

Stream: Red Canyon Creek

Executive Summary

**Water Division: 4 Water District: 60
HUC 1403000302**

Segment: Confluence with Big A Creek down to Confluence with Horsefly Creek

**Upper Terminus: Latitude: 38°16'18.116"N Longitude: 108°12'18.583"W
UTM 219602.4 Easting UTM 4240821.9 Northing
NAD 83 Zone 13N
SW1/4, NW1/4, Sec 4, T46N, R12W, NMPM**

**Lower Terminus: Latitude: 38°14'22.518"N Longitude: 108°13'24.235"W
UTM 217882.3 Easting UTM 4237313.2 Northing
NAD 83 Zone 13N
NW1/4, SW1/4, Sec 17, T46N, R12W, NMPM**

Counties: Montrose Length: 2.68 miles

USGS Quad(s): Antone Spring and Sanborn Park

Forest Service Instream Flow Recommendation:

**November 1 – March 31 = 1.0 cfs
April 1 – October 31 = 1.2 cfs**

Alternative Flow to meet water availability constraints

**May 1st – June 30th = 1.2 cfs
July 1st – Oct. 31st = .5 cfs
Nov 1nd – April 30th = .25 cfs**



Red Canyon Creek
June 27, 2007
R2X Survey

Summary

The information contained in this report and the associated instream flow file folder forms the basis for staff's instream flow recommendation to be considered by the Board. It is staff's opinion that the information contained in this report is sufficient to support the findings required in Rule 5.40.

Colorado's Instream Flow Program was created in 1973 when the Colorado State Legislature recognized "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3) C.R.S.). The statute vests the CWCB with the exclusive authority to appropriate and acquire instream flow and natural lake level water rights. In order to encourage other entities to participate in Colorado's Instream Flow Program, the statute directs the CWCB to request instream flow recommendations from other state and federal agencies. The United States Forest Service (USFS) recommended this segment of Red Canyon Creek to the CWCB for inclusion into the Instream Flow Program. Big Red Creek is being considered for inclusion into the Instream Flow Program because it has a natural environment that can be preserved to a reasonable degree with an instream flow water right. The USFS is very interested in protecting stream flows in Red Canyon Creek because it is a free flowing perennial stream which is supporting both aquatic and riparian values on public land. Forest Service investigations conducted in 2006 and 2007 have suggested that this is a fully functioning aquatic system that is contributing towards the agency stewardship mission of protecting sustainable ecosystems. This stream provides occupied habitat for both native and non-native trout species. It provides important refuge during periods of drought and elevated water temperatures. There are currently no withdrawals of water from Red Canyon Creek. There is currently an instream flow water

right held by the CWCB in Horsefly creek (05CW215) which begins approximately 1.2 miles downstream of where Red Canyon Creek flows into Horsefly, at a point where Sheep Creek enters Horsefly Creek, and then continues downstream to its confluence with the San Miguel River (see map). The protection is 13 cfs from April 1 thru June 5.

Red Canyon Creek is located entirely on Federal lands administered by the U.S. Forest Service. The drainage begins on the south end of the Uncompahgre Plateau in Montrose County, at an elevation of approximately 9,400 feet (see attachment 1 map). The stream flows for approximately 5.9 miles before it joins Horsefly Creek. Horsefly Creek flows into the San Miguel River approximately 6.5 miles below the lower terminus of Red Canyon Creek. Horsefly Creek and its lower tributaries, which include Red Canyon Creek, is a relatively remote setting located in moderately deep canyons. There is no road access to either Red Canyon Creek or Lower Horsefly Creek. The total drainage area of Red Canyon Creek is approximately 13.2 square miles.

The subject of this report is a segment of Red Canyon Creek beginning at its confluence with Big A Creek (Latitude: 38°16'18.195"N; Longitude: 108°12'18.486"W), where sufficient perennial flow exists to support a cold water fishery and other associated aquatic values. From this point it flows in a southwesterly direction 2.68 miles to its confluence with Horsefly Creek (Latitude: 38°14'22.605"N; Longitude: 108°13'24.026"W). The proposed segment is located 8.5 miles northeast of Norwood, Colorado. The staff has received only one recommendation for this segment, from the USFS. The recommendation for this segment is discussed below.

Instream Flow Recommendation(s)

Considerable field work has been conducted within the Horsefly watershed for the purpose of determining instream flow protection needs. Field work was initiated in 2006 and continued through 2007. Field study sites have been located on both Little Red Creek and Red Canyon Creek near their confluence with Horsefly Creek and also on Horsefly Creek near the Forest boundary. Based upon a recommendation by the Grand Mesa, Uncomphagre and Gunnison National Forest to the CWCB a notice to appropriate was issued in early 2009. At this time only Big Red Canyon Creek is being submitted as a recommendation by the agency for appropriation of instream flow rights under State statute.

The Forest Service is recommending flow protection on Red Canyon Creek for the period Nov 1st – April 31st of 1.0 cfs and the period May 1st – October 31st of 1.2 cfs. While it is unlikely that the Board would agree to a peak flow component for protection, our recommendation would be to have one that is based upon flows that meet or exceed 60% of bank full discharge for a period of at least 5 consecutive days during the period of April 15th thru May 15th. This rule of thumb comes from advice provided by Forest Service researchers who have conducted sediment transport studies in adjustable channels over the last 20 years. Stream systems need periodic high flows in order to accomplish scour and deposition of channel materials and floodplain inundation. This is an important function necessary to sustain the physical environment which in turns supports the biological values that we desire.

Land Status Review

Upper Terminus	Lower Terminus	Total Length (miles)	Land Ownership	
			% Private	% Public
Headwaters	Spring Creek	2.68	0%	100%

Biological Data

Fisheries surveys in the watershed indicate that the stream environment supports self-sustaining populations of native Colorado River cutthroat trout (CRCT) and mottled sculpin. A small rainbow trout population is also located near the mouth of the creek. Colorado River cutthroat trout are of limited distribution across the state of Colorado, particularly in the San Miguel River sub-basin, where Red Canyon Creek is one of only three populations that currently exist. Distribution of these genetically pure CRCT populations is limited to approximately 5-7% of their native distribution on the Grand Mesa, Uncompahgre, and Gunnison National Forests (GMUG NF) (James and Speas 2005). Electro-fishing surveys completed in 2005 indicate that there are approximately 40 adult fish per mile in Red Canyon Creek (USFS unpublished). Sampling was done again on July 6, 2009. Over a 188 ft sampling reach 27 CRCT were collected.

Low flows are common in the late summer and fall, and may be a limiting factor for fish production and movement during this time. The stream channel provides good pool habitat during summer and winter low flows. However, depth appears to limit movement and distribution of CRCT during this time. Low flows also limit aquatic insect production during this low period as well. Despite these natural flow limitations in the summer and winter seasons, the stream does support a full-functional riparian community, and suitable fish habitat to support the long-term persistence of native CRCT.

Field Survey Data

USFS staff used the R2Cross methodology to quantify the amount of water required to preserve the natural environment to a reasonable degree. A two person crew used a pygmy meter and current meter digitizer to measure cross section velocities in the stream. Channel widths and depths were surveyed with a stadia rod, engineering level and fiberglass tape. Channel gradients were determined from rod, level and tape survey. The R2Cross method requires that stream discharge and channel profile data be collected in a riffle stream habitat type. Riffles are most easily visualized, as the stream habitat types that would dry up first should stream flow cease. This type of hydraulic data collection consists of surveying the stream channel geometry, determining channel roughness by collecting a representative sample of bed particles, and measuring the stream discharge. Three cross sections were established and surveyed on 7/25/2006. The flow measurements were extremely low during that visit and the R2Cross solutions were outside the acceptable range. Therefore a second set of measurements were collected at the previously established cross-sections on 6/27/2007. When run through the R2Cross model the 2007 data results were felt to be reasonable and representative of observed flows and channel morphological characteristics. Two of the three data sets collected in 2007 were used to develop a flow protection recommendation. Channel roughness was estimated by measuring 100 channel substrate particles and then calculating the D84 size particle. Mountain streams like Red Canyon Creek are difficult to get precise flow measurements, particularly during low flows, due to the highly variable velocity profiles that occur in streams with high roughness and channel complexity. Most likely measured flows under estimate the actual flows in the channel as a result of not capturing the volume of water moving through the channel bed materials.

Biological Flow Recommendation

The CWCB staff relied upon the biological expertise of the cooperating agencies to interpret output from the R2Cross data collected to develop the initial, biologic instream flow recommendation. This initial recommendation is designed to address the unique biologic requirements of each stream without regard to water availability. Three instream flow hydraulic parameters, average depth, percent wetted perimeter, and average velocity are used to develop biologic instream flow recommendations. The CWCB has determined that maintaining these three hydraulic parameters at adequate levels across riffle habitat types, aquatic habitat in pools and runs will also be maintained for most life stages of fish and aquatic invertebrates.

For this segment of stream, three data sets were collected with the results shown in Table 1 below. Table 1 shows who collected the data (Party), the date the data was collected (Date), the measured discharge at the time of the survey (Q), the accuracy range of the predicted flows based on Manning's Equation (240% and 40% of Q), the summer flow recommendation based on meeting 3 of 3 hydraulic criteria and the winter flow recommendation based upon 2 of 3 hydraulic criteria and whether the data was used to make the recommendation. However, updates to the R2Cross program have the ability to vary Manning's n over a range of flows allowing for more accurate staging tables to be used in the prediction of hydraulic parameters. These changes allow for more accurate hydraulic modeling in periods outside of the typical accuracy range of R2Cross. For this exercise the USFS generated the Thorne-Zevenbergen staging table by supplying a D84 for use in setting Manning's roughness coefficient and also selected the Bathurst formula for calculation of velocity and discharge in streams with high relative roughness.

Table 1: Stream flow data and R2Cross outputs from three cross sections located on Red Canyon Creek near confluence with Horsefly Creek.

Party	X-sec	Date	Measured Q	40%-250%	Summer (3/3)	Winter (2/3)	Used
USFS	#1	6/27/2007	1.3 cfs	.5 – 3.3 cfs	1.2 cfs	1.2 cfs	Yes
USFS	#2	6/27/2007	2.08 cfs	.8 – 5.2 cfs	.98 cfs	.52 cfs	No
USFS	#3	6/27/2007	1.11 cfs	.4 – 2.8 cfs	1.2 cfs	.99 cfs	Yes

USFS = U.S. Forest Service

Outputs from cross sections 1 and 3 were used to develop a spring/summer and winter flow recommendations. The summer flow recommendation is 1.2 cfs and winter flow recommendation is 1.0 cfs. Xsection #2 was not utilized because it was judged to be markedly different than the results from #1 and #2 and therefore not representative.

Hydrologic Data

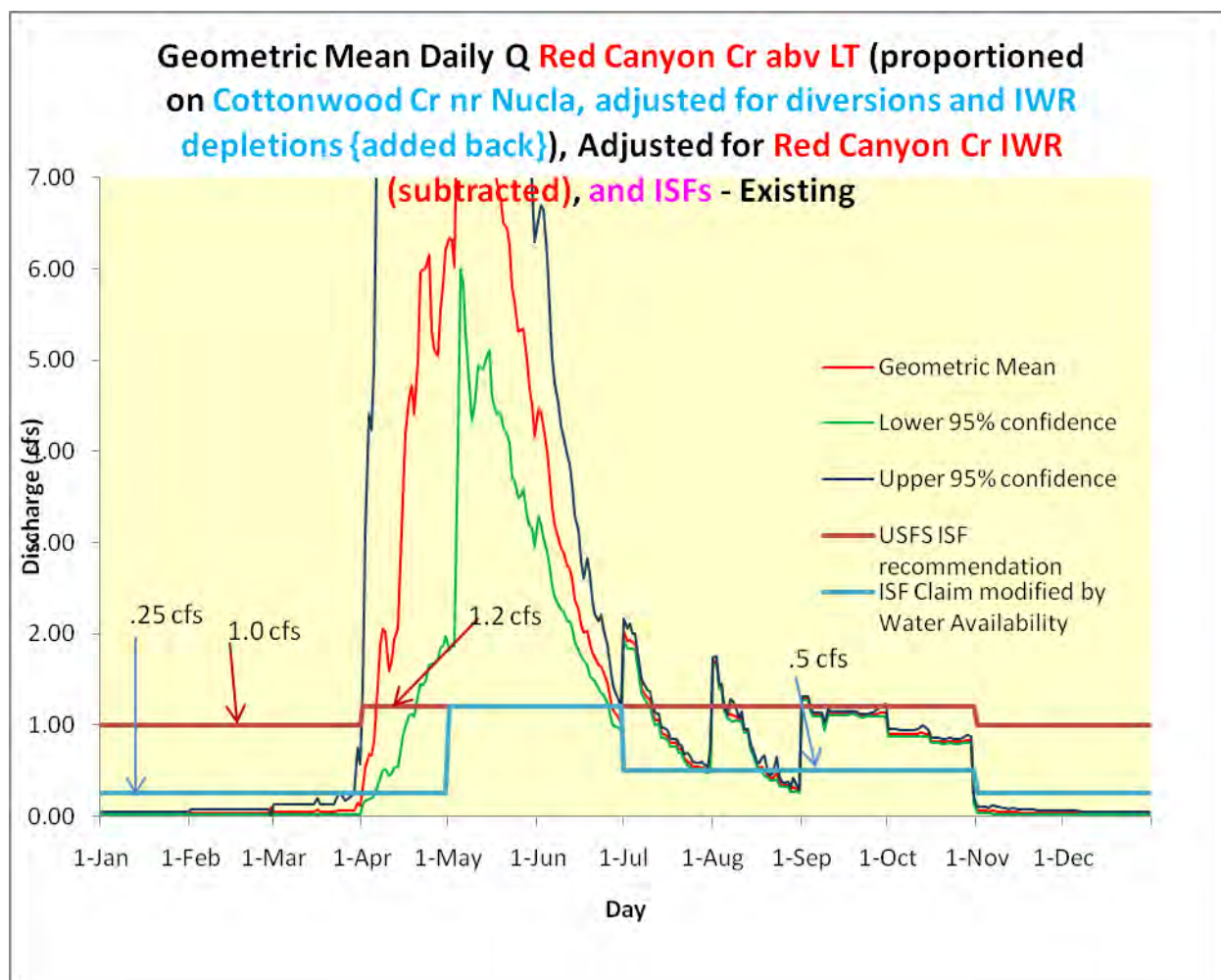
CWCB staff developed a model which estimates mean daily flows at the lower terminus of Red Canyon Creek. It was derived by extrapolating flow records for Cottonwood Creek near Nucla that was operated by the USGS from 1942 – 1951. While this is a common and reasonable approach, the U.S. Forest Service believes that it under represents the actual flows in the headwater streams particularly during the base flow winter period. The very low flows (< 0.1 cfs) during the winter period are likely a result of a frozen gage that did not accurately report actual flows. It is unlikely that the self sustaining fishery found in Big Red Creek could exist if the flows were really that low.

