Stream: Arapaho Creek

Executive Summary

Water Division: 5
Water District: 51
CDOW#: 19023
CWCB ID: 08/5/A-006

Segment: Caribou Lake Outlet to Confluence with Buchanan Creek
Upper Terminus: CARIBOU LAKE OUTLET AT
(Latitude 40° 1' 19.36" N) (Longitude 105° 40' 53.99" W)

Lower Terminus: CONFLUENCE WITH BUCHANAN CREEK AT
(Latitude 40° 6' 17.97" N) (Longitude 105° 43' 55.57" W)

Watershed: Colorado headwaters (HUC # 14010001)
Counties: Grand
Length: 7.8 miles
USGS Quad(s): Monarch Lake NW, NE, SW, & SE
Flow Recommendation: 4.5 cfs (April 15 – August 31)
1.9 cfs (September 1 – April 14)

Staff Analysis and Recommendation

Summary

The information contained in this report and the associated instream appendices (see CD entitled 2008 Instream Flow Recommendations) 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. Trout Unlimited (TU) and the Colorado Division of Wildlife (CDOW) recommended this segment of Arapaho to the CWCB for inclusion into the Instream Flow Program. Arapaho 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.

Arapaho Creek originates at the outflow of Caribou Lake, which sits at an elevation of 11,100 feet in a basin between North Arapaho Peak and Satana Peak. The total drainage area of the creek is approximately 17.4 square miles. It flows generally northwest through U.S. Forest Service dropping nearly 3,000 feet to its confluence with Buchanan Creek at 8,400 feet over a distance of approximately 7.8 miles. From there the stream continues northwest through Monarch Lake and on to Lake Granby. The proposed instream flow reach is between Caribou Lake and Arapaho's confluence with Buchanan Creek.

Instream Flow Recommendation (s)

TU and CDOW recommend 4.5 cfs, summer and 1.9 cfs, winter based on the September 19, 2006 data collection efforts. The modeling results from this survey effort are within the confidence interval produced by the R2Cross model.

Land Status Review

Upper Terminus	Lower Terminus	Total Length (miles)	Land Ownership	
			% Private	% Public
Caribou Lake	Confluence with Buchanan Creek	7.8	0%	100%

100% of the Public lands are managed by the U.S. Forest Service

Biological Data

The study reach was fished with fly rods for approximately one hour on July 31, 2006. Over 40 fish were caught. All the fish were brook trout ranging in size from 4" to 9". Additional, smaller brook trout (fry) were observed in shallow waters near the stream edge.

Field Survey Data & Biological Flow Quantification

TU and CDOW staff used the R2Cross methodology to quantify the amount of water required to preserve the natural environment to a reasonable degree. 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 streamflow cease. This type of hydraulic data collection consists of setting up a transect, surveying the stream channel geometry, and measuring the stream discharge.

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 CDOW 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 (Nehring 1979; Espegren 1996).

For this segment of stream, one data set was 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.

Table 1: Arapaho Creek R2Cross Summary

Party	Date	Q (cfs)	Confidence Intervals (cfs) 250%-40%	Recommended Flows * (cfs)	
				Summer 3/3	Winter 2/3
TU	9/17/2006	4.41	11.0 - 1.8	4.47	1.92

* Recommendations based on meeting specified number of hydrologic criteria (average depth, percent wetted perimeter and average velocity).

Hydrologic Data and Analysis

After receiving the cooperating agency's biologic recommendation, the CWCB staff conducted an evaluation of the stream hydrology to determine if water was physically available for an instream flow appropriation. This evaluation was done through a computation that is, in essence, a "water balance". In concept a "water balance"

computation can be viewed as an accounting exercise. When done in its most rigorous form, the water balance parses precipitation into all the avenues water pursues after it is deposited as rain, snow, or ice. In other words, given a specified amount of water deposition (input), the balance tries to account for all water depletions (losses) until a selected end point is reached. Water losses include depletions due to evaporation and transpiration, deliveries into ground water storage, temporary surface storage, incorporations into plant and animal tissue and so forth. These losses are individually or collectively subtracted from the input to reveal the net amount of stream runoff as represented by the discharge measured by stream gages. Of course, the measured stream flow need not be the end point of interest; indeed, when looking at issues of water use to extinction stream flow measurements may only describe intermediate steps in the complex accounting process that is a water balance carried out to a net value of zero.

In its analysis, CWCB staff has attempted to use this idea of balancing inputs and losses to determine if water is available for the recommended Instream Flow Appropriation. Of course, this analysis must be a practical exercise rather than a lengthy, and costly, scientific investigation. As a result, staff has simplified the process by lumping some variables and employing certain rational and scientifically supportable assumptions. The process may be described through the following description of the steps used to complete the evaluation for this particular stream.

The first step required in determining water availability is a determination of the hydrologic regime at the Lower Terminus (LT) of the recommended ISF reach. In the best case this means looking at the data from a gage at the LT. Further, this data, in the best case, has been collected for a long period of time (the longer the better) including wet and dry periods. In the case of **Arapaho Creek** such a gage is available near the LT. The gage station is ARAPAHO CREEK AT MONARCH LAKE OUTLET, CO (USGS 09016500), a gage with a 28 year period of record (POR) collected between 1944 and 1971. The gage is at an elevation of 8,310 ft above mean sea level (amsl) and has a drainage area of 46.9 mi^2. The hydrograph (plot of discharge over time) produced by this gage includes virtually no upstream consumption through diversions. While this lack of significant upstream diversion and use make this gage attractive for our purposes, the gage does have two drawbacks; namely, it is located just downstream of a reservoir (flow is regulated to some degree) and its POR, while not particularly short, is somewhat limited.

For these reasons an attempt was made to improve upon the representativeness of the Arapaho Creek gage data set by using a statistical procedure called linear regression. The procedure gives us the means to relate characteristics of a limited (short) data set to those of a larger (longer) data set and, if the two data sets are similar enough, to predict the data values "missing" from the short data set. The outcome is a "predicted" (called "Y – Hat" or $\hat{Y}$) set of data that augments the short data set; creating, in effect, a longer POR that is reflective of climate variation (i.e., it includes more wet-dry cycles.) Further, if the gage selected for the regression is unaffected by controls such as reservoirs, the predicted flow regime of Arapaho Creek should better describe the flow regime immediately upstream

of Monarch Lake. The gage that was selected to provide the longer POR was BOBTAIL CREEK NEAR JONES PASS, CO (USGS 09034900), a gage with a 41 year POR collected between 1965 and 2005. The Bobtail Creek gage is at an elevation of 10,430 ft amsl and has a drainage area of 5.49 $mi^{2.}$

Before performing the linear regression described above, the measured hydrographs of both gages must be adjusted to remove the effects of water consumption by upstream irrigation diversion. As mentioned above, the hydrograph of the Arapaho Creek gage includes virtually no upstream consumption through diversions. The same is true for Bobtail Creek. Thus, the two data sets were regressed one against the other to produce a "predicted" hydrograph for Arapaho Creek that displays the important attributes of a gage that is located nearby, is un-impacted (by irrigation consumption or "foreign water"), and exhibits a long-term POR.

The following hydrograph depicts the mean monthly discharge of Arapaho Creek. Included in the hydrograph are the recommended ISF values. The data used in the creation of this hydrograph are displayed in Table #2.

Figure 1 - Arapaho Cr Discharge at Lower Terminus & ISFs

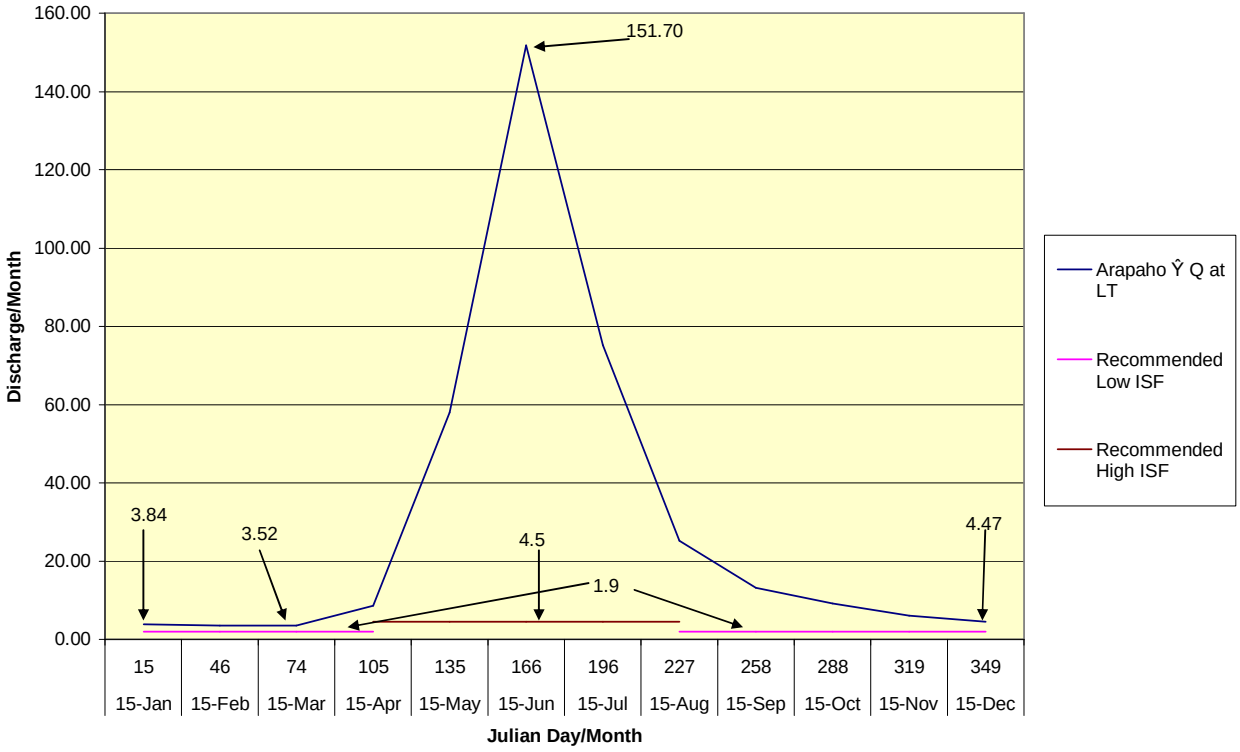


Table 2 – Mean Monthly Discharge and Recommended Instream Flows – Arapaho Cr.

Month	Julian Day	Arapaho Cr Ŷ Q	ISF Recommendation
1-Jan	1	3.84	1.9
1-Feb	32	3.55	1.9
1-Mar	60	3.52	1.9
1-Apr	91	8.56	1.9
14-Apr	105	8.56	1.9
15-Apr	106	8.56	4.5
1-May	121	57.99	4.5
1-Jun	152	151.70	4.5
1-Jul	182	75.15	4.5
1-Aug	213	25.23	4.5
31-Aug	243	25.23	4.5
1-Sep	244	13.13	1.9
1-Oct	274	9.21	1.9
1-Nov	305	6.09	1.9
1-Dec	335	4.47	1.9

Existing Water Right Information

Staff has analyzed the water rights tabulation to identify any potential water availability problems. At one time or another, three structures held water rights in the Arapaho Creek watershed that potentially could have impacted instream flows along Arapaho Creek. The Arapaho Creek Ditch (Structure ID Number: 511) and the Arapahoe (sic) Ditch and Tunnel System (Structure ID Number: 992) were both located along the main stem of Arapaho Creek while the Divide Ditch No 2 (Structure ID Number: 997) was located along Mill Creek, a tributary to Arapaho Creek. The water rights for three of these structures, however, have been abandoned. The Arapaho Creek Ditch rights were abandoned in 1984, the Arapahoe Creek Ditch and Tunnel System rights were abandoned in 1980 and the Divide Ditch No 2 rights were abandoned in 1981. Based on this analysis staff has determined that water is available for appropriation on Arapaho Creek, from the outlet of Caribou Lake to the confluence with Buchanan Creek, to preserve the natural environment to a reasonable degree without limiting or foreclosing the exercise of valid existing water rights.

