COLORADO
Colorado Water Conservation Board
Department of Natural Resources

West Fork Terror Creek

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Headwaters in the Vicinity of UTM North: 4317217.31 UTM East: 268584.11
LOWER TERMINUS:	Confluence East Fork Terror Creek UTM North: 4314191.79 UTM East: 276880.59
WATER DIVISION:	4
WATER DISTRICT:	40
COUNTY:	Delta
WATERSHED:	North Fork Gunnison
CWCB ID:	17/4/A-001
RECOMMENDER:	Bureau of Land Management (BLM)
LENGTH:	5.85 miles
FLOW RECOMMENDATION:	1.1 cfs (7/16-3/31) 2.2 cfs (4/1-7/15)

West Fork Terror Creek

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 (NLL). 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 BLM recommended that the CWCB appropriate an ISF water right on a reach of West Fork Terror Creek. West Fork Terror Creek originates roughly 12 miles northwest of Paonia on the south slopes of the Grand Mesa, near Mount Darline at an elevation of approximately 10,300 ft. The creek flows in an easterly direction as it drops to an elevation of approximately 7,070 ft where it joins East Fork Terror Creek to from Terror Creek. The proposed reach is located within Delta County (See Vicinity Map) and extends from its headwaters downstream to the confluence with East Fork Terror Creek. Seventy-eight percent of the land on the 5.85 mile proposed reach is publicly owned and managed by the BLM and the U.S. Forest Service; the remaining land is privately owned (See Land Ownership Map). The BLM recommended this reach of West Fork 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/2017ProposedISFRecommendations.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 the 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.

West Fork Terror Creek is a cold-water, high gradient stream. It flows through a narrow canyon that is typically less than 1,000 ft in width. The stream is generally constrained by bedrock, especially in locations where the stream comes close to the canyon walls. The stream generally has large-sized substrate, ranging from four-inch cobbles to boulders up to two ft in diameter. The stream has a high percentage of pool habitat, but sufficient riffle and side channel habitat exists to support salmonid fish reproduction.

Fisheries surveys have revealed self-sustaining populations of speckled dace and native cutthroat trout (See Table 1). Genetic testing has revealed that the trout population is comprised of genetically pure Colorado River Cutthroat Trout of the Colorado-Gunnison (GB) lineage, and that fish density is high. As such, the fishery has been identified as a core conservation population by the

Colorado River Cutthroat Conservation Team. Pending a status review, this population is currently being provided interim protection as a threatened species under the Endangered Species Act (ESA).

The riparian community in West Fork 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 West Fork Terror Creek.

Species Name	Scientific Name	Status
Colorado River cutthroat trout	*Oncorhynchus clarkii pleuriticus*	State – Species of Special Concern; BLM – Threatened (Interim protection pending status review under ESA)
speckled dace	*Rhinichthys osculus*	

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 macro-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 five 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 winter flow of 1.56 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 2.15 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

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

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
BLM	08/13/2015 # 1	1.11	0.44 - 2.78	0.83	out of range
BLM	07/23/2014 # 1	1.52	0.61 - 3.80	2.63	out of range
BLM	07/23/2014 # 2	1.46	0.58 - 3.65	1.13	out of range
BLM	07/23/2014 # 3	1.70	0.68 - 4.25	out of range	out of range
BLM	07/23/2014 # 4	1.80	0.72 - 4.50	1.65	2.15
			Mean	1.56	2.15

ISF Recommendation

BLM's analysis of these data, coordinated with Colorado Parks and Wildlife, indicates that the following flows are needed to preserve the fishery and natural environment to a reasonable degree:

2.2 cfs is recommended for the snowmelt runoff period from April 1 to July 15. This recommendation is driven by the wetted perimeter and velocity criteria. This flow rate will provide important physical habitat during a time of year when the fish population is completing key life cycle functions.

1.1 cfs is recommended during the base flow period between July 16 and March 31. This recommendation is driven by the wetted perimeter and average depth criteria. This flow rate should prevent excessively high stream temperatures during summer and should prevent icing in pools, allowing the fish population to successfully overwinter.