Antidotal evidence by water resource specialists and managers would support the conclusion that the Uncompahgre Plateau tends to be “flashy” with very high peaks and very low baseflows. However, elevation and position within the watershed is not well accounted for and tends to ameliorate these extremes. The streams draining the Plateau are losing systems. The source of water for streams, particularly the baseflow, is the headwaters above 8500 feet where snowpack accumulation occurs and water is stored in the soils beneath forested canopies and contributes to baseflows in the streams. Surface flows tend to diminish at lower elevations as groundwater aquifers are charged. Often during the baseflow periods there is more surface water

found in channels higher in the watershed than down lower, where the gaging stations tend to be located. This assertion cannot be substantiated with site specific data and therefore the structure of Forest Service recommendation has been modified but not completely constrained by the physical water availability model provide by the State of Colorado.

The alternative recommendation appearing on page 1 was developed in response to the water availability data supplied by CWCB.

Chart with Calculated Water Availability and ISF Protection



Existing Water Right Information

Staff has analyzed the water rights tabulation and consulted with the Division Engineer's Office (DEO) to identify any potential water availability problems. Records indicate that there are no surface water diversions on Red Canyon Creek. A conditional right was awarded on the Red Canyon Ditch in 1974 for 5 cfs. That right was abandoned by order of the Court in 1983 (83CW43).

Relationship to Management Plans

The Grand Mesa, Uncompahgre, and Gunnison National Forests (GMUG NF) Land and Resource Management Plan provide land management direction for FS lands located in the Red Canyon watershed. Forest Plan

direction for Fisheries, Threatened, Endangered, and Sensitive species suggest that land managers should among other things, maintain viable populations of native fish species, improve fish habitat conditions, and cooperate with state agencies to meet minimum flow needs to support fish populations. Additionally, agencies of the Colorado Division of Natural Resources and the Forest Service have signed agreements to assist in the conservation and protection of Colorado River cutthroat trout (CRCT River Cutthroat Trout Task Force 2006), and to work together to solve water issues in Colorado (Colorado DNR/USDA Forest Service MOU on water, 2004).

The Red Canyon stream segment is important to the FS because it is one of only three CRCT populations that currently exist in the San Miguel River. Red Canyon provides important spawning and rearing habitat for a self-sustaining Colorado River cutthroat trout fishery. Additionally, Red Canyon Creek is one of only a few perennial streams in the semi-arid landscape of the Uncompahgre Plateau. The stream is an important source of water for the lower reaches of Horsefly Creek, since headwater diversions currently divert a significant source of the summer flows for irrigation and small domestic use. Access into Red Canyon is very limited, so fishing pressure, and other land management uses are minimal, so stream level protection would be an important tool in maintaining aquatic values in this area of the Uncompahgre Plateau.

The FS requests that the Board recognize that this recommendation is based only upon the minimum flows necessary to support the cold-water fishery values. In the estimation of many Forest Service land managers and resource specialists the program as it currently exists does not provide sufficient flows throughout the year to insure that flow dependant resource values are sustained in the long term. The failure to incorporate at least a measure of periodic high flow into the protection strategy is a serious drawback. These fluvial systems require flows that are capable of transporting bedload, relocating course wood and providing periodic floodplain inundation. Given this shortcoming it is difficult to achieve a goal of “protecting the environment to a reasonable degree”. However, the GMUG NF feels some minimal protection under Colorado water law does have a benefit to the resource and therefore operating within the constraints of the program is an acceptable reality. The agency has Congressional authority, in fact a responsibility under the Federal Land Management and Policy Act (FLPMA), to protect natural resources and the processes which sustain them. To the extent that those processes cannot be protected under state law and authority they must be address by the Federal Land management agency at a time when actions are proposed that might require a determination of effects and conditions imposed felt to be necessary to insure sustainability.

We thank both the Colorado Division of Wildlife and the Water Conservation Board for their cooperation in this effort.

If you have any questions regarding our instream flow recommendation, please contact Clay Speas, Fisheries Biologist, at (970) 874-6650 or Gary Shellhorn, Watershed Program Manager, (970) 874-6666.

Exhibit 1 – Map of Red Canyon Creek Watershed

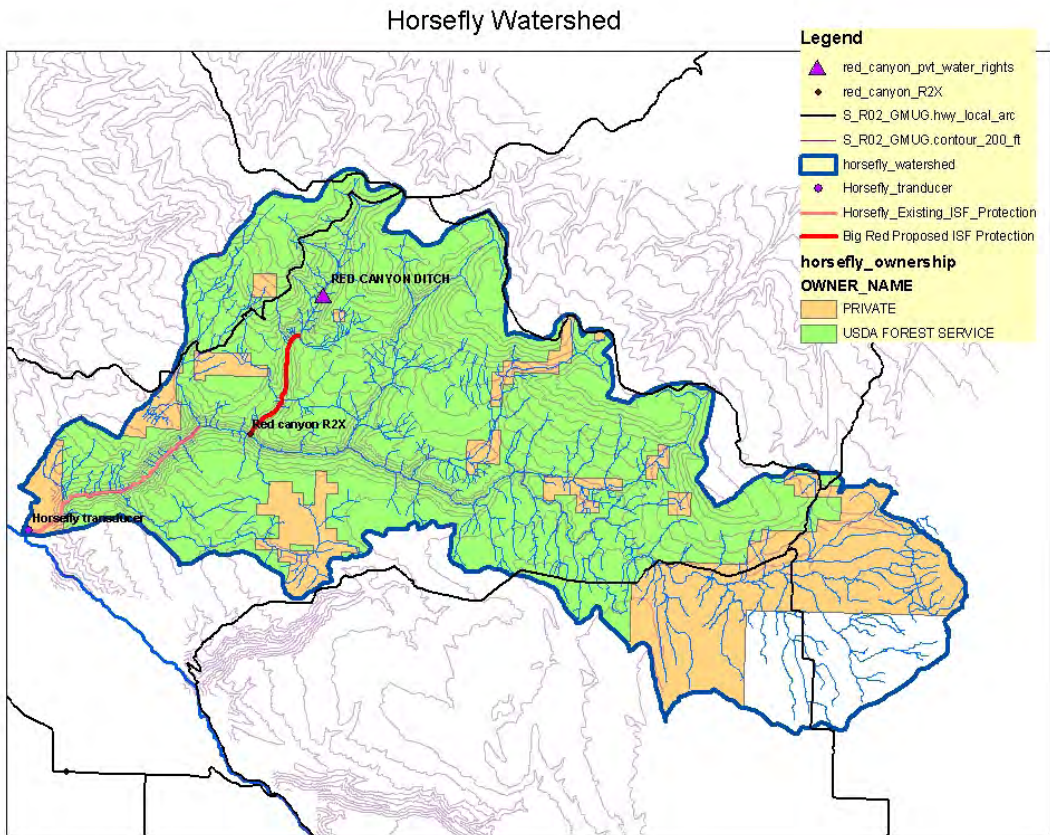
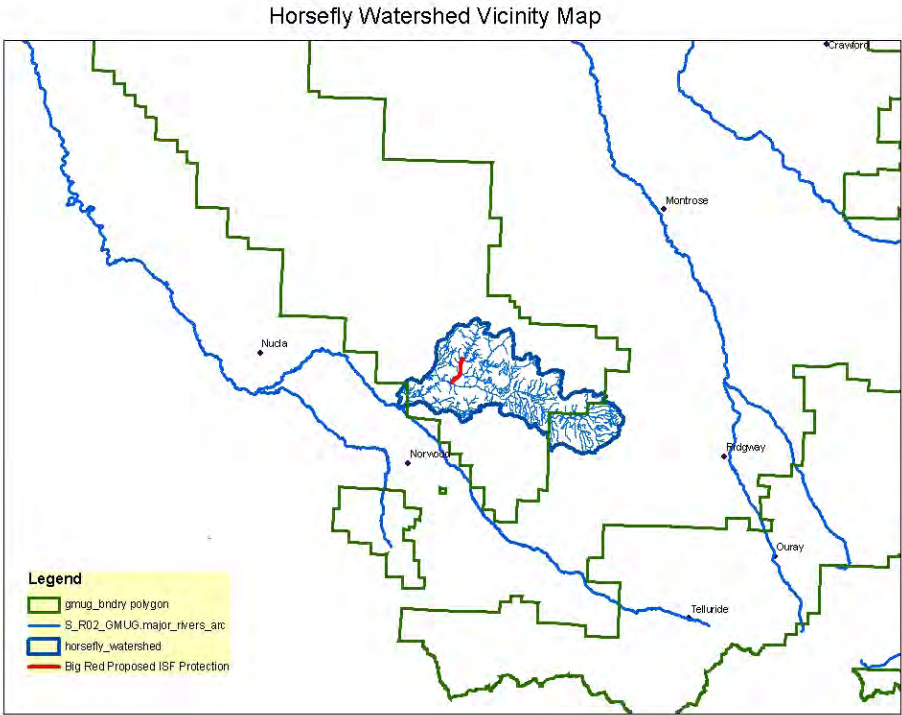


Exhibit 2 – Staging Tables from 2007 R2X Data

STREAM NAME: Red Canyon Creek

XS LOCATION:

XS NUMBER: 1

Thorne-Zevenbergen D84 Correction Applied

#REF! 0.58

GL = lowest Grassline elevation corrected for sag

STAGING TABLE *WL* = Waterline corrected for variations in field measured water surface elevations and sag

D84 Table

1-HeyD84

BathurstD84

3-Best Est

4-User

#REF!

	DIST TO	TOP	AVG.	MAX.			PERCENT	HYDR		AVG.	Bath	Hey
	WATER	WIDTH	DEPTH	DEPTH	AREA	WETTED PERIM.	WET PERIM	RADIUS	FLOW	VELOCITY	VELOCITY	VELOCITY
	(FT)	(FT)	(FT)	(FT)	(SQ FT)	(FT)	(%)	(FT)	(CFS)	(FT/SEC)	(FT/SEC)	(FT/SEC)
		0	#DIV/0!	0	0	0	#DIV/0!	#DIV/0!	#REF!	#REF!	#REF!	#REF!
GL	#REF!	8.91	0.69	1.27	6.12	9.75	100.0%	0.63	19.40	3.17	4.9976012	3.169497868
	0.00	9.76	0.97	1.63	9.46	10.94	112.2%	0.86	42.38	4.48	9.8408998	4.479672095
	0.00	9.62	0.93	1.58	8.98	10.76	110.4%	0.83	38.72	4.31	9.111514	4.313694003
	0.00	9.50	0.89	1.53	8.50	10.60	108.7%	0.80	35.17	4.14	8.3607547	4.13836353
	0.00	9.39	0.86	1.48	8.03	10.43	107.0%	0.77	31.78	3.96	7.6419455	3.959357581
	0.00	9.27	0.82	1.43	7.56	10.27	105.3%	0.74	28.55	3.78	6.9553405	3.776468157
	0.00	9.16	0.78	1.38	7.10	10.11	103.6%	0.70	25.48	3.59	6.3011817	3.589469506
	0.00	9.04	0.73	1.33	6.64	9.94	102.0%	0.67	22.58	3.40	5.679696	3.398116086
	0.00	8.93	0.69	1.28	6.19	9.78	100.3%	0.63	19.84	3.20	5.0910915	3.20214023
	0.00	7.80	0.74	1.23	5.77	8.59	88.1%	0.67	19.41	3.36	6.0622226	3.361956473
	0.00	7.43	0.73	1.18	5.39	8.20	84.1%	0.66	17.58	3.26	5.8695046	3.260754785
	0.00	7.07	0.71	1.13	5.03	7.82	80.2%	0.64	15.91	3.16	5.6949867	3.162657214
	0.00	6.71	0.70	1.08	4.69	7.44	76.3%	0.63	14.38	3.07	5.5409213	3.068240351
	0.00	6.34	0.69	1.03	4.36	7.05	72.3%	0.62	12.98	2.98	5.410238	2.978198738
	0.00	5.99	0.68	0.98	4.05	6.68	68.5%	0.61	11.71	2.89	5.2902599	2.889931374
	0.00	5.86	0.64	0.93	3.75	6.51	66.8%	0.58	17.84	4.75	4.7520772	2.709358165
	0.00	5.73	0.60	0.88	3.47	6.35	65.1%	0.55	14.69	4.24	4.2406657	2.524242167
	0.00	5.60	0.57	0.83	3.18	6.19	63.5%	0.51	11.95	3.76	3.7564687	2.334242503