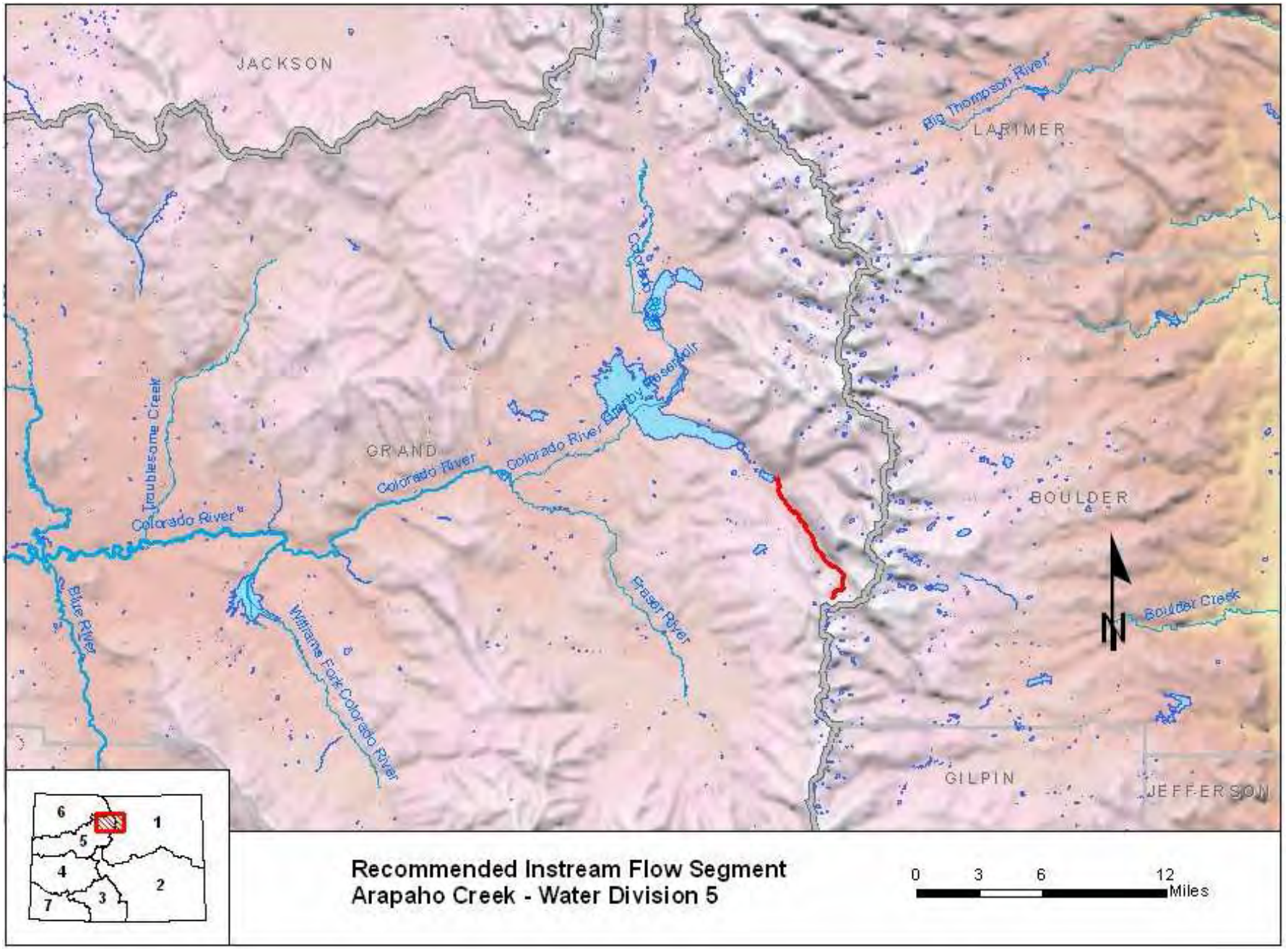
CWCB Staff's Instream Flow Recommendation
Staff recommends the Board form its intent to appropriate on the following stream reach:

Segment: Caribou Lake Outlet to Confluence with Buchanan Creek
Upper Terminus: CARIBOU LAKE OUTLET AT
(Latitude 40° 1' 19.36" N) (Longitude 105° 40' 53.99" W)
UTM = 4430426.5 N UTM = 441831.9E
SW NE S28 T1N R74W 6PM
2015' South of the North Section Line; 2335 West of the East Section Line

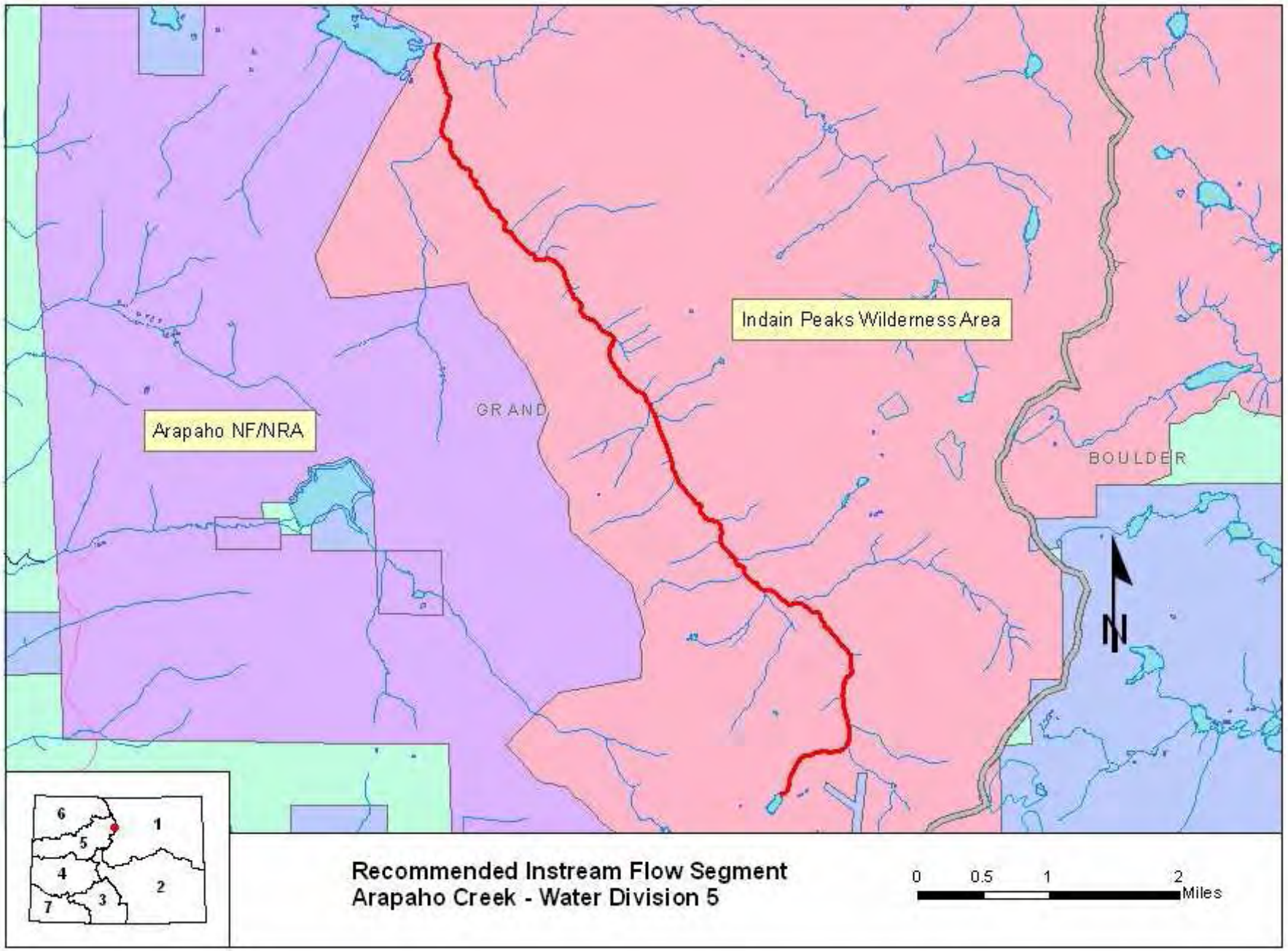
Lower Terminus: CONFLUENCE WITH BUCHANAN CREEK
(Latitude 40 6' 17.97" N) (Longitude 105° 43' 55.57" W)
UTM = 4439667.1 N UTM = 437603.5 E
NW SW S25 T2N R75W 6PM
2440' North of the South Section Line; 250' East of the West Section Line

Watershed: Colorado headwaters (HUC # 14010001)
Counties: Grand
Length: 7.8 miles
USGS Quad(s): Monarch Lake NW, NE, SW, & SE
Flow Recommendation: 4.5 cfs (April 15 – August 31)
1.9 cfs (September 1 – April 14)

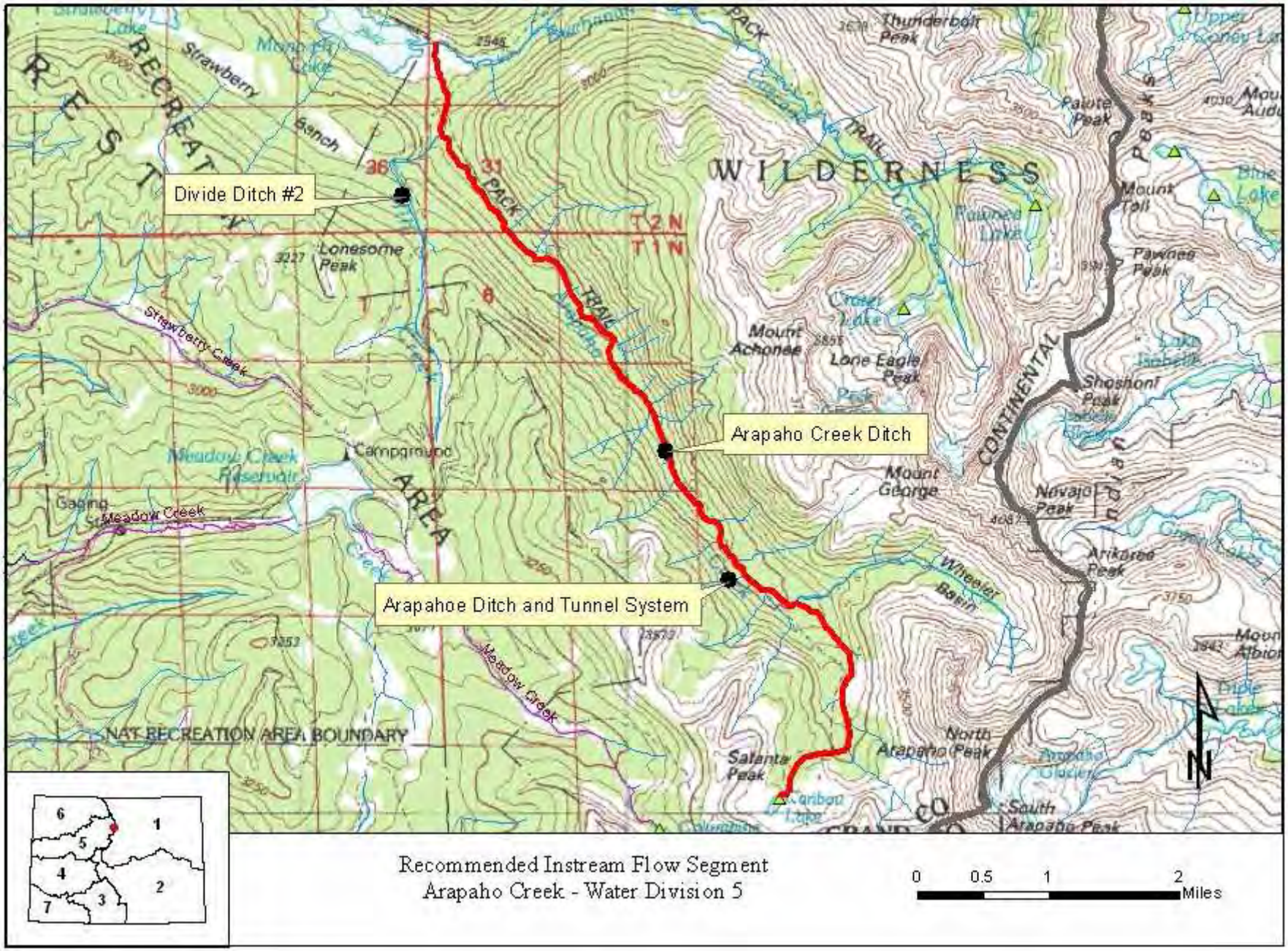
Vicinity Map



Land Use Map


Indain Peaks Wilderness Area
Arapaho NF/NRA
GRAND
BOULDER
N
6
1
5
4
2
7
3
Recommended Instream Flow Segment
Arapaho Creek - Water Division 5
0
0.5
1
2
Miles

Topographic & Water Rights Map



John Roach, Ph.D.
Aquatics Specialist
Colorado Water Project
1320 Pearl Street, Suite 320
Boulder, CO 80302
303.440.2937

February 21, 2007

Mr. Jeff Baessler and Mr. Todd Doherty
Stream and Lake Protection Section
Colorado Water Conservation Board
1313 Sherman Street, Room 723
Denver, Colorado 80203

Re: Trout Unlimited Instream Flow Recommendations for Arapaho Creek.