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 of 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. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics

The drainage basin of the proposed ISF on West Fork Terror Creek is 18.8 square miles, with an average elevation of 9,130 ft and average annual precipitation of 28.05 inches (See the Vicinity Map). The drainage basin tributary to the lower terminus has two primary diversions, the Overland Ditch and the Pitkin Mesa Pipeline. 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 (appropriation date 1893 and 1919) from each basin; however, the total from all basins cannot exceed 150 cfs. Pitkin Mesa Pipeline pipes water from 6 springs located near a tributary to West fork Terror Creek (2.5 cfs, appropriation dates 1883 and 1961) to a neighborhood for domestic uses. There are also a number of small reservoirs and two larger reservoirs including the Holy Terror Reservoir (168.6 AF, appropriation date 1893) and Rex Reservoir (18.4 AF, appropriation date 1907 and 1949). Water from the basins tributary to Rex and Holy Terror Reservoirs can end up in one of 3 places depending on the calling right: (1) the reservoirs are typically filled during spring runoff and then stored water is released to Leroux Creek, the basin to the west of Terror Creek; (2) the Overland Ditch may place a call and water is routed to the Overland Ditch via a portion of West Fork Terror Creek; or (3) the Terror Creek Ditch, located downstream on Terror Creek (appropriation dates 1884 and 1901) places a call and water is routed through West Fork Terror Creek to the Terror Creek Ditch.

Table 3. List of diversion structures in the drainage basin tributary to the lower terminus of West Fork Terror Creek.

Name	WDID	Adjudication Date	Appropriation Date	Administration Number	Amount cfs
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	0.49
		1/31/1964	8/13/1961	40767.00000	2.02

Available Data

There are two historic streamflow gages in the vicinity of the proposed ISF reach. The East Fork Terror Creek below Cottonwood Stomp near Bowie gage (USGS 09132985) measures streamflow on the East Fork of Terror Creek. This gage was not used in analysis as it only measures flow in East Fork Terror Ditch. The second gage is the Terror Creek at mouth near Bowie, CO gage (USGS 09132995) which is located approximately 3.4 miles downstream from the proposed lower terminus. This gage measures the streamflow from both East Fork Terror Creek and West Fork Terror Creek. 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 the diversion structures shown in Table 4. In addition, Bruce Park Reservoir is located on a tributary to East Fork of Terror Creek (631.99 AF, appropriation dates 1913 and 1950) and is used to supplement irrigation diversions. The Terror Ditch Extension (29 cfs total, appropriation dates 1894 and 1976) diverts water from the headwaters of Hubbard Creek into Bruce Park Reservoir (Steve Tuck, water commissioner, stated that there is a pipe to bypass the reservoir, but it is rarely used (personal communication, 11/17/2017)).

Table 4. List of additional diversion structures that affect the Terror Creek gage.

Name	WDID	Adjudication Date	Appropriation Date	Administration Number	Amount cfs
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	0.12
		3/20/1954	4/15/1944	34438.00000	1.25
		12/31/2005	5/1/1986	56613.49794	0.13

CWCB staff made one streamflow measurement on the proposed reach of West Fork Terror Creek as summarized in Table 5. In addition, four USGS streamflow measurements from 1982 and 2003 were identified in the West Fork Terror Creek reach.

Table 5. Summary of streamflow measurement visits and results for West Fork Terror Creek.

Visit Date	Flow (cfs)	Method	Party
10/5/1982	1.6	unknown	USGS
6/17/2003	3.17	unknown	USGS
6/18/2003	2.82	unknown	USGS
9/16/2003	2.21	unknown	USGS
09/14/2016	1.14	Wading, Marsh McBirney	CWCB

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 12/31/2013) available through HydroBase on 11/17/2016. A number of calculations were made to estimate natural streamflow on Terror Creek at the gage location. First, diversion records from Terror Ditch and Fawcett Ditch were added to the gage record. Fire Mountain Canal diversions were not added because there were no recorded diversions during the period analyzed. Holybee Ditch diversions were not added to avoid double counting flow because it was unclear if return flows accrue to Terror Creek. The portion of the diversions from the Terror Creek ditch that originate as releases from Bruce Park Reservoir were subtracted from the adjusted gage record because those flows largely originate from Hubbard Creek via the Terror Ditch Extension. The adjusted gage record was then scaled by 0.689 to the lower terminus using the area-precipitation method. The area-precipitation method estimates streamflow based on the ratio of the precipitation weighted drainage area at the lower terminus location to that of the gage location. The effects of diversions from the Overland Ditch, the Pitkin Mesa Pipeline, Holy Terror Reservoir, and Rex Reservoir were assumed to be included in the gage data.

