Attachment A

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Himes Creek
EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	headwaters in the vicinity of UTM North: 4144335.05 UTM East: 328210.38
LOWER TERMINUS:	Himes Ditch headgate UTM North: 4143682.20 UTM East: 331098.52
WATER DIVISION:	7
WATER DISTRICT:	29
COUNTY:	Mineral
WATERSHED:	Upper San Juan
CWCB ID:	17/7/A-001
RECOMMENDER:	U.S. Forest Service (USFS)
LENGTH:	2 miles
FLOW RECOMMENDATION:	All unappropriated flow

Himes 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 U.S. Forest Service (USFS) recommended that the CWCB appropriate an ISF water right on a reach of Himes Creek, which is located within Mineral County (See Vicinity Map). Himes Creek originates at an elevation of approximately 11,000 feet in the San Juan Mountains and flows southeast to the confluence with the West Fork San Juan River at an elevation of approximately 7,750 feet. The proposed reach extends from the headwaters downstream to the Himes Ditch headgate. One hundred percent of the land on this 2 mile reach is public land managed by the USFS (See Land Ownership Map). The USFS recommended this reach of Himes 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/2019ProposedISFRecommendations.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.

The natural environment of Himes Creek is a step-pool system that contains a self-reproducing population of the San Juan lineage of Colorado River cutthroat trout (San Juan lineage trout) that until recently was thought to be extinct. The USFS originally recommended an ISF water right on Himes Creek because it was known to support a Core Conservation population of pure-strain Colorado River cutthroat trout that shows no evidence of interbreeding with rainbow trout or Yellowstone cutthroat trout. During the ISF data collection process, the genetic lineage of the fish was confirmed by Colorado Parks and Wildlife (CPW) researchers (Rogers et al., 2018). This research demonstrated that the Himes Creek fish have the same genetic markers as museum samples of the San Juan lineage trout. The natural environment also consists of water-dependent wildlife habitat, aquatic macroinvertebrates, and healthy riparian vegetation.

Table 1. List of species identified in Himes Creek.

Species Name	Scientific Name	Status
Colorado River cutthroat trout, San Juan lineage	*Oncorhynchus clarkii pleuriticus*	State: Special Concern*

*Colorado River cutthroat trout are designated a state species of special concern, which is not a statutory category.

Himes Creek contains one of only five known distinct populations of the San Juan lineage trout. The total number of San Juan lineage trout in all known populations is estimated to be as few as 1,000. The total number of stream miles that the fish exists in is estimated to be 9.3 miles. Himes Creek contains the longest continuous section of known habitat.

Himes Creek is a small tributary to the West Fork San Juan River located in the San Juan National Forest. The drainage basin is 1.85 square miles and the recommended reach is just 2.0 miles in length. Himes Creek is a step-pool channel characterized by very steep slopes and large size sediment and wood that form steps and plunge pools. Himes Creek is exceptionally steep with channel gradients approaching 18% to 20% in many areas. Himes Creek is also quite small, just five feet wide on average. The sediment is dominated by large cobbles with many large boulders and bedrock throughout, but it also contains fine sediment supplied by eroding hillslopes adjacent to the stream. This creates a large range of sediment sizes throughout the reach. The abundant large wood within the bankfull channel creates channel complexity, entrains sediment, and creates fish habitat (Skinner, 2017). However, the steps created by large boulders and wood within the active channel also pose challenges for fish movement and underscore the importance of pools to provide fish resting areas and sufficient depth for fish to jump over steps. Himes Creek also contains a dense riparian corridor that includes willows and conifers that supply a source of large wood and shade the channel, protecting the thermal regime.

Although Himes Creek is a tributary to the West Fork of the San Juan River, they are rarely connected. The Himes Ditch, located at the proposed lower terminus, is decreed for up to 8 cfs and has the potential to divert the entire flow of the creek. When the ditch is operating, the channel below the diversion is dewatered. In addition, CPW constructed a barrier in 2001 downstream from the Himes Ditch. The purpose of the barrier is “to protect the population from subsequent invasions of nonnative salmonids” (Rogers et al, 2018). Both the ditch and the barrier serve to isolate the Himes Creek fish population from the West Fork San Juan River and to protect them from competition with nonnative fish.

The riparian forest consists mainly of coniferous species, with interspersed stands of cottonwood and aspen trees. The channel is lined with dense willows and alders that shade the stream. Thermal regimes of small streams, such as Himes Creek, are controlled by riparian shading from the forest canopy. Staff measured water temperature in Himes Creek staring in late summer 2018. Water temperature remained cold in Himes Creek during the summer due to abundant streamside vegetation blocking solar inputs, while stable flows during the winter keep pools clear of ice. The maximum water temperature recorded in 2018 was 59 degrees Fahrenheit on August 2, and the maximum seven-day average water temperature was 55 degrees Fahrenheit. Despite very low flows during the summer of 2018, water temperatures remained within the optimal temperature range for cutthroat trout, emphasizing the importance of the riparian community for buffering stressful conditions caused by drought.

Reference streams with a similar ecoregion provide context for the results of a habitat survey conducted by CPW in 2017 (Skinner, 2017). Of nine reference streams with similar habitat types and channel widths, Himes Creek channel gradient is at the upper range (18% slope) compared to slopes between 2-6% for the majority of the reference streams. Two pebble counts conducted in Himes Creek produced an average D50 particle size of 3.4 inches, which refers to the particle size at which 50% of the sample is finer. In comparison, the reference streams had an average D50 of 0.6 inches. Sediment size classes ranged from less than 0.08 inches to greater than 20 inches in Himes Creek, although numerous larger boulders and bedrock were observed outside of the pebble count cross-sections. Large wood (diameter greater than 0.1 feet and longer than 3 feet) is abundant throughout Himes Creek with 18 pieces per 100 feet, compared to an average of four pieces per 100 feet in the reference streams. The large and variable sediment sizes, abundant wood, and steep channel slopes interact to create complex and variable habitat types in Himes Creek that is distinct from many other streams in Colorado.

From an ecological perspective, Himes Creek represents the upper limit of viable trout habitat due to channel gradient, substrate size, and winter conditions. This extreme environment makes the fish population vulnerable to extirpation from catastrophic events, such as wildfire or drought, but is also likely responsible for the survival of the rare San Juan lineage trout. Cutthroat trout exist in fragmented, isolated habitats throughout their range due to habitat loss and nonnative species interactions. The extreme limits of viable trout habitat, such as Himes Creek, represents conditions where native species can out-compete nonnative species due to the unique and stressful conditions in which indigenous fauna have evolved. Himes Creek also represents an important opportunity for native species conservation in that the Himes Ditch, at the lower terminus of this recommendation, precludes the invasion of nonnative species that reside in the West Fork San Juan River.