WL

0.00	5.47	0.53	0.78	2.91	6.02	61.8%	0.48	9.59	3.30	3.2999486	2.138985123
0.00	5.34	0.49	0.73	2.63	5.86	60.1%	0.45	7.57	2.87	2.871584	1.938060931
0.00	5.21	0.45	0.68	2.37	5.70	58.4%	0.42	5.86	2.47	2.4718659	1.731025448
0.00	5.08	0.42	0.63	2.11	5.53	56.7%	0.38	4.44	2.10	2.1020267	1.517726309
0.00	4.93	0.38	0.58	1.86	5.35	54.8%	0.35	3.31	1.78	1.7754372	1.304498114
0.00	4.78	0.34	0.53	1.62	5.16	53.0%	0.31	2.39	1.48	1.4750868	1.084030592
0.00	4.62	0.30	0.48	1.39	4.98	51.1%	0.28	1.67	1.20	1.2016565	0.855811426
0.00	4.47	0.26	0.43	1.16	4.79	49.2%	0.24	1.11	0.96	0.9558619	0.619437688
0.00	4.26	0.22	0.38	0.94	4.56	46.7%	0.21	0.70	0.75	0.7495433	0.387336032
0.00	3.90	0.19	0.33	0.74	4.19	42.9%	0.18	0.44	0.59	0.5911644	0.180555004
0.00	3.70	0.15	0.28	0.55	3.96	40.6%	0.14	0.23	0.43	0.4303392	-0.063533295
0.00	3.51	0.10	0.23	0.37	3.74	38.4%	0.10	0.11	0.30	0.296695	-0.31025174
0.00	2.62	0.08	0.18	0.21	2.82	28.9%	0.07	0.04	0.20	0.2025164	-0.467997414
0.00	1.78	0.06	0.13	0.10	1.91	19.6%	0.05	0.01	0.12	0.1206427	-0.61240716
0.00	0.77	0.04	0.08	0.03	0.82	8.4%	0.04	0.00	0.05	0.0479683	-0.720947973
0.00	0.25	0.01	0.03	0.00	0.27	2.7%	0.01	0.00	0.01	0.0084598	-0.73758716

STREAM NAME: Red Canyon Creek

XS LOCATION: 0
XS NUMBER: 3

Thorne-Zevenbergen D84 Correction Applied

#REF! 0.58

GL = lowest Grassline elevation corrected for sag

STAGING TABLE

WL = Waterline corrected for variations in field measured water surface elevations and sag

D84 Table
1-HeyD84
BathurstD84
3-Best Est
4-User

#REF!											Bath	Hey
DIST TO	TOP	AVG.	MAX.				HYDR		AVG.			
WATER	WIDTH	DEPTH	DEPTH	AREA	WETTED PERIM.	PERCENT WET PERIM	RADIUS	FLOW	VELOCITY	VELOCITY	VELOCITY	VELOCITY
(FT)	(FT)	(FT)	(FT)	(SQ FT)	(FT)	(%)	(FT)	(CFS)	(FT/SEC)	(FT/SEC)	(FT/SEC)	(FT/SEC)
GL	#REF!	9.40	0.53	1.04	4.96	10.12	100.0%	0.49	17.14	3.46	3.4554276	2.6912772
	0.00	10.70	1.01	1.62	10.76	11.98	118.3%	0.90	56.96	5.30	11.775318	5.2961482
	0.00	10.56	0.97	1.57	10.22	11.79	116.5%	0.87	52.19	5.11	10.919497	5.1050312
	0.00	10.42	0.93	1.52	9.70	11.60	114.6%	0.84	47.63	4.91	10.094053	4.9103749
	0.00	10.30	0.89	1.47	9.18	11.44	113.0%	0.80	43.19	4.70	9.250807	4.704092
	0.00	10.19	0.85	1.42	8.67	11.28	111.5%	0.77	38.92	4.49	8.4183357	4.4888876
	0.00	10.09	0.81	1.37	8.16	11.13	110.0%	0.73	34.85	4.27	7.6272192	4.2691107
	0.00	9.98	0.77	1.32	7.66	10.98	108.4%	0.70	30.98	4.04	6.8774838	4.044512
	0.00	9.88	0.73	1.27	7.16	10.82	106.9%	0.66	27.33	3.81	6.1691194	3.8148214
	0.00	9.77	0.68	1.22	6.67	10.67	105.4%	0.63	23.89	3.58	5.5020752	3.5797458
	0.00	9.67	0.64	1.17	6.19	10.52	103.9%	0.59	20.66	3.34	4.8762555	3.3389667
	0.00	9.56	0.60	1.12	5.71	10.36	102.4%	0.55	24.49	4.29	4.291514	3.0921377
	0.00	9.46	0.55	1.07	5.23	10.21	100.9%	0.51	19.60	3.75	3.74765	2.838881
	0.00	9.09	0.52	1.02	4.76	9.81	96.9%	0.49	16.30	3.42	3.4232977	2.6506463
	0.00	8.36	0.52	0.97	4.33	9.07	89.6%	0.48	14.58	3.37	3.3701018	2.5646592
	0.00	7.64	0.51	0.92	3.93	8.34	82.4%	0.47	13.17	3.36	3.3552484	2.4935076
	0.00	7.13	0.50	0.87	3.56	7.82	77.2%	0.46	11.36	3.19	3.1922181	2.366221
	0.00	6.76	0.47	0.82	3.21	7.42	73.3%	0.43	9.41	2.93	2.9301666	2.197516
	0.00	6.40	0.45	0.77	2.88	7.03	69.4%	0.41	7.70	2.67	2.6725673	2.0250535
	0.00	6.29	0.41	0.72	2.57	6.88	67.9%	0.37	5.77	2.25	2.2508199	1.7650395
	0.00	6.18	0.36	0.67	2.25	6.73	66.5%	0.33	4.21	1.87	1.8679226	1.4968548
WL	0.00	6.04	0.32	0.62	1.95	6.54	64.6%	0.30	2.99	1.54	1.5378571	1.2302773

0.00	5.76	0.29	0.57	1.65	6.23	61.6%	0.27	2.12	1.28	1.2815321	0.9895614
0.00	5.31	0.26	0.52	1.37	5.72	56.5%	0.24	1.51	1.10	1.1012401	0.7947253
0.00	4.81	0.23	0.47	1.12	5.16	51.0%	0.22	1.06	0.94	0.9419128	0.6078414
0.00	4.34	0.21	0.42	0.89	4.62	45.7%	0.19	0.70	0.79	0.7863252	0.4118366
0.00	4.11	0.17	0.37	0.68	4.36	43.0%	0.16	0.40	0.59	0.5924625	0.1417872
0.00	3.12	0.16	0.32	0.50	3.33	32.9%	0.15	0.26	0.51	0.5140291	0.0409005
0.00	2.65	0.13	0.27	0.36	2.84	28.0%	0.13	0.14	0.39	0.3930452	-0.1524874
0.00	2.36	0.10	0.22	0.23	2.53	25.0%	0.09	0.06	0.26	0.262085	-0.4009053
0.00	1.50	0.09	0.17	0.14	1.64	16.2%	0.08	0.03	0.19	0.1865848	-0.5136597
0.00	1.18	0.05	0.12	0.06	1.28	12.6%	0.05	0.01	0.10	0.0992914	-0.7205663
0.00	0.53	0.03	0.07	0.02	0.58	5.7%	0.03	0.00	0.03	0.0333518	-0.8410347
0.00	0.14	0.01	0.02	0.00	0.15	1.5%	0.01	0.00	0.00	0.0040501	-0.824781

Water: Big Red Canyon
 Date: 7/06/09
 Location: Off FS Rd. 512.1H
 Drainage: San Miguel
 Water Code:
 42452
 UTM Zone: 12S
 UTM X: 744569
 m
 UTM Y: 4239436
 m
 Station Length = 222 ft
 Station Width =
 9 ft
 Crew: Forest Service
 Notes:
 Air Temp: 75F
 Water Temp:
 58F
 Efforts: 1st pass=1653sec 2nd pass=1298sec

Species	Count	Length (mm)	Weight (g)	Status	Mark	TagID
CRN	1	95	9	1		
CRN	1	192	67	1		
CRN	1	186	59	1		
CRN	1	96	8	1		
CRN	1	92	7	1		
CRN	1	103	11	1		
CRN	1	98	9	1		
CRN	1	106	11	1		
CRN	1	105	10	1		
CRN	1	88	6	1		
CRN	1	101	10	1		
CRN	1	81	6	1		
CRN	1	91	7	1		
CRN	1	101	9	1		
CRN	1	100	9	1		
CRN	1	199	71	1		
CRN	1	90	7	1		
CRN	1	83	6	1		
CRN	1	96	9	1		
CRN	1	98	9	1		
CRN	1	106	10	1		
CRN	1	99	10	1		
CRN	1	106	11	1		
CRN	1	156	33	1		
CRN	1	89	7	1		
CRN	1	145	27	1		
CRN	1	85	6	1		
CRN	1	96	7	1		
CRN	1	76	4	1		
CRN	1	94	7	1		
CRN	1	96	8	1		
CRN	1	99	9	1		
CRN	1	80	4	2		

CRN	1	94	9	2
CRN	1	102	10	2
CRN	1	96	1	2
CRN	1	84	5	2
CRN	1	106	12	2
CRN	1	91	8	2
CRN	1	189	62	2
CRN	1	203	69	2
CRN	1	94	9	2
CRN	1	94	7	2
CRN	1	153	39	2
CRN	1	138	24	2

Water: Big Red Canyon Creek
 Date: 7/6/2009
 Location: Off FS Rd. 512.1H
 Drainage: San Miguel
 Water Code: 42452
 UTM Zone: 12S
 744344
 UTM X: m
 UTM Y: 4239322 m
 Station Length = 188 ft
 Station Width = 9 ft
 Crew: Forest Service
 Notes:
 Air Temp: 79F
 Water Temp: 59F
 Efforts: 1st pass=1175sec 2nd pass=1147sec

Species	Count	Length (mm)	Weight (g)	Status	Mark	TagID
CRN		87	5	1		
CRN		88	8	1		
CRN		104	11	1		
CRN		102	12	1		
CRN		92	9	1		
CRN		189	70	1		
CRN		102	10	1		
CRN		99	10	1		
CRN		155	40	1		
CRN		94	7	1		
CRN		91	9	1		
CRN		111	14	1		
CRN		85	7	1		
CRN		106	13	1		
CRN		104	12	1		
CRN		87	9	1		
CRN		109	13	1		
CRN		104	12	1		
CRN		113	15	1		
CRN		95	8	1		
CRN		92	7	1		

CRN	90	7	1
CRN	211	92	2
CRN	95	8	2
CRN	88	6	2
CRN	86	6	2
CRN	161	45	2

Water: Big Red Canyon Creek

Date: 7/6/2005

Location: End of Hanks Valley Rd (FSR 512) ; appx. 200m below ATV trail crossing

Drainage:

Dolores

Water Code:

42452

UTM Zone: 12S

UTM X: 744281

m

UTM Y: 4239525

m

Station Length = 317 ft

Station Width = 9.7 ft

Crew: USFS crew: Frame, Harty

Notes: Long hike down into remote canyon area at the end of Hanks Valley Rd. No visible introgression; no gentic samples taken

Species	Count	Length (mm)	Weight (g)	Status	Mark	TagID
CRN	1	175	54	1		
CRN	1	264	209	1		
CRN	1	200	101	1		
CRN	1	245	146	1		
CRN	1	168	52	2		

Water: Big Red Canyon Creek

Date: 7/6/2005

Location: At the end of Hanks Valley Rd (FSR 512); immediatley above ATV trail crossing

Drainage: Dolores

Water

Code: 42452

UTM Zone: 12S

UTM X: 0744506 m

UTM Y: 4239640 m

Station Length = 364.2

Station Width = 11.02

Crew: Frame, Harty

Notes: None

Shock Seconds: 1st Pass = 327, 2nd Pass = 298

Temperature: Air = 26 C, Water = 14 C

GPS File: BIGRED2

Species	Count	Length (mm)	Weight (g)	Status	Mark	TagID
CRN	1	195	79	1		
CRN	1	205	91	1		
CRN	1	111	16	1		
CRN	1	112	13	1		
CRN	1	173	65	1		
CRN	1	121	17	2		
CRN	1	190	75	2		

Water: Big Red #1

Date: 07/25/06

Location: Approximately 200m above horsefly, started at house-sized boulder in streambed.