Dear Mr. Baessler and Mr. Doherty,

Trout Unlimited in conjunction with the Colorado Division of Wildlife (CDOW) is formally submitting this instream flow recommendation for Arapaho Creek, located in Grand County, Water Division 5.

Location and Land Status. Arapaho Creek originates at the outflow of Caribou Lake, which sits at an elevation of 11,100 feet in a basin between North Arapaho Peak and Satana Peak. It flows generally northwest through U.S. Forest Service dropping nearly 3,000 feet to its confluence with Buchanan Creek at 8,400 feet over a distance of approximately 7.8 miles. From there the stream continues northwest through Monarch Lake and on to Lake Granby. The proposed instream flow reach is between Caribou Lake and Arapaho's confluence with Buchanan Creek. It is entirely on Forest Service Land.

Biological Summary and R2CROSS Analysis. In July and September of 2006 TU and CDOW collected stream cross sectional data, natural environment data, and other data needed to quantify Instream Flow needs. Fishing surveys indicated a healthy, apparently self-sustaining population of brook trout in Arapaho Creek.

Stream cross sectional data were analyzed using the R2CROSS program, and the output was evaluated using the methods described in Nehring (1979) and Espegren (1996). Based on the results from the R2CROSS analysis of the cross section and the available biological data Trout Unlimited and CDOW recommend that the CWCB appropriate the following flow amounts to preserve the natural environment of Arapaho Creek to a reasonable degree:

- From **April 15 through August 31** the R2CROSS analysis indicates a flow appropriation of **4.5 cfs** is required to maintain the three principal criteria of average depth, average velocity and percent wetted perimeter;

- From **September 1 to April 14**, the R2CROSS indicates an instream flow appropriation of **1.9 cfs** to maintain two of the three principal criteria, specifically percent wetted perimeter and average depth;

Water Availability. The USGS maintained a gage (USGS gage 09016500) on Arapaho Creek between October, 1945 and October, 1971. This gage was located downstream of the confluence of Arapaho Creek and Buchanan Creek, below the outlet of Monarch Lake. Trout Unlimited recommends using the aerial apportionment method to estimate daily flows on Arapaho Creek. This approach assumes that discharge past any point on a stream is proportional to the basin area draining to that point. Thus discharge past any point upstream of a gage is equal to the discharge passing the gage multiplied by the ratio of the watershed area above the ungaged point to the watershed area above the gaged point. Although the watershed area above USGS gage 09016500 is approximately 46.9 square miles, Arapaho Creek above Buchanan Creek drains only 17.4 square miles. Thus, flows in Arapaho Creek above Buchanan Creek are expected to be 0.37 that of those measured at the USGS gage. This aerial apportionment approach was used to estimate the flow above Buchanan Creek for the period between 10/1/44 and 9/30/71. These dates assume a water year starting on 10/1.

Although the lake likely dampened the flows from further up in the basin, the reservoir is owned by the Forest Service who manages the lake to support a "high quality non-motorized experience". As such they attempt to maintain constant levels in the lake. According to the Forest Service, the dam is akin to a spillway and the discharge of water from the lake is approximately equal to the discharge into the lake minus losses to seepage and evaporation. Thus, flows past the USGS gage, as adjusted to for area, are likely a conservative estimate of flows in the proposed instream flow reach.

This analysis showed that the estimated average daily flow above the Arapaho Creek Diversion between 10/1/44 and 9/30/71 exceeded the recommended flows. Additionally, 50% of monthly flows were greater than the recommended flows throughout the year.

In an attempt to produce a more robust analysis of water availability, average monthly flows through the reach were also estimated using the Colorado StreamStats webpage maintained by the United States Geological Survey:

http://water.usgs.gov/osw/streamstats/colorado.html

StreamStats uses regression equations to provide estimates of discharge for ungaged sites. This analysis also indicated that throughout the year typical flows through the proposed instream flow reach would exceed the recommended flows.

Relationship to Existing State Policy. Trout Unlimited and the CDOW are forwarding this stream flow recommendation to the CWCB to meet the State of Colorado's policy "that the wildlife and their environment are to be protected, preserved, enhanced, and managed for the use, benefit, and enjoyment of the people of this state and its visitors … and that, to carry out such program and policy, there shall be a continuous operation of planning, acquisition, and development of wildlife habitats and facilities for wildlife-related opportunities." C.R.S. 33-1-101(1). Further, the CDOW Strategic Plan states "Healthy aquatic environments are essential to maintain healthy and viable fisheries, and critical for self-sustaining populations. The Division desires to protect and enhance the quality and quantity of aquatic habitats." TU and CDOW recommend that North Cheyenne Creek be considered for inclusion in the Instream Flow Program because doing so would help meet these stated policies. Specifically, establishing minimum flows through this reach would preserve the natural environment of the stream to a reasonable degree.

Attached in Appendix B, please find copies of the field data sheets, the R2CROSS modeling runs, fishery survey information, and stream photographs. Attached in Appendix C, please find copies of the water availability analysis spanning 10/1/44 to 9/30/71 and the StreamStats output as well as precipitation data from the Grand Lake 6 SSW weather station for the years 1948 – 2006. If you have any questions regarding the attached information or the instream flow recommendations, please feel free to contact me at (303) 440-2937.

Trout Unlimited thanks U.S. Forest Service, Colorado Division of Wildlife and the Colorado Water Conservation Board Staff for their support in preparing this recommendation.

Sincerely,

W. John Roach, Ph.D.
Trout Unlimited
Aquatic Specialist

Cc: Kevin Bayer, USFS Hydrologist
Jay Skinner, CDOW Water Unit Program Manager – w/o attachments
Mark Uppendahl, CDOW Instream Flow Program Coordinator

APPENDIX – B

Field Data

COLORADO WATER CONSERVATION BOARD
INSTREAM FLOW / NATURAL LAKE LEVEL PROGRAM
STREAM CROSS-SECTION AND FLOW ANALYSIS

LOCATION INFORMATION

STREAM NAME:	Arapahoe Creek
XS LOCATION:	N 40o 05.201 W 105o 43.411
XS NUMBER:	2
DATE:	17-Sep-06
OBSERVERS:	A. Todd, S. O'Grady
1/4 SEC:	0
SECTION:	31
TWP:	2N
RANGE:	74W
PM:	0
COUNTY:	Grand
WATERSHED:	Colorado
DIVISION:	5
DOW CODE:	0
USGS MAP:	0
USFS MAP:	0

SUPPLEMENTAL DATA

TAPE WT:	0.0106
TENSION:	99999

*** NOTE ***
Leave TAPE WT and TENSION at defaults for data collected with a survey level and rod

CHANNEL PROFILE DATA

SLOPE:	0.4125

INPUT DATA CHECKED BY: .....DATE.....

ASSIGNED TO: ….....……..…….....DATE.....

STREAM NAME: Arapahoe Creek
XS LOCATION: N 40o 05.201 W 105o 43.411
XS NUMBER: 2

DATA POINTS= 36

VALUES COMPUTED FROM RAW FIELD DATA

	FEATURE	DIST	VERT DEPTH	WATER DEPTH	VEL	WETTED PERIM.	WATER DEPTH	AREA (Am)	Q (Qm)	% Q CELL
	S	0.00	4.73			0.00		0.00	0.00	0.0%
1	G	0.90	6.43			0.00		0.00	0.00	0.0%
		2.00	6.80			0.00		0.00	0.00	0.0%
		4.00	7.27			0.00		0.00	0.00	0.0%
	W	5.50	7.77	0.00	0.00	0.00		0.00	0.00	0.0%
		6.00	7.82	0.10	0.00	0.50	0.10	0.05	0.00	0.0%
		6.50	7.92	0.10	0.39	0.51	0.10	0.05	0.02	0.4%
		7.00	7.98	0.25	0.00	0.50	0.25	0.13	0.00	0.0%
		7.50	8.02	0.20	0.54	0.50	0.20	0.10	0.05	1.2%
		8.00	8.00	0.15	0.70	0.50	0.15	0.08	0.05	1.2%
		8.50	8.10	0.35	0.65	0.51	0.35	0.18	0.11	2.6%
		9.00	8.05	0.20	0.97	0.50	0.20	0.10	0.10	2.2%
		9.50	8.22	0.50	1.33	0.53	0.50	0.25	0.33	7.5%
		10.00	8.19	0.30	0.81	0.50	0.30	0.15	0.12	2.8%
		10.50	8.19	0.40	0.86	0.50	0.40	0.20	0.17	3.9%
		11.00	8.19	0.30	1.23	0.50	0.30	0.15	0.18	4.2%
		11.50	7.82	0.10	1.26	0.62	0.10	0.05	0.06	1.4%
		12.00	8.06	0.30	1.75	0.55	0.30	0.15	0.26	5.9%
		12.50	7.97	0.30	0.25	0.51	0.30	0.15	0.04	0.8%
		13.00	8.27	0.55	1.11	0.58	0.55	0.28	0.31	6.9%
		13.50	8.35	0.40	1.85	0.51	0.40	0.20	0.37	8.4%
		14.00	8.30	0.50	0.63	0.50	0.50	0.25	0.16	3.6%
		14.50	8.22	0.45	1.30	0.51	0.45	0.23	0.29	6.6%
		15.00	8.15	0.40	1.80	0.50	0.40	0.20	0.36	8.2%
		15.50	8.27	0.45	1.80	0.51	0.45	0.23	0.41	9.2%
		16.00	8.23	0.30	1.18	0.50	0.30	0.15	0.18	4.0%
		16.50	8.17	0.35	1.22	0.50	0.35	0.18	0.21	4.8%
		17.00	7.94	0.40	1.20	0.55	0.40	0.20	0.24	5.4%
		17.50	8.17	0.35	0.95	0.55	0.35	0.18	0.17	3.8%
		18.00	8.42	0.65	0.52	0.56	0.65	0.33	0.17	3.8%
		18.50	8.21	0.40	0.24	0.54	0.40	0.20	0.05	1.1%
		19.00	7.92	0.20	0.00	0.58	0.20	0.10	0.00	0.0%
	W	19.50	7.75	0.00	0.00	0.53		0.00	0.00	0.0%
		22.00	7.51			0.00		0.00	0.00	0.0%
1	G	25.40	7.35			0.00		0.00	0.00	0.0%
	S	26.50	7.00			0.00		0.00	0.00	0.0%
	TOTALS ----------					14.67	0.65 (Max.)	4.48	4.41	100.0%

