COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Terror Creek (Lower)
Executive Summary

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Terror Ditch Headgate at UTM North: 4311776.78	UTM North: 276931.58
LOWER TERMINUS:	Fire Mountain Canal at UTM North: 4309509.78	UTM East: 277393.55
WATER DIVISION:	4	
WATER DISTRICT:	40	
COUNTY:	Delta	
WATERSHED:	North Fork Gunnison (HUC#:14020004)	
CWCB ID:	12/4/A-008	
RECOMMENDER	Bureau of Land Management	
LENGTH:	1.52 miles	
FLOW RECOMMENDATION:	4.2 cfs (4/1 – 5/31)	

TERROR CREEK (LOWER)

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "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 Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights. Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

The Bureau of Land Management (BLM) recommended that the CWCB appropriate an ISF water right on a reach of Terror Creek. This reach is located within Delta County about 2.5 miles northeast of the town of Paonia (See Vicinity Map). Terror Creek originates at the confluence of East Fork Terror Creek and West Fork Terror Creek at an elevation of 7,070 feet. It flows in a southerly direction as it drops to an elevation of 5,750 feet where it joins the North Fork Gunnison River. The proposed reach extends from the Terror Ditch headgate downstream to the Fire Mountain Canal. Ninety-six percent of the land on the 1.52 mile proposed reach is publicly owned and managed by the BLM (See Land Ownership Map). The BLM recommended this reach of Terror Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at http://cwcb.state.co.us/environment/instream-flow-program/Pages/2015ProposedISFAppropriations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

Terror Creek is a cold-water, high gradient stream. It flows through a narrow canyon with a floor approximately one-eight mile in width. The stream is generally constrained by bedrock, especially in locations where the streams come close to the canyon walls. The stream generally has large-sized substrate, ranging from four-inch cobbles to boulders up to two feet in diameter. The stream has a high percentage of pool habitat, but sufficient riffle and side channel habitat exists to support salmonid and other fish reproduction. Fisheries surveys have revealed self-sustaining populations of speckled dace

and native cutthroat trout. The BLM plans to collect fin samples from the cutthroat trout population to determine the genetic quality of the population.

The riparian community in this part of Terror Creek is generally comprised of willow species, alder, blue spruce, and narrowleaf cottonwood. In general, the riparian community is in very good condition, provides adequate shading and cover for fish habitat, and provides stream stability during flood events.

Table 1. List of species identified in lower Terror Creek.

Species Name	Scientific Name	Status
native cutthroat trout	*Oncorhynchus clarkii**	State Species of Special Concern BLM Sensitive Species
speckled dace	*Rhinichthys osculus*	none

**Identification of subspecies / lineage of native cutthroat trout in Colorado is ongoing through genetic testing and research.*

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

BLM staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic invertebrates (Nehring, 1979). BLM staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending

entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at four transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a summer flow of 4.8 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a winter flow of 3.9 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for lower Terror Creek.

Entity	Date Measured	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
BLM	9/27/2007	6.13	2.5 – 15.3	4.68	5.15
BLM	9/27/2007	5.73	2.3 – 14.3	4.08	Out of Range
BLM	10/21/2008	2.15	0.9 – 5.4	3.76	4.46
BLM	10/21/2008	1.82	0.7 – 4.5	3.21	Out of Range
			Mean	**3.93**	**4.80**

ISF Recommendation

The BLM recommends flows of 4.2 cfs (4/1 – 5/31) based on R2Cross modeling analyses, biological expertise, and staff's water availability analysis.

4.2 cubic feet per second is recommended for the snowmelt runoff period from April 1 through May 31. This recommendation is driven by limited water availability, but comes close to meeting the wetted perimeter and velocity criteria. Wetting at least 50% of the channel will provide important physical habitat during a time of year when the fish population moves into this reach and completes key life cycle functions. This flow rate will also assist in recharging stream-side aquifers. Storage in and discharge from these aquifers will assist in maintaining the riparian community during the June 1 to December 31 period, when flows are very low because of diversions.

The BLM has not made an instream flow recommendation for the period between June 1 and March 31. Because of diversions from senior water rights, there is insufficient water available in this reach to meet any of the instream flow criteria. If flows do become available because of changes in management

of diversions, the BLM recommends that the CWCB reconsider this stream for an appropriation during the June 1 to March 31 period.