Drainage:

Water Code:

UTM Zone: n/a

UTM X: n/a

UTM Y: n/a

Station Length = 398.5 ft

Station Width = 6.22 ft

Crew: Frame, DeBerard

Notes: unable to obtain G.P.S. coordinates, no signal in canyon

First Pass: 360

Second Pass: 224

Air Temperature:

24

Water Temperature: 21

Species	Count	Length (mm)	Weight (g)	Status	Mark	TagID
BRK		139	24	1		
RBT		136	21	1		
RBT		125	21	1		
RBT		214	111	1		
CRN		126	18	1		
RBT		109	12	1		
MTS		111	19	1		
MTS		101	14	1		
MTS		99	12	1		
MTS		98	12	1		
MTS		103	14	1		
MTS		115	22	1		
MTS		98	11	2		
MTS		98	11	2		
MTS		148	37	2		

no
morts



COLORADO WATER
CONSERVATION BOARD

FIELD DATA FOR INSTREAM FLOW DETERMINATIONS



LOCATION INFORMATION

STREAM NAME: <i>Big Red Cr near Horsefly Confluence</i>		CROSS-SECTION NO.: <i>#1</i>
CROSS-SECTION LOCATION: <i>Same location as 2006 survey</i>		
NAD 83 Zone 13N N. 4237345 E. 217921		
DATE: <i>6/27/07</i>	OBSERVERS: <i>Ally + Stratton</i>	
LEGAL DESCRIPTION	% SECTION	SECTION
TOWNSHIP	N/S	RANGE
E/W	PM	
COUNTY: <i>Montrose</i>	WATERSHED: <i>Horsefly</i>	WATER DIVISION: <i>4</i>
DOW WATER CODE		
USGS:		
USFS:		

27.7
16.9
44.6

SUPPLEMENTAL DATA

SAG TAPE SECTION SAME AS DISCHARGE SECTION	YES/NO	METER TYPE
METER NUMBER	DATE RATED	CALIB/SPIN
TAPE WEIGHT	Tape Tension	
CHANNEL BED MATERIAL SIZE RANGE	PHOTOGRAPHS TAKEN YES/NO	NUMBER OF PHOTOGRAPHS

CHANNEL PROFILE DATA

STATION	DISTANCE FROM TAPE (ft)	ROD READING (ft)
① Tape @ Stake LB	0.0	
② Tape @ Stake RB	0.0	
③ WS @ Tape LB/RB	0.0	
④ WS Upstream	38.0'	3.06'
⑤ WS Downstream	44.6'	6.10'
SLOPE		

SKETCH

LEGEND:

Stake (X)

Station (1)

Photo (1)

Direction of Flow (arrow)

AQUATIC SAMPLING SUMMARY

STREAM ELECTROFISHED YES/NO	DISTANCE ELECTROFISHED	FISH CAUGHT YES/NO	WATER CHEMISTRY SAMPLED YES/NO
LENGTH - FREQUENCY DISTRIBUTION BY ONE-INCH SIZE GROUPS (1.0-1.9, 2.0-2.9, ETC.)			
SPECIES (FILL IN)	1	2	3
	4	5	6
	7	8	9
	10	11	12
	13	14	15
	>15	TOTAL	
AQUATIC INSECTS IN STREAM SECTION BY COMMON OR SCIENTIFIC ORDER NAME			

COMMENTS

<i>Flag hanging at survey location</i>	<i>Photos</i>
<i>Observed 2 4-inch trout in</i>	<i>#10 View upstream</i>
<i>Horsefly below confluence with Big Red</i>	<i>#11 Across</i>
<i>Also found adult leopard frog</i>	<i>#12 Downstream</i>

DISCHARGE/CROSS SECTION NOTES

STREAM NAME		CROSS-SECTION NO		DATE		SHEET				
BEGINNING OF MEASUREMENT		EDGE OF WATER LOOKING DOWNSTREAM (0.0 AT STAKE)		LEFT / RIGHT		Gage Reading		TIME		
Stake Grassline (G) Waterline (W) Rock (R)	Distance From Initial Point (ft)	Width (ft)	Total Vertical Depth From Tape/Inst (ft)	Water Depth (ft)	Depth of Observation (ft)	Revolutions	Time (sec)	Velocity (ft/sec) At Point Mean in Vertical	Area (ft ²)	Discharge (cfs)
RS	0		1.95							
	2.2		2.66							
G	4.8		3.95							
	6.5		4.24							
W	6.9		4.58							
	7.2		4.83	.25				0		
	7.5		4.88	.30				0		
	7.8		5.00	.40				0.138		
	8.1		5.02	.42				0.146		
	8.4		5.22	.64				0.184		
	8.7		5.17	.56				0.279		
	9.0		5.04	.44				0.157		
	9.3		5.20	.60				0.883		
	9.6		5.10	.50				0.316		
	9.9		5.08	.52				0.260		
	10.2		5.02	.44				0.830		
	10.5		5.02	.44				0.961		
	10.8		5.14	.54				1.20		
	11.1		5.14	.53				1.173		
	11.4		4.91	.31				2.142		
W	12.0		4.59	0						
G	12.9		3.95							
	13.8		3.99							
	13.7		3.62							
LS	15.6		2.21							
TOTALS										
End of Measurement		Time:		Gage Reading		CALCULATIONS PERFORMED BY:		CALCULATIONS CHECKED BY:		



COLORADO WATER
CONSERVATION BOARD

FIELD DATA
FOR
INSTREAM FLOW DETERMINATIONS



LOCATION INFORMATION

STREAM NAME: <i>Big Red Ck near Horseshy Confluence</i>		CROSS-SECTION NO.: <i>#2</i>
CROSS-SECTION LOCATION: <i>Same as 2006. Survey</i>		
DATE: <i>6/27/07</i>	OBSERVERS: <i>Almy & Stratton</i>	
LEGAL DESCRIPTION	SECTION: <i>N/S</i>	RANGE: <i>E/W</i>
COUNTY: <i>Montrose</i>	WATERSHED: <i>Horseshy</i>	WATER DIVISION: <i>4</i>
USGS:	DOW WATER CODE:	
USFS:		

SUPPLEMENTAL DATA

SAG TAPE SECTION SAME AS DISCHARGE SECTION: YES/NO	METER TYPE
METER NUMBER	DATE RATED
CALIB/SPIN	SEC
TAPE WEIGHT	lbs/foot
TAPE TENSION	lbs
CHANNEL BED MATERIAL SIZE RANGE	PHOTOGRAPHS TAKEN YES/NO
NUMBER OF PHOTOGRAPHS	

CHANNEL PROFILE DATA

STATION	DISTANCE FROM TAPE (ft)	ROD READING (ft)
⊗ Tape @ Stake LB	0.0	
⊗ Tape @ Stake RB	0.0	
① WS @ Tape LB/RB	0.0	
② WS Upstream	<i>41.5'</i>	<i>2.04'</i>
③ WS Downstream	<i>47.0'</i>	<i>6.54'</i>
SLOPE	<i>88 S</i>	

SKETCH

LEGEND:

Stake ⊗

Station ①

Photo ①

Direction of Flow →

AQUATIC SAMPLING SUMMARY

STREAM ELECTROFISHED YES/NO	DISTANCE ELECTROFISHED _____ ft	FISH CAUGHT YES/NO	WATER CHEMISTRY SAMPLED YES/NO															
LENGTH - FREQUENCY DISTRIBUTION BY ONE-INCH SIZE GROUPS (1.0-1.9, 2.0-2.9, ETC.)																		
SPECIES (FILL IN)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15	TOTAL	
AQUATIC INSECTS IN STREAM SECTION BY COMMON OR SCIENTIFIC ORDER NAME																		

COMMENTS

<i>50' above XS 1 Orange flag & rock cairn</i>	<i>Photos</i>
	<i>#13 Upstream</i>
	<i>#14 Across</i>
	<i>#15 Downstream</i>

DISCHARGE/CROSS SECTION NOTES

STREAM NAME						CROSS-SECTION NO.	DATE	SHEET ____ OF ____				
BEGINNING OF MEASUREMENT	EDGE OF WATER LOOKING DOWNSTREAM 10.0 AT STAKE			LEFT / RIGHT	Gage Reading	N/A ft	TIME	1000				
Features	Stake (S) Grassline (G) Waterline (W) Rock (R)	Distance From Initial Point (ft)	Width (ft)	Total Vertical Depth From Tape/Inst (ft)	Water Depth (ft)	Depth of Observation (ft)	Revolutions	Time (sec)	Velocity (ft/sec)		Area (ft ²)	Discharge (cfs)
									At Point	Mean in Vertical		
RS		0		1.29								
		2.7		1.45								
		2.8		3.42								
-		3.0		3.97								
		3.1		3.22								
		4.7		3.59								
		4.9		4.33								
G		5.6		4.34								
W		5.8		4.92								
		5.9		5.56	.65					0.183		
		6.1		5.68	.76					0.123		
		6.3		5.53	.61					0.101		
		6.5		5.58	.68					0.169		
		6.7		5.57	.66					0.365		
		6.9		5.56	.65					0.468		
		7.1		5.77	.86					0.589		
		7.3		5.80	.90					1.145		
		7.5		5.82	.90					1.416		
		7.7		5.85	.93					0.973		
		7.9		5.79	.89					0.650		
		8.1		5.83	.92					0.363		
		8.3		5.77	.88					0.577		
		8.5		5.81	.90					0.685		
		8.7		5.85	.94					0.814		
		8.9		5.81	.88					1.124		
		9.1		5.75	.82					0.944		
		9.3		5.69	.77					0.640		
		9.5		5.69	.79					0.383		
		9.7		5.34	.42					0.480		
		9.9		5.34	.44					0.529		
W		10.1		4.92	0							
R		11.1		4.08								
		11.5		4.53								
G		11.8		4.35								
G		15.3		3.97								
		17.0		2.73								
		20.0		.48								
TOTALS												
End of Measurement	Time:	Gage Reading										
CALCULATIONS PERFORMED BY:										CALCULATIONS CHECKED BY:		

Ms. Linda Bassi
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, Colorado 80203

Dear Ms. Bassi:

The USDA Forest Service (FS) is writing this letter to formally communicate its instream flow recommendation for Red Canyon Creek, located in Water Division 4.

Location and Land Status. The FS is recommending stream flow protection under the CWCB Stream and Lake Protection program for 6.75 miles of Red Canyon Creek starting at the headwaters and terminating at the confluence of Red Canyon Creek and Horsefly Creek. Red Canyon is tributary to Horsefly Creek which flows into the San Miguel River approximately 13 miles east of Naturita. The stream reach covered by the surveys conducted on FS lands start at the confluence with Horsefly Creek and comprises the entire Red Canyon watershed. The proposed reach is entirely located on NFS lands. Two small 40-80 acre parcels of private land do exist in the watershed.

Biological Summary. Fisheries surveys in the watershed indicate that the stream environment supports self-sustaining populations of native Colorado River cutthroat trout and mottled sculpin. A small rainbow trout population is also located near the mouth of the creek. Colorado River cutthroat trout are of limited distribution across the state of Colorado, particularly in the San Miguel River sub-basin, where Red Canyon Creek is one of only three populations that currently exist. Distribution of these genetically pure CRCT populations is limited to approximately 5-7% of their native distribution on the Grand Mesa, Uncompahgre, and Gunnison National Forests (GMUG NF) (James and Speas 2005). Electrofishing surveys completed in 2005 indicate that there are approximately 40 adult fish per mile in Red Canyon Creek (USFS unpublished).

Low flows are common in the late summer and fall, and may be a limiting factor for fish production and movement during this time. The stream channel provides good pool habitat during summer and winter low flows. However, depth appears to limit movement and distribution of CRCT during this time. Low flows also limit aquatic insect production during this low period as well. Despite these natural flow limitations in the summer and winter seasons, the stream does support a full-functional riparian community, and suitable fish habitat to support the long-term persistence of native CRCT.

R2Cross Analysis. Three cross sections were collected on Red Canyon Creek on June 27, 2008, and used to quantify instream flow protection using R2Cross procedures outlined by the Colorado Water Conservation Board (CWCB 1996). FS data analysis indicates that the following flows are needed to preserve the fishery and natural environment to a reasonable degree.

A minimum flow of 3.8 cubic feet per second is recommended from January 1st to December 30th. If natural stream flows fall below 3.8 cubic feet per second, then all remaining water should be protected in order to “preserve the native fishery and natural environment to a reasonable degree.” Based on the FS observations of this stream the

protection of flows below 3.8 cubic feet per second is needed to protect existing fish habitat, fish migration, and spawning and incubation periods for Colorado River cutthroat trout. Water use and development during low flow periods would have severe detrimental effects incubation success, summer and fall distribution and migration patterns, and aquatic food abundance in a stream system where these fisheries habitat and food requirements are already strained by naturally occurring low flows.

Water Availability

In the absence of gage data from Red Canyon Creek, a hydrograph was constructed using a natural flow estimation model developed by Kircher et al (1985). The southwest regional equation was used to model streams on the Uncompahgre Plateau. A review of five Uncompahgre Plateau streams by the BLM was used to validate the use of southwest regional equations (Appendix B). Intermittent USGS gages from Spring Creek near Beaver Hill (1978 - 1980), Potter Creek near Olathe: (1980), and Hay Press Creek above Fruita Reservoir #3 (1984 - 1987) were used to develop monthly streamflow characteristics for Red Canyon Creek. Monthly water yield estimates were eventually converted to mean monthly discharge numbers to construct an annual hydrograph (Table 1). Annual yield was estimated at 5,963 acre-feet, with 95% of the annual yield occurring in April-June.