The Himes Creek fish population size has remained relatively stable since 1994 when population surveys began. The fish population estimates range from 116 fish per mile in 1998 to 264 fish per mile in 2013. The last population survey conducted in 2017 produced an estimate of 244 fish per mile. The fish surveys have also observed a wide range of size classes, indicating that the San Juan lineage trout population is naturally reproducing. Brook trout have been observed within the recommended ISF reach since 2007 and three brook trout were captured in 2017. When encountered, CPW and USFS personnel have removed brook trout to limit establishment of nonnative populations. Nonnative species removal, in conjunction with the fish barrier installed in 2001, have helped reduce impacts to the San Juan lineage trout populations from invasive species.

Basis of the Recommendation

The USFS recommends that all unappropriated flow in Himes Creek is the minimum amount necessary to preserve the natural environment to a reasonable degree. Based on their own investigations and experience, CWCB Staff and CPW confirm and agree with this finding. Further, the recommendation states the importance of maintaining the natural flow regime to preserve the limited available habitat in Himes Creek throughout the year. Baseflows, snowmelt runoff, and short duration high flow events all support different aspects of the natural environment as summarized here:

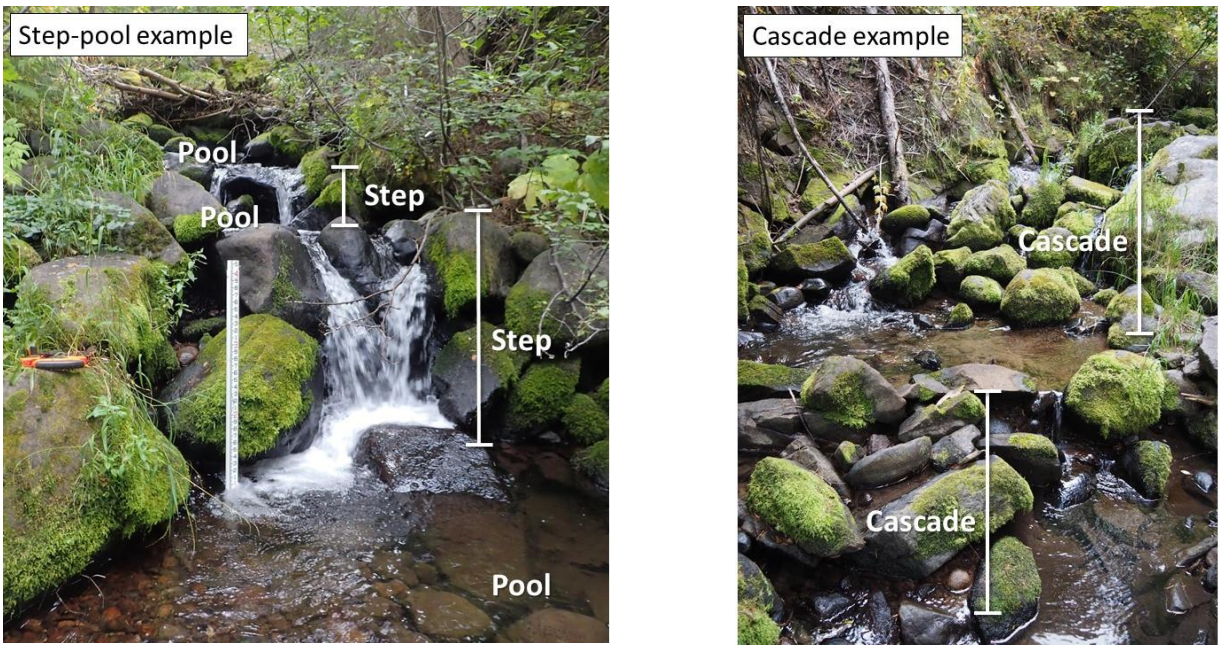
> Baseflows (typically August to March) are required to support macroinvertebrate life cycles, maintain temperature regime during summer, provide juvenile rearing and overwintering habitat, and prevent pools from freezing.
>
> Snowmelt Runoff Flows (typically March through July) are necessary to recharge aquifers to support riparian vegetation, remove fine sediment to maintain pool depth and volume for overwintering, and maintain spawning gravels for successful spawning.
>
> Short Duration Peak Flows (typically July through October) are necessary to entrain large woody debris, scour and form new pools, and maintain the riparian corridor.

The USFS, CWCB Staff, and CPW have conducted a number of studies and assembled a body of evidence and analysis that supports the finding that the natural flow regime is necessary to preserve the natural environment of Himes Creek, and that an ISF water right for all unappropriated flow will protect this flow regime. These investigations and the basis for the recommendation are discussed in further detail below.

The USFS evaluated the R2Cross methodology and determined that it is not an appropriate methodology to quantify the flow rates necessary to preserve the natural environment to a reasonable degree on Himes Creek. R2Cross is used to assess flow requirements in streams where riffles are the critical limiting habitat. The recommended reach of Himes Creek contains almost no riffle habitat, and riffles are not the limiting habitat type. Pools are the limiting habitat in Himes Creek. Pool habitat is the

primary habitat available for fish to complete the entire life cycle from spawning and fry to juvenile rearing and adult overwintering.

Both USFS observations and a CPW habitat assessment (Skinner, 2017) confirm that there is little to no riffle habitat within the proposed reach. The primary available habitat type is slow water habitat or pools (52% by area) formed by steps composed of large boulders or woody debris. The physical size of the available pool habitat is very limited; the average stream width is 4.8 feet and average pool depth is 0.4 feet or 4.8 inches. The residual pool depth, or the depth that would remain if water stopped flowing, is 0.8 feet and the maximum measured pool depth is 2 feet. The small pools and inundated portions of the boulders, woody debris, and sediment that form the steps are the primary habitat available for fish to complete their entire life cycle. The remainder of the surveyed habitat is fast water habitat, or cascades. These areas are characterized by steep gradients and large substrate that do not provide many opportunities for fish to spawn, rest, or overwinter. The photos below show the differences between the large steps and pool habitat and the cascades and smaller pocket water features. Fish will migrate through these steep habitat types when high flows inundate side channels or create slow water resting areas on the margins of the cascade. Given that the cascades do not provide sufficient usable habitat, the available pools are the only habitat that can sustain the population of San Juan lineage cutthroat trout in Himes Creek.