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology

Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data.

Basin Characteristics

The proposed ISF reach of Terror Creek has a 29.4 square mile drainage basin. The average elevation of the basin is 8,790 ft and the average annual precipitation is 26.00 inches. The drainage basin tributary to the lower terminus has several surface water diversions with active records (see Table 3). The Overland Ditch can divert from the headwaters of Muddy Creek, Hubbard Creek, Terror Creek,

and Leroux Creek. This ditch appears to be able to divert a maximum of 150 cfs from each basin; however, the total from all basins cannot exceed 150 cfs. Terror Ditch diverts up to 13.50 cfs out of basin just above the proposed ISF reach. Bruce Reservoir, located on the East Fork of Terror Creek, has a decreed volume of 631.99 AF and is used to supplement diversions. The Terror Ditch Extension (appropriation date 1894, 6 cfs; appropriation date 1976, 23 cfs) diverts water from the headwaters of Hubbard Creek into Terror Creek. Due to surface water diversions, transbasin imports and exports, and the reservoir, hydrology in this drainage basin does not represent natural flow conditions.

Table 3. List of diversion structures located within the lower Terror Creek drainage basin.

Name	WDID	Adjudication Date	Appropriation Date	Administration Number	Amount
Overland Ditch	4001739	6/23/1914	8/1/1893	21263.15919	75.00
		8/28/1919	4/10/1919	25301.00000	75.00
Pitkin Mesa Pipeline	4001191	6/17/1889	11/13/1883	12370.00000	0.4850
		1/31/1964	8/13/1961	40767.00000	2.0150
Terror Ditch	4001208	4/12/1901	12/11/1884	14413.12764	6.00
		2/10/1930	5/01/1901	25807.18748	6.00
		3/20/1954	12/11/1884	31924.12764	1.50
Holybee Ditch	4001155	6/17/1989	11/13/1883	12370.00000	0.40
Fire Mt Canal*	4001809	2/10/1930	7/1/1903	25807.19539	70.00
Fawcett Ditch*	4001130	6/17/1889	11/13/1883	12370.00000	0.1150
		3/20/1954	4/15/1944	34438.00000	1.25
		12/31/2005	5/1/1986	56613.49794	0.1250
				Total	237.89

**This diversion is located below the proposed ISF reach, but impacts the Terror Creek gage.*

Available Data

There are two historic gages in the vicinity of the proposed ISF reach. The East Fork Terror Creek below Cottonwood Stomp near Bowie gage (USGS 09132985) is located upstream from the proposed lower terminus. This gage measures streamflow on the East Fork of Terror Creek and therefore is not representative of flow in the ISF reach, which receives tributary inflow from the West Fork of Terror Creek. The Terror Creek at mouth near Bowie, CO gage (USGS 09132995) is located less than a half mile downstream from the proposed lower terminus. The Terror Creek at mouth gage (Terror Creek gage) was operated from 2001 to 2013 and discontinued in 2014 due to funding issues. The Terror Creek gage has a 29.5 square miles drainage basin and is influenced by the same diversions that affect the proposed ISF reach as well as four additional diversions that total 85.39 cfs.

Data Analysis

Due to the short period of record available at the Terror Creek gage, staff took additional steps to evaluate the record. Staff examined other gages in the region in an attempt to find a gage that could be

used to extend the record through regression analysis. However, none of the gages evaluated produced a reasonable regression coefficient and none were found suitable for regression extension.

Staff also examined streamflow gages and climate stations and found that the Paonia climate station (Paonia 1 SW, Station ID USC00056306, downloaded 11/7/2014) has a relatively long period of record and is located about 7 miles from the lower terminus. The average annual precipitation at the Paonia Station for the period of record (1893 to 1930, 1957 to 2014) is 15.14 inches. During the 13 years the Terror Creek gage operated (2001 to 2013), only two years (2005 and 2007) had above average precipitation at the Paonia Station and all others were below average. Therefore, the Terror Creek gage record likely represents below average streamflow conditions and likely underestimates the amount of water typically available in this drainage.