Table 1. Mean monthly hydrograph for Red Canyon Creek developed using southwest regional equations developed by Kircher et al (1985) and Bureau of Land Management (D. Murphy pers. communications) for streams on the Uncompahgre Plateau.

Water Yield Estimates – Kircher 1985 (southwest regional equation)

Watershed: **Red Canyon Creek**
Location: FS lands

Drainage Area (square miles): 12.90661
Mean Basin Elevation (ft): 8480.971
Mean Basin Elev. -5000 ft/1000 ft: 3.480971

Mean Annual Flow (cfs): 8.236
Mean Annual Yield (AF): 5963

	Percent of annual flow	AF/Month	AF/Day	Mean Monthly flow (cfs)
January	0.0032	19.085	0.616	0.311
February	0.0065	38.766	1.337	0.675
March	0.0100	59.640	1.924	0.972
April	0.1470	876.713	29.224	14.759
May	0.5541	3304.076	106.583	53.830
June	0.2461	1467.153	48.905	24.700
July	0.0130	77.532	2.501	1.263
August	0.0050	29.820	0.962	0.486
September	0.0040	23.856	0.795	0.402
October	0.0039	23.260	0.750	0.379
November	0.0037	22.067	0.736	0.371
December	0.0035	20.874	0.673	0.340

Relationship to Management Plans. The Grand Mesa, Uncompahgre, and Gunnison National Forests (GMUG NF) Land and Resource Management Plan provide land management direction for FS lands located in the Red Canyon watershed. Forest Plan direction for Fisheries, Threatened, Endangered, and Sensitive species suggest that land managers should among other things, maintain viable populations of native fish species, improve fish habitat conditions, and cooperate with state agencies to meet minimum flow needs to support fish populations. Additionally, agencies of the Colorado Division of Natural Resources and the Forest Service have signed agreements to assist in the conservation and protection of Colorado River cutthroat trout (CRCT River Cutthroat Trout Task Force 2006), and to work together to solve water issues in Colorado (Colorado DNR/USDA Forest Service MOU on water, 2004).

The Red Canyon stream segment is important to the FS because it is one of only three CRCT populations that currently exist in the San Miguel River. Red Canyon provides important spawning and rearing habitat for a self-sustaining Colorado River cutthroat trout fishery. Additionally, Red Canyon Creek is one of only a few perennial streams in the semi-arid landscape of the Uncompahgre Plateau. The stream is an important source of water for the lower reaches of Horseshoe Creek, since headwater diversions currently divert a significant source of the summer flows for irrigation and small domestic use. Access into Red Canyon is very limited, so fishing pressure, and other land management uses are minimal, so stream level protection would be an important tool in maintaining aquatic values in this area of the Uncompahgre Plateau.

The FS requests that the Board recognize that this recommendation is based only upon the minimum flows necessary to support the cold-water fishery values. FS may wish to work with the Board and/or through the Colorado water rights system to appropriate flows to optimally protect fish values and to protect other water-dependent values specified in FS resource management plans.

Data sheets, R2Cross output, fishery survey information, hydrology and water yield techniques, and photographs of the cross section are enclosed to support this recommendation. We thank both the Colorado Division of Wildlife and the Water Conservation Board for their cooperation in this effort.

If you have any questions regarding our instream flow recommendation, please contact Christopher James, Fisheries Biologist, at (970) 240-5421 or John Almy, Forest Hydrologist, at (970) 874-6656.

4 Enclosures

cc: Pauline Adams, GMUG NF, Water Rights Coordinator
Polly Hayes, Regional Office, Water Program Manager
Scott Ludwig, Regional Office, Water Rights Coordinator

Literature Cited

Colorado River Cutthroat Trout Task Force 2006. Conservation Agreement and Strategy for Colorado River cutthroat trout in the states of Colorado Wyoming, and Utah. April 2001, updated June 2006.

Colorado Water Conservation Board 1996. Development of instream flow recommendations in Colorado using R2Cross. By Greg Espegren, Senior Water Resource Specialist. January 1996.

James, C. and C. Speas. 2005. Colorado River cutthroat trout Species and Conservation Assessment. Prepared for the GMUG NF, November 2005.

Kircher, J.E., A.F. Choquette, and B.D. Richter, 1985. Estimation of Natural Streamflow Characteristics in Western Colorado. Water Resources Investigations Report 85-4086, 1985. U.S. Geological Survey, Prepared in Coordination with the Bureau of Land Management.

DISCHARGE/CROSS SECTION NOTES

STREAM NAME		CROSS-SECTION NO		DATE		SHEET		OF				
BEGINNING OF MEASUREMENT		EDGE OF WATER LOOKING DOWNSTREAM (0.0 AT STAKE)		LEFT / RIGHT		Gage Reading		TIME				
Features	Stake Grassline (G) Waterline (W) Rock (R)	Distance From Initial Point (ft)	Width (ft)	Total Vertical Depth From Tape/Inst (ft)	Water Depth (ft)	Depth of Observation (ft)	Revolutions	Time (sec)	Velocity (ft/sec) At Point Mean in Vertical	Area (ft ²)	Discharge (cfs)	
RS		0		3.00								
		2.0		3.96								
		3.8		4.69								
G		4.6		5.15								
		5.7		5.29								
W		5.9		5.56	0							
		6.9		5.76	.20				0.196			
		7.1		5.83	.28				0.343			
		7.3		5.87	.30				0.381			
		7.5		5.83	.28				0.608			
		7.7		5.86	.30				0.656			
		7.9		5.86	.28				0.562			
		8.1		5.88	.30				0.914			
		8.3		5.88	.30				0.992			
		8.5		5.98	.40				0.848			
		8.7		5.97	.40				0.729			
		8.9		6.00	.42				0.608			
		9.1		6.01	.40				0.331			
		9.3		6.00	.40				0.475			
		9.5		6.19	.58				0.584			
		9.7		6.16	.58				0.801			
		9.9		6.07	.48				1.065			
		10.1		6.07	.50				1.031			
		10.3		6.14	.58				0.816			
		10.5		6.11	.56				0.537			
		10.7		6.12	.55				0.200			
		10.9		5.96	.40				0.191			
		11.1		5.90	.35				0.254			
		11.4		5.63	.04				0			
		11.9		5.78	.22				0			
W		12.0		5.56	0							
		12.2		5.42								
G		14.0		5.15								
		14.3		4.31								
		16.7		4.39								
S		18.8		2.13								
TOTALS												
End of Measurement		Time	Gage Reading		CALCULATIONS PERFORMED BY:				CALCULATIONS CHECKED BY:			

Stream: Big Red Creek

Executive Summary

**Water Division: 4 Water District: 60
HUC 1403000302**

Segment: Confluence with Big A Creek down to Confluence with Horsefly Creek

**Upper Terminus: Latitude: 38°16'18.116"N Longitude: 108°12'18.583"W
UTM 219602.4 Easting UTM 4240821.9 Northing
NAD 83 Zone 13N
SW1/4, NW1/4, Sec 4, T46N, R12W, NMPM**

**Lower Terminus: Latitude: 38°14'22.518"N Longitude: 108°13'24.235"W
UTM 217882.3 Easting UTM 4237313.2 Northing
NAD 83 Zone 13N
NW1/4, SW1/4, Sec 17, T46N, R12W, NMPM**

Counties: Montrose Length: 2.68 miles

USGS Quad(s): Antone Spring and Sanborn Park

ISF Appropriation:

**March 16th – April 30th = 1.2 cfs
May 1 – May 15th = 12.7 cfs
May 16th – August 15th = 1.2 cfs
August 16th – March 15th = .85 cfs**



Red Canyon Creek
June 27, 2007
R2X Survey

Summary

The information contained in this report and the associated instream flow file folder forms the basis for staff's instream flow recommendation to be considered by the Board. It is staff's opinion that the information contained in this report is sufficient to support the findings required in Rule 5.40.

Colorado's Instream Flow Program was created in 1973 when the Colorado State Legislature recognized "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3) C.R.S.). The statute vests the CWCB with the exclusive authority to appropriate and acquire instream flow and natural lake level water rights. In order to encourage other entities to participate in Colorado's Instream Flow Program, the statute directs the CWCB to request instream flow recommendations from other state and federal agencies. The United States Forest Service (USFS) recommended this segment of Big Red Creek to the CWCB for inclusion into the Instream Flow Program. Big Red Creek is being considered for inclusion into the Instream Flow Program because it has a natural environment that can be preserved to a reasonable degree with an instream flow water right. The USFS is very interested in protecting stream flows in Big Red Creek because it is a free flowing perennial stream which is supporting both aquatic and riparian values on public land. Forest Service investigations conducted in 2006 and 2007 have suggested that this is a fully functioning aquatic system that is contributing towards the agency stewardship mission of protecting sustainable ecosystems. This stream provides occupied habitat for both native and non-native trout species. It provides important refuge during periods of drought and elevated water temperatures in the lower reaches of Horsefly Creek. There are currently no withdrawals of water from Big Red Creek. There is currently an instream flow water right held by the CWCB in Horsefly creek (05CW215) which begins approximately 1.2

miles downstream of where Big Red Creek flows into Horsefly, at a point where Sheep Creek enters Horsefly Creek, and then continues downstream to its confluence with the San Miguel River (see map). The protection is 13 cfs from April 1 thru June 5.

Big Red Creek is located entirely on Federal lands administered by the U.S. Forest Service. The drainage begins on the south end of the Uncompahgre Plateau in Montrose County, at an elevation of approximately 9,400 feet (see attachment 1 map). The stream flows for approximately 5.9 miles before it joins Horsefly Creek. Horsefly Creek flows into the San Miguel River approximately 6.5 miles below the lower terminus of Big Red Creek. Horsefly Creek and its lower tributaries, which include Big Red Creek, is a relatively remote setting located in moderately deep canyons. There is no road access to either Big Red Creek or Lower Horsefly Creek. The total drainage area of Big Red creek is approximately 13.2 square miles.

The subject of this report is a segment of Big Red Creek beginning at its confluence with Big A Creek (Latitude: 38°16'18.195"N; Longitude: 108°12'18.486"W), where sufficient perennial flow exists to support a cold water fishery and other associated aquatic values. From this point it flows in a southwesterly direction 2.68 miles to its confluence with Horsefly Creek (Latitude: 38°14'22.605"N; Longitude: 108°13'24.026"W). The proposed segment is located 8.5 miles northeast of Norwood, Colorado. The staff has received only one recommendation for this segment, from the USFS. The recommendation for this segment is discussed below.

Instream Flow Recommendation(s)

Considerable field work has been conducted within the Horsefly watershed for the purpose of determining instream flow protection needs. Field work was initiated in 2006 and continued through 2007. Field study sites have been located on both Little Red Creek and Big Red Creek near their confluence with Horsefly Creek and also on Horsefly Creek near the Forest boundary. Based upon a recommendation by the Grand Mesa, Uncompahgre and Gunnison National Forest to the CWCB a notice to appropriate was issued in early 2009. At this time only Big Red Canyon Creek is being submitted as a recommendation by the agency for appropriation of instream flow rights under State statute.

Land Status Review

Upper Terminus	Lower Terminus	Total Length (miles)	Land Ownership	
			% Private	% Public
Headwaters	Spring Creek	2.68	0%	100%

Biological Data

Fisheries surveys in the watershed indicate that the stream environment supports self-sustaining populations of native Colorado River cutthroat trout (CRCT) and mottled sculpin. A small rainbow trout population is also located near the mouth of the creek. Colorado River cutthroat trout are of limited distribution across the state of Colorado, particularly in the San Miguel River sub-basin, where Red Canyon Creek is one of only three populations that currently exist. Distribution of these genetically pure CRCT populations is limited to approximately 5-7% of their native distribution on the Grand Mesa, Uncompahgre, and Gunnison National Forests (GMUG NF) (James and Speas 2005). Electrofishing surveys completed in 2005 indicate that there are approximately 40 adult fish per mile in Red Canyon Creek (USFS unpublished). Sampling was done again on July 6, 2009. Over a 188 ft sampling reach 27 CFCT were collected.

Low flows are common in the late summer and fall, and may be a limiting factor for fish production and movement during this time. The stream channel provides good pool habitat during summer and winter low flows. However, depth appears to limit movement and distribution of CRCT during this time. Low flows also limit aquatic insect production during this low period as well. Despite these natural flow limitations in the summer and winter seasons, the stream does support a full-functional riparian community, and suitable fish habitat to support the long-term persistence of native CRCT.

Field Survey Data

USFS staff used the R2Cross methodology to quantify the amount of water required to preserve the natural environment to a reasonable degree. A two person crew used a pygmy meter and current meter digitizer to measure cross section velocities in the stream. Channel widths and depths were surveyed with a stadia rod, engineering level and fiberglass tape. Channel gradients were determined from rod, level and tape survey. The R2Cross method requires that stream discharge and channel profile data be collected in a riffle stream habitat type. Riffles are most easily visualized, as the stream habitat types that would dry up first should stream flow cease. This type of hydraulic data collection consists of surveying the stream channel geometry, determining channel roughness by collecting a representative sample of bed particles, and measuring the stream discharge. Three cross sections were established and surveyed on 7/25/2006. The flow measurements were extremely low during that visit and the R2X solutions were outside the acceptable range. Therefore a second set of measurements were collected at the previously established cross-sections on 6/27/2007. When run through the R2X model the 2007 data results were felt to be reasonable and representative of observed flows and channel morphological characteristics. Channel roughness was estimated by measuring 100 channel substrate particles and then calculating the D84 size particle. Mountain streams like Big Red Creek are difficult to get precise flow measurements, particularly during low flows, due to the highly variable velocity profiles that occur in streams with high roughness and channel complexity. Most likely measured flows under estimate the actual flows in the channel and that moving through the channel bed materials.