Manning's n = 0.4383
Hydraulic Radius= 0.304944633

STREAM NAME: Arapahoe Creek
XS LOCATION: N 40o 05.201 W 105o 43.411
XS NUMBER: 2

WATER LINE COMPARISON TABLE

WATER LINE	MEAS AREA	COMP AREA	AREA ERROR
	4.48	4.82	7.6%
7.51	4.48	8.72	94.8%
7.53	4.48	8.37	87.1%
7.55	4.48	8.04	79.6%
7.57	4.48	7.70	72.2%
7.59	4.48	7.38	64.8%
7.61	4.48	7.06	57.7%
7.63	4.48	6.74	50.6%
7.65	4.48	6.43	43.7%
7.67	4.48	6.12	36.8%
7.69	4.48	5.82	30.1%
7.71	4.48	5.53	23.5%
7.72	4.48	5.38	20.3%
7.73	4.48	5.24	17.1%
7.74	4.48	5.10	13.9%
7.75	4.48	4.96	10.7%
7.76	4.48	4.82	7.6%
7.77	4.48	4.68	4.5%
7.78	4.48	4.54	1.4%
7.79	4.48	4.40	-1.7%
7.80	4.48	4.26	-4.7%
7.81	4.48	4.13	-7.7%
7.83	4.48	3.86	-13.7%
7.85	4.48	3.60	-19.5%
7.87	4.48	3.34	-25.3%
7.89	4.48	3.09	-30.9%
7.91	4.48	2.84	-36.4%
7.93	4.48	2.60	-41.9%
7.95	4.48	2.36	-47.2%
7.97	4.48	2.13	-52.3%
7.99	4.48	1.91	-57.3%
8.01	4.48	1.70	-62.0%

WATERLINE AT ZERO
AREA ERROR = 7.785

STREAM NAME: Arapahoe Creek
XS LOCATION: N 40o 05.201 W 105o 43.411
XS NUMBER: 2

Constant Manning's n

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

	DIST TO WATER (FT)	TOP WIDTH (FT)	AVG. DEPTH (FT)	MAX. DEPTH (FT)	AREA (SQ FT)	WETTED PERIM. (FT)	PERCENT WET PERIM (%)	HYDR RADIUS (FT)	FLOW (CFS)	AVG. VELOCITY (FT/SEC)
GL	7.35	21.16	0.56	1.07	11.79	21.92	100.0%	0.54	16.98	1.44
	7.38	20.32	0.54	1.04	11.08	21.08	96.2%	0.53	15.71	1.42
	7.43	19.11	0.53	0.99	10.09	19.85	90.6%	0.51	13.99	1.39
	7.48	17.90	0.51	0.94	9.16	18.63	85.0%	0.49	12.43	1.36
	7.53	16.95	0.49	0.89	8.30	17.67	80.6%	0.47	10.91	1.32
	7.58	16.28	0.46	0.84	7.47	16.99	77.5%	0.44	9.40	1.26
	7.63	15.61	0.43	0.79	6.67	16.31	74.4%	0.41	8.00	1.20
	7.68	14.94	0.40	0.74	5.91	15.63	71.3%	0.38	6.72	1.14
	7.73	14.27	0.36	0.69	5.18	14.95	68.2%	0.35	5.56	1.07
WL	7.78	13.75	0.33	0.64	4.47	14.42	65.8%	0.31	4.47	1.00
	7.83	13.13	0.29	0.59	3.80	13.78	62.9%	0.28	3.51	0.92
	7.88	12.56	0.25	0.54	3.16	13.17	60.1%	0.24	2.66	0.84
	7.93	11.96	0.21	0.49	2.55	12.53	57.2%	0.20	1.92	0.75
	7.98	10.97	0.18	0.44	1.97	11.47	52.3%	0.17	1.33	0.67
	8.03	9.02	0.16	0.39	1.47	9.43	43.0%	0.16	0.93	0.63
	8.08	7.67	0.14	0.34	1.05	7.99	36.5%	0.13	0.60	0.56
	8.13	6.84	0.10	0.29	0.70	7.08	32.3%	0.10	0.32	0.46
	8.18	5.76	0.07	0.24	0.38	5.93	27.0%	0.06	0.13	0.35
	8.23	2.87	0.06	0.19	0.18	2.98	13.6%	0.06	0.06	0.34
	8.28	1.60	0.05	0.14	0.07	1.67	7.6%	0.04	0.02	0.27
	8.33	0.63	0.03	0.09	0.02	0.67	3.0%	0.03	0.00	0.20
	8.38	0.16	0.02	0.04	0.00	0.17	0.8%	0.02	0.00	0.14

Calculate Flow recommendations based on Average Depth, Percent Wetted Perimeter (50%), and Average Velocity (1 ft/s). Because the stream is is 21 ft wide, these three criteria need to be scaled according to its width thus:
Average depth = .21 ft.

2 of 3
Average Depth & Percent Wetted with Avg Depth determining flow

When Avg. depth = .21 ft, discharge = 1.92 cfs

3 of 3
Velocity determines flow

When Velocity = 1 ft/s, discharge = 4.47 cfs

STREAM NAME: Arapahoe Creek
XS LOCATION: N 40o 05.201 W 105o 43.411
XS NUMBER: 2

SUMMARY SHEET

MEASURED FLOW (Qm)=	4.41	cfs
CALCULATED FLOW (Qc)=	4.47	cfs
(Qm-Qc)/Qm * 100 =	-1.2	%
MEASURED WATERLINE (WLm)=	7.76	ft
CALCULATED WATERLINE (WLc)=	7.78	ft
(WLm-WLc)/WLm * 100 =	-0.3	%
MAX MEASURED DEPTH (Dm)=	0.65	ft
MAX CALCULATED DEPTH (Dc)=	0.64	ft
(Dm-Dc)/Dm * 100	2.2	%
MEAN VELOCITY=	1.00	ft/sec
MANNING'S N=	0.438	
SLOPE=	0.4125	ft/ft
.4 * Qm =	1.8	cfs
2.5 * Qm=	11.0	cfs

RECOMMENDED INSTREAM FLOW:
============================

FLOW (CFS)	PERIOD
===========	========
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

RATIONALE FOR RECOMMENDATION:
============================

RECOMMENDATION BY: ………………...………..……............................... AGENCY...……………………......……...…...……....... DATE:.......…..…......……………

CWCB REVIEW BY: ..……………………….....…………………………………………………...…............. DATE:.................…………….....

Data Input & Proofing

STREAM NAME:	Arapahoe Creek
XS LOCATION:	N 40o 05.201 W 105o 43.411
XS NUMBER:	2
DATE:	9/17/06
OBSERVERS:	A. Todd, S. O'Grady
1/4 SEC:	0
SECTION:	31
TWP:	2N
RANGE:	74W
PM:	
COUNTY:	Grand
WATERSHED:	Colorado
DIVISION:	5
DOW CODE:	
USGS MAP:	
USFS MAP:	
	Level and Rod Survey
TAPE WT:	0.0106 lbs / ft
TENSION:	99999 lbs
SLOPE:	0.4125 ft / ft

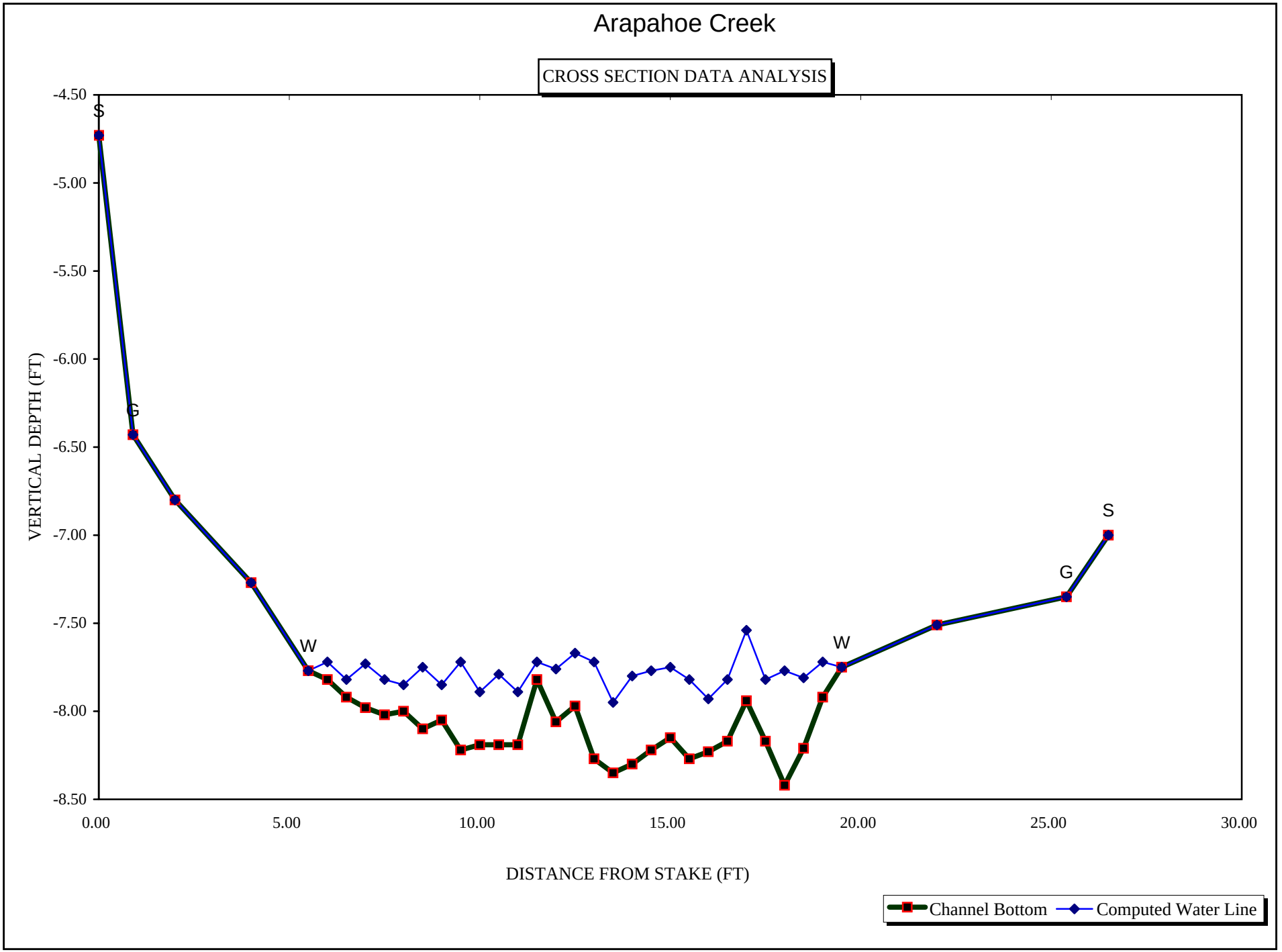
CHECKED BY:.....DATE.....

ASSIGNED TO: .....DATE.....