Median streamflow was calculated using the adjusted scaled Terror Creek gage record. 95% confidence intervals were not calculated due to the short period of record at the Terror Creek gage.

Water Availability Summary
The hydrographs (See Complete Hydrograph and Detailed Hydrograph) 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 West Fork 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. (2016), 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.

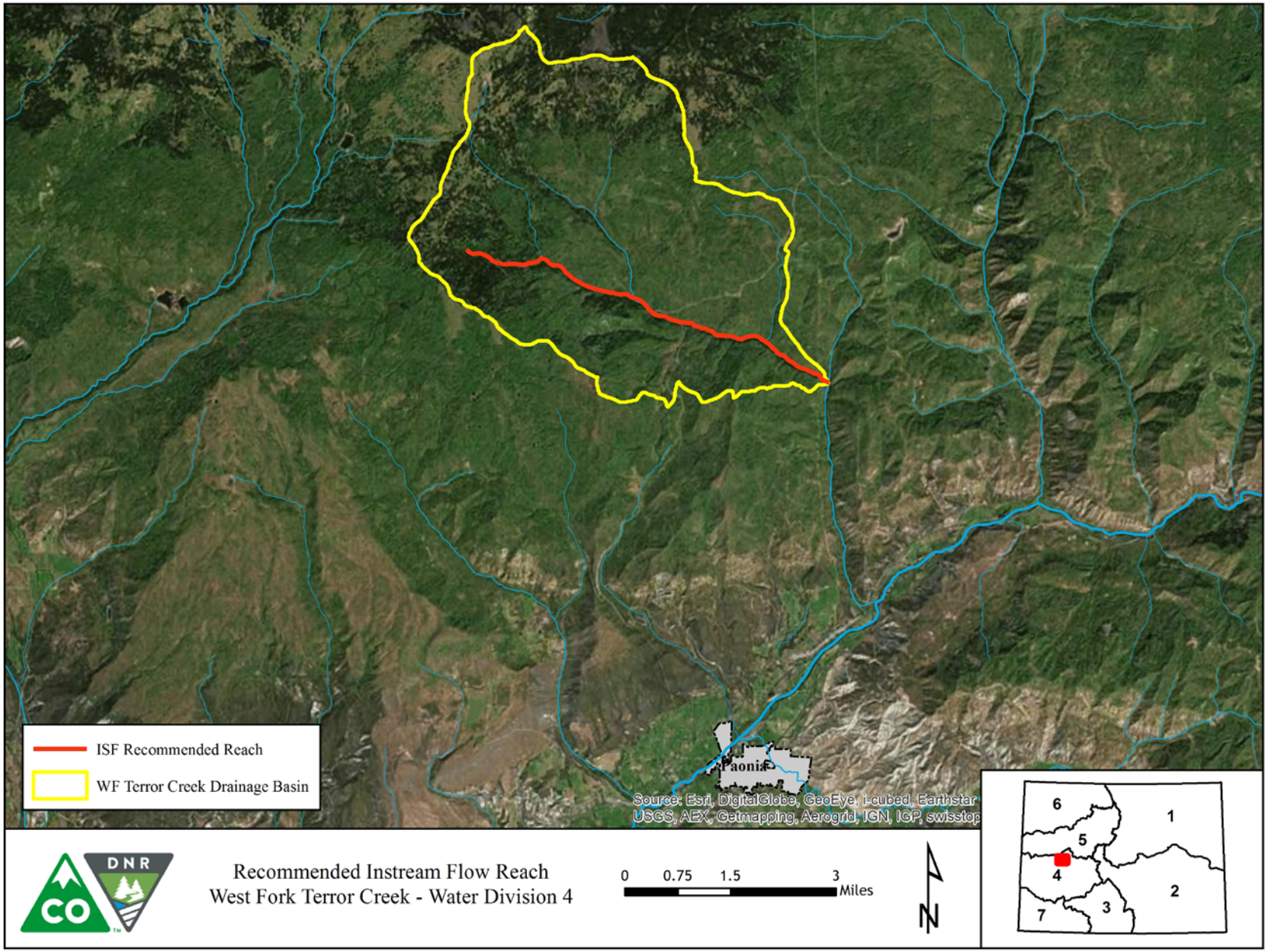
Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

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.