An estimate of bankful discharge was made which is roughly equivalent to the discharge at the grassline indicator utilized in the R2X program. In order to provide sufficient flow to periodically move channel materials and wood and thus sustain both aquatic and riparian habitat at a minimum 60% of bankful discharge is needed for a two week period most years

Biological Flow Recommendation

The CWCB staff relied upon the biological expertise of the cooperating agencies to interpret output from the R2Cross data collected to develop the initial, biologic instream flow recommendation. This initial recommendation is designed to address the unique biologic requirements of each stream without regard to water availability. Three instream flow hydraulic parameters, average depth, percent wetted perimeter, and average velocity are used to develop biologic instream flow recommendations. The CWCB has determined that maintaining these three hydraulic parameters at adequate levels across riffle habitat types, aquatic habitat in pools and runs will also be maintained for most life stages of fish and aquatic invertebrates (Espgren 1996).

For this segment of stream, three data sets were collected with the results shown in Table 1 below. Table 1 shows who collected the data (Party), the date the data was collected (Date), the measured discharge at the time of the survey (Q), the accuracy range of the predicted flows based on Manning's Equation (240% and 40% of Q), the summer flow recommendation based on meeting 3 of 3 hydraulic criteria and the winter flow recommendation based upon 2 of 3 hydraulic criteria and 60% of the bankful flow. However, updates to the R2Cross program have the ability to vary Manning's n over a range of flows allowing for more accurate staging tables to be used in the prediction of hydraulic parameters. These changes allow for more accurate hydraulic modeling in periods outside of the typical accuracy range of R2Cross. For this exercise the USFS generated the Thorne-Zevenbergen staging table by supplying a D84 for use in setting Mannings roughness coefficient and

also selected the Bathhurst formula for calculation of velocity and discharge in streams with high relative roughness.

Table 1: Stream flow data and R2Cross outputs from three cross sections located on Big Red Creek near confluence with Horsefly Creek.

Party	X-sec	Date	Measured Q	40%-250%	Summer (3/3)	Winter (2/3)	60% Bankful Q
USFS	#1	6/27/2007	1.3 cfs	.52 – 3.25 cfs	1.35 cfs	1.2 cfs	11.64 cfs
USFS	#2	6/27/2007	2.08 cfs	.8 – 5.2 cfs	.98 cfs	.52 cfs	16.2 cfs
USFS	#3	6/27/2007	1.11 cfs	.44 – 2.78 cfs	1.23 cfs	.81 cfs	10.3 cfs

USFS = U.S. Forest Service

Biologic Flow Recommendation

Outputs from cross sections 1 , 2 and 3 were averaged to develop a spring/summer and winter flow recommendations. The summer flow recommendation is 1.2 cfs; winter flow recommendation is .85 cfs. Spring snowmelt runoff recommendation is 12.7 cfs.

Hydrologic Data

No stream gaging records exist for Red Canyon Creek. Mean Annual and mean monthly flow data was calculated by using the USGS interactive Streamstats program available online <http://water.usgs.gov/osw/streamstats/>. Documentation for all the regression equations used in Streamstats can be found in Capesius and Stephens, 2009.

The basin characteristics flow model generates a number of stream flow statistics. Each are generated by slightly different regression equations and applied constants. Those of most interest in this application are mean annual flow and mean monthly flows projected over the 12 month period. Because it was believed that runoff from the Uncompahgre Plateau did not follow patterns for higher elevation basins in Southwest Colorado several years ago the Bureau of Land Management developed a flow distribution tool that took mean annual basin yield and distributed it by month for basins with flows originating on the Uncompahgre Plateau. Mean Annual flow has a relatively low mean standard error when compared to some of the individual mean monthly flow parameters. This was accomplished by examining historic stream flow records from gaging station sites surrounding the Uncompahgre Plateau. Snowmelt runoff tends to begin and end sooner. Basins tend to be flashier, meaning a larger percentage of the total yield is confined to a few months while base flows tend to be quite small.

Table 2 below displays the estimated mean annual and mean monthly flow of Red Canyon Creek

drainage area	8,448	acres	13.2	(mi ²)
Mean annual precip	25.29	inches	25.29	(inches -10 inches)
mean basin elev	8,609	ft	3,609	(ft -5,000 ft/1000ft)
mean basin slope	0.247	ft/ft	0.247	(ft/ft)

	Modeled (cfs)	Regression Constant a	b1	b2	b3	b4	# of stns	mean standard error
Annual Mean	10.3	9.70E-02	0.888		1.74		54	55

Mean	Oct	4.8	2.84	0.806			1.11	54	100
	Nov	3.1	1.83	0.815			1.13	54	87
	Dec	2.0	1.22	0.872			1.26	54	11
	Jan	1.5	9.33E-01	0.916			1.34	54	11
	Feb	1.9	6.47E-01	0.913			0.906	54	11
	Mar	5.8	1.24E-01	0.861	0.502			54	53
	Apr	19.4	4.22E-02	0.961	1.13			54	62
	May	20.5	1.00E-01	0.948		2.24		54	55
	Jun	14.8	3.17E-02	1.010		2.76		54	98
	Jul	9.6	1.12E+01	0.850			1.68	54	123
	Aug	6.2	5.13	0.790			1.32	54	135
	Sep	4.8	3.65	0.811			1.3	54	142

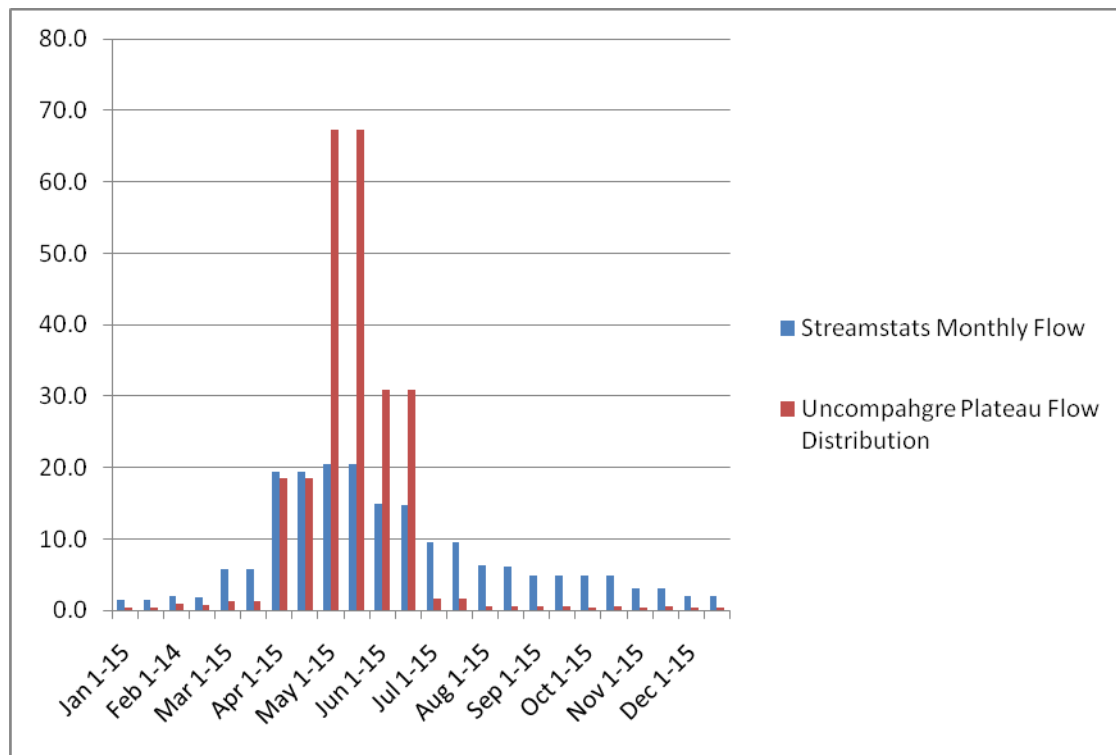
Using the calculated mean annual flow of 10.3 cfs it was then distributed over the 12 months using the BLM derived distribution model.

Table 3 – Red Canyon Mean Annual Flow distributed over the year

Mean Annual Flow (cfs): 10.300
Mean Annual Yield (AF): 7457

	%of flow	AF/Month	AF/Day	Mean Monthly flow cfs
January	0.0032	23.867	0.770	0.389
February	0.0065	48.480	1.672	0.844
March	0.0100	74.584	2.406	1.215
April	0.1470	1096.385	36.546	18.458
May	0.5541	4131.955	133.289	67.318
June	0.2461	1834.767	61.159	30.888
July	0.0130	96.959	3.128	1.580
August	0.0050	37.292	1.203	0.608
September	0.0040	29.834	0.994	0.502
October	0.0039	29.088	0.938	0.474
November	0.0037	27.596	0.920	0.465
December	0.0035	26.104	0.842	0.425

Chart 1 – Comparison of Estimated Mean Monthly Flows for Red Canyon



There is an obvious difference in how the two methods distribute flows for Red Canyon Creek. The presence of a self sustaining population of cold water fish suggests that there is adequate flow even during low flow conditions to support their spawning, rearing and overwintering needs. The estimate of flow presented in Table 3 is indicative of the flashy hydrograph that is typical of the Uncomcompahgre Plateau watersheds. However, the extreme disparity between high flow and low flow may be exaggerated. It is reasonable to assume that for the majority of years actual flows are somewhere within the range of what is represented in Chart 1.

Streamflow gaging records are very limited for the area around Red Canyon, in particular for small headwater streams. The USGS did operate a gage on Tabeguache Creek, which is in the near vicinity and also of very similar character, during the period 1946-1953. Records were retrieved from an open file report published in 2003 (USGS Report 02-471).

Table 4 -USGS stream flow records from Tabeguache Creek near Nucla operated 1946-1953
 Lat 38°22'08" Long 108°20'42"
 Drainage Area: 16.9 mi²
 Elevation: 8,010

Water year	Monthly mean discharge, in cubic feet per second, by water year											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
1946	--	--	--	--	--	--	32.50	30.30	3.26	0.22	0.09	0.15
1947	0.61	0.48	0.40	0.30	0.40	0.60	21.50	38.30	4.49	0.73	0.98	0.79
1948	4.40	4.50	3.20	3.80	6.00	8.00	79.80	104.60	12.30	0.27	0.08	0.04
1949	0.25	0.50	0.50	0.50	0.40	0.60	37.80	102.10	37.70	2.21	0.04	0.07
1950	0.59	0.63	0.62	0.60	0.80	1.70	78.10	63.30	10.90	0.20	0.00	0.03
1951	0.39	1.01	0.29	0.30	0.30	0.40	6.16	41.40	6.23	0.03	0.12	0.00
1952	0.07	0.06	0.19	0.30	0.30	0.30	47.10	123.50	25.10	0.42	0.17	0.05
1953	0.07	0.15	0.20	0.30	0.30	1.01	9.89	31.50	7.24	0.27	0.68	0.02

% of Time discharge was equaled or exceeded	Oct. Q	Nov. Q	Dec. Q	Jan Q	Feb Q	March Q	April Q	May Q	June Q	July Q	Aug Q	Sept Q
100.00	0.00	0.00	0.00	0.30	0.30	0.30	0.60	7.20	0.00	0.00	0.00	0.00
90.00	0.04	0.10	0.21	0.30	0.30	0.31	2.69	17.23	0.68	0.03	0.02	0.01
80.00	0.09	0.11	0.21	0.30	0.30	0.40	5.60	30.70	1.78	0.06	0.04	0.03
70.00	0.11	0.40	0.22	0.31	0.31	0.49	9.25	38.35	2.80	0.09	0.06	0.04
60.00	0.21	0.44	0.30	0.31	0.31	0.60	15.25	48.13	4.11	0.10	0.08	0.06
50.00	0.31	0.47	0.42	0.31	0.41	0.61	24.07	57.77	6.04	0.20	0.09	0.07
40.00	0.46	0.59	0.51	0.50	0.41	0.62	32.50	69.58	8.04	0.38	0.11	0.08
30.00	0.63	0.68	0.53	0.51	0.42	1.72	47.43	86.68	14.00	0.51	0.22	0.10
20.00	0.78	1.25	0.60			1.85	67.14	104.25	25.17	0.72	0.41	0.20
10.00	1.79	3.71					110.00	134.87	44.33	1.38	0.61	0.61
5.00	6.26	4.89					138.38	154.67	54.14	2.85	0.91	0.91
1.00	8.61	6.19					173.40	176.72		4.91	3.56	1.56

Precipitation Data

In order to evaluate the runoff during the period from 1946-1953 precipitation records for Norwood, Colorado for the same time period were retrieved from the Western Regional Climate Center website <http://www.wrcc.dri.edu>. This period represented a period that was 10% drier than the long term average (1924-2008). Therefore the mean monthly flows and exceedence table values displayed under Table 4 may under-represent a more accurate long term condition.

