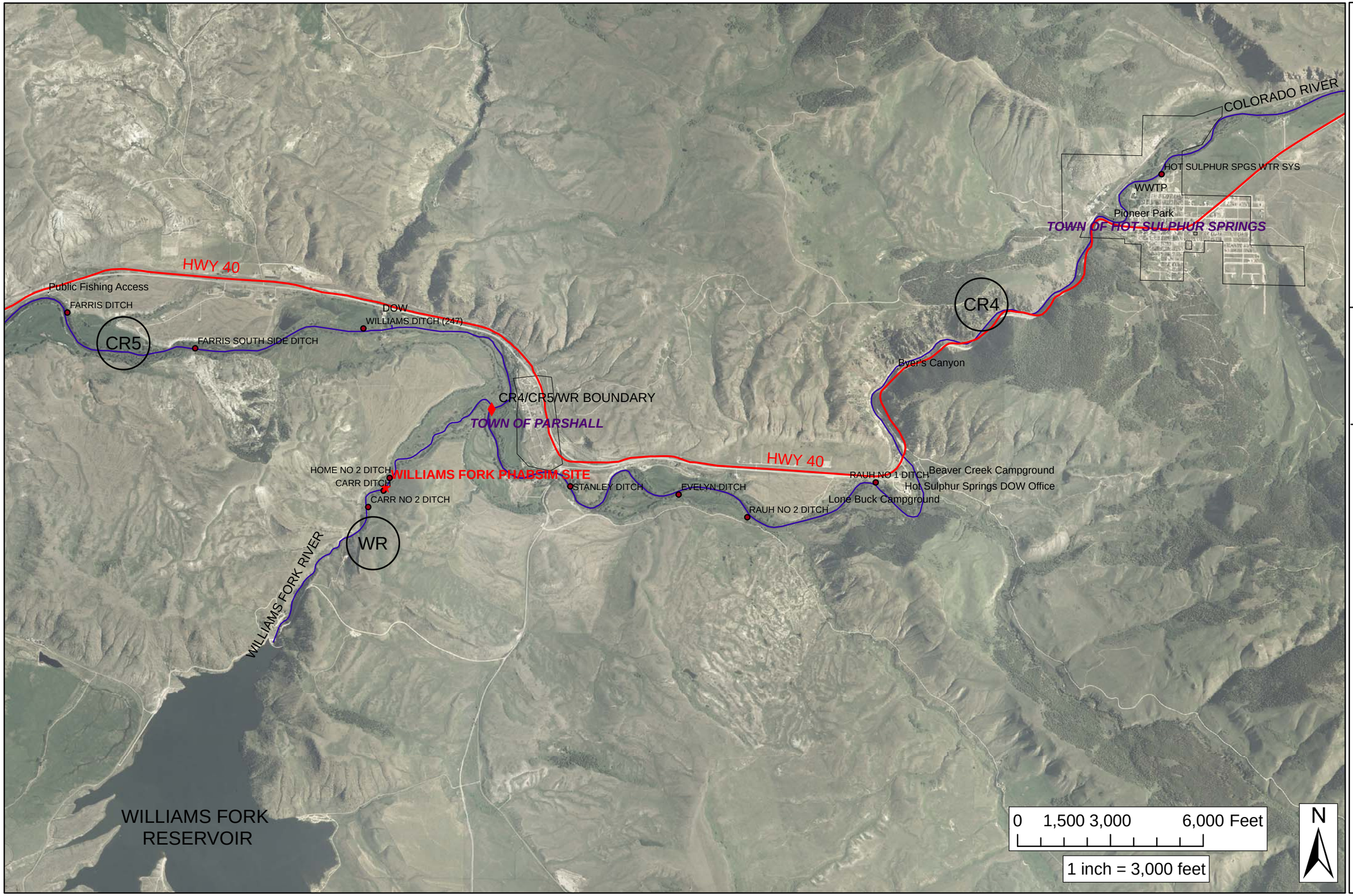
REACH: CR4

SHEET # :
1 OF 2

GRAND COUNTY Colorado · Est 1874

TETRA TECH

GRAND COUNTY STREAM MANAGEMENT PLAN REACHES



Legend

- REACH BOUNDARY
- PHABSIM SITES
- DIVERSIONS

REACH: CR4

SHEET # :
2 OF 2

GRAND COUNTY Colorado · Est 1874

TETRA TECH