The Terror Creek gage was analyzed using the approved period of record (6/28/2001 to 12/10/2013) available through HydroBase on 5/20/2014. The gage record was not scaled because there was negligible difference (0.2%) in drainage basin area between the lower terminus and the gage location. The diversions from Fawcett Ditch were added to the gage record because these flows are available in the proposed ISF reach, but do not reach the gage. 95% confidence intervals were not calculated due to the short period of record at the Terror Creek gage.

Water Availability Summary

The hydrographs (Figure 1 and 2) show the median streamflow based on the adjusted Terror Creek gage record. The proposed ISF is less than the median adjusted streamflow. Staff has concluded that water is available for appropriation.

Material Injury

Because the proposed ISF on Terror Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2014), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations

Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

Metadata Descriptions

The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

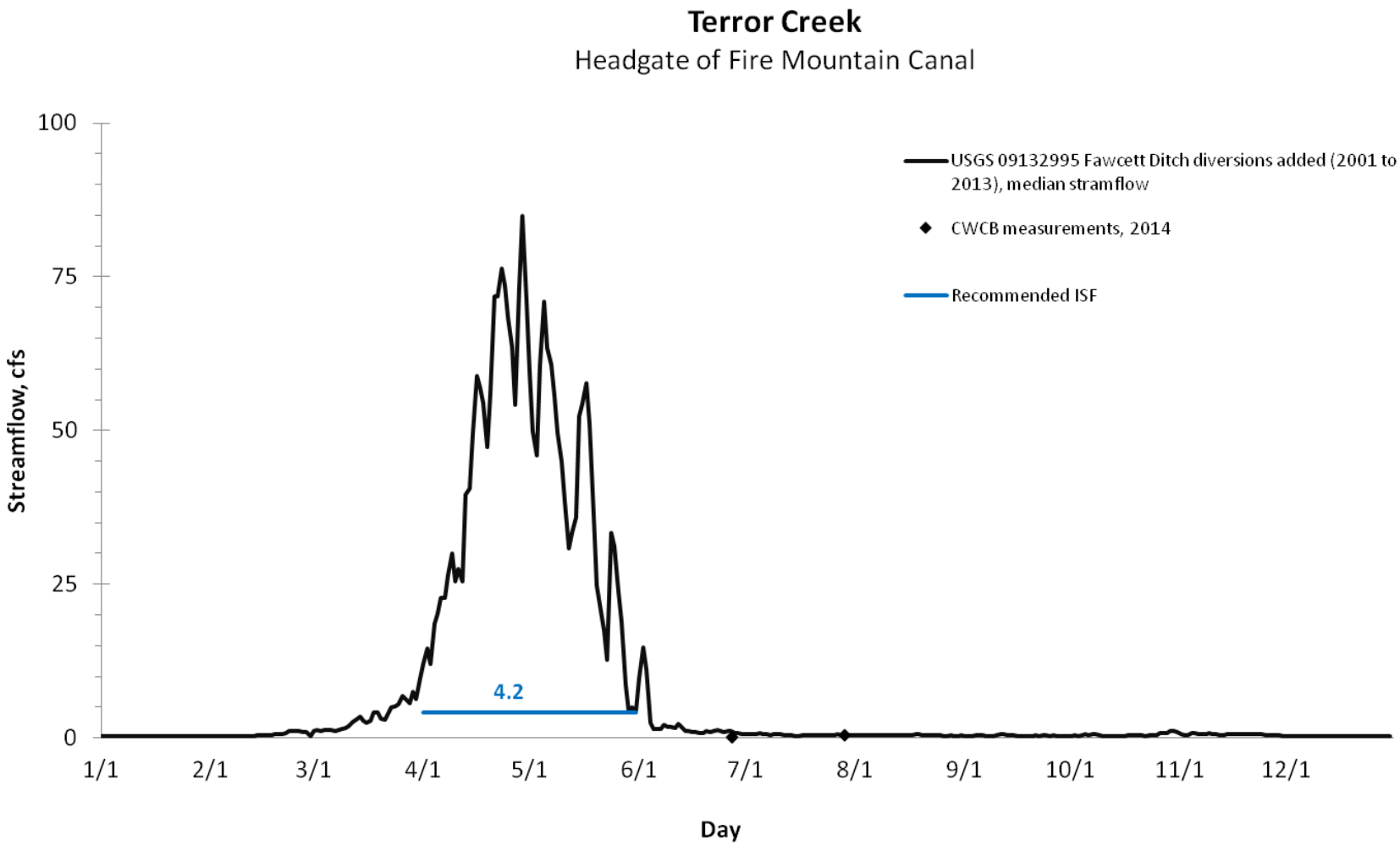


Figure 1. Complete hydrograph showing streamflow data and the proposed ISF rate on lower Terror Creek.