Table 5: Precipitation Data From Station at Norwood, Colorado

Year	Annual (inches)
1946	14.78
1947	19.58
1949	14.25
1950	9.84
1951	10.68
1952	14.19
1953	14.42
7 year mean	13.96
Long Term Mean 1924-2008	15.50

Existing Water Right Information

Staff has analyzed the water rights tabulation and consulted with the Division Engineer's Office (DEO) to identify any potential water availability problems. Records indicate that there are no surface water diversions on Red Canyon Creek. A conditional right was awarded on the Red Canyon Ditch in 1974 for 5 cfs. That right was abandoned by order of the Court in 1983 (83CW43).

Relationship to Management Plans

The Grand Mesa, Uncompahgre, and Gunnison National Forests (GMUG NF) Land and Resource Management Plan provide land management direction for FS lands located in the Red Canyon watershed. Forest Plan direction for Fisheries, Threatened, Endangered, and Sensitive species suggest that land managers should, among other things, maintain viable populations of native fish species, improve fish habitat conditions, and cooperate with state agencies to meet minimum flow needs to support fish populations. Additionally, agencies of the Colorado Division of Natural Resources and the Forest Service have signed agreements to assist in the conservation and protection of Colorado River cutthroat trout (CRCT River Cutthroat Trout Task Force 2006), and to work together to solve water issues in Colorado (Colorado DNR/USDA Forest Service MOU on water, 2004).

The Red Canyon stream segment is important to the FS because it is one of only three CRCT populations that currently exist in the San Miguel River. Red Canyon provides important spawning and rearing habitat for a self-sustaining Colorado River cutthroat trout fishery. Additionally, Red Canyon Creek is one of only a few perennial streams in the semi-arid landscape of the Uncompahgre Plateau. The stream is an important source of water for the lower reaches of Horseshoe Creek, since headwater diversions currently divert a significant source of the summer flows for irrigation and small domestic use. Access into Red Canyon is very limited, so fishing pressure, and other land management uses are minimal, so stream level protection would be an important tool in maintaining aquatic values in this area of the Uncompahgre Plateau.

The FS requests that the Board recognize that this recommendation is based only upon the minimum flows necessary to support the cold-water fishery values. FS may wish to work with the Board and/or through the Colorado water rights system to appropriate flows to optimally protect fish values and to protect other water-dependent values specified in FS resource management plans.

We thank both the Colorado Division of Wildlife and the Water Conservation Board for their cooperation in this effort.

If you have any questions regarding our instream flow recommendation, please contact Clay Speas, Fisheries Biologist, at (970) 874-6650 or John Almy, Forest Hydrologist, at (970) 874-6656.

Literature Cited

Capesius, J.P., and Stephens, V.C., 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado: U.S. Geological Survey Scientific Investigations Report 2009-5136, 46 p.

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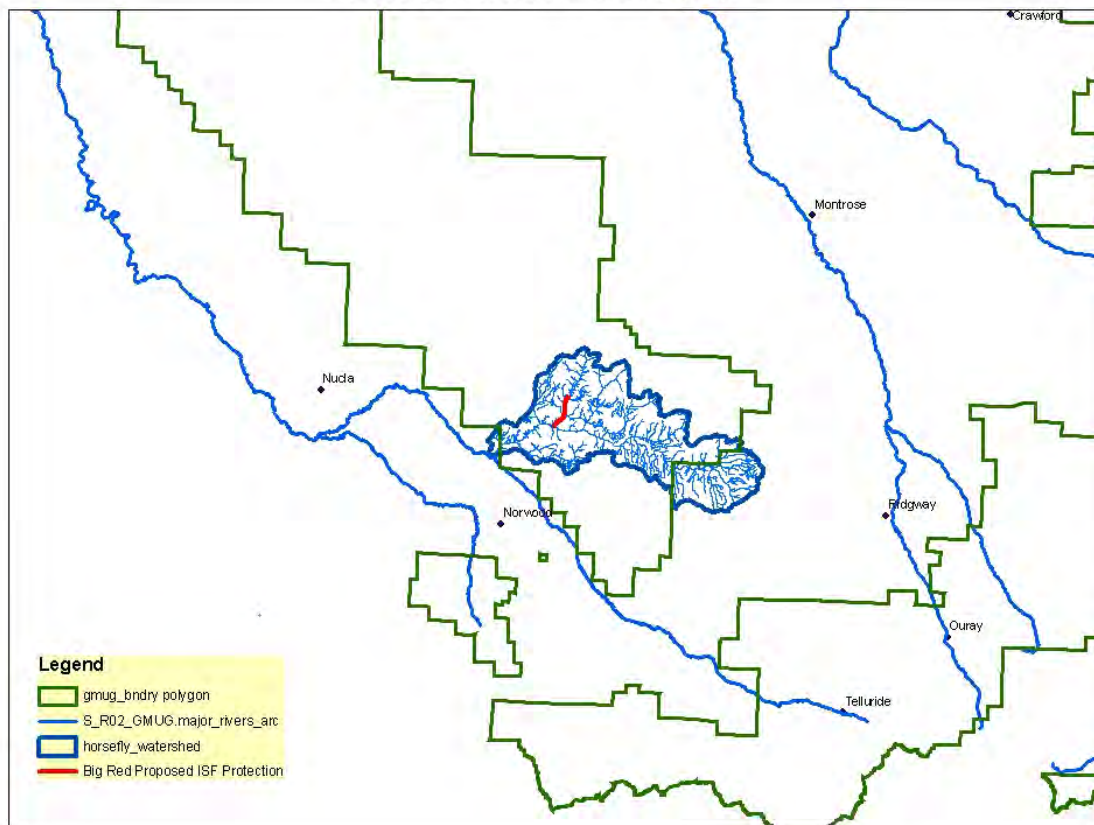
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Kircher, J.E., A.F. Choquette, and B.D. Richter, 1985. Estimation of Natural Streamflow Characteristics in Western Colorado. Water Resources Investigations Report 85-4086, 1985. U.S. Geological Survey, Prepared in Coordination with the Bureau of Land Management.

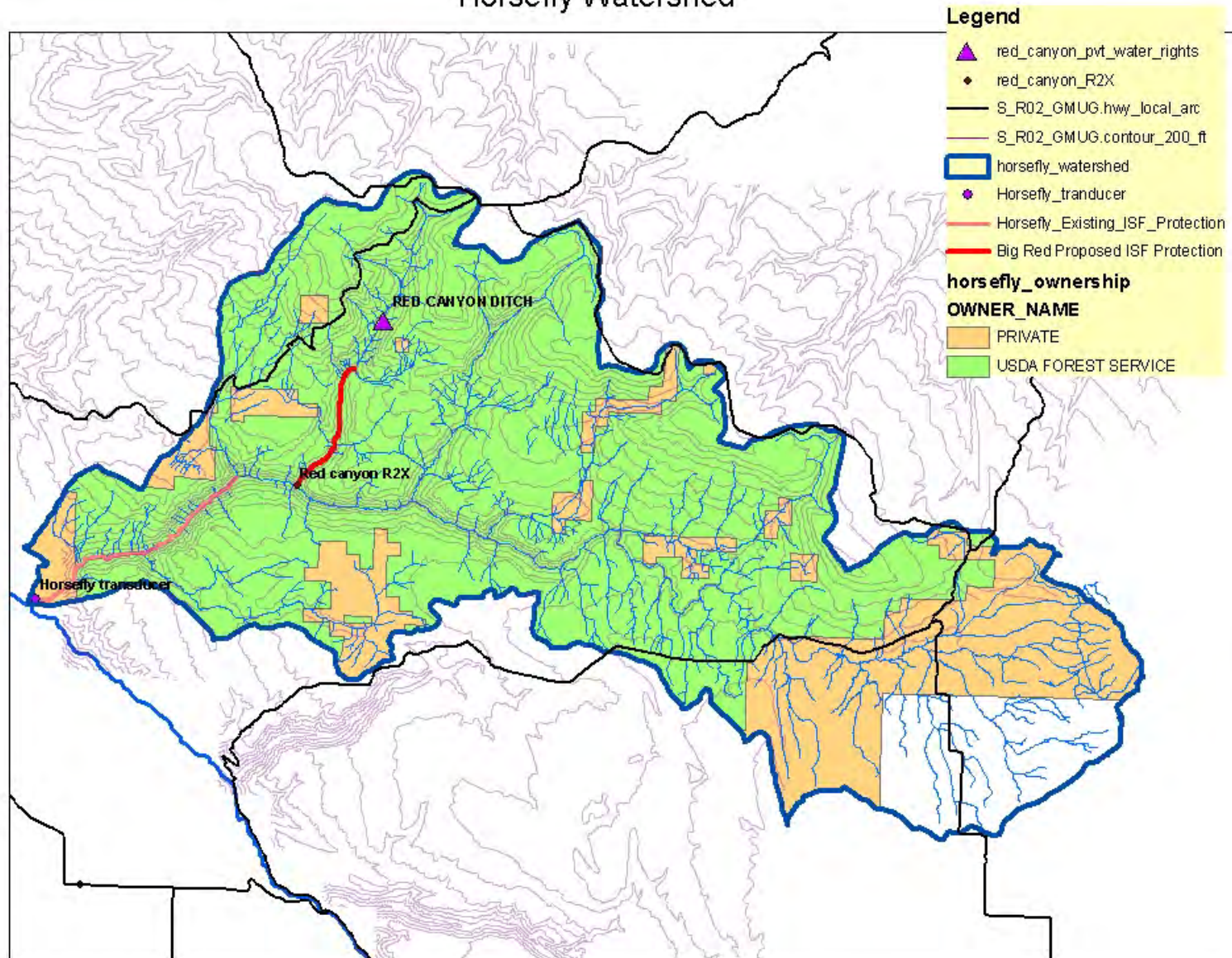
U.S. Geological Survey, 2003. Streamflow Characteristics for Selected Stations In and Near the Grand Mesa, Uncompahgre, and Gunnison National Forest, Southwestern Colorado. Open file report 02-471

Attachment 1 – Map of Big Red Creek Watershed

Horsefly Watershed Vicinity Map



Horsefly Watershed



Attachment 2 – Staging Tables from 2007 R2X Data

STREAM NAME: Big Red Creek

XS LOCATION:

XS NUMBER: 1

Thorne-Zevenbergen D84 Correction Applied

#REF! 0.58

GL = lowest Grassline elevation corrected for sag

STAGING TABLE *WL* = Waterline corrected for variations in field measured water surface elevations and sag

D84 Table

1-HeyD84

BathurstD84

3-Best Est

4-User

#REF!

	DIST TO	TOP	AVG.	MAX.			PERCENT	HYDR		AVG.	Bath	Hey
	WATER	WIDTH	DEPTH	DEPTH	AREA	WETTED PERIM.	WET PERIM	RADIUS	FLOW	VELOCITY	VELOCITY	VELOCITY
	(FT)	(FT)	(FT)	(FT)	(SQ FT)	(FT)	(%)	(FT)	(CFS)	(FT/SEC)	(FT/SEC)	(FT/SEC)
		0	#DIV/0!	0	0	0	#DIV/0!	#DIV/0!	#REF!	#REF!	#REF!	#REF!
GL	#REF!	8.91	0.69	1.27	6.12	9.75	100.0%	0.63	19.40	3.17	4.9976012	3.169497868
	0.00	9.76	0.97	1.63	9.46	10.94	112.2%	0.86	42.38	4.48	9.8408998	4.479672095
	0.00	9.62	0.93	1.58	8.98	10.76	110.4%	0.83	38.72	4.31	9.111514	4.313694003
	0.00	9.50	0.89	1.53	8.50	10.60	108.7%	0.80	35.17	4.14	8.3607547	4.13836353
	0.00	9.39	0.86	1.48	8.03	10.43	107.0%	0.77	31.78	3.96	7.6419455	3.959357581
	0.00	9.27	0.82	1.43	7.56	10.27	105.3%	0.74	28.55	3.78	6.9553405	3.776468157
	0.00	9.16	0.78	1.38	7.10	10.11	103.6%	0.70	25.48	3.59	6.3011817	3.589469506
	0.00	9.04	0.73	1.33	6.64	9.94	102.0%	0.67	22.58	3.40	5.679696	3.398116086
	0.00	8.93	0.69	1.28	6.19	9.78	100.3%	0.63	19.84	3.20	5.0910915	3.20214023
	0.00	7.80	0.74	1.23	5.77	8.59	88.1%	0.67	19.41	3.36	6.0622226	3.361956473
	0.00	7.43	0.73	1.18	5.39	8.20	84.1%	0.66	17.58	3.26	5.8695046	3.260754785
	0.00	7.07	0.71	1.13	5.03	7.82	80.2%	0.64	15.91	3.16	5.6949867	3.162657214
	0.00	6.71	0.70	1.08	4.69	7.44	76.3%	0.63	14.38	3.07	5.5409213	3.068240351
	0.00	6.34	0.69	1.03	4.36	7.05	72.3%	0.62	12.98	2.98	5.410238	2.978198738
	0.00	5.99	0.68	0.98	4.05	6.68	68.5%	0.61	11.71	2.89	5.2902599	2.889931374
	0.00	5.86	0.64	0.93	3.75	6.51	66.8%	0.58	17.84	4.75	4.7520772	2.709358165
	0.00	5.73	0.60	0.88	3.47	6.35	65.1%	0.55	14.69	4.24	4.2406657	2.524242167
	0.00	5.60	0.57	0.83	3.18	6.19	63.5%	0.51	11.95	3.76	3.7564687	2.334242503