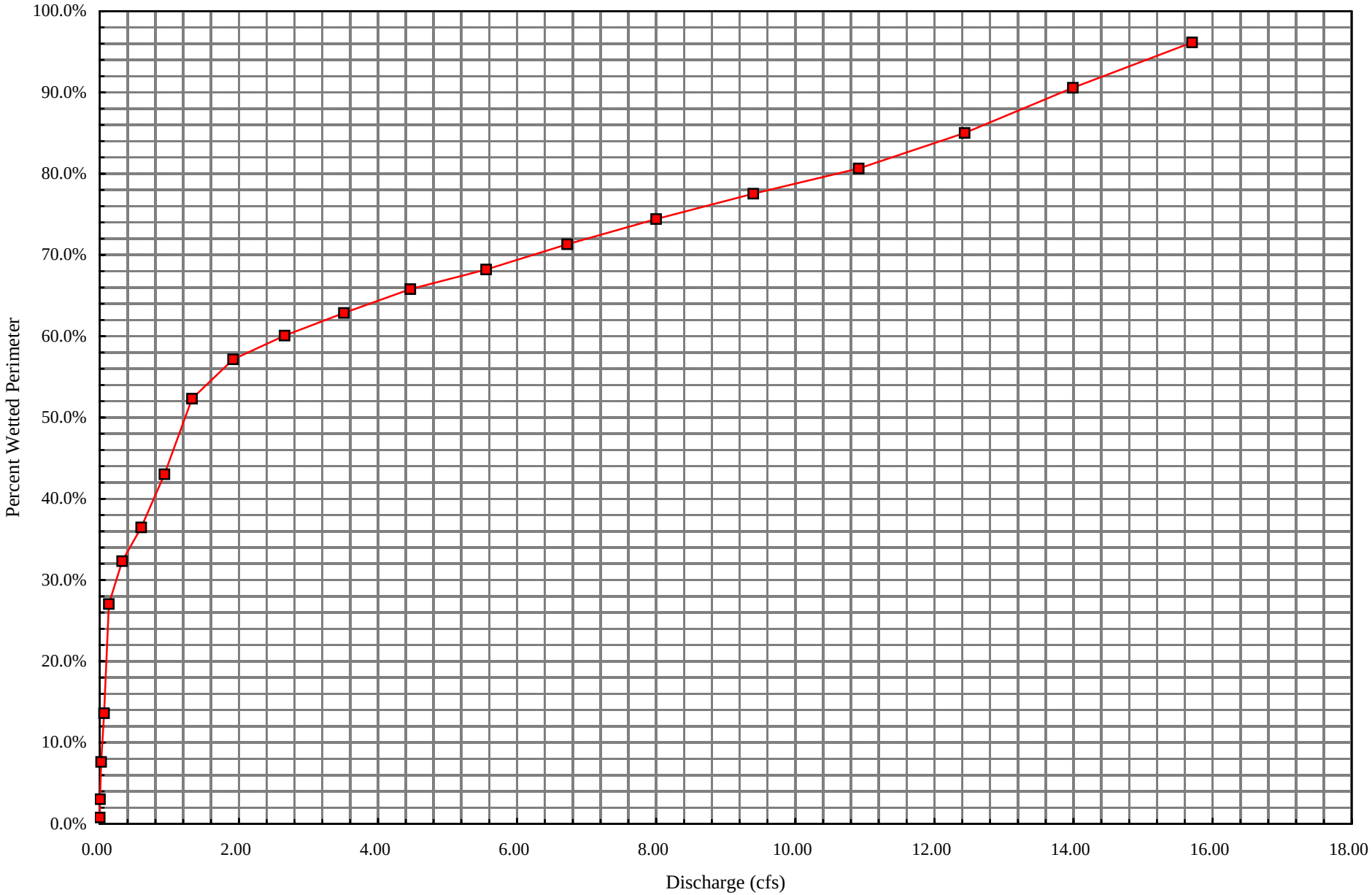
Total Data Points = 36

GL=1	FEATURE	DIST	VERT DEPTH	WATER DEPTH	VEL	A	Q	Tape to Water
	S	0.00	4.73			0.00	0.00	0.00
1	G	0.90	6.43			0.00	0.00	0.00
		2.00	6.80			0.00	0.00	0.00
		4.00	7.27			0.00	0.00	0.00
	W	5.50	7.77	0.00	0.00	0.00	0.00	0.00
		6.00	7.82	0.10	0.00	0.05	0.00	7.72
		6.50	7.92	0.10	0.39	0.05	0.02	7.82
		7.00	7.98	0.25	0.00	0.13	0.00	7.73
		7.50	8.02	0.20	0.54	0.10	0.05	7.82
		8.00	8.00	0.15	0.70	0.08	0.05	7.85
		8.50	8.10	0.35	0.65	0.18	0.11	7.75
		9.00	8.05	0.20	0.97	0.10	0.10	7.85
		9.50	8.22	0.50	1.33	0.25	0.33	7.72
		10.00	8.19	0.30	0.81	0.15	0.12	7.89
		10.50	8.19	0.40	0.86	0.20	0.17	7.79
		11.00	8.19	0.30	1.23	0.15	0.18	7.89
		11.50	7.82	0.10	1.26	0.05	0.06	7.72
		12.00	8.06	0.30	1.75	0.15	0.26	7.76
		12.50	7.97	0.30	0.25	0.15	0.04	7.67
		13.00	8.27	0.55	1.11	0.28	0.31	7.72
		13.50	8.35	0.40	1.85	0.20	0.37	7.95
		14.00	8.30	0.50	0.63	0.25	0.16	7.80
		14.50	8.22	0.45	1.30	0.23	0.29	7.77
		15.00	8.15	0.40	1.80	0.20	0.36	7.75
		15.50	8.27	0.45	1.80	0.23	0.41	7.82
		16.00	8.23	0.30	1.18	0.15	0.18	7.93
		16.50	8.17	0.35	1.22	0.18	0.21	7.82
		17.00	7.94	0.40	1.20	0.20	0.24	7.54
		17.50	8.17	0.35	0.95	0.18	0.17	7.82
		18.00	8.42	0.65	0.52	0.33	0.17	7.77
		18.50	8.21	0.40	0.24	0.20	0.05	7.81
		19.00	7.92	0.20	0.00	0.10	0.00	7.72
	W	19.50	7.75	0.00	0.00	0.00	0.00	0.00
		22.00	7.51			0.00	0.00	0.00
1	G	25.40	7.35			0.00	0.00	0.00
	S	26.50	7.00			0.00	0.00	0.00
					Totals	4.48	4.41	

Arapahoe Creek



Percent Wetted Perimeter vs. Discharge



COLORADO WATER CONSERVATION BOARD

FIELD DATA FOR INSTREAM FLOW DETERMINATIONS

COLORADO DIVISION OF WILDLIFE

LOCATION INFORMATION

STREAM NAME: ARAPAHOE CREEK					CROSS-SECTION NO.: 2
CROSS-SECTION LOCATION: N: 40° 05.201 W: -105° 43.411				438318	4437629
DATE: 9/17/06	OBSERVERS: A. TODD, S. O'GRADY				
LEGAL DESCRIPTION	¼ SECTION:	SECTION: 31	TOWNSHIP: 2 (N/S)	RANGE: 74W E/W	PM:
COUNTY: GRAND	WATERSHED: COLORADO	WATER DIVISION: 5	DOW WATER CODE:		
MAP(S):	USGS:				
	USFS:				

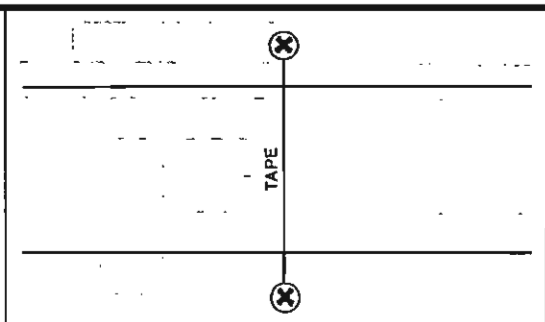
SUPPLEMENTAL DATA

SAG TAPE SECTION SAME AS DISCHARGE SECTION: YES / NO	METER TYPE: MARSH McBIRNEY FLO-MATE			
METER NUMBER:	DATE RATED:	CALIB/SPIN: ____ sec	TAPE WEIGHT: ____ lbs/foot	TAPE TENSION: ____ lbs
CHANNEL BED MATERIAL SIZE RANGE: GRAVEL → COBBLE (LARGE)	PHOTOGRAPHS TAKEN: (YES) NO	NUMBER OF PHOTOGRAPHS: 4		

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	7.825/7.8
② WS Upstream	9'	7.42
③ WS Downstream	7'	8.08
SLOPE	.04125	

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

FORM #ISF FD 1-85

DISCHARGE/CROSS SECTION NOTES

STREAM NAME:	CROSS-SECTION NO.:	DATE:	SHEET ___ OF ___
A - CREEK	2	9/17/06	

BEGINNING OF MEASUREMENT	EDGE OF WATER LOOKING DOWNSTREAM: (0.0 AT STAKE)	LEFT / RIGHT	Gage Reading: _____ ft	TIME: 1:47 pm

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		
S	0		4.73								
G	0.9		6.43								
	2		6.8								
	4		7.27								
W	5.5		7.77	0				0			
	6		7.82	0.1				0			
	6.5		7.92	0.1				0.39			
	7		7.98	0.25				0			
	7.5		8.02	0.2				0.54			
	8		8.0	0.15				0.7			
	8.5		8.1	0.35				0.65			
	9		8.05	0.2				0.97			
	9.5		8.22	0.5				1.33			
	10		8.19	0.3				0.81			
	10.5		8.19	0.4				0.86			
	11		8.19	0.3				1.23			
R	11.5		7.82	0.1				1.26			
	12		8.06	0.3				1.75			
	12.5		7.97	0.3				0.25			
	13		8.27	0.55				1.11			
	13.5		8.35	0.4				1.85			
	14		8.3	0.5				0.63			
	14.5		8.22	0.45				1.3			
	15		8.15	0.4				1.8			
	15.5		8.27	0.45				1.8			
	16		8.23	0.3				1.18			
	16.5		8.17	0.35				1.22			
	17		7.94	0.4				1.2			
	17.5		8.17	0.35				0.95			
	18		8.42	0.65				0.52			
	18.5		8.21	0.4				0.24			
	19		7.92	0.2				0			
W	19.5		7.75	0				0			
	22		7.51								
G	25.4		7.35								
S	26.5		7								
TOTALS:											

End of Measurement	Time:	Gage Reading: _____ ft	CALCULATIONS PERFORMED BY:	CALCULATIONS CHECKED BY:

Arapaho Creek #2 Cross Section Downstream Photograph

Arapaho Creek #2 Cross Section Upstream Photograph

Arapaho Creek #2 Cross Section Left Bank Photograph

Arapaho Creek #2 Cross Section Right Bank Photograph

Arapaho Creek Brook Trout Photograph #2

Arapaho Creek Brook Trout Photograph #1

Biological Data

The study reach was fished with fly rods for approximately one hour on July 31, 2006. Over 40 fish were caught. All the fish were brook trout ranging in size from 4" to 9". Additional, smaller brook trout (fry) were observed in shallow waters near the stream edge.

APPENDIX – C

Water Availability Analysis

Discharge in Arapaho Creek was estimated from gage data collected from USGS gage 09016500 (Fig. 1) aerial apportionment. Although the watershed area above USGS gage 09016500 is approximately 46.9 square miles, only 17.39 square miles lie above the Buchanan Creek. Thus, flows through the reach above Buchanan Creek are expected to be 0.37 that of those measured at the USGS gage. This aerial apportionment approach was used to estimate daily discharge rates above the diversion for each day of the period of record.

Estimates of the daily discharge rates above Buchanan Creek from 10/1/44 – 9/30/71 were used to calculate the average discharge for each day of the year (Fig 2) as well as the average, minimum and maximum daily discharge rate for each month (Table 1). These data were then used to estimate the percentage of days a given flow was exceeded. These data indicate that, throughout the year, the recommended flow was exceeded by 50 percent of observed daily discharges (Table 1).

The United State Geological Survey's StreamStats tool was used generate estimates of average monthly flows in Arapaho Creek (Table 2). StreamStats can be found at:

http://water.usgs.gov/osw/streamstats/colorado.html

StreamStats uses regression equations to provide estimates of discharge for ungaged sites. This analysis also indicated that throughout the year typical flows through the watershed would exceed the recommended flows.

Local climate data from the Grand Lake weather station have also been attached.