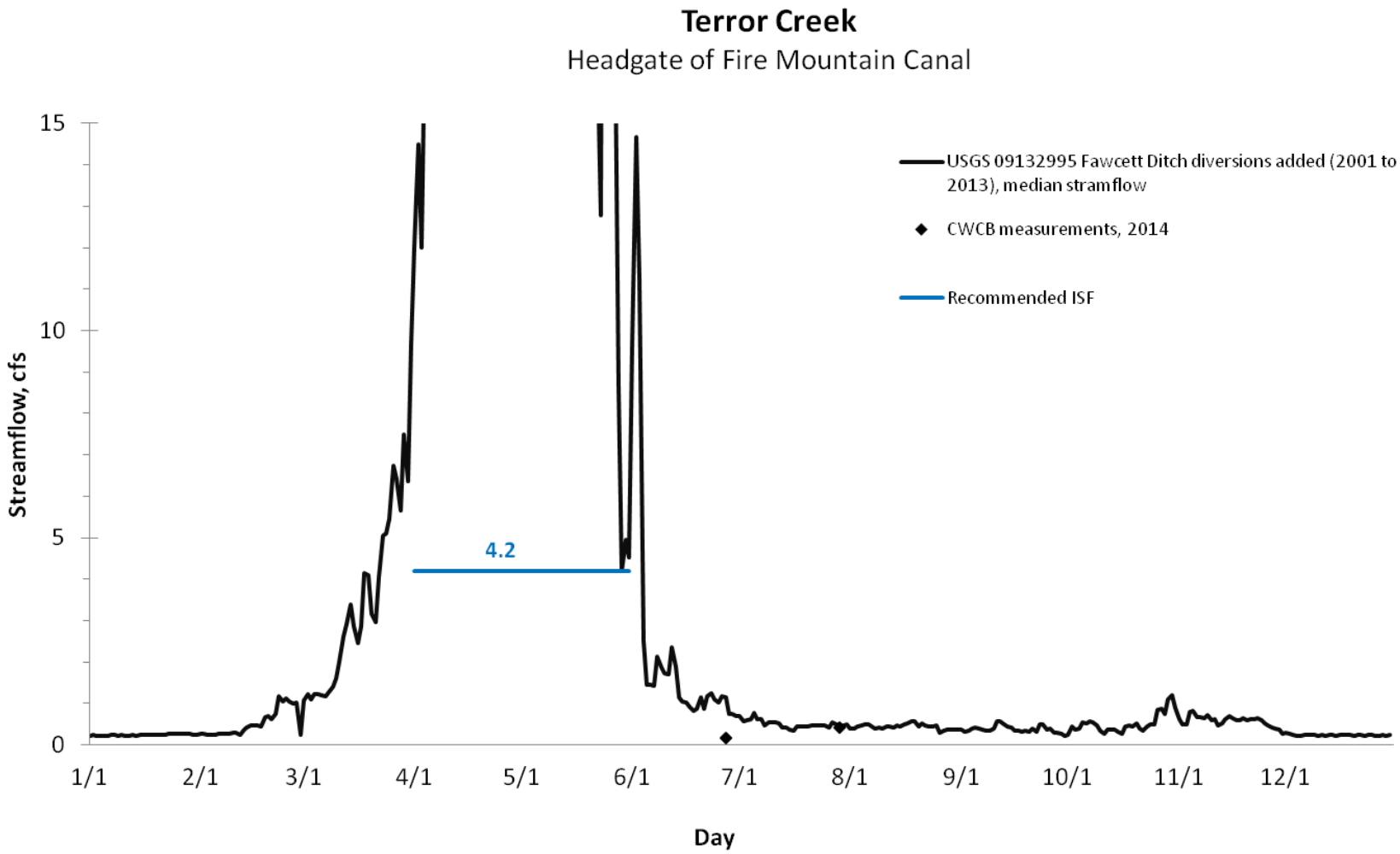
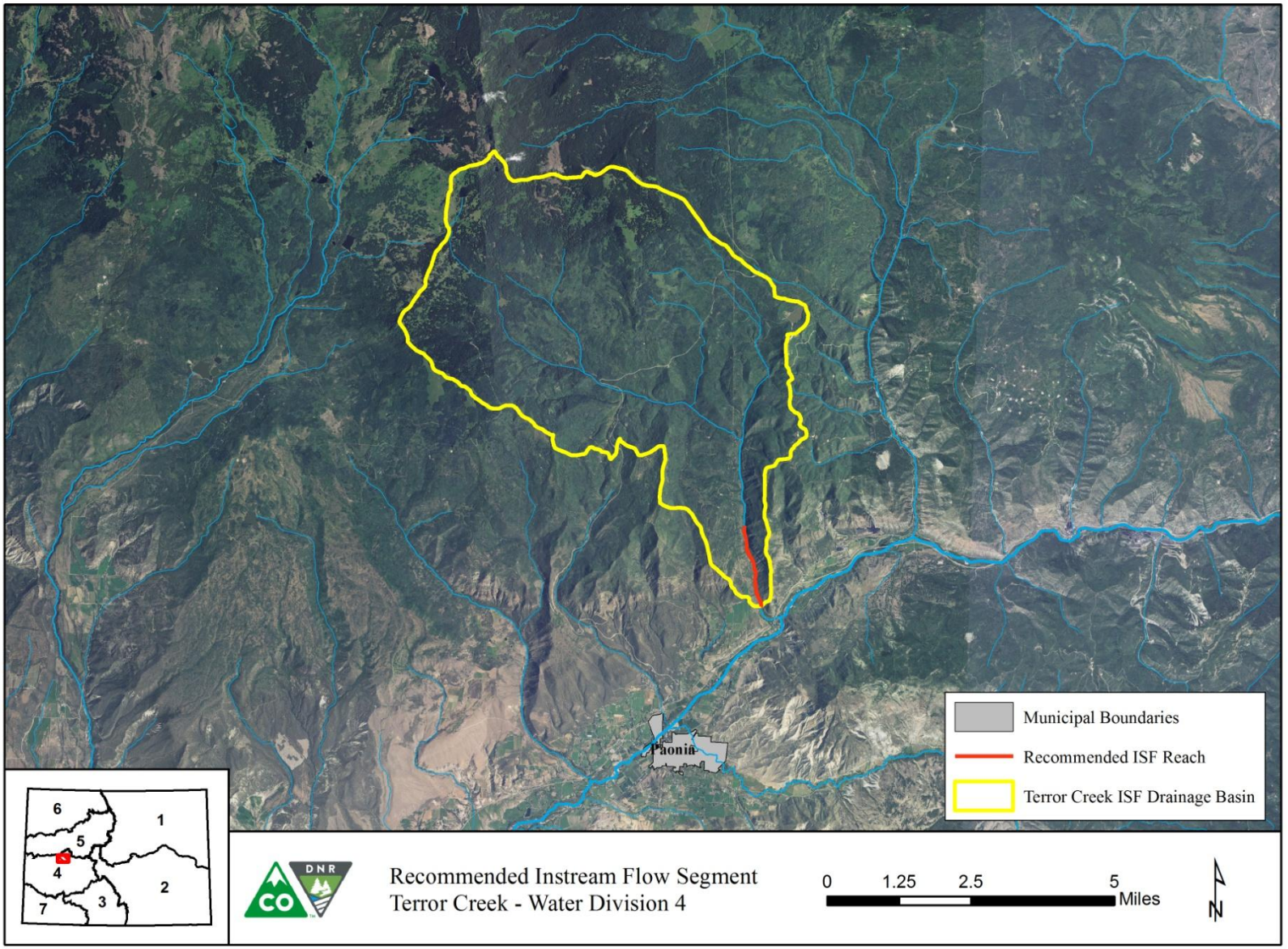
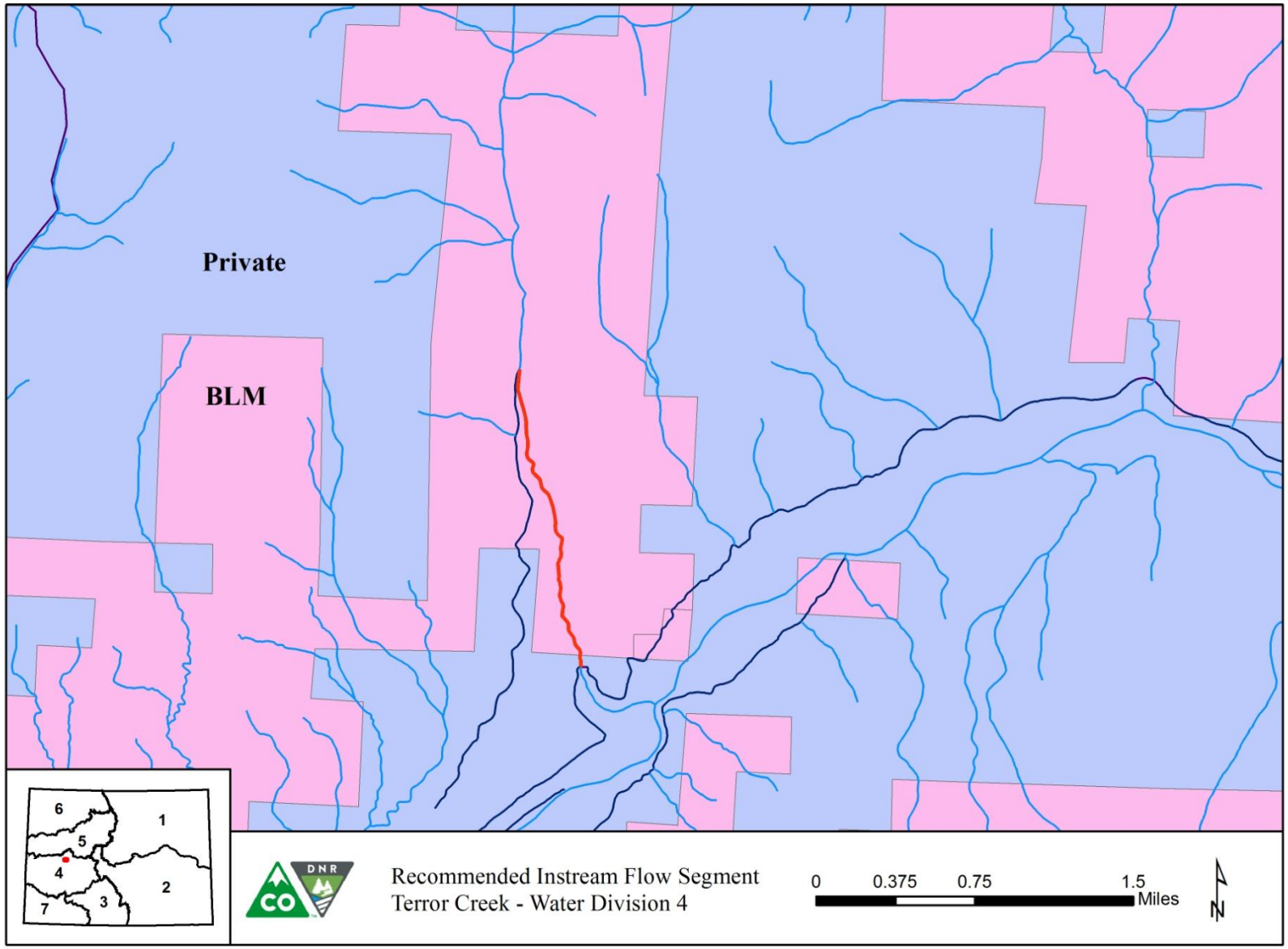


Figure 2. Detailed hydrograph showing streamflow data and the proposed ISF rate on lower Terror Creek.

Vicinity Map



Land Use Map


Private
BLM
6
1
5
4
2
7
3
DNR
CO
Recommended Instream Flow Segment
Terror Creek - Water Division 4
0
0.375
0.75
1.5
Miles
N

Water Rights Map