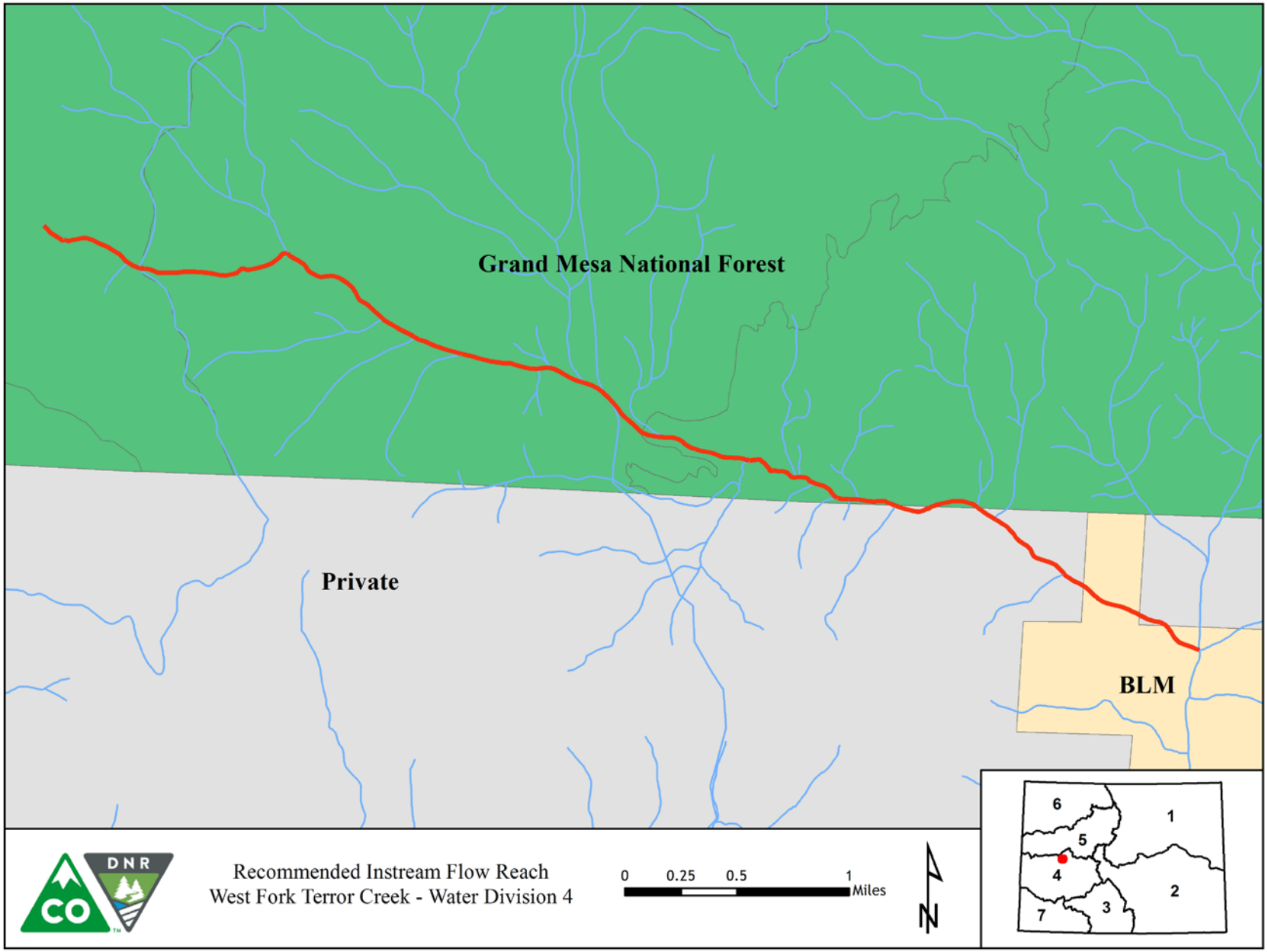
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