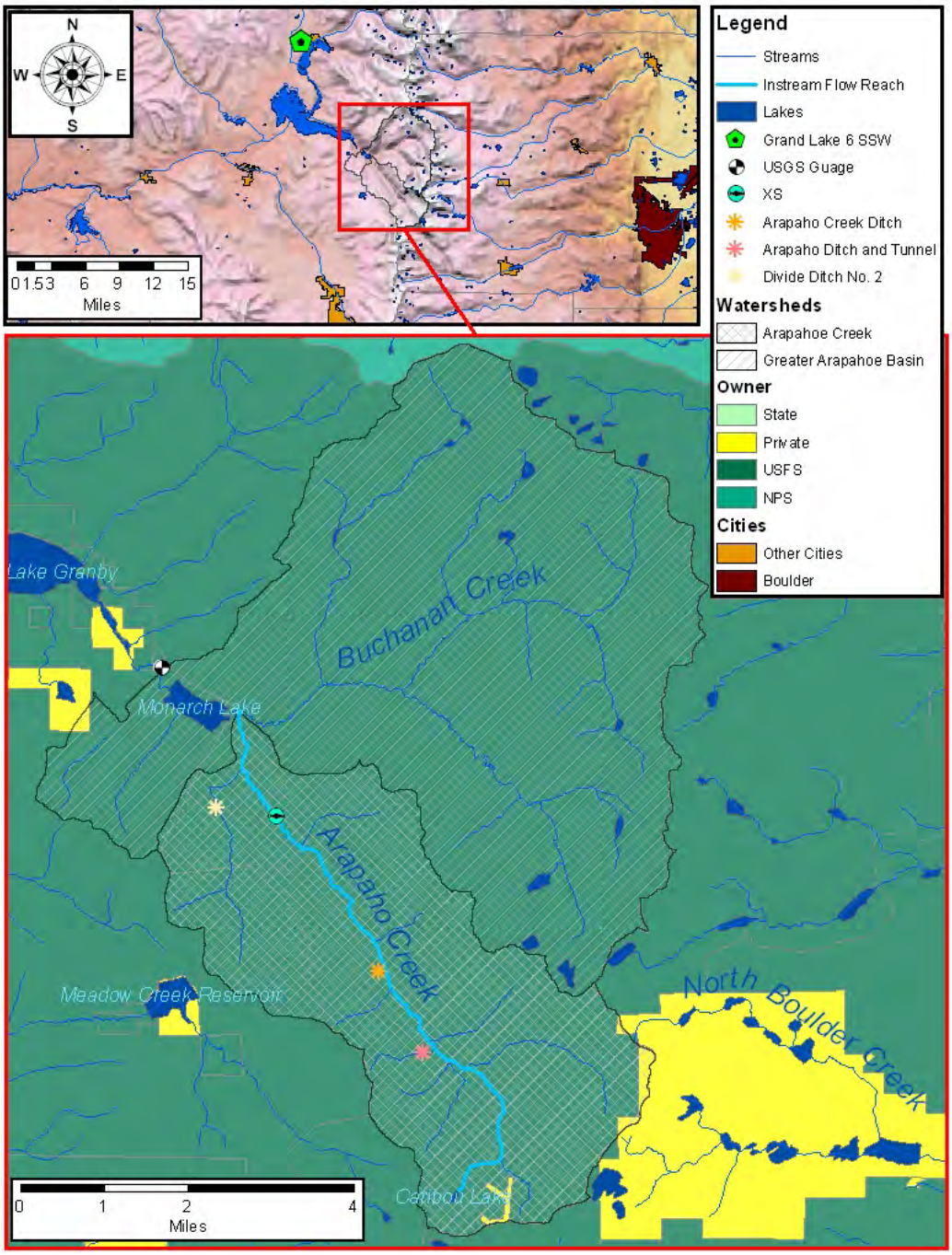


Fig 1. Map of continental divide between Lake Granby and Boulder with detail of the Arapaho Creek watershed. Approximate location of the USGS stream gage is indicated as is the approximate locations of Arapaho Creek cross section 2. Both the entire watershed above the USGS gage as well as the smaller portion above Buchanan creek are indicated. The proposed instream flow reach is shown in light blue. Although there are three historic diversion sites on in the watershed, all three have been abandoned. The approximate location of the Grand Lake weather station is also noted.

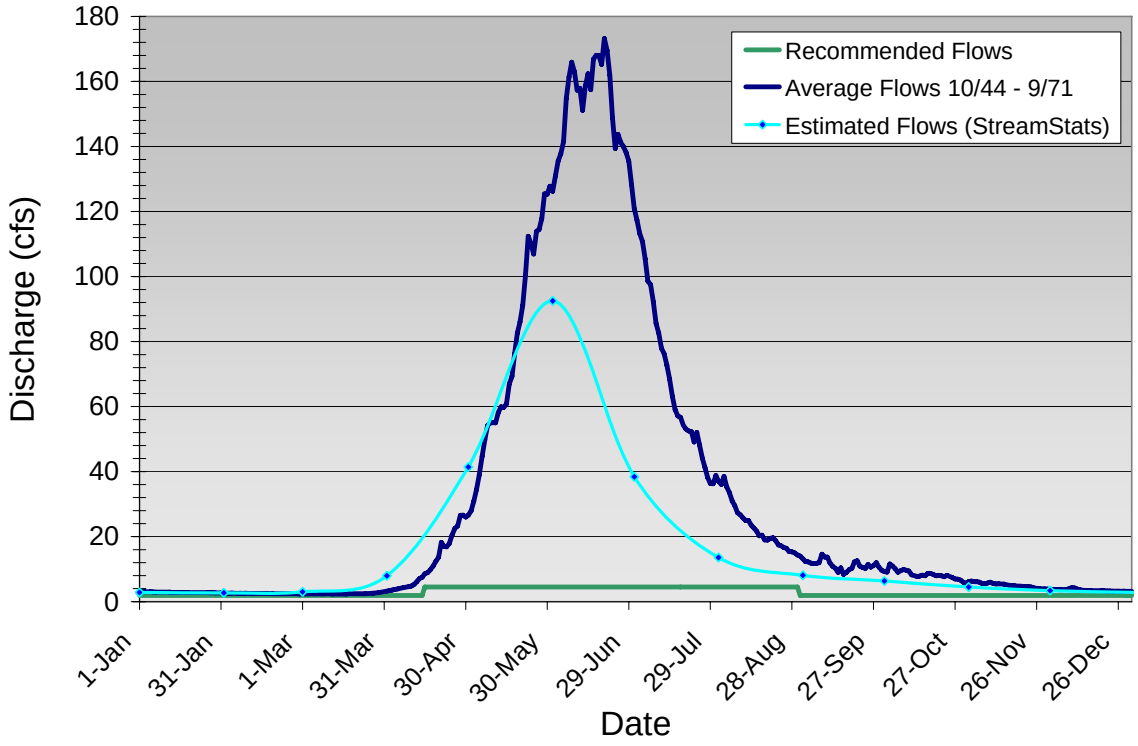


Fig. 2. Comparison of average flows in Arapaho Creek to recommended flows. The average daily discharge through Arapaho Creek above the Buchanan Creek between 10/1/44 through 9/30/71, as determined using aerial apportionment, is plotted as are the estimates of monthly average discharge produced by StreamStats. The StreamStats estimates are connected with a curved line to facilitate comparisons between these estimates and the recommended flows. The R2CROSS recommendations are plotted in green.

Table 1. Summary statistics of estimated mean daily discharge through Arapaho Creek based aerial apportionment of the watershed above UGS gage 7105000. For each month, the 50% exceedence is highlighted. Yellow indicates summer months and blue indicates winter months.

Station: Arapahoe Creek at Monarch Lake Outlet
Prameter: Daily Average
Year: 1944-1971
State: CO
County: Grand

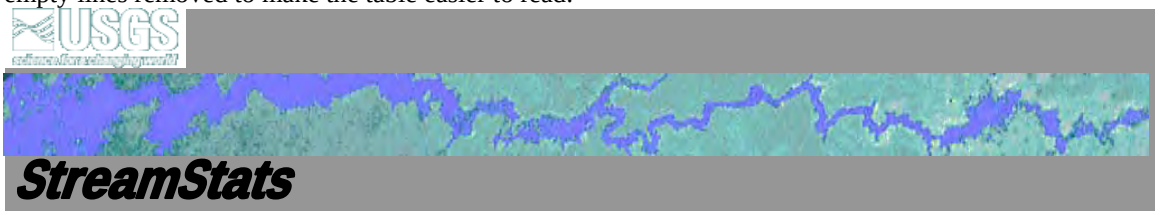
ID: 09016500
Statistic: Daily Discharge
Latitude: 40 06'45"
Longitude: 105 44'57"
Elevation: 8310 ft
Drainage Area: 17.4 mi^2

Monthly Statistics

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
# days	837	762	837	810	837	810	837	837	810	837	810	837	**9861**
Avg Day	2.9	2.5	2.5	11.5	75.4	151.6	69.4	23.1	11.3	8.4	5.1	3.5	**30.61**
Max Day	6	6	9	141	318	430	365	102	94	60	24	24	**430**
Min Day	1.67	1.67	1.48	1.67	5.56	43.75	5.93	0.48	1.22	1.78	0.07	1.52	**0.07**
# months	27	25	27	26	27	26	27	27	26	27	27	27	**25**
Sdev Month	0.75	0.65	0.74	9.82	24.71	43.00	35.68	8.85	7.23	6.33	2.51	1.10	
Skew Month	0.70	2.10	2.33	2.93	0.81	0.16	1.62	0.96	3.69	2.76	0.92	0.87	
Min Month	1.80	1.73	1.67	3.15	29.89	67.42	28.53	9.88	6.11	2.63	1.61	1.65	
Max Month	4.57	4.95	5.35	51.42	135.48	250.94	190.73	46.79	43.44	34.24	11.41	6.32	
Percentiles*													
1%	4.82	5.19	5.56	79.52	258.88	355.92	237.68	73.02	53.66	44.81	15.51	7.42	243.24
5%	4.45	3.52	3.78	50.45	197.56	275.61	162.55	47.68	27.27	22.32	10.75	5.19	152.02
10%	4.08	3.19	3.19	25.99	153.73	239.16	131.63	39.08	16.69	14.46	8.90	4.82	99.37
20%	3.56	2.92	2.89	16.69	112.94	202.90	98.26	31.52	13.35	10.38	6.30	4.45	46.35
50%	2.71	2.37	2.22	5.19	61.92	141.09	55.62	19.28	8.90	6.30	4.45	3.34	**6.30**
80%	2.15	2.00	1.89	3.26	28.55	90.47	32.63	13.35	6.30	3.52	3.03	2.60	2.71
90%	2.04	1.85	1.78	2.67	17.80	72.30	27.07	10.38	4.82	2.97	2.52	2.30	2.22
95%	1.93	1.78	1.71	2.11	13.35	62.29	22.25	8.16	3.71	2.60	2.26	2.07	1.93
99%	1.76	1.67	1.56	1.79	8.66	51.24	17.19	2.36	2.80	2.00	0.24	1.59	1.67

* Percentiles estimate the value (discharge) in the record associated with a given percentile. They provide an estimate of the percentage of days on which a given flow is exceeded. Percentiles were calculated using the PERCENTILE function in MicroSoft Excel.

Table 2. Results of USGS StreatmStats analysis of Arapaho Creek. Because StreamStats did not calculate all cell value, some cells are blank. No data have been deleted, though month names have been added and empty lines removed to make the table easier to read.