The left photo shows a typical step and pool section of Himes Creek. The right photo shows a section of a typical cascade. Pool habitat is the primary usable habitat available to fish on Himes Creek.

Dr. Brett Roper, professor of watershed science at Utah State University and National Aquatic Monitoring Program Leader for the USFS, authored a paper for the San Juan National Forest titled "Himes Creek Cutthroat Trout" (Roper, 2018). This paper describes the Himes Creek fishery as a resident population of San Juan lineage cutthroat trout that has adapted to a survival strategy that involves the population completing all life cycles in the habitat where they were hatched. Although other trout species may use a step-pool environment as migratory corridor, the Himes Creek fishery carries out its entire life cycle within this two-mile reach of isolated stream. Dr. Roper's paper further supports that pool habitat is the critical limiting habitat in Himes Creek. He surmises, "the absence of this pool habitat would almost certainly eliminate the presence of the Himes Creek cutthroat trout population." Further, he maintains that high spring flows are necessary "to flush sediment out of the

pools and sort the material in the pool tail-outs." Without these high flows, more fine material would be found in spawning locations and reduce survival both in times of drought and during periods with high ice coverage. A final point made by Dr. Roper is that maintaining temperatures conducive to these cutthroat trout is critical because lower temperatures help native species outcompete nonnative brook trout. After evaluating data on Himes Creek temperatures during the 2012 drought, he concluded that the existing temperatures in the stream appear to be perfect to foster growth within the Himes Creek trout population. Dr. Roper concludes that the uniqueness of this population of Himes Creek San Juan lineage cutthroat trout and its habitat provides strong support for maintaining the physical and ecosystem processes in as near a natural condition as possible.

A primary concern in Himes Creek is loss of pool habitat if sediment settles into the pools. As stated in the USFS recommendation letter, regional geology and local hillslope processes provide a readily available source of fine sediment to the stream. Maintaining pools is necessary to make sure the limited amount of available pool habitat does not decrease. Because pools provide critical habitat for the San Juan lineage trout, Staff investigated what flows maintain the characteristics of pools in Himes Creek, including the pool area and pool depth.

CWCB Staff contracted with Dr. Ellen Wohl, a professor of Geosciences at Colorado State University, to assist in this analysis. Dr. Wohl is a prominent scientist in the field of fluvial geomorphology with a significant body of research related to step-pool channels. Dr. Wohl produced a white paper that provides an overview of step-pool systems and assesses the current state of the science to evaluate flows necessary to scour pools and maintain pool habitat (Wohl, 2018). Dr. Wohl also conducted a site visit to Himes Creek in October 2018 with CWCB and CPW Staff. In the field, Dr. Wohl noted that Himes Creek appeared to have a substantial supply of fine sediment. See photograph demonstrating this point below.

Fine sediment in Himes Creek. Photographed by Ellen Wohl.

Dr. Wohl's report describes the difficulties associated with developing sediment transport equations for step-pool channels due to their high turbulence, significant three-dimensional flow, dissipation or loss of energy on the rough substrate and configuration of the bed and banks (the boundary), and large differences in grain size. She explains that small sediment can be protected from transport when it is shielded by larger sediment like boulders. She notes that "the greater the fluctuations in velocity and turbulence, and the greater the range of grain sizes present on a streambed, the less accurate the equations become" and that step-pool channels have all of these characteristics. The primary

conclusion is that "sediment transport equations over-predict sediment transport in step-pool channels by more than 1-2 orders of magnitude, or by more than a factor of 10 to 100 times." This means that the equations will predict that sediment transport occurs at much lower flows than what is actually necessary. Reliance on these models could significantly under-predict the flows necessary to preserve the natural environment.

Dr. Wohl's paper goes on to discuss the importance of maintaining the residual pool volume for fish survival. She explains that fish can survive very low flows caused by droughts and freezing conditions during winter if the pools are sufficiently deep. Dr. Wohl ends her paper with discussions of the importance of maintaining natural flow regimes, which she notes includes the magnitude, frequency, duration, timing (seasonality), and rate of change of flow. She states that "natural flow and sediment regimes are critical to channel morphology because they maintain the geometry, and grain-size distribution of a channel, to which stream organisms are adapted." She concludes that the natural flow regime is "critical to stream organisms because it maintains the habitat, food sources, and thermal and chemical cues on which their life cycles are built."

A literature review prepared by Jay Skinner provides further information about the importance of the natural flow regime. Mr. Skinner is a recently retired CPW fish biologist who spent the majority of his career working on ISF water rights and serving as the CWCB's biological expert. Prior to his retirement from CPW, he initiated a written review of applicable scientific literature that addresses the role of the natural flow regime to overall aquatic ecology, the physical and biological interrelationships between the flowing water environment and the adjacent terrestrial environment, and the contemporary body of knowledge in instream flow science and environmental flow protection (Skinner, 2019). In general, stream ecologists have long recognized, from an energy flow point of view, that aquatic and riparian food webs interact as energy and nutrients are transported between terrestrial and fluvial environments. In addition, aquatic organisms (macroinvertebrates, aquatic insects, and fish) use terrestrial habitats to complete life cycles and for reproduction, food, and habitat (physical cover for fish, overhead cover for fish, and water temperature moderation). Riparian habitats have numerous other biologic and hydrologic benefits as well; water quality protection, a water source for stream baseflow during the fall and winter, and overall stream channel stability (sediment dynamics). Mr. Skinner makes the case for protection of the full range of stream flows (the natural flow regime) in isolated circumstances where the biologic community of interest is unique, rare, or is otherwise significant for land, water, or fishery managers.

In addition to the investigations completed by USFS, CPW, and CWCB Staff, CPW asked an outside agency that is not associated with the development of the Himes Creek recommendation to review the USFS's recommendation. CPW, through its membership in the Instream Flow Council, requested and received a peer review of the USFS's written flow recommendations; this peer review came from ISF and Colorado River cutthroat trout experts with the Wyoming Game and Fish Department (WGDF). The authors of this review are Paul Dey, WGFD Aquatic Habitat Program Manager, and Dave Zafft, WGFD Fisheries Management Coordinator and Colorado River Cutthroat Trout Conservation Team interagency team leader. The reviewers concluded "we have reviewed the Forest Service's recommendation for an instream flow water right on Himes Creek and find it makes a strong case for protecting all of the flow in order to preserve a rare population of a genetically unique lineage of Colorado River Cutthroat Trout."

While it may be desirable to use equations and models to determine a specific required flow rate that will preserve the natural environment of Himes Creek to a reasonable degree, CWCB Staff, USFS, and CPW Staff believe such an approach is overly simplistic and is unreliable given the natural environment found in Himes Creek. R2Cross and other models may be reasonable for most streams in Colorado, but they may not be appropriate or produce valid results in cases where a unique species inhabits the natural environment to be preserved. In addition, a specific model-based approach is not necessary in

order to arrive at a flow determination that: (1) will preserve the natural environment to a reasonable degree, (2) has a sound basis in science, and (3) will have no effect on human needs located in developed areas downstream. As a result, Staff agrees with the USFS recommendation that all of the unappropriated flow in Himes Creek is necessary to preserve the natural environment for the following specific reasons:

1. Himes Creek contains one of the last remnant fish population of the San Juan lineage trout. This lineage of fish was once thought to be extinct. Protecting this rare fish is a top priority for both the USFS and CPW.

2. The geomorphic nature of Himes Creek results in exceptionally limited habitat due to the small drainage basin size, uncommonly high slope, very large substrate size that forms high steps, and the presence of fine sediment. Any reduction in flow has potential to reduce the amount of habitat available.

3. Himes Creek is physically disconnected from the West Fork of the San Juan River at most times and biologically isolated from any other known populations of this fish lineage. The fish must complete their entire life cycle within the available habitat in Himes Creek and have no opportunity to migrate to other locations or repopulate from other locations.

4. The best available science supports the importance of maintaining the full range of flows and natural hydrologic variability. Maintaining the natural flow variability preserves the conditions, to the extent possible, that have allowed this remnant population to persist to date.

5. Himes Creek is located above all headgates and entirely on public land. This location and the provisions of section 37-92-102(3)(b), C.R.S., where applicable, minimize impacts to other water users while fully protecting Himes Creek.

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.

The water availability analysis for Himes Creek is presented below to provide information about hydrology on Himes Creek and the typical range of streamflows that may be protected with this ISF appropriation. The water availability analysis in this context is not intended to limit or reduce the proposed ISF water right for all the unappropriated flow.

Basin Characteristics
The drainage basin of the proposed ISF on Himes Creek is 1.85 square miles, with an average elevation of 9,940 ft and average annual precipitation of 39.67 inches (See the Hydrologic Features Map). There are no known surface water diversions in the drainage basin tributary to the proposed ISF on Himes Creek. Hydrology in this drainage basin represents natural conditions.

Hydrology throughout the San Juan Mountains demonstrates a snowmelt runoff pattern that is also influenced by monsoon and late season storms. This results in high flow events that can occur between May and early July due to snowmelt and high flow events that can occur between August and October due to rain events. The magnitude of the rain event flows can be comparable to spring runoff flows; for example, the flood of record occurs in fall rather than spring or early summer for several nearby gages.

Available Data
There is not a current or historic streamflow gage on Himes Creek. There are several historic gages in the region near Himes Creek including: West Fork San Juan River above Borns Lake, near Pagosa Springs, CO (USGS 09340500, 1937-1953), Wolf Creek near Pagosa Springs, CO (USGS 09341200, 1968-1975), Wolf Creek at Wolf Creek Campground near Pagosa Springs, CO gage (USGS 09341300 1984-1987 and 1997-1999), and Windy Pass Creek near Pagosa Springs, CO (USGS 09341350, 1984-1987). The two gages on Wolf Creek were identified as most similar to Himes Creek in terms of drainage basin area and annual precipitation, while having a reasonably long period of record to analyze. The Wolf Creek gages also have few diversions; these diversions can be accounted for with available diversion records.

The upstream most gage on Wolf Creek is Wolf Creek near Pagosa Springs, CO (USGS 09341200, 1968-1975), which is approximately 2.0 miles northeast from the proposed lower terminus on Himes Creek. The drainage basin of the Wolf Creek near Pagosa gage is 14.1 square miles with an average elevation of 10,600 ft and average annual precipitation of 47.87 inches. The lower gage, Wolf Creek at Wolf Creek Campground near Pagosa Springs, CO gage (USGS 09341300), was installed approximately 1,800 ft downstream from the upper gage, approximately 1.7 miles northeast from the proposed lower terminus on Himes Creek. The drainage basin of the Wolf Creek at Wolf Creek Campground gage is 17.9 square miles with an average elevation of 10,500 feet and average annual precipitation of 46.29 inches. The lower gage was operated year round from 1984-1987 and seasonally from 1997-1999. A transbasin diversion, with alternate points near Wolf Creek Pass, exports water to Division 3 (Treasure Pass Ditch Division, appropriation date 1922, 8 cfs absolute). This diversion reduces streamflow for both gages on Wolf Creek; however, diversions are recorded by the Treasure Pass Ditch at Wolf Creek Pass gage (USGS 09341000). One other small diversion exists on a tributary to the lower Wolf Creek gage. Bruce Spruce

Ditch (appropriation date 1936, 2.68 cfs) diverts water from Fall Creek and any return flows accrue below the lower gage. No other surface water diversions appear to exist upstream of the gages.

In some cases, diversion records can be used to provide an indication of water availability in a stream reach. The Himes Ditch (appropriation dates 1889 and 1959, 2.5 cfs and 5.5 cfs) is located at the lower terminus on Himes Creek. The Himes Ditch diversion consists of a tarp and sandbags that are used to block Himes Creek and send water down a ditch that has a capacity of about 3 cfs (personal communication, water commissioner Bob Formwalt, May 15, 2018). This structure has the potential to divert nearly the entire flow of Himes Creek during most of the irrigation season and has diversion records from 1963 to 2017.

CWCB Staff made two streamflow measurements on Himes Creek, and the USFS made five streamflow measurements on Himes Creek, as summarized in Table 2.

Table 2. Summary of Streamflow Measurements for Himes Creek.