WL

0.00	5.47	0.53	0.78	2.91	6.02	61.8%	0.48	9.59	3.30	3.2999486	2.138985123
0.00	5.34	0.49	0.73	2.63	5.86	60.1%	0.45	7.57	2.87	2.871584	1.938060931
0.00	5.21	0.45	0.68	2.37	5.70	58.4%	0.42	5.86	2.47	2.4718659	1.731025448
0.00	5.08	0.42	0.63	2.11	5.53	56.7%	0.38	4.44	2.10	2.1020267	1.517726309
0.00	4.93	0.38	0.58	1.86	5.35	54.8%	0.35	3.31	1.78	1.7754372	1.304498114
0.00	4.78	0.34	0.53	1.62	5.16	53.0%	0.31	2.39	1.48	1.4750868	1.084030592
0.00	4.62	0.30	0.48	1.39	4.98	51.1%	0.28	1.67	1.20	1.2016565	0.855811426
0.00	4.47	0.26	0.43	1.16	4.79	49.2%	0.24	1.11	0.96	0.9558619	0.619437688
0.00	4.26	0.22	0.38	0.94	4.56	46.7%	0.21	0.70	0.75	0.7495433	0.387336032
0.00	3.90	0.19	0.33	0.74	4.19	42.9%	0.18	0.44	0.59	0.5911644	0.180555004
0.00	3.70	0.15	0.28	0.55	3.96	40.6%	0.14	0.23	0.43	0.4303392	-0.063533295
0.00	3.51	0.10	0.23	0.37	3.74	38.4%	0.10	0.11	0.30	0.296695	-0.31025174
0.00	2.62	0.08	0.18	0.21	2.82	28.9%	0.07	0.04	0.20	0.2025164	-0.467997414
0.00	1.78	0.06	0.13	0.10	1.91	19.6%	0.05	0.01	0.12	0.1206427	-0.61240716
0.00	0.77	0.04	0.08	0.03	0.82	8.4%	0.04	0.00	0.05	0.0479683	-0.720947973
0.00	0.25	0.01	0.03	0.00	0.27	2.7%	0.01	0.00	0.01	0.0084598	-0.73758716

STREAM NAME: Red Canyon
XS LOCATION: 0
XS NUMBER: 2

Thorne-Zevenbergen D84 Correction Applied

#REF! 0.58

GL = lowest Grassline elevation corrected for sag

STAGING TABLE *WL* = Waterline corrected for variations in field measured water surface elevations and sag

D84 Table

1-HeyD84

BathurstD84

3-Best Est

4-User

#REF!

	DIST TO	TOP	AVG.	MAX.				HYDR		AVG.	Bath	Hey
	WATER	WIDTH	DEPTH	DEPTH	AREA	WETTED PERIM.	PERCENT WET PERIM	RADIUS	FLOW	VELOCITY	VELOCITY	VELOCITY
	(FT)	(FT)	(FT)	(FT)	(SQ FT)	(FT)	(%)	(FT)	(CFS)	(FT/SEC)	(FT/SEC)	(FT/SEC)
GL	#REF!	5.64	1.05	1.50	5.92	7.63	100.0%	0.78	26.96	4.55	11.85025	4.551183
	0.00	10.61	0.92	1.94	9.76	13.29	174.2%	0.73	44.28	4.54	7.8228704	4.5383487
	0.00	10.51	0.88	1.89	9.23	13.06	171.1%	0.71	40.28	4.36	7.2074595	4.3643932
	0.00	10.10	0.86	1.84	8.71	12.59	164.9%	0.69	37.11	4.26	6.9974033	4.2593817
	0.00	9.63	0.85	1.79	8.22	12.07	158.2%	0.68	34.30	4.17	6.8843834	4.1728391
	0.00	9.09	0.85	1.74	7.75	11.47	150.2%	0.68	31.95	4.12	6.9331262	4.122605
	0.00	8.51	0.86	1.69	7.31	10.81	141.6%	0.68	29.99	4.10	7.1243666	4.102177
	0.00	7.93	0.87	1.64	6.90	10.15	132.9%	0.68	28.27	4.10	7.40714	4.0974247
	0.00	7.35	0.89	1.59	6.52	9.49	124.3%	0.69	26.80	4.11	7.8131804	4.1114743
	0.00	6.78	0.91	1.54	6.16	8.83	115.6%	0.70	25.57	4.15	8.3905491	4.1482938
	0.00	5.59	1.05	1.49	5.86	7.56	99.1%	0.77	26.57	4.54	11.826638	4.5357344
	0.00	5.38	1.04	1.44	5.58	7.27	95.2%	0.77	24.97	4.47	11.74791	4.4723556
	0.00	5.18	1.03	1.39	5.32	6.97	91.4%	0.76	23.48	4.41	11.707936	4.4130918
	0.00	4.97	1.02	1.34	5.07	6.68	87.5%	0.76	22.08	4.36	11.712642	4.3585101
	0.00	4.85	0.99	1.29	4.82	6.49	85.0%	0.74	20.46	4.24	11.203578	4.2435249
	0.00	4.77	0.96	1.24	4.58	6.36	83.3%	0.72	18.73	4.09	10.401733	4.0894127
	0.00	4.70	0.92	1.19	4.34	6.23	81.6%	0.70	17.08	3.93	9.6270875	3.9322107
	0.00	4.62	0.89	1.14	4.11	6.10	79.9%	0.67	15.50	3.77	8.8799103	3.7717257
	0.00	4.54	0.85	1.09	3.88	5.97	78.2%	0.65	14.00	3.61	8.1604878	3.6077472
	0.00	4.47	0.82	1.04	3.66	5.84	76.5%	0.63	12.58	3.44	7.4691247	3.4400449
	0.00	4.39	0.78	0.99	3.44	5.70	74.7%	0.60	11.23	3.27	6.806144	3.2683669
WL	0.00	4.31	0.75	0.94	3.22	5.57	73.0%	0.58	19.86	6.17	6.1718873	3.0924368

0.00	4.27	0.70	0.89	3.00	5.46	71.6%	0.55	16.50	5.49	5.4939062	2.899665
0.00	4.24	0.66	0.84	2.79	5.36	70.2%	0.52	13.51	4.84	4.842471	2.6979742
0.00	4.21	0.61	0.79	2.58	5.25	68.8%	0.49	10.92	4.23	4.233276	2.4892
0.00	4.18	0.57	0.74	2.37	5.15	67.4%	0.46	8.69	3.67	3.6665563	2.2728563
0.00	4.15	0.52	0.69	2.16	5.04	66.0%	0.43	6.79	3.14	3.1424766	2.0484208
0.00	4.12	0.47	0.64	1.95	4.93	64.6%	0.40	5.20	2.66	2.6611182	1.8153385
0.00	4.08	0.43	0.59	1.75	4.83	63.3%	0.36	3.89	2.22	2.2224646	1.5730311
0.00	4.05	0.38	0.54	1.55	4.72	61.9%	0.33	2.82	1.83	1.8263871	1.3209192
0.00	3.82	0.35	0.49	1.35	4.42	57.8%	0.31	2.17	1.61	1.6067236	1.1406598
0.00	3.78	0.31	0.44	1.16	4.31	56.4%	0.27	1.48	1.28	1.279102	0.8740945
0.00	3.75	0.26	0.39	0.97	4.20	55.0%	0.23	0.96	0.99	0.9923335	0.5964847
0.00	3.71	0.21	0.34	0.78	4.09	53.6%	0.19	0.58	0.75	0.7460651	0.3081914
0.00	3.46	0.17	0.29	0.60	3.76	49.3%	0.16	0.35	0.58	0.5754238	0.0648939
0.00	2.80	0.16	0.24	0.45	3.01	39.5%	0.15	0.23	0.50	0.4999795	-0.0628545
0.00	2.57	0.12	0.19	0.32	2.70	35.4%	0.12	0.11	0.36	0.3598487	-0.314946
0.00	2.18	0.09	0.14	0.20	2.26	29.6%	0.09	0.05	0.25	0.2453995	-0.5477236
0.00	1.97	0.05	0.09	0.09	2.02	26.4%	0.05	0.01	0.15	0.1453327	-0.7869211
0.00	0.94	0.02	0.04	0.02	0.96	12.6%	0.02	0.00	0.06	0.056327	-0.8620204

STREAM NAME: Big Red Creek
XS LOCATION: 0
XS NUMBER: 3

Thorne-Zevenbergen D84 Correction Applied

#REF! 0.58

GL = lowest Grassline elevation corrected for sag

STAGING TABLE *WL* = Waterline corrected for variations in field measured water surface elevations and sag

D84 Table

1-HeyD84

BathurstD84

3-Best Est

4-User

#REF!												
DIST TO	TOP	AVG.	MAX.				HYDR		AVG.	Bath	Hey	
WATER	WIDTH	DEPTH	DEPTH	AREA	WETTED PERIM.	PERCENT WET PERIM	RADIUS	FLOW	VELOCITY	VELOCITY	VELOCITY	
(FT)	(FT)	(FT)	(FT)	(SQ FT)	(FT)	(%)	(FT)	(CFS)	(FT/SEC)	(FT/SEC)	(FT/SEC)	
GL	#REF!	9.40	0.53	1.04	4.96	10.12	100.0%	0.49	17.14	3.46	3.4554276	2.6912772
	0.00	10.70	1.01	1.62	10.76	11.98	118.3%	0.90	56.96	5.30	11.775318	5.2961482
	0.00	10.56	0.97	1.57	10.22	11.79	116.5%	0.87	52.19	5.11	10.919497	5.1050312
	0.00	10.42	0.93	1.52	9.70	11.60	114.6%	0.84	47.63	4.91	10.094053	4.9103749
	0.00	10.30	0.89	1.47	9.18	11.44	113.0%	0.80	43.19	4.70	9.250807	4.704092
	0.00	10.19	0.85	1.42	8.67	11.28	111.5%	0.77	38.92	4.49	8.4183357	4.4888876
	0.00	10.09	0.81	1.37	8.16	11.13	110.0%	0.73	34.85	4.27	7.6272192	4.2691107
	0.00	9.98	0.77	1.32	7.66	10.98	108.4%	0.70	30.98	4.04	6.8774838	4.044512
	0.00	9.88	0.73	1.27	7.16	10.82	106.9%	0.66	27.33	3.81	6.1691194	3.8148214
	0.00	9.77	0.68	1.22	6.67	10.67	105.4%	0.63	23.89	3.58	5.5020752	3.5797458
	0.00	9.67	0.64	1.17	6.19	10.52	103.9%	0.59	20.66	3.34	4.8762555	3.3389667
	0.00	9.56	0.60	1.12	5.71	10.36	102.4%	0.55	24.49	4.29	4.291514	3.0921377
	0.00	9.46	0.55	1.07	5.23	10.21	100.9%	0.51	19.60	3.75	3.74765	2.838881
	0.00	9.09	0.52	1.02	4.76	9.81	96.9%	0.49	16.30	3.42	3.4232977	2.6506463
	0.00	8.36	0.52	0.97	4.33	9.07	89.6%	0.48	14.58	3.37	3.3701018	2.5646592
	0.00	7.64	0.51	0.92	3.93	8.34	82.4%	0.47	13.17	3.36	3.3552484	2.4935076
	0.00	7.13	0.50	0.87	3.56	7.82	77.2%	0.46	11.36	3.19	3.1922181	2.366221
	0.00	6.76	0.47	0.82	3.21	7.42	73.3%	0.43	9.41	2.93	2.9301666	2.197516
	0.00	6.40	0.45	0.77	2.88	7.03	69.4%	0.41	7.70	2.67	2.6725673	2.0250535
	0.00	6.29	0.41	0.72	2.57	6.88	67.9%	0.37	5.77	2.25	2.2508199	1.7650395
	0.00	6.18	0.36	0.67	2.25	6.73	66.5%	0.33	4.21	1.87	1.8679226	1.4968548

WL

0.00	6.04	0.32	0.62	1.95	6.54	64.6%	0.30	2.99	1.54	1.5378571	1.2302773
0.00	5.76	0.29	0.57	1.65	6.23	61.6%	0.27	2.12	1.28	1.2815321	0.9895614
0.00	5.31	0.26	0.52	1.37	5.72	56.5%	0.24	1.51	1.10	1.1012401	0.7947253
0.00	4.81	0.23	0.47	1.12	5.16	51.0%	0.22	1.06	0.94	0.9419128	0.6078414
0.00	4.34	0.21	0.42	0.89	4.62	45.7%	0.19	0.70	0.79	0.7863252	0.4118366
0.00	4.11	0.17	0.37	0.68	4.36	43.0%	0.16	0.40	0.59	0.5924625	0.1417872
0.00	3.12	0.16	0.32	0.50	3.33	32.9%	0.15	0.26	0.51	0.5140291	0.0409005
0.00	2.65	0.13	0.27	0.36	2.84	28.0%	0.13	0.14	0.39	0.3930452	-0.1524874
0.00	2.36	0.10	0.22	0.23	2.53	25.0%	0.09	0.06	0.26	0.262085	-0.4009053
0.00	1.50	0.09	0.17	0.14	1.64	16.2%	0.08	0.03	0.19	0.1865848	-0.5136597
0.00	1.18	0.05	0.12	0.06	1.28	12.6%	0.05	0.01	0.10	0.0992914	-0.7205663
0.00	0.53	0.03	0.07	0.02	0.58	5.7%	0.03	0.00	0.03	0.0333518	-0.8410347
0.00	0.14	0.01	0.02	0.00	0.15	1.5%	0.01	0.00	0.00	0.0040501	-0.824781