Streamflow Statistics Report

Date: Thu Feb 8 2007 14:49:56
Site Location: Colorado
Latitude: 40.1050
Longitude: -105.7321
Drainage Area: 17.4 mi2

Peak Flow Basin Characteristics			
100% Mountain Region Peak Flow (17.4 mi2)			
Parameter	**Value**	**Min**	**Max**
Drainage Area (square miles)	17.4	5.5	945
Mean Basin Slope ft per ft (dimensionless)	0.44	0.126	0.554

Low Flow Basin Characteristics			
100% Mountain Region Low Flow (17.4 mi2)			
Parameter	**Value**	**Min**	**Max**
Drainage Area (square miles)	17.4	1	1150
Mean Basin Elevation (feet)	10700	8400	12200
Mean Annual Precipitation (inches)	28.2	17.5	39.4

Streamflow Statistics					
		Standard Error	Equivalent years of	90-Percent Prediction Interval	
Statistic	**Flow (ft^3/s)**	**(percent)**	**record**	**Minimum**	**Maximum**
PK2	259	60			
PK5	336	49			
PK10	385	45			
PK25	445	42			
PK50	485	42			
PK100	527	43			
PK200	566	45			
PK500	617	49			

Streamflow Statistics					
		Estimation Error	Equivalent years of	90-Percent Prediction Interval	
Statistic	**Flow (ft^3/s)**	**(percent)**	**record**	**Minimum**	**Maximum**
Q1 -- January	2.84	49			
Q2 -- February	2.7	49			
Q3 -- March	3.02	43			
Q4 -- April	7.97	56			
Q5 -- May	41.4	58			
Q6 -- June	92.5	510			
Q7 -- July	38.4	63			
Q8 -- August	13.6	70			
Q9 -- September	8.11	63			
Q10 -- October	6.39	50			
Q11 -- November	4.51	43			
Q12 -- December	3.38	45			
QA -- Annual	20.3	43			
Low-Flow Statistics					
M7D2Y	1.92	62			
M7D10Y	1.11	100			
M7D50Y	0.74	160			

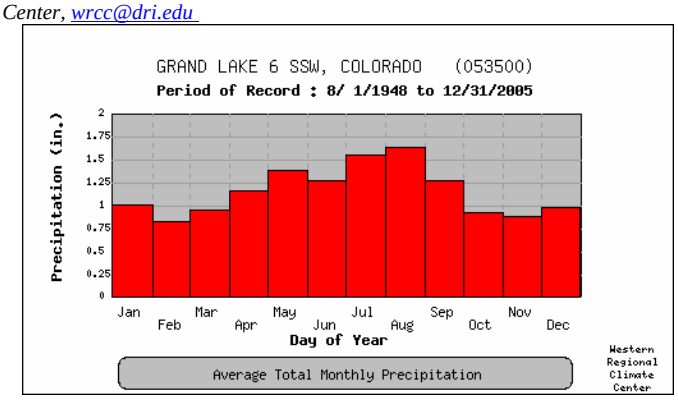
Local Climate Data for the period 1948 to 2006.

GRAND LAKE 6 SSW, COLORADO
Period of Record General Climate Summary – Precipitation

Station:(053500) GRAND LAKE 6 SSW														
From Year=1948 To Year=2006														
	Precipitation											Total Snowfall		
	Mean	High	Year	Low	Year	1 Day Max.		>= 0.01 in.	>= 0.10 in.	>= 0.50 in.	>= 1.00 in.	Mean	High	Year
	in.	in.	-	in.	-	in.	dd/yyyy or yyyymmdd	# Days	# Days	# Days	# Days	in.	in.	-
January	1.02	2.43	1980	0.08	1961	0.78	29/1951	13	3	0	0	16.1	44.5	1980
February	0.80	2.21	1986	0.23	1982	0.72	20/1986	11	3	0	0	12.6	32.4	1986
March	0.96	2.56	2003	0.25	2005	1.40	19/2003	13	4	0	0	13.4	33.0	1949
April	1.18	2.74	1957	0.12	1955	1.32	23/2000	11	4	0	0	8.5	28.6	1984
May	1.41	3.88	1995	0.25	1970	1.43	07/1969	12	5	0	0	2.3	18.0	1979
June	1.29	4.34	1969	0.00	1986	1.20	08/1984	10	4	1	0	0.4	14.0	1974
July	1.56	3.87	1998	0.36	1963	1.53	31/1997	13	5	1	0	0.0	0.0	1949
August	1.66	3.03	1983	0.26	1985	1.25	19/2004	13	6	1	0	0.0	0.0	1948
September	1.29	5.30	1961	0.09	1953	1.28	30/1993	10	4	1	0	1.2	38.0	1961
October	0.94	3.66	1969	0.00	1952	1.45	03/1969	8	3	0	0	2.1	38.9	1969
November	0.90	2.75	1985	0.10	1949	1.12	09/1985	10	3	0	0	9.4	26.8	1948
December	0.98	4.82	1951	0.07	1997	1.33	30/1951	12	3	0	0	16.8	72.3	1983
Annual	14.00	22.32	1951	10.08	1968	1.53	19970731	136	46	3	0	82.8	156.9	1983
Winter	2.80	7.01	1952	0.70	1981	1.33	19511230	37	9	0	0	45.5	90.7	1984
Spring	3.55	7.43	1995	1.29	1998	1.43	19690507	37	12	1	0	24.2	53.0	1984
Summer	4.51	7.70	1998	1.93	1978	1.53	19970731	35	15	2	0	0.4	14.0	1974
Fall	3.14	6.48	1961	1.05	1956	1.45	19691003	28	10	1	0	12.6	48.3	1961

Table updated on Jul 28, 2006
For monthly and annual means, thresholds, and sums:
Months with 5 or more missing days are not considered
Years with 1 or more missing months are not considered
Seasons are climatological not calendar seasons
Winter = Dec., Jan., and Feb. Spring = Mar., Apr., and May
Summer = Jun., Jul., and Aug. Fall = Sep., Oct., and Nov.

Western Regional Climate Center, wrcc@dri.edu



GRAND LAKE 6 SSW, COLORADO

Monthly Total Precipitation (inches)

(053500)

File last updated on Jul 24, 2006
*** Note *** Provisional Data *** After Year/Month 200603
a = 1 day missing, b = 2 days missing, c = 3 days, ..etc..,
z = 26 or more days missing, A = Accumulations present
Long-term means based on columns; thus, the monthly row may not
sum (or average) to the long-term annual value.
MAXIMUM ALLOWABLE NUMBER OF MISSING DAYS : 5
Individual Months not used for annual or monthly statistics if more than 5 days are missing.
Individual Years not used for annual statistics if any month in that year has more than 5 days missing.

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1948	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	1.59 a	0.95	0.43	1.85	2.93	7.75
1949	0.75	0.32	1.42	0.53	0.30	1.37	1.73	0.78	0.98 f	1.29	0.10	0.62	9.21
1950	1.89 a	0.84	0.82	1.37	1.01	0.68	1.02	0.86	1.93	0.22	2.05	1.85	14.54
1951	1.70	1.36	0.75	1.76	1.34	3.10	1.23	2.58	0.77	1.92	0.99	4.82	22.32
1952	1.45	0.74	1.95	0.53	1.39	1.79	1.44 c	2.13 b	0.39	0.00	0.80	0.81	13.42
1953	1.15	0.50	1.16	0.93	1.01	0.86	2.80	2.42	0.09	0.43	0.69	1.01	13.05
1954	0.57	0.36	1.19	0.54	0.77	0.39	2.17	1.12	2.10	0.55	0.72	0.86	11.34
1955	0.76	0.71	1.43 a	0.12	1.54	1.13 a	0.94	1.98	0.80	0.58	1.55	1.08	12.62
1956	1.78	1.57	0.47	1.41	1.36	0.08	1.82	2.08	0.35	0.28	0.42	1.30	12.92
1957	1.78	0.89	1.19	2.74	3.22	1.78	1.74	1.33 a	0.95	1.59	0.56	0.96	18.73
1958	0.53	0.94	1.59 a	0.98	1.74	0.57	0.70	1.84	0.68	0.26	0.66	1.38	11.87
1959	1.14	0.72	0.75	1.07	1.46	1.66	1.70	1.60	3.42	1.40	0.45	0.26	15.63
1960	0.51	0.94	1.46	0.80	1.74	0.63	1.17	0.75	0.77	0.84	0.58	0.74	10.93
1961	0.08	0.58	1.21	1.82	1.63	0.84	2.63	2.06	5.30	0.29	0.89	0.90	18.23
1962	2.05	1.50	0.65	1.24	1.14	1.69	0.66	0.34	0.75	0.77	0.45	0.54	11.78
1963	0.84	0.94	1.01	0.53	0.98	1.32 a	0.36	3.00	1.10	0.40	0.42	0.71	11.61
1964	0.64	0.50	1.73	1.26	0.69	1.71	1.09	1.51	0.88	0.18	0.92	2.10	13.21
1965	1.87	0.39	1.18	0.54 b	1.59	1.39	3.17	1.56	1.29	0.04	0.00 v	0.45	13.47
1966	0.38	0.43	0.44	1.10	0.91	0.85	0.94	1.48	1.23	0.83	0.52	1.76	10.87
1967	1.31	1.07	1.41	1.01	0.70	1.62	1.73	2.26	1.61	0.60	1.00	1.49	15.81
1968	0.48	1.21	0.33	0.56	1.52	0.31	0.62	1.49	0.53	0.86	1.60	0.57	10.08
1969	2.08	0.47	0.38	1.25	1.82	4.34	1.15	1.50	0.73	3.66	0.59	1.03	19.00
1970	0.94	0.70	0.92	1.16	0.25	1.25	0.86	1.97	1.71	1.62	0.99	0.58	12.95
1971	0.77	0.89	0.75	1.21	1.56	0.24	1.78	1.71	1.28	0.62	0.54	0.93	12.28
1972	1.53	0.66	0.84	1.36	0.72	1.65	0.94	1.74	1.50	1.66	0.40	0.84	13.84
1973	0.51	0.41	0.43	1.64	2.74	1.11	2.24	1.13	0.40	0.63	1.48	1.14	13.86
1974	0.89	0.55	1.03	1.35	0.30	1.80	1.95	0.47	0.91	1.21	0.45	0.60	11.51
1975	1.71	0.94	0.90	1.24	1.66	0.84	1.79	1.04	0.29	1.33	1.05	0.25	13.04
1976	0.66	0.84	0.74	0.73	1.62	1.16	1.48	1.69	2.31	0.21	0.51	0.29	12.24
1977	0.46	0.39	0.68	1.67	1.52	0.56	1.62	2.56	1.02	1.65	1.52	1.08	14.73
1978	1.06	1.23	0.96	0.92	1.55	0.95	0.43	0.55	0.45	0.34	0.60	1.30	10.34
1979	1.53	1.05	0.73	0.40	2.61	1.57	0.72	2.05	0.18	0.40	0.82	0.52	12.58
1980	2.43	1.48	0.75	0.80	1.34	0.23	0.93	1.65	1.24	0.45	0.68	0.22	12.20
1981	0.20	0.28	0.78	0.52	2.40	0.53	2.38	1.90	0.68	1.32	0.56	0.89	12.44
1982	1.08	0.23	0.87	0.96	2.20	0.90	1.22	1.54	1.85	0.92	1.08	0.94	13.79
1983	0.38	0.71	2.51	1.75	1.29	1.32	3.05	3.03	0.78	0.93	2.12 b	3.13	21.00
1984	0.37	0.24 d	0.65 b	1.91 a	1.34	3.31	2.48	1.60	2.00	1.51	0.64 a	0.52 b	16.57
1985	1.05 a	0.49 a	0.88	1.26	0.99	0.81	1.63	0.26	1.50	2.10	2.75	0.70 a	14.42
1986	0.31	2.21 a	0.60	2.58	0.84	0.00	1.68	2.51	1.70	1.74	0.66	0.17	15.00
1987	0.85	0.57	0.79	0.76	1.21	0.59	1.76	1.43	0.54	1.26	1.08	1.30	12.14
1988	1.30	0.77	1.33	1.35	1.55	1.83	0.53	0.92	0.65	0.22	1.18	1.09	12.72
1989	0.60	1.21	0.93	0.71	0.75	1.26	1.39	1.18	0.00 z	0.55	0.60	0.79	9.97
1990	0.51	0.50	1.88	1.92	1.88	0.29	2.55	0.99	1.82	1.15	0.60	0.91	15.00
1991	0.79	0.29	1.52	1.46	1.59	2.34	2.05	2.03	0.46	0.79	0.85	0.31	14.48
1992	0.69	0.55	1.20	1.74	1.91	1.23	0.91	1.73	0.66	0.82	0.95	0.65	13.04
1993	1.73	2.18	1.01	1.71	2.27	1.59	0.93	1.01	2.94	2.49	0.70	0.57	19.13
1994	0.65	1.00	0.94	1.03	0.44	1.07	0.61	2.08	0.83	0.68 b	0.84	0.50	10.67

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		ANN
1995	0.84	1.30	1.12	2.43	3.88	2.67	1.77	0.96	1.66	0.88	1.15	0.89	19.55	
1996	2.07	1.81	0.60	0.50	1.08	1.02	1.02	0.85	1.86	0.78	0.86	1.55	14.00	
1997	1.77	0.46	0.39	1.85	2.59	0.89	2.26	2.77	1.50	1.24	0.71	0.07	16.50	
1998	0.61 a	0.41	0.27	0.47	0.55	2.12	3.87	1.71	1.14	2.71	0.96	0.66	15.48	
1999	1.04	0.58	0.38	0.78	1.01	1.10	3.20	1.78	0.83	0.21 e	0.37	0.48	11.76	
2000	1.85	0.63	0.71	1.93	1.46	1.12 b	0.79	2.25	1.67	0.05	0.63	1.21 l	13.09	
2001	0.52	0.23	0.64	0.76	1.33 a	0.76	1.41	1.96	1.84	0.34	1.04	1.00 a	11.83	
2002	0.80	0.41	0.72	0.57	1.17	0.53	1.33	1.37	1.73 a	1.62	0.93	0.41	11.59	
2003	0.45	1.66	2.56	2.05 b	0.95	1.07	1.90	2.71	1.85	0.03	1.11	0.62	16.96	
2004	0.76	0.60	0.36	0.78	0.76	2.69	1.75	2.81	2.50	1.66	1.26	0.48	16.41	
2005	1.09	0.00 z	0.25	0.92	0.97	2.76	1.11	2.05	1.58	1.13	1.01	1.54	14.41	
2006	0.52	0.25	0.79	0.70	1.32	0.67	0.21 p	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	4.25	

Period of Record Statistics

MEAN	1.02	0.80	0.96	1.17	1.40	1.27	1.56	1.66	1.29	0.94	0.90	0.98	14.08
S.D.	0.57	0.48	0.50	0.58	0.70	0.84	0.77	0.67	0.89	0.73	0.48	0.79	2.83
SKEW	0.61	1.15	1.19	0.65	1.09	1.27	0.77	0.00	1.92	1.25	1.56	2.67	1.03
MAX	2.43	2.21	2.56	2.74	3.88	4.34	3.87	3.03	5.30	3.66	2.75	4.82	22.32
MIN	0.08	0.23	0.25	0.12	0.25	0.00	0.36	0.26	0.09	0.00	0.10	0.07	10.08
NO YRS	58	57	58	58	58	58	57	58	56	58	57	57	52

APPENDIX – D

Diversion Records

At one time or another, three structures held water rights in the Arapaho Creek watershed that potentially could have impacted instream flows along Arapaho Creek. The Arapaho Creek Ditch (Structure ID Number: 511) and the Arapahoe (sic) Ditch and Tunnel System (Structure ID Number: 992) were both located along the main stem of Arapaho Creek while the Divide Ditch No 2 (Structure ID Number: 997) was located along Mill Creek, a tributary to Arapaho Creek (Fig 1). The water rights for three of these structures, however, have been abandoned. The Arapaho Creek Ditch rights were abandoned in 1984, the Arapahoe Creek Ditch and Tunnel System rights were abandoned in 1980 and the Divide Ditch No 2 rights were abandoned in 1981. For a more complete description of these structures see the following Structure Summary Reports.

Structure Summary Report

State of Colorado

HydroBase

Structure Name: ARAPAHO CREEK DITCH **Water District:** 51 **Structure ID Number:** 511

Source: ARAPAHO CREEK

Location:	Q10	Q40	Q160	Section	Twnshp	Range	PM
	SE	NW	SE	8	1N	74W	S

Distance From Section From N/S Line: From E/W Line:

UTM Coordinates (NAD 83): Northing (UTM 4434651 Easting (UTM x): 440304.1 Spotted from PLSS distances from section lines

Latitude/Longitude (decimal degrees): 40.059997 -105.699954

Water Rights Summary:						
Total Decreed Rate(s) (CFS):	Absolute: 0.0000	Conditional: 0.0000	AP/EX: 0.0000
Total Decreed Volume(s) (AF):	Absolute: 0.0000	Conditional: 0.0000	AP/EX: 0.0000

Water Rights -- Transactions

Case Number	Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority Number	Decreed Amount	Adjudication Type	Uses	Action Comment
84CW0218	1937-11-05	1915-10-05	30870.24018	0	393	60.0000 C	S,C,AB	1	
CA0657	1937-11-05	1915-10-05	30870.24018	0	393	60.0000 C	S,C	1	

Water Rights -- Net Amounts

Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority/Case Number	Rate (CFS)			Volume (Acre-Feet)		
					Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX

No data available for this report

Irrigated Acres Summary -- Totals From Various Sources

GIS Total (Acres): Reported:

No data available for this report

Diversion Comments Total (Acres): Reported:

Structure Total (Acres): Reported:

Irrigated Acres From GIS Data

Year	Land Use	Acres Flood	Acres Furrow	Acres Sprinkler	Acres Drip	Acres	Acres Total

No data available for this report

Diversion Summary in Acre-Feet - Total Water Through Structure

Year	FDU	LDU	DWC	Maxq & Day	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Total

No data available for this report

Minimum

Maximum:

Average

Notes: The average considers all years with diversion records, even if no water is diverted.
The above summary lists total monthly diversions.
* = Infrequent Diversion Record. All other values are derived from daily records.
Average values include infrequent data if infrequent data are the only data for the year.

Diversion Comments

IYR	NUC Code	Acres Irrigated	Comment
1975		NOT BUILT	
1976		NOT BUILT	
1977		NOT BUILT	
1978	Structure not usable		
1979		NOT BUILT	
1980	Structure not usable		

Note: Diversion comments and reservoir comments may be shown for a structure, if both are available.

Structure Summary Report

State of Colorado

HydroBase

Structure Name: **ARAPAHOE D & TUNNEL SYS** **Water District:** **51** **Structure ID Number:** **992**

Source: ARAPAHO CREEK

Location:	Q10	Q40	Q160	Section	Twnshp	Range	PM
	SE	NW	SW	16	1N	74W	S

Distance From Section From N/S Line: From E/W Line:

UTM Coordinates (NAD 83): Northing (UTM 4433079 Easting (UTM x): 441165.6 Spotted from PLSS distances from section lines

Latitude/Longitude (decimal degrees): 40.045890 -105.689711

Water Rights Summary:						
Total Decreed Rate(s) (CFS):	Absolute:	0.0000	Conditional:	0.0000	AP/EX:	0.0000
Total Decreed Volume(s) (AF):	Absolute:	0.0000	Conditional:	0.0000	AP/EX:	0.0000

Water Rights -- Transactions

Case Number	Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority Number	Decreed Amount	Adjudication Type	Uses	Action Comment
80CW0187	1972-05-30	1961-06-10	40703.00000	0		30.0000 C	S,C,AB	28	
80CW0187	1972-05-30	1961-06-10	40703.00000	0		25.0000 C	S,C,AB	28	
80CW0187	1972-05-30	1961-06-10	40703.00000	0		25.0000 C	S,C,AB	28	
80CW0187	1972-05-30	1961-06-10	40703.00000	0		30.0000 C	S,C,AB	28	
80CW0187	1972-05-30	1961-06-10	40703.00000	0		40.0000 C	S,C,AB	28	
80CW0187	1972-05-30	1961-06-10	40703.00000	0		120.0000 C	S,C,AB	28	
80CW0187	1972-05-30	1961-06-10	40703.00000	0		50.0000 C	S,C,AB	28	
80CW0187	1972-05-30	1961-06-10	40703.00000	0		40.0000 C	S,C,AB	28	
80CW0187	1972-05-30	1961-06-10	40703.00000	0		40.0000 C	S,C,AB	28	
CA1430	1972-05-30	1961-06-10	40703.00000	0		25.0000 C	S,C	28	HDG NO 9
CA1430	1972-05-30	1961-06-10	40703.00000	0		25.0000 C	S,C	28	HDG NO 7
CA1430	1972-05-30	1961-06-10	40703.00000	0		120.0000 C	S,C	28	HDG NO 3
CA1430	1972-05-30	1961-06-10	40703.00000	0		30.0000 C	S,C	28	HDG NO 2
CA1430	1972-05-30	1961-06-10	40703.00000	0		30.0000 C	S,C	28	HDG NO 5
CA1430	1972-05-30	1961-06-10	40703.00000	0		40.0000 C	S,C	28	HDG NO 6
CA1430	1972-05-30	1961-06-10	40703.00000	0		40.0000 C	S,C	28	HDG NO 8
CA1430	1972-05-30	1961-06-10	40703.00000	0		40.0000 C	S,C	28	HDG NO 1
CA1430	1972-05-30	1961-06-10	40703.00000	0		50.0000 C	S,C	28	HDG NO 4

Water Rights -- Net Amounts

Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority/Case Number	Rate (CFS)			Volume (Acre-Feet)		
					Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX

No data available for this report

Irrigated Acres Summary -- Totals From Various Sources

GIS Total (Acres):		Reported:	
Diversion Comments Total (Acres):		Reported:	
Structure Total (Acres):	0	Reported:	

Irrigated Acres From GIS Data

Year	Land Use	Acres Flood	Acres Furrow	Acres Sprinkler	Acres Drip	Acres	Acres Total

No data available for this report

Diversion Summary in Acre-Feet - Total Water Through Structure

Year	FDU	LDU	DWC	Maxq & Day	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Total
No data available for this report																	
				Minimum													
				Maximum:													
				Average													

Notes: The average considers all years with diversion records, even if no water is diverted.
The above summary lists total monthly diversions.
* = Infrequent Diversion Record. All other values are derived from daily records.
Average values include infrequent data if infrequent data are the only data for the year.

Diversion Comments

IYR	NUC Code	Acres Irrigated	Comment
1975		NOT BUILT	
1976		NOT BUILT	
1977		NOT BUILT	
1978	Structure not usable		
1979		NOT BUILT	
1980	Structure not usable		

Note: Diversion comments and reservoir comments may be shown for a structure, if both are available.

Structure Summary Report

State of Colorado

HydroBase

Structure Name: DIVIDE DITCH NO 2 **Water District:** 51 **Structure ID Number:** 997

Source: ARAPAHO CREEK

Location:	Q10	Q40	Q160	Section	Twnshp	Range	PM
	SW	NE	SE	36	2N	75W	S

Distance From Section From N/S Line: From E/W Line:

UTM Coordinates (NAD 83): Northing (UTM 4437816 Easting (UTM x): 437184.4 Spotted from PLSS distances from section lines

Latitude/Longitude (decimal degrees): 40.088279 -105.736838

Water Rights Summary:						
Total Decreed Rate(s) (CFS):	Absolute: 0.0000	Conditional: 0.0000	AP/EX: 0.0000
Total Decreed Volume(s) (AF):	Absolute: 0.0000	Conditional: 0.0000	AP/EX: 0.0000

Water Rights -- Transactions

Case Number	Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority Number	Decreed Amount	Adjudication Type	Uses	Action Comment
CA1430	1972-05-30	1963-03-26	41357.00000	0		100.0000 C	S,C	1	MILL CR ABANDONED 06/23/1981
W2975	1972-05-30	1963-03-26	41357.00000	0		100.0000 C	S,C,AB	1	

Water Rights -- Net Amounts

Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority/Case Number	Rate (CFS)			Volume (Acre-Feet)		
					Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX

No data available for this report

Irrigated Acres Summary -- Totals From Various Sources

GIS Total (Acres):		Reported:	
Diversion Comments Total (Acres):		Reported:	
Structure Total (Acres):	0	Reported:	

Irrigated Acres From GIS Data

Year	Land Use	Acres Flood	Acres Furrow	Acres Sprinkler	Acres Drip	Acres	Acres Total

No data available for this report

Diversion Summary in Acre-Feet - Total Water Through Structure

Year	FDU	LDU	DWC	Maxq & Day	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Total

No data available for this report

Minimum
Maximum:
Average

Notes: The average considers all years with diversion records, even if no water is diverted.
The above summary lists total monthly diversions.
* = Infrequent Diversion Record. All other values are derived from daily records.
Average values include infrequent data if infrequent data are the only data for the year.

Diversion Comments

IYR	NUC Code	Acres Irrigated	Comment
1975	No information available		
1976			NOT BUILT
1977			NOT BUILT
1978	Structure not usable		
1979			NOT BUILT
1980	Structure not usable		

Note: Diversion comments and reservoir comments may be shown for a structure, if both are available.