Visit Date	Flow (cfs)	Collector
6/21/2016	3.18	USFS
6/21/2016	2.92	USFS
9/07/2016	0.62	USFS
9/07/2016	0.57	USFS
8/2/2018	0.19	CWCB
9/25/2018	0.07	USFS
10/16/2018	0.35	CWCB

Data Analysis

Due to the short period of record for the Wolf Creek gages, Staff examined available climate stations and found that the Pagosa Springs climate station (Station USC00056258, downloaded 2/28/2017) is located in vicinity of the Wolf Creek gages and Himes Creek. This station is located 14.5 miles southwest from the Wolf Creek gage locations and roughly 13 miles southwest from the proposed lower terminus on Himes Creek. The station has a relatively long period of record (1906 to 2016), although there are several periods without data. The average annual precipitation at the Pagosa Springs station for the period of record (based on 57 years with 350 or more days of data) was 20.2 inches. During the complete years the Wolf Creek gages operated (1969 to 1975 and 1985 to 1986), the average precipitation was 22.2 inches. Based on the available data, the Wolf Creek gage records may represent slightly above average precipitation conditions.

The Wolf Creek near Pagosa gage (USGS 09341200) was analyzed using the period of record available (1968-1975). Transbasin exports from the Treasure Pass Ditch (USGS 0934100) were added to the gage data to estimate natural streamflow. The adjusted gage record was scaled by 0.11 to the lower terminus on Himes Creek 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 Wolf Creek at Wolf Creek Campground gage (USGS 09341300) was analyzed using the period of record available (1984-1987 and 1997-1999). Transbasin exports from the Treasure Pass Ditch (USGS 09341000) and in-basin diversions from Bruce Spruce Ditch (WDID 2900548) were added to the gage data to estimate natural streamflow. The adjusted gage record was scaled by 0.09 to the lower terminus on Himes Creek using the area-precipitation method. The

scaled data from both gages was combined, resulting in 10 to 13 years of data, depending on the day of the year. Median stream flow was calculated; however, 95% confidence intervals were not calculated due to the short period of record from the combined gage data sets.

There are diversion records during the irrigation season for the Himes Ditch from 1964-2017 based on data available through HydroBase on 5/2/2018. A number of years have a water commissioner comment "water available, but not taken" (1982, 1986, 1987, 1996, 1999). The zero values in the record for these years were not used in the median diversion calculations. The year 2000 has the comment "ditch washed out"; however, the record contained several days with a diversion rate of 0.05 cfs. Records from the year 2000 were used as is. Other than these minor adjustments, the entire diversion record was used to calculate median and maximum diversions.

While the Himes Ditch diversion record can provide an estimate of streamflow, it is not a perfect proxy for streamflow. Diversion rates may be limited by a number of factors that are independent from the amount of water that is physically available. Limiting factors can include the type of structure used to divert water (tarps, pushup dams, etc.), the capacity of the headgate structure, the capacity of the ditch, and in many cases, the decreed flow rate. Diversions are also based on when the ditch owner or operator needs or wants to make diversions and specific to Himes Creek, when the tarp is manually installed. Diversion measurements are based on when a water commissioner can make an observation or when the ditch owner submits self-reported values, and the interval between reported observations can vary. The measured values may miss water that is not captured by the structure or water that leaks from the ditch if the measuring device is not located at the diversion structure. The periodic observations are then typically used to fill in the record until the next observation, which may or may not accurately reflect the actual amount of water diverted during the intervening time. In general, diversion records provide some information, but are likely to miss some water even at low flows, and are especially poor at accurately documenting rare high flow events.

Median Streamflow Estimates

The hydrograph (Complete Hydrograph) shows the median streamflow of the prorated and diversion adjusted data from the Wolf Creek gages. Median streamflow, based on the adjusted and prorated gage data is typically quite low, less than 1 cfs for nearly half of all days. The hydrograph also shows the median and maximum diversions from the Himes Ditch. The median diversion rate is quite low, often near zero due in part to a large number of years with no diversion records. If the zeros are removed, the median diversion rate is typically between 1 and 2 cfs. The maximum recorded diversion rate is 11.42 cfs. This analysis provides estimates about typical low conditions on Himes Creek.

High Flow Estimates

The ISF recommendation is based in part on the importance of rare high flow events that help to maintain pools that are critical habitat for the San Juan lineage trout in Himes Creek. The Maximum Daily Hydrograph shows the maximum daily streamflow based on the Wolf Creek gages. The highest prorated daily streamflow was 43.7 cfs, while the pro-rated peak flow (the maximum instantaneous streamflow) was 64 cfs. The hydrograph also illustrates late season storms, which typically occur during August through October. These peak flows are short in duration, but nearly reach the magnitude of spring runoff flows.

StreamStats also estimates peak flows for a number of different recurrence intervals; the 2-year recurrence interval flow is 43.7 cfs (the exact match to the prorated gage daily value is a coincidence), the 5-year recurrence interval flow is 82.2 cfs, the 10-year recurrence interval flow is 115 cfs, and the 100-year recurrence interval flow is 255 cfs. These estimates suggest that while flow on Himes Creek is usually quite low, rare events can produce more significant streamflow.

Water Availability Summary
The hydrographs presented below together with recurrence intervals from StreamStats provide an estimate of the range of streamflow conditions on Himes Creek. Staff has concluded that water is available for appropriation.

Material Injury
Because the proposed ISF on Himes 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. (2018), 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.

Rogers, K.B, White, J, and M. Japhet, 2018, Rediscovery of a lost Cutthroat Trout lineage in the San Juan Mountains of southwest Colorado. Colorado Parks and Wildlife, p 1-33.

Roper, B., 2018, Himes Creek Cutthroat Trout. Utah State University, p 1-7.

Skinner, J., 2019, Literature review on the importance of a natural flow regime to aquatic ecology in rivers and streams, p 1-13

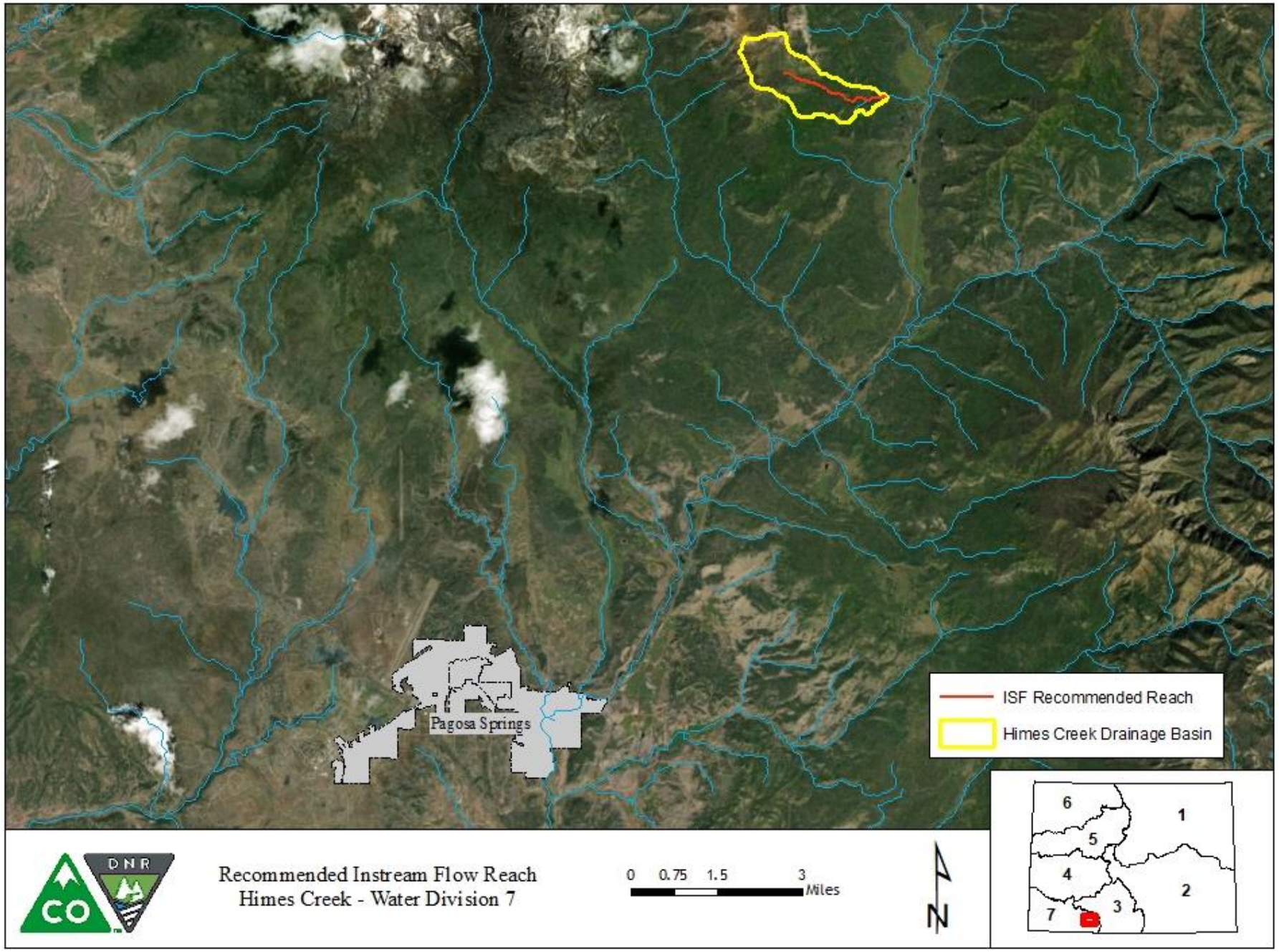
Skinner, J., 2017, Himes Creek Habitat Survey and Inventory Report. Colorado Parks and Wildlife, p 1-17.

Wohl, E., 2018, Himes Creek Flow Diversions. Colorado State University, p 1-14.

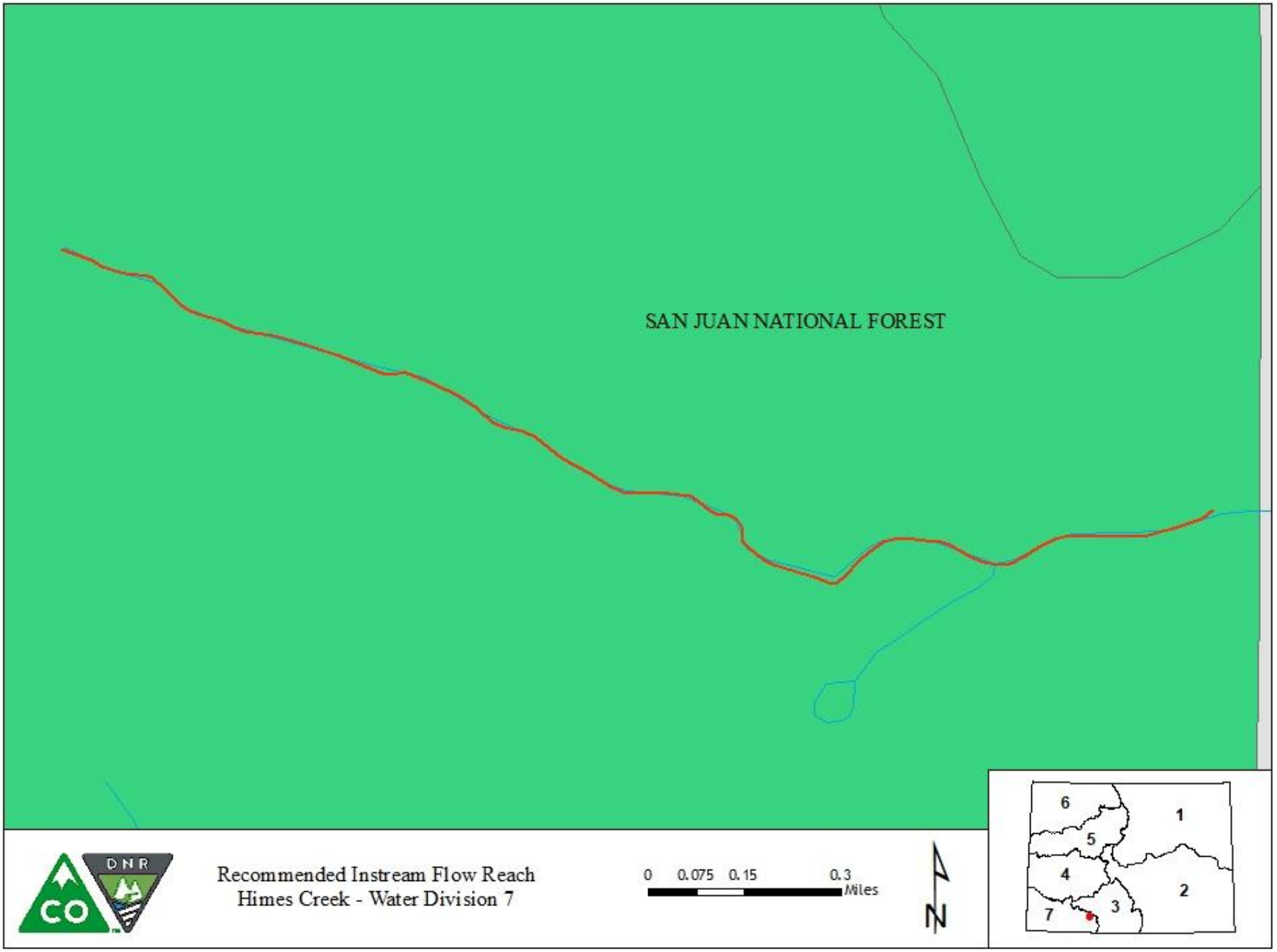
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

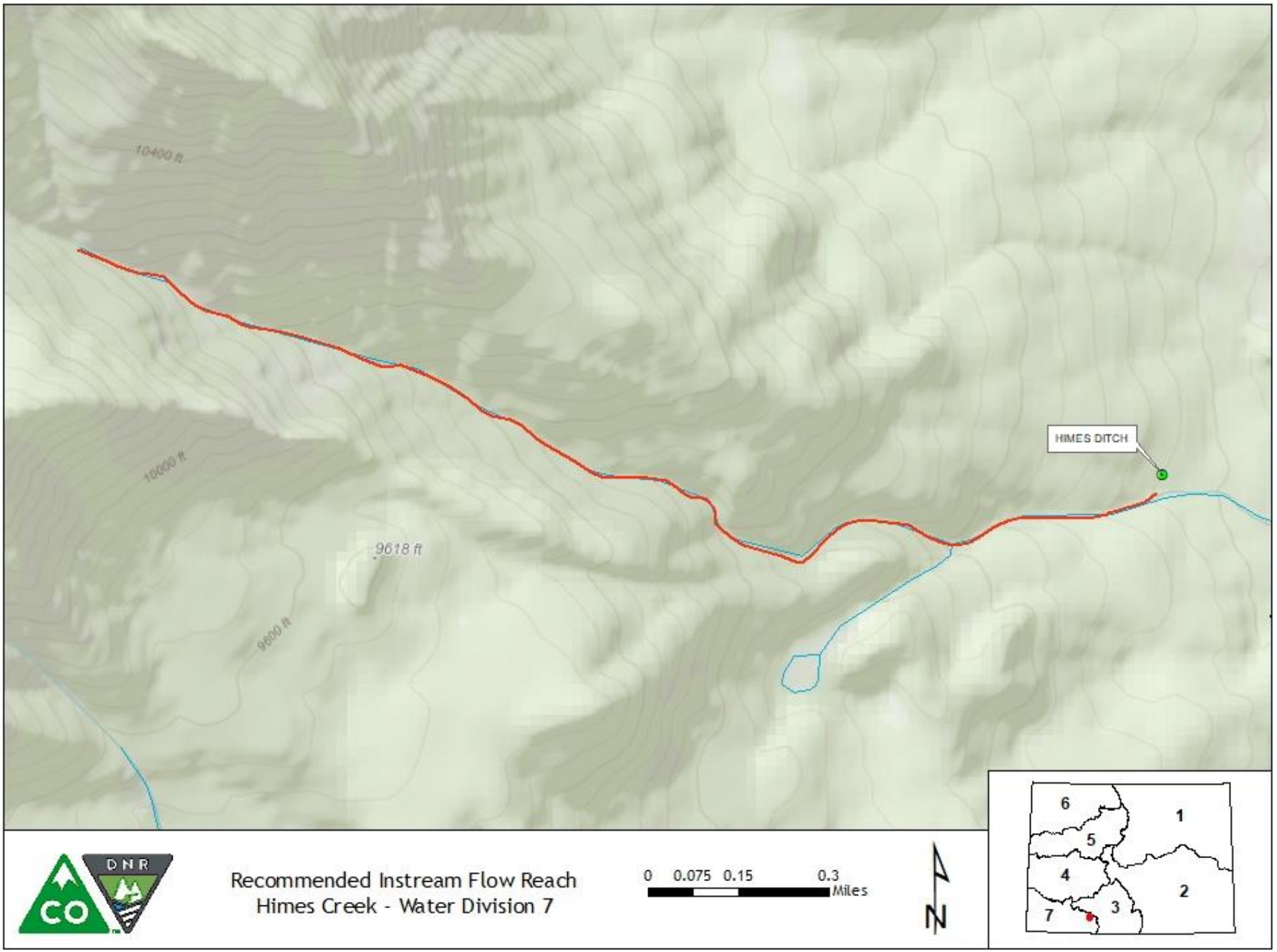
VICINITY MAP



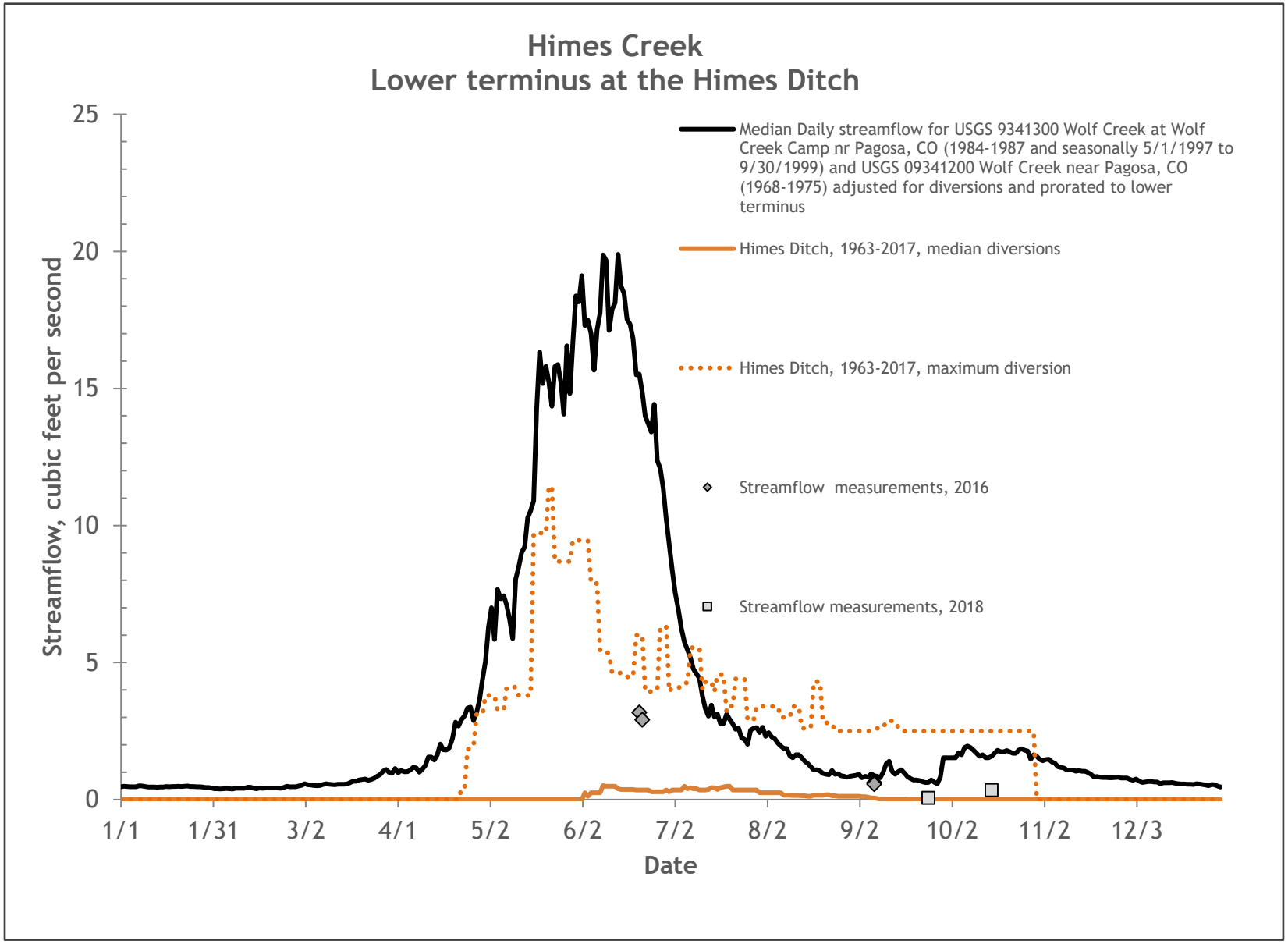
LAND OWNERSHIP MAP



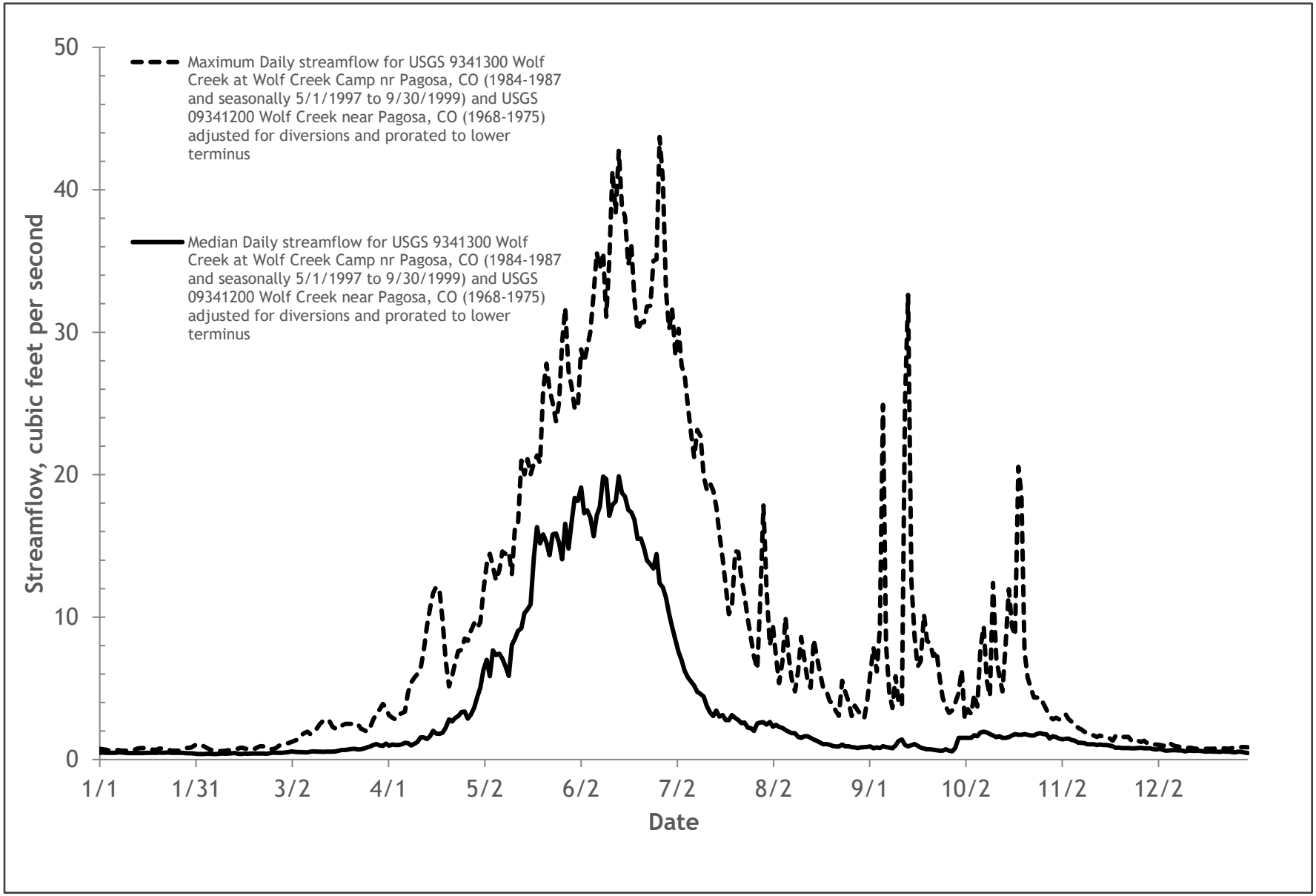
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



MAXIMUM DAILY HYDROGRAPH



SELECT PHOTOS

Unusually large step and pool.

Tarp being used to divert flow to the Himes Ditch.

Small pool that demonstrates a mix of sediment sizes.

Eroding hillslope adjacent to the channel.

San Juan lineage trout

SELECT PHOTOS

Himes Creek Fall 2018

Himes Creek Winter 2019