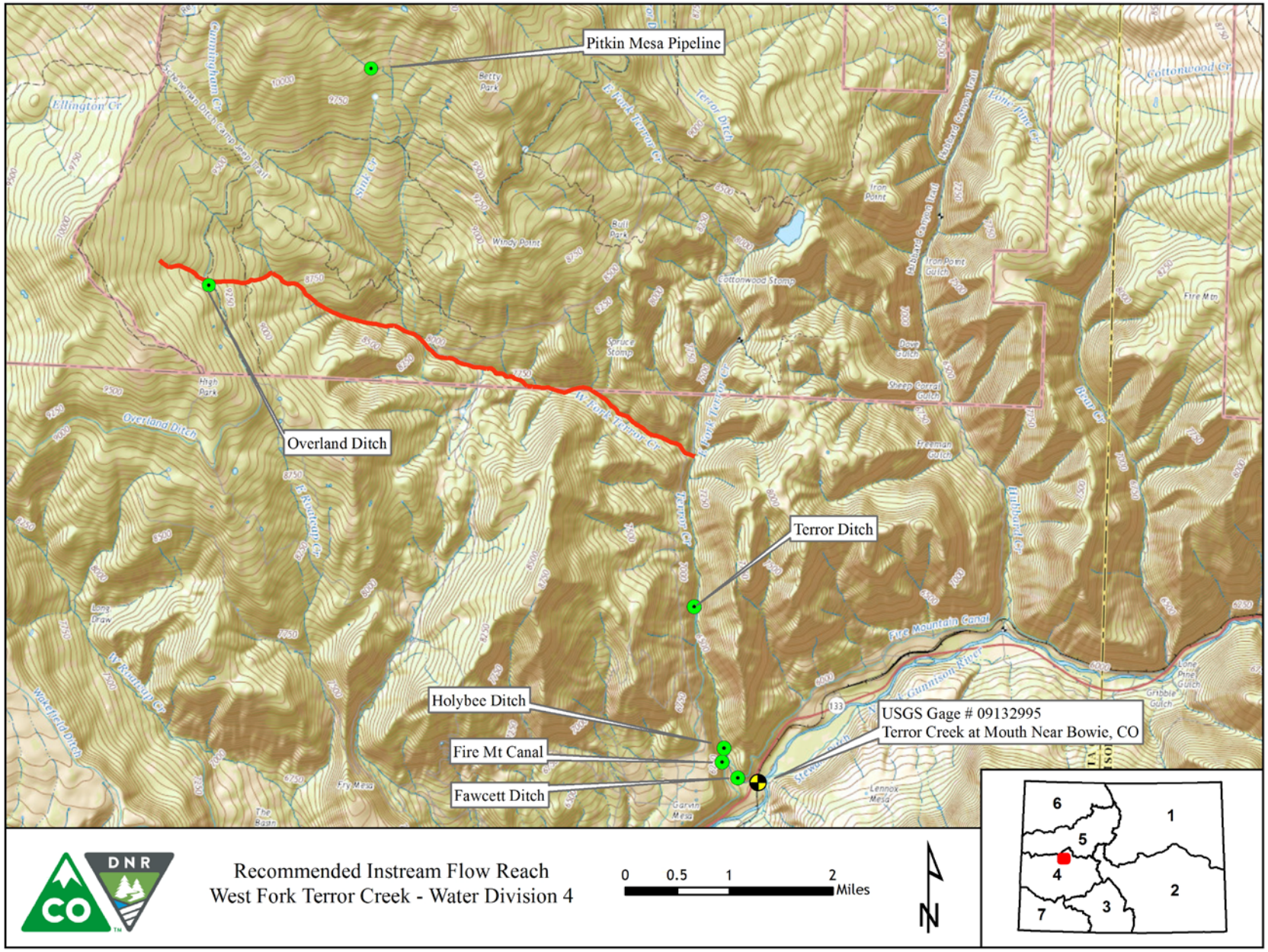
VICINITY MAP



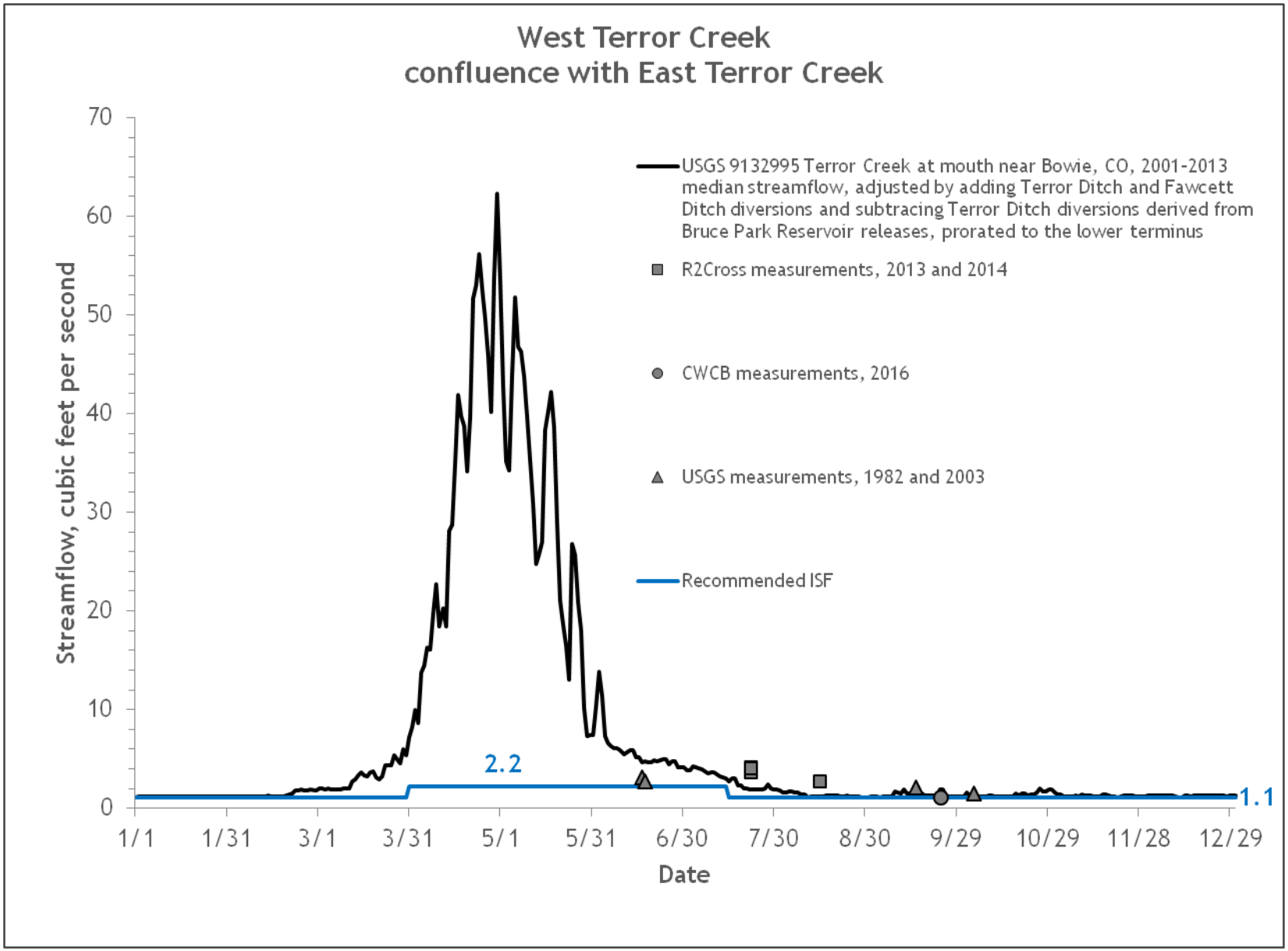
LAND OWNERSHIP MAP



HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH